Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2724511 A1 2009/11/26

(21) 2 724 511

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2009/05/19
(87) Date publication PCT/PCT Publication Date: 2009/11/26
(85) Entrée phase nationale/National Entry: 2010/11/15
(86) N° demande PCT/PCT Application No.: US 2009/044428
(87) N° publication PCT/PCT Publication No.: 2009/143092
(30) Priorité/Priority: 2008/05/21 (US12/124,655)

(51) Cl.Int./Int.Cl. *A61B 17/072* (2006.01)

(71) Demandeur/Applicant:
ETHICON ENDO-SURGERY, INC., US

(72) Inventeurs/Inventors:
SHELTON, FREDERICK E., IV, US;
YATES, DAVID C., US;
SMITH, RICHARD C., US

(74) Agent: OGILVY RENAULT LLP/S.E.N.C.R.L.,S.R.L.

(54) Titre : INSTRUMENT CHIRURGICAL AVEC EFFECTEUR TERMINAL ARTICULE POUVANT ETRE AUTOMATIQUEMENT RECONFIGURE

(54) Title: SURGICAL INSTRUMENT WITH AUTOMATICALLY RECONFIGURABLE ARTICULATING END EFFECTOR

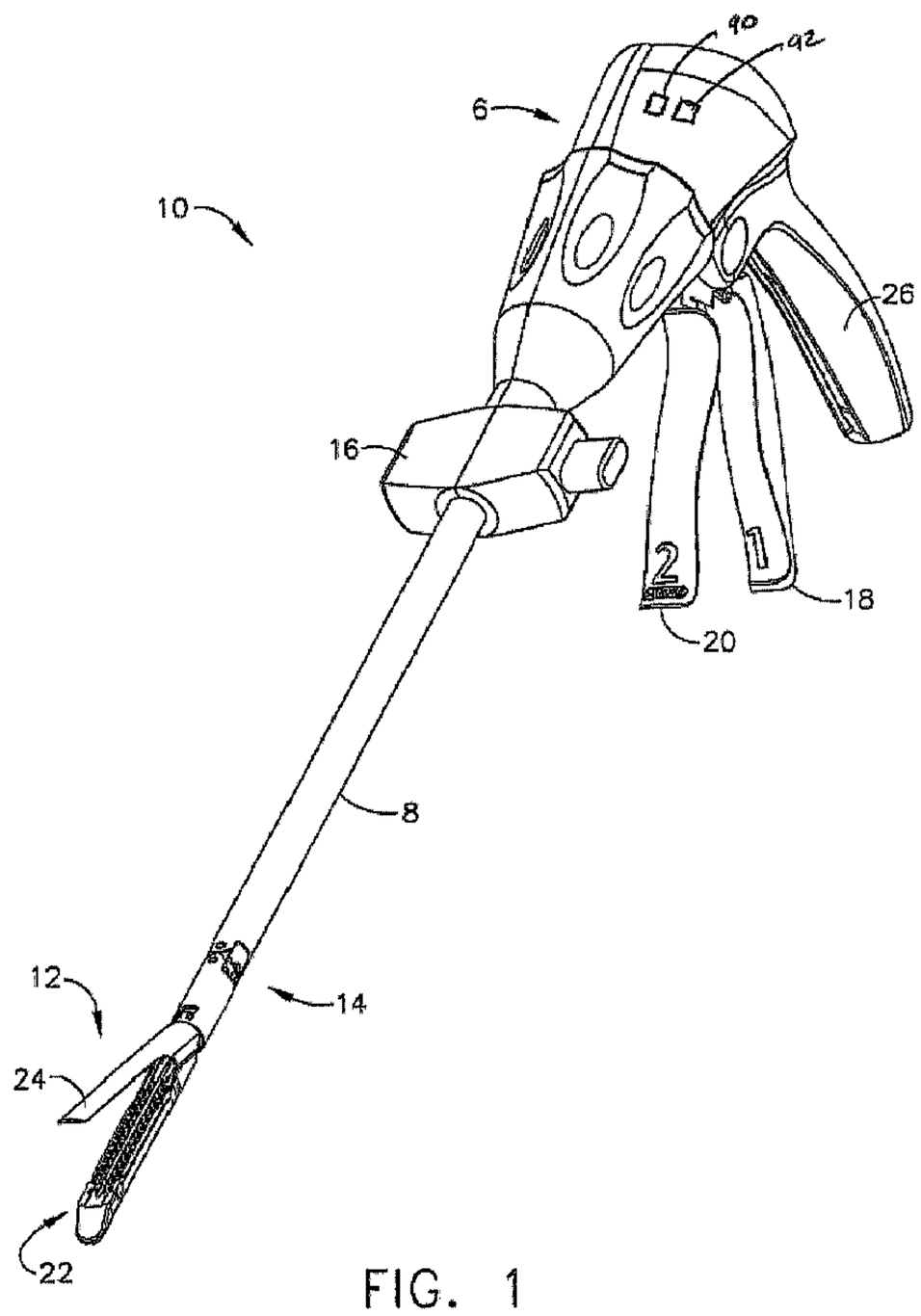


FIG. 1

(57) Abrégé/Abstract:
A surgical instrument, such as a surgical cutting and fastening instrument, with an automatically articulatable end effector. The surgical instrument may comprise an end effector, a shaft, and an articulatable joint assembly connected between the end effector

CA 2724511 A1 2009/11/26
(21) 2 724 511
(13) A1

(57) Abrégé(suite)/Abstract(continued):
and the shaft. The joint assembly comprises at least one motor for articulating the end effector relative to the shaft. The joint assembly comprises at least one articulation sensor for sensing articulation of the end effector relative to the shaft. The instrument further comprises a control unit in communication with the articulation sensor and the motor. The control unit comprises at least one memory unit for storing articulation data from the at least one articulation sensor. When activated, the control unit sends control signals to the motor of the joint assembly to articulate automatically the end effector to a desired position based on the articulation data from the articulation sensor that is stored in the memory unit of the control unit.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 November 2009 (26.11.2009)

PCT

(10) International Publication Number
WO 2009/143092 A1

(51) International Patent Classification:
A61B 17/072 (2006.01)

(21) International Application Number:
PCT/US2009/044428

(22) International Filing Date:
19 May 2009 (19.05.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/124,655 21 May 2008 (21.05.2008) US

(71) Applicant *(for all designated States except US)*: **ETHICON ENDO-SURGERY, INC.** [US/US]; 4545 Creek Road, Cincinnati, OH 45242 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **SHELTON, Frederick, E., IV** [US/US]; 245 East Main Street, Hillsboro, OH 45133 (US). **YATES, David, C.** [US/US]; 7534 Galway Court, West Chester, OH 45069 (US). **SMITH, Richard, C.** [US/US]; 1493 Greystone Lane, Milford, OH 45150 (US).

(74) Agents: **JOHNSON, Philip, S.** et al.; Johnson & Johnson, One Johnson & Johnson Plaza, New Brunswick, NJ 08933 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: SURGICAL INSTRUMENT WITH AUTOMATICALLY RECONFIGURABLE ARTICULATING END EFFECTOR

(57) Abstract: A surgical instrument, such as a surgical cutting and fastening instrument, with an automatically articulatable end effector. The surgical instrument may comprise an end effector, a shaft, and an articulatable joint assembly connected between the end effector and the shaft. The joint assembly comprises at least one motor for articulating the end effector relative to the shaft. The joint assembly comprises at least one articulation sensor for sensing articulation of the end effector relative to the shaft. The instrument further comprises a control unit in communication with the articulation sensor and the motor. The control unit comprises at least one memory unit for storing articulation data from the at least one articulation sensor. When activated, the control unit sends control signals to the motor of the joint assembly to articulate automatically the end effector to a desired position based on the articulation data from the articulation sensor that is stored in the memory unit of the control unit.

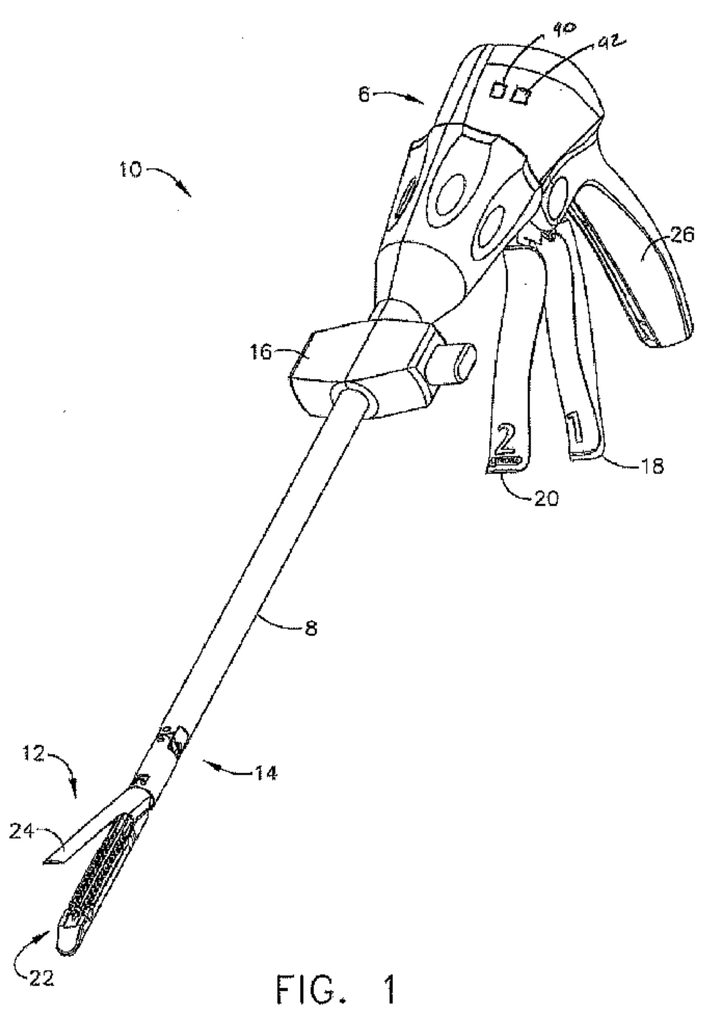


FIG. 1

WO 2009/143092 A1

WO 2009/143092 A1

Published:

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

SURGICAL INSTRUMENT WITH AUTOMATICALLY RECONFIGURABLE ARTICULATING END EFFECTOR

Inventors: Frederick E. Shelton, IV, David C. Yates, and Richard C. Smith

BACKGROUND

[0001] Surgical staplers have been used in the prior art to simultaneously make a longitudinal incision in tissue and apply lines of staples on opposing sides of the incision. Such instruments commonly include an end effector having 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—one on each side of the knife channel. 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 that, 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. Simultaneously, a cutting instrument (or knife) that is drawn distally along the jaw member so that the clamped tissue is cut and fastened (e.g., stapled) at the same time.

[0002] An example of a surgical stapler suitable for endoscopic applications is described in U.S. Patent No. 7,000,818 B2, entitled, “Surgical stapling instrument having separate distinct closing and firing systems,” the disclosure of which is herein incorporated by reference in its entirety. In use, a clinician is able to close the jaw

members of the stapler 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, thereby severing and stapling the tissue. The simultaneous severing and stapling actions avoid complications that may arise when performing such actions sequentially with different surgical tools that respectively only sever or staple.

[0003] The prior art also includes endocutters with articulatable end effectors, such as described in published U.S. patent application Pub. No. 2007/0175959, which is incorporated herein by reference in its entirety. Such an instrument comprises an articulation control that allows a user (e.g., an operating surgeon) to effect rotation of the end effector about an articulation pivot.

[0004] Commonly, a procedure that requires use of such an endocutter requires the operator to undertake several cutting/fastening strokes at a general common location within the patient. Thus, after each cutting/fastening stroke by the instrument, the clinician has to withdraw the instrument through the cannula and replace the now-spent staple cartridge in the end effector. Then the clinician has to reinsert the instrument back through the cannula into the patient and position the end effector again, including articulating the end effector back to the same general position it was in for the prior cutting/fastening stroke.

SUMMARY

[0005] In one general aspect, the present invention is directed to a surgical instrument, such as a surgical cutting and fastening instrument, with an automatically articulatable end effector. According to various embodiments, the surgical instrument

may comprise an end effector, a shaft, and an articulatable joint assembly connected between the end effector and the shaft. The joint assembly comprises at least one motor for articulating the end effector relative to the shaft. The joint assembly also comprises at least one articulation sensor for sensing articulation of the end effector relative to the shaft.

[0006] The instrument further comprises a control unit in communication with the articulation sensor and the motor. The control unit comprises at least one memory unit for storing articulation data from the at least one articulation sensor. In addition, when activated, the control unit sends control signals to the motor of the joint assembly to articulate automatically the end effector to a desired position (or articulation state) based on the articulation data from the articulation sensor that is stored in the memory unit of the control unit. For example, the control unit may cause the end effector to articulate to a prior state of articulation (such as the state of articulation when the instrument was last fired) or some other state of articulation. The control unit may also be able to cause the end effector to automatically articulate back to its original or unarticulated state. That way, a clinician can (i) insert the end effector into a patient through a cannula, (ii) automatically articulate the end effector to a desired position, (iii) fire the instrument, (iv) rearticulate the end effector back to its original state to (v) withdraw it from the patient through the cannula, and (vi) replace the cartridge so that the process can be repeated. This should tend to lead to greater accuracy and repeatability in repositioning the end effector, which is important in procedures where the end effector needs to be position in the same general position for repeated firings.

[0007] According to various implementations, the surgical instrument may be a surgical cutting and fastening instrument, such as an endocutter. As such, the end effector may comprise two opposing, pivotably connected jaw members. One jaw member may carry a cutting instrument for severing tissue clamped between the two jaw members. It may also comprise a replaceable staple cartridge carrying a number of staples, such that when the instrument is fired, the staples are urged through the clamped tissue and turned by the other jaw member, acting as an anvil.

[0008] In another general aspect, the present invention is directed to a method of performing a surgical procedure. In one embodiment, the process comprises:

(a) inserting the articulatable end effector into the patient through the cannula while the end effector is in a first articulation state; (b) after step (a), activating an input device on the surgical instrument to cause the end effector to automatically articulate to a second articulation state that is different from the first articulation state; (c) after step (b), firing the surgical instrument to sever and fasten tissue clamped in the end effector; (d) after step (c), activating the input device to cause the end effector to automatically articulate to the first articulation state; and (e) after step (d), withdrawing the end effector from the patient through the cannula.

[0009] These and other benefits of the present invention will be apparent from the description below.

FIGURES

[0010] Various embodiments of the present invention are described herein by way of example in conjunction with the following figures, wherein:

Figures 1 and 2 depict a surgical instrument with an articulatable end effector according to various embodiments of the present invention;

Figure 3 is an exploded view of the end effector of the surgical instrument of Figures 1 and 2 according to various embodiments of the present invention;

Figure 4 is a block diagram depicting a control unit and sensors of the surgical according to various embodiments of the present invention; and

Figure 5 is a diagram of a joint articulation assembly of the surgical instrument of according to various embodiments of the present invention.

DESCRIPTION

[0011] Figures 1 and 2 depict a surgical cutting and fastening instrument 10 with an automatically articulatable end effector according to various embodiments of the present invention. The illustrated embodiment is an endoscopic surgical instrument 10 and in general, the embodiments of the instrument 10 described herein are endoscopic surgical cutting and fastening instruments. It should be noted, however, that according to other embodiments of the present invention, the instrument 10 may be a non-endoscopic surgical cutting instrument, such as a laproscopic instrument, with an automatically articulatable end effector.

[0012] The surgical instrument 10 depicted in Figures 1 and 2 comprises a handle 6, a shaft 8, and an articulating end effector 12 pivotally connected to the shaft 8 at an articulation pivot 14. An articulation control 16 may be provided adjacent to the handle 6 to effect rotation 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 devices, such as graspers, cutters, staplers, clip appliers, access devices, drug/gene therapy devices, ultrasound, RF or laser devices, etc.

[0013] 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 a 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. One type of suitable articulation control is described in published U.S. patent application Pub. No. 2007/0158385 A1, entitled "Surgical Instrument Having An Articulating End Effector," by Geoffrey C. Hueil et al., which is incorporated herein by reference in its entirety.

[0014] The end effector 12 includes in this example, 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 toward which a closure trigger 18 is pivotally drawn by the clinician to cause clamping or closing of the anvil 24 towards the staple channel 22 of the end effector 12 to thereby clamp tissue positioned between the anvil 24 and channel 22. In the illustrated embodiment, the firing trigger 20 is farther outboard of the closure trigger 18. According to such an embodiment, 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 26 to cause the stapling and severing of clamped tissue in the end effector 12. In other embodiments, different types of clamping members besides the anvil 24 could be used, such as, for example, an opposing jaw, etc.

[0015] 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.

[0016] In use, 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 Figures 1 and 2) when the clinician removes pressure. A release button on the handle 6, when depressed, may release the locked closure trigger 18.

[0017] As shown in Figures 1-2, the handle 6 may comprise one or multiple external user input selection devices 90, 92, which may be, for example, a push-button switch(es), a toggle switch(es), a dial(s), a membrane switch(es), a microphone, a touchscreen, a trackball, or any other suitable type of switch or user input device, that allows the operator of the instrument 10 to automatically articulate the end effector 12 to

its prior state of articulation and back to its original/normal state (e.g., no articulation). More details regarding this feature are provided below.

[0018] Figure 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 a mechanical closure system 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 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. In various embodiments, the sled 33 maybe an integral component of the cartridge 34. U.S. Pat. No. 6,978,921, entitled “Surgical stapling instrument incorporating an E-beam firing mechanism,” which is incorporated herein by reference in its entirety, 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.

[0019] 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 in their entirety, disclose an endoscopic cutting instrument that uses RF energy to seal the severed tissue. Published U.S. patent application Pub. No. 2007/0102453, entitled "Surgical stapling instruments structured for delivery of medical agents," to Jerome R. Morgan, et. al, and published U.S. patent application Pub. No. 2007/0102452, entitled "Surgical stapling instruments structured for pump-assisted delivery of medical agents," to Frederick E. Shelton, IV, et. al., which are incorporated herein by reference in their entirety also, disclose an endoscopic cutting instrument that uses adhesives to fasten the severed tissue. Accordingly, although the description herein generally 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.

[0020] More details regarding suitable end effectors, closure trigger locking mechanisms, and mechanical closure systems for the end effector may be found in

published U.S. patent application Pub. No. 2007/0175958 A1, entitled "Motor-driven surgical cutting and fastening instrument with user feedback system," by Shelton et al., which is incorporated herein by reference in its entirety.

[0021] The instrument 10 may also comprise an electric motor for powering the end effector 12. Published U.S. patent application Pub. No. 2007/0175958 A1, referred to in the preceding paragraph, discloses an endocutter having an electric motor for powering the end effector. In such an embodiment, the motor, which may be powered by a battery (or batteries) in the handle, powers, through a drive train, the related cutting and fastening operations of the end effector.

[0022] The instrument 10 may also include a number of sensors that sense various conditions related to the instrument 10. For example, as described in published U.S. patent application Pub. No. 2007/0175958 A1, mentioned above, the instrument 10 may include an end-of-stroke sensor for sensing the end of the cutting stroke by the cutting instrument in the end effector and a beginning-of-stroke sensor for sensing the beginning of the cutting stroke by the cutting instrument. The signals from these sensors may be used to control the motor, for example.

[0023] In addition, with reference to Figure 4, the instrument 10 may comprise: a closure trigger sensor 50 for sensing retraction of the closure trigger 18; an anvil closure sensor 52 for sensing closure of the anvil 24; an anvil closure load sensor 54 for sensing force exerted on the sensor 54, which may be placed on an inside bottom surface of the staple cartridge 22, by the staple cartridge 22 due to the closing of the anvil 24; a firing trigger sensor 56 for sensing retraction of the firing trigger 20; a knife position sensor 58 for sensing the longitudinal position of the knife (i.e., cutting

instrument) along the channel 22 in the end effector 12; a cartridge present sensor 60 for sensing whether a staple cartridge 34 is present in the end effector 12; and a cartridge condition sensor 62 for sensing the condition of the staple cartridge 34 (e.g., whether the cartridge has been used or not).

[0024] The sensors 50-62 may be in communication with a control unit 64, preferably located in the handle 6 of the instrument. The control unit 64 may comprise a processor 70, a read-only memory unit 72, and a read-write memory unit 74. The control unit 64 may also comprise analog-to-digital converters (ADC) and digital-to-analog converters (DAC) (not shown) for communicating with the sensors 50-62. The read-only memory unit 72 may comprise EPROM and/or flash EEPROM memory units. The read-write memory unit 74 may comprise a volatile memory unit such a random access memory (RAM) unit. The various components of the control unit 64 may be discrete or they may be integrated in one or a few components. For example, in one embodiment, the processor 70, ROM 72, RAM 74, DACs, and ADCs may be part of a microcontroller or computer-on-a-chip.

[0025] The control unit 64 may be powered by a power source 76, such as a battery. For instruments 10 having a DC motor for powering the end effector, the power source 76 that powers the control unit 64 may be the same power source that powers the motor, or different power sources may be used for the control unit 64 and the motor.

[0026] Output from the various sensors may be stored in digital form in one or both of the memory units 72, 74. Published U.S. patent application Pub. No. 2007/0175964 A1, which is incorporated herein by reference in its entirety, discloses an endocutter having a memory device for storing and recording sensor data. The output from some of the

above-mentioned sensors may be in analog form. For such types of sensors, the ADCs may be used to convert the analog sensor signals to digital form for storing in the memory units 72, 74. Also, the sensors may be coupled to the control unit 64 via wired and/or wireless communication links. For embodiments where the sensors communicate with the control unit 64 wirelessly, the sensors may comprise transponders that communicate with a transceiver (not shown) of the control unit 64.

[0027] According to various embodiments, the instrument 10 may comprise a motorized articulation pivot. Figure 5 discloses an articulation pivot joint assembly 2400 according to such an embodiment. As can be seen in Figure 5, distal tube segment 2410 has a proximal end 2414 and a distal axis H″-H″. Although not shown in Figure 5, the distal tube segment 2410 has a distal end that is mechanically coupled to the end effector 12. Depending upon the anvil closure arrangement employed, the distal end may be non-movably attached to the end effector body or by a cable, flexible member, or pivotable member. The distal tube 2410 segment may be partially hollow with the proximal end 2414 being solid with a hose/wire receiving passage 2416 therethrough. The passage 2416 may have a conical shaped portion 2417. The joint assembly 2400 further includes a proximal tube segment 2450, that has a distal end 2454, and a proximal axis I″-I″. Although not shown in Figure 5, the proximal tube segment 2450 has a proximal end that is attached to the handle assembly 6.

[0028] In one embodiment, the distal tube segment 2410 is pivotally coupled to the proximal tube segment 2450 by a ball joint assembly 2460. In one embodiment, the ball joint assembly 2460 comprises a ball member 2462 that is mounted to or is formed on the distal end 2454 of the proximal tube segment 2450. The ball member 2462 has a

hollow passageway 2464 that has a flared or otherwise enlarged end portion 2465 to enable it to communicate with the passageway portions 2416, 2417 such that, regardless of the position of the ball member 2462, the hoses 480 and/or wires extending therethrough will not be pinched or otherwise damaged. The ball member 2462 is received in a socket 2458 provided in the proximal end 2414 of the distal tube segment 2410, such that the ball member 2462 is free to rotate therein.

[0029] In one embodiment, an actuation assembly, generally designated as 2500, is employed to articulate the distal tube segment 2410 relative to the proximal tube segment 2450. As can be seen in Figure 5, in one non-limiting embodiment, two flexible worm gear cables 2510, 2520 are employed. The first flexible worm gear cable 2510 is adapted to drivingly engage worm gear teeth, threads, etc. (not shown) within a first gear passage 2465 formed in the ball member 2462. The first flexible worm gear cable 2510 is coupled to a first motor 2512 that is mounted within the distal tube segment 2410. Similarly, in this non-limiting embodiment, a second flexible worm gear cable 2520 is adapted to drivingly engage gear teeth, threads, etc. within a second gear passage 2467 formed in the ball member 2462 that has worm gear teeth, threads, etc. 2469 formed therein. The second flexible worm gear cable 2520 is coupled to a second motor 2522 mounted in the distal tube segment 2410. While described herein as "flexible worm gear cables," it will be understood that this term is meant to encompass all types of flexible driven cable or driver arrangements that do not necessarily employ worm gear-type teeth thereon.

[0030] The first and second motors 2512, 2522 may be electrically powered by a battery (e.g., a local battery or a battery pack in the handle 6) or by alternating current,

or may be powered by hydraulic fluid or air. In one embodiment, the motors 2512, 2522 are electric powered and are operated by one or more switches or buttons on handle assembly 6. By controlling the amount of rotation and the direction of rotation of the first and second worm gear cables 2510, 2520, the ball member 2462 is caused to rotate within the socket 2458 and thereby articulate the distal tube segment 2410 (and the end effector 12 attached thereto) relative to the proximal tube segment 2450. The reader will appreciate that such arrangement facilitates left articulation as shown in Figure 5 and right articulation (not shown). Again, however, the reader will appreciate that, while two flexible worm gear cable/motor arrangements have been described above, other embodiments of the present invention may employ only one flexible worm gear cable arrangement if only one-degree articulation is needed or desired. Also, while the ball member 2462 has been described as being non-movably mounted to the proximal tube segment 2450 with the socket 2458 provided in the distal tube segment 2410, those of ordinary skill in the art will understand that the ball member 2462 may be non-movably attached to the distal tube segment 2410 and the socket 2458 provided in the proximal tube segment 2450 in other non-limiting embodiments without departing from the sprit and scope of the present invention.

[0031] The joint assembly 2400 may include one or more sensors 66 (see Figure 4) that sense the articulation of the articulation pivot 14. The output from the sensors 66 is recorded in one or both of the memory devices 72, 74 of the control unit 64. For example, the sensors 66 may include optical or magnetic rotary sensors (e.g., Hall effect sensors) and/or accelerometers that sense, collectively, the articulation, either directly or indirectly, of the end effector 12. For example, the sensors 66 may directly

sense the articulation/rotation of the end effector. In another embodiment, the sensors 66 may sense the rotation and direction of the worm gear cables 2510, 2520 to sense thereby indirectly the articulation of the end effector 12. The control unit 64 may store and record the information from the articulation sensors 66, which may facilitate the user of the instrument 10 in replicating the exact or approximate articulation in a subsequent use of the instrument, as described further below. The sensors 66 may communicate with the control unit 64 via wired and/or wireless communication links. Also, the output from the sensors 66 may be analog signals that are converted to digital form by ADCs of the control unit 64.

[0032] Published U.S. patent application Pub. No. 2007/0106317 A1, entitled "Hydraulically and electrically actuated articulation joints for surgical instruments," by Shelton et al., describes in more detail a motorized articulation pivot. This application also provides other embodiments for motorized articulation pivots. This application also described hydraulically powered articulation pivots. For instruments having hydraulic articulation pivots, the articulation sensors 66 may include accelerometers or other suitable sensors for sensing, directly or indirectly, the articulation of the end effector 12.

[0033] The selection device 90 (see Figures 1-2) may be a multi-state or 1-state device according to various embodiments. For a multi-state device, the user of the instrument may activate the switch to cause it to articulate to a prior state of articulation (e.g., the immediately prior state of articulation) when the instrument 10 was last fired. The user may then activate the switch again to return the end effector 12 to its normal, unarticulated state. The user may also activate the device 90 to record the articulation data in the control unit 64 when the clinician has positioned the end effector in a desired

state. In another embodiment, the articulate sensor data may be automatically recorded every time the instrument 10 is fired and/or clamped. That way, the clinician does not need to take an affirmative action, other than firing the instrument, such as pressing the device 90, to have the articulation data from the articulation sensors 66 recorded in the memory units 72, 74 of the control unit.

[0034] For an embodiment having multiple, 1-state input devices 90, 92, the user may use one input device 90 to articulate automatically the end effector to the prior state, and the second input device 92 to return the end effector 12 to its normal, unarticulated state. The input devices 90, 92 may be in communication with the control unit 64. There may also be a third input device (not shown) that the user may activate to cause the articulation data to be recorded in the control unit 64. Alternatively, the articulation sensor data may be automatically recorded every time the instrument 10 is fired and/or clamped.

[0035] To automatically articulate the end effector, when the selection device 90 is activated by the user, the control unit 64 may transmit signals to the motors 2512, 2522 in the joint assembly 2400 of the articulation pivot 14 (or hydraulic actuators for a joint assembly having hydraulic actuators). The signals sent to the motors 2512, 2522 may be based on the prior state of articulation of the end effector (e.g., the rotation and direction of the end effector 12 relative to the shaft) that is stored in one or both of the memory units 72, 74 based on the sensor data received from the articulation sensors 66. That way, by activating the selection device 90, the user of the instrument 10 may cause the end effector 12 to articulate automatically to the same articulation state in a prior use (e.g., the articulation state when the instrument 10 was last fired). This may

be advantageous for procedures where the clinician has to make repeated cutting/fastening strokes in the same general location of the patient. Instead of having to articulate the end effector 12 each time to the same general location, the clinician could automatically articulate the end effector 12 to its last position by activating the selection device 90.

[0036] The following describes one example of how the instrument 10 may be used. In this example, a multi-state user input selection device 90 is assumed, recognizing that the example can be extended readily to an embodiment having two or more input devices. In this example, the clinician could insert the end effector 12 through the cannula. Then, using the manual articulation control 16, the clinician could articulate the end effector 12 to the desired position, that is, the position where the clinician desires to execute the simultaneous cutting and fastening actions of the cutting instrument 10. After the clinician has articulated the end effector 12 to the desired position, the clinician may retract the closure trigger to its locked position, locking tissue between the opposing jaws 22, 24 of the end effector 12. Then the clinician may retract the firing trigger 20, causing the cutting instrument 32 to (1) traverse longitudinally the channel 22 of the end effector 12, thereby cutting the tissue clamped in the end effector 12, and (2) cause the staples in the staple cartridge 34 to be urged up through the clamped tissue and turned by the anvil 24, thereby stapling the clamped tissue on each side of the incision created by the cutting instrument 32. Prior to or after firing, or prior to or after clamping, the user may activate the input device 90 (or some other input device) to cause the articulation data from the articulation sensors 66, indicating The state of the articulation of the end effector 12 relative to the shaft 8, to be recorded by

the control unit 64. In another embodiment, the articulation data is recorded when the instrument is fired or when the end effector is clamped.

[0037] Then the clinician may automatically dearticulate the end effector 12 back to its normal, unarticulated state (e.g., straight) by pressing the user selection input device 90 (for a one-input, 2-state device embodiment, or the user selection input device 92 for a 2-input device embodiment) so that the clinician can withdraw it back through the cannula. Then the clinician can replace the spent staple cartridge 34 with a new one (i.e., one with staples) and insert the end effector 12 back through the cannula into the patient. Then, by pressing or otherwise activating the user input selection device 90, the clinician can cause the end effector 12 to articulate automatically to the same articulation position it was in when the instrument 10 was last fired based on the articulation sensor output from the last firing stored in the control unit 64. That way, the clinician can articulate automatically the end effector 12 back to the same general position it was in for the last firing, and not have to manual articulate the end effector 12. This should tend to lead to greater accuracy and repeatability in repositioning the end effector 12 when it is important to reposition it in the same general position as the prior firing.

[0038] Following the second firing of the instrument 10, the clinician may automatically dearticulate back to the unarticulated position, withdraw it through the cannula, and, if necessary, replace the staple cartridge again and reinsert the end effector for the next firing, with the end effector being automatically articulated to its state of articulation for the previous firing. For instruments that where the user activates a user input device to cause the articulate data to be recorded, the user could record

the articulate state for just the first firing, so that for subsequent firings, the end effector 12 would be articulated automatically to the same general position as the first firing. Alternatively, user could record the articulation state for each firing, so that the end effector would be articulated automatically to the same general position as the immediately preceding firing

[0039] The devices disclosed herein can be designed to be disposed of after a single procedure (which may comprise multiple firings), or they can be designed to be used in multiple procedures. In either case, however, the device can be reconditioned for reuse after at least one procedure. 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.

[0040] Preferably, the various embodiments of the invention described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a thermoformed plastic shell covered with a sheet of TYVEK. The container and instrument are then placed in

a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

[0041] It is preferred that the device is sterilized. This can be done by any number of ways known to those skilled in the art including beta or gamma radiation, ethylene oxide, steam and other methods.

[0042] 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. The various embodiments of the present invention represent vast improvements over prior staple methods that require the use of different sizes of staples in a single cartridge to achieve staples that have differing formed (final) heights.

[0043] Accordingly, the present invention has been discussed in terms of endoscopic procedures and apparatus. However, use herein of terms such as “endoscopic” should not be construed to limit the present invention to a surgical stapling and severing instrument for use only in conjunction with an endoscopic tube (i.e., cannula or trocar). On the contrary, it is believed that the present invention may find use in any procedure where access is limited, including but not limited to laparoscopic procedures, as well as open procedures. Moreover, the unique and novel aspects of the various staple cartridge embodiments of the present invention may find utility when used in connection

with other forms of stapling apparatuses without departing from the spirit and scope of the present invention.

CLAIMS

What is claimed is:

1. A surgical instrument comprising:

an end effector;

a shaft;

an articulatable joint assembly joint assembly connected between the end effector and the shaft for articulating the end effector relative to the shaft, wherein the automatically articulatable joint assembly comprises:

at least one articulation sensor for sensing articulation of the automatically articulatable joint assembly; and

at least one motor for automatically articulating the end effector relative to the shaft;

a control unit in communication with the at least one articulation sensor, wherein the control unit comprises at least one memory unit for storing articulation data from the at least one articulation sensor, and wherein the control unit is in communication with the at least one motor of the articulatable joint assembly.

2. The surgical instrument of claim 1, wherein the control unit is for controlling the at least one motor in the articulatable joint assembly to cause the motor to articulate the end effector to a position based on the articulation data stored in the at least one memory unit.

3. The surgical instrument of claim 2, wherein the at least one motor comprises an electric motor.

4. The surgical instrument of claim 2, wherein the at least one motor comprises a hydraulic motor.

5. The surgical instrument of claim 2, further comprising a handle connected to the shaft, wherein the control unit is in the handle.

6. The surgical instrument of claim 2, wherein the end effector comprises:

a first jaw member; and

a second jaw member pivotably connected to the first jaw member.

7. The surgical instrument of claim 6, wherein the control unit comprises a processor in communication with the at least one memory unit.

8. The surgical instrument of claim 7, further comprising at least one user input device in communication with the control unit, which, when activated a first time, causes the control unit to control the motor of the articulatable joint assembly to cause the articulatable joint assembly to articulate to an articulation state based on articulation data stored in the at least one memory unit of the control unit.

9. The surgical instrument of claim 8, wherein the at least one user input device is positioned on the handle.

10. The surgical instrument of claim 8, wherein, when the user input device is activated a second time, the control unit causes the motor of the articulatable joint assembly to cause the articulatable joint assembly to articulate to an unarticulated state.

11. The surgical instrument of claim 8, wherein the articulation state is based on the articulation of the end effector at a prior time.

12. The surgical instrument of claim 11, wherein the prior time comprises a time at which the instrument was previously fired.

13. A surgical cutting and fastening instrument comprising:

an end effector comprising:

a moveable cutting instrument for cutting an object positioned in the end effector;

a first jaw member comprising an elongate channel for carrying the cutting instrument; and

a second jaw member pivotably connected to and opposing the first jaw member;

a shaft;

an articulatable joint assembly joint assembly connected between the end effector and the shaft for articulating the end effector relative to the shaft, wherein the automatically articulatable joint assembly comprises:

at least one articulation sensor for sensing articulation of the automatically articulatable joint assembly; and

at least one motor for automatically articulating the end effector relative to the shaft;

a handle connected to the shaft, wherein the handle comprises:

a control unit in communication with the at least one articulation sensor, wherein the control unit comprises at least one memory unit for storing articulation data from the at least one articulation sensor, and wherein the control unit is in communication with the at least one motor of the articulatable joint assembly for controlling the at least one motor to cause the motor to articulate the end effector to a position based on the articulation data stored in the at least one memory unit; and

at least one user input device in communication with the control unit, which, when activated a first time, causes the control unit to control the motor of the articulatable joint assembly to cause the articulatable joint assembly to articulate to an articulation state based on articulation data stored in the at least one memory unit of the control unit.

14. The surgical instrument of claim 13, wherein, when the user input device is activated a second time, the control unit causes the motor of the articulatable joint assembly to cause the articulatable joint assembly to articulate to an unarticulated state.

15. The surgical instrument of claim 13, wherein the articulation state is based on the articulation of the end effector at a prior time.

16. The surgical instrument of claim 13, wherein the prior time comprises a time at which the instrument was previously fired.

17. A method of performing a medical procedure on a patient, the method comprising:

(a) inserting an articulatable end effector of a surgical cutting and fastening instrument into the patient through a cannula, wherein the end effector is in a first articulation state when the end effector is inserted through the cannula;

(b) after step (a), activating an input device on the surgical cutting and fastening instrument to cause the end effector to automatically articulate to a second articulation state that is different from the first articulation state;

(c) after step (b), firing the surgical cutting and fastening instrument to sever and fasten tissue clamped in the end effector;

(d) after step (c), activating the input device to cause the end effector to automatically articulate to the first articulation state; and

(e) after step (d), withdrawing the end effector from the patient through the cannula.

18. The method of claim 17, further comprising:

(f) after step (e), replacing a staple cartridge on the end effector; and

(g) repeating steps (a) through (e).

19. The method of claim 17, further comprising, prior to step (a):

(h) inserting the articulatable end effector into the patient through the cannula, wherein the end effector is in the first articulation state when the end effector is inserted through the cannula;

(i) after step (h), manually articulating the end effector to the second articulation state;

(j) after step (i), firing the surgical cutting and fastening instrument to sever and fasten tissue clamped in the end effector;

(k) after step (j), activating the input device to cause the end effector to automatically articulate to the first articulation state; and

(l) after step (k), withdrawing the end effector from the patient through the cannula

20. The method of claim 19, further comprising:

(m) after step (e), replacing a staple cartridge on the end effector; and

(n) repeating steps (a) through (e).

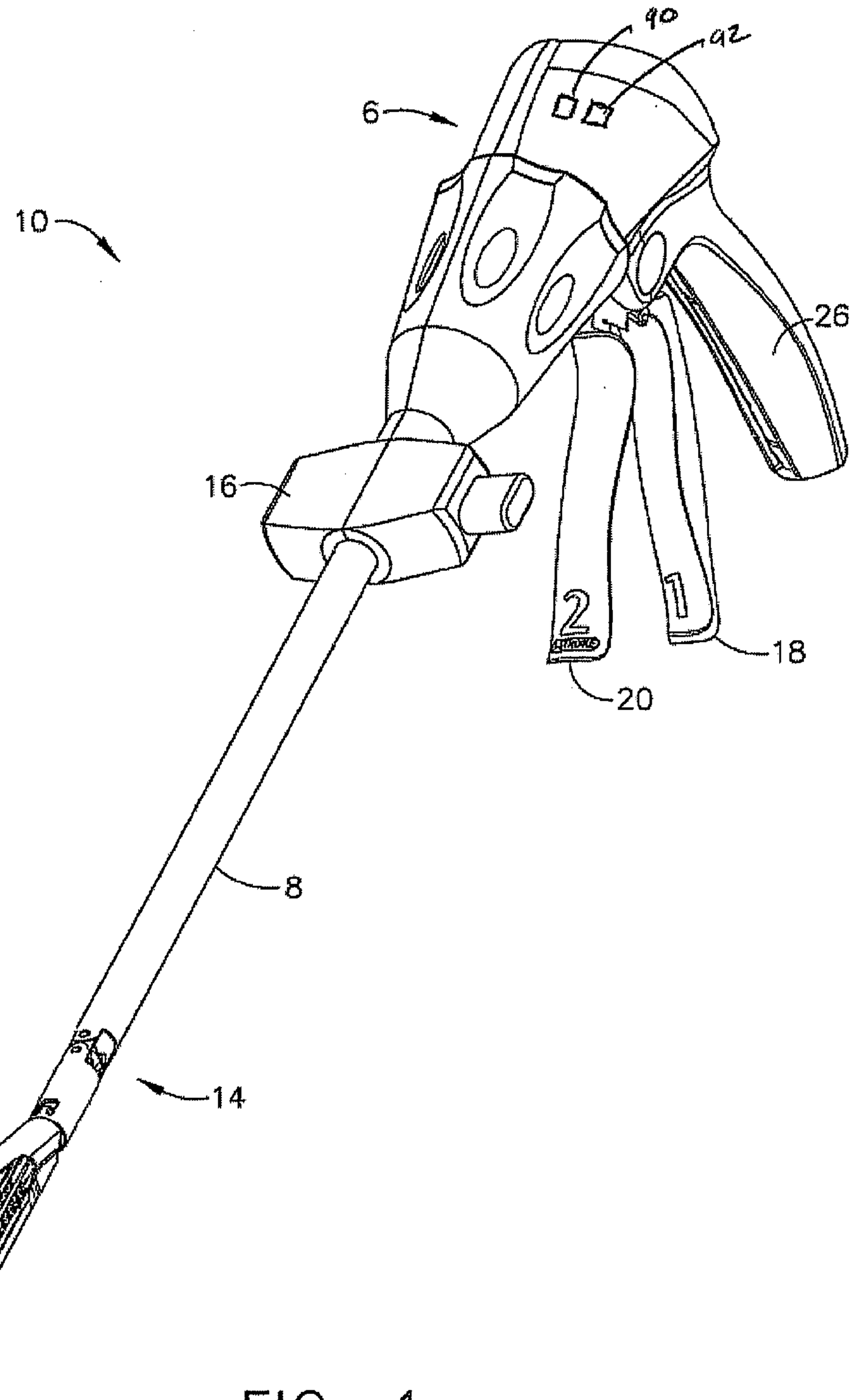


FIG. 1

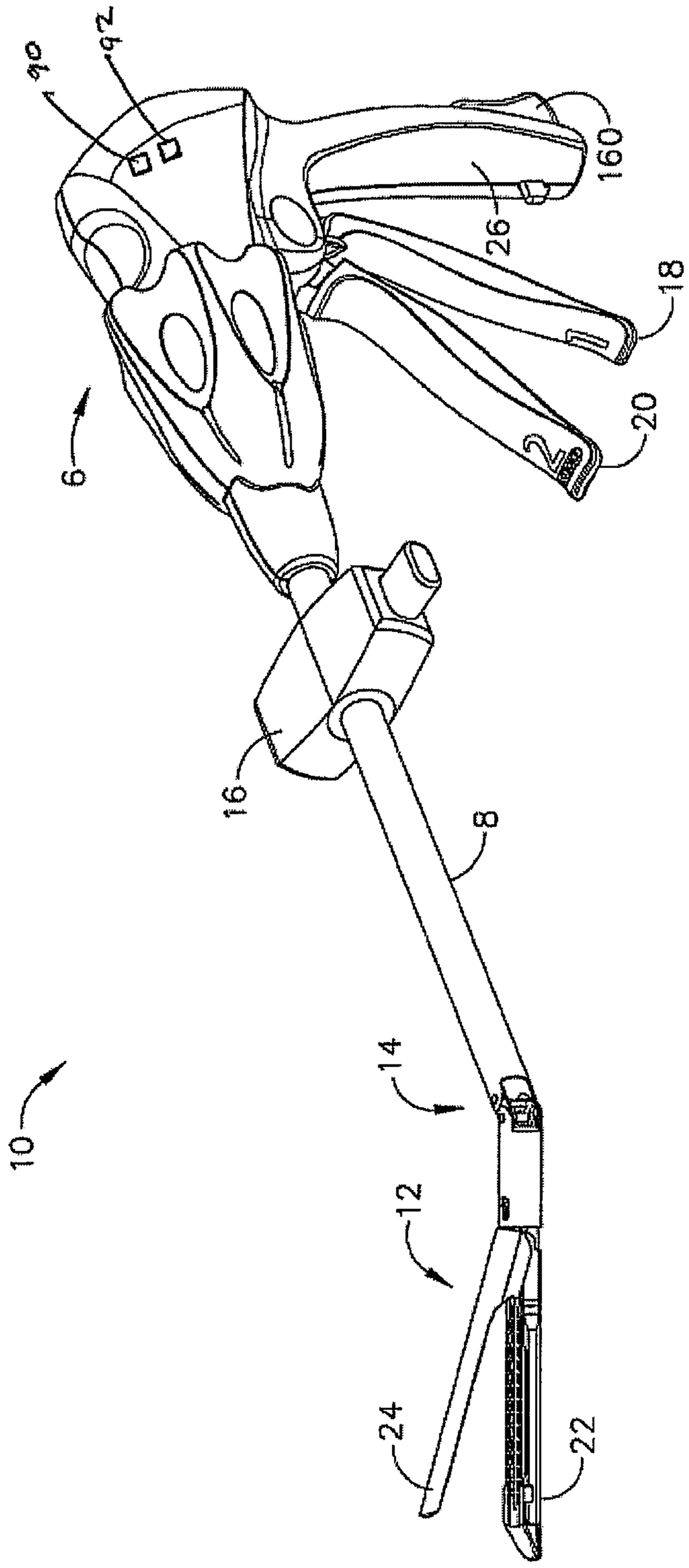


FIG. 2

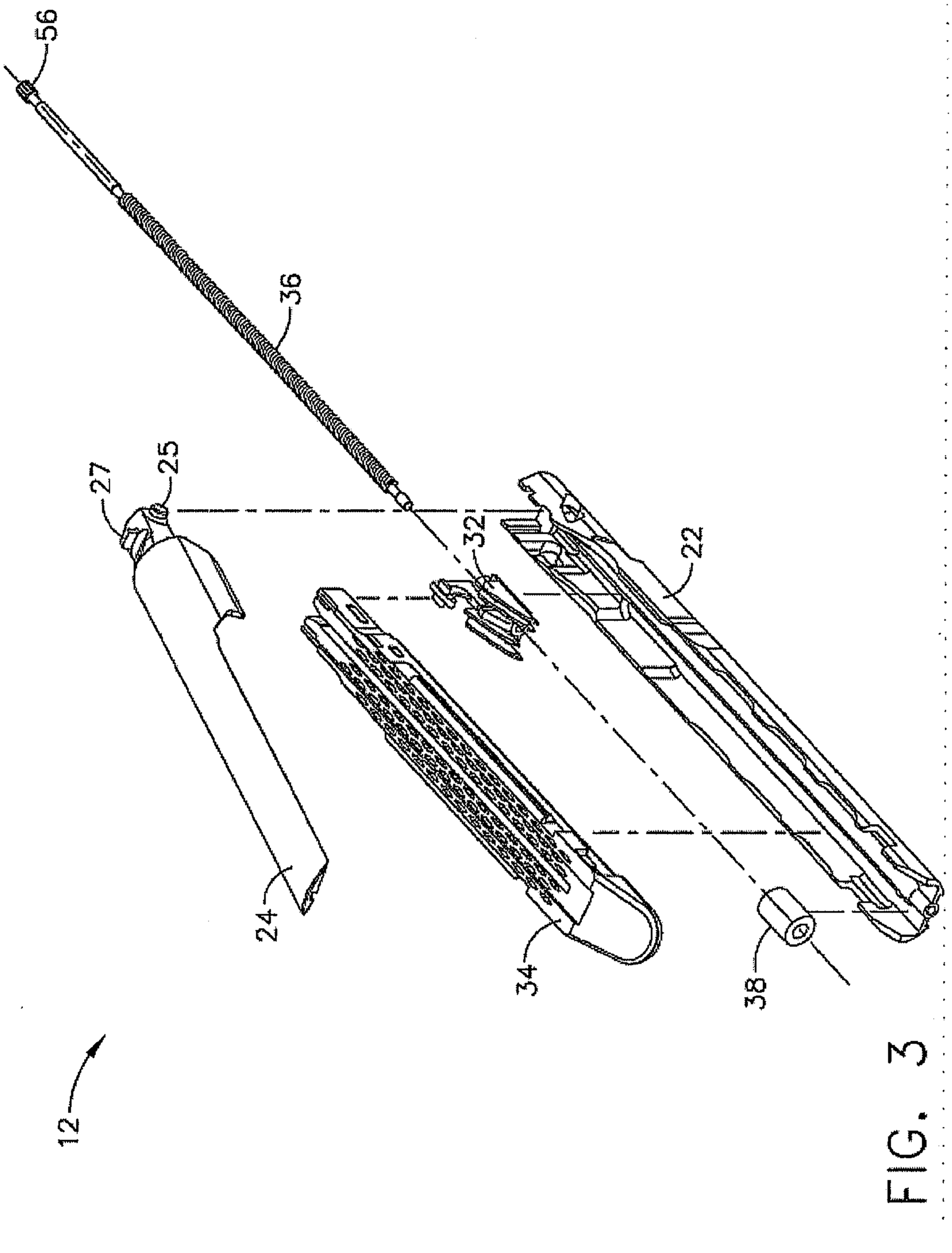
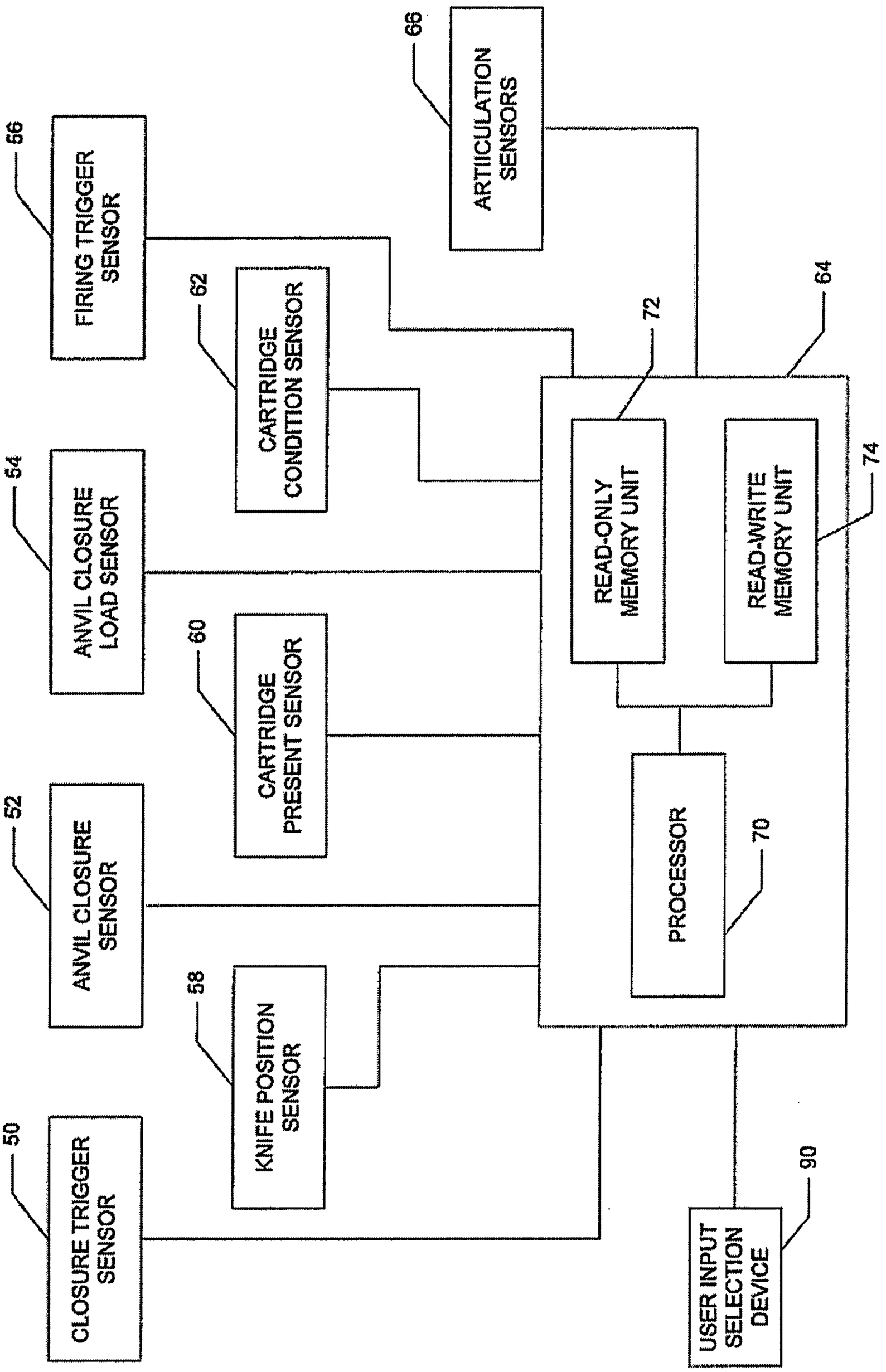


FIG. 3

Figure 4


66
ARTIICULATION SENSORS
56
FIRING TRIGGER SENSOR
62
CARTRIDGE CONDITION SENSOR
72
64
54
ANVIL CLOSURE LOAD SENSOR
READ-ONLY MEMORY UNIT
READ-WRITE MEMORY UNIT
74
60
CARTRIDGE PRESENT SENSOR
52
ANVIL CLOSURE SENSOR
PROCESSOR
70
58
KNIFE POSITION SENSOR
50
CLOSURE TRIGGER SENSOR
90
USER INPUT SELECTION DEVICE

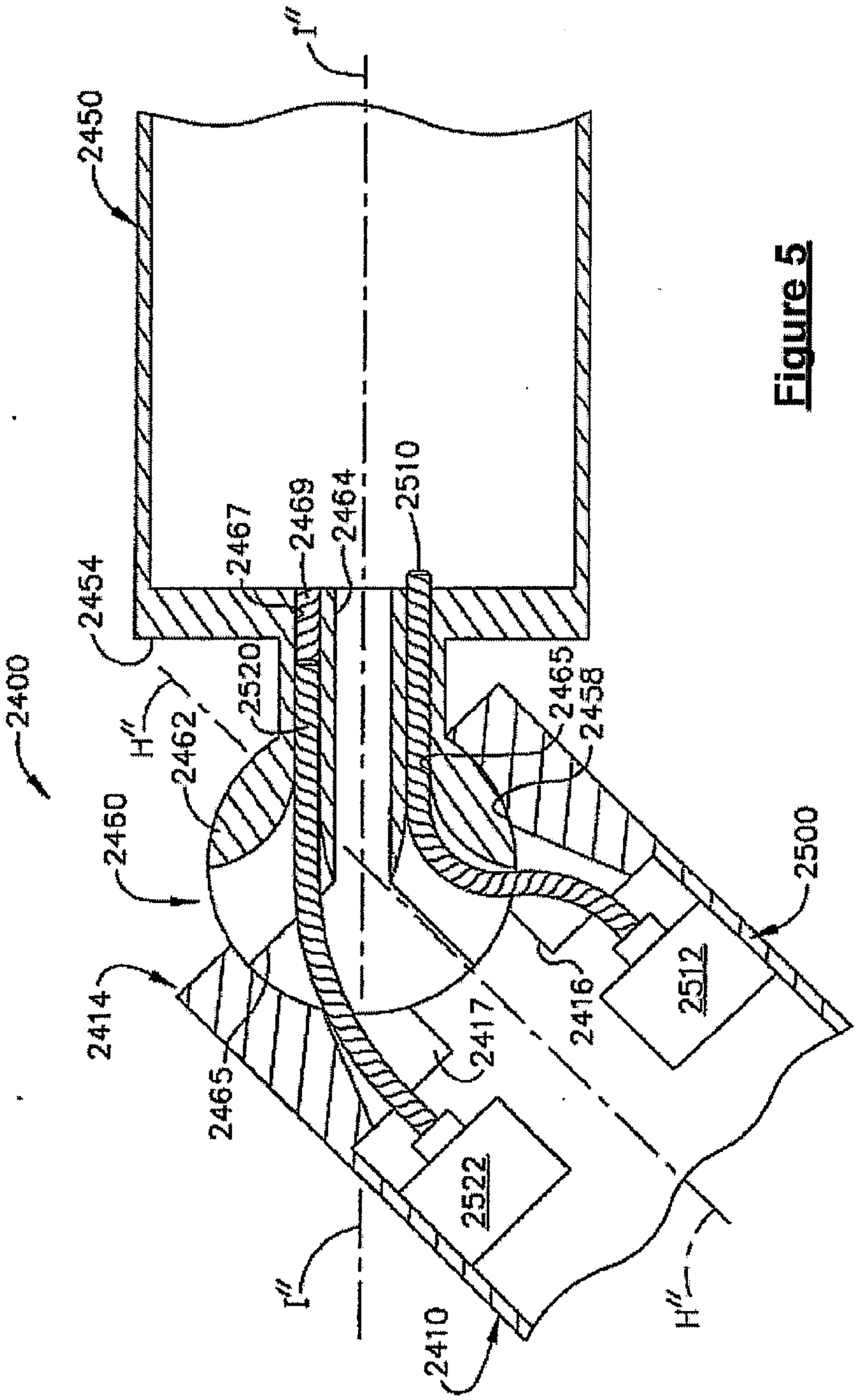

I''
2450
2400
H''
2462
2520
2460
2414
2465
I''
2410
2454
2467
2469
2464
2510
2465
2458
2500
2512
2416
2417
2522
H''

Figure 5

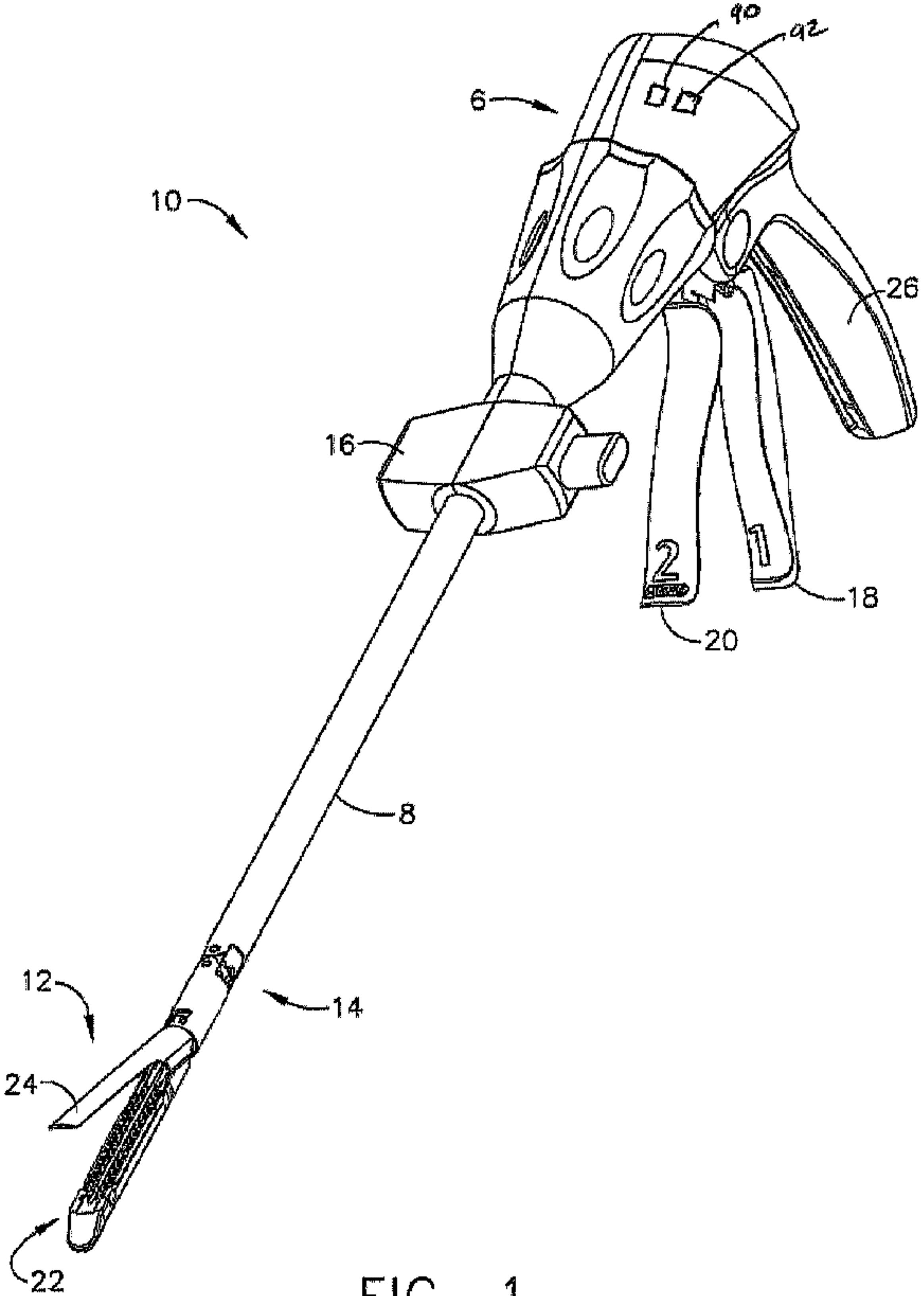


FIG. 1