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(54) Title: INTERCHANGEABLE SURGICAL TOOL ASSEMBLY WITH A SURGICAL END EFFECTOR THAT IS SELECTIVELY ROTATABLE ABOUT A SHAFT AXIS

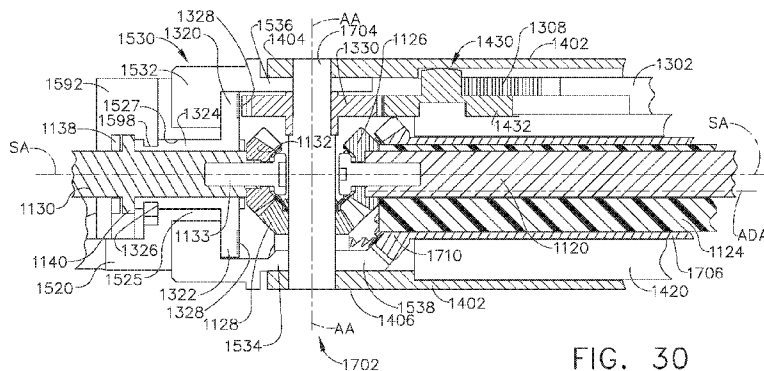


FIG. 30

(57) Abstract: A surgical instrument is disclosed. In one form, the surgical instrument comprises an elongate shaft assembly and an end effector that is configured for selective rotation relative to the axis of the elongate shaft assembly. The surgical instrument can include a rotary locking system for locking the surgical end effector in rotary orientations about the shaft axis upon application of axial locking and axial unlocking motions to the rotary locking system. The surgical instrument may further comprise a rotary drive system that is configured to apply rotary control motions to a firing member as well as to apply rotary positioning motions to the surgical end effector.

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## TITLE

### INTERCHANGEABLE SURGICAL TOOL ASSEMBLY WITH A SURGICAL END EFFECTOR THAT IS SELECTIVELY ROTATABLE ABOUT A SHAFT AXIS

#### BACKGROUND

**[0001]** The present invention relates to surgical instruments and, in various arrangements, to surgical stapling and cutting instruments and staple cartridges for use therewith that are designed to staple and cut tissue.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0002]** Various features of the embodiments described herein, together with advantages thereof, may be understood in accordance with the following description taken in conjunction with the accompanying drawings as follows:

**[0003]** FIG. 1 is a perspective view of a surgical instrument including an interchangeable surgical tool assembly in accordance with at least one embodiment;

**[0004]** FIG. 2 is another perspective view of a handle assembly of the surgical instrument of FIG. 1, with a portion of the handle housing omitted to expose components housed therein;

**[0005]** FIG. 3 is an exploded assembly view of portions of the handle assembly of the surgical instrument of FIGS. 1 and 2;

**[0006]** FIG. 4 is a cross-sectional perspective view of the handle assembly of FIGS. 2 and 3;

**[0007]** FIG. 5 is a partial cross-sectional side view of the handle assembly of FIGS. 2-4 with a grip portion of the handle assembly shown in solid lines in one position relative to a primary housing portion and in phantom lines in another position relative to the primary housing portion of the handle assembly;

**[0008]** FIG. 6 is an end cross-sectional view of the handle assembly of FIGS. 2-5 taken along line 6-6 in FIG. 5;

**[0009]** FIG. 7 is another end cross-sectional view of the handle assembly of FIGS. 2-6 taken along line 7-7 in FIG. 5;

- [0010]** FIG. 8 is another end cross-sectional view of the handle assembly of FIGS. 2-7 showing a shifter gear in meshing engagement with a drive gear on a rotary drive socket;
- [0011]** FIG. 9 is another end cross-sectional view of the handle assembly of FIGS. 2-8 showing the position of a shifter solenoid when the shifter gear is in meshing engagement with the drive gear on the rotary drive socket;
- [0012]** FIG. 10 is another perspective view of the handle assembly of FIGS. 2-9 with certain portions thereof shown in cross-section and with an access panel portion thereof shown in phantom;
- [0013]** FIG. 11 is a top view of the handle assembly of FIGS. 2-11 with a bailout system shown in an actuatable position;
- [0014]** FIG. 12 is a perspective view of a bailout handle of the bailout system depicted in FIGS. 2-11;
- [0015]** FIG. 13 is an exploded assembly view of portions of the bailout handle of FIG. 12 with portions thereof shown in cross-section;
- [0016]** FIG. 14 is a cross-sectional elevation view of the handle assembly of FIG. 11;
- [0017]** FIG. 15 is a perspective view of the handle assembly of FIGS. 2-11 and a tool attachment module portion of the interchangeable surgical tool assembly of FIG. 1;
- [0018]** FIG. 16 is a partial cross-sectional perspective view of the tool attachment module portion of FIG. 15;
- [0019]** FIG. 17 is an exploded assembly view of portions of the interchangeable surgical tool assembly of FIG. 16;
- [0020]** FIG. 18 is an exploded assembly view of the tool attachment module of FIG. 16;
- [0021]** FIG. 19 is a perspective view of one form of a shaft coupler release assembly;
- [0022]** FIG. 20 is a side cross-sectional view of the tool attachment module of FIGS. 16 and 18 being aligned for installation on a tool mounting portion of the handle assembly of FIG. 1;
- [0023]** FIG. 21 is another side cross-sectional view of the tool attachment module of FIG. 20 being initially inserted into tool mounting portion of the handle assembly of FIG. 1;
- [0024]** FIG. 22 is another side cross-sectional view of the tool attachment module of FIGS. 20 and 21 attached to the tool mounting portion of the handle assembly of FIG. 1;
- [0025]** FIG. 23 is a perspective view of the interchangeable surgical tool assembly of FIG. 1;

- [0026]** FIG. 24 is a cross-sectional perspective view the interchangeable surgical tool assembly of FIG. 23;
- [0027]** FIG. 25 is a perspective view of a surgical end effector portion of the interchangeable surgical tool assembly of FIG. 23;
- [0028]** FIG. 26 is a cross-sectional perspective view of the surgical end effector of FIG. 25;
- [0029]** FIG. 27 is an exploded assembly view of the surgical end effector of FIG. 25;
- [0030]** FIG. 28 is a partial rear cross-sectional view of the surgical end effector of FIG. 25;
- [0031]** FIG. 29 is a cross-sectional perspective view of a firing member or cutting member in accordance with at least one embodiment;
- [0032]** FIG. 30 is a cross-sectional elevational view of an articulation joint in accordance with at least one embodiment;
- [0033]** FIG. 31 is a cross-sectional view of the surgical end effector of FIG. 25 with the firing member of FIG. 29 in a firing position;
- [0034]** FIG. 32 is another cross-sectional view of the surgical end effector of FIG. 25 with the firing member FIG. 29 in an ending position;
- [0035]** FIG. 33 is another cross-sectional view of a portion of the surgical end effector of FIG. 25 with an anvil assembly in an open position;
- [0036]** FIG. 34 is another cross-sectional view of a portion of the surgical end effector of FIG. 25 with the firing member of FIG. 29 in a pre-firing position;
- [0037]** FIG. 35 is another cross-sectional view of a portion of the surgical end effector of FIG. 34 wherein the firing member has been returned to a starting position to thereby urge the internally threaded closure nut into threaded engagement with the closure thread segment on the distal power shaft;
- [0038]** FIG. 36 is a perspective view of a bearing spring in accordance with at least one embodiment;
- [0039]** FIG. 37 is an exploded assembly view of the articulation joint of FIG. 30;
- [0040]** FIG. 38 is a top view of the articulation joint of FIG. 30 with the surgical end effector of FIG. 25 in an unarticulated orientation;
- [0041]** FIG. 39 is another top view of the articulation joint of FIG. 30 with the surgical end effector in a maximum articulated orientation;

**[0042]** FIG. 40 is a perspective view of a portion of the elongate shaft assembly of FIG. 23 showing the articulation joint of FIG. 30 and portions of a surgical end effector rotary locking system embodiment;

**[0043]** FIG. 40A is a partial exploded perspective view of an articulation joint and end effector illustrating one arrangement for facilitating the supply of electrical signals to the end effector around the articulation joint in accordance with at least one embodiment;

**[0044]** FIG. 40B is a side elevational view of the articulation joint and end effector of FIG. 40A with some components thereof shown in cross-section;

**[0045]** FIG. 41 is a partial cross-sectional perspective view of the surgical end effector rotary locking system of FIG. 40 in an unlocked orientation;

**[0046]** FIG. 42 is another partial cross-sectional perspective view of the surgical end effector rotary locking system of FIGS. 40 and 41 in an unlocked orientation;

**[0047]** FIG. 43 is a top view of the surgical end effector rotary locking system of FIGS. 40-42 in a locked orientation; and

**[0048]** FIG. 44 is a top view of the surgical end effector rotary locking system of FIGS. 40-43 in an unlocked orientation.

**[0049]** Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate various embodiments of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

### DETAILED DESCRIPTION

**[0050]** Applicant of the present application owns the following patent applications that were filed on even date herewith and which are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. \_\_\_\_\_, entitled METHOD FOR OPERATING A SURGICAL STAPLING SYSTEM; Attorney Docket No. END7821USNP/150535;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled MODULAR SURGICAL STAPLING SYSTEM COMPRISING A DISPLAY; Attorney Docket No. END7822USNP/150536;

- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING A DISPLAY INCLUDING A RE-ORIENTABLE DISPLAY FIELD; Attorney Docket No. END7822USNP1/150536-1;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL INSTRUMENT HANDLE ASSEMBLY WITH RECONFIGURABLE GRIP PORTION; Attorney Docket No. END7823USNP/150537;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled ROTARY POWERED SURGICAL INSTRUMENT WITH MANUALLY ACTUATABLE BAILOUT SYSTEM; Attorney Docket No. END7824USNP/150538;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL CUTTING AND STAPLING END EFFECTOR WITH ANVIL CONCENTRIC DRIVE MEMBER; Attorney Docket No. END7825USNP/150539;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled CLOSURE SYSTEM ARRANGEMENTS FOR SURGICAL CUTTING AND STAPLING DEVICES WITH SEPARATE AND DISTINCT FIRING SHAFTS; Attorney Docket No. END7826USNP/150540;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING A SHIFTABLE TRANSMISSION; Attorney Docket No. END7829USNP/150543;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM CONFIGURED TO PROVIDE SELECTIVE CUTTING OF TISSUE; Attorney Docket No. END7830USNP/150544;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING A CONTOURABLE SHAFT; Attorney Docket No. END7831USNP/150545;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING A TISSUE COMPRESSION LOCKOUT; Attorney Docket No. END7832USNP/150546;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING AN UNCLAMPING LOCKOUT; Attorney Docket No. END7833USNP/150547;
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING A JAW CLOSURE LOCKOUT; Attorney Docket No. END7834USNP/150548;

- U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING A JAW ATTACHMENT LOCKOUT; Attorney Docket No. END7835USNP/150549;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING A SPENT CARTRIDGE LOCKOUT; Attorney Docket No. END7836USNP/150550;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL INSTRUMENT COMPRISING A SHIFTING MECHANISM; Attorney Docket No. END7837USNP/150551;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING INSTRUMENT COMPRISING MULTIPLE LOCKOUTS; Attorney Docket No. END7838USNP/150552;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING INSTRUMENT; Attorney Docket No. END7839USNP/150553;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM CONFIGURED TO APPLY ANNULAR ROWS OF STAPLES HAVING DIFFERENT HEIGHTS; Attorney Docket No. END7840USNP/150554;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled SURGICAL STAPLING SYSTEM COMPRISING A GROOVED FORMING POCKET; Attorney Docket No. END7841USNP/150555;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled ANVIL MODIFICATION MEMBERS FOR SURGICAL STAPLERS; Attorney Docket No. END7842USNP/150556;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled STAPLE CARTRIDGES WITH ATRAUMATIC FEATURES; Attorney Docket No. END7843USNP/150557;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled CIRCULAR STAPLING SYSTEM COMPRISING AN INCISABLE TISSUE SUPPORT; Attorney Docket No. END7844USNP/150558;
  - U.S. Patent Application Serial No. \_\_\_\_\_, entitled CIRCULAR STAPLING SYSTEM COMPRISING ROTARY FIRING SYSTEM; Attorney Docket No. END7845USNP/150559;
- and
- U.S. Patent Application Serial No. \_\_\_\_\_, entitled CIRCULAR STAPLING SYSTEM COMPRISING LOAD CONTROL; Attorney Docket No. END7845USNP1/150559-1.

**[0051]** The Applicant of the present application also owns the U.S. Patent Applications identified below which were filed on December 31, 2015 which are each herein incorporated by reference in their respective entirety:

- U.S. Patent Application Serial No. 14/984,488, entitled MECHANISMS FOR COMPENSATING FOR BATTERY PACK FAILURE IN POWERED SURGICAL INSTRUMENTS;
  - U.S. Patent Application Serial No. 14/984,525, entitled MECHANISMS FOR COMPENSATING FOR DRIVETRAIN FAILURE IN POWERED SURGICAL INSTRUMENTS;
- and
- U.S. Patent Application Serial No. 14/984,552, entitled SURGICAL INSTRUMENTS WITH SEPARABLE MOTORS AND MOTOR CONTROL CIRCUITS.

**[0052]** The Applicant of the present application also owns the U.S. Patent Applications identified below which were filed on February 9, 2016 which are each herein incorporated by reference in their respective entirety:

- U.S. Patent Application Serial No. 15/019,220, entitled SURGICAL INSTRUMENT WITH ARTICULATING AND AXIALLY TRANSLATABLE END EFFECTOR;
- U.S. Patent Application Serial No. 15/019,228, entitled SURGICAL INSTRUMENTS WITH MULTIPLE LINK ARTICULATION ARRANGEMENTS;
- U.S. Patent Application Serial No. 15/019,196, entitled SURGICAL INSTRUMENT ARTICULATION MECHANISM WITH SLOTTED SECONDARY CONSTRAINT;
- U.S. Patent Application Serial No. 15/019,206, entitled SURGICAL INSTRUMENTS WITH AN END EFFECTOR THAT IS HIGHLY ARTICULATABLE RELATIVE TO AN ELONGATE SHAFT ASSEMBLY;
- U.S. Patent Application Serial No. 15/019,215, entitled SURGICAL INSTRUMENTS WITH NON-SYMMETRICAL ARTICULATION ARRANGEMENTS;
- U.S. Patent Application Serial No. 15/019,227, entitled ARTICULATABLE SURGICAL INSTRUMENTS WITH SINGLE ARTICULATION LINK ARRANGEMENTS;
- U.S. Patent Application Serial No. 15/019,235, entitled SURGICAL INSTRUMENTS WITH TENSIONING ARRANGEMENTS FOR CABLE DRIVEN ARTICULATION SYSTEMS;
- U.S. Patent Application Serial No. 15/019,230, entitled ARTICULATABLE SURGICAL INSTRUMENTS WITH OFF-AXIS FIRING BEAM ARRANGEMENTS; and



- U.S. Patent Application Serial No. 15/019,245, entitled SURGICAL INSTRUMENTS WITH CLOSURE STROKE REDUCTION ARRANGEMENTS.

**[0053]** The Applicant of the present application also owns the U.S. Patent Applications identified below which were filed on February 12, 2016 which are each herein incorporated by reference in their respective entirety:

- U.S. Patent Application Serial No. 15/043,254, entitled MECHANISMS FOR COMPENSATING FOR DRIVETRAIN FAILURE IN POWERED SURGICAL INSTRUMENTS;

- U.S. Patent Application Serial No. 15/043,259, entitled MECHANISMS FOR COMPENSATING FOR DRIVETRAIN FAILURE IN POWERED SURGICAL INSTRUMENTS;

- U.S. Patent Application Serial No. 15/043,275, entitled MECHANISMS FOR COMPENSATING FOR DRIVETRAIN FAILURE IN POWERED SURGICAL INSTRUMENTS;  
and

- U.S. Patent Application Serial No. 15/043,289, entitled MECHANISMS FOR COMPENSATING FOR DRIVETRAIN FAILURE IN POWERED SURGICAL INSTRUMENTS.

**[0054]** Applicant of the present application owns the following patent applications that were filed on June 18, 2015 and which are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. 14/742,925, entitled SURGICAL END EFFECTORS WITH POSITIVE JAW OPENING ARRANGEMENTS;

- U.S. Patent Application Serial No. 14/742,941, entitled SURGICAL END EFFECTORS WITH DUAL CAM ACTUATED JAW CLOSING FEATURES;

- U.S. Patent Application Serial No. 14/742,914, entitled MOVABLE FIRING BEAM SUPPORT ARRANGEMENTS FOR ARTICULATABLE SURGICAL INSTRUMENTS;

- U.S. Patent Application Serial No. 14/742,900, entitled ARTICULATABLE SURGICAL INSTRUMENTS WITH COMPOSITE FIRING BEAM STRUCTURES WITH CENTER FIRING SUPPORT MEMBER FOR ARTICULATION SUPPORT;

- U.S. Patent Application Serial No. 14/742,885, entitled DUAL ARTICULATION DRIVE SYSTEM ARRANGEMENTS FOR ARTICULATABLE SURGICAL INSTRUMENTS; and

- U.S. Patent Application Serial No. 14/742,876, entitled PUSH/PULL ARTICULATION DRIVE SYSTEMS FOR ARTICULATABLE SURGICAL INSTRUMENTS.

**[0055]** Applicant of the present application owns the following patent applications that were filed on March 6, 2015 and which are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. 14/640,746, entitled POWERED SURGICAL INSTRUMENT;
- U.S. Patent Application Serial No. 14/640,795, entitled MULTIPLE LEVEL THRESHOLDS TO MODIFY OPERATION OF POWERED SURGICAL INSTRUMENTS;
- U.S. Patent Application Serial No. 14/640,832, entitled ADAPTIVE TISSUE COMPRESSION TECHNIQUES TO ADJUST CLOSURE RATES FOR MULTIPLE TISSUE TYPES; Attorney Docket No. END7557USNP/140482;
- U.S. Patent Application Serial No. 14/640,935, entitled OVERLAID MULTI SENSOR RADIO FREQUENCY (RF) ELECTRODE SYSTEM TO MEASURE TISSUE COMPRESSION;
- U.S. Patent Application Serial No. 14/640,831, entitled MONITORING SPEED CONTROL AND PRECISION INCREMENTING OF MOTOR FOR POWERED SURGICAL INSTRUMENTS;
- U.S. Patent Application Serial No. 14/640,859, entitled TIME DEPENDENT EVALUATION OF SENSOR DATA TO DETERMINE STABILITY, CREEP, AND VISCOELASTIC ELEMENTS OF MEASURES;
- U.S. Patent Application Serial No. 14/640,817, entitled INTERACTIVE FEEDBACK SYSTEM FOR POWERED SURGICAL INSTRUMENTS;
- U.S. Patent Application Serial No. 14/640,844, entitled CONTROL TECHNIQUES AND SUB-PROCESSOR CONTAINED WITHIN MODULAR SHAFT WITH SELECT CONTROL PROCESSING FROM HANDLE;
- U.S. Patent Application Serial No. 14/640,837, entitled SMART SENSORS WITH LOCAL SIGNAL PROCESSING;
- U.S. Patent Application Serial No. 14/640,765, entitled SYSTEM FOR DETECTING THE MIS-INSERTION OF A STAPLE CARTRIDGE INTO A SURGICAL STAPLER;
- U.S. Patent Application Serial No. 14/640,799, entitled SIGNAL AND POWER COMMUNICATION SYSTEM POSITIONED ON A ROTATABLE SHAFT; and
- U.S. Patent Application Serial No. 14/640,780, entitled SURGICAL INSTRUMENT COMPRISING A LOCKABLE BATTERY HOUSING.

**[0056]** Applicant of the present application owns the following patent applications that were filed on February 27, 2015, and which are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. 14/633,576, entitled SURGICAL INSTRUMENT SYSTEM COMPRISING AN INSPECTION STATION;
- U.S. Patent Application Serial No. 14/633,546, entitled SURGICAL APPARATUS CONFIGURED TO ASSESS WHETHER A PERFORMANCE PARAMETER OF THE SURGICAL APPARATUS IS WITHIN AN ACCEPTABLE PERFORMANCE BAND;
- U.S. Patent Application Serial No. 14/633,576, entitled SURGICAL CHARGING SYSTEM THAT CHARGES AND/OR CONDITIONS ONE OR MORE BATTERIES;
- U.S. Patent Application Serial No. 14/633,566, entitled CHARGING SYSTEM THAT ENABLES EMERGENCY RESOLUTIONS FOR CHARGING A BATTERY;
- U.S. Patent Application Serial No. 14/633,555, entitled SYSTEM FOR MONITORING WHETHER A SURGICAL INSTRUMENT NEEDS TO BE SERVICED;
- U.S. Patent Application Serial No. 14/633,542, entitled REINFORCED BATTERY FOR A SURGICAL INSTRUMENT;
- U.S. Patent Application Serial No. 14/633,548, entitled POWER ADAPTER FOR A SURGICAL INSTRUMENT;
- U.S. Patent Application Serial No. 14/633,526, entitled ADAPTABLE SURGICAL INSTRUMENT HANDLE;
- U.S. Patent Application Serial No. 14/633,541, entitled MODULAR STAPLING ASSEMBLY; and
- U.S. Patent Application Serial No. 14/633,562, entitled SURGICAL APPARATUS CONFIGURED TO TRACK AN END-OF-LIFE PARAMETER.

**[0057]** Applicant of the present application owns the following patent applications that were filed on December 18, 2014 and which are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. 14/574,478, entitled SURGICAL INSTRUMENT SYSTEMS COMPRISING AN ARTICULATABLE END EFFECTOR AND MEANS FOR ADJUSTING THE FIRING STROKE OF A FIRING;
- U.S. Patent Application Serial No. 14/574,483, entitled SURGICAL INSTRUMENT ASSEMBLY COMPRISING LOCKABLE SYSTEMS;

- U.S. Patent Application Serial No. 14/575,139, entitled DRIVE ARRANGEMENTS FOR ARTICULATABLE SURGICAL INSTRUMENTS;
- U.S. Patent Application Serial No. 14/575,148, entitled LOCKING ARRANGEMENTS FOR DETACHABLE SHAFT ASSEMBLIES WITH ARTICULATABLE SURGICAL END EFFECTORS;
- U.S. Patent Application Serial No. 14/575,130, entitled SURGICAL INSTRUMENT WITH AN ANVIL THAT IS SELECTIVELY MOVABLE ABOUT A DISCRETE NON-MOVABLE AXIS RELATIVE TO A STAPLE CARTRIDGE;
- U.S. Patent Application Serial No. 14/575,143, entitled SURGICAL INSTRUMENTS WITH IMPROVED CLOSURE ARRANGEMENTS;
- U.S. Patent Application Serial No. 14/575,117, entitled SURGICAL INSTRUMENTS WITH ARTICULATABLE END EFFECTORS AND MOVABLE FIRING BEAM SUPPORT ARRANGEMENTS;
- U.S. Patent Application Serial No. 14/575,154, entitled SURGICAL INSTRUMENTS WITH ARTICULATABLE END EFFECTORS AND IMPROVED FIRING BEAM SUPPORT ARRANGEMENTS;
- U.S. Patent Application Serial No. 14/574,493, entitled SURGICAL INSTRUMENT ASSEMBLY COMPRISING A FLEXIBLE ARTICULATION SYSTEM; and
- U.S. Patent Application Serial No. 14/574,500, entitled SURGICAL INSTRUMENT ASSEMBLY COMPRISING A LOCKABLE ARTICULATION SYSTEM.

**[0058]** Applicant of the present application owns the following patent applications that were filed on March 1, 2013 and which are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. 13/782,295, entitled ARTICULATABLE SURGICAL INSTRUMENTS WITH CONDUCTIVE PATHWAYS FOR SIGNAL COMMUNICATION, now U.S. Patent Application Publication No. 2014/0246471;
- U.S. Patent Application Serial No. 13/782,323, entitled ROTARY POWERED ARTICULATION JOINTS FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0246472;
- U.S. Patent Application Serial No. 13/782,338, entitled THUMBWHEEL SWITCH ARRANGEMENTS FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0249557;

- U.S. Patent Application Serial No. 13/782,499, entitled ELECTROMECHANICAL SURGICAL DEVICE WITH SIGNAL RELAY ARRANGEMENT, now U.S. Patent Application Publication No. 2014/0246474;
- U.S. Patent Application Serial No. 13/782,460, entitled MULTIPLE PROCESSOR MOTOR CONTROL FOR MODULAR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0246478;
- U.S. Patent Application Serial No. 13/782,358, entitled JOYSTICK SWITCH ASSEMBLIES FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0246477;
- U.S. Patent Application Serial No. 13/782,481, entitled SENSOR STRAIGHTENED END EFFECTOR DURING REMOVAL THROUGH TROCAR, now U.S. Patent Application Publication No. 2014/0246479;
- U.S. Patent Application Serial No. 13/782,518, entitled CONTROL METHODS FOR SURGICAL INSTRUMENTS WITH REMOVABLE IMPLEMENT PORTIONS, now U.S. Patent Application Publication No. 2014/0246475;
- U.S. Patent Application Serial No. 13/782,375, entitled ROTARY POWERED SURGICAL INSTRUMENTS WITH MULTIPLE DEGREES OF FREEDOM, now U.S. Patent Application Publication No. 2014/0246473; and
- U.S. Patent Application Serial No. 13/782,536, entitled SURGICAL INSTRUMENT SOFT STOP, now U.S. Patent Application Publication No. 2014/0246476.

**[0059]** Applicant of the present application also owns the following patent applications that were filed on March 14, 2013 and which are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. 13/803,097, entitled ARTICULATABLE SURGICAL INSTRUMENT COMPRISING A FIRING DRIVE, now U.S. Patent Application Publication No. 2014/0263542;
- U.S. Patent Application Serial No. 13/803,193, entitled CONTROL ARRANGEMENTS FOR A DRIVE MEMBER OF A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0263537;
- U.S. Patent Application Serial No. 13/803,053, entitled INTERCHANGEABLE SHAFT ASSEMBLIES FOR USE WITH A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0263564;

- U.S. Patent Application Serial No. 13/803,086, entitled ARTICULATABLE SURGICAL INSTRUMENT COMPRISING AN ARTICULATION LOCK, now U.S. Patent Application Publication No. 2014/0263541;
- U.S. Patent Application Serial No. 13/803,210, entitled SENSOR ARRANGEMENTS FOR ABSOLUTE POSITIONING SYSTEM FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0263538;
- U.S. Patent Application Serial No. 13/803,148, entitled MULTI-FUNCTION MOTOR FOR A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0263554;
- U.S. Patent Application Serial No. 13/803,066, entitled DRIVE SYSTEM LOCKOUT ARRANGEMENTS FOR MODULAR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0263565;
- U.S. Patent Application Serial No. 13/803,117, entitled ARTICULATION CONTROL SYSTEM FOR ARTICULATABLE SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0263553;
- U.S. Patent Application Serial No. 13/803,130, entitled DRIVE TRAIN CONTROL ARRANGEMENTS FOR MODULAR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0263543; and
- U.S. Patent Application Serial No. 13/803,159, entitled METHOD AND SYSTEM FOR OPERATING A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0277017.

**[0060]** Applicant of the present application also owns the following patent application that was filed on March 7, 2014 and is herein incorporated by reference in its entirety:

- U.S. Patent Application Serial No. 14/200,111, entitled CONTROL SYSTEMS FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2014/0263539.

**[0061]** Applicant of the present application also owns the following patent applications that were filed on March 26, 2014 and are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. 14/226,106, entitled POWER MANAGEMENT CONTROL SYSTEMS FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2015/0272582;

- U.S. Patent Application Serial No. 14/226,099, entitled STERILIZATION VERIFICATION CIRCUIT, now U.S. Patent Application Publication No. 2015/0272581;
- U.S. Patent Application Serial No. 14/226,094, entitled VERIFICATION OF NUMBER OF BATTERY EXCHANGES/PROCEDURE COUNT, now U.S. Patent Application Publication No. 2015/0272580;
- U.S. Patent Application Serial No. 14/226,117, entitled POWER MANAGEMENT THROUGH SLEEP OPTIONS OF SEGMENTED CIRCUIT AND WAKE UP CONTROL, now U.S. Patent Application Publication No. 2015/0272574;
- U.S. Patent Application Serial No. 14/226,075, entitled MODULAR POWERED SURGICAL INSTRUMENT WITH DETACHABLE SHAFT ASSEMBLIES, now U.S. Patent Application Publication No. 2015/0272579;
- U.S. Patent Application Serial No. 14/226,093, entitled FEEDBACK ALGORITHMS FOR MANUAL BAILOUT SYSTEMS FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2015/0272569;
- U.S. Patent Application Serial No. 14/226,116, entitled SURGICAL INSTRUMENT UTILIZING SENSOR ADAPTATION, now U.S. Patent Application Publication No. 2015/0272571;
- U.S. Patent Application Serial No. 14/226,071, entitled SURGICAL INSTRUMENT CONTROL CIRCUIT HAVING A SAFETY PROCESSOR, now U.S. Patent Application Publication No. 2015/0272578;
- U.S. Patent Application Serial No. 14/226,097, entitled SURGICAL INSTRUMENT COMPRISING INTERACTIVE SYSTEMS, now U.S. Patent Application Publication No. 2015/0272570;
- U.S. Patent Application Serial No. 14/226,126, entitled INTERFACE SYSTEMS FOR USE WITH SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2015/0272572;
- U.S. Patent Application Serial No. 14/226,133, entitled MODULAR SURGICAL INSTRUMENT SYSTEM, now U.S. Patent Application Publication No. 2015/0272557;
- U.S. Patent Application Serial No. 14/226,081, entitled SYSTEMS AND METHODS FOR CONTROLLING A SEGMENTED CIRCUIT, now U.S. Patent Application Publication No. 2015/0277471;

- U.S. Patent Application Serial No. 14/226,076, entitled POWER MANAGEMENT THROUGH SEGMENTED CIRCUIT AND VARIABLE VOLTAGE PROTECTION, now U.S. Patent Application Publication No. 2015/0280424;
- U.S. Patent Application Serial No. 14/226,111, entitled SURGICAL STAPLING INSTRUMENT SYSTEM, now U.S. Patent Application Publication No. 2015/0272583; and
- U.S. Patent Application Serial No. 14/226,125, entitled SURGICAL INSTRUMENT COMPRISING A ROTATABLE SHAFT, now U.S. Patent Application Publication No. 2015/0280384.

**[0062]** Applicant of the present application also owns the following patent applications that were filed on September 5, 2014 and which are each herein incorporated by reference in their respective entireties:

- U.S. Patent Application Serial No. 14/479,103, entitled CIRCUITRY AND SENSORS FOR POWERED MEDICAL DEVICE, now U.S. Patent Application Publication No. 2016/0066912;
- U.S. Patent Application Serial No. 14/479,119, entitled ADJUNCT WITH INTEGRATED SENSORS TO QUANTIFY TISSUE COMPRESSION, now U.S. Patent Application Publication No. 2016/0066914;
- U.S. Patent Application Serial No. 14/478,908, entitled MONITORING DEVICE DEGRADATION BASED ON COMPONENT EVALUATION, now U.S. Patent Application Publication No. 2016/0066910;
- U.S. Patent Application Serial No. 14/478,895, entitled MULTIPLE SENSORS WITH ONE SENSOR AFFECTING A SECOND SENSOR'S OUTPUT OR INTERPRETATION, now U.S. Patent Application Publication No. 2016/0066909;
- U.S. Patent Application Serial No. 14/479,110, entitled USE OF POLARITY OF HALL MAGNET DETECTION TO DETECT MISLOADED CARTRIDGE, now U.S. Patent Application Publication No. 2016/0066915;
- U.S. Patent Application Serial No. 14/479,098, entitled SMART CARTRIDGE WAKE UP OPERATION AND DATA RETENTION, now U.S. Patent Application Publication No. 2016/0066911;
- U.S. Patent Application Serial No. 14/479,115, entitled MULTIPLE MOTOR CONTROL FOR POWERED MEDICAL DEVICE, now U.S. Patent Application Publication No. 2016/0066916; and



- U.S. Patent Application Serial No. 14/479,108, entitled LOCAL DISPLAY OF TISSUE PARAMETER STABILIZATION, now U.S. Patent Application Publication No. 2016/0066913.

**[0063]** Applicant of the present application also owns the following patent applications that were filed on April 9, 2014 and which are each herein incorporated by reference in their respective entirety:

- U.S. Patent Application Serial No. 14/248,590, entitled MOTOR DRIVEN SURGICAL INSTRUMENTS WITH LOCKABLE DUAL DRIVE SHAFTS, now U.S. Patent Application Publication No. 2014/0305987;

- U.S. Patent Application Serial No. 14/248,581, entitled SURGICAL INSTRUMENT COMPRISING A CLOSING DRIVE AND A FIRING DRIVE OPERATED FROM THE SAME ROTATABLE OUTPUT, now U.S. Patent Application Publication No. 2014/0305989;

- U.S. Patent Application Serial No. 14/248,595, entitled SURGICAL INSTRUMENT SHAFT INCLUDING SWITCHES FOR CONTROLLING THE OPERATION OF THE SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0305988;

- U.S. Patent Application Serial No. 14/248,588, entitled POWERED LINEAR SURGICAL STAPLER, now U.S. Patent Application Publication No. 2014/0309666;

- U.S. Patent Application Serial No. 14/248,591, entitled TRANSMISSION ARRANGEMENT FOR A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0305991;

- U.S. Patent Application Serial No. 14/248,584, entitled MODULAR MOTOR DRIVEN SURGICAL INSTRUMENTS WITH ALIGNMENT FEATURES FOR ALIGNING ROTARY DRIVE SHAFTS WITH SURGICAL END EFFECTOR SHAFTS, now U.S. Patent Application Publication No. 2014/0305994;

- U.S. Patent Application Serial No. 14/248,587, entitled POWERED SURGICAL STAPLER, now U.S. Patent Application Publication No. 2014/0309665;

- U.S. Patent Application Serial No. 14/248,586, entitled DRIVE SYSTEM DECOUPLING ARRANGEMENT FOR A SURGICAL INSTRUMENT, now U.S. Patent Application Publication No. 2014/0305990; and

- U.S. Patent Application Serial No. 14/248,607, entitled MODULAR MOTOR DRIVEN SURGICAL INSTRUMENTS WITH STATUS INDICATION ARRANGEMENTS, now U.S. Patent Application Publication No. 2014/0305992.

**[0064]** Applicant of the present application also owns the following patent applications that were filed on April 16, 2013 and which are each herein incorporated by reference in their respective entireties:

- U.S. Provisional Patent Application Serial No. 61/812,365, entitled SURGICAL INSTRUMENT WITH MULTIPLE FUNCTIONS PERFORMED BY A SINGLE MOTOR;
- U.S. Provisional Patent Application Serial No. 61/812,376, entitled LINEAR CUTTER WITH POWER;
- U.S. Provisional Patent Application Serial No. 61/812,382, entitled LINEAR CUTTER WITH MOTOR AND PISTOL GRIP;
- U.S. Provisional Patent Application Serial No. 61/812,385, entitled SURGICAL INSTRUMENT HANDLE WITH MULTIPLE ACTUATION MOTORS AND MOTOR CONTROL; and
- U.S. Provisional Patent Application Serial No. 61/812,372, entitled SURGICAL INSTRUMENT WITH MULTIPLE FUNCTIONS PERFORMED BY A SINGLE MOTOR.

**[0065]** Numerous specific details are set forth to provide a thorough understanding of the overall structure, function, manufacture, and use of the embodiments as described in the specification and illustrated in the accompanying drawings. Well-known operations, components, and elements have not been described in detail so as not to obscure the embodiments described in the specification. The reader will understand that the embodiments described and illustrated herein are non-limiting examples, and thus it can be appreciated that the specific structural and functional details disclosed herein may be representative and illustrative. Variations and changes thereto may be made without departing from the scope of the claims.

**[0066]** The terms "comprise" (and any form of comprise, such as "comprises" and "comprising"), "have" (and any form of have, such as "has" and "having"), "include" (and any form of include, such as "includes" and "including") and "contain" (and any form of contain, such as "contains" and "containing") are open-ended linking verbs. As a result, a surgical system, device, or apparatus that "comprises," "has," "includes" or "contains" one or more elements possesses those one or more elements, but is not limited to possessing only those one or more elements. Likewise, an element of a system, device, or apparatus that "comprises," "has," "includes" or "contains" one or more features possesses those one or more features, but is not limited to possessing only those one or more features.

**[0067]** The terms “proximal” and “distal” are used herein with reference to a clinician manipulating the handle portion of the surgical instrument. The term “proximal” refers to the portion closest to the clinician and the term “distal” refers to the portion located away from the clinician. It will be further appreciated that, for convenience and clarity, spatial terms such as “vertical”, “horizontal”, “up”, and “down” may be 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/or absolute.

**[0068]** Various exemplary devices and methods are provided for performing laparoscopic and minimally invasive surgical procedures. However, the reader will readily appreciate that the various methods and devices disclosed herein can be used in numerous surgical procedures and applications including, for example, in connection with open surgical procedures. As the present Detailed Description proceeds, the reader will further appreciate that the various instruments disclosed herein can be inserted into a body in any way, such as through a natural orifice, through an incision or puncture hole formed in tissue, etc. The working portions or end effector portions of the instruments can be inserted directly into a patient’s body or can be inserted through an access device that has a working channel through which the end effector and elongate shaft of a surgical instrument can be advanced.

**[0069]** A surgical stapling system can comprise a shaft and an end effector extending from the shaft. The end effector comprises a first jaw and a second jaw. The first jaw comprises a staple cartridge. The staple cartridge is insertable into and removable from the first jaw; however, other embodiments are envisioned in which a staple cartridge is not removable from, or at least readily replaceable from, the first jaw. The second jaw comprises an anvil configured to deform staples ejected from the staple cartridge. The second jaw is pivotable relative to the first jaw about a closure axis; however, other embodiments are envisioned in which first jaw is pivotable relative to the second jaw. The surgical stapling system further comprises an articulation joint configured to permit the end effector to be rotated, or articulated, relative to the shaft. The end effector is rotatable about an articulation axis extending through the articulation joint. Other embodiments are envisioned which do not include an articulation joint.

**[0070]** The staple cartridge comprises a cartridge body. The cartridge body includes a proximal end, a distal end, and a deck extending between the proximal end and the distal end. In use, the staple cartridge is positioned on a first side of the tissue to be stapled and

the anvil is positioned on a second side of the tissue. The anvil is moved toward the staple cartridge to compress and clamp the tissue against the deck. Thereafter, staples removably stored in the cartridge body can be deployed into the tissue. The cartridge body includes staple cavities defined therein wherein staples are removably stored in the staple cavities. The staple cavities are arranged in six longitudinal rows. Three rows of staple cavities are positioned on a first side of a longitudinal slot and three rows of staple cavities are positioned on a second side of the longitudinal slot. Other arrangements of staple cavities and staples may be possible.

**[0071]** The staples are supported by staple drivers in the cartridge body. The drivers are movable between a first, or unfired position, and a second, or fired, position to eject the staples from the staple cavities. The drivers are retained in the cartridge body by a retainer which extends around the bottom of the cartridge body and includes resilient members configured to grip the cartridge body and hold the retainer to the cartridge body. The drivers are movable between their unfired positions and their fired positions by a sled. The sled is movable between a proximal position adjacent the proximal end and a distal position adjacent the distal end. The sled comprises a plurality of ramped surfaces configured to slide under the drivers and lift the drivers, and the staples supported thereon, toward the anvil.

**[0072]** Further to the above, the sled is moved distally by a firing member. The firing member is configured to contact the sled and push the sled toward the distal end. The longitudinal slot defined in the cartridge body is configured to receive the firing member. The anvil also includes a slot configured to receive the firing member. The firing member further comprises a first cam which engages the first jaw and a second cam which engages the second jaw. As the firing member is advanced distally, the first cam and the second cam can control the distance, or tissue gap, between the deck of the staple cartridge and the anvil. The firing member also comprises a knife configured to incise the tissue captured intermediate the staple cartridge and the anvil. It is desirable for the knife to be positioned at least partially proximal to the ramped surfaces such that the staples are ejected ahead of the knife.

## **HANDLE ASSEMBLY**

**[0073]** FIG. 1 depicts a motor-driven surgical system 10 that may be used to perform a variety of different surgical procedures. In the illustrated embodiment, the motor driven surgical system 10 comprises a selectively reconfigurable housing or handle assembly 20

that is attached to one form of an interchangeable surgical tool assembly 1000. For example, the system 10 that is depicted in FIG. 1 includes an interchangeable surgical tool assembly 1000 that comprises a surgical cutting and fastening instrument which may be referred to as an endocutter. As will be discussed in further detail below, the interchangeable surgical tool assemblies may include end effectors that are adapted to support different sizes and types of staple cartridges and, have different shaft lengths, sizes, and types, etc. Such arrangements, for example, may utilize any suitable fastener, or fasteners, to fasten tissue. For instance, a fastener cartridge comprising a plurality of fasteners removably stored therein can be removably inserted into and/or attached to the end effector of a surgical tool assembly. Other surgical tool assemblies may be interchangeably employed with the handle assembly 20. For example, the interchangeable surgical tool assembly 1000 may be detached from the handle assembly 20 and replaced with a different surgical tool assembly that is configured to perform other surgical procedures. In other arrangements, the surgical tool assembly may not be interchangeable with other surgical tool assemblies and essentially comprise a dedicated shaft that is non-removably affixed or coupled to the handle assembly 20, for example. The surgical tool assemblies may also be referred to as elongate shaft assemblies. The surgical tool assemblies may be reusable or, in other configurations, the surgical tool assemblies may be designed to be disposed of after a single use.

**[0074]** As the present Detailed Description proceeds, it will be understood that the various forms of interchangeable surgical tool assemblies disclosed herein may also be effectively employed in connection with robotically-controlled surgical systems. Thus, the terms “housing” and “housing assembly” may also encompass a housing or similar portion of a robotic system that houses or otherwise operably supports at least one drive system that is configured to generate and apply at least one control motion which could be used to actuate the elongate shaft assemblies disclosed herein and their respective equivalents. The term “frame” may refer to a portion of a handheld surgical instrument. The term “frame” may also represent a portion of a robotically controlled surgical instrument and/or a portion of the robotic system that may be used to operably control a surgical instrument. For example, the surgical tool assemblies disclosed herein may be employed with various robotic systems, instruments, components and methods such as, but not limited to, those disclosed in U.S. Patent Application Serial No. 13/118,241, entitled SURGICAL STAPLING INSTRUMENTS WITH ROTABLE STAPLE DEPLOYMENT ARRANGEMENTS, now U.S. Patent

Application Publication No. 2012/0298719 which is hereby incorporated by reference herein in its entirety.

**[0075]** Referring now to FIGS. 1 and 2, the housing assembly or handle assembly 20 comprises a primary housing portion 30 that may be formed from a pair of housing segments 40, 70 that may be fabricated from plastic, polymer materials, metal, etc. and be joined together by an appropriate fastener arrangement such as, for example, adhesive, screws, press-fit features, snap-fit features, latches, etc. As will be discussed in further detail below, the primary housing portion 30 operably supports a plurality of drive systems therein that are configured to generate and apply various control motions to corresponding portions of the interchangeable surgical tool assembly that is operably attached thereto. The handle assembly 20 further comprises a grip portion 100 that is movably coupled to the primary housing portion 30 and is configured to be gripped and manipulated by the clinician in various positions relative to the primary housing portion 30. The grip portion 100 may be fabricated from a pair of grip segments 110, 120 that may be fabricated from plastic, polymer materials, metal, etc. and are joined together by an appropriate fastener arrangement such as, for example, adhesive, screws, press-fit features, snap-fit features, latches, etc. for assembly and maintenance purposes.

**[0076]** As can be seen in FIG. 2, the grip portion 100 comprises a grip housing 130 that defines a hollow cavity 132 that is configured to operably support a drive motor and gearbox which will be discussed in further detail below. The upper portion 134 of the grip housing 130 is configured to extend through an opening 80 in the primary housing portion 30 and be pivotally journaled on a pivot shaft 180. The pivot shaft 180 defines a pivot axis designated as "PA". See FIG. 3. For reference purposes, the handle assembly 20 defines a handle axis designated as "HA" that may be parallel to the shaft axis "SA" of the elongate shaft assembly of the interchangeable surgical tool that is operably attached to the handle assembly 20. The pivot axis PA is transverse to the handle axis HA. See FIG. 1. Such arrangement enables the grip portion 100 to be pivoted relative to the primary housing portion 30 about the pivot axis PA to a position that is best suited for the type of interchangeable surgical tool assembly that is coupled to the handle assembly 20. The grip housing 130 defines a grip axis, generally designated as "GA". See FIG. 2. When the interchangeable surgical tool assembly that is coupled to the handle assembly 20 comprises an endocutter for example, the clinician might want to position the grip portion 100 relative to the primary housing portion 30 such that

the grip axis GA is perpendicular or approximately perpendicular (angle "H1") to the handle axis HA (referred to herein as a "first grip position"). See FIG. 5. However, if the handle assembly 20 is being used to control an interchangeable surgical tool assembly that comprises a circular stapler for example, the clinician may wish to pivot the grip portion 100 relative to the primary housing portion 30 to a position wherein the grip axis GA is at a forty-five degree or approximately forty-five degree angle or other suitable acute angle (angle "H2") relative to the handle axis HA. This position is referred to herein as a "second grip position". FIG. 5 illustrates the grip portion 100 in phantom lines in the second grip position.

**[0077]** Referring now to FIGS. 3-5, the handle assembly 20 also includes a grip locking system, generally designated as 150, for selectively locking the grip portion 100 in the desired orientation relative to the primary housing portion 30. In one arrangement, the grip locking system 150 comprises an arcuate series 152 of pointed teeth 154. The teeth 154 are spaced from each other and form a locking groove 156 therebetween. Each locking groove 156 corresponds to a particular angular locking position for the grip portion 100. For example, in at least one arrangement, the teeth 154 and locking grooves or "locking locations" 156 are arranged to permit the grip portion 100 to be locked at 10-15 degree intervals between the first grip position and the second grip position. The arrangement may employ two stop positions which are tailored to the type of instrument (shaft arrangement) employed. For example, for an endocutter shaft arrangement, it may be approximately around ninety degrees to the shaft and for a circular stapler arrangement, the angle may be approximately forty-five degrees to the shaft while being swept forward towards the surgeon. The grip locking system 150 further includes a locking button 160 that has a locking portion that is configured to lockingly engage the locking grooves 156. For example, the locking button 160 is pivotally mounted in the primary handle portion 30 on a pivot pin 131 to permit the locking button 160 to pivot into engagement with a corresponding locking groove 156. A locking spring 164 serves to bias the locking button 160 into an engaged or locked position with the corresponding locking groove 156. The locking portion and the teeth configurations serve to enable the teeth 154 to slide past the locking portion when the clinician depresses the locking button 160. Thus, to adjust the angular position of the grip portion 100 relative to the primary housing portion 30, the clinician depresses the locking button 160 and then pivots the grip portion 100 to the desired angular position. Once the grip portion 100 has been moved to the desired position, the clinician releases the locking button 160. The locking

spring 164 will then bias the locking button 160 toward the series of teeth 154 so that the locking portion enters the corresponding locking groove 156 to retain the grip portion 100 in that position during use.

## **DRIVE SYSTEMS**

**[0078]** The handle assembly 20 operably supports a first rotary drive system 300, a second rotary drive system 320 and a third axial drive system 400. The rotary drive systems 300, 320 are each powered by a motor 200 that is operably supported in the grip portion 100. As can be seen in FIG. 2, for example, the motor 200 is supported within the cavity 132 in the grip portion 100 and has a gear box assembly 202 that has an output drive shaft 204 protruding therefrom. In various forms, the motor 200 may be a DC brushed driving motor having a maximum rotation of, approximately, 25,000 RPM, for example. In other arrangements, the motor may include a brushless motor, a cordless motor, a synchronous motor, a stepper motor, or any other suitable electric motor. The motor 200 may be powered by a power source 210 that, in one form, may comprise a removable power pack 212. The power source 210 may comprise, for example, anyone of the various power source arrangements disclosed in further detail in U.S. Patent Application Publication No. 2015/0272575 and entitled SURGICAL INSTRUMENT COMPRISING A SENSOR SYSTEM, the entire disclosure of which is hereby incorporated by reference herein. In the illustrated arrangement, for example, the power pack 212 may comprise a proximal housing portion 214 that is configured for attachment to a distal housing portion 216. The proximal housing portion 214 and the distal housing portion 216 are configured to operably support a plurality of batteries 218 therein. Batteries 218 may each comprise, for example, a Lithium Ion ("LI") or other suitable battery. The distal housing portion 216 is configured for removable operable attachment to a handle circuit board assembly 220 which is also operably coupled to the motor 200. The handle circuit board assembly 220 may also be generally referred to herein as the "control system or CPU 224". A number of batteries 218 may be connected in series may be used as the power source for the handle assembly 20. In addition, the power source 210 may be replaceable and/or rechargeable. In other embodiments, the surgical instrument 10 may be powered by alternating current (AC) for example. The motor 200 may be controlled by a rocker switch 206 that is mounted to the grip portion 100.

**[0079]** As outlined above, the motor 200 is operably coupled to a gear box assembly 202 that includes an output drive shaft 204. Attached to the output drive shaft 204 is a driver



bevel gear 230. The motor 200, the gear box assembly 202, the output drive shaft 204 and the driver bevel gear 230 may also be collectively referred to herein as a “motor assembly 231”. The driver bevel gear 230 interfaces with a driven bevel gear 234 that is attached to a system drive shaft 232 as well as a pivot bevel gear 238 that is journaled on the pivot shaft 180. The driven bevel gear 234 is axially movable on the system drive shaft 232 between an engaged position wherein the driven bevel gear 234 is in meshing engagement with the driver bevel gear 230 (FIG. 5) and a disengaged position wherein the driven bevel gear 234 is out of meshing engagement with the drive bevel gear 230 (FIG. 14). A drive system spring 235 is journaled between the driven bevel gear 234 and a proximal end flange 236 that is formed on a proximal portion of the system drive shaft 232. See FIGS. 4 and 14. The drive system spring 235 serves to bias the driven bevel gear 234 out of meshing engagement with the driver bevel gear 230 as will be discussed in further detail below. The pivot bevel gear 238 facilitates pivotal travel of the output drive shaft 204 and driver bevel gear 230 with the grip portion 100 relative to the primary handle portion 30.

**[0080]** In the illustrated example, the system drive shaft 232 interfaces with a rotary drive selector system, generally designated as 240. In at least one form, for example, the rotary drive selector system 240 comprises a shifter gear 250 that is selectively movable between the first rotary drive system 300 and the second rotary drive system 320. As can be seen in FIGS. 6-9, for example, the drive selector system 240 comprises a shifter mounting plate 242 that is non-movably mounted within primary handle portion 30. For example, the shifter mounting plate 242 may be frictionally retained between mounting lugs (not shown) formed in the housing segments 40, 70 or be otherwise retained therein by screws, adhesive, etc. Still referring to FIGS. 6-9, the system drive shaft 232 extends through a hole in the shifter mounting plate 242 and has the central, or system, drive gear 237 non-rotatably attached thereto. For example the central drive gear 237 may be attached to the system drive shaft 232 by a keyway arrangement 233. See FIGS. 6-9. In other arrangements, the system drive shaft 232 may be rotatably supported in the shifter mounting plate 242 by a corresponding bearing (not shown) that is mounted thereto. In any event, rotation of the system drive shaft 232 will result in rotation of the central drive gear 234.

**[0081]** As can be seen in FIG. 3, the first drive system 300 includes a first drive socket 302 that is rotatably supported in a distal wall 32 formed in the primary handle portion 30. The first drive socket 302 may comprise a first body portion 304 that has a splined socket formed

therein. A first driven gear 306 is formed on or is non-movably attached to the first body portion 304. The first body portion 304 may be rotatably supported in a corresponding hole or passage provided the distal wall 32 or it may be rotatably supported in a corresponding bearing (not shown) that is mounted in the distal wall 32. Similarly, the second rotary drive system 320 includes a second drive socket 322 that is also rotatably supported in the distal wall 32 of the primary handle portion 30. The second drive socket 322 may comprise a second body portion 324 that has a splined socket formed therein. A second driven gear 326 is formed on or is non-rotatably mounted to the second body portion 324. The second body portion 324 may be rotatably supported in a corresponding hole or passage provided the distal wall 32 or it may be rotatably supported in a corresponding bearing (not shown) that is mounted in the distal wall 32. The first and second drive sockets 302, 322 are spaced from each other on each lateral side of the handle axis HA. See FIG. 4, for example.

**[0082]** As indicated above, in the illustrated example, the rotary drive selector system 240 includes a shifter gear 250. As can be seen in FIGS. 6-9, the shifter gear 250 is rotatably mounted on an idler shaft 252 that is movably supported in an arcuate slot 244 in the shifter mounting plate 242. The shifter gear 250 is mounted so as to freely rotate on the idler shaft 252 and remain in meshing engagement with the central drive gear 234. The idler shaft 252 is coupled to an end of a shaft 262 of a shifter solenoid 260. The shifter solenoid 260 is pinned or otherwise mounted with the primary handle housing 30 such that when the shifter solenoid 260 is actuated, the shifter gear 250 is moved into meshing engagement with one of the first driven gear 306 or the second driven gear 326. For example, in one arrangement, when the solenoid shaft is 262 is retracted (FIGS. 6 and 7), the shifter gear 250 is in meshing engagement with the central drive gear 234 and the first driven gear 306 such that actuation of the motor 200 will result in rotation of the first drive socket 302. As can be seen in FIGS. 6 and 7, a shifter spring 266 may be employed to bias the shifter gear 250 into that first actuation position. Thus, should power be lost to the surgical instrument 10, the shifter spring 266 will automatically bias the shifter gear 250 into the first position. When the shifter gear 250 is in that position, subsequent actuation of the motor 200 will result in rotation of the first drive socket 302 of the first rotary drive system 300. When the shifter solenoid is actuated, the shifter gear 250 is moved into meshing engagement with the second driven gear 326 on the second drive socket 322. Thereafter, actuation of the motor 200 will result in actuation or rotation of the second drive socket 322 of the second rotary drive system 320.

## BAILOUT SYSTEM

**[0083]** As will be discussed in further detail below, the first and second rotary drive systems 300, 320 may be used to power various component portions of the interchangeable surgical tool assembly that is coupled thereto. As indicated above, in at least one arrangement, if during the actuation of the interchangeable surgical tool assembly, power was lost to the motor, the shifter spring 266 will bias the shifter gear 250 to the first position. Depending upon which component portion of the interchangeable surgical tool assembly was being operated, it may be necessary to reverse the application of the rotary drive motion to the first drive system 300 to enable the interchangeable surgical tool assembly to be removed from the patient. The handle assembly 20 of the illustrated example employs a manually actuatable “bailout” system, generally designated as 330, for manually applying a rotary drive motion to the first rotary drive system 300 in the above described scenario, for example.

**[0084]** Referring now to FIGS. 3, 10 and 11, the illustrated bailout system 330 comprises a bailout drive train 332 that includes a planetary gear assembly 334. In at least one form, the planetary gear assembly 334 includes a planetary gear housing 336 that houses a planetary gear arrangement (not shown) that includes a planetary bevel gear 338. The planetary gear assembly 334 includes a bailout drive shaft 340 that is operably coupled to the planetary gear arrangement within the planetary gear housing 336. Rotation of the planetary bevel gear 338 rotates the planetary gear arrangement which ultimately rotates the bailout drive shaft 340. A bailout drive gear 342 is journaled on the bailout drive shaft 340 so that the bailout drive gear 342 can move axially on the bailout drive shaft 340, yet rotate therewith. The bailout drive gear 342 is movable between a spring stop flange 344 that is formed on the bailout drive shaft 340 and a shaft end stop 346 that is formed on the distal end of the bailout drive shaft 340. A bailout shaft spring 348 is journaled on the bailout drive shaft 340 between the bailout drive gear 342 and the spring stop flange 344. The bailout shaft spring 348 biases the bailout drive gear 342 distally on the bailout drive shaft 340. When the bailout drive gear 342 is in its distal-most position on the bail out drive shaft 340, it is in meshing engagement with a bailout driven gear 350 that is non-rotatably mounted to the system drive shaft 232. See FIG. 14.

**[0085]** Referring now to FIGS. 12 and 13, the bailout system 330 includes a bailout actuator assembly or bailout handle assembly 360 that facilitates the manual application of a bailout drive motion to the bailout drive train 332. As can be seen in those Figures, the bailout handle assembly 360 includes a bailout bevel gear assembly 362 that comprises a

bailout bevel gear 364 and a ratchet gear 366. The bailout handle assembly 360 further includes a bailout handle 370 that is movably coupled to the bailout bevel gear assembly 362 by a pivot yoke 372 that is pivotally mounted on the ratchet gear 366. The bailout handle 370 is pivotally coupled to the pivot yoke 372 by a pin 374 for selective pivotal travel between a stored position "SP" and an actuation position "AP". See FIG. 12. A handle spring 376 is employed to bias the bailout handle 370 into the actuation position AP. In at least one arrangement, the angle between the axis SP representing the stored position and the axis AP representing the actuation position may be approximately thirty degrees, for example. See FIG. 13. As can also be seen in FIG. 13, the bailout handle assembly 360 further includes a ratchet pawl 378 that is rotatably mounted in a cavity or hole 377 in the pivot yoke 372. The ratchet pawl 378 is configured to meshingly engage the ratchet gear 366 when rotated in an actuation direction "AD" and then rotate out of meshing engagement when rotated in the opposite direction. A ratchet spring 384 and ball member 386 are movably supported in a cavity 379 in the pivot yoke 372 and serve to lockingly engage detents 380, 382 in the ratchet pawl 378 as the bailout handle 370 is actuated (ratcheted).

**[0086]** Referring now to FIGS. 3 and 10, the bailout system 330 further includes a bailout access panel 390 that is maneuverable between an open position and a closed position. In the illustrated arrangement, the bailout access panel 390 is configured to be removably coupled to the housing segment 70 of the primary housing portion 30. Thus, in at least that embodiment, when the bailout access panel 390 is removed or detached from the primary housing portion 30, it is said to be in an "open" position and when the bailout access panel 390 is attached to the primary housing portion 30 as illustrated, it is said to be in a "closed" position. Other embodiments are contemplated, however, wherein the access panel is movably coupled to the primary housing portion such that when the access panel is in the open position, it remains attached thereto. For example, in such embodiments, the access panel may be pivotally attached to the primary housing portion or slidably attached to the primary housing portion and be maneuverable between an open position and a closed position. In the illustrated example, the bailout access panel 390 is configured to snappingly engage corresponding portions of the housing segment 70 to removably retain it in a "closed" position. Other forms of mechanical fasteners such as screws, pins, etc. could also be used.

**[0087]** Regardless of whether the bailout access panel 390 is detachable from the primary housing portion 30 or it remains movably attached to the primary housing portion 30, the

bailout access panel 390 includes a drive system locking member or yoke 392 and a bailout locking member or yoke 396 that each protrudes out from the backside thereof or are otherwise formed thereon. The drive system locking yoke 392 includes a drive shaft notch 394 that is configured to receive a portion of the system drive shaft 232 therein when the bailout access panel 390 is installed in the primary housing portion 30 (i.e., the bailout access panel is in the "closed" position). When the bailout access panel 390 is positioned or installed in the closed position, the drive system locking yoke 392 serves to bias the driven bevel gear 234 into meshing engagement with the driver bevel gear 230 (against the bias of the drive system spring 235). In addition, the bailout locking yoke 396 includes a bailout drive shaft notch 397 that is configured to receive a portion of the bailout drive shaft 340 therein when the bailout access panel 390 is installed or positioned in the closed position. As can be seen in FIGS. 5 and 10, the bailout locking yoke 396 also serves to bias the bailout drive gear 342 out of meshing engagement with the bailout driven gear 350 (against the bias of the bailout shaft spring 348). Thus, the bailout locking yoke 396 prevents the bailout drive gear 342 from interfering with rotation of the system drive shaft 232 when the bailout access panel 390 is installed or in the closed position. In addition, the bailout locking yoke 396 includes a handle notch 398 for engaging the bailout handle 370 and retaining it in the stored position SP.

**[0088]** FIGS. 4, 5 and 10 illustrate the configurations of the drive system components and the bailout system components when the bailout access panel 390 is installed or is in the closed position. As can be seen in those Figures, the drive system locking member 392 biases the driven bevel gear 234 into meshing engagement with the driver bevel gear 230. Thus, when the bailout access panel 390 is installed or is in the closed position, actuation of the motor 200 will result in the rotation of the driver bevel gear 230 and ultimately the system drive shaft 232. Also, when in that position, the bailout locking yoke 396 serves to bias the bailout drive gear 342 out of meshing engagement with the bailout driven gear 350 on the system drive shaft 232. Thus, when the bailout access panel 390 is installed or is in the closed position, the drive system is actuatable by the motor 200 and the bailout system 330 is disconnected or prevented from applying any actuation motion to the system drive shaft 232. To activate the bailout system 330, the clinician first removes the bailout access panel 390 or otherwise moves the bailout access panel 390 to the open position. This action removes the drive system locking member 392 from engagement with the driven bevel gear 234 which

thereby permits the drive system spring 235 to bias the driven bevel gear 234 out of meshing engagement with the driver bevel gear 230. In addition, removal of the bailout access panel 390 or movement of the bailout access panel to an open position also results in the disengagement of the bailout locking yoke 396 with the bailout drive gear 342 which thereby permits the bailout shaft spring 348 to bias the bailout drive gear 342 into meshing engagement with the bailout driven gear 350 on the system drive shaft 232. Thus, rotation of the bailout drive gear 342 will result in rotation of the bailout driven gear 350 and the system drive shaft 232. Removal of the bailout access panel 390 or otherwise movement of the bailout access panel 390 to an open position also permits the handle spring 376 to bias the bailout handle 370 into the actuation position shown in FIGS. 11 and 14. When in that position, the clinician can manually ratchet the bailout handle 370 in the ratchet directions RD which results in the rotation of the of the ratchet bevel gear 364 (in a clockwise direction in FIG. 14, for example) which ultimately results in the application of a retraction rotary motion to the system drive shaft 232 through the bailout drive train 332. The clinician may ratchet the bailout handle 370 a number of times until the system drive shaft 232 has been sufficiently rotated a number of times to retract a component of the surgical end effector portion of the surgical tool assembly that is attached to the handle assembly 20. Once the bailout system 330 has been sufficiently manually actuated, the clinician may then replace the bailout access panel 390 (i.e., return the bailout access panel 390 to the closed position) to thereby cause the drive system locking member 392 to bias the driven bevel gear 234 into meshing engagement with the driver bevel gear 230 and the bailout locking yoke 396 to bias the bailout drive gear 342 out of meshing engagement with the bailout driven gear 350. As was discussed above, should power be lost or interrupted, the shifter spring 266 will bias the shifter solenoid 260 into the first actuation position. As such, actuation of the bailout system 330 will result in the application of reversing or retraction motions to the first rotary drive system 300.

**[0089]** As discussed above, a surgical stapling instrument can comprise a manually-actuated bailout system configured to retract a staple firing drive, for example. In many instances, the bailout system may need to be operated and/or cranked more than one time to fully retract the staple firing drive. In such instances, the user of the stapling instrument may lose track of how many times they have cranked the bailout and/or otherwise become confused as to how much further the firing drive needs to be retracted. Various embodiments

are envisioned in which the stapling instrument comprises a system configured to detect the position of a firing member of the firing drive, determine the distance in which the firing member needs to be retracted, and display that distance to the user of the surgical instrument.

**[0090]** In at least one embodiment, a surgical stapling instrument comprises one or more sensors configured to detect the position of the firing member. In at least one instance, the sensors comprise Hall Effect sensors, for example, and can be positioned in a shaft and/or end effector of the stapling instrument. The sensors are in signal communication with a controller of the surgical stapling instrument which is, in turn, in signal communication with a display on the surgical stapling instrument. The controller comprises a microprocessor configured to compare the actual position of the firing member to a datum, or reference, position - which comprises a fully retracted position of the firing member - and calculate the distance, i.e., the remaining distance, between the actual position of the firing member and the reference position.

**[0091]** Further to the above, the display comprises an electronic display, for example, and the controller is configured to display the remaining distance on the electronic display in any suitable manner. In at least one instance, the controller displays a progress bar on the display. In such instances, an empty progress bar can represent that the firing member is at the end of its firing stroke and a full progress bar can represent that the firing member has been fully retracted, for example. In at least one instance, 0% can represent that the firing member is at the end of its firing stroke and 100% can represent that the firing member has been fully retracted, for example. In certain instances, the controller is configured to display how many actuations of the bailout mechanism are required to retract the firing member to its fully retracted position on the display.

**[0092]** Further to the above, the actuation of the bailout mechanism can operably disconnect a battery, or power source, of the surgical stapling instrument from an electric motor of the firing drive. In at least one embodiment, the actuation of the bailout mechanism flips a switch which electrically decouples the battery from the electric motor. Such a system would prevent the electric motor from resisting the manual retraction of the firing member.

**[0093]** The illustrated handle assembly 20 also supports a third axial drive system that is generally designated as 400. As can be seen in FIGS. 3 and 4, the third axial drive system 400, in at least one form, comprises a solenoid 402 that has a third drive actuator member or

rod 410 protruding therefrom. The distal end 412 of the third drive actuator member 410 has a third drive cradle or socket 414 formed therein for receiving a corresponding portion of a drive system component of an interchangeable surgical tool assembly that is operably attached thereto. The solenoid 402 is wired to or otherwise communicates with the handle circuit board assembly 220 and the control system or CPU 224. In at least one arrangement, the solenoid 402 is "spring loaded" such that when the solenoid 402 is unactuated, the spring component thereof biases the third drive actuator 410 back to an unactuated starting position.

**[0094]** As indicated above, the reconfigurable handle assembly 20 may be advantageously employed to actuate a variety of different interchangeable surgical tool assemblies. To that end, the handle assembly 20 includes a tool mounting portion that is generally designated as 500 for operably coupling an interchangeable surgical tool assembly thereto. In the illustrated example, the tool mounting portion 500 includes two inwardly facing dovetail receiving slots 502 that are configured to engage corresponding portions of a tool attachment module portion of the interchangeable surgical tool assembly. Each dovetail receiving slot 502 may be tapered or, stated another way, be somewhat V-shaped. The dovetail receiving slots 502 are configured to releasably receive corresponding tapered attachment or lug portions that are formed on a portion of the tool attachment nozzle portion of the interchangeable surgical tool assembly. Each interchangeable surgical tool assembly may also be equipped with a latching system that is configured to releasably engage corresponding retention pockets 504 that are formed in the tool mounting portion 500 of the handle assembly 20.

**[0095]** The various interchangeable surgical tool assemblies may have a "primary" rotary drive system that is configured to be operably coupled to or interface with the first rotary drive system 310 as well as a "secondary" rotary drive system that is configured to be operably coupled to or interface with the second rotary drive system 320. The primary and secondary rotary drive systems may be configured to provide various rotary motions to portions of the particular type of surgical end effector that comprises a portion of the interchangeable surgical tool assembly. To facilitate operable coupling of the primary rotary drive system to the first rotary drive system and the secondary drive system to the second rotary drive system 320, the tool mounting portion 500 of the handle assembly 20 also includes a pair of insertion ramps 506 that are configured to bias portions of the primary and secondary rotary drive systems of the interchangeable surgical tool assembly distally during the coupling



process so as to facilitate alignment and operable coupling of the primary rotary drive system to the first rotary drive system 300 on the handle assembly 20 and the secondary rotary drive system to the second rotary drive system 320 on the handle assembly 20.

**[0096]** The interchangeable surgical tool assembly may also include a “tertiary” axial drive system for applying axial motion(s) to corresponding portions of the surgical end effector of the interchangeable surgical tool assembly. To facilitate operable coupling of the tertiary axial drive system to the third axial drive system 400 on the handle assembly 20, the third drive actuator member 410 is provided with a socket 414 that is configured to operably receive a lug or other portion of the tertiary axial drive system therein.

### **INTERCHANGEABLE SURGICAL TOOL ASSEMBLY**

**[0097]** FIG. 15 illustrates use of an interchangeable surgical tool assembly 1000 that may be used in connection with the handle assembly 20. As can be seen in that Figure, for example, the interchangeable surgical tool assembly 1000 includes a tool attachment module 1010 that is configured for operable and removable attachment to the tool mounting portion 500 of the handle assembly 20. The tool attachment module 1010 in the illustrated arrangement includes a nozzle frame 1020. In the illustrated arrangement, the interchangeable surgical tool assembly 1000 includes a primary rotary drive system 1100 and a secondary rotary drive system 1200. The primary rotary drive system 1100 is configured to operably interface with the first rotary drive system 300 on the handle assembly 20 and apply rotary firing motions to the surgical end effector 1500 attached thereto as will be discussed in further detail below. The secondary rotary drive system 1200 is configured to operably interface with the second rotary drive system 320 on the handle assembly 20 and apply articulation control motions to an articulation system 1700. The articulation system 1700 couples the surgical end effector 1500 to an elongate shaft assembly 1400 that is coupled to the nozzle frame 1020. The interchangeable surgical tool assembly 1000 further includes a tertiary drive system 1300 that is configured to operably interface with the third axial drive system 400 in the handle assembly 20. The tertiary axial drive system 1300 of the surgical tool assembly comprises a tertiary actuation shaft 1302 that has a shaft attachment lug 1306 formed on the proximal end 1304 thereof. As will be discussed in further detail below, when the interchangeable surgical tool assembly 1000 is coupled to the handle assembly 20, the shaft attachment lug 1306 is received in the shaft attachment socket 414 on the distal end 412 of the third drive actuator member 410.

**[0098]** Still referring to FIG. 15, the reader will observe that the tool mounting portion 500 of the handle assembly 20 includes two inwardly facing dovetail receiving slots 502. Each dovetail receiving slot 502 may be tapered or, stated another way, be somewhat V-shaped. The dovetail receiving slots 502 are configured to releasably receive corresponding tapered attachment or lug portions 1022 formed on the nozzle frame 1020. Turning next to FIG. 18, in at least one form, the tool attachment module 1010 is removably latched to the tool mounting portion 500 of the handle assembly 20 by a latching system generally designated as 1030. In the illustrated embodiment, the latching system 1030 comprises a lock yoke 1032 that includes a pair of inwardly extending pivot pins 1034 (only one is shown in FIG. 18) that are received in corresponding pivot holes (not shown) in the nozzle frame 1020. Such arrangement serves to pivotally or movably couple the lock yoke 1032 to the nozzle frame 1020. The lock yoke 1032 further includes a pair of retention lugs or hook formations 1036 (only one can be seen in FIG. 18) that are configured to be hookingly or otherwise retainingly received in corresponding retention pockets 504 that are formed in the tool mounting portion 500 of the handle assembly 20. The lock yoke 1032 may be pivoted out of retaining engagement by applying an unlocking motion (represented by arrow 1041 in FIGS. 18, 20 and 21) to a release button 1038 that is attached to the lock yoke 1032. A lock yoke spring 1040 is received on a spring lug 1039 that is formed on the lock yoke 1032 and a spring mounting lug 1021 that is formed on the nozzle frame 1020. The lock yoke spring 1040 serves to bias the lock yoke 1032 into the locked position.

**[0099]** The latching system 1030 of the illustrated example further comprises a shaft coupler release assembly 1031 for releasably engaging the primary rotary drive system 1100 to the first rotary drive system 300 as well as the secondary rotary drive system 1200 to the second rotary drive system 320 on the handle assembly 20. Referring now to FIGS. 18 and 19, the primary rotary drive system 1100 includes a primary drive key 1102 that is configured to be axially received within the first drive socket 302 of the first rotary drive system 300. The primary drive key 1102 is slidably received on a primary transfer shaft 1104 that is rotatably supported by a bulkhead 1023 that is formed in the nozzle frame 1020. The primary drive key 1102 also movably extends through a hole 1025 in another bulkhead 1024 that is formed in the nozzle frame 1020. See FIG. 18. The primary transfer shaft 1104 is splined so that the primary drive key 1102 is free to axially move on the primary transfer shaft 1104 but not rotate relative thereto such that rotation of the primary drive key 1102 results in rotation of the

primary transfer shaft 1104. As can be further seen in FIG. 18, the primary drive key 1102 includes an attachment flange 1106 that is received within a cavity 1044 in a coupler release tab 1042. Thus, the primary drive key 1102 and the coupler release tab 1042 move as a unit. A primary transfer spring 1108 is journaled on the primary transfer shaft 1104 and extends between the bulkhead 1023 and the coupler release tab 1042 to bias the coupler release tab 1042 and the primary drive key 1102 in the proximal direction "PD" on the primary transfer shaft 1104.

**[0100]** Still referring to FIGS. 18 and 19, the secondary rotary drive system 1200 includes a secondary drive key 1202 that is configured to be axially received within the second drive socket 322 of the second rotary drive system 320. The secondary drive key 1202 is slidably received on a secondary transfer shaft 1204 that is rotatably supported by the bulkhead 1023. The secondary drive key 1202 also movably extends through a hole 1026 in bulkhead 1024. The secondary transfer shaft 1204 is splined so that the secondary drive key 1202 is free to axially move on the secondary transfer shaft 1204 but not rotate relative thereto such that rotation of the secondary drive key 1202 results in rotation of the secondary transfer shaft 1204. The secondary drive key 1202 includes an attachment flange (not shown) that is received within a cavity (not shown) in the coupler release tab 1042. Thus, the secondary drive key 1202 and the coupler release tab 1042 move as a unit. A secondary transfer spring 1208 is journaled on the secondary transfer shaft 1204 and extends between the bulkhead 1023 and the coupler release tab 1042 to bias the coupler release tab 1042 and the secondary drive key 1202 in the proximal direction PD on the secondary transfer shaft 1204. As can be seen in FIG. 18, the coupler release tab 1042 is formed with two upstanding actuator portions 1046 that correspond to inwardly extending coupler release tabs 1048 formed on the lock yoke 1032.

**[0101]** Operation of the latching system 1030 may be understood from reference to FIGS. 20-22. FIG. 20 illustrates the beginning of the coupling process wherein the interchangeable surgical tool assembly 1000 is moved in the installation direction "ID" relative to the handle assembly 20. To commence the installation process, the clinician aligns the tapered attachment lugs 1022 on the nozzle frame 1020 with their corresponding dovetail slot 502 on the tool mounting portion 500 of the handle assembly 20 and moves the interchangeable surgical tool assembly 1000 in the insertion direction ID relative to the handle assembly 20. Insertion and movement of the tapered attachment lugs 1022 in their respective dovetail slot

502 serves to align the shaft attachment lug 1306 on the tertiary actuation shaft 1302 with the shaft attachment socket 414 on the distal end 412 of the third drive actuator member 410. Likewise, the primary drive key 1102 and the secondary drive key 1202 are each aligned for contact with corresponding insertion ramps 506 that are formed on the tool mounting portion 500 of the handle assembly 20.

**[0102]** FIG. 21 illustrates contact between the primary drive key 1102 and the corresponding insertion ramp 506 with it being understood that the secondary drive key 1202 would be in a similar position with its corresponding insertion ramp 506. As can be seen in that Figure, the primary drive key 1102 has contacted the insertion ramp 506 and continued advancement of the interchangeable surgical tool assembly 1000 in the installation direction ID causes the insertion ramp 506 to bias the primary drive key 1102 in the distal direction DD on the primary transfer shaft 1104. The secondary drive key 1202 would similarly move in the distal direction DD on the secondary transfer shaft 1204. This movement may be further achieved by pushing the release button 1038 in the direction represented by arrow 1041 which causes the lock yoke 1032 to contact the coupler release tab 1042 and move it in the distal direction DD against the biasing force of the first and second transfer springs 1108, 1208. The clinician may maintain the pressure on the release button 1038 so that once the primary drive key 1102 and secondary drive key 1202 clear their corresponding insertion ramps 506, the primary drive key 1102 and secondary drive key 1202 can move into alignment with the corresponding first and second drive sockets 302, 322, respectively. When the tapered attachment lugs 1022 are seated in their respective dovetail slots 502, the primary drive key 1102 is axially aligned with the first drive socket 302 and the secondary drive key 1202 is axially aligned with the second drive socket 322, such that when the clinician releases the release button 1038, the primary drive key 1102 enters the first drive socket 302 and the secondary drive key 1202 enters the second drive socket 322. See FIG. 22. Thus, rotation of the first drive socket 302 will result in rotation of the primary drive key 1102 and the primary transfer shaft 1104 and rotation of the second drive socket 322 will result in rotation of the secondary drive key 1202 and the secondary transfer shaft 1204. In addition, the shaft attachment lug 1306 is received within the shaft attachment socket 414 on the distal end 412 of the third drive actuator member 410. Thus, axial movement of the third drive actuator member 410 will result in the axial movement of the tertiary actuation shaft 1302. As can also be seen in FIGS. 20-22, the interchangeable surgical tool assembly 1000

further includes an onboard “tool” circuit board 1060 that has a connector portion 1062 that is configured to mate with a corresponding connector 222 on the handle circuit board 220. When the tool circuit board 1060 is coupled to the handle circuit board 220, the tool circuit board provides an identification signal to the control system or CPU 224 so that the control system or CPU 224 can select the appropriate control actions for the type of interchangeable surgical tool assembly that is being employed.

## **END EFFECTORS**

**[0103]** The interchangeable surgical tool assembly 1000 includes a surgical end effector 1500 that is configured to cut and fasten tissue. As can be seen in FIGS. 23 and 24, the surgical end effector 1500 is operably coupled to an elongate shaft assembly 1400 by an articulation joint 1702. As will be discussed in further detail below, the elongate shaft assembly 1400 is operably coupled to the tool attachment module 1010 and comprises portions of the primary rotary drive system 1100, the secondary rotary drive system 1200 and the tertiary axial drive system 1300. Referring now to FIGS. 25-28, the surgical end effector 1500 includes an elongate channel 1520 that is configured to operably support a surgical staple cartridge 1550 therein. The surgical staple cartridge 1550 may comprise a compressible or implantable staple cartridge that has a body portion 1552 that consists of a compressible hemostat material such as, for example, oxidized regenerated cellulose (“ORC”) or a bio-absorbable foam in which lines of unformed metal staples or other forms of fasteners are supported. In at least some embodiments, in order to prevent the staple from being affected and the hemostat material from being activated during the introduction and positioning process, the entire cartridge may be coated and/or wrapped in a biodegradable film such as a polydioxanon film, sold under the trademark PDS®, a polyglycerol sebacate (PGS) film, and/or other biodegradable films formed from PGA (polyglycolic acid), PCL (polycaprolactone), PLA or PLLA (polylactic acid), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone 25) and/or a composite of PGA, PCL, PLA, PDS, for example, that would be impermeable until ruptured. Varieties of different implantable cartridge arrangements are known and may be employed. For example, various implantable/compressible cartridge arrangements are disclosed in further detail in many of the patent applications and patents that have been incorporated by reference herein in their respective entireties. In the illustrated example, the cartridge body portion 1552 of surgical staple cartridge 1550 is sized to be removably supported within the elongate channel 1520.

**[0104]** The elongate channel 1520 and surgical staple cartridge 1550 installed therein may also be referred to herein a “first jaw” 1502. The surgical end effector 1500 also includes a second jaw 1504 in the form of an anvil assembly 1560 that is supported for movable travel relative to the first jaw. Stated another way, the first and second jaws 1502 and 1504 may be configured for movable travel relative to each other between open positions and closed positions. In the illustrated arrangement, the anvil assembly 1560 comprises an anvil body portion or anvil frame 1562. The anvil frame 1562 includes a proximal anvil portion 1570 that has a pair of trunnion pins 1572 extending laterally therefrom. The trunnion pins 1572 are movably received in pivot slots 1526 that are formed in corresponding upstanding walls 1524 of a channel mounting portion 1522 of the elongate channel 1520. See FIGS. 27 and 28. The anvil frame 1562, in at least one form, includes a pair of downwardly extending tissue stops 1564 that serve to limit the distance in which the target tissue may extend proximally between the first and second jaws 1502, 1504 so that when the target tissue is severed, the fasteners are properly positioned to fasten the cut tissue. When the first and second jaws 1502, 1504 are in the closed position, the tissue stops 1564 are outside of the upstanding walls 1524 of the channel mounting portion 1522 and the proximal anvil portion 1570 is located between the upstanding walls 1524. See FIG. 28.

#### **ANVIL CONCENTRIC DRIVE MEMBER**

**[0105]** The anvil assembly 1560 operably supports an anvil concentric drive member 1600 for operably driving a firing member 1620 through the end effector 1500. The anvil concentric drive member 1600 may, for example, be centrally disposed within the anvil frame 1562 and substantially extend the length thereof. The anvil concentric drive member 1600 in the illustrated embodiment comprises an anvil drive shaft 1610 that includes a distal bearing lug 1611 and a proximal bearing lug 1612. The distal bearing lug 1611 is rotatably housed in a distal bearing housing 1580 that is supported in a bearing pocket in the anvil frame 1562. The proximal bearing lug 1612 is rotatably supported in the anvil assembly 1560 by a floating bearing housing 1582 that is movably supported in a bearing pocket 1574 that is formed in the proximal anvil portion 1570. See FIG. 27. The proximal and distal bearing housing arrangements may serve to prevent or at least minimize an occurrence of compressive forces on the anvil drive shaft 1610 which might otherwise cause the anvil drive shaft 1610 to buckle under high force conditions. The anvil drive shaft 1610 further includes a driven firing gear 1614, a proximal threaded or helix section 1616 and a distal threaded or helix section 1618.

In the illustrated arrangement, the proximal threaded section 1616 has a first length "FL" and the distal threaded section 1618 has a distal length "DL" that is greater than the first length FL. In at least one arrangement, for example, the first length FL may be approximately 3-5 threads per inch using only one acme thread lead and the distal length DL may be approximately 9-15 threads per inch with 2-4 acme thread leads for more power. However, the proximal threaded section 1616 and the distal threaded section 1618 may have other lengths. See FIG. 31. As can be seen in FIG. 26, the pitch of the distal threaded section 1618 is greater than the pitch of the proximal threaded section 1616. Stated another way, the lead of the distal threaded section 1618 is greater than the lead of the proximal threaded section 1616. In one arrangement, the lead of the distal threaded section 1618 may be approximately twice as large as the lead of the proximal threaded section 1616. As can also be seen in FIG. 31, a dead space 1617 may be provided between the proximal threaded section 1616 and the distal threaded section 1618. In at least one example, the anvil drive shaft 1610 may be fabricated in one piece from extruded gear stock.

**[0106]** To facilitate assembly of the various anvil components, the anvil assembly 1560 includes an anvil cap 1563 that may be attached to the anvil frame 1562 by welding, snap features, etc. In addition, the anvil assembly 1560 includes a pair of anvil plates or staple forming plates 1568 that may contain various patterns of staple forming pockets or forming pockets on the bottom surfaces thereof that correspond to the staple arrangements in the surgical staple cartridge 1550 that is supported in the elongate channel 1520. The staple forming plates 1568 may be made of a metal or similar material and be welded to or otherwise attached to the anvil frame 1562. In other arrangements, a single anvil plate that has a slot therein to accommodate a firing member may also be employed. Such anvil plate or combination of plates may serve to improve the overall stiffness of the anvil assembly. The anvil plate(s) may be flat and have the staple forming pockets or forming pockets "coined" therein, for example.

**[0107]** FIG. 29 illustrates one form of a firing member 1620 that includes a body portion 1622 that has a knife nut portion 1624 formed thereon or otherwise attached thereto. The knife nut portion 1624 is configured to be received on the anvil drive shaft 1610. A distal thread nodule 1626 and a proximal thread nodule 1628 that are configured to engage the proximal threaded section 1616 and the distal threaded section 1618 are formed in the knife nut portion 1624. The distal thread nodule 1626 is spaced from the proximal thread nodule

1628 relative to the length of the dead space 1617 such that when the knife nut portion 1624 spans across the dead space 1617, the distal thread nodule 1626 is in threaded engagement with the distal threaded section 1618 and the proximal thread nodule 1628 is in threaded engagement with the proximal threaded section 1616. In addition, an anvil engaging tab 1630 protrudes laterally from opposite lateral portions of the knife nut 1624 and is oriented to engage the corresponding staple forming plate 1568 that are attached to the anvil frame 1562. The firing member 1620 further includes a channel engaging tab 1632 that protrudes from each lateral side of the body portion 1622 to engage portions of the elongate channel 1520 as will be discussed in further detail below. The firing member 1620 also includes a tissue cutting surface 1634.

**[0108]** Rotation of the anvil drive shaft 1610 in a first rotary direction will result in the axial movement of the firing member 1620 from a starting position (FIG. 35) to an ending position (FIG. 32). Similarly, rotation of the anvil drive shaft 1610 in a second rotary direction will result in the axial retraction of the firing member 1620 from the ending position back to the starting position. The anvil drive shaft 1610 ultimately obtains rotary motion from a proximal drive shaft 1120 that operably interfaces with the primary transfer shaft 1104. Referring again to FIGS. 16-18, a proximal drive gear 1110 is mounted to the primary transfer shaft 1104 and is supported in meshing engagement with a power driven gear 1122 that is mounted to a proximal end of the proximal drive shaft 1120. The proximal drive shaft 1120 is rotatably supported within a power shaft support tube 1124 and has a power bevel gear 1126 attached to its distal end. See FIG. 30. As indicated above, the illustrated interchangeable surgical tool assembly 1000 includes an articulation joint 1702 that facilitates articulation of the surgical end effector 1500. In at least one embodiment as illustrated in FIG. 30, the articulation joint 1702 comprises an articulation shaft 1704 that is mounted to a distal end of an outer spine tube 1402 of the elongate shaft assembly. In particular, the outer spine tube 1402 includes a pair of distally protruding pivot tabs 1404, 1406 that are attached to the corresponding ends of the articulation shaft 1704 such that the articulation shaft 1704 defines an articulation axis "A-A" that is transverse to a shaft axis "SA-SA" defined by the elongate shaft assembly 1400.

**[0109]** Still referring to FIG. 30, the power bevel gear 1126 is in meshing engagement with a centrally disposed power transfer gear 1128 that is rotatably journaled on the articulation shaft 1704. The primary rotary drive system 1100 of the illustrated embodiment further



includes a distal power shaft 1130 that has a distal driven gear 1132 attached to the proximal end thereof by a screw or other fastener 1133. The distal power shaft 1130 may also be referred to herein as a rotary output drive shaft. The distal driven gear 1132 is in meshing engagement with the centrally disposed power transfer gear 1128. Turning next to FIGS. 31 and 32, a distal drive gear 1134 is attached to the distal end of the distal power shaft 1130. The distal drive gear 1134 is configured for meshing engagement with the driven firing gear 1614 on the anvil drive shaft 1610 when the anvil assembly 1560 is in the closed position as shown in FIGS. 31 and 32. The anvil drive shaft 1610 is said to be "separate and distinct" from the distal power shaft 1130. That is, at least in the illustrated arrangement for example, the anvil drive shaft 1610 is not coaxially aligned with the distal power shaft 1130 and does not form a part of the distal power shaft 1130. In addition, the anvil drive shaft 1610 is movable relative to the distal power shaft 1130, for example, when the anvil assembly 1560 is moved between open and closed positions. FIG. 31 illustrates the anvil assembly 1560 in a closed position and the firing member 1620 in a pre-firing position. As can be seen in that Figure, the distal thread nodule 1626 in the knife nut 1624 of the firing member 1620 is engaged with the distal threaded portion 1618 such that rotation of the anvil drive shaft 1610 drives (fires) the firing member 1620 to the end position illustrated in FIG. 32. Further details regarding the operation of the firing member 1620 are provided below.

### **OPENING AND CLOSING SYSTEMS**

**[0110]** In the illustrated arrangement, the anvil assembly 1560 is closed by distally advancing a closure tube 1410 that is a portion of the elongate shaft assembly 1400. As can be seen in FIGS. 27 and 31-35, the closure tube 1410 includes an internally threaded closure nut 1412 that is configured for threaded engagement with a closure thread segment 1136 that is formed on the distal power shaft 1130. FIG. 33 illustrates the anvil assembly 1560 in an open position. As was discussed above, the proximal bearing lug 1612 is rotatably supported in the anvil assembly 1560 by a floating bearing housing 1582 that is movably supported in a bearing pocket 1574 in the proximal anvil portion 1570. A bearing spring 1584 is journaled on the distal power shaft 1130 and is configured to apply a biasing force to the bearing housing 1582 during opening and closing of the anvil assembly 1560. Such biasing force serves to urge the anvil assembly 1560 into the open position. In at least one arrangement, the bearing spring 1584 comprises an assembly of plates 1586 fabricated from, for example, 17-4, 416 or 304 stainless steel that are laminated together by a more annealed stainless

steel material and which have a hole 1588 for receiving the distal power shaft 1130 therethrough. See FIG. 36.

**[0111]** As indicated above, the anvil trunnion pins 1572 are received in vertically oriented pivot slots 1526 that are formed in the upstanding walls 1524 of the elongate channel 1520 to afford the anvil assembly 1560 with the ability to move vertically relative to the elongate channel 1520 as well as relative to the surgical staple cartridge 1550 supported therein. Such movement of the anvil assembly 1560 relative to the elongate channel 1520 may serve to accommodate different thicknesses of tissue that is clamped therebetween. To that end, in the illustrated example, the surgical end effector 1500 also includes an anvil spring assembly 1590 for managing the magnitude of the tissue gap between the staple forming plates 1568 and the upper surface of the surgical staple cartridge 1550. As can be most particularly seen in FIG. 27, the anvil spring assembly 1590 in the illustrated example includes a bearing mount 1592 that is mounted between the upstanding walls 1524 of the elongate channel 1520. As can be seen in FIGS. 27 and 33, the bearing mount 1592 has a somewhat U-shaped bearing cavity 1594 therein that is configured to operably receive therein a shaft bearing 1138 as well as a bearing stop flange 1140 that is formed on or otherwise attached to the distal power shaft 1130. Such arrangement serves to rotatably support the distal power shaft 1130 within the proximal end portion or channel mounting portion 1522 of the elongate channel 1520. Two spring tabs 1596 extend from the bearing mount 1592 and are oriented to apply a downward biasing force to the proximal anvil portion 1570. See FIG. 32. Such biasing force serves to bias the proximal anvil portion 1570 downward such that the anvil trunnion pins 1572 are biased downward within their corresponding vertical pivot slots 1526 and enable the anvil assembly 1560 to vertically move to accommodate different thicknesses of tissue. As the anvil assembly 1560 is closed, the target tissue that is captured between the anvil assembly 1560 and the surgical staple cartridge 1550 will result in the compression of the cartridge body 1552 and the staples or fasteners supported therein will be pressed through the tissue into forming contact with the staple forming plates 1568 on the underside of anvil assembly 1560. Depending upon the arrangement of staples or fasteners in the staple cartridge 1550, the staples may be formed in several discreet lines through the staple cartridge body and the clamped tissue. For example, there may be a total of six lines of staples (three lines of staple on each side of a central area through which the firing member

1620 may pass). In at least one arrangement, for example, the staples in one line may be offset or staggered from the staples in adjacent lines.

**[0112]** As can be seen in FIG. 33 when the anvil assembly 1560 is in the open position, the closure thread segment 1136 on the distal power shaft 1130 remains in threaded engagement with the closure nut 1412. When in the open position, the firing member 1620 is located in its proximal-most or starting position on the proximal threaded portion 1616 of the anvil drive shaft 1610. As can be seen in FIG. 33, when in that proximal starting position, the channel engagement tabs 1632 on the firing member are able to clear the channel ledges 1528 formed in the elongate channel 1520 to enable the firing member 1620 to pivot with the anvil assembly 1560 to the open position. When in that position (which may also be referred to as a “fully open position”), the driver firing gear 1614 may remain in contact with the distal drive gear 1134, but it is not in meshing engagement therewith. Thus, rotation of the distal power shaft 1130 will not result in rotation of the anvil drive shaft 1610.

**[0113]** To commence the closing process, the distal power shaft 1130 is rotated in a first rotary direction. This initial rotation of the distal power shaft 1130 causes the closure tube 1410 to move in the distal direction DD by virtue of the threaded engagement between the closure thread segment 1136 on the distal power shaft 1130 and the internally threaded closure nut 1412. As the closure tube 1410 moves distally, a closure tab 1414 that is formed on the distal end of the closure tube 1410 contacts the proximal anvil portion 1570 and moves into camming contact therewith to cause the anvil assembly 1560 to pivot to an initial closed position. Further rotation of the distal power shaft 1130 will result in the distal movement of the closure tube 1410 until the closure tube reaches a “fully closed” position wherein the internally threaded closure nut 1412 has threadably disengaged from the closure thread segment 1136. When in that position, for example, the internally threaded closure nut 1412 is distal to the closure thread segment 1136 and further rotation of the distal power shaft 1130 in the first rotary direction will not affect movement of the closure tube 1410. A closure spring 1416 serves to bias the closure tube 1410 distally to retain the internally threaded closure nut 1412 out of threaded engagement with the closure thread segment 1136.

**[0114]** Once the anvil assembly 1560 has been moved to the closed position, the driven firing gear 1614 on the anvil drive shaft 1610 will now be in meshing engagement with the distal drive gear 1134 on the distal power shaft 1130. Further rotation of the distal power

shaft 1130 in the first rotary direction will thereby result in the rotation of the anvil drive shaft 1610 and cause the firing member 1620 to move distally on the proximal threaded portion 1616. Continued rotation of the anvil drive shaft 1610 in the first rotary direction will result in the distal movement of the firing member 1620. FIG. 34 illustrates the position of the firing member 1620 just prior to engagement between the distal thread nodule 1626 and the distal threaded portion 1618 of the firing drive shaft. FIG. 31 illustrates the position of the firing member 1620 after the distal thread nodule 1626 has initially threadably engaged the distal threaded portion 1618 of the anvil drive shaft 1610. When in that position, the anvil engaging tabs 1630 on the firing member 1620 have engaged the corresponding staple forming plates 1568 that are attached to the anvil frame 1562 and the channel engaging tabs 1632 have engaged the corresponding ledges 1528 on the elongate channel 1520 to maintain a desired spacing between the anvil assembly 1560 and the elongate channel 1520.

**[0115]** Continued rotation of the distal power shaft 1130 in the first rotary direction causes the anvil drive shaft 1610 to also rotate. Now that the distal thread nodule 1626 has engaged the distal threaded portion 1618 of the anvil drive shaft 1610, the firing member 1620 will move at a “firing speed” that is faster than a “pre-firing speed” that the firing member 1620 moves when threadably engaged with the proximal threaded portion 1616 of the anvil drive shaft 1610. This speed difference is due to the differences in the thread leads of the proximal and distal threaded portions 1616, 1618. As the firing member 1620 moves distally through the end effector 1500, the tissue cutting surface 1634 passes between the staple forming plates 1568 and cuts through the tissue that has been clamped between the anvil assembly 1560 and the surgical staple cartridge 1550. Thus, the tissue is first stapled when the anvil assembly 1560 is moved to the fully closed position. The tissue is thereafter cut when the firing member is distally advanced through the end effector 1500. Thus, the staple forming process may “separate and distinct” from the tissue cutting process.

**[0116]** FIG. 32 illustrates the position of the firing member 1620 at the end firing position or near the end firing position. Once the firing member 1620 has reached the end firing position which may, for example, be determined by sensors, encoders, etc. - not shown, the distal power shaft 1130 may be rotated in a second rotary direction or “retraction direction” which also causes the anvil drive shaft 1610 to rotate in the opposite direction. Rotation of the anvil drive shaft 1610 in the second rotary direction will cause the firing member 1620 to move proximally to the position shown in FIG. 35. As can be seen in FIG. 35, the closure tube

1410 is fitted with a closure tube reset spring 1418 that extends distally from a lug 1413 on the closure nut 1412. The firing member 1620 is formed with a proximally extending reset tab 1636 that is configured to contact and apply a proximal compression force to the closure tube reset spring 1418 when the firing member 1620 returns to the starting position. Such proximal compression force serves to urge the closure tube 1410 and, more particularly, the internally threaded closure nut 1412 against the closure thread segment 1136 on the distal power shaft 1130 so that the closure nut threads threadably re-engage the closure thread segment 1136 on the distal power shaft 1130. As the distal power shaft 1130 continues to rotate in the second rotary direction, the interaction between the closure thread segment 1136 and the closure nut 1412 causes the closure tube 1410 to move proximally so that the closure tab 1414 moves out of camming contact with the proximal anvil portion 1570 to thereby permit the bearing spring 1584 to urge the anvil assembly 1560 to the open position (FIG. 33). The tissue contained between the anvil assembly 1560 and the elongate channel 1520 may also serve to urge the anvil assembly 1560 to the open position wherein the tissue may be removed therefrom.

## **ARTICULATION SYSTEM**

**[0117]** As indicated above, the illustrated example includes an articulation system 1700 that facilitates articulation of the surgical end effector 1500 about the articulation axis AA that is transverse to the shaft axis SA. In the illustrated example, the surgical end effector 1500 is also capable of being selectively rotated about the shaft axis SA distal to the articulation joint 1702 as represented by arrow 1703 in FIG. 24. In the illustrated example, the articulation system 1700 is actuated by the second rotary drive system 320 in the handle assembly 20. As was discussed above, the interchangeable surgical tool assembly 1000 includes a secondary rotary drive system 1220 that is configured to operably interface with a second rotary drive system 320 on the handle assembly. In the illustrated arrangement, the secondary rotary drive 1220 comprises a portion of the articulation system 1700. In the illustrated example, the articulation system 1700 comprises an articulation drive shaft 1706 that is rotatably supported on the power shaft support tube 1124. As indicated above, the proximal drive shaft 1120 rotatably extends through the power shaft support tube 1124. In the illustrated arrangement, the proximal drive shaft 1120 is coaxially aligned on the shaft axis SA. The power shaft support tube 1124 is configured such that the articulation drive shaft 1706 is not coaxially aligned on the shaft axis SA. Stated another way, the articulation

drive shaft 1706 has an articulation drive shaft axis "ADA" that is offset from the shaft axis SA when the articulation drive shaft 1706 is mounted on the power shaft support tube 1124. See FIG. 30. Such arrangement facilitates the formation of a relatively compact nested gear arrangement in the vicinity of the articulation joint 1702 as can be seen in FIG. 38-42. In the illustrated arrangement for example, a proximal articulation driven gear 1708 is mounted to the proximal end of the articulation drive shaft 1706. See FIG. 19. The proximal articulation driven gear 1708 is arranged in meshing engagement with a secondary drive gear 1206 that is mounted to a distal end of the secondary transfer shaft 1204. Rotation of the secondary transfer shaft 1204 and the secondary drive gear 1206 will result in the rotation of the proximal articulation driven gear 1708 as well as of the articulation drive shaft 1706. A distal articulation drive gear 1710 is attached to the distal end of the articulation drive shaft 1706. The distal articulation drive gear 1710 is supported in meshing engagement with a channel articulation gear 1538 that is formed on a channel mounting fixture 1530.

**[0118]** More specifically and with reference to FIGS. 30 and 37, in the illustrated example, the channel mounting fixture 1530 comprises a disc-like body portion 1532 that has a lower shaft attachment tab 1534 and an upper shaft attachment tab 1536 formed thereon. The articulation shaft 1704 extends through corresponding holes in the lower and upper shaft attachment tabs 1536, 1534 to be attached to the pivot tabs 1404, 1406 in the outer spine tube 1402. Such arrangement serves to permit the channel mounting fixture 1530 to rotate about the articulation axis AA relative to the outer shaft spine tube 1402. The channel articulation gear 1538 is formed on the lower shaft attachment tab 1534 and is retained in meshing engagement with distal articulation drive gear 1710. Referring now to FIG. 27, in the illustrated example, the channel mounting portion 1522 of the elongate channel 1520 includes an upstanding proximal wall 1523 that has a mounting hub 1525 proximally protruding therefrom. A shaft hole 1527 extends through the mounting hub 1525 and upstanding proximal wall 1523 that is configured to permit the distal power shaft 1130 to extend therethrough. In the illustrated example, the channel mounting fixture 1530 is frictionally mounted on the mounting hub 1525 to complete the coupling of the end effector 1500 to the articulation joint 1702. See FIG. 30.

**[0119]** FIGS. 30, 38 and 39 best illustrate operation of the articulation joint 1702. Rotation of the articulation drive shaft 1704 in a first rotary direction by the second rotary drive system 320 will result in rotation or articulation of the surgical end effector 1500 in an articulation

angle 1711 (FIG. 39) relative to the shaft axis SA. In at least one example, the articulation angle 1711 may be between 0° - 90°, for example. Rotation of the articulation drive shaft 1704 in an opposite rotary direction will result in the articulation of the surgical end effector 1500 in an opposite articulation direction. Once the surgical end effector 1500 has been articulated to the desired orientation, power to the second rotary drive system 320 (and ultimately to the secondary rotary drive system 1200) is discontinued. The friction between the components (i.e., gears) of the secondary rotary drive system 1200, as well as the components (i.e., gears) of the articulation system 1700, serves to retain the surgical end effector 1500 in the articulated orientation. In alternative arrangements, however, gears 306 and 326 may be locked in place. For example, when gear 252 engages these gears, the shifting mechanism that engages gear 252 with gear 306 can disengage the lock. This can be accomplished with a simple cam surface that disengages the locking means when the gear 252 moves to engage.

#### **END EFFECTOR ROTATION**

**[0120]** The illustrated interchangeable surgical tool assembly 1000 is configured to employ the primary rotary drive system 1100 to selectively rotate the surgical end effector 1500 about the shaft axis SA. In addition, in the illustrated example, the tertiary axial drive system 1300 is configured to selectively lock the surgical end effector 1500 in the desired rotary orientation. As can be seen in FIGS. 37 and 42, for example, the elongate shaft assembly 1400 includes an elongate shaft support tube 1420 that extends from the tool mounting portion 1010 to just proximal of the articulation joint 1702. The elongate shaft support tube 1420 includes an “off-axis” passageway 1422 for rotatably supporting the articulation drive shaft 1706 therethrough. The elongate shaft support tube 1420 further includes a distal end 1424 that has a gear cavity 1426 and a gear axle 1428 formed therein for accommodating a locking gear assembly 1430 therein. See FIG. 37. The locking gear assembly 1430 includes drive gear 1432 that is received within the gear cavity 1426 in the elongate shaft support tube 1420. In addition, the locking gear assembly 1430 has a smaller driven gear 1434 attached thereto. As was briefly discussed above, the tertiary axial drive system 1300 includes a tertiary actuation shaft 1302 that is also referred to herein as a locking control rod 1302. The locking control rod 1302 has a shaft attachment lug 1306 formed on the proximal end 1304 thereof. When the interchangeable surgical tool assembly 1000 is coupled to the handle assembly 20, the shaft attachment lug 1306 is received in the shaft attachment socket 414 on

the distal end 412 of the third drive actuator member 410. Thus, actuation of the third axial drive 400 will result in the axial movement of the locking control rod 1302. In the illustrated arrangement, the axially movable locking control rod 1302 has a gear rack 1308 formed in its distal end that is configured for meshing engagement with the driven gear 1434. Axial movement of the locking control rod 1302 will result in rotation of the locking gear assembly 1430 in a first rotary direction about the gear axle 1428 and axial movement of the locking control rod 1302 in the proximal direction will result in rotation of the locking gear assembly 1430 in a second rotary direction.

**[0121]** In the illustrated example, the tertiary drive system 1300 is configured to operably interface with an end effector rotary locking system 1310. In at least one embodiment, the end effector rotary locking system 1310 comprises a rotation locking disc 1320 that includes a disc-like body 1322 that has a hollow mounting stem 1324 protruding therefrom. As can be seen in FIG. 30, the mounting stem 1324 extends through the shaft hole 1527 in the mounting hub 1525. The distal end of the mounting stem 1324 includes an annular groove 1326 that is configured to receive an inwardly extending fastener flange 1598 that is formed on the bearing housing 1592 of the anvil spring assembly 1590. The proximal-facing surface of the disc-like body 1322 of the rotation locking disc 1320 has a plurality of lock detents 1328 radially arranged thereon. The lock detents 1328 are arranged to be frictionally engaged by a lock member that, in at least one form comprises a lock lug 1332 that is formed on a lock gear 1330 that is journaled on the articulation shaft 1704. See FIGS. 43 and 44. As can be seen in those Figures, the lock gear 1330 is supported in meshing engagement with drive gear 1432 of the locking gear assembly 1430. Actuation of the tertiary actuation shaft 1302 by the tertiary drive system 1300 will result in rotation of the locking gear assembly 1430. Actuation of the locking gear assembly 1430 will result in the rotation of the lock gear 1330 about the articulation shaft 1704. When the lock lug 1332 on the lock gear 1330 is in engagement with a lock detent 1328, the rotation locking disc 1320, as well as the end effector 1500, is prevented from rotating about the shaft axis SA. For example, the lock lug 1332 frictionally engages the corresponding lock detent 1328 and serves to urge the rotation locking disc 1320 into further frictional engagement with the body portion 1532 of the channel mounting fixture 1530. Such frictional engagement between those two components serves to prevent the locking disc 1320 as well as the elongate channel 1520 from rotating about the shaft axis SA. FIG. 43 illustrates the lock lug 1332 in locking engagement with one of the



lock detents 1328 and FIG. 44 illustrates the lock lug 1332 in an unlocked orientation whereby the locking disc 1320 is free to rotate about the shaft axis SA.

**[0122]** In the illustrated embodiment of the interchangeable surgical tool assembly 1000, rotation of the end effector 1500 about the shaft axis SA is controlled by a remote rotation dial 1340 that is rotatably supported on the nozzle frame 1020. The remote rotation dial 1340 operably interfaces with a rheostat mounting assembly 1350 that is mounted within the nozzle frame 1020. As can be seen in FIG. 23, for example, the remote rotation dial 1340 includes a plurality of scallops 1341 around its perimeter and is accessible on both sides of the nozzle frame 1020. Such arrangement may enable the user to engage and rotate the remote rotation dial 1340 with a finger of the same hand that is gripping the handle assembly 20 or the remote rotation dial may be engaged with the user's other hand as well. Referring to FIGS. 18, 20 and 21, the rheostat mounting assembly 1350 includes a hollow mounting hub 1352 that has an annular groove 1354 for receiving a corresponding mounting bulkhead 1028 that is formed in the nozzle frame 1020. In at least one arrangement, the mounting hub 1352 includes an annular retention detent 1356 that is configured to retain the remote rotation dial 1340 on the hollow mounting hub 1352 while permitting the remote rotation dial 1340 to rotate relative thereto. The rheostat mounting assembly 1350 includes a radially extending flange portion 1358 that supports a collection of stationary contacts 1360 thereon. See FIG. 18. The flange portion 1358 is received within a rheostat cavity 1342 in the remote rotation dial 1340. A rotary contact assembly 1344 is mounted within the rheostat cavity 1342 and is configured to interface with the stationary contacts 1360 as the remote rotation dial 1340 is rotated on the rheostat mounting assembly 1350. The rheostat mounting assembly is wired to or is otherwise in communication with the tool circuit board 1060.

**[0123]** In at least one arrangement, rotation of the surgical end effector 1500 about the shaft axis SA is commenced by rotating the remote rotation dial 1340. In at least one arrangement, the control system or CPU 224 is configured to rotate the surgical end effector 1500 in the same rotary direction as the remote rotation dial 1340 is rotated. Initial rotation of the remote rotation dial 1340 will cause the control system or CPU 224 in the handle assembly 20 to activate the third axial drive system 400 in the handle assembly 20. In particular, the control system or CPU 224 actuates the solenoid 402 which results in the axial movement of the third actuator member 410. Axial movement of the third actuator member 410 results in the axial movement of the tertiary actuation shaft or locking control rod 1302

which is operably coupled thereto. Axial movement of the locking control rod 1302 results in the rotation of the locking gear assembly 1430. Rotation of the locking gear assembly 1430 will cause the lock gear 1330 to rotate to the unlocked position (FIG. 44). The control system or CPU 224 will then activate the first rotary drive system 300. The reader will appreciate that because the lock lug 1332 has rotated out of engagement with the corresponding lock detent 1328 on the rotation locking disc 1320 that the rotation locking disc 1320 is now capable of rotating about the shaft axis SA. However, friction between the rotation locking disc 1320 and the mounting hub 1525 on the channel mounting portion 1522 may temporarily prevent the surgical end effector 1500 from rotating.

**[0124]** Actuation of the first rotary drive system 300 will result in the application of rotary drive motion to the first drive socket 302 because the shifter solenoid 260 has not been actuated and shifter spring 166 has biased the shifter gear 250 into meshing engagement with the first driven gear 306 on the first drive socket 302. See FIGS. 6 and 7. Rotation of the first drive socket 302 will result in rotation of the primary transfer shaft 1104 which is in operable engagement with the first drive socket 302. Rotation of the primary transfer shaft 1104 will result in the rotation of the proximal drive gear 1110 that is attached to the primary transfer shaft 1104. Because the proximal drive gear 1110 is in meshing engagement with the power driven gear 1122 that is attached to the proximal drive shaft 1120, the proximal drive shaft 1120 is also rotated. See FIG. 19.

**[0125]** Referring now to FIG. 30, rotation of the proximal drive shaft 1120 will ultimately result in the rotation of the distal driven gear 1132 that is attached to the distal power shaft 1130. Rotation of the distal driven gear 1132 will result in rotation of the distal power shaft 1130. The friction between the distal power shaft 1130 and the rotation locking disc 1320, as well as the friction between the bearing housing 1592 and the distal power shaft 1130 and the rotation locking disc 1320, as well as the friction between the closure nut 1412 of the closure tube 1410 and the closure thread segment 1136 on the distal power shaft 1130 in total ("second amount of friction") is greater than the friction between the mounting hub portion 1525 of the elongate channel 1520 and the channel mounting fixture 1530, as well as the friction between the rotation locking disc 1320 and the channel mounting fixture 1530 in total ("first amount of friction") so as to permit the elongate channel 1520 and closure tube 1410 to rotate with the distal power shaft 1130 relative to the channel mounting fixture 1530 about the shaft axis SA. In one arrangement, for example, the rotary position of the remote rotation dial

1340 will, through the control system or CPU 224, determine the rotary position of the distal power shaft 1130 and ultimately the surgical end effector 1500. Once the user has positioned the surgical end effector 1500 in the desired rotary position about the shaft axis SA and has discontinued rotation of the remote rotation dial 1340, the control system or CPU 224 will discontinue power to the first rotary drive system 300 as well as to the third axial drive system 400. In at least one embodiment, the solenoid 402 is "spring loaded" such that upon deactivation, the spring component thereof will bias the third drive actuator member 410 distally which will result in the proximal movement of the locking control rod 1302. Such axial movement of the locking control rod 1302 will result in the rotation of the lock gear 1330 to thereby bring the lock lug 1332 into retaining engagement with the corresponding lock detent 1328 on the rotation locking disc 1320 and thereby lock the surgical end effector 1500 into that rotary orientation. Thus, should power be lost to the handle assembly 20 and, more particularly to the third drive system 400, the solenoid spring will cause the end effector rotary locking system 1310 to move to the locked orientation to thereby prevent rotation of the surgical end effector 1500 relative to the elongate shaft assembly 1400. As can be appreciated from the foregoing discussion, when the interchangeable surgical tool assembly 1000 is operably coupled to the handle assembly 20, the third axial drive system 400 is employed to unlock the end effector locking system 1310 and the first rotary drive system 300 is employed to rotate the surgical end effector 1500 relative to the elongate shaft assembly 1400. The reader will appreciate that such rotation of the surgical end effector 1500 is completely distal to the articulation joint 1702. Thus, the outer spine tube 1402, as well as the articulation joint 1702, remain stationary during the rotation process.

**[0126]** One general method of operating and controlling the surgical instrument 10 will now be described. FIG. 1 illustrates the surgical instrument 10 after the interchangeable surgical tool assembly 1000 has been operably attached to the handle assembly 20. As indicated above, coupling the tool attachment module portion 1010 of the interchangeable surgical tool assembly 1000 to the tool attachment portion 500 of the handle assembly 20 causes the tool circuit board 1060 to be coupled to or otherwise communicate with the handle circuit board 220 that comprises the control system or CPU 224. Once connected or in communication with the control system or CPU 224, the tool circuit board 1060 may provide specific software to the control system or CPU 224 that is unique to that particular interchangeable surgical tool assembly. The clinician may also position the grip portion 100 of the handle assembly 20

in the desired position relative to the primary housing portion 30 that may be best suited for the type of interchangeable surgical tool assembly being used.

**[0127]** As can be seen in FIG. 3, the illustrated handle assembly 20 includes right and left control button assemblies 270R, 270L that interface with the control system or CPU 224. In one exemplary arrangement, each control button assembly 270R, 270L includes a first button 272, a second button 274 and a third button 276 that each interface with the control system or CPU 224. It will be understood that in at least one embodiment, the control button 272 on the right control button assembly 270R may perform the same control function as the control button 272 on the left control button assembly 270L. Similarly, the control button 274 on the right control button assembly 270R may perform the same control function as the control button 274 on the left control button assembly 270L. Likewise, the control button 276 on the right control button assembly 270R may perform the same control function as the control button 276 on the left control button assembly 270L. Such arrangements enable the clinician to control the surgical instrument from both sides of the handle assembly 20. In at least one arrangement, the control buttons 272, 274, 276 comprise “Hall Effect” sensors or linear sensors so actuation of the buttons can indicate the intensity of the user’s request as well as the speed desired, for example.

**[0128]** In one arrangement, the first and second control buttons 272, 274 may be used to control operation of the articulation system 1700. For example, the control button 272 may be used to initiate articulation of the surgical end effector 1500 about the articulation axis AA to the right (arrow “R” in FIG. 1). Upon actuation of the first control button 272, the control system or CPU 224 activates the shifter solenoid 260 of the rotary drive selector system 240 to move the shifter gear 250 into meshing engagement with the second driven gear 326 on the second drive socket 322. Thereafter, the control system 224 or CPU actuates the motor 200 to apply rotary motion to the second rotary drive system 320 in the rotary direction necessary to cause the articulation system 1700 to articulate the surgical end effector to the right (arrow R). In one arrangement, the amount of depression or actuation force applied to the control button, may dictate the speed at which the motor rotates. In addition, or in the alternative, the clinician may also depress the rocker switch 206 to affect the motor rotation speed. Once the surgical end effector 1500 has been articulated to the desired position, the user discontinues actuation of the first control button 270 (and the rocker switch 206). Once the control button 270 has been deactivated, the control system or CPU 224 deactivates the

shifter solenoid 260. The spring component of the shifter solenoid 260 moves the shifter gear 250 into meshing engagement with the first driven gear 306 on the first drive socket 302. Thus, further actuation of the motor 200 will result in actuation of the first rotary drive 300. Actuation of the second control button 274 will operate in the same manner, but will result in rotation of the motor 200 so as to cause the articulation system 1700 to articulate the surgical end effector 1500 to the left (arrow L in FIG. 1).

**[0129]** As was discussed above, the surgical end effector 1500 may also be rotated about the shaft axis relative to the articulation joint 1702. To commence rotation of the surgical end effector 1500, the clinician rotates the remote rotational dial 1340 in the rotary direction in which he or she intends the surgical end effector 1500 to rotate. Rotation of the remote rotation dial 1340 causes the control system or CPU 224 to actuate the third axial drive system 400. In particular, the solenoid 402 is actuated to axially move the third drive actuator member 410 and the locking control rod 1302 in the proximal direction. As the locking control rod 1302 moves proximally, the gear rack 1308 causes the locking gear assembly 1430 to rotate the lock gear 1330 so as to disengage the lock lug 1332 from the corresponding lock detent 1328 in the rotation locking disc 1320. See FIGS. 41 and 42. The control system or CPU retains the solenoid 402 in that actuated orientation and then activates the motor 200 to apply rotary motion to the first rotary drive system 300 in the direction necessary to rotate the surgical end effector 1500 in the desired rotary direction. Actuation of the first rotary drive system 300 will result in rotation of the distal drive shaft 1130 which will result in rotation of the surgical end effector 1500 about the shaft axis SA. Once the surgical end effector 1500 has been rotated to the desired position, rotation of the remote rotation dial 1340 by the clinician is discontinued. Thereafter, the control system or CPU 224 will deactivate the motor 200 as well as the solenoid 402. The spring component of the solenoid 402 will then bias the third drive actuator member 410 and the locking control rod 1302 in the distal position to thereby cause the lock gear 1330 to rotate in an opposite direction so as to cause the lock lug 1332 to engage the corresponding lock detent 1328 in the rotation locking disc 1320. The surgical end effector 1500 is locked in that rotary position.

**[0130]** In at least one arrangement, the third buttons 276 may comprise a “home state” button that communicates with the control system or CPU 224 to return the surgical end effector 1500 to a home state wherein the surgical end effector is unarticulated and also rotated back to an initial rotary orientation. For example, when the third button 276 is

actuated, the CPU may unlock the end effector rotary locking system 1310 by actuating the solenoid 402 to cause the lock lug 1332 to disengage from the rotation locking disc 1320 and then actuate the first rotary drive system 300 to cause the surgical end effector to rotate back to a starting rotary position. Thereafter, the solenoid 402 is de-actuated to cause the lock lug 1332 to re-engage the rotation locking disc to lock the surgical end effector 1500 in that rotary orientation. The control system or CPU 224 may then actuate the shifter solenoid 260 to bring the shifter gear 250 into meshing engagement with the second driven gear 326 on the second drive socket 322. After the second rotary drive system 320 is ready for actuation, the control system or CPU 224 may then actuate the motor 200 to return the surgical end effector 1500 to the unarticulated position.

**[0131]** Once the surgical end effector 1500 has been rotated and/or articulated into a desired configuration, discontinuing actuation of the articulation system 1700 as well discontinuing rotation of the remote rotation dial 1340 will result in the motor 200 being operably engaged with the first rotary drive system 300 in the manner discussed herein. The clinician may then manipulate the surgical end effector 1500 so as to position the target tissue between the anvil assembly 1560 and the surgical staple cartridge 1550. The clinician may commence the closing and firing processes by actuating the rocker switch 206. Actuation of the rocker switch 206 will cause the control system or CPU 224 to actuate the motor 200 to cause the motor to apply a rotary control motion in a first rotary direction to the first rotary drive system 300. Rotation of the first rotary drive system 300 will cause the distal power shaft 1130 to rotate and commence the closing process in the manner described above. Once the anvil assembly 1560 is fully closed, the control system or CPU 224 may stop the motor 200 and provide the clinician with an indication (sound, vibration, notice on a display screen, etc.) that the anvil is fully closed. This may happen regardless of whether the rocker switch 206 remains actuated or not. Then, when the clinician desires for the firing member to cut the target tissue which was stapled during the closing process, the clinician may then re-actuate the rocker switch 206 to start the motor and cause the firing member to be distally driven through the end effector in the above-described manner. The rocker switch 206 may be configured such that the speed in which the motor rotates is proportional to the distance that the rocker switch is depressed or otherwise actuated. In other arrangements, the control system or CPU 224 may not stop the motor between the closure and firing sequences. Various forms of sensors and/or encoders may be employed to monitor the

position of the firing member during the firing process. Once the firing member has reached the ending position, the rotary direction of the motor is reversed by the control system or CPU 224 until the firing member is returned to the starting position wherein the anvil assembly 1560 is biased to the open position in the above described manner.

**[0132]** FIGS. 40A and 40B illustrate one example arrangement for supplying electrical signals from the circuit board 1060 in the tool attachment module portion 1010 to the end effector attached thereto while enabling the end effector to be selectively articulated and rotated in the various manners described herein. As can be seen in those Figures, conductors (wires) 1401A, 1401B extend along the exterior of the outer spine tube 1402 of the elongate shaft assembly. The conductors 1401A, 1401B extend from the tool attachment module 1010 along the spine tube 1402 and enter a hole 1531 in the channel mounting fixture 1530. To accommodate articulation of the end effector about the articulation joint 1702, a loop 1403 may be provided in the conductors 1401A, 1401B to provide a sufficient amount of slack therein. Conductor 1401A extends into the channel mounting fixture 1530 and has a proximally-facing contact 1405A attached thereto. Similarly, conductor 1401B extends into the channel mounting fixture 1530 and has a proximally-facing contact 1405B attached thereto. These contacts 1405A, 1405B correspond to conductive tracks 1325A, 1325B, respectively that are mounted on the distal surface 1323 of the disc-like body 1322 of the rotation locking disc 1320. When assembled together, contact 1405A is in rotational electrical contact with track 1325A and contact 1405B is in rotational electrical contact with track 1325B. Such arrangement permits relative rotation of the channel mounting fixture 1530 and the rotation locking disc 1320 while facilitating electrical contact between the conductors 1401A, 1401B and the tracks 1325A, 1325B. End effector wires 1327A, 1327B are attached to the tracks 1325A, 1325B, respectively and extend through the hollow mounting stem 1324 of the rotation locking disc 1320. The end effector wires 1327A, 1327B may then be attached to sensors, lights, etc. in the end effector. Such arrangement serves to supply electrical power to the end effector from the tool attachment module 1010 while facilitating articulation and rotation of the end effector.

**[0133]** Many of the surgical instrument systems described herein are motivated by an electric motor; however, the surgical instrument systems described herein can be motivated in any suitable manner. In various instances, the surgical instrument systems described herein can be motivated by a manually-operated trigger, for example. In certain instances,

the motors disclosed herein may comprise a portion or portions of a robotically controlled system. Moreover, any of the end effectors and/or tool assemblies disclosed herein can be utilized with a robotic surgical instrument system. U.S. Patent Application Serial No. 13/118,241, entitled SURGICAL STAPLING INSTRUMENTS WITH ROTATABLE STAPLE DEPLOYMENT ARRANGEMENTS, now U.S. Patent Application Publication No. 2012/0298719, for example, discloses several examples of a robotic surgical instrument system in greater detail.

**[0134]** The surgical instrument systems described herein have been described in connection with the deployment and deformation of staples; however, the embodiments described herein are not so limited. Various embodiments are envisioned which deploy fasteners other than staples, such as clamps or tacks, for example. Moreover, various embodiments are envisioned which utilize any suitable means for sealing tissue. For instance, an end effector in accordance with various embodiments can comprise electrodes configured to heat and seal the tissue. Also, for instance, an end effector in accordance with certain embodiments can apply vibrational energy to seal the tissue.

**[0135]** The entire disclosures of:

- U.S. Patent No. 5,403,312, entitled ELECTROSURGICAL HEMOSTATIC DEVICE, which issued on April 4, 1995;
- U.S. Patent No. 7,000,818, entitled SURGICAL STAPLING INSTRUMENT HAVING SEPARATE DISTINCT CLOSING AND FIRING SYSTEMS, which issued on February 21, 2006;
- U.S. Patent No. 7,422,139, entitled MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH TACTILE POSITION FEEDBACK, which issued on September 9, 2008;
- U.S. Patent No. 7,464,849, entitled ELECTRO-MECHANICAL SURGICAL INSTRUMENT WITH CLOSURE SYSTEM AND ANVIL ALIGNMENT COMPONENTS, which issued on December 16, 2008;
- U.S. Patent No. 7,670,334, entitled SURGICAL INSTRUMENT HAVING AN ARTICULATING END EFFECTOR, which issued on March 2, 2010;
- U.S. Patent No. 7,753,245, entitled SURGICAL STAPLING INSTRUMENTS, which issued on July 13, 2010;



- U.S. Patent No. 8,393,514, entitled SELECTIVELY ORIENTABLE IMPLANTABLE FASTENER CARTRIDGE, which issued on March 12, 2013;
- U.S. Patent Application Serial No. 11/343,803, entitled SURGICAL INSTRUMENT HAVING RECORDING CAPABILITIES; now U.S. Patent No. 7,845,537;
- U.S. Patent Application Serial No. 12/031,573, entitled SURGICAL CUTTING AND FASTENING INSTRUMENT HAVING RF ELECTRODES, filed February 14, 2008;
- U.S. Patent Application Serial No. 12/031,873, entitled END EFFECTORS FOR A SURGICAL CUTTING AND STAPLING INSTRUMENT, filed February 15, 2008, now U.S. Patent No. 7,980,443;
- U.S. Patent Application Serial No. 12/235,782, entitled MOTOR-DRIVEN SURGICAL CUTTING INSTRUMENT, now U.S. Patent No. 8,210,411;
- U.S. Patent Application Serial No. 12/249,117, entitled POWERED SURGICAL CUTTING AND STAPLING APPARATUS WITH MANUALLY RETRACTABLE FIRING SYSTEM, now U.S. Patent No. 8,608,045;
- U.S. Patent Application Serial No. 12/647,100, entitled MOTOR-DRIVEN SURGICAL CUTTING INSTRUMENT WITH ELECTRIC ACTUATOR DIRECTIONAL CONTROL ASSEMBLY, filed December 24, 2009; now U.S. Patent No. 8,220,688;
- U.S. Patent Application Serial No. 12/893,461, entitled STAPLE CARTRIDGE, filed September 29, 2012, now U.S. Patent No. 8,733,613;
- U.S. Patent Application Serial No. 13/036,647, entitled SURGICAL STAPLING INSTRUMENT, filed February 28, 2011, now U.S. Patent No. 8,561,870;
- U.S. Patent Application Serial No. 13/118,241, entitled SURGICAL STAPLING INSTRUMENTS WITH ROTABLE STAPLE DEPLOYMENT ARRANGEMENTS, now U.S. Patent No. 9,072,535;
- U.S. Patent Application Serial No. 13/524,049, entitled ARTICULATABLE SURGICAL INSTRUMENT COMPRISING A FIRING DRIVE, filed on June 15, 2012; now U.S. Patent No. 9,101,358;
- U.S. Patent Application Serial No. 13/800,025, entitled STAPLE CARTRIDGE TISSUE THICKNESS SENSOR SYSTEM, filed on March 13, 2013, now U.S. Patent Application Publication No. 2014/0263551;

- U.S. Patent Application Serial No. 13/800,067, entitled STAPLE CARTRIDGE TISSUE THICKNESS SENSOR SYSTEM, filed on March 13, 2013, now U.S. Patent Application Publication No. 2014/0263552;
- U.S. Patent Application Publication No. 2007/0175955, entitled SURGICAL CUTTING AND FASTENING INSTRUMENT WITH CLOSURE TRIGGER LOCKING MECHANISM, filed January 31, 2006; and
- U.S. Patent Application Publication No. 2010/0264194, entitled SURGICAL STAPLING INSTRUMENT WITH AN ARTICULATABLE END EFFECTOR, filed April 22, 2010, now U.S. Patent No. 8,308,040, are hereby incorporated by reference herein.

**[0136]** Although various devices have been described herein in connection with certain embodiments, modifications and variations to those embodiments may be implemented. Also, where materials are disclosed for certain components, other materials may be used. Furthermore, according to various embodiments, a single component may be replaced by multiple components, and multiple components may be replaced by a single component, to perform a given function or functions. The foregoing description and following claims are intended to cover all such modification and variations.

**[0137]** 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, a device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps including, but not limited to, the disassembly of the device, followed by cleaning or replacement of particular pieces of the device, and subsequent reassembly of the device. In particular, a reconditioning facility and/or surgical team can disassemble a device and, after cleaning and/or replacing particular parts of the device, the device can be reassembled for subsequent use. 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.

**[0138]** The devices disclosed herein may be processed before surgery. First, a new or used instrument may be obtained and, when necessary, cleaned. The instrument may then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and instrument may then be placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays,

and/or high-energy electrons. The radiation may kill bacteria on the instrument and in the container. The sterilized instrument may then be stored in the sterile container. The sealed container may keep the instrument sterile until it is opened in a medical facility. A device may also be sterilized using any other technique known in the art, including but not limited to beta radiation, gamma radiation, ethylene oxide, plasma peroxide, and/or steam.

**[0139]** While this invention has been described as having exemplary designs, the present invention may be further modified within the spirit and scope of the disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles.

**[0140]** 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 do 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.

**WHAT IS CLAIMED IS:**

1. A surgical instrument, comprising:
  - an elongate shaft assembly defining a shaft axis;
  - a surgical end effector operably interfacing with said elongate shaft assembly for selective rotation relative to said elongate shaft assembly about said shaft axis, said surgical end effector comprising a firing member configured for selective axial movement therein in response to an application of at least one rotary control motion thereto;
  - an end effector rotary locking system interfacing with said surgical end effector and being configured to lock said surgical end effector in rotary orientations about said shaft axis upon application of an axial locking motion to said end effector rotary locking system and to unlock said surgical end effector for selective rotation about said shaft axis upon application of an axial unlocking motion to said end effector rotary locking system; and
  - a rotary drive system configured to apply said at least one rotary control motion to said firing member, said rotary drive system configured to apply at least one rotary positioning motion to said surgical end effector when said end effector rotary locking system is in an unlocked configuration to position said surgical end effector in a selected one of said rotary orientations about said shaft axis.
  
2. The surgical instrument of Claim 1, wherein said elongate shaft assembly further comprises an articulation joint operably coupling said surgical end effector to said elongate shaft assembly to facilitate selective articulation of said surgical end effector about an articulation axis that is transverse to said shaft axis upon application of articulation motions thereto.
  
3. The surgical instrument of Claim 1, wherein said surgical end effector is operably coupled to said elongate shaft assembly by a mounting fixture configured to permit said surgical end effector to selectively rotate about said shaft axis upon application of said at least one rotary positioning motion thereto and wherein said end effector rotary locking system comprises a rotation locking disc coupled to said surgical end effector for rotational travel therewith upon said application of said at least one rotary positioning motion to said surgical end effector, said rotation locking disc further configured to frictionally engage said

mounting fixture to prevent rotation of said surgical end effector about said shaft axis upon application of said axial locking motion to said end effector rotary locking system.

4. The surgical instrument of Claim 3, wherein said rotation locking disc comprises a plurality of locking detents radially arranged thereon wherein each of said locking detent corresponds to one of said rotary orientations and wherein said end effector rotary locking system further comprises a lock member supported for selective movement into locking engagement with a corresponding one of said locking detents upon said application of said axial locking motion thereto.
5. The surgical instrument of Claim 4, wherein said end effector rotary locking system further comprises an axially movable locking control rod configured to apply said axial locking motion to said lock member.
6. The surgical instrument of Claim 5, wherein said lock member comprises:
  - a locking gear assembly rotatably supported in meshing engagement with a gear rack on said locking control rod;
  - a lock gear supported in meshing engagement with said locking gear assembly; and
  - a lock lug formed on said lock gear for selective locking engagement with said corresponding one of said locking detents.
7. The surgical instrument of Claim 6, wherein when said lock lug is in locking engagement with said corresponding one of said locking detents, said rotation locking disc frictionally engages said mounting fixture to prevent rotation of said surgical end effector about said shaft axis.
8. The surgical instrument of Claim 2, wherein said articulation joint comprises:
  - an articulation shaft coupled to said elongate shaft assembly, said articulation shaft defining said articulation axis; and
  - a mounting fixture pivotally journaled on said articulation shaft for selective articulation about said articulation axis, said mounting fixture operably interfacing with said surgical end

effector to permit said surgical end effector to selectively rotate about said shaft axis upon application of said at least one rotary positioning motion thereto.

9. The surgical instrument of Claim 8, wherein said end effector rotary locking system comprises a rotation locking disc coupled to said surgical end effector for rotational travel therewith upon said application of said at least one rotary positioning motion to said surgical end effector, said rotation locking disc further configured to frictionally engage said mounting fixture to prevent rotation of said surgical end effector about said shaft axis upon application of said axial locking motion to said end effector rotary locking system.

10. The surgical instrument of Claim 9, wherein said elongate shaft assembly further comprising an articulation drive shaft configured to apply articulation motions to said mounting fixture upon application of rotary articulation drive motions to said articulation drive shaft.

11. The surgical instrument of Claim 10, wherein said rotary drive system comprises:  
a distal power shaft operably supported by said surgical end effector and configured to apply said rotary control motions to said firing member and said rotary positioning motions to said surgical end effector when said end effector rotary locking system is in said unlocked configuration; and  
a proximal rotary drive shaft in operable engagement with said distal power shaft.

12. A surgical instrument, comprising:  
an elongate shaft assembly defining a shaft axis;  
a surgical end effector operably interfacing with said elongate shaft assembly for selective rotation relative to said elongate shaft assembly about said shaft axis, said surgical end effector comprising a firing member configured for selective axial movement therein in response to an application of at least one rotary control motion thereto;  
means for selectively locking said surgical end effector in any one of a plurality of predetermined rotary orientations about said shaft axis upon application of an axial locking motion thereto; and

means for applying said at least one rotary control motion to said firing member and at least one rotary positioning motion to said surgical end effector when said means for selectively locking is in an unlocked configuration to position said surgical end effector in a selected one of said predetermined rotary orientations about said shaft axis.

13. The surgical instrument of Claim 12 further comprising means for selectively articulating said surgical end effector about an articulation axis that is transverse to said shaft axis.

14. A surgical cutting and fastening instrument, comprising:

an elongate shaft assembly defining a shaft axis;

a surgical end effector comprising:

an elongate channel configured to operably support a surgical staple cartridge therein;

an anvil supported relative to said elongate channel for selective movement between open and closed positions relative to said elongate channel; and

a cutting member configured for selective axial movement through said elongate channel and said anvil when said anvil is in said closed position in response to an application of at least one rotary control motion thereto and wherein said surgical cutting and fastening instrument further comprises:

an end effector rotary locking system interfacing with said elongate channel and said elongate shaft assembly and being configured to lock said elongate channel in rotary orientations about said shaft axis upon application of an axial locking motion to said end effector rotary locking system and to unlock said elongate channel for selective rotation about said shaft axis upon application of an axial unlocking motion to said end effector rotary locking system; and

a rotary drive system configured to apply said at least one rotary control motion to said cutting member, said rotary drive system configured to apply at least one rotary positioning motion to said elongate channel when said end effector rotary locking system is in an unlocked configuration to position said surgical end effector in a selected one of said rotary orientations about said shaft axis.

15. The surgical cutting and fastening instrument of Claim 14, wherein said elongate channel is operably coupled to said elongate shaft assembly by a mounting fixture configured to permit said elongate channel to selectively rotate about said shaft axis upon application of said at least one rotary positioning motion thereto and wherein said end effector rotary locking system comprises a rotation locking disc coupled to said elongate channel for rotational travel therewith upon said application of said at least one rotary positioning motion to said elongate channel, said rotation locking disc further configured to frictionally engage said mounting fixture to prevent rotation of said surgical end effector about said shaft axis upon application of said axial locking motion to said end effector rotary locking system.

16. The surgical cutting and fastening instrument of Claim 15, wherein said rotary drive system comprises:

a distal power shaft operably supported by said surgical end effector and configured to apply said rotary control motions to said cutting member and said rotary positioning motions to said elongate channel when said end effector rotary locking system is in said unlocked configuration; and

a proximal rotary drive shaft in operable engagement with said distal power shaft.

17. The surgical cutting and fastening instrument of Claim 16, wherein said rotary drive system further comprises an anvil drive shaft rotatably supported in said anvil and in operable engagement with said distal power shaft, said proximal rotary drive shaft in operable engagement with said cutting member for axially driving said cutting member through said elongate channel and said anvil.

18. The surgical cutting and fastening instrument of Claim 15, further comprising an articulation joint operably coupled to said elongate shaft assembly and said mounting fixture to facilitate selective articulation of said surgical end effector about an articulation axis that is transverse to said shaft axis and rotation of said surgical end effector about said shaft axis distal to said articulation joint.

19. The surgical cutting and fastening instrument of Claim 16 further comprising:



an articulation joint operably coupled to said elongate shaft assembly and said mounting fixture to facilitate selective articulation of said surgical end effector about an articulation axis that is transverse to said shaft axis and rotation of said surgical end effector about said shaft axis distal to said articulation joint; and

an articulation drive shaft configured to apply articulation motions to said mounting fixture upon application of rotary articulation drive motions to said articulation drive shaft.

20. The surgical cutting and fastening instrument of Claim 19, wherein said proximal rotary drive shaft is coaxially aligned on said shaft axis and wherein said articulation drive shaft comprises an articulation drive shaft axis that is offset from said shaft axis.

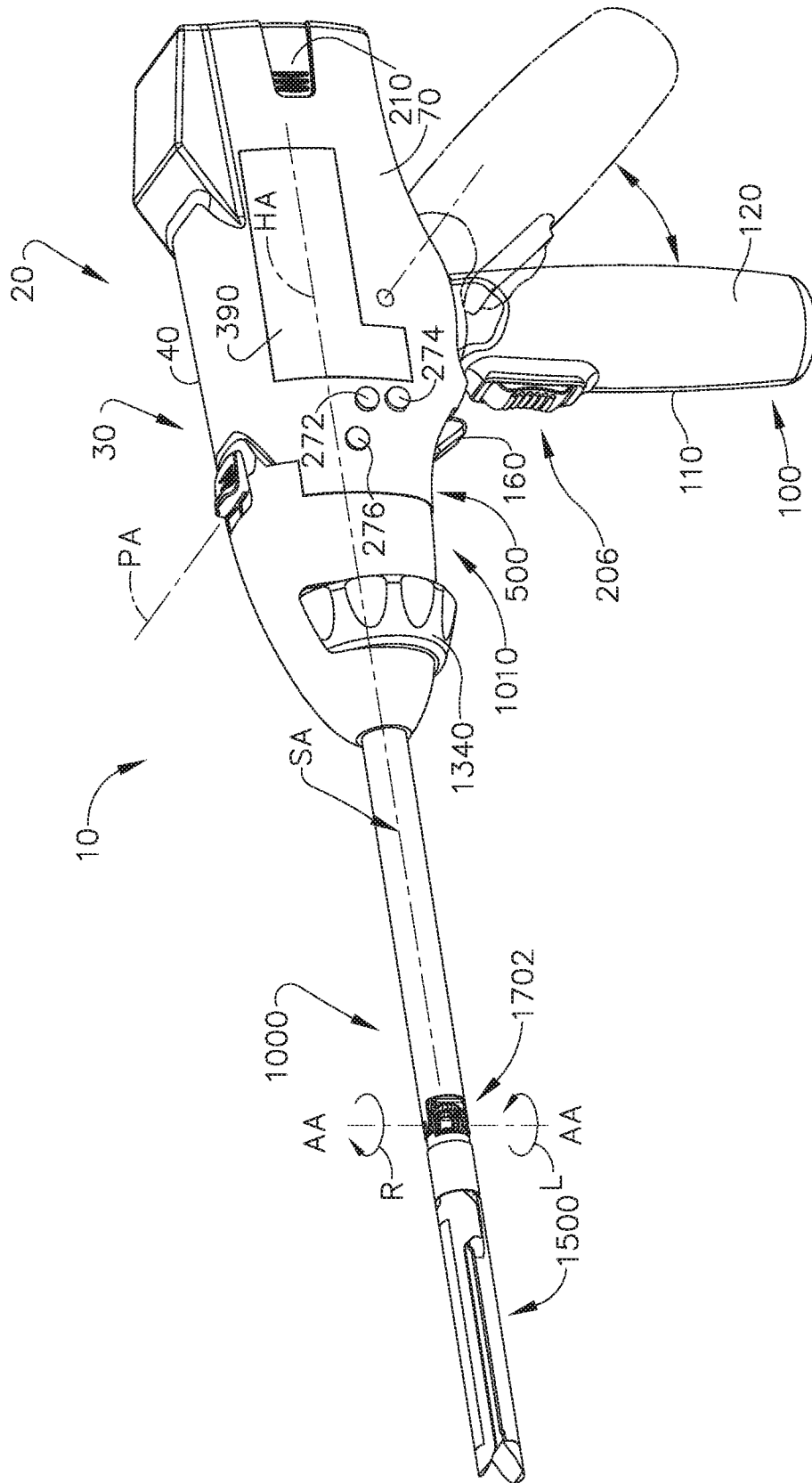


FIG. 1

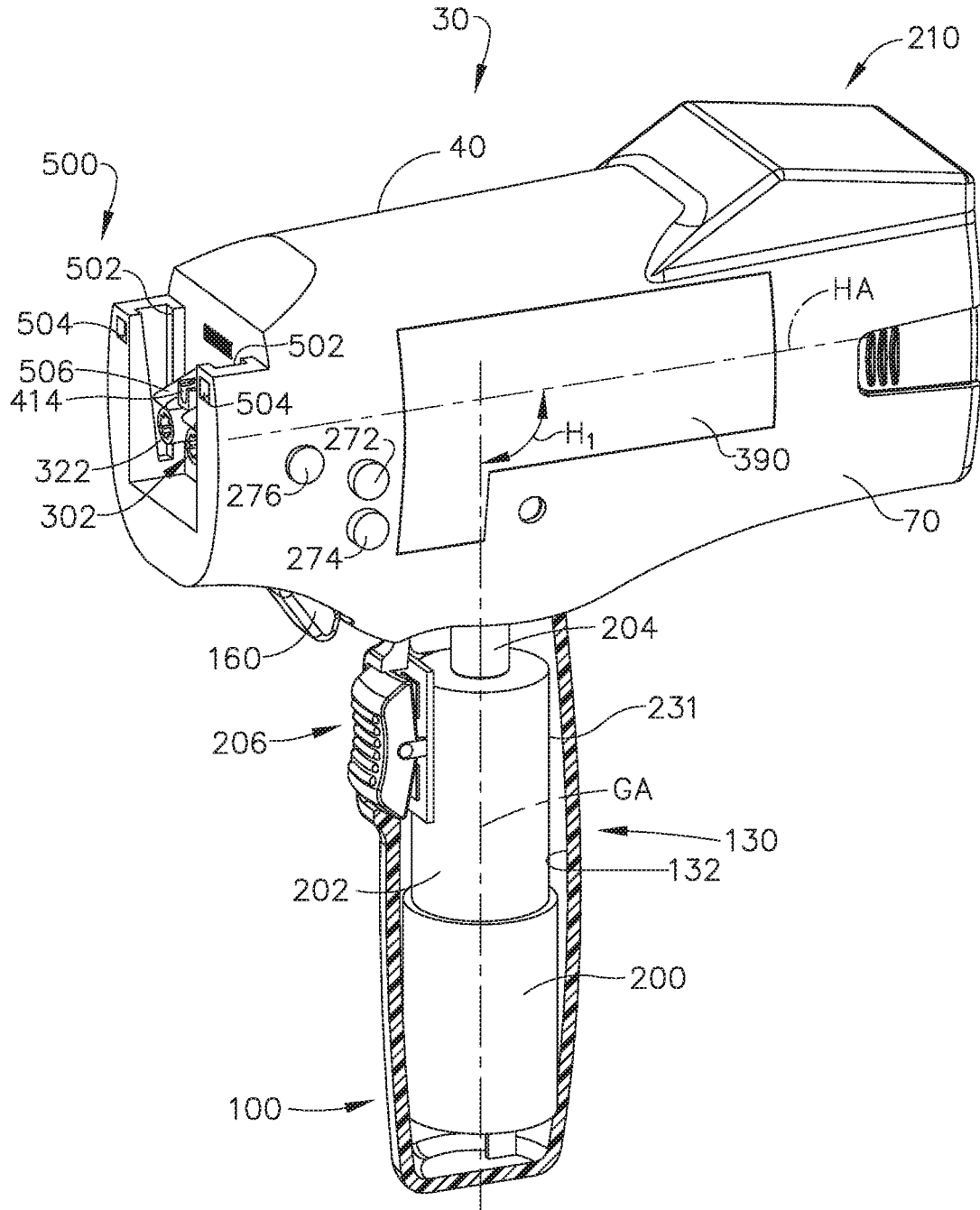


FIG. 2

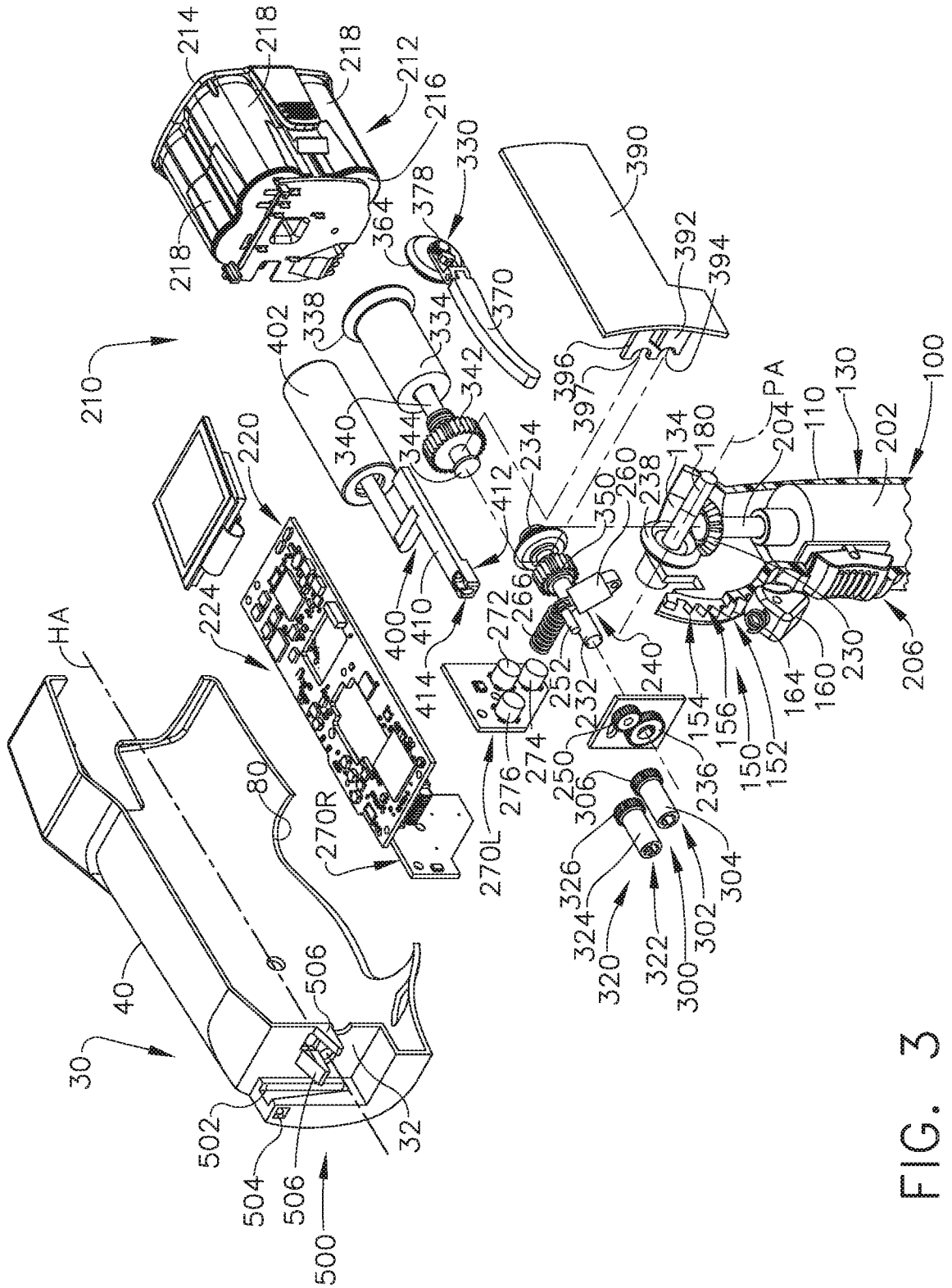


FIG. 3

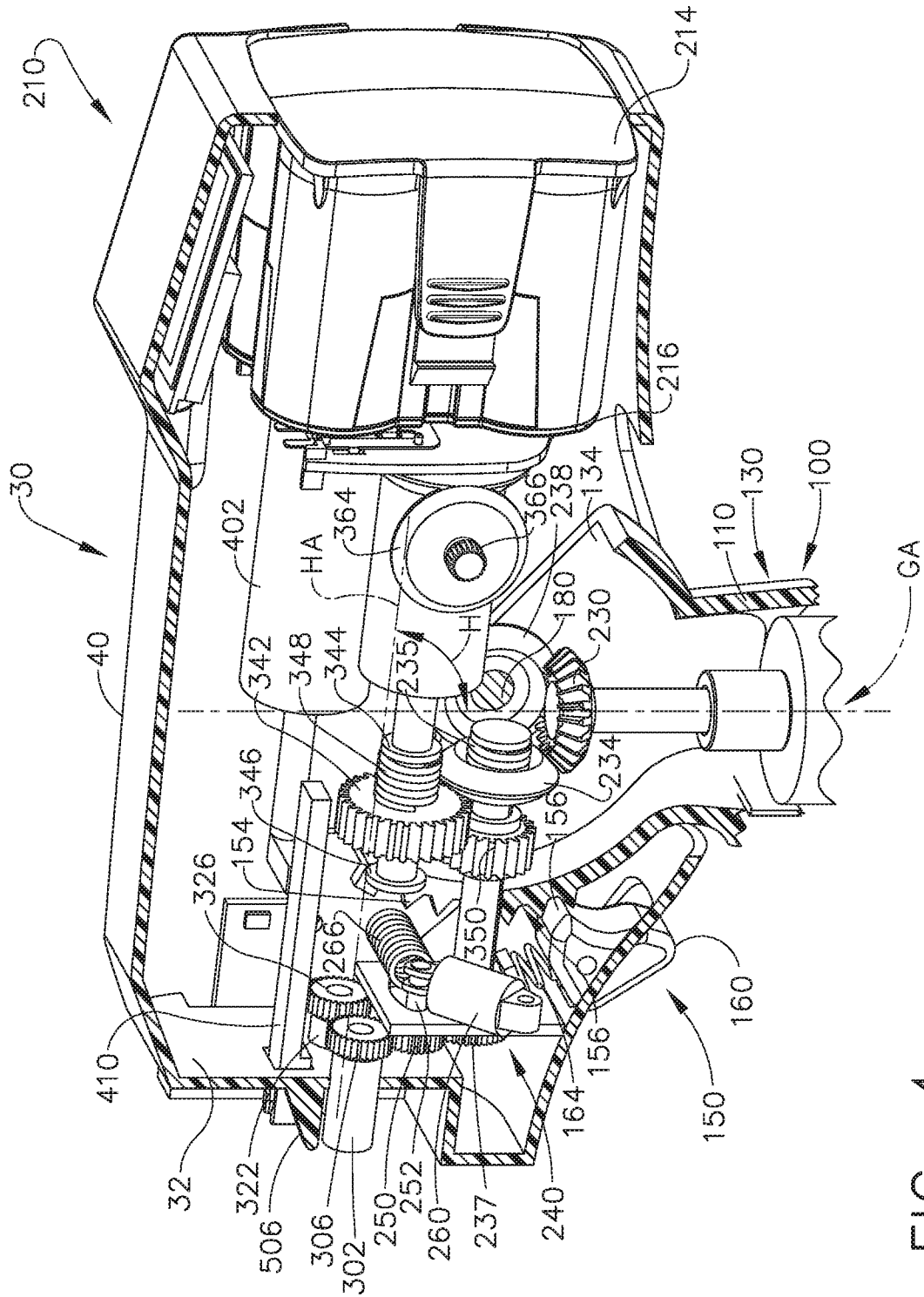


FIG. 4

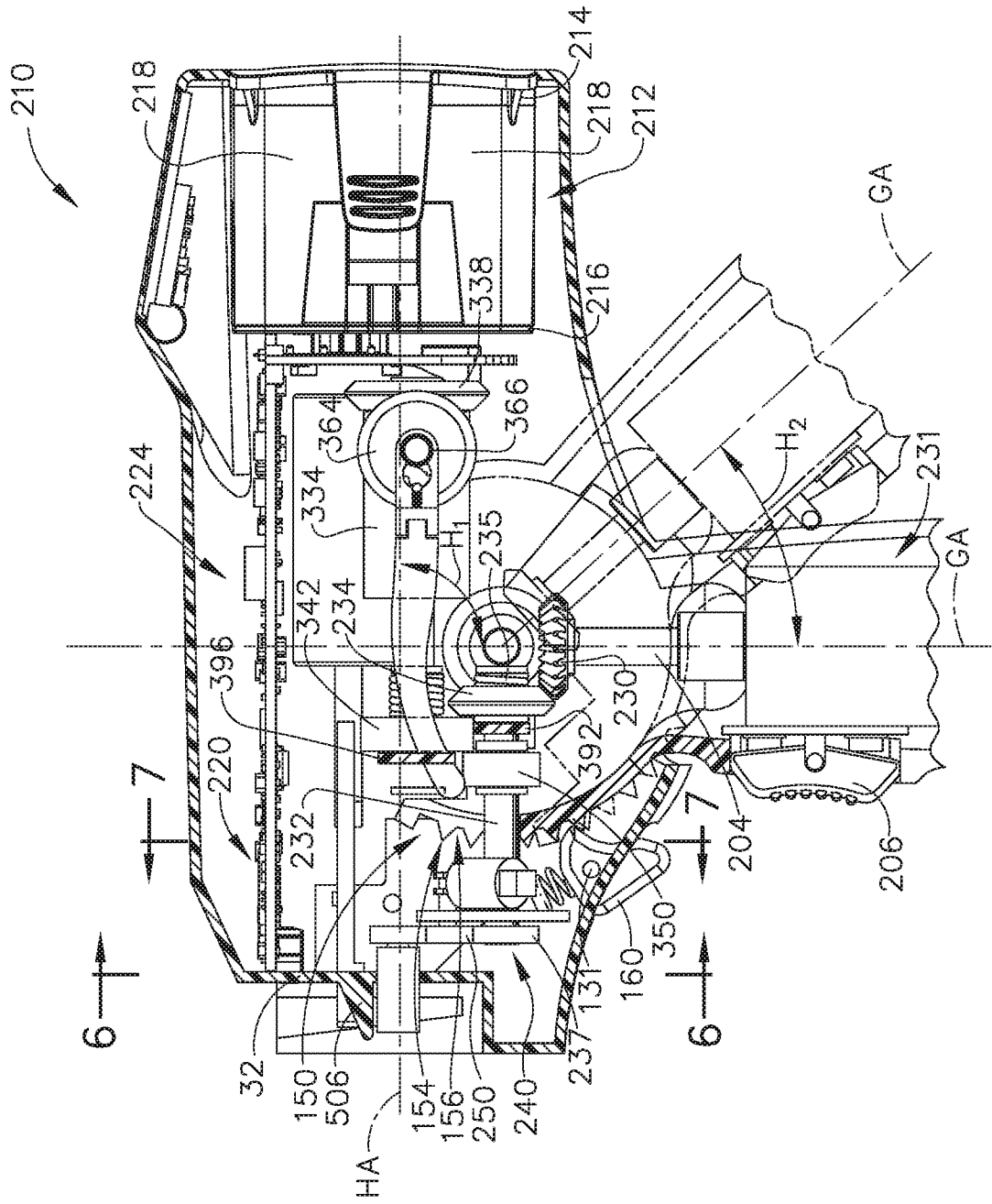


FIG. 5

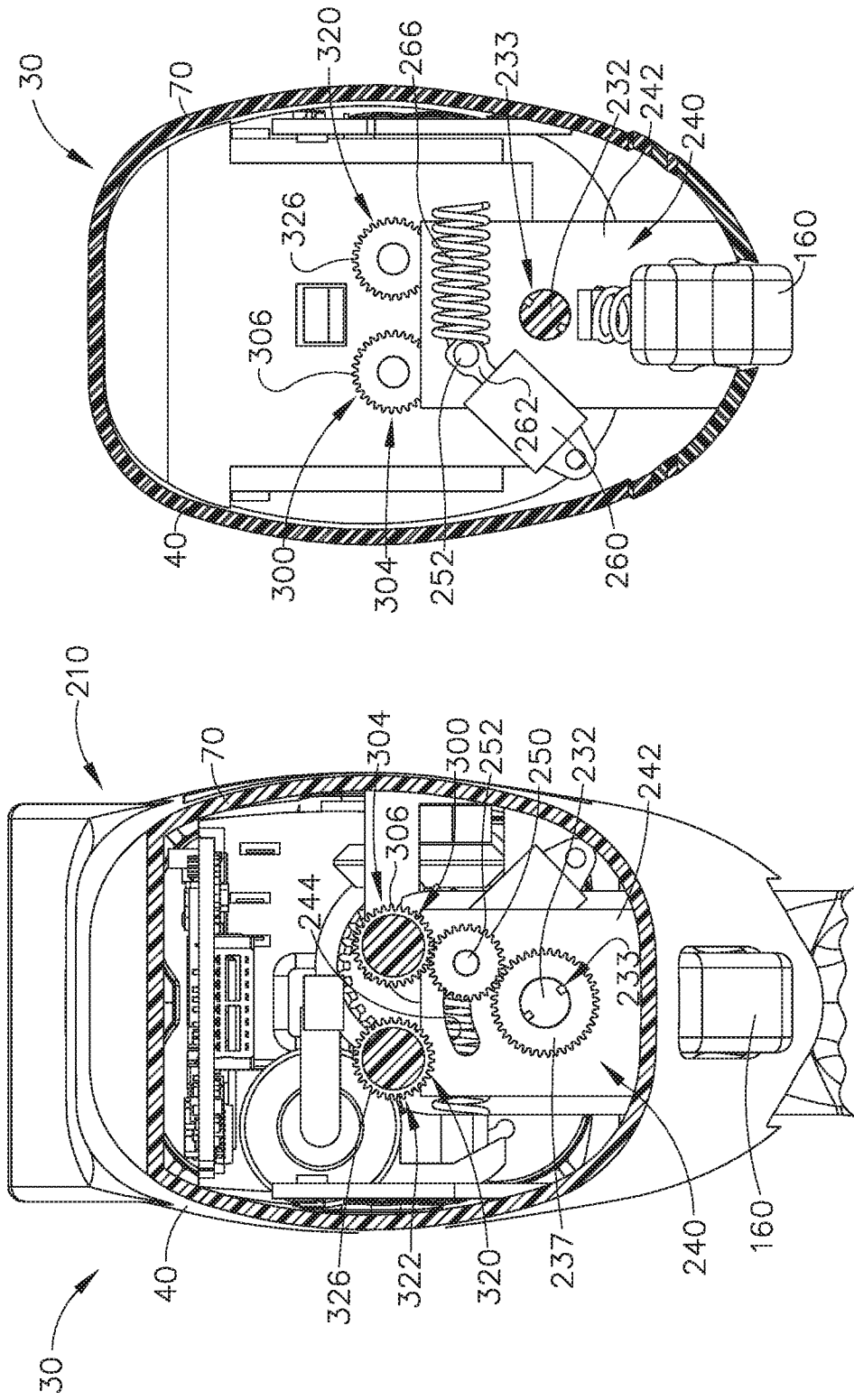


FIG. 7

FIG. 6

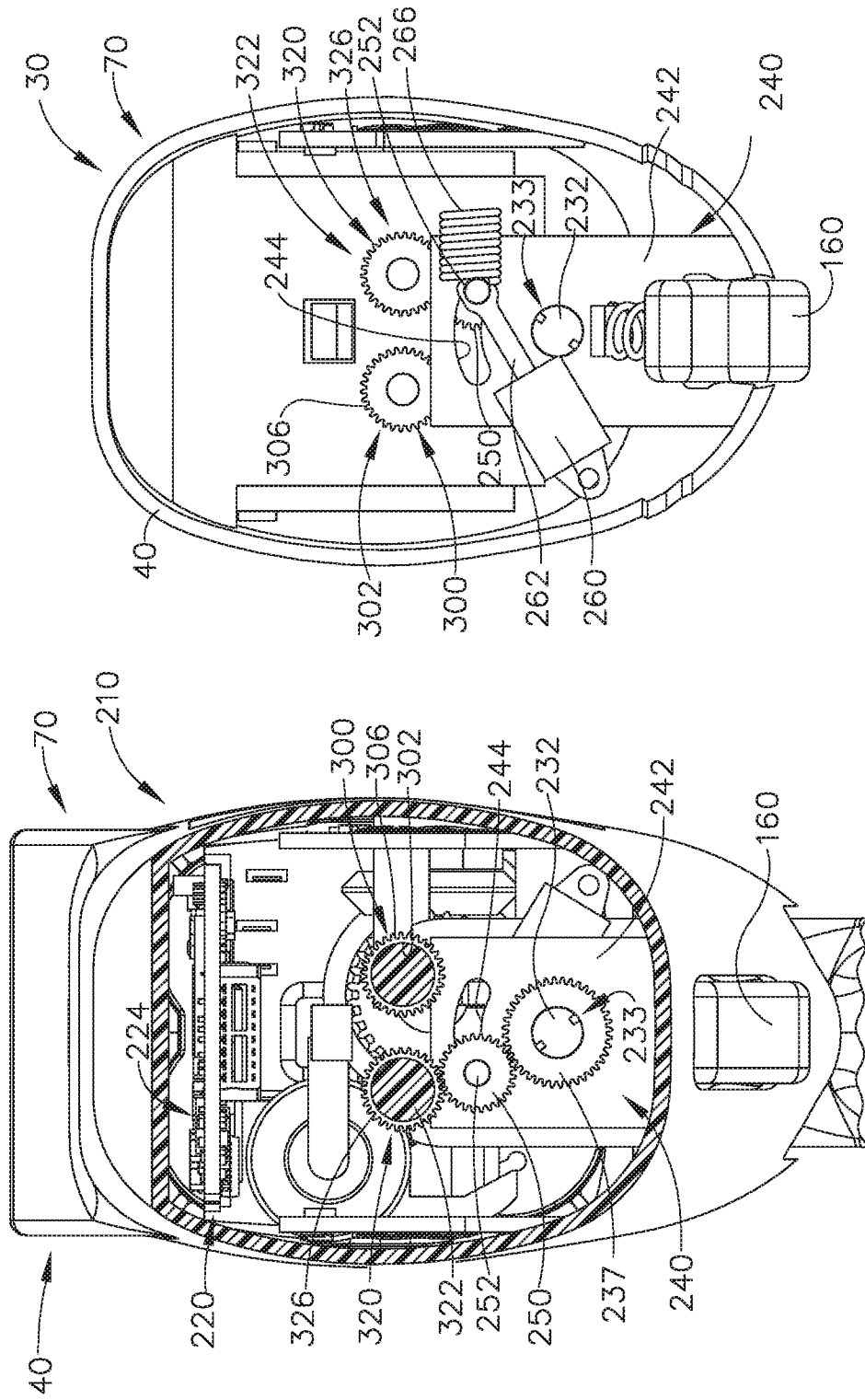


FIG. 9

FIG. 8



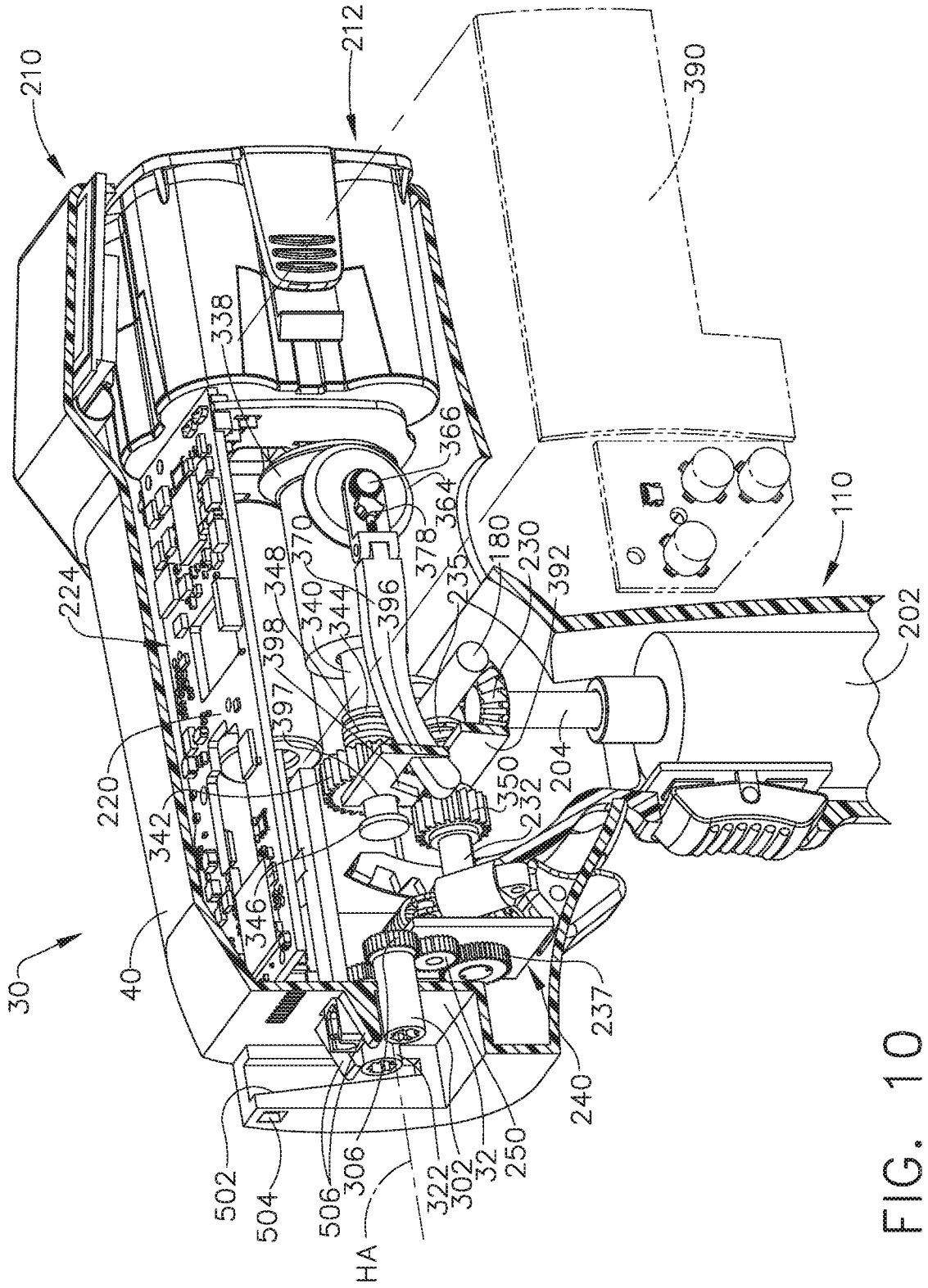


FIG. 10

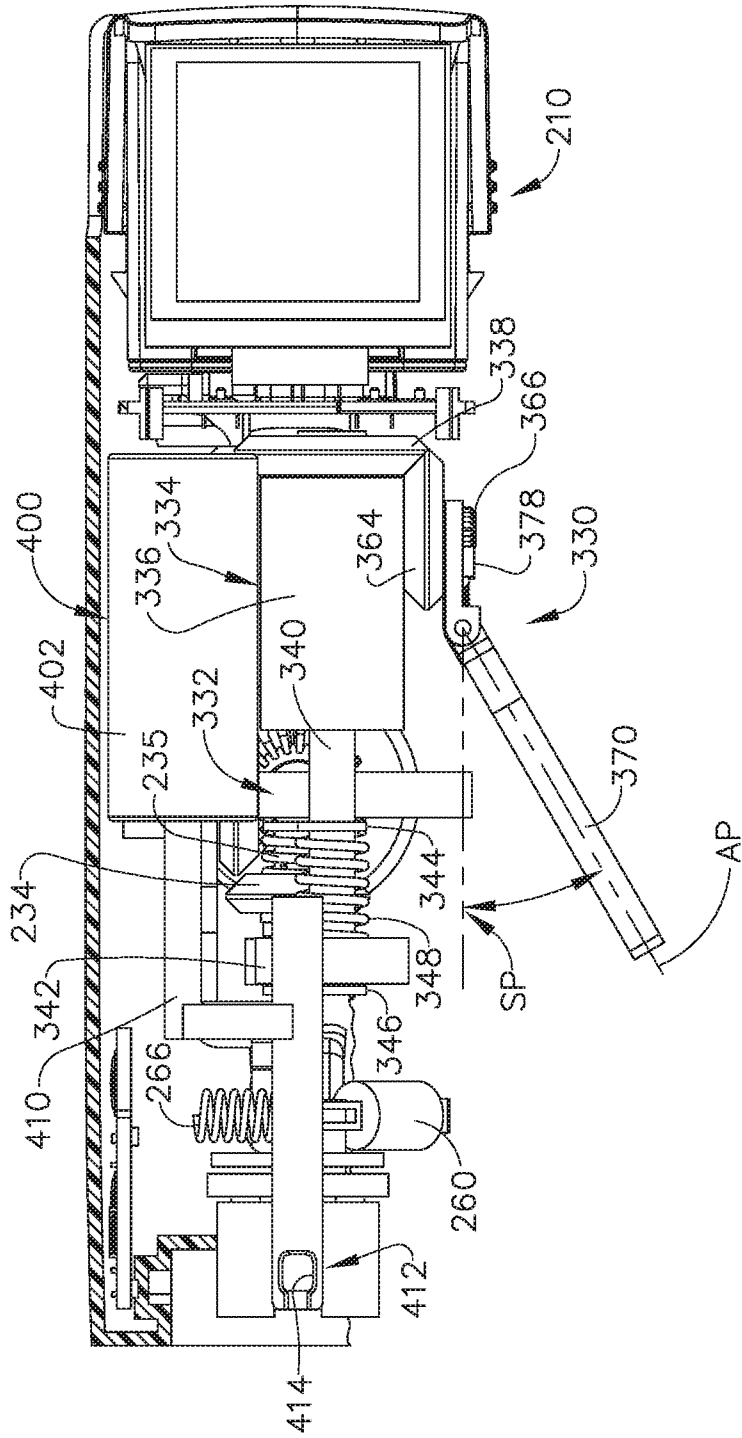


FIG. 11

10/36

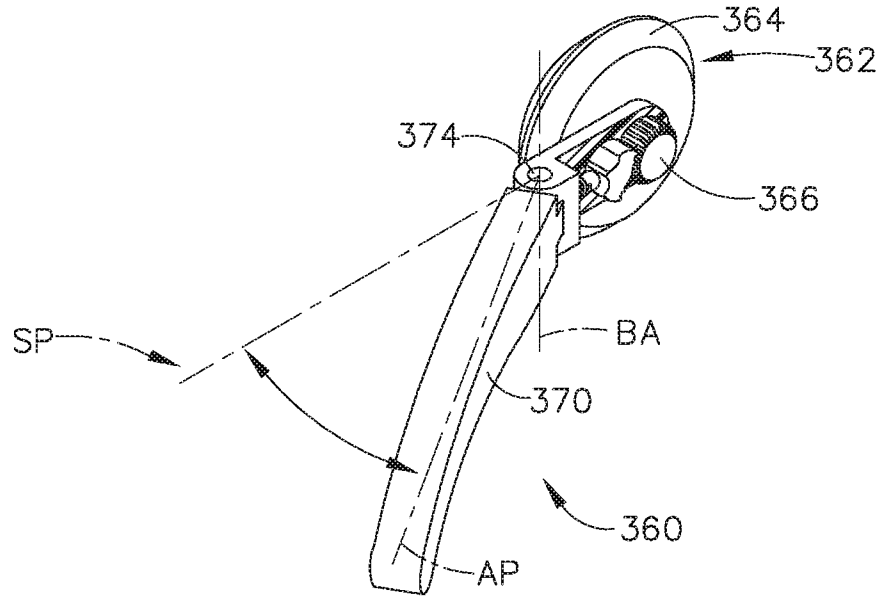


FIG. 12

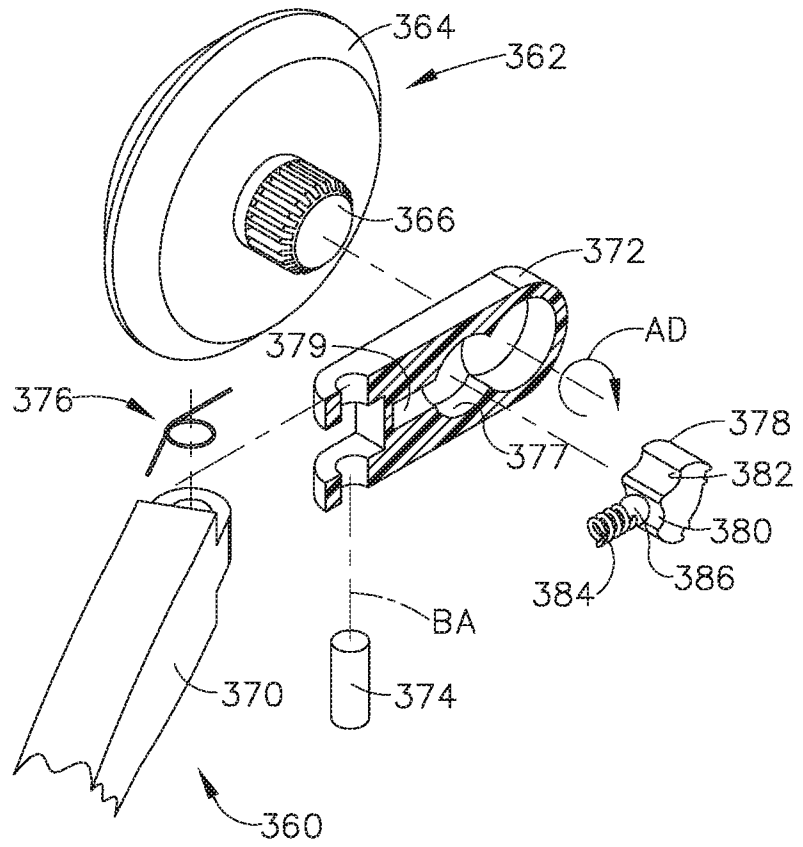


FIG. 13

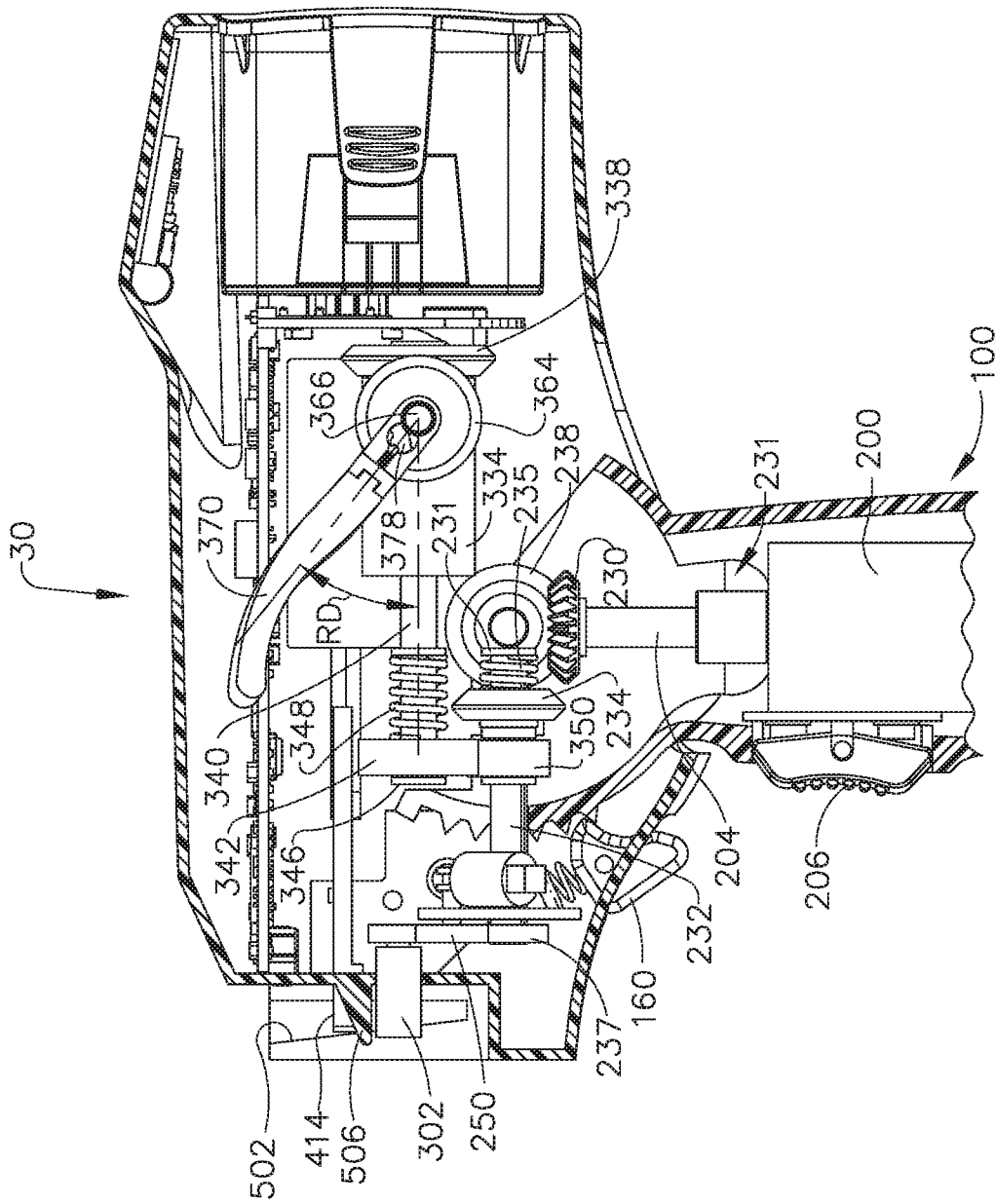


FIG. 14

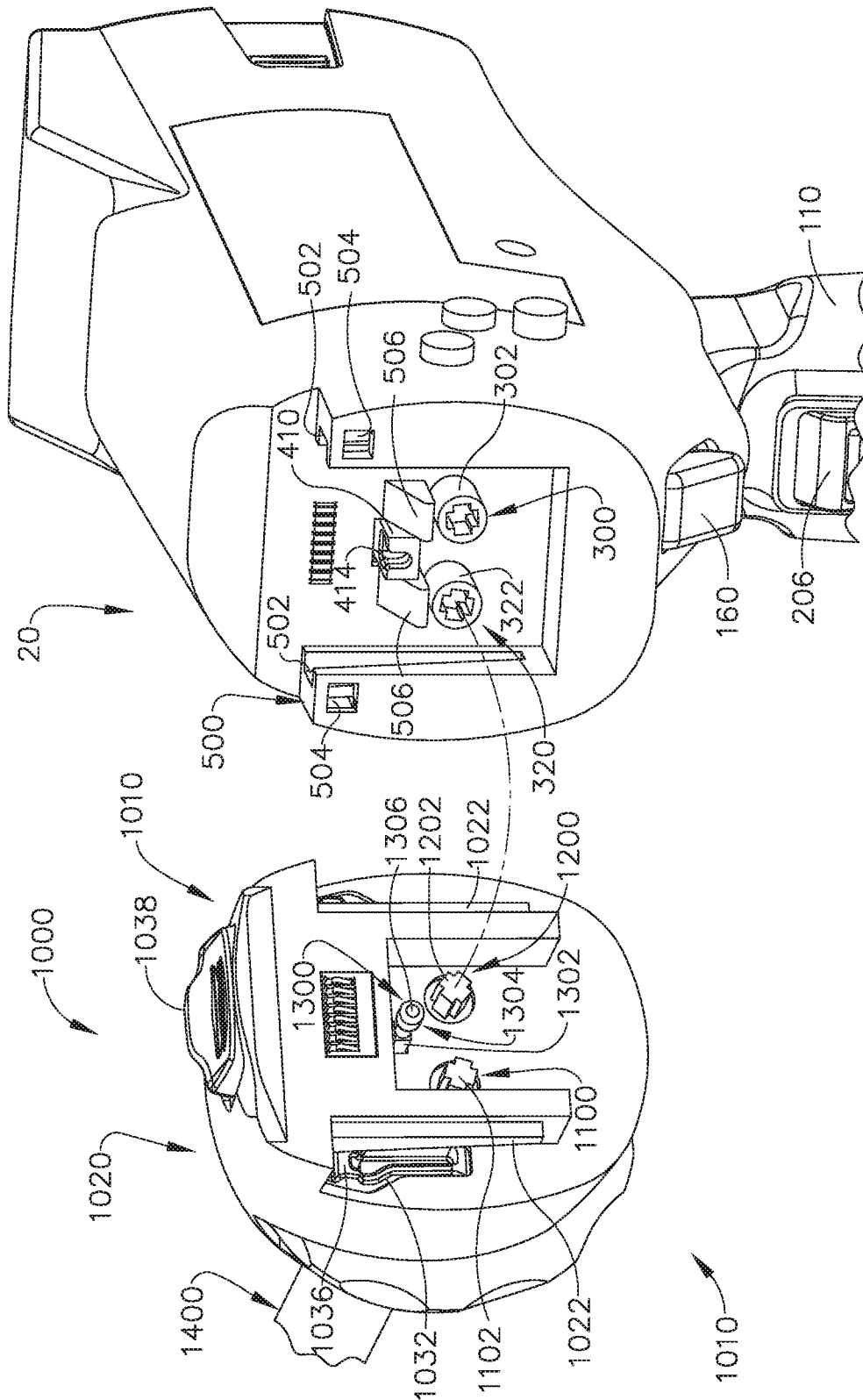


FIG. 15

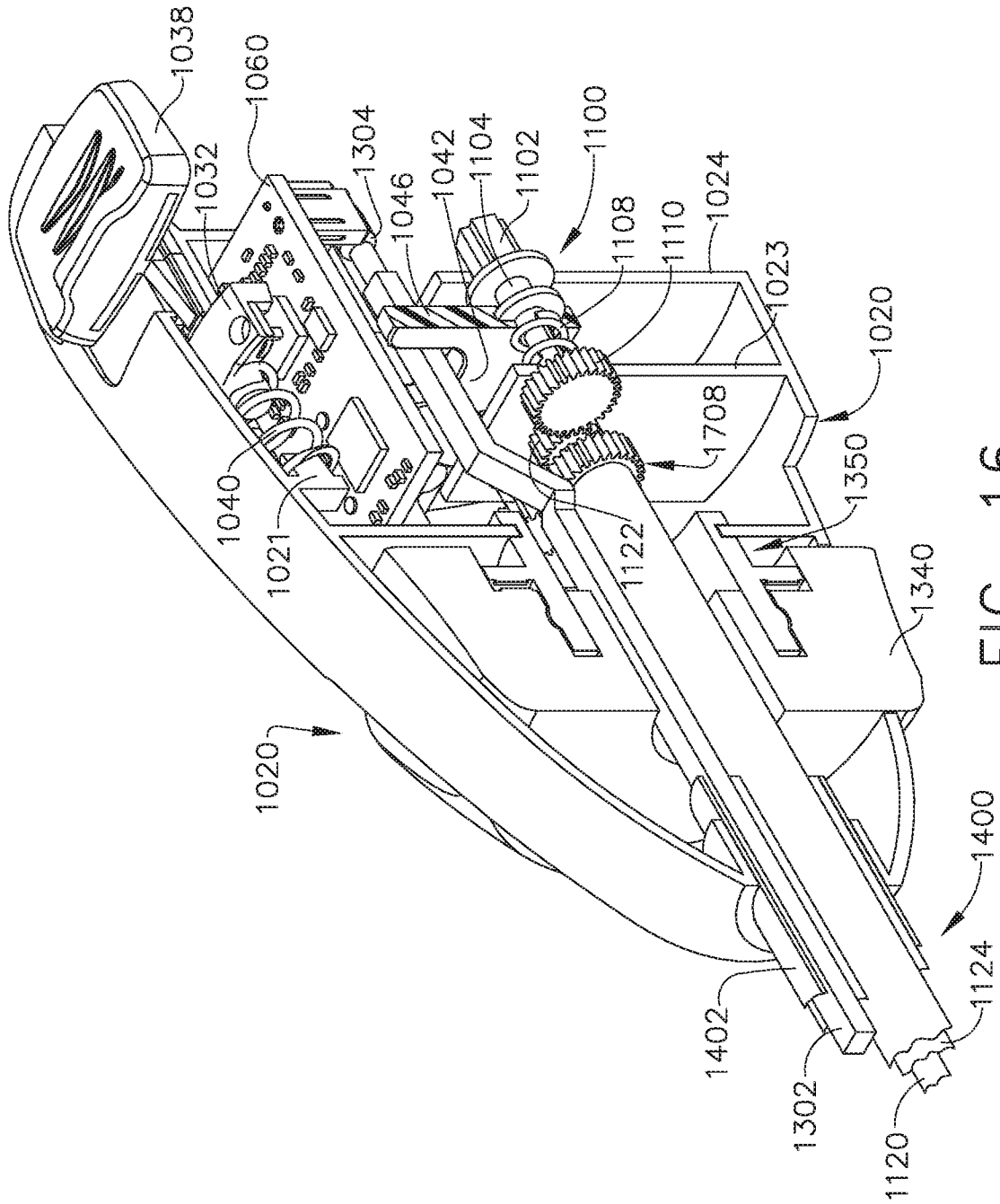


FIG. 16

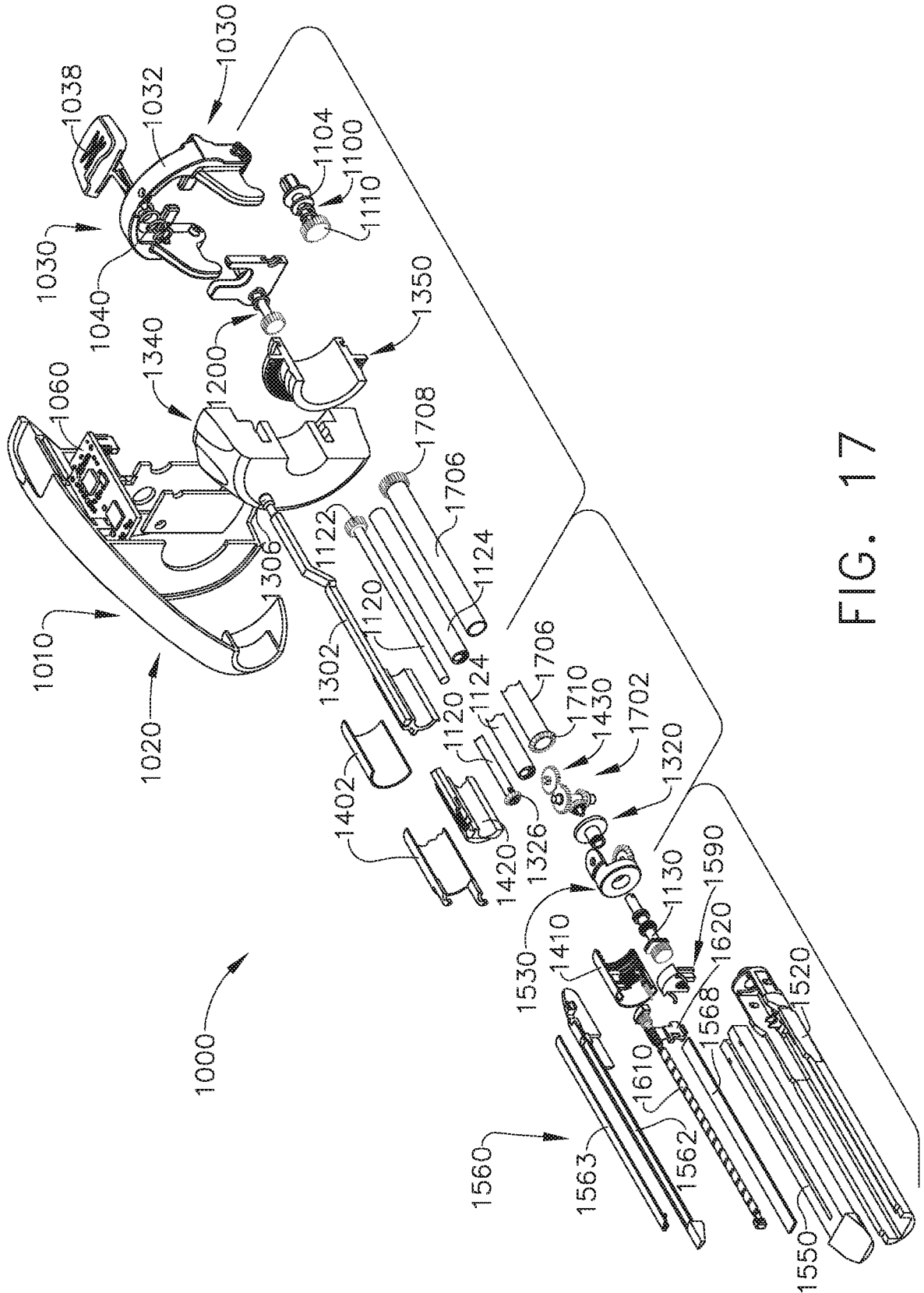


FIG. 17

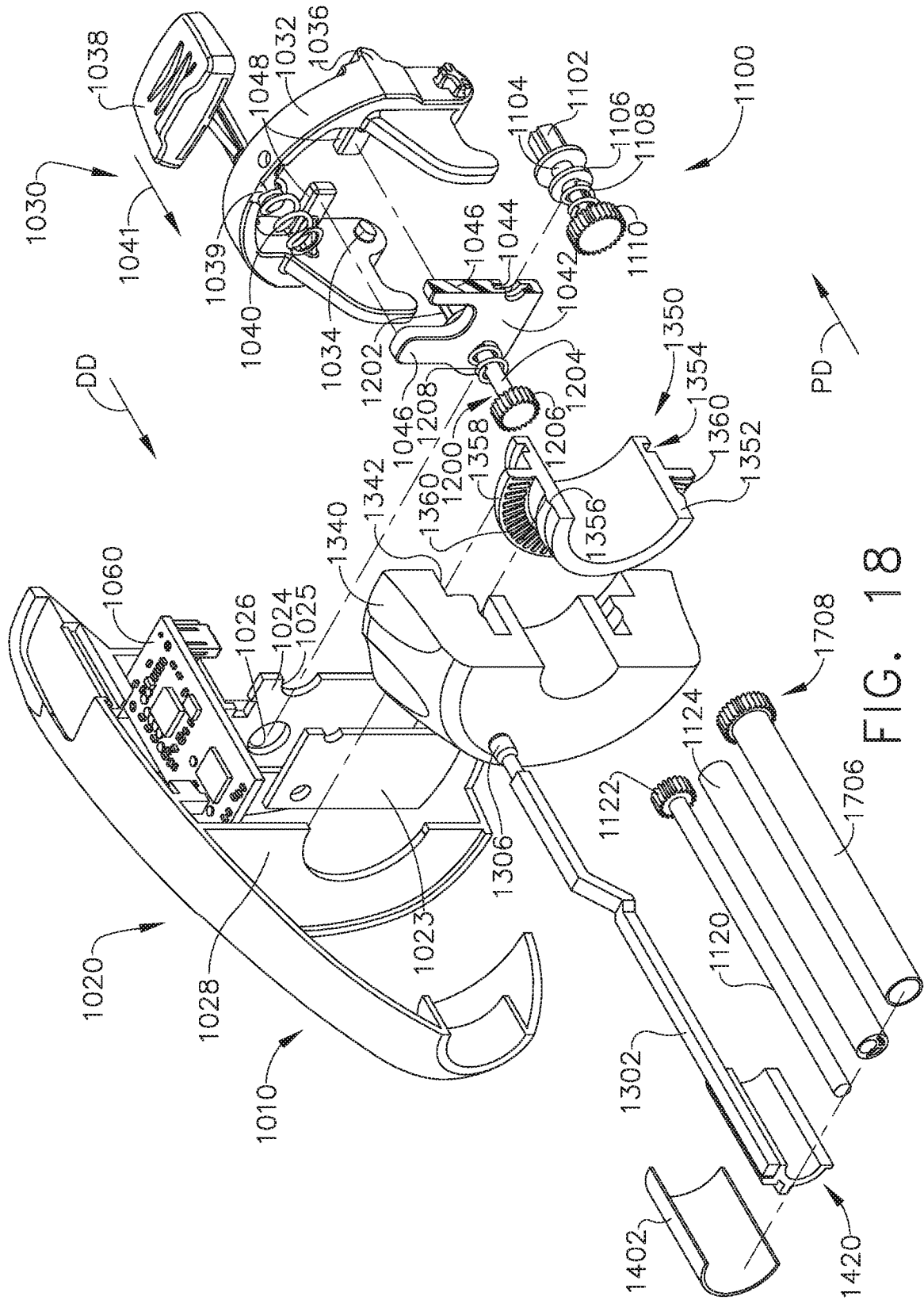


FIG. 18



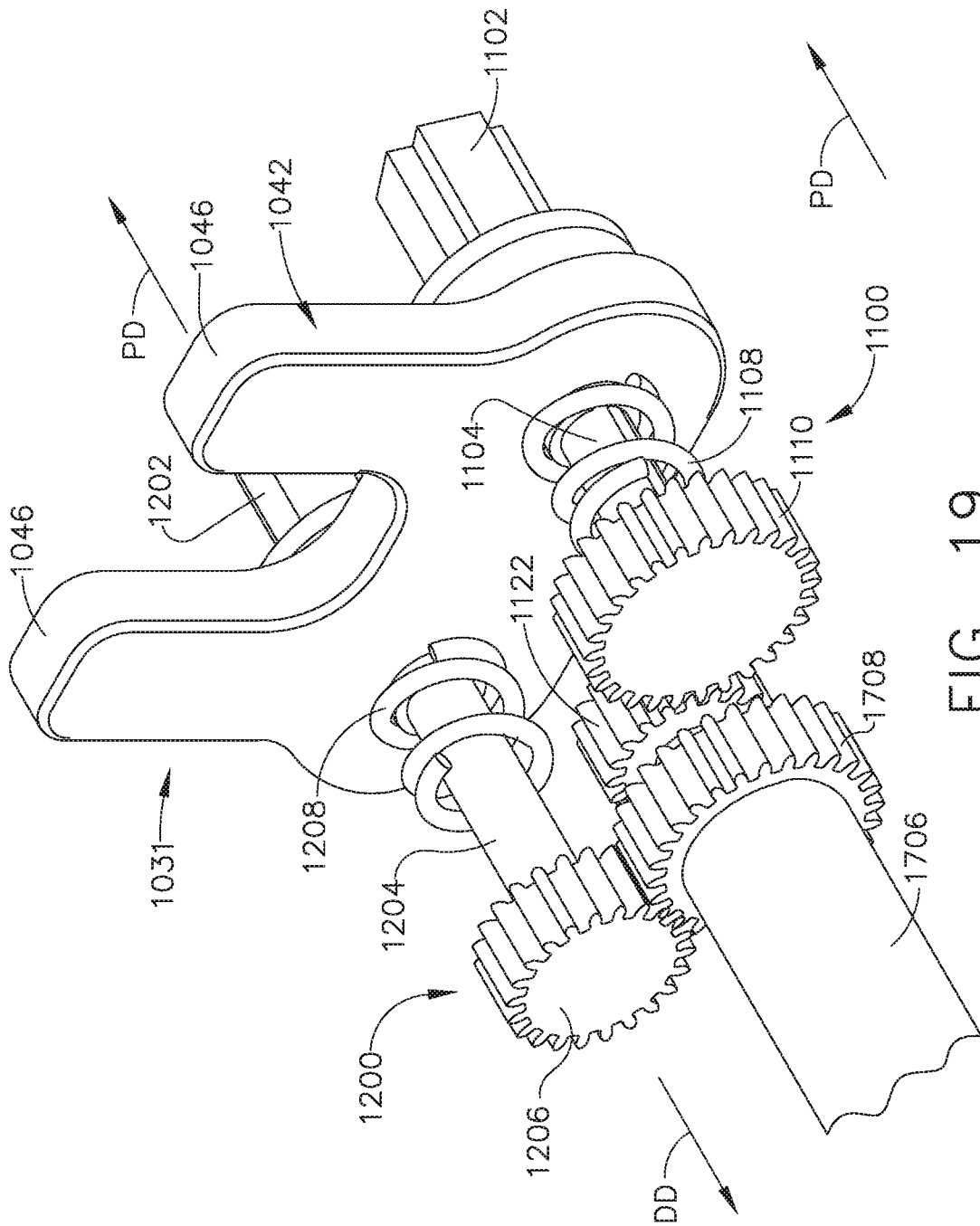


FIG. 19

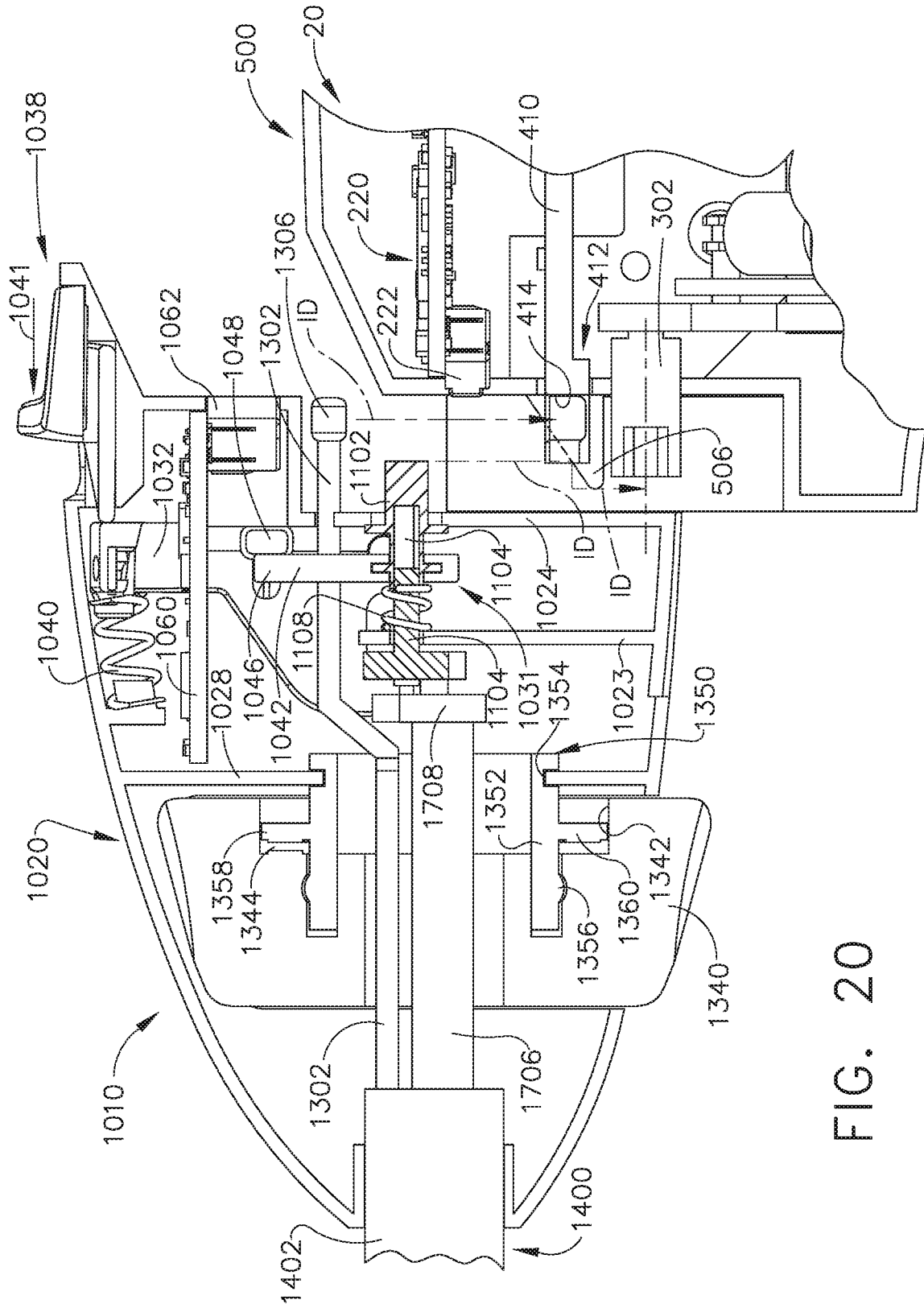


FIG. 20

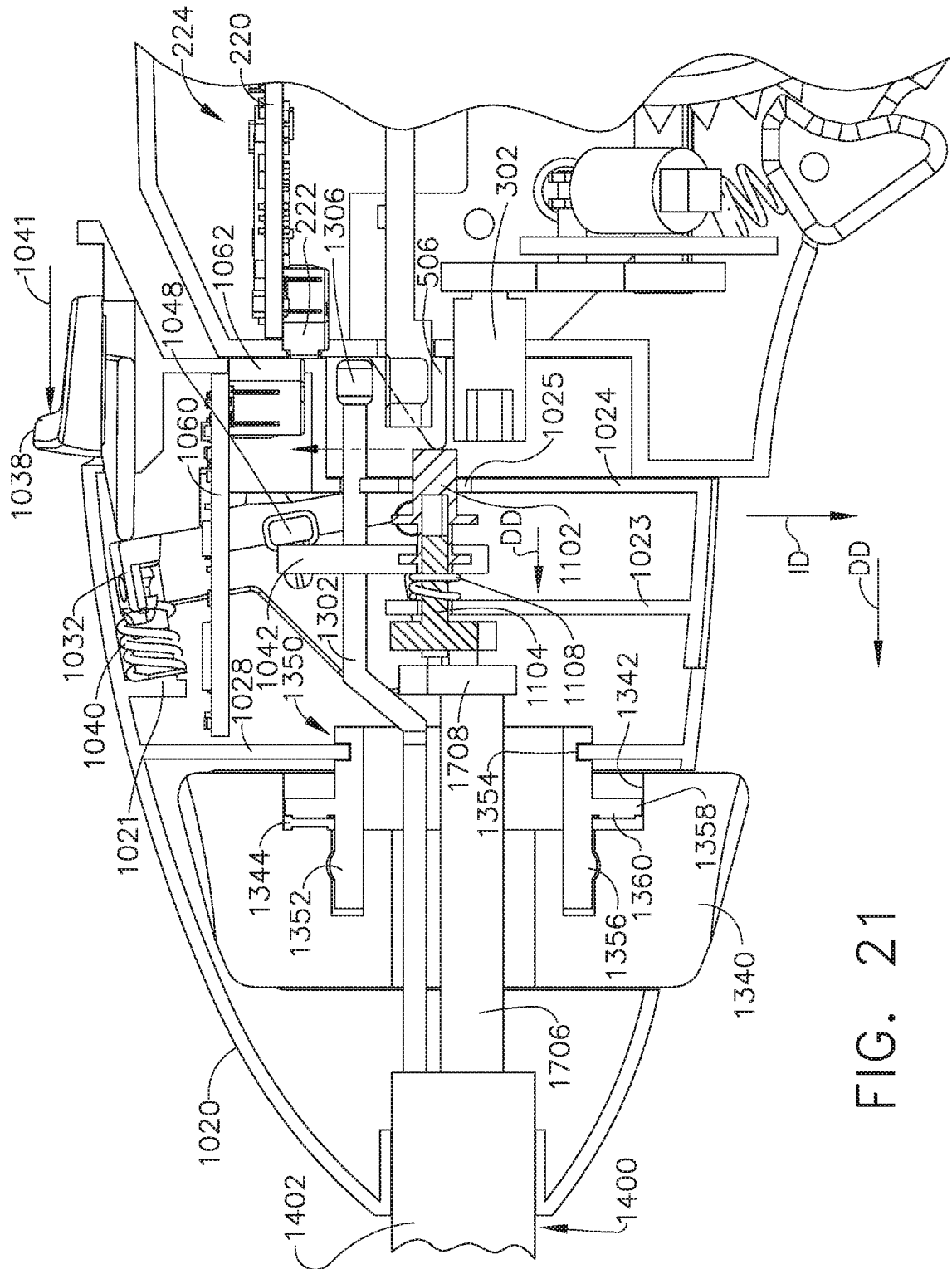


FIG. 21

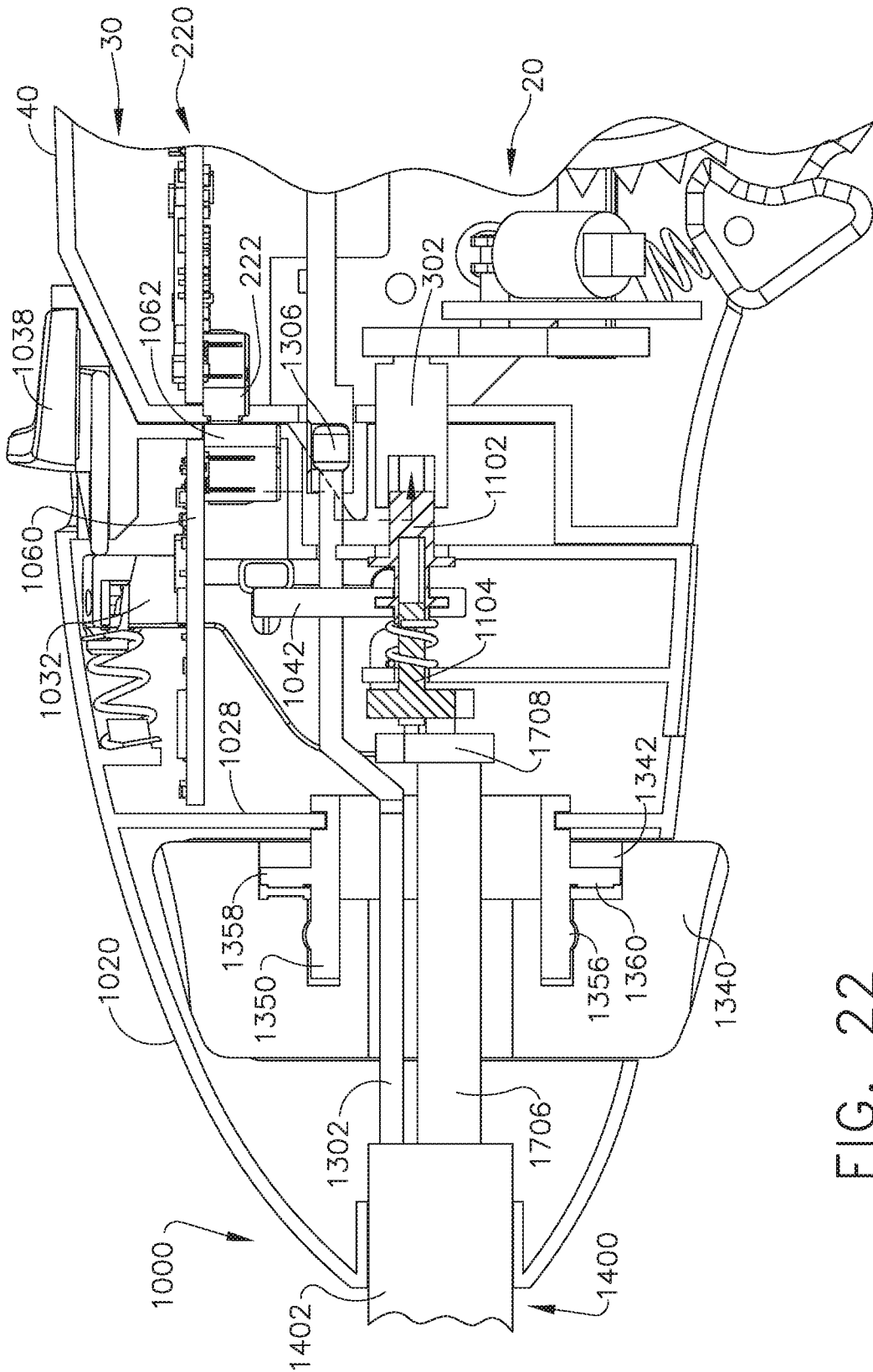


FIG. 22

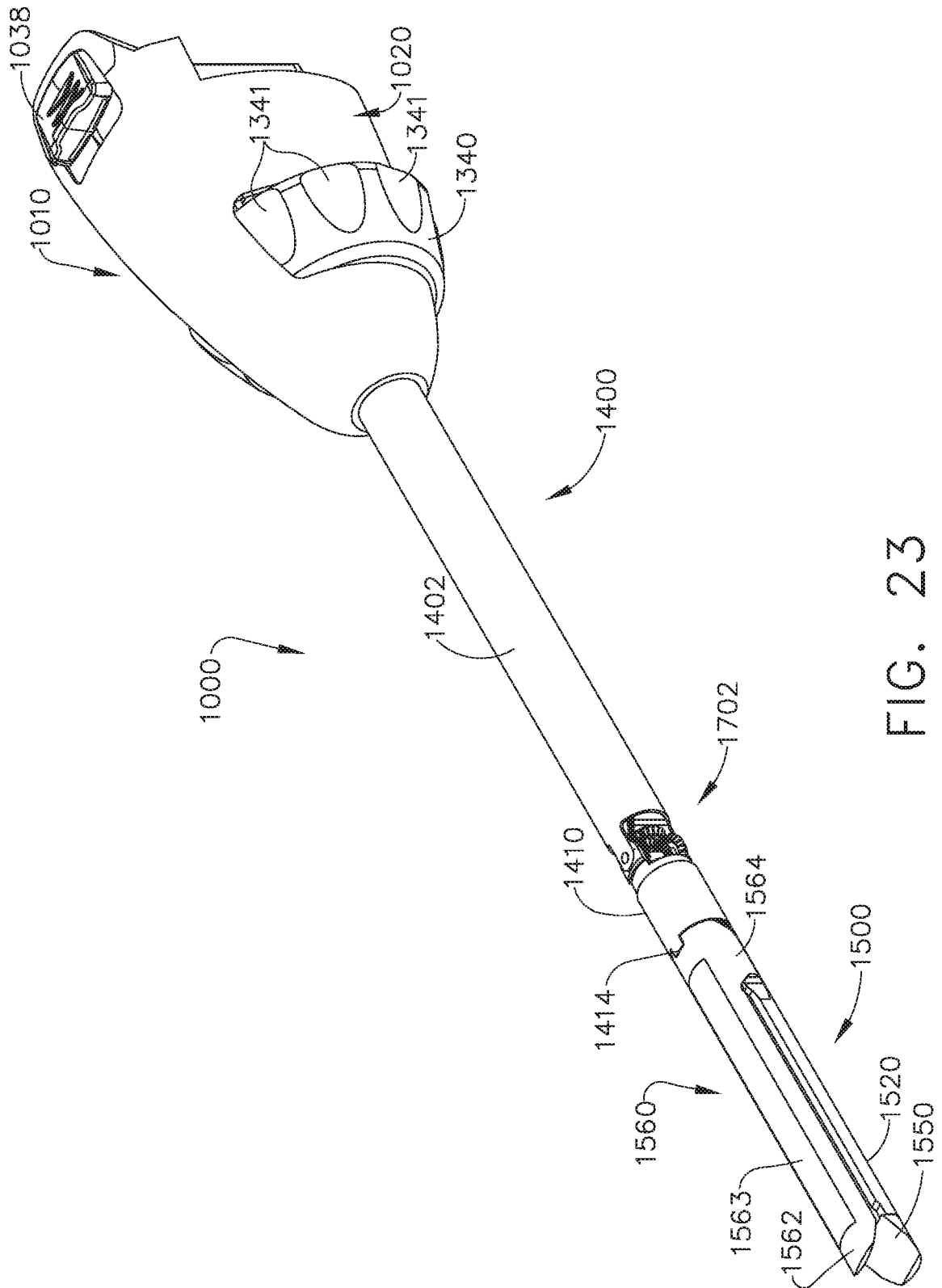


FIG. 23

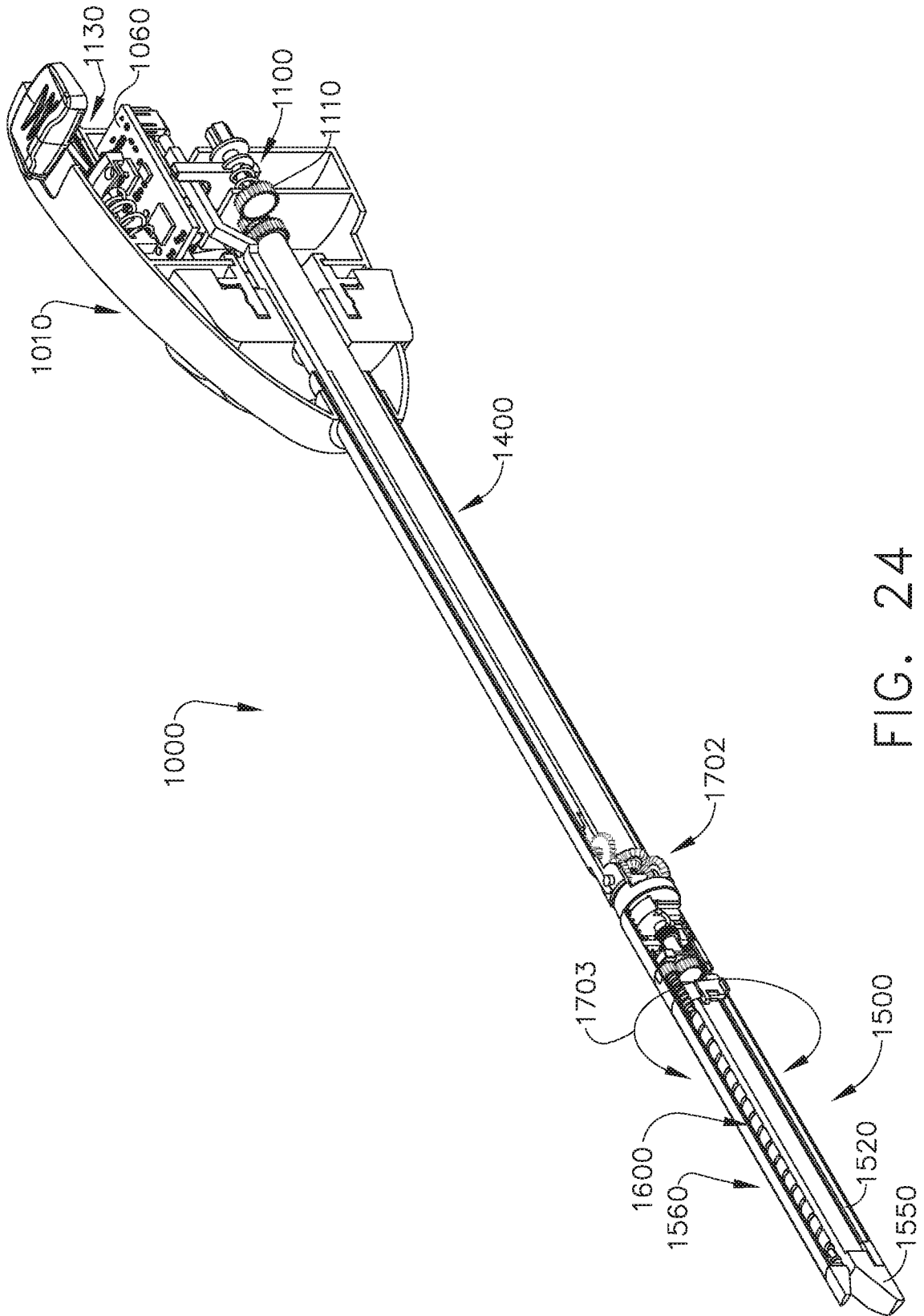


FIG. 24

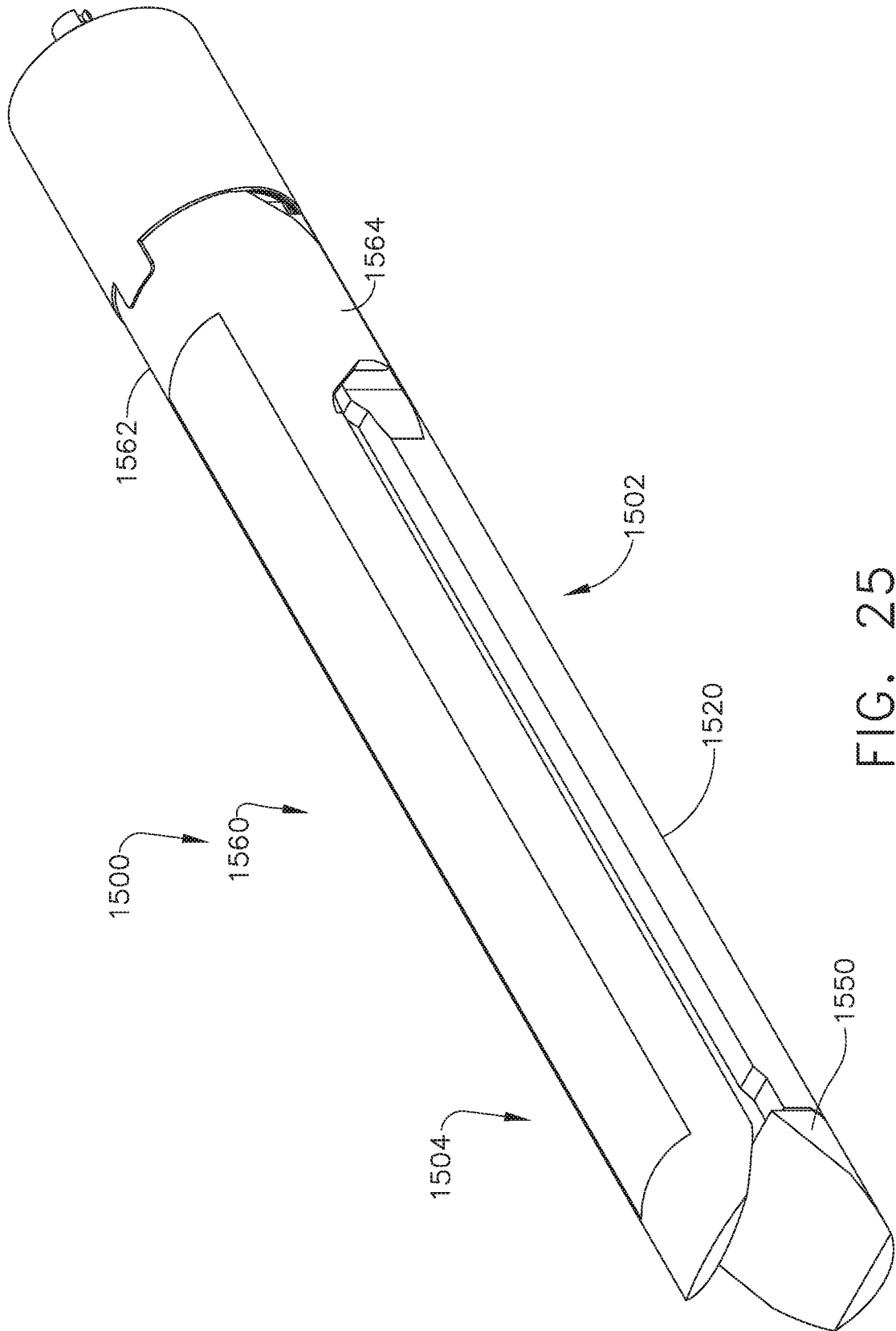


FIG. 25

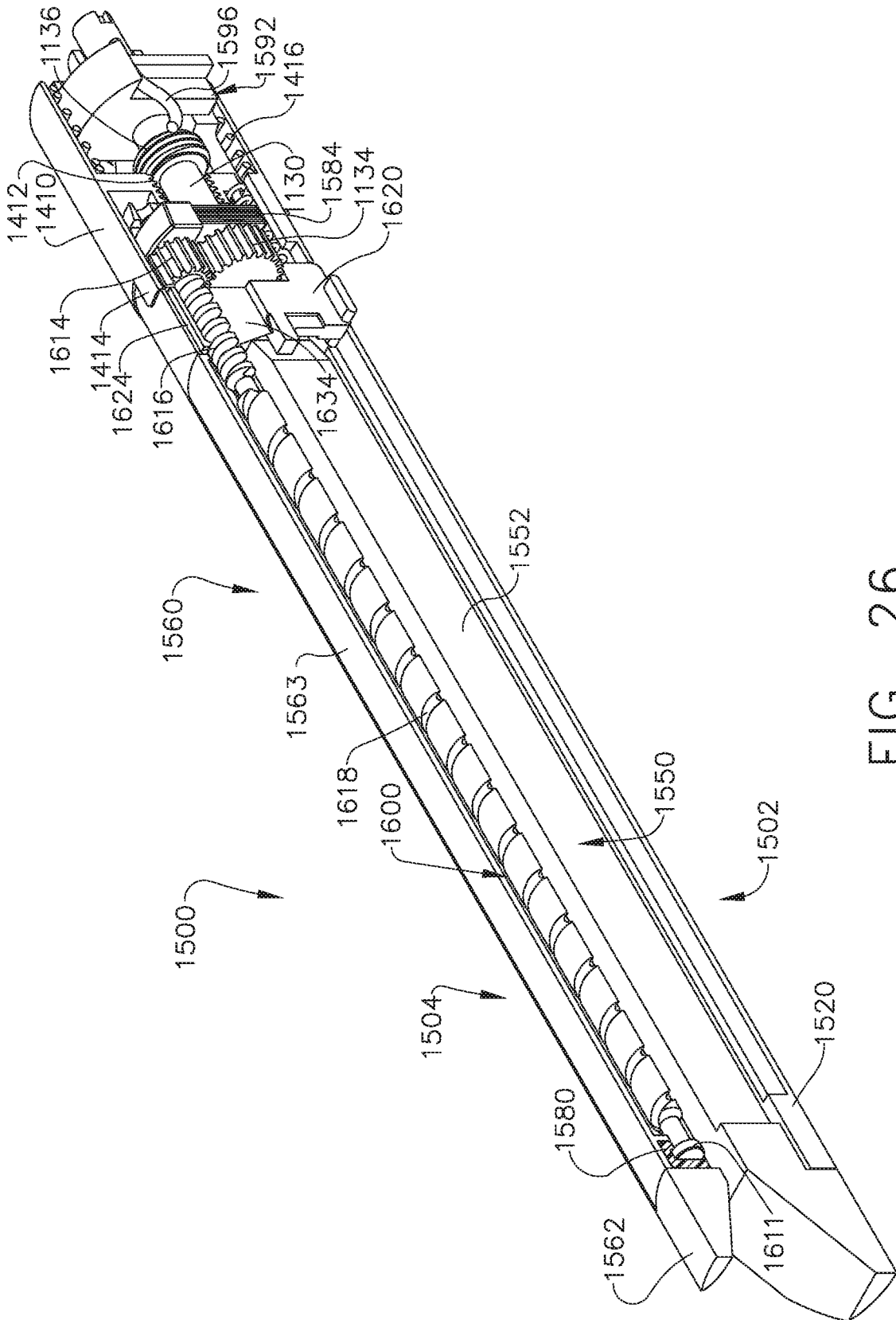


FIG. 26



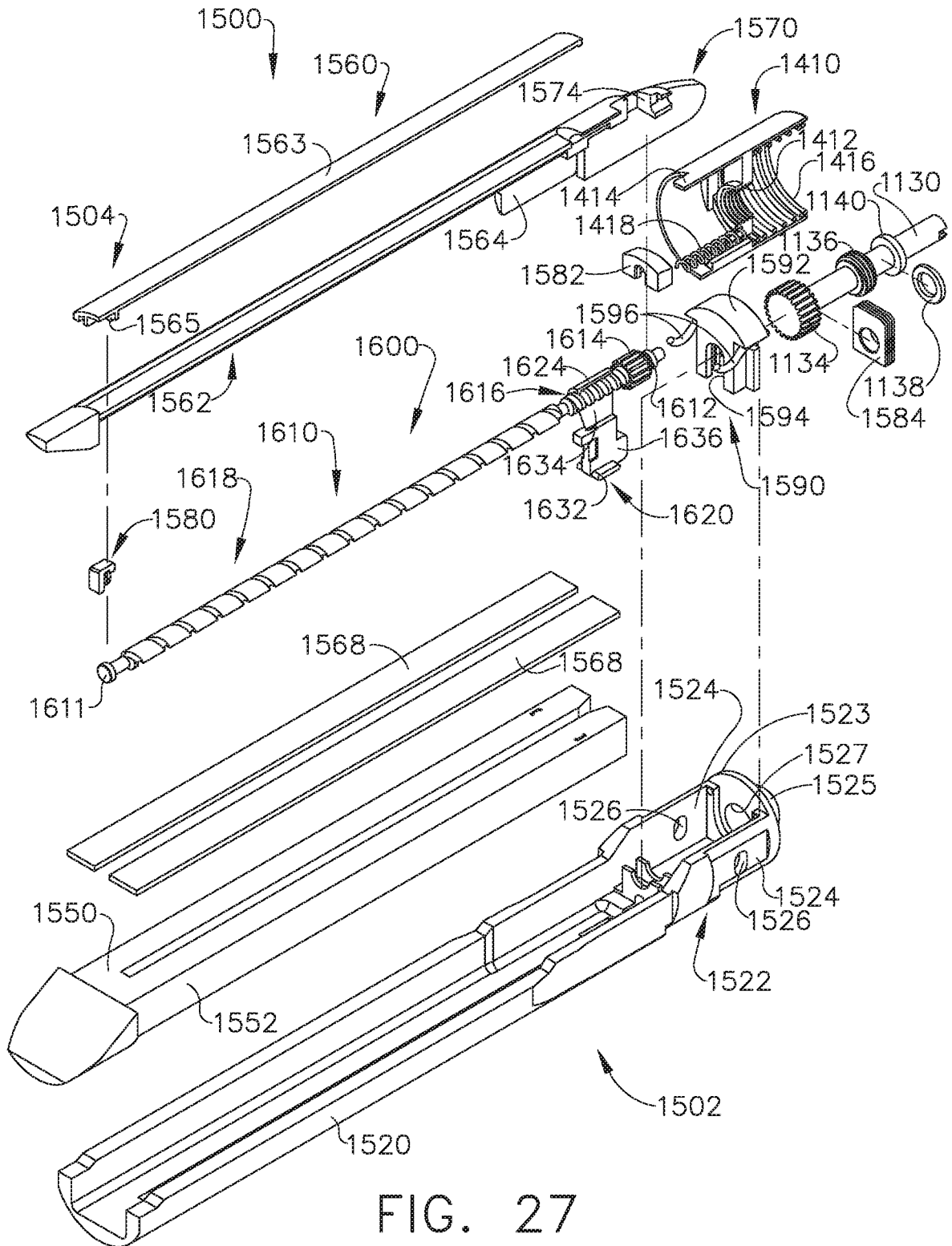


FIG. 27

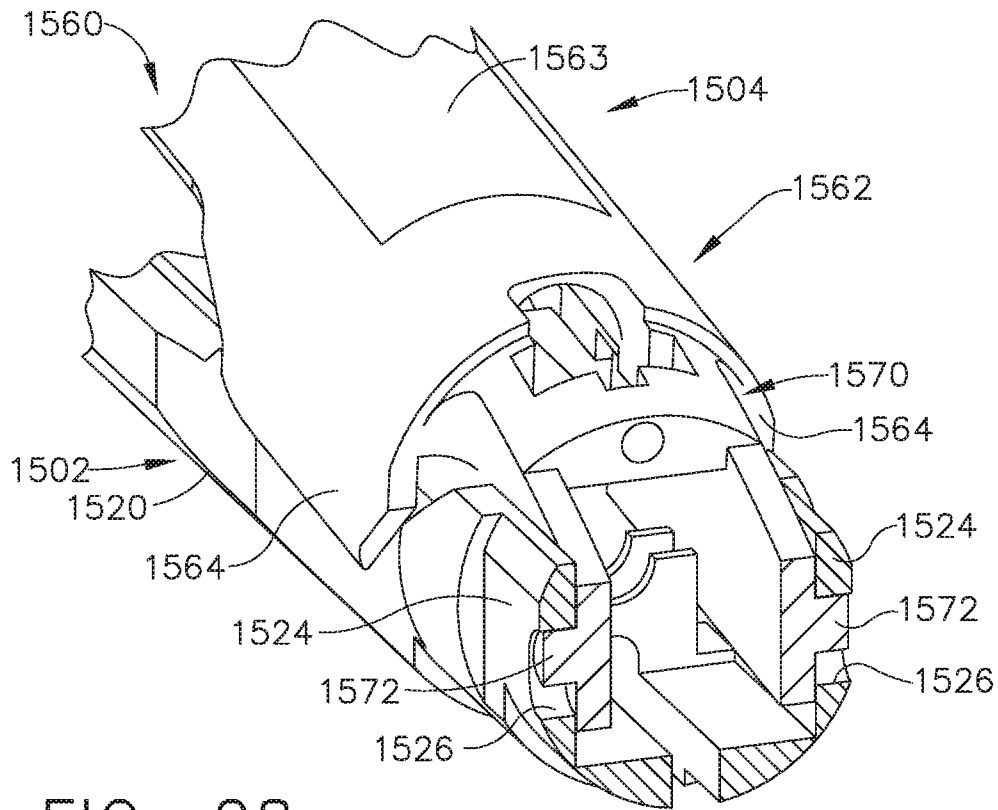


FIG. 28

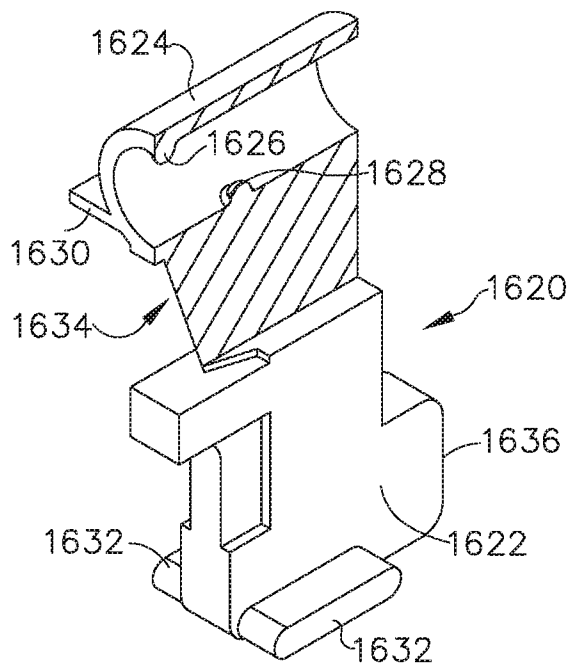


FIG. 29

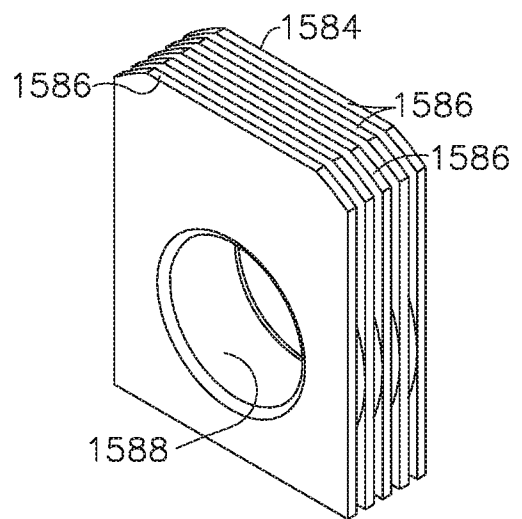


FIG. 36

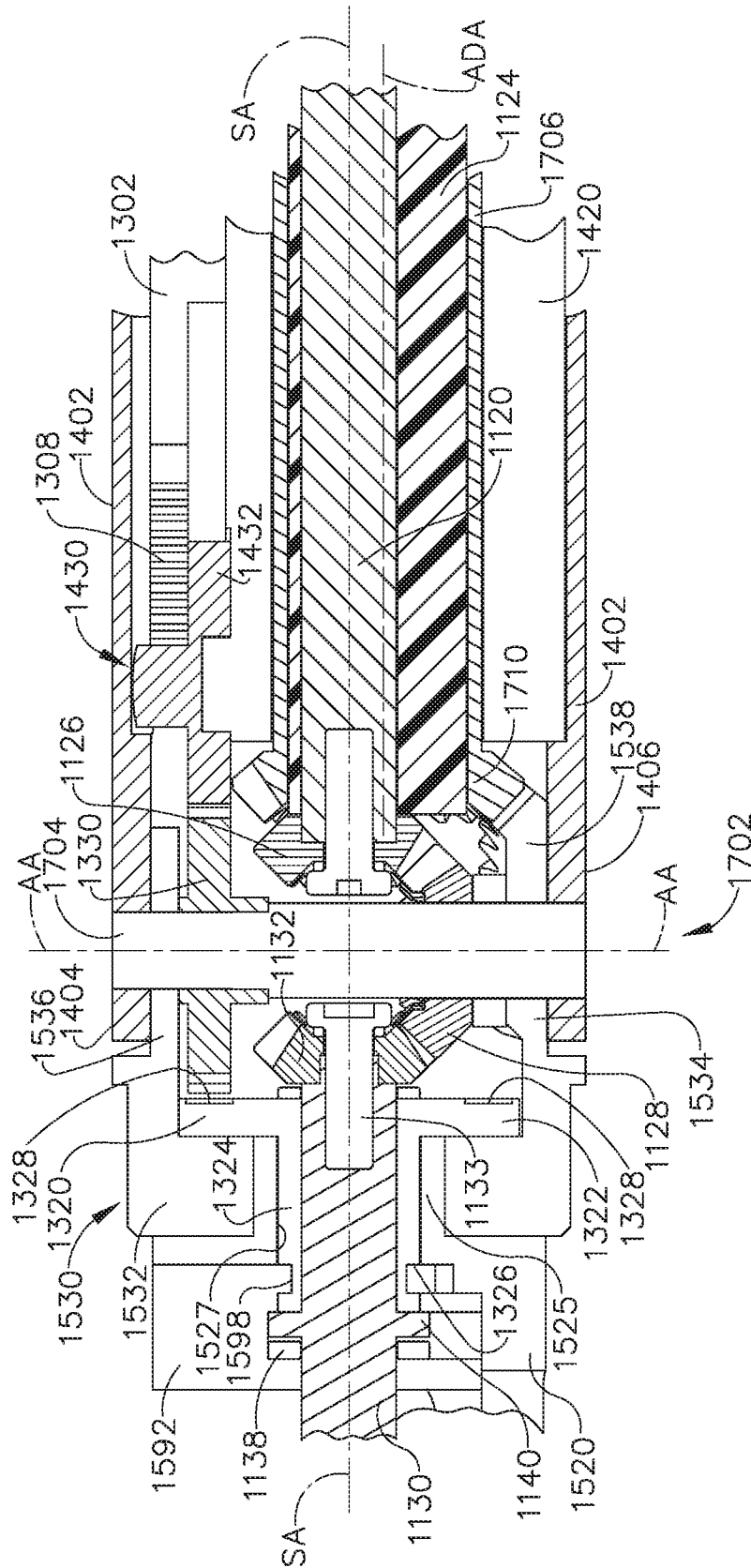


FIG. 30

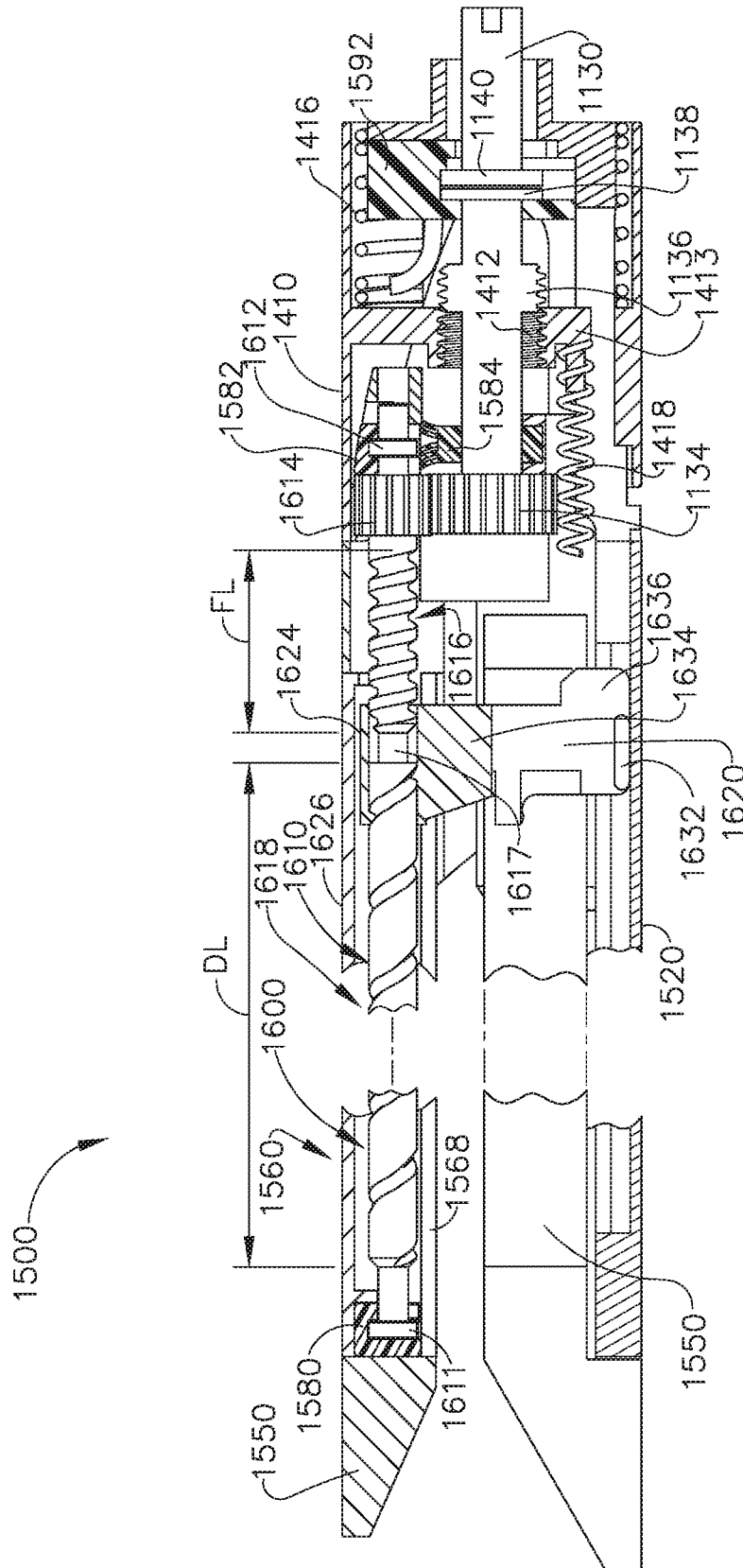


FIG. 31

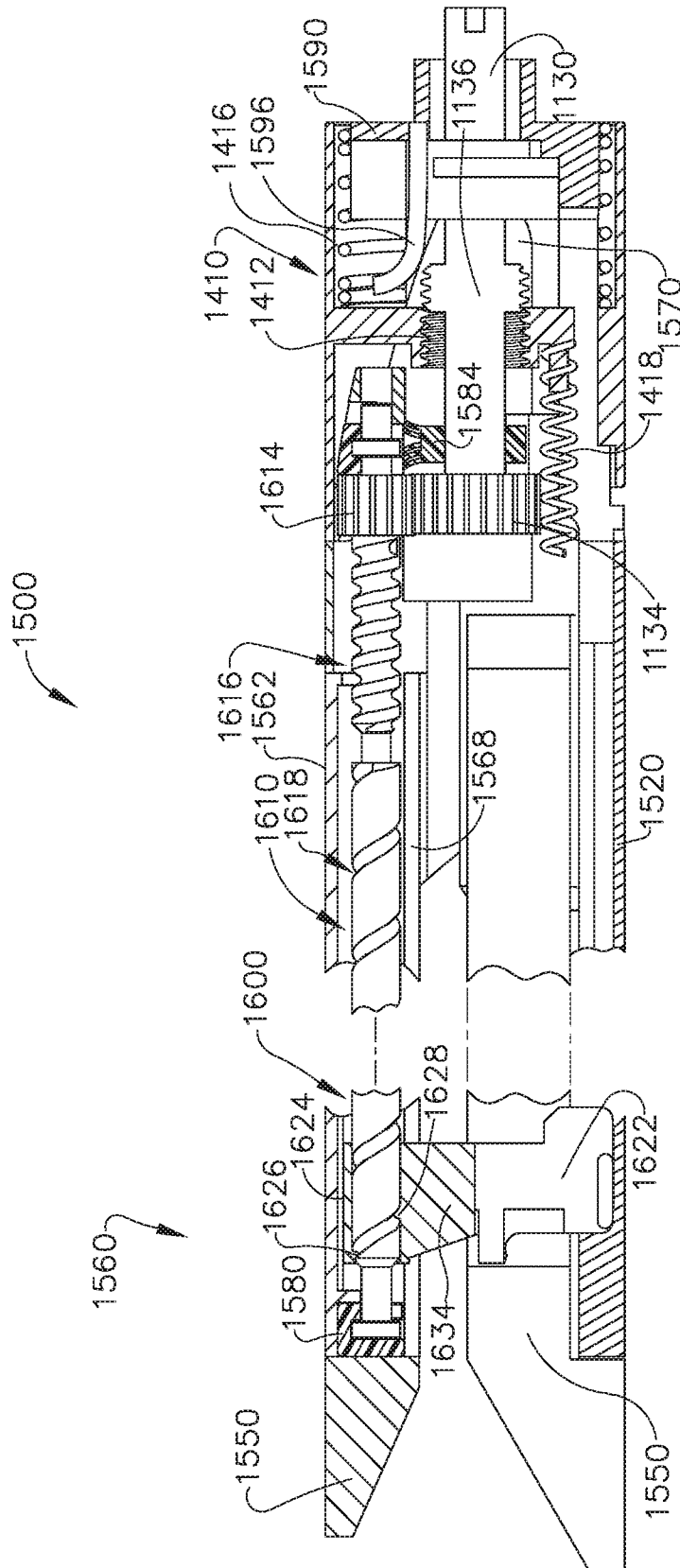


FIG. 32

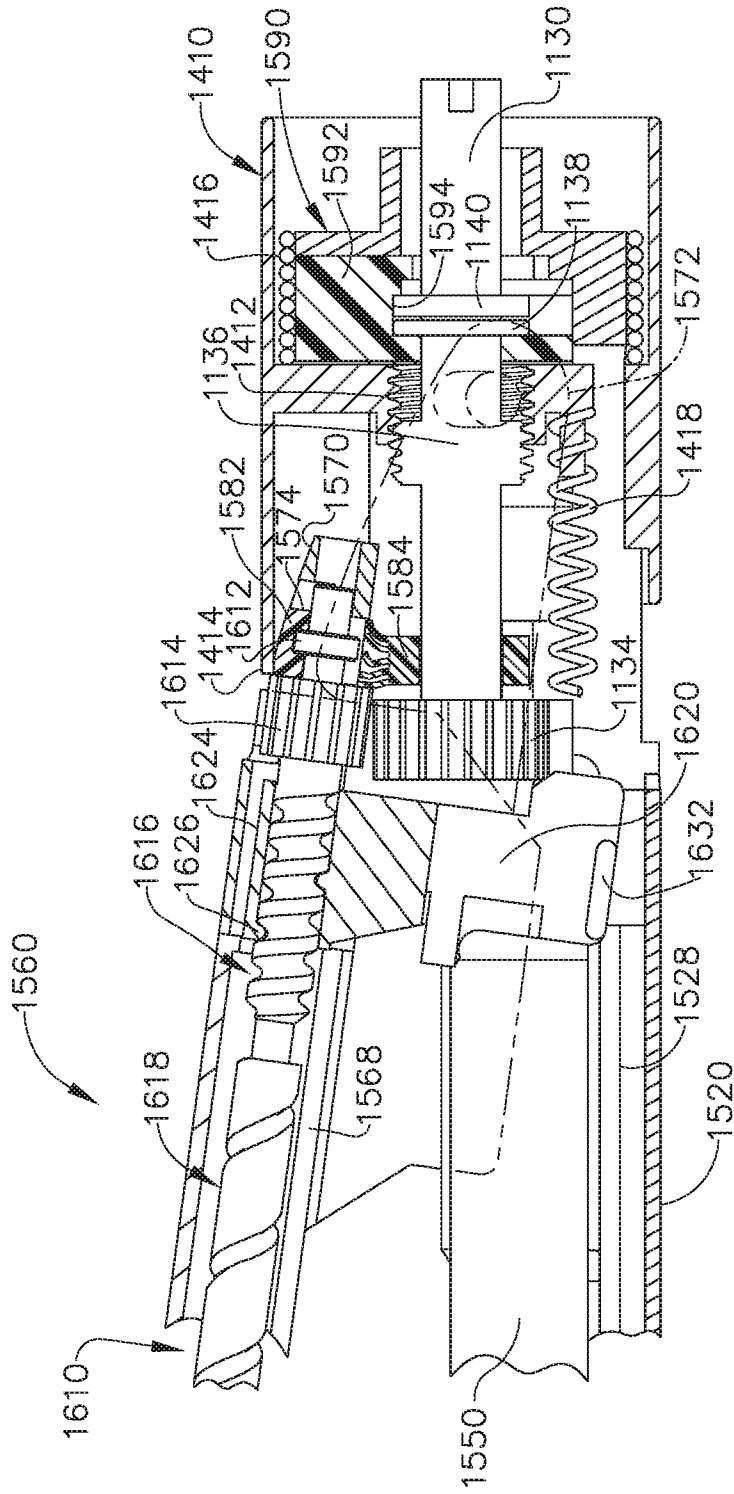


FIG. 33

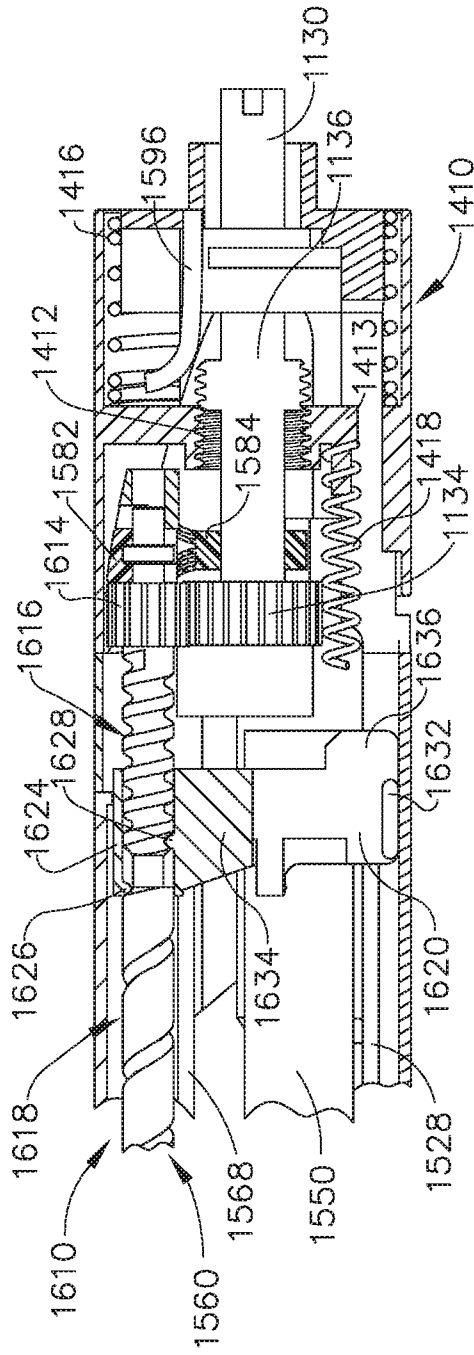


FIG. 34

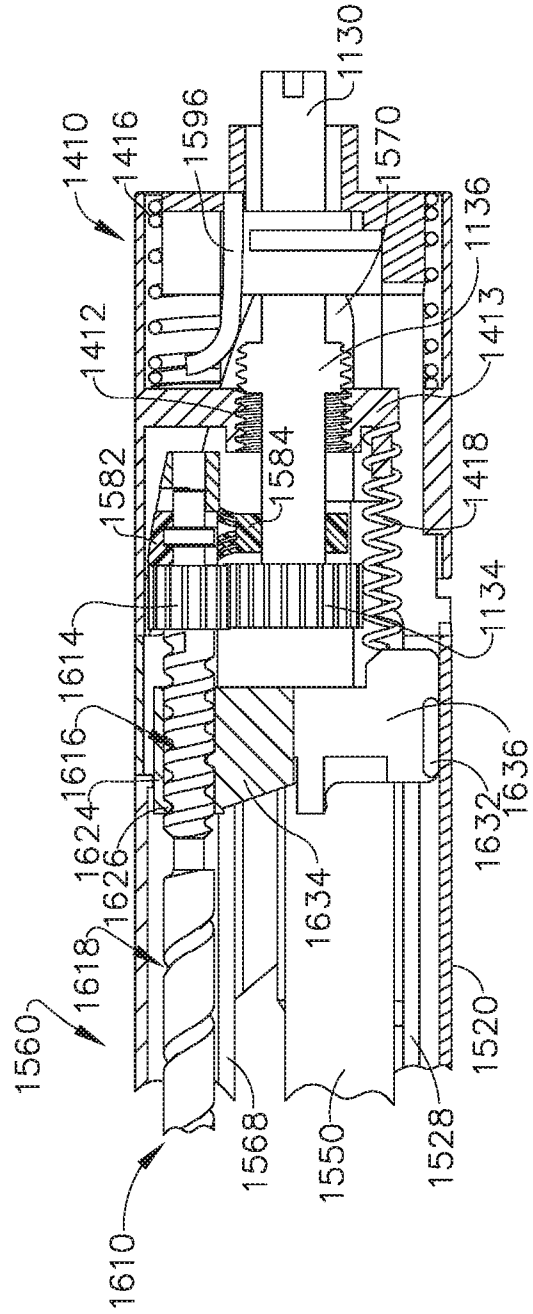


FIG. 35

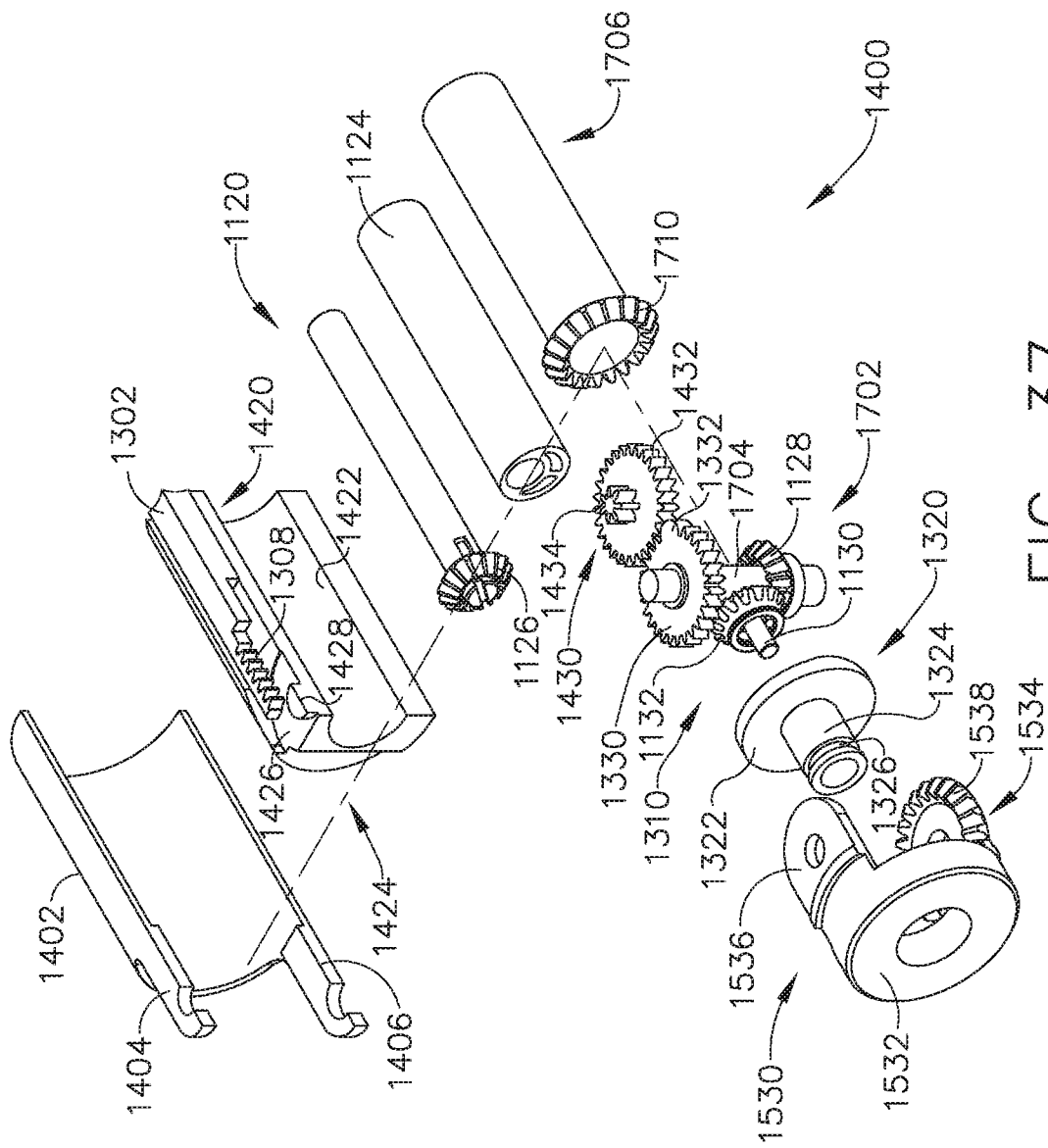


FIG. 37



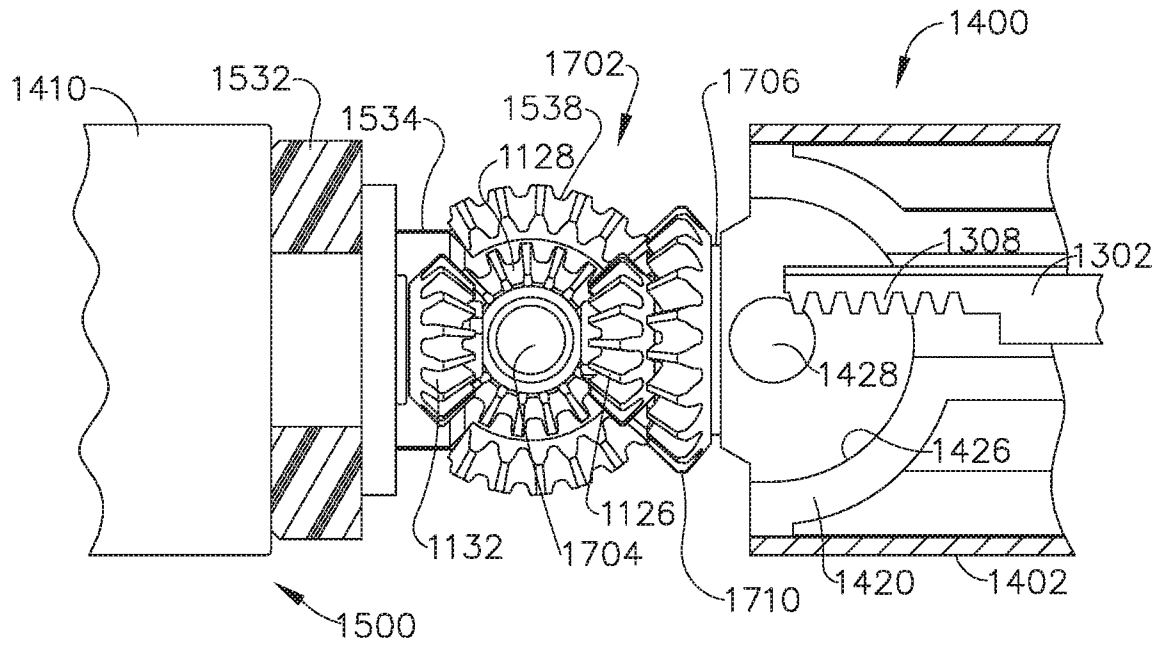


FIG. 38

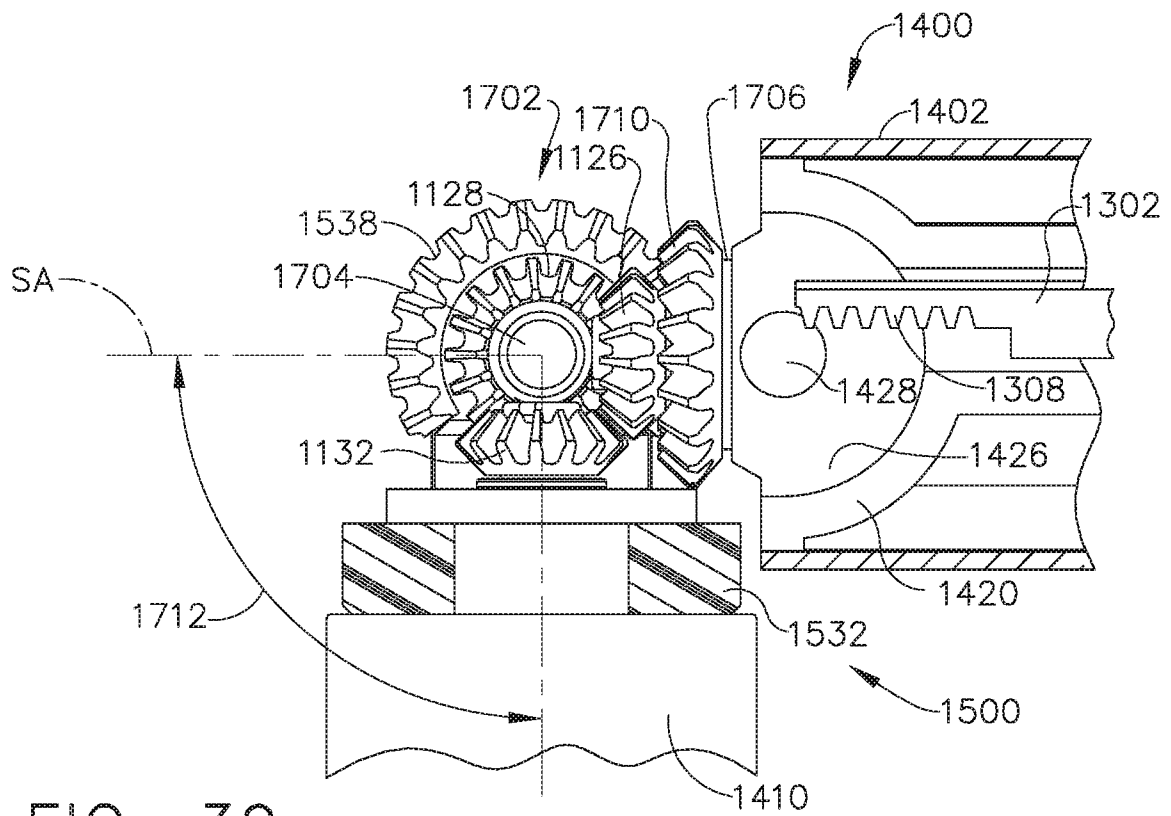


FIG. 39

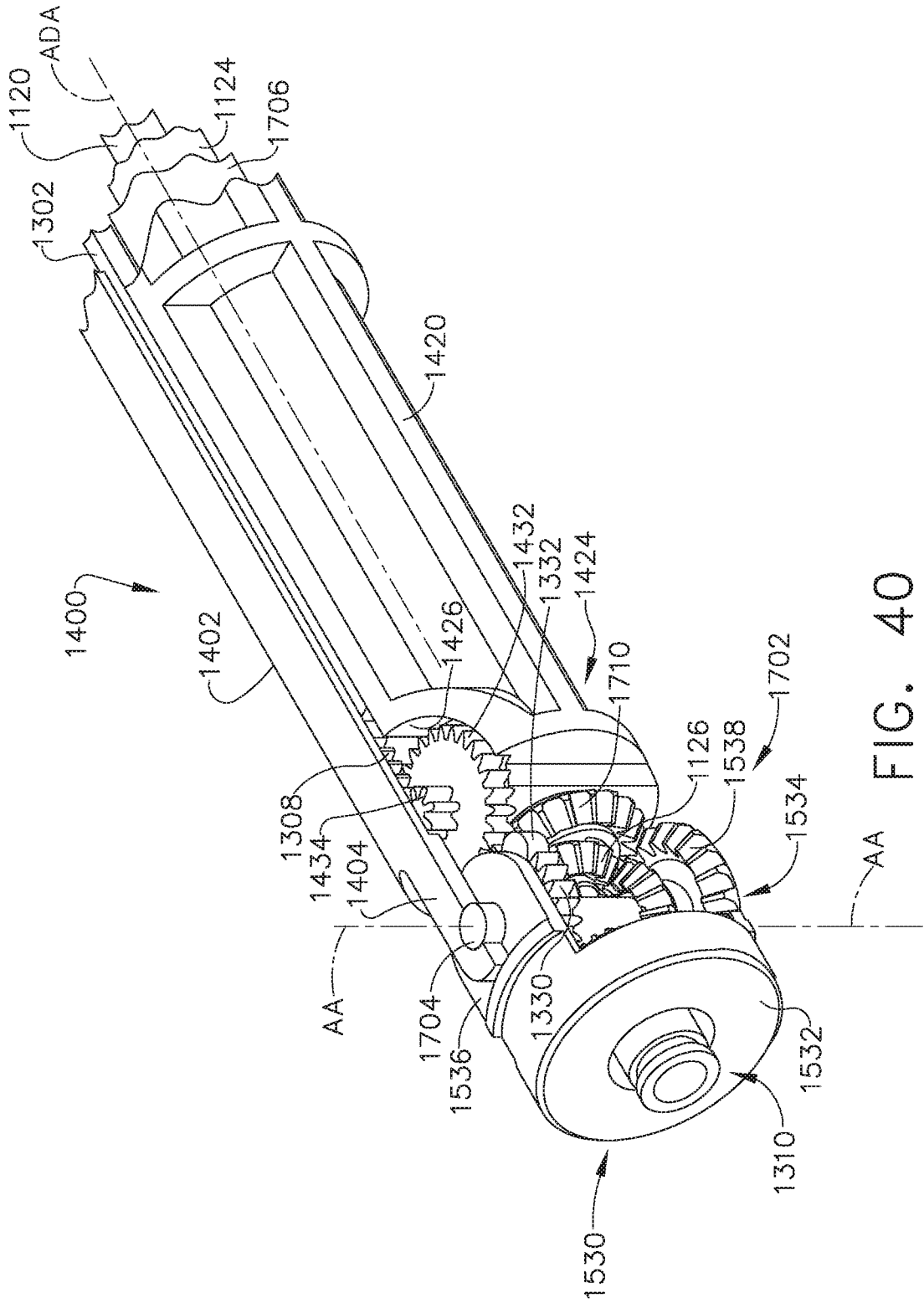


FIG. 40

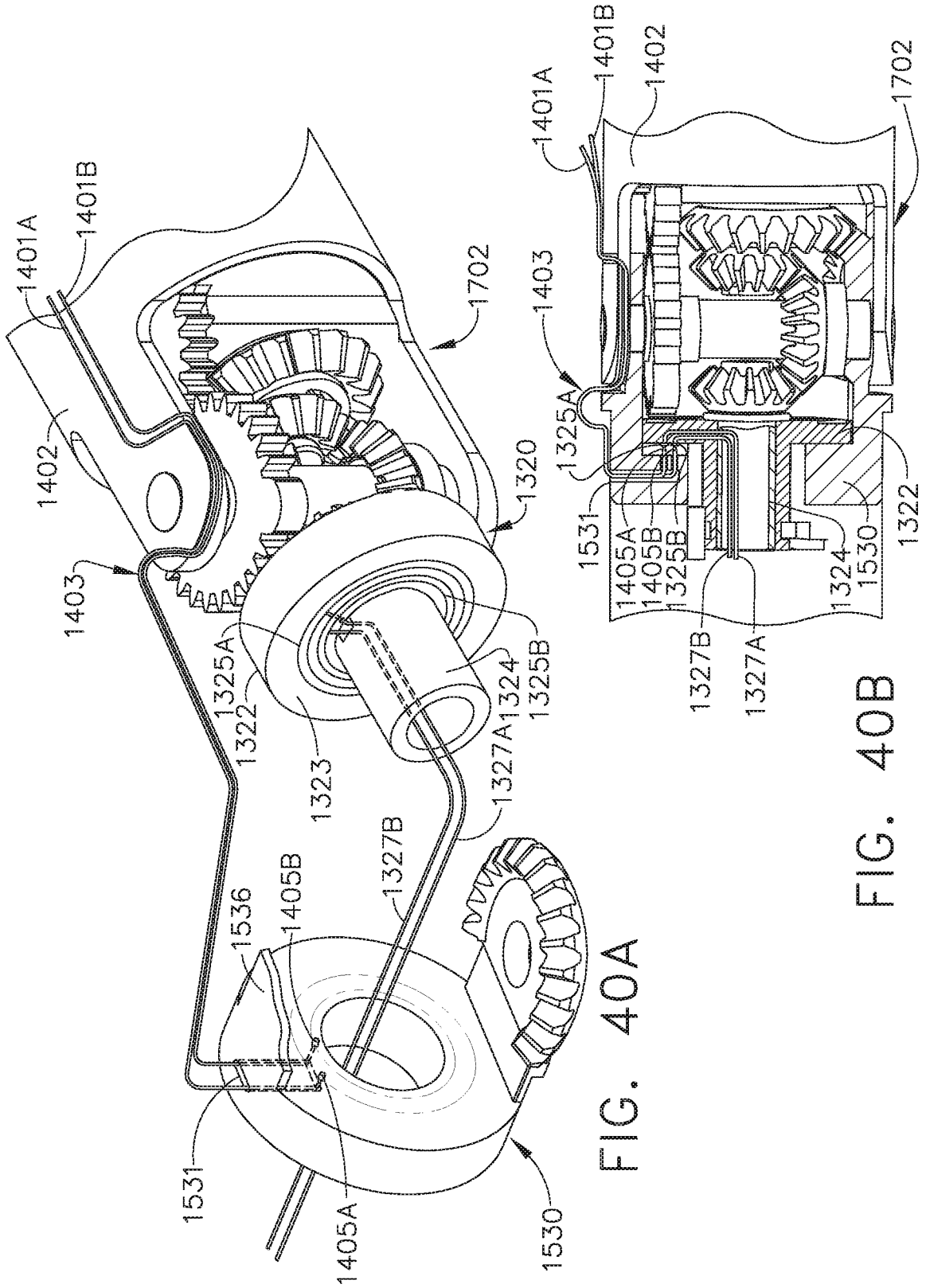


FIG. 40A

FIG. 40B

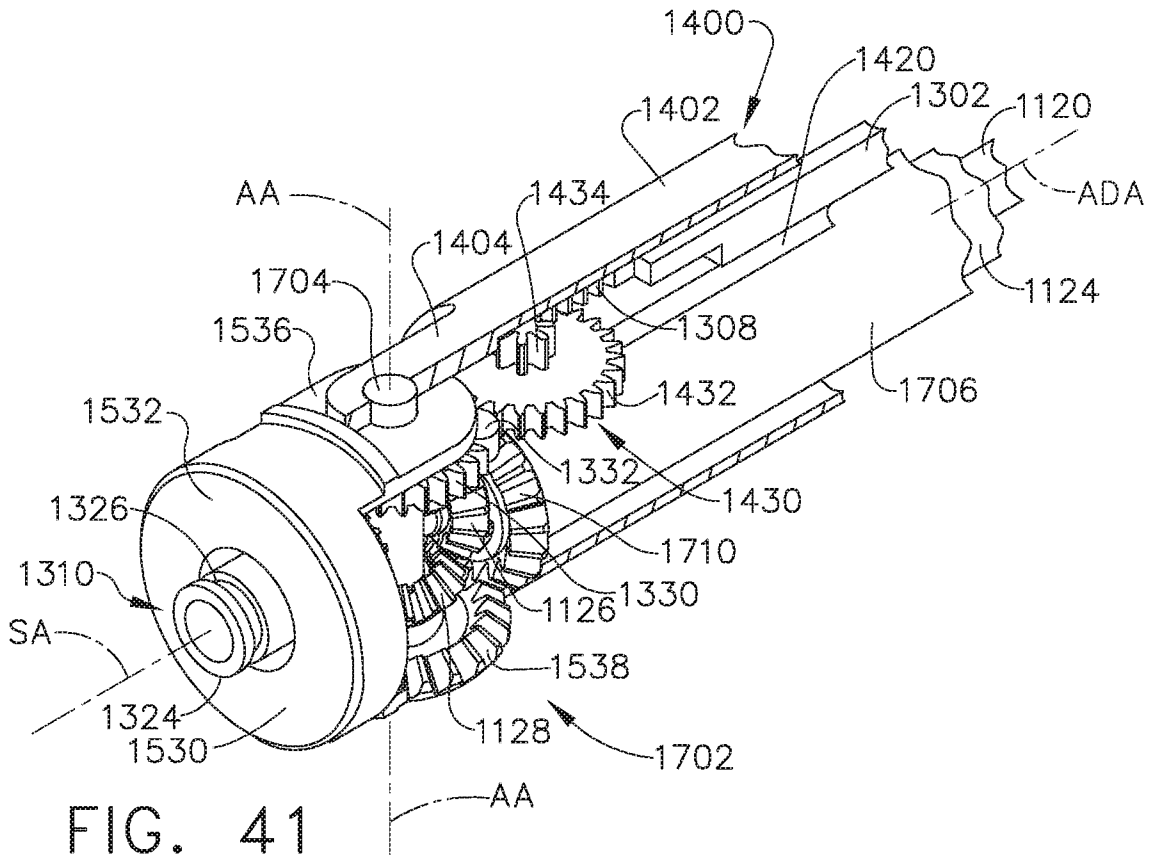


FIG. 41

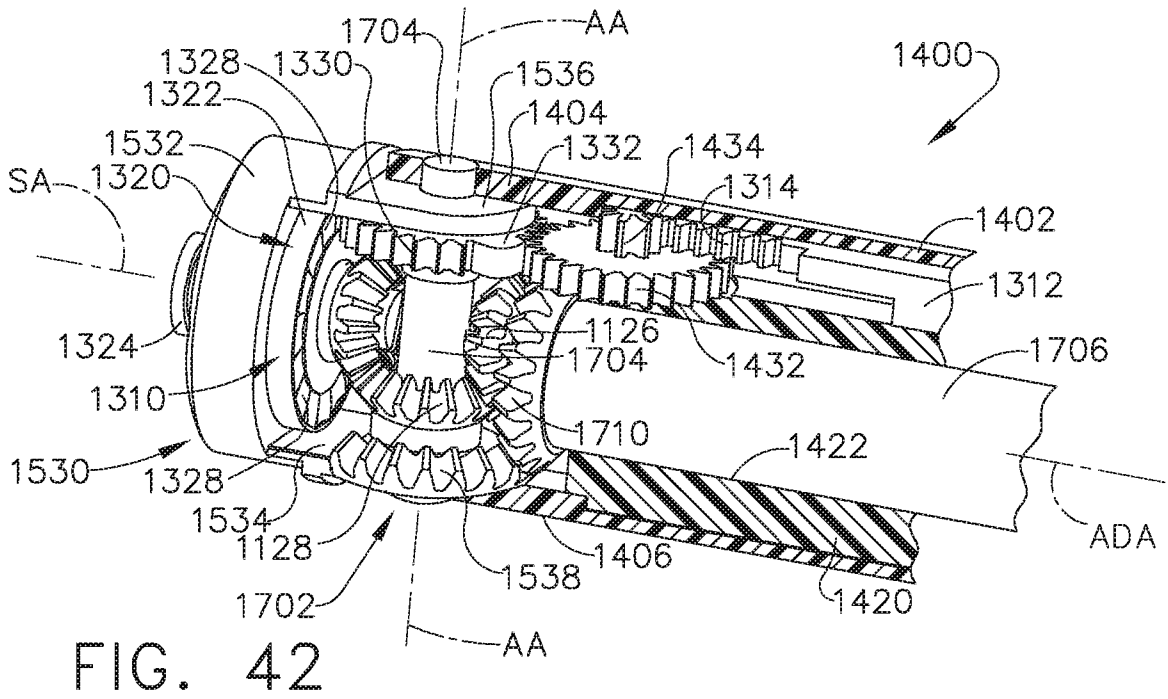


FIG. 42

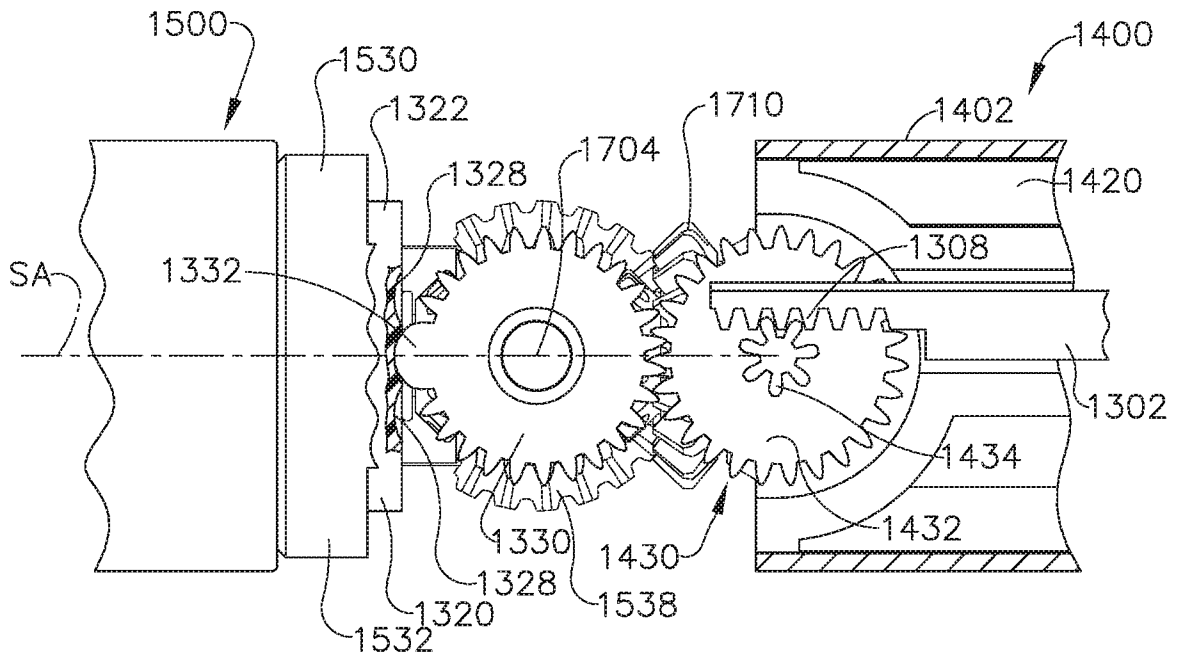


FIG. 43

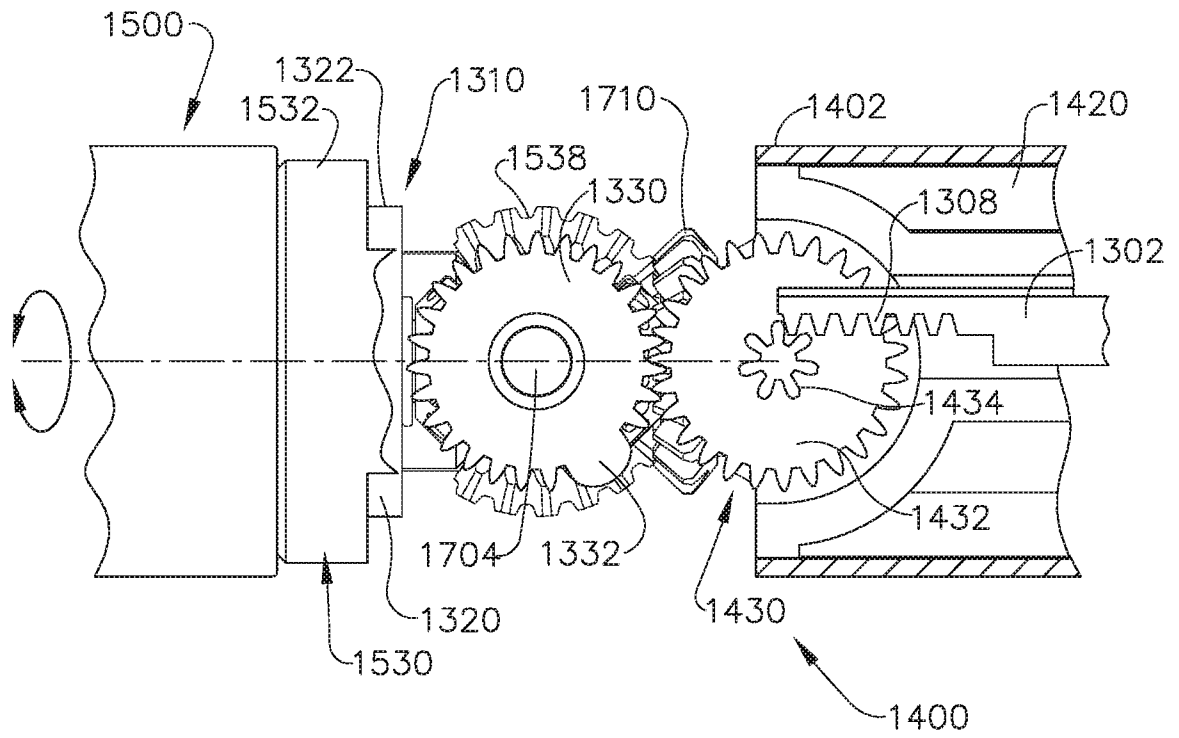


FIG. 44

INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2017/024513

A. CLASSIFICATION OF SUBJECT MATTER  
 INV. A61B17/072  
 ADD. A61B17/29 A61B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
 EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 777 539 A2 (ETHICON ENDO SURGERY INC [US]) 17 September 2014 (2014-09-17) paragraph [0119]; figures 104, 2 paragraph [0048] paragraph [0153]	1-3,8, 12-14
X	US 2014/005718 A1 (SHELTON IV FREDERICK E [US] ET AL) 2 January 2014 (2014-01-02) paragraph [0290] paragraph [0303] paragraph [0304] paragraph [0082]	1-3,8, 12-14
A	EP 1 987 780 A2 (TYCO HEALTHCARE [US]) 5 November 2008 (2008-11-05) paragraph [0047]	1,12,14

Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search  15 May 2017	Date of mailing of the international search report  23/05/2017
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Hausmann, Alexander
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/US2017/024513
---

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
EP 2777539	A2	17-09-2014	AU 2014242023 A1	10-09-2015
			CA 2905698 A1	02-10-2014
			CN 104042269 A	17-09-2014
			CN 104042278 A	17-09-2014
			CN 104042284 A	17-09-2014
			CN 105142541 A	09-12-2015
			EP 2777536 A1	17-09-2014
			EP 2777537 A1	17-09-2014
			EP 2777539 A2	17-09-2014
			EP 2777540 A2	17-09-2014
			JP 2014176695 A	25-09-2014
			JP 2014176701 A	25-09-2014
			JP 2014176703 A	25-09-2014
			RU 2014109797 A	20-09-2015
			RU 2014109798 A	20-09-2015
			RU 2014109799 A	20-09-2015
			US 2014263537 A1	18-09-2014
			US 2014263541 A1	18-09-2014
			US 2014263564 A1	18-09-2014
			US 2014263565 A1	18-09-2014
WO 2014158636 A1	02-10-2014			
US 2014005718	A1	02-01-2014	CN 104582601 A	29-04-2015
			EP 2866694 A1	06-05-2015
			JP 2015527902 A	24-09-2015
			RU 2015102539 A	20-08-2016
			US 2014005718 A1	02-01-2014
			WO 2014004236 A1	03-01-2014
EP 1987780	A2	05-11-2008	AU 2008201630 A1	20-11-2008
			CA 2627954 A1	01-11-2008
			CA 2894076 A1	01-11-2008
			EP 1987780 A2	05-11-2008
			JP 5252692 B2	31-07-2013
			JP 2008272482 A	13-11-2008
			US 2008272172 A1	06-11-2008
			US 2010320254 A1	23-12-2010
			US 2013284790 A1	31-10-2013
			US 2016287255 A1	06-10-2016