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(54) Title: SURGICAL INSTRUMENT WITH ARTICULATING AND AXIALLY TRANSLATABLE END EFFECTOR

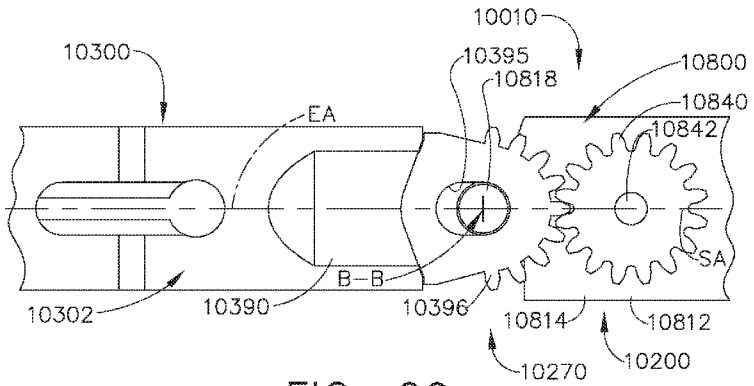

FIG. 99

(57) Abstract: A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. The surgical instrument includes a surgical end effector that has a distal end and a proximal end. The proximal end is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical end effector is selectively pivotable about the articulation axis from an unarticulated position wherein the distal end of the surgical end effector is located an unarticulated distance from the articulation axis to articulated positions wherein the distal end of the surgical end effector is located a corresponding articulated distance from the articulation axis that is less than the unarticulated distance.

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TITLE

SURGICAL INSTRUMENT WITH ARTICULATING AND AXIALLY TRANSLATABLE END EFFECTOR

BACKGROUND

[0001] The present invention relates to surgical instruments and, in various embodiments, to surgical stapling and cutting instruments and staple cartridges for use therewith.

[0002] A stapling instrument can include a pair of cooperating elongate jaw members, wherein each jaw member can be adapted to be inserted into a patient and positioned relative to tissue that is to be stapled and/or incised. In various embodiments, one of the jaw members can support a staple cartridge with at least two laterally spaced rows of staples contained therein, and the other jaw member can support an anvil with staple-forming pockets aligned with the rows of staples in the staple cartridge. Generally, the stapling instrument can further include a pusher bar and a knife blade which are slidable relative to the jaw members to sequentially eject the staples from the staple cartridge via camming surfaces on the pusher bar and/or camming surfaces on a wedge sled that is pushed by the pusher bar. In at least one embodiment, the camming surfaces can be configured to activate a plurality of staple drivers carried by the cartridge and associated with the staples in order to push the staples against the anvil and form laterally spaced rows of deformed staples in the tissue gripped between the jaw members. In at least one embodiment, the knife blade can trail the camming surfaces and cut the tissue along a line between the staple rows.

[0003] The foregoing discussion is intended only to illustrate various aspects of the related art in the field of the invention at the time, and should not be taken as a disavowal of claim scope.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] 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:

[0005] FIG. 1 is a perspective view of a surgical instrument and an elongate shaft assembly embodiment;

[0006] FIG. 2 is an exploded assembly view of the handle or housing portion of the surgical instrument of FIG. 1;

[0007] FIG. 3 is an exploded assembly view of a portion of an elongate shaft assembly;

[0008] FIG. 4 is another exploded assembly view of another portion of the elongate shaft assembly of FIG. 3;

[0009] FIG. 5 is an exploded assembly view of a portion of a surgical end effector embodiment and closure sleeve embodiment;

[0010] FIG. 6 is a partial cross-sectional view of a portion of the surgical end effector and closure sleeve arrangement of FIG. 5;

[0011] FIG. 7 is a perspective view of the surgical end effector and closure sleeve arrangement of FIGS. 5 and 6 with the anvil thereof in an open position or configuration;

[0012] FIG. 8 is another perspective view of the surgical end effector and closure sleeve arrangement of FIGS. 5-7 with the anvil thereof in a closed position or configuration;

[0013] FIG. 9 is a perspective view of a surgical end effector and elongate shaft assembly embodiment with portions thereof omitted for clarity;

[0014] FIG. 10 is a top view of portions of the surgical end effector and elongate shaft assembly embodiment of FIG. 9 with the surgical end effector in an articulated position or configuration;

[0015] FIG. 11 is a partial exploded assembly view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 9 and 10;

[0016] FIG. 12 is a top view of portions of the surgical end effector and elongate shaft assembly of FIGS. 9-11;

[0017] FIG. 13 is a perspective view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 9-12 with the surgical end effector in an articulated position or configuration;

[0018] FIG. 14 is a top view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 9-13 with the surgical end effector in an articulated configuration and with some of the components thereof shown in cross-section for clarity;

[0019] FIG. 15 is a perspective view of a portion of another elongate shaft assembly embodiment;

[0020] FIG. 16 is another perspective view of the elongate shaft assembly embodiment of FIG. 15 with the closure sleeve and closure sleeve components omitted for clarity;

[0021] FIG. 17 is a top view of portions of the elongate shaft assembly embodiment of FIGS.15 and 16;

[0022] FIG. 18 is a cross-sectional side elevational view of the elongate shaft assembly embodiment of FIGS. 15-17 with a surgical staple cartridge mounted in the surgical end effector portion;

[0023] FIG. 19 is another cross-sectional side elevational view of the elongate shaft assembly of FIGS. 15-18 with a surgical staple cartridge mounted in the surgical end effector portion;

[0024] FIG. 20 is a top view of portions of the surgical end effector and elongate shaft assembly of FIGS. 15-19 with the surgical end effector in an articulated position or configuration;

[0025] FIG. 20A is a side elevational view of a portion of another surgical end effector and closure sleeve embodiment;

[0026] FIG. 21 is a perspective view of another surgical end effector and elongate shaft assembly embodiment with portions thereof omitted for clarity;

[0027] FIG. 22 is an exploded assembly view of portions of the surgical end effector and elongate shaft assembly embodiment of FIG. 21;

[0028] FIG. 23 is a top view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 21 and 22;

[0029] FIG. 24 is another top view of the portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 21-23 with portions thereof omitted for clarity;

[0030] FIG. 25 is another top view of the portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 21-24 with the surgical end effector in an articulated position or configuration;

[0031] FIG. 26 is an exploded perspective view of a portion of another elongate shaft assembly embodiment;

[0032] FIG. 27 is an exploded assembly view of portions of another surgical end effector and elongate shaft assembly embodiment;

[0033] FIG. 28 is a partial perspective view of a portion of the elongate shaft assembly embodiment of FIG. 27 with portions thereof omitted for clarity;

[0034] FIG. 29 is another partial perspective view of portions of the elongate shaft assembly embodiment of FIGS. 27 and 28 with portions thereof omitted for clarity;

[0035] FIG. 30 is another partial perspective view of portions of the elongate shaft assembly embodiment of FIGS. 27-29 with portions thereof omitted for clarity;

[0036] FIG. 31 is a top view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 27-30 with portions thereof omitted for clarity;

[0037] FIG. 32 is another top view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 27-31 with portions thereof omitted for clarity and with the surgical end effector in an articulated position or configuration;

[0038] FIG. 33 is a side elevational view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 27-32 with portions thereof omitted for clarity;

[0039] FIG. 34 is a perspective view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 27-33 with portions thereof omitted for clarity;

[0040] FIG. 35 is another partial perspective view of portions of the surgical end effector and elongate shaft assembly embodiment of FIGS. 27-34 with portions thereof omitted for clarity;

[0041] FIG. 36 is an exploded assembly view of portions of a distal firing beam assembly embodiment and lateral load carrying member embodiments;

[0042] FIG. 37 is a perspective view of the distal firing beam assembly and lateral load carrying members of FIG. 36;

[0043] FIG. 38 is an enlarged cross-sectional view of portions of the distal firing beam assembly and lateral load carrying members of FIGS. 36 and 37;

[0044] FIG. 39 is another cross-sectional view of the distal firing beam assembly and lateral load carrying members of FIGS. 36-38;

[0045] FIG. 40 is a side elevational view of a portion of a distal firing beam assembly embodiment attached to a firing member embodiment;

[0046] FIG. 41 is a top view of a portion of the distal firing beam assembly embodiment and firing member embodiment of FIG. 40;

[0047] FIG. 42 is a cross-sectional view of a portion of the distal firing beam assembly embodiment of FIGS. 40 and 41 with lateral load carrying members journaled thereon and with the distal firing beam assembly embodiment in a flexed position or configuration;

[0048] FIG. 43 is a perspective view of the distal firing beam assembly embodiment and lateral load carrying embodiments of FIG. 42;

[0049] FIG. 44 is a perspective view of portions of another surgical end effector embodiment and elongate shaft assembly embodiment with portions thereof omitted for clarity and with the surgical end effector in an articulated position or configuration;

[0050] FIG. 45 is a top view of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 44;

[0051] FIG. 46 is another top view of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 45 with portions of the pivot link thereof shown in cross-section;

[0052] FIG. 47 is a partial perspective view of portions of another surgical end effector embodiment and elongate shaft assembly embodiment with portions thereof omitted for clarity;

[0053] FIG. 48 is a top view of portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 47 with portions thereof omitted for clarity;

[0054] FIG. 49 is another top view of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 48;

[0055] FIG. 50 is a top perspective view of portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIGS. 47-49 with portions thereof omitted for clarity and the surgical end effector in an articulated position or configuration;

[0056] FIG. 51 is another top perspective view of portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 50;

[0057] FIG. 52 is an enlarged perspective view of portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 51;

[0058] FIG. 53 is a top view of portions of another surgical end effector embodiment and elongate shaft assembly embodiment with portions thereof omitted for clarity and illustrating the surgical end effector in an unarticulated position or configuration and an articulated position or configuration;

[0059] FIG. 54 is a top view of a portion of the elongate shaft assembly embodiment of FIG. 53 with the articulation system in a neutral or unarticulated position or configuration and with portions of the elongate shaft assembly omitted for clarity;

[0060] FIG. 55 is another top view of a portion of the elongate shaft assembly embodiment of FIG. 54 with the articulation system in a first articulated position or configuration;

[0061] FIG. 56 is another top view of a portion of the elongate shaft assembly embodiment of FIGS. 54 and 55 with the articulation system in a second articulated position or configuration;

[0062] FIG. 57 is a partial perspective view of other portions of the elongated shaft assembly embodiment of FIGS. 53-56 and portions of the surgical end effector embodiment in an unarticulated position or configuration and with portions thereof omitted for clarity;

[0063] FIG. 58 is another partial perspective view of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 57 with portions thereof omitted for clarity;

[0064] FIG. 59 is a top view of a portion of another elongate shaft assembly embodiment with portions thereof omitted for clarity;

[0065] FIG. 60 is a top view of portions of another articulation system embodiment in a neutral or unarticulated position;

[0066] FIG. 61 is a top view of a driver articulation disc embodiment of the articulation system of FIG. 60;

[0067] FIG. 62 is a top view of a driven articulation disc embodiment of the articulation system FIG. 60;

[0068] FIG. 63 is another top view of the articulation system embodiment of FIG. 60 in a position or configuration after an articulation control motion has been initially applied thereto;

[0069] FIG. 64 is another top view of the articulation system embodiment of FIG. 63 in a first articulated position or configuration;

[0070] FIG. 65 is another top view of the articulation system embodiment of FIGS. 63 and 64 in a second articulated position or configuration;

[0071] FIG. 66 is a perspective view of another surgical end effector and closure sleeve embodiment with the jaws thereof in a closed position or configuration;

[0072] FIG. 67 is another perspective view of the surgical end effector and closure sleeve embodiment of FIG. 66 with the jaws thereof in an open position or configuration;

[0073] FIG. 68 is a side elevational view of the surgical end effector and closure sleeve embodiment of FIGS. 66 and 67 with the closure sleeve shown in cross-section and the jaws thereof in an open position or configuration;

[0074] FIG. 69 is a side elevational view of the surgical end effector and closure sleeve embodiment of FIGS. 66-68 shown in cross-section and with the jaws thereof in an open position or configuration;

[0075] FIG. 70 is an exploded assembly view of the surgical end effector and closure sleeve embodiment of FIGS. 66-69;

[0076] FIG. 71 is an exploded assembly view of another surgical end effector and closure sleeve embodiment;

[0077] FIG. 72 is a perspective view of another surgical end effector and closure sleeve embodiment with the jaws thereof in an open position or configuration;

[0078] FIG. 73 is another perspective view of the surgical end effector and closure sleeve embodiment of FIG. 72 with the jaws thereof in a closed position or configuration;

[0079] FIG. 74 is an exploded perspective assembly view of the surgical end effector and closure sleeve embodiment of FIGS. 72 and 73;

[0080] FIG. 75 is a side elevational view of the surgical end effector and closure sleeve embodiment of FIGS. 72-74 with the jaws thereof in a closed position or configuration;

[0081] FIG. 76 is a rear perspective view of the surgical end effector embodiment of FIGS. 72-75 with the closure sleeve embodiment thereof shown in phantom lines for clarity;

[0082] FIG. 77 is a side cross-sectional view of the surgical end effector and closure sleeve embodiment of FIGS. 72-76 with the jaws thereof in a closed position or configuration;

[0083] FIG. 78 is another side cross-sectional view including one of the cam plates of the surgical end effector and closure sleeve embodiment of FIGS. 72-77 with the jaws thereof in a closed position or configuration;

[0084] FIG. 79 is another side cross-sectional view including one of the cam plates of the surgical end effector and closure sleeve embodiment of FIGS. 72-78 with the jaws thereof in an open position or configuration;

[0085] FIG. 80 is a partial perspective view of another surgical end effector and closure sleeve embodiment with the jaws thereof in an open position or configuration;

[0086] FIG. 81 is a partial perspective view of the surgical end effector and closure sleeve embodiment of FIG. 80 with the jaws thereof in a closed position or configuration;

[0087] FIG. 82 is an exploded perspective assembly view of the surgical end effector and closure sleeve embodiment of FIGS. 80 and 81;

[0088] FIG. 83 is a side elevational view of the surgical end effector and closure sleeve embodiment of FIGS. 80-82 with the jaws thereof in a closed position or configuration;

[0089] FIG. 84 is a side elevational view of the surgical end effector and closure sleeve embodiment of FIGS. 80-83 with a portion of the closure sleeve shown in cross-section and with the jaws thereof in an open position or configuration;

[0090] FIG. 85 is an exploded perspective assembly view of another surgical end effector and closure sleeve embodiment;

[0091] FIG. 86 is a side elevational view of the surgical end effector and closure sleeve embodiment of FIG. 85 with the jaws thereof in a closed position or configuration;

[0092] FIG. 87 is a side elevational view of the surgical end effector and closure sleeve embodiment of FIGS. 85 and 86 with the jaws thereof in an open position or configuration with a portion of the closure sleeve shown in cross-section;

[0093] FIG. 88 is a perspective view of a portion of another elongate shaft assembly embodiment;

[0094] FIG. 89 is another perspective view of the elongate shaft assembly embodiment of FIG. 88 with some components thereof omitted for clarity;

[0095] FIG. 90 is another perspective view of the elongate shaft assembly of FIGS. 88 and 89 with the surgical end effector in an articulated position or configuration;

[0096] FIG. 91 is an exploded assembly view of the elongate shaft assembly of FIGS. 88-90;

[0097] FIG. 92 is a top view of the elongate shaft assembly of FIGS. 88-91 with some components omitted for clarity and the surgical end effector thereof articulated in one direction;

[0098] FIG. 93 is another top view of the elongate shaft assembly of FIGS. 88-92 with some components thereof omitted for clarity and with the surgical end effector articulated in another direction;

[0099] FIG. 94 is a perspective view of a surgical staple cartridge embodiment;

[0100] FIG. 95 is a perspective view of another surgical staple cartridge embodiment;

[0101] FIG. 96 is a perspective view of a portion of another elongate shaft assembly coupled to a surgical end effector;

[0102] FIG. 97 is another perspective view of the elongate shaft assembly and surgical end effector of FIG. 96 in an unarticulated orientation and with portions thereof omitted for clarity;

[0103] FIG. 98 is a top view of the portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIGS. 96 and 97 with the surgical end effector in an articulated orientation;

[0104] FIG. 99 is another top view of the portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIGS. 96-98 with portions thereof omitted for clarity;

[0105] FIG. 100 is another top view of portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 99 in an articulated orientation;

[0106] FIG. 101 is another top view of portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 100 in an unarticulated orientation;

[0107] FIG. 102 is another top view of portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 101 with the surgical end effector articulated in a first articulation direction;

[0108] FIG. 103 is another top view of portions of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 102 with the surgical end effector articulated in a second articulation direction;

[0109] FIG. 104 is a top view of portions of another surgical end effector embodiment and another elongate shaft assembly embodiment in an unarticulated orientation;

[0110] FIG. 105 is another top view of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 104 with the surgical end effector in an articulated orientation;

[0111] FIG. 106 is a top view of a portion of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation with portions thereof omitted for clarity;

[0112] FIG. 107 is another top view of the surgical end effector and elongate shaft assembly of FIG. 106 in a first articulated orientation;

[0113] FIG. 108 is another top view of the surgical end effector and elongate shaft assembly of FIG. 107 in a second articulated orientation;

[0114] FIG. 109 is a top view of a portion of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation with portions thereof omitted for clarity;

[0115] FIG. 110 is another top view of the surgical end effector and elongate shaft assembly of FIG. 109 in a first articulated orientation;

[0116] FIG. 111 is another top view of the surgical end effector and elongate shaft assembly of FIG. 110 in a second articulated orientation;

[0117] FIG. 112 is a top view of a portion of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation with portions thereof omitted for clarity;

[0118] FIG. 113 is another top view of the surgical end effector and elongate shaft assembly of FIG. 112 in a first articulated orientation;

[0119] FIG. 114 is another top view of the surgical end effector and elongate shaft assembly of FIG. 113 in a second articulated orientation;

[0120] FIG. 115 is a top view of a portion of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation with portions thereof omitted for clarity;

[0121] FIG. 116 is another top view of the surgical end effector and elongate shaft assembly of FIG. 115 in a first articulated orientation;

[0122] FIG. 117 is another top view of the surgical end effector and elongate shaft assembly of FIG. 116 in a second articulated orientation;

[0123] FIG. 118 is a top view of a portion of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation with portions thereof omitted for clarity;

[0124] FIG. 119 is another top view of the surgical end effector and elongate shaft assembly of FIG. 118 in a first articulated orientation;

[0125] FIG. 120 is a partial perspective view of a portion of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation with portions thereof omitted for clarity;

[0126] FIG. 121 is a top view of the surgical end effector and elongate shaft assembly of FIG. 120 in an unarticulated orientation;

[0127] FIG. 122 is another top view of the surgical end effector and elongate shaft assembly of FIG. 121 in a first articulated orientation;

[0128] FIG. 123 is a partial perspective view of a portion of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation with portions thereof omitted for clarity;

[0129] FIG. 124 is another perspective view of the surgical end effector embodiment and elongate shaft assembly embodiment of FIG. 123 in an unarticulated orientation;

[0130] FIG. 125 is an exploded assembly perspective view of the surgical end effector embodiment and elongate shaft assembly embodiment of FIGS. 123 and 124;

[0131] FIG. 126 is a top view of the surgical end effector embodiment and elongate shaft assembly embodiment of FIGS. 123-125 in an unarticulated orientation;

[0132] FIG. 127 is another top view of the surgical end effector and elongate shaft assembly of FIGS. 123-126 in a first articulated orientation;

[0133] FIG. 128 is another top view of the surgical end effector and elongate shaft assembly of FIGS. 123-128 in a second articulated orientation;

[0134] FIG. 129 is a partial perspective view of a portion of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation with portions thereof omitted for clarity;

[0135] FIG. 130 is a top view of the surgical end effector and elongate shaft assembly of FIG. 129 in a an unarticulated orientation;

[0136] FIG. 131 is another top view of the surgical end effector and elongate shaft assembly of FIGS. 129 and 130 in a first articulated orientation;

[0137] FIG. 132 is a partial perspective view of portions of a spine of an elongate shaft assembly and firing beam coupler embodiment;

[0138] FIG. 132A is a partial cross-sectional view of portions of a spine of an elongate shaft assembly another firing beam coupler and lock arrangement;

[0139] FIG. 133 is a top view of the spine and firing beam coupler embodiment of FIG. 132 with a firing beam embodiment installed therein;

[0140] FIG. 134 is a top view of a proximal end of a firing beam embodiment;

[0141] FIG. 135 is a top view of a proximal end of another firing beam embodiment;

[0142] FIG. 136 is a top view of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation and with various components omitted for clarity;

[0143] FIG. 137 is another top view of the surgical end effector and elongate shaft assembly of FIG. 136 in a first articulated orientation;

[0144] FIG. 138 is a partial perspective view of another surgical end effector and elongate shaft assembly embodiment in an unarticulated orientation and with components thereof omitted for clarity;

[0145] FIG. 139 is an exploded perspective assembly view of the surgical end effector and elongate shaft assembly of FIG. 138;

[0146] FIG. 140 is another exploded perspective view of portions of the surgical end effector and elongate shaft assembly of FIG. 139;

[0147] FIG. 141 is another perspective view of the surgical end effector and elongate shaft assembly of FIGS. 138-140 in a first articulated orientation;

[0148] FIG. 142 is another perspective view of the surgical end effector and elongate shaft assembly of FIGS. 138-141 in a second articulated orientation;

[0149] FIG. 143 is a top view of a portion of another elongate shaft assembly;

[0150] FIG. 144 is a partial exploded assembly view of the elongate shaft assembly of FIG. 143 and a portion of a surgical end effector;

[0151] FIG. 145 is a perspective view of another surgical end effector embodiment and elongate shaft assembly embodiment in an unarticulated orientation;

[0152] FIG. 146 is a top view of the cable member and pulley arrangement of the surgical end effector and elongate shaft assembly of FIG. 145;

[0153] FIG. 147 is an exploded assembly view of portions of the surgical end effector and elongate shaft assembly of FIG. 145;

[0154] FIG. 148 is a side elevational view of a portion of another elongate shaft assembly;

[0155] FIG. 149 is an exploded assembly view of the elongate shaft assembly of FIG. 148;

[0156] FIG. 150 is a top view of portions of another elongate shaft assembly with components thereof omitted for clarity;

[0157] FIG. 151 is a partial cross-sectional view of a portion of a cable member of an elongate shaft assembly and a tensioning screw arrangement for introducing tension into the cable member;

[0158] FIG. 152 is a cross-sectional perspective view of a closure sleeve embodiment;

[0159] FIG. 153 is a cross-sectional view of another closure sleeve embodiment;

[0160] FIG. 154 is a cross-sectional view of portions of another closure sleeve embodiment;

[0161] FIG. 155 is a cross-sectional view of portions of another closure sleeve embodiment;

[0162] FIG. 156 is a cross-sectional view of portions of another closure sleeve embodiment;

[0163] FIG. 157 is a cross-sectional perspective view of portions of another elongate shaft assembly; and

[0164] FIG. 158 is another cross-sectional view of portions of the elongate shaft assembly of FIG. 157.

[0165] 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

[0166] 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 SURGICAL INSTRUMENTS WITH NON-SYMMETRICAL ARTICULATION ARRANGEMENTS, Attorney Docket No. END7851USNP/150530;
- U.S. Patent Application Serial No. _____, entitled ARTICULATABLE SURGICAL INSTRUMENTS WITH OFF-AXIS FIRING BEAM ARRANGEMENTS, Attorney Docket No. END7854USNP/150533;
- U.S. Patent Application Serial No. _____, entitled ARTICULATABLE SURGICAL INSTRUMENTS WITH SINGLE ARTICULATION LINK ARRANGEMENTS, Attorney Docket No. END7852USNP/150531;
- U.S. Patent Application Serial No. _____, entitled SURGICAL INSTRUMENTS WITH AN END EFFECTOR THAT IS HIGHLY ARTICULATABLE RELATIVE TO AN ELONGATE SHAFT ASSEMBLY, Attorney Docket No. END7850USNP/150529;

- U.S. Patent Application Serial No. _____, entitled SURGICAL INSTRUMENT ARTICULATION MECHANISM WITH SLOTTED SECONDARY CONSTRAINT, Attorney Docket No. END7849USNP/150528;
- U.S. Patent Application Serial No. _____, entitled SURGICAL INSTRUMENTS WITH MULTIPLE LINK ARTICULATION ARRANGEMENTS, Attorney Docket No. END7848USNP/150527;
- U.S. Patent Application Serial No. _____, entitled SURGICAL INSTRUMENTS WITH TENSIONING ARRANGEMENTS FOR CABLE DRIVEN ARTICULATION SYSTEMS, Attorney Docket No. END7853USNP/150532; and
- U.S. Patent Application Serial No. _____, entitled SURGICAL INSTRUMENTS WITH CLOSURE STROKE REDUCTION ARRANGEMENTS, Attorney Docket No. END7855USNP/150534.

[0167] 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. 14/742,933, entitled SURGICAL STAPLING INSTRUMENTS WITH LOCKOUT ARRANGEMENTS FOR PREVENTING FIRING SYSTEM ACTUATION WHEN A CARTRIDGE IS SPENT OR MISSING;
- 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; and
- U.S. Patent Application Serial No. 14/742,876, entitled PUSH/PULL ARTICULATION DRIVE SYSTEMS FOR ARTICULATABLE SURGICAL INSTRUMENTS.

[0168] 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;
- 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.

[0169] 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.

[0170] 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.

[0171] 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.

[0172] 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.

[0173] 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.

[0174] 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.

[0175] 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;

- U.S. Patent Application Serial No. 14/479,119, entitled ADJUNCT WITH INTEGRATED SENSORS TO QUANTIFY TISSUE COMPRESSION;
- U.S. Patent Application Serial No. 14/478,908, entitled MONITORING DEVICE DEGRADATION BASED ON COMPONENT EVALUATION;
- U.S. Patent Application Serial No. 14/478,895, entitled MULTIPLE SENSORS WITH ONE SENSOR AFFECTING A SECOND SENSOR'S OUTPUT OR INTERPRETATION;
- U.S. Patent Application Serial No. 14/479,110, entitled USE OF POLARITY OF HALL MAGNET DETECTION TO DETECT MISLOADED CARTRIDGE;
- U.S. Patent Application Serial No. 14/479,098, entitled SMART CARTRIDGE WAKE UP OPERATION AND DATA RETENTION;
- U.S. Patent Application Serial No. 14/479,115, entitled MULTIPLE MOTOR CONTROL FOR POWERED MEDICAL DEVICE; and
- U.S. Patent Application Serial No. 14/479,108, entitled LOCAL DISPLAY OF TISSUE PARAMETER STABILIZATION.

[0176] 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 entireties:

- 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.

[0177] 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.

[0178] 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.

[0179] 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.

[0180] 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.

[0181] 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.

[0182] 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.

[0183] 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.

[0184] 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.

[0185] 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.

[0186] FIGS. 1-4 depict a motor-driven surgical cutting and fastening instrument 10 that may or may not be reused. In the illustrated embodiment, the instrument 10 includes a housing 12 that comprises a

handle 14 that is configured to be grasped, manipulated and actuated by the clinician. The housing 12 is configured for operable attachment to an elongate shaft assembly 200 that has a surgical end effector 300 operably coupled thereto that is configured to perform one or more surgical tasks or procedures. The elongate shaft assembly 200 may be interchangeable with other shaft assemblies in the various manners disclosed, for example, in 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, the entire disclosure of which is hereby incorporated by reference herein. In other arrangements, the elongate shaft assembly may not be interchangeable with other shaft assemblies and essentially comprise a dedicated non-removable portion of the instrument.

[0187] As the present Detailed Description proceeds, it will be understood that the various forms of interchangeable shaft assemblies disclosed herein may also be effectively employed in connection with robotically-controlled surgical systems. Thus, the term "housing" 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 shaft assemblies disclosed herein may be employed with various robotic systems, instruments, components and methods disclosed in U.S. Patent Application Serial No. 13/118,241, entitled SURGICAL STAPLING INSTRUMENTS WITH ROTATABLE STAPLE DEPLOYMENT ARRANGEMENTS, now U.S. Patent No. 9,072,535, which is hereby incorporated by reference herein in its entirety.

[0188] The housing 12 depicted in FIG. 1 is shown in connection with the elongate shaft assembly 200 that includes a surgical end effector 300 that comprises a surgical cutting and fastening device that is configured to operably support a surgical staple cartridge 304 therein. The housing 12 may be configured for use in connection with shaft assemblies that include end effectors that are adapted to support different sizes and types of staple cartridges, have different shaft lengths, sizes, and types, etc. In addition, the housing 12 may also be effectively employed with a variety of other shaft assemblies including those assemblies that are configured to apply other motions and forms of energy such as, for example, radio frequency (RF) energy, ultrasonic energy and/or motion to end effector arrangements adapted for use in connection with various surgical applications and procedures. Furthermore, the end

effectors, shaft assemblies, handles, surgical instruments, and/or surgical instrument systems can 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 shaft assembly.

[0189] FIG. 1 illustrates the housing 12 or handle 14 of the surgical instrument 10 with an interchangeable elongate shaft assembly 200 operably coupled thereto. As can be seen in FIG. 1, the handle 14 may comprise a pair of interconnectable handle housing segments 16 and 18 that may be interconnected by screws, snap features, adhesive, etc. In the illustrated arrangement, the handle housing segments 16, 18 cooperate to form a pistol grip portion 19 that can be gripped and manipulated by the clinician. As will be discussed in further detail below, the handle 14 operably supports a plurality of drive systems therein that are configured to generate and apply various control motions to corresponding portions of the interchangeable shaft assembly that is operably attached thereto.

[0190] Referring now to FIG. 2, the handle 14 may further include a frame 20 that operably supports a plurality of drive systems. For example, the frame 20 can operably support a "first" or closure drive system, generally designated as 30, which may be employed to apply closing and opening motions to the elongate shaft assembly 200 that is operably attached or coupled thereto. In at least one form, the closure drive system 30 may include an actuator in the form of a closure trigger 32 that is pivotally supported by the frame 20. More specifically, as illustrated in FIG. 2, the closure trigger 32 is pivotally coupled to the housing 14 by a pin 33. Such arrangement enables the closure trigger 32 to be manipulated by a clinician such that when the clinician grips the pistol grip portion 19 of the handle 14, the closure trigger 32 may be easily pivoted from a starting or "unactuated" position to an "actuated" position and more particularly to a fully compressed or fully actuated position. The closure trigger 32 may be biased into the unactuated position by spring or other biasing arrangement (not shown). In various forms, the closure drive system 30 further includes a closure linkage assembly 34 that is pivotally coupled to the closure trigger 32. As can be seen in FIG. 2, the closure linkage assembly 34 may include a first closure link 36 and a second closure link 38 that are pivotally coupled to the closure trigger 32 by a pin 35. The second closure link 38 may also be referred to herein as an "attachment member" and include a transverse attachment pin 37.

[0191] Still referring to FIG. 2, it can be observed that the first closure link 36 may have a locking wall or end 39 thereon that is configured to cooperate with a closure release assembly 60 that is pivotally coupled to the frame 20. In at least one form, the closure release assembly 60 may comprise

a release button assembly 62 that has a distally protruding locking pawl 64 formed thereon. The release button assembly 62 may be pivoted in a counterclockwise direction by a release spring (not shown). As the clinician depresses the closure trigger 32 from its unactuated position towards the pistol grip portion 19 of the handle 14, the first closure link 36 pivots upward to a point wherein the locking pawl 64 drops into retaining engagement with the locking wall 39 on the first closure link 36 thereby preventing the closure trigger 32 from returning to the unactuated position. Thus, the closure release assembly 60 serves to lock the closure trigger 32 in the fully actuated position. When the clinician desires to unlock the closure trigger 32 to permit it to be biased to the unactuated position, the clinician simply pivots the closure release button assembly 62 such that the locking pawl 64 is moved out of engagement with the locking wall 39 on the first closure link 36. When the locking pawl 64 has been moved out of engagement with the first closure link 36, the closure trigger 32 may pivot back to the unactuated position. Other closure trigger locking and release arrangements may also be employed.

[0192] When the closure trigger 32 is moved from its unactuated position to its actuated position, the closure release button 62 is pivoted between a first position and a second position. The rotation of the closure release button 62 can be referred to as being an upward rotation; however, at least a portion of the closure release button 62 is being rotated toward the circuit board 100. Still referring to FIG. 2, the closure release button 62 can include an arm 61 extending therefrom and a magnetic element 63, such as a permanent magnet, for example, mounted to the arm 61. When the closure release button 62 is rotated from its first position to its second position, the magnetic element 63 can move toward the circuit board 100. The circuit board 100 can include at least one sensor that is configured to detect the movement of the magnetic element 63. In at least one embodiment, a "Hall effect" sensor can be mounted to the bottom surface of the circuit board 100. The Hall effect sensor can be configured to detect changes in a magnetic field surrounding the Hall effect sensor that are caused by the movement of the magnetic element 63. The Hall effect sensor can be in signal communication with a microcontroller, for example, which can determine whether the closure release button 62 is in its first position, which is associated with the unactuated position of the closure trigger 32 and the open configuration of the end effector, its second position, which is associated with the actuated position of the closure trigger 32 and the closed configuration of the end effector, and/or any position between the first position and the second position.

[0193] Also in the illustrated arrangement, the handle 14 and the frame 20 operably support another drive system referred to herein as a firing drive system 80 that is configured to apply firing motions to

corresponding portions of the interchangeable shaft assembly attached thereto. The firing drive system may 80 also be referred to herein as a "second drive system". The firing drive system 80 may employ an electric motor 82, located in the pistol grip portion 19 of the handle 14. In various forms, the motor 82 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 82 may be powered by a power source 90 that in one form may comprise a removable power pack 92. As can be seen in FIG. 2, for example, the power pack 92 may comprise a proximal housing portion 94 that is configured for attachment to a distal housing portion 96. The proximal housing portion 94 and the distal housing portion 96 are configured to operably support a plurality of batteries 98 therein. Batteries 98 may each comprise, for example, a Lithium Ion ("LI") or other suitable battery. The distal housing portion 96 is configured for removable operable attachment to a control circuit board assembly 100 which is also operably coupled to the motor 82. A number of batteries 98 may be connected in series may be used as the power source for the surgical instrument 10. In addition, the power source 90 may be replaceable and/or rechargeable.

[0194] As outlined above with respect to other various forms, the electric motor 82 includes a rotatable shaft (not shown) that operably interfaces with a gear reducer assembly 84 that is mounted in meshing engagement with a with a set, or rack, of drive teeth 122 on a longitudinally-movable drive member 120. In use, a voltage polarity provided by the power source 90 can operate the electric motor 82 in a clockwise direction wherein the voltage polarity applied to the electric motor by the battery can be reversed in order to operate the electric motor 82 in a counter-clockwise direction. When the electric motor 82 is rotated in one direction, the drive member 120 will be axially driven in the distal direction DD. When the motor 82 is driven in the opposite rotary direction, the drive member 120 will be axially driven in a proximal direction PD. The handle 14 can include a switch which can be configured to reverse the polarity applied to the electric motor 82 by the power source 90. As with the other forms described herein, the handle 14 can also include a sensor that is configured to detect the position of the drive member 120 and/or the direction in which the drive member 120 is being moved.

[0195] Actuation of the motor 82 is controlled by a firing trigger 130 that is pivotally supported on the handle 14. The firing trigger 130 may be pivoted between an unactuated position and an actuated position. The firing trigger 130 may be biased into the unactuated position by a spring 132 or other biasing arrangement such that when the clinician releases the firing trigger 130, it may be pivoted or otherwise returned to the unactuated position by the spring 132 or biasing arrangement. In at least one

form, the firing trigger 130 can be positioned "outboard" of the closure trigger 32 as was discussed above. In at least one form, a firing trigger safety button 134 may be pivotally mounted to the closure trigger 32 by pin 35. The safety button 134 may be positioned between the firing trigger 130 and the closure trigger 32 and have a pivot arm 136 protruding therefrom. See FIG. 2. When the closure trigger 32 is in the unactuated position, the safety button 134 is contained in the handle 14 where the clinician cannot readily access it and move it between a safety position preventing actuation of the firing trigger 130 and a firing position wherein the firing trigger 130 may be fired. As the clinician depresses the closure trigger 32, the safety button 134 and the firing trigger 130 pivot down wherein they can then be manipulated by the clinician.

[0196] As discussed above, the handle 14 includes a closure trigger 32 and a firing trigger 130. The firing trigger 130 can be pivotably mounted to the closure trigger 32. When the closure trigger 32 is moved from its unactuated position to its actuated position, the firing trigger 130 can descend downwardly, as outlined above. After the safety button 134 has been moved to its firing position, the firing trigger 130 can be depressed to operate the motor of the surgical instrument firing system. In various instances, the handle 14 can include a tracking system configured to determine the position of the closure trigger 32 and/or the position of the firing trigger 130.

[0197] As indicated above, in at least one form, the longitudinally movable drive member 120 has a rack of drive teeth 122 formed thereon for meshing engagement with a corresponding drive gear 86 of the gear reducer assembly 84. At least one form also includes a manually-actuatable "bailout" assembly 140 that is configured to enable the clinician to manually retract the longitudinally movable drive member 120 should the motor 82 become disabled. The bailout assembly 140 may include a lever or bailout handle assembly 142 that is configured to be manually pivoted into ratcheting engagement with teeth 124 also provided in the drive member 120. Thus, the clinician can manually retract the drive member 120 by using the bailout handle assembly 142 to ratchet the drive member 120 in the proximal direction PD. U.S. Patent Application Publication No. 2010/0089970, now U.S. Patent No. 8,608,045, discloses bailout arrangements and other components, arrangements and systems that may also be employed with the various instruments disclosed herein. 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, is hereby incorporated by reference in its entirety.

[0198] Turning now to FIGS. 1 and 3, the elongate shaft assembly 200 includes a surgical end effector 300 that comprises an elongate channel 302 that is configured to operably support a staple

cartridge 304 therein. The end effector 300 may further include an anvil 310 that is pivotally supported relative to the elongate channel 302. As will be discussed in further detail below, the surgical end effector 300 may be articulated relative to the elongate shaft assembly about an articulation joint 270. As can be seen in FIGS. 3 and 4, the shaft assembly 200 can further include a proximal housing or nozzle 201 comprised of nozzle portions 202 and 203. The shaft assembly 200 further includes a closure sleeve 260 which can be utilized to close and/or open an anvil 310 of the end effector 300. As can be seen in FIG. 4, the shaft assembly 200 includes a spine 210 which can be configured to fixably support a shaft frame portion 212 of an articulation lock 350. Details regarding the construction and operation of the articulation lock 350 are set forth in 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, the disclosure of which is hereby incorporated by reference herein in its entirety. The spine 210 is configured to, one, slidably support a firing member 220 therein and, two, slidably support the closure sleeve 260 which extends around the spine 210. The spine 210 also slidably supports a proximal articulation driver 230. The proximal articulation driver 230 has a distal end 231 that is configured to operably engage the articulation lock 350. In one arrangement, the articulation lock 350 interfaces with an articulation frame 352 that is adapted to operably engage a drive pin (not shown) on the end effector frame (not shown).

[0199] In the illustrated arrangement, the spine 210 comprises a proximal end 211 which is rotatably supported in a chassis 240. In one arrangement, for example, the proximal end 211 of the spine 210 has a thread 214 formed thereon for threaded attachment to a spine bearing 216 configured to be supported within the chassis 240. See FIG. 3. Such arrangement facilitates rotatable attachment of the spine 210 to the chassis 240 such that the spine 210 may be selectively rotated about a shaft axis SA-SA relative to the chassis 240. The shaft assembly 200 also includes a closure shuttle 250 that is slidably supported within the chassis 240 such that it may be axially moved relative thereto. As can be seen in FIG. 3, the closure shuttle 250 includes a pair of proximally-protruding hooks 252 that are configured for attachment to the attachment pin 37 that is attached to the second closure link 38 as will be discussed in further detail below. See FIG. 2. A proximal end 261 of the closure sleeve 260 is coupled to the closure shuttle 250 for relative rotation thereto. For example, a U-shaped connector 263 is inserted into an annular slot 262 in the proximal end 261 of the closure sleeve 260 and is retained within vertical slots 253 in the closure shuttle 250. See FIG. 3. Such arrangement serves to attach the closure sleeve 260 to the closure shuttle 250 for axial travel therewith while enabling the closure sleeve

260 to rotate relative to the closure shuttle 250 about the shaft axis SA-SA. A closure spring 268 is journaled on the closure sleeve 260 and serves to bias the closure sleeve 260 in the proximal direction PD which can serve to pivot the closure trigger into the unactuated position when the shaft assembly 200 is operably coupled to the handle 14.

[0200] As was also indicated above, the elongate shaft assembly 200 further includes a firing member 220 that is supported for axial travel within the shaft spine 210. The firing member 220 includes an intermediate firing shaft portion 222 that is configured for attachment to a distal cutting portion or firing beam 280. The firing member 220 may also be referred to herein as a "second shaft" and/or a "second shaft assembly". As can be seen in FIG. 4, the intermediate firing shaft portion 222 may include a longitudinal slot 223 in the distal end thereof which can be configured to receive a tab 284 on the proximal end 282 of the distal firing beam 280. The longitudinal slot 223 and the proximal end 282 can be sized and configured to permit relative movement therebetween and can comprise a slip joint 286. The slip joint 286 can permit the intermediate firing shaft portion 222 of the firing drive 220 to be moved to articulate the surgical end effector 300 without moving, or at least substantially moving, the firing beam 280. Once the surgical end effector 300 has been suitably oriented, the intermediate firing shaft portion 222 can be advanced distally until a proximal sidewall of the longitudinal slot 223 comes into contact with the tab 284 in order to advance the firing beam 280 and fire a staple cartridge that may be supported in the end effector 300. As can be further seen in FIG. 4, the shaft spine 210 has an elongate opening or window 213 therein to facilitate assembly and insertion of the intermediate firing shaft portion 222 into the shaft frame 210. Once the intermediate firing shaft portion 222 has been inserted therein, a top frame segment 215 may be engaged with the shaft frame 212 to enclose the intermediate firing shaft portion 222 and firing beam 280 therein. Further description of the operation of the firing member 220 may be found in U.S. Patent Application Serial No. 13/803,086, now U.S. Patent Application Publication No. 2014/0263541.

[0201] Further to the above, the illustrated shaft assembly 200 includes a clutch assembly 400 which can be configured to selectively and releasably couple the articulation driver 230 to the firing member 220. In one form, the clutch assembly 400 includes a lock collar, or sleeve 402, positioned around the firing member 220 wherein the lock sleeve 402 can be rotated between an engaged position in which the lock sleeve 402 couples the articulation driver 360 to the firing member 220 and a disengaged position in which the articulation driver 360 is not operably coupled to the firing member 200. When lock sleeve 402 is in its engaged position, distal movement of the firing member 220 can move the articulation driver 360 distally and, correspondingly, proximal movement of the firing member 220 can

move the proximal articulation driver 230 proximally. When lock sleeve 402 is in its disengaged position, movement of the firing member 220 is not transmitted to the proximal articulation driver 230 and, as a result, the firing member 220 can move independently of the proximal articulation driver 230. In various circumstances, the proximal articulation driver 230 can be held in position by the articulation lock 350 when the proximal articulation driver 230 is not being moved in the proximal or distal directions by the firing member 220.

[0202] As can be further seen in FIG. 4, the lock sleeve 402 can comprise a cylindrical, or an at least substantially cylindrical, body including a longitudinal aperture 403 defined therein configured to receive the firing member 220. The lock sleeve 402 can comprise diametrically-opposed, inwardly-facing lock protrusions 404 and an outwardly-facing lock member 406. The lock protrusions 404 can be configured to be selectively engaged with the firing member 220. More particularly, when the lock sleeve 402 is in its engaged position, the lock protrusions 404 are positioned within a drive notch 224 defined in the firing member 220 such that a distal pushing force and/or a proximal pulling force can be transmitted from the firing member 220 to the lock sleeve 402. When the lock sleeve 402 is in its engaged position, a second lock member 406 is received within a drive notch 232 defined in the proximal articulation driver 230 such that the distal pushing force and/or the proximal pulling force applied to the lock sleeve 402 can be transmitted to the proximal articulation driver 230. In effect, the firing member 220, the lock sleeve 402, and the proximal articulation driver 230 will move together when the lock sleeve 402 is in its engaged position. On the other hand, when the lock sleeve 402 is in its disengaged position, the lock protrusions 404 may not be positioned within the drive notch 224 of the firing member 220 and, as a result, a distal pushing force and/or a proximal pulling force may not be transmitted from the firing member 220 to the lock sleeve 402. Correspondingly, the distal pushing force and/or the proximal pulling force may not be transmitted to the proximal articulation driver 230. In such circumstances, the firing member 220 can be slid proximally and/or distally relative to the lock sleeve 402 and the proximal articulation driver 230.

[0203] As can also be seen in FIG. 4, the elongate shaft assembly 200 further includes a switch drum 500 that is rotatably received on the closure sleeve 260. The switch drum 500 comprises a hollow shaft segment 502 that has a shaft boss 504 formed thereon for receive an outwardly protruding actuation pin 410 therein. In various circumstances, the actuation pin 410 extends through a slot 267 into a longitudinal slot 408 provided in the lock sleeve 402 to facilitate axial movement of the lock sleeve 402 when it is engaged with the proximal articulation driver 230. A rotary torsion spring 420 is configured to engage the shaft boss 504 on the switch drum 500 and a portion of the nozzle housing

203 to apply a biasing force to the switch drum 500. The switch drum 500 can further comprise at least partially circumferential openings 506 defined therein which, referring to FIGS. 5 and 6, can be configured to receive circumferential mounts extending from the nozzle portions 202, 203 and permit relative rotation, but not translation, between the switch drum 500 and the proximal nozzle 201. The mounts also extend through openings 266 in the closure sleeve 260 to be seated in recesses in the shaft spine 210. However, rotation of the nozzle 201 to a point where the mounts reach the end of their respective slots 506 in the switch drum 500 will result in rotation of the switch drum 500 about the shaft axis SA-SA. Rotation of the switch drum 500 will ultimately result in the rotation of the actuation pin 410 and the lock sleeve 402 between its engaged and disengaged positions. Thus, in essence, the nozzle 201 may be employed to operably engage and disengage the articulation drive system with the firing drive system in the various manners described in further detail in U.S. Patent Application Serial No. 13/803,086, now U.S. Patent Application Publication No. 2014/0263541.

[0204] As also illustrated in FIGS. 3 and 4, the elongate shaft assembly 200 can comprise a slip ring assembly 600 which can be configured to conduct electrical power to and/or from the end effector 300 and/or communicate signals to and/or from the surgical end effector 300, for example. The slip ring assembly 600 can comprise a proximal connector flange 604 mounted to a chassis flange 242 extending from the chassis 240 and a distal connector flange 601 positioned within a slot defined in the shaft housings 202, 203. The proximal connector flange 604 can comprise a first face and the distal connector flange 601 can comprise a second face which is positioned adjacent to and movable relative to the first face. The distal connector flange 601 can rotate relative to the proximal connector flange 604 about the shaft axis SA-SA. The proximal connector flange 604 can comprise a plurality of concentric, or at least substantially concentric, conductors 602 defined in the first face thereof. A connector 607 can be mounted on the proximal side of the distal connector flange 601 and may have a plurality of contacts (not shown) wherein each contact corresponds to and is in electrical contact with one of the conductors 602. Such arrangement permits relative rotation between the proximal connector flange 604 and the distal connector flange 601 while maintaining electrical contact therebetween. The proximal connector flange 604 can include an electrical connector 606 which can place the conductors 602 in signal communication with a shaft circuit board 610 mounted to the shaft chassis 240, for example. In at least one instance, a wiring harness comprising a plurality of conductors can extend between the electrical connector 606 and the shaft circuit board 610. The electrical connector 606 may extend proximally through a connector opening 243 defined in the chassis mounting flange 242. See FIG. 7. 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, is incorporated by reference herein in its entirety. 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 is incorporated by reference herein in its entirety. Further details regarding slip ring assembly 600 may be found in U.S. Patent Application Serial No. 13/803,086, now U.S. Patent Application Publication No. 2014/0263541.

[0205] As discussed above, the elongate shaft assembly 200 can include a proximal portion which is fixably mounted to the handle 14 and a distal portion which is rotatable about a longitudinal shaft axis SA-SA. The rotatable distal shaft portion can be rotated relative to the proximal portion about the slip ring assembly 600, as discussed above. The distal connector flange 601 of the slip ring assembly 600 can be positioned within the rotatable distal shaft portion. Moreover, further to the above, the switch drum 500 can also be positioned within the rotatable distal shaft portion. When the rotatable distal shaft portion is rotated, the distal connector flange 601 and the switch drum 500 can be rotated synchronously with one another. In addition, the switch drum 500 can be rotated between a first position and a second position relative to the distal connector flange 601. When the switch drum 500 is in its first position, the articulation drive system (i.e., the proximal articulation driver 230) may be operably disengaged from the firing drive system and, thus, the operation of the firing drive system may not articulate the end effector 300 of the shaft assembly 200. When the switch drum 500 is in its second position, the articulation drive system (i.e., the proximal articulation driver 230) may be operably engaged with the firing drive system and, thus, the operation of the firing drive system may articulate the end effector 300 of the shaft assembly 200. When the switch drum 500 is moved between its first position and its second position, the switch drum 500 is moved relative to distal connector flange 601. In various instances, the shaft assembly 200 can comprise at least one sensor that is configured to detect the position of the switch drum 500.

[0206] Referring again to FIG. 4, the closure sleeve assembly 260 includes a double pivot closure sleeve assembly 271. According to various forms, the double pivot closure sleeve assembly 271 includes an end effector closure sleeve 272 that includes upper and lower distally projecting tangs 273, 274. An upper double pivot link 277 includes upwardly projecting distal and proximal pivot pins that engage respectively an upper distal pin hole in the upper proximally projecting tang 273 and an upper proximal pin hole in an upper distally projecting tang 264 on the closure sleeve 260. A lower double pivot link 278 includes upwardly projecting distal and proximal pivot pins that engage respectively a

lower distal pin hole in the lower proximally projecting tang 274 and a lower proximal pin hole in the lower distally projecting tang 265. See also FIG. 6.

[0207] FIGS. 5-8 illustrate one form of surgical end effector 300 that is configured to be operably attached to an elongate shaft assembly of a surgical instrument of the type described above or other surgical instrument arrangements that include a closure system that is configured to generate control motions for axially moving a closure member that is configured to apply closing and opening motions to portions of the surgical end effector. In the illustrated example, as will be discussed in further detail below, the surgical end effector is configured to be articulated relative to a proximal portion of the elongate shaft assembly about an articulation joint, generally designated as 339. Other arrangements, however, may not be capable of articulation. As can be seen in FIG. 6, the articulation joint 339 defines an articulation axis B-B about which the surgical end effector 300 may be selectively articulated. In the illustrated example, the articulation axis B-B is substantially transverse to the shaft axis SA-SA of the elongate shaft assembly.

[0208] The illustrated surgical end effector 300 includes a first jaw 308 and a second jaw 309 that is selectively movable relative to the first jaw 308 between an open position (FIG. 7) and various closed positions (FIG. 8). In the illustrated embodiment, the first jaw 308 comprises an elongate channel 302 that is configured to operably support a surgical staple cartridge 304 therein and the second jaw 309 comprises an anvil 310. However, other surgical jaw arrangements may be employed without departing from the spirit and scope of the present invention. As can be seen in FIG. 5, a support pan 305 may be attached to the surgical staple cartridge 304 to provide added support thereto as well as to prevent the staple drivers (not shown) that are supported in the staple pockets 306 that are formed in the surgical staple cartridge 304 from falling out of the surgical staple cartridge prior to use. As can be seen in FIG. 5, the elongate channel 302 has a proximal end portion 320 that includes two upstanding lateral walls 322. The anvil 310 includes an anvil body 312 that has a staple-forming undersurface 313 formed thereon. A proximal end 314 of the anvil body is bifurcated by a firing member slot 315 that defines a pair of anvil attachment arms 316. Each anvil attachment arm 316 includes a sloping upper surface 321 and includes a laterally protruding anvil trunnion 317 and a cam slot 318 that defines a cam surface or "slotted cam surface" 319. See FIG. 5. One of the cam slots 318 may be referred to herein as a "first cam slot" with the cam surface thereof being referred to as the "first cam surface". Similarly, the other cam slot 318 may be referred to as a "second cam slot" with the cam surface thereof being referred to herein as the "second cam surface". A trunnion hole 324 is provided in each lateral wall 322 of the elongate channel 302 for receiving a corresponding one of the anvil trunnions

317 therein. Such arrangement serves to movably affix the anvil 310 to the elongate channel 302 for selective pivotable travel about an anvil axis A-A that is defined by trunnion holes 324 and which is transverse to the shaft axis SA-SA. See FIG. 6.

[0209] In the illustrated arrangement, the anvil 310 is pivotally moved relative to the elongate channel 302 and the surgical staple cartridge 304 supported therein to an open position by a pair of opening cams 354 that may be removably supported in or removably attached to or permanently attached to or integrally formed in an anvil actuator member. In the illustrated embodiment, the anvil actuator member comprises the end effector closure sleeve 272. See FIG. 5. Each opening cam 354 includes an outer body portion 356 that has a cam tab 358 protruding inwardly therefrom. The outer body portion 356 is, in at least one arrangement, configured to be snapped into removable engagement within a corresponding cam hole 355 formed in the end effector closure sleeve 272. For example, the outer body portion 356 may include a chamfered stop portion 357 that is configured to snappingly engage a corresponding portion of the end effector closure sleeve wall that defines the cam hole 355. Another portion of the outer body portion 356 may have a dog leg feature 359 formed thereon that is configured to be received inside a portion of the end effector closure sleeve 272 adjacent the cam hole 355. Other snap tab arrangements may also be employed to removably affix the outer body portion 356 to the end effector closure sleeve 272. In other arrangements, for example, the outer body portion may not be configured for snapping engagement with the end effector closure sleeve 272. In such arrangements, the outer body portions may be retained in position by an annular crimp ring that extends around the outer circumference of the end effector closure sleeve over the outer body portions of the opening cams and be crimped in place. The crimp ring serves to trap the outer body portions against the outer surface of the end effector closure sleeve. To provide the end effector closure sleeve with a relatively smooth or uninterrupted outer surface which may advantageously avoid damage to adjacent tissue and/or collection of tissue/fluid etc. between those components, the crimp ring may actually be crimped into an annular recess that is formed in the end effector closure sleeve.

[0210] When the opening cams 350 are installed in the end effector closure sleeve 272, each cam tab 358 extends through an elongate slot 326 in the corresponding lateral wall 322 of the elongate channel 302 to be received in a corresponding cam slot 318 in the anvil 310. See FIG. 6. In such arrangement, the opening cams 350 are diametrically opposite of each other in the end effector closure sleeve. In use, the closure sleeve 260 is translated distally (direction DD) to close the anvil 310, for example, in response to the actuation of the closure trigger 32. The anvil 310 is closed as the closure sleeve 260 is translated in the distal direction DD so as to bring the distal end 275 of the of end effector closure

sleeve 272 into contact with a closure lip 311 on the anvil body 312. In particular, the distal end 275 of the end effector closure sleeve 272 rides on the upper surfaces 321 of the anvil attachment arms 316 as the closure sleeve 260 is moved distally to begin to pivot the anvil 310 to a closed position. In one arrangement for example, closure of the anvil 310 is solely caused by contact of the end effector closure sleeve 272 with the anvil 310 and is not caused by the interaction of the opening cams with the anvil. In other arrangements, however, the opening cams could be arranged to also apply closing motions to the anvil as the closure sleeve 260 is moved distally. The anvil 310 is opened by proximally translating the closure sleeve 260 in the proximal direction PD which causes the cam tabs 358 to move in the proximal direction PD within the cam slots 318 on the cam surfaces 319 to pivot the anvil 310 into the open position as shown in FIGS. 6 and 7.

[0211] The surgical end effector embodiment 300 employs two opening cams to effect positive opening of the end effector jaws, even when under a load. Other arrangements could conceivably employ only one opening cam or more than two opening cams without departing from the spirit and scope of the present invention. In the illustrated example, the opening cams are removably affixed to the end effector closure sleeve which facilitates easy assembly or attachment of the surgical end effector components to the elongate shaft assembly as well as disassembly thereof. Such configurations also enable the use of more compact or shorter articulation joint arrangements which further facilitate better manipulation of the surgical end effector within the confined spaces inside of a patient. To facilitate easy detachment of those opening cams that are snapped in place, additional strategically placed holes may be provided in the end effector closure sleeve to enable a pry member to be inserted therethrough to pry the opening cams out of the end effector closure sleeve. In still other arrangements, the opening cam(s) may be integrally formed in the anvil actuator member or end effector closure sleeve. For example, the opening cam(s) may each comprise a tab that is cut into or otherwise formed into the wall of the anvil actuator member or end effector closure sleeve and then bent, crimped or permanently deformed inward so as to engage the corresponding cam surface on the second jaw. For example, the tab may be bent inward at ninety degrees (90°) relative to the outer wall of the end effector closure sleeve. Such arrangements avoid the need for separate opening cam components. Other variations may employ a pin or pins that are attached to the second jaw and configured to ride on corresponding cam surfaces on the first jaw. The pin or pins may be pressed into the first jaw, knurled and then pressed in and/or welded to the first jaw, for example. While the opening cam arrangements discussed above have been described in the context of a surgical end effector that is configured to support a surgical staple cartridge and includes an anvil that is configured

to move relative to the surgical staple cartridge, the reader will appreciate that the opening cam arrangements may also be employed with other end effector arrangements that have jaw(s) that are movable relative to each other.

[0212] FIGS. 9 and 10 illustrate an elongate shaft assembly designated as 200' that employs many of the features of elongate shaft assembly 200 described above. In the illustrated example, the elongate shaft assembly 200' includes a dual articulation link arrangement designated as 800 that employs an articulation lock 810 that is similar to articulation lock 350 described above. Those components of articulation lock 810 that differ from the components of articulation lock 350 and which may be necessary to understand the operation of articulation lock 350 will be discussed in further detail below. Further details regarding articulation lock 350 may be found in 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, the entire disclosure of which is hereby incorporated by reference herein. The articulation lock 810 can be configured and operated to selectively lock the surgical end effector 300 in various articulated positions. Such arrangement enables the surgical end effector 300 to be rotated, or articulated, relative to the shaft closure sleeve 260 when the articulation lock 810 is in its unlocked state.

[0213] As was discussed above, when the proximal articulation driver 230 is operatively engaged with the firing member 220 via the clutch system 400, the firing member 220 can move the proximal articulation driver 230 proximally and/or distally. For instance, proximal movement of the firing member 220 can move the proximal articulation driver 230 proximally and, similarly, distal movement of the firing member 220 can move the proximal articulation driver 230 distally. Movement of the proximal articulation driver 230, whether it be proximal or distal, can unlock the articulation lock 810, as described in greater detail further below. As can be seen in FIG. 9 for example, the elongate shaft assembly 200' includes a shaft frame 812 which is somewhat co-extensive with a first distal articulation driver 820. A first distal articulation driver 820 is supported within the elongate shaft assembly 200' for selective longitudinal travel in a distal direction DD and a proximal direction PD in response to corresponding articulation control motions applied thereto. The shaft frame 812 includes a distal end portion 814 that has a downwardly protruding pivot pin (not shown) thereon that is adapted to be pivotally received within a pivot hole 328 formed in the proximal end portion 320 of the elongate channel 302. See, for example, the similar arrangement depicted in FIG. 5. Such arrangement facilitates pivotal travel of the elongate channel 302 of the surgical end effector 300 relative to the shaft frame 812 about an articulation axis B-B that is defined by the pivot hole 328. As indicated

above, the articulation axis B-B is transverse to the shaft axis SA-SA that is defined by elongate shaft assembly 200'.

[0214] Referring again to FIG. 9, the first distal articulation driver 820 includes a first, or distal, lock cavity 822 and a second, or proximal, lock cavity 824, wherein the first lock cavity 822 and the second lock cavity 824 can be separated by an intermediate frame member 825. The articulation lock 810 can further include at least one first lock element 826 at least partially positioned within the first lock cavity 822 which can be configured to inhibit or prevent the proximal movement of the first distal articulation driver 820. In the embodiment illustrated in FIG. 9, for example, there are three first lock elements 826 positioned within the first lock cavity 822 which can all act in a similar, parallel manner and can co-operatively act as a single lock element. Other embodiments are envisioned which can utilize more than three or less than three first lock elements 826. Similarly, the articulation lock 810 can further include at least one second lock element 828 at least partially positioned within the second lock cavity 824 which can be configured to inhibit or prevent the distal movement of the first distal articulation driver 820. With regard to the particular embodiment illustrated in FIG. 9, there are three second lock elements 828 positioned within the second lock cavity 824 which can all act in a similar, parallel manner and can co-operatively act as a single lock element. Other embodiments are envisioned which can utilize more than three or less than three second lock elements 828.

[0215] Further to the above, referring primarily to FIG. 9, each first lock element 826 is slidably supported on a frame rail 830 and includes a lock tang 827. Each of the first lock elements 826 have a lock aperture therein (not shown) for receiving the frame rail 830 therethrough. The lock tang 827 can be disposed within the first lock cavity 822 and the lock aperture can be slidably engaged with a frame rail 830 mounted to the shaft frame 812. The first lock elements 826 are not oriented in a perpendicular arrangement with the frame rail 830; rather, the first lock elements 826 are arranged and aligned at a non-perpendicular angle with respect to the frame rail 830 such that the edges or sidewalls of the lock apertures are engaged with the frame rail 830. Moreover, the interaction between the sidewalls of the lock apertures and the frame rail 830 can create a resistive or friction force therebetween which can inhibit relative movement between the first lock elements 826 and the frame rail 830 and, as a result, resist a proximal pushing force P applied to the first distal articulation driver 820. Stated another way, the first lock elements 826 can prevent or at least inhibit the surgical end effector 300 from rotating in a direction indicated by arrow 821. If a torque is applied to the end effector 300 in the direction of arrow 821, a proximal pushing force P will be transmitted to the distal articulation driver 820. The proximal pushing force P will only serve to bolster the locking

engagement between the first lock elements 826 and the frame rail 830. More particularly, the proximal pushing force P can be transmitted to the tangs 827 of the first lock elements 826 which can cause the first lock elements 826 to rotate and decrease the angle defined between first lock elements 826 and the frame rail 830 and, as a result, increase the bite between the sidewalls of the lock apertures and the frame rail 830. Ultimately, then, the first lock elements 826 can lock the movement of the first distal articulation driver 820 in one direction.

[0216] To release the first lock elements 826 and permit the surgical end effector 300 to be rotated in the direction indicated by arrow 821, the proximal articulation driver 230 can be pulled proximally to straighten, or at least substantially straighten, the first lock elements 826 into a perpendicular, or at least substantially perpendicular, position. In such a position, the bite, or resistive force, between the sidewalls of the lock apertures and the frame rail 830 can be sufficiently reduced, or eliminated, such that the first distal articulation driver 820 can be moved proximally. To straighten the first lock elements 826, the proximal articulation driver 230 can be pulled proximally such that a distal arm 233 of the proximal articulation driver 230 contacts the first lock elements 826 to pull and rotate the first lock elements 826 into their straightened position. In various circumstances, the proximal articulation driver 230 can continue to be pulled proximally until a proximal arm 235 extending therefrom contacts, or abuts, a proximal drive wall 832 of the first distal articulation driver 820 and pulls the distal articulation driver 820 proximally to articulate the surgical end effector 300. In essence, a proximal pulling force can be applied from the proximal articulation driver 230 to the distal articulation driver 820 through the interaction between the proximal arm 235 and the proximal drive wall 832 wherein such a pulling force can be transmitted through the first distal drive member 820 to the end effector 300 as will be further discussed below to articulate the end effector 300 in the direction indicated by arrow 821. After the surgical end effector 300 has been suitably articulated in the direction of arrow 821, the first distal articulation driver 820 can be released, in various circumstances, to permit the articulation lock 810 to re-lock the first distal articulation driver 820, and the surgical end effector 300, in position.

[0217] Concurrent to the above, referring again to FIG. 9, the second lock elements 828 can remain in an angled position while the first lock elements 826 are locked and unlocked as described above. The reader will appreciate that, although the second lock elements 828 are arranged and aligned in an angled position with respect to the shaft rail 830, the second lock elements 828 are not configured to impede, or at least substantially impede, the proximal motion of the first distal articulation driver 820. When the first distal articulation driver 820 and articulation lock 810 are slid proximally, as described

above, the second lock elements 828 can slide distally along the frame rail 830 without, in various circumstances, changing, or at least substantially changing, their angled alignment with respect to the frame rail 830. While the second lock elements 828 are permissive of the proximal movement of the first distal articulation driver 820 and the articulation lock 810, the second lock elements 828 can be configured to selectively prevent, or at least inhibit, the distal movement of the first distal articulation driver 820, as discussed in greater detail further below.

[0218] Each second lock element 828 can comprise a lock aperture (not shown) and a lock tang 829. The lock tang 829 can be disposed within the second lock cavity 824 and the lock aperture can be slidably engaged with the frame rail 830 mounted to the shaft frame 812. The frame rail 830 extends through the apertures in the second lock elements 828. The second lock elements 828 are not oriented in a perpendicular arrangement with the frame rail 830; rather, the second lock elements 828 are arranged and aligned at a non-perpendicular angle with respect to the frame rail 830 such that the edges or sidewalls of the lock apertures are engaged with the frame rail 830. Moreover, the interaction between the sidewalls of the lock apertures and the frame rail 830 can create a resistive or friction force therebetween which can inhibit relative movement between the second lock elements 828 and the frame rail 830 and, as a result, resist a distal force D applied to the first distal articulation driver 820. Stated another way, the second lock elements 828 can prevent or at least inhibit the surgical end effector 300 from rotating in a direction indicated by arrow 823. If a torque is applied to the end effector 300 in the direction of arrow 823, a distal pulling force D will be transmitted to the first distal articulation driver 820. The distal pulling force D will only serve to bolster the locking engagement between the second lock elements 828 and the frame rail 830. More particularly, the distal pulling force D can be transmitted to the tangs 829 of the second lock elements 828 which can cause the second lock elements 828 to rotate and decrease the angle defined between second lock elements 828 and the frame rail 830 and, as a result, increase the bite between the sidewalls of the lock apertures and the frame rail 830. Ultimately, then, the second lock elements 828 can lock the movement of the first distal articulation driver 820 in one direction.

[0219] To release the second lock elements 828 and permit the surgical end effector 300 to be articulated in the direction indicated by arrow 823, the proximal articulation driver 230 can be pushed distally to straighten, or at least substantially straighten, the second lock elements 828 into a perpendicular, or at least substantially perpendicular, position. In such a position, the bite, or resistive force, between the sidewalls of the lock apertures and the frame rail 830 can be sufficiently reduced, or eliminated, such that the first distal articulation driver 820 can be moved distally. To straighten the

second lock elements 828, the proximal articulation driver 230 can be pushed distally such that the proximal arm 235 of the proximal articulation driver 230 contacts the second lock elements 828 to push and rotate the second lock elements 828 into their straightened position. In various circumstances, the proximal articulation driver 230 can continue to be pushed distally until the distal arm 233 extending therefrom contacts, or abuts, a distal drive wall 833 of the first distal articulation driver 820 and pushes the first distal articulation driver 820 distally to articulate the surgical end effector 300. In essence, a distal pushing force can be applied from the proximal articulation driver 230 to the first distal articulation driver 820 through the interaction between the distal arm 233 and the distal drive wall 833 wherein such a pushing force can be transmitted through the first distal articulation driver 820 to articulate the end effector 300 in the direction indicated by arrow 823. After the surgical end effector 300 has been suitably articulated in the direction of arrow 823, the first distal articulation driver 820 can be released, in various circumstances, to permit the articulation lock 810 to re-lock the first distal articulation driver 820, and the surgical end effector 300, in position.

[0220] Concurrent to the above, the first lock elements 826 can remain in an angled position while the second lock elements 828 are locked and unlocked as described above. The reader will appreciate that, although the first lock elements 826 are arranged and aligned in an angled position with respect to the shaft rail 830, the first lock elements 826 are not configured to impede, or at least substantially impede, the distal motion of the first distal articulation driver 820. When the first distal articulation driver 820 and articulation lock 810 are slid distally, as described above, the first lock elements 826 can slide distally along the frame rail 830 without, in various circumstances, changing, or at least substantially changing, their angled alignment with respect to the frame rail 830. While the first lock elements 826 are permissive of the distal movement of the first distal articulation driver 820 and the articulation lock 810, the first lock elements 826 are configured to selectively prevent, or at least inhibit, the proximal movement of the first distal articulation driver 820, as discussed above.

[0221] In view of the above, the articulation lock 810, in a locked condition, can be configured to resist the proximal and distal movements of the first distal articulation driver 820. In terms of resistance, the articulation lock 810 can be configured to prevent, or at least substantially prevent, the proximal and distal movements of the first distal articulation driver 820. Collectively, the proximal motion of the first distal articulation driver 820 is resisted by the first lock elements 826 when the first lock elements 826 are in their locked orientation and the distal motion of the first distal articulation driver 820 is resisted by the second lock elements 828 when the second lock elements 828 are in their locked orientation, as described above. Stated another way, the first lock elements 826 comprise a first

one-way lock and the second lock elements 828 comprise a second one-way lock which locks in an opposite direction.

[0222] Discussed in connection with the exemplary embodiment illustrated in FIGS. 9 and 10, an initial proximal movement of the proximal articulation driver 230 can unlock the proximal movement of the first distal articulation driver 820 and the articulation lock 810 while a further proximal movement of the proximal articulation driver 230 can drive the first distal articulation driver 820 and the articulation lock 810 proximally. Similarly, an initial distal movement of the proximal articulation driver 230 can unlock the distal movement of the first distal articulation driver 820 and the articulation lock 810 while a further distal movement of the proximal articulation driver 230 can drive the first distal articulation driver 820 and the articulation lock 810 distally. Such a general concept is discussed in connection with several additional exemplary embodiments disclosed below. To the extent that such discussion is duplicative, or generally cumulative, with the discussion provided above, such discussion is not reproduced for the sake of brevity.

[0223] Still referring to FIGS. 9 and 10, the dual articulation link arrangement 800 is configured to establish a "push/pull" arrangement when an articulation force is applied thereto through the first distal articulation driver 820. As can be seen in those Figures, the first distal articulation driver 820 has a first drive rack 842 formed therein. A first articulation rod 844 protrudes distally out of the first distal articulation driver 820 and is attached to a first movable coupler 850 that is attached to the first distal articulation driver 820 by a first ball joint 852. The first coupler 850 is also pivotally pinned to the proximal end portion 320 of the elongate channel 302 by a first pin 854 as can be seen in FIG. 9. The dual articulation link arrangement 800 further comprises a second distal articulation driver 860 that has a second drive rack 862 formed therein. The second distal articulation driver 860 is movably supported within the elongate shaft assembly 200' for longitudinal travel in the distal direction DD and the proximal direction PD. A second articulation rod 864 protrudes distally out of the second distal articulation driver 860 and is attached to a second movable coupler 870 that is attached to the second distal articulation driver 860 by a second ball joint 872. The second coupler 870 is also pivotally pinned to the proximal end portion 320 of the elongate channel 302 by a second pin 874 as can be seen in FIG. 9. As can be seen in FIG. 9, the first coupler 850 is attached to the elongate channel 302 on one lateral side of the shaft axis SA and the second coupler 870 is attached to the elongate channel 302 on an opposite lateral side of the shaft axis. Thus, by simultaneously pulling on one of the couplers 850, 870 and pushing on the other coupler 850,870, the surgical end effector 300 will be articulated about the articulation axis B-B relative to the elongate shaft assembly 200'. In the illustrated

arrangements, although the couplers 850, 870 that facilitate relative movement between the first and second distal articulation drivers 820, 860, respectively and the elongate channel 302 are fabricated from relatively rigid components, other arrangements may employ relatively "flexible" coupler arrangements. For example cable(s), etc. may extend through one or both of the distal articulation drivers 820, 860, couplers 850, 870 and the ball joints 852, 872, to be coupled to the elongate channel to facilitate the transfer of articulation motions thereto.

[0224] As can also be seen in FIGS. 9 and 10, a proximal pinion gear 880 and a distal pinion gear 882 are centrally disposed between the first drive rack 842 and the second drive rack 862 and are in meshing engagement therewith. In alternative embodiments, only one pinion gear or more than two pinion gears may be employed. Thus, at least one pinion gear is employed. The proximal pinion gear 880 and the distal pinion gear 882 are rotatably supported in the shaft frame 812 for free rotation relative thereto such that as the first distal articulation driver 820 is moved in the distal direction DD, the pinion gears 870, 872 serve to drive the second distal articulation driver 860 in the proximal direction PD. Likewise, when the first distal articulation driver 820 is pulled in the proximal direction PD, the pinion gears 880, 882 drive the second distal articulation driver 860 in the distal direction DD. Thus, to articulate the end effector 300 about the articulation axis B-B in the direction of arrow 821, the articulation driver 230 is operatively engaged with the firing member 220 via the clutch system 400 such that the firing member 220 moves or pulls the proximal articulation driver 230 in the proximal direction PD. Movement of the proximal articulation driver 230 in the proximal direction moves the first distal articulation driver 820 in the proximal direction as well. As the first distal articulation driver 820 moves the in the proximal direction, the pinion gears 880, 882 serve to drive the second distal articulation driver 860 in the distal direction DD. Such movement of the first and second distal articulation drivers 820, 860 causes the surgical end effector 300 and more specifically, the elongate channel 302 of the surgical end effector 300 to pivot about the articulation axis B-B in the articulation direction of arrow 821. Conversely, to articulate the end effector 300 in the direction of arrow 823, the firing member 220 is actuated to push the first distal articulation driver 820 in the distal direction DD. As the first distal articulation driver 820 moves the in the distal direction, the pinion gears 880, 882 serve to drive the second distal articulation driver 860 in the proximal direction PD. Such movement of the first and second distal articulation drivers 820, 860 causes the surgical end effector 300 and more specifically, the elongate channel 302 of the surgical end effector 300 to pivot about the articulation axis B-B in the articulation direction of arrow 823.

[0225] The dual solid link articulation arrangement 800 and its variations may afford the surgical end effector with a greater range of articulation when compared to other articulatable surgical end effector configurations. In particular, the solid link articulation arrangements disclosed herein may facilitate ranges of articulation that exceed ranges of 45-50° that are commonly achieved by other articulatable end effector arrangements. Use of at least one pinion gear to interface between the distal articulation drivers enable the end effector to be "pushed" and "pulled" into position also may reduce the amount of end effector "slop" or undesirable or unintended movement during use. The dual solid link articulation arrangements disclosed herein also comprise an articulation system that has improved strength characteristics when compared to other articulation system arrangements.

[0226] As was briefly discussed above, the intermediate firing shaft portion 222 is configured to operably interface with a distal cutting or firing beam 280. The distal firing beam 280 may comprise a laminated structure. Such arrangement enables the distal firing beam 280 to sufficiently flex when the surgical end effector 300 is articulated about the articulation axis B-B. The distal firing beam 280 is supported for axial movement within the shaft assembly 200' and is slidably supported by two upstanding lateral support walls 330 formed on the proximal end of the elongate channel 302. Referring to Fig. 11, the distal firing beam 280 is attached to a firing member 900 that includes a vertically-extending firing member body 902 that has a tissue cutting surface or blade 904 thereon. In addition, a wedge sled 910 may be mounted within the surgical staple cartridge 304 for driving contact with the firing member 900. As the firing member 900 is driven distally through the cartridge body 304, the wedge surfaces 912 on the wedge sled 910 contact the staple drivers to actuate the drivers and the surgical staples supported thereon upwardly in the surgical staple cartridge 304.

[0227] End effectors that employ firing beams or firing members and which are capable of articulating over a range of, for example, forty five degrees (45°) may have numerous challenges to overcome. To facilitate operable articulation of such end effectors, the firing member or firing beam must be sufficiently flexible to accommodate such range of articulation. However, the firing beam or firing member must also avoid buckling while encountering the compressive firing loads. To provide additional support to the firing beam or firing member various "support" or "blowout" plate arrangements have been developed. Several of such arrangements are disclosed in U.S. Patent No. 6,964,363, entitled SURGICAL STAPLING INSTRUMENT HAVING ARTICULATION JOINT SUPPORT PLATES FOR SUPPORTING A FIRING BAR and U.S. Patent No. 7,213,736, entitled SURGICAL STAPLING INSTRUMENT INCORPORATING AN ELECTROACTIVE POLYMER ACTUATED FIRING BAR TRACK THROUGH AN ARTICULATION JOINT, the entire

disclosures of each being hereby incorporated by reference herein. Blowout plates that provide substantial buckle resistance also are difficult to bend in general which adds to the forces the articulation joint system must accommodate. Other firing beam support arrangements are disclosed in U.S. Patent Application Serial No. 14/575,117, entitled SURGICAL INSTRUMENTS WITH ARTICULATABLE END EFFECTORS AND MOVABLE FIRING BEAM SUPPORT ARRANGEMENTS, the entire disclosure of which is hereby incorporated by reference herein.

[0228] Referring to FIGS. 11-15, the elongate shaft assembly 200' further comprises a multiple support link assembly 920 for providing lateral support to the distal firing beam 280 as the surgical end effector 300 is articulated about the articulation axis B-B. As can be seen in FIG. 11, the multiple support link assembly 920 comprises a middle support member 922 that is movably coupled to the surgical end effector 300 as well as the elongate shaft assembly 200'. For example, the middle support member 922 is pivotally pinned to the proximal end 320 of the elongate channel 302 such that it is pivotable relative thereto about a pivot axis PA. As can be seen in FIG. 11, the middle support member 922 includes a distally protruding tab 923 that has a distal pivot hole 924 therein for receiving an upstanding support pin 332 that is formed on the proximal end portion 320 of the elongate channel 302. As can be further seen in FIG. 11, the middle support member 922 further includes a proximally protruding tab 926 that has an elongate proximal slot 928 therein. The proximal slot 928 is configured to slidably receive a middle support pin 816 that is formed on the frame portion 812. Such arrangement enables the middle support member 922 to pivot and move axially relative to said elongate shaft assembly 200', for example. As can be seen in FIGS.11-13, the middle support member 922 further includes centrally disposed slot 930 for movably receiving the distal firing beam 280 therethrough.

[0229] Still referring to FIGS. 11-15, the multiple support link assembly 920 further comprises a proximal support link 940 and a distal support link 950. The proximal support link 940 includes an elongate proximal body 942 that has a rounded proximal nose portion 943 and a rounded distal nose portion 944. The proximal support link 940 further includes a pair of downwardly protruding, opposed proximal support walls 945, 946 that define a proximal slot 947 therebetween. Similarly, the distal support link 950 includes an elongate distal body 952 that has a rounded proximal nose portion 953 and a rounded distal nose portion 954. The distal support link 950 further includes a pair of downwardly protruding opposed distal support walls 955, 956 that define a distal slot 957 therebetween. As can be seen in FIG. 14, the flexible distal firing beam 280 is configured to extend between the proximal support walls 945, 946 of the proximal support link 940 and the distal support

walls 955, 956 of the distal support link 950. The proximal support wall 945 includes an inwardly facing proximal arcuate surface 948 and the proximal support wall 946 includes an inwardly facing proximal arcuate support surface 949 that opposes said inwardly facing proximal arcuate surface 948. The proximal arcuate support surfaces 948, 949 serve to provide lateral support to the lateral side portions of a proximal portion of the flexible distal firing beam 280 as it flexes during articulation of the end effector and traverses the articulation joint. The radiused surfaces may match the outer radius of the distal firing beam 280 depending upon the direction of articulation. Similarly, the distal support wall 955 includes an inwardly facing distal arcuate surface 958 and the distal support wall 956 includes an inwardly facing distal arcuate support surface 959 that opposes said distal arcuate surface 958. The distal arcuate support surfaces 958, 959 serve to provide lateral support to the lateral side portions of a distal portion of the distal firing beam 280 as it flexes during articulation of the surgical end effector 300 and traverses the articulation joint. The distal arcuate surfaces 958, 959 may match the outer radius of the distal firing beam 280 depending upon the direction of articulation. As can be seen in FIGS. 12 and 13, the distal end 217 of the shaft spine 210 includes a distally-facing arcuate spine pocket 218 into which the rounded proximal nose portion 943 of the proximal support link 940 extends. The rounded distal nose portion 944 of the proximal support link 940 is pivotally received in an arcuate proximal pocket 932 in the middle support member 922. In addition, the rounded proximal nose portion 953 of the distal support link is received in an arcuate distal support member pocket 934 in the distal end of the middle support member 922. The rounded distal nose portion 954 of the distal support link 950 is movably received within a V-shaped channel cavity 334 formed in the upstanding lateral support walls 330 formed on the proximal end 320 of the elongate channel 302.

[0230] The multiple support linkage assembly may provide higher lateral support to the flexible firing beam laminates as the beam flexes across higher articulation angles. Such arrangements also prevent the firing beam from buckling under high firing loads and across relatively high articulation angles. The elongate support links, in connection with the middle support member, serve to provide improved lateral support to the firing beam across the articulation zone when compared to many prior support arrangements. In alternative arrangements, the support links may be configured to actually interlock with the middle support member at various articulation angles. The U-shaped support links facilitate easy installation and serve to provide support to the flexible support beams on each lateral side as well as to the top of the firing beam to prevent the firing beam from bowing upwards during firing while being articulated.

[0231] In those embodiments wherein the firing member includes a tissue cutting surface, it may be desirable for the elongate shaft assembly to be configured in such a way so as to prevent the inadvertent advancement of the firing member unless an unspent staple cartridge is properly supported in the elongate channel 302 of the surgical end effector 300. If, for example, no staple cartridge is present at all and the firing member is distally advanced through the end effector, the tissue would be severed, but not stapled. Similarly, if a spent staple cartridge (i.e., a staple cartridge wherein at least some of the staples have already been fired therefrom) is present in the end effector and the firing member is advanced, the tissue would be severed, but may not be completely stapled, if at all. It will be appreciated that such occurrences could lead to undesirable catastrophic results during the surgical procedure. U.S. Patent No. 6,988,649 entitled SURGICAL STAPLING INSTRUMENT HAVING A SPENT CARTRIDGE LOCKOUT, U.S. Patent No. 7,044,352 entitled SURGICAL STAPLING INSTRUMENT HAVING A SINGLE LOCKOUT MECHANISM FOR PREVENTION OF FIRING, and U.S. Patent No. 7,380,695 entitled SURGICAL STAPLING INSTRUMENT HAVING A SINGLE LOCKOUT MECHANISM FOR PREVENTION OF FIRING each disclose various firing member lockout arrangements, each of which is hereby incorporated by reference in its entirety herein.

[0232] Such lockout arrangements may be effectively employed with a variety of surgical stapling instruments. Those arrangements, however, may not be particularly well-suited for use in connection with various surgical stapling instruments disclosed herein that employ relatively compact and short articulation joint configurations. For example, FIGS. 15-19 illustrate a surgical end effector 300 that is operably attached to an elongate shaft assembly 200' by an articulation joint 270'. The elongate shaft assembly 200' defines a shaft axis SA-SA and the articulation joint 270' facilitates selective articulation of the surgical end effector 300 relative to the elongate shaft assembly 200' about an articulation axis B-B that is transverse to the shaft axis SA-SA. In the illustrated embodiment, a dual solid link articulation arrangement 800 (as was described above) may be employed to selectively apply articulation motions to the surgical end effector 300. The elongate shaft assembly 200' comprises a distal firing beam 280 of the type described above that is selectively axially movable within the surgical end effector 300 from a starting position to an ending position upon application of firing motions thereto. The distal firing beam 280 extends through the articulation joint 270' and is configured to flex about the articulation axis B-B to accommodate articulation of the surgical end effector 300 in the various manners described herein. In the illustrated embodiment, the articulation joint 270' includes a middle support member 922 that is movably attached to the distal end 814 of the shaft frame 812 and the proximal end 320 of the elongate channel 302. As was discussed above, the

middle support member 922 includes a distally protruding tab 923 that has a distal pivot hole 924 therein for receiving an upstanding support pin 332 formed on the proximal end portion 320 of the elongate channel 302. The middle support member 922 further includes a proximally protruding tab 926 that has an elongate proximal slot 928 therein. The proximal slot 928 is configured to slidably receive a middle support pin 816 formed on the frame portion 812. The middle support 922 further includes a centrally disposed slot 930 for axially receiving the distal firing beam 280 therethrough. The middle support member 922 provides lateral support to the distal firing beam 280 during articulation of the surgical end effector 300 about the articulation axis B-B while facilitating its axial passage of the distal firing beam 280 therethrough during firing.

[0233] In the illustrated embodiment, a firing beam locking assembly 980 is employed to prevent the distal firing beam 280 from being inadvertently advanced from the starting position to the ending position unless an unfired surgical staple cartridge 304 has been operably seated in the cartridge support member or elongate channel 302. As can be seen in FIGS. 15-19, the firing beam locking assembly 980 in one form includes a locking cam or detent 281 that is formed in the distal firing beam 280 such that it protrudes upwardly from the upper surface thereof. A biasing member 984 is supported on and attached to the middle support member 922. As can be seen in FIG. 16, for example, the biasing member 984 is substantially planar and includes a window 985 that is configured to accommodate the locking cam 281 therein during articulation of the surgical end effector 300. Thus, as the surgical end effector 300 is articulated about the articulation axis B-B, the biasing member 984 does not apply any biasing force or load to the distal firing beam 280. This feature may avoid adding to the amount of articulation forces that must be generated to articulate the surgical end effector 300 about the articulation axis B-B. The biasing member 984 may be tack welded to the middle support member 922 or be attached thereto by other fastener methods such as by screws, pins, adhesive, etc. The window 985 may also define a locking band or portion 986 that serves to contact the locking cam 281 when the distal firing beam 280 is in the starting position. The locking cam 281 may be formed with a distal-facing sloping surface 283 and a proximally-facing sloping surface 285 to reduce the amount of firing force and retraction force required to axially move the distal firing beam 280. See FIG. 19.

[0234] As was described above, the distal firing beam 280 is operably attached to a firing member 900 that includes a tissue cutting surface 904 on the firing member body 902. In alternative arrangements, the tissue cutting surface may be attached to or otherwise formed on or directly supported by a portion of the distal firing beam 280. In the illustrated arrangement, a laterally

extending foot 905 is formed on the bottom of the firing member body 902. The firing member body 902 further includes a wedge sled engagement member 906 that is configured to engage a wedge sled in the surgical staple cartridge 304 as will be discussed in further detail below.

[0235] FIG. 18 illustrates an "unspent" or "unfired" surgical staple cartridge 304 that has been properly installed in the elongate channel 302. As can be seen in that Figure, the wedge sled 910 is located in an "unfired" (proximal-most) position in the surgical staple cartridge 304. The wedge sled 910 includes a proximally-facing sloping surface 914 that is configured to engage the wedge sled engagement member 906 on the firing member 900 to thereby bias the firing member 900 in an upward direction represented by arrow 988 such that the bottom portion and foot 905 of the firing member 900 are free to clear a lock wall 307 formed by a lock opening 303 in the bottom of the elongate channel 302. When in that position, the distal firing beam 280 and the firing member 900 may be distally advanced within the elongate channel 302 and, more precisely, the surgical staple cartridge 304 mounted therein from the starting position illustrated in FIG. 18 to the ending position with the surgical staple cartridge 304 wherein the wedge sled 910 has ejected all of the surgical staples that were operably supported in the surgical staple cartridge 304. In such arrangements, after the firing member 900 has been completely fired (i.e., completely advanced from its starting position to is ending position within the surgical staple cartridge 304), the firing member 900 is retracted back to the starting position shown in FIG. 19. Because the wedge sled 910 has been distally advanced to the ending position in the staple cartridge 304 by the firing member 900 and the firing member 900 is not attached to the wedge sled 910, when the firing member 900 is retracted back to the starting position, the wedge sled 910 remains in the ending position within the surgical staple cartridge 304 and does not return with the firing member 900 back to the starting position. Thus, the surgical staple cartridge 304 is said to be in a "used", "spent" or "fired" condition. As can be seen in FIG. 19, when no wedge sled is present in an unfired state, the bottom of the body portion 902 as well as the foot 905 of the firing member 900 extends into the lock opening 303 in the bottom of the elongate channel 302 due to the biasing motion applied by the locking band 986 of the biasing member 984 to locking cam 281 on the distal firing beam 280. When in that position, if the clinician were to unwittingly attempt to refire the spent surgical staple cartridge, the body portion 902 and/or the foot 905 would contact the wall 307 in the elongate channel 302 and would be prevented from moving from the starting position to the ending position. Thus, the firing beam locking assembly 980 prevents the advancement of the distal firing beam 280 as well as the firing member 900 from the starting position to the ending position unless an unfired or unspent surgical staple cartridge has been properly/operably installed in the elongate

channel of the surgical end effector. It will also be appreciated that the firing beam locking assembly 980 also prevents advancement of the distal firing beam 280 when no staple cartridge at all has been installed in the elongate channel 302. In addition to accommodating articulation of the surgical end effector 300 about the articulation axis B-B without applying additional load to the distal firing beam which could result in the need for increased articulation forces to articulate the surgical end effector, the firing beam locking assembly 980 applies no additional load on the firing member and/or the distal firing beam once it has been distally advanced past the lockout wall whether or not the end effector jaws are open or closed.

[0236] FIG. 20A illustrates another articulatable surgical end effector embodiment 300' that employs a firing beam locking assembly 980' that comprises a biasing member 984' that is mounted within the end effector closure sleeve 272. As can be seen in that Figure, for example, the biasing member 984' applies a biasing force to a sloped or tapered portion 283' of the distal firing beam 280'. The firing beam locking assembly 980' otherwise operates in the same manner as described above with respect to the firing beam locking assembly 980. More specifically, the biasing member 984' applies a biasing force to the distal firing beam 280' that forces the distal firing beam 280' and the firing member attached thereto downward within the elongate channel. Unless an unspent surgical staple cartridge with a wedge sled or other staple ejector member in an unfired position has been properly installed within the elongate channel or cartridge support member so as to operably engage with the firing member or firing beam to move the firing member/firing beam out of engagement with the lock wall, the firing member/firing beam would be prevented from being axially advanced from the starting to ending position.

[0237] FIGS. 21-25 illustrate a portion of another elongate shaft assembly 1200 that is similar to the elongate shaft assembly 200 described above, except for various differences discussed in further detail below. Those components of the elongate shaft assembly 1200 that have been discussed in detail above are referenced with like element numbers and, for the sake of brevity, will not be further discussed in great detail beyond that which may be necessary to understand the operation of shaft assembly 1200 when, for example, employed with portions of the surgical instrument 10 as described above. As can be seen in FIG. 21, the elongate shaft assembly 1200 includes an articulation lock 1810 that is substantially similar to articulation lock 810 and operates in essentially the same manner. As can be seen in FIG. 22, the elongate shaft assembly 1200 includes a shaft frame 1812 that has a proximal cavity 1815 that is configured to movably support a proximal portion 1821 of a first distal articulation driver 1820 therein. The first distal articulation driver 1820 is movably supported within

the elongate shaft assembly 1200 for selective longitudinal travel in a distal direction DD and a proximal direction PD in response to articulation control motions applied thereto. The shaft frame 1812 further includes a distal end portion 1814 that has a pivot pin 1818 formed thereon. The pivot pin 1818 is adapted to be pivotally received within a pivot hole (not shown) in a proximal end portion 1320 of an elongate channel 1302 of a surgical end effector 1300. Such arrangement facilitates pivotal travel (i.e., articulation) of the elongate channel 1302 of the surgical end effector 1300 elative to the shaft frame 1812 about an articulation axis B-B defined by the pivot hole and the pin 1818. The shaft frame 1812 further includes a centrally disposed cavity 1817 and a distal notch 1819 that is located between the distal end 1814 and the centrally disposed cavity 1817.

[0238] The shaft assembly 1200 further includes a second distal articulation driver 1860 that comprises an endless member 1862 that is rotatably journaled on a proximal pulley 1840 and a distal pulley 1340. Still referring to FIG. 22, the proximal pulley 1840 is rotatably journaled on a pulley spindle 1842 that is mounted within the centrally disposed cavity 1817 within the shaft frame 1812. The distal pulley 1340 is non-rotatably supported or formed on the proximal end 1320 of the elongate channel 1302 of the surgical end effector 1300. In one form, the endless member 1862 comprises a cable that is fabricated from stainless steel, tungsten, aluminum, or titanium, etc., for example. The cable may be of braided or multi-stranded construction with various numbers of strands to attain desired levels of tensile strength and flexibility. In various arrangements, for example, the cable 2382 may have a diameter in the range of 0.03 inches to 0.08 inches and more preferably in the range of 0.05 - 0.08 inches. A preferred cable may, for example, be fabricated from 300 series stainless steel - half hard to full hard. In various arrangements, the cable may also be coated with, for example, Teflon®, copper, etc. for improved lubricity and/or to reduce stretching, for example. A first lug 1863 is attached to one end of the cable and a second lug 1864 is attached to the other end of the cable by, for example, crimping. The cable is stretched in tension while the ends and/or the lugs 1863, 1864 are welded, glued, mechanically fastened, etc. together to form the endless member 1862. The spindle 1842 may comprise a cam mount that engages the proximal pulley 1840 so as to move the pulley 1840 proximally. Other forms of tensioning arrangements such as belt tensioners, turnbuckle arrangements, etc. may also be employed to tension the endless member 1862.

[0239] Still referring to FIG. 22, the endless member 1862 is coupled to a distal end 1821 of the first distal articulation driver 1820 by a coupler assembly 1830. The coupler assembly 1830 comprises an upper coupler portion 1832 formed on the distal end 1822 of the first distal articulation driver 1820 and a lower coupler portion 1834. The lower coupler portion 1834 is formed with two cradles 1835 that

are configured to receive the lugs 1862, 1864 therein. A pair of attachment pins 1836 is configured to be pressed into holes 1837 in the upper coupler portion 1832 to affix the two coupler portions 1832 and 1834 together. Other fastener arrangements, screws, rivets, adhesive, etc. may be employed. When the endless member 1862 is journaled on the pulleys 1840 and 1340, the coupler assembly 1830 is free to move axially within the distal notch 1819 in the shaft frame 1812 in response to the axial movement of the first distal articulation driver 1820. The articulation motions generated by the axial movement of the first distal articulation driver 1820 are transferred to the second distal articulation driver 1860 or the endless member 1862. An attachment ball or lug 1866 is attached to the endless member 1862 and is received in a groove or pocket 1342 formed in the distal pulley 1340. Thus, movement of the endless member 1862 is transferred to the surgical end effector 1300 and more specifically to the elongate channel 1302 of the surgical end effector 1300 to articulate the end effector about articulation axis B-B. Thus, when the first distal articulation driver 1820 is moved in the distal direction DD, the endless member 1862 causes the surgical end effector 1300 to articulate about the articulation axis B-B in the articulation direction represented by arrow 823. See FIG. 21. Likewise, when the first distal articulation driver 1820 is moved in the proximal direction PD, the endless member 1862 causes the surgical end effector 1300 to articulate about the articulation axis B-B in the articulation direction represented by arrow 821. See FIGS. 21 and 25. As shown in FIG. 21, articulation direction 823 is opposite to articulation direction 821.

[0240] FIGS. 26-31 illustrate portions of another elongate shaft assembly 2200 that is similar to the elongate shaft assembly 200 described above, except for various differences discussed in further detail below. Those components of the elongate shaft assembly 2200 that have been discussed in detail above are referenced with like element numbers and, for the sake of brevity, will not be further discussed in great detail beyond that which may be necessary to understand the operation of the elongate shaft assembly 2200 when, for example, employed with portions of the surgical instrument 10 as described above. As can be seen in FIG. 26, the elongate shaft assembly 2200 includes a proximal housing or nozzle 201 comprised of nozzle portions 202 and 203. The elongate shaft assembly 2200 further includes an anvil actuator member in the form of a closure sleeve 2260 which can be utilized to close and/or open the anvil 2310 of the surgical end effector 2300 that is operably attached thereto. As can be seen in FIG. 26, the elongate shaft assembly 2200 includes a proximal spine 2210 which is configured to operably interface with an articulation lock 2350. The proximal spine 2210 is configured to, one, slidably support a firing member 2220 therein and, two, slidably support the closure sleeve 2260 which extends around the proximal spine 2210. The proximal spine 2210 also slidably supports a

proximal articulation driver 2230. The proximal articulation driver 2230 has a distal end 2231 that is configured to operably engage the articulation lock 2350.

[0241] In the illustrated arrangement, the proximal spine 2210 comprises a proximal end 2211 which is rotatably supported in a chassis 240. In one arrangement, for example, the proximal end 2211 of the proximal spine 2210 has a thread 2214 formed thereon for threaded attachment to a spine bearing configured to be supported within the chassis 240. Such an arrangement facilitates rotatable attachment of the proximal spine 2210 to the chassis 240 such that the proximal spine 2210 may be selectively rotated about a shaft axis SA-SA relative to the chassis 240. The proximal end of the closure sleeve 2260 is attached to a closure shuttle supported in the chassis as was described in detail above. When the elongate shaft assembly 2200 is operably coupled to the handle or housing of the surgical instrument 10, operation of the closure trigger distally advances the closure sleeve 2260.

[0242] As was also indicated above, the elongate shaft assembly 2200 further includes a firing member 2220 that is supported for axial travel within the proximal spine 2210. The firing member 2220 includes an intermediate firing shaft portion 2222 that is configured for attachment to a distal cutting or firing beam assembly 2280. See FIG. 27. The intermediate firing shaft portion 2222 may include a longitudinal slot 2223 in the distal end thereof which can be configured to receive a tab on the proximal end of the distal firing beam assembly 2280. The longitudinal slot 2223 and the proximal end of the distal firing beam assembly 2280 can be sized and configured to permit relative movement therebetween and can comprise a slip joint. The slip joint can permit the intermediate firing shaft portion 2222 of the firing drive 2220 to be moved to articulate the end effector 300 without moving, or at least substantially moving, the distal firing beam assembly 2280. Once the surgical end effector 2300 has been suitably oriented, the intermediate firing shaft portion 2222 can be advanced distally until a proximal sidewall of the longitudinal slot 2223 comes into contact with the tab in order to advance the distal firing beam assembly 2280 and fire a staple cartridge that may be supported in the end effector 300. The proximal spine 2210 is also coupled to a distal spine 2212.

[0243] Similar to the elongate shaft assembly 200, the illustrated elongate shaft assembly 2200 includes a clutch assembly 2400 which can be configured to selectively and releasably couple the proximal articulation driver 2230 to the firing member 2220. In one form, the clutch assembly 2400 includes a lock collar, or sleeve 2402, positioned around the firing member 2220 wherein the lock sleeve 2402 can be rotated between an engaged position in which the lock sleeve 2402 couples the proximal articulation driver 2230 to the firing member 2220 and a disengaged position in which the proximal articulation driver 2230 is not operably coupled to the firing member 2220. When the lock

sleeve 2402 is in its engaged position, distal movement of the firing member 2220 can move the proximal articulation driver 2230 distally and, correspondingly, proximal movement of the firing member 2220 can move the proximal articulation driver 2230 proximally. When lock sleeve 2402 is in its disengaged position, movement of the firing member 2220 is not transmitted to the proximal articulation driver 2230 and, as a result, the firing member 2220 can move independently of the proximal articulation driver 2230. In various circumstances, the proximal articulation driver 2230 can be held in position by the articulation lock 2350 when the proximal articulation driver 2230 is not being moved in the proximal or distal directions by the firing member 2220.

[0244] As discussed above, the lock sleeve 2402 can comprise a cylindrical, or at least a substantially cylindrical body including a longitudinal aperture 2403 defined therein configured to receive the firing member 2220. The lock sleeve 2402 can comprise diametrically-opposed, inwardly-facing lock protrusions 2404 and an outwardly-facing lock member 2406. The lock protrusions 2404 can be configured to be selectively engaged with the firing member 2220. More particularly, when the lock sleeve 2402 is in its engaged position, the lock protrusions 2404 are positioned within a drive notch 2224 defined in the firing member 2220 such that a distal pushing force and/or a proximal pulling force can be transmitted from the firing member 2220 to the lock sleeve 2402. When the lock sleeve 2402 is in its engaged position, the second lock member 2406 is received within a drive notch 2232 defined in the articulation driver 2230 such that the distal pushing force and/or the proximal pulling force applied to the lock sleeve 2402 can be transmitted to the proximal articulation driver 2230. In effect, the firing member 2220, the lock sleeve 2402, and the proximal articulation driver 2230 will move together when the lock sleeve 2402 is in its engaged position. On the other hand, when the lock sleeve 2402 is in its disengaged position, the lock protrusions 2404 may not be positioned within the drive notch 2224 of the firing member 2220 and, as a result, a distal pushing force and/or a proximal pulling force may not be transmitted from the firing member 2220 to the lock sleeve 2402. Correspondingly, the distal pushing force and/or the proximal pulling force may not be transmitted to the proximal articulation driver 2230. In such circumstances, the firing member 2220 can be slid proximally and/or distally relative to the lock sleeve 2402 and the proximal articulation driver 2230.

[0245] As was also discussed above, the elongate shaft assembly 2200 further includes a switch drum 2500 that is rotatably received on the closure sleeve 2260. The switch drum 2500 comprises a hollow shaft segment 2502 that has a shaft boss 2504 formed thereon for receive an outwardly protruding actuation pin 2410 therein. In various circumstances, the actuation pin 2410 extends through a slot into a longitudinal slot provided in the lock sleeve 2402 to facilitate axial movement of

the lock sleeve 2402 when it is engaged with the articulation driver 2230. A rotary torsion spring 2420 is configured to engage the boss 2504 on the switch drum 2500 and a portion of the nozzle housing 203 to apply a biasing force to the switch drum 2500. The switch drum 2500 can further comprise at least partially circumferential openings 2506 defined therein which can be configured to receive circumferential mounts extending from the nozzle halves 202, 203 and permit relative rotation, but not translation, between the switch drum 2500 and the proximal nozzle 201. As described above, rotation of the switch drum 2500 will ultimately result in the rotation of an actuation pin 2410 and the lock sleeve 2402 between its engaged and disengaged positions. Thus, in essence, the nozzle 201 may be employed to operably engage and disengage the articulation drive system with the firing drive system in the various manners described above as well as in U.S. Patent Application Serial No. 13/803,086, now U.S. Patent Application Publication No. 2014/0263541.

[0246] Referring to FIG. 27, the closure sleeve assembly 2260 includes a double pivot closure sleeve assembly 2271. According to various forms, the double pivot closure sleeve assembly 2271 includes an end effector closure sleeve 2272 having upper and lower distally projecting tangs. An upper double pivot link 2277 includes upwardly projecting distal and proximal pivot pins that engage respectively an upper distal pin hole in the upper proximally projecting tang and an upper proximal pin hole in an upper distally projecting tang on the closure sleeve 2260. A lower double pivot link 2278 includes upwardly projecting distal and proximal pivot pins that engage respectively a lower distal pin hole in the lower proximally projecting tang and a lower proximal pin hole in the lower distally projecting tang.

[0247] The elongate shaft assembly 2200 also includes a surgical end effector 2300 that is similar to the surgical end effector 300 that was described above. As can be seen in FIG. 27, the surgical end effector 2300 includes an elongate channel 2302 that is configured to operably support a surgical staple cartridge 2304 therein. The elongate channel 2302 has a proximal end portion 2320 that includes two upstanding lateral walls 2322. The surgical end effector 2300 further includes an anvil 2310 that has an anvil body 2312 that has a staple-forming undersurface 2313 formed thereon. The proximal end 2314 of the anvil body 2312 is bifurcated by a firing member slot 2315 to form two anvil attachment arms 2316. Each anvil attachment arm 2316 includes a laterally protruding anvil trunnion 2317. A trunnion slot 2324 is provided in each lateral wall 2322 of the elongate channel 2302 for receiving a corresponding one of the anvil trunnions 2317 therein. Such arrangement serves to movably affix the anvil 2310 to the elongate channel 2302 for selective pivotable travel between open and closed or clamped positions. The anvil 2310 is moved to a closed position by distally advancing the closure

sleeve 2260 and more particularly, the end effector closure sleeve 2272 up the tapered attachment arms 2316 which causes the anvil 2310 to move distally while pivoting to the closed position. A horseshoe-shaped opening 2273 is provided in the end effector closure sleeve 2272 that is configured to engage an upstanding tab 2318 on the anvil 2310 of the end effector 2300. To open the anvil 2310, the closure sleeve 2260 and, more particularly, the end effector closure sleeve 2272 is moved in the proximal direction. In doing so, a central tab portion defined by the horseshoe shaped opening 2273 cooperates with the tab 2318 on the anvil 2310 to pivot the anvil 2310 back to an open position.

[0248] Turning to FIGS. 26, 28 and 29, as mentioned above, the elongate shaft assembly 2200 includes an articulation lock 2350 that is substantially similar to articulation locks 350 and 810 that were described above. Those components of articulation lock 2350 that differ from the components of articulation lock 350 and are necessary to understand the operation of articulation lock 350 will be discussed in further detail below. As discussed above, the articulation lock 2350 can be configured and operated to selectively lock the end effector 2300 in position. Such arrangement enables the surgical end effector 2300 to be rotated, or articulated, relative to the shaft closure sleeve 2260 when the articulation lock 2350 is in its unlocked state. When the proximal articulation driver 2230 is operatively engaged with the firing member 2220 via the clutch system 2400, further to the above, the firing member 2220 can move the proximal articulation driver 2230 proximally and/or distally. Movement of the proximal articulation driver 2230, whether it is proximal or distal, can unlock the articulation lock 2350 as was described above. This embodiment includes a proximal lock adapter member 2360 that is movably supported between the proximal spine 2210 and the distal spine 2212. The proximal lock adapter 2360 includes a lock cavity 2362 for receiving therein first lock elements 2364 and second lock elements 2366 that are journaled on a frame rail 2368 that extends between the proximal frame 2210 and the distal frame 2212. The articulation lock 2350 operates in the various manners described above and, for the sake of brevity, will not be further discussed herein.

[0249] As can be seen in FIGS. 26, 28 and 29, a first distal articulation driver 2370 is attached to the proximal lock adapter 2360. The first distal articulation driver 2370 is operably attached to a second distal articulation driver 2380 that operably interfaces with the elongate channel 2302 of the end effector 2300. The second distal articulation driver 2380 comprises a cable 2382 that is rotatably journaled on a proximal pulley 2383 and a distal pulley 2392. The distal pulley 2392 is non-rotatably supported or integrally formed on an end effector mounting assembly 2390 and includes a detent or pocket 2396. In the illustrated example, the end effector mounting assembly 2390 is non-movably attached to the proximal end 2320 of the elongate channel 2302 by a spring pin 2393 that extends

through a hole in the end effector mounting assembly 2390 and holes 2394 in the proximal end 2320 of the elongate channel 2302. The proximal pulley 2383 is rotatably supported on the distal spine 2212. The distal end of the distal spine 2212 has a pivot pin 2213 formed thereon that is configured to be rotatably received within a pivot hole 2395 formed in the end effector mounting member 2390. Such arrangement facilitates pivotal travel (i.e., articulation) of the elongate channel 2302 relative to the distal spine 2212 about an articulation axis B-B defined by the pivot hole 2395 and the pin 2213.

[0250] In one form, the cable 2382 may be fabricated from stainless steel, tungsten, aluminum, titanium, etc., for example. The cable may be of braided or multi-stranded construction with various numbers of strands to attain desired levels of tensile strength and flexibility. In various arrangements, for example, the cable 2382 may have a diameter in the range of 0.03 inches to 0.08 inches and more preferably in the range of 0.05 - 0.08 inches. A preferred cable may, for example, be fabricated from 300 series stainless steel - half hard to full hard. In various arrangements, the cable may also be coated with, for example, Teflon®, copper, etc. for improved lubricity and/or to reduce stretching, for example. In the illustrated example, the cable 2382 has a lug 2384 attached to one end thereof and a lug 2385 attached to the other end thereof by, for example, crimping. The first distal articulation driver 2370 includes a pair of spaced cleats 2372, 2374 that are spaced from each other sufficiently so as to accommodate the lugs 2384, 2385 therebetween. For example, the proximal cleat 2372 includes a proximal slot 2373 for receiving a portion of the cable 2382 adjacent the lug 2384 and the distal cleat 2374 includes a distal slot 2375 for receiving a corresponding portion of the cable 2382 adjacent the lug 2385. The slots 2373 and 2375 are sized relative to the lugs 2384, 2385, respectively so as to prevent the lugs 2384, 2385 from pulling therethrough. The proximal slot 2375 is oriented at an angle as compared to the distal slot 2375 so as to cinchingly grip the corresponding portion of the cable 2382 therein. See FIG. 30. An attachment ball or lug 2398 is attached to the endless member 2382 and is received in the detent or pocket 2396 formed in the distal pulley 2392. See FIG. 31. Thus, when the first distal articulation driver 2370 is axially retracted in the proximal direction PD, in the manners described above, the endless member 2382 will articulate the end effector 2300 in the direction represented by arrow 2376 in FIG. 31. Conversely, when the first distal articulation driver 2370 is axially advanced in the distal direction DD, the surgical end effector 2300 is articulated in the direction represented by arrow 2399 in FIG. 31. In addition, the proximal and distal cleats 2372, 2374 are spaced sufficiently so as to accommodate the lugs 2384, 2385 therebetween. A tensioning wedge 2378 is used as shown in FIGS. 29-32 to apply sufficient tension to the cable 2382 such that when the cable is actuated, it will apply an articulation motion to the end effector 2300. In the alternative arrangement

depicted in FIG. 35, the proximal cleat 2374' is initially not attached to the first articulation driver 2370. The proximal cleat 2374' is positioned on the first distal articulation driver 2370 so as to capture the lugs 2384 and 2385 between the distal cleat 2372 and the proximal cleat 2374'. The proximal cleat 2374' is moved toward the distal cleat 2372 until a sufficient amount of tension is generated in the cable 2382 and then the proximal cleat 2374' is attached to the first distal articulation driver 2370. For example, the proximal cleat 2374' may be attached to the first distal articulation driver 2370 by laser welding or other suitable form of attachment means or fastener arrangement.

[0251] Referring FIGS. 36-39, the surgical instrument includes for example, a central firing beam support member 2286 that is configured to extend across an articulation joint to provide support to a flexible firing beam assembly 2280. In one form, the central firing beam support member 2286 comprises a flexible plate member or band and includes a downwardly protruding distal attachment tab 2287 that is attached to the surgical end effector and an upwardly extending proximal end portion 2288 that is attached to the elongate shaft assembly. In at least one arrangement, the distal attachment tab 2287 is attached to the end effector mounting assembly 2390 by the spring pin 2393 and the proximal end portion 2288 is pinned to the distal spine 2212 by pins (not shown). The central firing beam support member 2286 is located along the centerline or shaft axis of the device and serves to provide support to the firing beam during articulation. This is different from those arrangements that employ "blow-out" plates or lateral support plates that are located on the lateral sides of the firing beam and which are thereby offset from the shaft axis increasing the tension and compression forces that they experience during articulation. In the illustrated example, the longitudinally movable flexible firing beam assembly 2280 comprises a laminated beam structure that includes at least two beam layers wherein at least one beam layer is configured to pass adjacent one lateral side of the central firing beam support member and at least one other beam member is configured to pass adjacent another lateral side of the central firing beam support member. In the illustrated example, two laminated layers 2282 and 2284 are configured to pass adjacent each side of the flexible tension carrying member. See, for example, FIGS. 35 and 36. In various embodiments, the laminated layers 2282 and 2284 may comprise, for example, stainless steel bands that are interconnected by, for example, welding or pinning together at their proximal ends, while their respective distal ends are not connected together to allow the laminates or bands to splay relative to each other when the end effector is articulated. Each pair of laminated layers or bands 2282, 2284 is represented as a lateral firing band assembly 2285 of the firing beam assembly 2280. Thus, as shown in FIG. 36, one lateral firing band assembly 2285 is supported on each lateral side of the central articulation bar 2286 for axial travel relative thereto by a

series of lateral load carrying members 2290. Each lateral load carrying member 2290 may be fabricated from, for example, stainless steel, aluminum, titanium, liquid crystal polymer material, plastic material, Nylon, Acrylonitrile butadiene styrene (ABS), polyethylene, etc. and be formed with opposed arcuate ends 2292. Each lateral load carrying member 2290 also has an axial passage 2294 extending therethrough to receive the assembly of the lateral firing band assemblies 2285 and the central articulation bar 2286. As can be most particularly seen in FIG. 38, each axial passage is defined by two opposed arcuate surfaces 2295 that facilitate movement of lateral load carrying members 290 on the longitudinally movable flexible firing beam assembly 2280. The lateral load carrying members 2290 are serially arranged on the lateral firing band assemblies 2285 and the central articulation bar 2286 such that the opposed arcuate ends 2292 abut corresponding arcuate ends 2292 of adjacent lateral load carrying members 2290. See, for example, FIGS. 36 and 37.

[0252] Referring again to FIG. 37, it can be seen that the proximal end portion 2288 of the central articulation bar 2286 extends downwardly for attachment to the distal spine 2212. The distal end 2287 of the firing beam assembly 2280 is attached to a firing member 2900 of the type and construction describe above, for example. As can be seen in that Figure, the firing member 2900 includes a vertically-extending firing member body 2902 that has a tissue cutting surface or blade 2904 thereon. In addition, a wedge sled 2910 may be mounted within the surgical staple cartridge 2304 for driving contact with the firing member 2900. As the firing member 2900 is driven distally through the cartridge body 2304, the wedge surfaces 2912 of the wedge sled 2910 contact the staple drivers to actuate the drivers and the surgical staples supported thereon upwardly in the cartridge 2304. The firing beam assembly 2280 is operated in the various manners described above. As the firing beam assembly 2280 is distally advanced about the articulation joint, the lateral load carrying members 2290 may help to resist buckling loads on the firing beam assembly 2280. The lateral load carrying members 2290 may also reduce the amount of force required to articulate the end effector and also accommodate greater articulation angles when compared to other articulation joint arrangements. The fixed central firing beam support member 2286 serves to carry the tension loads that are generated during articulation and firing.

[0253] As described above, the firing beam assembly comprises a laminated beam structure that includes at least two beam layers. As the firing beam assembly is advanced distally (during firing), the firing beam assembly is essentially bifurcated by the central firing beam support member so that portions of the firing beam assembly (i.e., laminate layers) pass on both sides of the of the central firing beam support member.

[0254] FIGS. 40-43 illustrate a portion of another firing beam assembly 2280' that is attached to a firing member 2900. As can be seen in those Figures, the firing beam assembly 2280' comprises a laminated structure that includes two outer lateral beams or layers 2282' that each have a thickness that is designated as "a" and four central layers 2284' that each have a thickness designated as "b". In at least one arrangement, for example, "a" may be approximately 0.005 - 0.008 inches and more preferably 0.008 inches and "b" may be approximately 0.008 - 0.012 inches and more preferably 0.010 inches. However, other thicknesses may be employed. In the illustrated example, "a" is less than "b". In other arrangements, "a" is greater than "b". In alternative arrangements, for example, the laminates may be made up of three different thicknesses "a", "b", "c", wherein "a" = 0.006 inches, "b" = 0.008 inches, and "c" = 0.010 inches (with the thickest laminate or band being in the center of the assembly). In various arrangements, there may be an odd number of laminates or bands where "c" is the single thickest laminate in the center.

[0255] The laminate composition is relevant because of the amount of strain that is applied to a beam assembly based on its thickness and its distance from the centerline of bending. Thicker laminates or bands that are closer to the centerline may experience the same levels of strain as the thinner ones that are farther away from the centerline because they have to be bent more in view of the fact that they are stacked together. The radius of curvature is more aggressive on the inside of the curve the father away from the centerline. Thicker laminates or bands tend to experience more internal stress than thinner laminates given the same radius of curvature. Thus, thinner side laminates or bands that have the smallest radius of curvature may have the same likelihood of plastically deforming as the thicker ones that are closure to the centerline. Stated another way, when the end effector articulates in one direction, the laminates or bands located away from the direction of articulation have the largest bend radius and the laminates or bands closest to the direction of articulation have the tightest bend radius. However, when the end effector is articulated in the opposite direction, the inverse is true. The laminates on the inside of the laminate stack experience the same deviation, but their bend radius will always fall within the range of the outer ones. Thus, to maintain flexibility, locating thinner laminates on the outside of the stack may be desired. However, to maximize stiffness and buckling resistance, thicker materials on the inside add additional benefit. Alternately, if the end effector needs only to articulate in a single direction, the laminates or bands located away from the direction of articulation will experience the greatest bend radius and the laminates or bands located in the direction of articulation have the tightest bend radius. However, because the end effector does not articulate in an opposite direction, the inverse is no longer true and therefor, the laminate stack does not need to be

symmetric. Thus, in such arrangement, it would be desirable to have the thinnest laminate or band be the one that will experience the tightest bend radius (the laminate or band on the side of the direction of articulation).

[0256] In still other arrangements, the laminates or bands may be fabricated from different metals with different strengths and modulus. For example, the outer laminates or bands could have the same thickness as the inner laminates or bands with the inner laminates or bands being fabricated from 300 series stainless steel and the outer laminates or bands being fabricated from titanium or nitinol.

[0257] As can also be seen in FIGS. 42 and 43, the distal firing beam assembly 2280' may be effectively employed with the series of lateral load carrying members 2290 described above. It will be appreciated that the distal firing beam assembly 2280' may also be used in connection with a central articulation bar 2286 in the manner described above so that some of the layers or lateral beams (or bands or laminates) thereof axially advance along the sides of the central articulation bar. In some embodiments, the layers advancing on each side of the central articulation bar 2286 may have the same thickness, composition, shape and configuration. In other arrangements the layer or layers passing along one side of the central articulation bar may have a different thickness and/or composition and/or shape than the thickness and/or composition and/or shape of the layer or layers passing along the opposite side of the central articulation bar, so as to achieve a desired range of travel and flexibility while maintaining a desired amount of stiffness so as to avoid buckling during firing.

[0258] FIGS. 44-46 illustrate a portion of another elongate shaft assembly 3200 that includes a surgical end effector 300 of the type and construction described above. Other forms of surgical end effectors may also be employed. The elongate shaft assembly 3200 also includes a longitudinally movable flexible firing beam assembly 3280 that is attached to a firing member 900. In alternative arrangements, the distal end of the firing beam assembly 3280 may be configured to perform various actions within the surgical end effector without the need for a firing member attached thereto. The flexible firing beam assembly 3280 may comprise a laminated beam arrangement of the various types described herein. In one arrangement, at least two compression bands are employed to provide lateral support to the flexible firing beam assembly 3280 as it traverses the articulation joint. The illustrated embodiment employs a total of four compression bands for providing lateral support to the flexible firing beam as it traverses the articulation joint. For example, the elongate shaft assembly 3200 further includes a spine 3210 that includes a distal end 3217 that has two distal cavities, or notches 3219, and two proximal cavities, or notches 3219', formed therein. One distal cavity 3219 accommodates a first proximal end 3904 of a first compression band 3900 located on one lateral side 3281 of said flexible

firing beam assembly 3280 and the other distal cavity 3219 accommodates a second proximal end 3905 of a second compression band 3901 located on another lateral side 3283 of the flexible firing beam assembly 3280. The first compression band 3900 includes a first distal end 3902 that is mounted within a corresponding upstanding lateral support wall 330 formed on the proximal end 320 of the elongate channel 302 of the surgical end effector 300. Similarly, the second compression band 3901 includes a second distal end 3907 that is also mounted within a corresponding upstanding lateral support wall 330 formed on the proximal end 320 of the elongate channel 302 of the surgical end effector 300. The first and second distal compression bands 3900, 3901 may be fabricated from spring steel or the like and the proximal ends 3904, 3905 may be folded in a U-shaped fashion to form a biasing portion configured to be movably received within the distal notches 3219 as shown. Such arrangement permits the first and second distal compression bands 3900, 3901 to flex in response to the articulation of the surgical end effector 300 while retaining the proximal ends 3904, 3905 within their corresponding distal notches 3219.

[0259] As can also be seen in FIGS. 44-46, the elongate shaft assembly 3200 further includes a third compression band 3910 and a fourth compression band 3911. Like the first and second compression bands 3900, 3901, the third and fourth compression bands 3910, 3911 may be fabricated from spring steel. As can be seen in FIGS. 44-46, the third compression band 3910 may be situated between the first compression band 3900 and the lateral side 3281 of the flexible firing beam assembly 3280 and the fourth compression band 3911 may be situated between the second compression band 3901 and the other lateral side 3283 of the flexible firing band assembly 3280. The third proximal end 3914 of the third compression band 3910 as well as the fourth proximal end 3915 of the fourth compression band 3911 may each be folded in a U-shaped fashion to form a biasing portion that is movably received within a corresponding proximal cavity 3219' in the spine 3210. The third distal end 3912 of the third compression band 3910 and the fourth distal end 3917 of the fourth compression band 3911 are mounted in a corresponding lateral support wall 330 in the surgical end effector 300.

[0260] The elongate shaft assembly 3200 further comprises a movable support link assembly 3920 for providing further lateral support to the flexible firing beam assembly 3280 as the end effector 300 is articulated about the articulation axis. As can be seen in FIGS. 44-46, the movable support link assembly 3920 comprises a middle support member 3922 that is movably coupled to the surgical end effector 300 as well as the elongate shaft assembly 3200. In one embodiment, the middle support member 3922 is pivotally pinned to the proximal end 320 of the elongate channel 302. The middle support member 3922 further includes a proximally protruding tab 3926 that has an elongate proximal

slot 3928 therein. The proximal slot 3928 is configured to slidably receive a middle support pin 3211 formed on the spine 3210. Such arrangement permits the relative pivotal and axial movement between the middle support member 3922 and the spine 3210 of the elongate shaft assembly 3200 so as to accommodate a larger range of articulation while being able to dynamically move so as to maintain adequate lateral support on the firing beam assembly 3280. As can be seen in FIGS. 44-46, the middle support member 3922 further includes centrally disposed slot 3930 for axially receiving the firing beam assembly 3280 therethrough.

[0261] As can be further seen in FIGS. 44-46, the movable support link assembly 3920 further comprises an elongate movable pivot link 3940. The pivot link 3940 includes a central body portion 3942 that has proximally protruding proximal nose portion 3943 and a distally-protruding distal nose portion 3944. The pivot link 3940 further includes a first downwardly-protruding lateral support wall 3945 and a second downwardly protruding lateral support wall 3946 that define a beam slot 3947 therebetween. As can be seen in FIG. 46, the firing beam assembly 3280 is configured to extend between the first and second lateral support walls 3945, 3946 during actuation of the firing beam assembly 3280 and articulation of the surgical end effector 300. Further, in the illustrated arrangement, for example, the first compression band 3900 extends between the first lateral support wall 3945 and the third compression band 3910 and the second compression band 3901 extends between the second lateral support wall 3946 and the fourth compression band 3911. The first lateral support wall 3945 includes an inwardly facing first arcuate surface 3948 and the second lateral support wall 3946 includes an inwardly facing second arcuate surface 3949. The first and second arcuate surfaces 3948, 3949 serve to provide lateral support to the firing beam assembly 3280 as it flexes during articulation of the end effector 300. The radiused surfaces may match the outer radius of the firing beam assembly 3280 and compression bands 3900, 3901, 3910, 3911 depending upon the direction and degree of articulation. As can also be seen in FIGS. 44 and 45, the distal end 3217 of the spine 3210 includes a pair of right and left opposing shaft notches 3218 into which the rounded proximally-protruding proximal nose portion 3943 of the pivot link 3940 extends depending upon the direction in which the surgical end effector is articulated about the articulation axis. Similarly, right and left opposed support notches 3932 are provided in the middle support 3922 to accommodate the distally-protruding distal nose portion 3944 of the pivot link 3940 depending upon the direction in which the end effector is articulated. Such notch arrangements serve to properly align the pivot link 3940 in an orientation suited to accommodate the direction of articulation while affording lateral support to the pivot link 3940.

[0262] FIGS. 47-51 illustrate another elongate shaft assembly 4200 that is, in some aspects, similar to the elongate shaft assembly 2200 described above, except for various differences discussed in further detail below. Those components of the elongate shaft assembly 2200 that have been discussed in detail above will contain like element numbers and, for the sake of brevity, will not be further discussed in great detail beyond that which may be necessary to understand the operation of elongate shaft assembly 4200 when, for example, employed with portions of the surgical instrument 10 as described above. As can be seen in FIG. 47, in at least one example, the elongate shaft assembly 4200 includes an articulation lock 2350. As was discussed in detail above, the articulation lock assembly 2350 includes a proximal lock adapter 2360 that is coupled (e.g., pinned) to a first distal articulation driver 4370. As can be seen in FIGS. 47 and 50, the first distal articulation driver 4370 includes a first proximal gear rack segment 4371 and a first distal gear rack segment 4373 formed on a distal end 4372 thereof. The elongate shaft assembly 4200 also includes a second distal articulation driver 4380 that includes a second proximal gear rack segment 4381 and a second distal gear rack segment 4383 that is formed on a distal end 4382 thereof.

[0263] The first distal articulation driver 4370 and the second distal articulation driver 4380 are configured to move axially relative to the distal spine assembly 4212 in the proximal direction PD and the distal direction DD. As can be seen in FIG. 50, the first proximal gear rack segment 4371 and the second proximal gear rack segment 4381 are in meshing engagement with a proximal power transfer gear 4390 that is rotatably supported by the distal spine assembly 4212. Likewise, the first distal gear rack segment 4373 and the second distal gear rack segment 4383 are in meshing engagement with a distal power transfer gear assembly 4392. In particular, in at least one arrangement, the distal power transfer gear assembly 4392 includes a pinion gear 4393 that is in meshing engagement with the first distal gear rack segment 4373 and the second distal gear rack segment 4383. The distal power transfer gear assembly 4392 further includes a drive gear 4394 that is arranged in meshing engagement with an idler gear 4395. The idler gear 4395 is, in turn, supported in meshing engagement with a driven gear 4306 that is formed on the proximal end portion 4320 of the elongate channel 4302 of a surgical end effector 4300. The surgical end effector 4300 may otherwise be similar to the surgical end effector 2300 and include an anvil 4310 that may be opened and closed in the various manners described above. Referring to FIGS. 48, 49 and 51, the distal spine assembly 4212 may comprise an upper spine portion 4212A and a lower spine portion 4212B. The distal power transfer gear assembly 4392, the idler gear 4395 and the driven gear portion 4306 of the elongate channel 4302 are each pivotally attached to or supported on the bottom portion 4212B of the distal spine assembly 4212.

[0264] The elongate shaft assembly 4200 depicted in FIG. 47 includes a firing beam assembly 3280 that is attached to a firing member (not shown). The firing beam assembly 3280 may comprise a laminated beam arrangement of the types described herein. Operation of the firing member was described in detail above and will not be repeated for the sake of brevity. As can also be seen in FIG. 47, a firing beam support member 4400 of the type disclosed in U.S. Patent Application Serial No. 14/575,117, entitled SURGICAL INSTRUMENTS WITH ARTICULATABLE END EFFECTORS AND MOVABLE FIRING BEAM SUPPORT ARRANGEMENTS, the entire disclosure of which is hereby incorporated by reference herein, is employed to provide support to the firing beam assembly 3280 during articulation of the surgical end effector 4300. FIG. 52 illustrates use of a distal firing beam assembly 2280 in an elongate shaft assembly 4200. As can be seen in that Figure, a plurality of lateral load carrying members 2290 are employed in the manner described above to provide support to the distal firing beam assembly 2280 as the surgical end effector 4300 is articulated.

[0265] FIGS. 53-58 illustrate another elongate shaft assembly 5200 that is, in some aspects, similar to the elongate shaft assembly 2200 described above, except for various differences discussed in further detail below. Those components of the elongate shaft assembly 5200 that have been discussed in detail above with respect to the elongate shaft assembly 2200 will be identified with like element numbers and, for the sake of brevity, will not be further discussed in great detail beyond that which may be necessary to understand the operation of the elongate shaft assembly 5200 when, for example, employed with portions of the surgical instrument 10 as described above.

[0266] Similar to the elongate shaft assembly 2200, the illustrated elongate shaft assembly 5200 includes a clutch assembly 2400 which is configured to operably engage an articulation system 5600 that is configured to apply push and pulling articulation motions to the surgical end effector 300 that is operably coupled thereto. In this embodiment, the clutch assembly 2400 includes a lock collar, or lock sleeve 2402, that is positioned around the firing member 2220 wherein the lock sleeve 2402 can be rotated between an engaged position in which the lock sleeve 2402 operably engages the articulation system 5600 to the firing member 2220 and a disengaged position in which the articulation system 5600 is not operably coupled to the firing member 2220. Referring specifically to FIGS. 54-56, in the illustrated example, the articulation system 5600 comprises an articulation disc or rotary member 5602 that is supported for rotational movement within the nozzle 201. The articulation disc 5602 is rotatably driven by a drive connection assembly 5610. In the illustrated example, the drive connection assembly 5610 includes a drive pin 5612 that is attached to the articulation disc 5602. An articulation drive link 5614 is operably attached to the drive pin 5612 by a connector 5616 that facilitates some

movement of the articulation drive link 5614 relative to the drive pin 5612. See FIGS. 54-56. The articulation drive link 5614 includes a drive coupler 5618 that is configured to drivingly engage the outwardly facing lock member 2406 on the lock sleeve 2402. See FIG. 53.

[0267] As discussed above, the lock sleeve 2402 can comprise a cylindrical, or at least a substantially cylindrical body including a longitudinal aperture 2403 defined therein configured to receive the firing member 2220. See FIG. 53. The lock sleeve 2402 can comprise diametrically-opposed, inwardly-facing lock protrusions 2404 and an outwardly-facing lock member 2406. The lock protrusions 2404 can be configured to be selectively engaged with the firing member 2220. More particularly, when the lock sleeve 2402 is in its engaged position, the lock protrusions 2404 are positioned within a drive notch 2224 defined in the firing member 2220 such that a distal pushing force and/or a proximal pulling force can be transmitted from the firing member 2220 to the lock sleeve 2402. When the lock sleeve 2402 is in its engaged position, the outwardly facing lock member 2406 is received within a drive notch 5619 in the drive coupler 5618 as shown in FIG. 53 such that the distal pushing force and/or the proximal pulling force applied to the lock sleeve 2402 can be transmitted to the articulation drive link 5614. In effect, the firing member 2220, the lock sleeve 2402, and the articulation drive link 5614 will move together when the lock sleeve 2402 is in its engaged position. On the other hand, when the lock sleeve 2402 is in its disengaged position, the lock protrusions 2404 may not be positioned within the drive notch 2224 of the firing member 2220 and, as a result, a distal pushing force and/or a proximal pulling force may not be transmitted from the firing member 2220 to the lock sleeve 2402. Correspondingly, a drive force DF may not be applied to the articulation disc 5602. In such circumstances, the firing member 2220 can be slid proximally and/or distally relative to the lock sleeve 2402 and the proximal articulation driver 2230.

[0268] As was also discussed above, the elongate shaft assembly 5200 further includes a switch drum 2500 that is rotatably received on the closure sleeve 2260. See FIG. 53. The switch drum 2500 comprises a hollow shaft segment 2502 that has a shaft boss 2504 formed thereon for receive an outwardly protruding actuation pin 2410 therein. In various circumstances, the actuation pin 2410 extends into a longitudinal slot 2401 provided in the lock sleeve 2402 to facilitate axial movement of the lock sleeve 2402 when it is engaged with the articulation drive link 5614. A rotary torsion spring 2420 is configured to engage the boss 2504 on the switch drum 2500 and a portion of the nozzle housing 201 to apply a biasing force to the switch drum 2500. As also discussed above, the switch drum 2500 can further comprise at least partially circumferential openings defined therein which can be configured to receive circumferential mounts extending from the nozzle halves and permit relative

rotation, but not translation, between the switch drum 2500 and the nozzle housing 201. As described above, rotation of the switch drum 2500 will ultimately result in the rotation of an actuation pin 2410 and the lock sleeve 2402 between its engaged and disengaged positions. Thus, in essence, the nozzle housing 201 may be employed to operably engage and disengage the articulation system 5600 with the firing drive system in the various manners described above as well as in U.S. Patent Application Serial No. 13/803,086, now U.S. Patent Application Publication No. 2014/0263541.

[0269] Referring again to FIGS. 53-56, the articulation system 5600 of the illustrated example, further includes a "first" or right articulation linkage 5620 and a "second" or left articulation linkage 5640. The first articulation linkage 5620 includes a first articulation link 5622 that includes a first articulation pin 5624 that is movably received within a first articulation slot 5604 in the articulation disc 5602. The first articulation link 5622 is movably pinned to a first articulation connector 5626 that is configured to engage an articulation lock 2350. As discussed above, the articulation lock 2350 can be configured and operated to selectively lock the surgical end effector 300 in position. Such arrangement enables the surgical end effector 300 to be rotated, or articulated, relative to the shaft closure sleeve 2260 when the articulation lock 2350 is in its unlocked state. When the articulation drive link 5614 is operably engaged with the firing member 2220 via the clutch system 2400, further to the above, the firing member 2220 can rotate the articulation disc 6502 to move the first articulation linkage 5620 proximally and/or distally. Movement of the first articulation connector 5626 of the first articulation linkage 5620, whether it is proximal or distal, can unlock the articulation lock 2350 as was described above. The proximal lock adapter 2360 includes a lock cavity 2362 for receiving therein first lock elements 2364 and second lock elements 2366 that are journaled on a frame rail that extends between the proximal frame 2210 and the distal frame. Operation of the articulation lock 2350 was described above and, for the sake of brevity, will not be further discussed herein. As can be seen in FIG. 53, a first distal articulation driver 5370 is attached to the proximal lock adapter 2360. The first distal articulation driver 5370 is operably attached to the proximal end 320 of the elongate channel 302 of the surgical end effector 300.

[0270] As was also indicated above, the articulation system 5600 of the illustrated example, further includes a "second" or left articulation linkage 5640. As can be seen in FIGS. 54-56, the second articulation linkage 5640 includes a second articulation link 5642 that includes a second articulation pin 5644 that is movably received within a second articulation slot 5606 in the articulation disc 5602. The second articulation link 5642 is pinned to a second articulation bar 5646 that is attached to the proximal end 320 of the elongate channel 302 of the surgical end effector 300. Referring to FIG. 54,

the articulation system 5600 further includes a first articulation biasing member 5628 that is received within the first articulation slot 5604 and a second articulation biasing member 5648 that is received within the second articulation slot 5606. FIG. 54 illustrates the articulation system 5600 in a neutral or unarticulated configuration. As can be seen in that Figure, the first articulation pin 5624 is in contact with the first articulation biasing member 5628 and the second articulation pin 5644 is in contact with the second articulation biasing member 5648. However, when in that neutral position, the first and second articulation biasing members 5628, 5648 may not be in a compressed state. FIG. 55 illustrates application of the drive force DF to the articulation disc 5602 in the proximal direction PD by the articulation drive link 5614 in the above-described manner. Application of the drive force DF in the proximal direction PD results in rotation of the articulation disc 5602 in the rotary direction represented by arrow 5601. As the articulation disc 5602 rotates in the rotary direction 5601, the end of the second articulation slot contacts the second articulation pin 5644 and applies a pushing force to the second articulation linkage 5640 and ultimately to the second articulation bar 5646. Conversely, the first articulation biasing member 5628 urges the first articulation pin 5624 in the direction of arrow 5601 within the first articulation slot 5604 such that a pulling force is applied to the first articulation linkage 5620 in the proximal direction PD. This proximal pulling force is transmitted to the first distal articulation driver 5370 through the articulation lock 2350. Such "pushing and pulling motions" as applied to the surgical end effector causes the surgical end effector 300 to articulate about the articulation axis in the direction represented by arrow 5300. See FIG. 53. When the articulation disc 5602 is in the position illustrated in FIG. 55, the second articulation biasing member 5648 may be in a compressed state and the first articulation biasing member may not be compressed. Thus, when the application of drive force DF to the articulation drive link 5614 is discontinued, the second articulation biasing member 5648 may bias the articulation disc 5602 back to the neutral position shown in FIG. 54, for example.

[0271] Conversely, when the drive force DF is applied to the articulation drive link 5614 in the distal direction DD as shown in FIG. 56, the articulation disc 5602 rotates in the rotary direction represented by arrow 5603. As the articulation disc 5602 rotates in the rotary direction 5603, the end of the first articulation slot 5604 contacts the first articulation pin 5624 and applies a pushing force to the first articulation linkage 5620 and ultimately to the first distal articulation driver 5370 through the articulation lock 2350. In addition, the second articulation biasing member 5648 urges the second articulation pin 5644 in the direction of arrow 5603 within the second articulation slot 5606 such that a pulling force is applied to the second articulation linkage 5640 in the proximal direction PD. This

proximal pulling force is transmitted to the second articulation bar 5646. Such "pushing and pulling motions" as applied to the surgical end effector 300 causes the surgical end effector 300 to articulate about the articulation axis in the direction represented by arrow 5302. See FIG. 53. When the articulation disc 5602 is in the position illustrated in FIG. 56, the first articulation biasing member 5628 may be in a compressed state and the second articulation biasing member 5648 may not be compressed. Thus, when the application of drive force DF to the articulation drive link 5614 is discontinued, the first articulation biasing member 5628 may bias the articulation disc 5602 back to the neutral position shown in FIG. 54, for example.

[0272] FIG. 57 illustrates the attachment of the distal end portion 814 of the shaft frame 812 to the surgical end effector 300 that is operably coupled to the elongate shaft assembly 5200. As described above, the distal end portion 814 has a downwardly protruding pivot pin (not shown) thereon that is adapted to be pivotally received within a pivot hole (not shown) that is formed in the proximal end portion 320 of the elongate channel 302. Such arrangement facilitates pivotal travel of the elongate channel 302 relative to the shaft frame 812 about an articulation axis B-B defined by the pivot hole. As can also be seen in FIG. 57, the first distal articulation driver 5370 is attached to a first coupler 850 by a first ball joint 852. The first coupler 850 is also pivotally pinned to the proximal end portion 320 of the elongate channel 302 by a first pin 854 as can be seen in FIG. 57. Similarly, the second articulation bar 5646 is attached to a second coupler 870 by a second ball joint 872. The second coupler 870 is also pivotally pinned to the proximal end portion 320 of the elongate channel 302 by a second pin 874 as can be seen in FIG. 57.

[0273] Referring to FIGS. 53 and 58, the elongate shaft assembly 5200 may also include a firing beam assembly 2280 that is attached to a firing member 900 of the type described above. The firing beam assembly 2280 is attached to the firing member 2220 and may be axially advanced and retracted in the various manners described above. The elongate shaft assembly 5200 may further comprise a multiple support link assembly 920 for providing lateral support to the distal firing beam 2280 as the surgical end effector 300 is articulated about the articulation axis B-B. As can be seen in FIG. 58, the multiple support link assembly 920 comprises a middle support member 922 that is pivotally pinned to the proximal end 320 of the elongate channel 302 in the manners described above. The middle support member 922 further includes centrally disposed slot 930 for axially receiving the distal firing beam 2280 therethrough. The multiple support link assembly 920 further comprises a proximal support link 940 and a distal support link 950. The proximal support link 940 includes a body portion 942 that has a rounded proximal end 943 and a rounded distal end 944. The proximal support link 940 further

includes a pair of downwardly protruding lateral support walls 945 that define a proximal slot therebetween. Similarly, the distal support link 950 includes a body portion 952 that has a rounded proximal end 953 and a rounded distal end 954. The distal support link 950 further includes a pair of downwardly protruding lateral support walls 955 that define a distal slot therebetween. As can be seen in FIG. 58, the distal firing beam 2280 is configured to extend between the lateral support walls 945 of the proximal support link 940 and the lateral support walls 955 of the distal support link 950. Each support wall 945 and 955 includes an inwardly facing arcuate surface as was described above. The support surfaces serve to provide lateral support to the distal firing beam 2280 as it flexes during articulation of the surgical end effector 300. In addition, the closure sleeve assembly 2260 may include a double pivot closure sleeve assembly of the type described above that is configured to operably interact with the anvil on the surgical end effector 300. Operation of the closure sleeve assembly 2260 results in the opening and closing of the anvil of the surgical effector in the various manners described above.

[0274] FIG. 59 illustrates a portion of another elongate shaft assembly 5700 that may be substantially similar to the elongate shaft assembly 5200 except for the differences discussed below. In particular, the articulation disc 5702 of the articulation system 5701 is rotated by a worm gear motor 5710 that is operably supported in the nozzle housing 201. In one embodiment, for example, a driven gear 5703 is integrally formed or otherwise non-movably attached to the articulation disc 5702 such that it is in meshing engagement with the worm gear drive 5712 of the motor 5710. In the illustrated example, a first articulation rod or member 5720 may be directly attached to a portion of a surgical end effector in any of the various manners described herein. A first articulation pin 5722 is attached to the first articulation rod 5720 and is received within an arcuate first articulation slot 5704 formed in the articulation disc 5702. A first articulation biasing member 5705 is received within the first articulation slot 5704 for biasing contact with the first articulation pin 5722. Likewise, a second articulation rod or member 5730 may be directly or indirectly attached to a portion of a surgical end effector in any of the various manners described herein. A second articulation pin 5732 is attached to the second articulation rod 5730 and is received within an arcuate second articulation slot 5706 formed in the articulation disc 5702. A second articulation biasing member 5707 is received within the second articulation slot 5706 for biasing contact with the second articulation pin 5732.

[0275] FIG. 59 illustrates the articulation system 5701 in a neutral or unarticulated configuration. As can be seen in that Figure, the first articulation pin 5722 is in contact with the first articulation biasing member 5705 and the second articulation pin 5732 is in contact with the second articulation biasing

member 5707. However, when in that neutral position, the first and second articulation biasing members 5705, 5707 may not be in a compressed state. Actuation of the motor 5710 to rotate the articulation disc 5702 in the rotary direction represented by arrow 5601 will apply a pulling motion to the first articulation rod 5720 to cause the first articulation rod 5720 to move in the proximal direction PD as well as to apply a pushing motion to the second articulation rod 5730 to cause the second articulation rod 5730 to move in the distal direction DD. Conversely, actuation of the motor 5710 to rotate the articulation disc 5702 in the rotary direction represented by arrow 5603 will apply a pushing motion to the first articulation rod 5720 to cause the first articulation rod 5720 to move in the distal direction DD as well as to apply a pulling motion to the second articulation rod 5730 to cause the second articulation rod 5730 to move in the proximal direction PD. Such "pushing and pulling motions" as applied to the surgical end effector, causes the surgical end effector to articulate about the articulation axis in the various manners described above.

[0276] FIGS. 60-65 illustrate another articulation system 5800 that may be employed with various elongate shaft assemblies and effector arrangements described herein. In this embodiment, however, the articulation system 5800 comprises a dual articulation disc assembly 5810 that comprises a driver articulation disc 5820 and a driven articulation disc 5830. Both of the articulation discs 5820, 5830 may, for example, be rotatably supported within the nozzle housing of the elongate shaft assembly such that both discs 5820, 5830 are independently rotatable about a common axis. In various embodiments, drive motions may be applied to the driver articulation disc 5820 by an articulation drive link 5614 and firing member arrangement 2220 as was described above. In other embodiments, rotary drive motions may be applied to the driver articulation disc 5820 by a worm gear motor 5710 in the manner described above.

[0277] FIG. 61 illustrates one form of a driver disc 5820. As can be seen in that Figure, the driver disc 5820 includes a first pair of first arcuate articulation slots 5822L, 5822R that each has a first arcuate length FL. In addition, the driver articulation disc 5820 further includes a driver slot 5824 that is centrally disposed between the first articulation slots 5822 as can be seen in FIG. 61. Depending upon the method employed to drive the driver articulation disc 5820, the articulation drive link 5614 or the worm gear motor 5710 may interface with the driver articulation disc 5820 in the various manners described above to apply rotary motions to the driver articulation disc 5820. FIG. 62 illustrates one form of a driven articulation disc 5830. As can be seen in that Figure, the driven articulation disc 5830 includes a second pair of second arcuate articulation slots 5832L, 5832R that each have a second arcuate length "SL" that is less than the first arcuate length FL. In addition, the driven articulation disc

5830 further includes a driver post 5834 that is configured to be movably received within the driver slot 5824.

[0278] Referring now to FIGS. 60 and 63-65, the articulation system 5800 further comprises a first articulation rod 5840 that may be directly or indirectly attached to a portion of a surgical end effector in any of the various manners described herein. A first articulation pin 5842 is attached to the first articulation rod 5840 and is received within corresponding first and second arcuate articulation slots 5822L, 5832L. Likewise, a second articulation rod or member 5850 may be directly attached to a portion of the same surgical end effector in any of the various manners described herein. A second articulation pin 5852 is attached to the second articulation rod 5850 and is received within corresponding first and second arcuate articulation slots 5822R, 5832R. FIG. 60 illustrates the articulation system 5800 in a null position wherein the surgical end effector may be freely moved. FIG. 63 illustrates the position of the articulation system 5800 upon an initial application of rotary motion to the driver articulation disc 5820 in the direction represented by arrow 5860. As can be seen in that Figure, upon initial rotation of the driver articulation disc 5820, the articulation slots 5822L, 5832L are offset from each other and the articulation slots 5822R, 5832R are offset from each other, but no motion has yet been transferred to articulation rods 5840, 5850. FIG. 64 illustrates the position of the articulation system 5800 upon continued application of the rotary motion to the driver articulation disc 5820 in the direction of arrow 5860 sufficient enough to result in, for example, a seventy-five degree of articulation of the surgical end effector relative to the shaft axis. As can be seen in that Figure, a pushing motion is applied to the first articulation rod 5840 to cause the first articulation rod 5840 to axially move in the distal direction DD and a pulling motion is applied to the second articulation rod 5850 to cause the second articulation rod 5850 to axially move in the proximal direction PD. The movement of the first and second articulation rods 5840, 5850 in opposite directions results in the articulation of the surgical end effector operably interfacing therewith. FIG. 65 illustrates the position of the articulation system 5800 upon application of the rotary motion to the driver articulation disc 5820 in an opposite direction represented by arrow 5862 that is sufficient enough to result in, for example, a seventy-five degree of articulation of the surgical end effector relative to the shaft axis in an opposite articulation direction. As can be seen in that Figure, a pushing motion is applied to the second articulation rod 5850 to cause the second articulation rod 5850 to axially move in the distal direction DD and a pulling motion is applied to the first articulation rod 5840 to cause the first articulation rod 5840 to axially move in the proximal direction PD. Such opposing movements of the first and second articulation rods 5840, 5850 result in the articulation of the surgical end effector

that is operably attached thereto. In one configuration, the first articulation rod 5840 may only apply a pulling force to the surgical end effector when the articulation driver disc 5820 has been rotated a sufficient distance as to attain a seventy-five degree range of articulation.

[0279] FIGS. 66-70 illustrate a surgical end effector 6300 that comprises first and second jaws that are simultaneously movable between open and closed positions relative to the shaft axis SA-SA. The first and second jaws may comprise a variety of surgical jaw arrangements without departing from the spirit and scope of the present invention. Gaining access to target tissue with the jaws of a surgical end effector can, at times, be challenging. The maneuverability of a surgical end effector, particularly a surgical end effector that is configured to cut and staple tissue, may be enhanced if the distance between the point at which the jaws are supported relative to each other and the proximal-most staple locations is minimized. For example, those surgical end effectors that only employ one movable jaw (i.e., one of the jaws is fixed relative to the shaft axis) may require that the one movable jaw have a relatively large range of travel in order to accommodate the target tissue. Such larger range of travel can complicate the process of using the end effector to advantageously position the target tissue. The surgical end effector 6300 employs first and second jaws that move relative to each other and the shaft axis about a common pivot axis. Such arrangement enables the distance between the pivot axis and the proximal-most staple locations to be shortened when compared to the same distance on certain surgical end effectors that employ only one movable jaw, for example.

[0280] In the illustrated example, a first jaw 6310 includes an elongate channel 6312 that is configured to support a surgical staple cartridge 6320 therein. As can be seen in FIG. 70, the surgical staple cartridge 6320 is configured to operably support a plurality of staple drivers 6322 therein that operably support surgical staples 6324 thereon. The staple drivers 6322 are movably supported within corresponding driver slots 6321 formed in the surgical staple cartridge 6320. The staple drivers 6322 are retained within their respective driver slot 6321 by a cartridge pan 6330 that clips to or is otherwise attached to the surgical staple cartridge 6320. The staple drivers 6322 are arranged in rows on each side of an elongate slot 6326 in the surgical staple cartridge 6320 to accommodate the axial passage of a firing member 6340 therethrough. A wedge sled 6350 is movably supported within the surgical staple cartridge 6320 and is configured to be drivingly engaged by the firing member 6340 as the firing member 6340 is driven from a starting position adjacent to the proximal end of the surgical staple cartridge 6320 and an ending position within a distal portion of the surgical staple cartridge 6320. As was discussed above, as the wedge sled 6350 is driven in the distal direction through the surgical staple cartridge 6320, the wedge sled 6350 drivingly contacts the staple drivers 6322 to drive them toward the

cartridge deck surface 6323. The firing member 6340 includes a tissue cutting surface 6346 that serves to cut the tissue clamped between the jaws as the firing member 6340 is driven distally. A distal firing beam (not shown) of the various types described herein is operably attached to the firing member 6340 as well as to an intermediate firing shaft portion 2222 or other firing system arrangement. Operation of the intermediate firing shaft portion 2222 to drive and retract the distal firing beam was discussed in detail above and will not be repeated for the sake of brevity. Other firing beam and firing system arrangements (motor-powered as well as manually-powered) may also be employed to power the firing member without departing from the spirit and scope of the present invention.

[0281] The illustrated surgical end effector 6300 is also configured for selective articulation about an articulation axis B-B that is substantially transverse to the shaft axis SA-SA. As can be seen in FIGS. 66-70, the surgical end effector 6300 includes an end effector mounting assembly 6390 that is adapted to be pivotally mounted to, for example, a distal shaft frame (not shown) that includes a pivot pin that is configured to be rotatably received within the mounting hole 6392 in the end effector mounting assembly 6390. The surgical end effector 6300 may be articulated by an articulation lock and first and second articulation rod arrangements of the type described above. As can be seen in FIG. 70, the end effector mounting assembly 6390 further includes a pair of opposed, laterally extending trunnion pins 6394. The trunnion pins 6394 extend laterally from the opposed lateral sides 6391 of the end effector mounting assembly 6390 that also define a pocket area 6395 that is configured to receive the firing member 6340 therein. The trunnion pins 6394 serve to define a pivot axis PA-PA about which the first and second jaws 6310, 6360 may pivot. The proximal end 6314 of the first jaw 6310 or elongate channel 6312 includes a pair of opposed U-shaped or open ended slots 6316 that are adapted to receive a corresponding one of the trunnion pins 6394 therein. Such arrangement serves to movably or pivotally journal the first jaw 6310 to the end effector mounting assembly 6390.

[0282] The illustrated surgical end effector 6300 further comprises a second jaw 6360 that may comprise an anvil 6362. The illustrated anvil 6362 includes an anvil body 6364 that includes an elongate slot 6366 and two staple forming surfaces 6368 formed on each side thereof. The anvil 6362 further has a proximal end portion 6370 that has a pair of U-shaped or open ended slots 6372 that are also adapted to receive a corresponding one of the trunnion pins 6394 therein. Such arrangement serves to movably or pivotally journal the second jaw 6360 to the end effector mounting assembly 6390 such that the first and second jaws may move relative to each other as well as to relative to the shaft axis SA-SA. The first and second jaws 6310 and 6360 may be movably actuated by a closure system of the various types disclosed herein. For example, a first closure drive system of the type

described herein may be employed to actuate a closure sleeve in the above-described manner. The closure sleeve may also be attached to an end effector closure sleeve 6272 that may be pivotally attached to the closure sleeve by a double pivot closure sleeve assembly in the manner described above. As was described above, for example, axial movement of the closure sleeve may be controlled through actuation of a closure trigger 32. As can be seen in FIGS. 67-69, the end effector closure sleeve 6272 extends over the end effector mounting assembly 6390 and is configured to engage the proximal end 6370 of the second jaw 6360 as well as the proximal end 6314 of the first jaw 6310. At least one cam surface 6336 may be formed on the proximal end 6314 of the first jaw 6310 such that when the distal end 6274 of the end effector closure sleeve 6272 contacts the cam surface(s) 6336, the first jaw 6310 is cammed toward the second jaw and the shaft axis SA-SA. Likewise, one or more cam surfaces 6376 may be formed on the proximal end portion 6370 of the second jaw 6360 such that when contacted by the distal end 6274 of the end effector closure sleeve 6272, the second jaw 6360 is moved toward the first jaw 6310 and the shaft axis SA-SA. The cam surfaces 6336, 6376 may be configured and positioned relative to each other such that the first and second jaws close at different "closure rates" or closure times relative to each other. One such arrangement is depicted in FIG. 68. As can be seen in FIG. 68, the distance along an arcuate path between a point P_1 on the first jaw 6310 and a corresponding point P_2on the second jaw 6360 when the first and second jaws are in their respective fully opened position is represented by D_T. The first and second points P_1 and P_2 are said to "correspond to" each other. For example, the first point P_1 and the second point P_2 may each lie on a common line or axis that extends therebetween and is perpendicular to the shaft axis SA-SA. The distance along an arcuate path between another point P_A on the first jaw 6310 and the shaft axis SA-SA is represented by D_1 and the distance along another arcuate path between another corresponding point P_B on the second jaw and the shaft axis SA-SA is represented by D_2. Point P_A and point P_B are also said to correspond to each other. For example, point P_A and point P_B may lie on a common line or axis that extends therebetween and which is perpendicular to the shaft axis SA-SA. In the illustrated arrangement, the distance D_2 that the second jaw 6360 or anvil 6362 moves from the fully open to the closed position wherein the staple-forming surface of the anvil 6362 lies along the shaft axis SA-SA is greater than the distance D_1 that the first jaw 6310 or surgical staple cartridge 6320 moves from the fully open position to the closed position wherein the cartridge deck surface lies along the shaft axis SA-SA. For example, in at least one arrangement, the second jaw or anvil will open or move 2/3 of the distance D_T (or another distance along another travel path between the jaws) and the first jaw or staple cartridge will open or move 1/3 of the distance D_T (or other distance along yet another travel path

between the jaws), so that, in essence, one jaw attains its fully closed position quicker or faster than the other jaw attains its fully closed position even though a closure motion or motions were initially applied to both jaws at the same or similar times. For example, the cam surfaces on the first and second jaws may be arranged/configured to attain different jaw-movement ratios/rates without departing from the spirit and scope of this embodiment of the present invention. An opening spring 6380 (FIG. 70) may be positioned between the proximal end 6314 of the first jaw 6310 and the proximal end 6370 of the second jaw 6360 to bias the first and second jaws 6310, 6360 to the open position when the end effector closure sleeve 6272 is positioned in the starting or unactuated position. See FIGS. 67-69.

[0283] To move the first and second jaws 6310, 6360 to a closed position (FIG. 66), the clinician actuates the closure system to move the end effector closure sleeve 6272 in the distal direction DD to simultaneously contact the cam surface(s) 6336 on the proximal end 6314 of the first jaw 6310 and the cam surface(s) 6376 on the proximal end 6370 of the second jaw 6360 to bias the first and second jaws 6310, 6360 towards each other (and shaft axis SA-SA) to the position shown in FIG. 66. While the end effector closure sleeve 6272 is retained in that position, the first and second jaws 6310 and 6360 are retained in that closed position. Thereafter, the firing system may be actuated to axially advance the firing member 6340 distally through the surgical end effector 6300. As can be seen in FIG. 70, the firing member 6340 may have a foot portion 6342 that is configured to slidably engage a slotted passage 6374 of the anvil 6362 and a top tab portion 6344 that is adapted to be slidably received within a slotted passage 6318 in the elongate channel 6312. See FIG. 69. Thus, such firing member arrangement serves to positively retain the first and second jaws 6310, 6360 at a desired spacing arrangement during firing of the firing member (i.e., during firing of the staples and cutting of the tissue that is clamped between the first and second jaws 6310, 6360). A first jaw cover 6315 is removably attached to the elongate channel 6312 and a second jaw cover 6363 is removably attached to the anvil 6362 for assembly purposes as well as to prevent the infiltration of tissue and/or body fluid into the first and second jaws which may hamper or interfere with operation of the firing member 6340.

[0284] FIG. 71 illustrates another surgical end effector 6300' that is similar to surgical end effector 6300. As can be seen in that Figure, the surgical end effector 6300' comprises two jaws that are simultaneously movable between open and closed positions relative to the shaft axis SA-SA. In the illustrated example, a first jaw 6310' includes an elongate channel 6312' that is configured to support a surgical staple cartridge 6320' therein. The surgical staple cartridge 6320' is configured to operably

support a plurality of staple drivers 6322 therein that operably support surgical staples 6324 thereon. The staple drivers 6322 are movably supported within corresponding driver pockets 6321' formed in the surgical staple cartridge 6320'. The staple drivers 6322 are retained within their respective driver pocket 6321' by a cartridge pan 6330' that clips to or is otherwise attached to the surgical staple cartridge 6320'. The staple drivers 6322 are arranged in rows on each side of an elongate slot 6326' in the surgical staple cartridge 6320 to accommodate the axial passage of a firing member 6340' therethrough. A wedge sled 6350' is movably supported within the surgical staple cartridge 6320' and is configured to be driving engaged by the firing member 6340' as the firing member 6340' is driven from a starting position adjacent to the proximal end of the surgical staple cartridge 6320' and an ending position within a distal portion of the surgical staple cartridge 6320'. As was discussed above, as the wedge sled 6350' is driven in the distal direction through the surgical staple cartridge 6320', the wedge sled 6350' drivingly contacts the staple drivers 6322 to drive them toward the cartridge deck surface 6323'. The firing member 6340' includes a tissue cutting surface 6346' that serves to cut the tissue clamped between the jaws as the firing member 6340 is driven distally. A distal firing beam (not shown) of the various types described herein is operably attached to the firing member 6340' as well as to an intermediate firing shaft portion 2222 or other firing system arrangement. Operation of the intermediate firing shaft portion 2222 to drive and retract the distal firing beam was discussed in detail above and will not be repeated for the sake of brevity. Other firing beam and firing system arrangements (motor-powered as well as manually-powered) may also be employed to power the firing member without departing from the spirit and scope of the present invention.

[0285] The illustrated surgical end effector 6300' is also configured for selective articulation about an articulation axis B-B that is substantially transverse to the shaft axis SA-SA. The end effector 6300' includes an end effector mounting assembly 6390' that is adapted to be pivotally mounted to, for example, a distal shaft frame that includes a pivot pin configured to be rotatably received within a mounting hole 6392' in the end effector mounting assembly 6390'. The surgical end effector 6300' may be articulated by an articulation lock and first and second articulation rod arrangements of the type described above. As can be seen in FIG. 71, the end effector mounting assembly 6390' further includes a pair of opposed, laterally extending trunnion pins 6394'. The trunnion pins 6394' extend laterally from the opposed lateral sides 6391' of the end effector mounting assembly 6390' that also define a pocket area 6395' that is configured to receive the firing member 6340' therein. The trunnion pins 6394' serve to define a pivot axis PA-PA about which the first and second jaws 6310', 6360' may pivot. The proximal end 6314' of the first jaw 6310' or elongate channel 6312' includes a pair of

opposed U-shaped or open ended slots 6316' that are adapted to receive a corresponding one of the trunnion pins 6394' therein. Such arrangement serves to movably or pivotally journal the first jaw 6310' to the end effector mounting assembly 6390'.

[0286] The illustrated surgical end effector 6300' further comprises a second jaw 6360' that may comprise an anvil 6362'. The illustrated anvil 6362' includes an anvil body 6364' that includes an elongate slot 6366' and two staple forming surfaces formed on each side thereof. The anvil 6362' further has a proximal end portion 6370' that has a pair of U-shaped or open ended slots 6372' that are also adapted to receive a corresponding one of the trunnion pins 6394' therein. Such arrangement serves to movably or pivotally journal the second jaw 6360' to the end effector mounting assembly 6390'. The first and second jaws 6310' and 6360' are movably actuated by a closure system of the various types disclosed herein. For example, a first closure drive system 30 may be employed to actuate a closure sleeve 260 in the manner described herein. The closure sleeve 260 may also be attached to an end effector closure sleeve 6272 that may be pivotally attached to the closure sleeve 260 by a double pivot closure sleeve assembly 271 in the manner described above. As was described above, for example, axial movement of the closure sleeve 260 may be controlled through actuation of a closure trigger 32. The end effector closure sleeve 6272 extends over the end effector mounting assembly 6390' and is configured to engage the proximal end 6370' of the second jaw 6360' as well as the proximal end 6314' of the first jaw 6310'. At least one cam surface 6336' may be formed on the proximal end 6314' of the first jaw 6310' such that when the distal end 6274 of the end effector closure sleeve 6272 contacts the cam surfaces 6336', the first jaw 6310' is cammed toward the second jaw 6360' and the shaft axis SA-SA. Likewise, one or more cam surfaces 6376' may be formed on the proximal end portion 6370' of the second jaw 6360' such that when contacted by the distal end 6274 of the end effector closure sleeve 6272, the second jaw 6360' is moved toward the first jaw 6310' and the shaft axis SA-SA. A spring (not shown) may be positioned between the proximal end 6314' of the first jaw 6310' and the proximal end 6370' of the second jaw 6360' to bias the first and second jaws 6310', 6360' to the open position when the end effector closure sleeve 6272 is positioned in the starting or unactuated position.

[0287] To move the first and second jaws 6310', 6360' to a closed position, the clinician actuates the closure system to move the end effector closure sleeve 6272 in the distal direction DD to simultaneously contact the cam surface(s) 6336' on the proximal end 6314' of the first jaw 6310' and the cam surface(s) 6376' on the proximal end 6370' of the second jaw 6360' to bias the first and second jaws 6310', 6360' towards each other (and shaft axis SA-SA). While the end effector closure

sleeve 6272 is retained in that position, the first and second jaws 6310' and 6360' are retained in that closed position. Thereafter, the firing system may be actuated to axially advance the firing member 6340' distally through the surgical end effector 6300'. The firing member 6340' may have a top tab portion 6344' that is configured to slidably engage a slotted passage 6374' of the anvil 6362' and a foot portion 6342' that is adapted to be slidably received within a slotted passage in the elongate channel 6312'. Thus, such firing member arrangement serves to positively retain the first and second jaws 6310', 6360' at a desired spacing arrangement during firing of the firing member (i.e., during firing of the staples and cutting of the tissue that is clamped between the first and second jaws 6310', 6360'). A first jaw cover 6315' is removably attached to the elongate channel 6312' and a second jaw cover 6363' is removably attached to the anvil 6362' for assembly purposes as well as to prevent the infiltration of tissue and/or body fluid into the first and second jaws which may hamper or interfere with operation of the firing member 6340'.

[0288] The surgical end effector embodiments described herein that employ jaws that both move relative to each other and relative to the shaft axis may offer various advantages over other surgical end effector arrangements wherein one of the jaws is fixed and does not move, for example relative to the shaft axis. In such configurations, it is often desirable for the one movable jaw to have a relatively large range of movement relative to the fixed jaw to enable the target tissue to be manipulated, positioned and then clamped therebetween. In the embodiments wherein both jaws are movable, each jaw doesn't require as large of range of motion to accommodate manipulation, positioning and clamping of the target tissue between the jaws. Such reduced movement of the anvil, for example, may provide for improved tissue positioning. Such arrangements may also enable the distance between the pivot axis and the first staple positions to be minimized. In addition, the firing member may always remain engaged with the movable jaws (anvil and elongate channel) even during opening and closing actions.

[0289] FIGS. 72-79 illustrate another surgical end effector 6400 that is configured to be operably attached to an elongate shaft assembly of the types described herein which define a shaft axis SA-SA. The surgical end effector 6400 comprises two jaws that are simultaneously movable between open and closed positions relative to the shaft axis SA-SA. The first and second jaws may comprise a variety of different surgical related jaw arrangements. In the illustrated example, a first jaw 6410 includes an elongate channel 6412 that is configured to support a surgical staple cartridge 6420 therein. As in the various surgical staple cartridges discussed above, the surgical staple cartridge 6420 is configured to operably support a plurality of staple drivers (not shown) therein that operably support surgical staples

(not shown) thereon. The staple drivers are movably supported within corresponding driver pockets formed in the surgical staple cartridge 6420. The staple drivers are arranged in rows on each side of an elongate slot (not shown) in the surgical staple cartridge 6420 to accommodate the axial passage of a firing member 6440 therethrough. A wedge sled (not shown) is movably supported within the surgical staple cartridge 6420 and is configured to be driving engaged by the firing member 6440 as the firing member 6440 is driven from a starting position adjacent to the proximal end of the surgical staple cartridge 6420 and an ending position within a distal portion of the surgical staple cartridge 6420. As was discussed above, as the wedge sled is driven in the distal direction through the surgical staple cartridge 6420, the wedge sled drivingly contacts the staple drivers to drive them toward the cartridge deck surface (not shown). The firing member 6440 includes a tissue cutting surface 6446 that serves to cut the tissue clamped between the jaws as the firing member 6440 is driven distally. A distal firing beam (not shown) of the various types described herein is operably attached to the firing member 6440 as well as to an intermediate firing shaft portion 2222 or other firing system arrangement. Operation of the intermediate firing shaft portion 2222 to drive and retract the distal firing beam was discussed in detail above and will not be repeated for the sake of brevity. Other firing beam and firing system arrangements (motor-powered as well as manually-powered) may also be employed to power the firing member without departing from the spirit and scope of the present invention.

[0290] The illustrated surgical end effector 6400 is also configured for selective articulation about an articulation axis B-B that is substantially transverse to the shaft axis SA-SA. As can be seen in FIGS. 72-79, the surgical end effector 6400 includes an end effector mounting assembly 6490 that is adapted to be pivotally mounted to, for example, a distal shaft frame that includes a pivot pin that is configured to be rotatably received within the mounting hole 6492 in the end effector mounting assembly 6490. The surgical end effector 6400 may be articulated by an articulation lock and first and second articulation rod arrangements of the type described above. As can be seen in FIG. 74, a pair of cam plates 6500 are non-movably attached by a spring pin 6502, for example, to the end effector mounting assembly 6490. As can be further seen in FIG. 74, each cam plate 6500 has a cam slot 6504 that has a closure wedge portion 6505 and an opening wedge portion 6507. The closure wedge portion 6505 is formed from two opposed closure cam surfaces 6506 and the opening wedge portion 6507 is formed from two opposed opening cam surfaces 6508. The elongate channel 6412 includes two proximally extending actuator arms 6416 that each has an opening trunnion pinion 6418 and a closing trunnion pin 6419 protruding laterally therefrom. The opening and closing trunnion pins 6418 and 6419 are

received with the cam slot 6504 of a corresponding cam plate 6500. Such arrangement serves to movably or pivotally journal the first jaw 6410 to the end effector mounting assembly 6490.

[0291] The illustrated surgical end effector 6400 further comprises a second jaw 6460 that may comprise an anvil 6462. The illustrated anvil 6462 includes an anvil body 6464 that includes an elongate slot 6466 and two staple forming surfaces 6468 formed on each side thereof. The anvil 6462 further has a proximal end portion 6470 that includes two proximally extending actuator arms 6472 protruding therefrom. Each actuator arm 6472 has an opening trunnion pinion 6474 and a closing trunnion pin 6476 protruding laterally therefrom that are also received in the cam slot 6504 of a corresponding cam plate 6500. Such arrangement serves to movably or pivotally journal the second jaw 6460 to the end effector mounting assembly 6490.

[0292] The first and second jaws 6410 and 6460 are movably actuated by a closure system of the various types disclosed herein. For example, a first closure drive system 30 may be employed to actuate a closure sleeve in the manner described herein. The closure sleeve 260 may also be attached to an end effector closure sleeve 6572 that may be pivotally attached to the closure sleeve by a double pivot closure sleeve assembly in the manner described above. As was described above, for example, axial movement of the closure sleeve may be controlled through actuation of a closure trigger. As can be seen in FIGS. 77 and 78, the end effector closure sleeve 6572 extends over the end effector mounting assembly 6490 as well as the actuator arms 6416 of the first jaw 6410 and the actuator arms 6472 of the second jaw 6460. As the closure sleeve 6572 is advanced distally, the distal end 6574 of the closure sleeve 6572 contacts a proximal end 6411 of the first jaw 6410 and a proximal end 6461 of the second jaw 6460 and moves the first and second jaws 6410, 6460 in the distal direction DD. As the first and second jaws 6410 , 6460 move distally, the closing trunnions 6419, 6476 enter the closure wedge portion 6505 of the cam slot 6504 and the closure cam surfaces 6506 cam the first and second jaws 6410, 6460 toward each other to a closed position (FIGS. 73, 75, 77 and 78).

[0293] To facilitate opening of the first and second jaws 6410, 6460 with the closure sleeve 6572, the closure sleeve 6572 is provided with two inwardly extending opening tabs 6576 that are configured to engage the closure trunnions 6419, 6476 when the closure sleeve 6572 is retracted in the proximal direction PD by the closure system. As can be seen in FIGS. 72 and 76, for example, as the closure sleeve 6572 moves in the proximal direction PD, the opening tabs 6576 contact the closure trunnions 6419, 6476 and drives the closure trunnions 6419, 6476 in the proximal direction as well. The proximal movement of the closure trunnions 6419, 6476 causes the opening trunnions 6418 and 6474 to enter the opening wedge portion 6507 of the cam plate slots 6504. The opening cam surfaces 6508

interact with the opening trunnions 6418, 6474 and cause the actuator arms 6416 and 6472 to rock open on their respective rocker surfaces 6417 and 6475 as shown in FIGS. 76 and 79. As with the above-described arrangements wherein both the first and second jaws move relative to the shaft axis SA-SA, the closure wedge portion 6505 and the opening wedge portion 6507 may be configured so that the first and second jaws close at different closure rates or closure times relative to each other upon application of a closure motion thereto.

[0294] FIGS. 80-84 illustrate another surgical end effector 7400 that comprises two jaws wherein one jaw is movable relative to the other jaw between open and closed positions. In the illustrated example, the first jaw 7410 comprises an anvil 7412. The illustrated anvil 7412 has an anvil body 7414 that has a proximal end portion 7416 that is non-movably attached to an end effector mounting assembly 7430. For example, the proximal end portion 7416 comprises two upstanding lateral walls 7418 that each has a mounting hole 7419 therein. See FIG. 82. The end effector mounting assembly 7430 is received between the upstanding lateral walls 7418 and is non-movably attached thereto by a spring pin 7421 that extends therethrough into holes 7419. The end effector mounting assembly 7430 is adapted to be pivotally mounted to, for example, a distal shaft frame that includes a pivot pin that is configured to be rotatably received within the mounting hole 7432 in the end effector mounting assembly 7430. The surgical end effector 7400 may be articulated by an articulation lock and first and second articulation rod arrangements of the type described above or by any of the various articulation systems and articulation rod and/or rod/cable arrangements described herein without departing from the spirit and scope of the present invention. As can also be seen in FIGS. 80 and 82, the anvil body 7414 also includes an elongate slot 7422 with two staple forming surfaces 7424 formed on each side thereof.

[0295] The surgical end effector 7400 further includes a second jaw 7440 that comprises an elongate channel 7442 that is configured to support a surgical staple cartridge 7450 therein. As in certain surgical staple cartridges discussed above, the surgical staple cartridge 7450 is configured to operably support a plurality of staple drivers (not shown) therein that operably support surgical staples (not shown) thereon. The staple drivers are movably supported within corresponding driver pockets 7452 formed in the surgical staple cartridge 7450. The staple drivers are arranged in rows on each side of an elongate slot 7454 in the surgical staple cartridge 7450 to accommodate the axial passage of a firing member 7460 therethrough. A cartridge pan 7451 is attached to the staple cartridge 7450 to prevent the staple drivers from falling out of their respective driver pockets 7452 when the surgical end effector 7400 is manipulated into various orientations. A wedge sled 7462 is movably supported

within the surgical staple cartridge 7450 and is configured to be driving engaged by the firing member 7460 as the firing member 7460 is driven from a starting position adjacent to the proximal end of the surgical staple cartridge 7450 and an ending position within a distal portion of the surgical staple cartridge 7450. As was discussed above, as the wedge sled 7462 is driven in the distal direction through the surgical staple cartridge 7450, the wedge sled 7462 drivingly contacts the staple drivers to drive them toward the cartridge deck surface (not shown). The firing member 7460 includes a tissue cutting surface 7464 that serves to cut the tissue clamped between the jaws 7410, 7440 as the firing member 7460 is driven distally. A distal firing beam 280 or of the other various types described herein is operably attached to the firing member 7460 as well as to an intermediate firing shaft portion 2222 or other firing system arrangement. Operation of the intermediate firing shaft portion 2222 to drive and retract the distal firing beam 280 was discussed in detail above and will not be repeated for the sake of brevity. Other firing beam and firing system arrangements (motor-powered as well as manually-powered) may also be employed to power the firing member without departing from the spirit and scope of the present invention. A first jaw cover 7415 is removably attached to the anvil 7412 a second jaw cover 7441 is removably attached to the second jaw 7440 for assembly purposes as well as to prevent the infiltration of tissue and/or body fluid into the first and second jaws which may hamper or interfere with operation of the firing member 6340.

[0296] As can be seen in FIG. 82, the elongate channel 7442 includes a proximal end portion 7444 that has two lateral side portions 7445. Each lateral side portion 7445 has a corresponding U-shaped or open ended slot 7446 therein that is adapted to receive a corresponding pivot pin 7426 that laterally protrudes from the proximal end portion 7416 of the anvil body 7414. Such arrangement serves to movably or pivotally journal the second jaw 7440 or elongate channel 7442 to the first jaw 7410 or anvil 7412. As can be most particularly seen in FIGS. 80, 82 and 84, closure ramp segments 7447 are formed on the proximal end 7444 of the elongate channel 7442. In addition, each lateral side 7445 of the proximal end portion 7444 has a lateral recess area 7448 formed therein. Each lateral recessed area 7448 is located proximal to a corresponding closure ramp segment 7447. An opening ramp or cam 7449 is formed adjacent the proximal end of each lateral recessed area 7448. Each opening ramp or cam 7449 terminates in a top surface 7580. See FIGS. 82 and 84.

[0297] The second jaw 7440 or elongate channel 7442 may be movably actuated relative to the first jaw 7410 or anvil 7412 by a closure system of the various types disclosed herein. For example, a closure drive system of the types described herein may be employed to actuate a closure sleeve of the types described herein as was discussed in detail above. The closure sleeve may also be attached to an

end effector closure sleeve 7572 that may be pivotally attached to the closure sleeve by a double pivot arrangement in the manner described above. As was described above, for example, axial movement of the closure sleeve may be controlled through actuation of a closure trigger. In other arrangements, the closure sleeve may be axially moved by means of a robotic control system, etc. As can be seen in FIGS. 80, 81, 83 and 84, the end effector closure sleeve 7572 extends over the end effector mounting assembly 7430 as well as the proximal end portion 7444 of the elongate channel 7442 of the second jaw 7440. The end effector closure sleeve 7572 includes two diametrically opposed opening members 7574 that are configured to operably engage the proximal end portion 7444 of the second jaw 7440 or elongate channel 7442. In the illustrated embodiment, the opening members 7574 comprise inwardly extending opening tabs 7576 that are formed in portions of the end effector closure sleeve 7572.

[0298] The second jaw 7440 is moved to a closed position (FIGS. 81 and 83) by advancing the end effector closure sleeve 7572 in the distal direction DD. As the end effector closure sleeve 7572 moves distally, the distal end 7575 thereof contacts the closure ramp segments 7447 that are formed on the proximal end 7444 of the elongate channel 7442 and serves to cam the elongate channel 7442 towards the anvil 7412. Once the end effector closure sleeve 7552 has been moved to its distal-most position, the distal end 7575 contacts an abutment surface 7443 on the elongate channel 7442 to maintain the closure load or closing force on the elongate channel 7442. See FIGS. 81 and 83. When the end effector closure sleeve 7572 is in the fully-closed position, the ends of the opening tabs 7576 are received in the corresponding lateral recess areas 7448. To move the second jaw 7440 or elongate channel 7442 to an open position, the closure system is actuated to move the closure sleeve 7572 in the proximal direction PD. As the end effector closure sleeve 7572 moves proximally, the opening tabs 7572 ride up the corresponding opening ramp or cam 7449 on the proximal end portion 7444 of the elongate channel 7442 to cam or pivot the elongate channel 7442 away from the anvil 7412. Each tab rides up the cam 7449 onto the top surface top surface 7580 and serves to positively retain the elongate channel 7442 in that fully open position. See FIG. 84.

[0299] FIGS. 85-87 illustrate another surgical end effector 8400 that comprises two jaws 8410, 8440 that are simultaneously movable between open and closed positions relative to the shaft axis SA-SA. In the illustrated example, the first jaw 8410 comprises an anvil 8412. The illustrated anvil 8412 has an anvil body 8414 that has a proximal end portion 8416 that movably interfaces with an end effector adapter 8600. As can be seen in FIG. 85, the end effector adapter 8600 includes two distally extending distal walls 8602 that each has a lateral pivot pin 8604 protruding laterally therefrom. Each lateral pivot pin 8604 is received in a corresponding open ended U-shaped slot 8418 formed in the lateral side

walls 8417 of the proximal end portion 8416 of the anvil 8412. See FIG. 85. Such arrangement permits the elongate channel 8412 to move or pivot relative to the end effector adapter 8600. As can be further seen in FIG. 85, the end effector adapter 8600 is non-movably attached to and end effector mounting assembly 8430. For example, the end effector adapter 8600 further includes two upstanding lateral walls 8606 that each has a mounting hole 8608 therein. The end effector mounting assembly 8430 is received between the upstanding lateral walls 8606 and is non-movably attached thereto by a spring pin 8421 that extends therethrough into holes 8608. The effector mounting assembly 8430 is adapted to be pivotally mounted to, for example, a distal shaft frame that includes a pivot pin that is configured to be rotatably received within the mounting hole 8432 in the end effector mounting assembly 8430. The surgical end effector 8400 may be articulated by an articulation lock and first and second articulation rod arrangements of the type described above or by any of the various articulation systems and articulation rod and/or rod/cable arrangements described herein without departing from the spirit and scope of the present invention. As can also be seen in FIG. 85, the anvil body 8414 also includes an elongate slot 8422 with two staple forming surfaces 8424 formed on each side thereof.

[0300] The surgical end effector 8400 further includes a second jaw 8440 that comprises an elongate channel 8442 that is configured to support a surgical staple cartridge 8450 therein. As in the various surgical staple cartridges discussed above, the surgical staple cartridge 8450 is configured to operably support a plurality of staple drivers (not shown) therein that operably support surgical staples (not shown) thereon. The staple drivers are movably supported within corresponding driver pockets 8452 formed in the surgical staple cartridge 8450. The staple drivers are arranged in rows on each side of an elongate slot 8454 in the surgical staple cartridge 8450 to accommodate the axial passage of a firing member 8460 therethrough. A cartridge pan 8451 is attached to the staple cartridge 8450 to prevent the staple drivers from falling out of their respective driver pockets 8452 when the surgical end effector 8400 is manipulated into various orientations. A wedge sled 8462 is movably supported within the surgical staple cartridge 8450 and is configured to be drivingly engaged by the firing member 8460 as the firing member 8460 is driven from a starting position adjacent to the proximal end of the surgical staple cartridge 8450 and an ending position within a distal portion of the surgical staple cartridge 8450. As was discussed above, as the wedge sled 8462 is driven in the distal direction through the surgical staple cartridge 8450, the wedge sled 8462 drivingly contacts the staple drivers to drive them toward the cartridge deck surface (not shown). The firing member 8460 includes a tissue cutting surface 8464 that serves to cut the tissue clamped between the jaws 8410, 8440 as the firing member 8460 is driven distally. A distal firing beam 280 or of the other various types described herein

is operably attached to the firing member 8460 as well as to an intermediate firing shaft portion 2222 or other firing system arrangement. Operation of the intermediate firing shaft portion 2222 to drive and retract the distal firing beam 280 was discussed in detail above and will not be repeated for the sake of brevity. Other firing beam and firing system arrangements (motor-powered as well as manually-powered) may also be employed to power the firing member without departing from the spirit and scope of the present invention. A first jaw cover 8415 is removably attached to the anvil 8412 and a second jaw cover 8441 is removably attached to the second jaw 8440 for assembly purposes as well as to prevent the infiltration of tissue and/or body fluid into the first and second jaws which may hamper or interfere with operation of the firing member 8460.

[0301] As can be seen in FIG. 85, the elongate channel 8442 includes a proximal end portion 8444 that has two lateral side portions 8445. Each lateral side portion 8445 has a corresponding U-shaped or open ended slot 8446 therein that is adapted to receive a corresponding t lateral pivot pin 8604 that protrudes laterally from the end effector adapter 8600. Such arrangement serves to movably or pivotally journal the second jaw 8440 or elongate channel 8442 to the first jaw 8410 or anvil 8412. As can also be seen in FIG. 85, closure ramp segments 8447 are formed on the proximal end 8444 of the elongate channel 8442. In addition, each lateral side 8445 of the proximal end portion 8444 has a second lateral recessed area 8448 formed therein. Each second lateral recessed area 8448 is located proximal to a corresponding second closure ramp segment 8447. A second opening ramp or cam 8449 is formed adjacent the proximal end of each second lateral recessed area 8448. Each second opening ramp or cam 8449 terminates in a second top surface 8450. Similarly, a first recessed area 8420 is formed on the bottom of each of the side walls 8417 of the proximal end portion 8416 of the anvil 8412. A first opening ramp or cam 8426 is formed adjacent the proximal end of each first lateral recessed area 8420. Each first opening ramp or cam 8426 terminates in a first top surface 8428.

[0302] The second jaw 8440 or elongate channel 8442 and the first jaw 8410 or anvil 8412 may be simultaneously moved between open and closed positions by a closure system of the various types disclosed herein. For example, a closure drive system 30 may be employed to actuate a closure sleeve 260 in the manner described herein. The closure sleeve 260 may also be attached to an end effector closure sleeve 8572 that may be pivotally attached to the closure sleeve 260 by a double pivot arrangement in the manner described above. As was described above, for example, axial movement of the closure sleeve 260 may be controlled through actuation of a closure trigger 32. In other arrangements, the closure sleeve may be axially moved by means of a robotic control system, etc. As can be seen in FIGS. 86 and 87, the end effector closure sleeve 8572 extends over the end effector

mounting assembly 8430, the end effector adapter 8600 as well as the proximal end portion 8444 of the elongate channel 8442 of the second jaw 8440 and the proximal end portion 8416 of the first jaw 8410 or anvil 8412. The end effector closure sleeve 8572 includes two diametrically opposed, first opening members 8574 that are configured to operably engage the proximal end portion 8416 of the first jaw 8410. In the illustrated embodiment, the first opening members 8574 comprise inwardly extending first opening tabs 8576 that are formed in portions of the end effector closure sleeve 8572. Likewise, the end effector closure sleeve 8572 further includes two diametrically opposed, second opening members 8580 that are configured to operably engage the proximal end portion 8444 of the second jaw 8440. In the illustrated embodiment, the second opening members 8580 comprise inwardly extending second opening tabs 8582 that are formed in portions of the end effector closure sleeve 8572.

[0303] The first and second jaws, 8410, 8440 are simultaneously moved to a closed position (FIG. 86) by advancing the end effector closure sleeve 8572 in the distal direction DD. As the end effector closure sleeve 8572 moves distally, the distal end 8575 thereof contacts the bottom of the proximal end portion 8416 of the first jaw 8410 or anvil 8412 as well as the closure ramp segments 8447 that are formed on the proximal end 8444 of the elongate channel 8442 and serves to cam the first and second jaws 8410, 8440 towards each other. Once the end effector closure sleeve 8572 has been moved to its distal-most position, the distal end 8575 of the end effector closure sleeve 8572 contacts first abutment surfaces 8419 on the first jaw 8410 or anvil 8412 as well as a second abutment surface 8443 on the second jaw 8440 or elongate channel 8442 to maintain the closure load or closing force on both of the jaws 8410, 8440. See FIG. 86. When the end effector closure sleeve 8572 is in the fully-closed position, the ends of the first opening tabs 8576 are received in the corresponding first lateral recesses areas 8420 and the ends of the second opening tabs 8582 are received in the corresponding second lateral recess areas 8448. To move the first and second jaws 8410, 8440 away from each other to open positions, the closure system is actuated to move the closure sleeve 8572 in the proximal direction PD. As the end effector closure sleeve 8572 moves proximally, the first opening tabs 8576 ride up the corresponding first opening ramp or cam 8426 on the bottom of the proximal end portion 8416 of the first jaw 8410 to cam or pivot the first jaw 8410 or anvil 8412 in a direction away from the second jaw 8440 or elongate channel 8442 and the second opening tabs 8582 ride up the corresponding second ramps 8449 on the proximal end portion 8444 of the elongate channel 8442 to cam or pivot the elongate channel 8442 in a direction away from the first jaw or anvil 8412. Each of the first tabs 8576 rides up the corresponding cam or ramp 8426 onto the corresponding first locking surface 8428 and each of the second tabs 8582 rides up the corresponding second cam or ramp 8449 onto the

corresponding second locking surface 8450 to thereby retain the first and second jaws 8410, 8400 in the open position. The reader will appreciate that the axial position of the first tabs 8576 relative to the second tabs 8582 may be positioned so as to simultaneously move the first and second jaws away from each other or they may be axially offset so that one of the jaws moves before the other jaw moves.

[0304] FIGS. 88-93 illustrate portions of another surgical instrument 9010 that includes a surgical end effector 9300 that operably interfaces with an elongate shaft assembly 9200. The surgical end effector 9300 is similar to surgical end effector 300 that was discussed in detail above and includes a first jaw in the form of an elongate channel 9302 that is configured to operably support a surgical staple cartridge 304 therein. The illustrated surgical end effector 9300 further includes a second jaw in the form of an anvil 310 that is supported on the elongate channel 9302 for movement relative thereto. The anvil 310 may be movably actuated by the closure system described above and shown in FIGS. 88 and 91. For example, a first closure drive system may be employed to actuate a closure sleeve 260 in the manner described herein. The closure sleeve 260 is attached to an end effector closure sleeve 272 that is pivotally attached to the closure sleeve 260 by a double pivot closure sleeve assembly 271 in the manner described above. As was described above, for example, axial movement of the closure sleeve 260 may be controlled through actuation of a closure trigger. As was also described above, the closure sleeve 272 incudes opening cams that serve to movably actuate the anvil 310 to an open position. In use, the closure sleeve 260 is translated distally (direction DD) to close the anvil 310, for example, in response to the actuation of the closure trigger. The anvil 310 is closed by distally translating the closure sleeve 260 in the distal direction DD and as well as the end effector closure sleeve 272 that is pivotally coupled thereto. As the end effector closure sleeve 272 is driven distally, the cam tabs 358 of the opening cams 354 move distally within the cam slots 318 in the anvil 310 to operably interface or ride on the cam surfaces 319 to cam the body portion 312 of the anvil 310 away from the surgical staple cartridge 304 into an open position. The anvil 310 is closed by distally translating the closure sleeve 260 in the distal direction DD until the distal end 275 of the end effector closure sleeve 272 rides up the anvil attachment arms 316 to contact the which causes the cam tabs 358 to move in the proximal direction PD within the cam slots 318 on the cam surfaces 319 to pivot the anvil 310 into the open position.

[0305] As can be seen in FIG. 91 for example, the elongate shaft assembly 9200 includes a two piece shaft frame or spine assembly 9812 upon which the closure sleeve assembly 260 is received. The spine assembly 9812 includes a proximal spine portion 9814 and a distal spine portion 9816. The proximal spine portion 9816 may be rotatably journaled in the handle or housing (not shown) in the

various manners described herein to facilitate rotation of the surgical end effector 9300 about the shaft axis SA. Although not shown, the surgical instrument 9010 may also include a firing beam arrangement and any of the various firing drive system arrangements disclosed herein for driving a firing member through the surgical staple cartridge in the various manners discussed above. As can be seen in FIG. 91, the distal spine portion 9816 includes a distal end portion 9818 that has an upwardly protruding pivot pin 9819 thereon that is adapted to be pivotally received within a pivot hole 9328 formed in the proximal end portion 9320 of the elongate channel 9302. Such arrangement facilitates pivotal travel of the elongate channel 9302 of the surgical end effector 9300 relative to the spine assembly 9812 about an articulation axis B-B that is defined by the pivot hole 9328. As indicated above, the articulation axis B-B is transverse to the shaft axis SA-SA that is defined by elongate shaft assembly 9200.

[0306] Still referring to FIG. 91, the elongate shaft assembly 9200 further includes an articulation system, generally designated as 9900 that includes a first articulation bar 9910 and a second articulation bar 9920. The first articulation bar 9910 operably interfaces with a first articulation motor 9912 that is operably supported in the surgical instrument handle or housing or portion of a robotically controlled system. As can be seen in FIGS. 92 and 93, the first articulation bar 9910 is attached to a first articulation nut 9914 that is threadably received on a first threaded drive shaft 9916 of the first articulation motor 9912. Rotation of the first threaded drive shaft 9916 in a first rotary direction will result in the distal advancement of the first articulation bar 9910 in the distal direction DD and rotation of the first threaded drive shaft 9916 in a second or opposite rotary direction will result in the proximal advancement of the first articulation drive bar 9910 in the proximal direction PD.

[0307] The illustrated articulation system 9900 further includes a second articulation bar 9920 that operably interfaces with a second articulation motor 9922 that is operably supported in the surgical instrument handle or housing or portion of a robotically controlled system. As can be seen in FIGS. 92 and 93, the second articulation bar 9920 is attached to a second articulation nut 9924 that is threadably received on a second threaded drive shaft 9926 of the second articulation motor 9922. Rotation of the second threaded drive shaft 9926 in a first rotary direction will result in the proximal advancement of the second articulation bar 9920 in the proximal direction PD and rotation of the second threaded drive shaft 9926 in a second or opposite rotary direction will result in the distal advancement of the second articulation drive bar 9920 in the distal direction DD.

[0308] The articulation system 9900 further includes a cross-linkage assembly 9940 that is operably attached to the first and second articulation bars 9910, 9920. As can be seen in FIG. 91, the cross-

linkage assembly 9940 includes a middle support member 9950 that is pivotally pinned to the proximal end 9320 of the elongate channel 9302 with a first pin 9952. The middle support member 9950 further includes a proximal connector tab 9954 that includes a slot 9956 for receiving a second pin 9958 therein for pivotally attaching the proximal connector tab 9954 to the distal end portion 9818 of the distal spine portion 9816. The pin and slot arrangement facilitate pivotal and axial travel of the middle support member 9950 relative to the spine assembly 9812. The middle support member 9950 further includes a slot 9960 for receiving a firing beam therethrough. The middle support member 9950 serves to provide lateral support to the firing beam as it flexes to accommodate articulation of the surgical end effector 9300.

[0309] As can be most particularly seen in FIGS. 92 and 93, the middle support member 9950 has a proximal linkage tab portion 9970 that facilitates attachment of the first and second articulation bars 9910, 9920 thereto. In particular, a distal end 9911 of the first articulation bar 9910 is pivotally attached to a first articulation link 9972 that is pivotally pinned to the proximal linkage tab portion 9970. Likewise, a distal end 9921 of the second articulation bar 9920 is pivotally pinned to a second articulation link 9974 that is pivotally pinned to the proximal linkage tab portion 9970 of the middle support member 9950. FIG. 92 illustrates articulation of the surgical end effector 9300 in the direction represented by arrow 9980. As can be seen in that Figure, the first threaded drive shaft 9916 of the first articulation motor is rotated in a first rotary direction to drive the first articulation bar 9910 in the distal direction. In addition, the second threaded drive shaft 9926 of the second articulation motor 9922 is rotated in a second rotary direction to draw the second articulation bar 9920 in the proximal direction. The first and second articulation motors 9912, 9922 are operated by a computer controlled system and, as can be seen in FIG. 92, the distance that first articulation bar 9910 moves in the distal direction is not equal to the distance in which the second articulation bar 9920 moves in the proximal direction.

[0310] FIG. 93 illustrates articulation of the surgical end effector 9300 in the direction represented by arrow 9982. As can be seen in that Figure, the second threaded drive shaft 9926 of the second articulation motor 9922 is rotated in a first rotary direction to drive the second articulation bar 9920 in the distal direction. In addition, the first threaded drive shaft 9916 of the first articulation motor 9912 is rotated in a second rotary direction to draw the first articulation bar 9910 in the proximal direction. The first and second articulation motors 9912, 9922 are operated by a computer controlled system and, as can be seen in FIG. 92, the distance that second articulation bar 9920 moves in the distal direction is not equal to the distance in which the first articulation bar 9910 moves in the proximal direction. In

alternative arrangements, only one articulation motor may be employed to articulate the end effector. In such arrangements, for example, the second link may be proximally coupled to the first link by means of a rack and pinion arrangement similar to those rack and pinion arrangements disclosed in detail herein.

[0311] FIG. 94 and 95 illustrate surgical staple cartridges 9304 and 9304' that each include a light member 9305 for illuminating the distal end of the surgical end effector in which it is supported. Each of the staple cartridges 9304, 9304' may have conductors (not shown) that are arranged on the bottom of the cartridge or on the cartridge sides that are configured to electrically contact corresponding conductors in the elongate channel that communicate with a source of electrical energy located in the instrument handle or housing. Thus, when the cartridge 9304, 9304' are properly seated in the elongate channel of the surgical end effector, the light 9305 therein may receive power from the source of electrical power in the handle or housing through the corresponding conductors.

[0312] FIGS. 96-105 illustrate portions of another surgical instrument 10010 that includes a surgical end effector 10300 that operably interfaces with an elongate shaft assembly 10200 that employs many of the features of the various shaft assemblies disclosed herein. The surgical end effector 10300 may essentially comprise any of the various end effectors described herein or it may comprise other forms of surgical end effectors that are configured to perform other surgical actions/procedures. In the illustrated arrangement, for example, the surgical end effector 10300 is adapted to cut and staple tissue and includes a first jaw in the form of an elongate channel 10302 that is configured to operably support a surgical staple cartridge 10304 therein. See FIGS. 96 and 97. The illustrated surgical end effector 10300 further includes a second jaw in the form of an anvil 10310 that is supported on the elongate channel 10302 for movement relative thereto. See FIG. 96. The anvil 10310 may be movably actuated by one of the closure drive systems described herein. For example, a first closure drive system may be employed to actuate a closure sleeve 260 in the manner described herein. The closure sleeve 260 is attached to an end effector closure sleeve 272 that is pivotally attached to the closure sleeve 260 by a double pivot closure sleeve assembly 271 in any of the manners described herein. As was described above, for example, axial movement of the closure sleeve 260 may be controlled through actuation of a closure trigger. As the end effector closure sleeve 272 is advanced in the distal direction D-D, the anvil 10310 is cammed closed. In at least one arrangement, a spring (not shown) may be employed to pivot the anvil 10310 to an open position when the end effector closure sleeve 272 is retracted back to a starting position.

[0313] As can be seen in FIGS. 96-105, the surgical end effector 10300 may be articulated relative to the elongate shaft assembly 10200 about an articulation joint 10270. In the illustrated example, the elongate shaft assembly 10200 includes articulation system designated as 10800 that employs an articulation lock 10810 that is similar to articulation locks 350 and 810 described above. See FIG. 97. Those components of articulation lock 10810 that differ from the components of articulation lock 810 and/or articulation lock 350 for example and which may be necessary to understand the operation of articulation lock 10810 will be discussed in further detail below. As noted above, further details regarding articulation lock 350 may be found in 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, the entire disclosure of which was incorporated by reference herein. The articulation lock 10810 can be configured and operated to selectively lock the surgical end effector 10300 in various articulated positions. Such arrangement enables the surgical end effector 10300 to be rotated, or articulated, relative to the shaft closure sleeve 260 when the articulation lock 10810 is in its unlocked state.

[0314] Referring specifically to FIGS. 96 and 97, the elongate shaft assembly 10200 includes a spine 210 that is configured to, one, slidably support a firing member 220 therein and, two, slidably support the closure sleeve 260 which extends around the spine 210. The spine 210 also slidably supports a proximal articulation driver 230. The proximal articulation driver 230 has a distal end 231 that is configured to operably engage the articulation lock 10810. The articulation lock 10810 further comprises a shaft frame 10812 that is attached to the spine 210 in the various manners disclosed herein. As shown in FIG. 97, the shaft frame 10812 is configured to movably support a proximal portion 10821 of a distal articulation driver 10820 therein. The distal articulation driver 10820 is movably supported within the elongate shaft assembly 10200 for selective longitudinal travel in a distal direction DD and a proximal direction PD in response to articulation control motions applied thereto.

[0315] One feature that many clinicians may be concerned with during the performance of a surgical procedure is the net length of the articulatable end effector from its pivot point. This dimension impacts upon the amount of access that the end effector can achieve in the confined space within the patient. The surgical instrument 10010 may be configured to address this issue. In the illustrated arrangement, for example, the shaft frame 10812 includes a distal end portion 10814 that has a pivot pin 10818 formed thereon. The pivot pin 10818 is adapted to be pivotally received within a slot 10395 formed in an end effector mounting assembly 10390 that is attached to the proximal end 10303 of the

elongate channel 10302 by a spring pin 10393 or other suitable member. The pivot pin 10818 defines an articulation axis B-B that is transverse to the shaft axis SA-SA. Such arrangement facilitates pivotal travel (i.e., articulation) of the end effector 10300 about the articulation axis B-B relative to the shaft frame 10812 as well as axial or translational travel of the elongate channel 10302 relative to a point of reference one shaft frame 10812, for example the articulation axis B-B. As can be seen in FIGS. 99 and 100, the articulation system 10800 further includes an articulation drive gear 10840 that is rotatably supported on a shaft 10842 that is formed on or otherwise attached to the shaft frame 10812. As can be further seen in FIGS. 99 and 100, the end effector mounting assembly 10390 has an articulation gear profile 10396 formed thereon that is configured for meshing engagement with the articulation drive gear 10840. As can be most particularly seen in FIGS. 97 and 101-103, a drive pin 10844 protrudes from the articulation drive gear 10840. The drive pin 10844 is received within a slot 10822 in the distal articulation driver 10820. Thus, movement of the distal articulation driver 10820 in the proximal direction PD (in the various manners discussed herein) will cause the articulation drive gear 10840 to rotate in the counter clockwise direction (arrow CCW in FIG. 103) which, in turn, will articulate the surgical end effector 10300 in the direction represented by arrow 10848. Likewise, movement of the distal articulation driver 10820 in the distal direction DD will cause the articulation drive gear 10840 to rotate in the clockwise direction (arrow CW in FIG. 102) which will articulate the surgical end effector 10300 in the direction represented by arrow 10849.

[0316] Still referring to FIGS. 99-105, in at least one arrangement, the articulation gear profile 10396 is elliptical in shape. The elliptical configuration of the articulation gear profile 10396, in connection with the slot 10395, allows for the end effector 10300 to translate (or move axially) as it is being rotated or articulated. The eccentricity of the elliptical articulation gear profile 10396 allows for the "center-to-center" distance between the articulation drive gear 10840 and the gear profile 10396 to be reduced and then converts that reduction into translation of the end effector 10300. FIGS. 101 and 103 illustrate the surgical end effector 10300 in an unarticulated position. Stated another way, the end effector axis EA that is defined by the elongate channel 10302 is aligned with the shaft axis SA-SA. As used in this context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA-SA or simply parallel with the shaft axis SA-SA. When in that unarticulated position, the elongate channel 10302 occupies a certain amount of space (i.e., which may be referred to as a "footprint"). Stated another way, a distal end 10309 of the elongate channel 10302 is located a first distance D1 (which may also be referred to herein as an "unarticulated distance") from the articulation axis B-B which is defined by the pin 10818. See FIG. 104. When the surgical end effector 10300 is articulated,

the elongate channel 10302 translates proximally (arrow TL in FIGS. 102 and 103) relative to the shaft frame 10812 and more particularly relative to the articulation axis B-B so that the distance D2 between the distal end 10309 of the elongate channel 10302 and the articulation axis B-B (which may also be referred to herein as an "articulated distance") is less than the distance D1. See FIG. 105. This reduced overall length of the surgical end effector 10300 allows for greater access when the end effector 10300 is in an articulated position and will maintain the same net length when straight. Stated another way, as the end effector is articulated, the distance between the first staples in the end effector and the articulation axis will decrease to thereby reduce the end effector's footprint while being in an articulated configuration.

[0317] The surgical end effector 10300 of the embodiment illustrated in FIGS. 96-105 comprises a surgical cutting and stapling device that employs a firing beam 220 of the various types and configurations described herein. However, the surgical end effector 10300 of this embodiment may comprise other forms of surgical end effectors that do not cut and/or staple tissue. In the illustrated arrangement, a middle support member 10950 is pivotally and slidably supported relative to the shaft frame 10812. As can be seen in FIG. 98, the middle support member 10950 includes a slot 10952 that is adapted to receive therein a pin 10954 that protrudes from or is attached to or is formed in the spine 210. Such arrangement enables the middle support member 10950 to pivot and translate relative to the pin 10954 when the surgical end effector 10300 is articulated. The middle support member 10950 further includes a slot 10960 for receiving a firing beam 220 therethrough. The middle support member 10950 serves to provide lateral support to the firing beam 220 as it flexes to accommodate articulation of the surgical end effector 10300.

[0318] FIGS. 106-108 illustrate portions of another surgical instrument 11010 that includes a surgical end effector 11300 that operably interfaces with an elongate shaft assembly 11200 that may employ many of the features of the various shaft assemblies disclosed herein. The surgical end effector 11300 may essentially comprise any of the various end effectors described herein or it may comprise other forms of surgical end effectors that are configured to perform other surgical actions/procedures. In the illustrated arrangement, for example, the surgical end effector 11300 includes an elongate channel 11302 that may be adapted to support a surgical staple cartridge therein, for example. The elongate shaft assembly 11200 may comprise a spine 11210 that is pivotally coupled to the elongate channel 11302 by an articulation joint 11270. In the illustrated arrangement, the elongate channel 11302 of the surgical end effector 11300 is coupled to the spine 11210 by an articulation pin 11818 that is movably received in an elongate articulation slot 11395 formed in the

elongate channel 11302 or in an end effector mounting assembly (not shown). The pin and slot arrangement facilitates pivotal and translational travel of the elongate channel 11302 relative to spine 11210 of the elongate shaft assembly 11200. The articulation pin 11818 defines an articulation axis B-B that extends through the center of the pin 11818 and would come out of the page in FIGS. 106-108 such that it its transverse to the shaft axis SA-SA. The spine 11210 may otherwise be similar to spine 210 described above and support a firing member and closure sleeve arrangements as described herein and which are not specifically illustrated in FIGS. 106-108 for the purpose of clarity.

[0319] In the illustrated example, the elongate shaft assembly 11200 includes articulation system designated as 11800 that may include an articulation lock that is similar to articulation locks 350, 810 and/or 10810 described above and which may be actuated in any of the various manners described herein. The articulation system 11800 includes a distal articulation driver 11820 that may comprise a portion of the articulation lock (not shown) or may otherwise simply interface with an articulation control system that is constructed to selective move the distal articulation driver 11820 in distal and proximal directions to articulate the surgical end effector 11300. The articulation system 11800 further includes a central articulation link 11900 that is rotatably journaled on the articulation pin 11818 for rotation about the articulation axis B-B. In the illustrated arrangement, the central articulation link 11900 has a triangular shape that defines three end portions 11902, 11904, 11906. The articulation system 11800 in the illustrated embodiment further includes a driver link 11910 that is pivotally coupled to an end of the distal articulation driver 11820 as well as to end 11902 of the central articulation link 11900. As will be discussed in further detail below, movement of the distal articulation driver 11820 in the proximal and distal directions will cause the central articulation link 11900 to rotate or pivot about the articulation axis B-B.

[0320] The articulation system 11800 further includes an end effector driver link 11920 that has a first end 11922 that is pivotally coupled to the elongate channel 11302. A second end 11924 of the end effector driver link 11920 is pivotally coupled to the end 11904 of the central articulation link 11900. The point at which the driver link 11910 is attached to the central articulation link 11900 and the point at which the second end 11924 of the end effector driver link 11920 is attached to the central articulation link 11900 may lie along a common axis OAS, but that axis is offset from the articulation axis B-B. See FIG. 106. The second end 11924 of the end effector driver link 11920 has a gear profile 11926 thereon that is configured for meshing engagement with a central articulation gear 11930 that is rotatably journaled on the articulation pin 11818. When the distal articulation driver 11820 is moved in the distal direction DD, central articulation link 11900 moves the second end 11924 of the end

effector driver link 11920 in a clockwise direction CW while maintaining in meshing engagement with the central articulation gear 11930. Movement of the articulation driver link 11920 in the clockwise direction also moves the surgical end effector 11300 in the clockwise direction about the articulation axis B-B relative to the elongate shaft assembly 11200. See FIG. 107. Similarly, movement of the distal articulation driver 11820 in the proximal direction will move the central articulation link 11900 in the counter clockwise CCW direction. Such movement of the central articulation link 11900 also causes the second end 11924 to move in the counterclockwise direction CCW while maintaining in meshing engagement with the central articulation gear 11930. Movement of the articulation driver link 11920 in the counterclockwise direction causes the surgical end effector 11300 to pivot about the articulation axis B-B in the counterclockwise direction relative to the elongate shaft assembly 11200. See FIG. 108.

[0321] FIG. 106 illustrates the surgical end effector 11300 in an unarticulated position relative to the elongate shaft assembly 11200. When in that unarticulated position, the end effector axis EA of the elongate channel 11302 is essentially aligned with the shaft axis SA-SA. Stated another way, the end effector axis EA defined by the elongate channel 10302 is aligned with the shaft axis SA-SA. As used in this context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA-SA or simply parallel with the shaft axis SA-SA. FIG. 107 illustrates the position of the surgical end effector 11300 after it has been moved in the clockwise direction to a fully articulated position relative to the elongate shaft assembly 11200 wherein an angle 11950 between the end effector axis EA and the shaft axis SA-SA is approximately ninety degrees (90°). FIG. 108 illustrates the position of the surgical end effector 11300 after it has been moved in the counterclockwise direction to a fully articulated position relative to the elongate shaft assembly 11200 wherein an angle 11950 between the end effector axis EA and the shaft axis SA-SA is approximately ninety degrees (90°). As can also be seen in FIGS. 107 and 108, the distal end 11201 of the elongate shaft assembly 11200 is notched on both sides of the shaft axis SA to permit the elongate channel 11302 to translate in a direction toward the shaft axis SA-SA (represented by arrows TD in FIGS. 107 and 108) to effectively shorten the distance between the distal end of the elongate channel 11302 and the articulation axis B-B. Such arrangement may represent a vast improvement over prior articulation joint arrangements that cannot afford articulation of the end effector to positions that are ninety degrees (90°) relative to the shaft axis (through a 180 degree path that is transverse to the shaft axis. This embodiment also effectively reduces the footprint of the end effector when articulated by allowing the end effector to translate toward the shaft axis while being articulated.

[0322] Referring to FIG. 106, it can be observed that the driver link 11910 is coupled to the first end of the central articulation link 11900 at a location located on one side of the shaft axis and the second end 11924 of the end effector driver link 11920 is attached to end 11904 of the central articulation link 11900 at a location that is on the opposite side of the shaft axis when the end effector 11300 is in the unarticulated position. The central articulation gear arrangement serves to minimize the backlash and serves to transmit such forces into the articulation pin 11818 which may increase the overall strength of the articulation joint when compared to other articulation joint arrangements of similar sizes. The ability to articulate the surgical end effector relative to the shaft to which it is attached at relative high angles is often desirable when performing various surgical procedures where transections need to happen in a constrained space and access to targeted soft tissue can be difficult such as in the thoracic cavity or the pelvic bowl. Prior end effectors suffer from the inability to articulate to angles that are greater than forty-five degrees (45°) relative to the shaft axis. The above-described embodiment may overcome these deficiencies.

[0323] FIGS. 109-111 illustrate portions of another surgical instrument 12010 that includes a surgical end effector 12300 that operably interfaces with an elongate shaft assembly 12200 that may employ many of the features of the various shaft assemblies disclosed herein. The surgical end effector 12300 may essentially comprise any of the various end effectors described herein or it may comprise other forms of surgical end effectors that are configured to perform other surgical actions/procedures. In the illustrated arrangement, for example, the surgical end effector 12300 includes an elongate channel 12302 that may be adapted to support a surgical staple cartridge therein, for example. The elongate shaft assembly 12200 may comprise a spine 12210 that is pivotally coupled to the elongate channel 12302 by an articulation joint 12270. In the illustrated arrangement, the elongate channel 12302 of the surgical end effector 12300 is configured to extend into a distal end portion 12213 of the spine 12210 and is operably coupled thereto by an articulation system 12800.

[0324] In the illustrated example, the articulation system 12800 includes a distal articulation driver 12820 that is pivotally coupled to the spine 12210 and the elongate channel 12302. As can be seen in FIG. 109, the distal articulation driver 12820 is configured to movably extend on a first side of the shaft axis SA-SA. In addition, articulation system 12800 further includes a second articulation link 12900 that is attached to the spine 12210 on a second side of the shaft axis SA. When the distal articulation driver 12820 is moved in the distal direction DD, the elongate channel 12302 is moved in the clockwise direction CW. During such articulation, the proximal end 12303 of the elongate channel 12302 translates in the direction represented by arrow TD to reduce the end effector footprint. See

FIG. 110. Similarly, when the distal articulation driver 12820 is moved in the proximal direction PD, the elongate channel 12302 is pivoted in a counterclockwise CCW direction. During such articulation, the proximal end of the elongate channel 12302 translates in the direction represented by the arrow TD to reduce the end effector footprint during articulation.

[0325] FIG. 109 illustrates the surgical end effector 12300 in an unarticulated position relative to the elongate shaft assembly 12200. When in that unarticulated position, the end effector axis EA of the elongate channel 12302 is essentially aligned with the shaft axis SA-SA. Stated another way, the end effector axis EA defined by the elongate channel 10302 is aligned with the shaft axis SA-SA. As used in this context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA or simply parallel with the shaft axis SA-SA. FIG. 110 illustrates the position of the surgical end effector 12300 after it has been moved in the clockwise CW direction to a fully articulated position relative to the elongate shaft assembly 12200. FIG. 111 illustrates the position of the surgical end effector 12300 after it has been moved in the counterclockwise direction to a fully articulated position relative to the elongate shaft assembly 12200.

[0326] The ability to articulate the surgical end effector relative to the shaft to which it is attached at relative high angles is often desirable when performing various surgical procedures where transections need to happen in a constrained space and access to targeted soft tissue can be difficult such as in the thoracic cavity or the pelvic bowl. However, in prior end effectors, the larger articulation angles typically results in a larger moment around the articulation system that may more easily bend or break the mechanism. The embodiment depicted in FIGS. 112 - 114 includes features that may address those shortcomings of prior articulatable end effectors. FIGS. 112 -114 illustrate portions of another surgical instrument 13010 that includes a surgical end effector 13300 that operably interfaces with an elongate shaft assembly 13200 that may employ many of the features of the various shaft assemblies disclosed herein. The elongate shaft assembly 13200 defines a shaft axis SA-SA. In addition, the surgical end effector 13300 may essentially comprise any of the various end effectors described herein or it may comprise other forms of surgical end effectors that are configured to perform other surgical actions/procedures. In the illustrated arrangement, for example, the surgical end effector 13300 includes an elongate channel 13302 that may be adapted to support a surgical staple cartridge therein, for example. The elongate channel 13302 defines an end effector axis EA. The elongate shaft assembly 13200 may comprise a spine 13210 that is pivotally coupled to the elongate channel 13302 by an articulation joint 13270. In the illustrated arrangement, the elongate channel 13302 of the surgical end effector 13300 is coupled to the spine 13210 by an articulation pin 13818 that defines an

articulation axis B-B that that is transverse to the shaft axis SA-SA. In FIGS. 112-114, the articulation axis B-B may coincide with the center axis of the articulation pin 13818, for example, and would essentially protrude out of the page in each of those Figures. The spine 13210 may otherwise be similar to spine 210 described above and support a firing member and closure sleeve arrangements as described herein and which are not specifically illustrated in FIGS. 112-114 for the purpose of clarity.

[0327] In the illustrated example, the elongate shaft assembly 13200 includes articulation system designated as 13800 that may include an articulation lock that is similar to articulation locks 350, 810 and/or 10810 described above and which may be actuated in any of the various manners described herein. The articulation system 13800 includes a distal articulation driver 13820 that may comprise a portion of an articulation lock (not shown) or may otherwise simply interface with an articulation control system that is constructed to selectively move the distal articulation driver 13820 in distal and proximal directions to articulate the surgical end effector 13300 about the articulation axis B-B. The articulation system 13800 further includes a central articulation link 13900 that is rotatably journaled on the articulation pin 13818 for rotation about the articulation axis B-B relative to a distal end of the elongate shaft assembly 13200. In the illustrated arrangement, the central articulation link 13900 has a triangular shape and defines three end portions 13902, 13904, 13906. The articulation system 13800 in the illustrated embodiment further includes an intermediate driver link 13910 that is pivotally coupled to an end of the distal articulation driver 13820 as well as to end 13902 of the central articulation link 13900. As will be discussed in further detail below, movement of the distal articulation driver 13820 in the proximal and distal directions will cause the central articulation link 13900 to rotate about the articulation axis B-B.

[0328] The articulation system 13800 further includes an end effector driver link 13920 that has a first or distal driver link end 13922 that has a slot 13923 therein. An end effector attachment member or pin 13960 is attached to the end effector 13300 and is received in the slot 13923. Such arrangement facilitates pivotal and translatable or axial travel (represented by arrow AT) of the pin 13960 within the slot 13923. A second or proximal driver link end 13924 of the end effector driver link 13920 is pivotally coupled to the end 13904 of the central articulation link 13900. The point at which the intermediate driver link 13910 is attached to the central articulation link 13900 and the point at which the second end 13924 of the end effector driver link 13920 is attached to the central articulation link 13900 may lie along a common axis OAS, but that axis is offset from the articulation axis B-B. See FIG. 112. The second end 13924 of the end effector driver link 13920 has a gear profile 13926 thereon that is configured for meshing engagement with a gear profile 13930 formed on or otherwise attached

to the spine 13210. When the distal articulation driver 13820 is moved in the proximal direction PD, central articulation link 13900 causes the end effector 13300 to move in a counterclockwise direction CCW about the articulation axis B-B relative to the distal end of the elongate shaft assembly 13200. During such movement, the second end 11924 of the end effector driver link 13920 remains in meshing engagement with the gear profile 13930. Depending upon the amount of proximal travel of the distal articulation driver 13820, the surgical end effector 13300 may be pivoted to the articulation position shown in FIG. 113 wherein the end effector axis EA is perpendicular to the shaft axis SA-SA (represented by angle 13950 in FIG. 113). Similarly, movement of the distal articulation driver 11820 in the distal direction DD will cause the end effector 13300 to move in a clockwise direction CW about the articulation axis B-B relative to the distal end of the elongate shaft assembly 13200. During such movement, the second end 11924 of the end effector driver link 13920 remains in meshing engagement with the gear profile 13930. Depending upon the amount of distal travel of the distal articulation driver 13820, the surgical end effector 13300 may be pivoted to the articulation position shown in FIG. 114 wherein the end effector axis EA is perpendicular to the shaft axis SA-SA (represented by angle 13952 in FIG. 114).

[0329] As can be seen in FIG. 112, when in an unarticulated position, the end effector axis EA is in axial alignment with the shaft axis SA. In addition, as can be further seen in FIGS. 112-114, the distal articulation driver 13820, as well as the intermediate driver 13910, are each supported for selective longitudinal travel along one lateral side of the shaft axis SA and the end effector attachment pin 13960 is located on a secondary lateral side of the end effector axis EA that corresponds to a second lateral side of the shaft axis SA. Alternative embodiments may employ other means for applying an articulation control motion to the central articulation link 13900. For example, a cable arrangement may be directly attached to the central articulation link in place of the distal articulation driver 13820 and 13910. In such arrangement, the central articulation link would be pivoted when a corresponding articulation system located in the handle or housing of the instrument tensions or pulls the cable. In still other alternative embodiments, the distal articulation driver 13820 is directly coupled to the central articulation link 13900. In such arrangement, for example, the central articulation link 13900 may include a slot instead of a pin at this connection to enable rotation of the articulation axis B-B. In yet another embodiment, the slot 13923 in the end effector drive link 13920 may be replaced by a pin connection. To achieve articulation of the surgical end effector 13300 about articulation axis B-B, the gear profile 13926 on the end effector driver link 13920 is cam shaped so as to maintain meshing engagement with the gear profile 13390 formed on or otherwise attached to the spine 13210.

[0330] The embodiment of FIGS. 112-114 is more robust than prior arrangements and provides a greater range of articulation when compared to joint arrangements that cannot accommodate articulation of the end effector to positions that are ninety degrees (90°) relative to the shaft axis (through a 180 degree path that is transverse to the shaft axis). This embodiment may also effectively reduce the footprint of the end effector when articulated by allowing the end effector to translate toward the shaft axis while being articulated. This greater range of articulation may also be attained with articulation driver stroke lengths that are generally less than the stroke lengths that are normally required to articulate prior articulation joint arrangements. The triangular-shaped central articulation link may also provide several advantages. The triangular (three-point) central articulation link connects the distal articulation driver (through the intermediate drive link), the articulation pin and the end effector driver link together. This triangular shaped central link may provide improved resistance to forces that might cause the end effector to undesirably de-articulate. Such triangular link arrangement may also provide higher resistance to bending forces that may be encountered by the articulation driver rod. Further, such arrangement may also experience reduced backlash due to the direct connection of the central articulation link to the spine portion of the elongate shaft assembly. In the above-described arrangement, a planetary gear rotates around a stationary gear located on the distal end of the elongate shaft. A slotted driver arm extends off the planetary gear and creates a moment that articulates the end effector at higher angles for less articulation driver stroke length. The slot allows for a second center of rotation for the end effector. The triangular central articulation link also reduces the buckling load or the articulation mechanism and backlash of the system. A larger planetary gear results in more mechanical advantage, but less articulation and vice versa for a smaller planetary gear.

[0331] The ability to articulate the surgical end effector relative to the shaft to which it is attached at relative high angles is often desirable when performing various surgical procedures where transections need to happen in a constrained space and access to targeted soft tissue can be difficult such as in the thoracic cavity or the pelvic bowl. Commercially available endocutters typically are unable to articulate beyond angles of forty-five degrees (45°) relative to the elongate shaft. FIGS. 115-117 depict portions of another surgical instrument 14010 that is capable of articulating ninety degrees (90°) to both sides of the elongate shaft and providing a higher mechanical advantage than that is attainable with many commercially available endocutter arrangements. As can be seen in those Figures, the surgical instrument 14010 includes a surgical end effector 14300 that operably interfaces with an elongate shaft assembly 14200 that may employ many of the features of the various shaft assemblies

disclosed herein. The elongate shaft assembly 14200 defines a shaft axis SA-S. In addition, the surgical end effector 14300 may essentially comprise any of the various end effectors described herein or it may comprise other forms of surgical end effectors that are configured to perform other surgical actions/procedures. In the illustrated arrangement, for example, the surgical end effector 14300 includes an elongate channel 14302 that may be adapted to support a surgical staple cartridge therein. The elongate channel 14302 defines an end effector axis EA. The elongate shaft assembly 14200 may comprise a spine 14210 that is pivotally coupled to the elongate channel 14302 by an articulation joint 14270. In the illustrated arrangement, the elongate channel 14302 of the surgical end effector 14300 is coupled to the spine 14210 by an articulation pin 14818 that defines an articulation axis B-B that that is transverse to the shaft axis SA-SA. In FIGS. 115-117, the articulation axis B-B may coincide with the center axis of the articulation pin 14818, for example, and would essentially protrude out of the page in each of those Figures. The spine 14210 may otherwise be similar to spine 210 described above and support a firing member and closure sleeve arrangements as described herein and which are not specifically illustrated in FIGS. 115-117 for the purpose of clarity.

[0332] In the illustrated example, the elongate shaft assembly 14200 includes articulation system designated as 14800 that may include an articulation lock that is similar to articulation locks 350, 810 and/or 10810 described above and which may be actuated in any of the various manners described herein. The articulation system 14800 includes a distal articulation driver 14820 that may comprise a portion of an articulation lock (not shown) or may otherwise simply interface with an articulation control system that is constructed to selectively move the distal articulation driver 14820 in distal and proximal directions to articulate the surgical end effector 14300 about the articulation axis B-B. The articulation system 14800 further includes a central link 14900 that is pivotally attached to the spine 14210 by a link pin 14902. In the illustrated arrangement, the link pin 14901 defines a link axis LA about which the central link 14900 may pivot which is offset from the articulation axis B-B. In FIGS. 115-117, the link axis LA may coincide with the center axis of the link pin 14901, for example, and would essentially protrude out of the page in each of those Figures and be offset from and parallel with the articulation axis B-B. As can be further seen in those Figures, in the illustrated arrangement, the central articulation link 14900 is pivotally coupled to the spine 14210 in an asymmetric configuration. More specifically, a first distance between a first end 14902 of the central articulation link 14900 and the link axis LA is less than a second distance between a second end 14904 of the central articulation link 14900 and the link axis LA.

[0333] The articulation system 14800 in the illustrated embodiment further includes an intermediate driver link 14910 that is pivotally coupled to an end of the distal articulation driver 14820 as well as to the first end 14902 of the central articulation link 14900. The articulation system 14800 also includes an end effector driver link 14920 that has a first or distal driver link end 14922 that is pivotally or movably coupled to the elongate channel 14302. A second or proximal driver link end 14924 of the end effector driver link 14920 is pivotally coupled to a second end 14904 of the central articulation link 14900. In the illustrated arrangement, the intermediate link 14910 is the shortest of the three links 14910, 14900 and 14920 and, in at least one arrangement, has a slight arcuate shape. The end effector driver link 14920 is the longest of the three links 14910, 14900 and 14920 and, in at least one arrangement, also has a slight arcuate shape. When the distal articulation driver 14820 is moved in the distal direction DD, the central articulation link 14900 causes the end effector driver link 14920 to pull the end effector 14300 in the clockwise direction CW about the articulation axis B-B relative to the distal end of the elongate shaft assembly 14200. See FIG. 116. Depending upon the amount of proximal travel of the distal articulation driver 14820, the surgical end effector 14300 may be pivoted to the articulation position shown in FIG. 116 wherein the end effector axis EA is perpendicular to the shaft axis SA-SA (represented by angle 14950 in FIG. 116). Similarly, movement of the distal articulation driver 14820 in the proximal direction PD will cause the end effector driver link 14920 to push the end effector 14300 in a counterclockwise direction CCW about the articulation axis B-B relative to the distal end of the elongate shaft assembly 14200. See FIG. 117. Depending upon the amount of distal travel of the distal articulation driver 14820, the surgical end effector 14300 may be pivoted to the articulation position shown in FIG. 117 wherein the end effector axis EA is perpendicular to the shaft axis SA-SA (represented by angle 14952 in FIG. 117).

[0334] As can be seen in FIG. 115, when in an unarticulated position, the end effector axis EA is in axial alignment with the shaft axis SA-SA. As used in this context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA-SA or simply parallel with the shaft axis SA-SA . The embodiment of FIGS. 115-117 is more robust than prior arrangements and provides a greater range of articulation when compared to joint arrangements that cannot afford articulation of the end effector to positions that are ninety degrees (90°) relative to the shaft axis (through a 180 degree path that is transverse to the shaft axis). This embodiment may also effectively reduce the footprint of the end effector 14300 when articulated by allowing the end effector 14300 to translate toward the shaft axis SA-SA while being articulated. This greater range of articulation may also be attained while providing a higher amount of resistance to bending forces. The second point of attachment (link pin 14901) to

the spine 14210 of the elongate shaft assembly 14200 may reduce the amount of backlash experienced by the articulation joint 14270. The articulation joint arrangement of FIGS. 115-117 may also provide a high amount of mechanical advantage relative to the amount of force required to articulate the end effector 14300. Further, a high amount of mechanical advantage may be obtained during de-articulation when the asymmetric central link 14900 is rotated one hundred eighty degrees (180°). The end effector driver link 14920 translates forward and backward in order to articulate the end effector 14300 about the articulation axis B-B. The proximal end 14912 of the smallest link (intermediate link 14910) translates back and forth with the distal articulation driver 14820 as the distal end 14914 of the small link (intermediate link 14910) rotates about its proximal end (point of attachment to the distal articulation driver). As the distal end 14914 of the small link 14910 pivots, a lever effect is created on the central (grounded) link 14900 which produces an articulation force mechanical advantage while reducing the backlash experienced by the articulation system. The central (grounded) link 14900 pivots about its pinned position (pin 14901) to push/pull the longest link (end effector driver 14920). The longest link 14920 then pivots to articulate the end effector 14300.

[0335] As indicated above, the ability to articulate the surgical end effector relative to the shaft to which it is attached at relative high angles is often desirable when performing various surgical procedures where transections need to happen in a constrained space and access to targeted soft tissue can be difficult such as in the thoracic cavity or the pelvic bowl. Commercially available endocutters typically are unable to articulate beyond angles of forty-five degrees (45°) relative to the elongate shaft. FIGS. 118 and 119 depict portions of another surgical instrument 15010 that is capable of articulating ninety degrees (90°) to one side of the elongate shaft while providing a higher mechanical advantage than that is typically attainable with many commercially available endocutter arrangements. As can be seen in those Figures, the surgical instrument 15010 includes a surgical end effector 15300 that operably interfaces with an elongate shaft assembly 15200 that may employ many of the features of the various shaft assemblies disclosed herein. The elongate shaft assembly 15200 defines a shaft axis SA-SA. In addition, the surgical end effector 15300 may essentially comprise any of the various end effectors described herein or it may comprise other forms of surgical end effectors that are configured to perform other surgical actions/procedures. In the illustrated arrangement, for example, the surgical end effector 15300 includes an elongate channel 15302 that may be adapted to support a surgical staple cartridge therein. In other end effector embodiments that are not specifically constructed to cut and staple tissue, element 15302 may comprise a jaw or other portion of the end effector. The elongate channel 15302 defines an end effector axis EA. The elongate shaft assembly

15200 may comprise a spine 15210 that is pivotally coupled to the elongate channel 15302 by an articulation joint 15270. In the illustrated arrangement, the elongate channel 15302 of the surgical end effector 15300 is coupled to the spine 15210 by an articulation pin 15818 that defines an articulation axis B-B that that is transverse to the shaft axis SA-SA. In FIGS. 118 and 119, the articulation axis B-B may coincide with the center axis of the articulation pin 15818, for example, and would essentially protrude out of the page in each of those Figures. As can also be seen in those Figures, in the illustrated arrangement, the articulation axis B-B is offset to one lateral side of the shaft axis SA-SA. Stated another way, the articulation axis B-B does not intersect the shaft axis SA-SA or the end effector axis EA. The spine 15210 may otherwise be similar to spine 210 described above and support a firing member and closure sleeve arrangements as described herein and which are not specifically illustrated in FIGS. 118-119 for the purpose of clarity.

[0336] In the illustrated example, the elongate shaft assembly 15200 includes articulation system designated as 15800 that may include an articulation lock that is similar to articulation locks 350, 810 and/or 10810 described above and which may be actuated in any of the various manners described herein. The articulation system 15800 includes a distal articulation driver 15820 that may comprise a portion of an articulation lock (not shown) or may otherwise simply interface with an articulation control system that is constructed to selectively move the distal articulation driver 15820 in distal and proximal directions to articulate the surgical end effector 15300 about the articulation axis B-B. The articulation system 15800 further includes an end effector link 15900 that is pivotally attached to the distal end of the distal articulation driver 15820 as well as the elongate channel 15302 of the surgical end effector 15300. Thus, when the distal articulation driver 15820 is moved in the proximal direction PD, the surgical end effector 15300 is pivoted in the counterclockwise CCW direction about the articulation axis B-B.

[0337] As can be seen in FIG. 118, when in an unarticulated position, the end effector axis EA is in axial alignment with the shaft axis SA. As used in this context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA-SA or simply parallel with the shaft axis SA-SA. Advancement of the distal articulation driver 15820 in the proximal direction PD will cause the surgical end effector 15300 to pivot about the articulation axis B-B in the counterclockwise direction. The proximal end 15305 of the elongate channel 15302 and the distal end 15211 of the spine 15210 are angled to enable the surgical end effector 15300 to pivot to a fully articulated position wherein, for example, the end effector axis EA is perpendicular to the shaft axis SA (angle 15952 is ninety degrees (90°)). See FIG. 119. In one arrangement, the proximal end 15305 of the surgical end effector 15300

is oriented relative to said end effector axis EA at an end effector angle 15307 and the distal end 15211 of the elongate shaft assembly 15200 is oriented relative to the shaft axis SA-SA at a shaft angle 15213. In one arrangement, the end effector angle 15307 is equal to the shaft angle 15213. For example, the end effector angle 15307 and the shaft angle 15213 may both be approximately forty-five degrees (45°).

[0338] The embodiment of FIGS. 118 and 119 also includes a flexible de-articulation member 15910 that may be attached to a portion of the surgical instrument that is configured to selectively only apply a pulling motion in the proximal direction PD to the de-articulation member. As can be seen in FIG. 119, the de-articulation member 15910 is oriented to flex around the articulation pin 15818 during articulation of the surgical end effector 15300. In an alternative arrangement, the de-articulation member is elastic and is attached to the spine 15210 or other portion of the surgical instrument 15010 at a location that is proximal to the articulation joint 15270 as well as to the proximal end 15305 of the elongate channel 15302 or other portion of the surgical end effector 15300. The flexible de-articulation member may be fabricated from, for example, spring tempered stainless steel, plastic material, Nylon, etc. and be formed into flat bands or cables so as to help de-articulate the surgical end effector 15300 from an articulated position back to the unarticulated position. Once the clinician desires to return the surgical end effector 15300 to the unarticulated orientation, the distal articulation driver 15820 is moved in the distal direction DD, which will start to move the surgical end effector in a clockwise CW direction and the de-articulation member 15910 is pulled in the proximal direction PD. The de-articulation member 15910 also serves to help pull the surgical end effector in the clockwise CW direction back to the unarticulated position.

[0339] The embodiment of FIGS. 118 and 119 may have several advantages over other commercially available articulatable surgical instruments. Such arrangement, for example, may experience lower backlash during articulation due to the minimal number of links. Such arrangement also affords an increased articulation angle over prior designs. As indicated above, the surgical end effector may comprise a surgical stapling arrangement of the various types described herein. Such arrangements employ an axially movable firing member or firing bar or beam that experiences a certain amount of flexure when the end effector is articulated. The embodiment of FIGS. 118 and 119 may provide an improved radius of curvature for the firing member due to the non-symmetric articulation. Stated another way, the distal articulation driver 15820 as well as the end effector link 15910 are located to one side of the shaft axis SA-SA, which provides more clearance for attaining a more gradual flexure of the firing member during articulation. Such offset articulation axis arrangement which affords

articulation in a single articulation direction that is transverse to the shaft axis may also be referred to herein as a "non-symmetrical" articulation arrangement or system that can facilitate relatively high articulation angles. Also, in this embodiment, the articulation axis B-B is laterally offset from the shaft axis. In such embodiment, the distance between the point of intersection of the shaft axis and the end effector axis to the distal end of the end effector is shorter when the device is in an articulated state verses when it is in an unarticulated state.

[0340] FIGS. 120-122 depict portions of another articulatable surgical instrument 16010 that includes a surgical end effector 16300 that operably interfaces with an elongate shaft assembly 16200 that may employ many of the features of the various shaft assemblies disclosed herein. The elongate shaft assembly 16200 defines a shaft axis SA-SA. In addition, the surgical end effector 16300 may essentially comprise any of the various end effectors described herein or it may comprise other forms of surgical end effectors that are configured to perform other surgical actions/procedures. In the illustrated arrangement, for example, the surgical end effector 16300 includes an elongate channel 16302 that may be adapted to support a surgical staple cartridge therein, for example. In other end effector embodiments that are not specifically constructed to cut and staple tissue, element 16302 may comprise a jaw or other portion of the end effector. The elongate channel 16302 defines an end effector axis EA. The elongate shaft assembly 16200 may comprise a spine 16210 that is pivotally coupled to the elongate channel 16302 by an articulation joint 16270. In the illustrated arrangement, the elongate channel 16302 of the surgical end effector 16300 includes a proximally protruding attachment arm 16309 that is coupled to the spine 16210 by a spring pin 16818 that defines an articulation axis B-B. The articulation axis B-B is transverse to the shaft axis SA-SA. In FIGS. 121 and 122, the articulation axis B-B may coincide with the center axis of the spring pin 16818, for example, and would essentially protrude out of the page in each of those Figures. As can also be seen in those Figures, in the illustrated arrangement, the articulation axis B-B is offset to one lateral side of the shaft axis SA-SA. Stated another way, the articulation axis B-B does not intersect the shaft axis SA-SA or the end effector axis EA. The spine 16210 may otherwise be similar to spine 210 described above and support a firing member and closure sleeve arrangements as described herein and which are not specifically illustrated in FIGS. 120-122 for the purpose of clarity. The spring pin 16818 is configured to apply a biasing force to the attachment arm 16309 to bias the attachment arm 16309 as well as the surgical end effector 16300 in the clockwise direction CW. Thus, the spring pin 16818 serves to bias the surgical end effector 16300 into the unarticulated position shown in FIG. 121 wherein the end effector axis EA and the shaft axis SA-SA are axially aligned. As used in this

context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA-SA or simply parallel with the shaft axis SA-SA .

[0341] In the illustrated example, the elongate shaft assembly 16200 also includes an articulation system designated as 16800 that may include an articulation lock that is similar to articulation locks 350, 810 and/or 10810 described above and which may be actuated in any of the various manners described herein. The articulation system 16800 includes a distal articulation driver 16820 that may comprise a portion of an articulation lock (not shown) or may otherwise simply interface with an articulation control system that is constructed to selectively move the distal articulation driver 16820 in distal and proximal directions to articulate the surgical end effector 16300 about the articulation axis B-B. The distal articulation driver 16820 is pivotally pinned to the proximal end 16305 of the elongate channel 16302. As can be seen in FIG. 121, the distal articulation driver 16820 is pinned to the elongate channel 16302 at a location that is on one side of the shaft axis SA-SA and end effector axis EA. The articulation axis B-B is located on an opposite of the shaft axis from the point at which the distal articulation driver is attached to the elongate channel 16302. As can also be seen in FIG. 121, in the illustrated arrangement, the point at which the distal articulation driver 16820 is attached to the elongate channel 16302 is distal to the articulation axis B-B. When the distal articulation driver 15820 is moved in the proximal direction, the surgical end effector 16300 is pivoted in the counterclockwise CCW direction about the articulation axis B-B.

[0342] As can be seen in FIG. 121, when in an unarticulated position, the end effector axis EA is in axial alignment with the shaft axis SA. As used in this context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA-SA or simply parallel with the shaft axis SA-SA Advancement of the distal articulation driver 16820 in the proximal direction PD will cause the surgical end effector 16300 to pivot about the articulation axis B-B in the counterclockwise direction. Once the clinician desires to return the surgical end effector 16300 to the unarticulated orientation, the distal articulation driver 16820 is moved in the distal direction DD, which will start to move the surgical end effector 16300 in a clockwise CW direction. The spring pin 16818 also serves to help pull the surgical end effector 16300 in the clockwise CW direction back to the unarticulated position.

[0343] FIGS. 123-128 illustrate portions of another surgical instrument 17010 that includes a surgical end effector 17300 that operably interfaces with an elongate shaft assembly 17200 that employs many of the features of the various shaft assemblies disclosed herein. The surgical end effector 17300 may essentially comprise any of the various end effectors described herein or it may comprise other forms of surgical end effectors that are configured to perform other surgical

actions/procedures. In the illustrated arrangement, for example, the surgical end effector 17300 is adapted to cut and staple tissue and includes a first jaw in the form of an elongate channel 17302 that is configured to operably support a surgical staple cartridge 17304 therein. See FIGS. 123 and 124. The illustrated surgical end effector 17300 further includes a second jaw in the form of an anvil 17310 that is supported on the elongate channel 17302 for movement relative thereto. See FIG. 123. The anvil 17310 may be movably actuated by one of the closure systems described herein. For example, a first closure drive system may be employed to actuate a closure sleeve 260 in the manner described herein. The closure sleeve 260 is attached to an end effector closure sleeve 272 that is pivotally attached to the closure sleeve 260 by a double pivot closure sleeve assembly 271 in any of the manners described herein. As was described above, for example, axial movement of the closure sleeve 260 may be controlled through actuation of a closure trigger. As the end effector closure sleeve 272 is advanced in the distal direction DD, the anvil 17310 is cammed closed. In at least one arrangement, a spring (not shown) may be employed to pivot the anvil 17310 to an open position when the end effector closure sleeve 272 is retracted back to a starting position.

[0344] As can be seen in FIGS. 123-128, the surgical end effector 17300 may be articulated relative to the elongate shaft assembly 17200 about an articulation joint 17270. In the illustrated example, the elongate shaft assembly 17200 includes articulation system designated as 17800 that employs an articulation lock 17810 that is similar to articulation locks 350, 810 and 10810 described above. See FIGS. 124 and 125. Those components of articulation lock 17810 that differ from the components of articulation lock 810 and/or articulation lock 350 and or articulation lock 10810 for example and which may be necessary to understand the operation of articulation lock 17810 will be discussed in further detail below. As noted above, further details regarding articulation lock 350 may be found in 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, the entire disclosure of which was incorporated by reference herein. The articulation lock 17810 can be configured and operated to selectively lock the surgical end effector 17300 in various articulated positions. Such arrangement enables the surgical end effector 17300 to be rotated, or articulated, relative to the shaft closure sleeve 260 when the articulation lock 17810 is in its unlocked state.

[0345] Referring specifically to FIG. 125, the elongate shaft assembly 17200 includes a spine 210 that is configured to, one, slidably support a firing member (not shown) therein and, two, slidably support the closure sleeve 260 (FIG. 123) which extends around the spine 210. The spine 210 also

slidably supports a proximal articulation driver 230. The proximal articulation driver 230 has a distal end 231 that is configured to operably engage the articulation lock 17810. The articulation lock 17810 further comprises a shaft frame 17812 that is attached to the spine 210 in the various manners disclosed herein. The shaft frame 17812 is configured to movably support a proximal portion 17821 of a distal articulation driver 17820 therein. The distal articulation driver 17820 is movably supported within the elongate shaft assembly 17200 for selective longitudinal travel in a distal direction DD and a proximal direction PD along an articulation actuation axis AAA that is laterally offset and parallel to the shaft axis SA-SA in response to articulation control motions applied thereto.

[0346] Still referring to FIGS. 124 and 125, in the illustrated arrangement, the shaft frame 17812 includes a distal end portion 17814 that has a pivot pin 17818 formed thereon. The pivot pin 17818 is adapted to be pivotally received within a pivot hole 17397 formed in pivot base portion 17395 of an end effector mounting assembly 17390. The end effector mounting assembly 17390 is attached to the proximal end 17303 of the elongate channel 10302 by a spring pin 17393 or other suitable member. The pivot pin 17818 defines an articulation axis B-B that is transverse to the shaft axis SA-SA. Such arrangement facilitates pivotal travel (i.e., articulation) of the end effector 17300 about the articulation axis B-B relative to the shaft frame 17812.

[0347] As can be seen in FIG. 125, a link pin 17825 is formed on a distal end 17823 of the distal articulation link 17820 and is configured to be received within a hole 17904 in a proximal end 17902 of a cross link 17900. The cross link 17900 extends transversely across the shaft axis SA-SA and includes a distal end portion 17906. A distal link hole 17908 is provided through the distal end portion 17906 of the cross link 17900 and is configured to pivotally receive therein a base pin 17398 extending from the bottom of the pivot base portion 17395 of the end effector mounting assembly 17390. The base pin 17395 defines a link axis LA that is parallel to the articulation axis B-B. FIGS. 124 and 127 illustrate the surgical end effector 17300 in an unarticulated position. Stated another way, the end effector axis EA defined by the elongate channel 17302 is aligned with the shaft axis SA-SA. As used in this context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA-SA or simply parallel with the shaft axis SA-SA. Movement of the distal articulation driver 17820 in the proximal direction PD (in the various manners discussed herein) will cause the cross link 17900 to draw the surgical end effector 17300 in a clockwise CW direction about the articulation axis B-B as shown in FIG. 126. Movement of the distal articulation driver 17820 in the distal direction DD will cause the cross link 17900 to move the surgical end effector 17300 in the counterclockwise CCW direction about the articulation axis B-B as shown in FIG. 128. As can be seen in that Figure, the cross

link 17900 has a curved shape that permits the cross-link 17900 to curve around the articulation pin 17818 when the surgical end effector 17300 is articulated in that direction. When the surgical end effector 17300 is in a fully articulated position on either side of the shaft axis SA-SA, the articulation angle 17700 between the end effector axis EA and the shaft axis SA-SA is approximately sixty-five degrees (65°). Thus, the range of articulation on either said of the shaft axis is from one degree (1°) to sixty five degrees (65°).

[0348] The surgical end effector 17300 of the embodiment illustrated in FIGS. 123-128 comprises a surgical cutting and stapling device that employs a firing beam 220 of the various types and configurations described herein. However, the surgical end effector 17300 of this embodiment may comprise other forms of surgical end effectors that do not cut and/or staple tissue. In the illustrated arrangement, a middle support member 17950 is pivotally and slidably supported relative to the spine 210. As can be seen in FIG. 125, the middle support member 17950 includes a slot 17952 that is adapted to receive therein a pin 17954 that protrudes from the spine 210. Such arrangement enables the middle support member 17950 to pivot and translate relative to the pin 17954 when the surgical end effector 17300 is articulated. A pivot pin 17958 protrudes from the underside of the middle support member 17950 to be pivotally received within a corresponding pivot hole 17399 provided in the base portion 17395 of the end effector mounting assembly 17390. The middle support member 17950 further includes a slot 17960 for receiving a firing beam 220 therethrough. The middle support member 17950 serves to provide lateral support to the firing beam 220 as it flexes to accommodate articulation of the surgical end effector 17300.

[0349] FIGS. 129-131 illustrate portions of another surgical instrument 18010 that includes a surgical end effector 18300 that operably interfaces with an elongate shaft assembly 18200 that employs many of the features of the various shaft assemblies disclosed herein. The surgical end effector 18300 is adapted to cut and staple tissue and includes a first jaw in the form of an elongate channel 18302 that is configured to operably support a surgical staple cartridge therein. The illustrated surgical end effector 18300 further includes a second jaw in the form of an anvil 18310 that is supported on the elongate channel 18302 for movement relative thereto. The anvil 18310 may be movably actuated by one of the closure systems described herein.

[0350] The elongate shaft assembly 18200 includes a shaft spine 18210 that defines a shaft axis SA-SA that coincides with the center of the elongate shaft assembly 18200. Stated another way, the shaft axis SA-SA extends axially down the geometric center of the elongate shaft assembly 18200. The spine 18210 may otherwise be similar to spine 210 described above and support a firing member and

closure sleeve arrangements as described herein and which are not specifically illustrated in FIGS. 129-131 for the purpose of clarity. As can be seen in FIG. 131, the surgical end effector 18300 may be articulated relative to the elongate shaft assembly 18200 about an articulation joint 18270. The articulation joint 18270 serves to couple the elongate channel 18302 to a distal end 18215 of the spine 18210. The surgical end effector 18300 and, more particularly, the elongate channel 18302 of the surgical end effector 18300 defines an end effector axis EA that represents the axial center of the elongate channel 18302. When the surgical end effector 18300 is in an unarticulated orientation, the end effector axis EA is axially aligned with the shaft axis SA-SA as illustrated in FIG. 130. As used in this context, the term "aligned with" may mean "coaxially aligned" with the shaft axis SA-SA or simply parallel with the shaft axis SA-SA. In the illustrated arrangement, the elongate channel 18302 of the surgical end effector 18300 includes a proximally protruding attachment arm 18309 that is coupled to the spine 18210 by a spring pin 18818 that defines an articulation axis B-B. The articulation axis B-B is transverse to the shaft axis SA-SA. In FIGS. 130 and 131, the articulation axis B-B may coincide with the center axis of the spring pin 18818, for example, and would essentially protrude out of the page in each of those Figures. As can also be seen in those Figures, in the illustrated arrangement, the articulation axis B-B is offset to one lateral side 18213 of the shaft axis SA-SA. Stated another way, the articulation axis B-B does not intersect the shaft axis SA or the end effector axis EA. The spring pin 18818 is configured to apply a biasing force to the attachment arm 18309 to bias the attachment arm 18309 as well as the surgical end effector 18300 in the clockwise direction CW. Thus, the spring pin 18818 serves to bias the surgical end effector 18300 into the unarticulated position shown in FIG. 130 wherein the end effector axis EA and the shaft axis SA-SA are axially aligned.

[0351] The illustrated embodiment further includes an articulation system designated as 18800 that employs an articulation lock 18810 that is similar to articulation locks 350, 810 and 10810 described above. The articulation lock 18810 can be configured and operated to selectively lock the surgical end effector 18300 in various articulated positions. Such arrangement enables the surgical end effector 18300 to be rotated, or articulated, relative to the elongate shaft assembly 18200 when the articulation lock 18810 is in its unlocked state. The articulation lock 18810 includes a distal articulation driver 18820 that is movably supported within the elongate shaft assembly 18200 for selective longitudinal travel in a distal direction DD and a proximal direction PD. The distal articulation driver 18820 is movable along an articulation actuation axis AAA that is laterally offset and parallel to the shaft axis SA-SA in response to articulation control motions applied thereto. In alternative embodiments, the

distal articulation driver 18820 does not comprise a portion of an articulation lock, but instead operably interfaces with a source of articulation motions (in a handle or in a robotic system) that serves to selectively axially advance the distal articulation driver 18820 in the distal direction DD and retract the distal articulation driver 18820 in the proximal direction PD. The distal articulation driver 18820 is pivotally pinned to the proximal end 18305 of the elongate channel 18302. As can be seen in FIG. 130, the distal articulation driver 18820 is pinned to the elongate channel 18302 at a location that is on one lateral side 18211 of the shaft axis SA-SA and end effector axis EA. The articulation axis B-B is located on an opposite lateral side 18213 of the shaft axis SA-SA from the point at which the distal articulation driver 18820 is attached to the elongate channel 18302. As can also be seen in FIG. 130, in the illustrated arrangement, the point at which the distal articulation driver 18820 is attached to the elongate channel 18302 is distal to the articulation axis B-B. As can be seen in FIG. 130, when in an unarticulated position, the end effector axis EA is in axial alignment with the shaft axis SA-SA. Advancement of the distal articulation driver 18820 in the proximal direction PD will cause the surgical end effector 18300 to pivot about the articulation axis B-B in the counterclockwise direction CCW. Stated another way, the surgical end effector 18300 is articulatable to positions on one side of the shaft axis SA that coincide with the first side 18211 of the spine 18210. Once the clinician desires to return the surgical end effector 18300 to the unarticulated orientation, the distal articulation driver 18820 is moved in the distal direction DD, which will start to move the surgical end effector 18300 in a clockwise direction CW. The spring pin 16818 also serves to help pull the surgical end effector 18300 in the clockwise direction CW back to the unarticulated position.

[0352] The surgical end effector 18300 of the embodiment illustrated in FIGS. 129-131 comprises a surgical cutting and stapling device that employs a firing beam 18220 of the various types and configurations described herein. In one arrangement, for example, the firing beam 18220 may be of laminated construction as described herein. In the illustrated embodiment, the firing beam 18220 is slidably supported within a pathway 18230 that is formed in the spine 18210 and interfaces with a firing system of the various types described herein which are configured to selectively advance the firing beam 18220 in the distal direction DD and retract the firing beam 18220 in the proximal direction PD. The distal end of the firing beam 18220 is coupled to or otherwise operably interfaces with a firing member (not shown) or tissue cutting member (not shown) of the various types disclosed herein. In at least one form, for example, the firing member 18220 includes a tissue cutting surface and is configured to interact with staple support members that are operably supported within the staple

cartridge so as to drive the staple support members (and the staples supported thereon) toward the anvil as the firing member 18220 is driven distally through the staple cartridge.

[0353] The articulation joint 18270 of the illustrated embodiment facilitates articulation of the surgical end effector 18300 only in one direction (CCW). Stated another way, the surgical end effector 18300 is pivotable to an articulated position that coincides with the first lateral side 18211 of the spine 18210. In one example, the surgical end effector 18300 may articulate to a fully articulated position shown in FIG. 131 wherein the angle 18950 between the end effector axis EA and the shaft axis is approximately seventy-five degrees (75°). To accommodate such range of articulation, the distal end 18215 of the spine 18210 has a notch 18217 that is adjacent to the first side 18211 of the spine 18210.

[0354] As indicated above, the firing beam 18220 is slidably supported in a pathway 18220 that is provided in the spine 18210. In the illustrated arrangement, the pathway 18230 includes a "first" or proximal portion 18232 that is axially aligned with the shaft axis SA-SA and a "second" or distal portion 18234 that is not axially aligned on the shaft axis SA-SA. In the illustrated embodiment, the distal portion 18234 of the pathway 18230 opens at the distal end of the spine at a location that is not axially aligned with the shaft axis SA-SA. As can be seen in FIGS. 130 and 131, for example, the distal portion 18234 of the pathway 18230 opens at a location (designated as 18236 in FIGS. 130 and 131) that is laterally offset to a second lateral side 18213 of the shaft axis SA-SA. Further, in at least the illustrated embodiment, the distal portion 18234 of the pathway 18230 is curved so as to cause the firing beam 18220 to start bending in the articulation direction before the firing beam 18220 exits the spine 18210. Such arrangement provides the firing beam 18220 with a higher bend radius when compared to the bend radiuses of the firing beams of other articulatable end effector arrangements that articulate in one direction and wherein the firing beam exits the spine 18210 while aligned on the shaft axis SA-SA. Further, the pathway 18230 in the illustrated arrangement includes a first or proximal portion 18232 that is axially aligned with the shaft axis SA-SA, a second arcuate portion 18233 that curves in a first direction away from the shaft axis SA-SA and a third arcuate section 18235 that curves toward the shaft axis SA-SA. As can be further seen in FIGS. 130 and 131, the location 18236 at which the firing beam 18220 exits the spine 18210 is located on the second side 18213 of the shaft axis SA that is opposite from the first side 18211 to which the end effector 18300 articulates. Thus, the distal portion 18234 of the pathway 18230 serves to position or bias the firing beam 18220 to an "off axis position" relative to the shaft axis SA-SA (a position that is not axially aligned with the shaft axis SA). Such arrangement provides the firing beam 18220 with a gradual arc as it exits the spine 18210. This feature may serve to reduce the likelihood of the firing beam 18220 buckling as it spans the

articulation joint 18270 to enter the surgical end effector 18300. In other arrangements, the proximal portion of the pathway may be laterally offset from the shaft axis. In still other arrangements, the proximal portion of the pathway may be axially aligned with the shaft axis and the distal portion of the pathway may angle to one side of the shaft axis such that when the firing beam exits the distal portion of the pathway, the firing beam is axially offset to the opposite side of the shaft axis to which the end effector is articulatable. In such arrangement, the distal portion of the pathway may be relatively straight and not curved. In still other arrangements, the distal portion and proximal portion of the pathway may lie along a common axis that is laterally offset from the shaft axis on the side that is opposite from the side to which the end effector is articulatable. All of such arrangements shift the firing beam off center as it exits the spine and allow for a larger bend radius without adding space distal to the articulation axis.

[0355] The firing beams employed in the various surgical instruments disclosed herein are configured to sufficient flex to accommodate the various articulated positions of the end effector. In some arrangements, the firing beam may actually comprise a firing rod 18600 which is coupled to a flexible firing beam 18700 at a coupling or connection 18702. See FIG. 132. The firing rod 18600 is slidably supported in the spine 18210 of the elongate shaft assembly and can translate in response to driving motions initiated in the handle of the surgical instrument or by a robotic system, for example. In various instances, the firing rod 18600 can resist deformation, torqueing and/or bowing when transferring a firing motion. For example, the firing rod 18600 can be comprised of a rigid and/or inflexible material and/or structure.

[0356] At the coupling 18702, the firing rod 18600 is engaged with a downwardly-protruding key 18701 of the flexible firing beam 18700 (see, e.g., FIG. 132A). For example, the key 18701 can extend into an elongate aperture 18606 formed in a distal end 18604 of the firing rod 18600. The firing rod-key engagement is configured to transfer the translation of the firing rod 18600 to the flexible firing beam 18700. In various instances, the coupling 18702 can be proximate to the articulation joint 18270 such that the flexible firing beam 18700 extends from the coupling 18702 and through the articulation joint 18270.

[0357] In the arrangement depicted in FIGS. 133, 135, the flexible firing beam 18700 includes a plurality of lateral portions or layers 18702a, 18702b, 18702c, 18702d, 18702e, 18702f. In various instances, the portions 18702a, 18702b, 18702c, 18702d, 18702e, 18702f can be held together and movable and/or shiftable relative to each other. For example, the lateral portions 18702a, 18702b, 18702c, 18702d, 18702e, 18702f can be fixed together at the distal end of the flexible firing beam

18700. The portions 18702a, 18702b, 18702c, 18702d, 18702e, 18702f can be welded, formed together, fastened and/or otherwise secured together at the distal ends thereof, for example. At least a portion of the remaining length of the lateral portions 18702a, 18702b, 18702c, 18702d, 18702e, 18702f can be configured to move and/or shift relative to the adjacent lateral portion(s) 18702a, 18702b, 18702c, 18702d, 18702e, 18702f. For example, when the flexible firing beam 18700 bends at the articulation joint 18270, the lateral portions 18702a, 18702b, 18702c, 18702d, 18702e, 18702f can shift into a staggered and/or offset configuration between the bend in the articulation joint 18270 and the proximal end of the flexible firing beam 18700. FIG. 134 illustrates a proximal end 18704 of one form of the firing beam 18700' wherein the lateral portions 18702a, 18702b, 18702c, 18702d, 18702e are even with each other when the firing beam 18700 is straight. FIG. 135 illustrates another flexible beam arrangement wherein the layer portions 18702a, 18702b, 18702c, 18702d, 18702e and 18702f are staggered at the proximal end 18704.

[0358] Referring again to FIGS. 132 and 133, the proximal end 18704 of the flexible firing beam 18700 extends into a cavity 18608 that is formed in the distal end 18604 of the firing rod 18600, the portions 18702a, 18702b, 18702c, 18702d, 18702e 18702f of the flexible firing beam 18700 can extend along firing paths through the articulation joint 18270. When the end effector 18300 is articulated relative to the elongate shaft assembly 18200, the flexible firing beam 18700 and portions 18702a, 18702b, 18702c, 18702d, 18702e 18702f thereof can bend within the articulation joint 18270. In such instances, the lateral portions adjacent lateral portion(s) 18702a, 18702b, 18702c, 18702d, 18702e 18702f can extend along altered paths when the end effector 18300. A bumper member 18610 is supported in the cavity to accommodate shifting of the portions 18702a, 18702b, 18702c, 18702d, 18702e 18702f during articulation. For example, the bumper member 18610 may rotate within the cavity 18608 as the firing beam portions 18702a, 18702b, 18702c, 18702d, 18702e 18702f splay relative to each other such that the portions 18702a, 18702b, 18702c, 18702d, 18702e 18702f would likely become evenly loaded by the bumper member 18610 during firing (i.e., advanced in the distal direction). The bumper member 18610 may or may not be fabricated from a compliant material. Further details and specifics concerning the above-described firing beam/firing rod arrangement as well as other configurations that may be employed with the various embodiments disclosed herein may be found in 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 MEMBER, the entire disclosure of which is hereby incorporated by reference herein.

[0359] FIG. 132A depicts a coupling arrangement 18702' that employs a one-way latch arrangement for limiting the distal travel of the firing rod 18600'. As can be seen in that Figure, the firing rod 18600' includes a lock aperture 18620 that has an angled distal surface 18622 and a perpendicular surface 18624 that is perpendicular to or transverse to the direction in which the firing rod 18600' travels. A lock member 18630 is movably supported in a lock cavity 18640 in the shaft spine 18210. A lock spring 18642 is supported in the lock cavity 18640 to bias lock member 18630 into sliding contact with the firing rod 18600'. In the illustrated embodiment, the lock member 18630 has an angled distal surface 18632 and a perpendicular rear surface 18634 and is sized to extend into the lock aperture 18620 when the firing rod 18600' has moved to a predetermined distal-most position. When the firing rod 18600' is distally advanced to the position shown in FIG. 132A, the lock member 18630 spring 18642 biases the lock member into the lock aperture 18620 to thereby further prevent any further distal movement of the firing rod 18600'. However, when the firing rod 18600' is retracted in the proximal direction PD, the firing rod 18600' will contact the angled distal surface 18632 and bias the lock member 18630 into the lock cavity 18640 in the shaft spine 18210 to permit the firing rod 18600'to move in the proximal direction PD past the lock member 18630.

[0360] FIGS. 136 AND 137 illustrate portions of another surgical instrument 19010 that includes a surgical end effector 19300 that operably interfaces with an elongate shaft assembly 19200 that employs many of the features of the various shaft assemblies disclosed herein. For example, the elongate shaft assembly 19200 is similar to elongate shaft assembly 200' described in detail above except for the differences discussed below. In the illustrated example, the elongate shaft assembly 19200 includes a dual articulation link arrangement designated as 19800 that employs an articulation lock 19810 that is similar to articulation locks 350, 810 and 10810 described above. The articulation lock 19810 can be configured and operated to selectively lock the surgical end effector 19300 in various articulated positions. Such arrangement enables the surgical end effector 19300 to be rotated, or articulated, relative to the elongate shaft assembly 19200 when the articulation lock 19810 is in its unlocked state. A first distal articulation driver 19820 is supported within the spine 19210 of the elongate shaft assembly 19200 for selective longitudinal travel in a distal direction DD and the proximal direction PD in response to corresponding articulation control motions applied thereto. A downwardly protruding pivot pin 19818 is adapted to be pivotally received within a pivot hole (not shown) formed in the proximal end portion of the elongate channel 19302 of the surgical end effector 19800. Such arrangement facilitates pivotal travel of the elongate channel 19302 of the surgical end effector 19300 relative to the spine 19210 about an articulation axis B-B that is defined by the pivot

hole. As indicated above, the articulation axis B-B is transverse to the shaft axis SA-SA that is defined by elongate shaft assembly 19200.

[0361] Still referring to FIGS. 136 and 137, the dual articulation link arrangement 19800 is configured to establish a "push/pull" arrangement when an articulation force is applied thereto through the first distal articulation driver 19820. As can be seen in those Figures, the first distal articulation driver 19820 has a first drive rack 19842 formed therein. A first articulation rod 19844 protrudes distally out of the first distal articulation driver 19820 and has a first axial slot 19845 therein. In addition, a first end effector link 19850 is movably coupled to the surgical end effector 19300. In one arrangement, for example, the distal end 19852 of the first end effector link 19850 is pivotally pinned to the elongate channel 19302 of the end effector 19300. A proximal end 19854 of the first end effector link 19850 includes a first pin 19856 that is slidably received within the first axial slot 19845 in the first articulation rod 19844 of the first distal articulation driver 19820. The dual articulation link arrangement 19800 further comprises a second distal articulation driver 19860 that has a second drive rack 19862 formed therein. The second distal articulation driver 19860 is movably supported within the elongate shaft assembly 19200 for longitudinal travel in the distal direction DD and the proximal direction PD. A second articulation rod 19864 protrudes distally out of the second distal articulation driver 19860 and has a second axial slot 19865 therein. In addition, a second end effector link 19870 is movably coupled to the surgical end effector 19300. In one arrangement, for example, the distal end 19872 of the second end effector link 19870 is pivotally pinned to the elongate channel 19302 of the end effector 19300. A proximal end 19874 of the second end effector link 19870 includes a second pin 19876 that is slidably received within the second axial slot 19865 in the second articulation rod 19864 of the second distal articulation driver 19860. As can be seen in FIG. 136, the first end effector link 19850 is attached to the elongate channel 19302 for longitudinal travel along a first articulation axis FA that is parallel and located on a first axial side of the shaft axis SA-SA. The second end effector link 19870 is attached to the elongate channel 19302 for longitudinal travel along a second articulation axis SDA that is parallel to and off to a second lateral side of the shaft axis SA-SA. See FIG. 136. Thus, by simultaneously pulling on one of the end effector links 19850, 19870, the surgical end effector 19300 will be articulated about the articulation axis B-B relative to the elongate shaft assembly 19200. In the illustrated arrangement, the first axial slot 19845 and the second slot 19865 are parallel to each other and are parallel to the shaft axis SA-SA. As can be further seen in FIGS. 136 and 137, the first end effector link 19850 and the second end effector link 19870 each have a curved or arcuate shape that curves around the articulation axis B-B. Such curved shape may further lead to an

increased range of articulation. Further each of the first and second axial slots 19845, 19865 may each have a predetermined length that facilitates a desired amount of articulation.

[0362] As can also be seen in FIGS. 136 and 137, a proximal pinion gear 19880 and a distal pinion gear 19882 are centrally disposed between the first drive rack 19842 and the second drive rack 19862 and are in meshing engagement therewith. In alternative embodiments, only one pinion gear or more than two pinion gears may be employed. Thus, at least one pinion gear is employed. The proximal pinion gear 19880 and the distal pinion gear 19882 are rotatably supported in the spine 19810 for free rotation relative thereto such that as the first distal articulation driver 19820 is moved in the distal direction DD, the pinion gears 19880, 19882 serve to drive the second distal articulation driver 19860 in the proximal direction PD. Likewise, when the first distal articulation driver 19820 is pulled in the proximal direction PD, the pinion gears 19880, 19882 drive the second distal articulation driver 19860 in the distal direction DD. As the first distal articulation driver 19820 moves the in the proximal direction, the pinion gears 19880, 19882 serve to drive the second distal articulation driver 19860 in the distal direction DD. Such movement of the first and second distal articulation drivers 19820, 19860 causes the surgical end effector 19300 and more specifically, the elongate channel 19302 of the surgical end effector 19300 to pivot about the articulation axis B-B in the articulation direction of arrow 19821. Conversely, to articulate the end effector 19300 in the direction of arrow 19823, the first distal articulation driver 19820 is moved the in the distal direction which causes the pinion gears 19880, 19882 to drive the second distal articulation driver 19860 in the proximal direction PD. Such movement of the first and second distal articulation drivers 19820, 19860 causes the surgical end effector 19300 and more specifically, the elongate channel 19302 of the surgical end effector 19300 to pivot about the articulation axis B-B in the articulation direction of arrow 19823.

[0363] The dual solid link articulation arrangement 19800 and its variations may afford the surgical end effector with a greater range of articulation when compared to other articulatable surgical end effector configurations. In particular, the solid link articulation arrangements disclosed herein may facilitate ranges of articulation in the range of between one degree (1°) to sixty-five degrees (65°). Use of at least one pinion gear to interface between the distal articulation drivers enables the end effector to be "pushed" and "pulled" into position and also may reduce the amount of end effector "slop" or undesirable or unintended movement during use. The dual solid link articulation arrangements disclosed herein also comprise an articulation system that has improved strength characteristics when compared to other articulation system arrangements. The proximal ends of the dual links translate forward and backward along their respective slots as the end effector is articulated. These slots may

provide the system with higher resistance to bending forces on the dual links and reduced backlash of the system by constraining the motion of the dual links.

[0364] FIGS. 138-142 illustrate portions of another surgical instrument 20010 that includes a surgical end effector 20300 that operably interfaces with an elongate shaft assembly 20200 that employs many of the features of the various shaft assemblies disclosed herein. For example, the elongate shaft assembly 20200 is similar to elongate shaft assembly 200' described in detail above except for the differences discussed below. A downwardly protruding pivot pin 20818 is adapted to be pivotally received within a pivot hole 20305 formed in the proximal end portion of the elongate channel 20302 of the surgical end effector 20300. See FIG. 139. Such arrangement facilitates pivotal travel of the elongate channel 20302 of the surgical end effector 20300 relative to the spine 20210 about an articulation axis B-B that is defined by the pivot hole 20305. The articulation axis B-B is transverse to the shaft axis SA-SA that is defined by elongate shaft assembly 20200. In the illustrated example, the elongate shaft assembly 20200 includes a dual articulation driver arrangement designated as 20800 that employs an articulation lock 20810 (FIG. 139) that is similar to articulation locks 350, 810 and 10810 described above. The articulation lock 20810 can be configured and operated to selectively lock the surgical end effector 20300 in various articulated positions. Such arrangement enables the surgical end effector 20300 to be rotated, or articulated, relative to the elongate shaft assembly 20200 when the articulation lock 20810 is in its unlocked state. A first distal articulation driver 20820 is supported within the spine 20210 of the elongate shaft assembly 20200 for selective longitudinal travel along a first articulation axis FA in a distal direction DD and the proximal direction PD in response to corresponding articulation control motions applied thereto. The first articulation axis FA is parallel to and located to a first lateral side of the shaft axis SA-SA. The first distal articulation driver 20820 includes a first proximal drive rack 20842 and a first distal drive rack 20844 formed therein. The dual articulation link arrangement 20800 further comprises a second distal articulation driver 20860 that has a second proximal drive rack 20862 and a second distal drive rack 20864 formed therein. The second distal articulation driver 20860 is movably supported within the elongate shaft assembly 20200 for longitudinal travel along a second articulation axis SDA in the distal direction DD and the proximal direction PD. The second articulation axis SDA is parallel to and located to a second lateral side of the shaft axis SA-SA. See FIG. 138. The first and second distal articulation drivers 20820, 20860 operably interface with a central articulation member 20850. As can be seen in FIG. 140, the central articulation member 20850 is pivotally attached to the shaft spine 20210 by a pin 20851 that serves to define a gear axis GA about which the central articulation member

20850 may pivot. The gear axis GA is parallel to the articulation axis BB. See FIG. 139. The central articulation member 20850 includes a body portion 20852 that has a gear portion 20854 formed thereon. The gear portion is 20854 is in meshing engagement with the first distal drive rack 20844 and the second distal drive rack 20864.

[0365] The surgical end effector 20300 of the embodiment illustrated in FIGS. 138-142 comprises a surgical cutting and stapling device. The elongate channel 20302 is configured to operably support a surgical staple cartridge (not shown) and an anvil assembly 20310. The surgical end effector 20300 also employs a firing beam (not shown) of the various types and configurations described herein. In the illustrated arrangement, a middle support member 20950 is pivotally and slidably supported relative to the shaft spine frame 20810. As can be seen in FIG. 140, the middle support member 20950 includes a central body portion 20952 that defines a central slot 20954 that is configured to slidably receive the firing member therethrough to provide lateral support to the firing member as it traverses from the elongate shaft assembly 20200 across the articulation joint 20270 to the elongate channel 20302. A proximal tongue 20955 protrudes proximally from the body portion 20952 to be movably coupled to the central articulation member 20850. In the illustrated arrangement, an attachment pin 20960 extends through a proximal hole 20956 in the proximal tongue 20955. The attachment pin 20960 is received within an attachment slot 20856 that is provided in the body portion 20852 of the central articulation member 20850. The proximal tongue 20955 further includes an elongate slot 20957 that is configured to receive therein a pivot pin 20211 formed in the shaft spine 20210. See FIG. 139. The middle support member 20950 further includes a distal tongue 20958 that is movably coupled to the proximal end of the elongate channel 20302. As can be further seen in FIG. 139, a coupler assembly 20970 pivotally couples the middle support member 20950 to the elongate channel 20302. More specifically, the coupler assembly 20970 includes a body plate 20972 that has an end effector attachment pin 20974 protruding therefrom that is configured to extend through a first pivot hole 20307 in the elongate channel 20302 and a distal pivotal hole 20959 in the distal tongue 20958 of the middle support member 20950. Such arrangement serves to facilitate pivotal travel of the middle support member 20950 relative to the elongate channel 20302 about an end effector pivot axis EPA that is defined by the end effector attachment pin 20974. As can be seen in FIG. 139, the end effector pivot axis EPA is parallel to the articulation axis B-B. In the illustrated arrangement, the multiple support link assembly 920 further comprises a proximal support link 940 and a distal support link 950. See FIG. 139. Specific details regarding the operation of the proximal and distal support links and the middle support member have been discussed above and will not be repeated for the sake of brevity.

[0366] The dual articulation driver arrangement 20800 is configured to establish a "push/pull" arrangement when an articulation force is applied thereto through the first distal articulation driver 20820. As can also be seen in FIGS. 138, 139, 141 and 142, a proximal pinion gear 20880 and a distal pinion gear 20882 are centrally disposed between the first proximal drive rack 20842 and the second proximal drive rack 20862 and are in meshing engagement therewith. In alternative embodiments, only one pinion gear or more than two pinion gears may be employed. Thus, at least one pinion gear is employed. The proximal pinion gear 20880 and the distal pinion gear 20882 are rotatably supported in the spine 20810 for free rotation relative thereto such that as the first distal articulation driver 20820 is moved in the distal direction DD, the pinion gears 20880, 20882 serve to drive the second distal articulation driver 20860 in the proximal direction PD. Likewise, when the first distal articulation driver 20820 is pulled in the proximal direction PD, the pinion gears 20880, 20882 drive the second distal articulation driver 20860 in the distal direction DD. As the first distal articulation driver 20820 moves the in the proximal direction, the pinion gears 20880, 20882 serve to drive the second distal articulation driver 20860 in the distal direction DD. Such movement of the first and second distal articulation drivers 20820, 20860 causes the central articulation member 20850 through the middle support member 20950 to articulate the surgical end effector 20300 and more specifically, the elongate channel 20302 of the surgical end effector 20300 about the articulation axis B-B in the articulation direction of arrow 20821. See FIG. 141. Conversely, to articulate the end effector 20300 in the direction of arrow 20823, the first distal articulation driver 20820 is moved the in the distal direction DD which causes the pinion gears 20880, 20882 to drive the second distal articulation driver 20860 in the proximal direction PD. Such movement of the first and second distal articulation drivers 20820, 20860 causes the surgical end effector 20300 and more specifically, the elongate channel 20302 of the surgical end effector 20300 to pivot about the articulation axis B-B in the articulation direction of arrow 20823. See FIG. 142.

[0367] The dual solid articulation driver arrangement 20800 and its variations may afford the surgical end effector with a greater range of articulation when compared to other articulatable surgical end effector configurations. In particular, the dual solid driver articulation arrangements disclosed herein may facilitate ranges of articulation in the range of sixty-five degrees (65°). Use of at least one pinion gear to interface between the distal articulation drivers enable the end effector to be "pushed" and "pulled" into position also may reduce the amount of end effector "slop" or undesirable or unintended movement during use. The dual solid driver articulation arrangements disclosed herein

also comprise an articulation system that has improved strength characteristics when compared to other articulation system arrangements.

[0368] FIGS. 143 and 144 depict a portion of an elongate shaft assembly 21200 that is substantially similar to the elongate shaft assembly 1200 described above, except for various differences discussed in further detail below. As can be seen in FIG. 143, the elongate shaft assembly 21200 includes an articulation lock 21810 that is substantially similar to articulation locks 810 and 1810 and operates in essentially the same manner. As can be seen in FIG. 22, the elongate shaft assembly 21200 includes a shaft frame 21812 that comprises a portion of a shaft frame 21210. A first distal articulation driver 21820 is movably supported within the elongate shaft assembly 21200 for selective longitudinal travel in a distal direction DD and a proximal direction PD in response to articulation control motions applied thereto. The shaft frame 21812 further includes a distal end portion 21814 that has a pivot pin 21818 formed thereon. The pivot pin 21818 is adapted to be pivotally received within a pivot hole (not shown) provided in a distal pulley 21340 that is non-rotatably formed on the proximal end 21320 of the elongate channel 21302 of a surgical end effector 21300. See FIG. 144. Such arrangement facilitates pivotal travel (i.e., articulation) of the elongate channel 21302 of the surgical end effector 21300 relative to the shaft frame 21812 about an articulation axis B-B defined by the pivot hole and the pin 21818. The shaft frame 21812 further includes a centrally disposed cavity 21817 and a distal notch 21819 that is located between the distal end 21814 and the centrally disposed cavity 21817.

[0369] The shaft assembly 21200 further includes a second distal articulation driver 21860 that comprises a cable member 21862 that is rotatably journaled on a proximal pulley assembly 21840 and the distal pulley 21340. In one form, the cable member 21862 comprises a cable that is fabricated from stainless steel, tungsten, aluminum, titanium, etc., for example. The cable may be of braided or multi-stranded construction with various numbers of strands to attain desired levels of tensile strength and flexibility. In various arrangements, for example, the cable member 21862 may have a diameter in the range of 0.03 inches to 0.08 inches and more preferably in the range of 0.05 - 0.08 inches. A preferred cable may, for example, be fabricated from 300 series stainless steel - half hard to full hard. In various arrangements, the cable 21862 may also be coated with, for example, Teflon®, copper, etc. for improved lubricity and/or to reduce stretching, for example. A first lug 21863 is attached to one end of the cable 21862 and a second lug 21864 is attached to the other end of the cable 21862 by, for example, crimping. See FIG. 144.

[0370] Still referring to FIG. 144, the cable member 21862 is coupled to a distal end 21821 of the first distal articulation driver 21820 by a coupler assembly 21830. The coupler assembly 21830

includes a coupler body 21832 that a proximal lug cavity 21834 formed therein and a distal lug cavity 21836 formed therein. The first lug 21863 is configured to be retainingly received within the first lug cavity 21834 and the second lug 21836 is configured to be retainingly received within the second lug cavity 21836. Other fastener arrangements, screws, rivets, clamps, adhesive, etc. may also be employed. When the cable member 21862 is journaled on the pulleys 21840 and 21340, the coupler assembly 21830 is free to move axially within the distal notch 21819 in the shaft frame 21812 in response to the axial movement of the first distal articulation driver 21820. The articulation motions generated by the axial movement of the first distal articulation driver 21820 are transferred to the second distal articulation driver 21860 or the cable 21862. An attachment ball or lug 21866 is attached to the cable 21862 and is received in a groove or pocket (not shown) formed in the distal pulley 21340. Thus, movement of the endless member 21862 is transferred to the surgical end effector 21300 and more specifically to the elongate channel 21302 of the surgical end effector 21300 to articulate the end effector about articulation axis B-B. As such, when the first distal articulation driver 21820 is moved in the distal direction DD, the cable member 21862 causes the surgical end effector 21300 to articulate about the articulation axis B-B in one articulation direction and when the first distal articulation driver 21820 is moved in the proximal direction PD, the cable member 21862 causes the surgical end effector 21300 to articulate about the articulation axis B-B in an opposite articulation direction.

[0371] In the illustrated arrangement, the proximal pulley assembly 21840 is configured to selectively introduce tension into the cable member 21862. For example, as can be seen in FIG. 144, the proximal pulley assembly 21840 comprises a proximal pulley 21842 that is rotatably mounted on a pulley mount or bearing 21844. The axis of the pulley mount 21844 is concentric with the center pulley axis CPA so that the proximal pulley 21842 is freely rotatable on the pulley mount 21844. The pulley mount 21844 is affixed to the shaft frame 21812 by an eccentric mounting shaft 21846 that is attached to the pulley mount 21844. Stated another way, the central axis MSA of the mounting shaft 21846 is offset from the center pulley axis CPA (and the center axis of the pulley mount). See FIG. 143. The mounting shaft 21846 is sized to be frictionally received in a mounting hole 21813 provided in the shaft frame 21812. A hexagonal socket 21848 that is configured to receive a standard hexagonal wrench is provided in the pulley mount 21844. See FIG. 143. Thus, the tension in the cable member 21862 may be increased by inserting a hexagonal wrench into the hexagonal socket 21848 and turning the mounting shaft 21846 in the appropriate direction. Such action will cause the mounting shaft 21846 as well as the pulley mount 21844 to rotate. Because the center axis CPA of the pulley mount 21844 is offset from the center axis MSA of the mounting shaft 21846, the center axis CPA may be

moved further away from the center axis of the distal pulley 21340 (which may be coaxial with the articulation axis B-B) to thereby increase the tension in the cable member 21862.

[0372] FIGS. 145-147 depict a portion of an elongate shaft assembly 22200 that is substantially similar to the elongate shaft assembly 1200 described above, except for various differences discussed in further detail below. Those components of the elongate shaft assembly 1200 that have been discussed in detail above are referenced with like element numbers and, for the sake of brevity, will not be further discussed in great detail beyond that which may be necessary to understand the operation of shaft assembly 22200. As can be seen in FIG. 147, the elongate shaft assembly 22200 includes an articulation lock 22810 that is substantially similar to articulation locks 810 and 1810 and operates in essentially the same manner. As can be seen in FIG. 147, the elongate shaft assembly 22200 includes a shaft frame 22812 that comprises a portion of a shaft spine 22210. A first distal articulation driver (omitted for clarity in FIGS. 145-147) is movably supported within the elongate shaft assembly 22200 for selective longitudinal travel in a distal direction DD and a proximal direction PD in response to articulation control motions applied thereto. The shaft frame 22812 further includes a distal end portion 22814 that has a pivot pin 22818 formed thereon. The pivot pin 22818 is adapted to be pivotally received within a pivot hole 22342 formed in a distal pulley 22340 that is non-rotatably formed in a proximal end portion 22320 of an elongate channel 22302 of a surgical end effector 22300. See FIG. 147. Such arrangement facilitates pivotal travel (i.e., articulation) of the elongate channel 22302 of the relative to the shaft frame 22812 about an articulation axis B-B defined by the pivot hole 22342 and the pin 22818. The shaft frame 22812 further includes a centrally disposed cavity 22817 and a distal notch 22819 that is located between the distal end 22814 and the centrally disposed cavity 22817.

[0373] The shaft assembly 22200 further includes a second distal articulation driver 22860 that comprises a cable member 1862 that is rotatably journaled on a proximal pulley assembly 22840 and the distal pulley 22340. In one form, the cable member 1862 comprises a cable that is fabricated from stainless steel, tungsten, aluminum, titanium, etc., for example. The cable may be of braided or multi-stranded construction with various numbers of strands to attain desired levels of tensile strength and flexibility. In various arrangements, for example, the cable member 1862 may have a diameter in the range of 0.03 inches to 0.08 inches and more preferably in the range of 0.05 - 0.08 inches. A preferred cable may, for example, be fabricated from 300 series stainless steel - half hard to full hard. In various arrangements, the cable may also be coated with, for example, Teflon®, copper, etc. for improved lubricity and/or to reduce stretching, for example. A first lug 1863 is attached to one end of the cable

and a second lug 1864 is attached to the other end of the cable member 1862 by, for example, crimping.

[0374] Referring now to FIGS. 145 and 147, the cable member 1862 is coupled to a distal end 1821 of the first distal articulation driver by a coupler assembly 1830. The articulation driver may comprise a distal articulation driver portion of the articulation lock 22810 and is not shown in FIGS. 145 and 147 for clarity purposes. The coupler assembly 1830 comprises an upper coupler portion (not shown) formed on the distal end of the first distal articulation driver (not shown) and a lower coupler portion 1834. The lower coupler portion 1834 is formed with two cradles 1835 that are configured to receive the lugs 1862, 1864 therein. A pair of attachment pins 1836 is configured to be pressed into holes (not shown) in the upper coupler portion (not shown) to affix the two coupler portions together. Other fastener arrangements, screws, rivets, adhesive, etc. may be employed. When the cable member 1862 is journaled on the proximal pulley assembly 22840 and the distal pulley 22340, the coupler assembly 1830 is free to move axially within the distal notch 22819 in the shaft frame 22812 in response to the axial movement of the first distal articulation driver. The articulation motions generated by the axial movement of the first distal articulation driver are transferred to the second distal articulation driver 22860 or the cable member 1862. An attachment ball or lug 1866 is attached to the cable member 1862 and is received in a groove or pocket 1342 formed in the distal pulley 22340. Thus, movement of the cable member 1862 is transferred to the surgical end effector 22300 and more specifically to the elongate channel 22302 of the surgical end effector 22300 to articulate the end effector about articulation axis B-B. Thus, when the first distal articulation driver is moved in the distal direction DD, the cable member 1862 causes the surgical end effector 22300 to articulate about the articulation axis B-B in one articulation direction and when the first distal articulation driver is moved in the proximal direction PD, the cable member 1862 causes the surgical end effector 22300 to articulate about the articulation axis B-B in an opposite articulation direction.

[0375] In the illustrated arrangement, the proximal pulley assembly 22840 is configured to selectively introduce tension into the cable member 1862. For example, as can be seen in FIG. 147, the proximal pulley assembly 22840 comprises a proximal pulley 22842 that is rotatably mounted on a pulley mount or bearing 22844. The pulley mount 22844 is attached to a mounting block 22846 that is movably received within an axial mounting cavity 22821 formed in the shaft frame 22812. A tensioning screw 22823 is positioned within the shaft frame 22812 to adjust the position of the mounting block 22846 within the axial mounting cavity 22821. See FIGS. 145 and 147. Screwing the tensioning screw 22823 inward will cause the end 22825 of the tensioning screw 22823 to bias the

mounting block 22846 in the proximal direction to introduce tension in the cable member 1862. Such action will move the central axis CPA of the proximal pulley 22842 away from the center axis of the distal pulley 22340 a tension distance DT. Thus as the tension distance DT increases, so does the tension in the cable member 1862.

[0376] FIGS. 148 and 149 depict an alternative proximally pulley assembly 22840' that may be used to tension the cable member 1862. For example, as can be seen in FIG. 148, the proximal pulley assembly 22840' comprises a proximal pulley 22842 that is rotatably mounted on a pulley mount or bearing 22844. The pulley mount 22844 is attached to a mounting block 22846 that is movably received within an axial mounting cavity 22821 formed in the shaft frame 22812'. In this arrangement, a tension cam 22850 is attached to an eccentric mounting spindle 22854. The eccentric mounting spindle 22854 defines a central axis MSA' that is offset from the center axis of the tension cam 22850. As can be seen in FIG. 149, the mounting spindle 22854 has a knurled outer surface and is adapted to be received within a knurled bore 22855 in the shaft frame 22812'. A hexagonal socket 22856 that is configured to receive a standard hexagonal wrench is provided in the mounting spindle 22854. See FIG. 149. Thus, the tension in the cable member 1862 may be increased by inserting a hexagonal wrench into the hexagonal socket 22856 and turning the mounting spindle 22854 in the appropriate direction. Rotation of the mounting spindle 22854 will cause the tension cam 22852 to rotate and cam the mounting block 22846 in the proximal direction PD within the axial slot 22821 to introduce tension in the cable member 1862. Such action will move the central axis CPA of the proximal pulley 22842 away from the center axis of the distal pulley 22340 a tension distance DT. Thus, as the tension distance DT increases, so does the tension in the cable member 1862.

[0377] FIG. 150 illustrates another second distal articulation driver 23860 that comprises a cable member 1862 that is rotatably journaled on a proximal pulley 23842 and a distal pulley 22340. A first lug 1863 is attached to one end of the cable 1862 and a second lug 1864 is attached to the other end of the cable 1862 by, for example, crimping. The cable member 1862 is coupled to a distal end 1821 of a first distal articulation driver 1820 by a coupler assembly 1830 in the manners described herein. In this embodiment, a cable tensioning assembly 23900 is employed to introduce a desired amount of tension into the cable member 1862. As can be seen in FIG. 150, the cable tensioning assembly 23900 includes a mounting bracket 23902 that is mounted on one lateral side of the shaft frame and a tension roller assembly 23910 that is oriented to contact the cable member 1862 adjacent a second lateral side of the shaft frame. The tension roller assembly 23910 comprises a lateral bracket 23912 that is movably coupled to the mounting bracket 23902. In the illustrated arrangement, the lateral bracket

23912 is configured for threaded engagement with the mounting bracket 23902. A tension roller 23914 is mounted to the lateral bracket 23912 in contact with the cable member 1862. To increase the tension in the cable member 1862 the lateral bracket 23912 is moved toward the mounting bracket in the lateral direction LD. Such movement causes the tension roller 23914 to move laterally inward toward the mounting member and contacts the cable member 1862 to bias the cable member 1862 in the lateral direction LD that is transverse to the rotary direction RD1 and rotary direction RD2 to thereby increase tension in the cable member 1862.

[0378] FIG. 151 illustrates another second distal articulation driver 23860' that comprises a cable member 1862 that is rotatably journaled on a proximal pulley (not shown) and a distal pulley (not shown). A first lug 1863 is attached to one end of the cable 1862 and a second lug 1864 is attached to the other end of the cable 1862 by, for example, crimping. The cable member 1862 is coupled to a distal end 1821 of a first distal articulation driver 1820 by a tensioning assembly 1830' in the manners described herein. In this embodiment, the distal end 1821' of the first distal articulation driver 1820' comprises a proximal cleat 1823' and a distal cleat 1825'. The distal cleat 1825' is movably affixed to the proximal cleat 1823' by a tensioning screw member 23900'. In the illustrated arrangement, the tensioning screw member 23900' includes a first or proximal threaded portion 23922 that is threaded in a first threaded direction into a threaded hole 23940 in the proximal cleat 1823' and a second or distal threaded portion 23924 that is threaded in a second threaded direction into a threaded hole 23942 in the distal cleat 1825' that is opposite to the first threaded direction. An actuation nut 23926 is fixed to the screw member 23900' in a central position between the first threaded portion 23922 and the second threaded portion 23924. The tensioning screw 23900' may be rotated by using a wrench or other appropriate tool to rotate the actuation nut 23926. Rotation of the tensioning screw 23900' in a first direction will draw the proximal cleat 1823' and the distal cleat in a first direction toward each other along a tensioning axis TA that is parallel to the cable member axis CA. As the proximal cleat 1823' and the distal cleat 1825' move toward each other, the first and second lugs 1863, 1864 also move toward each other to introduce tension into the cable member 1862. Rotation of the tensioning screw 23920 in a second opposite direction will drive the first and second cleats away from each other along the tensioning axis TA. Such movement of the first and second cleats 1823', 1825' away from each other will permit the first and second lugs 1863, 1864 to move away from each other to thereby reduce the tension in the cable member 1862.

[0379] FIG. 152 illustrates a closure sleeve 260 which can be utilized to close and/or open an anvil of an end effector 300 as was described in detail above or stated another way, the closure sleeve may be

used to close a movable jaw or jaws of a surgical end effector. Shown in cross-section in that Figure, the closure sleeve 260 includes proximal end 261 that has an annular slot 262 therein. Such arrangement serves to attach the closure sleeve 260 to a closure shuttle for axial travel therewith while enabling the closure sleeve 260 to rotate relative to the closure shuttle about the shaft axis. As was also described above, the closure shuttle is axially actuated by a corresponding closure system or closure drive system that is configured to generate closure actuation motions. The closure sleeve 260 further includes openings 266 that enable mounts on a rotation nozzle to extend therethrough to be seated in recesses in the shaft spine. Such arrangement facilitates rotation of the shaft spine and closure sleeve 260 about the shaft axis when the nozzle is rotated relative to the handle. As was discussed above, the elongate shaft assembly 200 further includes a switch drum 500 that is rotatably received on the closure sleeve 260. See FIGS. 3 and 4. The switch drum 500 comprises a hollow shaft segment 502 that has a shaft boss 504 formed thereon for receive an outwardly protruding actuation pin 410 therein. In various circumstances, the actuation pin 410 extends through a slot 267 into a longitudinal slot 408 provided in the lock sleeve 402 to facilitate axial movement of the lock sleeve 402 when it is engaged with the proximal articulation driver 230. Further details regarding those structures and their operation are set forth above. As further discussed above, the closure sleeve 260 also includes double pivot closure sleeve assembly to facilitate attachment of the closure sleeve 260 to an end effector closure sleeve 272. Upper and lower tangs 264 and 265 are formed on the distal end of the closure sleeve 260 to facilitate such attachment in the various manners described above.

[0380] As was also discussed above, to close the anvil of the end effector (or to apply closure motions to the jaws or other portions of the end effector), the closure sleeve 260 is axially advanced in the distal direction DD upon actuation of the closure system or closure drive system. The axial distance in which the closure sleeve 260 must move on the shaft spine to cause the anvil (or jaw) to be moved to a closed position is referred to as the "closure stroke". The maximum axial distance that the closure sleeve must move to completely close the jaws or other portion of the end effector may be referred to herein as the "complete closure stroke distance". That distance, for example, may comprise the total axial distance that the closure sleeve 260 moves from a starting or unactuated position to an ending position that corresponds to fully closed end effector position. In one embodiment, the complete closure stroke distance of the closure sleeve 260 is approximately 0.230 inches, for example.

[0381] FIG. 153 illustrates a multi-part closure member assembly 24260 that is configured to be movably supported on a spine assembly (not shown) of an elongate shaft assembly of the various types disclosed herein. As will be described below, a "distal closure member" or "distal closure sleeve"

24400 is configured to move an "axial closure distance" on the spine assembly that is less than a "complete closure stroke distance" that a corresponding "proximal closure member" or "proximal closure sleeve" 24261 moves in response to an application of a closure actuation motion from a closure system. As can be seen in FIG. 153, the proximal closure sleeve 24261 may be identical to the portion of the closure sleeve 260 that is proximal to the point where the diameter of the closure sleeve 260 is reduced. Thus, those features of the proximal closure sleeve 24261 that are identical to the features of the closure sleeve 260 are identified in FIG. 153 with like element numbers. The proximal closure sleeve 24261 differs from the closure sleeve 260 in the following manners. First, the proximal closure sleeve 24261 terminates at a "necked portion" generally designated as 24300 and includes an internal stop wall or contact portion 24302. In the illustrated embodiment, a distal end 24402 of the distal closure sleeve 24400 is identical to the distal end of the closure sleeve 260 and includes the upper and lower tangs 264 and 265 to facilitate attachment to the end effector closure sleeve in the various manner disclosed herein. The proximal end 24404 of the distal closure sleeve 24400 slidably extends through an opening 24304 in the necked portion or the distal end 24300 of the proximal closure sleeve 24261. The proximal end 24404 of the distal closure sleeve portion 24400 is flared outward to prevent the distal closure sleeve 24400 from separating from the proximal closure sleeve 24261 while facilitating relative sliding motion between those components. Still referring to FIG. 153, such arrangement facilitates the proximal closure sleeve 24261 to travel an axial distance in the distal direction DD before the distal closure sleeve 24400 is axially advanced. This distance is referred to as a "proximal travel zone" or "dead zone" designated as 24307. In one arrangement, for example, the proximal closure sleeve 24261 is configured to move through a complete closure stroke distance of 0.230 inches. In such arrangement, for example, (referring to FIG. 153) the "proximal axial length" DZ of the proximal travel zone 24307 may be, for example, in the range of 0.050 inches - 0.150 inches. Thus, the proximal axial length DZ is less than the complete closure stroke distance that the proximal closure sleeve 24261 moves from a starting position to an ending position that corresponds to a complete closed condition of the end effector. Stated another way, this arrangement serves to reduce the distal closure sleeve's amount of axial travel during actuation of the closure system. Such arrangement also enables the distal closure sleeve 24400 to have a diameter that is smaller than the diameter of the proximal closure sleeve 24261.

[0382] FIG. 154 illustrates another multi-part closure member assembly 25260 that may be used in connection with an elongate shaft assembly of the various constructions described herein that include a spine assembly or arrangement upon which the closure member assembly 25260 may be movably

supported. In this embodiment, the axial travel of the distal closure sleeve 25400 is less than the axial travel of the proximal closure sleeve 25261 when the proximal closure sleeve 25261 is axially advanced by the closure system through a complete closure stroke or sequence. The proximal closure sleeve 25261 may be identical to the portion of the closure sleeve 260 that is proximal to the point where the diameter of the closure sleeve 260 is reduced. Thus, those features of the proximal closure sleeve 25261 that are identical to the features of the closure sleeve 260 are identified with like element numbers. The proximal closure sleeve 25261 interfaces with the closure system or closure drive system in the manner described above and thus, when the closure system is actuated, the proximal closure sleeve 25261 will axially travel the same axial distance that the closure sleeve 260 would travel upon actuation. The proximal closure sleeve 25261 differs from the closure sleeve 260 in the following manners. First, the proximal closure sleeve 25261 terminates at the necked portion generally designated as 25300. The distal end 24402 of the distal closure sleeve portion 24400 is identical to the distal end of the closure sleeve 260 and includes the upper and lower tangs to facilitate attachment to the end effector closure sleeve in the various manner disclosed herein. The proximal end 25404 of the distal closure sleeve 25400 slidably extends through an opening 25304 in the necked portion 25300 of the proximal closure sleeve 25261. The proximal end 25404 of the distal closure sleeve 25400 includes an opening 25406 through which a center tab member 25306 extends. The center tab member 25306 serves to prevent the distal closure sleeve 25400 from separating from the proximal closure sleeve 25261. In addition, the proximal end 25404 includes diametrically opposed slots 25308 that are configured to receive corresponding upper and lower tabs 25310 therein. Such arrangement facilitates travel of the proximal closure sleeve 25261 an axial distance in the distal direction DD before the distal closure sleeve 24400 is axially advanced thereby. The space between the tabs 25310 and the bottom of the slots 25308 is referred to as a "proximal travel zone" or "dead zone" designated as 25307. The proximal closure sleeve 25261 is configured to move through a complete closure stroke distance of 0.230 inches. In such arrangement, for example, (referring to FIG. 154) the "proximal axial length" DZ of the proximal travel zone 25307 may be, for example, in the range of 0.050 inches - 0.150 inches. Thus, the proximal axial length DZ is less than the complete closure stroke distance that the proximal closure sleeve 25261 moves from a starting position to an ending position that corresponds to a complete closed condition of the end effector. Stated another way, this arrangement serves to reduce the distal closure sleeve's amount of axial travel during actuation of the closure system. Such arrangement also enables the distal closure sleeve 25400 to have a diameter that is smaller than the diameter of the proximal closure sleeve 25261.

[0383] FIG. 155 illustrates another two-part closure member assembly 26260 that may be used in connection with an elongate shaft assembly of the various constructions described herein that include a spine assembly or arrangement upon which the closure member assembly 26260 may be movably supported. In this embodiment, the axial travel of the distal closure sleeve 26400 is less than the axial travel of the proximal closure sleeve 26261 when the proximal closure sleeve 26261 is axially advanced by the closure system through a complete closure stroke or sequence. The proximal closure sleeve 26261 may be identical to the portion of the closure sleeve 260 that is proximal to the point where the closure sleeve's diameter is reduced. Thus, those features of the proximal closure sleeve portion 26261 that are identical to the features of the closure sleeve 260 are identified with like element numbers. The proximal closure sleeve portion 26261 interfaces with the closure system in the manner described above and thus, when the closure system or closure drive system is actuated, the proximal closure sleeve portion 26261 may axially travel the same distance that the closure sleeve 260 would travel upon actuation. The proximal closure sleeve 26261 differs from the closure sleeve 260 in the following manners. First, the proximal closure sleeve 26261 has a flanged distal end 26300. In particular, an annular flange 26302 extends inwardly from the distal end 26300 and defines an opening 26304. The distal end of the distal closure sleeve 26400 is identical to the distal end of the closure sleeve 260 and includes the upper and lower tangs to facilitate attachment to the end effector closure sleeve in the various manner disclosed herein. The proximal end 26404 of the distal closure sleeve 26400 slidably extends through an opening 26304 in the distal end 26300 of proximal closure sleeve 26261. The proximal end 26404 of the distal closure sleeve 26400 extends through the opening 26304 and includes an outwardly extending annular flange 26406 which, in cooperation with the inwardly extending annular flange 26302 prevents the distal closure sleeve 26400 from separating from the proximal closure sleeve 26261. In addition, the proximal closure sleeve 26261 includes a stop portion that is proximal to said distal end 26300. In the illustrated arrangement, the stop portion comprises an inwardly extending crimped portion 26306. Such arrangement facilitates travel of the proximal closure sleeve 26261 an axial distance in the distal direction DD before the crimped portion 26306 contacts the annular flange 26406 to axially drive the distal closure sleeve 26400 in the distal direction DD. The space between the crimped portion 26306 and the outwardly extending flange 26406 is referred to as a "proximal travel zone" or "dead zone" designated as 26307. The proximal closure sleeve 26261 is configured to move through a complete closure stroke distance of, for example, 0.230 inches. In such arrangement, for example, (referring to FIG. 154) the "proximal axial length" DZ of the proximal travel zone 26307 may be, for example, in the range of 0.050 inches - 0.150 inches. Thus, the

proximal axial length DZ is less than the complete closure stroke distance that the proximal closure sleeve 26261 axially moves from a starting position to an ending position that corresponds to a complete closed condition of the end effector. Stated another way, this arrangement serves to reduce the distal closure sleeve's amount of axial travel during actuation of the closure system. Such arrangement also enables the distal closure sleeve 26400 to have a diameter that is smaller than the diameter of the proximal closure sleeve 26261.

[0384] FIG. 156 illustrates another two-part closure member assembly 27260 that may be used in connection with an elongate shaft assembly of the various constructions described herein that include a spine assembly or arrangement upon which the closure member assembly 27260 may be movably supported. In this embodiment, the axial travel of the distal closure sleeve 27400 is less than the axial travel of the proximal closure sleeve 27261 when the proximal closure sleeve 27261 is axially advanced by the closure system through a complete closure stroke or sequence. The proximal closure sleeve portion 27261 may be identical to the portion of the closure sleeve 260 that is proximal to the point where the closure sleeve's diameter is reduced. Thus, those features of the proximal closure sleeve portion 27261 that are identical to the features of the closure sleeve 260 are identified with like element numbers. The proximal closure sleeve portion 27261 interfaces with the closure system or closure drive system in the manner described above and thus, when the closure system or closure drive system is actuated, the proximal closure sleeve 27261 may axially travel the same distance that the closure sleeve 260 would travel upon actuation. The proximal closure sleeve 27261 differs from the closure sleeve 260 in the following manners. First, the proximal closure sleeve 27261 has a flanged distal end 27300. In particular, an annular flange 27302 extends inwardly from the distal end 27300 and defines an opening 27304. The distal end of the distal closure sleeve 27400 is identical to the distal end of the closure sleeve 260 and includes the upper and lower tangs o facilitate attachment to the end effector closure sleeve in the various manner disclosed herein. The proximal end 27404 of the distal closure sleeve 27400 slidably extends through an opening 27304 in the distal end 27300 of proximal closure sleeve 27261. The proximal end 27404 of the distal closure sleeve 27400 extends through the opening 27304 and includes an outwardly extending annular flange 27406 which cooperates with the inwardly extending annular flange 27302 to prevent the distal closure sleeve 27400 from separating from the proximal closure sleeve 27261. In addition, a stop ring 27305 is attached to the proximal closure sleeve 27261 within the distal end 27300. The stop ring 27305 may be welded to the proximal closure sleeve 27261, for example. The stop ring 27305 includes an inwardly extending proximal stop flange 27306. Such arrangement facilitates travel of the proximal closure sleeve 27261

an axial distance in the distal direction DD before the stop flange 27306 contacts the annular flange 27406 to axially drive the distal closure sleeve portion 27400 in the distal direction DD. The space 27307 between the proximal stop flange 27306 and the outwardly extending flange 27406 is referred to as a "proximal travel zone" or "dead zone". In one arrangement, for example, that has a complete closure stroke distance of 0.230 inches, the "proximal axial length" DZ of the proximal travel zone 27307 may be, for example, in the range of 0.050 inches - 0.150 inches. Thus, the proximal axial length DZ is less than the complete closure stroke distance that the proximal closure sleeve 27261 axially moves from a starting position to an ending position that corresponds to a complete closed condition of the end effector. Stated another way, this arrangement serves to reduce the distal closure sleeve's amount of axial travel during actuation of the closure system. Such arrangement also enables the distal closure sleeve 27400 to have a diameter that is smaller than the diameter of the proximal closure sleeve 27261.

[0385] FIGS. 157-158 illustrate another multi-part closure sleeve embodiment 28260 wherein the distal closure sleeve portion 28400 that moves a distance that is shorter than a distance that a proximal closure sleeve portion 28261 moves when the closure system is actuated through a complete closure stroke or sequence. The proximal closure sleeve portion 28261 may be essentially identical to the portion of the closure sleeve 260 that is proximal to the point where the closure sleeve's diameter is reduced. Thus, those features of the proximal closure sleeve portion 28261 that are identical to the features of the closure sleeve 260 are identified with like element numbers. The proximal closure sleeve portion 28261 interfaces with the closure system in the manner described above and thus, when the closure system is actuated, the proximal closure sleeve portion 28261 may axially travel the same distance that the closure sleeve 260 would travel upon actuation. The proximal closure sleeve portion 28261 differs from the closure sleeve 260 in manner discussed below. First, the proximal closure sleeve portion 28261 is configured to interface with a closure stroke reduction assembly, generally designated as 29000.

[0386] As can be seen in FIGS. 157-158, in the illustrated arrangement, the closure stroke reduction assembly 29000 comprises a proximal mounting ring 29002 that has a proximal hub portion 29004 on which the distal end 28300 of the proximal closure sleeve 28261 is received and attached thereto. For example, the distal end 28300 of the proximal closure sleeve 28261 may be attached to the proximal hub portion 29004 by welding, adhesive, etc. Thus, the proximal mounting ring 29002 will move axially with the proximal closure sleeve 28261. As can be further seen in FIGS. 157 and 158, an inwardly extending proximal flange 29006 extends from the proximal end of the proximal hub portion

29004. A hole 29008 is provided through the proximal flange 29006 to slidably receive the shaft spine assembly 2210, 2212 therethrough. A distal conical shaped member 29010 is attached to the distal end of the proximal mounting ring 29002. The distal conical shaped member 29010 may be attached to the proximal mounting ring 29002 by, for example, welding, adhesive, etc. and is free to slide on the distal closure sleeve portion 28400 when the proximal mounting ring 29002 is distally advanced.

[0387] The proximal mounting ring 29002 is slidably supported on a distal mounting ring 29020 that is attached to the distal closure sleeve portion 28400. The distal mounting ring 29020 includes a distal portion 29022 that has a proximal mounting hub 29024 protruding therefrom. The proximal mounting hub 29024 has a diameter that is less than the diameter of the distal portion 29022 of the distal mounting ring 29020. The proximal mounting hub 29024 may be attached to the proximal end 28404 of the distal closure sleeve portion 28400 by welding, adhesive, etc. The proximal hub portion 29004 of the proximal mounting ring 29002 is slidably received on the proximal mounting hub 29024 for axial travel thereon. A compression spring 29032 is received within a spring cavity 29030 formed between the distal portion 29022 of the distal mounting ring 29020 and the proximal hub portion 29004 of the proximal mounting ring 29002. When the closure system is in an unactuated configuration, the proximal flange 29006 of the proximal hub portion 29004 is spaced a "proximal travel zone" or "proximal dead zone" 29009 from the proximal end 28404 of the distal closure sleeve 28400. The proximal axial length of the proximal travel zone 29009 is designated as DZ. The spring cavity 29030 may also be referred to as a "distal travel zone" or "distal dead zone" and has a distal axial length DS that may comprise the dead zone axial length DZ plus an amount of clearance required to accommodate the compression spring 29032 when in its fully compressed state. In one arrangement, for example, that has a complete closure stroke distance of 0.230 inches, the "proximal axial length" DZ of the proximal travel zone 29009 may be, for example, in the range of 0.050 inches - 0.150 inches and the distal axial length DS may be in the range of 0.100 inches -0.200 inches plus the length necessary to accommodate a fully compressed compression spring 29032. Stated another way, in the illustrated arrangement, DS is always greater than DZ. Thus, the proximal axial length DZ is less than the complete closure stroke distance that the proximal closure sleeve 27261 axially moves from a starting position to an ending position that corresponds to a complete closed condition of the end effector. Such arrangement facilitates travel of the proximal closure sleeve portion 28261 an axial distance in the distal direction DD before the proximal flange 29006 of the proximal mounting ring 29002 contacts the proximal end 28404 of the distal closure sleeve portion 28400 to axially drive the distal closure sleeve portion 28400 in the distal direction DD. The closure stroke reduction assembly

29000 is provided in multiple pieces to facilitate ease of assembly. This arrangement serves to reduce the amount of axial travel of the distal closure sleeve portion 28400 during actuation of the closure system. Such arrangement employs a distal closure sleeve portion 28400 that has an outer diameter that is smaller than the outer diameter of the proximal closure sleeve portion 28261. In alternative embodiments, the closure stroke reduction assembly could be located anywhere within the shaft assembly (e.g., within the nozzle portion, along the length of the shaft, in the articulation joint or at the end effector pivot). Specifically, there could be a slot at the end effector pivot/joint to allow for dead stroke during closure.

[0388] 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. The motor or motor(s) may comprise a portion or portions of a robotically controlled system.

[0389] 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.

[0390] The surgical instrument systems described herein are motivated by one or more electric motors; 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.

Examples

[0391] Example 1 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective articulation relative to the elongate shaft assembly about an articulation axis that is transverse to, and laterally offset from, the shaft axis. The surgical end effector defines an end effector axis and is configured to be selectively articulated between an unarticulated position wherein the effector axis is axially aligned with the shaft axis to a maximum articulated position on one side of the shaft axis wherein the end effector axis is perpendicular to the shaft axis. An articulation system operably

interfaces with the surgical end effector to selectively move the surgical end effector between the unarticulated position and the articulated positions.

[0392] Example 2 - The surgical instrument of Example 1, wherein the articulation system comprises an articulation drive member that is operably coupled to the surgical end effector for selectively applying pushing and pulling motions thereto.

[0393] Example 3 - The surgical instrument of Examples 1 or 2, wherein the articulation system comprises a de-articulation member that is configured to selectively only apply a pulling motion to the surgical end effector.

[0394] Example 4 - The surgical instrument of Examples 1, 2 or 3, wherein the articulation system comprises an end effector driver link that is coupled to the surgical end effector. A distal articulation driver is coupled to the end effector driver link and is configured to selectively apply a pushing motion and a pulling motion thereto. A de-articulation member is attached to the surgical end effector and is configured to only apply a pulling motion thereto.

[0395] Example 5 - The surgical instrument of Examples 1, 2 or 3, wherein the articulation system comprises an end effector driver link that is coupled to the surgical end effector. A distal articulation driver is coupled to the end effector driver link and is configured to selectively apply a pushing motion and a pulling motion thereto. A de-articulation member is configured to apply a de-articulation motion to the surgical end effector.

[0396] Example 6 - The surgical instrument of Examples 1, 2, 3, 4 or 5, wherein the surgical end effector is pivotally coupled to the elongate shaft assembly by a spring pin that defines the articulation axis and which is configured to apply a de-articulation biasing motion to the surgical end effector.

[0397] Example 7 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis. The surgical instrument further comprises a surgical end effector that defines an end effector axis. A articulation joint is configured to facilitate articulation of the surgical end effector relative to the elongate shaft assembly between an unarticulated position wherein the end effector axis is axially aligned with the shaft axis and a fully articulated position wherein the end effector axis is perpendicular to the shaft axis. The surgical instrument further comprises means for applying an articulation motion to the surgical end effector. The means for applying is positioned only along one lateral side of the shaft axis.

[0398] Example 8 - The surgical instrument of Example 7, wherein a proximal end of the surgical end effector is angled relative to the end effector axis and wherein a distal end of the elongate shaft assembly is angled relative to the shaft axis.

[0399] Example 9 - The surgical instrument of Example 8, wherein the proximal end of the surgical end effector is oriented at an end effector angle relative to the end effector axis and wherein the distal end of the elongate shaft assembly is oriented at a shaft angle relative to the shaft axis.

[0400] Example 10 - The surgical instrument of Example 8, wherein the end effector angle and the shaft angle are equal to each other.

[0401] Example 11 - The surgical instrument of Examples 7, 8, 9 or 10 further comprising means for applying a de-articulation motion to the surgical end effector.

[0402] Example 12 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis and includes a distal end. The surgical instrument further comprises a surgical end effector that comprises a proximal end that is pivotally coupled to the distal end of the elongate shaft assembly for selective pivotal travel relative thereto about an articulation axis that is laterally offset from the shaft axis and extends transversely relative thereto. The surgical instrument further comprises an articulation system that comprises an end effector driver link that is operably coupled to the surgical end effector. An articulation driver is supported for longitudinal travel in distal and proximal directions upon application of articulation motions thereto. The articulation driver is coupled to the end effector driver link to selectively articulate the surgical end effector relative to the elongate shaft assembly about the articulation axis. A flexible de-articulation member is coupled to the elongate shaft assembly and the surgical end effector to apply de-articulation motions to the surgical end effector.

[0403] Example 13 - The surgical instrument of Example 12, wherein the articulation driver is configured to apply a first articulation motion to the surgical end effector only in one articulation direction that is transverse to the shaft axis.

[0404] Example 14 - The surgical instrument of Examples 12 or 13, wherein the surgical end effector defines an end effector axis and wherein the end effector is movable between an unarticulated position wherein the effector axis is axially aligned with the shaft axis to a maximum articulated position on one lateral side of the shaft axis wherein the end effector axis is perpendicular to the shaft axis.

[0405] Example 15 - The surgical instrument of Examples 12, 13 or 14, wherein the articulation driver and the end effector driver link are located on one lateral side of the shaft axis when the surgical end effector is in an unarticulated orientation.

[0406] Example 16 - The surgical instrument of Examples 12, 13, 14 or 15, wherein the surgical end effector comprises a firing member that is configured for axial travel within the surgical end effector and wherein the elongate shaft assembly further comprises an axially movable firing beam that operably interfaces with the firing member and is selectively movable in the distal direction in

response to a firing motion applied thereto. The firing beam is also selectively movable in the proximal direction in response to a retraction motion that is applied thereto.

[0407] Example 17 - The surgical instrument of Examples 12, 13, 14, 15 or 16, wherein the proximal end of the surgical end effector is pivotally pinned to the distal end of the elongate shaft assembly by an articulation pin and wherein the flexible de-articulation member is configured to flex around the articulation pin when the surgical end effector is articulated about the articulation axis.

[0408] Example 18 - The surgical instrument of Examples 12, 13, 14, 15, 16 or 17, wherein the proximal end of the surgical end effector is angled relative to the end effector axis and wherein the distal end of the elongate shaft assembly is angled relative to the shaft axis.

[0409] Example 19 - The surgical instrument of Example 18, wherein the proximal end of the surgical end effector is oriented at an end effector angle relative to the end effector axis and wherein the distal end of the elongate shaft assembly is oriented at a shaft angle relative to the shaft axis.

[0410] Example 20 - The surgical instrument of Example 19, wherein the end effector angle and the shaft angle are equal to each other.

[0411] Example 21 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis and includes a distal end. The surgical instrument further comprises a proximal end that is pivotally coupled to the distal end of the elongate shaft assembly such that the surgical end effector is selectively movable between an unarticulated position and a fully articulated position relative to the shaft axis. A firing beam is movably supported within a pathway in the elongate shaft assembly for selective longitudinal travel therein. The pathway is configured to position a portion of the firing beam that exits the distal end of the elongate shaft member to an off axis position relative to the shaft axis.

[0412] Example 22 - The surgical instrument of Example 21, wherein the pathway comprises a first pathway portion that is aligned on the shaft axis and a second arcuate pathway portion that communicates with the first pathway portion and curves in a first direction away from the shaft axis. The pathway further comprises a third arcuate pathway portion that communicates with the second arcuate pathway portion and curves in a second direction toward the shaft axis.

[0413] Example 23 - The surgical instrument of Examples 22 or 21, wherein the surgical end effector is configured to articulate in only one articulation direction that is transverse to the shaft axis.

[0414] Example 24 - The surgical instrument of Examples 21, 22 or 23, wherein the proximal end of the surgical end effector is pivotally coupled to the elongate shaft assembly at an attachment location on the distal end of the elongate shaft assembly for selective pivotal travel between the unarticulated

position and the fully articulated position about an articulation axis that extends transversely relative to the shaft axis, but does not intersect the shaft axis.

[0415] Example 25 - The surgical instrument of Examples 21, 22, 23 or 24, further comprising an articulation driver that is supported for longitudinal travel relative to the elongate shaft assembly and is coupled to the surgical end effector for applying articulation motions thereto.

[0416] Example 26 - The surgical instrument of Example 25, wherein the articulation driver is configured to apply pushing and pulling motions to the surgical end effector.

[0417] Example 27 - The surgical instrument of Examples 21, 23, 24, 25 or 26, wherein the pathway comprises a first pathway portion that is axially aligned on the shaft axis and a second pathway portion that communicates with the first pathway portion and extends distally therefrom such that at least a portion of the second pathway portion is not axially aligned with the shaft axis.

[0418] Example 28 - The surgical instrument of Examples 21, 22, 23, 24, 25, 26 or 27, wherein the firing beam comprises a plurality of beam layers that are laminated together.

[0419] Example 29 - The surgical instrument of Examples 21, 22, 23, 24, 25, 26, 27 or 28, wherein the surgical end effector comprises a firing member that operably interfaces with the firing beam and is configured for axial travel within the surgical end effector.

[0420] Example 30 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis and includes a distal end. The surgical instrument further comprises a surgical end effector that includes a proximal end. An articulation joint couples the proximal end of the surgical end effector to the distal end of the elongate shaft assembly. A firing beam is movably supported within the elongate shaft assembly for longitudinal travel therein along the shaft axis. The surgical instrument further comprises means for biasing a portion of the firing beam into an arcuate configuration out of axial alignment with the shaft axis prior to the articulation joint.

[0421] Example 31 - The surgical instrument of Example 30, wherein the articulation joint pivotally couples the proximal end of the surgical end effector to the distal end of the elongate shaft assembly for selective articulation relative to the elongate shaft assembly about an articulation axis that is transverse to, and laterally offset from, the shaft axis.

[0422] Example 32 - The surgical instrument of Examples 30 or 31, wherein the surgical end effector defines an end effector axis and wherein the surgical end effector is selectively articulatable between a non-articulated position wherein the end effector axis is axially aligned with the shaft axis and a fully articulated position located to one lateral side of the shaft axis.

[0423] Example 33 - The surgical instrument of Examples 30, 31 or 32, wherein the firing beam comprises a plurality of beam layers that are laminated together.

[0424] Example 34 - The surgical instrument of Examples 30, 31, 32 or 33, wherein the surgical end effector comprises a firing member operably interfacing with the firing beam and being configured for axial travel within the surgical end effector.

[0425] Example 35 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis and includes a distal end. The surgical instrument further comprises a surgical end effector that includes a proximal end. An articulation joint couples the proximal end of the surgical end effector to the distal end of the elongate shaft assembly. A firing beam is movably supported within the elongate shaft assembly for longitudinal travel therein along the shaft axis. The surgical instrument further comprises means for biasing a portion of the firing beam out of the axial alignment with the shaft axis prior to the articulation joint.

[0426] Example 36 - The surgical instrument of Example 35, wherein the articulation joint pivotally couples the proximal end of the surgical end effector to the distal end of the elongate shaft assembly for selective articulation relative to the elongate shaft assembly about an articulation axis that is transverse to, and laterally offset from, the shaft axis.

[0427] Example 37 - The surgical instrument of Examples 35 or 36, wherein the surgical end effector defines an end effector axis and wherein the surgical end effector is selectively articulatable between a non-articulated position wherein the end effector axis is axially aligned with the shaft axis and a fully articulated position located to one lateral side of the shaft axis.

[0428] Example 38 - The surgical instrument of Examples 35, 36 or 37, wherein the firing beam comprises a plurality of beam layers that are laminated together.

[0429] Example 39 - The surgical instrument of Examples 35, 36, 37 or 38, wherein the surgical end effector comprises a firing member that operably interfaces with the firing beam and is configured for axial travel within the surgical end effector.

[0430] Example 40 - The surgical instrument of Example 35, 36, 37, 38 or 39, wherein the means comprises an arcuate path in a spine portion of the elongate shaft assembly. The arcuate path is configured to slidably receive the firing beam therein and opens at a distal end of the spine portion at a location that is axially offset from the shaft axis.

[0431] Example 41- A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical

instrument further comprises an articulation system that includes a single articulation driver that is supported for longitudinal travel along a path that is laterally offset from the shaft axis. A cross link is coupled to the articulation driver and extends transversely across the shaft axis to be coupled to the surgical end effector.

[0432] Example 42 - The surgical instrument of Example 41, wherein the articulation axis intersects the shaft axis.

[0433] Example 43 - The surgical instrument of Example 41, wherein the surgical end effector defines an end effector axis and wherein the surgical end effector is selectively articulatable between a non-articulated position wherein the end effector axis is axially aligned with the shaft axis and a fully articulated position located to one lateral side of the shaft axis wherein the end effector axis is transverse to the shaft axis.

[0434] Example 44 - The surgical instrument of Example 43, wherein when the surgical end effector is in the fully articulated position, the end effector axis is located at an articulation angle relative to the shaft axis. The articulation angle is at least sixty-five degrees.

[0435] Example 45 - The surgical stapling instrument of Examples 43 or 44, wherein the surgical end effector is selectively articulatable to another fully articulated position located on another lateral side of the shaft axis.

[0436] Example 46 - The surgical instrument of Examples 41, 42, 43, 44 or 45, wherein the cross link is pivotally coupled to the proximal end of the surgical end effector about a link axis that is parallel to the articulation axis.

[0437] Example 47 - The surgical instrument of Examples 41, 42, 43, 44, 45, or 46, wherein the single distal articulation driver is configured to apply pushing and pulling motions to the cross link.

[0438] Example 48 - The surgical instrument of Examples 41, 42, 43, 44, 45, 46 or 47, wherein the surgical end effector comprises a firing member that is configured for axial travel within the surgical end effector and wherein the elongate shaft assembly further comprises an axially movable firing beam that operably interfaces with the firing member and is selectively movable in a distal direction in response to an application of a firing motion thereto and in a proximal direction in response to a retraction motion applied thereto.

[0439] Example 49 - The surgical instrument of Example 48, further comprising a middle support member that is configured to laterally support the firing member when the surgical end effector is articulated about the articulation axis. The middle support member is pivotally coupled to the surgical end effector and is pivotally and slidably supported relative to the elongate shaft assembly.

[0440] Example 50 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis and includes a distal end. The surgical instrument further comprises a surgical end effector that includes a proximal end that is pivotally coupled to the elongate shaft assembly at an attachment location on the distal end of the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. An articulation drive assembly is supported for longitudinal travel relative to the elongate shaft assembly along an articulation actuation axis that is parallel to the shaft axis and is spaced to a first lateral side of the shaft axis. The articulation drive assembly is coupled to the surgical end effector at a single attachment location that is located on another lateral side of the shaft axis.

[0441] Example 51 - The surgical instrument of Example 50, wherein the articulation drive assembly comprises a distal articulation driver that is supported by the elongate shaft assembly for longitudinal travel along the articulation actuation axis in response to articulation control motions applied thereto. A cross link is coupled to the distal articulation driver and extends transversely across the shaft axis to be coupled to the surgical end effector at the single attachment location.

[0442] Example 52 - The surgical instrument of Examples 50 or 51, wherein the proximal end of the surgical end effector is pivotally coupled to the distal end of the elongate shaft assembly by a pivot member that defines the articulation axis.

[0443] Example 53 - The surgical instrument of Examples 51 or 52 wherein the cross link has a curved shape.

[0444] Example 54 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis and includes a distal end. The surgical instrument further comprises a surgical end effector that comprises a proximal end that is pivotally coupled to the elongate shaft assembly at an attachment location on the distal end of the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis through a first range of articulation angles on a first lateral side of the shaft axis and through a second range of articulation angles on a second lateral side of the shaft axis. An articulation drive assembly is supported for longitudinal travel relative to the elongate shaft assembly along an articulation actuation axis that is parallel to and laterally offset on one of the first and second lateral sides of the shaft axis. The articulation drive assembly is coupled to the surgical end effector at a single attachment location that is located on the other one of the first and second lateral sides of the shaft axis to selectively apply pulling and pushing motions to the surgical end effector.

[0445] Example 55 - The surgical stapling instrument of Example 54, wherein the first range of articulation angles is between one degree and sixty five degrees and wherein the second range of articulation angles is between one degree and sixty five degrees.

[0446] Example 56 - The surgical stapling instrument of Examples 54 or 55, wherein the articulation drive assembly comprises a distal articulation driver that is supported by the elongate shaft assembly for longitudinal travel in response to articulation control motions applied thereto. A cross link is coupled to the distal articulation driver and extends transversely across the shaft axis to be coupled to the surgical end effector at the attachment location.

[0447] Example 57 - The surgical stapling instrument of Example 56, wherein when the distal articulation driver is moved in a distal direction, the surgical end effector is pivoted in a first articulation direction and when the distal articulation driver is moved in a proximal direction, the surgical end effector is pivoted in a second articulation direction.

[0448] Example 58 - The surgical stapling instrument of Example 57, wherein the surgical end effector comprises a firing member that is configured for axial travel within the surgical end effector and wherein the elongate shaft assembly further comprises an axially movable firing beam that operably interfaces with the firing member and is selectively movable in the distal direction in response to an application of a firing motion thereto and in a proximal direction in response to a retraction motion applied thereto.

[0449] Example 59 - The surgical stapling instrument of Example 58, further comprising a middle support member that is configured to laterally support the firing member when the surgical end effector is articulated about the articulation axis. The middle support member is pivotally coupled to the surgical end effector and is pivotally and slidably supported relative to the elongate shaft assembly.

[0450] Example 60 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis and includes a distal end. The surgical instrument further comprises a surgical end effector that includes a proximal end that is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. An articulation link arrangement is configured for rotation relative to the shaft axis such that rotation of the articulation link arrangement induces articulation of the surgical end effector about the articulation axis relative to the elongate shaft assembly. The surgical instrument further comprises means for selectively rotating the articulation link arrangement about the shaft axis.

[0451] Example 61 - The surgical instrument of Example 60, wherein the articulation link arrangement comprises a central articulation link that is movably coupled to the distal end of the elongate shaft

assembly. An end effector driver link is movably coupled to the central articulation link for pivotal travel relative thereto. The end effector driver link is operably coupled to the surgical end effector for selective pivotal and axial travel relative thereto. The means for selectively rotating comprises an articulation driver that is supported for selective longitudinal travel relative to the elongate shaft assembly in a distal direction and a proximal direction. The articulation driver is operably coupled to the central articulation link.

[0452] Example 62 - The surgical instrument of Example 61, wherein the end effector driver link comprises a proximal driver link end that is pivotally coupled to the central articulation link and a distal driver link end that comprises an axial slot that is configured to slidably receive therein an end effector attachment member therein.

[0453] Example 63 - The surgical instrument of Example 62, wherein the proximal driver link end is in meshing pivotal engagement with a distal end of the elongate shaft assembly.

[0454] Example 64 - The surgical instrument of Example 62, wherein the articulation driver is movably coupled to the central articulation link by an intermediate driver link.

[0455] Example 65 - The surgical instrument of Examples 62, 63 or 64, wherein the central articulation link is pivotally coupled to the distal end of the elongate shaft assembly for pivotal travel relative thereto about the articulation axis.

[0456] Example 66 - The surgical instrument of Examples 62, 63, 64 or 65, wherein the central articulation link comprises a triangular-shaped link that is pivotally coupled to the distal end of the elongate shaft assembly for pivotal travel relative thereto about the articulation axis.

[0457] Example 67 - The surgical instrument of Examples 62, 63, 64, 65 or 66, wherein the surgical end effector defines an end effector axis that is configured for axial alignment with the shaft axis when the surgical end effector is in an unarticulated position and wherein the articulation driver is supported for selective longitudinal travel along one lateral side of the shaft axis and wherein the end effector attachment member is located on a secondary lateral side of the end effector shaft axis that corresponds to a second lateral side of the shaft axis.

[0458] Example 68 - The surgical instrument of Examples 62, 63, 64, 65, 66 or 67, wherein the distal end of the elongate shaft assembly comprises an arcuate sun gear segment and wherein the end effector driver link comprises a planet gear portion in meshing engagement with the arcuate sun gear segment.

[0459] Example 69 - The surgical instrument of Example 68, wherein the planet gear portion comprises a plurality of planet gear teeth that is formed on a proximal end of the end effector driver link.

[0460] Example 70 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical instrument further includes an articulation system that comprises an articulation driver that is supported for selective longitudinal travel relative to the elongate shaft assembly in a distal direction and a proximal direction. The articulation system further comprises means for operably coupling the articulation driver to the surgical end effector. The means for operably coupling is configured to apply articulation motions to the surgical end effector in response to longitudinal movement of the articulation driver. The means for operably coupling is further configured to pivotally and axially move relative to the surgical end effector.

[0461] Example 71 - The surgical instrument of Example 70, wherein the articulation driver is coupled to the means for operably coupling on one lateral side of the shaft axis and wherein the means for operably coupling is coupled to the surgical end effector on another lateral side of the shaft axis.

[0462] Example 72 - The surgical instrument of Examples 70 or 71, wherein the surgical end effector comprises a firing member that is configured for axial travel within the surgical end effector and wherein the elongate shaft assembly further comprises an axially movable firing beam that operably interfaces with the firing member and is selectively movable in the distal direction in response to an application of a firing motion thereto and in a proximal direction in response to a retraction motion applied thereto.

[0463] Example 73 - The surgical instrument of Examples 71 or 72, wherein the means for operably coupling comprises a triangular shaped link that comprises a first link corner portion that is operably coupled to the articulation driver. The triangular shaped link further comprises a second link corner portion that operably interfaces with the surgical end effector and a third link corner portion that is pivotally coupled to a distal end of the elongate shaft assembly.

[0464] Example 74 - The surgical instrument of Example 73, wherein the third link corner portion is pivotally coupled to the distal end of the elongate shaft assembly for pivotal travel relative thereto about the articulation axis.

[0465] Example 75 - The surgical instrument of Examples 73 or 74, wherein the second corner portion of the triangular shaped link is operably coupled to an end effector driver link that is coupled to the surgical end effector for pivotal and axial travel relative thereto.

[0466] Example 76 - The surgical instrument of Examples 73, 74 or 75, wherein the end effector driver link comprises an intermediate proximal drive link end that is pivotally coupled to the triangular

shaped link and an end effector driver link end that comprises an axial slot that is configured to slidably receive an end effector attachment member therein.

[0467] Example 77 - A surgical instrument comprising an elongate shaft assembly that includes a distal end and a shaft axis. A surgical end effector is pivotally coupled to the distal end of the elongate shaft assembly for selective pivotal travel about an articulation axis that is transverse to the shaft axis. A stationary sun gear segment is on the distal end of the elongate shaft assembly. The surgical instrument further comprises an end effector driver link that includes a distal end that is coupled to the end effector for pivotal and axial travel relative thereto and a proximal end that comprises a planetary gear segment that is supported in meshing engagement with the stationary sun gear segment. A selectively movable articulation driver assembly operably interfaces with the end effector driver link to apply articulation motions thereto.

[0468] Example 78 - The surgical instrument of Example 77, wherein the articulation driver assembly comprises an articulation driver member that is supported for selective longitudinal travel relative to the elongate shaft assembly in a distal direction and a proximal direction along an axis that is offset from and parallel to the shaft axis. A linkage assembly is coupled to the distal articulation driver member at a first attachment location on one side of the shaft axis. In addition, the linkage assembly is further coupled to the end effector driver link.

[0469] Example 79 - The surgical instrument of Examples 77 or 78, wherein the surgical end effector comprises a firing member that is configured for axial travel within the surgical end effector and wherein the elongate shaft assembly further comprises an axially movable firing beam that operably interfaces with the firing member and is selectively movable in the distal direction in response to an application of a firing motion thereto and in a proximal direction in response to a retraction motion applied thereto.

[0470] Example 80 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical instrument further comprises an articulation system that comprises a first articulation driver that is supported for selective longitudinal travel relative to the elongate shaft assembly in a distal direction and a proximal direction. The articulation system further comprises a first end effector link that is movably coupled to the surgical end effector. The first end effector link is coupled to the first articulation driver for axial and pivotal travel relative thereto. A second articulation driver is supported for selective longitudinal travel relative to the elongate shaft assembly in the distal and proximal

directions. A second end effector link is movably coupled to the surgical end effector. The second end effector link is coupled to the second articulation driver for axial and pivotal travel relative thereto.

[0471] Example 81 - The surgical instrument of Example 80, wherein the first end effector link is coupled to the first articulation driver by a first coupler member received within a first axial slot in the first articulation driver for selective axial travel therein and wherein the second end effector link is coupled to the second articulation driver by a second coupler member received within a second axial slot in the second articulation driver.

[0472] Example 82 - The surgical instrument of Example 81, wherein the first axial slot is parallel to the shaft axis and wherein the second axial slot is parallel to the shaft axis.

[0473] Example 83 - The surgical instrument of Examples 81 or 82, wherein the first coupler member comprises a first pin sized to rotate and move axially within the first axial slot and wherein the second coupler member comprises a second pin sized to rotate and move axially within the second axial slot.

[0474] Example 84 - The surgical instrument of Examples 80, 81, 82 or 83, wherein the first articulation driver is supported for selective longitudinal travel along a first articulation axis that extends along one lateral side of the shaft axis and wherein the second articulation driver is supported for selective longitudinal travel along a second articulation axis that extends along another lateral side of the shaft axis.

[0475] Example 85 - The surgical instrument of Examples 80,81, 82, 83 or 84, wherein the surgical end effector is configured to pivot about the articulation axis through a first range of articulation angles on a first lateral side of the shaft axis and through a second range of articulation angles on a second lateral side of the shaft axis.

[0476] Example 86 - The surgical instrument of Example 85, wherein the first range of articulation angles is between one degree and sixty five degrees and wherein the second range of articulation angles is between one degree and sixty five degrees.

[0477] Example 87 - The surgical instrument of Examples 80, 81, 82, 83, 84, 85 or 86, wherein the surgical end effector comprises a firing member that is configured for axial travel within the surgical end effector and wherein the elongate shaft assembly further comprises an axially movable firing beam that operably interfaces with the firing member and is selectively movable in the distal direction in response to an application of a firing motion thereto and in the proximal direction in response to a retraction motion applied thereto.

[0478] Example 88 - The surgical instrument of Examples 80, 81, 82, 83, 84, 85, 86 or 87, wherein the first end effector link is curved and wherein the second end effector link is curved.

[0479] Example 89 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical instrument further comprises an articulation system that comprises a first articulation driver that is supported for selective longitudinal travel relative to the elongate shaft assembly in a distal direction and a proximal direction. A first end effector link is pivotably coupled to the surgical end effector. The first end effector link is coupled to the first articulation driver at a first attachment point. A second articulation driver is supported for selective longitudinal travel relative to the elongate shaft assembly in the distal and proximal directions. A second end effector link is pivotably coupled to the surgical end effector. The second end effector link is coupled to the second articulation driver at a second attachment point. The articulation system further comprises first means for constraining travel of the first attachment point to a first path that has a first predetermined shape and a first length. The articulation system further comprises a second means for constraining travel of the second attachment point to a second path that has a second predetermined shape and a second length.

[0480] Example 90 - The surgical instrument of Example 89, wherein the first means for constraining comprises a first axial slot in a first distal end of the first articulation driver and wherein the second means for constraining comprises a second axial slot in a second distal end of the second articulation driver.

[0481] Example 91 - The surgical instrument of Example 90, wherein the first and second axial slots are parallel to each other.

[0482] Example 92 - The surgical instrument of Examples 89, 90 or 91, wherein the first and second lengths are equal to each other.

[0483] Example 93 - The surgical instrument of Examples 89, 90, 91 or 92, wherein the first end effector link is pivotable about the first attachment point and wherein the second end effector link is pivotable about the second attachment point.

[0484] Example 94 - The surgical instrument of Examples 89, 90, 91, 92 or 93 wherein the surgical end effector is configured to pivot about the articulation axis through a first range of articulation angles on a first lateral side of the shaft axis and through a second range of articulation angles on a second lateral side of the shaft axis.

[0485] Example 95 - The surgical instrument of Example 94, wherein the first range of articulation angles is between one degree and sixty five degrees and wherein the second range of articulation angles is between one degree and sixty five degrees.

[0486] Example 96 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical instrument further comprises an articulation system that comprises a first articulation driver that is supported for selective longitudinal travel relative to the elongate shaft assembly in a distal direction and a proximal direction. A first curved end effector link is pivotably coupled to the surgical end effector and is movably coupled to the first articulation driver. A first pin protrudes from the first curved end effector link and is movably received in a first axial slot in the first articulation driver. A second articulation driver is supported for selective longitudinal travel relative to the elongate shaft assembly in the distal and proximal directions. A second curved end effector link is pivotably coupled to the surgical end effector and is movably coupled to the second articulation driver. A second pin protrudes from the second curved end effector link and is movably received in a second axial slot in the second articulation driver.

[0487] Example 97 - The surgical instrument of Example 96, wherein the first pin is rotatable within the first axial slot and wherein the second pin is rotatable in the second axial slot.

[0488] Example 98 - The surgical instrument of Example 97, wherein the first and second axial slots are parallel to each other.

[0489] Example 99 - The surgical instrument of Examples 96, 97 or 98, wherein the surgical end effector comprises a firing member that is configured for axial travel within the surgical end effector and wherein the elongate shaft assembly further comprises an axially movable firing beam that operably interfaces with the firing member and is selectively movable in the distal direction in response to an application of a firing motion thereto and in the proximal direction in response to a retraction motion applied thereto.

[0490] Example 100 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical instrument further comprises an articulation system that comprises an articulation driver that is supported for selective longitudinal travel relative to the elongate shaft assembly in a distal direction and a proximal direction. A central articulation link is pivotally coupled to the elongate shaft assembly for pivotal travel relative thereto. An intermediate link is movably coupled to the articulation driver and the central articulation link. An end effector driver is movably coupled to the central articulation link and the surgical end effector.

[0491] Example 101 - The surgical instrument of Example 100, wherein the central articulation link is pivotally coupled to the elongate shaft assembly for pivotal travel relative thereto about a link axis that is offset from the articulation axis.

[0492] Example 102 - The surgical instrument of Example 101, wherein the first axial slot is parallel to the shaft axis and wherein the second axial slot is parallel to the shaft axis.

[0493] Example 103 - The surgical instrument of Examples 101 or 102, wherein the central articulation link comprises a first central link end that is movably coupled to the intermediate link and a second central link end that is movably attached to the end effector driver and wherein the first central link end is a first distance from the link axis and wherein the second central link end is a second distance from the link axis and wherein the first distance differs from the second distance.

[0494] Example 104 - The surgical instrument of Example 103, wherein the first distance is less than the second distance.

[0495] Example 105 - The surgical instrument of Examples 100, 101, 102, 103 or 104, wherein the central articulation link includes a first length and the intermediate link includes a second length and wherein the end effector driver includes a third length and wherein the second length is shorter than the first and third lengths.

[0496] Example 106 - The surgical instrument of Example 105, wherein the first length is shorter than the third length.

[0497] Example 107 - The surgical instrument of Examples 100, 101, 102, 103, 104, 105 or 106, wherein the intermediate link curves in a first direction.

[0498] Example 108 - The surgical stapling instrument of Example 107, wherein the end effector driver curves in a second direction that is opposite to the first direction.

[0499] Example 109 - The surgical instrument of Examples 100, 101, 102, 103, 104, 105, 106, 107 or 108, wherein the surgical end effector is pushed in a first articulation direction upon application of a pulling motion to the articulation driver and wherein the surgical end effector is pulled in a second articulation direction upon application of a pushing motion to the articulation driver.

[0500] Example 110 - The surgical instrument of Examples 100, 101, 102, 103, 104, 105, 106, 107, 108 or 109, wherein the surgical end effector is selectively articulatable between an unarticulated position and first articulated positions through a first range of articulation angles and wherein the surgical end effector is articulatable between the unarticulated position and second articulated positions through a second range of articulation angles.

[0501] Example 111 - The surgical instrument of Example 110 wherein the first range of articulation angles is between one degree and ninety degrees and wherein the second range of articulation angles is between one degree and ninety degrees.

[0502] Example 112 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical instrument further includes an articulation system that comprises an articulation driver that is supported for selective longitudinal travel relative to the elongate shaft assembly in a distal direction and a proximal direction. A central articulation link is pivotally coupled to the elongate shaft assembly for selective pivotal travel about a link axis that is offset from the articulation axis. A curved intermediate link is movably coupled to the articulation driver and the central articulation link. A curved end effector driver is movably coupled to the central articulation link and the surgical end effector.

[0503] Example 113 - The surgical instrument of Example 112, wherein the central articulation link comprises a first central link end that is movably coupled to the intermediate link and a second central link end that is movably attached to the end effector driver and wherein the first central link end is a first distance from the link axis and wherein the second central link end is a second distance from the link axis and wherein the first distance differs from the second distance.

[0504] Example 114 - The surgical instrument of Example 113, wherein the first distance is less than the second distance.

[0505] Example 115 - The surgical instrument of Examples 112, 113 or 114, wherein the central articulation link includes a first length and the intermediate link includes a second length and the end effector driver includes a third length and wherein the second length is shorter than the first and third lengths.

[0506] Example 116 - The surgical instrument of Example 115, wherein the first length is shorter than the third length.

[0507] Example 117 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical end effector also comprises a firing member that is configured for axial travel within the surgical end effector. The surgical instrument further includes an articulation system that comprises a distal articulation driver that is supported for selective longitudinal travel relative to the elongate shaft

assembly in a distal direction and a proximal direction. A central articulation link is movably pinned to the distal end of the elongate shaft assembly. An intermediate link is movably coupled to the distal articulation link and the central articulation link. An end effector driver is movably coupled to the central link and the surgical end effector.

[0508] Example 118 - The surgical instrument of Example 117, wherein the surgical end effector defines an end effector axis and wherein the surgical end effector is selectively articulatable between a first unarticulated position wherein the end effector axis is aligned with the shaft axis and a first maximum articulated position on a first lateral side of the shaft axis wherein the end effector axis extends perpendicular to the shaft axis and a second maximum articulated position on a second lateral side of the shaft axis wherein the end effector axis is perpendicular to the shaft axis.

[0509] Example 119 - The surgical instrument of Examples 117 or 118, wherein the central articulation link comprises a first central link end that is movable coupled to the intermediate link and a second central link end that is movably attached to the end effector driver and wherein the first central link end is a first distance from the link axis and wherein the second central link end is a second distance from the link axis and wherein the first distance differs from the second distance.

[0510] Example 120 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. The surgical instrument further comprises a surgical end effector that comprising a distal end and a proximal end. The proximal end is pivotally coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis. The surgical end effector is selectively pivotable about the articulation axis from an unarticulated position wherein the distal end of the surgical end effector is located an unarticulated distance from the articulation axis to articulated positions wherein the distal end of the surgical end effector is located a corresponding articulated distance from the articulation axis that is less than the unarticulated distance.

[0511] Example 121 - The surgical instrument of Example 120, wherein the elongate shaft assembly comprises a pivot member that defines the articulation axis and wherein the proximal end of the surgical end effector comprises an elongate slot configured to slidably receive the pivot member therein.

[0512] Example 122 - The surgical instrument of Examples 120 or 121, further comprising means for selectively applying articulation motions to the surgical end effector.

[0513] Example 123 - The surgical instrument of Example 122, wherein the means for selectively applying comprises a rotary gear in meshing engagement with the surgical end effector.

[0514] Example 124 - The surgical instrument of Example 123, wherein the proximal end of the surgical end effector comprises an elliptical gear profile in meshing engagement with the rotary gear.

[0515] Example 125 - The surgical instrument of Examples 123 or 124, wherein the means for selectively applying comprises a selectively axially moveable distal articulation driver that operably interfaces with the rotary gear.

[0516] Example 126 - The surgical instrument of Example 125, further comprising a drive slot in the selectively axially movable distal articulation driver and a drive pin that is attached to the rotary gear and is slidably received in the drive slot.

[0517] Example 127 - The surgical instrument of Examples 120, 121, 122, 123, 124, 125 or 126, wherein the surgical end effector defines an end effector axis that is located such that when the surgical end effector is in the unarticulated position, the end effector axis is aligned with the shaft axis and wherein when the surgical end effector is articulated to a full one of the articulated positions, the end effector axis is perpendicular to the shaft axis.

[0518] Example 128 - The surgical instrument of Examples 122, 123, 124, 125, 126 or 127, wherein the means for selectively applying comprises a central articulation link that is supported for rotational travel about the articulation axis. A selectively axially movable articulation driver interfaces with the central articulation link at a first location on a first side of the shaft axis. The means for selectively applying further comprises an articulation drive link that includes a first end that is coupled to the surgical end effector and a second end that is coupled to the central articulation link at a second location on a second side of the shaft axis.

[0519] Example 129 - The surgical instrument of Example 128, wherein the means for selectively applying comprises a central articulation gear that is supported for travel about the articulation axis and a gear profile that is located on the second end of the articulation drive link. The gear profile is in meshing engagement with the central articulation gear.

[0520] Example 130 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis and includes a distal shaft portion. The surgical instrument further comprises a surgical end effector that defines an end effector axis and includes a distal end and a proximal end. The proximal end is movably coupled to the distal shaft portion for selective travel between an unarticulated position wherein the end effector axis is aligned with the shaft axis and the distal end of the surgical end effector is located an unarticulated distance from the distal end portion of the elongate shaft assembly to articulated positions wherein the end effector axis is transverse to the shaft axis and the distal end of

the surgical end effector is located a corresponding articulated distance from the distal shaft portion that is less than the unarticulated distance.

[0521] Example 131 - The surgical instrument of Example 130, wherein the proximal end of the surgical end effector is movably coupled to the distal shaft portion of the elongate shaft assembly by a selectively axially movable articulation driver and an articulation link.

[0522] Example 132 - The surgical instrument of Examples 130 or 131, wherein when the surgical end effector is articulated in one of the articulated positions, the end effector axis is perpendicular to the shaft axis.

[0523] Example 133 - A surgical instrument, comprising an elongate shaft assembly that defines a shaft axis. The surgical instrument further comprises a surgical end effector that includes a distal end and a proximal end. The proximal end being is movably coupled to the elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to the shaft axis and translational travel relative to the articulation axis. An articulation system operably interfaces with the surgical end effector to selectively apply articulation motions thereto.

[0524] Example 134 - The surgical instrument of Example 133, wherein the articulation system comprises a rotary gear that is in meshing engagement with the surgical end effector and means for rotating the rotary gear.

[0525] Example 135 - The surgical instrument of Example 134, further comprising an elliptical gear segment on the proximal end of the surgical end effector in meshing engagement with the rotary gear.

[0526] Example 136 - The surgical instrument of Examples 134 or 135, wherein the means for rotating the rotary gear comprises a selectively axially moveable distal articulation driver that includes a drive slot and a drive pin that is attached to the rotary gear and is slidably received in the drive slot.

[0527] Example 137 - The surgical instrument of Example 136, wherein the drive slot is transverse to the shaft axis.

[0528] Example 138 - The surgical instrument of Examples 133, 134, 135, 136 or 137, wherein the surgical end effector is configured to cut and staple tissue.

[0529] Example 139 - The surgical instrument of Examples 133, 134, 135, 136, 137 or 138, wherein the articulation system comprises a central articulation link that is supported for rotational travel about the articulation axis. A selectively axially movable articulation driver interfaces with the central articulation link at a first location on a first side of the shaft axis. The articulation system further comprises an articulation drive link that includes a first end that is coupled to the surgical end effector

and a second end that is coupled to the central articulation link at a second location on a second side of the shaft axis.

[0530] Example 140 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective articulation relative to the elongate shaft assembly about an articulation axis that is transverse to the shaft axis. The surgical instrument further comprises an articulation system that includes an articulation cable that is coupled to the surgical end effector at a point of attachment and is journaled on a proximal pulley that is supported on the elongate shaft assembly. The proximal pulley defines a proximal pulley axis that is located a tension distance from the point of attachment. An articulation driver is coupled to the articulation cable for selectively causing the articulation cable to rotate about the proximal pulley in first and second articulation directions. An adjustable tensioning assembly interfaces with the proximal pulley to selectively adjust the tensioning distance.

[0531] Example 141 - The surgical instrument of Example 140, further comprising a distal pulley that is attached to the surgical end effector and defines the point of attachment.

[0532] Example 142 - The surgical instrument of Example 141, wherein the distal pulley defines the articulation axis.

[0533] Example 143 - The surgical instrument of Examples 140, 141 or 142, wherein the adjustable tensioning assembly comprises a pulley mount that supports the proximal pulley thereon. A mounting shaft is coupled to the pulley mount and is supported in a portion of the elongate shaft assembly for selective rotation relative thereto. The mounting shaft is eccentrically attached to the pulley mount such that rotation of the mounting shaft causes the proximal pulley to move axially to adjust the tension distance between the proximal pulley axis and the point of attachment.

[0534] Example 144 - The surgical stapling instrument of Example 143, wherein the mounting shaft defines a mounting shaft axis that is offset from the proximal pulley axis.

[0535] Example 145 - The surgical instrument of Examples 140, 141 or 142, wherein the adjustable tensioning assembly comprises a pulley mount that supports the proximal pulley thereon. A mounting member is attached to the pulley mount and is slidably supported on the elongate shaft assembly for selective axial travel relative thereto. The adjustable tensioning assembly further comprises means for selectively axially moving the mounting member on the elongate shaft assembly.

[0536] Example 146 - The surgical instrument of Example 145, wherein the means for selectively axially moving comprises a tensioning screw that is mounted in the elongate shaft assembly and is configured to axially move the mounting member within an axial slot in the elongate shaft assembly.

[0537] Example 147 - The surgical instrument of Example 145, wherein the means for selectively axially moving comprises a rotary cam assembly that is mounted in the elongate shaft assembly and is configured to axially move the mounting member within an axial slot in the elongate shaft assembly.

[0538] Example 148 - The surgical instrument of Example 147, wherein the rotary cam assembly comprises a tension cam that is configured for camming contact with the mounting member. A mounting spindle is coupled to the tension cam and is supported in a portion of the elongate shaft assembly for selective rotation relative thereto. The mounting spindle is attached to the tension cam such that rotation of the mounting spindle in a first direction causes the tension cam to axially bias the mounting member within the axial slot.

[0539] Example 149 - The surgical instrument of Example 148, wherein the mounting spindle has a knurled outer surface and is configured to be received within a knurled hole in the portion of the elongate shaft assembly.

[0540] Example 150 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective articulation relative to the elongate shaft assembly about an articulation axis that is transverse to the shaft axis. The surgical instrument further comprises an articulation system that includes an articulation cable that is journaled on a distal pulley that is attached to the surgical end effector and a proximal pulley that is supported on the elongate shaft assembly. An articulation driver is coupled to the articulation cable for selectively causing the articulation cable to rotate about the proximal pulley in first and second rotation directions. An adjustable tensioning assembly is supported on the elongate shaft assembly and is configured to selectively contact a portion of the articulation cable in a direction that is transverse to the first and second rotation directions to increase an amount of tension in the articulation cable.

[0541] Example 151 - The surgical instrument of Example 150, wherein the articulation cable comprises a first cable end and a second cable end and wherein the first and second cable ends operably interface with the articulation driver.

[0542] Example 152 - The surgical instrument of Example 151, wherein the articulation driver comprises a distal end portion that includes a pair of cleats. The cleats define a mounting space therebetween. The first cable end comprises a first lug attached to the cable that is received within the mounting space and wherein the second cable end comprises a second lug attached thereto and is received within the mounting space between the pair of cleats.

[0543] Example 153 - The surgical instrument of Examples 150, 151 or 152, wherein the articulation cable is non-rotatably coupled to the distal pulley.

[0544] Example 154 - A surgical instrument comprising an elongate shaft assembly that defines a shaft axis. A surgical end effector is pivotally coupled to the elongate shaft assembly for selective articulation relative to the elongate shaft assembly about an articulation axis that is transverse to the shaft axis. The surgical instrument further comprises an articulation system that includes an articulation cable that is journaled on a distal pulley that is attached to the surgical end effector and a proximal pulley that is supported on the elongate shaft assembly. The articulation cable comprises a first cable end and a second cable end. The articulation system further comprises an articulation driver for selectively causing the articulation cable to rotate about the proximal pulley in first and second articulation directions. The articulation driver includes a first cleat that is attached to the first cable end and a second cleat that is attached to the second cable end and is spaced from the first cleat. The articulation system also includes means that is coupled to the first and second cleats for moving the first and second cable ends toward each other to increase an amount of tension in the articulation cable.

[0545] Example 155 - The surgical instrument of Example 154, wherein the means that is coupled to the first and second cleats for moving the first and second cable ends toward each other comprises a rotary member that is coupled to the first and second cleats such that rotation of the rotary member in a first rotary direction causes the first and second cleats to move toward each other and rotation of the rotary member in a second rotary direction causes the first and second cleats to move away from each other.

[0546] Example 156 - The surgical instrument of Example 155, wherein the rotary member comprises a tension screw that is in threaded engagement with the first and second cleats.

[0547] Example 157 - The surgical instrument of Example 154, wherein the first cable end comprises a first lug that is attached to the cable that is received between the first and second cleats and wherein the second cable end comprises a second lug that is attached to the cable and is received between the first and second cleats.

[0548] Example 158 - The surgical instrument of Examples 154, 155, 156 or 157, wherein the articulation cable is non-rotatably coupled to the distal pulley.

[0549] Example 159 - The surgical instrument of Examples 154, 155, 156, 157 or 158, wherein the surgical end effector is configured to cut and staple tissue.

[0550] Example 160 - A surgical instrument comprising a surgical end effector that includes a first jaw and a second jaw, wherein one of the first jaw and the second jaw is selectively movable relative to the

other of the first jaw and the second jaw upon application of a closure motion to the surgical end effector. The surgical instrument further comprises an elongate shaft assembly that includes a closure member assembly that is supported for axial travel relative to the surgical end effector. The closure member assembly comprises a proximal closure member that is configured to be axially advanced a complete closure stroke distance upon application of a closure actuation motion thereto. A distal closure member movably interfaces with the proximal closure member such that the distal closure member moves an axial closure distance in response to axial movement of the proximal closure member through the complete closure stroke distance to thereby cause the distal closure member to apply the closure motion to the surgical end effector and wherein the axial closure distance is less than the complete closure stroke distance.

[0551] Example 161 - The surgical instrument of Example 160, wherein the proximal closure member comprises a distal end and wherein the distal closure member comprises a proximal end that is slidably affixed to the distal end of the proximal closure member such that, as the proximal closure member moves through the complete closure stroke distance, the distal closure member does not begin to axially move through the axial closure distance until the proximal closure member has axially moved through a portion of the complete closure stroke distance.

[0552] Example 162 - The surgical instrument of Example 161, wherein the elongate shaft assembly comprises a spine assembly that is coupled to the surgical end effector and wherein the proximal closure member comprises a proximal closure sleeve that is supported on a portion of the spine assembly for axial travel through the complete closure stroke distance thereon and wherein the distal closure member comprises a distal closure sleeve that is slidably journaled on another portion of the spine assembly and is movably coupled to the proximal closure sleeve.

[0553] Example 163 - The surgical instrument of Example 162, wherein the proximal closure sleeve has an opening in a distal end thereof and wherein a proximal end of the distal closure sleeve extends through the opening and is configured to prevent the proximal end of the distal closure sleeve from separating from the distal end of the proximal closure sleeve.

[0554] Example 164 - The surgical instrument of Example 163, wherein the distal end of the proximal closure sleeve is flared inwardly around the opening and wherein the proximal end of the distal closure sleeve is flared outwardly to prevent the proximal end of the distal closure sleeve from separating from the distal end of the proximal closure sleeve while facilitating axial travel of the proximal closure sleeve through a portion of the complete closure stroke distance relative to the distal closure sleeve.

[0555] Example 165 - The surgical instrument of Example 162, wherein the proximal closure sleeve comprises an inwardly extending flange that defines an opening in a distal end thereof and wherein a proximal end of the distal closure sleeve extends through the opening and comprises an outwardly extending flange that cooperates with the inwardly extending flange to prevent the proximal end of the distal closure sleeve from separating from the distal end of the proximal closure sleeve.

[0556] Example 166 - The surgical instrument of Example 162, wherein the proximal closure sleeve comprises a contact portion that is proximal to the distal end of the proximal closure sleeve. The contact portion is configured to axially contact the proximal end of the distal closure sleeve after the proximal closure sleeve has axially advanced through a predetermined portion of the complete closure stroke distance.

[0557] Example 167 - The surgical instrument of Example 166, wherein the contact portion comprises a crimped portion of the proximal closure sleeve.

[0558] Example 168 - The surgical instrument of Example 166, wherein the contact portion comprises at least one inwardly extending tab member that is formed in the proximal closure sleeve and is orientated to contact a corresponding portion of the proximal end of the distal closure sleeve.

[0559] Example 169 - The surgical instrument of Examples 166, wherein the contact portion comprises an inwardly extending flange that is formed on a stop member that is attached to an inside wall of the proximal closure sleeve.

[0560] Example 170 - A surgical instrument comprising a surgical end effector that includes a first jaw and a second jaw, wherein one of the first jaw and the second jaw is selectively movable relative to the other of the first jaw and the second jaw upon application of a closure motion to the surgical end effector. The surgical instrument further comprises an elongate shaft assembly that includes a closure member assembly that is supported for axial travel relative to the surgical end effector. The closure member assembly comprises a proximal closure member that is configured to be axially advanced a complete closure stroke distance upon application of a closure actuation motion thereto. A distal closure member is supported for axial travel an axial closure distance that is less than the complete closure stroke distance to apply the closure motion to the surgical end effector. A closure stroke reduction assembly interfaces with the proximal closure member and the distal closure member such that, as the proximal closure member moves through the complete closure stroke distance, the distal closure member does not begin to axially move through the closure distance until the proximal closure member has axially moved through a portion of the complete closure stroke distance.

[0561] Example 171 - The surgical instrument of Example 170, wherein the elongate shaft assembly comprises a spine assembly that is coupled to the surgical end effector and wherein the proximal closure member comprises a proximal closure sleeve that is supported on a portion of the spine assembly for axial travel through the complete closure stroke distance thereon and wherein the distal closure member comprises a distal closure sleeve that is slidably supported on another portion of the spine assembly for axial travel through the closure distance.

[0562] Example 172 - The surgical instrument of Examples 170 or 171, wherein the closure stroke reduction assembly comprises a proximal mounting member coupled to the proximal closure sleeve for axial travel therewith through the complete closure stroke distance and a distal mounting member that is coupled to the distal closure sleeve for axial travel therewith through the closure distance.

[0563] Example 173 - The surgical instrument of Example 172, wherein the proximal mounting member comprises a contact portion that is configured to contact at least one of the proximal mounting member and the proximal closure sleeve after the proximal closure sleeve has moved through the portion of the complete closure stroke distance.

[0564] Example 174 - The surgical instrument of Example 173, wherein the distal mounting member defines a distal ledge and wherein the proximal mounting member defines a proximal ledge that is spaced from the distal ledge to form a distal travel zone therebetween and wherein the contact portion is spaced from the at least one of the proximal mounting member and the proximal closure sleeve to define a proximal travel zone between the contact portion and the at least one of the proximal mounting member and the proximal closure sleeve.

[0565] Example 175 - The surgical instrument of Example 174, wherein the proximal travel zone has a proximal axial width and wherein the distal travel zone has a distal axial width that differs from the proximal axial width.

[0566] Example 176 - The surgical instrument of Examples 172, 173, 174 or 175, further comprising a biasing member that is located between the proximal mounting member and the distal mounting member.

[0567] Example 177 - The surgical instrument of Examples 174 or 175, further comprising a biasing member that is supported within the distal travel zone.

[0568] Example 178 - A surgical instrument comprising a surgical end effector that includes a first jaw and a second jaw wherein one of the first jaw and the second jaw is selectively movable relative to the other of the first jaw and the second jaw upon application of a closure motion to the surgical end effector. The surgical instrument further comprises an elongate shaft assembly that includes a closure

member assembly that is supported for axial travel relative to the surgical end effector. The closure member assembly comprises a proximal closure member that is configured to be axially advanced a complete closure stroke distance upon application of a closure actuation motion thereto. The proximal closure member is configured to apply a maximum closure force upon reaching an end of the maximum closure stroke distance. A distal closure member is supported for axial travel an axial closure distance that is less than the complete closure stroke distance to apply the closure motion to the surgical end effector. A closure stroke reduction assembly interfaces with the proximal closure member and the distal closure member such that, as the proximal closure member moves through the complete closure stroke distance, the proximal closure member applies another closure force to the distal closure member that is less than the maximum closure force.

[0569] Example 179 - The surgical instrument of Example 178, wherein the closure stroke reduction assembly comprises a proximal mounting member that is coupled to the proximal closure member for axial travel therewith through the complete closure stroke distance. A distal mounting member is coupled to the distal closure member for axial travel therewith through the axial closure distance. A biasing member is located between a portion of the proximal mounting member and another portion of the distal mounting member.

[0570] 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 Ser. 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 Ser. No. 12/893,461, entitled STAPLE CARTRIDGE, filed September 29, 2012, now U.S. Patent No. 8,733,613;

U.S. Patent Application Ser. 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 ROTATABLE 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.

[0571] Although the various embodiments of the devices have been described herein in connection with certain disclosed embodiments, many 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.

[0572] The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

[0573] By way of example only, aspects described 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, 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 also may be sterilized using any other technique known in the art, including but not limited to beta or gamma radiation, ethylene oxide, plasma peroxide, or steam.

[0574] 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.

[0575] Any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated materials does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

WHAT IS CLAIMED IS:

1. A surgical instrument, comprising:

an elongate shaft assembly defining a shaft axis; and

a surgical end effector comprising a distal end and a proximal end, said proximal end being pivotally coupled to said elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to said shaft axis, said surgical end effector selectively pivotable about said articulation axis from an unarticulated position wherein said distal end of said surgical end effector is located an unarticulated distance from said articulation axis to articulated positions wherein said distal end of said surgical end effector is located a corresponding articulated distance from said articulation axis that is less than said unarticulated distance.

2. The surgical instrument of Claim 1, wherein said elongate shaft assembly comprises a pivot member that defines said articulation axis and wherein said proximal end of said surgical end effector comprises an elongate slot configured to slidably receive said pivot member therein.

3. The surgical instrument of Claim 1, further comprising means for selectively applying articulation motions to said surgical end effector.

4. The surgical instrument of Claim 3, wherein said means for selectively applying comprises a rotary gear in meshing engagement with said surgical end effector.

5. The surgical instrument of Claim 4, wherein said proximal end of said surgical end effector comprises an elliptical gear profile in meshing engagement with said rotary gear.

6. The surgical instrument of Claim 5, wherein said means for selectively applying comprises a selectively axially moveable distal articulation driver that operably interfaces with said rotary gear.

7. The surgical instrument of Claim 6, further comprising:

a drive slot in said selectively axially movable distal articulation driver; and

a drive pin attached to said rotary gear and slidably received in said drive slot.

8. The surgical instrument of Claim 1, wherein said surgical end effector defines an end effector axis located such that when said surgical end effector is in said unarticulated position, said end effector axis is aligned with said shaft axis and wherein when said surgical end effector is articulated to a full one of said articulated positions, said end effector axis is perpendicular to said shaft axis.

9. The surgical instrument of Claim 3, wherein said means for selectively applying comprises:

a central articulation link supported for rotational travel about said articulation axis;

a selectively axially movable articulation driver interfacing with said central articulation link at a first location on a first side of said shaft axis; and

an articulation drive link comprising a first end coupled to said surgical end effector and a second end coupled to said central articulation link at a second location on a second side of said shaft axis.

10. The surgical instrument of Claim 9, wherein said means for selectively applying comprises:

a central articulation gear supported for travel about said articulation axis; and

a gear profile on said second end of said articulation drive link, said gear profile in meshing engagement with said central articulation gear.

11. A surgical instrument, comprising:

an elongate shaft assembly defining a shaft axis and comprising a distal shaft portion; and

a surgical end effector defining an end effector axis and comprising a distal end and a proximal end, said proximal end being movably coupled to said distal shaft portion for selective travel between an unarticulated position wherein said end effector axis is aligned with said shaft axis and said distal end of said surgical end effector is located an unarticulated distance from said distal shaft portion of said elongate shaft assembly to articulated positions wherein said end effector axis is transverse to said shaft axis and said distal end of said surgical end effector is located a corresponding articulated distance from said distal shaft portion that is less than said unarticulated distance.

12. The surgical instrument of Claim 11, wherein said proximal end of said surgical end effector is movably coupled to said distal shaft portion of said elongate shaft assembly by a selectively axially movable articulation driver and an articulation link.

13. The surgical instrument of Claim 11, wherein when said surgical end effector is articulated in one of said articulated positions, said end effector axis is perpendicular to said shaft axis.

14. A surgical instrument, comprising:

an elongate shaft assembly defining a shaft axis;

a surgical end effector comprising a distal end and a proximal end, said proximal end being movably coupled to said elongate shaft assembly for selective pivotal travel about an articulation axis that extends transversely relative to said shaft axis and translational travel relative to said articulation axis; and

an articulation system operably interfacing with said surgical end effector to selectively apply articulation motions thereto.

15. The surgical instrument of Claim 14, wherein said articulation system comprises:

a rotary gear in meshing engagement with said surgical end effector; and

means for rotating said rotary gear.

16. The surgical instrument of Claim 15, further comprising an elliptical gear segment on said proximal end of said surgical end effector in meshing engagement with said rotary gear.

17. The surgical instrument of Claim 15, wherein said means for rotating said rotary gear comprises:

a selectively axially moveable distal articulation driver comprising a drive slot; and

a drive pin attached to said rotary gear and slidably received in said drive slot.

18. The surgical instrument of Claim 17, wherein said drive slot is transverse to said shaft axis.

19. The surgical instrument of Claim 14, wherein said surgical end effector is configured to cut and staple tissue.

20. The surgical instrument of Claim 14, wherein said articulation system comprises:

a central articulation link supported for rotational travel about said articulation axis;

a selectively axially movable articulation driver interfacing with said central articulation link at a first location on a first side of said shaft axis; and

an articulation drive link comprising a first end coupled to said surgical end effector and a second end coupled to said central articulation link at a second location on a second side of said shaft axis.

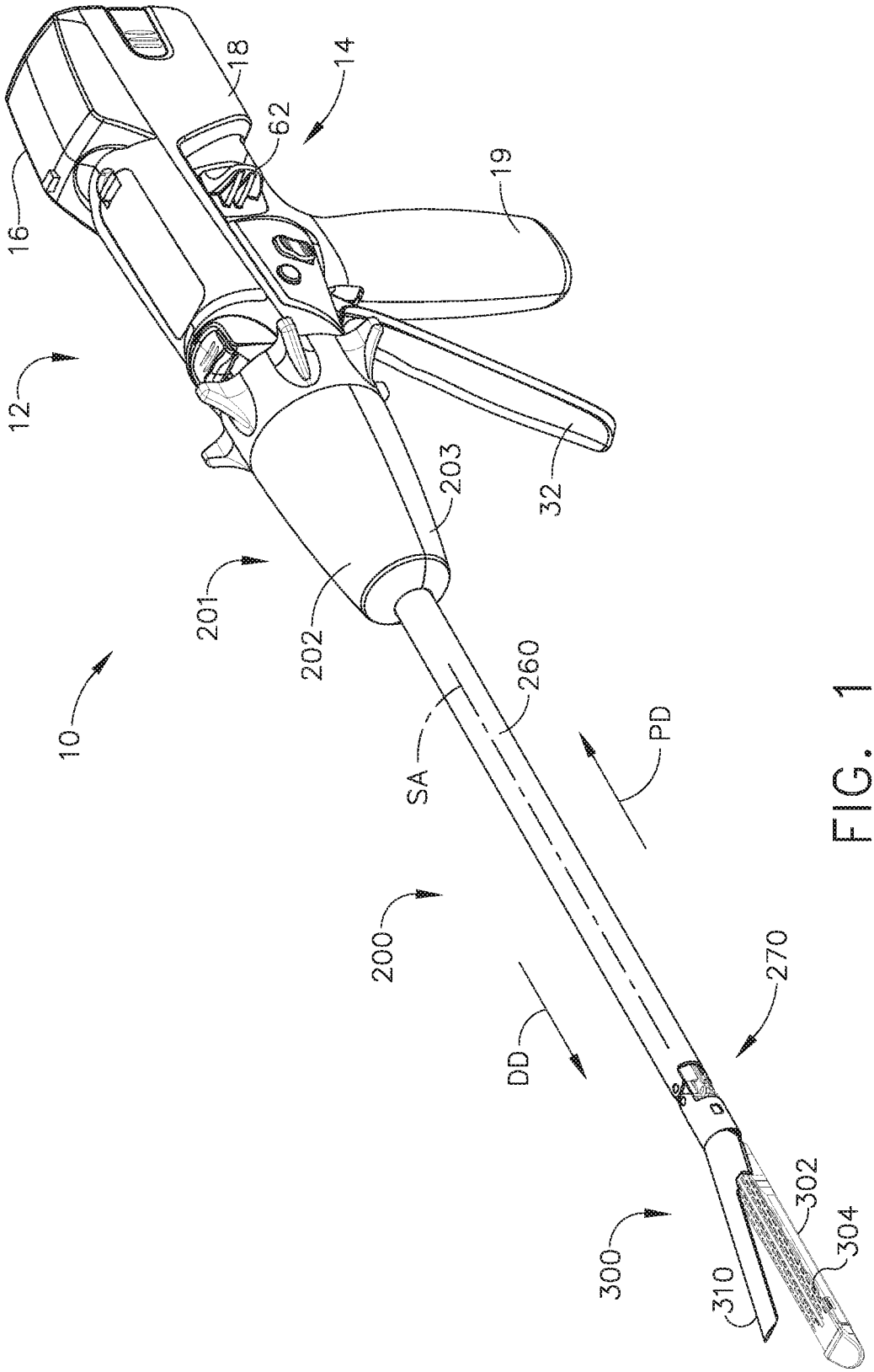
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FIG. 1

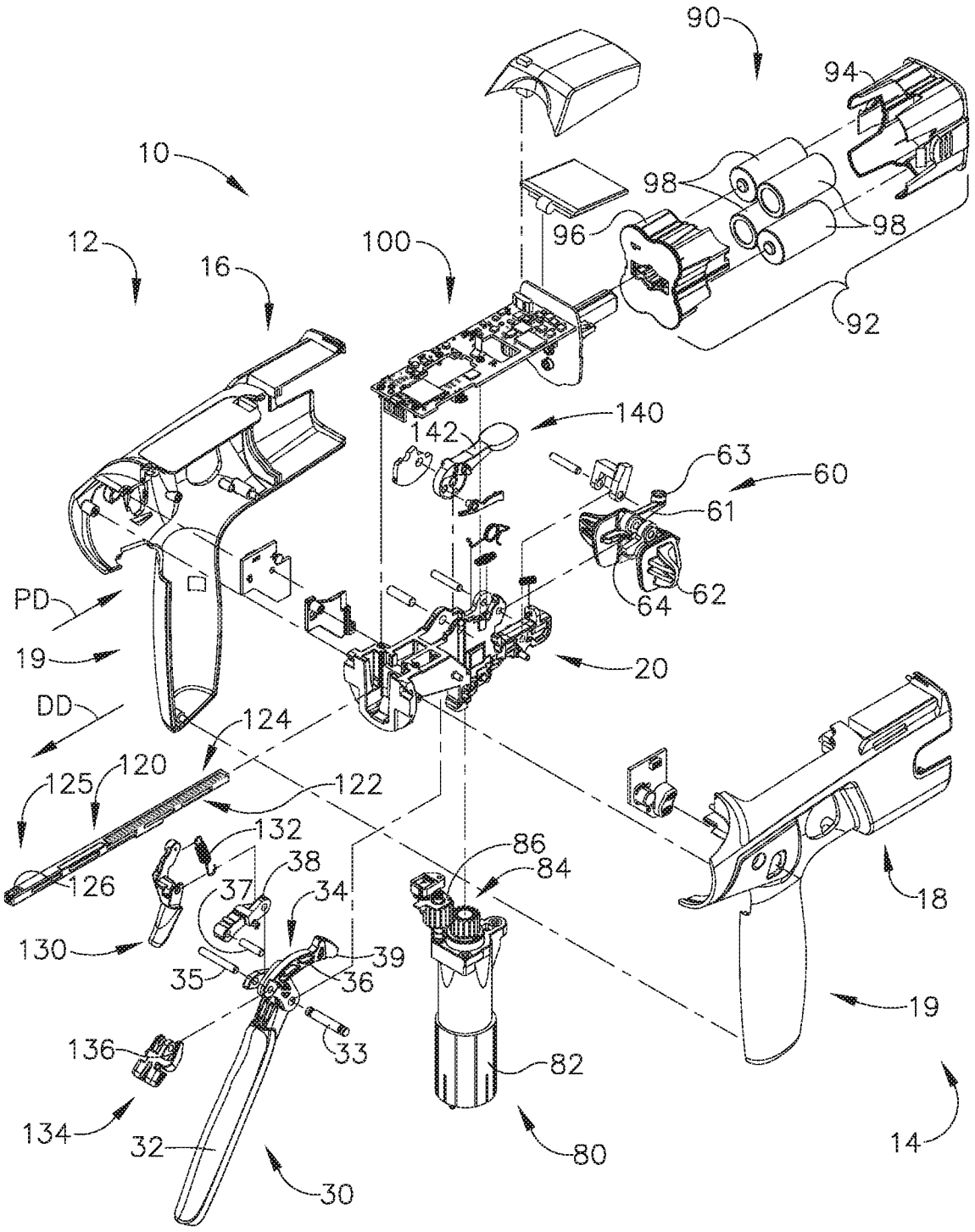
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FIG. 2

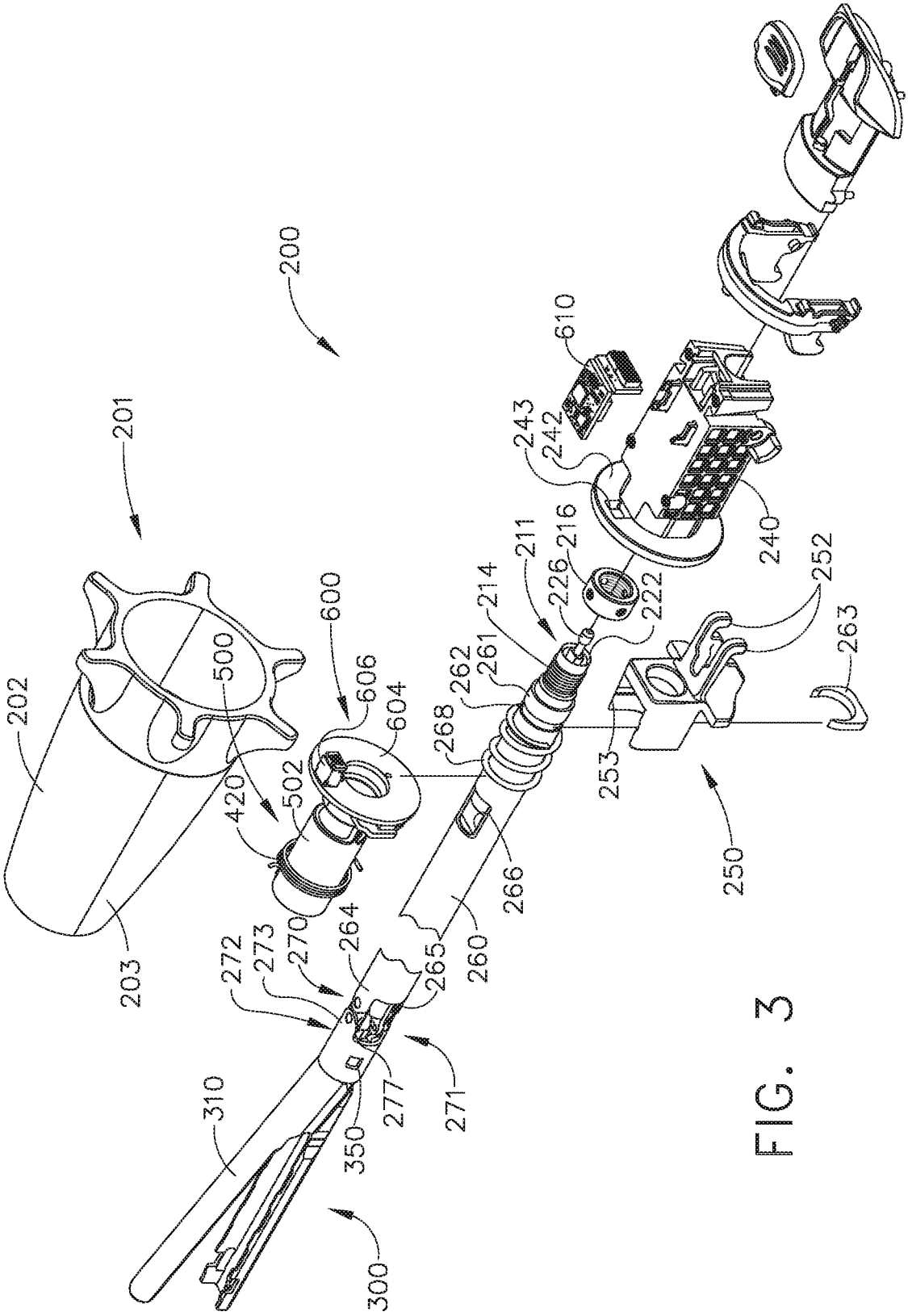
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FIG. 3

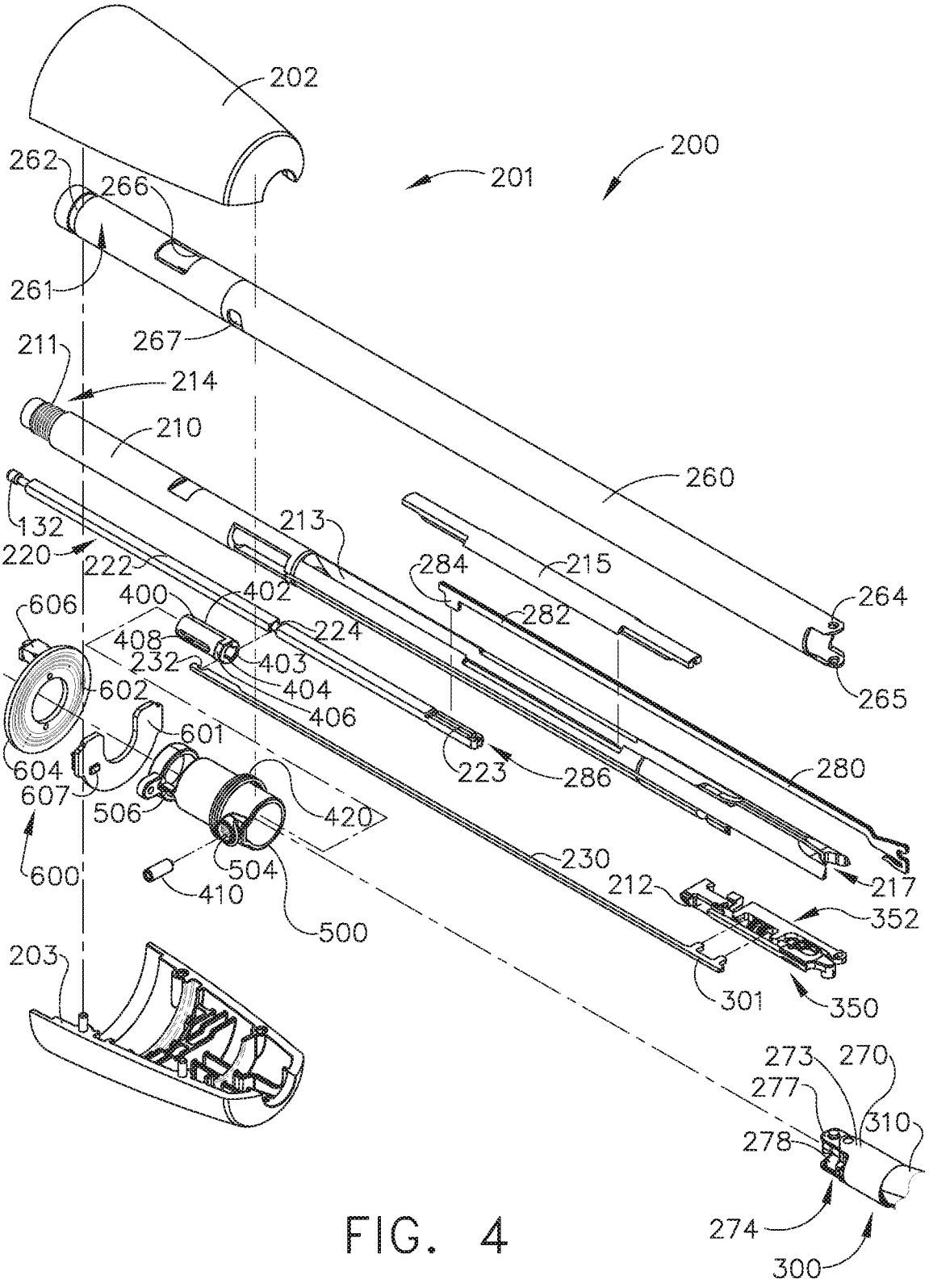
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FIG. 4

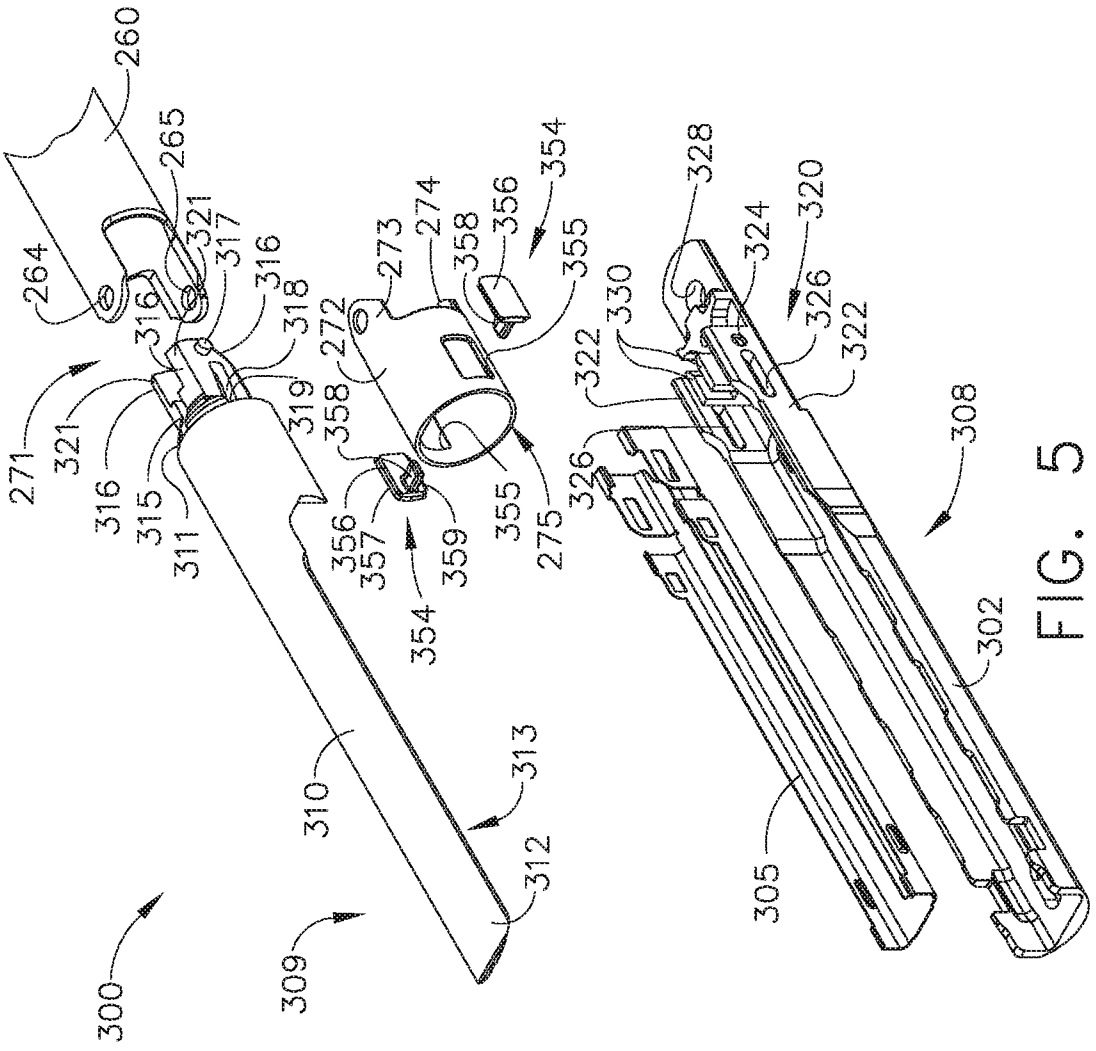
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FIG. 5

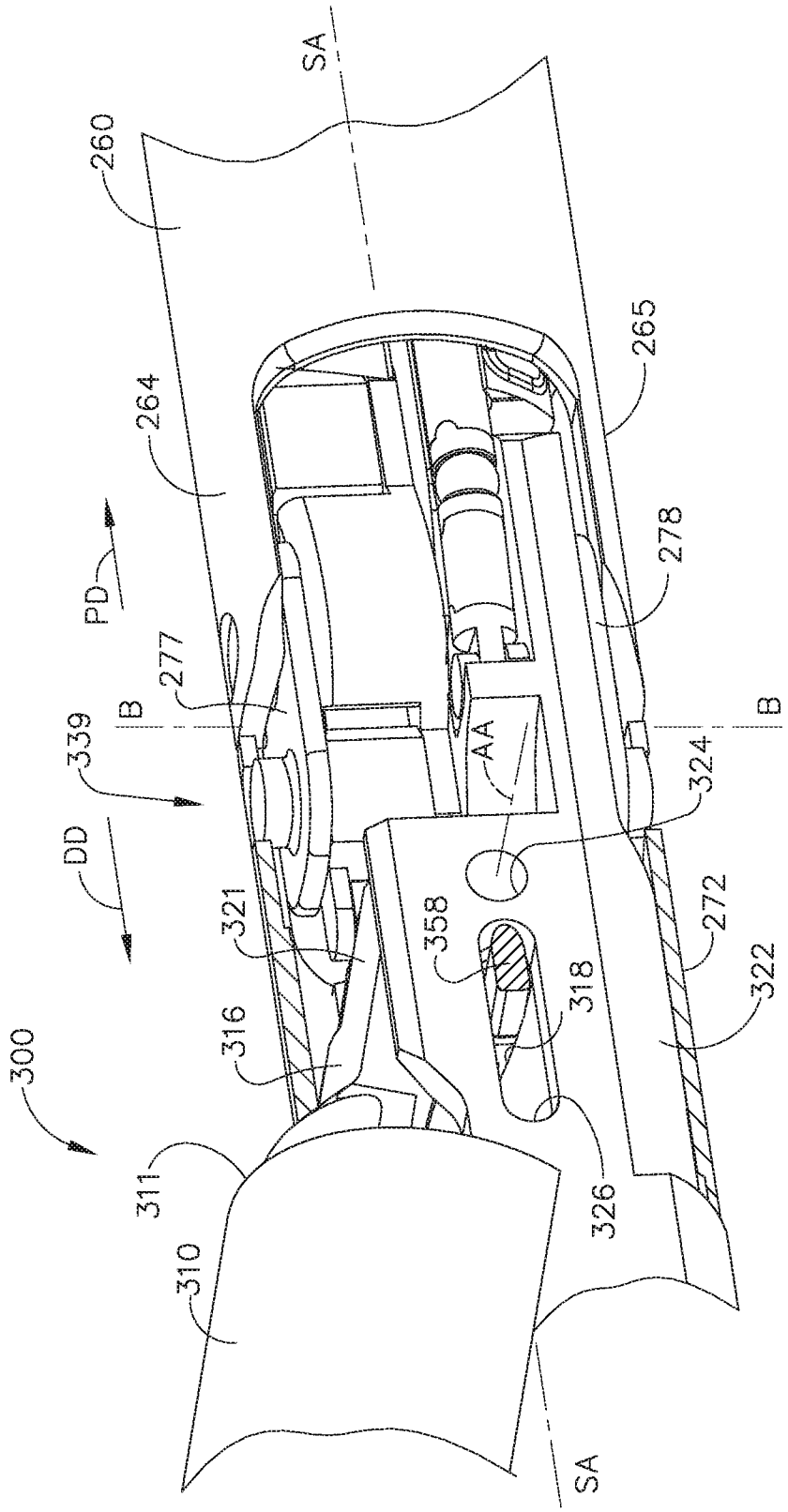
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FIG. 6

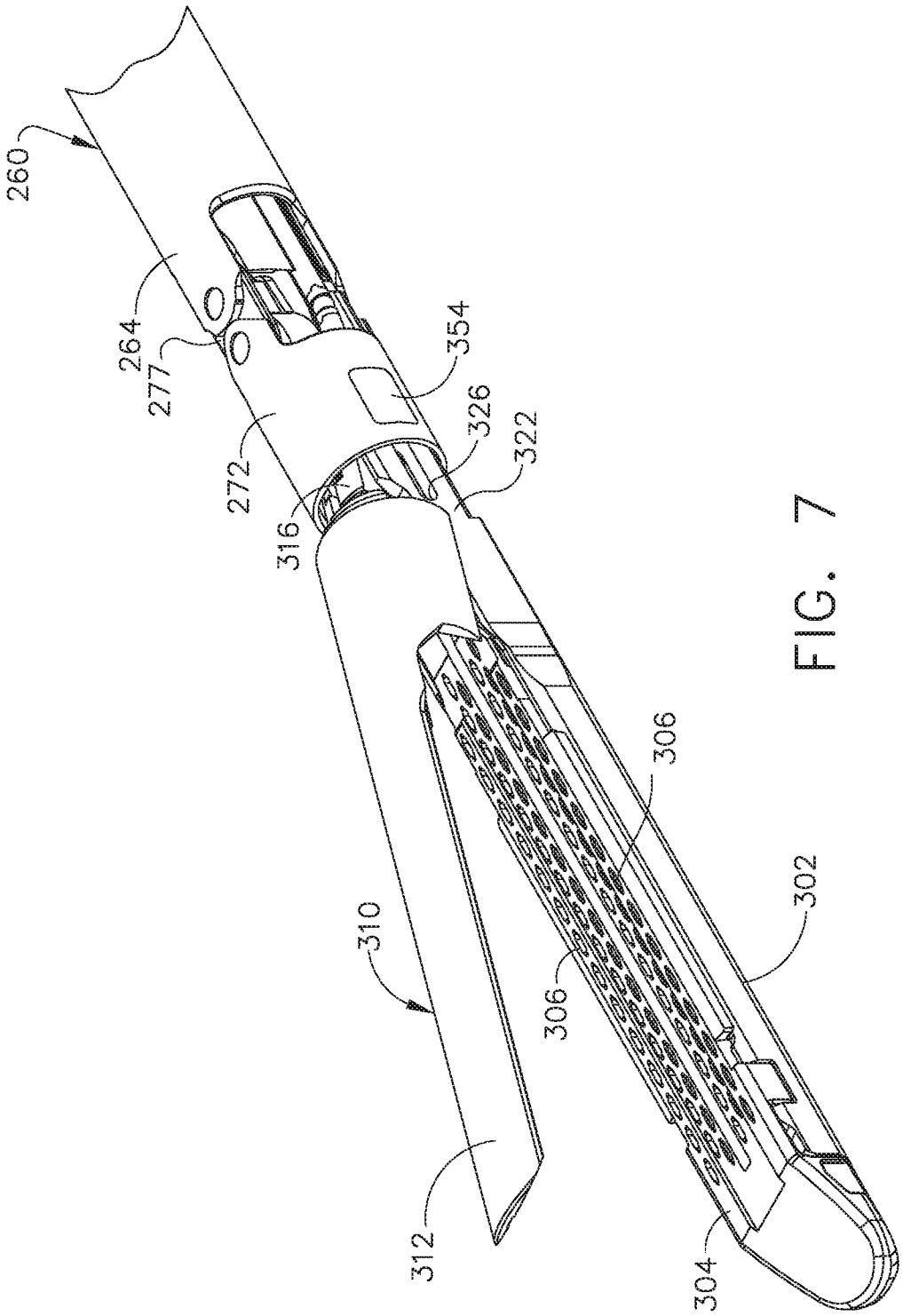

FIG. 7

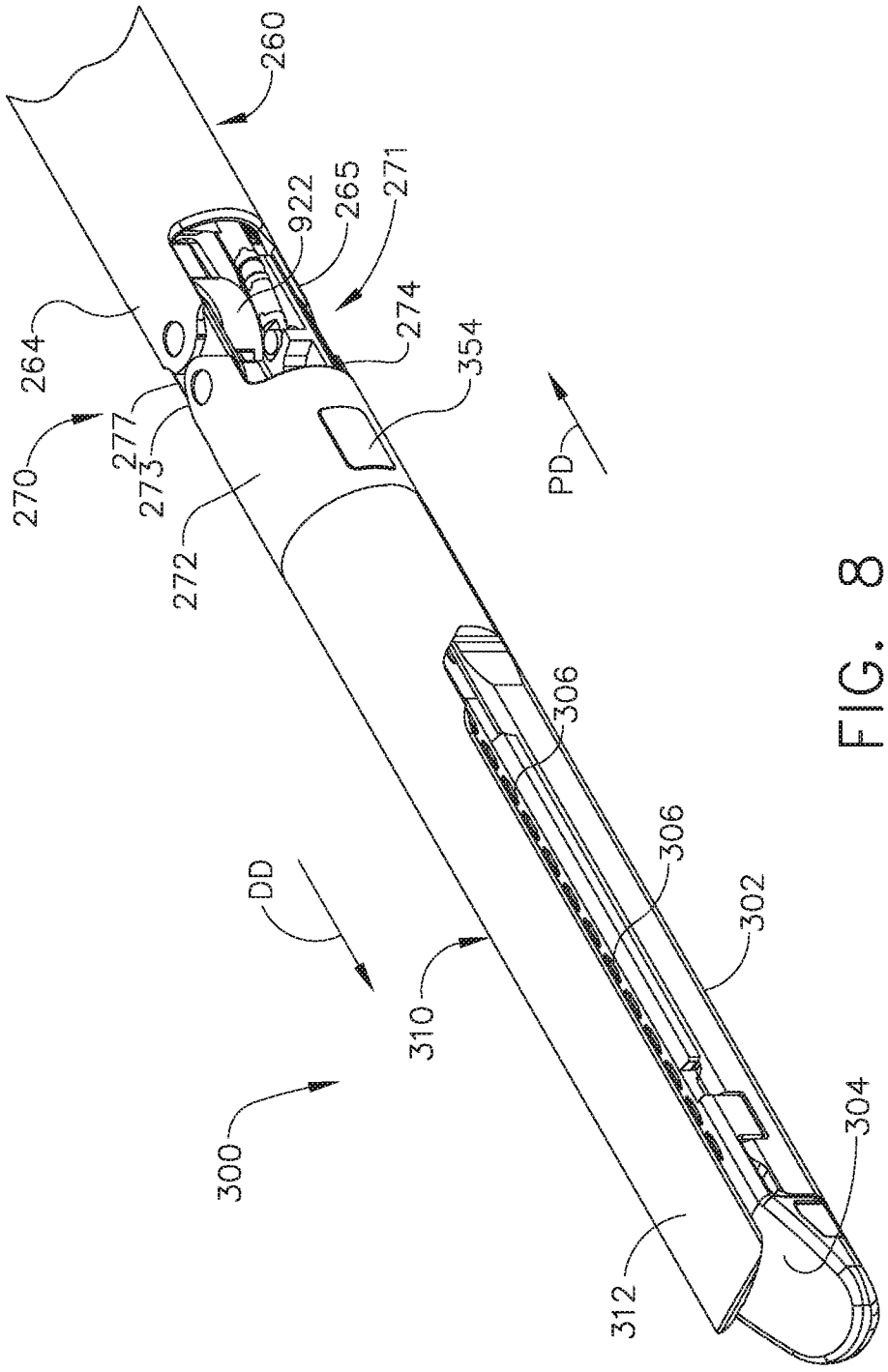
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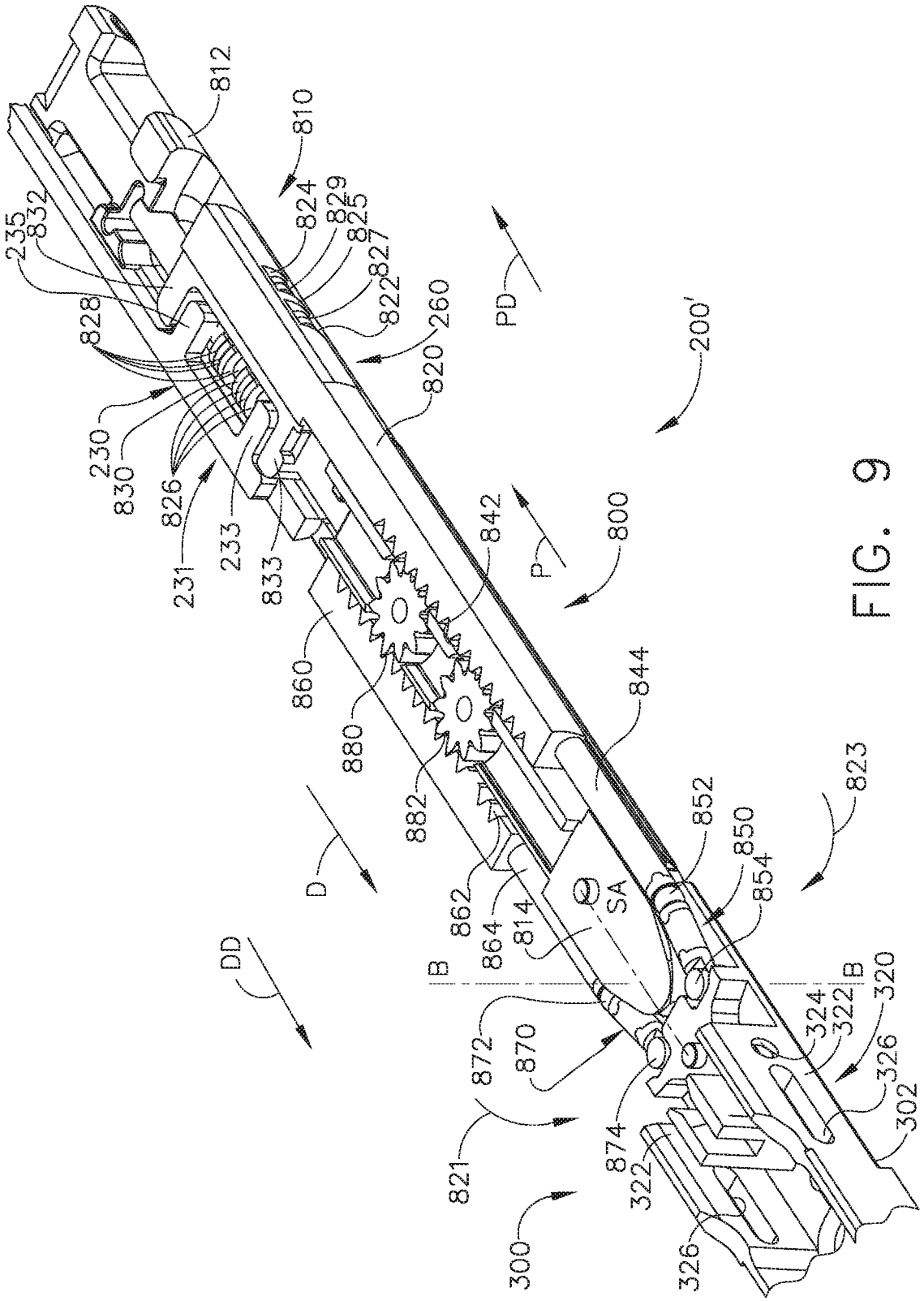
FIG. 8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B

FIG. 9

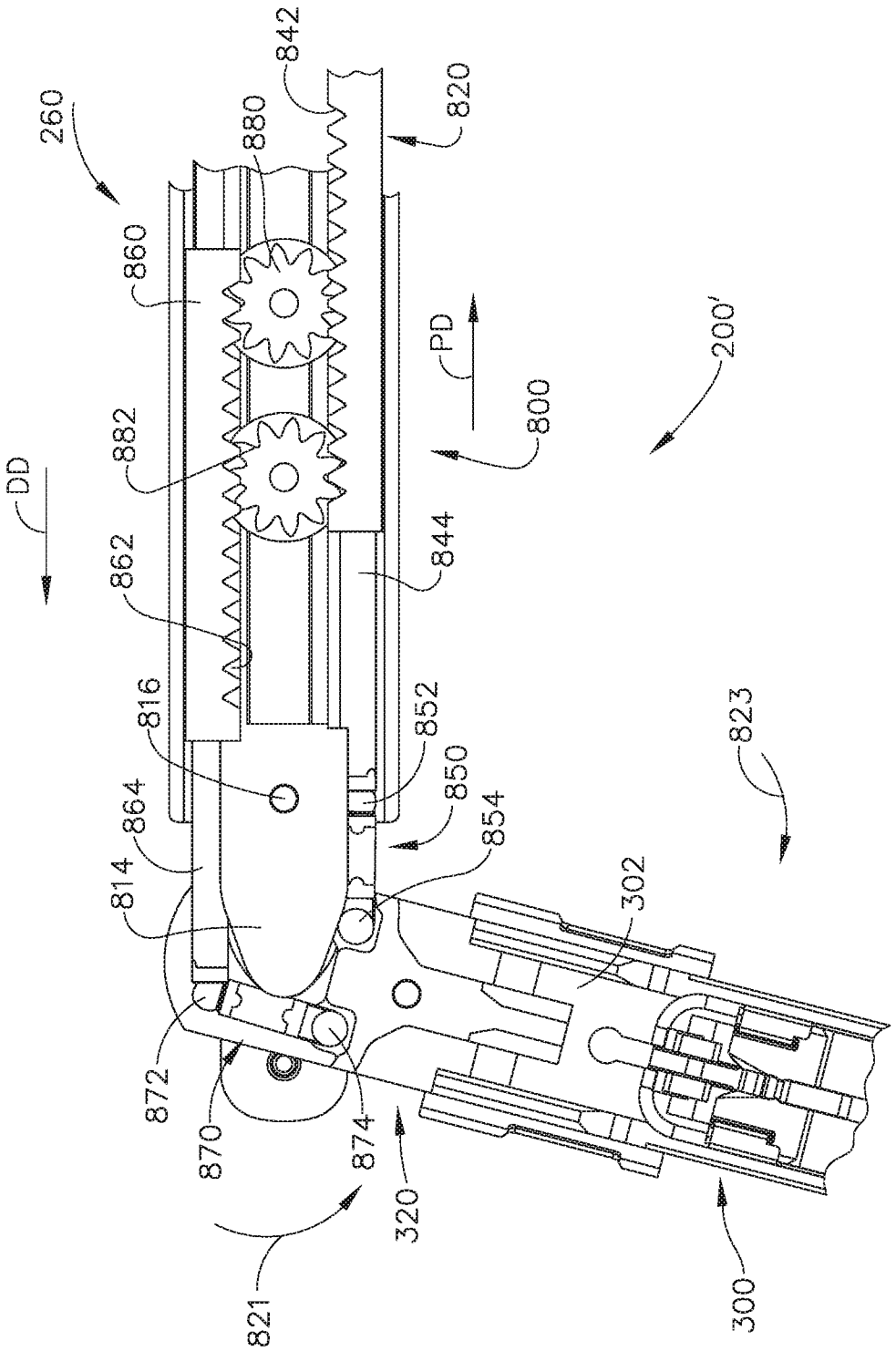

260
880
842
820
860
PD
200'
800
DD
882
862
844
816
852
823
850
864
854
814
302
872
870
874
320
821
300

FIG. 10

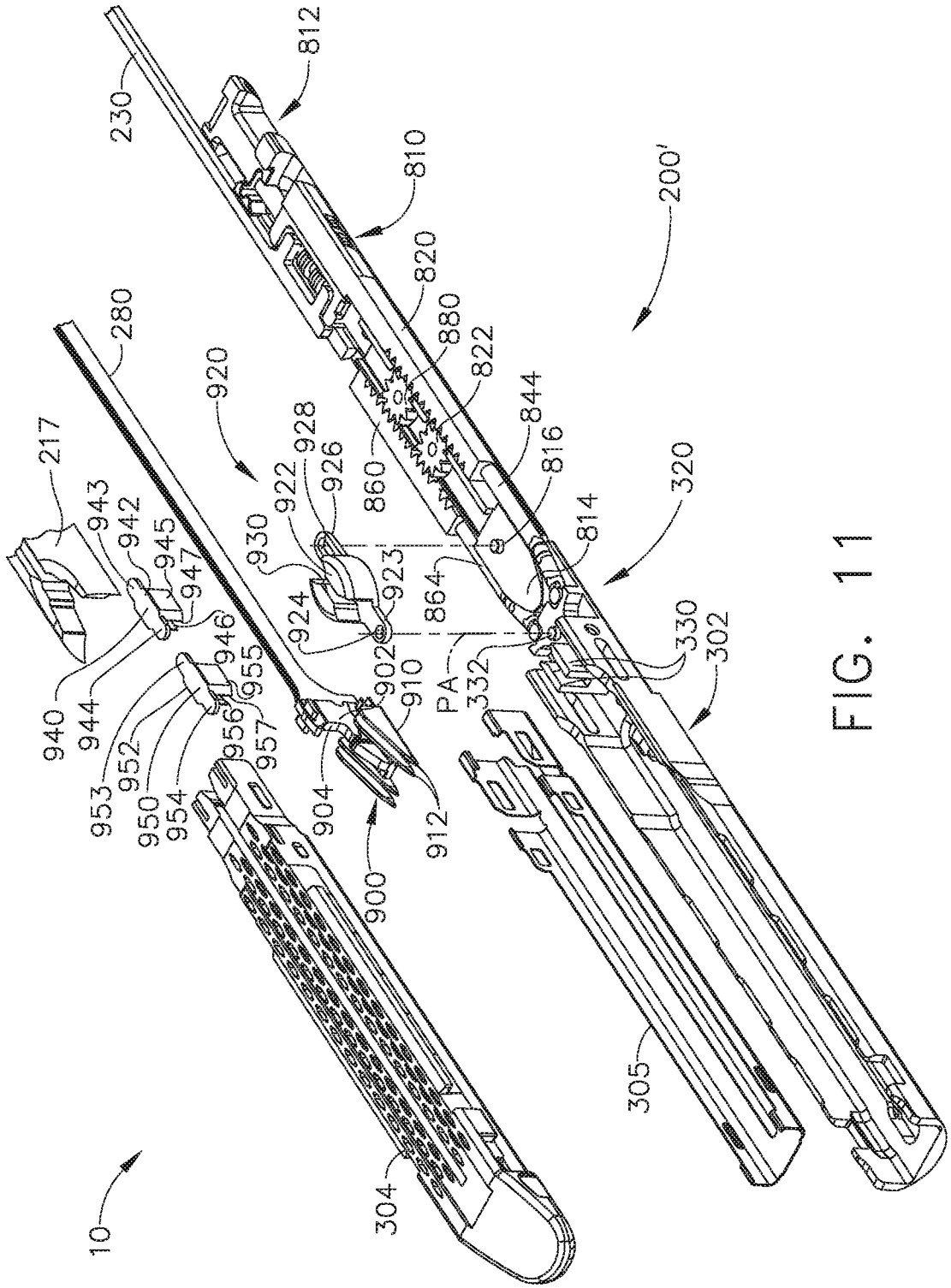

230
812
810
820
880
822
844
816
814
200'
280
920
928
926
922
930
923
924
902
910
912
900
904
860
864
PA
332
320
330
302
305
304
10
217
943
942
945
947
946
955
956
957
940
944
952
953
950
954

FIG. 11

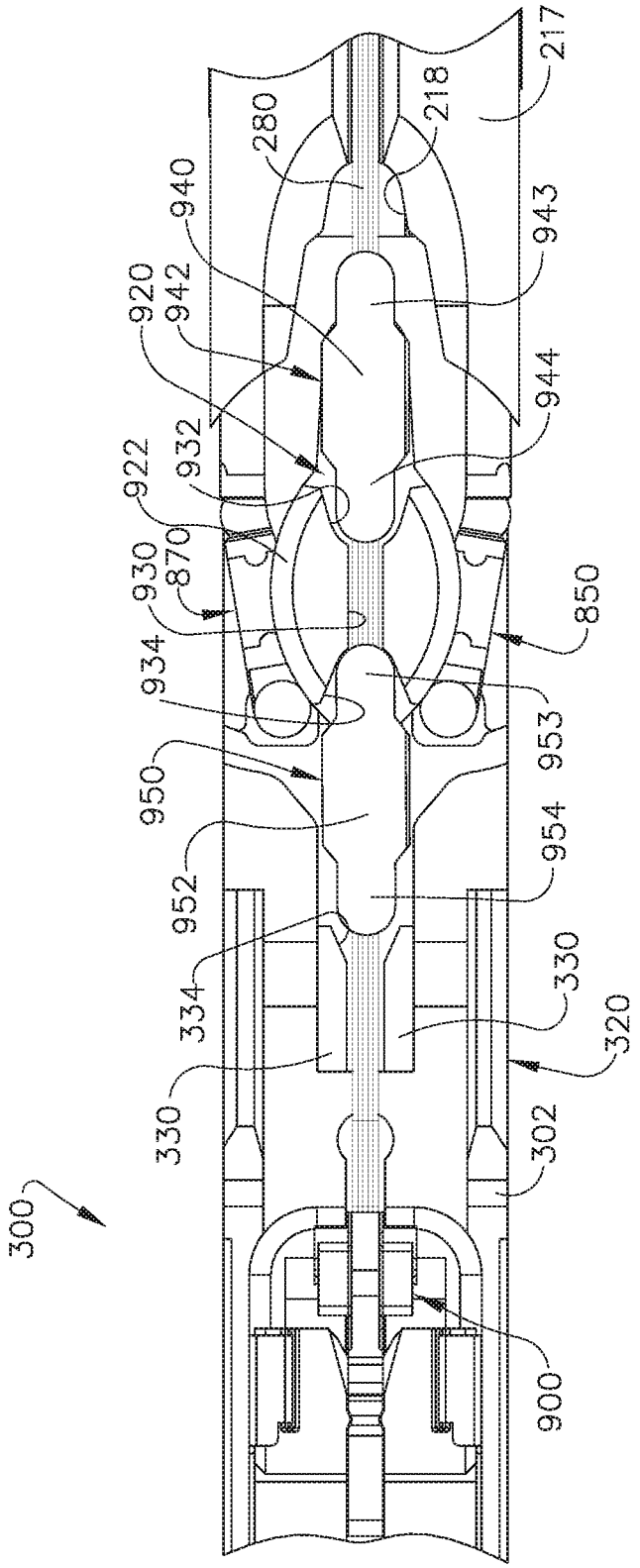

217
218
280
940
943
920
942
944
200'
922
932
930
870
850
934
953
950
954
952
330
334
320
330
302
300
900

FIG. 12

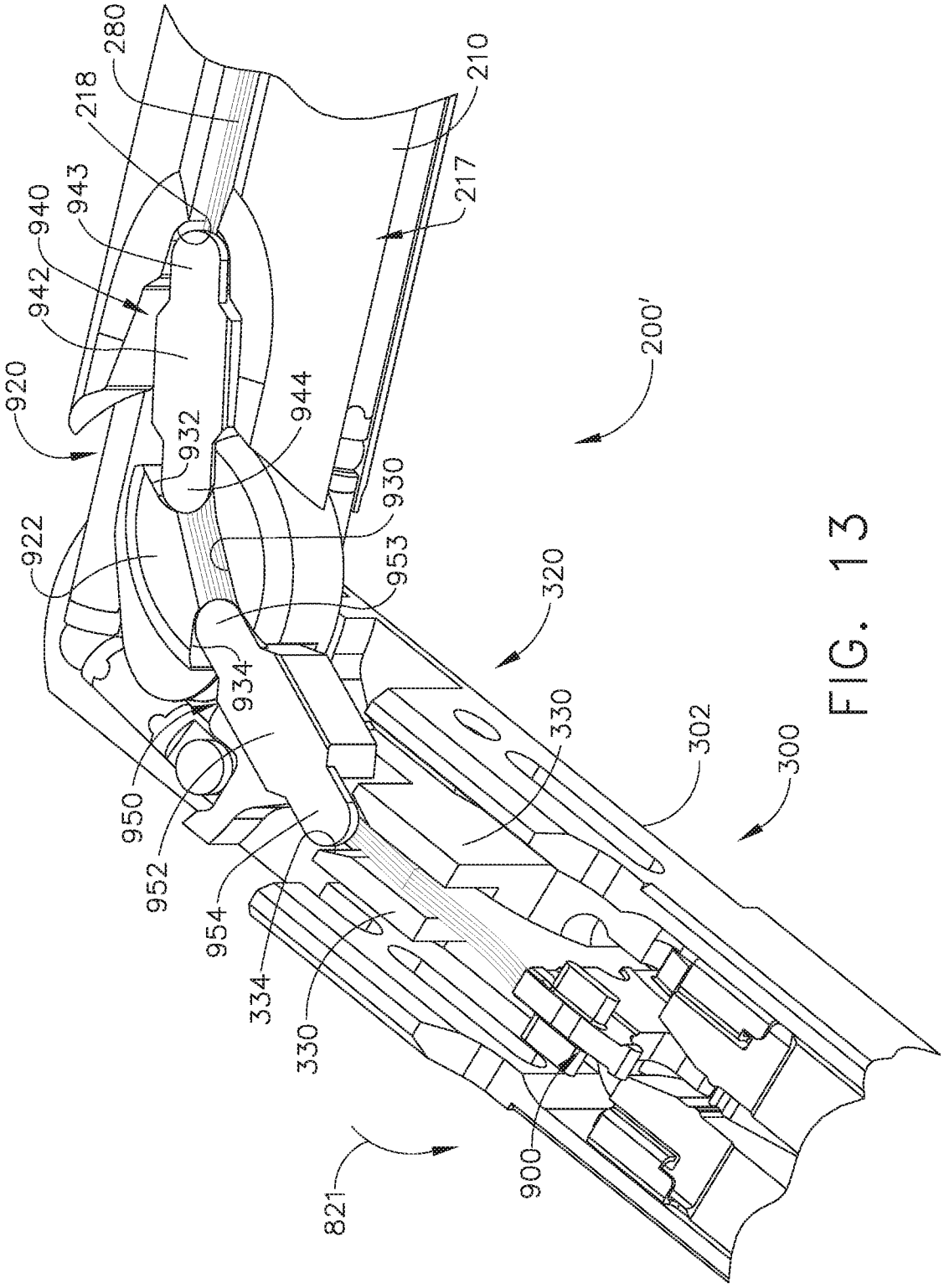

280
218
210
217
940
943
942
920
944
932
930
953
922
320
934
330
302
300
950
952
954
334
330
900
821
200'

FIG. 13

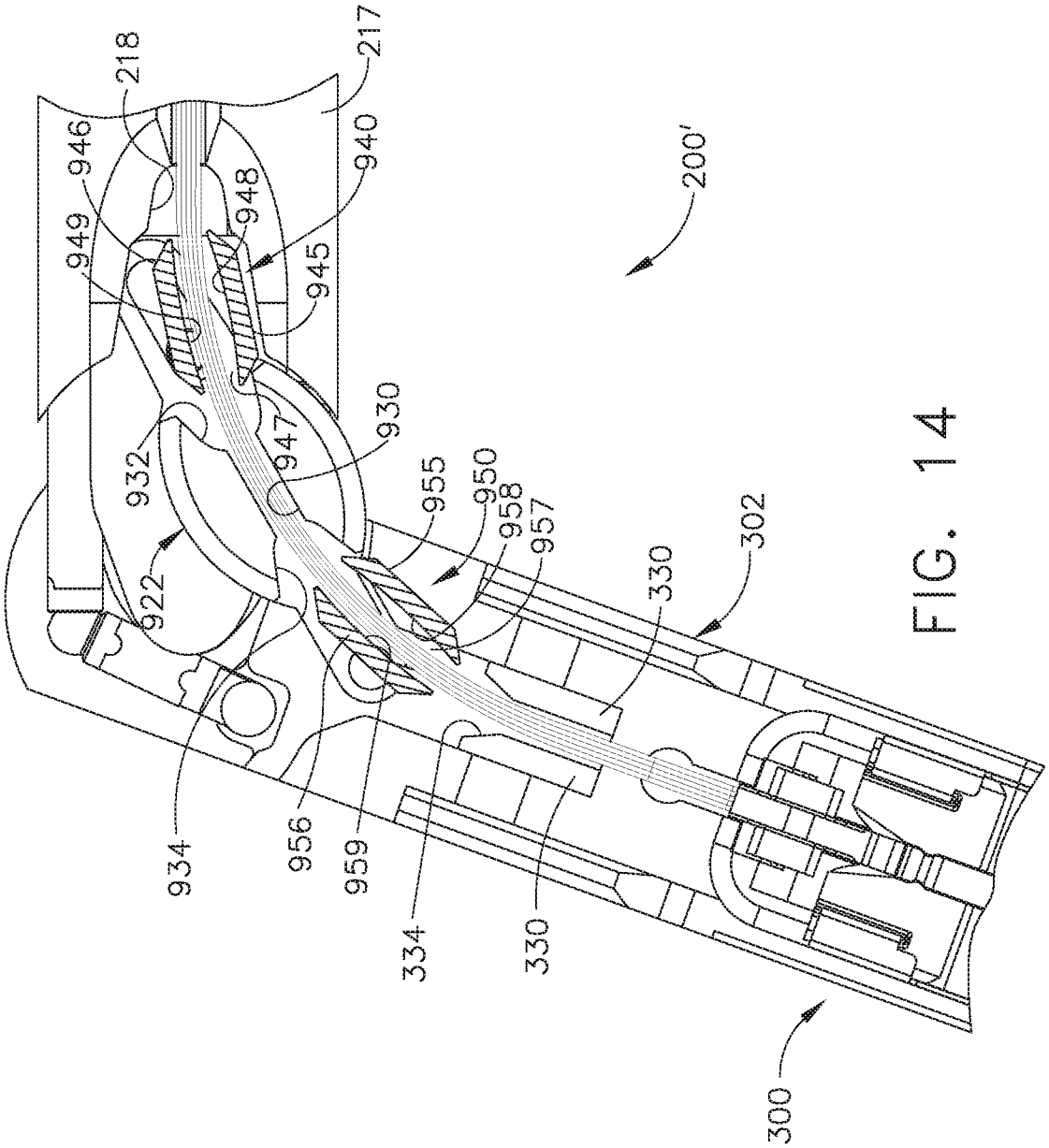

218
217
946
940
948
949
945
200'
930
947
932
955
950
958
957
922
302
330
934
956
959
334
330
300

FIG. 14

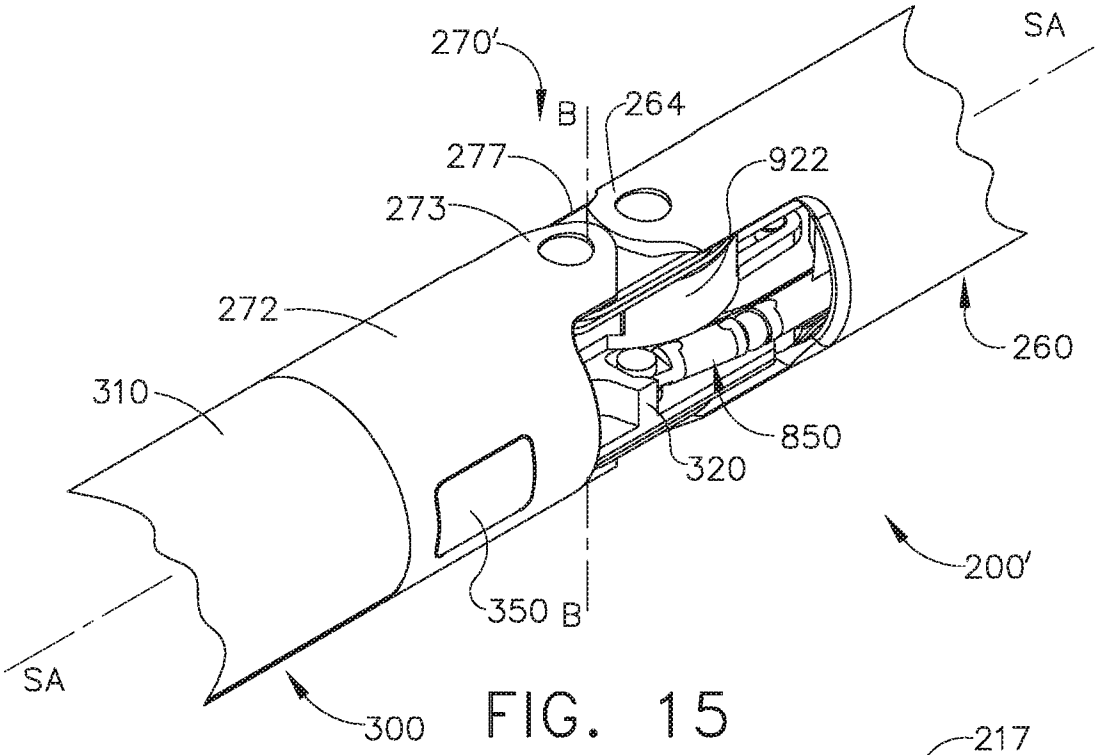

270'
B
264
277
273
272
310
922
260
850
320
200'
350
B
SA
SA
300

FIG. 15

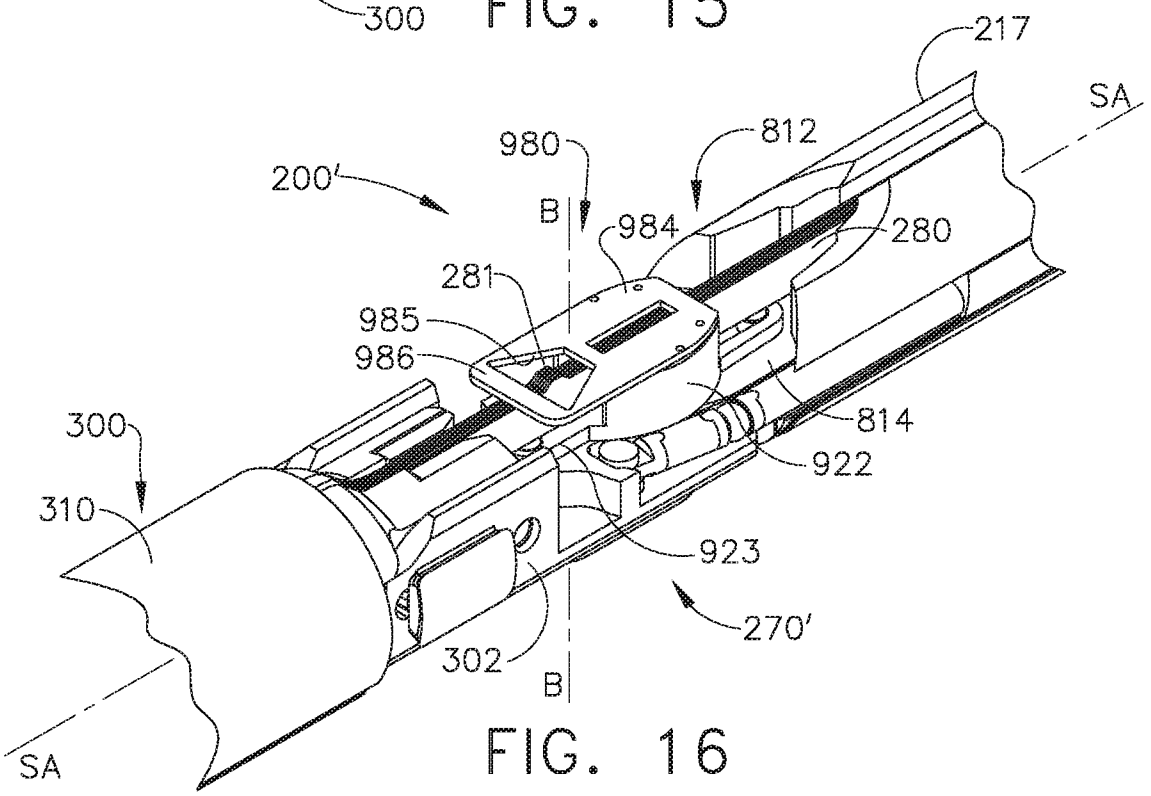

217
SA
812
980
200'
B
984
280
281
985
986
814
922
300
310
923
270'
302
B
SA

FIG. 16

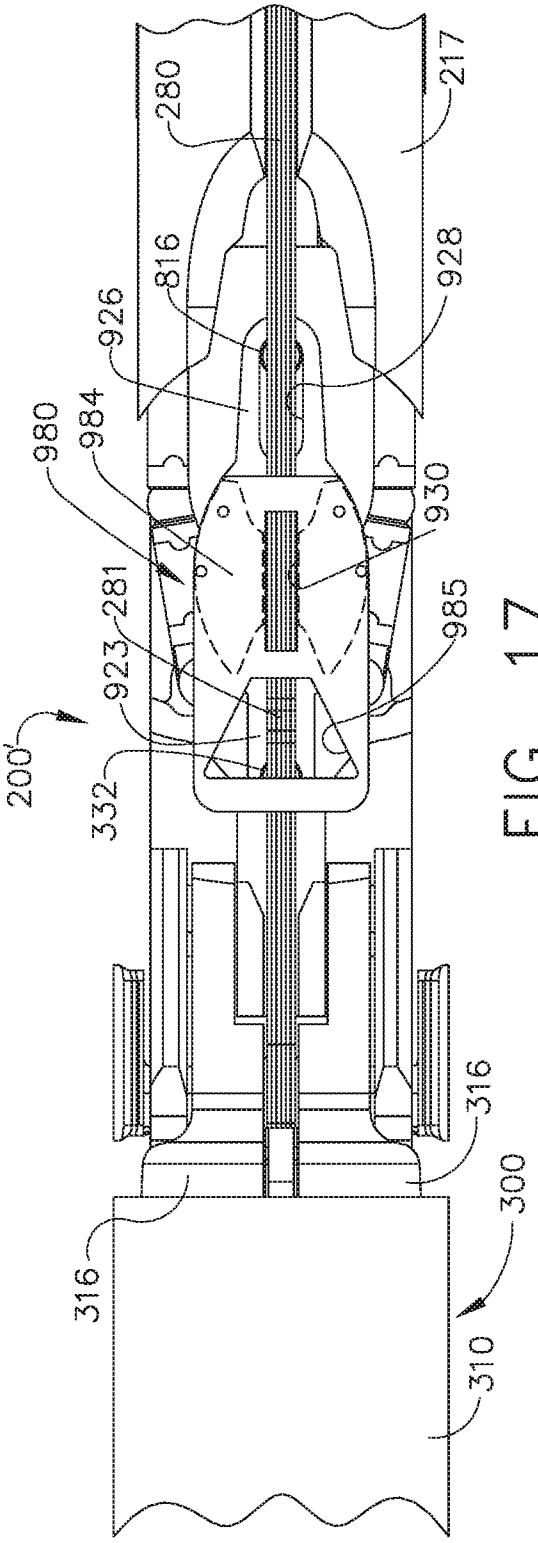

200'
280
217
816
928
926
980
984
930
281
923
985
332
316
316
300
310

FIG. 17

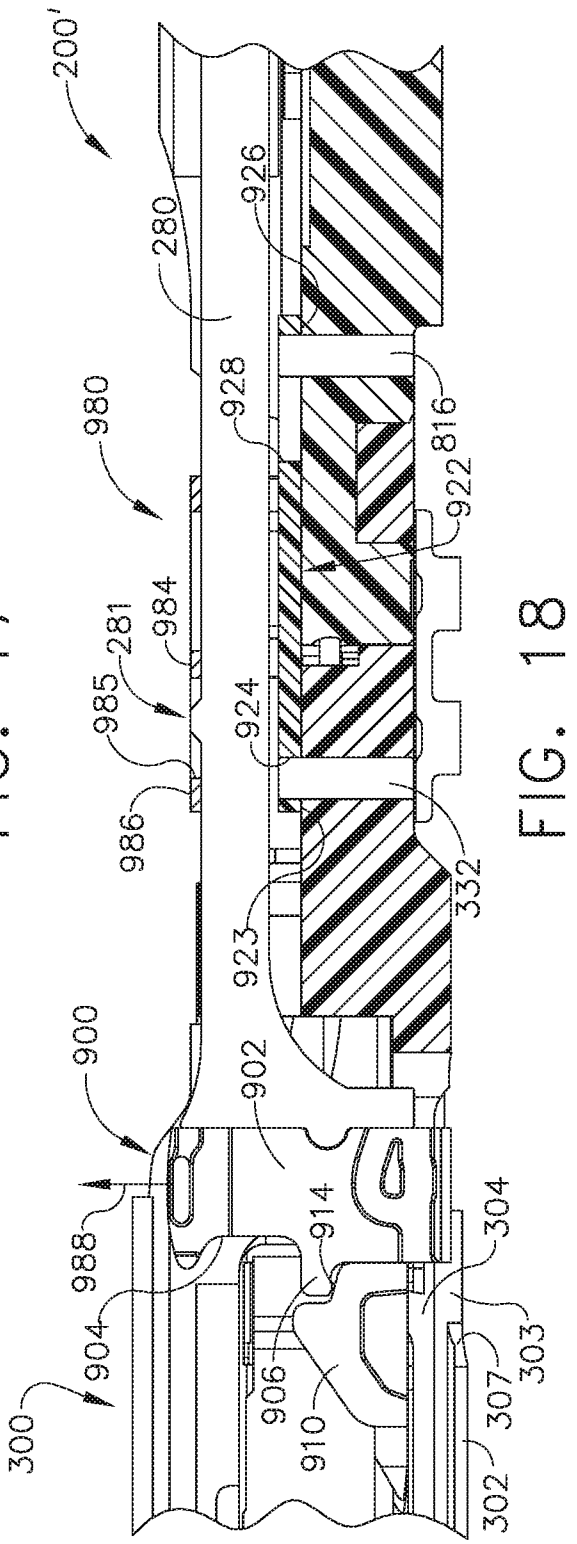

200'
280
926
928
816
980
922
984
281
985
924
986
332
923
900
902
988
914
304
904
906
303
307
910
300
302

FIG. 18

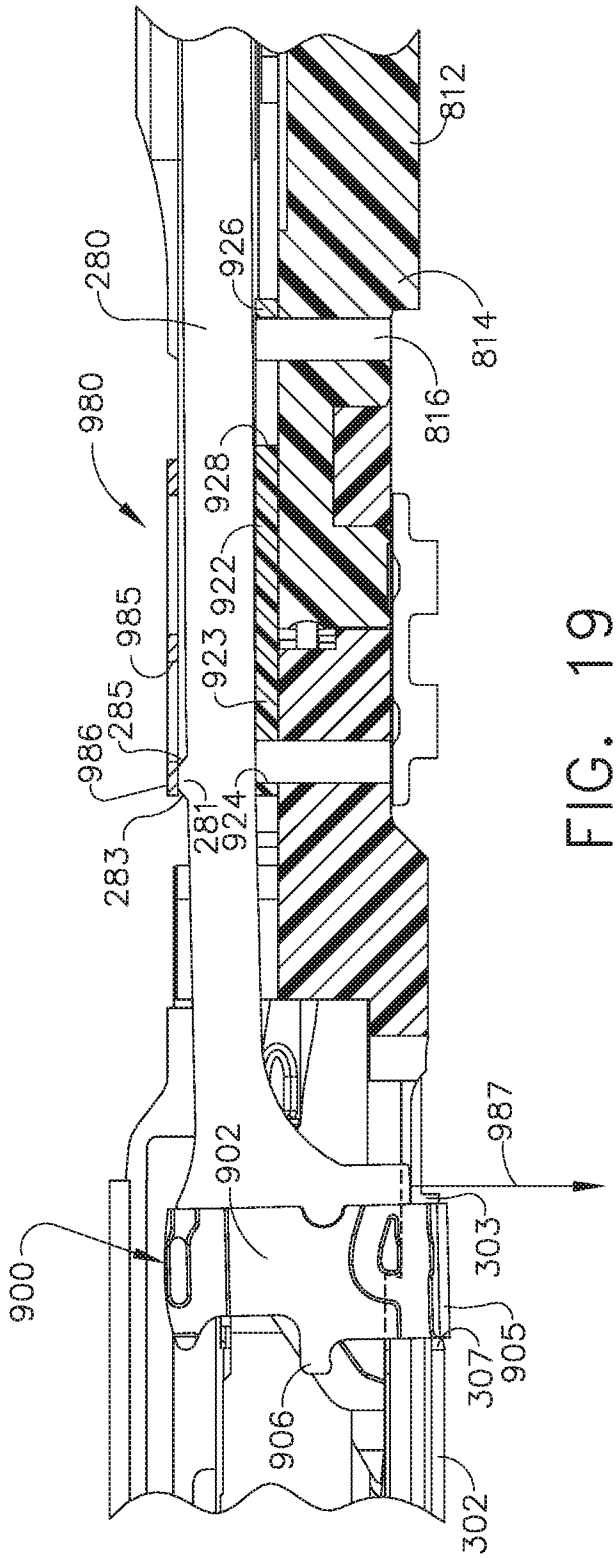

200'
280
926
812
814
816
980
928
922
923
985
285
986
281
924
283
987
902
900
303
905
307
906
302

FIG. 19

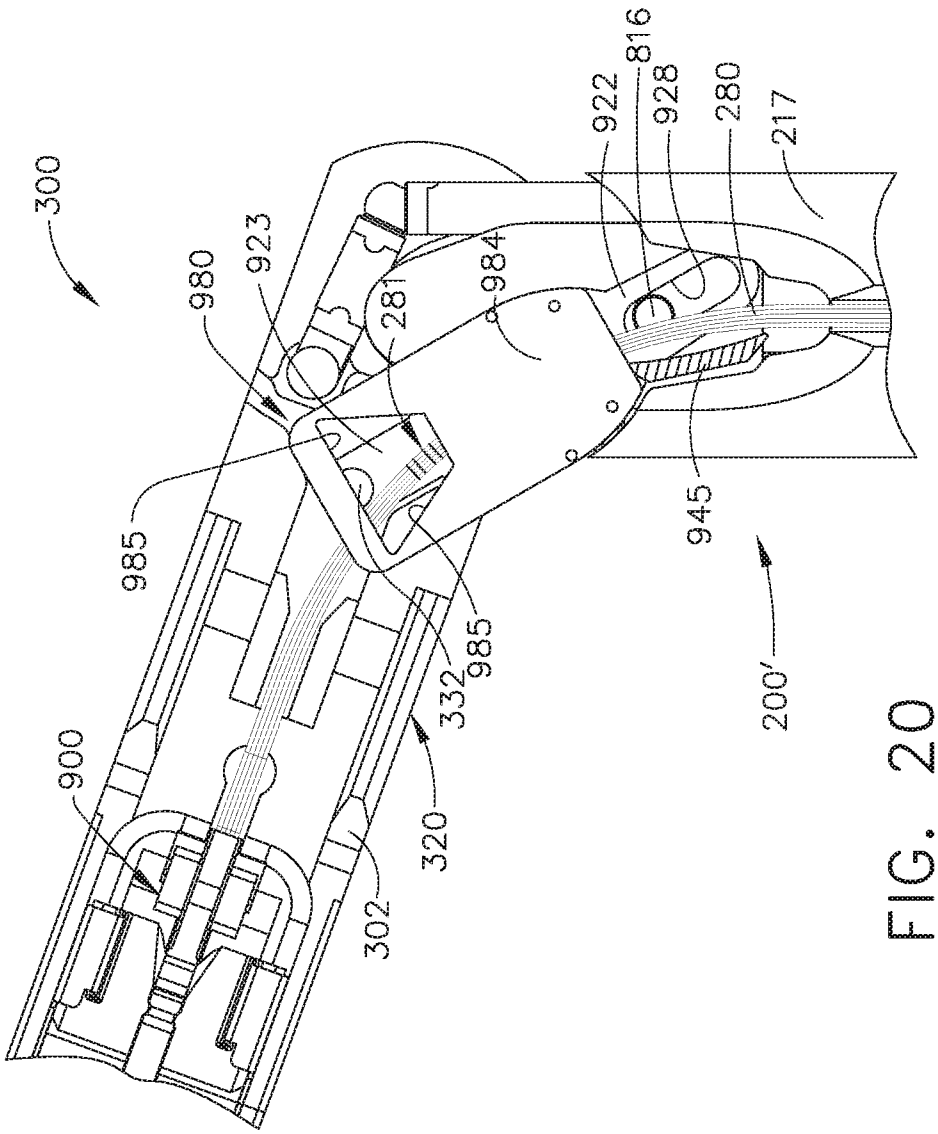

300
980
923
281
984
922
816
928
280
217
985
985
945
200'
900
332
320
302

FIG. 20

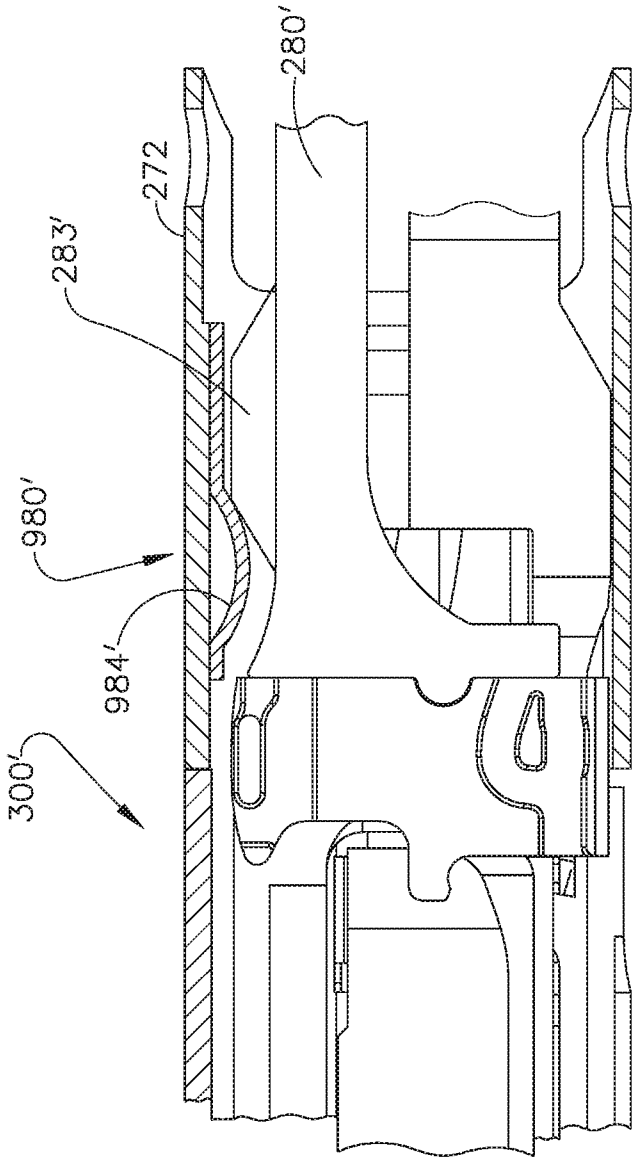


FIG. 20A

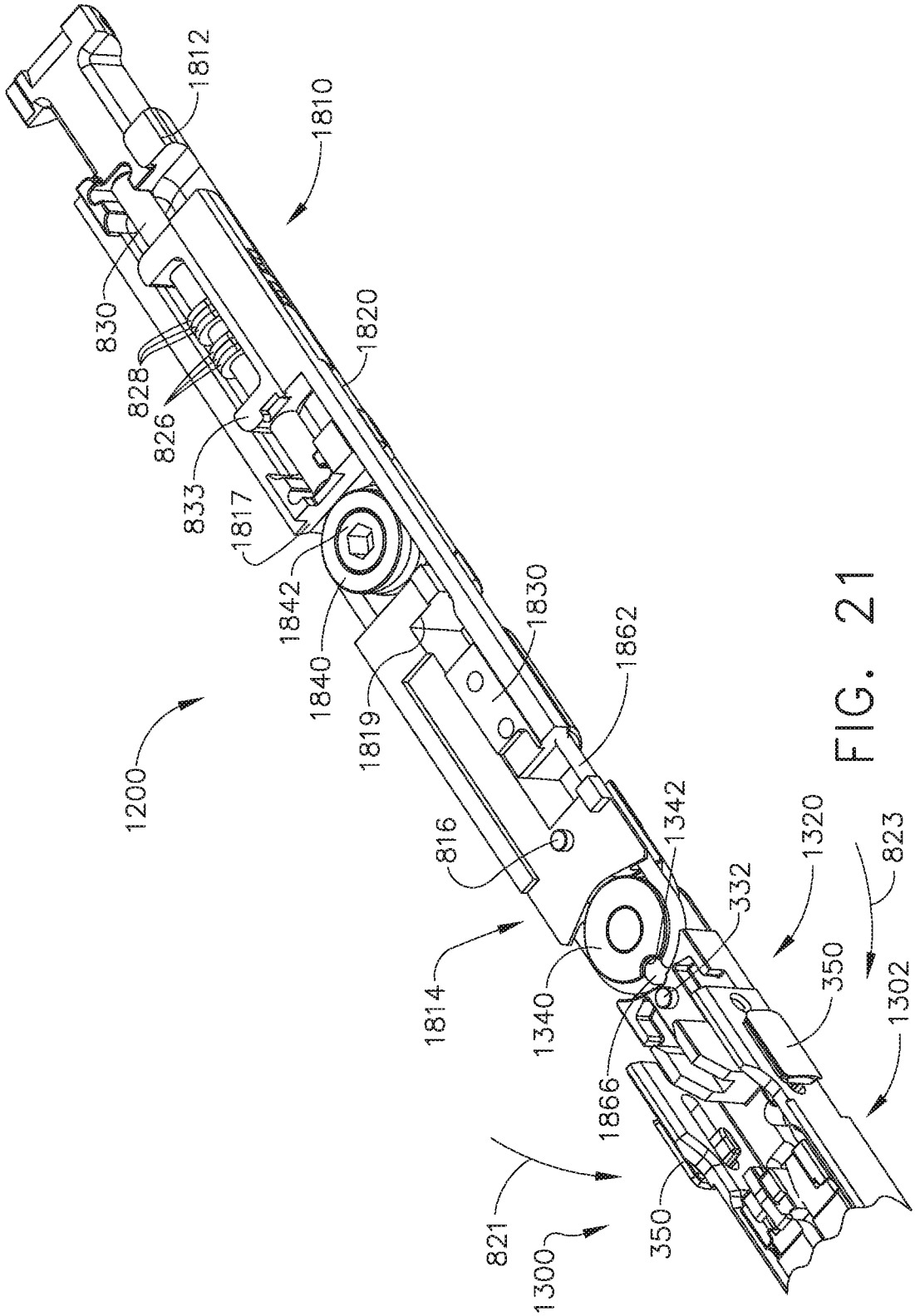

1812
1810
830
828
826
833
1817
1820
1842
1840
1819
1830
1862
1200
816
1342
1320
823
332
1814
1340
350
1302
1866
821
1300
350

FIG. 21

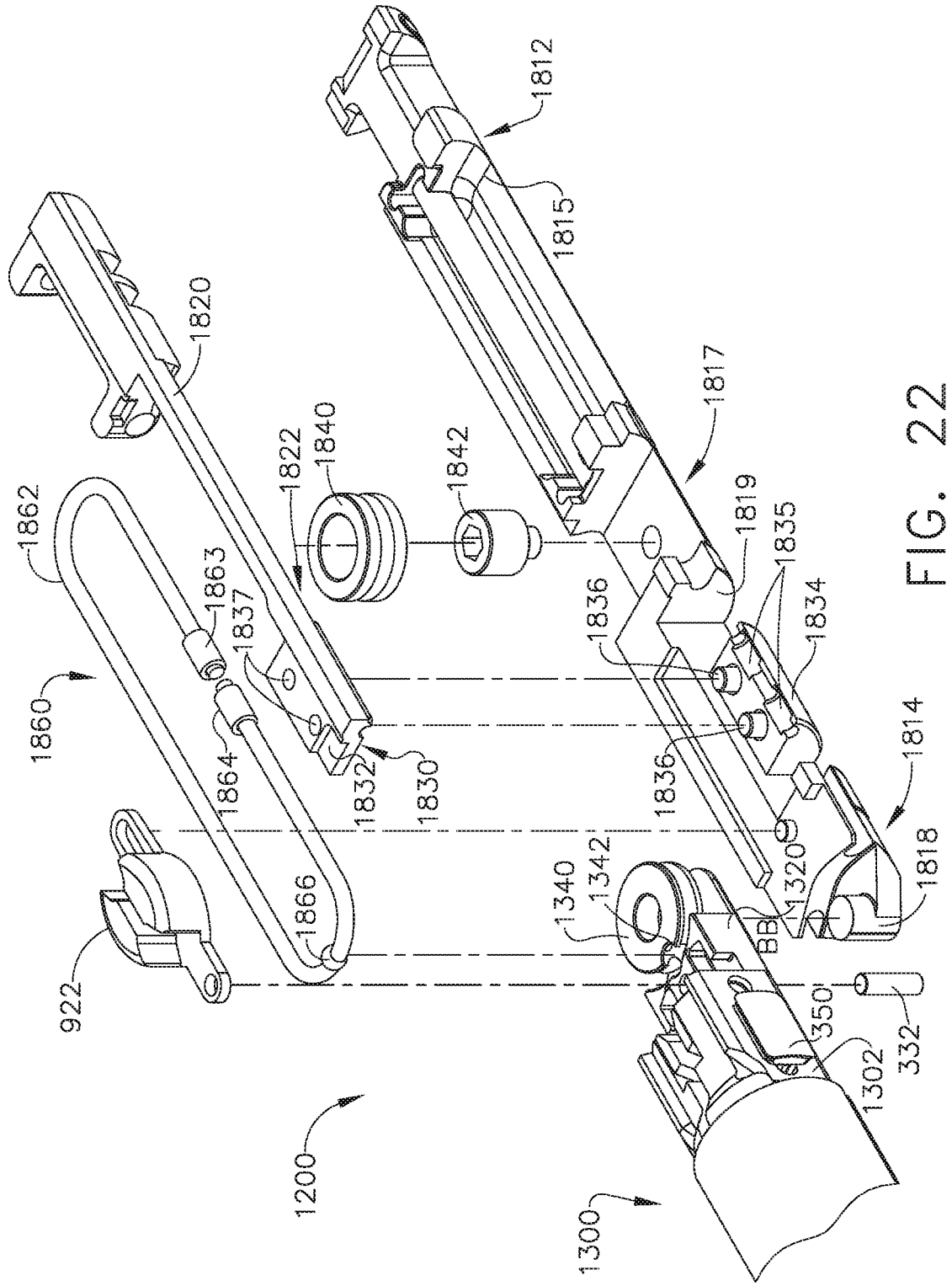

1812
1815
1820
1817
1822
1840
1842
1819
1835
1862
1863
1837
1836
1834
1860
1864
1832
1830
1836
1814
1866
1340
1342
1320
1818
922
BB
350
332
1302
1200
1300

FIG. 22

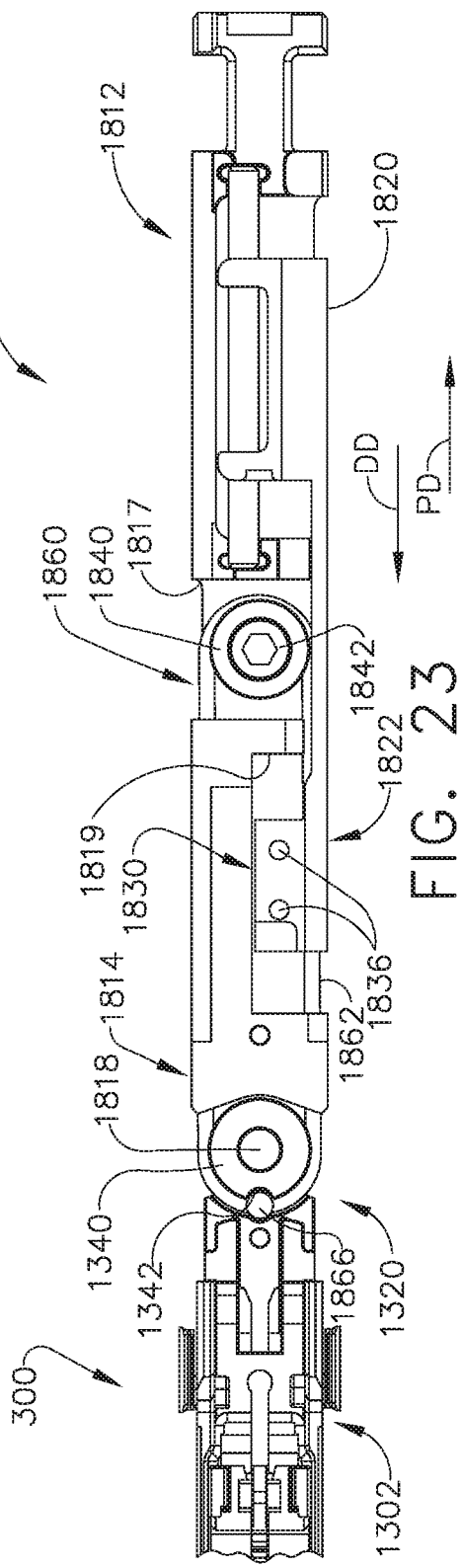

1200
1812
1820
DD
PD
1860
1840
1817
1842
1822
1819
1830
1836
1862
1814
1818
1340
1342
1866
1320
300
1302

FIG. 23

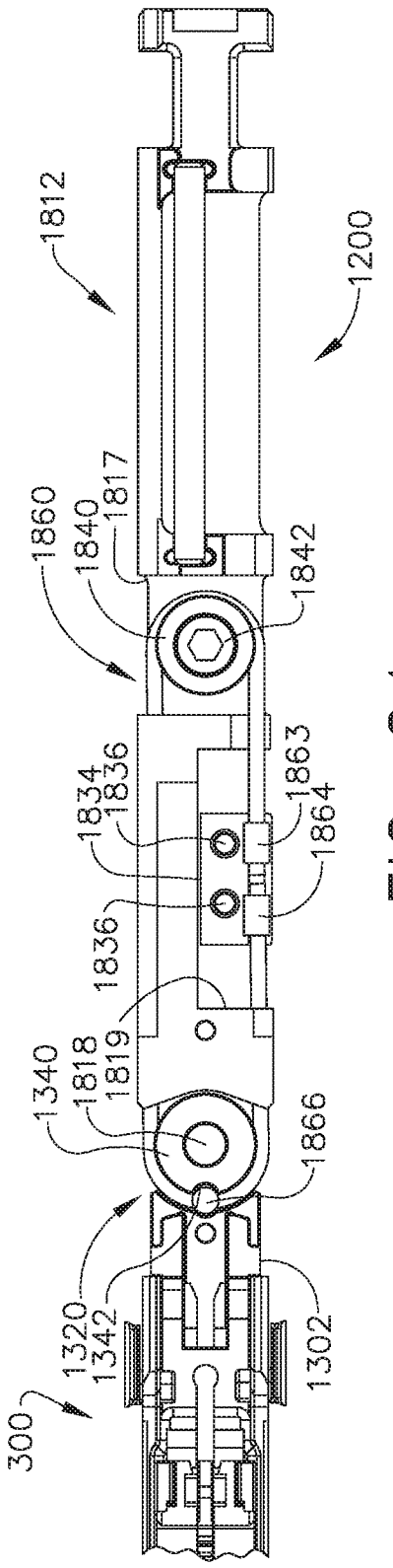

1812
1200
1860
1840
1817
1842
1834
1836
1863
1864
1836
1340
1818
1819
1866
1320
1342
1302
300

FIG. 24

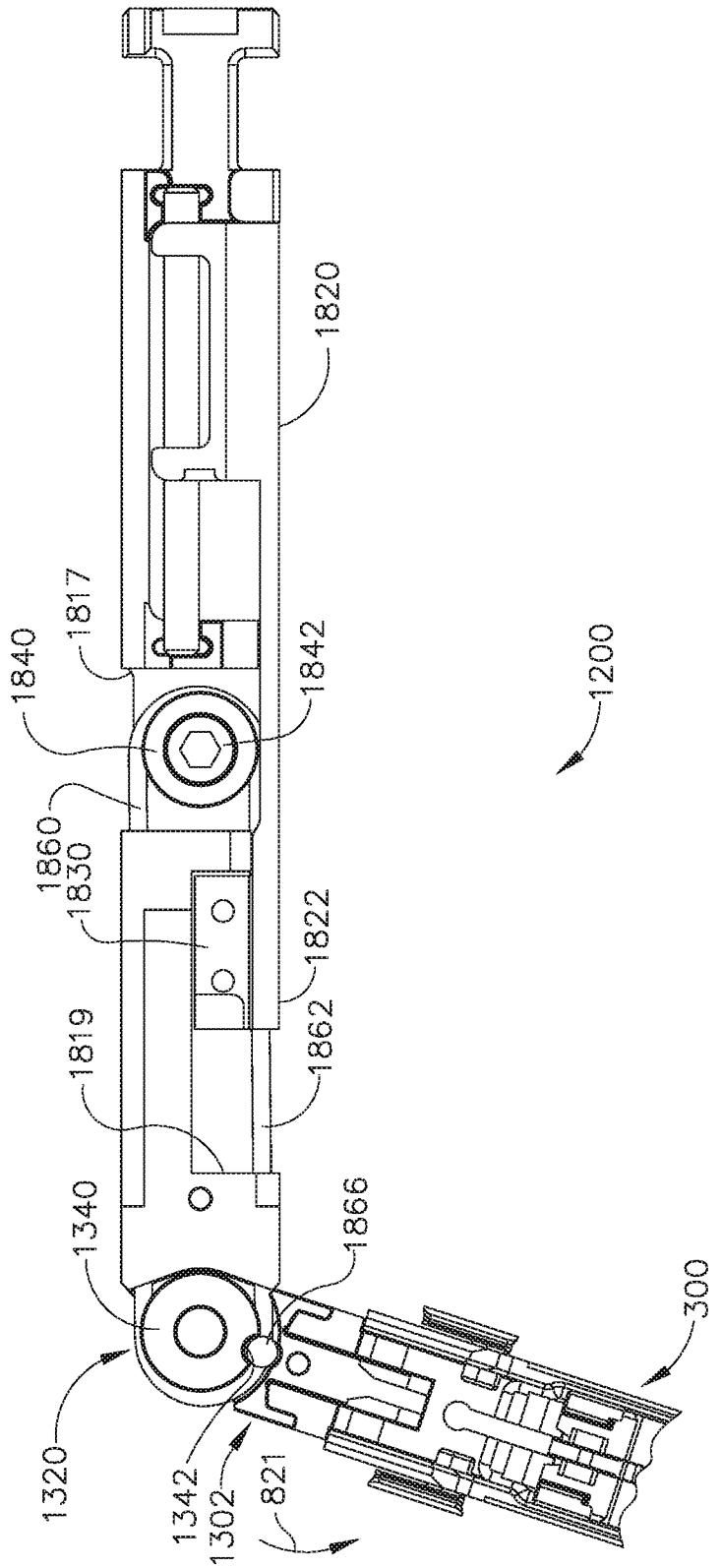

1200
1820
1817
1840
1842
1860
1830
1822
1819
1862
1340
1866
300
1320
1342
1302
821

FIG. 25

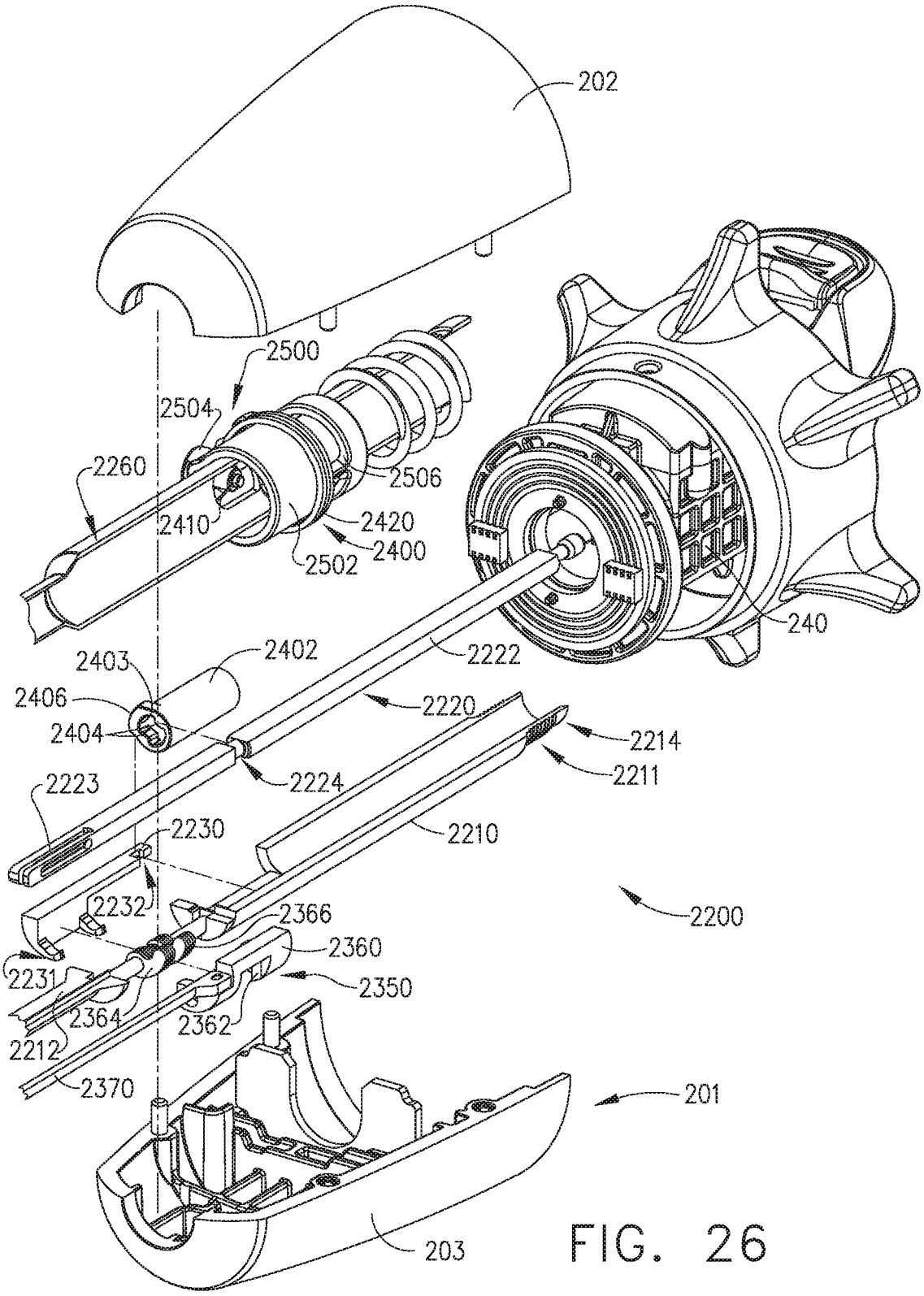

202
2500
2504
2260
2506
2410
2420
2400
2502
240
2403
2402
2222
2406
2220
2214
2404
2211
2224
2223
2230
2210
2232
2366
2200
2360
2231
2350
2364
2362
2212
2370
201
203

FIG. 26

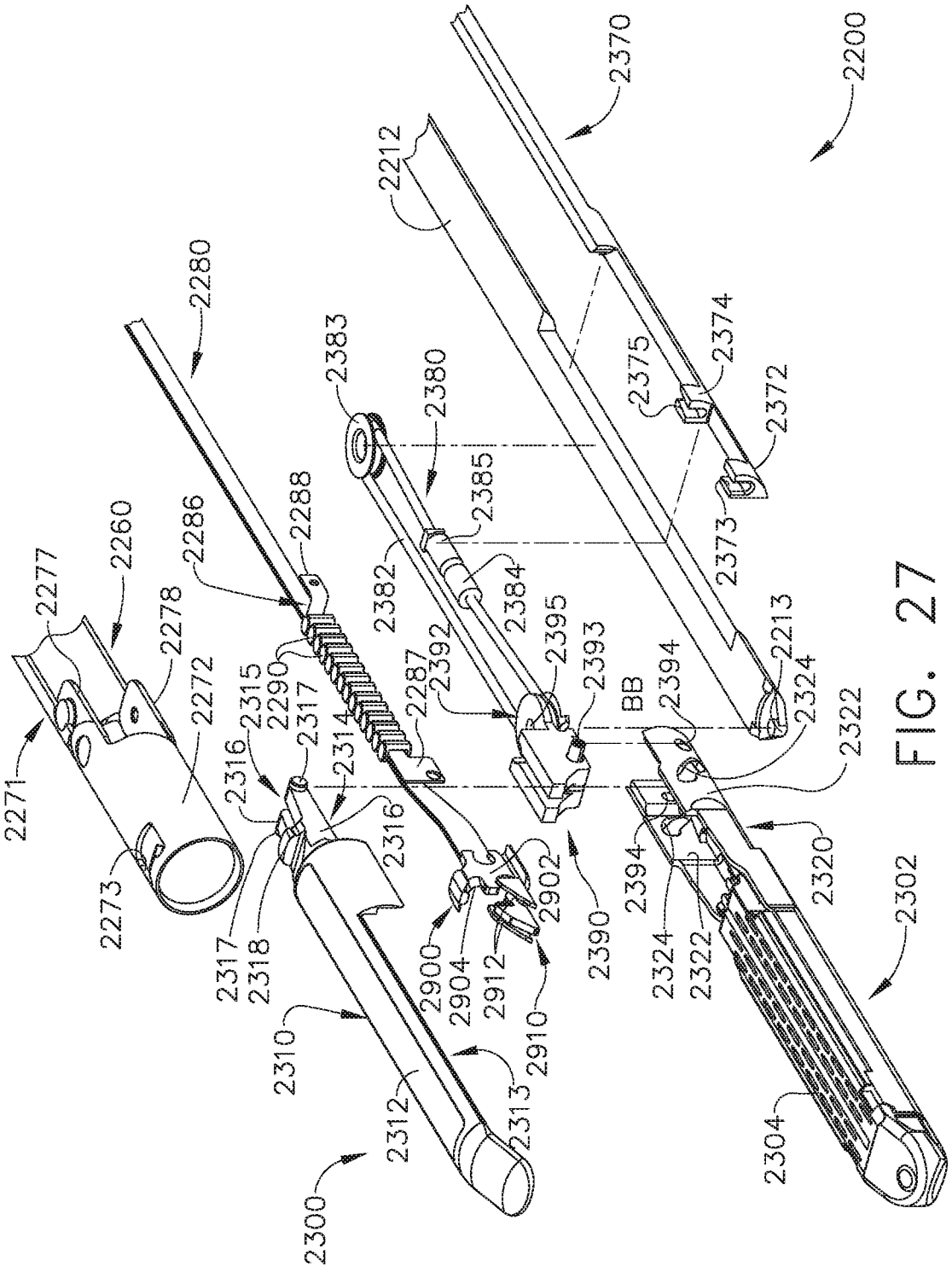

2200
2370
2212
2280
2383
2380
2375
2374
2372
2373
2385
2382
2384
2395
2393
2392
2287
2394
2213
2324
2322
2320
2302
2304
2260
2277
2278
2272
2286
2288
2290
2315
2317
2314
2316
2271
2273
2317
2318
2310
2312
2300
2313
2910
2912
2904
2900
2902
2390
BB

FIG. 27

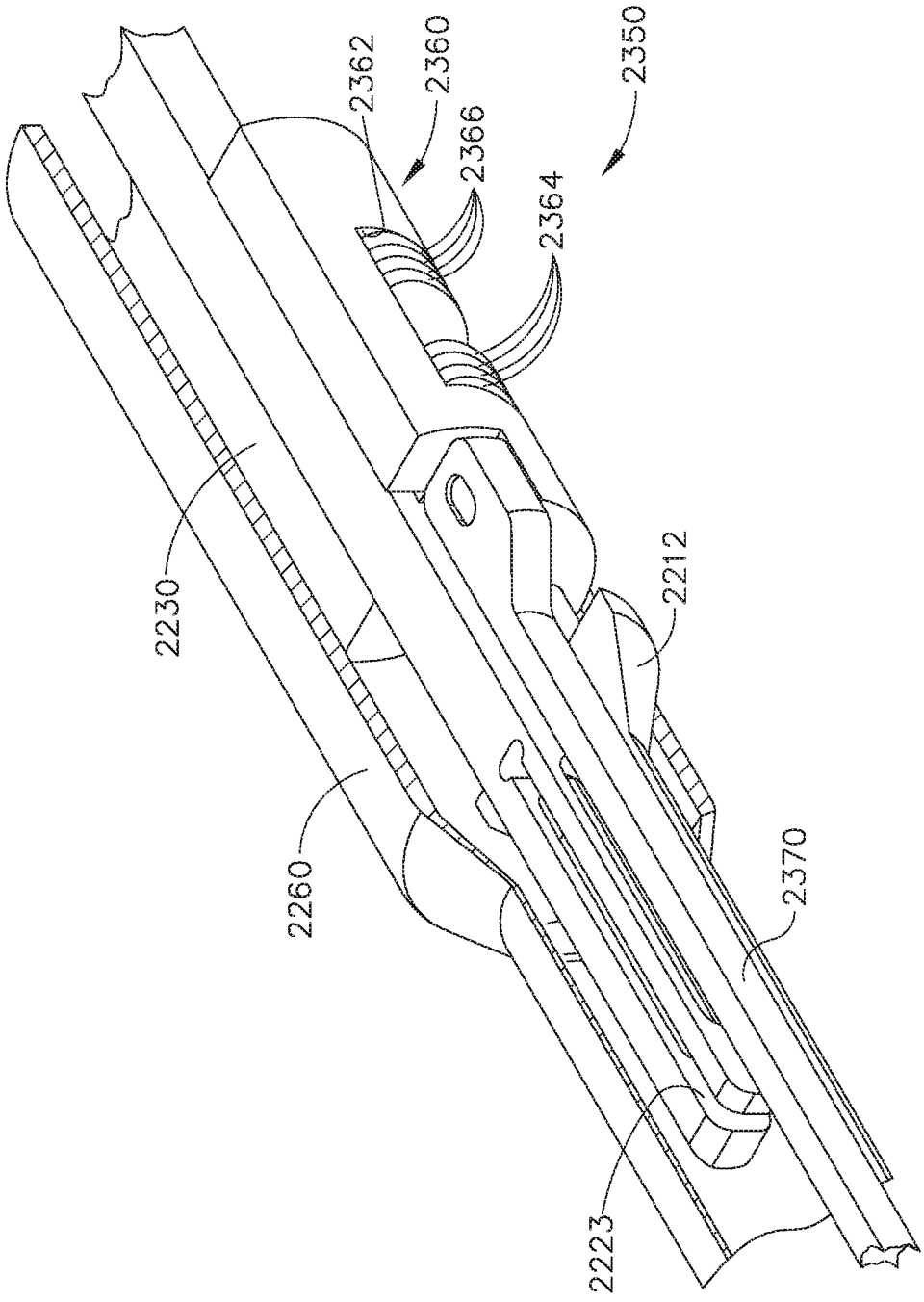


FIG. 28

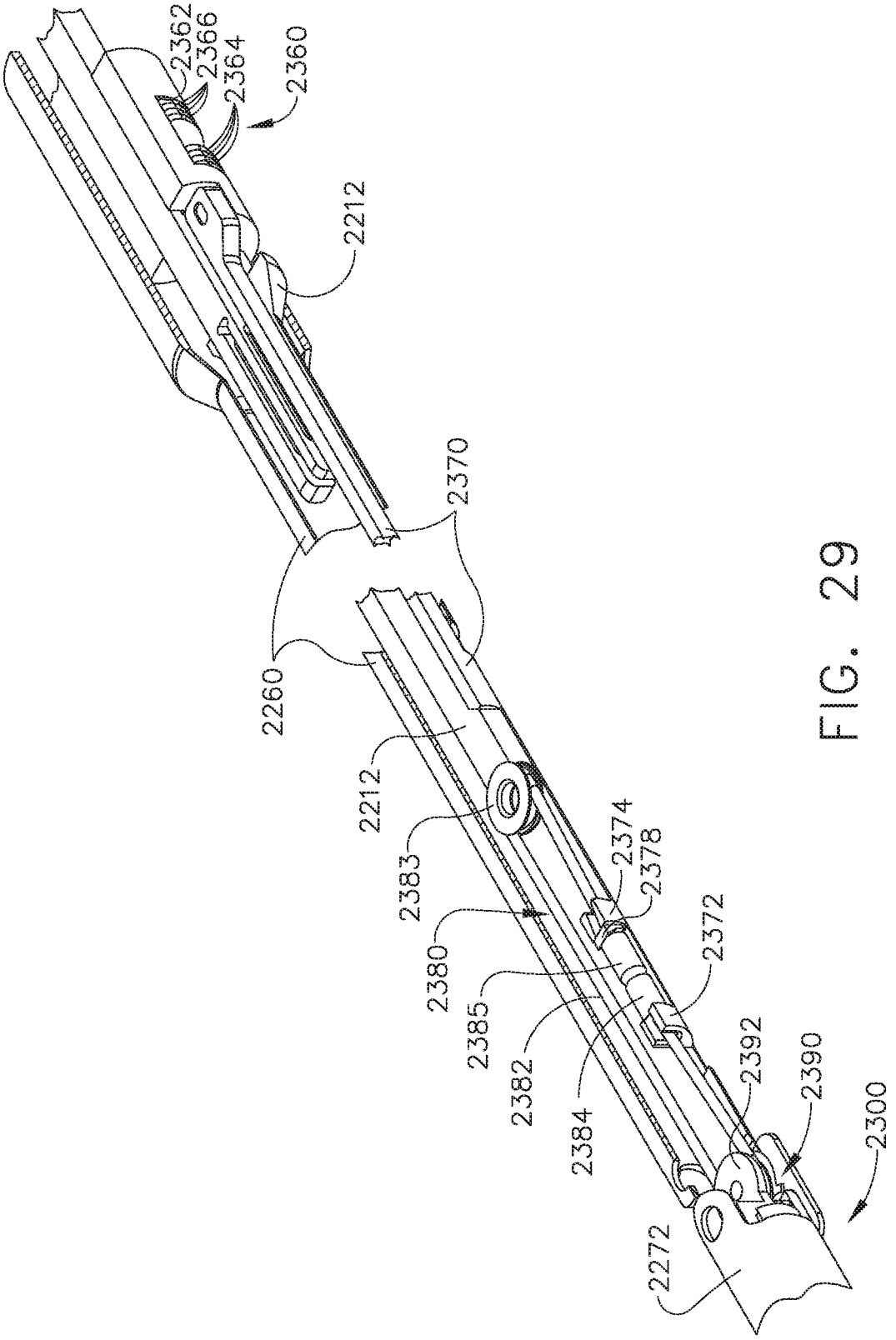

2362
2366
2364
2360
2212
2370
2260
2212
2383
2374
2378
2380
2372
2385
2382
2392
2390
2384
2300
2272

FIG. 29

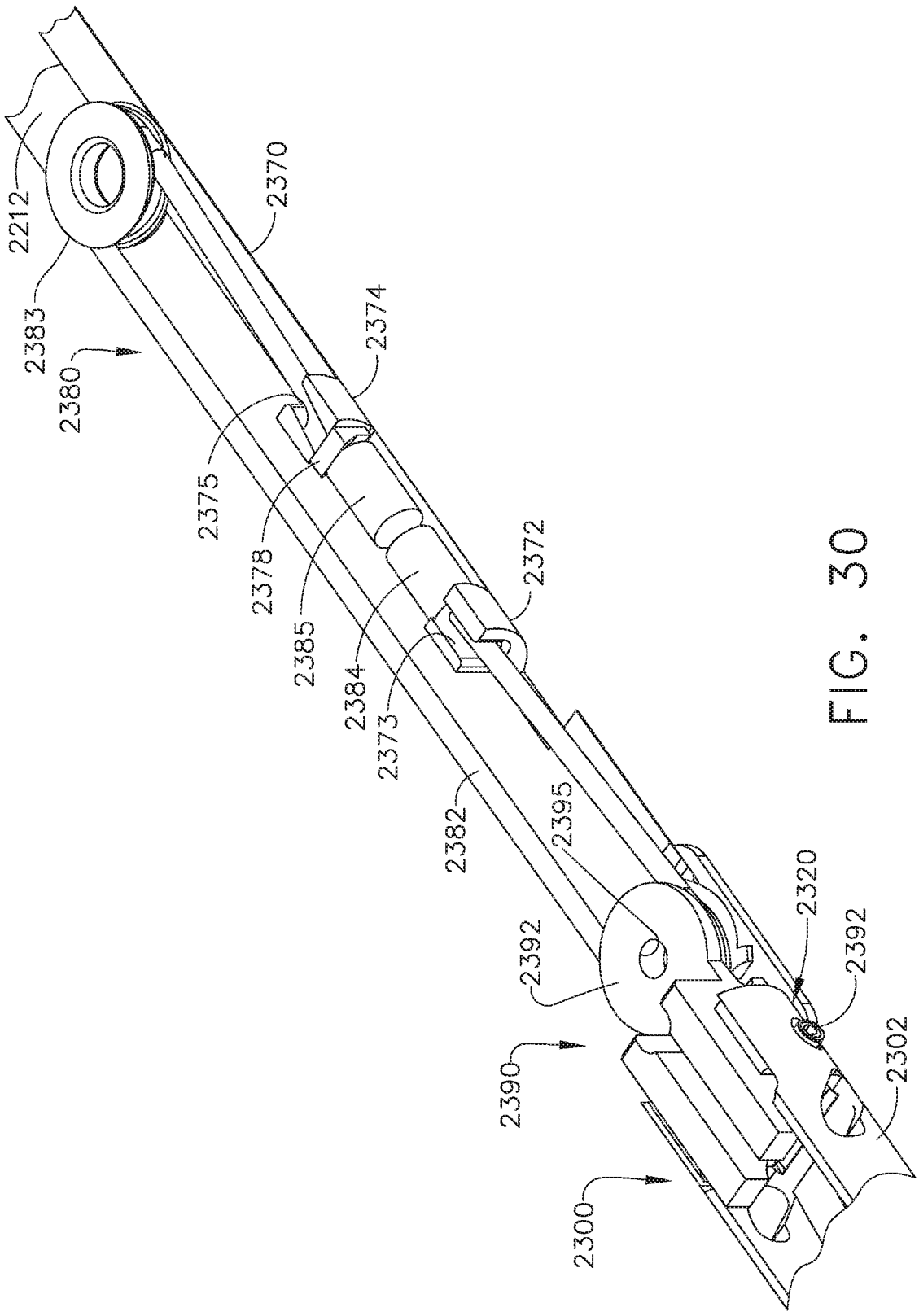

2212
2370
2383
2374
2380
2375
2378
2372
2385
2384
2373
2382
2395
2320
2392
2392
2390
2302
2300

FIG. 30

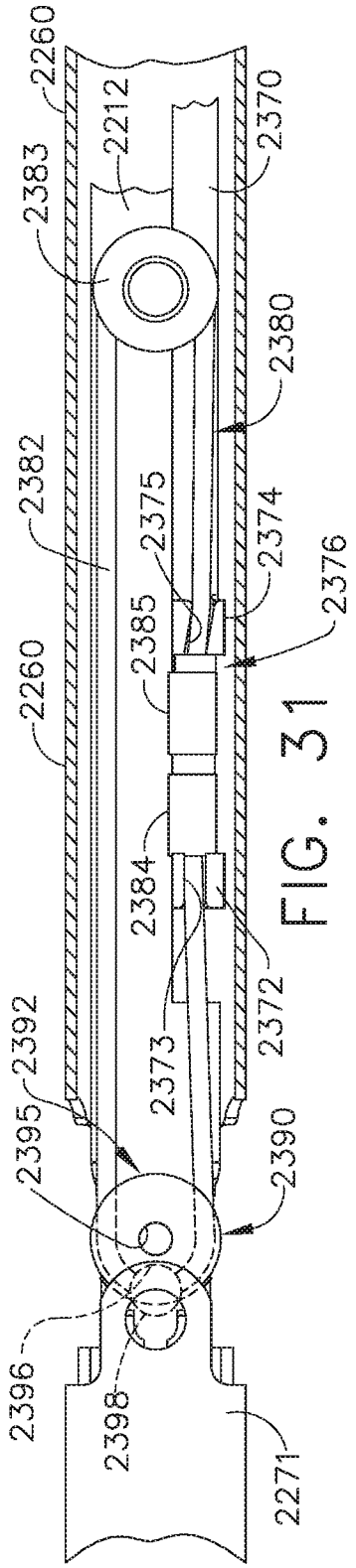

2260
2212
2370
2383
2380
2382
2375
2374
2376
2385
2384
2372
2373
2392
2395
2390
2396
2398
2271

FIG. 31

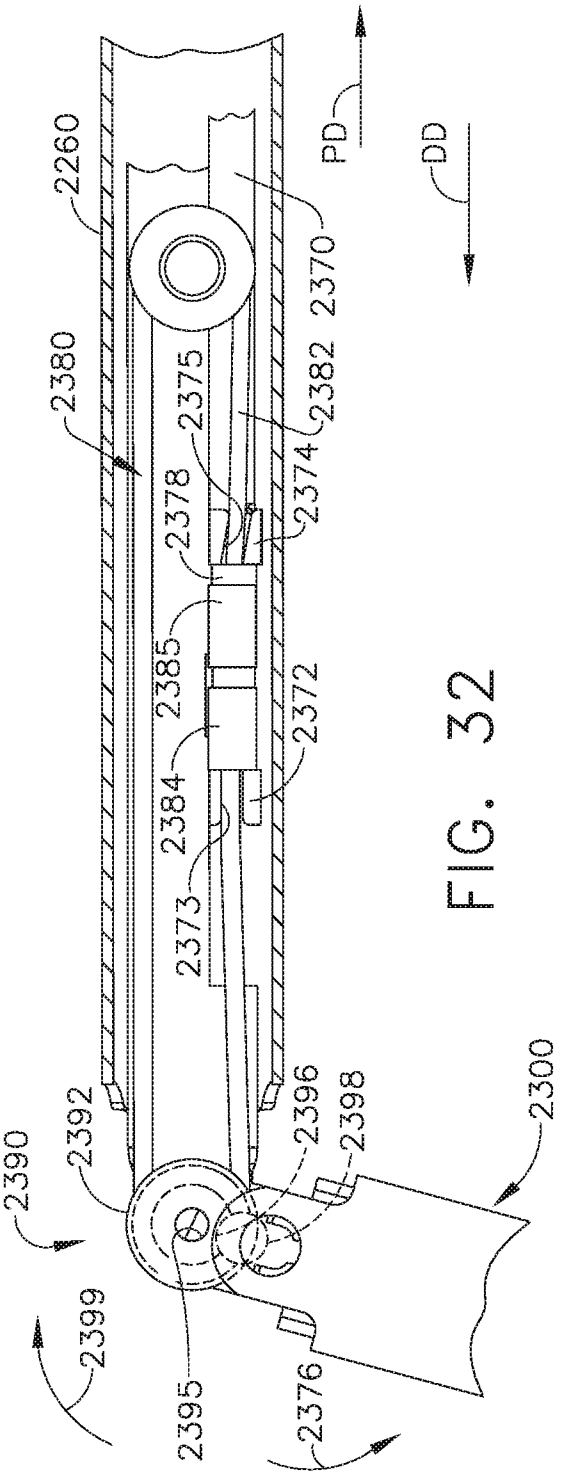

2260
PD
DD
2370
2380
2382
2375
2374
2378
2385
2372
2384
2373
2390
2392
2396
2398
2300
2399
2395
2376

FIG. 32

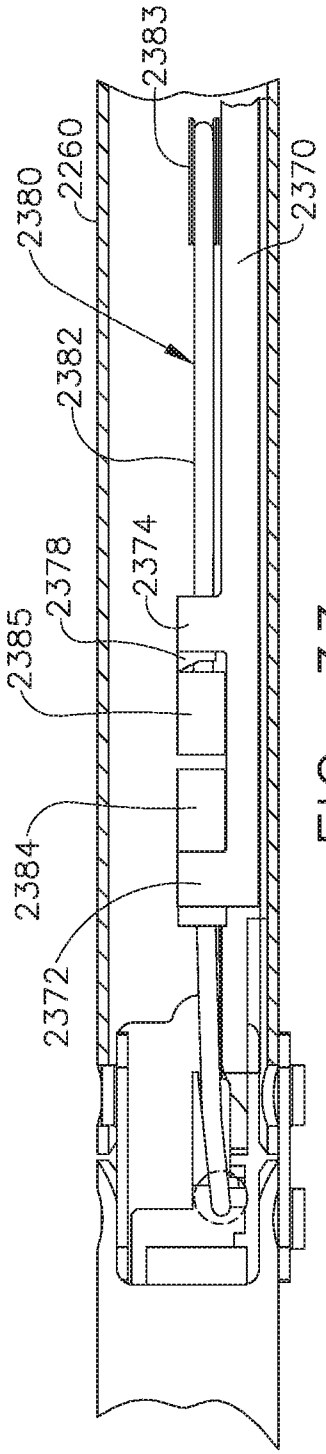

2383
2260
2380
2370
2382
2374
2378
2385
2384
2372

FIG. 33

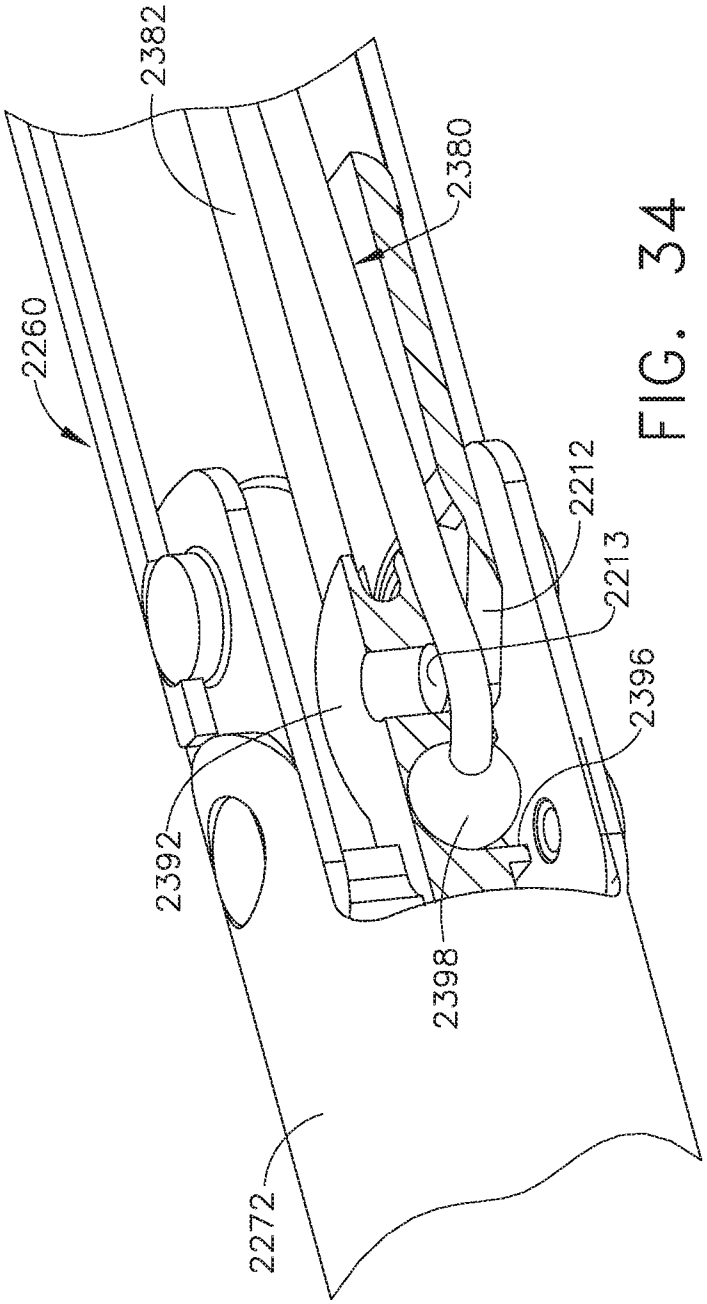

2382
2380
2260
2212
2213
2396
2392
2398
2272

FIG. 34

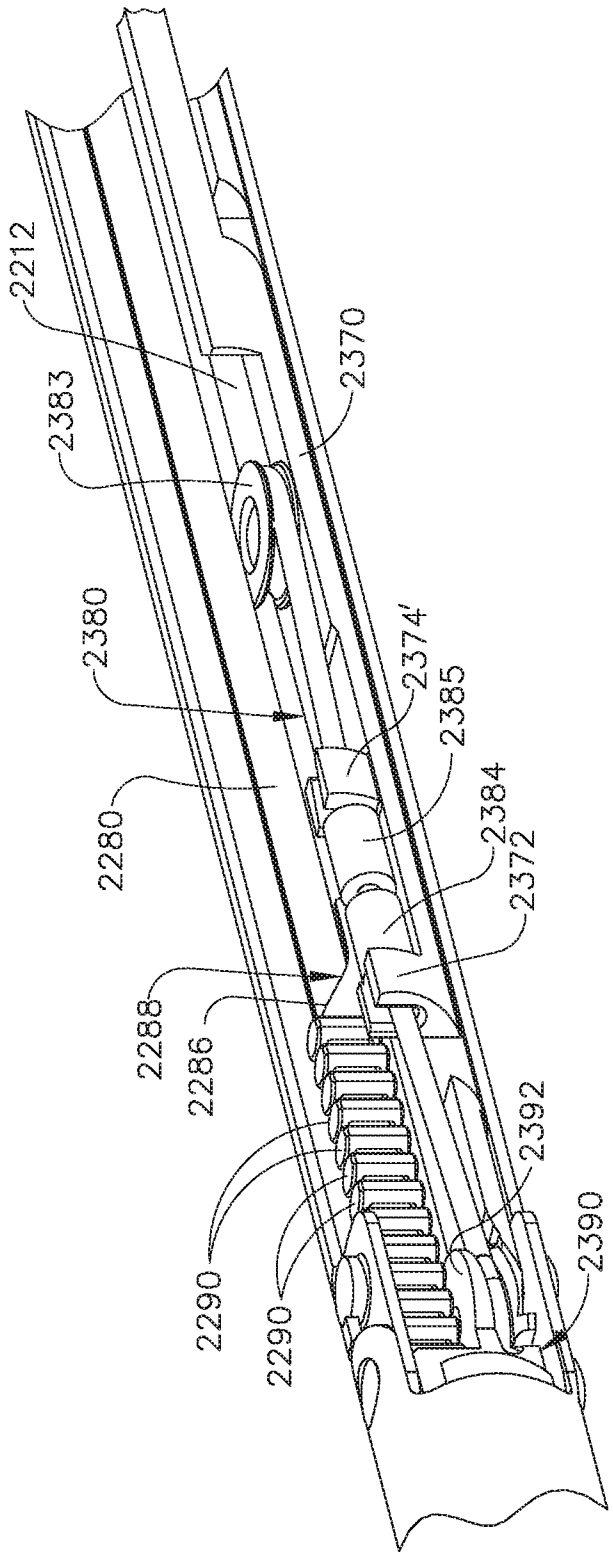

2212
2383
2370
2380
2374'
2385
2280
2384
2372
2288
2286
2392
2290
2290
2390

FIG. 35

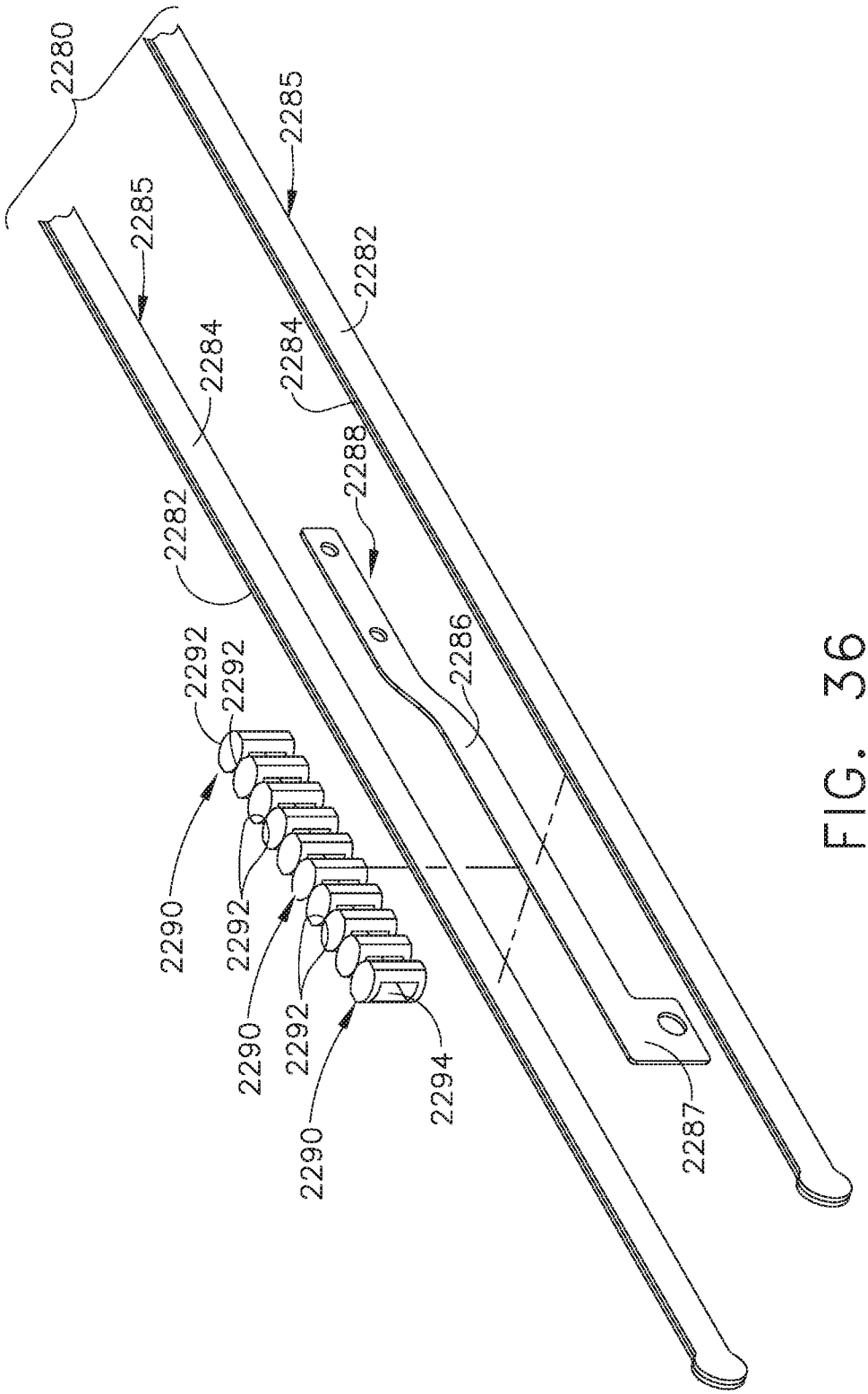

2280
2285
2285
2282
2284
2284
2288
2282
2292
2292
2286
2290
2292
2290
2292
2294
2290
2287

FIG. 36

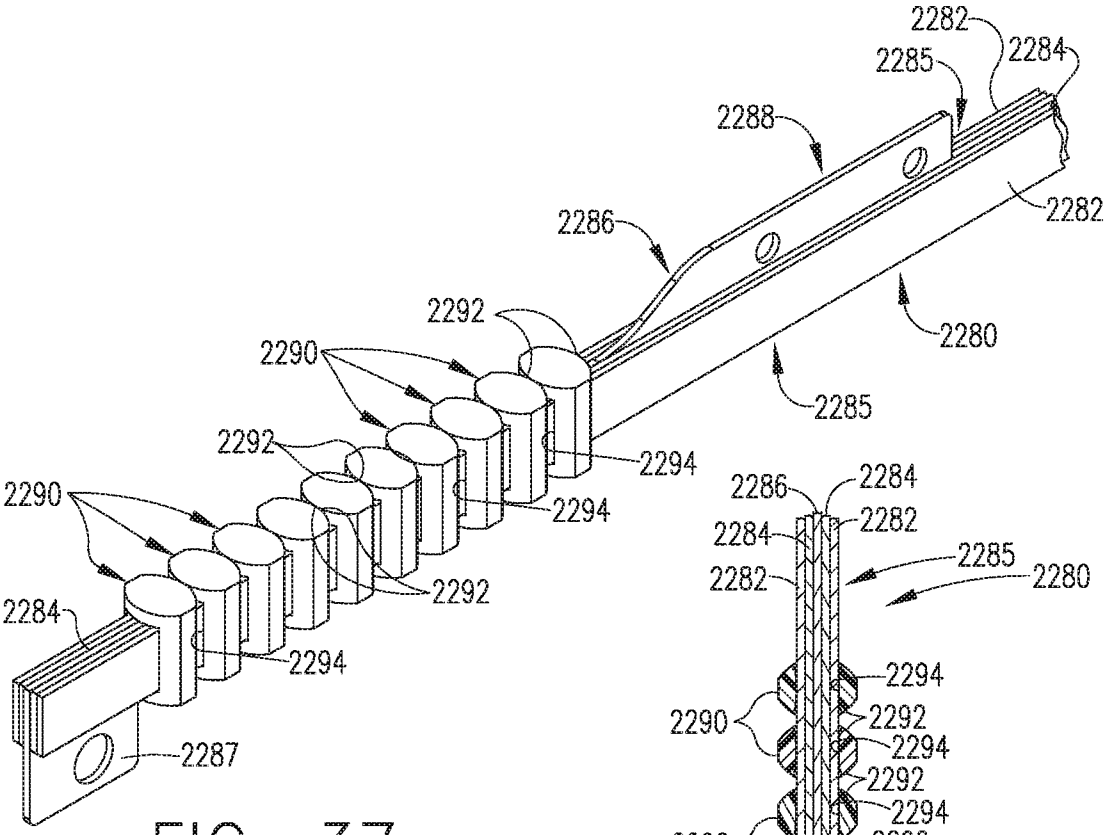


FIG. 37

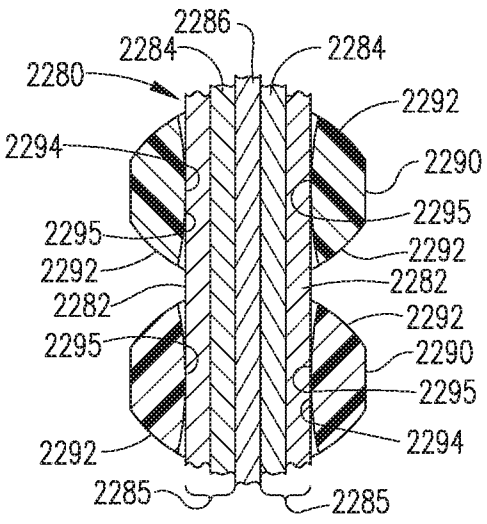


FIG. 38

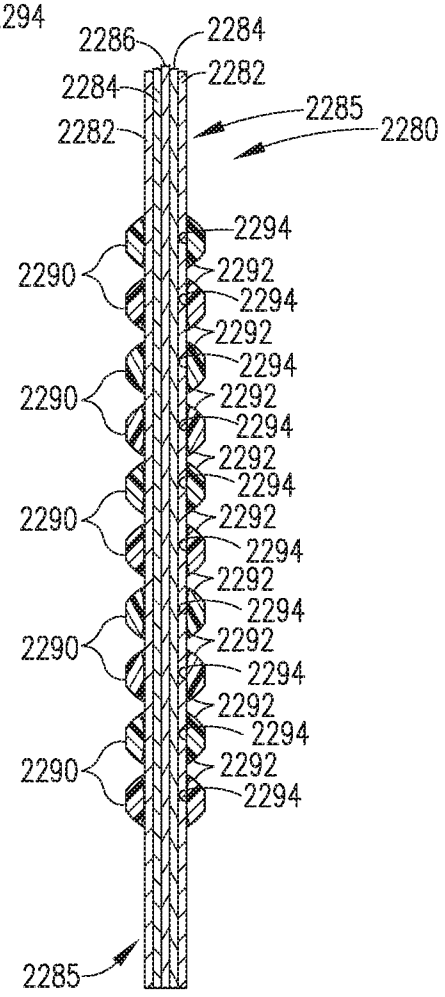


FIG. 39

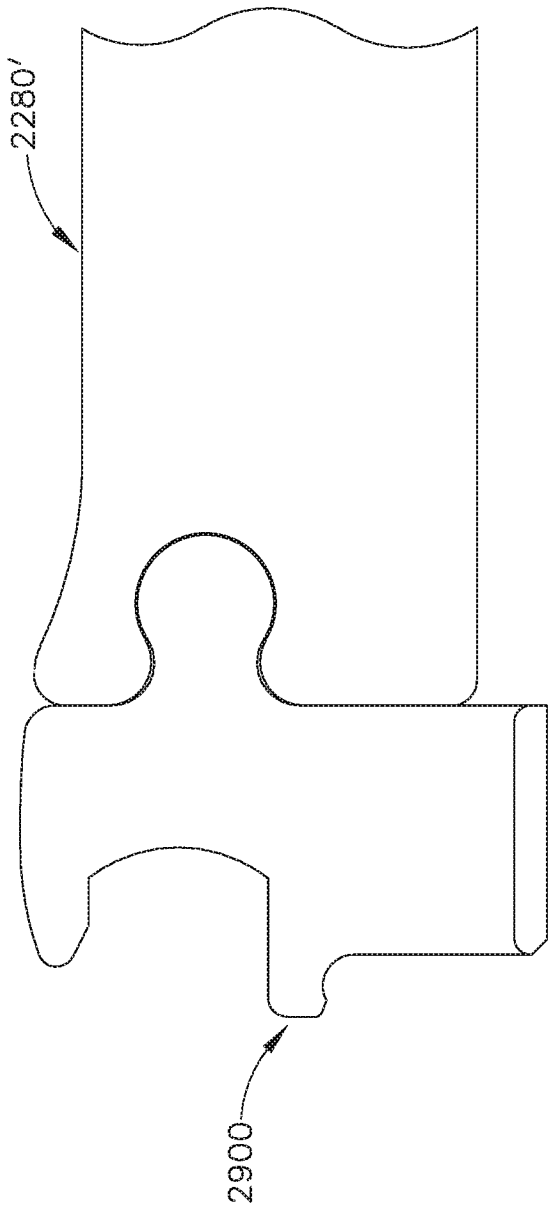


FIG. 40

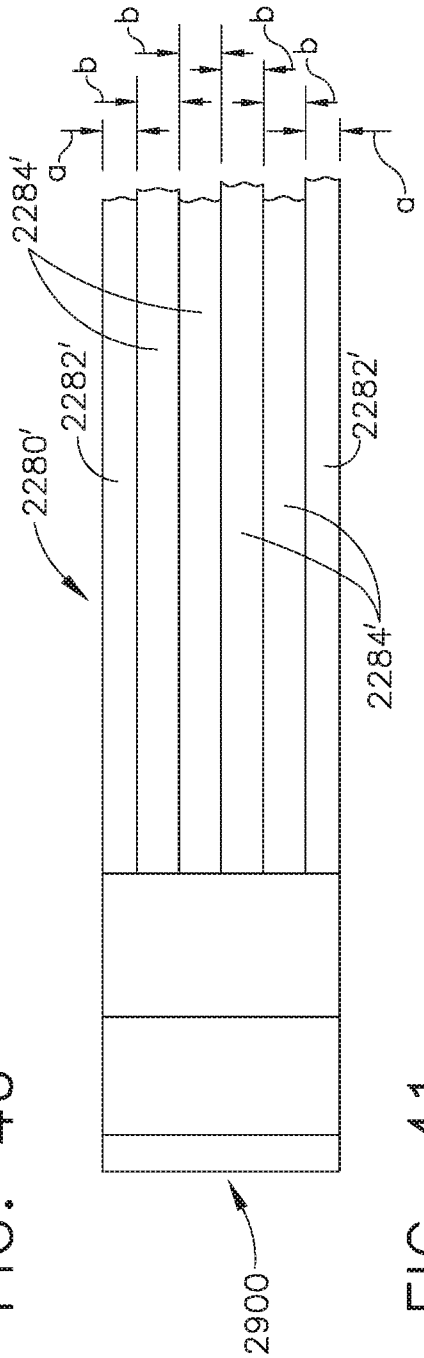


FIG. 41

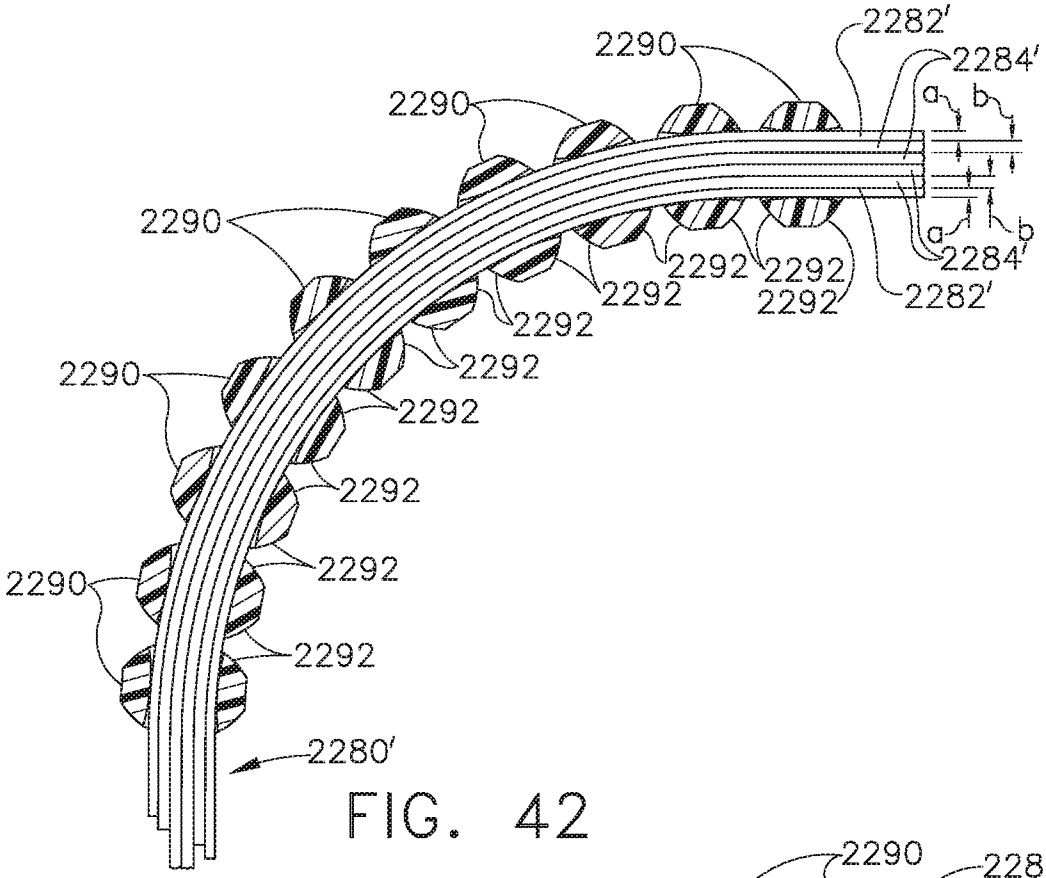

2282′
2290
2284′
a
b
2290
2290
a
b
2284′
2292
2292
2292
2292
2282′
2290
2292
2292
2292
2290
2292
2292
2290
2280′

FIG. 42

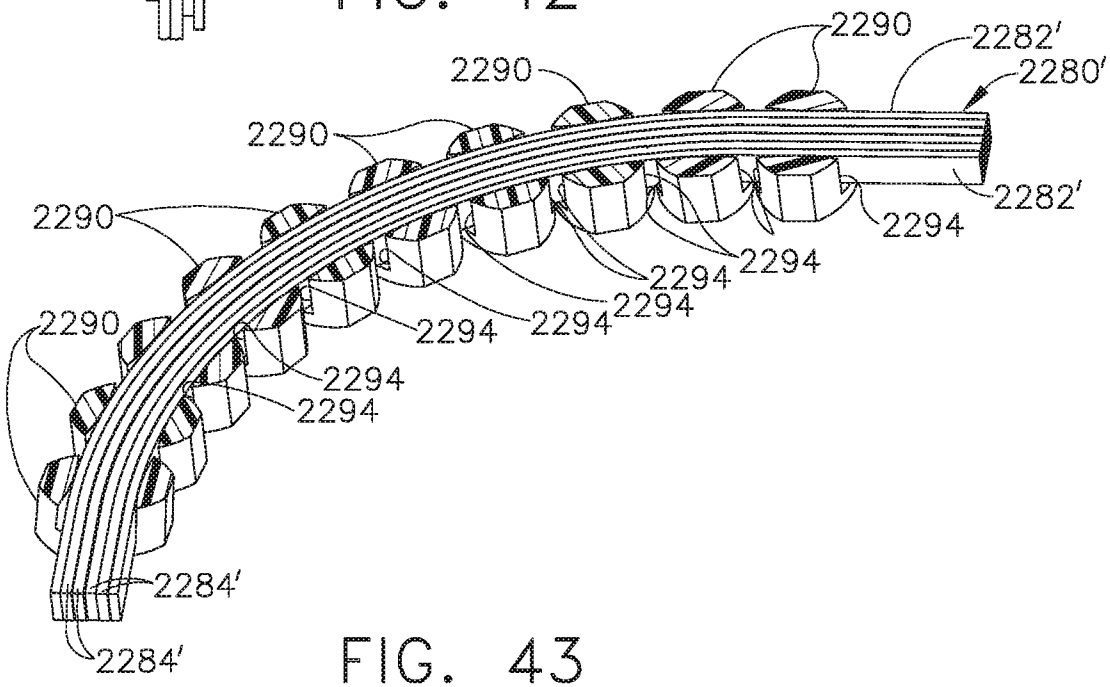

2290
2282′
2290
2280′
2290
2282′
2290
2294
2294
2294
2294
2294
2290
2294
2294
2294
2284′
2284′

FIG. 43

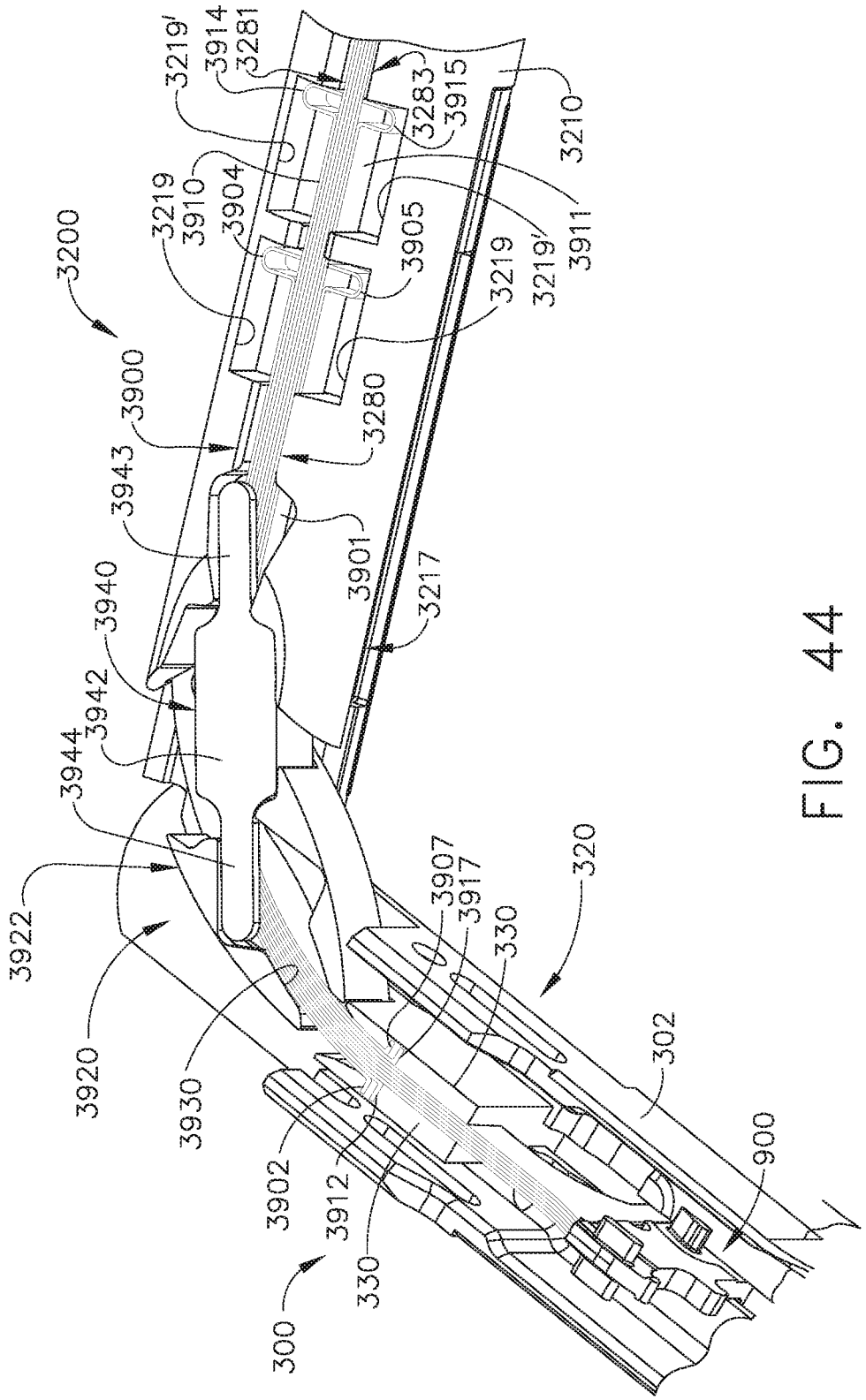

3219'
3914
3281
3283
3915
3210
3219
3910
3904
3905
3911
3219'
3219
3200
3900
3280
3943
3901
3217
3940
3942
3944
3922
3907
3917
320
330
3920
3930
302
3902
3912
900
330
300

FIG. 44

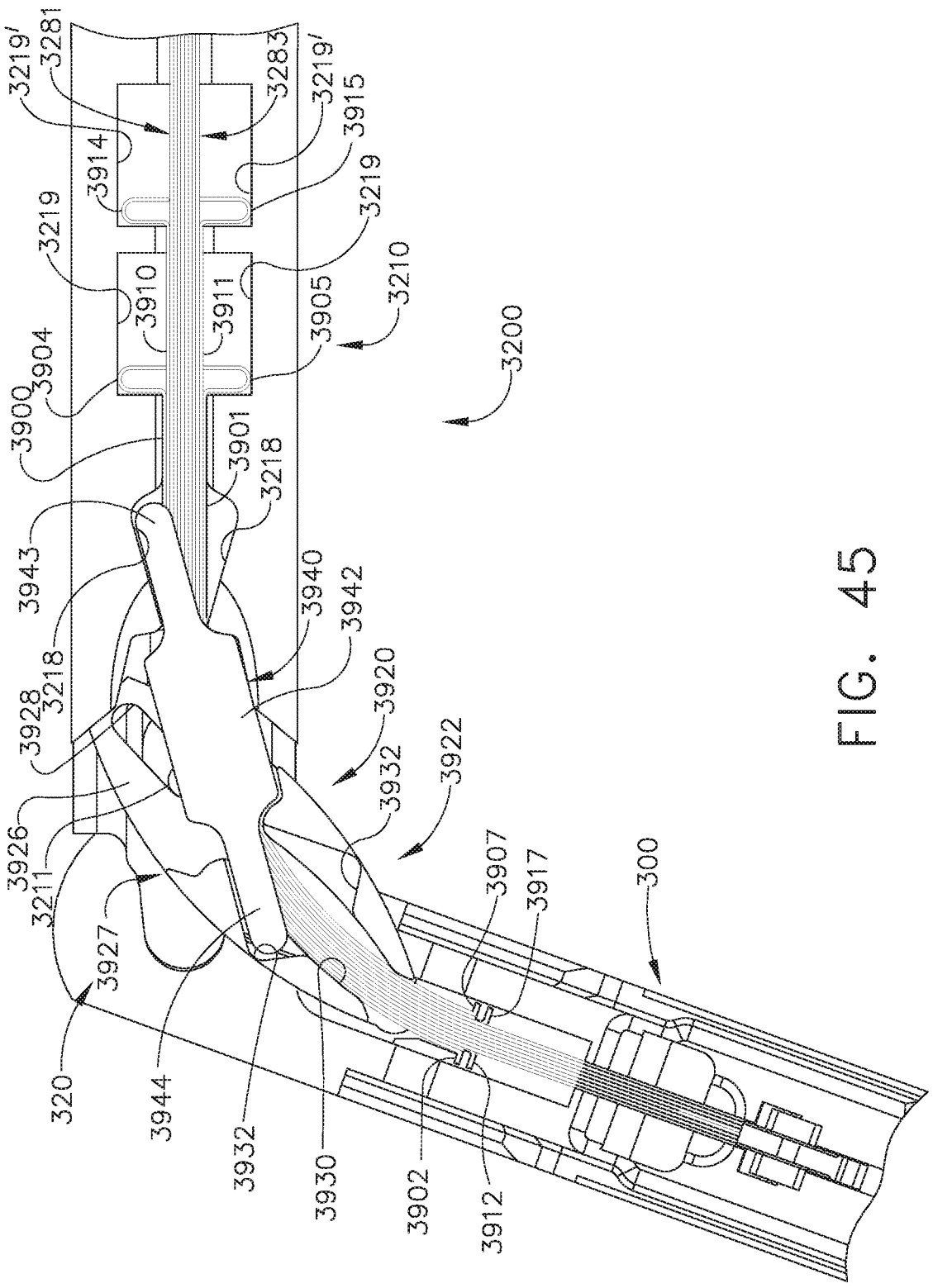

3219'
3281
3283
3219'
3915
3914
3219
3219
3910
3911
3905
3210
3904
3900
3200
3901
3218
3943
3940
3942
3218
3928
3920
3926
3932
3922
3211
3907
3917
300
3927
320
3944
3932
3930
3902
3912

FIG. 45

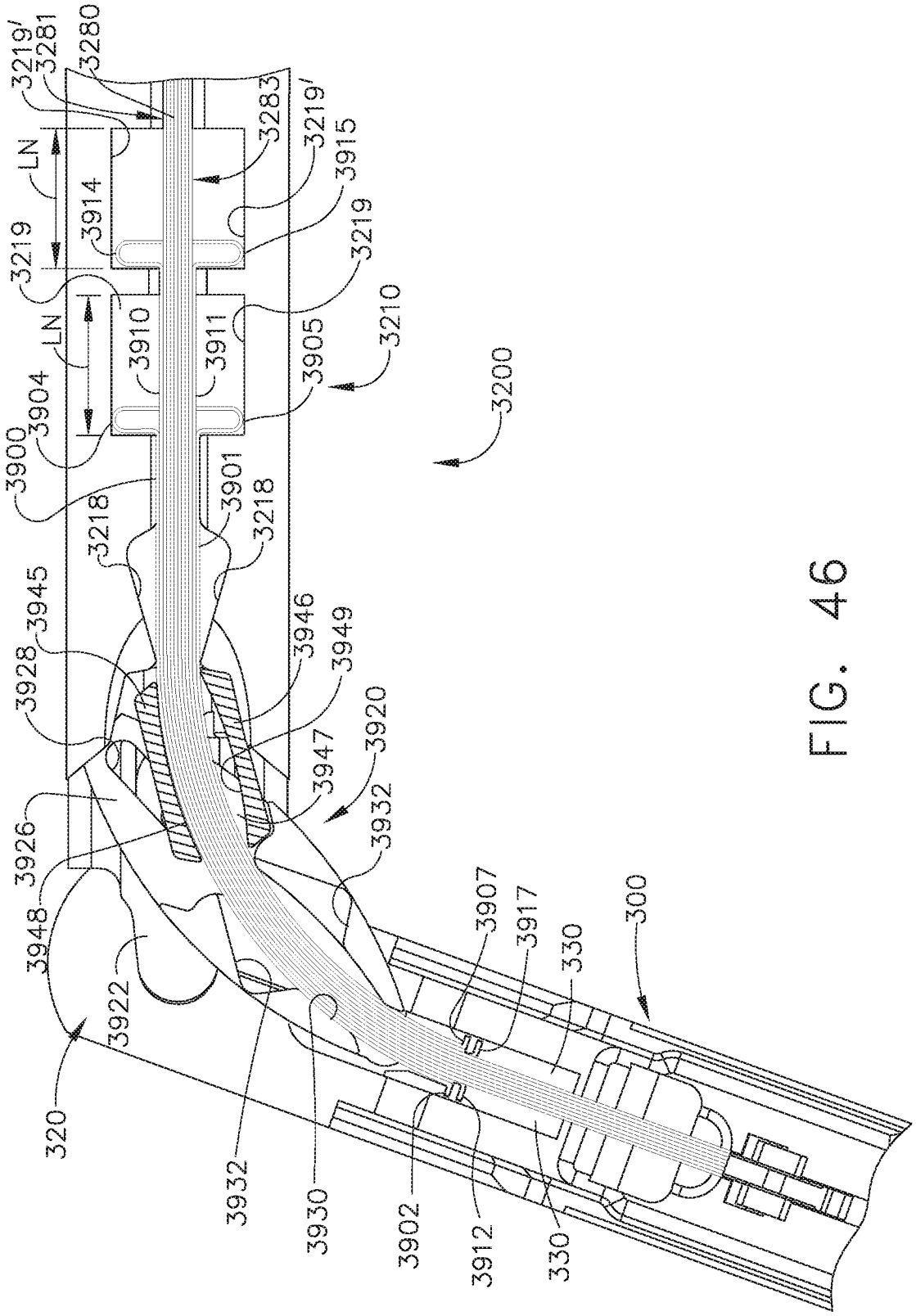

3219'
3281
3280
3283
3219'
3915
3219
3210
3200
LN
3914
3219
LN
3910
3911
3905
3904
3900
3901
3218
3218
3945
3928
3946
3949
3920
3947
3932
3926
3948
3907
3917
330
300
3922
320
3932
3930
3902
3912
330

FIG. 46

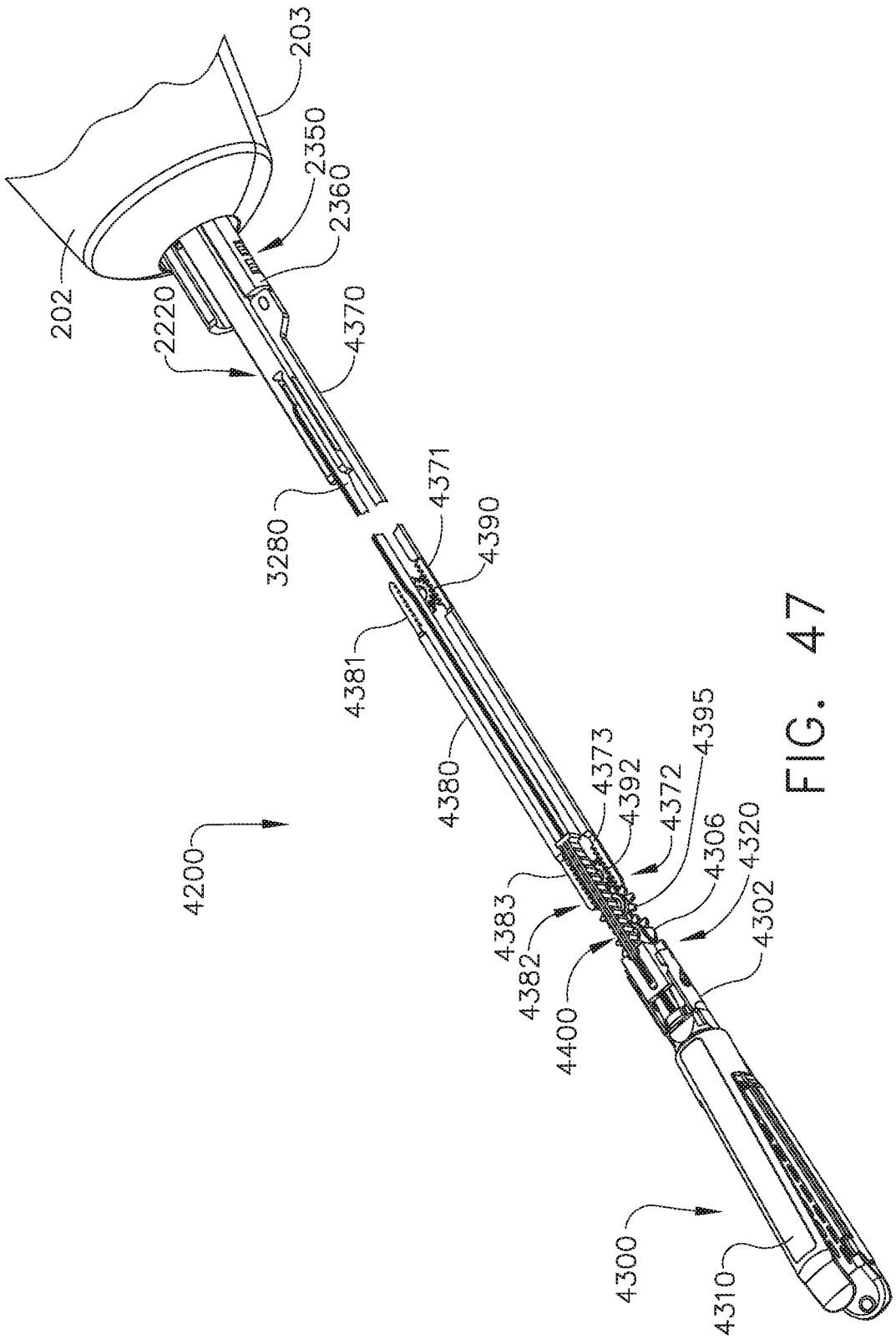

203
2350
2360
202
2220
4370
3280
4371
4390
4381
4380
4373
4392
4372
4395
4306
4320
4302
4383
4382
4400
4200
4300
4310

FIG. 47

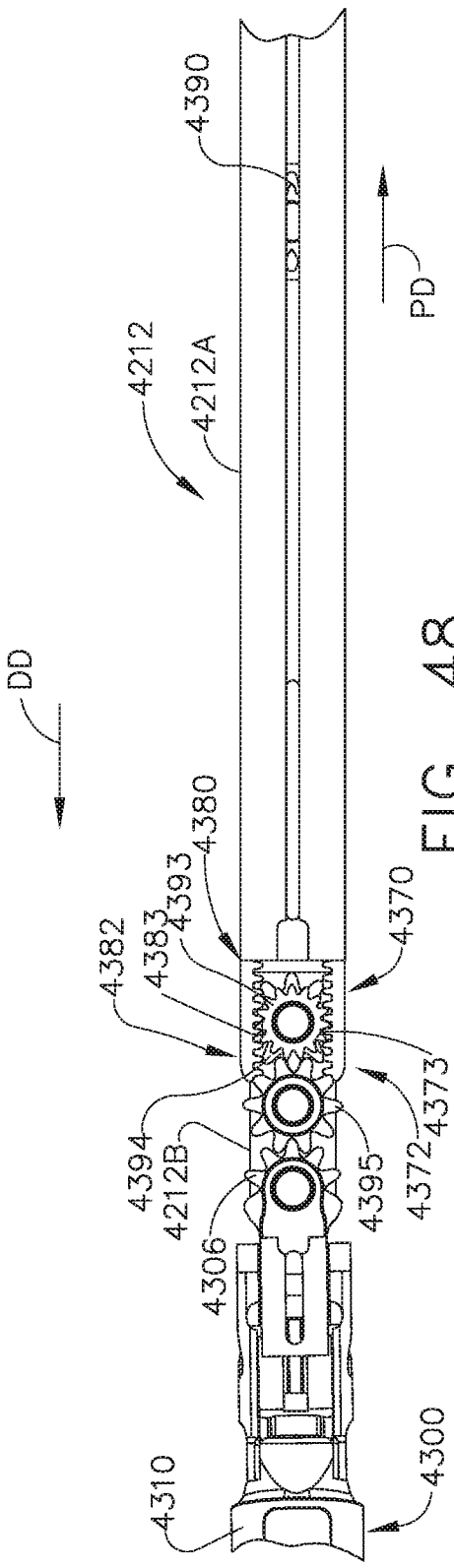

DD
4310
4300
4306
4394
4212B
4382
4383
4393
4380
4395
4372
4373
4370
4212
4212A
4390
PD

FIG. 48

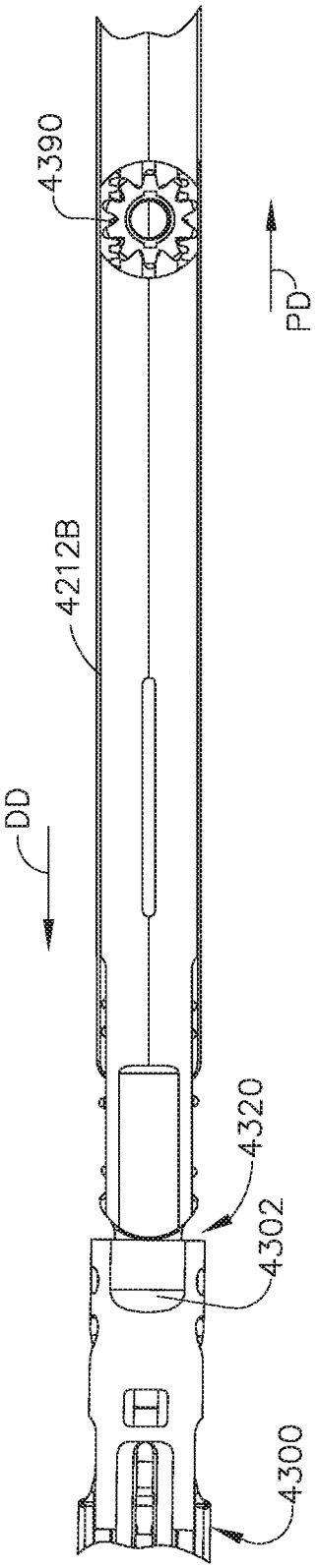

DD
4212B
4390
PD
4320
4302
4300

FIG. 49

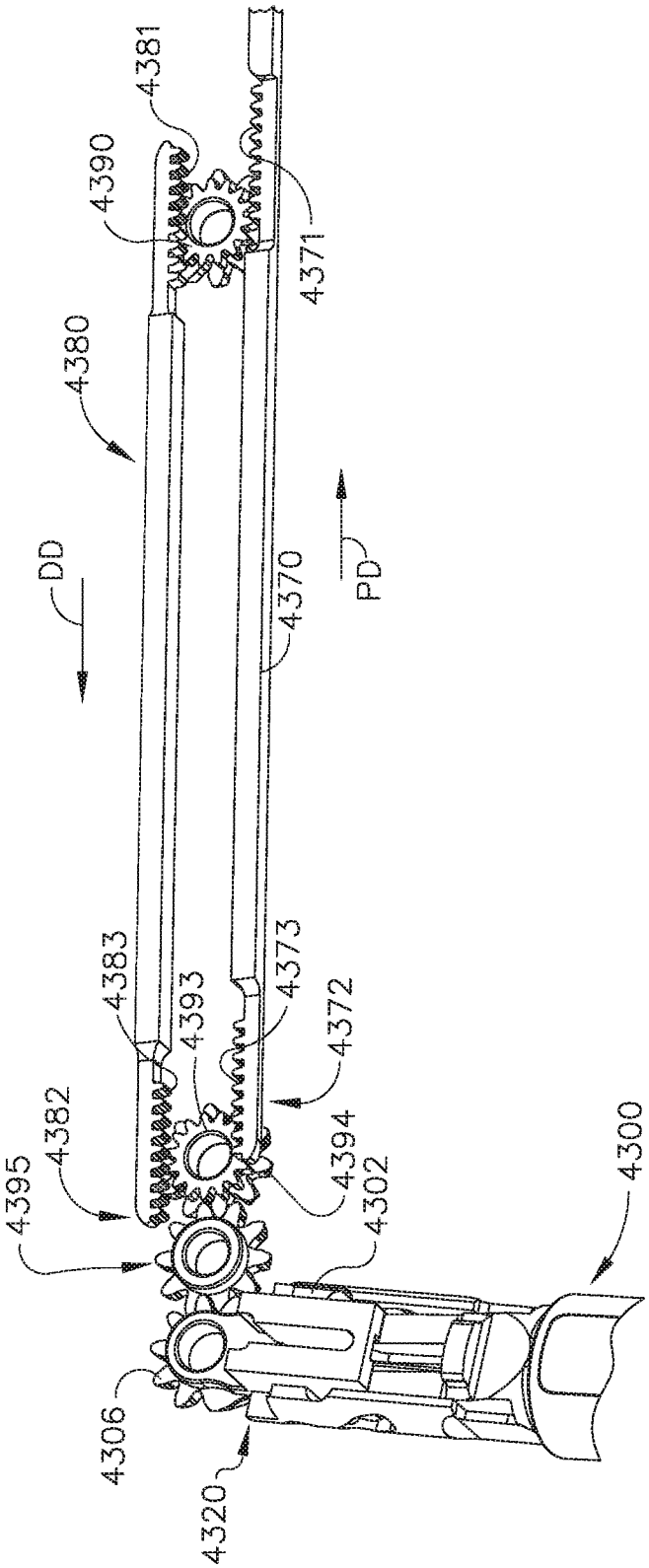

4381
4390
4371
4380
DD
PD
4370
4383
4373
4393
4372
4382
4394
4395
4302
4300
4306
4320

FIG. 50

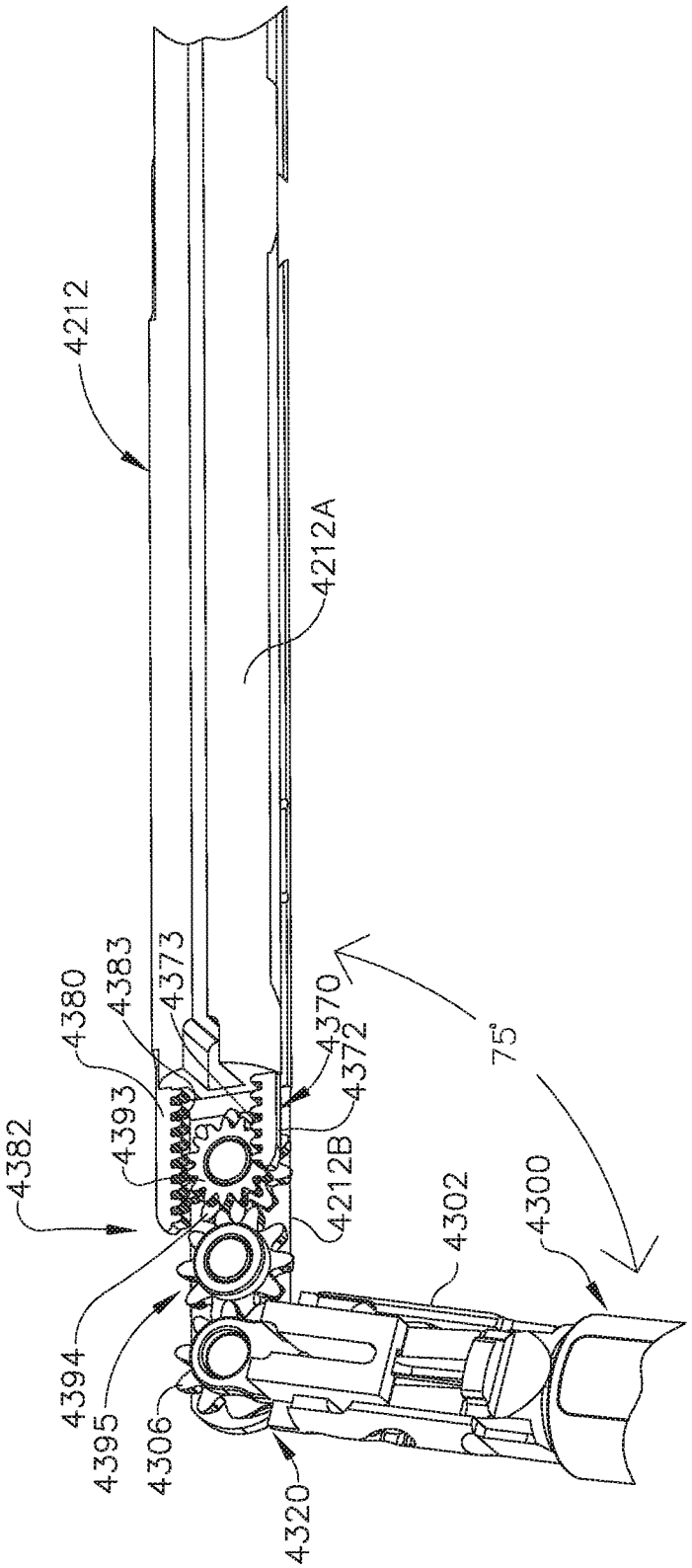

4212
4212A
4380
4383
4373
4370
4372
4393
4382
4212B
4302
4300
75°
4394
4395
4306
4320

FIG. 51

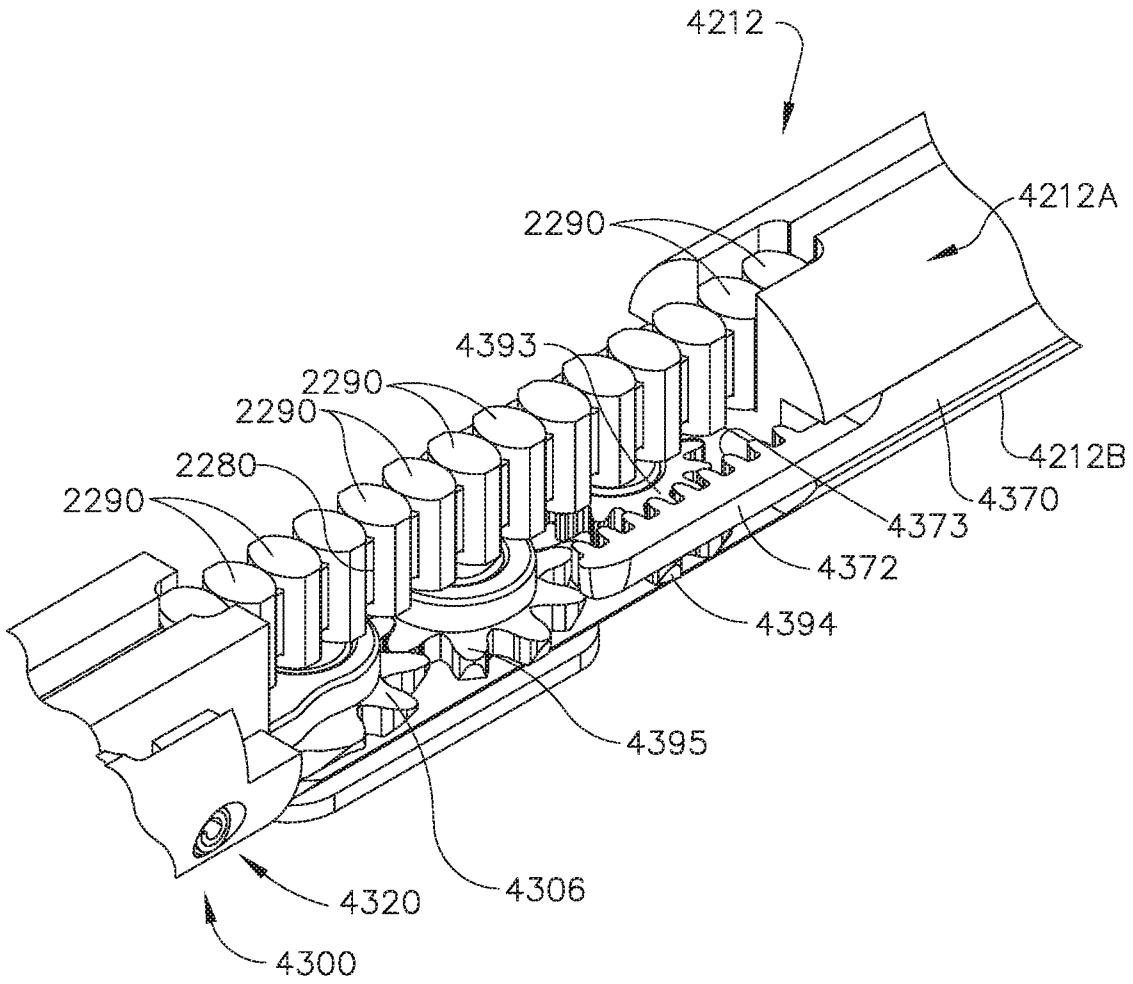

4212
4212A
2290
4393
2290
2290
2280
2290
4212B
4370
4373
4372
4394
4395
4306
4320
4300

FIG. 52

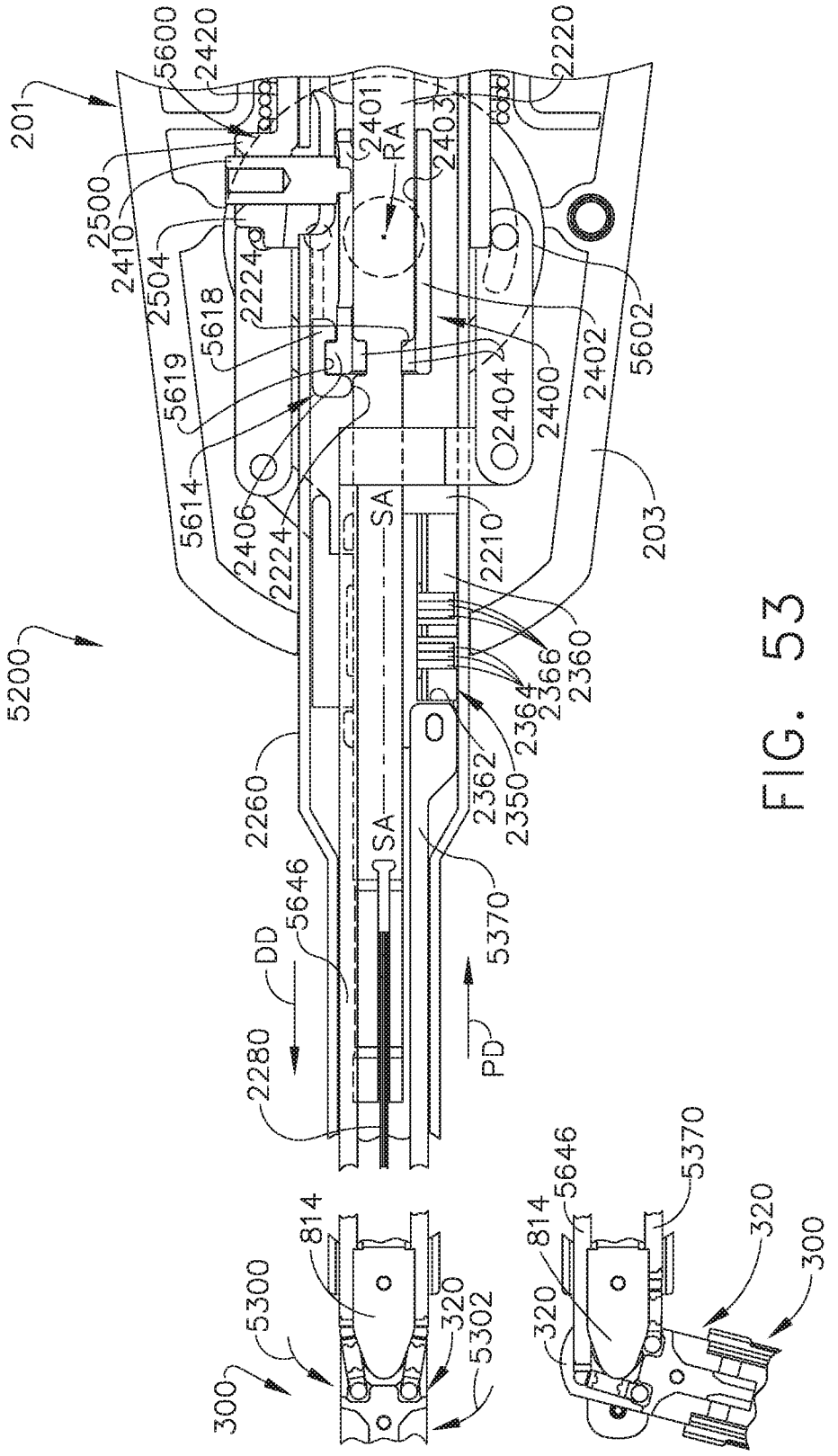

201
5600
2420
2220
2500
2410
2504
5618
2224
2401
RA
2403
5619
5614
2406
2224
SA
2210
2404
2400
2402
5602
203
5200
2360
2366
2364
2362
2350
2260
SA
5646
DD
2280
5370
PD
814
5300
320
5302
300
814
5646
5370
320
320
300

FIG. 53

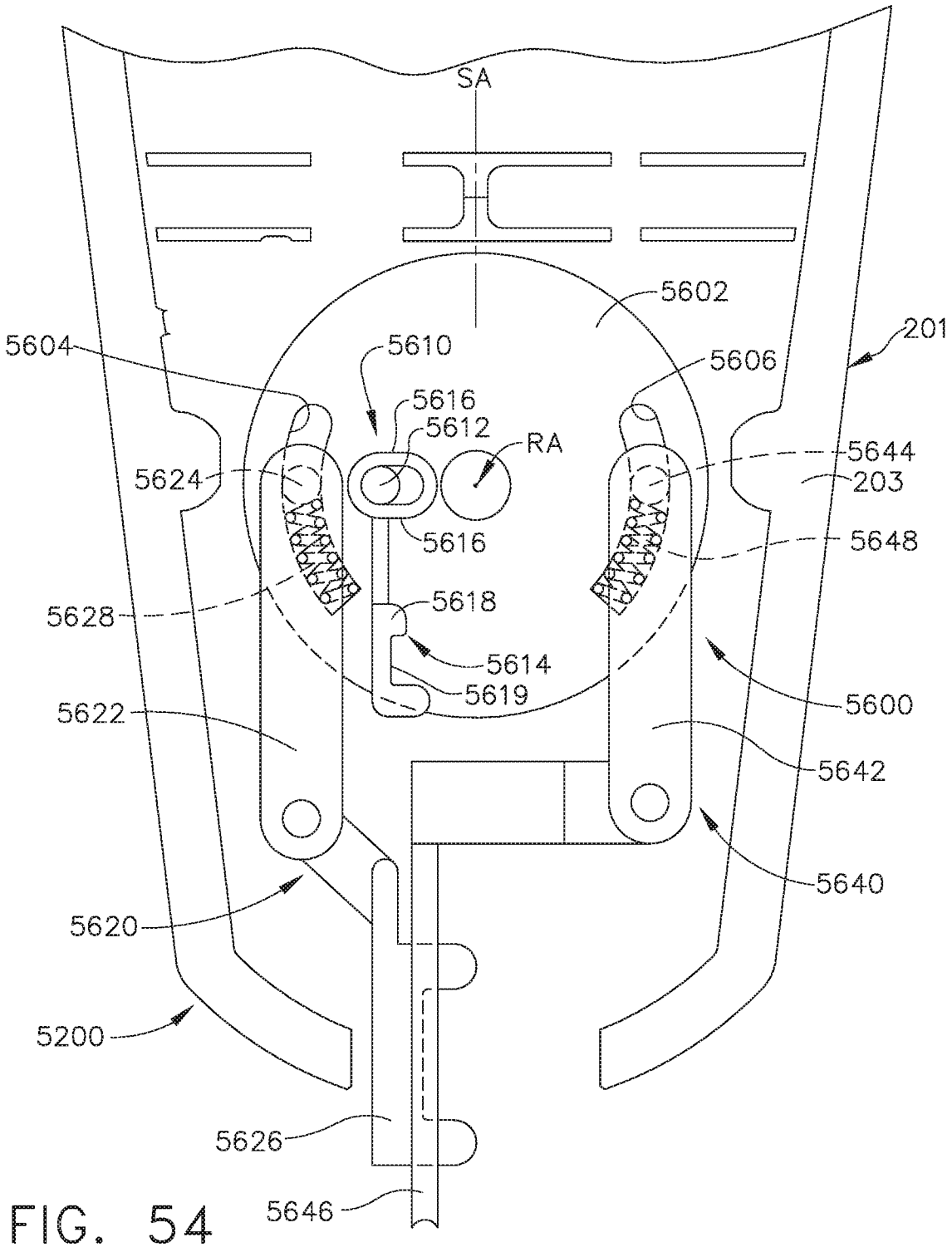

SA
5602
5604
5610
5606
201
5616
5612
RA
5644
5624
203
5616
5648
5628
5618
5614
5619
5600
5622
5642
5640
5620
5200
5626
5646

FIG. 54

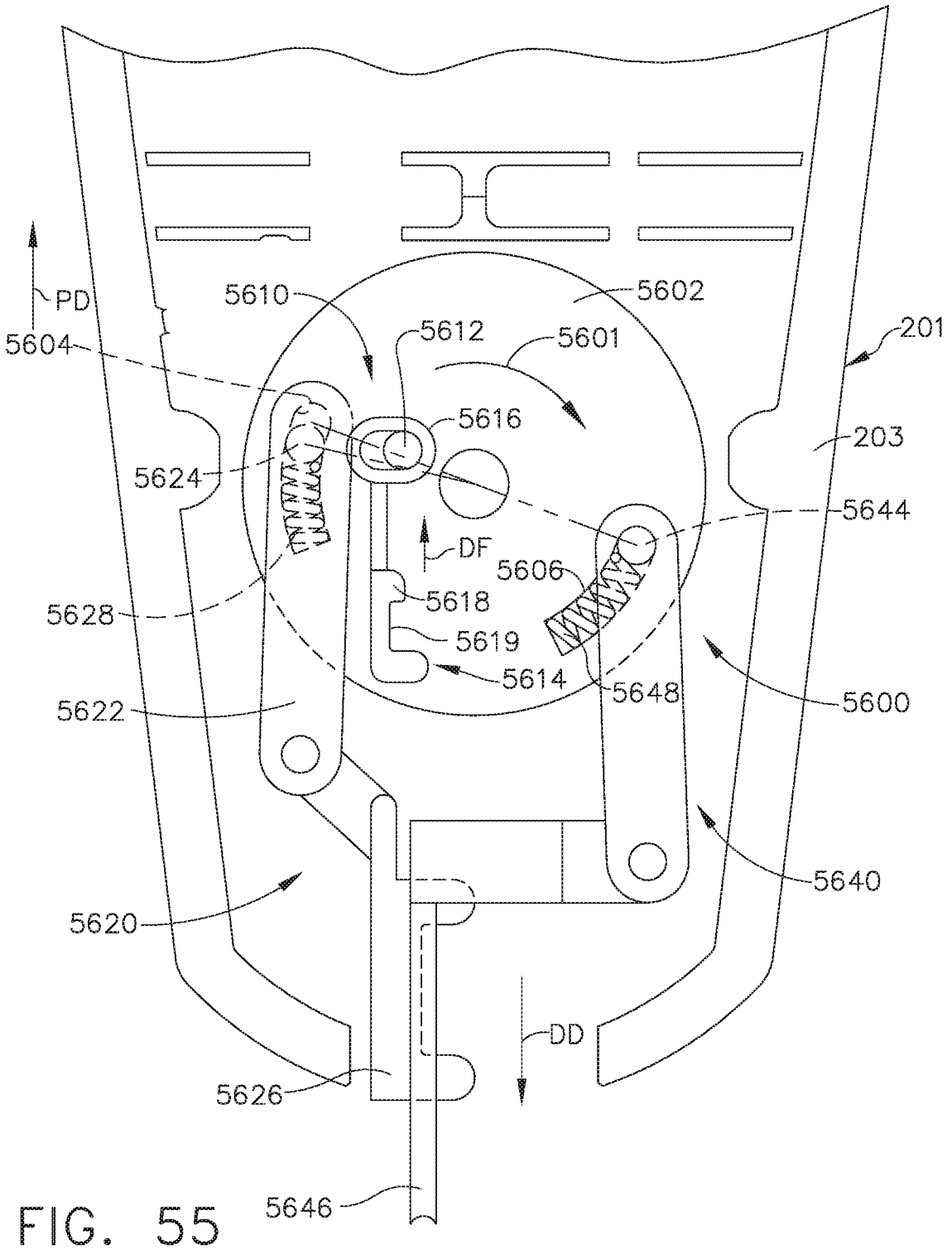

PD
5604
5610
5602
5612
5601
201
5616
203
5624
5644
DF
5606
5618
5628
5619
5614
5648
5600
5622
5640
5620
DD
5626
5646

FIG. 55

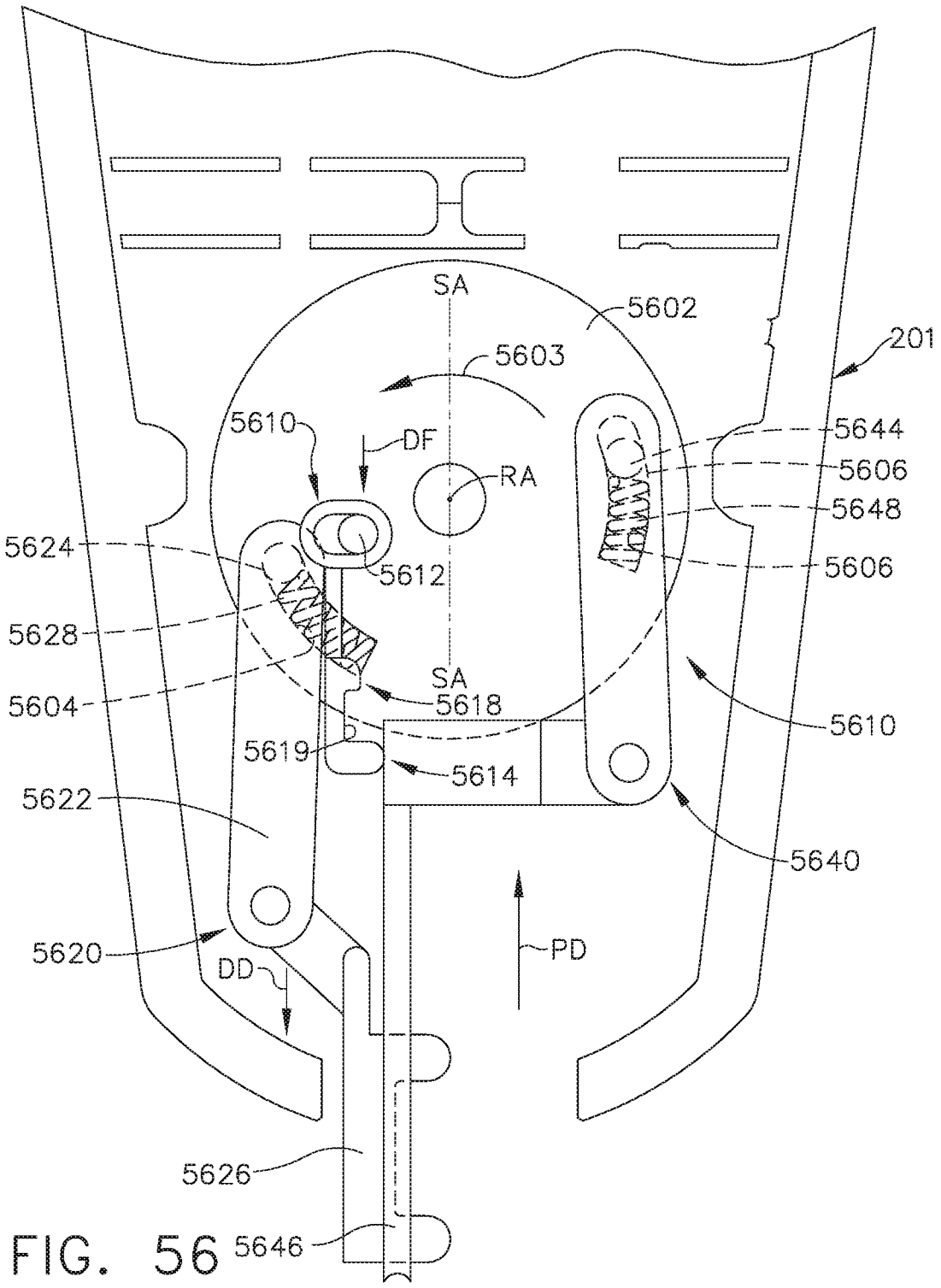

SA
5602
201
5603
5610
DF
RA
5644
5606
5648
5624
5612
5606
5628
SA
5604
5618
5610
5619
5614
5622
5640
5620
DD
PD
5626
5646

FIG. 56

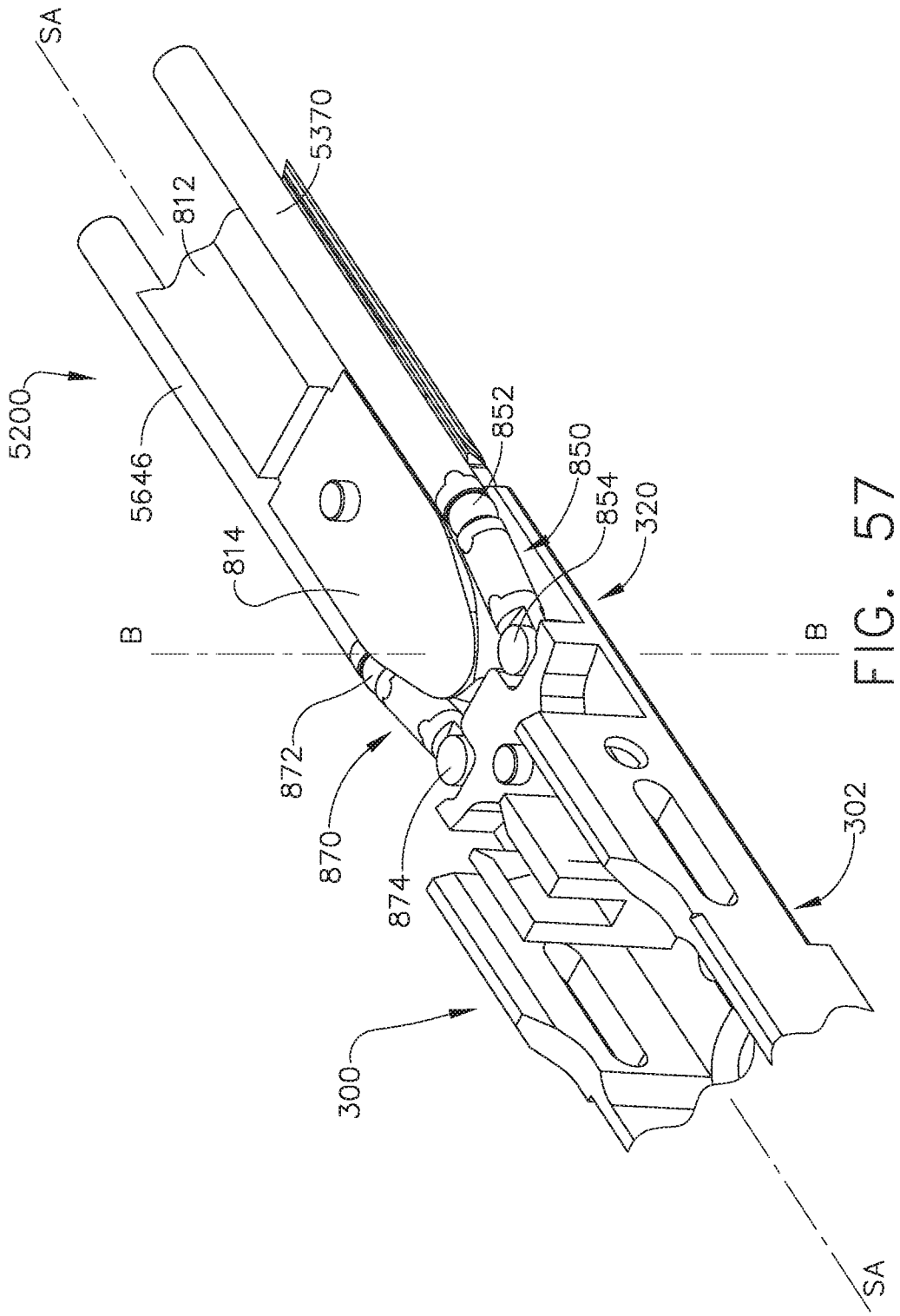

SA
5370
812
5200
5646
814
852
850
854
320
B
B
872
870
874
302
300
SA

FIG. 57

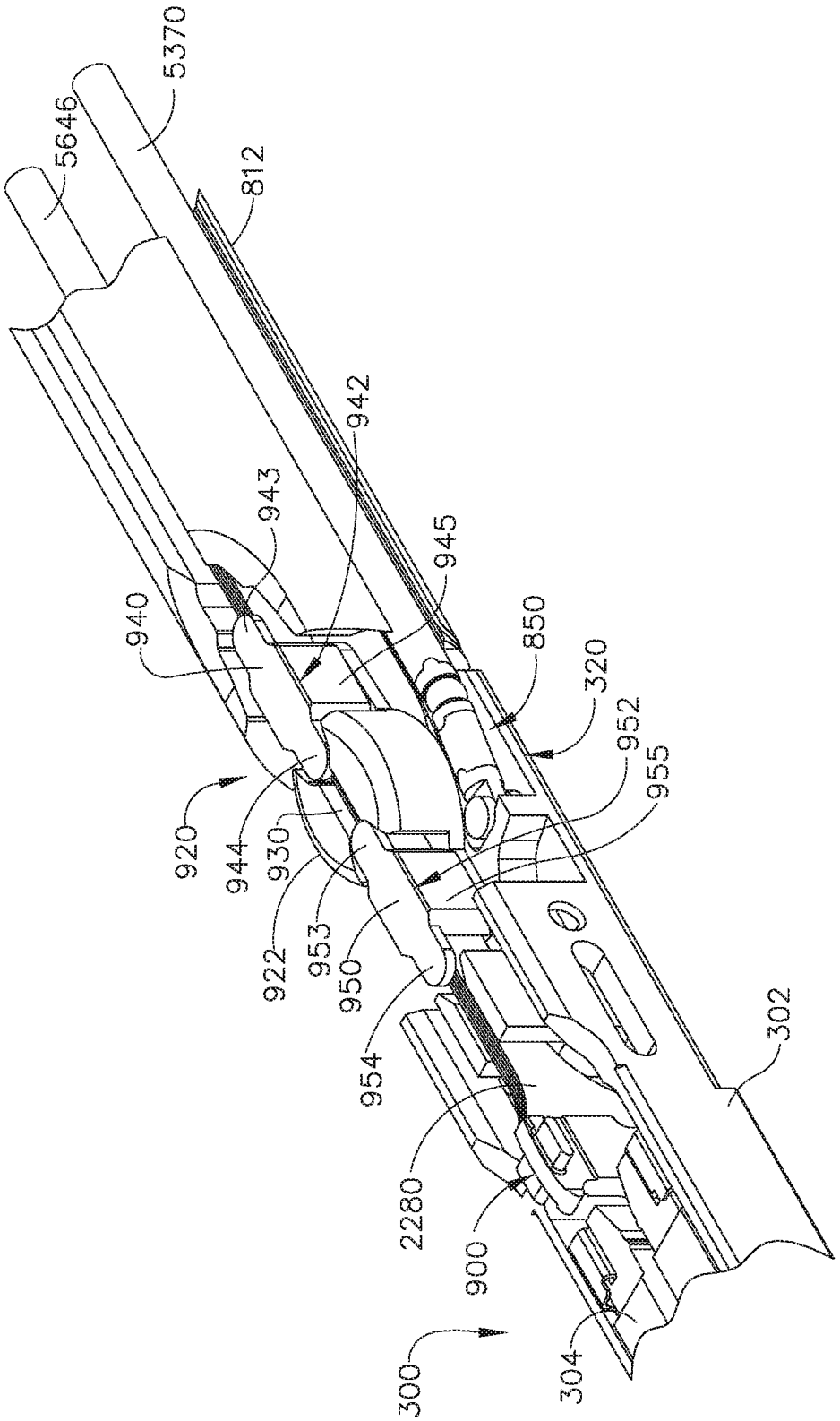

5370
5646
812
942
943
945
940
850
320
952
955
920
944
930
922
953
950
954
302
2280
900
300
304

FIG. 58

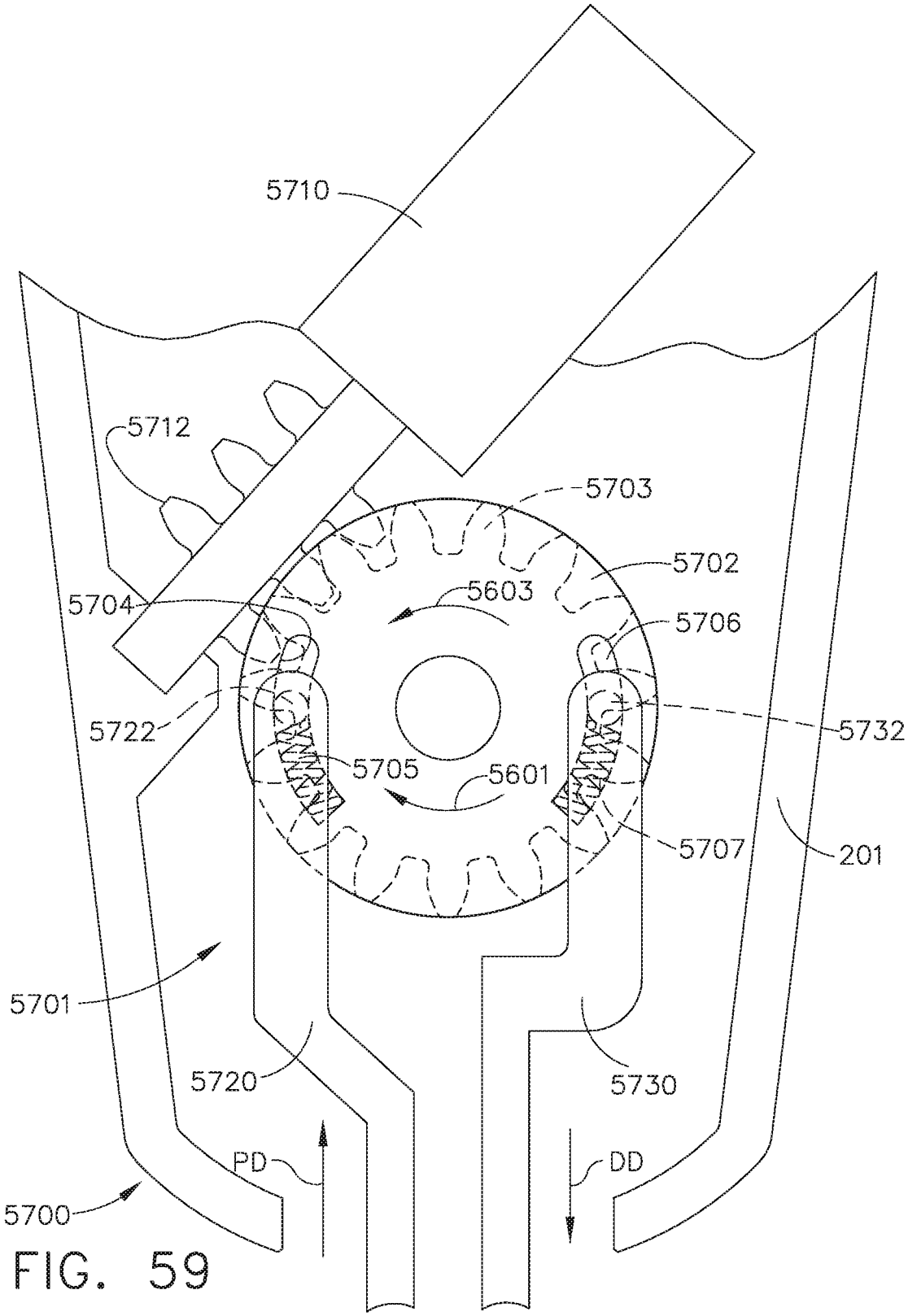

5710
5712
5703
5702
5704
5603
5706
5722
5732
5705
5601
5707
201
5701
5720
5730
PD
DD
5700

FIG. 59

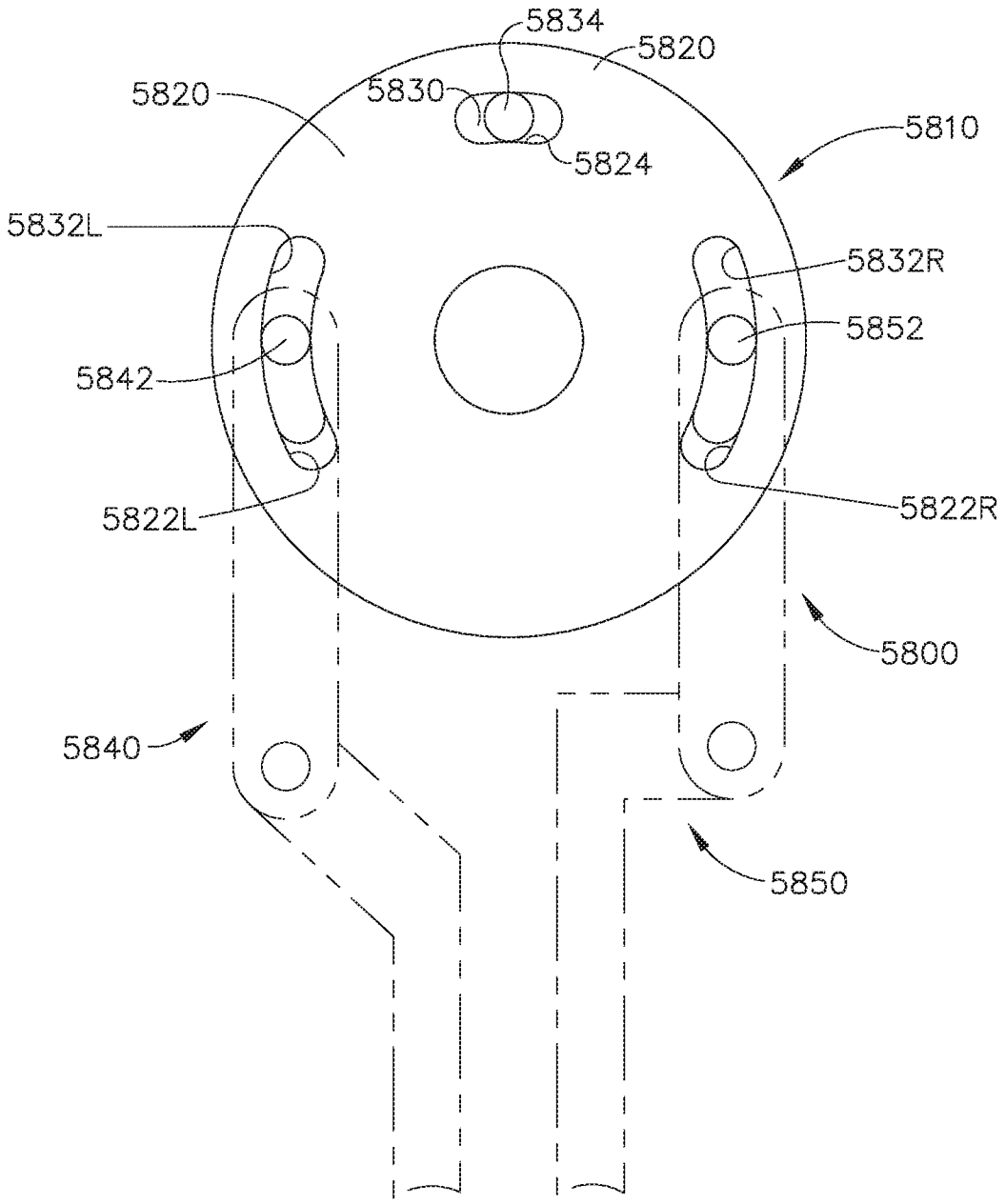

5834
5820
5820
5830
5810
5824
5832L
5832R
5852
5842
5822L
5822R
5800
5840
5850

FIG. 60

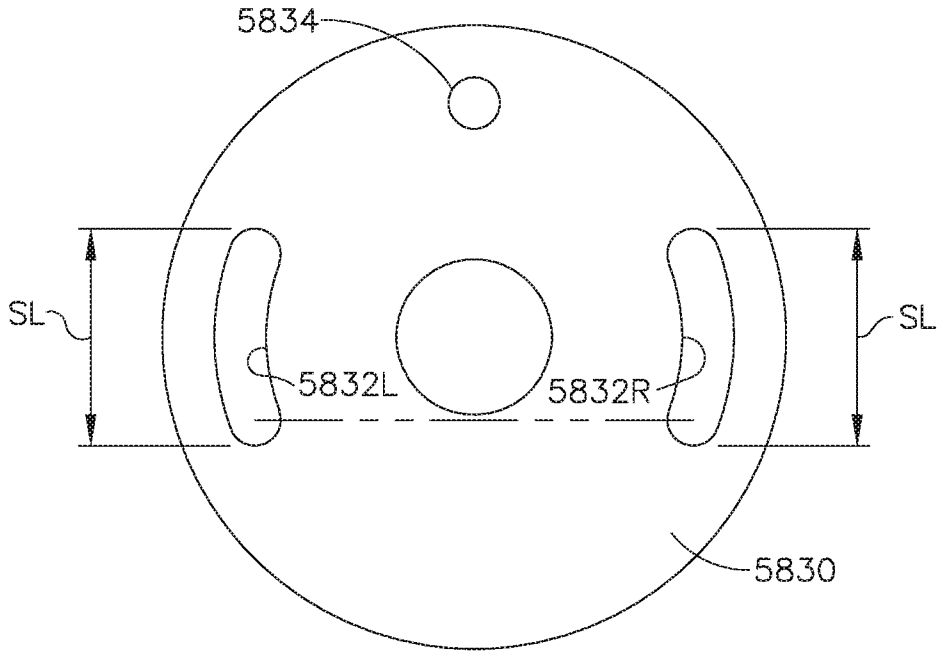


FIG. 62

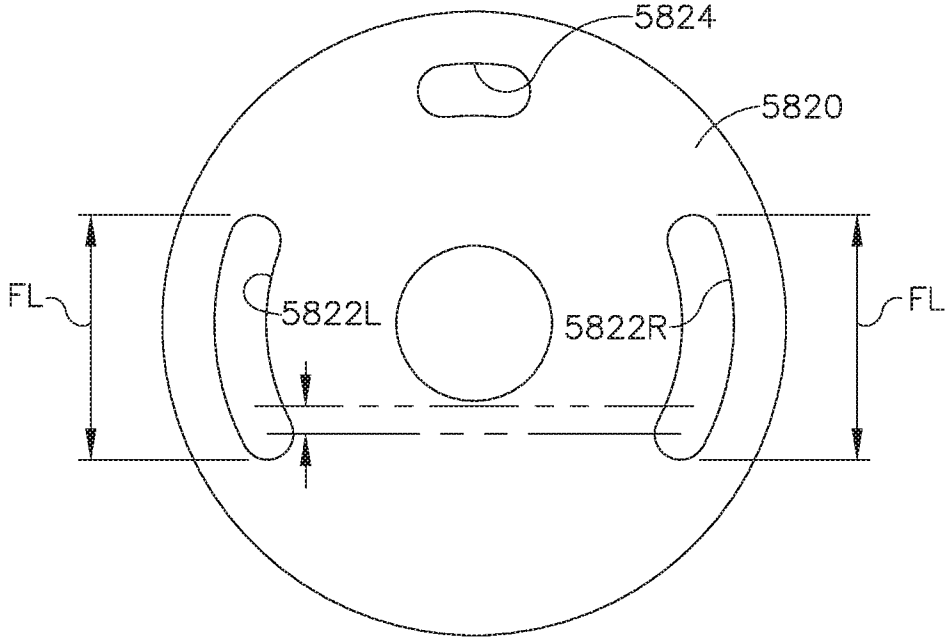


FIG. 61

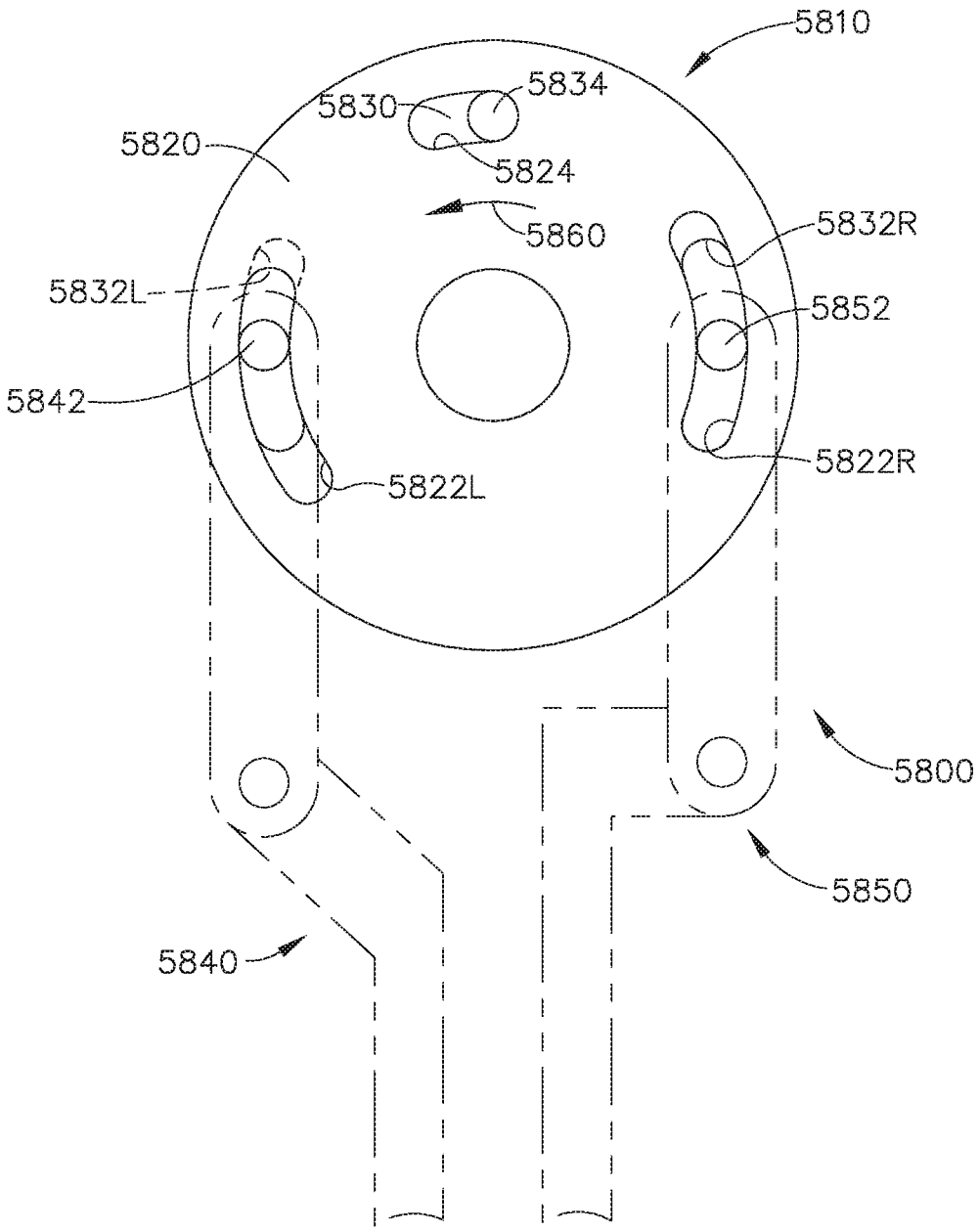

5810
5834
5830
5820
5824
5860
5832R
5832L
5852
5842
5822R
5822L
5800
5850
5840

FIG. 63

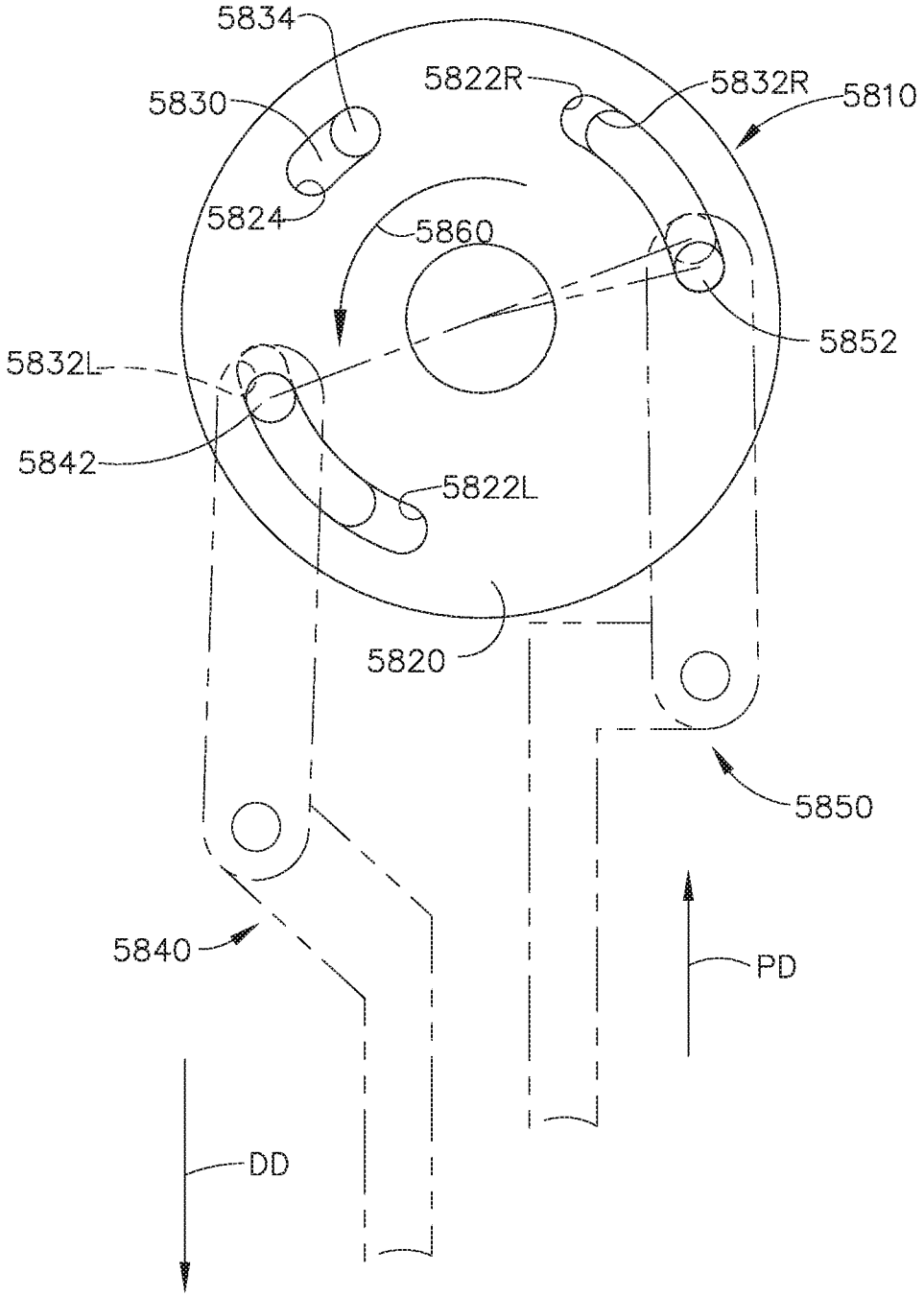

5834
5830
5822R
5832R
5810
5824
5860
5852
5832L
5842
5822L
5820
5850
5840
PD
DD

FIG. 64

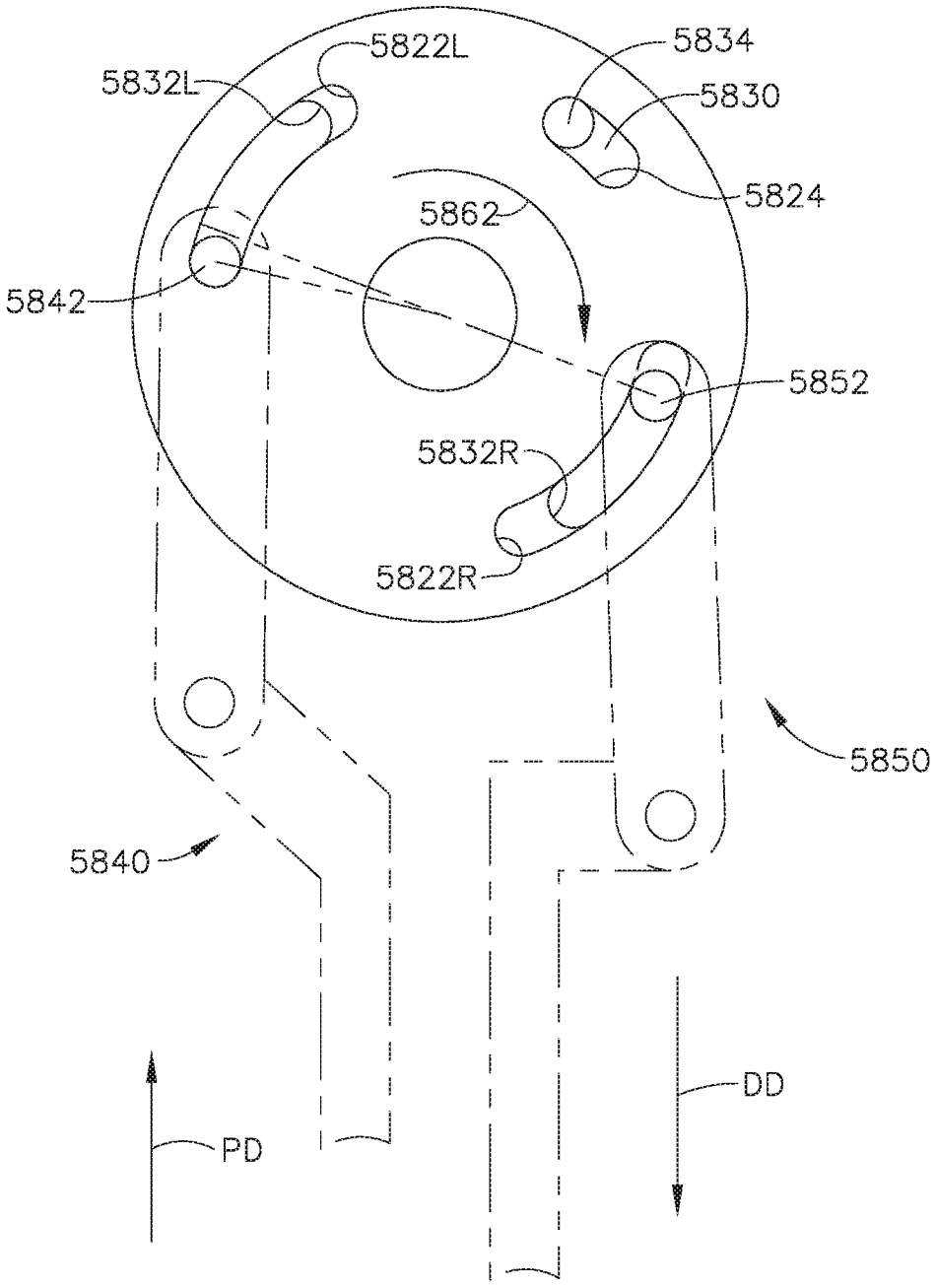

5822L
5834
5832L
5830
5824
5862
5842
5852
5832R
5822R
5850
5840
PD
DD

FIG. 65

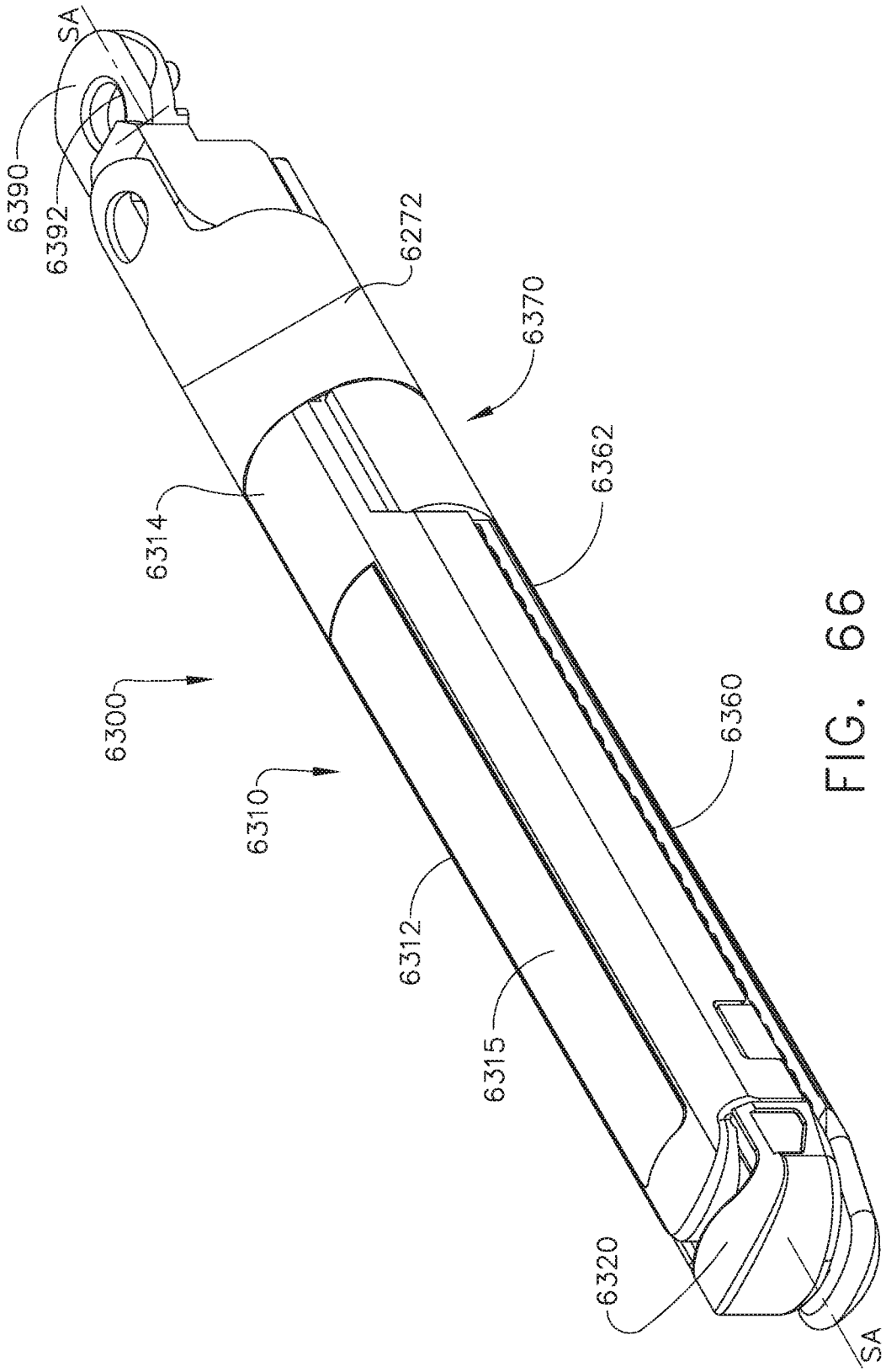

SA
6390
6392
6272
6370
6362
6314
6300
6360
6310
6312
6315
6320
SA

FIG. 66

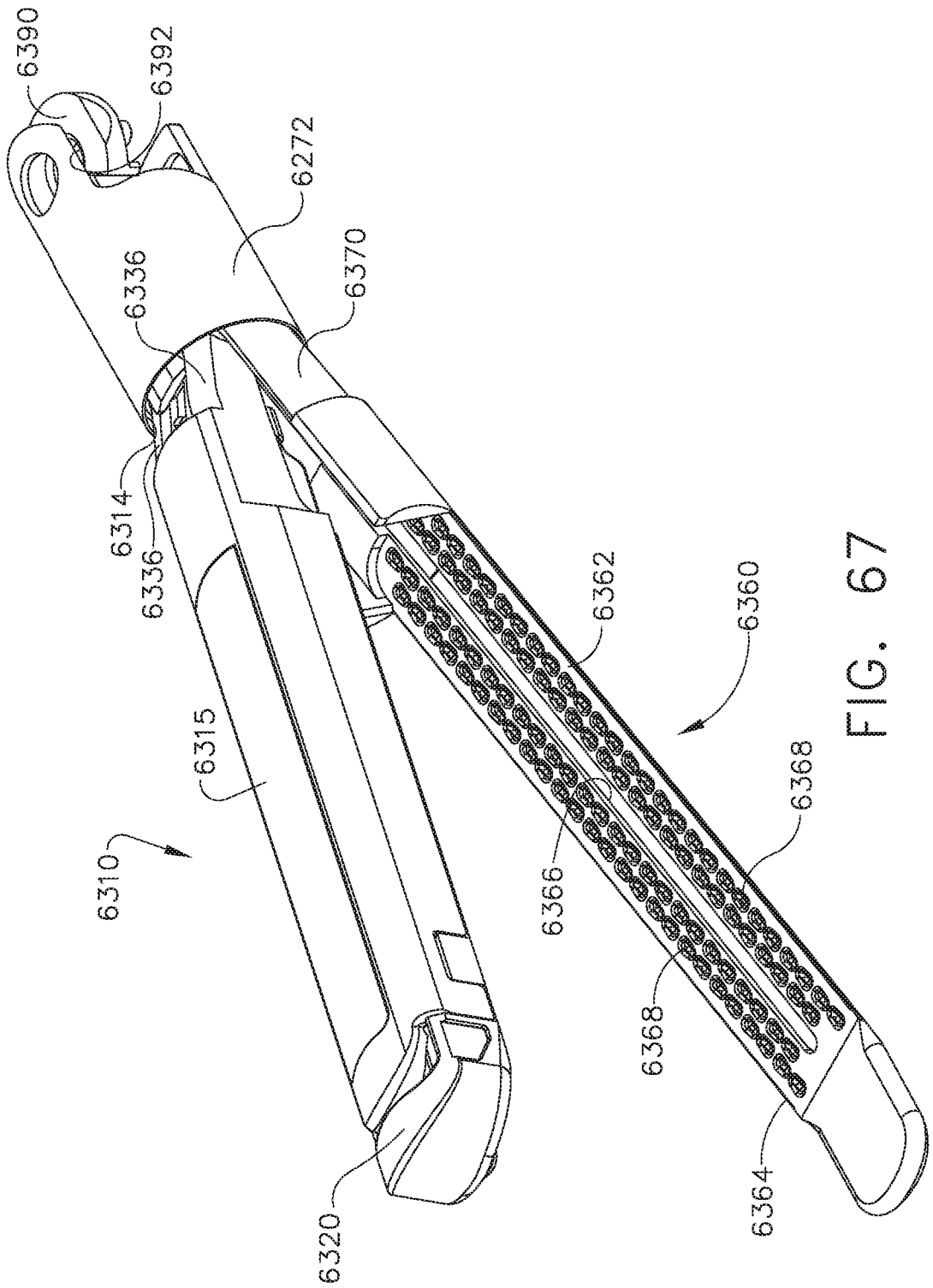

6390
6392
6272
6336
6370
6314
6336
6362
6360
6315
6310
6368
6366
6368
6320
6364

FIG. 67

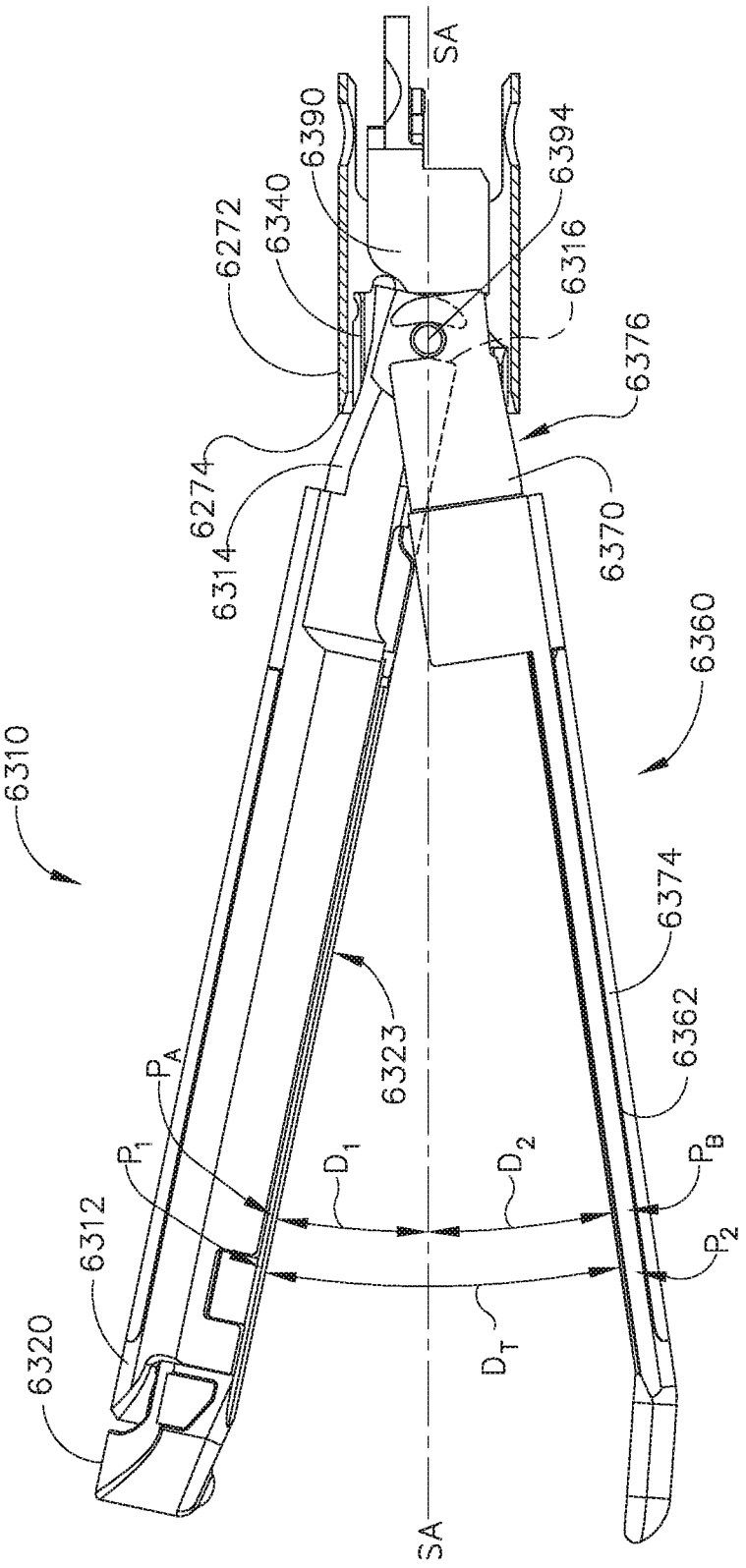

SA
6390
6394
6340
6272
6316
6376
6274
6314
6370
6360
6310
6374
6323
6362
P_A
P_1
D_1
D_2
P_B
6312
P_2
6320
D_T
SA

FIG. 68

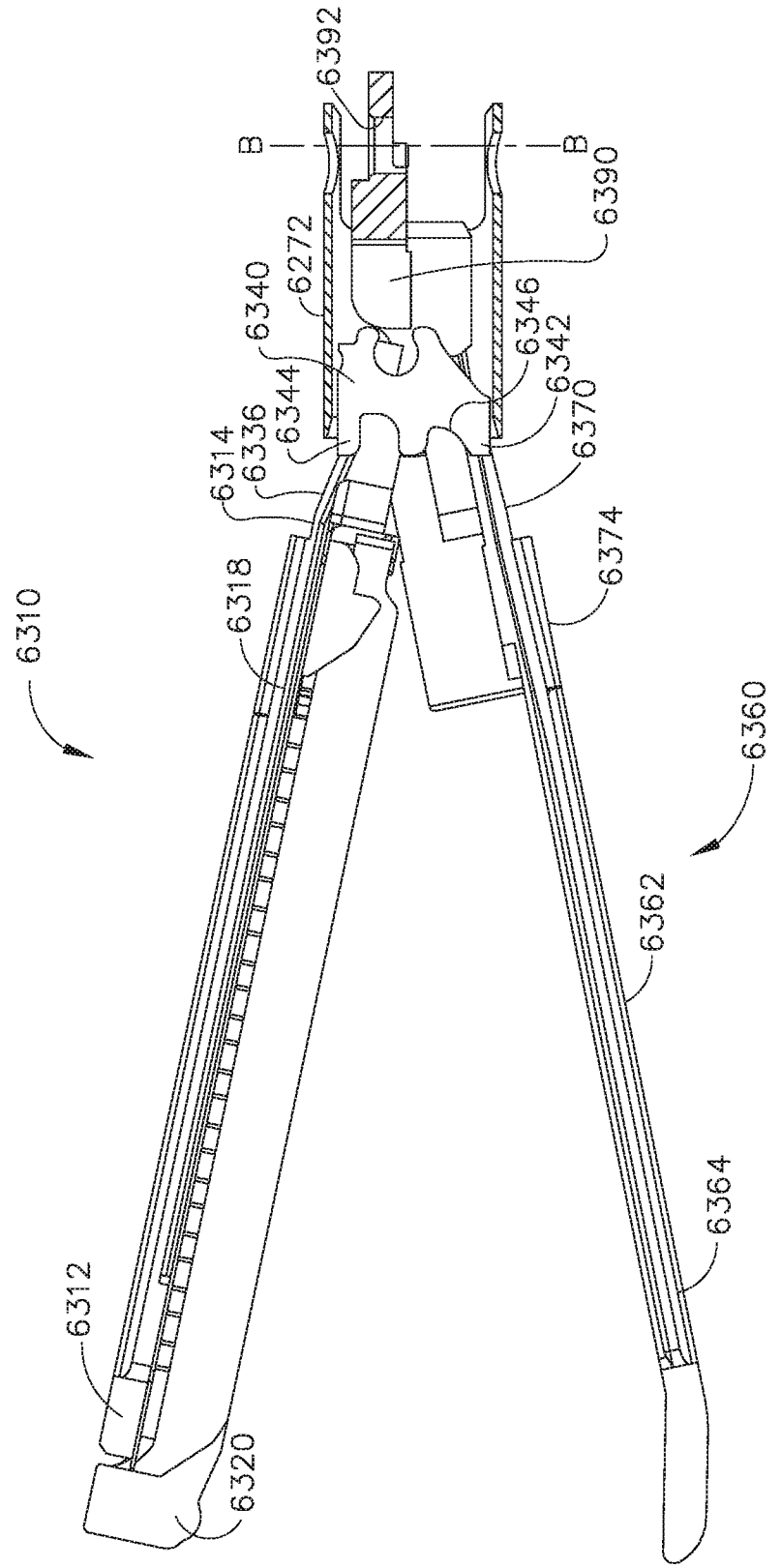

6392
B
B
6390
6272
6340
6346
6342
6344
6370
6336
6314
6374
6318
6310
6360
6362
6364
6312
6320

FIG. 69

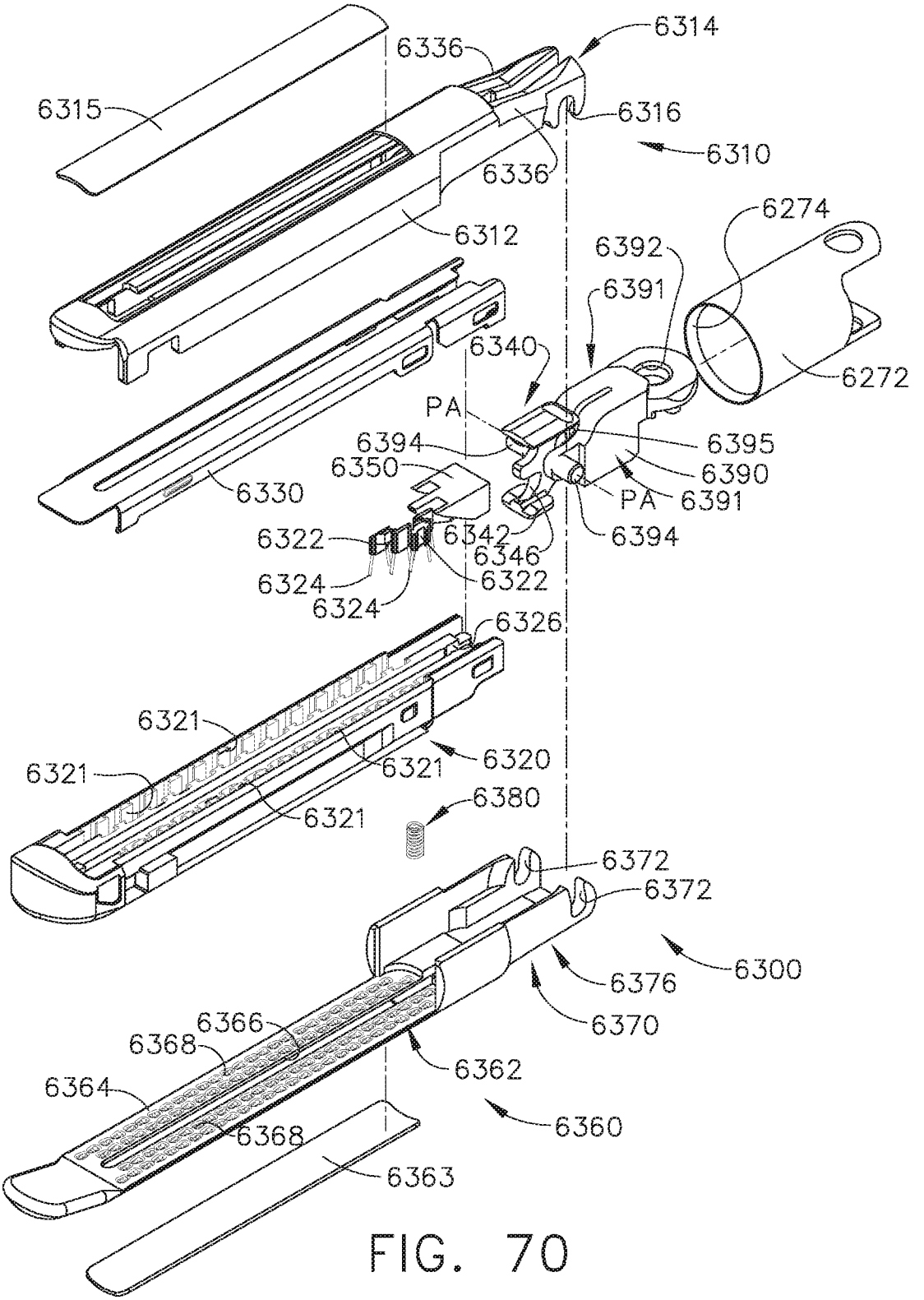

6314
6336
6315
6316
6310
6336
6312
6274
6392
6391
6340
6272
PA
6394
6395
6350
6390
6330
PA
6391
6322
6342
6394
6346
6324
6322
6324
6326
6321
6321
6320
6321
6380
6372
6372
6300
6376
6370
6366
6368
6362
6364
6360
6368
6363

FIG. 70

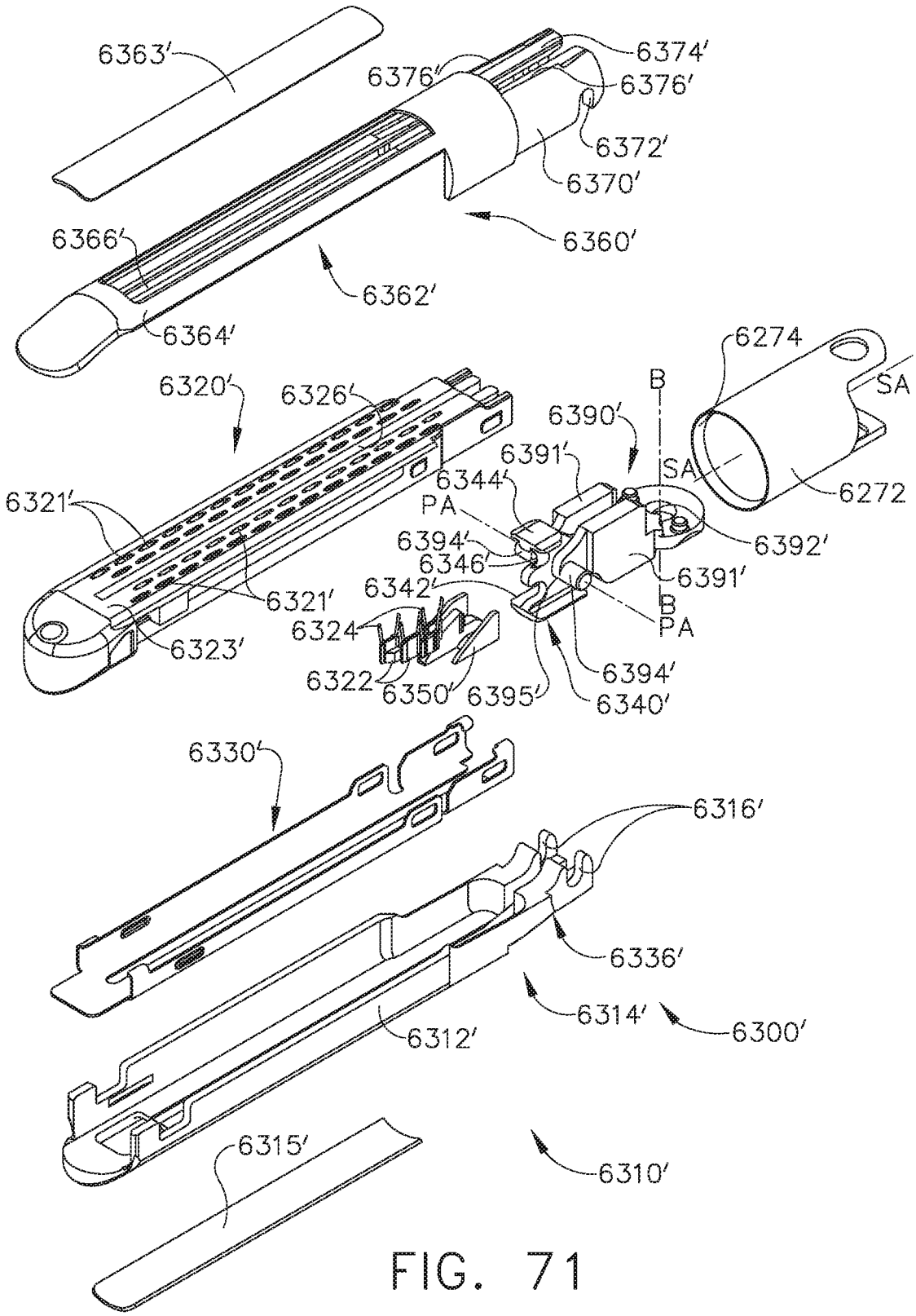

6363'
6376'
6374'
6376'
6372'
6370'
6360'
6366'
6362'
6364'
6320'
6326'
6321'
6321'
6323'
6324
6322
6350'
6395'
6340'
6394'
6390'
6391'
6344'
PA
6394'
6346
6342'
6274
B
SA
SA
6272
6392'
6391'
B
PA
6330'
6316'
6336'
6314'
6300'
6312'
6315'
6310'

FIG. 71

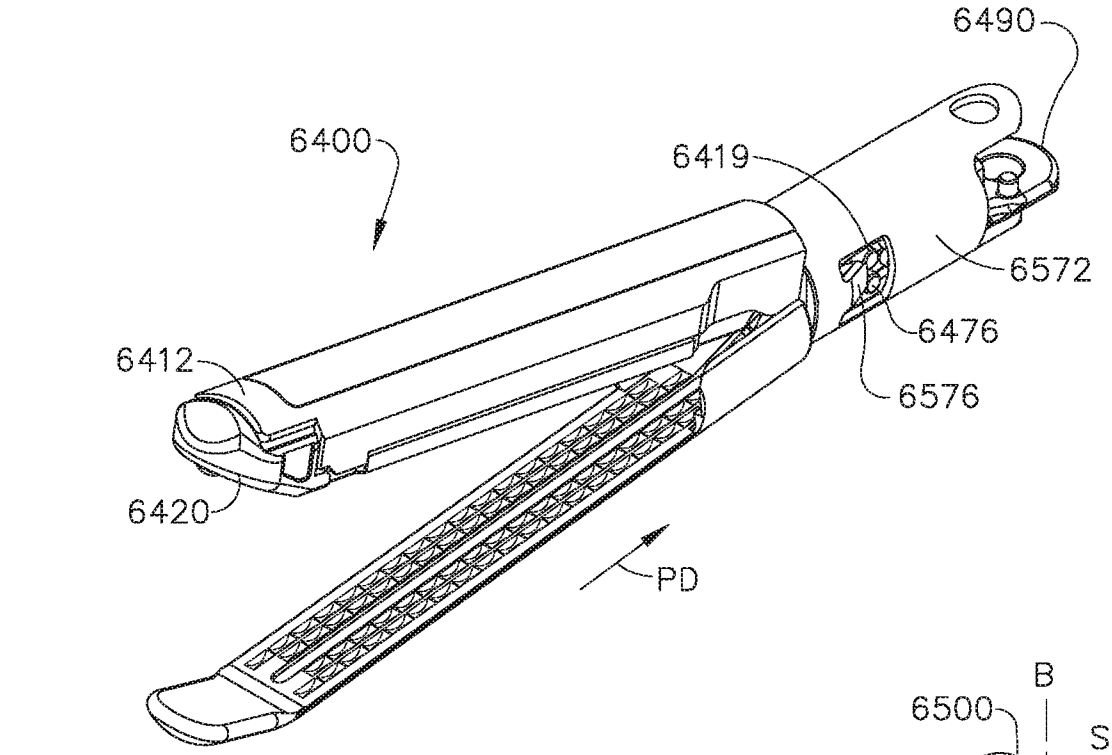

6490
6400
6419
6572
6476
6412
6576
6420
PD

FIG. 72

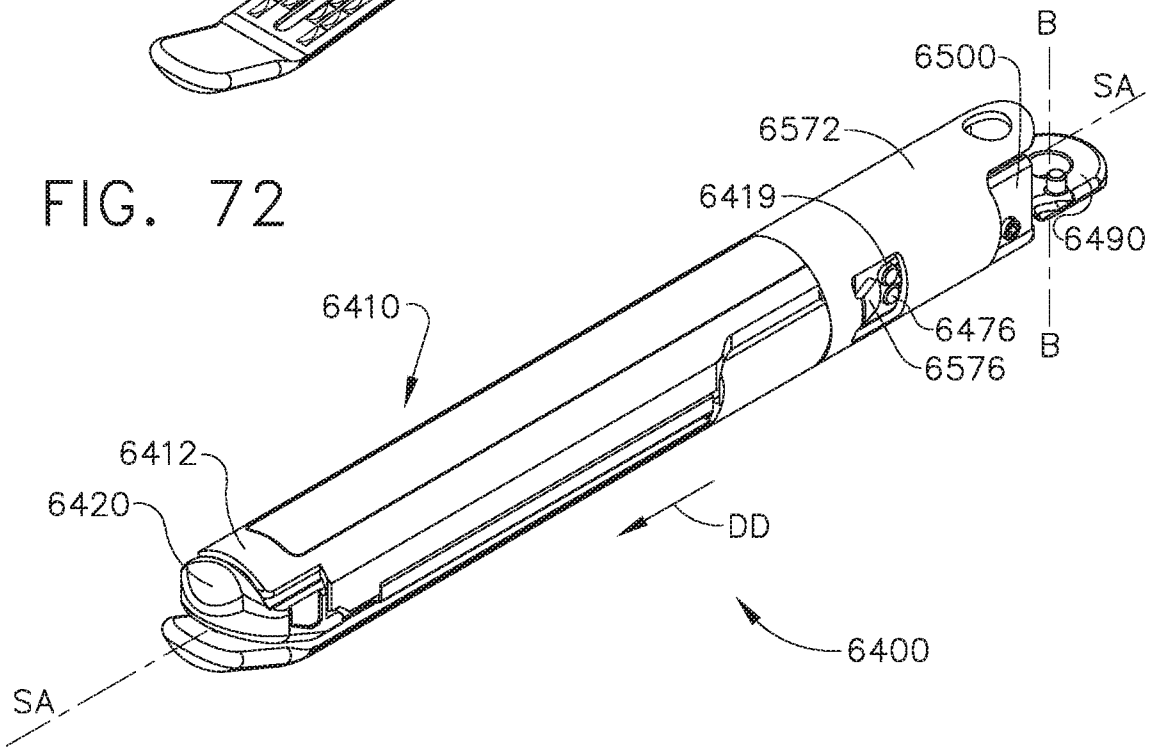

B
6500
SA
6572
6419
6490
6476
B
6576
6410
6412
6420
DD
6400
SA

FIG. 73

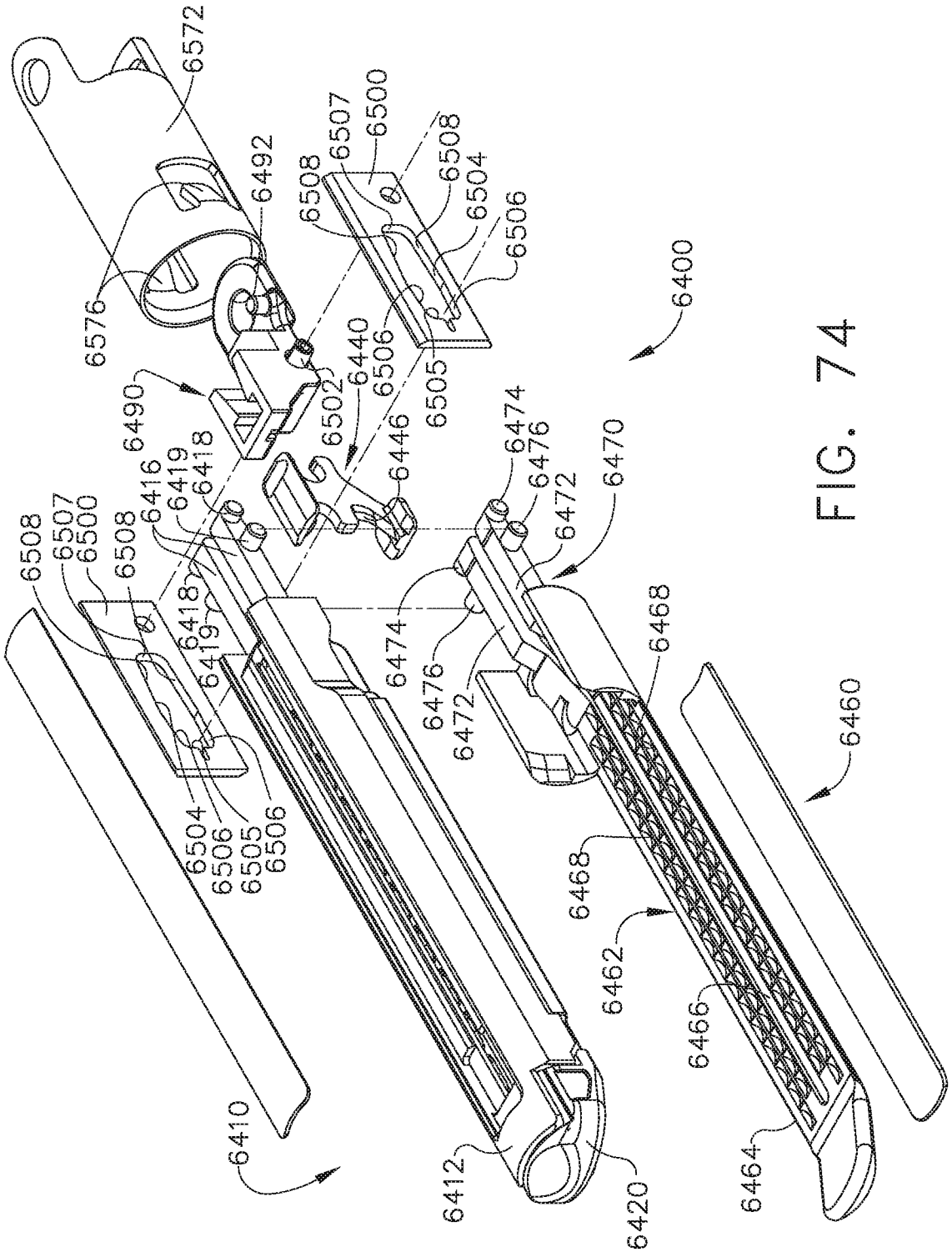

6572
6492
6576
6508
6507
6500
6504
6506
6400
6490
6502
6440
6446
6505
6474
6476
6472
6470
6418
6419
6416
6468
6460
6462
6466
6464
6410
6412
6420

FIG. 74

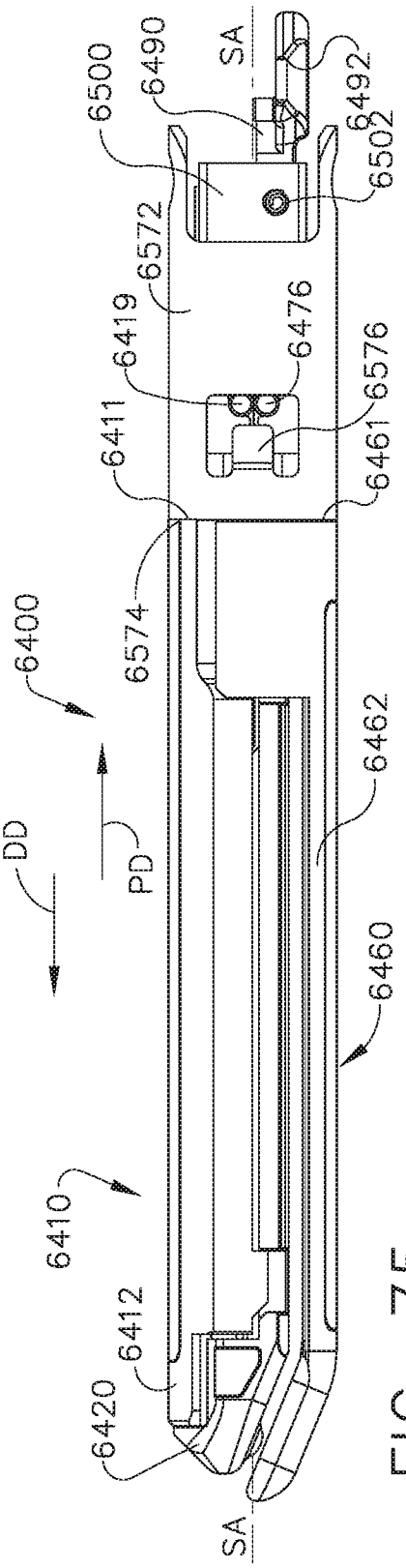

6500
6490
SA
6492
6502
6572
6419
6476
6576
6411
6461
6574
6400
6462
DD
PD
6460
6410
6412
6420
SA

FIG. 75

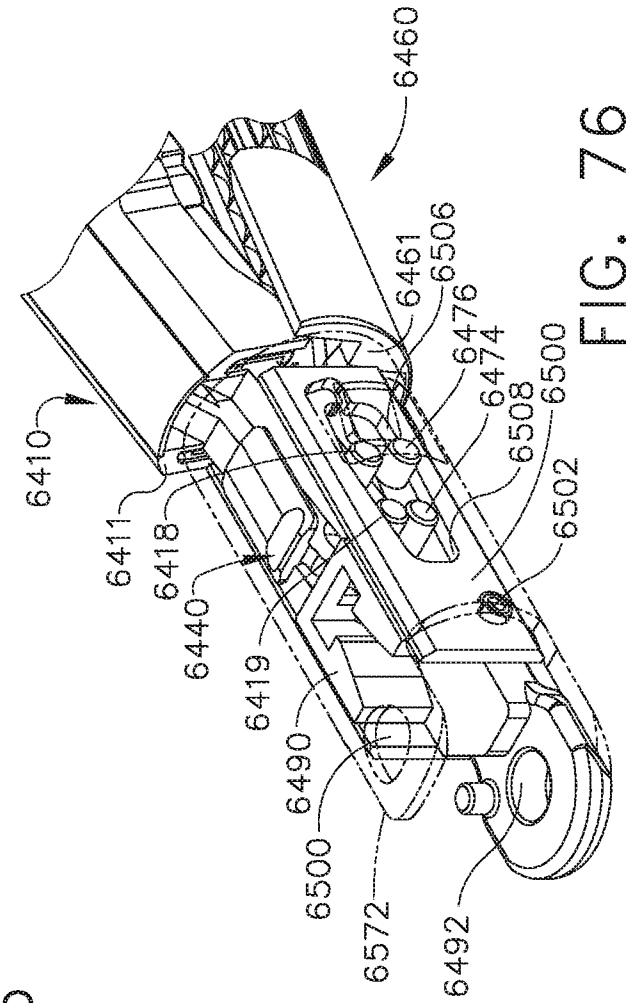

6460
6461
6506
6476
6474
6500
6508
6410
6502
6411
6418
6440
6419
6490
6500
6572
6492

FIG. 76

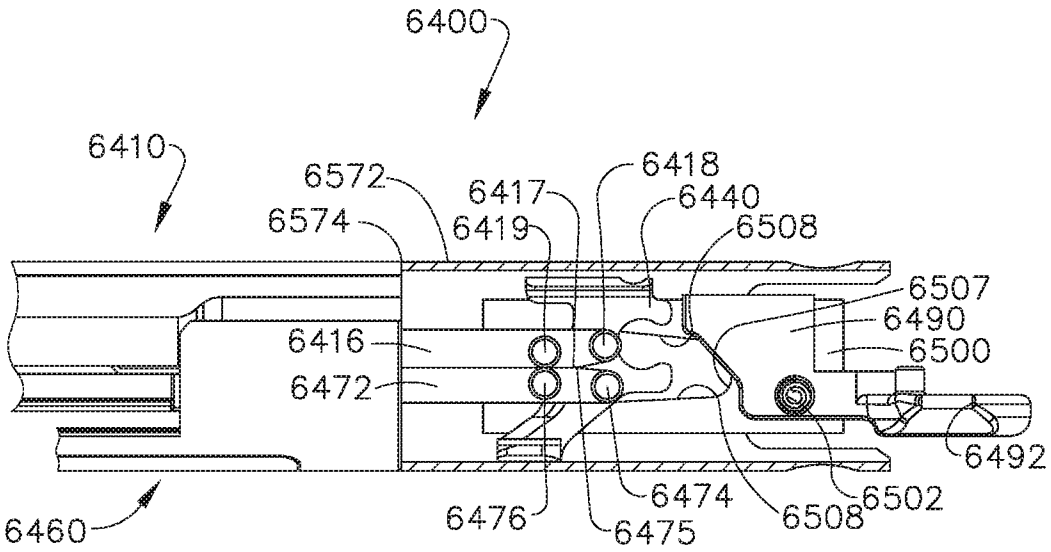

6400
6410
6572
6574
6417
6419
6418
6440
6508
6507
6490
6500
6416
6472
6492
6460
6476
6475
6474
6508
6502

FIG. 77

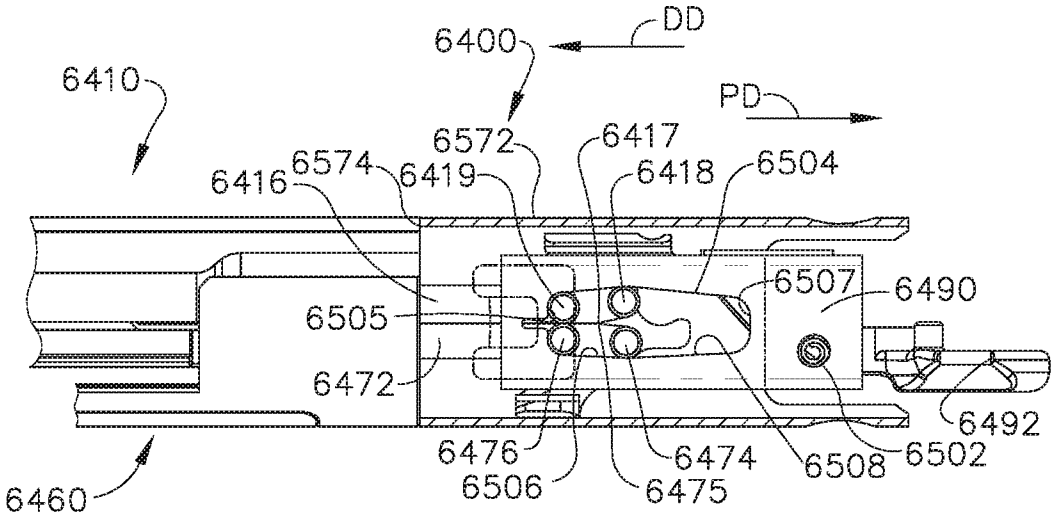

DD
6400
6410
PD
6572
6574
6416
6419
6417
6418
6504
6507
6490
6505
6472
6492
6460
6476
6506
6475
6474
6508
6502

FIG. 78

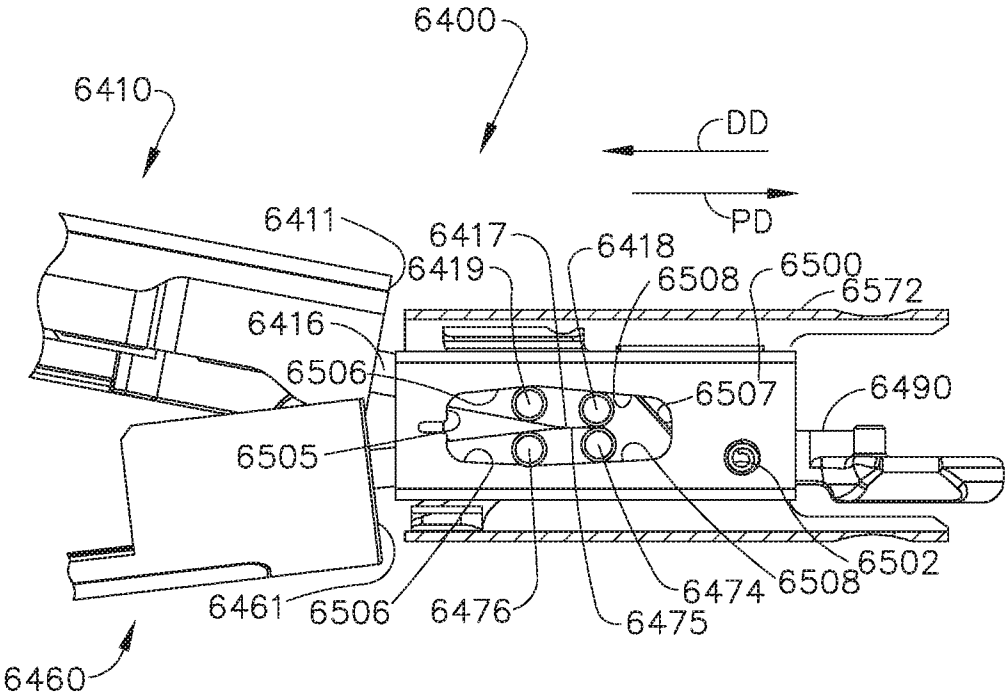

6400
6410
DD
PD
6411
6417
6418
6419
6508
6500
6572
6416
6506
6507
6490
6505
6502
6461
6506
6476
6474
6508
6475
6460

FIG. 79

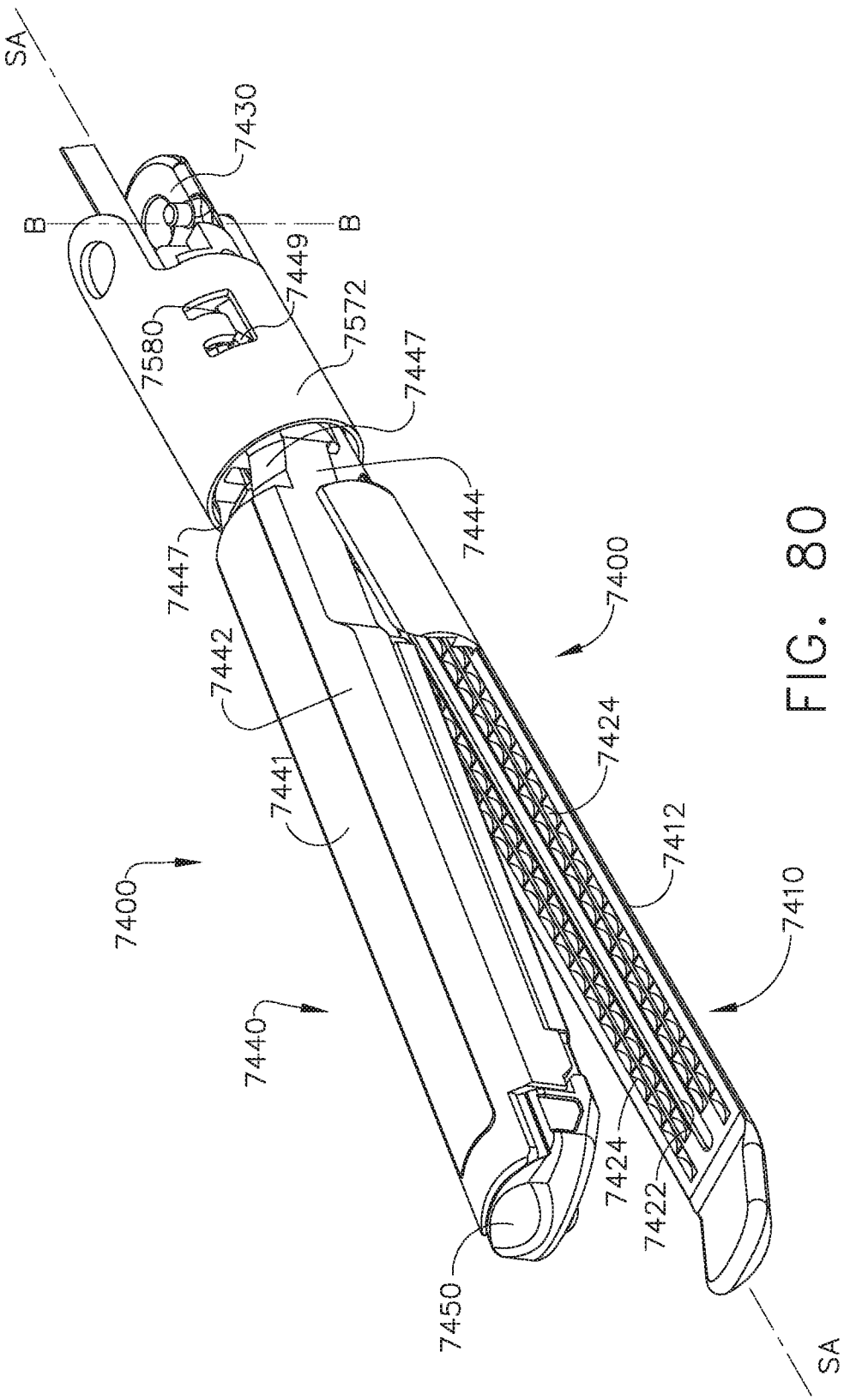

SA
7430
B
B
7449
7572
7580
7447
7444
7447
7400
7442
7424
7441
7412
7400
7410
7440
7424
7422
7450
SA

FIG. 80

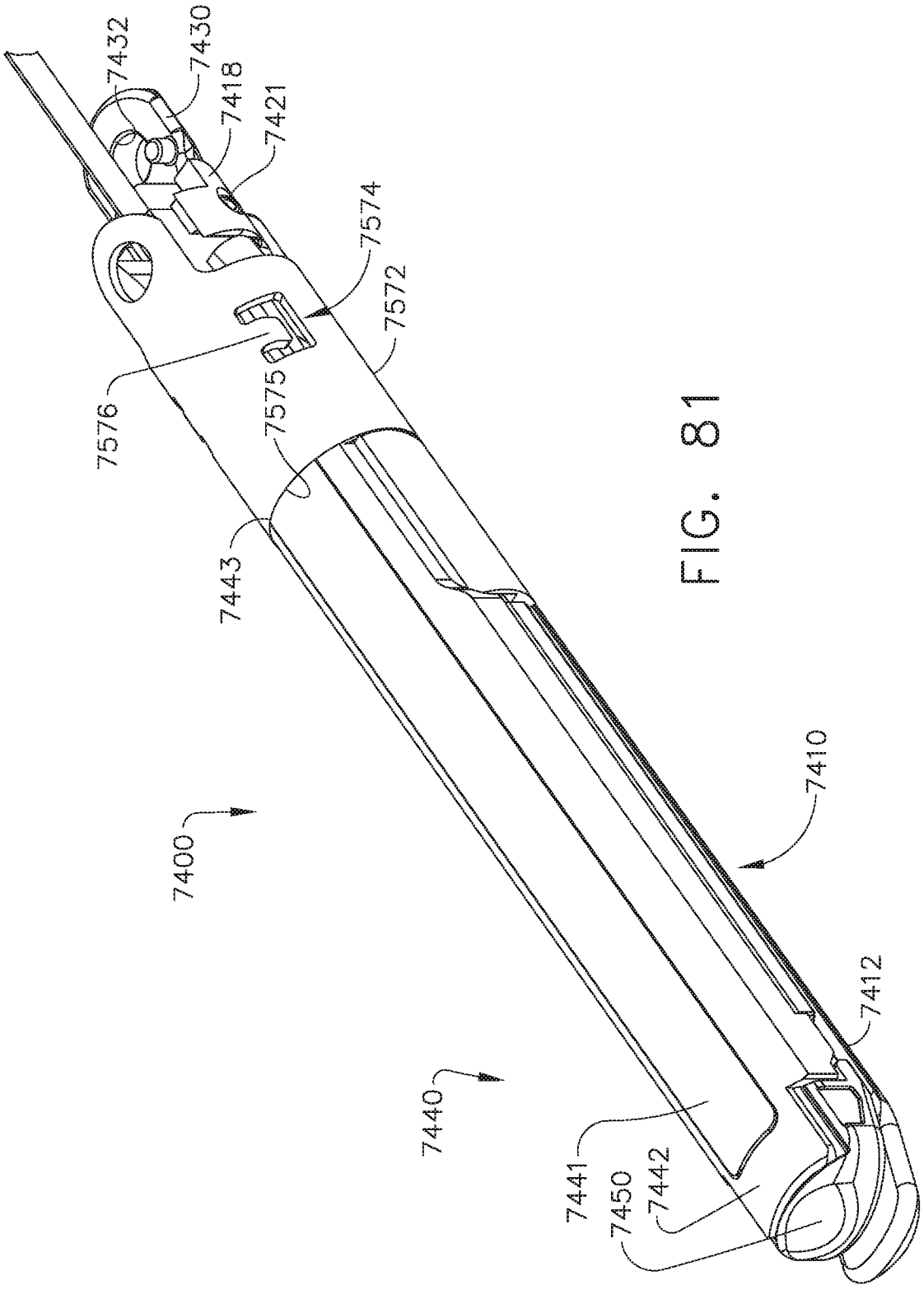

7432
7430
7418
7421
7574
7572
7576
7575
7443
7400
7410
7412
7440
7441
7450
7442

FIG. 81

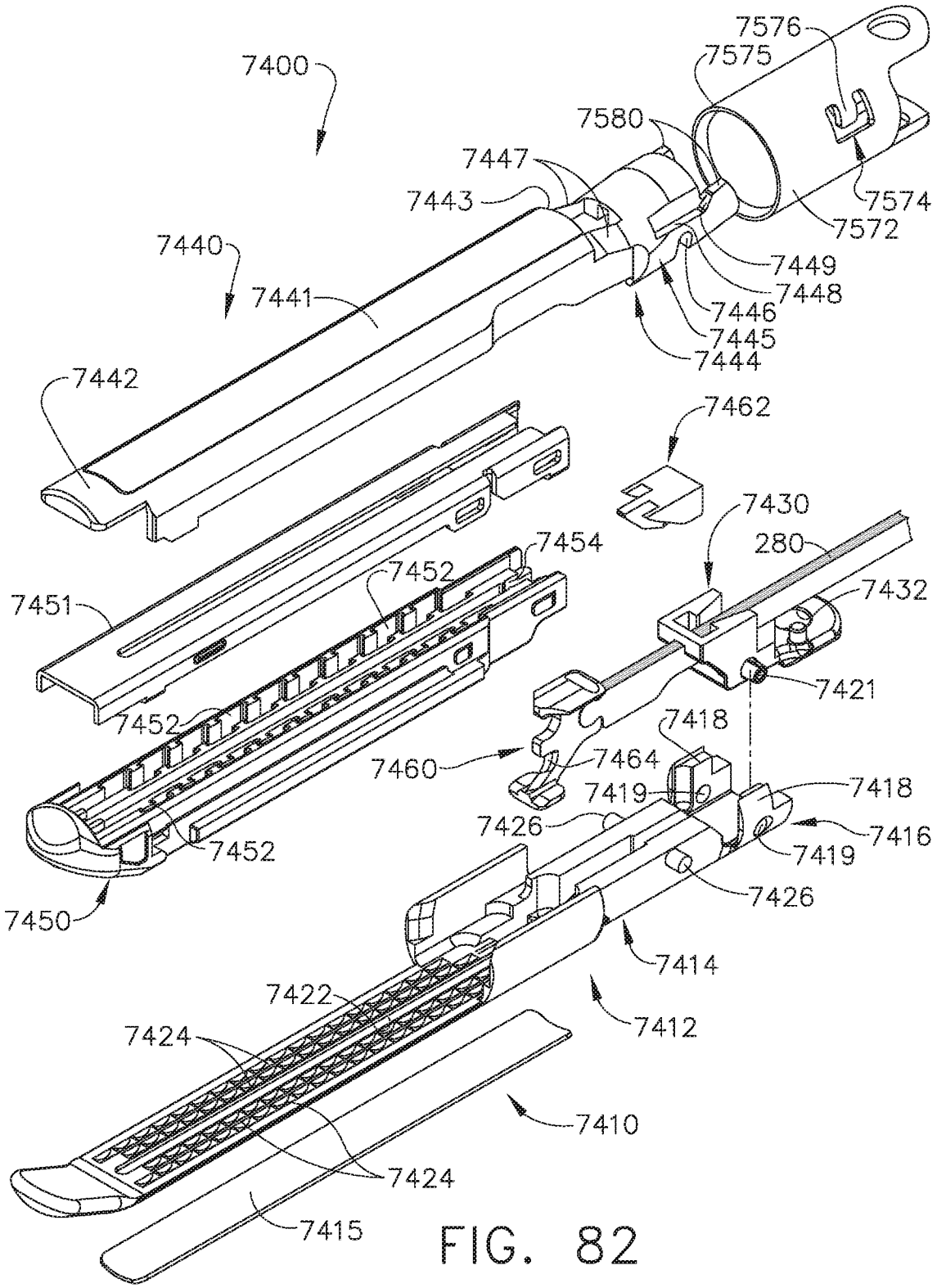

7400
7576
7575
7580
7447
7443
7574
7572
7440
7441
7449
7448
7446
7445
7444
7442
7462
7430
280
7454
7452
7451
7432
7421
7452
7418
7460
7464
7419
7418
7426
7416
7419
7452
7426
7450
7414
7422
7412
7424
7410
7424
7415

FIG. 82

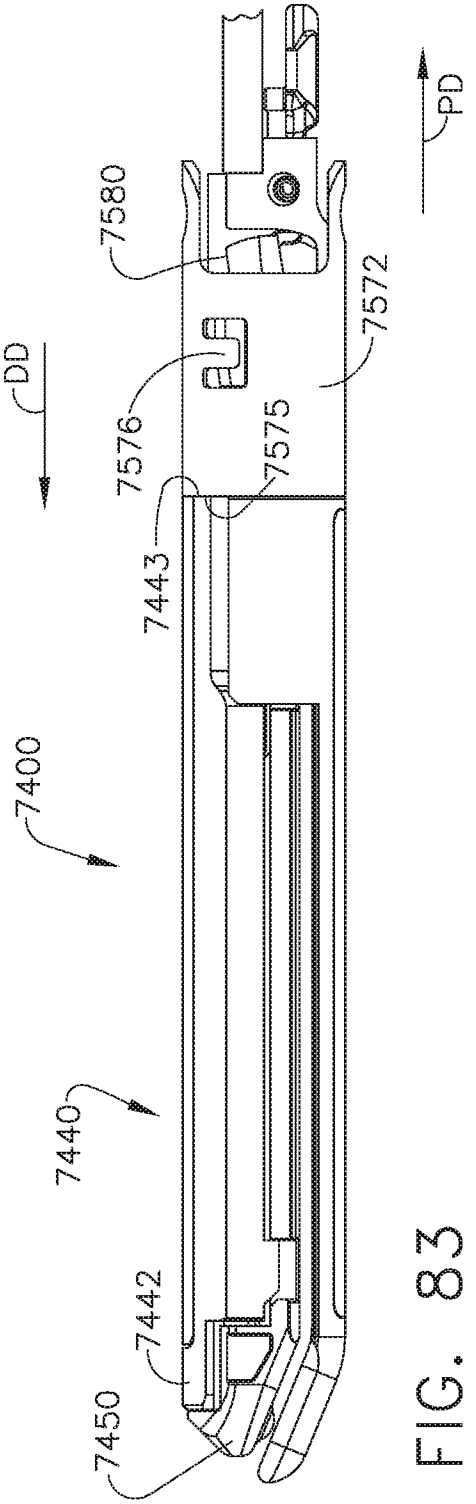

DD
PD
7580
7572
7576
7575
7443
7400
7440
7442
7450

FIG. 83

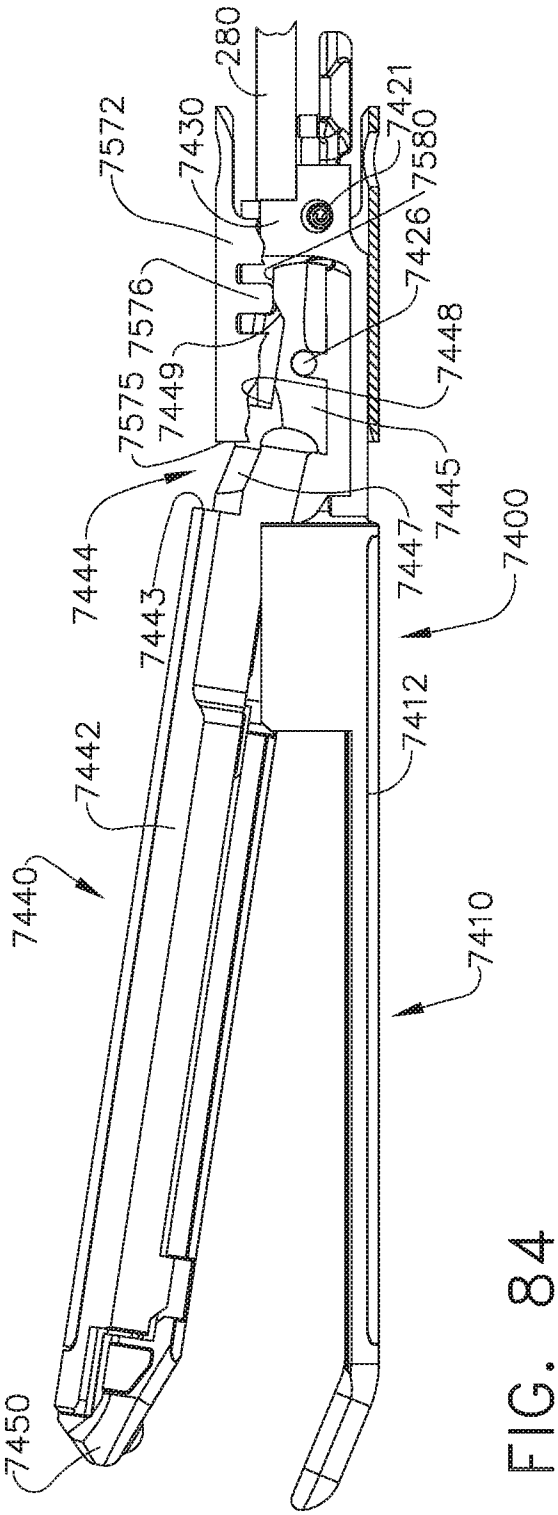

280
7572
7430
7421
7580
7426
7576
7575
7449
7448
7445
7444
7443
7447
7400
7442
7412
7440
7410
7450

FIG. 84

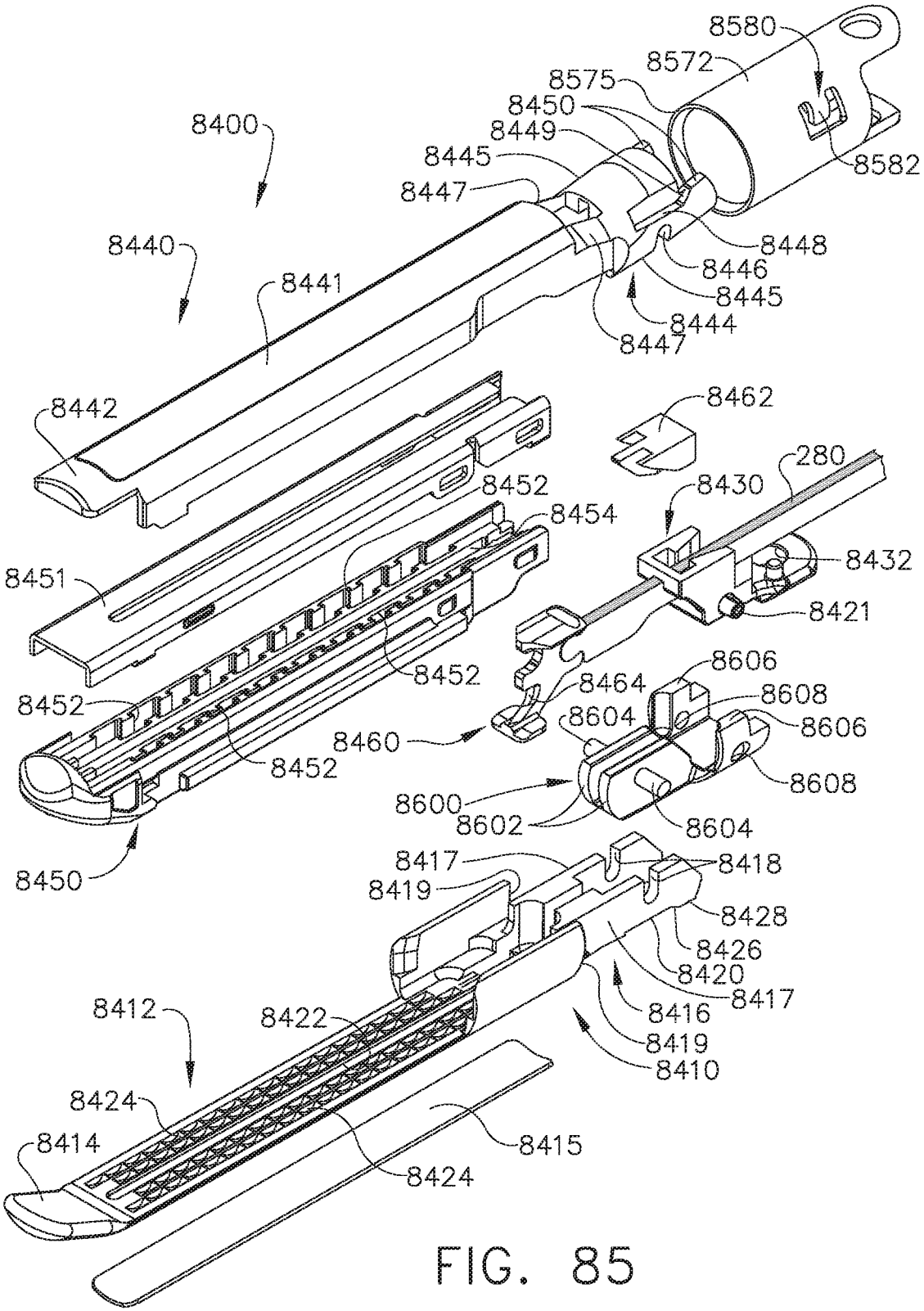

8580
8572
8575
8450
8449
8445
8447
8400
8582
8440
8448
8446
8445
8444
8447
8441
8442
8462
280
8452
8454
8430
8451
8432
8421
8606
8464
8608
8604
8606
8460
8452
8452
8608
8600
8602
8604
8450
8417
8418
8419
8428
8426
8420
8417
8416
8419
8410
8412
8422
8424
8414
8415
8424

FIG. 85

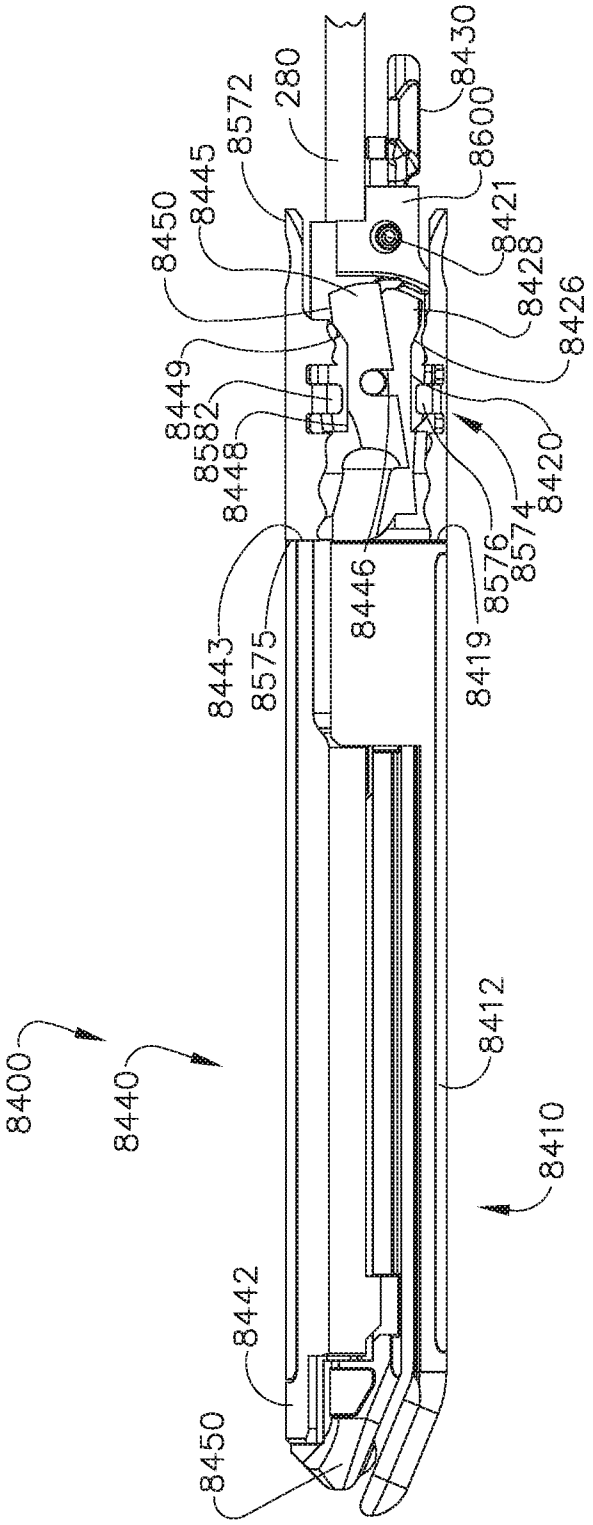

8400
8440
8450
8442
8412
8410
8443
8575
8446
8419
8576
8574
8420
8426
8428
8421
8600
8430
8582
8448
8449
8450
8445
8572
280

FIG. 86

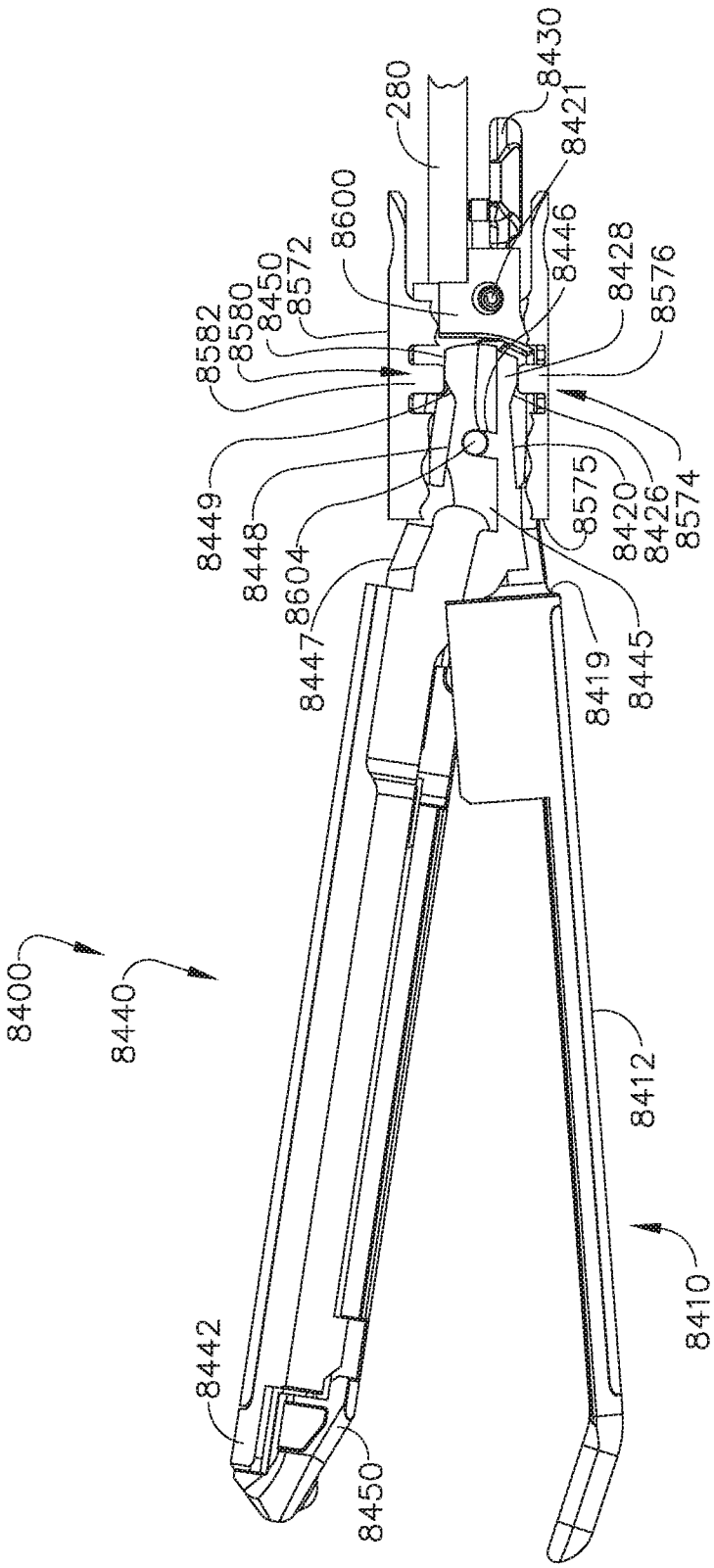

8400
8440
8442
8450
8410
8412
8447
8604
8448
8449
8582
8580
8450
8572
8600
280
8430
8421
8446
8428
8576
8574
8426
8420
8575
8445
8419

FIG. 87

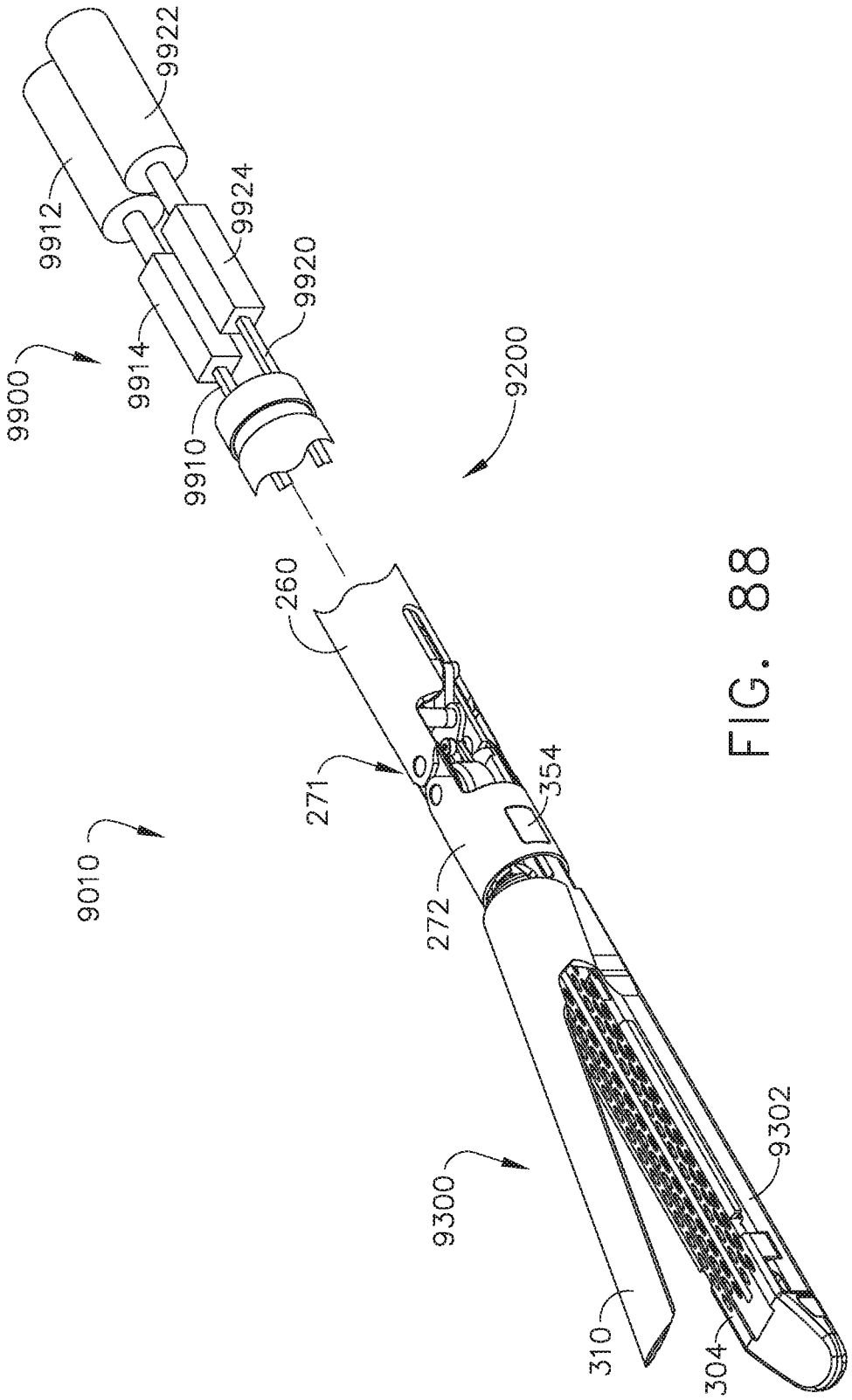

9922
9912
9924
9920
9914
9900
9910
9200
260
271
354
9010
272
9300
9302
310
304

FIG. 88

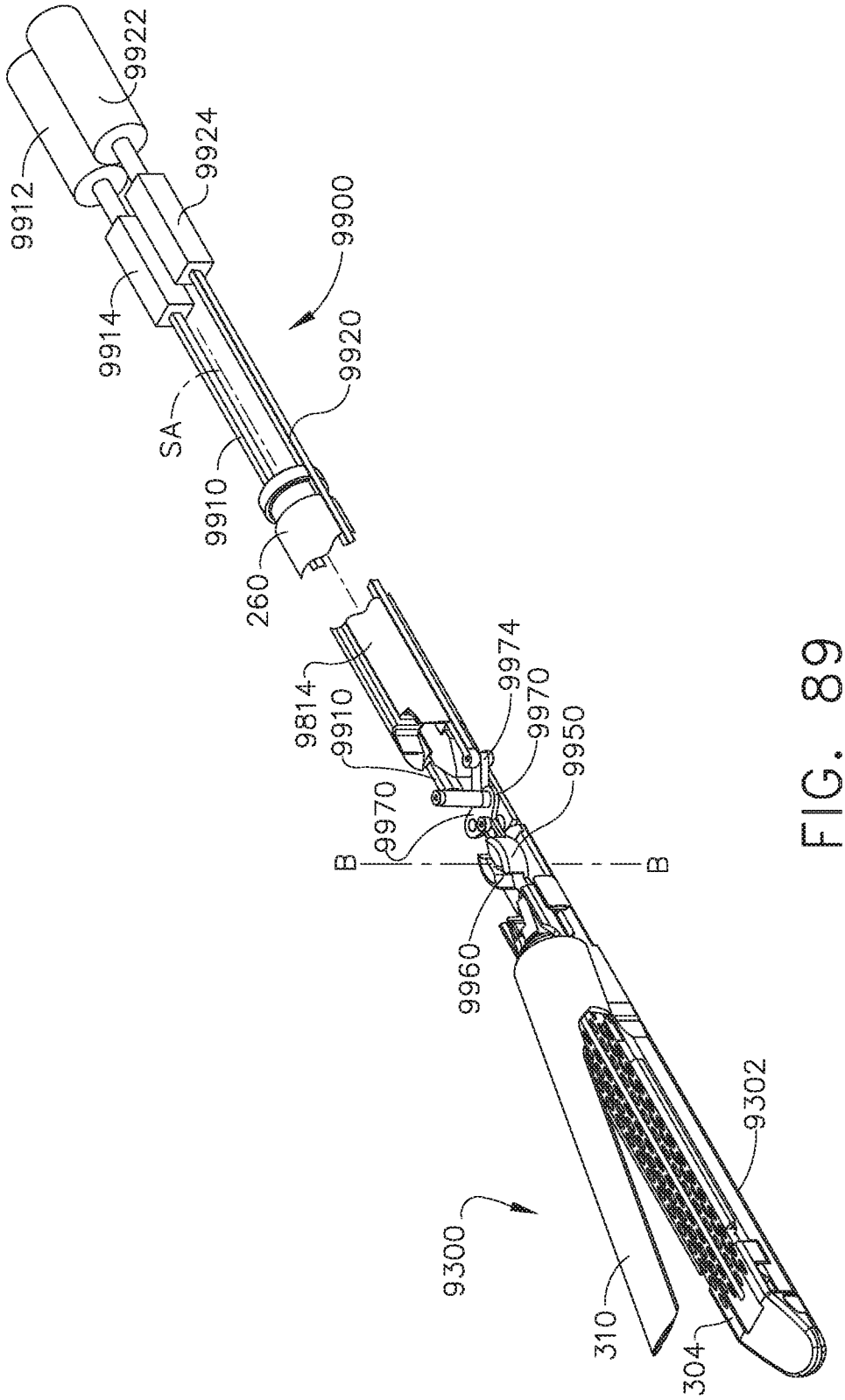

9912
9922
9924
9900
9914
9920
SA
9910
260
9814
9910
9974
9970
9950
9970
B
B
9960
9300
9302
310
304

FIG. 89

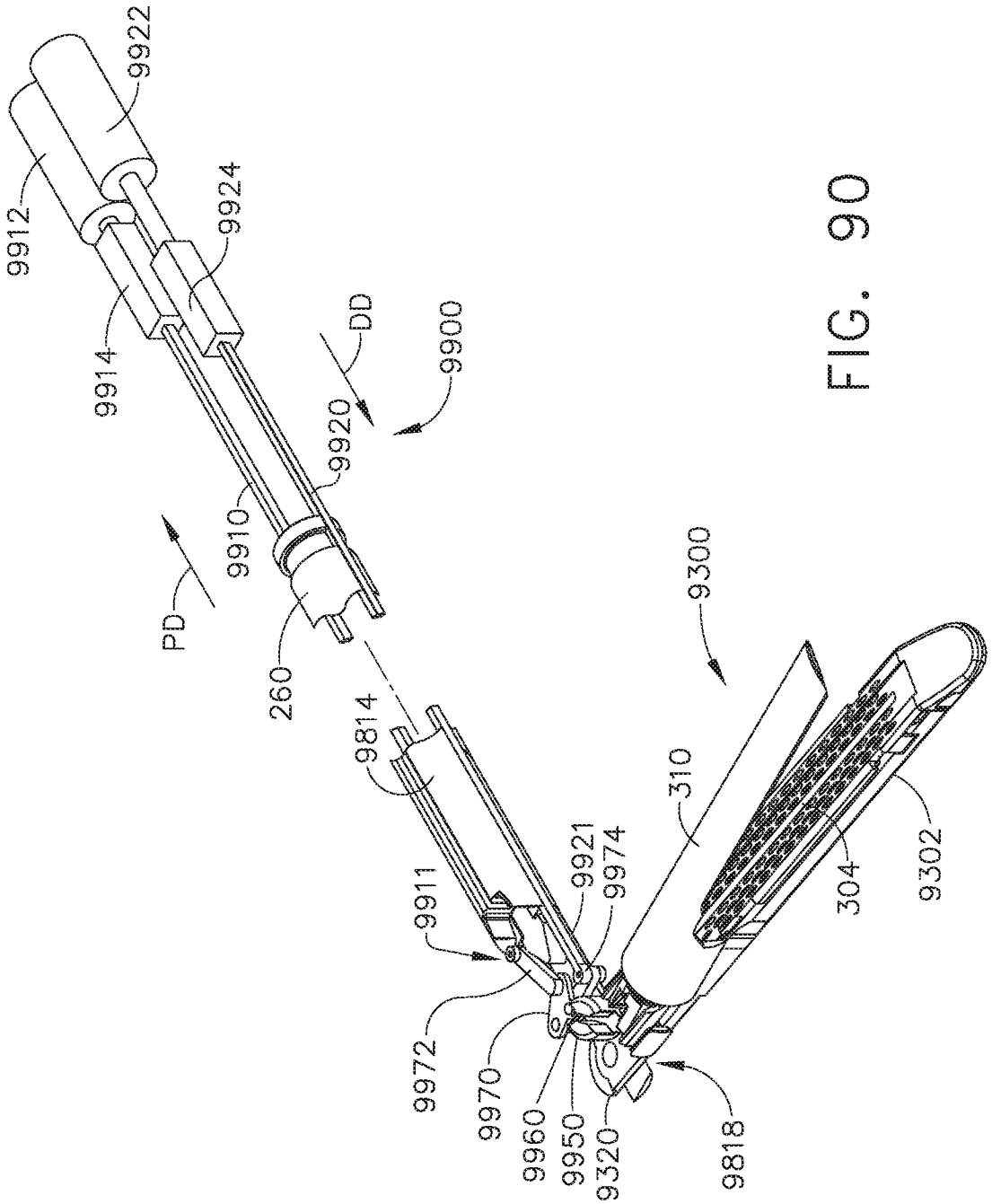

9922
9912
9924
9914
DD
9900
9920
9910
PD
260
9814
9300
310
9921
9974
9911
9304
9302
9972
9970
9960
9950
9320
9818

FIG. 90

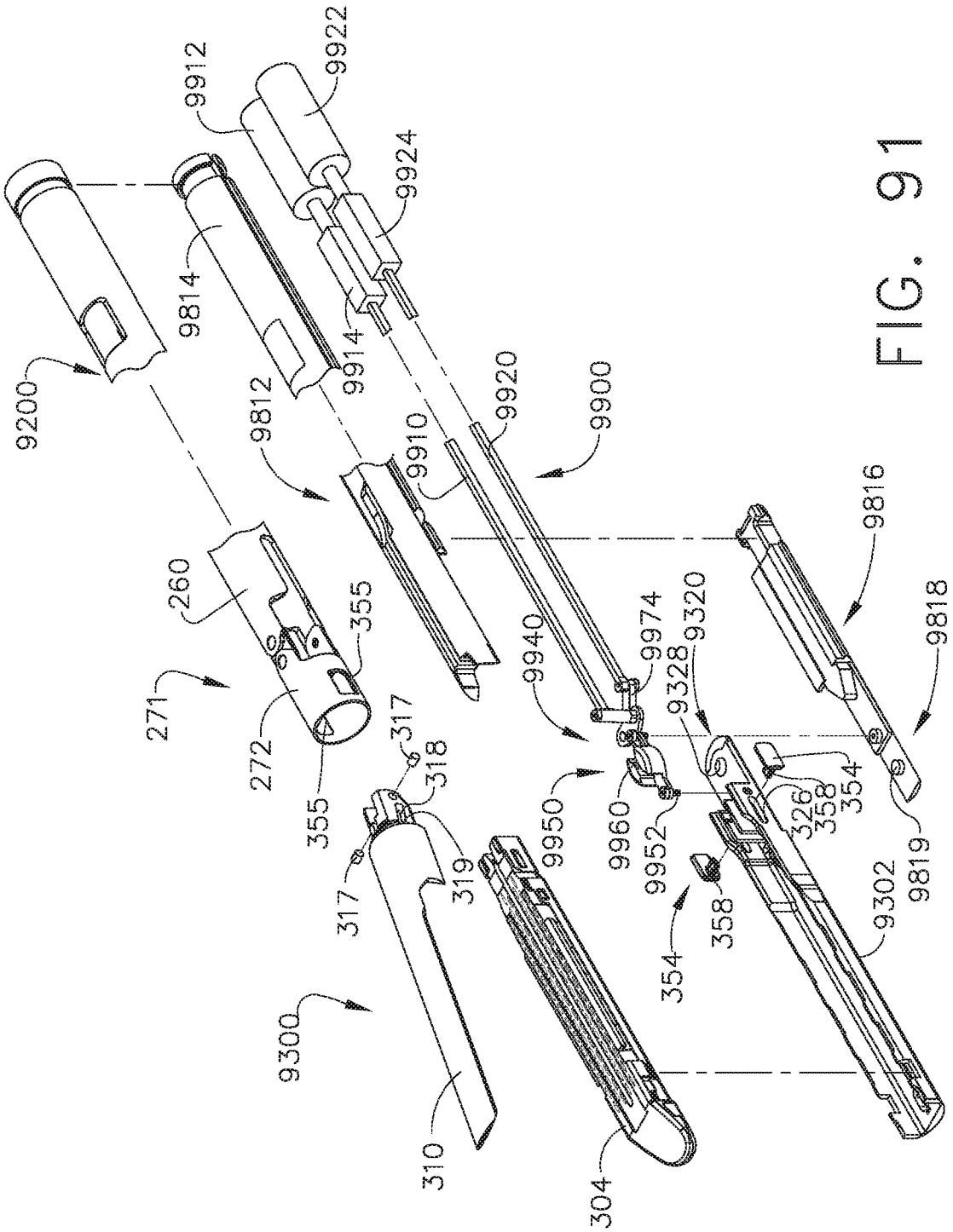

9200
9912
9922
9924
9814
9914
9812
9920
9900
9910
9816
260
355
9940
9974
9320
9818
271
272
317
9328
318
354
9950
9960
326
358
9952
9819
319
9302
358
354
9300
310
304

FIG. 91

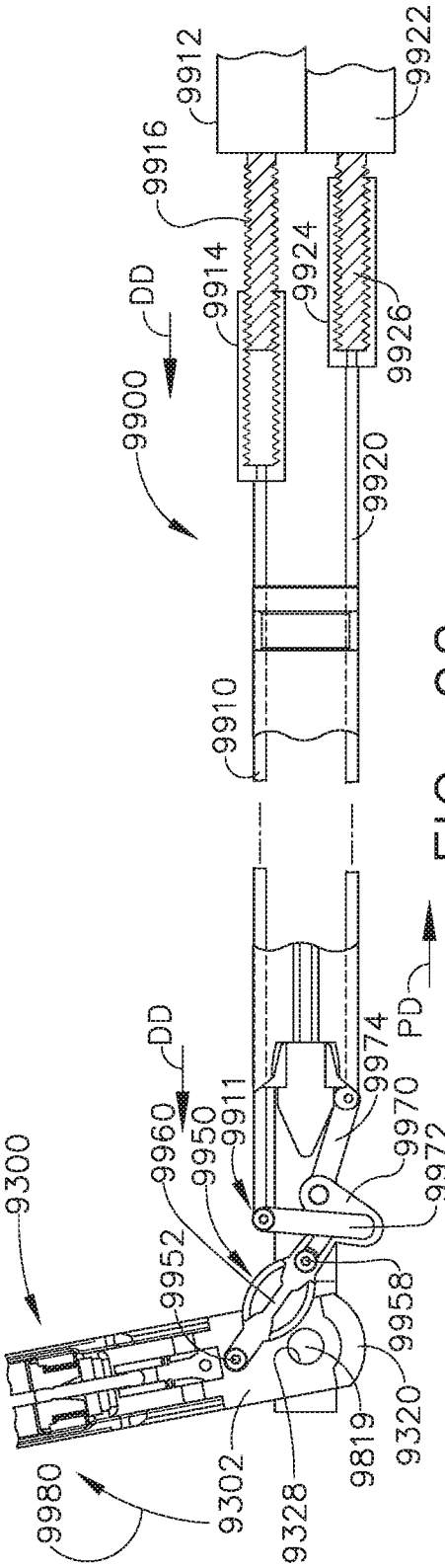

9912
9922
9916
9914
9924
9926
DD
9900
9920
9910
PD
9974
DD
9960
9950
9911
9970
9972
9300
9952
9958
9320
9819
9302
9328
9980

FIG. 92

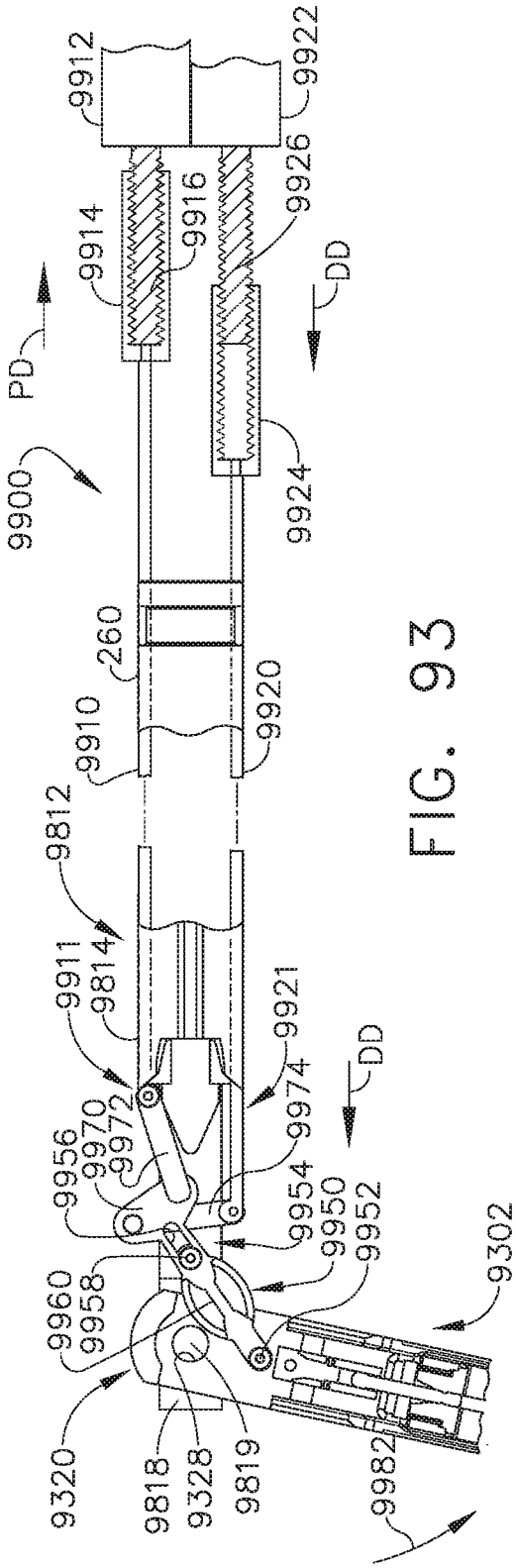

9912
9922
9926
9916
9914
DD
PD
9900
9924
260
9920
9910
9812
9911
9814
9921
DD
9974
9956
9970
9972
9954
9950
9952
9960
9958
9302
9320
9818
9328
9819
9982

FIG. 93

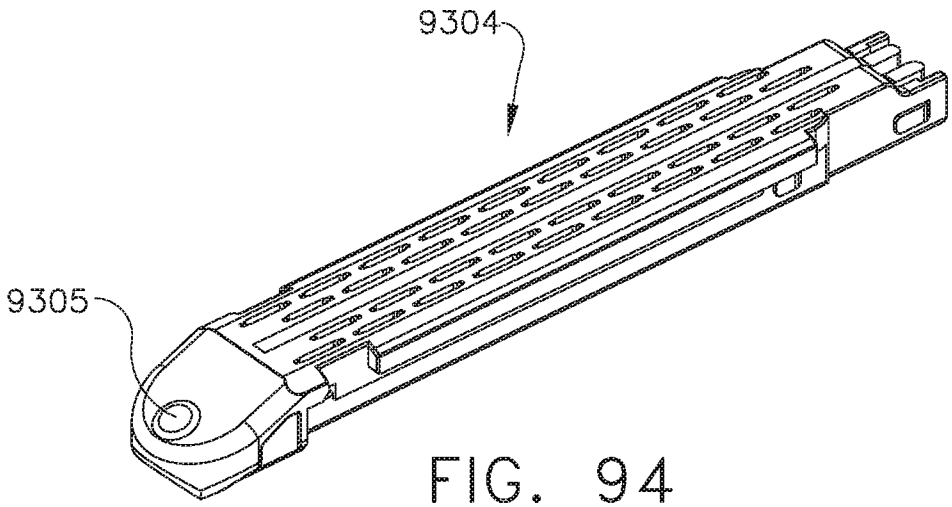


FIG. 94

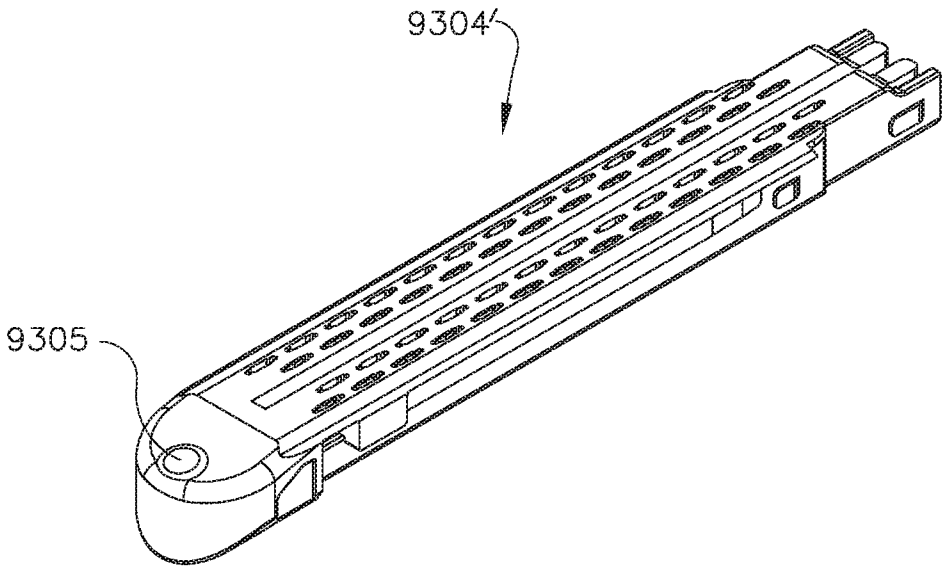


FIG. 95

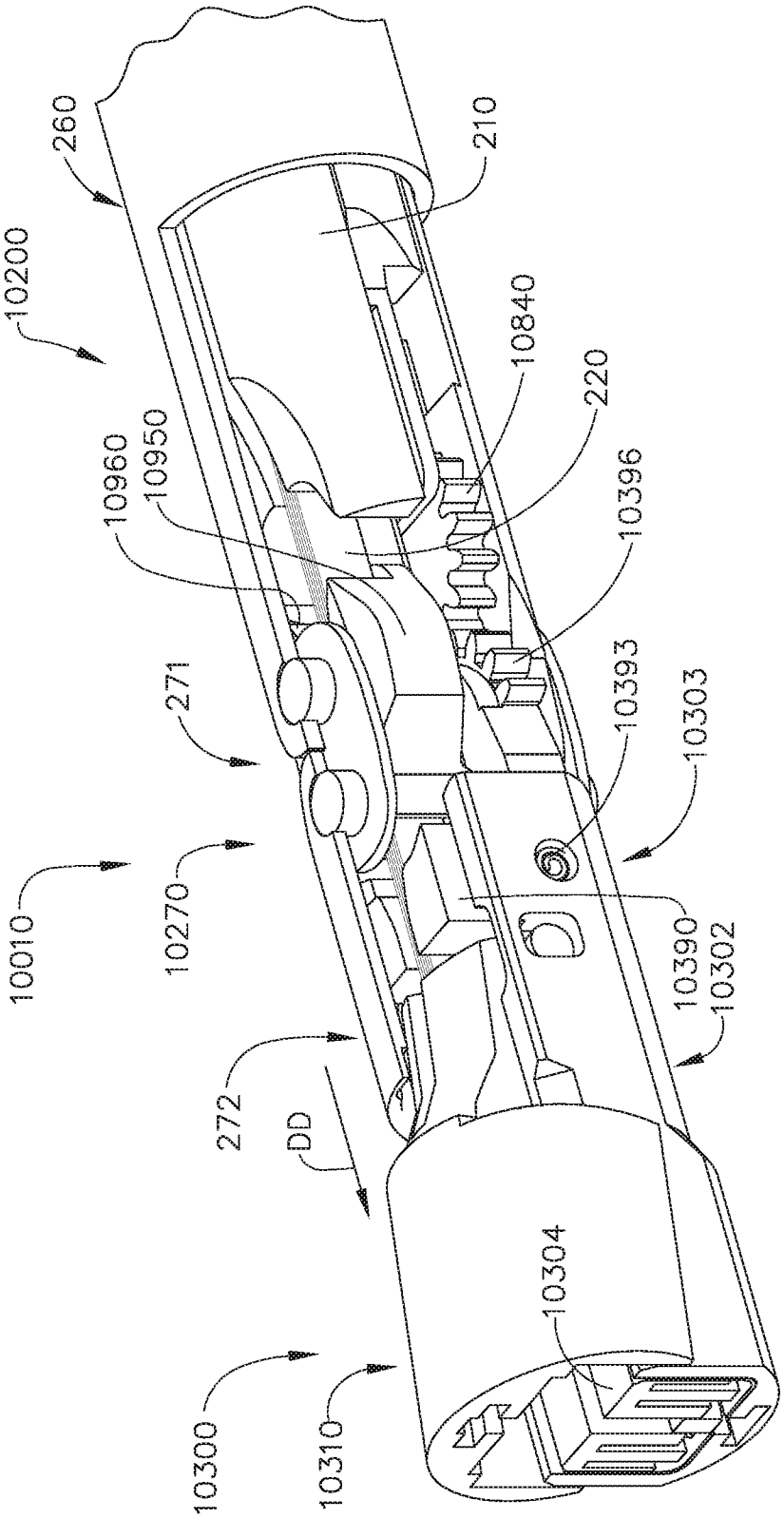

260
210
10200
10840
220
10960
10950
10396
271
10393
10303
10010
10270
10390
10302
272
DD
10304
10300
10310

FIG. 96

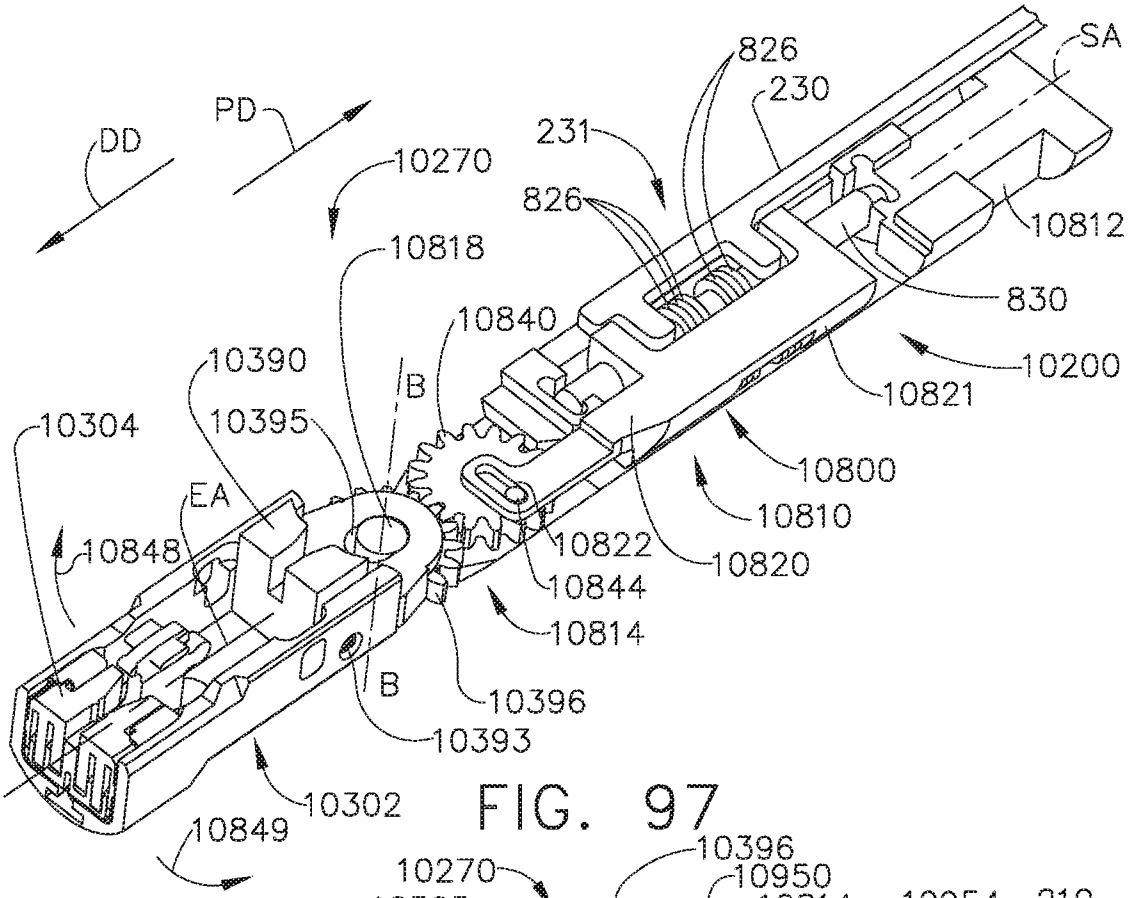

SA
826
230
231
826
10812
830
10200
10821
10800
10810
10820
10822
10844
10814
10396
10393
10302
10849
10848
EA
10304
10395
10390
B
10840
10818
10270
PD
DD

FIG. 97

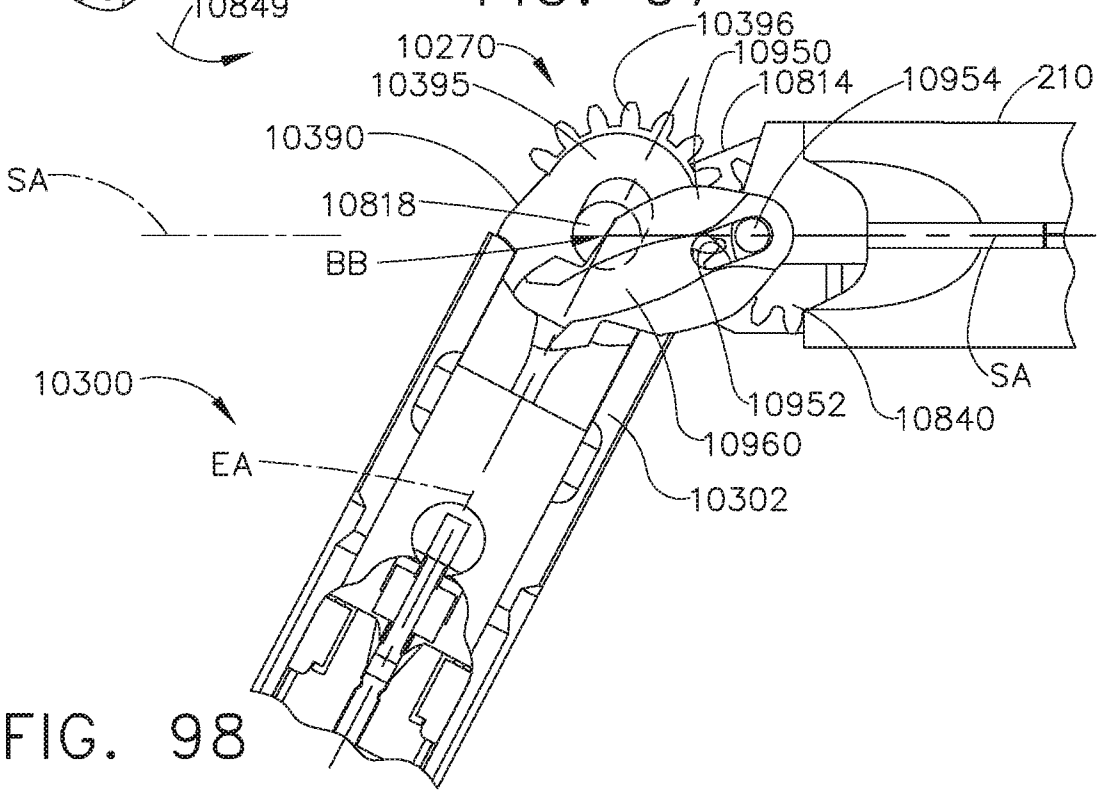

10396
10950
10814
10954
210
10270
10395
10390
SA
10818
BB
10300
EA
10952
10840
SA
10960
10302

FIG. 98

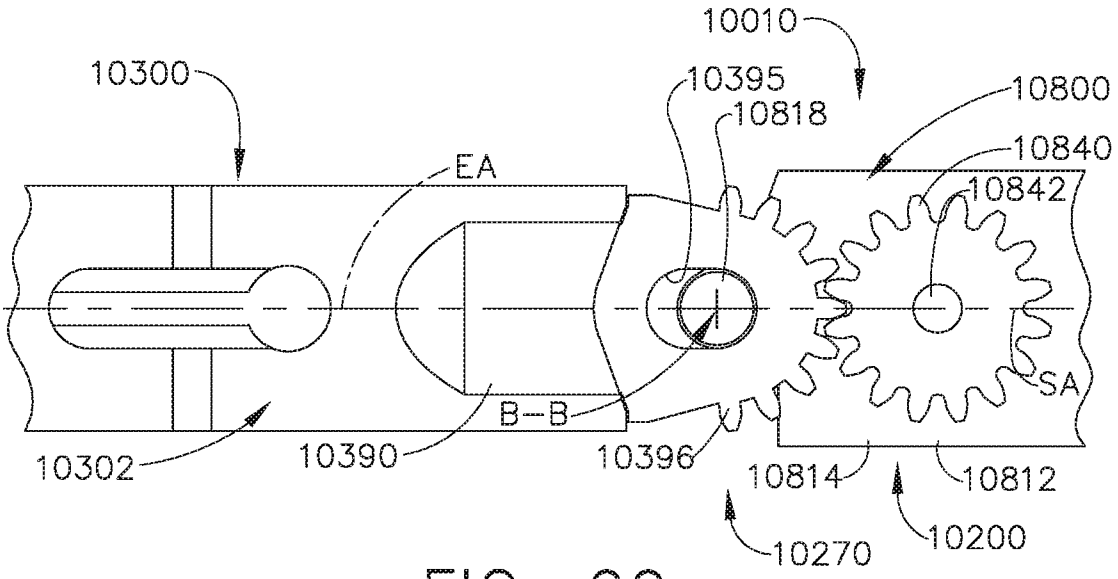


FIG. 99

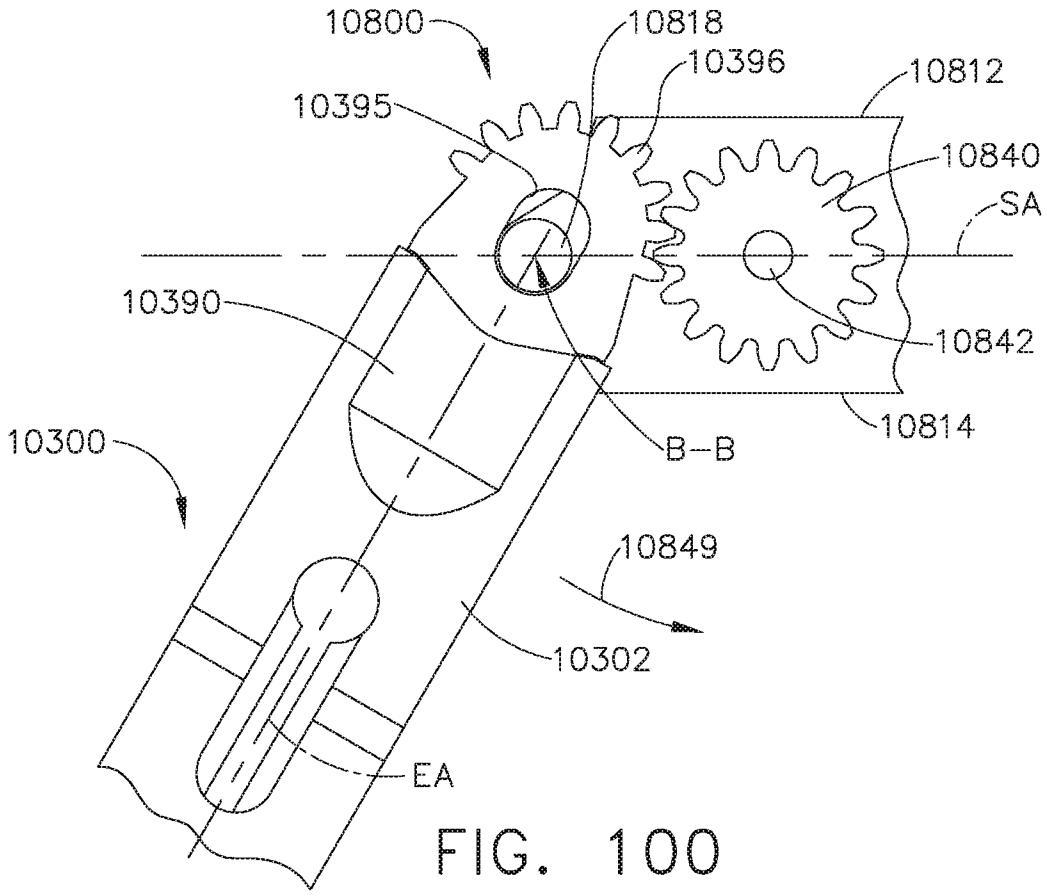


FIG. 100

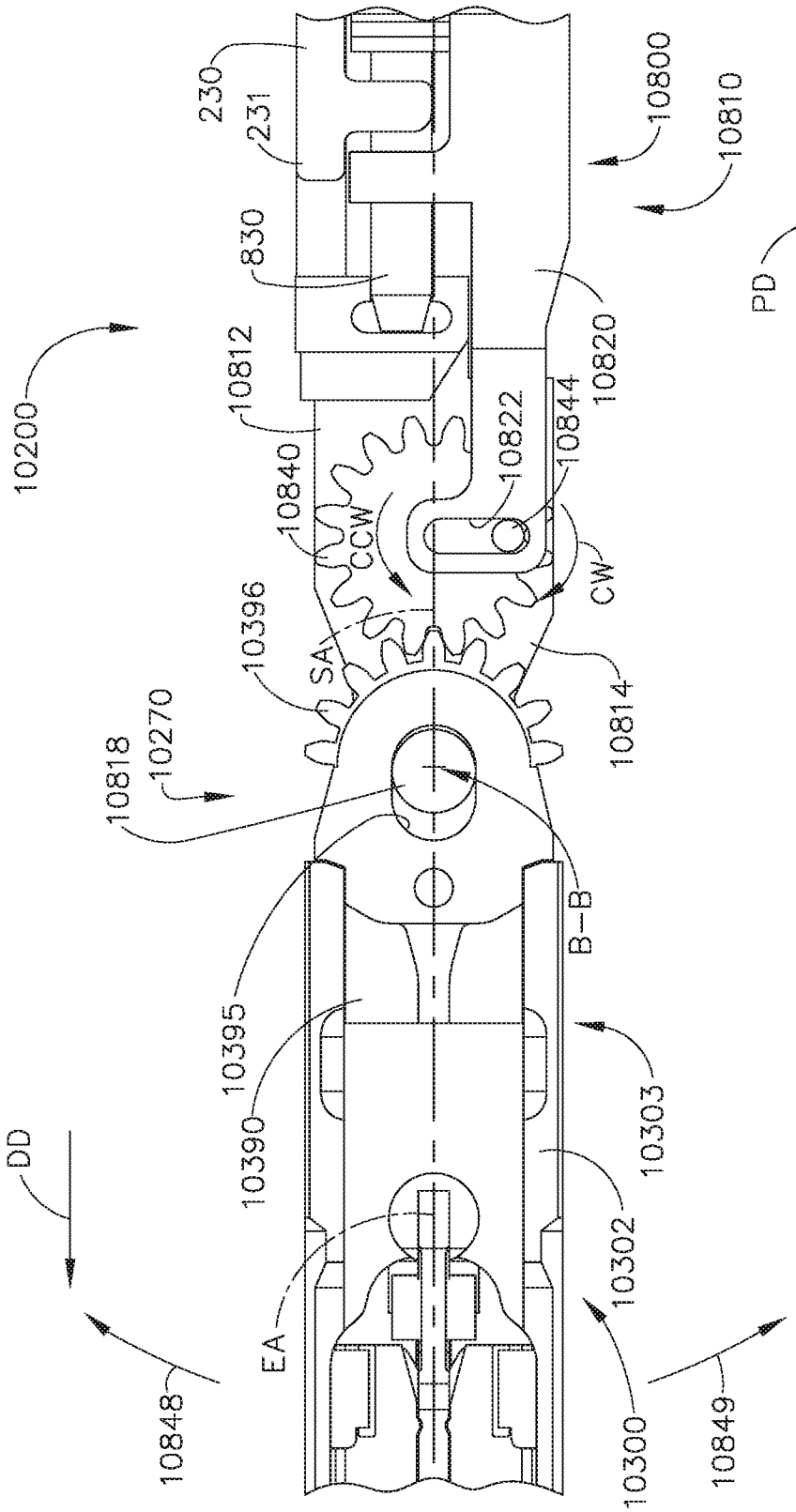

230
231
10800
10810
830
PD
10812
10820
10200
10844
10822
10840
CCW
CW
10396
SA
10814
10818
10270
B-B
10395
10303
10390
DD
10302
EA
10848
10300
10849

FIG. 101

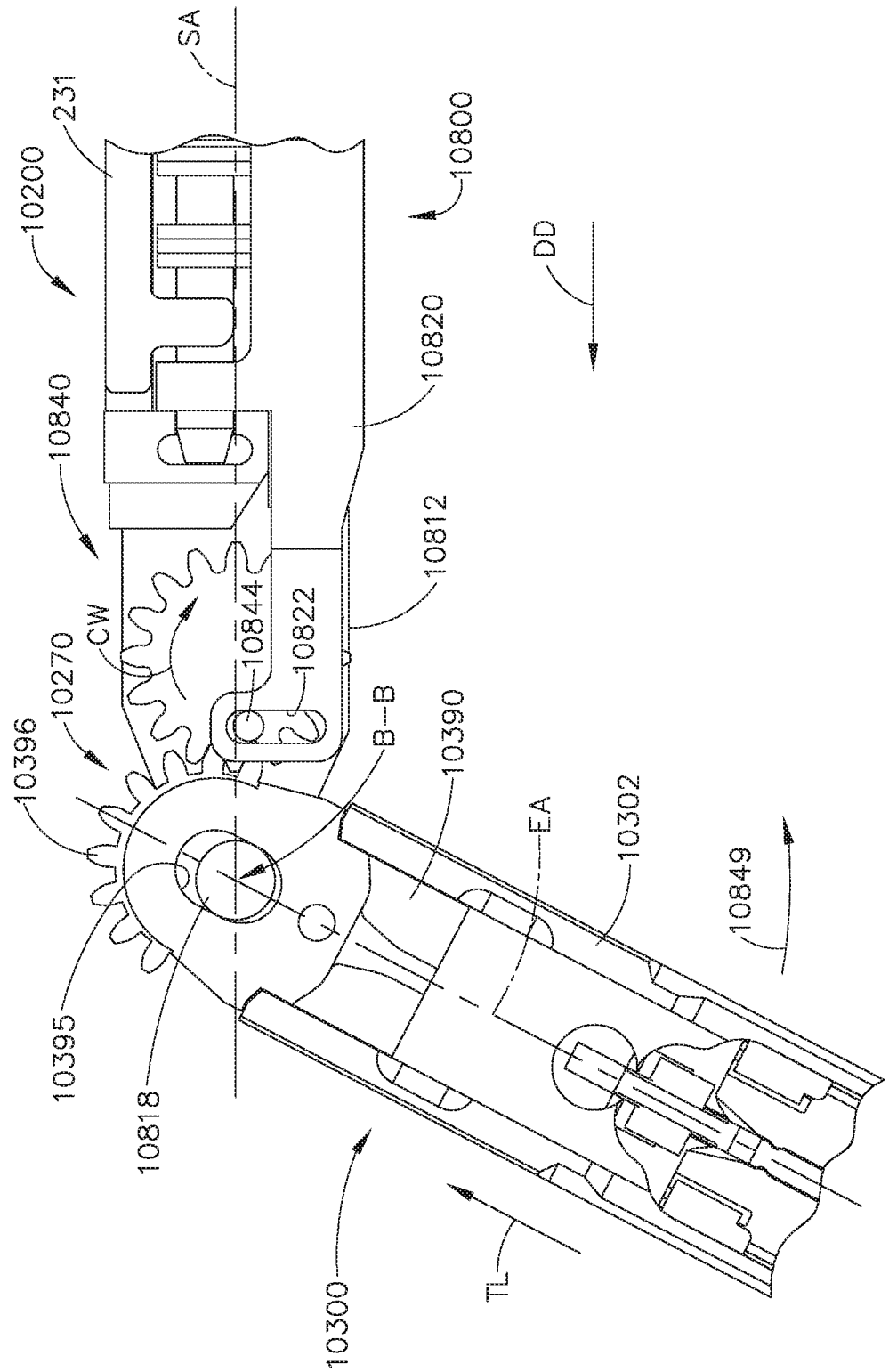

SA
231
10200
10800
DD
10820
10840
10812
10844
10822
CW
10270
B-B
10396
10390
EA
10302
10849
10395
10818
10300
TL

FIG. 102

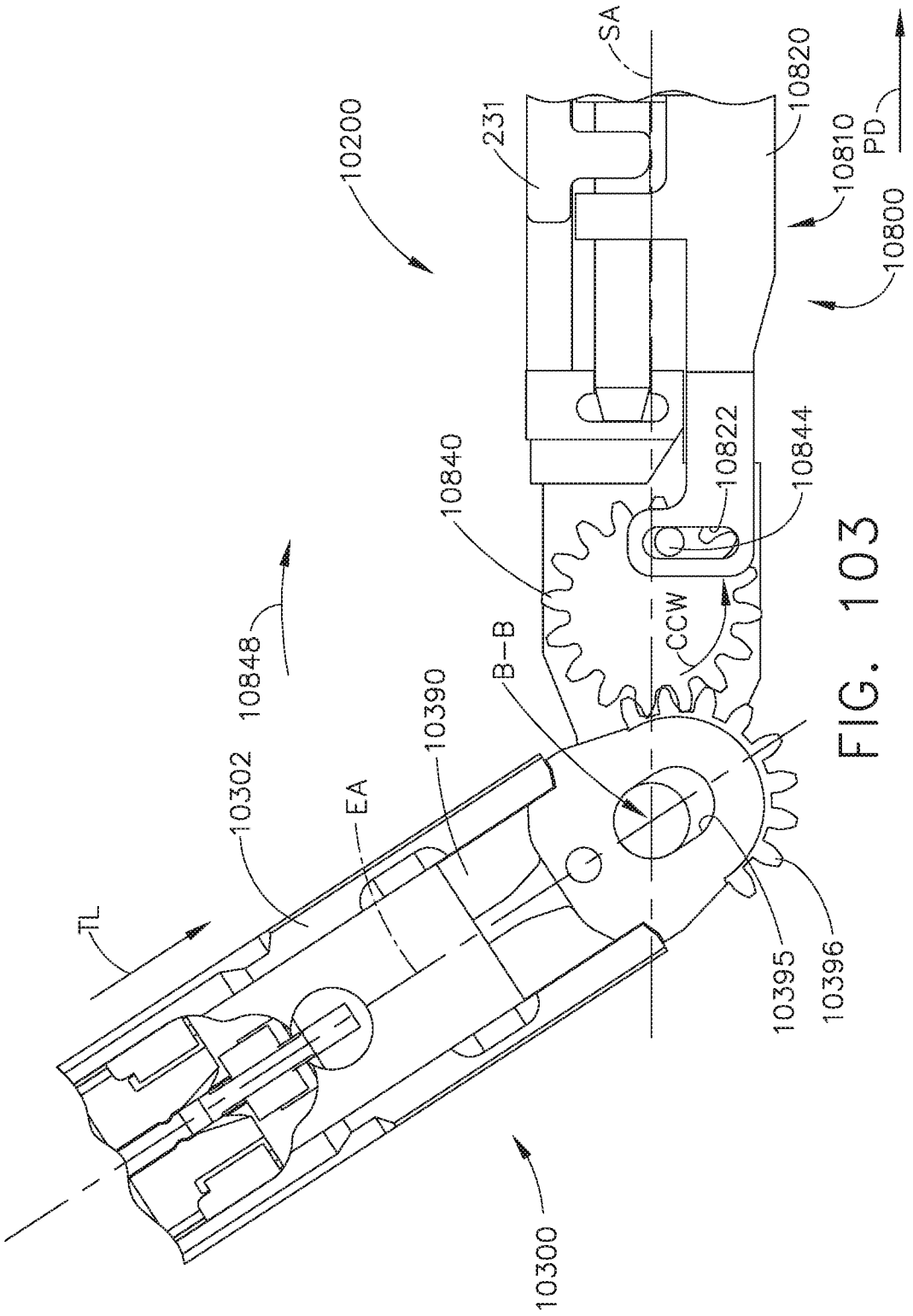

10200
231
SA
10820
10810
PD
10800
10840
10822
10844
10848
B–B
CCW
10390
10302
EA
TL
10395
10396
10300

FIG. 103

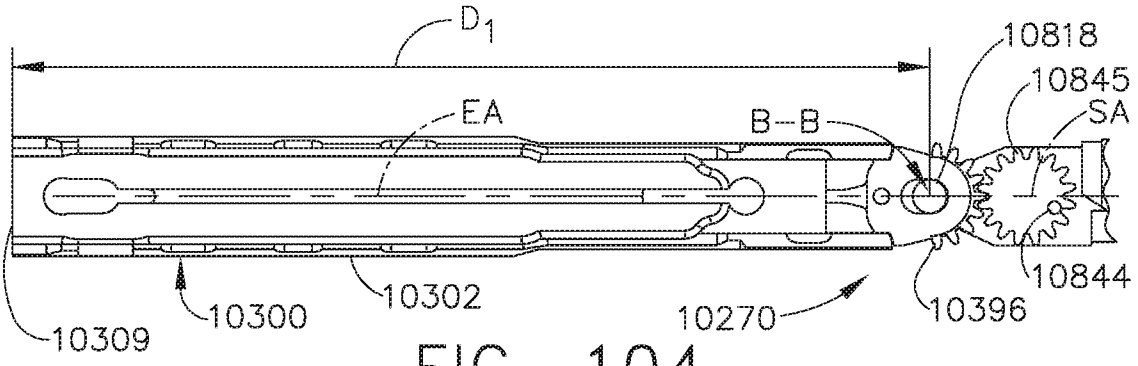


FIG. 104

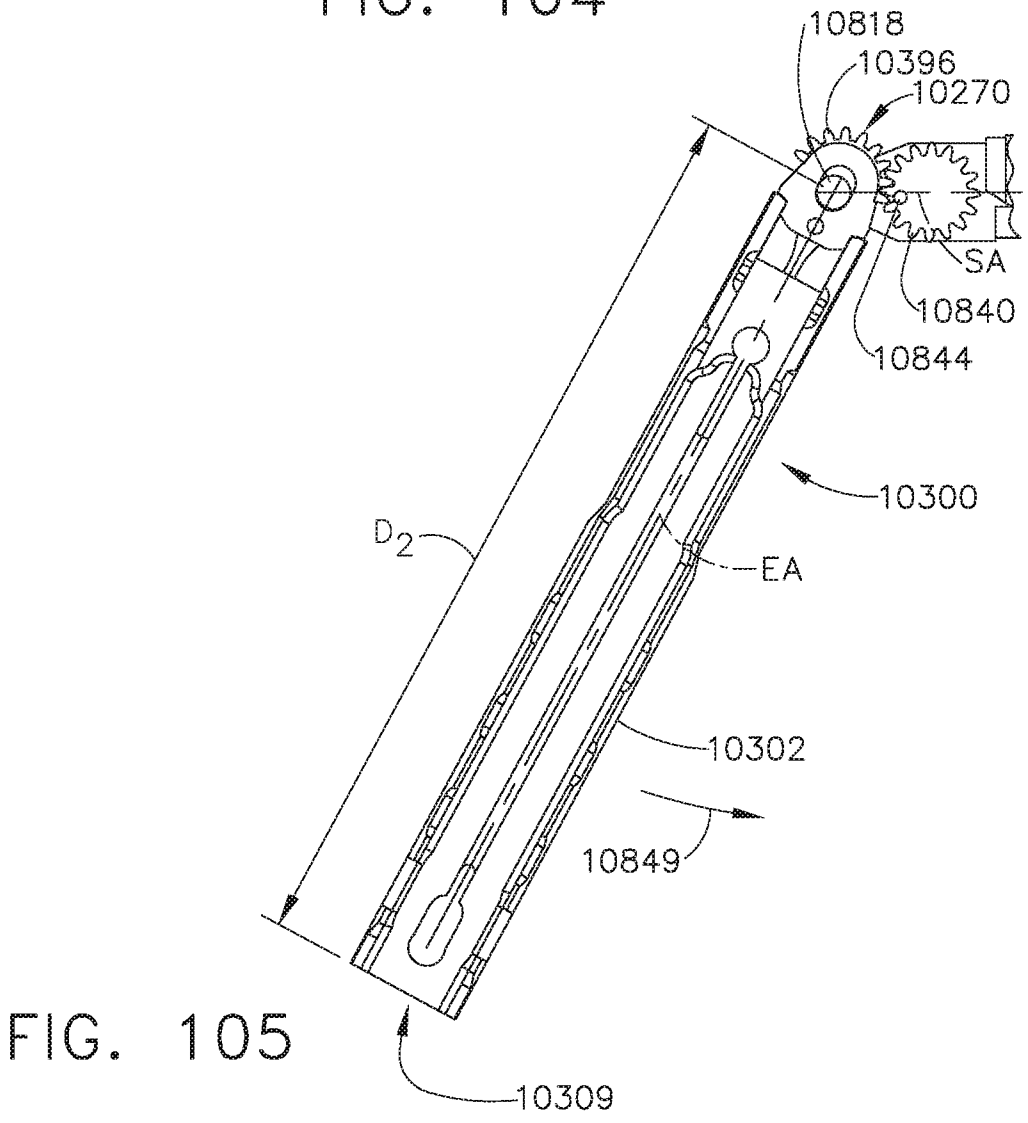


FIG. 105

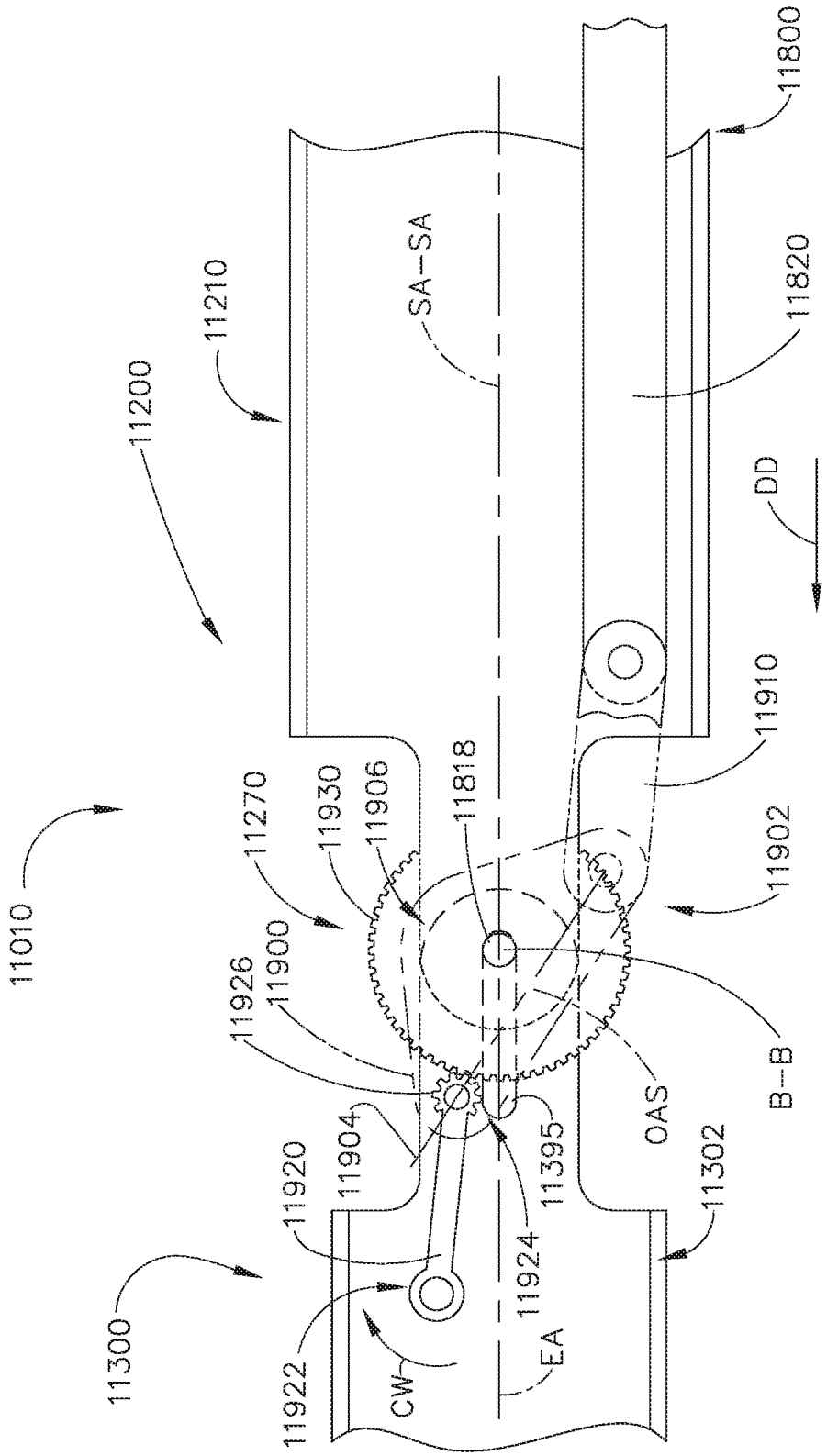

11800
11210
SA–SA
11820
11200
DD
11910
11010
11270
11930
11906
11818
11902
11926
11900
B–B
OAS
11904
11920
11395
11302
11924
11300
11922
CW
EA

FIG. 106

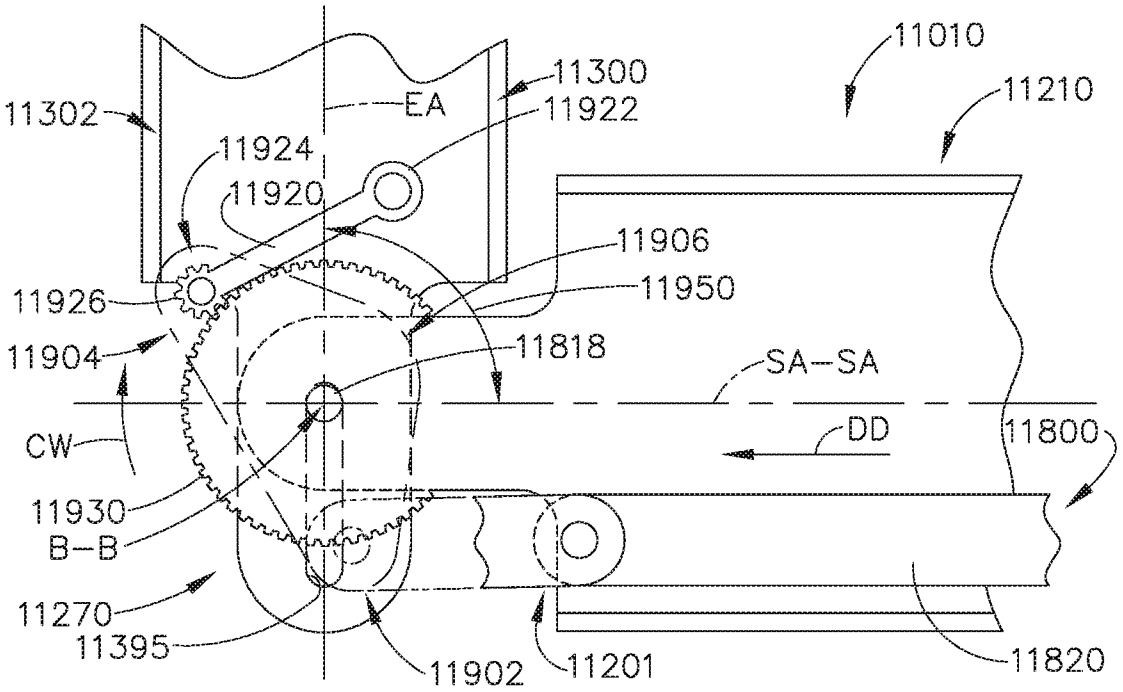


FIG. 107

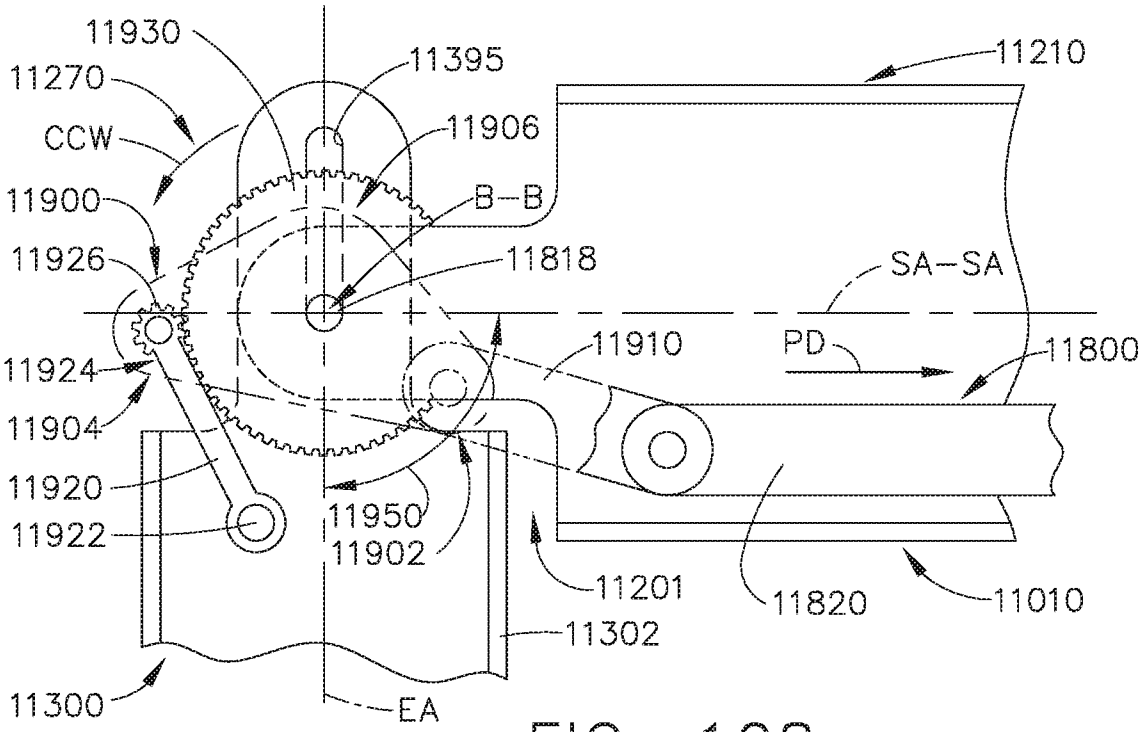


FIG. 108

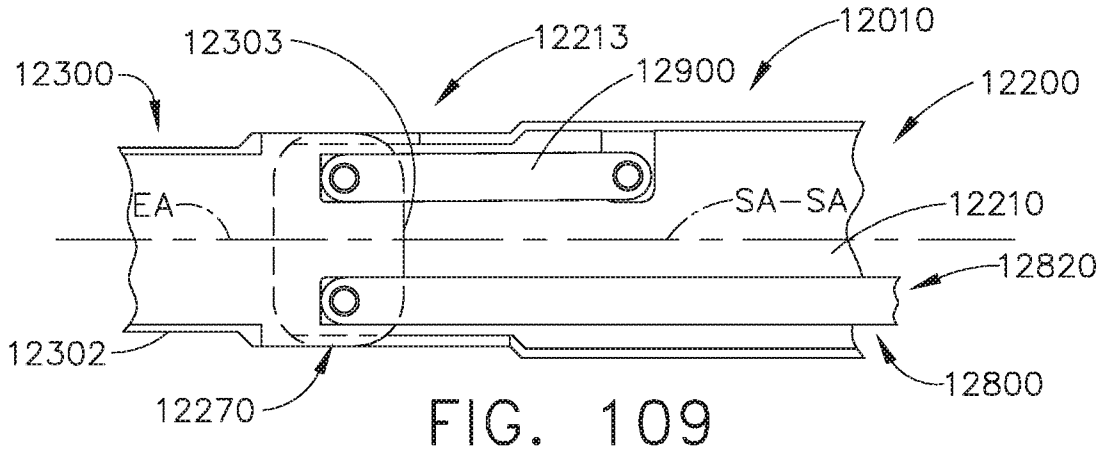


FIG. 109

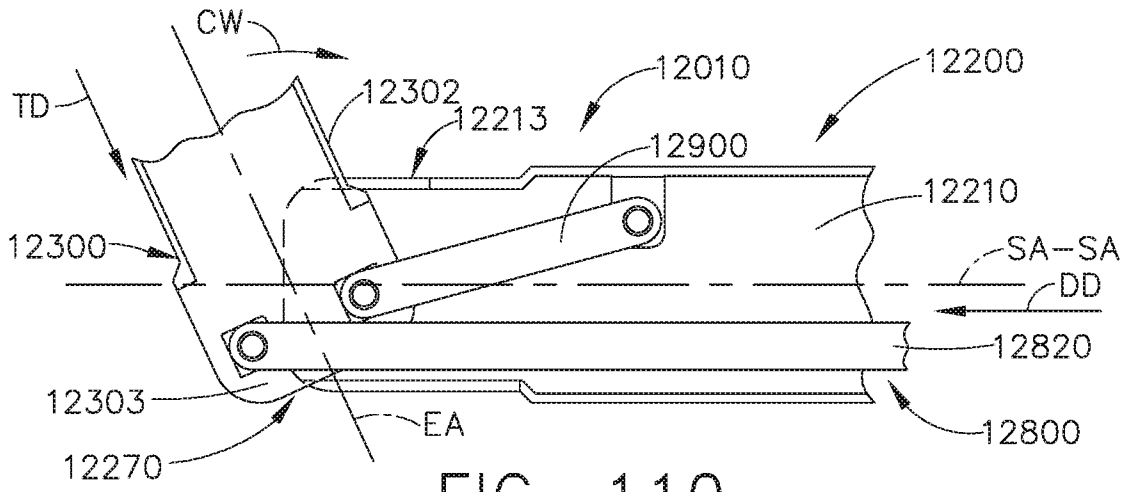


FIG. 110

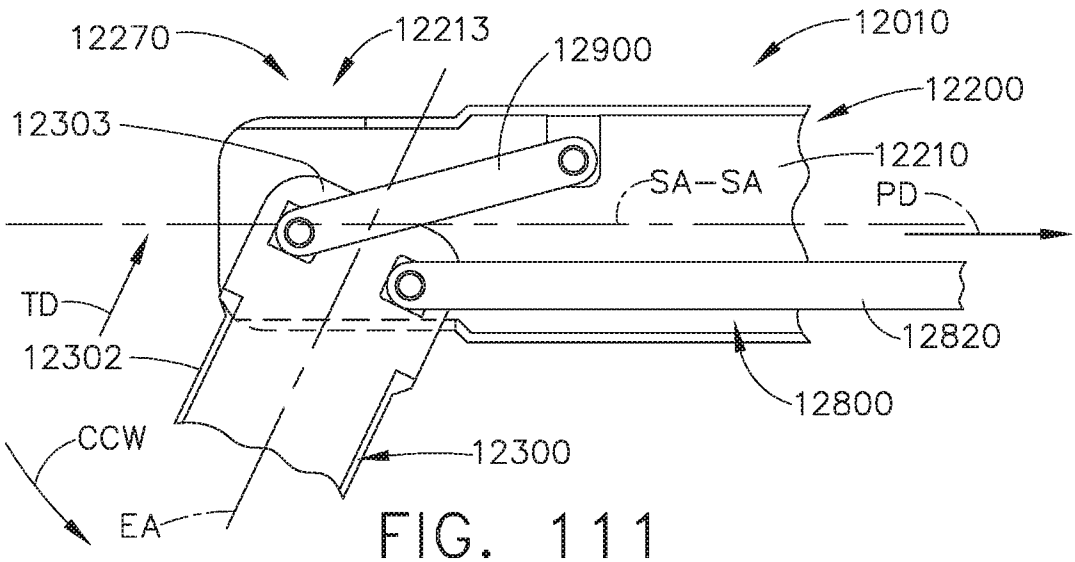


FIG. 111

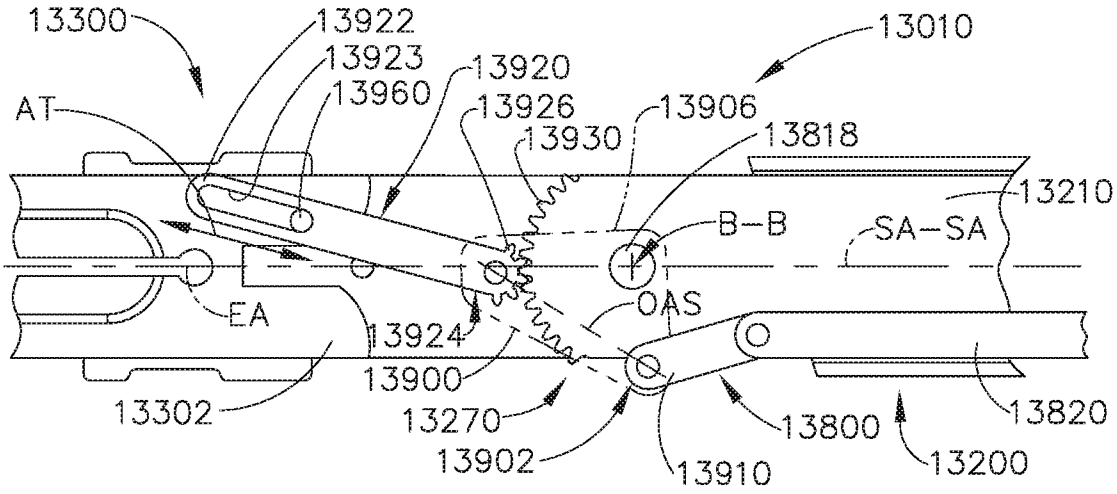


FIG. 112

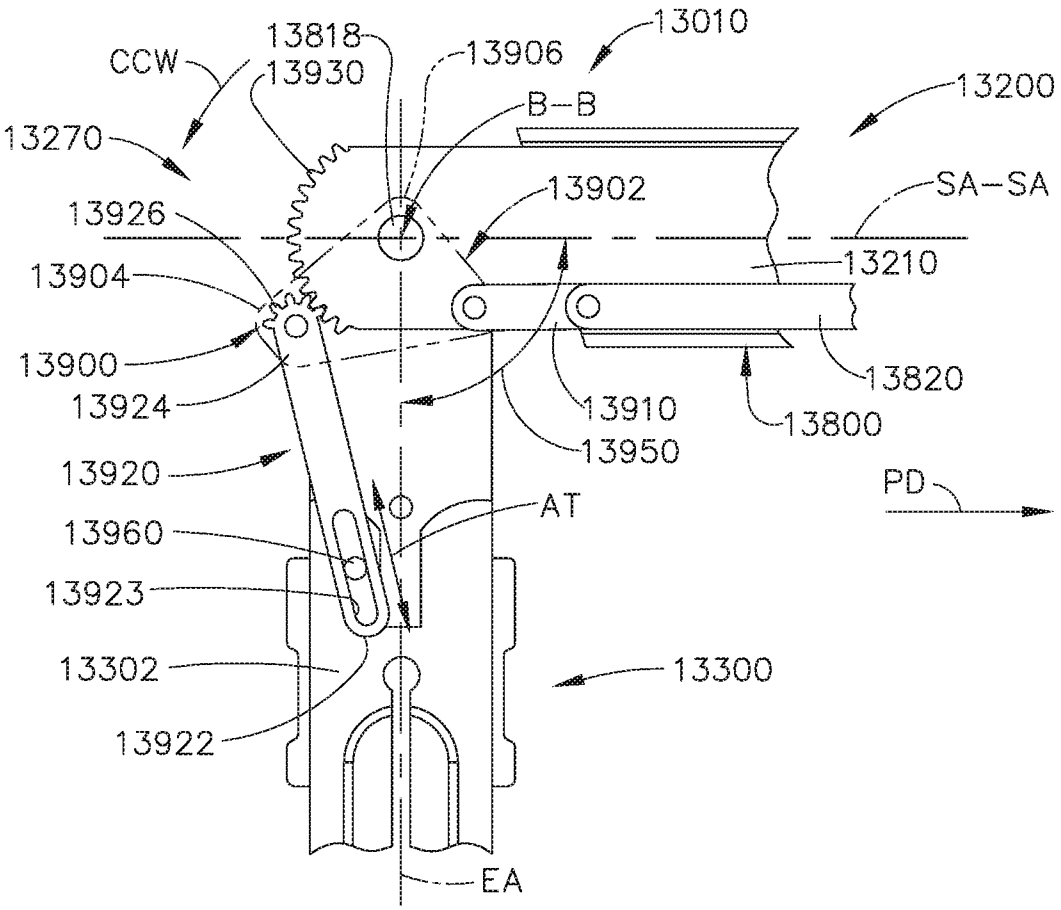


FIG. 113

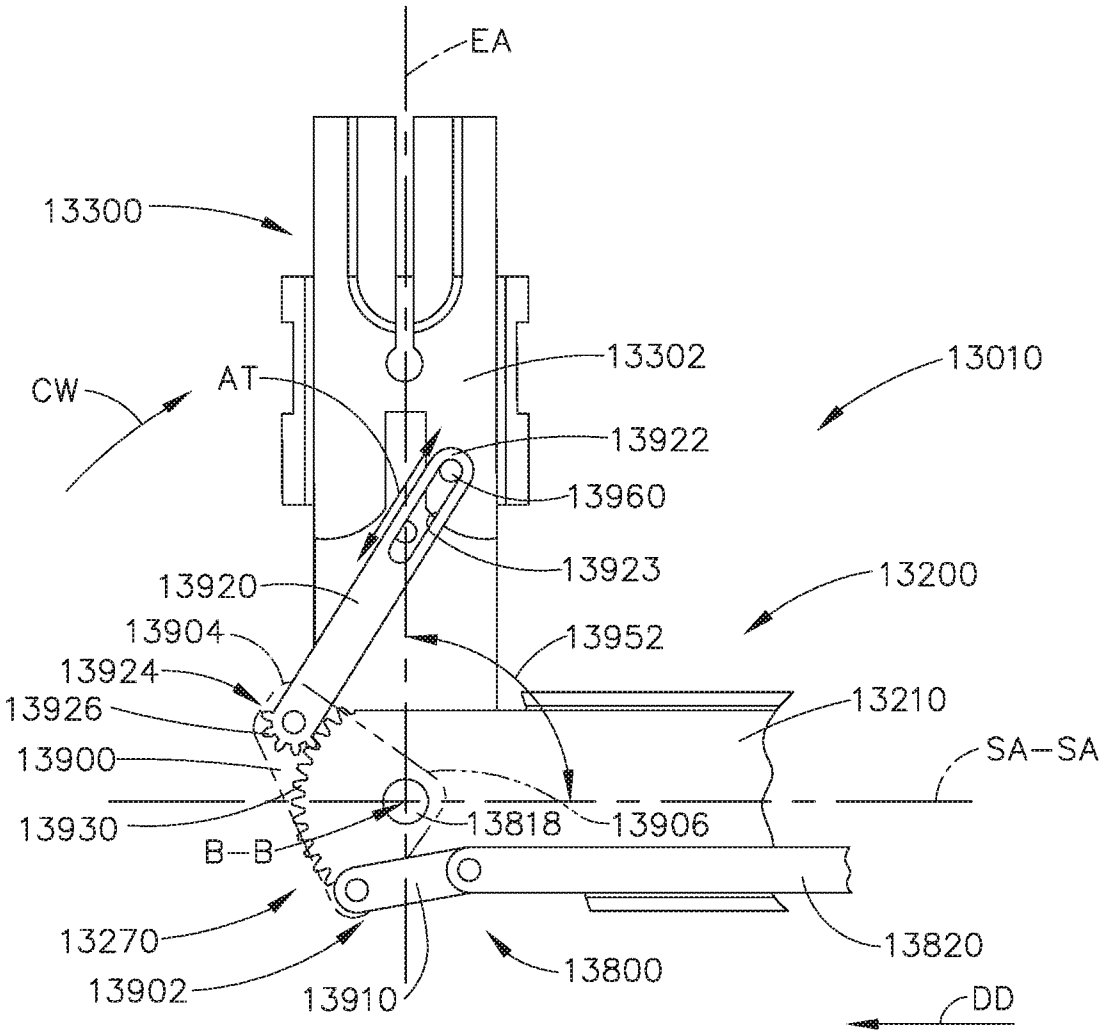

EA
13300
13302
13010
CW
AT
13922
13960
13923
13920
13200
13904
13952
13924
13926
13210
SA—SA
13900
13930
13818
13906
B—B
13270
13820
13902
13910
13800
DD

FIG. 114

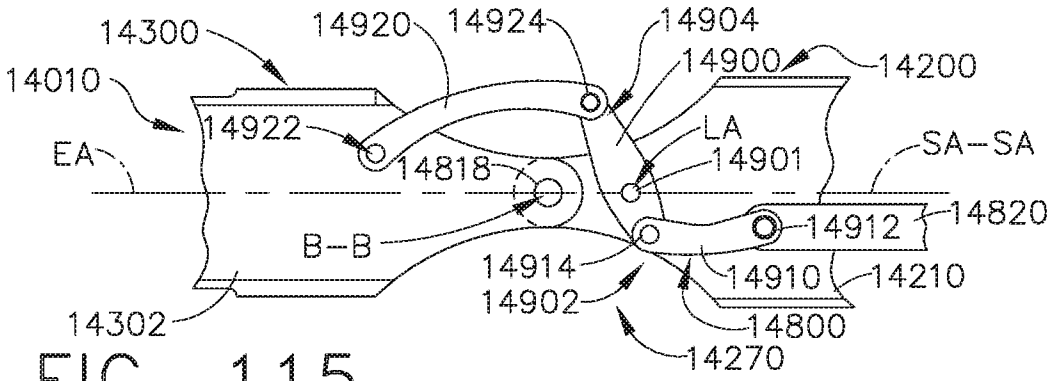


FIG. 115

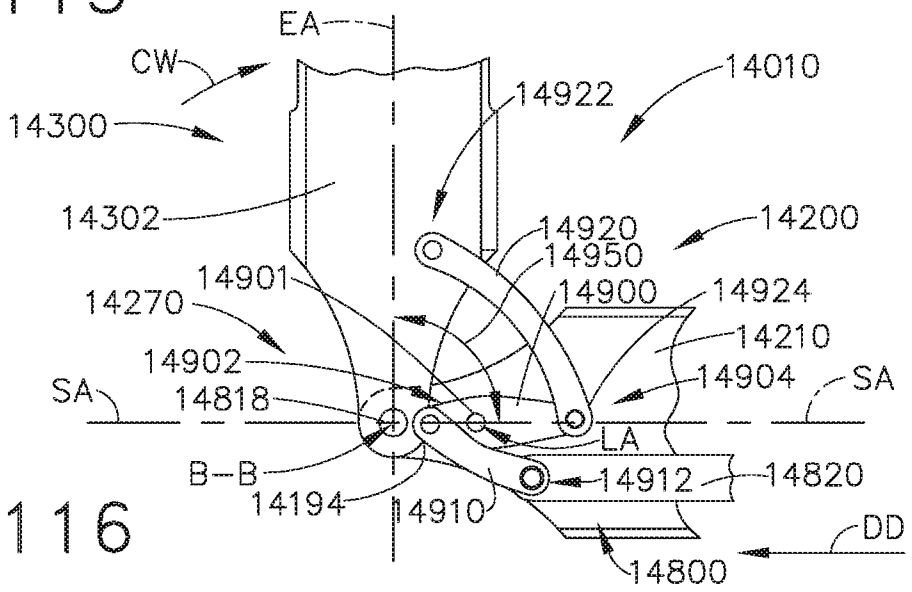


FIG. 116

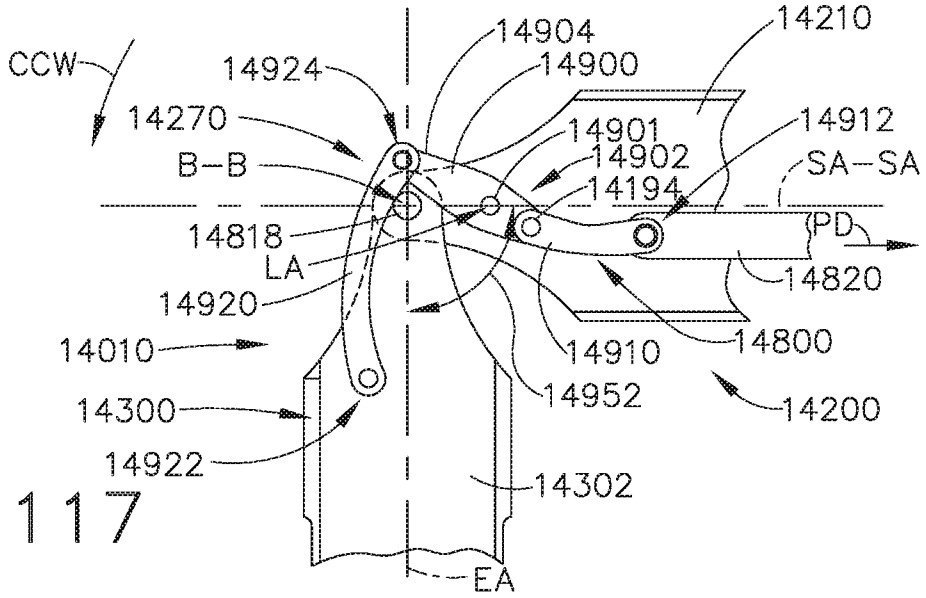


FIG. 117

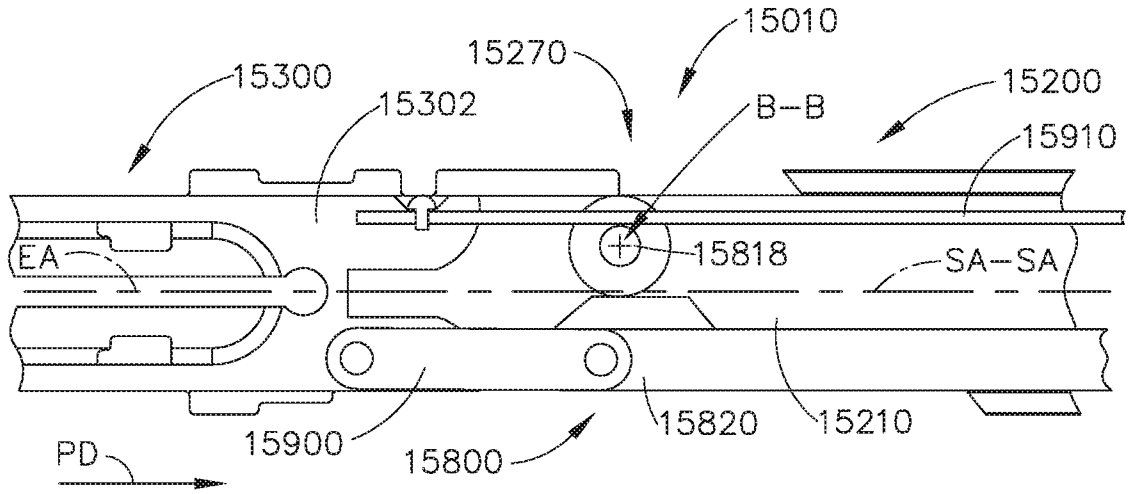


FIG. 118

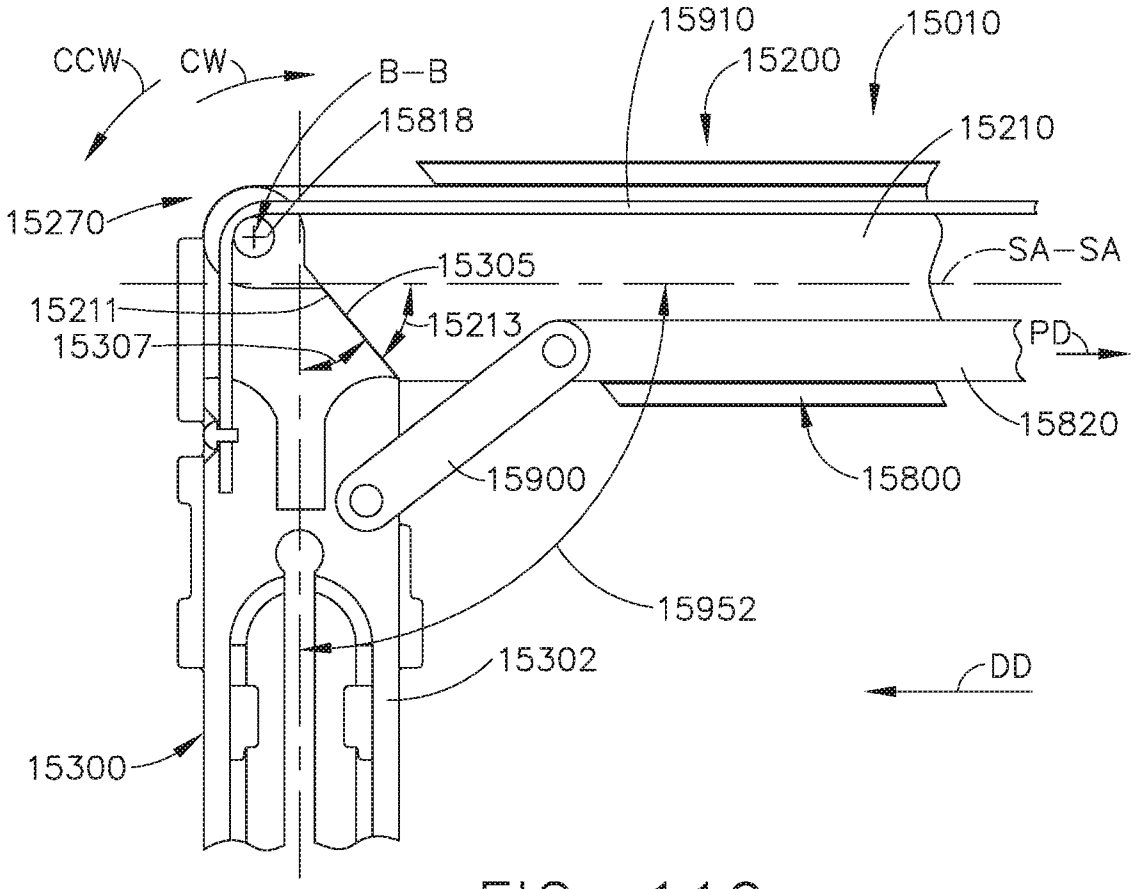


FIG. 119

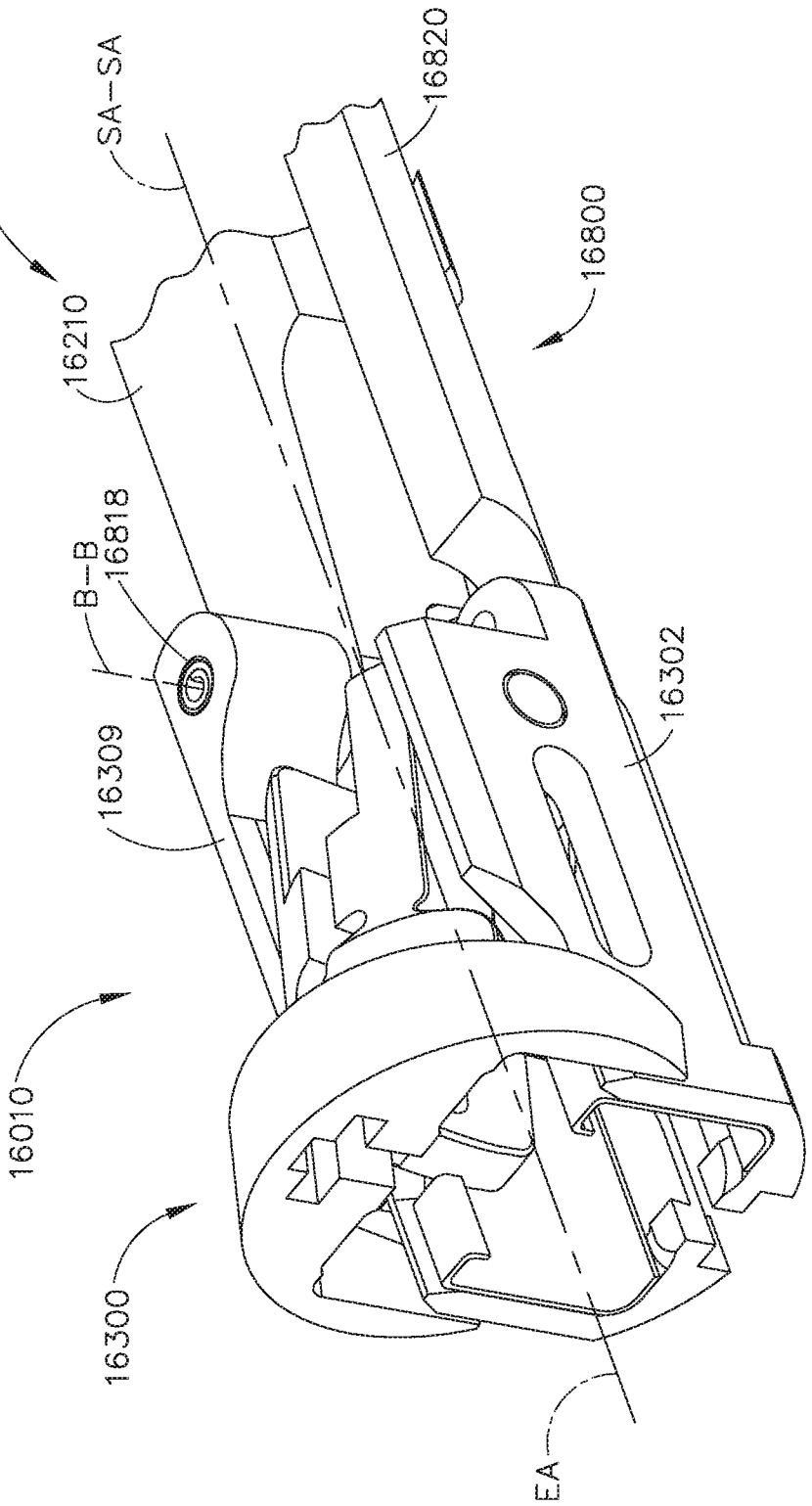

16200
SA–SA
16820
16800
16210
B–B
16818
16309
16302
16010
16300
EA

FIG. 120

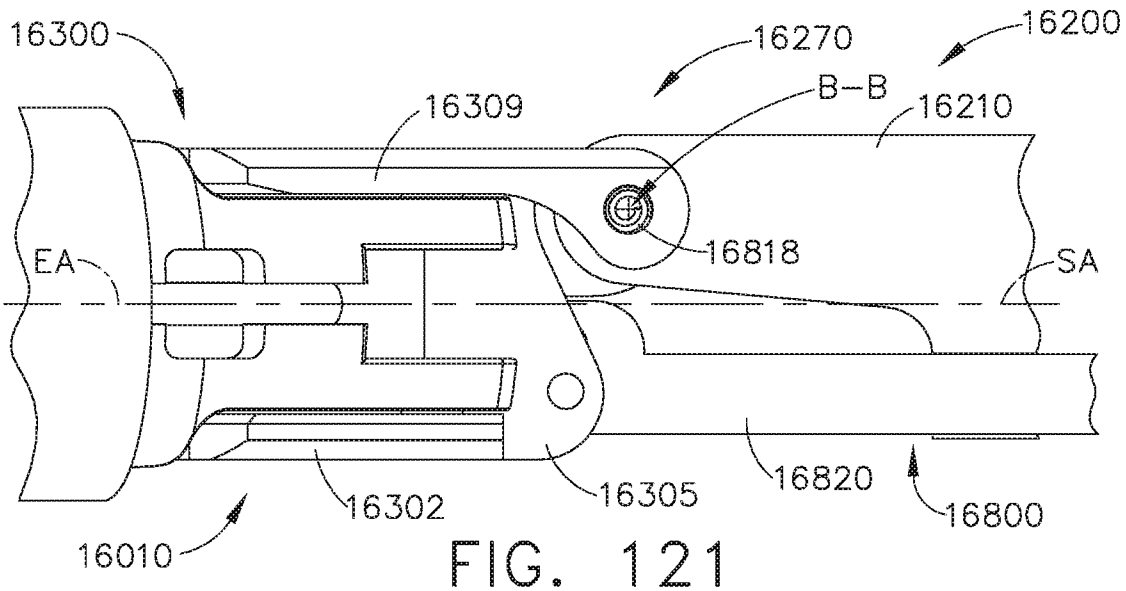


FIG. 121

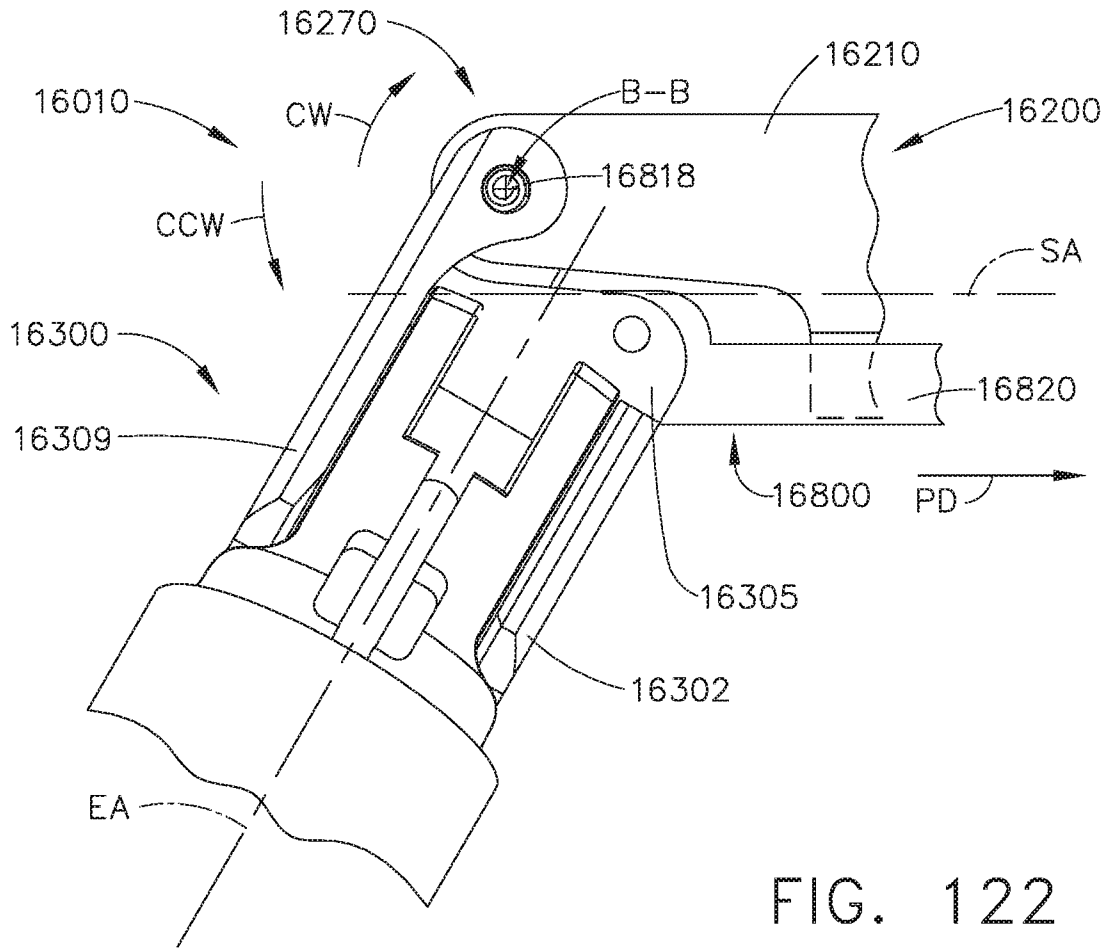


FIG. 122

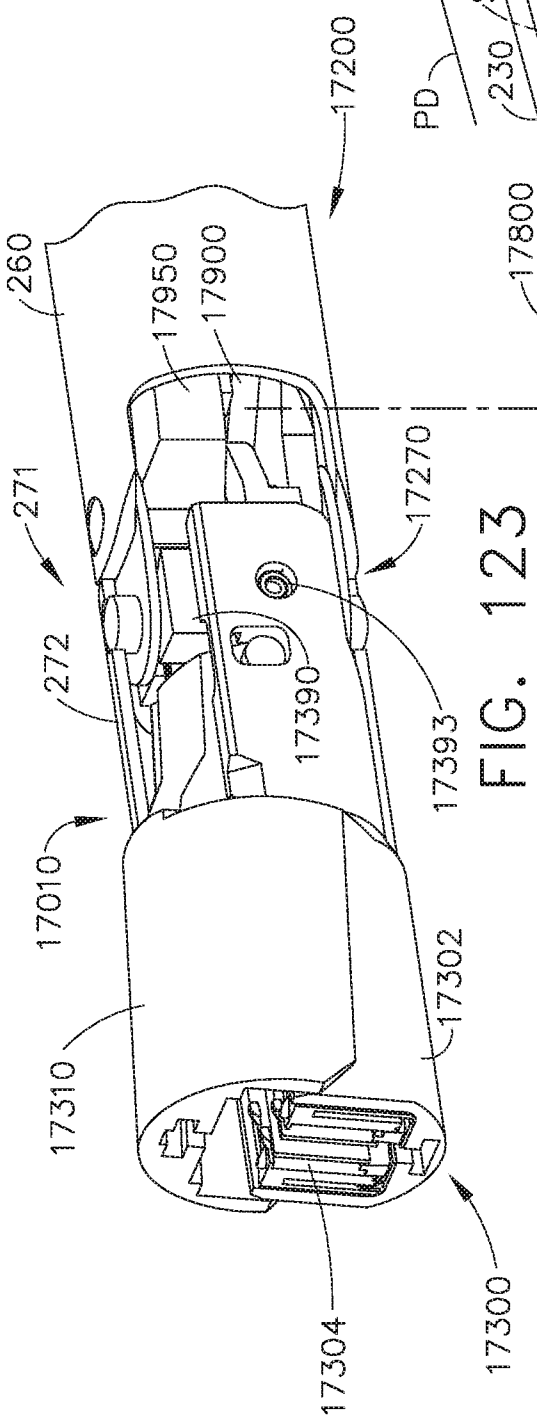


FIG. 123

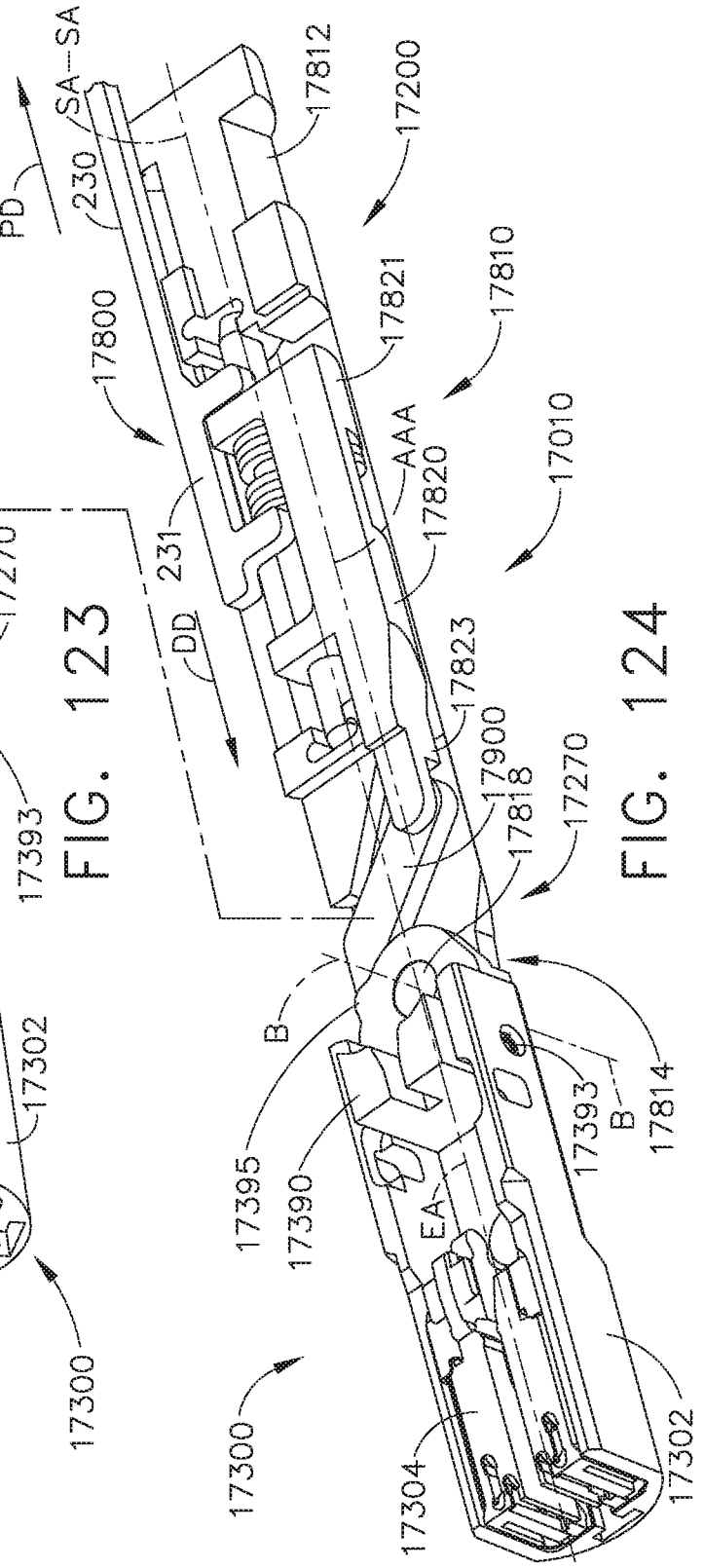
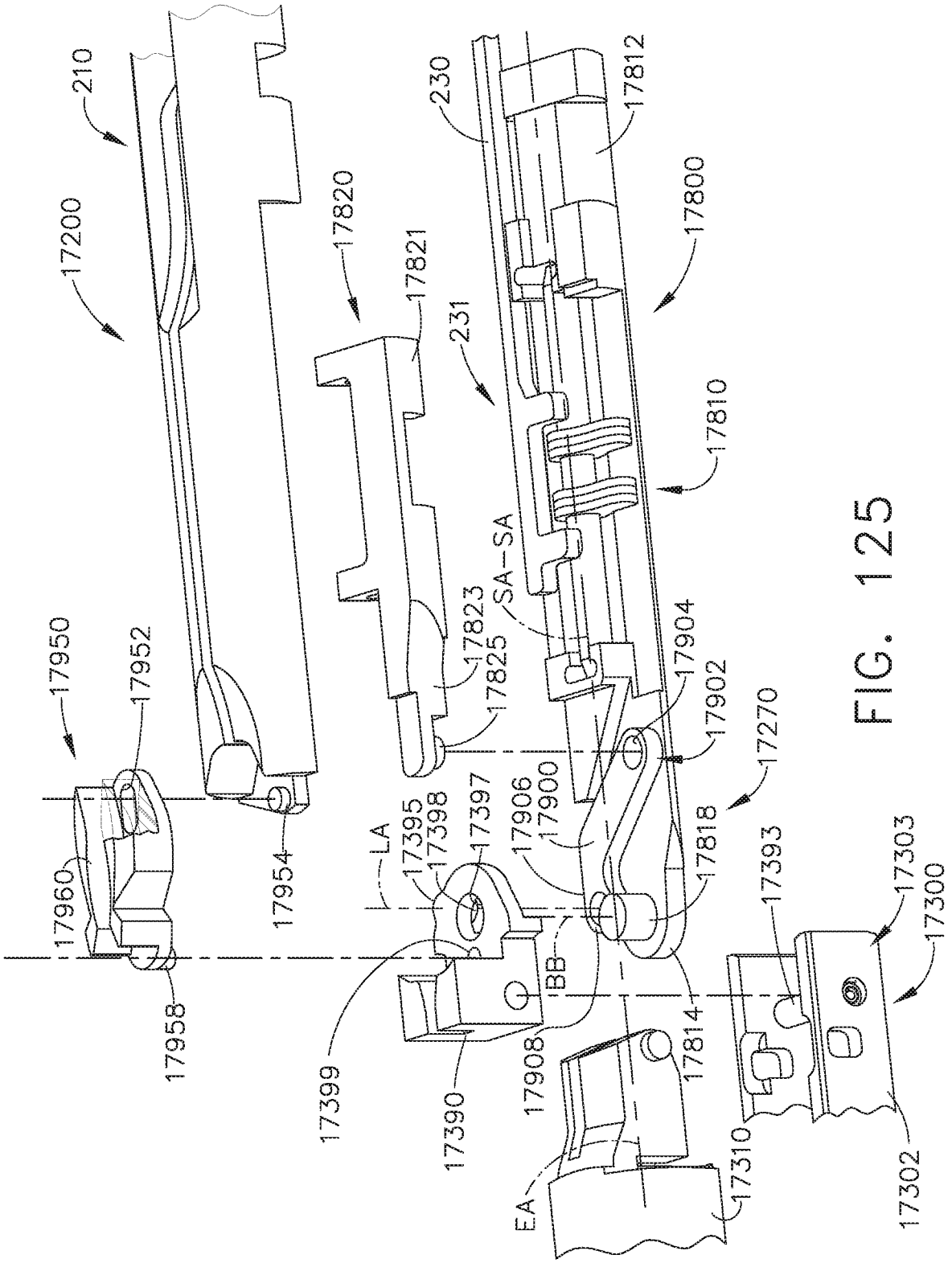


FIG. 124


210
17200
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230
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SA-SA
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LA
17395
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17302
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FIG. 125

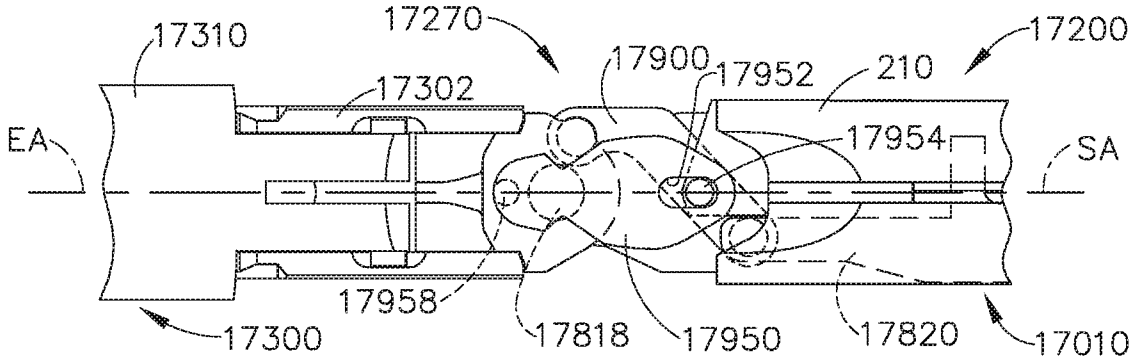

FIG. 126

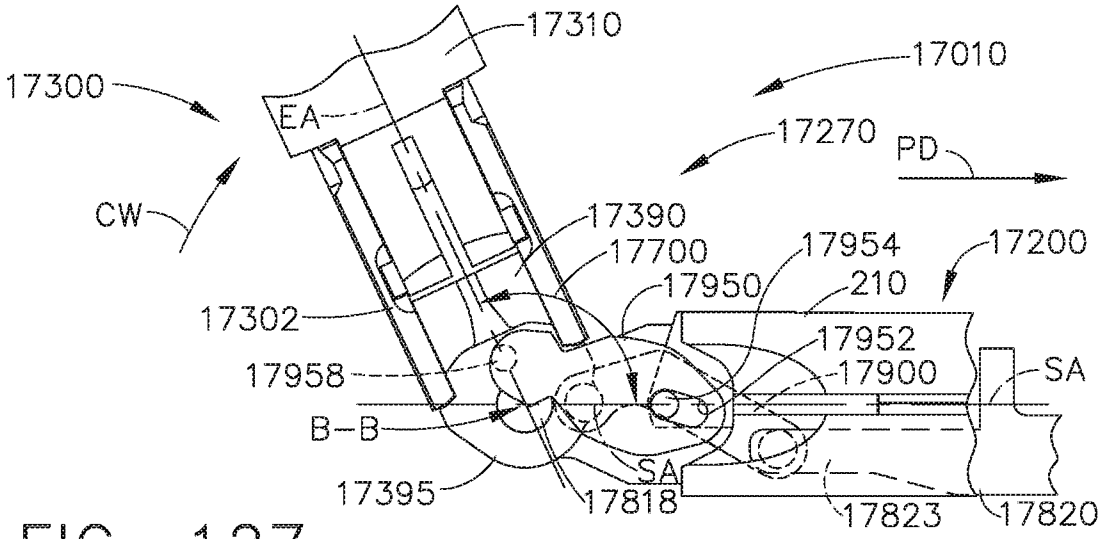

FIG. 127

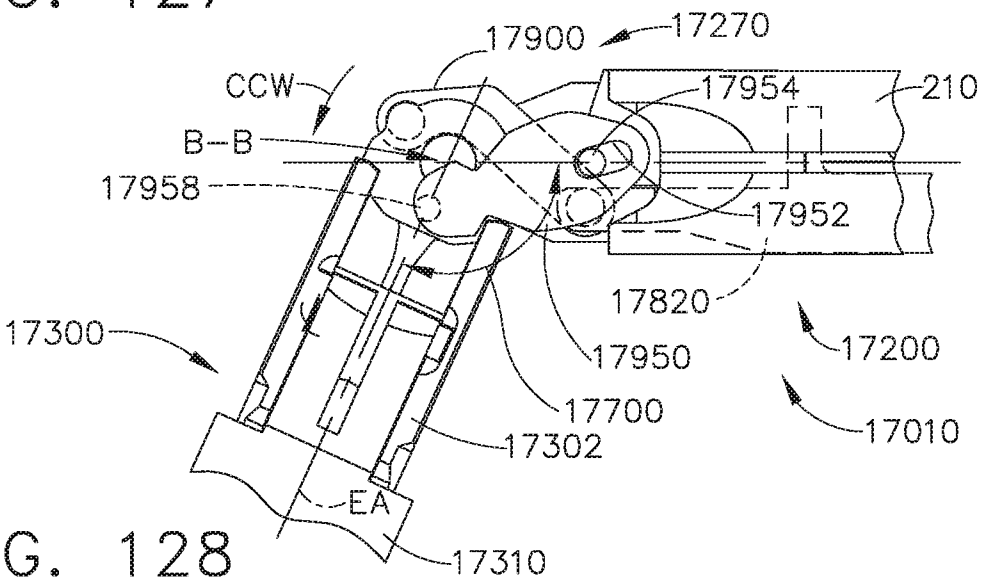

FIG. 128

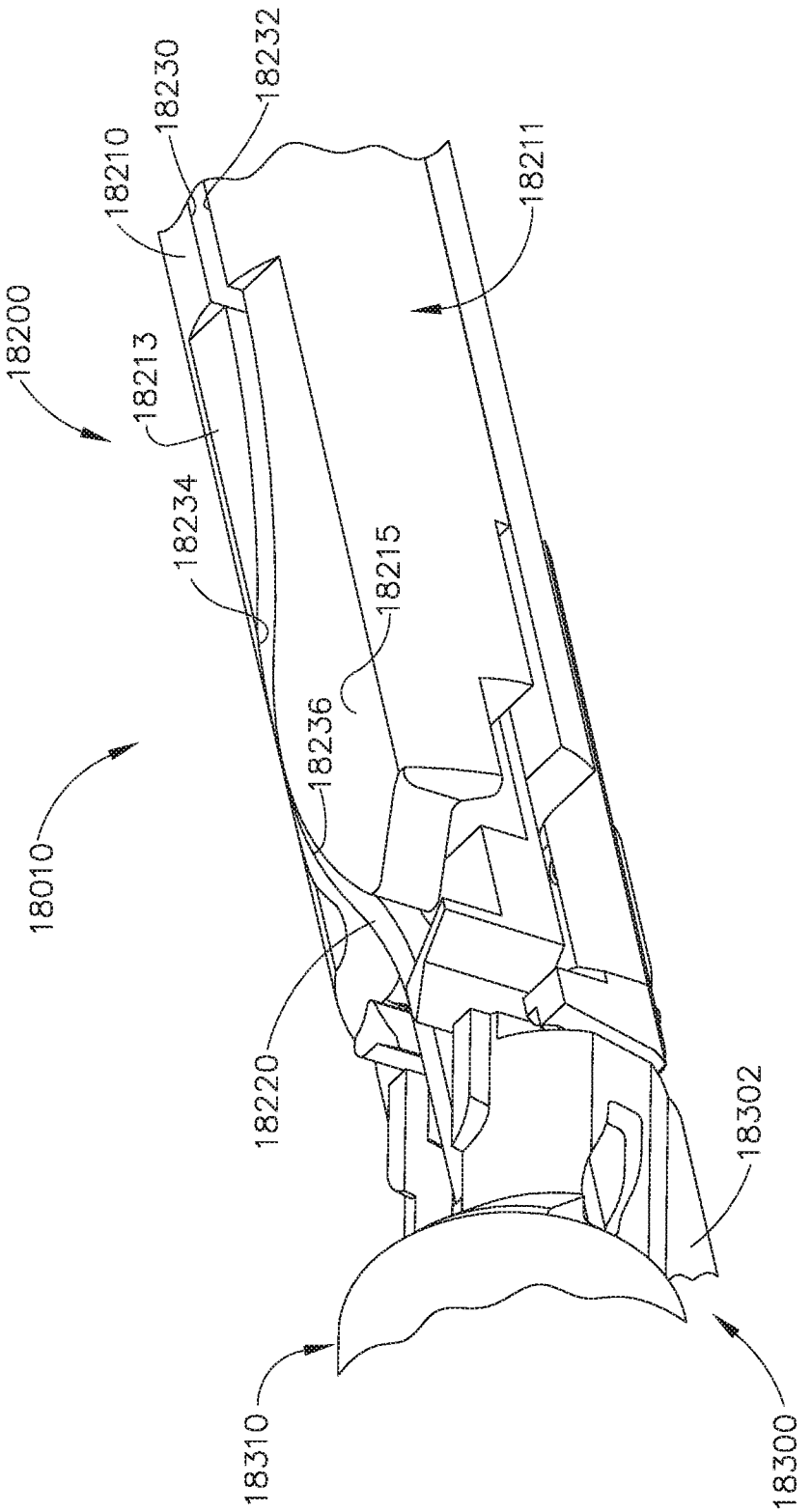
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FIG. 129

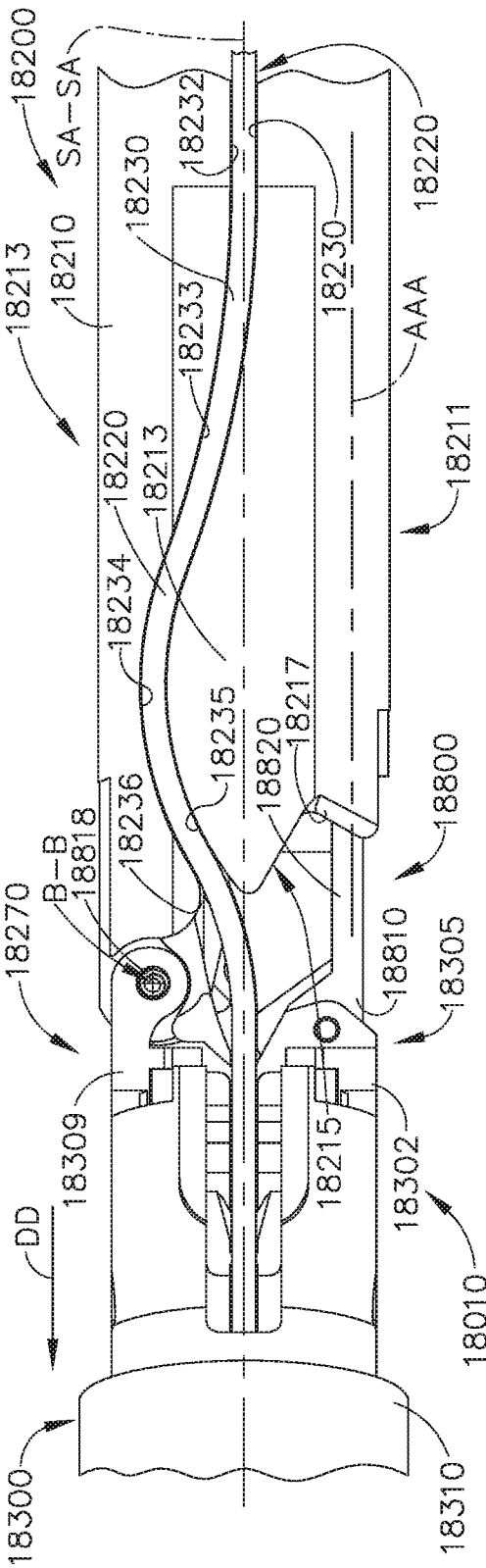


FIG. 130

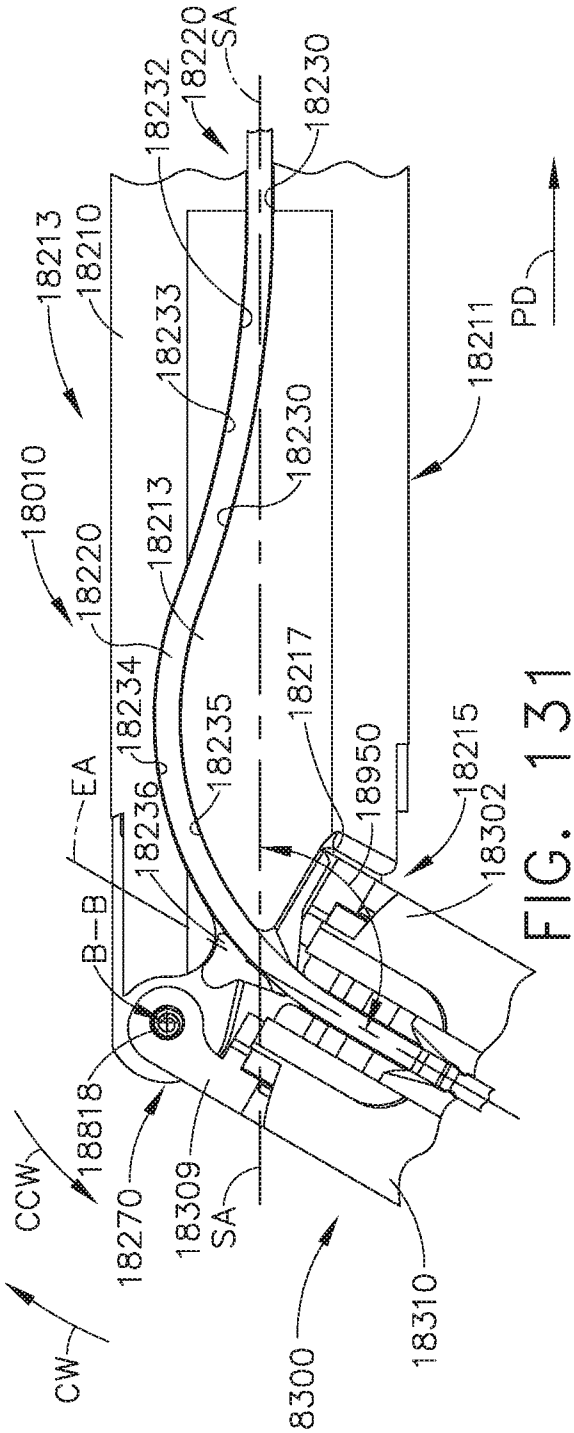


FIG. 131

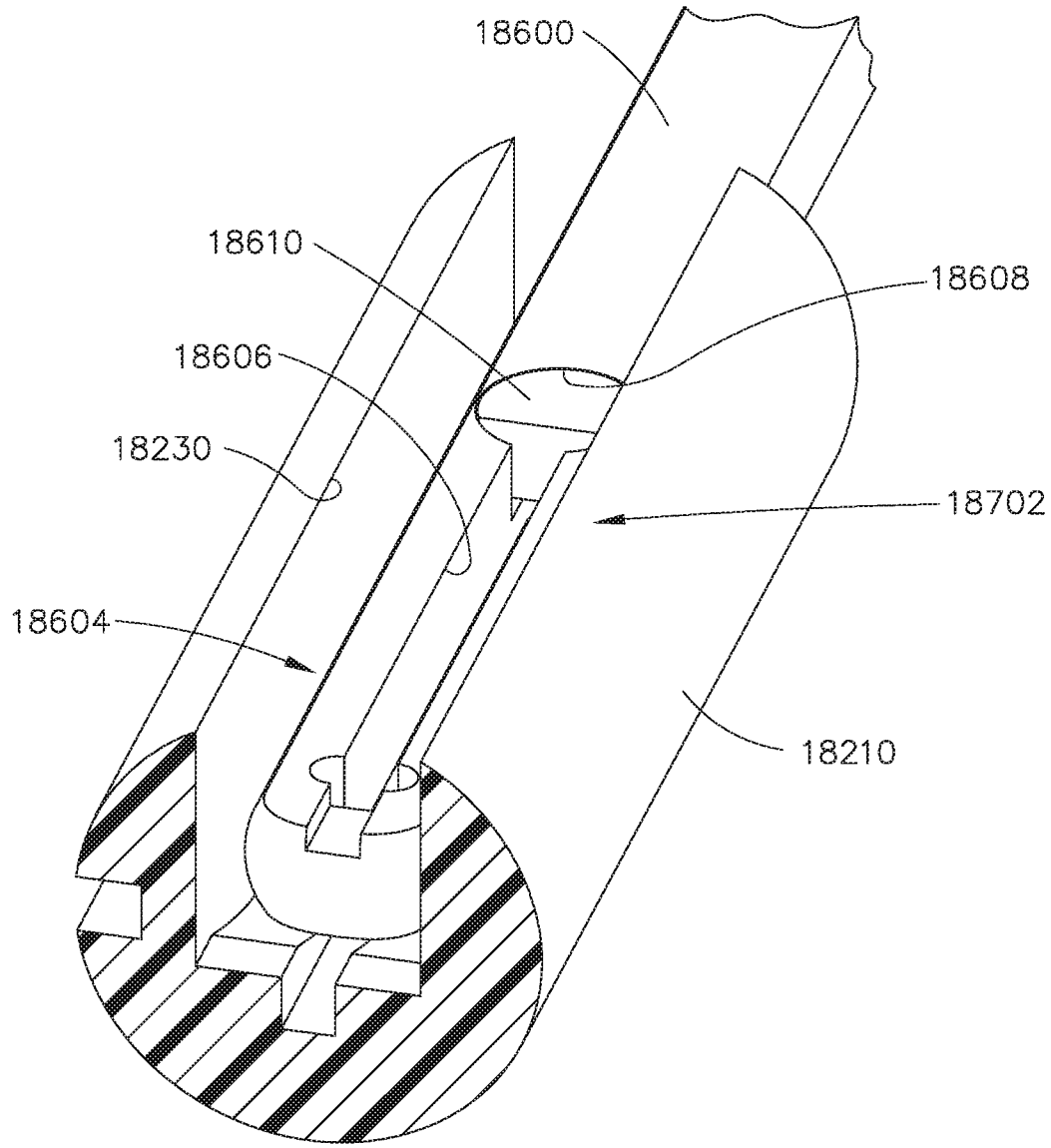
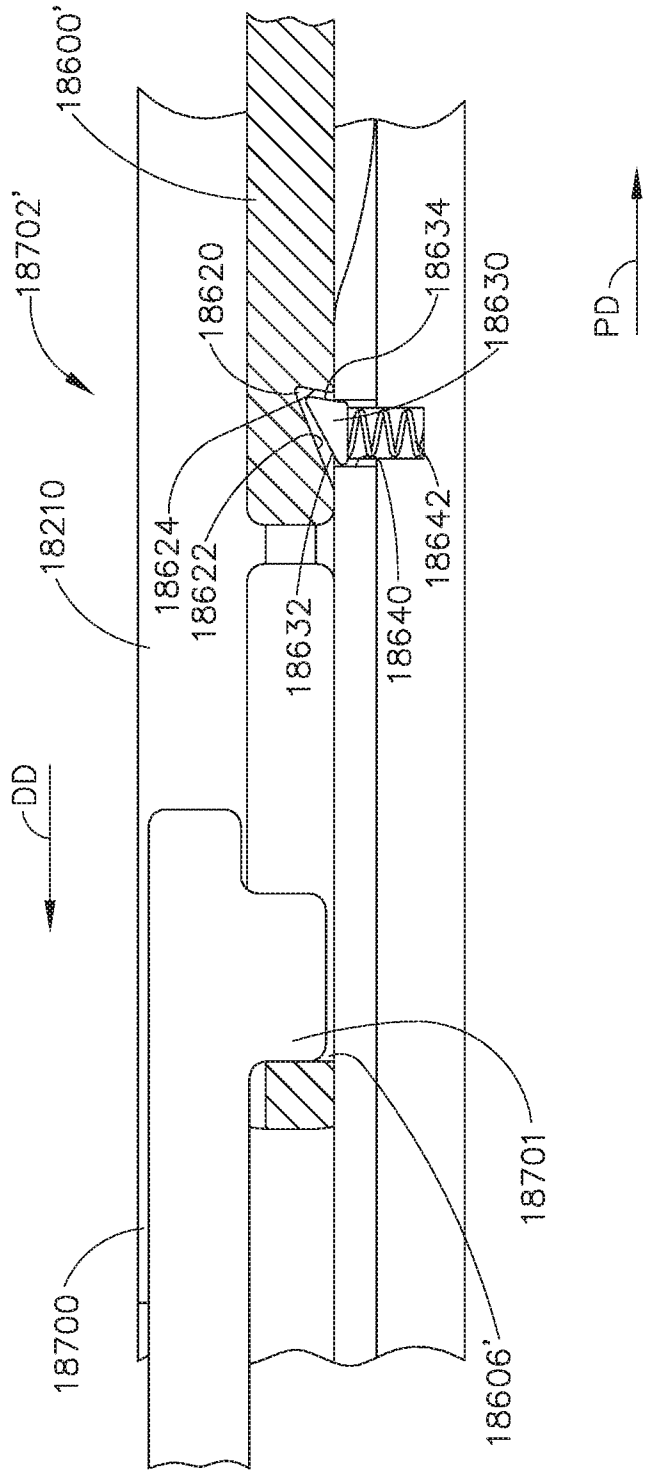


FIG. 132


18600'
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PD
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18640
18642
DD
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18606'

FIG. 132A

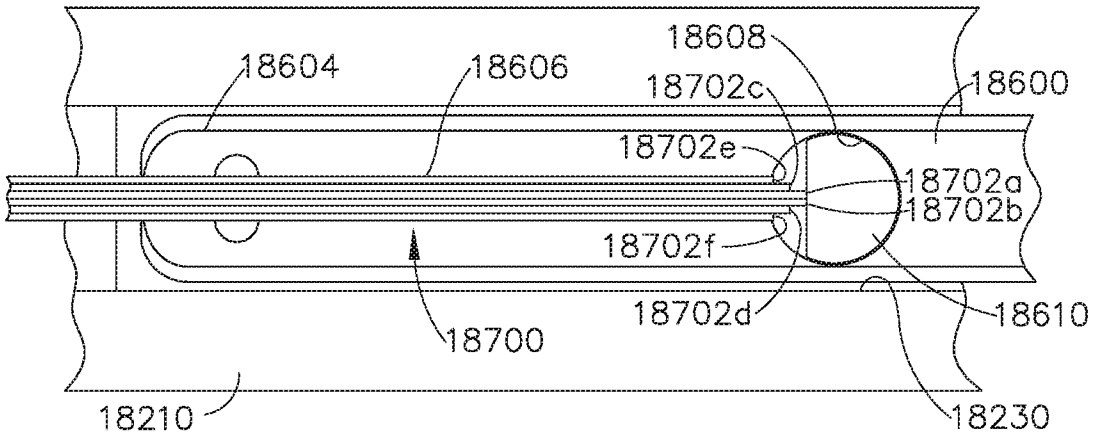

FIG. 133

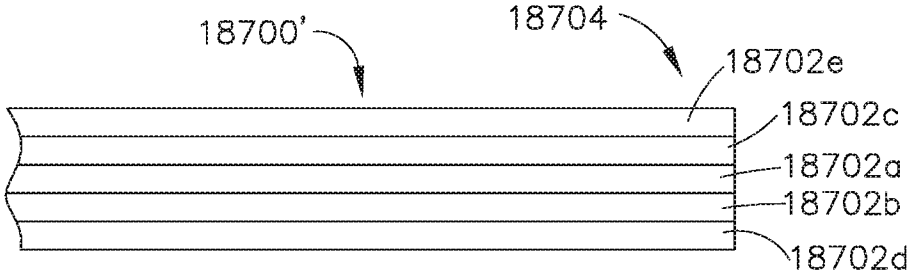

FIG. 134

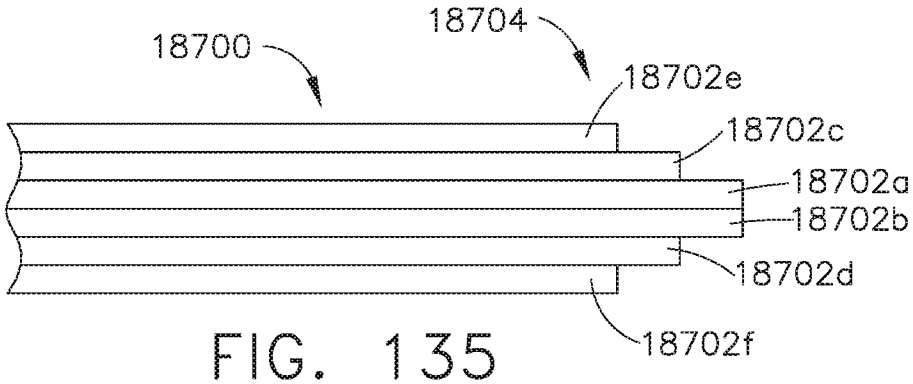

FIG. 135

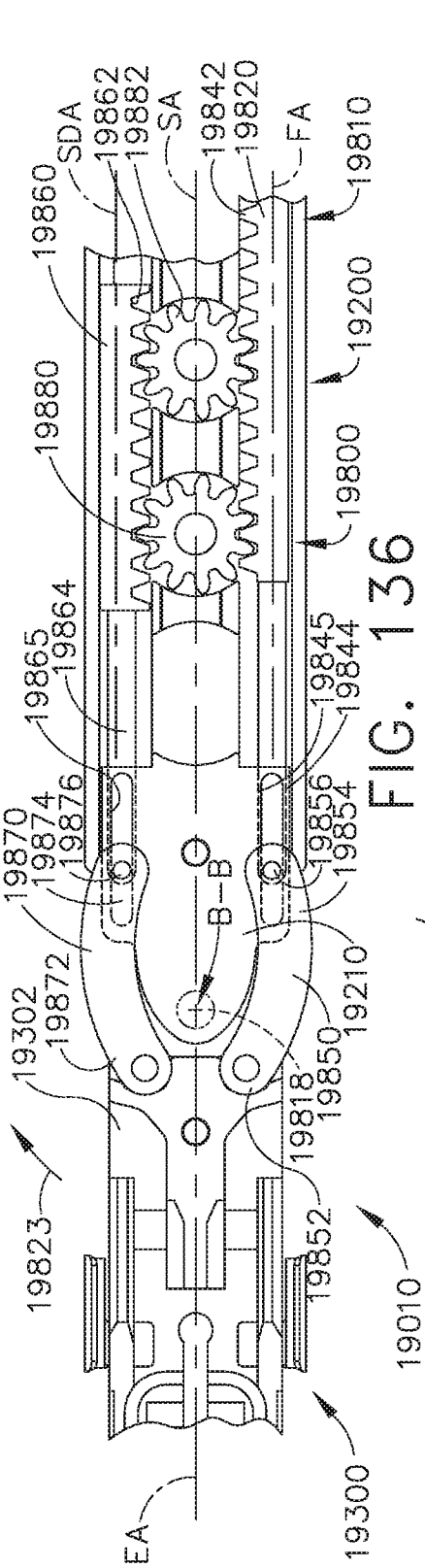

FIG. 136

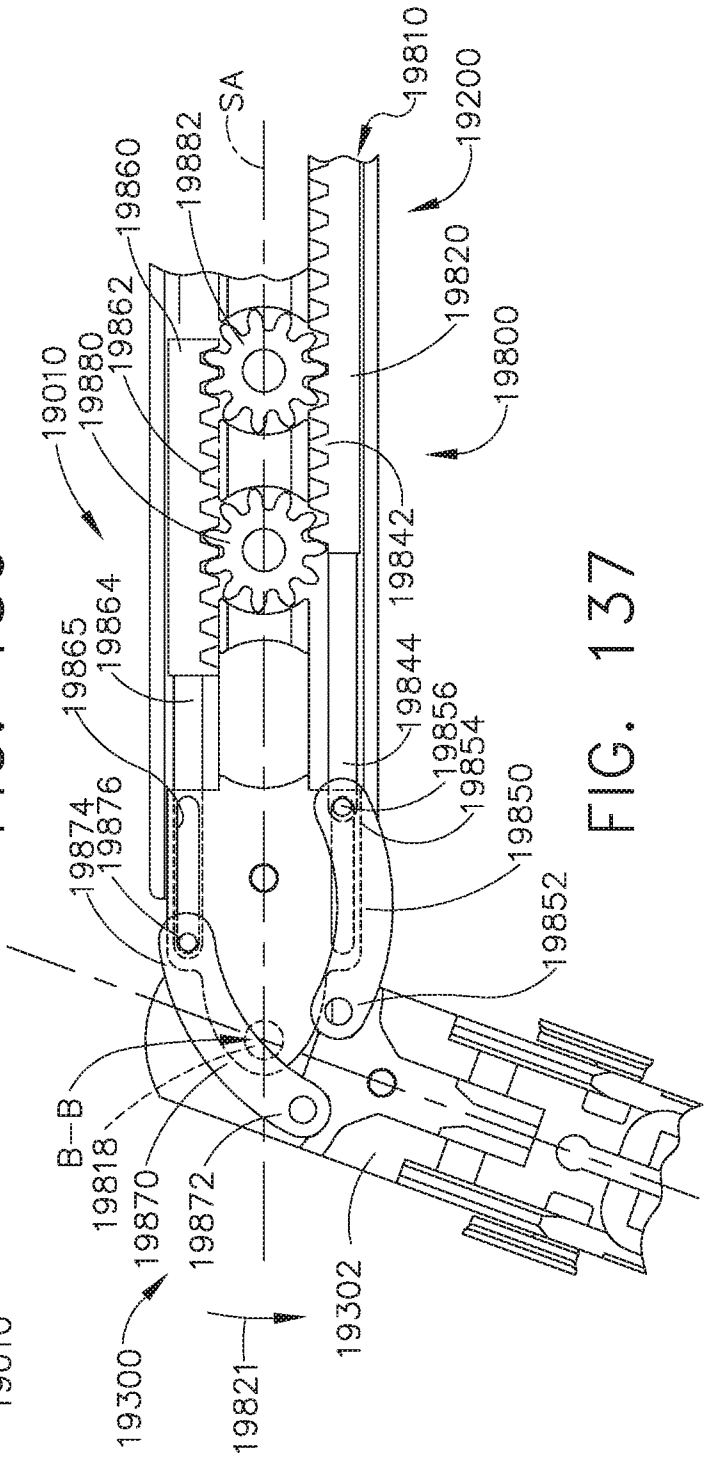

FIG. 137

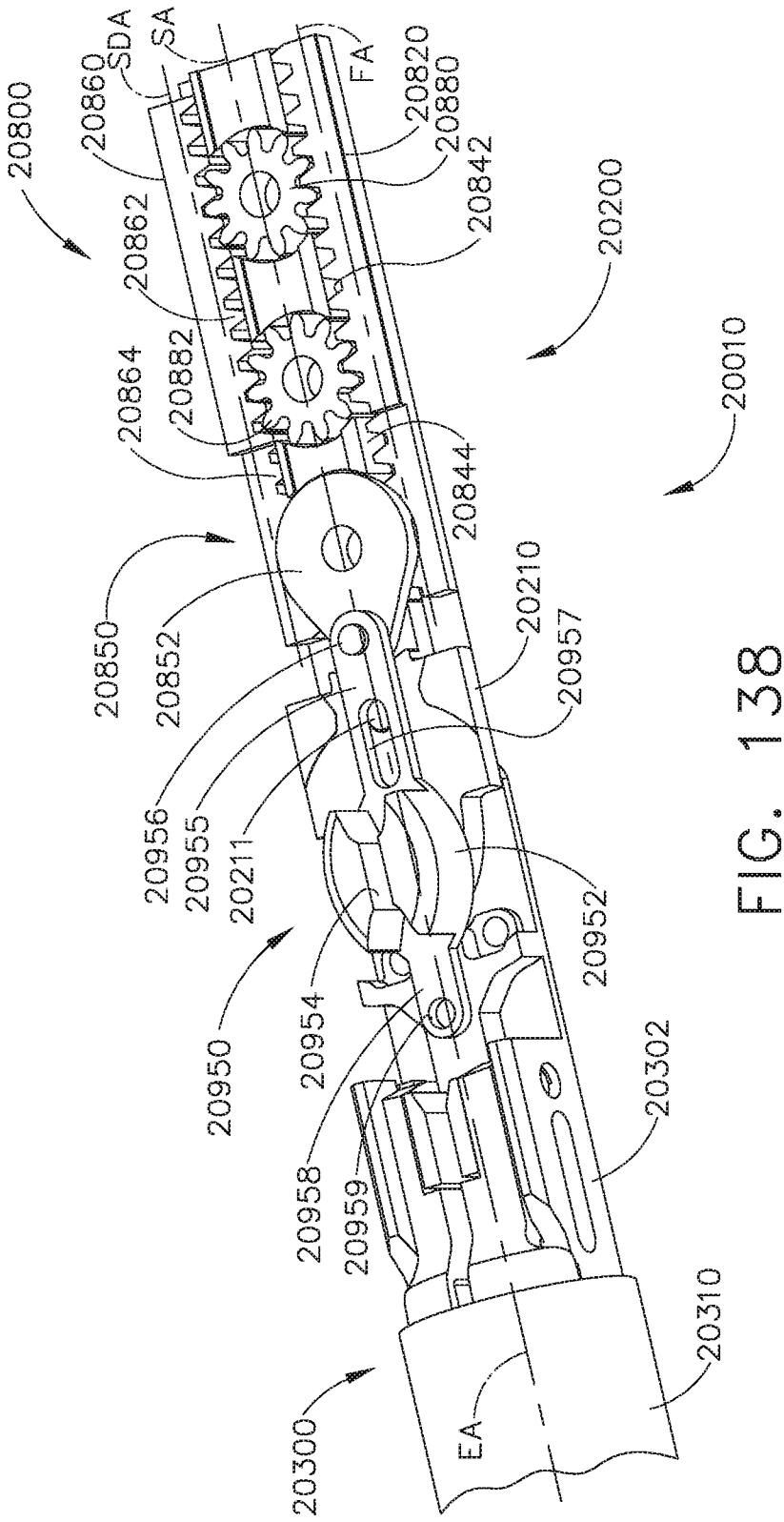
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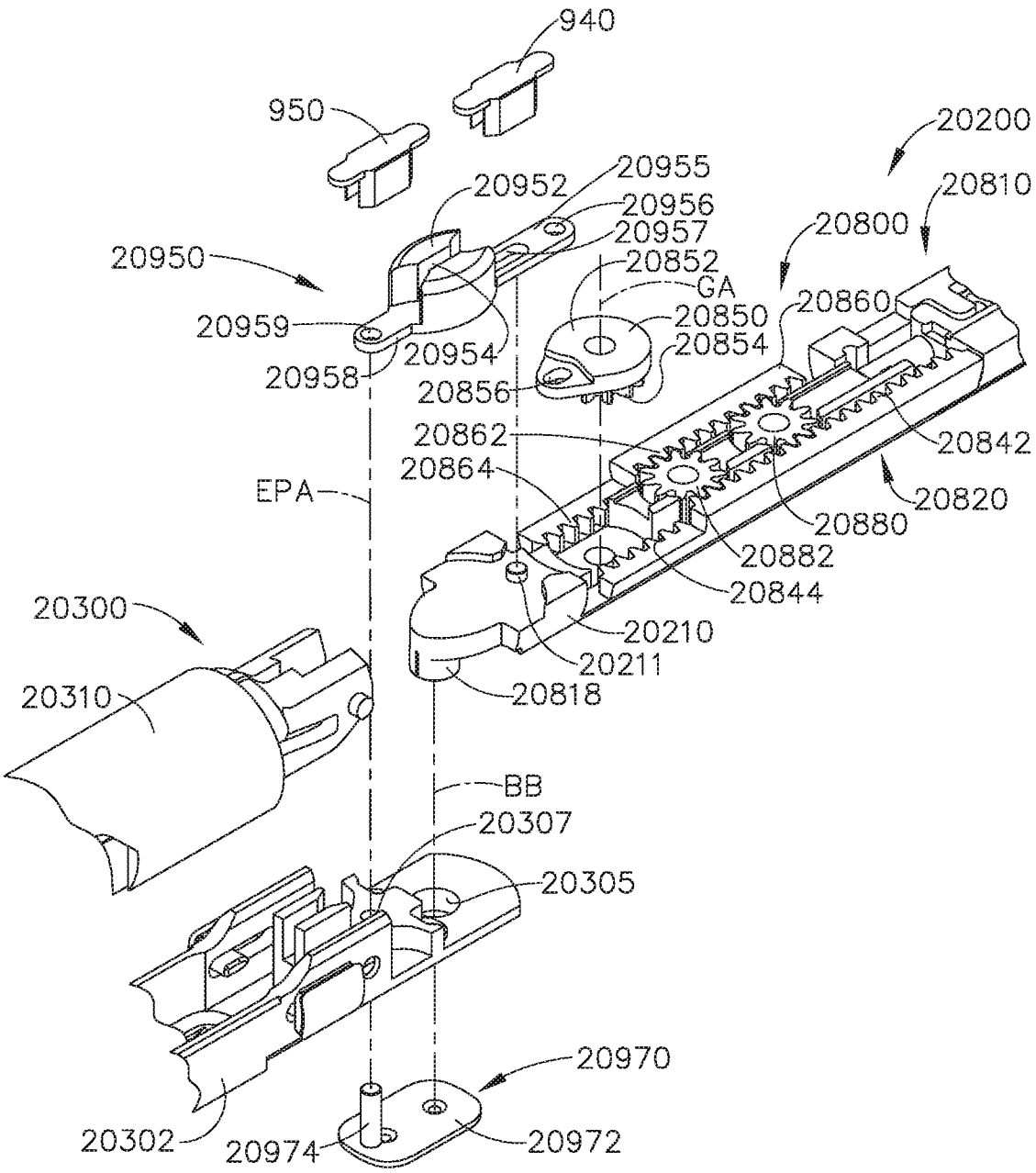
FIG. 138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20862
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EPA
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FIG. 139

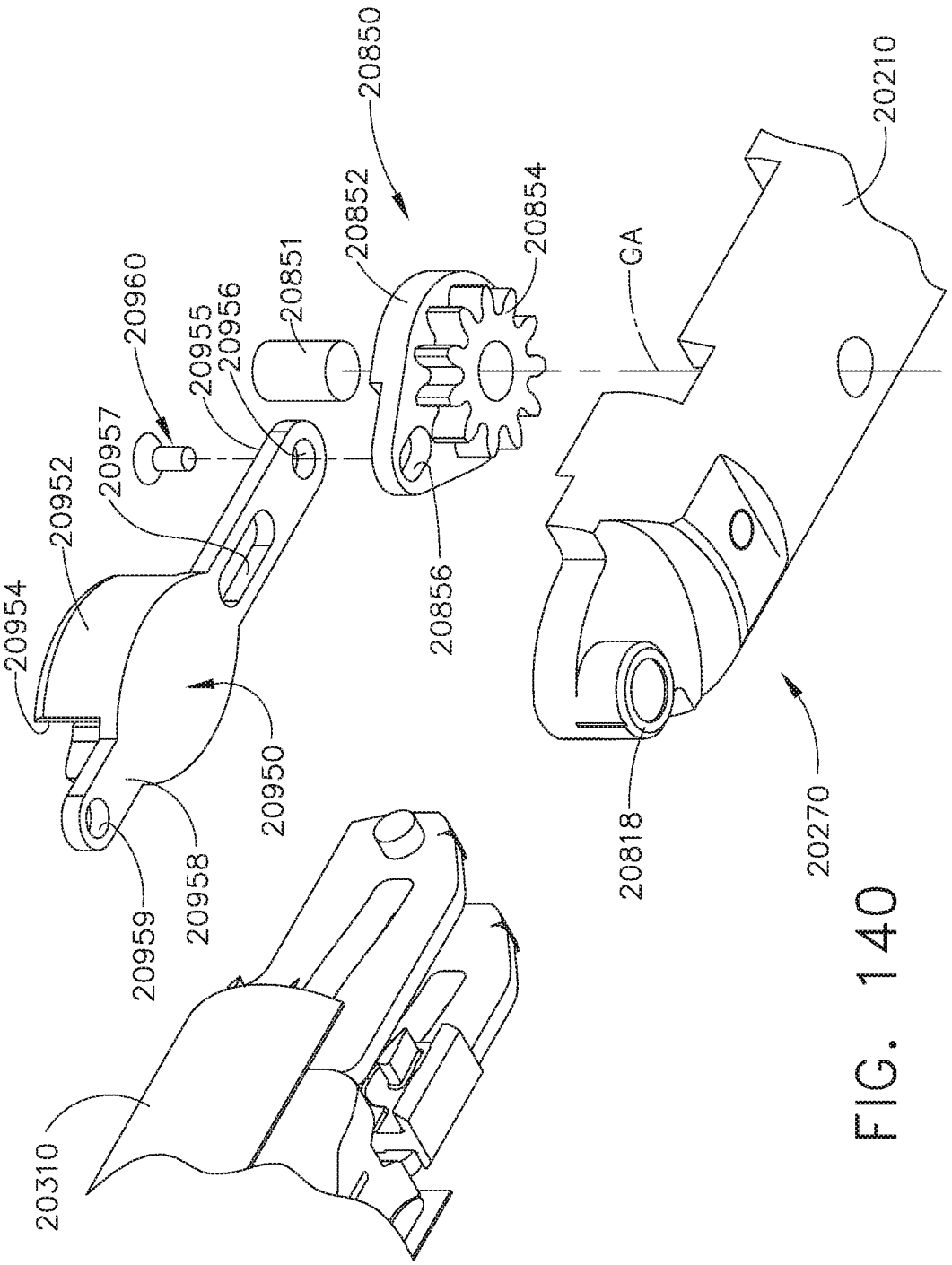
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FIG. 140

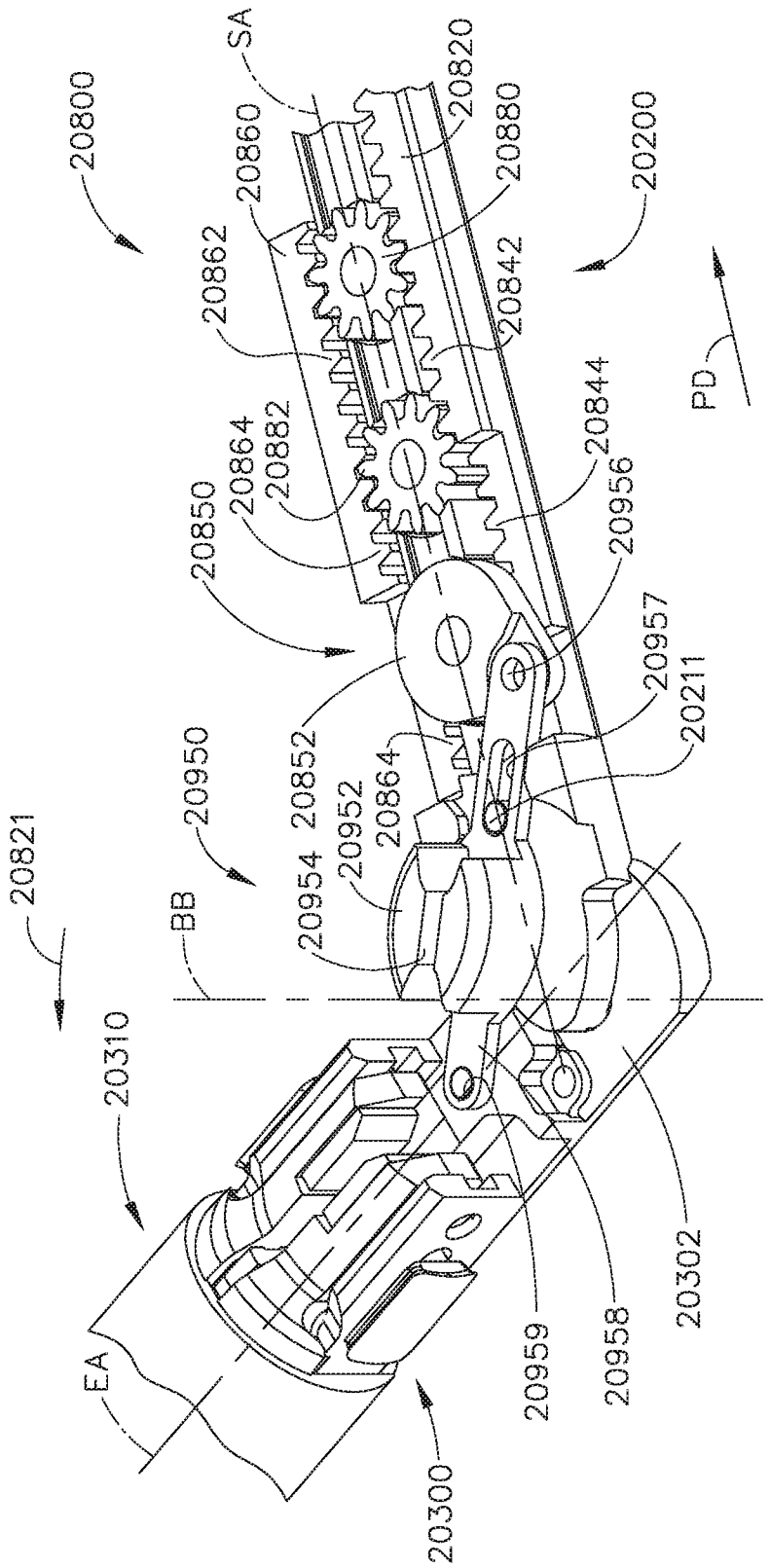
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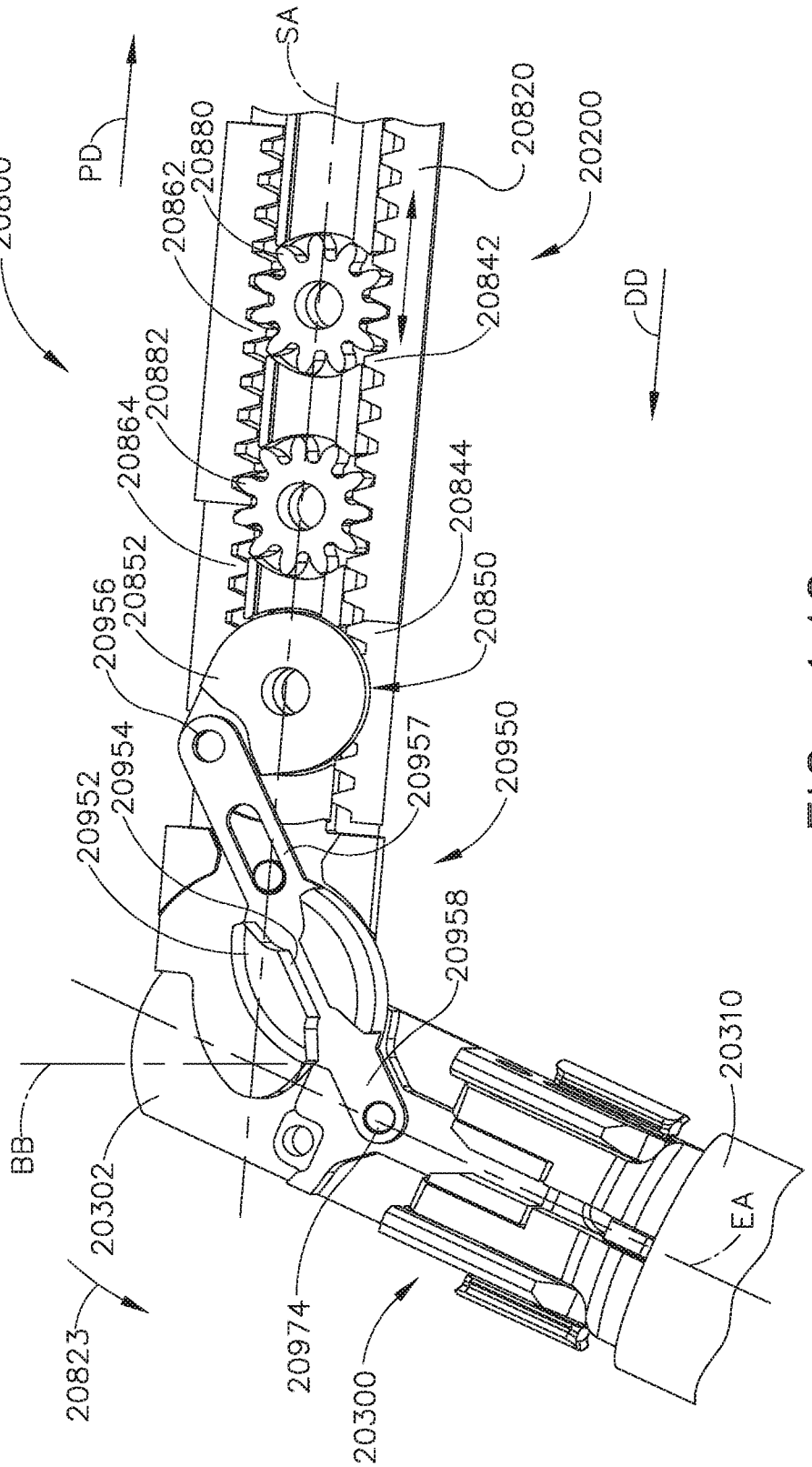
FIG. 141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EA
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FIG. 142

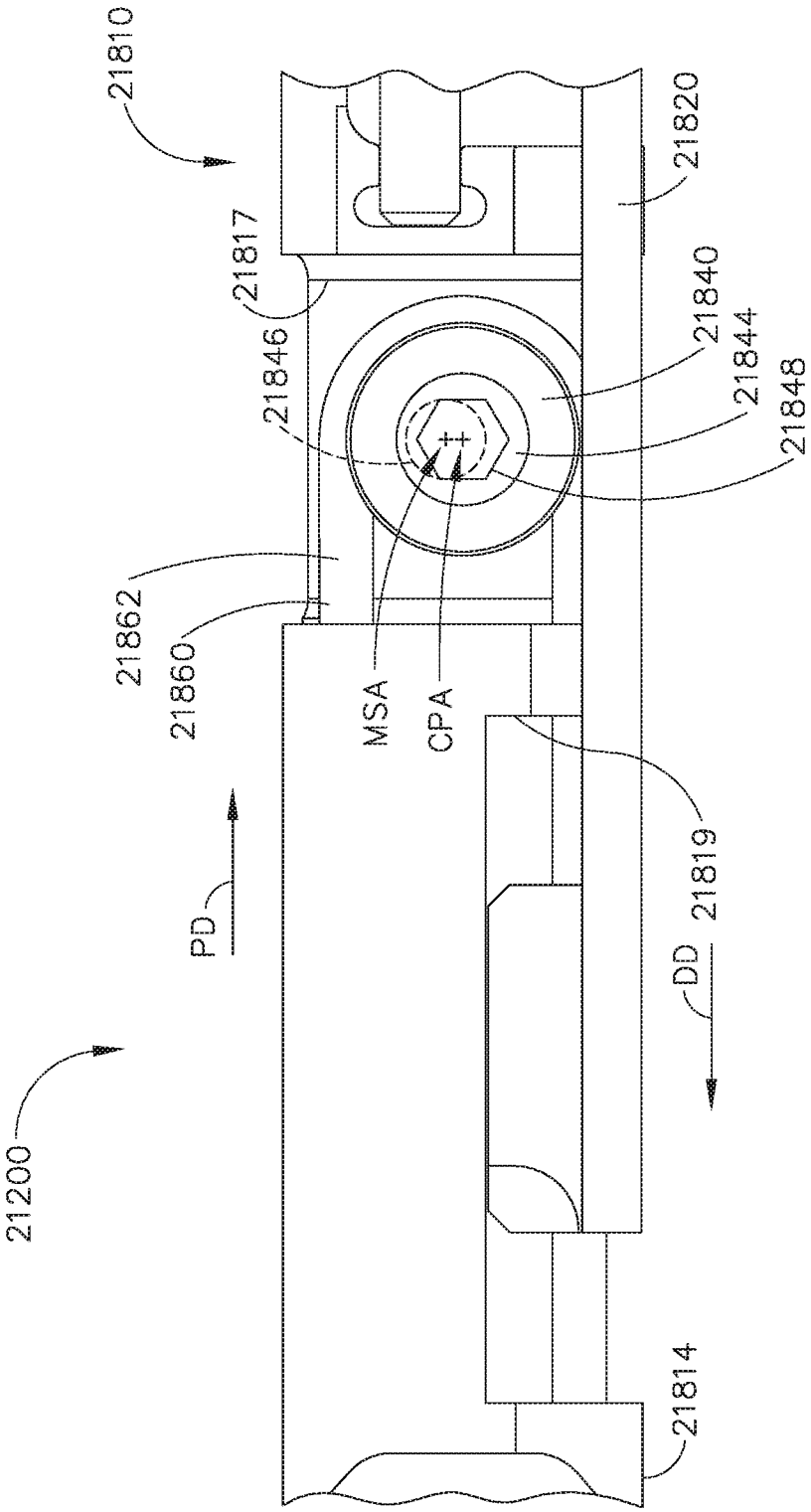
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FIG. 143

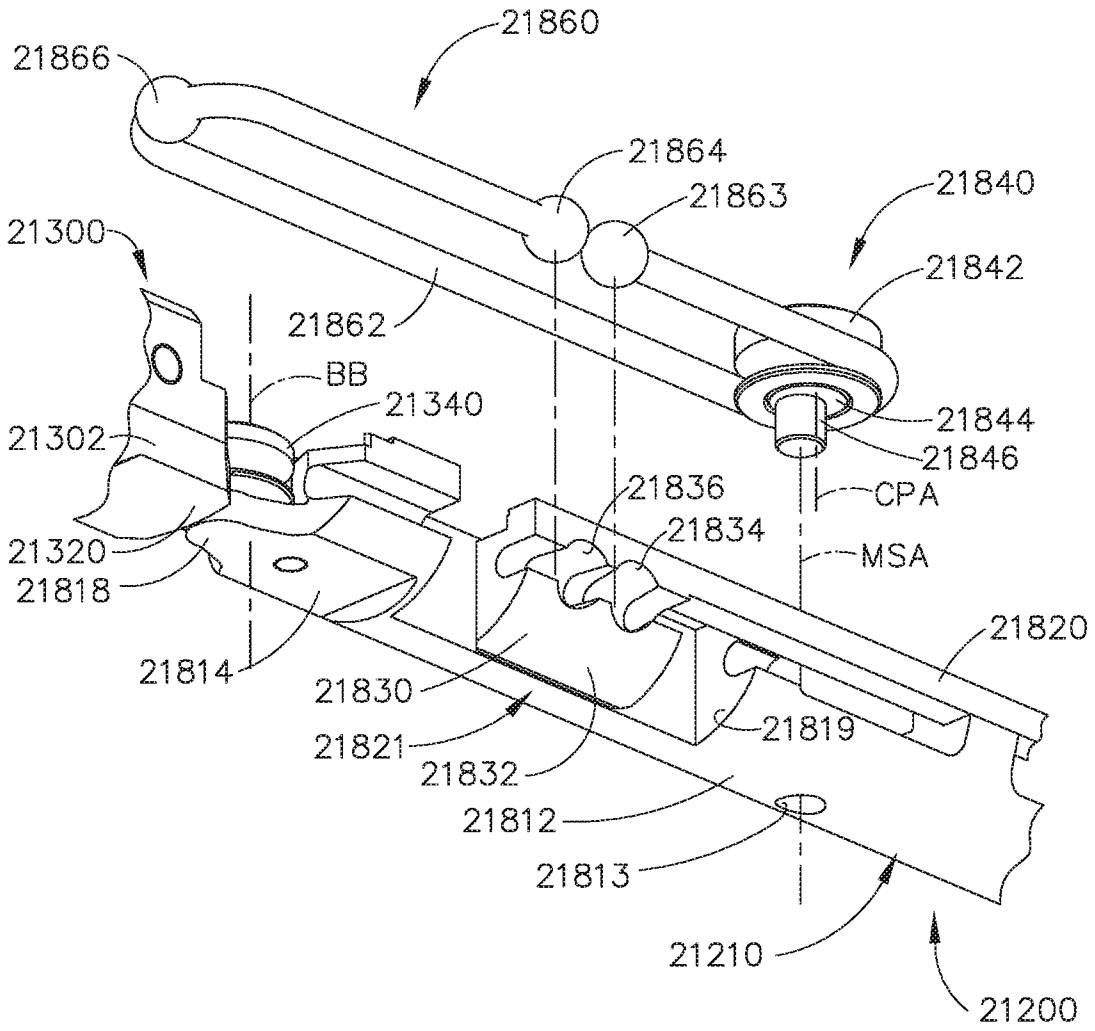
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FIG. 144

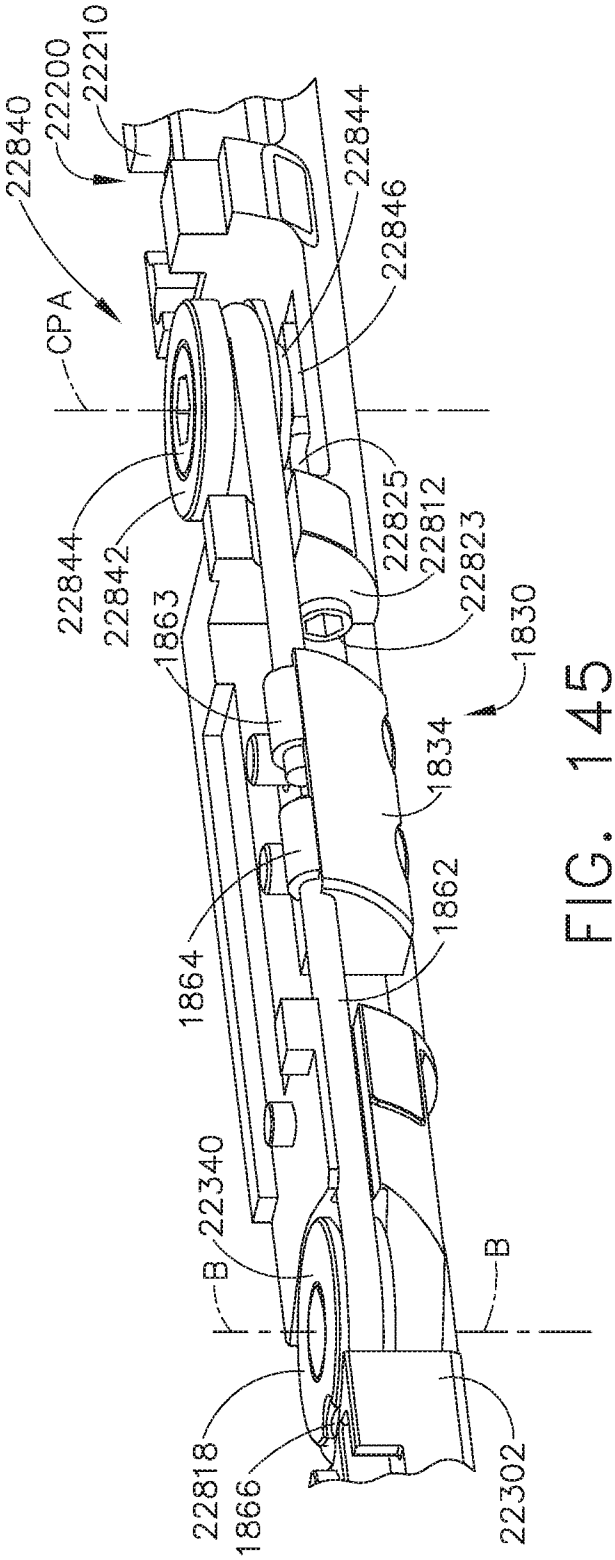


FIG. 145

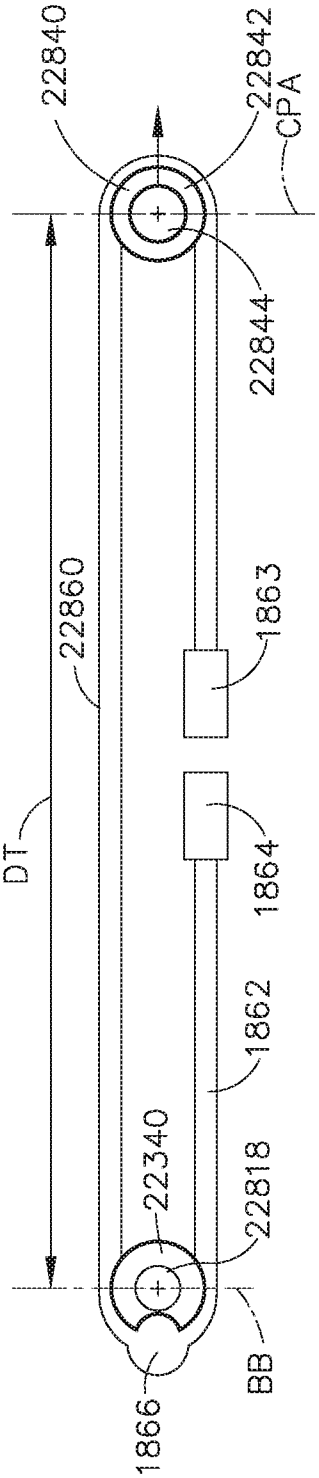
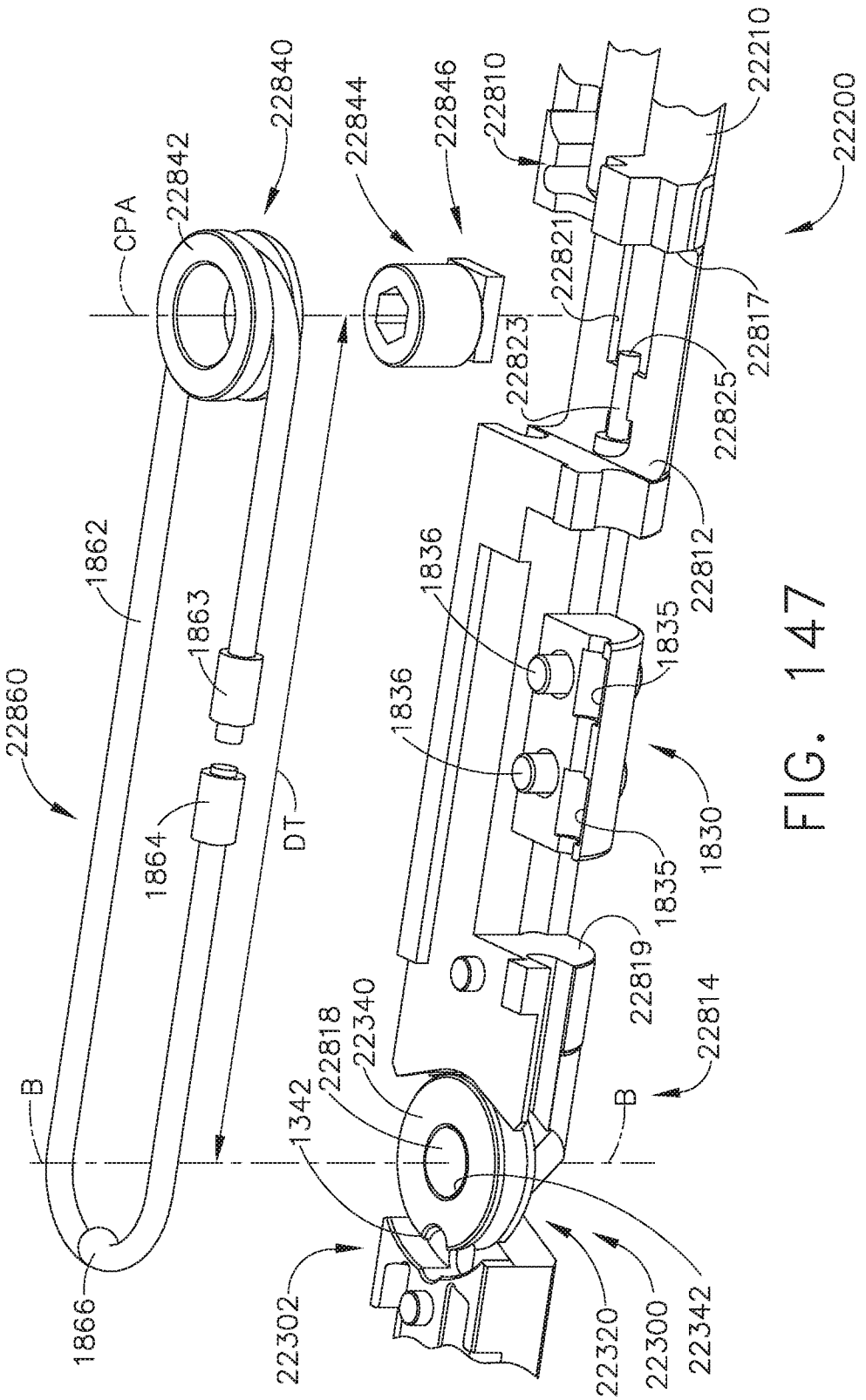


FIG. 146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B
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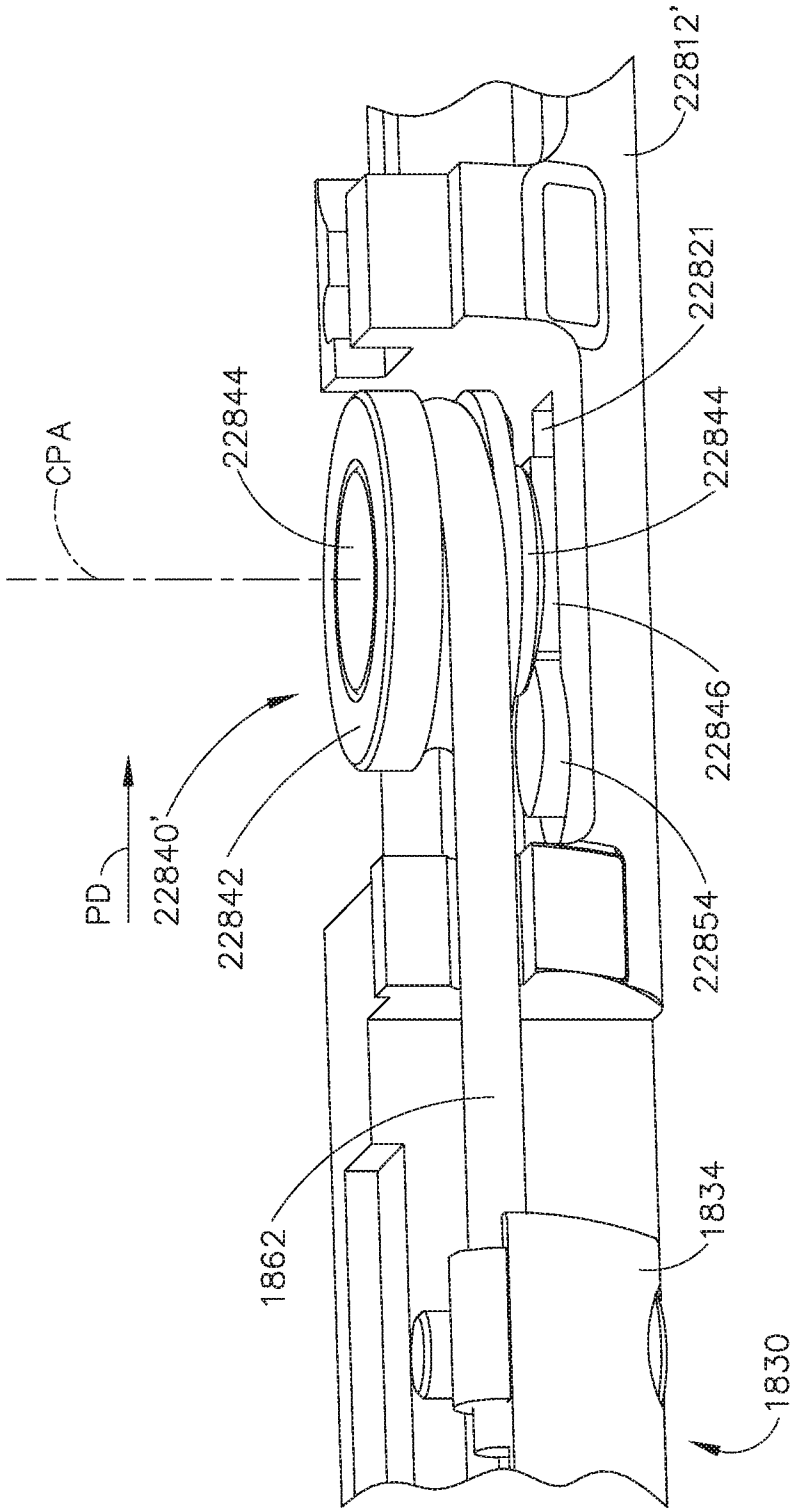
22300
22342

FIG. 147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22844
CPA
22846
PD
22840'
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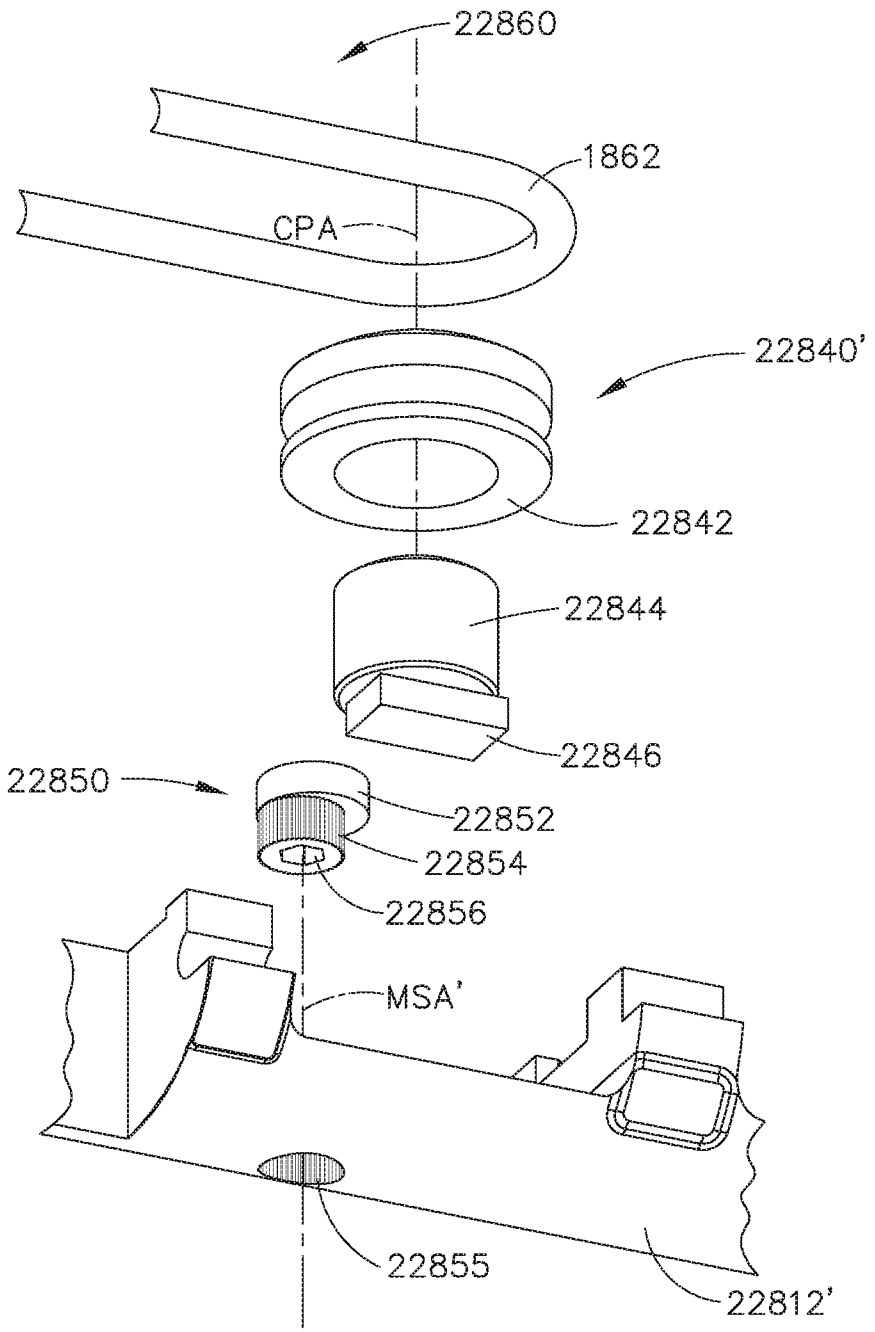
1834
1830

FIG. 148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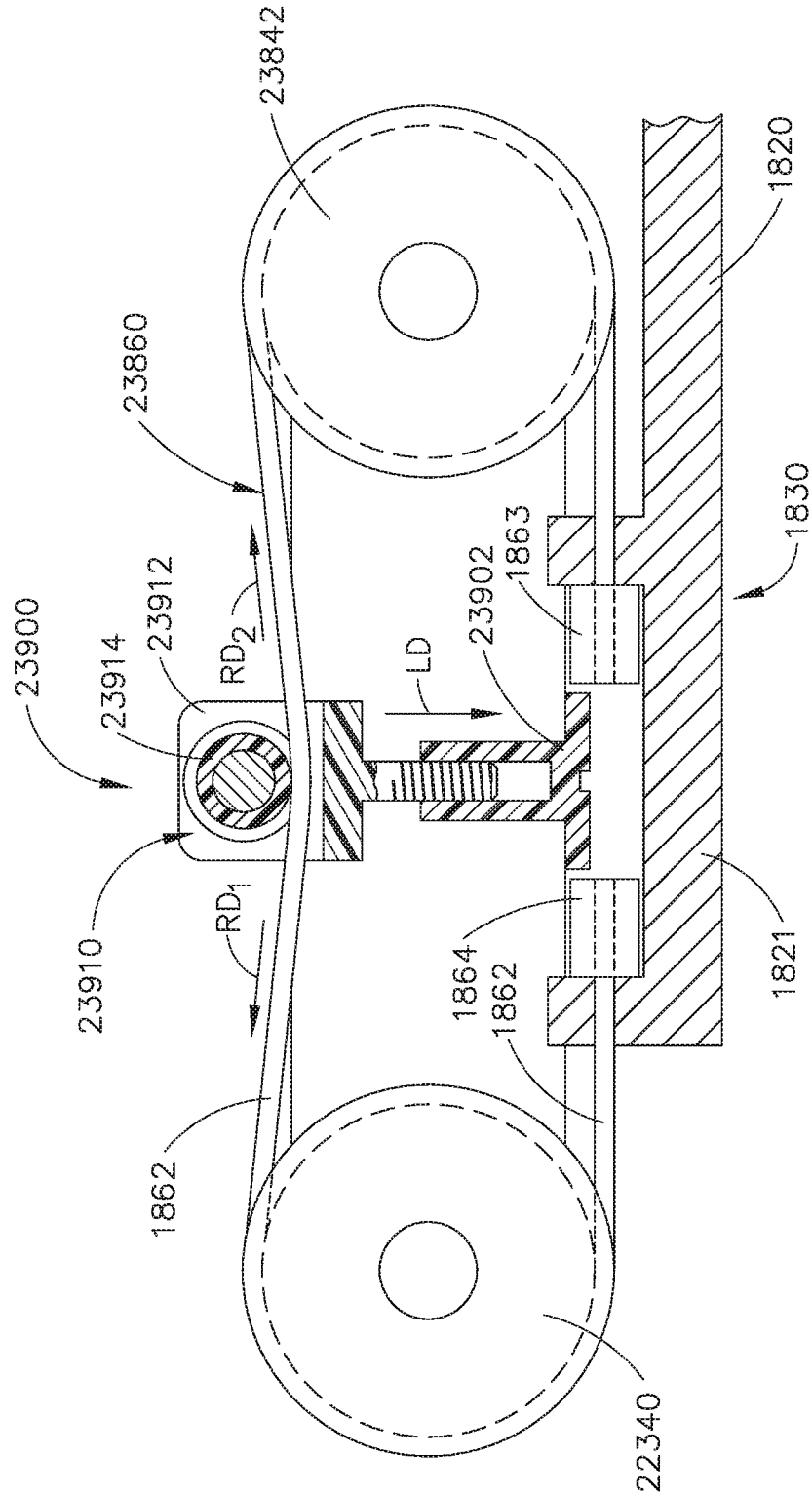
22812'

FIG. 149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LD
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RD1
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1821
1862
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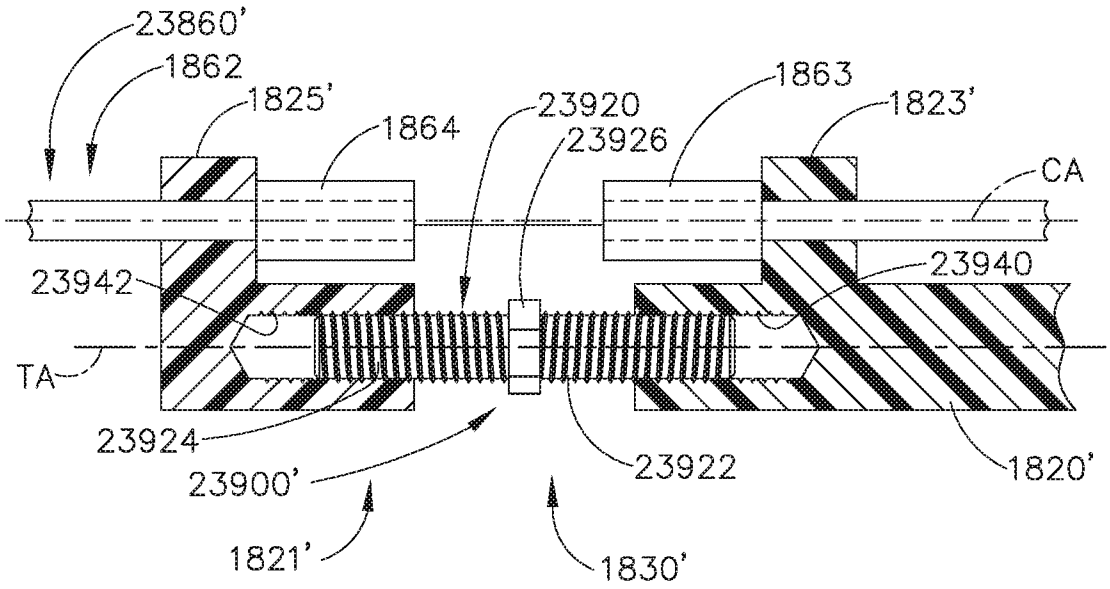
FIG. 150


23860'
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1825'
1864
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1863
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23940
23942
TA
23924
23900'
1821'
23922
1830'
1820'

FIG. 151

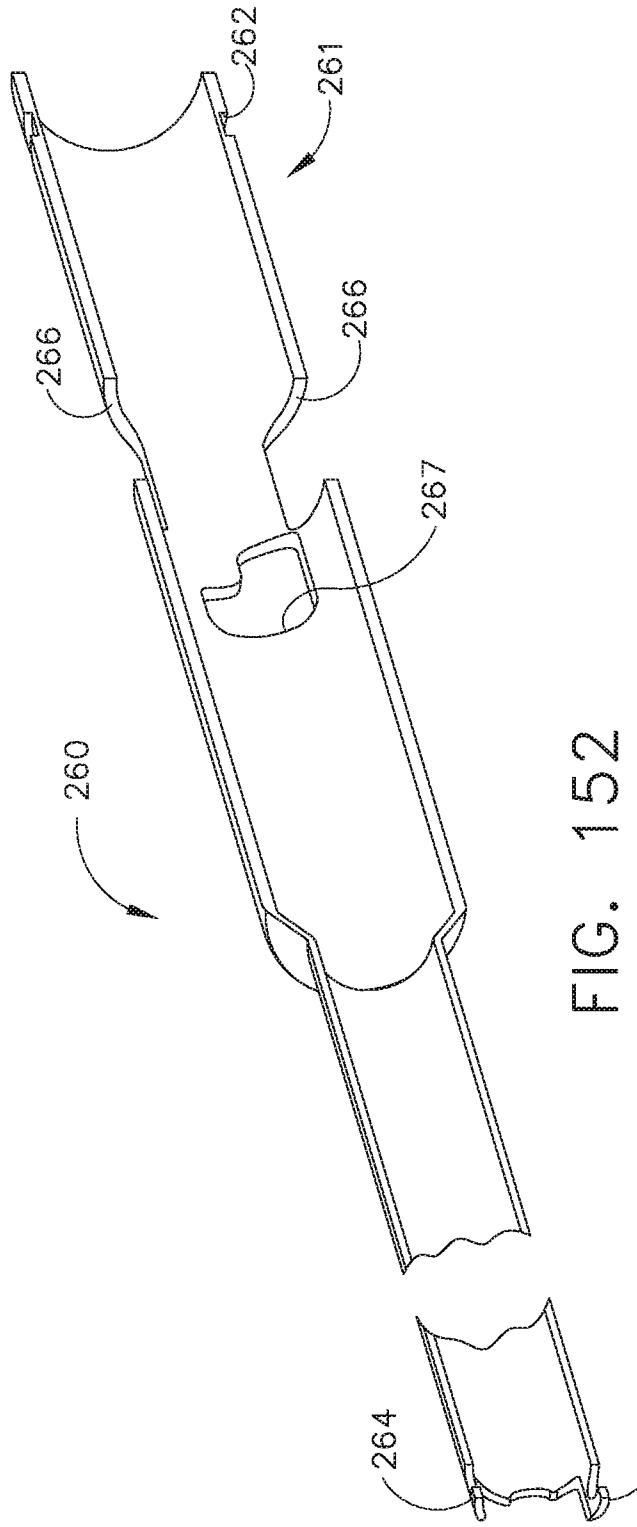


FIG. 152

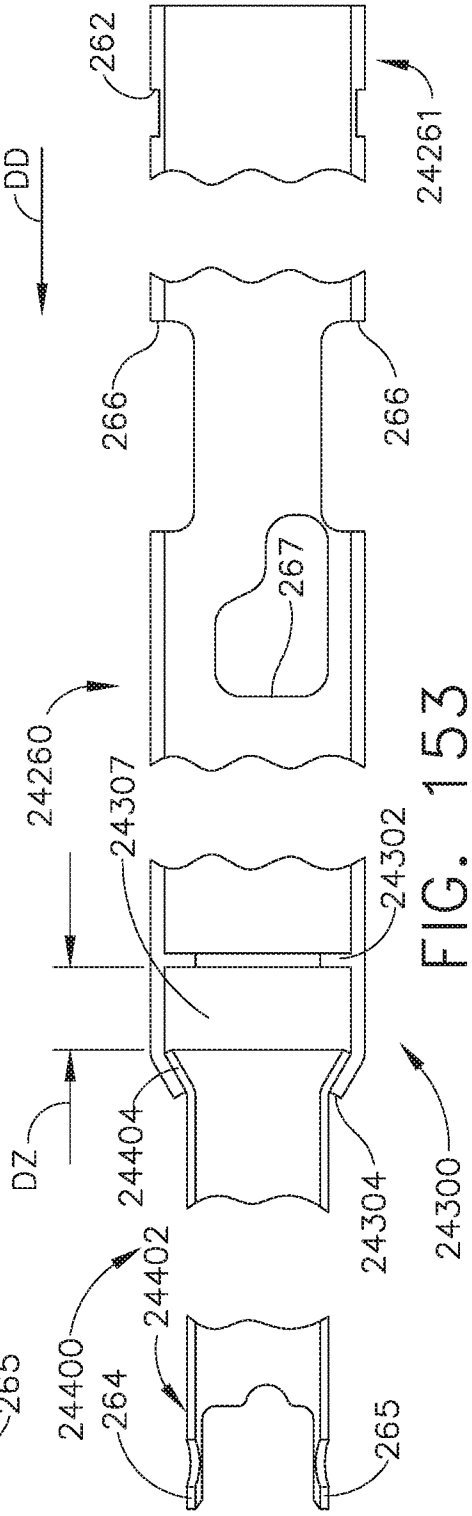


FIG. 153

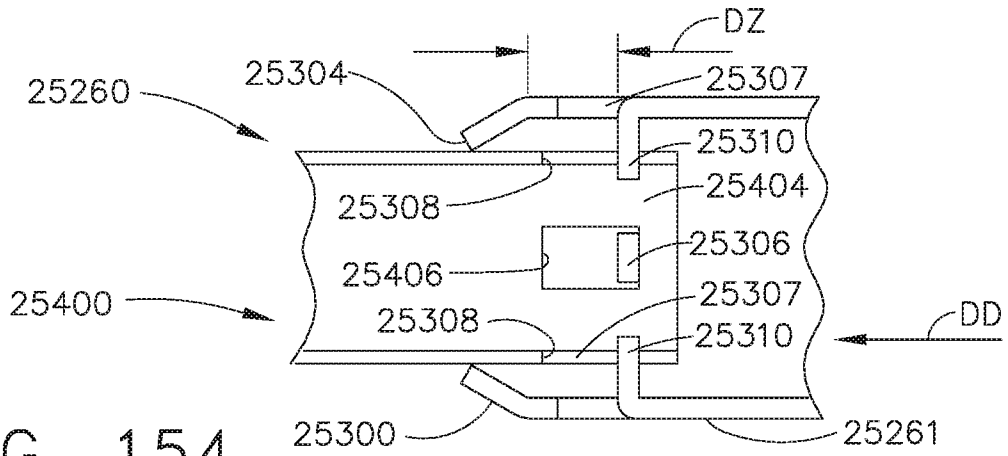


FIG. 154

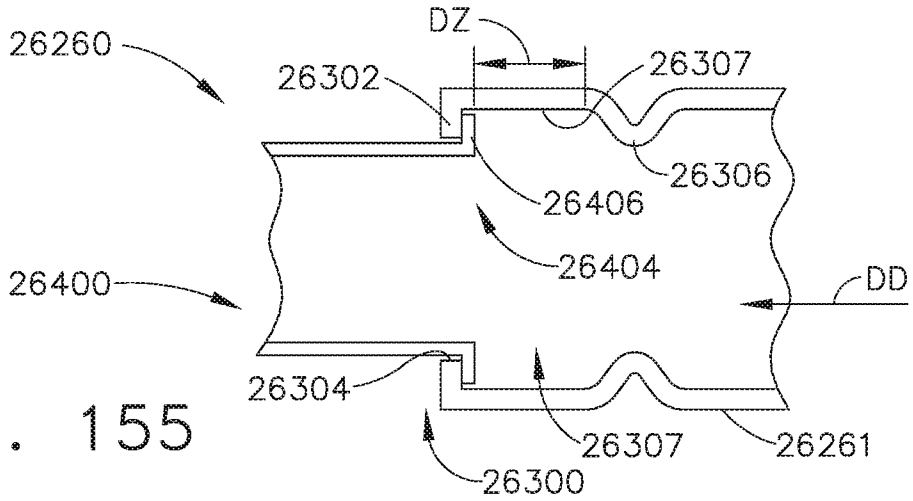


FIG. 155

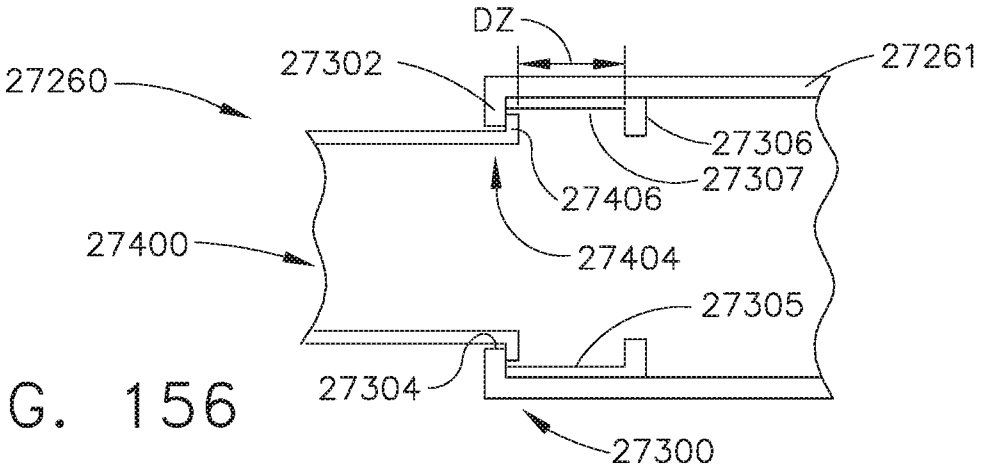
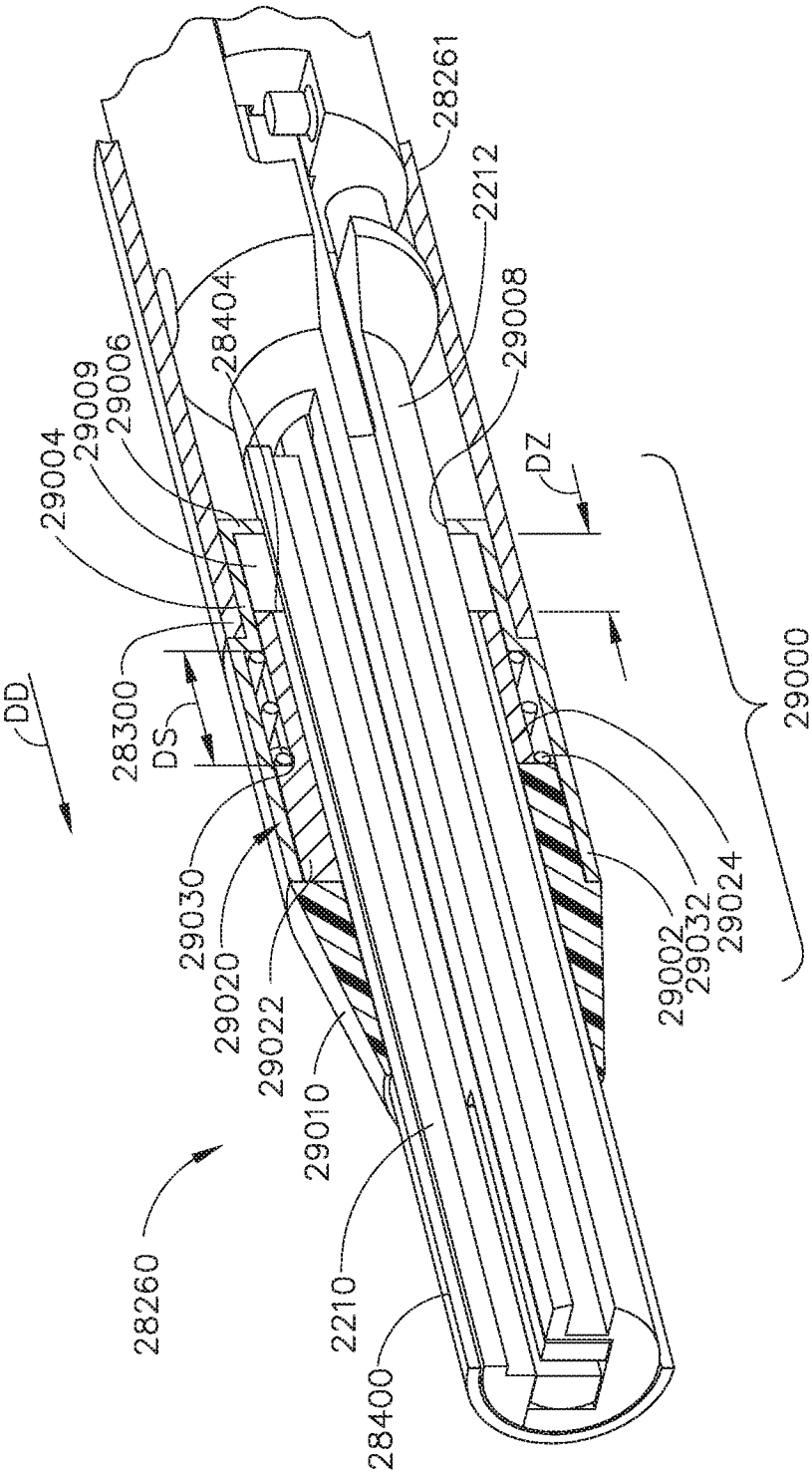


FIG. 156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DZ
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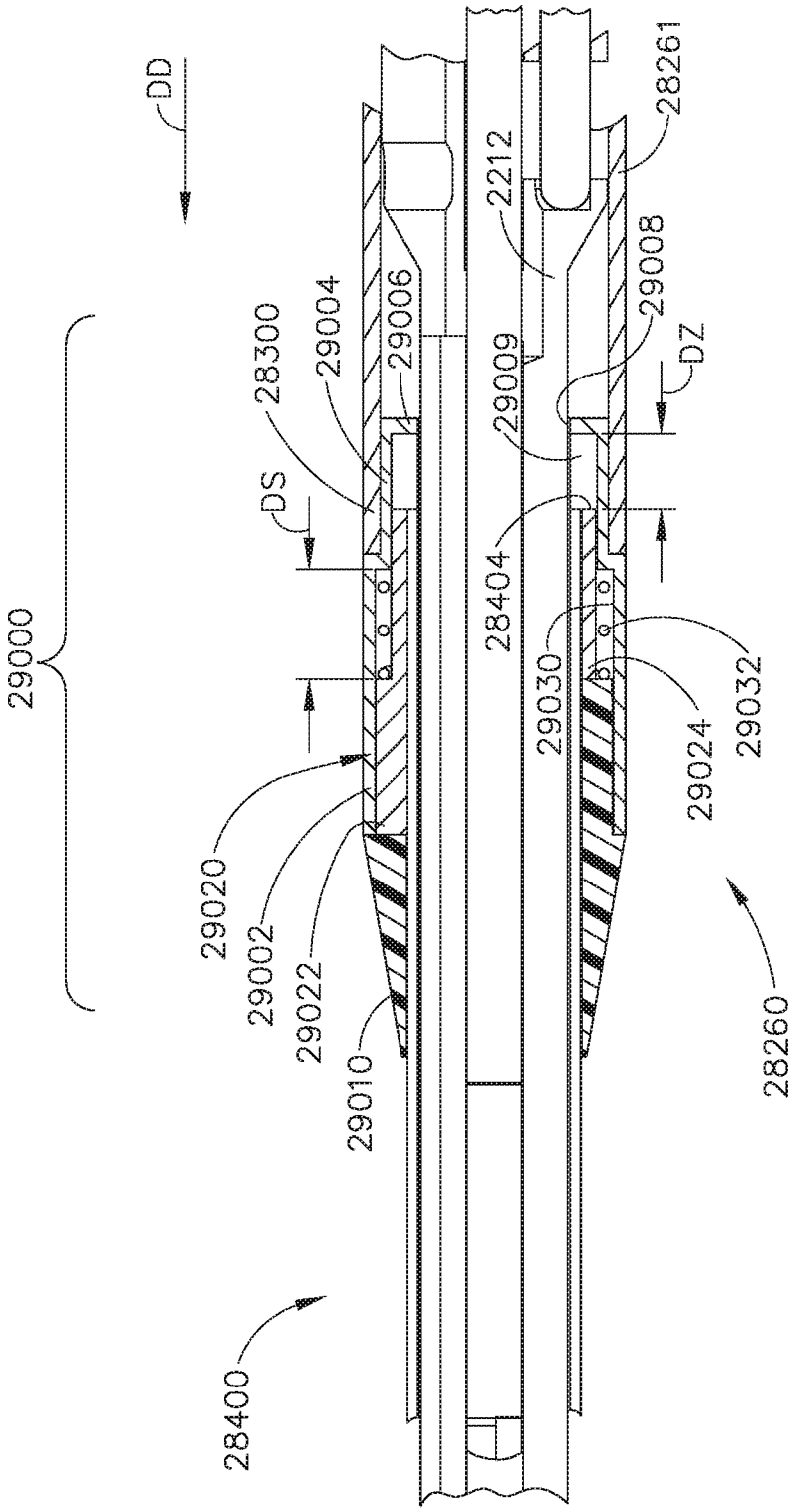
FIG. 157


DD
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29020
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29022
29010
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28400

FIG. 158

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/016110

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

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	WO 03/090628 A1 (TERUMO CORP [JP]; MARUYAMA TOMOJI [JP]; KAWAURA MASAKATSU [JP]) 6 November 2003 (2003-11-06) page 16, line 24 - page 18, line 5; figures 7-11 page 17, line 8 - page 17, line 22 page 31, line 20 - page 31, line 23	1-3,8, 11,13,14

X	US 2012/323262 A1 (IBRAHIM TAMER [US] ET AL) 20 December 2012 (2012-12-20)	1,3,8, 11-14
A	para. 53-59, 93, 101; figures 5, 12A	9,20

X	WO 2010/134913 A1 (CALIFORNIA INST OF TECHN [US]; MANOHARA HARISH M [US]; LIAO ANNA [US];) 25 November 2010 (2010-11-25) page 16, line 13 - page 16, line 26; figures 7A, 7B	1,11

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 May 2017	12/05/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kamp, Martin

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/016110

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2 957 353 A (LEWIS BABACZ) 25 October 1960 (1960-10-25) slotted articulatable connection; figures 1-9	1,11,14
A	US 2014/249557 A1 (KOCH JR ROBERT L [US] ET AL) 4 September 2014 (2014-09-04) cited in the application gear system; figures 18,19,21-22, 50, 52, 53	1,4-7, 10,15-19

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/016110

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 03090628 A1	06-11-2003	AU 2003234088 A1	10-11-2003
		US 2005228405 A1	13-10-2005
		WO 03090628 A1	06-11-2003
US 2012323262 A1	20-12-2012	US 2012323262 A1	20-12-2012
		US 2014303651 A1	09-10-2014
		US 2015190135 A1	09-07-2015
WO 2010134913 A1	25-11-2010	NONE	
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