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(57) Abstract:

TITLE

SURGICAL CUTTING AND STAPLING METHODS

BACKGROUND

[0001] The present invention relates to surgical instruments and, in various embodiments, to surgical cutting and stapling instruments and staple cartridges therefor that are designed to cut and staple tissue.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The various features and advantages of this invention and the manner of attaining them will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

[0003] FIG. 1 is a perspective view of one surgical instrument arrangement;

[0004] FIG. 2 is an enlarged perspective view of an end effector and a portion of the elongated shaft assembly of the surgical instrument of FIG. 1;

[0005] FIG. 3 is an exploded perspective view of the end effector and portion of the elongated shaft assembly of FIGS. 1 and 2;

[0006] FIG. 4 is a perspective view of a portion of a distal anvil portion of the end effector of FIGS. 2 and 3;

[0007] FIG. 5 is a lower perspective view of a proximal anvil mounting tube arrangement of the end effector of FIGS. 2 and 3;

[0008] FIG. 6 is an elevational view of the distal end of the proximal anvil mounting tube of FIG. 5;

[0009] FIG. 7 is an end cross-sectional view of the distal anvil portion and proximal anvil mounting tube assembled together;

[0010] FIG. 8 is an exploded perspective assembly view of a portion of the handle assembly of the surgical instrument of FIG. 1;

[0011] FIG. 9 is another perspective view of the end effector and elongated shaft assembly of FIG. 2 with the anvil assembly in an open position;

[0012] FIG.10 is a perspective view of portions of the elongated shaft assembly, articulation system and firing system of the surgical instrument of FIG. 1;

[0013] FIG. 11 is a side view of a portion of the articulation system of the surgical instrument of FIG. 1 with portions thereof shown in cross-section;

[0014] FIG. 12 is a cross-sectional view of the end effector and elongated shaft assembly portion of FIGS. 2 and 9 with the anvil assembly in a closed, but unfired position;

[0015] FIG. 13 is a cross-sectional view of the end effector and elongated shaft assembly portion of FIGS. 2, 9 and 12 in an articulated position and after the cutting head assembly has been retracted to a starting position after being fired;

[0016] FIG. 14 is a partial perspective view of the end effector and portion of the elongated shaft assembly after the cutting head assembly has been retracted to a starting position after being fired;

[0017] FIG. 15 is a partial perspective view of an another end effector and elongated shaft assembly with the end effector in a closed position;

[0018] FIG. 16 is a cross-sectional perspective view of the end effector and elongated shaft assembly of FIG. 15;

[0019] FIG. 17 is an exploded perspective assembly view of the end effector and elongated shaft assembly of FIGS. 15 and 16;

[0020] FIG. 18 is a cross-sectional perspective view of the end effector and elongated shaft assembly of FIGS. 15-17;

[0021] FIG. 19 is an exploded perspective assembly view of a handle assembly portion of a surgical instrument;

[0022] FIG. 20 is a perspective view of another surgical instrument;

[0023] FIG. 21 is a partial perspective view of the end effector of the surgical instrument of FIG. 20 in a closed position;

[0024] FIG. 22 is a cross-sectional perspective view of the end effector of FIG. 21;

[0025] FIG. 23 is an exploded perspective assembly view of the end effector of FIGS. 21 and 22;

[0026] FIG. 24 is a cross-sectional elevational view of the end effector of FIGS. 21-23 with the anvil assembly thereof in an open position;

[0027] FIG. 25 is another cross-sectional view of the end effector of FIGS. 21-24 in an articulated position and with the anvil assembly thereof in an open position;

[0028] FIG. 26 is another cross-sectional view of the end effector of FIG. 24 after the anvil has been closed onto tissue;

[0029] FIG. 27 is a perspective view of another surgical instrument;

[0030] FIG. 28 is a partial perspective view of the end effector of the surgical instrument of FIG. 27 in a closed position;

[0031] FIG. 29 is an exploded perspective assembly view of the end effector and elongated shaft assembly of FIGS. 27 and 28;

[0032] FIG. 30 is a cross-sectional perspective view of the end effector of FIGS. 28 and 29;

[0033] FIG. 31 is a cross-sectional side view of the end effector of FIGS. 28-30 with the anvil assembly thereof in a closed position;

[0034] FIG. 32 is another cross-sectional side view of the end effector of FIGS. 28-31 with the anvil assembly thereof in an open position;

[0035] FIG. 33 is a cross-sectional side view of the end effector of FIGS. 28-32 in an articulated position and with the anvil assembly thereof in an open position;

[0036] FIG. 34 is a perspective assembly view of portions of the articulation system and firing system of the surgical instrument of FIG. 27;

[0037] FIG. 35 is a side view of a portion of the articulation system of FIG. 34 with portions thereof shown in cross-section;

[0038] FIG. 36 is a perspective view of another surgical instrument;

[0039] FIG. 37 is a partial perspective view of the end effector of the surgical instrument of FIG. 36 in a closed position;

[0040] FIG. 38 is a distal exploded perspective assembly view of the end effector and elongated shaft assembly of FIGS. 36 and 37;

[0041] FIG. 39 is a proximal exploded perspective assembly view of the end effector and elongated shaft assembly of FIGS. 36-38;

[0042] FIG. 40 is a cross-sectional end view of a portion of the end effector of FIGS. 36-39;

[0043] FIG. 41 is a partial perspective view of portions of the end effector of FIGS. 36-40 with the anvil assembly thereof in an open position;

[0044] FIG. 42 is another partial perspective view of portions of the end effector of FIGS. 36-41 with the anvil assembly thereof in an open position;

[0045] FIG. 43 is a partial side view of a cutting beam head in its uncompressed state;

[0046] FIG. 44 is another partial side view of the cutting beam head of FIG. 43 in its maximum compressed state;

[0047] FIG. 45 is a cross-sectional end view of an end effector and a cutting beam head of FIGS. 43 and 44 in its maximum compressed state;

[0048] FIG. 46 is another cross-sectional view of the end effector and cutting beam head of FIG. 45 after the end effector has cut and stapled tissue;

[0049] FIG. 47 is a perspective view of another surgical instrument;

[0050] FIG. 48 is an exploded perspective view of another surgical end effector of the present invention;

[0051] FIG. 49 is an exploded assembly view of the handle assembly of the surgical instrument of FIG. 47;

[0052] FIG. 50 is an exploded assembly view of an elongated shaft assembly of the surgical instrument of FIGS. 47-49;

[0053] FIG. 51 is a cross-sectional side view of a portion of the surgical instrument of FIGS. 47-50 inserted through a portion of a trocar port;

[0054] FIG. 52 is another cross-sectional side view of the surgical instrument of FIG. 51 after it has exited through the trocar port inside the patient;

[0055] FIG. 53 is another cross-sectional side view of the surgical instrument of FIGS. 51 and 52 after the anvil assembly has been moved to an open position;

[0056] FIG. 54 is another cross-sectional side view of the surgical instrument of FIGS. 51-53 with the anvil in the closed firing position;

[0057] FIG. 55 is a cross-sectional side view of a portion of another surgical instrument inserted through a portion of a trocar port;

[0058] FIG. 56 is another cross-sectional side view of the surgical instrument of FIG. 55 after the end effector has passed through the trocar port into the patient;

[0059] FIG. 57 is a perspective view of one form of a control insert;

[0060] FIG. 58 is a cross-sectional side view of a portion of another end effector inserted through a portion of a trocar port;

[0061] FIG. 59 is another cross-sectional side view of the end effector of FIG. 58 exiting the trocar port;

[0062] FIG. 60 is a cross-sectional view of another end effector arrangement;

[0063] FIG. 61 is a cross-sectional view of another end effector arrangement;

[0064] FIG. 62 is a cross-sectional side view of a portion of another end effector and distal closure tube arrangement wherein a portion of the end effector is inserted through a portion of a trocar port;

[0065] FIG. 63 is another cross-sectional side view of the end effector of FIG. 62 exiting the trocar port;

[0066] FIG. 64 is a perspective view of one form of a surgical instrument of the present invention;

[0067] FIG. 65 is an exploded perspective view of one form of surgical end effector of the present invention;

[0068] FIG. 66 is an exploded perspective view of a portion of the surgical instrument of FIG. 64;

[0069] FIG. 67 is an exploded perspective assembly view of another portion of the surgical instrument of FIG. 64;

[0070] FIG. 68 is an exploded perspective assembly view of a portion of the elongated shaft assembly of the surgical instrument of FIG. 64;

[0071] FIG. 69 is a perspective view of the surgical end effector of FIG. 65 and a distal closure tube segment;

[0072] FIG. 70 is a rear perspective view of a portion of an anvil embodiment;

[0073] FIG. 70A is an exploded perspective assembly view of another surgical end effector assembly;

[0074] FIG. 70B is a rear perspective view of a portion of another anvil assembly embodiment and another closure tube segment embodiment;

[0075] FIG. 70C is a perspective view of a portion of another anvil assembly and another distal closure tube segment;

[0076] FIG. 70D is an exploded perspective assembly view of another surgical end effector embodiment;

[0077] FIG. 70E is an exploded perspective assembly view of another surgical end effector embodiment;

[0078] FIG. 71 is a side cross-sectional view of a surgical end effector and distal closure tube segment with the anvil assembly in an open position;

[0079] FIG. 72 is another side cross-sectional view of the surgical end effector and distal closure tube segment of FIG. 71;

[0080] FIG. 73 is a perspective view of a portion of the surgical instrument of FIG. 64 with a portion of the handle housing removed;

[0081] FIG. 74 is a perspective view of a portion of a firing drive system;

[0082] FIG. 75 is a perspective view of an intermediate portion of an elongated shaft assembly embodiment;

[0083] FIG. 76 is an elevational view of the distal end of the intermediate shaft portion of FIG. 75;

[0084] FIG. 77 is side elevational view of the intermediate shaft portion of FIGS. 74 and 75;

[0085] FIG. 78 is a plan view of the intermediate shaft portion of FIGS. 74-77;

[0086] FIG. 79 is an enlarged side elevational view of portions of adjacent ribs of the intermediate shaft portion of FIGS. 74-78;

[0087] FIG. 80 is a plan view of another intermediate shaft portion embodiment;

[0088] FIG. 81 is a side elevational view of the intermediate shaft portion of FIG. 80;

[0089] FIG. 82 is a cross-sectional plan view of the intermediate shaft portion of FIGS. 80 and 81 articulated into a substantial U-shape;

[0090] FIG. 83 is a perspective view of one surgical instrument arrangement;

[0091] FIG. 84 is an exploded perspective assembly view of a surgical end effector arrangement;

[0092] FIG. 85 is a side elevational view of an anvil;

[0093] FIG. 86 is a side cross-sectional view of an end effector and portion of an elongated shaft assembly with the end effector shown in an unarticulated position in solid lines and the end effector shown in articulated positions in broken lines;

[0094] FIG. 87 is another side cross-sectional view of an end effector and portion of an elongated shaft assembly with the anvil in a closed position and the cutting head in an end position after being fired distally through the staple cartridge;

[0095] FIG. 88 is another side cross-sectional view of the end effector and elongated shaft assembly portion of FIG. 87 after the cutting head has been retracted proximally back to its starting position;

[0096] FIG. 89 is another side cross-sectional view of an end effector and portion of an elongated shaft assembly with the anvil in an open position and the cutting head in a starting position;

[0097] FIG. 90 is an enlarged cross-sectional view of the end effector and portion of the elongated shaft assembly of FIG. 89;

[0098] FIG. 91 is a cross-sectional perspective view of the end effector and portion of the elongated shaft assembly of FIG. 89;

[0099] FIG. 92 is a perspective assembly view of an end effector and elongated shaft assembly;

[0100] FIG. 93 is a cross-sectional view of a distal portion of an elongated shaft assembly;

[0101] FIG. 94 is a cross-sectional view of a proximal portion of the elongated shaft assembly of FIG. 11 along with a portion of an articulation system;

[0102] FIG. 95 is a perspective view of an elongated shaft assembly and end effector;

[0103] FIG. 96 is a partial perspective exploded view of a handle assembly;

[0104] FIG. 97 is a perspective view of a surgical instrument arrangement of the present invention;

[0105] FIG. 98 is a perspective view of an exemplary loading unit that may be employed in connection with various surgical instruments disclosed herein;

[0106] FIG. 99 is another partial cross-sectional view of a portion of the loading unit depicted in FIG. 98;

[0107] FIG. 100 is an exploded perspective view of the loading unit of FIGS. 98 and 99;

[0108] FIG. 101 is a partial perspective view of a portion of a carrier and an articulation ball assembly embodiment;

[0109] FIG. 102 is a perspective view of an articulation tube embodiment;

[0110] FIG. 103 is a partial cross-sectional view of a loading unit of FIGS. 98-100;

[0111] FIG. 104 is another cross-sectional view of the loading unit of FIG. 103 in an unarticulated position;

[0112] FIG. 105 is another cross-sectional view of the loading unit of FIGS. 103 and 104 with the carrier and anvil assembly articulated as a unit in a second direction;

[0113] FIG. 106 is a partial perspective view of a loading unit and a portion of an elongated shaft assembly prior to commencing a coupling operation between the loading unit and a distal end of the elongated shaft assembly;

[0114] FIG. 107 is another perspective view of portions of the loading unit and elongated shaft assembly of FIG. 106 after being coupled together;

[0115] FIG. 108 is a partial exploded perspective view of portions of the elongated shaft assembly, a coupling assembly and the loading unit of FIG. 106;

[0116] FIG. 109 is another partial exploded perspective view of the shaft assembly, the coupling assembly and the loading unit of FIG. 106;

[0117] FIG. 110 is a perspective view of a distal attachment portion of the loading unit of FIG. 106;

[0118] FIG. 111 is another perspective view of the distal attachment portion of the loading unit of FIG. 106;

[0119] FIG. 112 is a perspective view of a proximal attachment portion of the elongated shaft assembly of FIG. 109;

[0120] FIG. 113 is another perspective view of the proximal attachment portion of the elongated shaft assembly of FIG. 109;

[0121] FIG. 114 is a perspective view of the collar and a firing shaft arrangement;

[0122] FIG. 115 is a partial perspective, cross-section view of the loading unit, the coupling assembly, and a proximal end of the elongated shaft assembly of FIG. 109, depicting the loading unit attached to the elongated shaft assembly;

[0123] FIG. 116 is a partial elevation, cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit unattached to the elongated shaft assembly;

[0124] FIG. 117 is a partial elevation, cross-sectional view of the loading unit, the coupling assembly and the elongated shaft assembly of FIG. 109, depicting the loading unit attached to the elongated shaft assembly;

[0125] FIG. 118 is an elevational view of the coupling assembly and the elongated shaft assembly of FIG. 109 taken along the plane indicated in FIG. 115;

[0126] FIG. 119 is a perspective, partial cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit unattached to the elongated shaft assembly, and further depicting the coupling collar in an initial orientation relative to the elongated shaft assembly;

[0127] FIG. 120 is a perspective, partial cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit unattached to the shaft, and further depicting the coupling collar in the initial orientation relative to the elongated shaft assembly;

[0128] FIG. 121 is a perspective, partial cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit entering the elongated shaft assembly, and further depicting the coupling collar in the initial orientation relative to the elongated shaft assembly;

[0129] FIG. 122 is a perspective, partial cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit entering the elongated shaft assembly, and further depicting the coupling collar in a secondary, rotated orientation relative to the elongated shaft assembly;

[0130] FIG. 123 is a perspective, partial cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit entering the elongated shaft assembly, and further depicting the coupling collar in the secondary, rotated orientation relative to the elongated shaft assembly;

[0131] FIG. 124 is a perspective, partial cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit fully inserted into the elongated

shaft assembly, and further depicting the coupling collar in the secondary, rotated orientation relative to the elongated shaft assembly;

[0132] FIG. 125 is a perspective, partial cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit fully inserted into the elongated shaft assembly, and further depicting the coupling collar in the initial orientation relative to the elongated shaft assembly;

[0133] FIG. 126 is a perspective, partial cross-sectional view of the loading unit, the coupling assembly, and the elongated shaft assembly of FIG. 109, depicting the loading unit fully inserted into the elongated shaft assembly, and further depicting the coupling collar in the initial orientation relative to the elongated shaft assembly;

[0134] FIG. 127 is a perspective view of a surgical instrument according to various embodiments of the present disclosure;

[0135] FIG. 128 is an exploded perspective view of a handle assembly of the surgical instrument of FIG. 127 according to various embodiments of the present disclosure;

[0136] FIG. 129 is an exploded perspective view of an end effector of the surgical instrument of FIG. 127 according to various embodiments of the present disclosure;

[0137] FIG. 130 is a perspective view of a staple cartridge of the end effector of FIG. 129 according to various embodiments of the present disclosure;

[0138] FIG. 131 is a cross-sectional perspective view of the staple cartridge of FIG. 130 taken along the plane indicated in FIG. 130 according to various embodiments of the present disclosure;

[0139] FIG. 132 is a perspective view of the staple depicted in the staple cartridge of FIG. 130 according to various embodiments of the present disclosure;

[0140] FIG. 133 is a front elevation view of the staple of FIG. 132;

[0141] FIG. 134 is a rear elevation view of the staple of FIG. 132;

[0142] FIG. 135 is a top plan view of the staple of FIG. 132;

[0143] FIG. 136 is a bottom plan view of the staple of FIG. 132;

[0144] FIG. 137 is a right elevation view of the staple of FIG. 132;

[0145] FIG. 138 is a left elevation view of the staple of FIG. 132;

[0146] FIG. 139 is a perspective view of the staple of FIG. 132;

[0147] FIG. 140 is an elevation view of the staple of FIG. 132 and a sled of the end effector of FIG. 129, depicting a leading surface of the sled contacting an initial drive surface of the staple, according to various embodiments of the present disclosure;

[0148] FIG. 141 is a perspective view of the staple and the sled of FIG. 140, depicting the leading surface of the sled contacting the initial drive surface of the staple;

[0149] FIG. 142 is an elevation view of the staple and the sled of FIG. 140, depicting a trailing surface of the sled contacting a secondary drive surface of the staple, according to various embodiments of the present disclosure;

[0150] FIG. 143 is a perspective view of the staple and the sled of FIG. 140, depicting the trailing surface of the sled contacting the secondary drive surface of the staple;

[0151] FIGS. 144-147 are cross-sectional elevation views of the end effector of FIG. 129, depicting a firing progression of staples from the staple cartridge, according to various embodiments of the present disclosure;

[0152] FIG. 148 is a cross-sectional elevation view of the staple cartridge and the sleds of FIG. 129, depicting the staples in unfired positions, according to various embodiments of the present disclosure;

[0153] FIG. 149 is a cross-sectional perspective view of the cartridge and the sleds of FIG. 148, depicting the staples in the unfired positions depicted in FIG. 148;

[0154] FIG. 150 is a cross-sectional elevation view of the cartridge and the sleds of FIG. 148, depicting a proximal pair of staples in partially fired positions and the remaining staples in unfired positions, according to various embodiments of the present disclosure;

[0155] FIG. 151 is a cross-sectional perspective view of the cartridge and the sleds of FIG. 148, depicting the proximal pair of staples in the partially fired positions depicted in FIG. 150 and the remaining staples in the unfired positions depicted in FIG. 150;

[0156] FIG. 152 is a cross-sectional elevation view of the cartridge and the sleds of FIG. 148, depicting multiple pairs of staples in partially fired positions and the proximal pair of staples in partially deformed configurations, according to various embodiments of the present disclosure;

[0157] FIG. 153 is a cross-sectional perspective view of the cartridge and the sleds of FIG. 148, depicting the multiple pairs of staples in the partially fired positions of FIG. 152 and the proximal pair of staples in the partially deformed configurations depicted in FIG. 152;

[0158] FIG. 154 is a cross-sectional elevation view of the cartridge and the sleds of FIG. 148, depicting multiple pairs of staples in further fired positions and the proximal pair of staples in further deformed configurations, according to various embodiments of the present disclosure;

[0159] FIG. 155 is a cross-sectional perspective view of the cartridge and the sleds of FIG. 148, depicting the multiple pairs of staples in the partially fired positions depicted in FIG. 154 and the proximal pair of staples in the partially deformed configurations depicted in FIG. 154;

[0160] FIG. 156 is a cross-sectional elevation view of the cartridge and the sleds of FIG. 148, depicting multiple pairs of staples in partially fired positions and in partially deformed configurations and the proximal pair of staples in ejected positions and in fully deformed configurations, according to various embodiments of the present disclosure;

[0161] FIG. 157 is a cross-sectional perspective view of the cartridge and the sleds of FIG. 148, depicting the multiple pairs of staples in the partially fired positions and in the partially deformed configurations

depicted in FIG. 156 and the proximal pair of staples in the ejected positions and in the fully deformed configurations depicted in FIG. 156;

[0162] FIGS. 158A-158C illustrate a method for forming staples from a sheet of material according to various embodiments of the present disclosure;

[0163] FIG. 159 is a perspective view of the staple formed from the method depicted in FIGS. 158A-158C, according to various embodiments of the present disclosure;

[0164] FIG. 160 is a plan view of the staple of FIG. 159;

[0165] FIG. 161 is a front elevation view of the staple of FIG. 159;

[0166] FIG. 162 is a side elevation view of the staple of FIG. 159;

[0167] FIG. 163 is a perspective view of a staple according to various embodiments of the present disclosure;

[0168] FIG. 164 is a plan view of the staple of FIG. 163;

[0169] FIG. 165 is a front elevation view of the staple of FIG. 163;

[0170] FIG. 166 is a side elevation view of the staple of FIG. 163;

[0171] FIG. 167 is a perspective view of a staple according to various embodiments of the present disclosure;

[0172] FIG. 168 is a plan view of the staple of FIG. 167;

[0173] FIG. 169 is a front elevation view of the staple of FIG. 167;

[0174] FIG. 170 is a side elevation view of the staple of FIG. 167;

[0175] FIG. 171 is a perspective view of a staple cartridge according to various embodiments of the present disclosure;

[0176] FIG. 172 is a cross-sectional perspective view of the staple cartridge of FIG. 171 taken along the plane indicated in FIG. 171;

[0177] FIG. 173 is a plan view of the staple cartridge of FIG. 171;

[0178] FIG. 174 is a perspective view of a staple according to various embodiments of the present disclosure;

[0179] FIG. 175 is a plan view of the staple of FIG. 174;

[0180] FIG. 176 is a front elevation view of the staple of FIG. 174;

[0181] FIG. 177 is a side elevation view of the staple of FIG. 174;

[0182] FIG. 178 is a perspective view of a staple according to various embodiments of the present disclosure;

[0183] FIG. 179 is a plan view of the staple of FIG. 178;

[0184] FIG. 180 is a front elevation view of the staple of FIG. 178;

[0185] FIG. 181 is a side elevation view of the staple of FIG. 178;

[0186] FIG. 182 is a partial, cross-sectional elevation view of the staple cartridge of FIG. 130, depicting a staple in a partially-fired position in a staple cavity, according to various embodiments of the present disclosure;

[0187] FIG. 183 is a partial plan view of the staple cartridge of FIG. 182, depicting the staple in the partially-fired position depicted in FIG. 182;

[0188] FIG. 184 is a partial, cross-sectional elevation view of the staple cartridge of FIG. 182, depicting the staple in the partially-fired position depicted in FIG. 182;

[0189] FIG. 185 is a partial, cross-sectional elevation view of the staple cartridge of FIG. 182, depicting the staple in another partially-fired position, according to various embodiments of the present disclosure;

[0190] FIG. 186 is a partial, plan view of the staple cartridge of FIG. 182, depicting the staple in the partially-fired position depicted in FIG. 185;

[0191] FIG. 187 is a partial, cross-sectional elevation view of the staple cartridge of FIG. 182, depicting the staple in the partially-fired position depicted in FIG. 185;

[0192] FIG. 188 is a partial, cross-sectional elevation view of the staple cartridge of FIG. 182, depicting the staple in an ejected position and in a deformed configuration, according to various embodiments of the present disclosure;

[0193] FIG. 189 is a partial plan view of the staple cartridge of FIG. 182, depicting the staple in the ejected position and in the deformed configuration depicted in FIG. 188;

[0194] FIG. 190 is a partial, cross-sectional elevation view of the staple cartridge of FIG. 182, depicting the staple in the ejected position and the deformed configuration depicted in FIG. 188;

[0195] FIG. 191 is an exploded perspective view of an end effector comprising a plurality of fasteners and a firing actuator configured to eject the fasteners from the end effector according to various embodiments of the present disclosure;

[0196] FIG. 192 is a plan view of a first portion of the fastener firing actuator of FIG. 191;

[0197] FIG. 193 is an elevational view of the first portion of FIG. 192;

[0198] FIG. 194 is a plan view of a second portion of the fastener firing actuator of FIG. 191;

[0199] FIG. 195 is an elevational view of the second portion of FIG. 194;

[0200] FIG. 196 is a cross-sectional view of the end effector of FIG. 191 illustrating the firing actuator in an unfired, unextended condition;

[0201] FIG. 197 is a cross-sectional view of the end effector of FIG. 191 illustrating the firing actuator in an extended condition;

[0202] FIG. 198 is a cross-sectional view of the end effector of FIG. 191 illustrating the firing actuator in an extended, advanced condition;

[0203] FIG. 199 is a cross-sectional view of the end effector of FIG. 191 illustrating an anvil of the end effector in an open position and the firing actuator in an unfired, unextended condition;

[0204] FIG. 200 is a cross-sectional view of the end effector of FIG. 191 illustrating the anvil in a closed position and the firing actuator in an unfired, unextended condition;

[0205] FIG. 201 is a cross-sectional perspective view of the end effector of FIG. 191 illustrated in the configuration depicted in FIG. 199;

[0206] FIG. 202 is a cross-sectional view of the end effector of FIG. 191 illustrated in the configuration depicted in FIG. 200;

[0207] FIG. 203 is a cross-sectional view of the end effector of FIG. 191 illustrating the firing actuator in an extended condition and, in addition, a knife member in an unadvanced position;

[0208] FIG. 204 is a cross-sectional view of the end effector of FIG. 191 illustrating the firing actuator in an advanced, extended condition and the knife member in an advanced position;

[0209] FIG. 205 is a cross-sectional perspective view of the end effector of FIG. 191 illustrated in the configuration depicted in FIG. 204;

[0210] FIG. 206 is a partial cross-sectional plan view of the end effector of FIG. 191 illustrated in a fully-fired condition;

[0211] FIG. 207 is a cross-sectional elevational view of the end effector of FIG. 191 illustrated in the configuration depicted in FIG. 206;

[0212] FIG. 208 is a cross-sectional perspective view of the end effector of FIG. 191 illustrated in the configuration depicted in FIG. 206;

[0213] FIG. 209 is a cross-sectional elevational view of the end effector of FIG. 191 illustrating the knife member in a retracted position;

[0214] FIG. 210 is a cross-sectional perspective view of the end effector of FIG. 191 illustrated in the configuration depicted in FIG. 209;

[0215] FIG. 211 is a perspective view of the firing member of the end effector of FIG. 191 illustrated in the unextended configuration depicted in FIG. 200;

[0216] FIG. 212 is a perspective view of the firing member of the end effector of FIG. 191 illustrated in the extended configuration depicted in FIG. 203;

[0217] FIG. 213 is a perspective view of the firing member of the end effector of FIG. 191 illustrated in a configuration just prior to the fully-fired configuration depicted in FIG.206;

[0218] FIG. 214 is a perspective view of the firing member of the end effector of FIG. 191 illustrated in the fully-fired configuration depicted in FIG. 206;

[0219] FIG. 215 is a cross-sectional view of an end effector including a firing actuator configured to eject fasteners from a fastener cartridge illustrating the firing actuator in an unfired position;

[0220] FIG. 216 is a cross-sectional view of the end effector of FIG. 215 illustrating the firing actuator in a partially fired position;

[0221] FIG. 217 is a plan view of a staple cartridge body of the end effector of FIG. 215;

[0222] FIG. 218 is a perspective view of a firing actuator for use with the cartridge body of FIG. 217;

[0223] FIG. 219 is a perspective view of the cartridge body of FIG. 217; and

[0224] FIG. 220 is a cross-sectional view of the cartridge body of FIG. 217 taken along line 220-220 in FIG. 219.

[0225] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate preferred 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

[0226] Applicant of the present application also 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 entitled SURGICAL STAPLES AND STAPLE CARTRIDGES, Attorney Docket No. END7341USNP/130301;
- U.S. Patent Application entitled SURGICAL STAPLES AND STAPLE CARTRIDGES, Attorney Docket No. END7331USNP/130304:
- U.S. Patent Application entitled SURGICAL STAPLES AND METHODS FOR MAKING THE SAME, Attorney Docket No. END7335USNP/130305;
- U.S. Patent Application entitled SURGICAL STAPLES, STAPLE CARTRIDGES AND SURGICAL END EFFECTORS, Attorney Docket No. END7332USNP/130306;
- U.S. Design Patent Application entitled SURGICAL FASTENER, Attorney Docket No. END7338USDP/130307;
- U.S. Patent Application entitled FASTENER CARTRIDGE COMPRISING AN EXTENDABLE FIRING MEMBER, Attorney Docket No. END7344USNP/130308;
- U.S. Patent Application entitled FASTENER CARTRIDGE COMPRISING A FIRING MEMBER CONFIGURED TO DIRECTLY ENGAGE AND EJECT FASTENERS FROM THE FASTENER CARTRIDGE, Attorney Docket No. END7339USNP/130309;
- U.S. Patent Application entitled FASTENER CARTRIDGE COMPRISING A FIRING MEMBER INCLUDING FASTENER SURFACES, Attorney Docket No. END7340USNP/130310;
- U.S. Patent Application entitled SURGICAL INSTRUMENTS WITH ARTICULATABLE SHAFT ARRANGEMENTS, Attorney Docket No. END7343USNP/130300;
- U.S. Patent Application entitled ARTICULATABLE SURGICAL INSTRUMENTS WITH SEPARATE AND DISTINCT CLOSING AND FIRING SYSTEMS, Attorney Docket No. END7333USNP/130322;
- U.S. Patent Application entitled SURGICAL CUTTING AND STAPLING INSTRUMENTS WITH INDEPENDENT JAW CONTROL FEATURES, Attorney Docket No. END7336USNP/130303;

- U.S. Patent Application entitled SURGICAL CUTTING AND STAPLING INSTRUMENTS WITH ARTICULATABLE END EFFECTORS, Attorney Docket No. END7334USNP/130312; and
- U.S. Patent Application entitled MODULAR SURGICAL INSTRUMENTS, Attorney Docket No. END7342USNP/130311.

[0227] Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those of ordinary skill in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the various embodiments of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

[0228] Reference throughout the specification to "various embodiments," "some embodiments," "one embodiment," or "an embodiment", or the like, means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in various embodiments," "in some embodiments," "in one embodiment", or "in an embodiment", or the like, in places throughout the specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. Thus, the particular features, structures, or characteristics illustrated or described in connection with one embodiment may be combined, in whole or in part, with the features structures, or characteristics of one or more other embodiments without limitation. Such modifications and variations are intended to be included within the scope of the present invention.

[0229] The terms "proximal" and "distal" are used herein with reference to a clinician manipulating the handle portion of the surgical instrument. The term "proximal" referring to the portion closest to the clinician and the term "distal" referring 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.

[0230] Various exemplary devices and methods are provided for performing laparoscopic and minimally invasive surgical procedures. However, the person of ordinary skill in the art 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, those of ordinary skill in the art 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 elongated shaft of a surgical instrument can be advanced.

[0231] Turning to the Drawings wherein like numerals denote like components throughout the several views, FIG. 1 depicts a surgical instrument 10010 that is capable of practicing several unique benefits of the present invention. The surgical instrument 10010 is designed to manipulate and/or actuate various forms and sizes of end effectors 10012 that are operably attached to an elongated shaft assembly 10100 of the surgical instrument. In the depicted embodiment, for example, the end effector 10012 comprises a surgical stapling device that has openable and closable jaws 10013 and 10015. More specifically, the end effector 10012 includes an elongated channel 10014 that forms a lower jaw 10013 of the end effector 10012. See FIG. 2. In the illustrated arrangement, the elongated channel 10014 is configured to operably support a staple cartridge 10030 and also movably supports an anvil assembly 10020 that functions as an upper jaw 10015 of the end effector 10012.

[0232] In various implementations, the end effector 10012 is configured to be coupled to an elongated shaft assembly 10100 that protrudes from a handle assembly or housing 10400. See FIG. 1. The end effector 10012 (when closed) and the elongated shaft assembly 10100 may have similar cross-sectional shapes and be sized to operably pass through a trocar tube or working channel in another form of access instrument. As used herein, the term "operably pass" means that the end effector and at least a portion of the elongated shaft assembly 10100 may be inserted through or passed through the channel or tube opening and can be manipulated therein as needed to complete the surgical stapling procedure. In some embodiments, for example, when in a closed position, the jaws 10013 and 10015 of the end effector 10012 may provide the end effector with a roughly circular cross-sectional shape that facilitates its passage through a circular passage/opening. However, the end effectors of various embodiments of the present invention, as well as the elongated shaft assembly embodiments, could conceivably be provided with other cross-sectional shapes that could otherwise pass through access passages and openings that have non-circular cross-sectional shapes. Thus, an overall size of a cross-section of a closed end effector will be related to the size of the passage or opening through which it is intended to pass. Thus, one end effector for example, may be referred to as a "5 mm" end effector which means it can operably pass through an opening that is at least approximately 5 mm in diameter.

[0233] In various implementations, the elongated shaft assembly 10100 may have an outer diameter that is substantially the same as the outer diameter of the end effector 10012 when the end effector 10012 is in a closed position. For example, a 5 mm end effector may be coupled to an elongated shaft assembly 10100 that has 5 mm cross-sectional diameter. However, as the present Detailed Description proceeds, it will become apparent that various embodiments of the present may be effectively used in connection with different sizes of end effectors. For example, a 10 mm end effector may be attached to an elongated shaft that has a 5 mm cross-sectional diameter. Conversely, for those applications wherein a 10 mm or larger

access opening or passage is provided, the elongated shaft assembly 10100 may have a 10 mm (or larger) cross-sectional diameter, but may also be able to actuate a 5 mm or 10 mm end effector. Accordingly, the outer shaft assembly 10100 may have an outer diameter that is the same as or is different from the outer diameter of a closed end effector 10012 attached thereto.

[0234] Referring now to FIGS. 2 and 3, the elongated channel 10014 may comprise an elongated trough 10700 that is configured to removably support a surgical staple cartridge 10030 thereon. In various implementations, for example, the elongated channel 10014 may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and be formed with spaced side walls 10702. As will be discussed in further detail below, the anvil assembly 10020 may include a distal anvil portion 10800 and a proximal anvil mounting tube 10820. The distal anvil portion 10800 may, for the most part, be substantially coextensive with the portion of the elongated channel 10014 that supports the staple cartridge 10030. The distal anvil portion 10800 may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and have a staple forming undersurface, generally labeled as 10022 that has a plurality of staple forming pockets (not shown) formed therein.

[0235] The elongated channel 10014 may be configured to support a variety of different surgical staple cartridges that are designed to be "implanted" within the patient. For example, the implantable surgical staple cartridge 10030 may comprise any of the various surgical staple cartridge arrangements disclosed in U.S. Patent Application Publication No. US 2012/0080484, filed on September 30, 2010, and entitled SURGICAL STAPLING INSTRUMENT WITH A VARIABLE STAPLE FORMING SYSTEM, the entire disclosure of which is hereby incorporated by reference herein. In at least one implementation for example, the staple cartridge 10030 includes a body portion 10031 that consists of a compressible hemostat material such as, for example, oxidized regenerated cellulose ("ORC") or a bio-absorbable foam in which lines of unformed metal staples 10032 are supported. In at least some embodiments, in order to prevent the staple from being affected and the hemostat material from being activated during the introduction and positioning process, the entire cartridge may be coated or wrapped in a biodegradable film such as a polydioxanon film sold under the trademark PDS.RTM. or with a Polyglycerol sebacate (PGS) film or other biodegradable films formed from PGA (Polyglycolic acid, marketed under the trade mark Vicryl), PCL (Polycaprolactone), PLA or PLLA (Polylactic acid), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone 25, sold under the trademark Monocryl) or a composite of PGA, PCL, PLA, PDS that would be impermeable until ruptured. The body 10031 of staple cartridge 10030 is sized to be removably supported within the elongated channel 10014 as shown such that each staple 10032 therein is aligned with corresponding staple forming pockets in the distal anvil portion 10800 when the distal anvil portion 10800 is driven into forming contact with the staple cartridge 10030.

[0236] Referring to FIG. 3, the elongated channel 10014 may further include a boxed mounting end 10710 that includes a pair of spaced side walls 10712 and a top wall 10714. In at least one implementation, the end

effector 10012 is configured to be articulated relative to the elongated shaft assembly 10100 about an articulation and pivot axis A-A about which the anvil assembly 10020 is pivoted relative to the elongated channel 10014. The elongated shaft assembly 10100 defines a longitudinal tool axis LT-LT. The articulation and pivot axis A-A is transverse to the longitudinal tool axis LT-LT. The elongated shaft assembly 10100 comprises a hollow outer shaft 10300 and serves to function as the shaft spine of the elongated shaft assembly 10100. The proximal end of the elongated shaft assembly 10100 may be rotatably supported by the handle assembly 10400 so that the clinician may selectively rotate the elongated shaft assembly 10100 and the end effector 10012 attached thereto about the longitudinal tool axis LT-LT. The distal end 10302 of the outer shaft 10300 is formed with a clevis arrangement 10304 that comprises a pair of spaced attachment tabs 10306. Each attachment tab 10306 has a mounting hole 10308 therein that is adapted to receive a corresponding pivot pin 10310 therethrough.

[0237] In various implementations, the anvil assembly 10020 includes a distal anvil portion 10800 and a proximal anvil mounting tube 10820. As can be seen in FIGS. 2, 3 and 5, the proximal anvil mounting tube 10820 includes a body portion 10821 that has a proximally extending clevis portion 10822 that is formed by two proximally extending anvil attachment tabs 10824. Each anvil attachment tab 10824 has an anvil mounting hole 10826 therethrough that is configured to be pivotally journaled on the pivot pins 10310. In various implementations, the distal anvil portion 10800 is configured to be coupled to the proximal anvil mounting tube 10820 such that the distal anvil portion 10800 may "float" relative to the proximal anvil mounting tube 10820. Referring to FIG. 5, the body 10821 of the proximal anvil mounting tube 10820 may be formed with a series of opposed, vertically-extending opened ended grooves 10830. Grooves 10830 are sized to slidably receive therein corresponding vertically extending attachment lugs 10812 formed on a proximal end 10810 of the distal anvil portion 10800. See FIG. 4. Each attachment lug 10812 has a stop lug 10814 formed thereon that is sized to be movably received in a stop groove 10832 formed in each groove 10830 as shown in FIG. 5. Each stop groove 10832 has a closed end 10834. The proximal end 10810 of the distal anvil portion 10800 is movably coupled to the proximal anvil mounting tube 10820 by aligning the attachment lugs 10812 with the open bottom ends of the corresponding grooves 10830 and then inserting the proximal end upward into the proximal anvil mounting tube 10820. This assembly may be completed before the anvil assembly 10020 is pivotally journaled on the pivot pins 10310. Once assembled and pivotally coupled to the elongated channel 10014, the distal anvil portion 10800 will be unable to slidably disengage the proximal anvil mounting tube 10820 due to contact with elongated channel 10014. The stop lugs 10812 will likewise contact the closed ends 10834 of the corresponding stop groove 10832 to prevent the proximal end 10810 of the distal anvil portion 10800 from becoming disconnected from the proximal anvil mounting tube 10820. See FIG. 7. As can be seen in FIG. 7, the distal anvil portion 10820 may move upward (arrow "U") and downward (arrow "D") relative to the proximal anvil mounting tube 10820. Such range of vertical

travel of the distal anvil portion 10800 relative to the proximal anvil mounting portion 10820 may be referred to herein as "floating" vertical travel or movement.

[0238] Referring now to FIG. 8, initial closure of the anvil assembly 10020 relative to the elongated channel assembly 10014 and the surgical staple cartridge 10030 operably supported therein may be accomplished by a unique and novel closure system, generally designated as 10110. The closure system 10110 may also be referred to herein as the "second jaw closure system". In one implementation, the closure system 10110 includes an anvil closure rod 10112 that has a proximal end 10114 that has a flanged end 10116 that is configured to be rotatably attached to a closure carriage 10420 of the closure system that is operably supported within the housing assembly 10400. See FIG. 8. The anvil closure rod 10112 may also be referred to herein as the "second jaw actuator bar 10112." The closure carriage and firing system may be similar in construction and operation to the closure carriage and closure system disclosed in U.S. Patent Application Publication No. 2012/0074200, entitled SURGICAL INSTRUMENT WITH SELECTIVELY ARTICULATABLE END EFFECTOR, which was filed on September 23, 2011, the entire disclosure of which is hereby incorporated by reference herein.

[0239] Referring again to FIG. 8, the closure carriage 10420 may comprise two carriage segments 10422 (only one is illustrated) that are interconnected together by adhesive, snap features, screws, etc. As used herein, the term "snap feature" includes, but is not limited to, for example, a tab that has a protrusion thereon that is configured to retainingly engage a corresponding mating portion of another component. Such features may be designed to releasably engage the mating portion or it may not be designed or intended to be removed. In at least one form, the closure carriage 10420 has a distal end 10424 that has a groove arrangement 10426 that is adapted to receive the flanged end 10116 of the anvil closure rod 10112. Such arrangement serves to attach the proximal end 10114 of the anvil closure rod 10112 to the closure carriage 10420 while facilitating its selective rotation of the anvil closure rod 10112 relative to the closure carriage 10420. Therefore, the elongated shaft assembly 10100 and the end effector 10012 that is operably coupled thereto may be selectively rotated about the longitudinal tool axis LT-LT relative to the housing assembly 10400.

[0240] Still referring to FIG. 8, in various implementations, the housing assembly 10400 comprises a pistol-shaped handle housing that may be fabricated in two or more pieces for assembly purposes. For example, the housing assembly 10400 as shown comprises a right hand case member 10402 and a left hand case member 10404 (FIG. 1) that are molded or otherwise fabricated from a polymer or plastic material and are designed to mate together. Such case members 10402 and 10404 may be attached together by snap features, pegs and sockets molded or otherwise formed therein and/or by adhesive, screws, etc. When assembled, the housing assembly 10400 movably supports the closure carriage 10420 for selective axial travel therein in response to actuation motions from a trigger, generally designated as 10430. As the present Detailed Description proceeds, however, it will be understood that the various unique and novel aspects and

attributes of the various implementations of the present invention may be effectively attained when employed with robotically controlled or otherwise remotely controlled systems. Thus, the term "housing" or "housing assembly" may also encompass a housing or similar portion of a robotic or automated control 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 various forms of surgical end effectors attached thereto. For example, various implementations of the surgical instruments described herein may be used in connection with those robotic systems and arrangements disclosed in U.S. Patent Application Serial No. 13/536,323, entitled ROBOTICALLY POWERED SURGICAL DEVICE WITH MANUALLY ACTUATABLE REVERSING SYSTEM, and filed June 28, 2012, the entire disclosure of which is hereby incorporated by reference herein.

[0241] The trigger assembly 10430 may, for example, comprise a primary trigger 10440 and a secondary trigger 10460. The primary and secondary triggers 10440 and 10460 are pivotally journaled on a pivot pin assembly 10430 formed in the housing assembly 10400 such that the triggers 10440 and 10460 may essentially move relative to each other. Such arrangement permits the trigger assembly 10430 to pivot relative to the housing assembly 10400 about a pivot axis PA-PA. See FIG. 8. The primary trigger 10440 has an elongated, grippable primary trigger paddle 10442 that protrudes from a primary drive portion 10444 that has a firing rack 10446 formed thereon. In one embodiment, the secondary trigger 10460 has a secondary trigger paddle 10462 that protrudes from a secondary drive portion 10464 that is pivotally journaled on the pivot pin assembly 10430. The primary drive portion 10444 has a slot 10448 that is adapted to receive the secondary drive portion 10464 of the secondary trigger 10460 therein as the primary trigger paddle 10442 is pivoted towards a pistol grip portion 10406 of the housing assembly 10400. Such arrangement essentially enables the secondary trigger 10460 to "nest" within the primary trigger 10440 during actuation. As will be discussed in detail below, the secondary trigger 10460 is pivotally actuated by pivoting the primary trigger 10440. Thus, in other embodiments, the secondary trigger 10460 may lack the secondary trigger paddle 10442. In various forms, the trigger assembly 10430 may be biased into the unactuated position by a trigger spring (not shown).

[0242] As can be seen in FIG. 8, the secondary drive portion 10464 of the secondary trigger 10460 may have a closure gear segment 10466 formed thereon that is configured for meshing engagement with a carriage gear rack 10423 formed on the underside of the closure carriage 10420. Thus, when the secondary trigger 10460 is pivoted toward the pistol grip 10406, the closure carriage 10420 is driven in the distal direction "DD" which thereby drives the anvil closure rod 10112 in the distal direction.

[0243] Referring again to FIG. 3, a distal end 10118 of the anvil closure rod 10112 is configured to be pinned to an anvil closure link 10120. The anvil closure link 10120 is pivotally pinned to an anvil pin slide 10122. An anvil cam pin 10124 is mounted to the anvil pin slide 10122 an is configured to be received within anvil pin slots 10720 provided in each of the lateral side walls 10712 of the boxed mounting end

10710 of the elongated channel 10014 as well as anvil cam slots 10840 in the proximal anvil mounting tube 10820. Movement of the anvil closure rod 10112 in the distal direction "DD" will cause the anvil assembly 10020 to move from an open position towards the elongated channel 10014 (referred to herein as the "closing direction "CD") and movement of the anvil closure rod 10112 in the proximal direction "PD" will cause the anvil assembly 10020 to move from a closed position to an open position (referred to herein as the opening direction "OD"). Such opening and closing of the anvil assembly 10020 is accomplished by the camming action or movement of the anvil pin 10124 in the anvil camming slots 10840 in the proximal anvil mounting tube 10820. Thus, actuation of the closure system 10110, also known as the "second jaw closure system" will result in movement of the anvil assembly 10020, also known as the "second jaw 10015" relative to the elongated channel 10014, also known as the "first jaw 10013". Such movement may, for example, comprise pivotal travel of the second jaw (anvil assembly 10020) relative to the first jaw (elongated channel 10014) about a common pivot axis A-A that is established at their points of attachment to the distal end of the elongated shaft assembly 10100.

[0244] In various arrangements, the end effector 10012 may be configured to be selectively articulated relative to the longitudinal tool axis LT-LT. Stated another way, however, the first jaw 10013 which comprises the elongated channel 10014 may be selectively movable relative to the second jaw 10015 which comprises the anvil assembly 10020. As described above, the elongated channel 10014 is pivotally coupled to the distal end 10302 of the outer tube 10300 by pivot pins 10310. Such attachment arrangement permits the elongated channel 10014 to articulate or move in a first direction "FD" about the pivot axis A-A which is essentially the same direction that the anvil assembly 10020 moves in when the anvil assembly 10020 is moved from a closed position to an open position (the anvil opening direction "OD"). See FIG. 9. Such arrangement further facilitates movement or articulation in a second articulation direction "SD" that is essentially the same as the direction that the anvil assembly 10020 moves from an open position to a closed position (the anvil closing direction "CD"). To facilitate such movement of the elongated channel 10014, a reciprocatable articulation rod 10150 is employed. The articulation rod 10150 may also be referred to herein as the "first jaw actuator bar 10150". More specifically and with reference to FIG. 3, the articulation rod 10150 is sized to be movably received with the outer tube 10300 and has a distal end 10152 that is pivotally pinned to an articulation link 10160. The articulation link 10160 is pivotally pinned to a proximal attachment lug 10722 on the proximal boxed mounting end 10710 of the elongated channel 10014. As can be seen in FIG. 10, a proximal end 10154 of the articulation rod 10150 has an articulation rack 10156 formed thereon that drivingly interfaces with an articulation control system 10200. The articulation control system 10200 may also be referred to herein as the "first jaw closure system 10200".

[0245] The component parts of one form of articulation control system 10200 are illustrated in FIGS. 10 and 11. In one form, the articulation control system 10200 may include an actuator 10210, an articulation body 10220 and a nozzle 10250. Rotational movement of the actuator 10210 causes corresponding rotation

of the articulation body 10220 within the nozzle 10250. Rotation of the actuator 10210 thereby results in the axial travel of the articulation rod 10150 within the outer shaft 10300 to cause the remote articulation of the end effector 10012.

[0246] Still referring to FIG. 10, the articulation body 10220 has a deck 10222 consisting of first and second spaced-apart, semicircular deck halves, 10224, 10226. The deck halves are mutually opposed to each other and essentially represent mirror images of each other. The first and second deck halves 10224, 10226 have protruding from their surfaces mutually opposed first and second detents 10225, 10227, respectively. Each deck half 10224, 10226 has a set of deck teeth 10228 spaced about 180 degrees from the set of deck teeth on the other deck half. The articulation body 10220 has a pair of rotation stops 10230 protruding from its surface as well as a pair of finger recesses 10232. A drive gear 10240 protrudes laterally from the articulation body 10220. The drive gear 10240 has a flared opening 10242 through it, and a lateral pivot 10244. Within the flared opening 10242 of the drive gear 10240, there is a firing rod orifice (not shown) for receiving a firing rod 10530 therethrough enabling the application of a firing motion to the end effector 10012. The drive gear 10240 is configured to intermesh with the articulation rack 10156 to effect the desired reciprocating movement of the articulation rod 10150.

[0247] The nozzle 10250 of the articulation control system 10200 may include a nozzle body 10252. The nozzle body 10252 may have an axial bore 10254 therethrough that facilitates the passage of the articulation rod 10150 and other operative components of the instrument 10010 including a the proximal end 10306 of the outer shaft 10300. See FIG. 11. The nozzle body 10252 may also have a frame groove 10256 and flange 10258 to rotatably fasten the nozzle body 10252 to the housing 10400. In various forms, a detent housing 10260 comprises a portion of the nozzle body 10252. See FIG. 1. An annular array of detent teeth (not shown) is formed within the detent housing 10260. A detent housing floor is spaced from the detent teeth. The floor may have a pair of ledges which interact within the rotation stops 10230 of the articulation body 10220 to limit the degree of rotation. When the articulation body 10220 is inserted into the detent housing 10260, the base of the articulation body 10220 is supported on the floor within the detent housing 10260, and the deck teeth 10228 of the first and second deck halves, 10224, 10226 are aligned for meshing engagement with the detent teeth of the detent housing 10260. A spring member 10268 is supported within the articulation body to bias the deck teeth 10228 into meshing engagement with the detent teeth.

[0248] Referring again to FIG. 10, the actuator 10210 may consist of a lever arm 10212, a cap 10214 and a pair of retaining fingers 10216. The lever arm 10212 is mounted on the top of the cap 10214. The pair of retaining fingers 10216 protrudes laterally from the underside of the cap 10214. Each of the retaining fingers 10216 has a retaining clip. The retaining fingers 10216 are received within the finger recesses 10232 of the articulation body 10220. First and second detents, 10225, 10227, on the deck halves of the articulation body are inserted into a slot depression within the underside of the circular cap 10214. Advantageously, each of the three significant components of the articulation control system, namely the actuator, articulation body

and nozzle, may be injection molded components. Such components, for example, may be fabricated from a glass fiber-reinforced amorphous polyamide, sold commercially under the trade name Grivory GV-4H by EMS--American Grilon 150.

[0249] Ratcheting rotation of the actuator 10210 causes articulation of the elongated channel 10014 in the first or second directions relative to the longitudinal tool axis LT-LT. FIGS. 1, 2, 9 and 12 illustrate the elongated channel 10014 in an unarticulated position. When the drive gear 10240 on the articulation body 10220 of the articulation transmission 10200 is rotated to thereby push the articulation rod 10150 in the distal direction "DD", the elongated channel 10014 will articulate in the first articulation direction "FD" relative to the longitudinal tool axis LT-LT as shown in FIG. 13. When the drive gear 10240 on the articulation body 10220 of the articulation transmission 10200 has been rotated to thereby pull the articulation rod 10112 in the proximal direction "PD", the elongated channel 10014 will pivot in a second direction "SD" relative to the longitudinal tool axis LT-LT. The second direction "SD" is the same as the closure direction "CD". See FIG. 9.

[0250] The surgical instrument 10010 may include a firing system generally designated as 10410 that is supported within the housing assembly 10400 and is operable to actuate various components of the instrument 10010. Referring to FIG. 8, the firing system 10410 may, for example, include an actuation bar 10470. The actuation bar 10470 has a first actuation rack 10472 formed thereon that is configured for meshing engagement with the firing rack 10446 on the primary trigger 10440. Thus, when the firing rack 10446 is in meshing engagement with the first actuation rack 10472, the actuation bar 10470 is driven in the distal direction "DD" when the primary trigger 10440 is pivoted toward the pistol grip 10406. The actuation bar 10470 has a second actuation rack 10474 formed thereon configured to meshingly engage clutch teeth 10484 on a clutch shaft 10482 of a clutch assembly 10480. In various embodiments, the clutch shaft 10482 is rotatably is supported within the housing assembly 10400 and is also laterally movable therein. The clutch shaft 10482 has a hub portion 10486 that has a plurality of spaced teeth 10488 that are configured to drivingly engage teeth openings 10492 in a drive gear 10490 that is rotatably supported on the clutch shaft 10482. The drive gear 10490 has a segment of drive gears 10494 thereon that are adapted for meshing engagement with a firing rack 10500 that is movably supported in the housing assembly 10400.

[0251] Various embodiments of the clutch assembly 10480 may further comprise a clutch plate 10510 that is slidably journaled on a clutch pin 10449 provided on the primary drive portion 10444 of the primary trigger 10440. The clutch pin 10449 may be movably received within a vertical slot 10512 in the clutch plate 10510. The clutch plate 10510 also has a distally-extending clutch arm 10514 that is adapted to actuatably engage a bevel plate 10489 formed on the clutch shaft 10482. In addition, a clutch spring 10520 is employed to bias the clutch shaft 10480 laterally such that the teeth 10488 on the clutch shaft 10482 are brought into meshing engagement with the teeth openings 10492 in the drive gear 10490.

[0252] As can be seen in FIG. 8, the firing rack 10500 is coupled to a firing rod 10530 that is attached to the proximal end of a knife bar assembly 10600. In various embodiments, the knife bar assembly 10600 may comprise a three-ply flexible knife bar 10602 that is flexible enough to accommodate articulation of the end effector 10012, while remaining sufficiently rigid to be driven distally through the elongated shaft assembly 10100. An axial passage 10157 may be provided in the articulation bar 10150 for axially receiving the knife bar 10602 therein. See FIG. 10. In the depicted embodiment, the knife bar 10602 is attached to an I beam cutting head 10610. As can be seen in FIG. 3, for example, the I-beam cutting head 10610 includes a vertically oriented body portion 10612 that has a bottom foot 10614 and an upper tab 10616 formed thereon. A tissue cutting edge 10620 is formed on the vertically oriented body portion 10612.

[0253] Still referring to FIG. 3, the vertically oriented body portion 10612 extends through a longitudinally extending slot 10704 in the elongated channel 10014 and a longitudinally extending slot 806 in the distal anvil portion 10800. The distal anvil portion 10800 further has a trough 10809 formed in the upper surface for slidably receiving the upper tab 10616 therein. The distal end 10618 of the upper tab 10616 is sloped to interface with sloped surfaces 10811 formed on the portions 10805 of the distal anvil portion 10800 forming the slot 806. See FIG. 14. The flexible firing bar 10602 extends through the elongated shaft assembly 10100 to be coupled to a distal end portion 10532 of a firing rod 10530 are supported in a contiguous orientation relative to each other as shown in FIG. 10. The proximal end of the firing bar 10602 may be attached to the distal end portion 10532 of the firing rod 10530 by a coupler member 10650. As will be discussed in further detail below, the firing rod 10530 facilitates the application of firing and retraction motions to the knife bar assembly 10600 by the firing system 10410.

[0254] Referring again to FIG. 8, the firing rod 10530 extends through a closure bushing 10540 that is mounted within the housing assembly 10400. In at least one form, a pair of mounting studs 10407 protrude from the handle case members 10402, 10404 and extend through corresponding slots in the closure carriage 10420 to be received in a retaining slot in the bushing 10540. A closure spring 10550 that is attached to a retainer clip 10552 is journaled on the closure bushing 10540. The closure spring 10550 extends between the nozzle body 10252 and an internal wall 10425 in the closure carriage 10420. Thus, the closure spring 10550 serves to bias the closure carriage 10420 in the proximal direction "PD".

[0255] Various embodiments may also include a releasable closure locking assembly 10560 that interfaces with the closure carriage 10420 to selectively retain the closure carriage 10420 in its distal-most closed or clamped position. In at least one form, the closure locking assembly 10560 includes a locking button 10562 that is pivotally supported in the housing assembly 10400. The locking button 10562 has a latch arm 10564 that is configured to abut a locking ledge 10421 formed on the closure carriage 10420 when the button 10562 is in the locked position. In addition, the latch arm 10564 has a catch 10566 formed thereon that is configured to releasably latch with a locking latch 10502 on the proximal end of the firing rack 10500. A locking spring 10568 serves to bias the locking button 10562 into the locked position.

[0256] Operation of the surgical instrument 10010 will now be described. FIG. 9 illustrates the jaws 10013 and 10015 of the end effector 10012 in an open position. When the end effector 10012 is in the open position, the latch arm 10564 is located on top of the locking ledge 10421 formed on the closure carriage 10420 such that the catch 10566 of the latch arm 10564 is in retaining engagement with the locking latch 10502 on the firing rack 10500. See FIG. 8. Thus, when in this initial starting position, the knife bar assembly 10600 cannot be inadvertently actuated. The clutch plates 10510, as well as the closure carriage, are each in their proximal-most unactuated positions. When in those positions, the clutch drive bevel 10489 on the clutch shaft 10482 is in contact with a portion of the closure carriage 10420, which prevents the clutch shaft 10482 from laterally moving into meshing engagement with the drive gear 10490 under the bias of the clutch spring 10520.

[0257] To initiate the closure process, a first stroke is applied to the trigger assembly 10430. That is, the trigger assembly 10430 is initially pivoted toward the pistol grip 10406. Such pivoting action serves to drive the closure carriage 10420 in the distal direction "DD" by virtue of the meshing engagement between the closure gear segment 10466 on the secondary trigger 10460 and the carriage rack 10423 formed on the underside of the closure carriage 10420. Such distal movement of the closure carriage 10420 also axially advances the anvil closure rod 10112 in the distal direction "DD". As the anvil closure rod 10112 moves distally, the closure link 10120 moves the anvil pin slide 10122 distally. As the anvil pin slide 10122 moves distally, anvil pin 10124 moves up cam slots 10840 in the proximal anvil portion 10820 to cam the anvil assembly 10020 towards the elongated channel 10014 and the staple cartridge 10030 supported therein. If the surgeon desires to simply grasp and manipulate tissue prior to clamping it between the anvil assembly 10020 and the surgical staple cartridge 10030, the trigger assembly 10430 may be pivoted to open and close the anvil assembly 10020 without fully pivoting the trigger assembly 10430 to the fully closed position.

[0258] Those of ordinary skill in the art will understand that, as the trigger assembly 10430 is pivoted toward the pistol grip 10406, the actuation bar 10470 will necessarily also be driven distally by virtue of the meshing engagement between the primary gear segment 10446 on the primary trigger 10440 and the first actuation rack 10472 on the actuation bar 10470. The distal movement of the actuation bar 10470 will also result in the an application of a rotary actuation motion to the clutch shaft 10482 by virtue of the meshing engagement between the clutch teeth 10484 on the clutch shaft 10482 and the second actuation rack 10474 on the actuation bar 10470. However, such rotary motion is not applied to the drive gear 10490 because the clutch arm 10514 of the clutch plate 10510, in contact with the clutch drive bevel 10489 on the clutch shaft 10482, prevents the axial movement of the clutch shaft 10482 into meshing engagement with the drive gear 10490. Thus, the clutch shaft 10482 freely rotates relative to the drive gear 10490. Accordingly, the clutch assembly 10480 automatically prevents the activation of the firing rack 10500 during the initial actuation of the trigger assembly 10430.

[0259] Once the trigger assembly 10430 has been initially fully compressed into the closed position, the anvil assembly 10020 will be locked in the closed position by the closure locking assembly 10560 which prevents the proximal movement of the closure carriage 10420. To drive the knife bar assembly 10600 distally through the tissue clamped in the end effector 10012, the surgeon again pivots the primary trigger 10440 toward the pistol grip 10406 of the housing assembly 10400. As the primary trigger 10440 is pivoted, the firing rack 10500, the firing rod 10530, and the knife bar assembly 10600 are driven in the distal direction "DD". As the knife bar assembly 10600 is driven in the distal direction, the cutting head 10610 also moves distally. As the cutting head 10610 moves distally, the sloped surface 10618 on the upper tab 10616 travels up the sloped surfaces 10811 on the distal anvil portion 10800 moving the floating distal anvil portion 10800 in the down direction "D" towards the staple cartridge 10030. As the distal anvil portion 10800 is driven downwardly towards the clamped tissue and the staple cartridge 10030, the clamping or crushing action causes the staples to be formed against the underside of the distal anvil portion 10800. Thus, as the cutting head 10610 is driven distally through the end effector 10012, the tissue cutting surface 10620 thereon severs the clamped tissue while forming the staples in the staple cartridge 10030 on both sides of the cut tissue. Such two part anvil assembly enables the distal anvil portion to essentially remain parallel to the elongated channel and top of the surgical staple cartridge during firing. Stated even more succinctly, the two part floating anvil arrangement enables the staple-forming undersurfaces to remain parallel with the top of the surgical staple cartridge and the elongated channel during firing.

[0260] After the cutting head 10610 has been driven through the tissue clamped in the end effector 10012, the surgeon then releases the primary trigger 10440 to thereby permit the primary trigger 10440 to pivot to its unactuated position under the bias of the firing spring 10432. As the primary trigger 10440 pivots back to the starting position, the firing rack 10500, firing rod 10530, and knife bar assembly 10600 are drawn proximally back to their respective starting positions. The end effector 10012 remains in its clamped position as shown in FIG. 13.

[0261] To unlock the closure carriage 10420 and the secondary trigger 10460, the surgeon depresses the locking button 10562. As the locking button 10562 is depressed, the locking arm 10564 is pivoted out of abutting engagement with the locking ledge 10426 on the closure carriage 10420. Further details regarding the operation of the firing and closure systems may be found in U.S. Patent Application Publication No. US 2012/0074200 which has been herein incorporated by reference in its entirety. As the closure carriage 10420 moves proximally, the anvil closure rod 10112 is also drawn proximally. As the anvil closure rod 10112 moves proximally, the anvil pin slide 10122 and anvil pin 10124 move proximally camming the anvil assembly 10020 to the open position.

[0262] The surgical instrument 10010 provides a host of advantages over prior surgical instruments. For example, the unique and novel floating anvil arrangement is able to automatically adjust the anvil gap between the undersurface of the anvil and the staple cartridge or elongated channel. Thus, the floating anvil

arrangement can automatically compensate for different thickness of tissue while enabling the staple forming undersurface(s) of the anvil to remain parallel to the staple cartridge and elongated channel. This is all accomplished without sacrificing anvil stability.

[0263] Another distinct advantage that the surgical instrument 10010 enjoys over prior surgical instruments with an articulatable end effector is the nature in which the present end effector is articulatable relative to the elongated shaft assembly. As described in detail above, the elongated channel portion of the end effector is pivotally mounted to the elongated shaft assembly for selective pivotal travel relative thereto about a pivot axis. The pivot axis is transverse to the longitudinal tool axis defined by the elongated shaft assembly. The anvil assembly is also pivotally coupled to the elongated channel for selective pivotal travel relative thereto about the same pivot axis. This provides another distinct advantage over prior articulatable end effector arrangements for at least the following reason.

[0264] During typical surgical procedures, the surgeon is viewing the surgical site and the end effector through a camera that can provide somewhat limited viewing. For example, such camera arrangements commonly only afford the surgeon with a view of a portion of the surgical end effector. When using an endocutter for example, the camera may only afford the surgeon a view of a portion of the endocutter's anvil and/or channel. In prior articulatable endocutter arrangements, the endocutter was coupled to the end of the elongated shaft by a flexible joint or other arrangement that did not always afford a consistent reference axis about which the end effector would pivot relative to the elongated shaft. So it was difficult for the surgeon when viewing a portion of the end effector to have a reliable frame of reference to know where the pivot axis resided. By having the articulation axis also be the axis about which the anvil pivots, the surgeon has a much more reliable frame of reference regarding the location of the pivot axis when viewing the endocutter's anvil through the camera. Stated another way, when using the end effector arrangement of the surgical instrument 10010 the surgeon can determine where the elongated channel is going to pivot relative to the elongated shaft by viewing where the anvil is pivotally mounted to the elongated channel.

[0265] The surgical instrument 10010 also employs separate control systems for moving the end effector jaws 10013 and 10015 relative to each other. For example, the clinician may elect to move or articulate the lower jaw 10013 (elongated channel 10014) about the pivot axis A-A toward or way from the upper jaw 10015 (anvil assembly 10020) without actuating the upper jaw 10015 (anvil assembly 10020). This may be accomplished by actuating the articulation control system (or first jaw closure system) without actuating the second jaw closure system 10110. Thus, the elongated channel 10014 may be selectively pivoted about the pivot axis A-A while the anvil assembly 10020 remains in an open or closed position. Similarly, the anvil assembly 10020 may be actuated or moved without moving the elongated channel 10014 by actuating the closure system 10110 without actuating the articulation control system. Such unique and novel arrangement provides the clinician with more flexibility when positioning the end effector jaws within the patient.

[0266] FIGS. 15-19 illustrate another surgical instrument 1010 that is capable of practicing several unique benefits of the present invention. The surgical instrument 1010 is designed to manipulate and/or actuate various forms and sizes of end effectors 1012 that are operably attached to an elongated shaft assembly 1100 of the surgical instrument. In the depicted embodiment, for example, the end effector 1012 comprises a surgical stapling device that has openable and closable jaws 1013 and 1015. More specifically, the end effector 1012 includes a jaw channel 1014 that forms a lower jaw 1013 of the end effector 1012. See FIG. 16. In the illustrated arrangement, the jaw channel 1014 is configured to operably support a staple cartridge 10030 and also movably supports an anvil assembly 1020 that functions as an upper jaw 1015 of the end effector 1012.

[0267] Referring now to FIGS. 15 and 17, the anvil assembly 1020 comprises a two-part arrangement including an anvil body portion 1021 and an anvil cap member 1023. The anvil body portion 1021 may include a mounting portion 1022 that has mounting trunnions 1024 protruding therefrom. The mounting trunnions 1024 are configured to be received in vertically elongated mounting slots 1018 in the upstanding side walls 1017 of a proximal mounting portion 1016 of the jaw channel 1014. Such arrangement permits the anvil assembly to somewhat float up and down relative to the elongated channel. Stated another way, the anvil body portion 1021 may move relative to the elongated channel or the top of a staple cartridge supported in the elongated channel such that the staple forming undersurfaces of the anvil body portion 1021 are parallel to the top of the staple cartridge and the elongated channel. As will be discussed in further detail below, the anvil assembly 1020 is moved between open and closed positions by manipulating the position of a tissue cutting head 1190.

[0268] In various arrangements, the end effector 1012 may be configured to be selectively articulated about a longitudinal tool axis LT-LT that is defined by the elongated shaft assembly 1100. As can be seen in FIGS. 15-18, for example, the elongated shaft assembly 1100 may include a flexible neck assembly 1110 to facilitate such articulation. Various flexible neck assemblies are know and may be employed. For example, flexible neck assemblies are disclosed in U.S. Provisional Patent Application Serial No. 61/386,117, entitled ARTICULATING SURGICAL DEVICE, and filed September 24, 2010, the entire disclosure of which is herein incorporated by reference. Other flexible neck assemblies which may be employed are disclosed in U.S. Patent No. 5,704,534, entitled ARTICULATION ASSEMBLY FOR SURGICAL INSTRUMENTS, and issued on January 6, 1998; U.S. Patent Application Publication No. US 2012/0074200, entitled SURGICAL INSTRUMENT WITH SELECTIVELY ARTICULATABLE END EFFECTOR, and filed on September 23, 2011; and U.S. Patent Application Publication No. US 2009/0090764, entitled SURGICAL STAPLER HAVING AN ARTICULATION MECHANISM, and filed October 3, 2008, the entire disclosures of each being hereby incorporated by reference herein in their respective entireties. As will be discussed in further detail below, however, the flexible neck assembly 1110 is configured to facilitate

articulation of the end effector 1012 in directions that are the same directions in which the jaws of the end effector travel between open and closed positions.

[0269] In at least one implementation, the flex neck assembly 1110 may, for example, be fabricated in two pieces 1110R and 1110L that are configured to be coupled together by, fasteners such as snap features, screws, bolts, adhesive, etc. The flexible neck pieces 1110R and 1110L may be composed of rigid thermoplastic polyurethane sold commercially as ISOPLAST grade 2510 by the Dow Chemical Company. The right flexible neck portion 1110R includes a right upper rib segment 1112R and a right lower rib segment 1112L that are separated by an elongated right lateral spine (not shown). Similarly, the left flexible neck portion 1110L includes a left upper rib segment 1112L and a left lower rib segment 1114L that are separated by a left elongated lateral spine 1116. See FIG. 17. When assembled together, the right upper rib segments 1112R and the left upper rib segments 1112L form upper ribs 1112 and the right lower rib segments 1114R and the left lower rib segments 1114L form lower ribs 1114 that are spaced from each other and which together form a cylindrical configuration as shown in FIG. 15. Such arrangement enables the end effector 1012 to articulate in a first direction "FD" that is essentially the same direction that the anvil assembly 1020 moves in when the anvil assembly 1020 is moved from a closed position to an open position (hereinafter referred to as the anvil opening direction "OD"). See FIG. 18. The flexible neck assembly 1110 will further facilitate articulation of the end effector 1012 in a second articulation direction "SD" that is essentially the same as the direction that the anvil moves from an open position to a closed position (hereinafter referred to the anvil closing direction "CD"). In various embodiments, the right flexible neck portion 1110R further has a right tubular portion 1113R and the left flexible neck portion 1110L has a left tubular portion 1113L. When joined together, the right and left tubular portions 1113R, 1113L serve to receive therein two distally protruding attachment arms 1019 that protrude proximally from the jaw channel 1014. See FIGS. 16 and 17. The attachment arms 1019 have attachment tabs thereon that engage the tubular portions 1113R, 1113L to affix the jaw channel 1014 to the elongated shaft assembly 1100. Other methods of attaching the jaw channel 1014 to the elongated shaft assembly 1100 may also be employed. In at least one embodiment, the elongated shaft assembly 1100 includes a substantially rigid proximal outer shaft segment 1300 that has a distal end 1302. The distal end 1302 has a pair of opposed lateral slots 1303 therein for receiving the corresponding proximally protruding ends of the lateral spine portions 1116L (the right spine portion is not shown). See FIG. 15 and 17. The outer shaft segment 1300 may be pressed onto the flexible neck assembly 1110 or otherwise attached thereto by fasteners, pins, screws, etc.

[0270] The proximal end of the outer shaft segment 1300 may be attached to a handle assembly of the type disclosed in U.S. Patent Application Publication No. 2012/0074200, entitled SURGICAL INSTRUMENT WITH SELECTIVELY ARTICULATABLE END EFFECTOR, which has been herein incorporated by reference in its entirety. Further details regarding at least one method of attaching the outer shaft segment to the handle assembly and operation of the outer shaft segment and related components may be gleaned from

reference to that publication. Such arrangement permits the surgeon to rotate the outer shaft segment 1300 and the end effector 1012 operably coupled thereto about the longitudinal tool axis LT-LT by rotating the nozzle member relative to the handle assembly as discussed in detail therein.

[0271] Referring to FIGS. 16 and 18, an upper slot 1120 extends through each of the upper ribs 1112 to form a passage through the flexible neck assembly 1110 for receiving a first flexible articulation band assembly 1150 therethrough. Similarly, a lower slot 1121 extends through each of the lower ribs 1114 in the flexible neck assembly 1110 to form a passage for receiving a second flexible articulation band assembly 1170 therethrough. Referring to FIG. 17, in at least one embodiment, the first flexible articulation band assembly 1150 comprises a flexible first distal segment 1152 that is fabricated from, for example, spring steel, 420 stainless steel, titanium, 400 or 300 grade stainless steel and has a first hook 1154 formed in its distal end. The first hook 1154 is configured to hookingly engage a first or upper hook-receiving feature 1155U formed in the proximal end of the jaw channel 1014. The first articulation band assembly 1150 further includes a first structural band portion 1156 that is attached to (e.g., pinned) to the first distal segment 1152. The first structural band portion 1156 may be fabricated from, for example, spring steel, 420 stainless steel, titanium. Likewise, the second articulation band assembly 1170 comprises a flexible second distal segment 1172 that is fabricated from, for example, spring steel, 420 stainless steel, and titanium and has a second or lower hook 1174 formed in its distal end. See FIG. 17. The second hook 1174 is configured to hookingly engage a second or lower hook-receiving feature 1155L formed in the jaw channel 1014. See FIG. 18. The second articulation band assembly 1170 further includes a second structural band portion 1176 that is attached to (e.g., pinned) to the second distal segment 1172. The second structural band portion 1176 may be fabricated from, for example, 400 or 300 grade stainless steel. The upper and lower articulation band assemblies 1150, 1170 may interface with and be controlled by an articulation transmission and control system 2000 of the type described in U.S. Patent Publication No. 2012/0074200 which has been incorporated by reference herein in its entirety.

[0272] Referring to FIG.19, various embodiments of the articulation system 2000 include a novel articulation transmission 2030 that is supported within the handle assembly 1900 for applying articulation motions to the first and second articulation band assemblies 1150, 1170. In various forms, the articulation transmission 2030 includes an actuator wheel 2040 that is rotatably supported on the handle assembly 1900 for selective rotation about an actuation axis. In at least one embodiment, the actuation axis coincides with or is substantially coaxial with the longitudinal tool axis LT-LT. Thus the actuation axis does not transversely intersect the longitudinal axis. In other embodiments, the actuation axis may be substantially parallel to the longitudinal axis. To facilitate ease of assembly and manufacturing, the actuator wheel 2040 is fabricated in two pieces 2040A that may be attached together by screws, snap features, adhesive etc. When assembled, the actuator wheel 2040 has a first set of actuator threads 2042 which are configured in a first direction for threaded engagement with a first thread nut assembly 2060. In addition, the actuator wheel

2040 also has a second set of actuator threads 2044 which are configured in a second direction that differs from the first direction. For example, the first threads 2042 may comprise "right hand" threads and the second threads 2044 may comprise "left hand" threads or visa versa. The second threads 2044 are adapted to threadably engage a second threaded nut assembly 2070.

[0273] In various embodiments, the first threaded nut assembly 2060 comprises a first disc 2062 that has first threads 2064 formed thereon. The first disc 2062 is supported on a knife tube 1800 by a first bearing bushing 2066. The first bearing bushing 2066 facilitates movement of the first disc 2062 relative to the knife tube 1800. Similarly, the second threaded nut assembly 2070 comprises a second disc 2072 that has second threads 2074 formed thereon. The second disc 2072 is supported on the knife tube 1800 by a second bearing bushing 2076 that facilitates movement of the second disc 2072 relative to the knife tube 1800. The first and second discs 2062, 2072 are also movably supported on upper and lower nut rails 2050, 2052 that are mounted to standoff posts 1905 molded into the handle cases 1904. See FIG. 19. The upper and lower nut rails 2050, 2052 serve to prevent the first and second discs 2062, 2072 from rotating relative to the handle housing and therefore, as the actuator wheel 2040 is rotated relative to the handle housing, the first and second bearing bushings 2066, 2076 move axially on the knife tube 1800 in different directions.

[0274] The first and second articulation band assemblies 1150, 1170 are controlled by rotating the actuator wheel 2040 relative to the handle assembly 1900. To facilitate the application of such control motions, the first structural band portion 1156 has a first catch member configured to retainingly engage the first bearing bushing 2066 and the second structural band portion 1176 has a second catch member configured to retainingly engage the second bearing bushing 2076. In addition, the articulation system 2000 in at least one form includes an elongated support beam 2080 that extends longitudinally within the knife tube 1800 to provide lateral support to the first and second structural band portions 1156, 1176 within the knife tube 1800. The support beam 2080 may be fabricated from, for example, 400 or 300 grade stainless steel and is configured to facilitate axial movement of the first and second structural band portions 1156, 1176 while providing lateral support thereto.

[0275] FIGS. 15 and 16 illustrate the surgical instrument 1010 in an unarticulated position. That is, when in an unarticulated position, the end effector 1012 is substantially axially aligned on the longitudinal tool axis LT-LT. When in that "neutral" position, the first and second discs 2062, 2072 are spaced away from each other. To provide the surgeon with an indication when the articulation system 2000 has been parked in the neutral position, a detent assembly 2090 is mounted within the handle housing. The detent assembly 2090 into the housing and is adapted to engage a recess (not shown) in the hub portion 2041 of the actuator wheel 2040. See FIG. 19. The detent assembly 2090 is configured to engage the recess when the actuator wheel 2040 is in the neutral position. When the detent 2090 engages the recess, the surgeon may receive a tactile and/or audible indication.

[0276] The articulation system 2000 may articulate the end effector 1012 about the flexible neck assembly 1110 in the following manner. First, the surgeon rotates the articulation actuator wheel 2040 in a first rotary direction which causes the first and second discs 2062, 2072 to move toward each other. As the first disc 2062 moves in the proximal direction "PD", the first articulation band assembly 1150 is pulled in the proximal direction "PD" by virtue of the first catch feature 2017 which is coupled to the first bearing bushing 2066. Likewise, as the second disc 2072 moves in the distal direction "DD", the second articulation band assembly 1170 is pushed in the distal direction "DD" by virtue of the second catch feature 2027 which is coupled to the second bearing bushing 2076. Such action of the first and second articulation band assemblies 1150, 1170 causes the end effector 10612 to articulate in the first articulation direction "FD" by virtue of the first and second articulation bands 1150, 1170 interconnection with the end effector 1012. To articulate the end effector in the second articulation direction "SD", the user simply rotates the articulation actuator wheel 2040 in a second rotary direction that is opposite to the first rotary direction.

[0277] As indicated above, the articulation system 2000 in at least one form also includes an elongated support beam 2080 that extends longitudinally within the knife tube 1800 to provide lateral support to the first and second structural band portions 1150 and 1170 within the knife tube 1800. The support beam 2080 may be fabricated from, for example, 400 or 300 grade stainless steel and is configured to facilitate axial movement of the first and second structural band portions 1156, 1176 while providing lateral support thereto. In addition, the right and left segments 1110R, 1110L of the flexible neck assembly 1110, when joined together, form a passage 1118 for receiving a knife bar assembly 1180. In various forms, the knife bar assembly 1180 includes a distal knife bar portion 1182 that includes an upper knife bar 1184 and a lower knife bar 1186 that are attached to a tissue cutting head 1190. The upper knife bar 1184 is attached to a top portion 1192 of the tissue cutting head 1190 and the lower knife bar 1186 is attached to a lower portion 1194 of the tissue cutting head 1190. The upper knife bar 1184 and the lower knife bar 1186 are configured to flex as the flexible neck assembly 1110 flexes.

[0278] As will be discussed in further detail below, in at least one embodiment, the axial advancement and withdrawal of the knife bar assembly 1180 may be controlled by, for example, the manual activation of a firing trigger that is operably supported on the handle assembly 1900. As can be seen in FIG. 19, a connector member 1790 is coupled to a proximal end 1183 of the distal knife bar portion 1182. In at least one embodiment, for example, the connector member 1790 is pinned to the proximal end 1787 of the distal knife bar portion 1182 and has a proximally protruding attachment feature 1792 that is configured to be coupled to a distal end 1802 of the hollow knife tube 1800. The hollow knife tube 1800 extends through the outer shaft segment 1300 and into the handle assembly 1900 and is attached to a carriage assembly 1810. In various embodiments, for example, the carriage assembly 1810 comprises a flanged carriage bushing 1812 that is press fit onto a portion of the knife tube 1800. The carriage assembly 1810 further comprises a firing carriage 1814 that has a saddle formed therein configured to extend over the carriage bushing 1812 between

the bushing flanges 1813. In at least one form, the firing carriage 1814 also has a pair of laterally extending portions 1816 that each have a support tab 1818 formed thereon. The support tabs 1818 are configured to be slidably received in a corresponding slide passage (not shown) formed in the handle housing 1904. Such arrangement permits the firing carriage 1814 to move axially within the handle assembly 1900 and thereby apply axial actuation motions to the knife tube 1800 while permitting the knife tube 1800 to rotate about the longitudinal tool axis LT-LT relative to the firing carriage 1814 as the nozzle assembly 1770 is rotated.

[0279] In at least one embodiment, actuation motions may be manually applied to the firing carriage 1814 by a firing trigger assembly 1820 that is pivotally supported on the handle assembly 1900. The firing trigger assembly 1820 includes a firing trigger 1822 that has an attachment plate 1824 that is configured to operably interface with a pair of actuation plates 1826. As can be seen in FIG. 19, the attachment plate 1824 is located between the actuation plates 1826 and is pivotally pinned thereto by a first pivot pin 1828 that extends through slots 1830 in the actuation plates 1826 and a hole 1825 in the attachment plate 1824. A second pivot pin 1832 is received within or is supported by mounting lugs in the handle cases 1904 and extends between holes 1834 in the actuation plates 1826. Each of the actuation plates 1826 have a lug 1836 that extends into a corresponding pocket or opening 1815 in the firing carriage 10814. Such arrangement facilitates the application of axial actuation motions to the knife tube 1800 by pivoting the firing trigger 1822 relative to the handle housing 1900. As the firing trigger 10822 is pivoted towards the pistol grip portion 1908 of the handle housing 1900, the firing carriage 1814 is driven in the distal direction "DD". As the firing trigger 1822 is pivoted away from the pistol grip portion 1908 of the handle housing 1900, the firing carriage 1814 draws the knife tube 1800 in the proximal direction "PD".

[0280] Various embodiments of the surgical instrument 1010 may further include a locking system 1840 that includes a locking trigger 1842 that is pivotally coupled to the handle housing 1900. The locking trigger 1842 includes a locking bar portion that is configured to operably engage a locking member 1846 that is pivotally attached to the attachment plate 1824 of the firing trigger 1822 by pin 1849. Further discussion regarding the operation of the locking system 1840 may be found in U.S. Patent Application Publication No. US 2012/0074200 A1.

[0281] Actuation of the end effector 1012 will now be explained. While grasping the pistol grip portion 1908 of the handle assembly 1900, the surgeon may apply a closing motion to the anvil assembly 1020 of the end effector 1012 by applying an actuation force to the firing trigger 1822. Such action results in the application of an actuation motion to the firing carriage 1814 by the actuation plates 1826 which ultimately results in the axial displacement of the knife tube 1800 in the distal direction "DD". As the knife tube 1800 is advanced in the distal direction "DD", the knife bar assembly 1180 is likewise driven in the distal direction "DD". As the knife bar assembly 1180 and, more particularly the tissue cutting head 1190, is driven in the distal direction "DD", the upper tab portions 1196 on the tissue cutting head 1190 contact sloped surfaces 1025 on the anvil body 1021 to start to apply a closing motion to the anvil assembly 1020. Further

application of the actuation force to the firing trigger 1822 results in further axial displacement of the knife tube 1800 and the tissue cutting head 1090. Such action further moves the anvil assembly 1020 towards the elongated jaw channel 1014. As the firing trigger 1822 is pivoted towards the pistol grip portion 1908 of the handle assembly 1900, the locking member 1848 also pivots in the counterclockwise "CCW" direction about the pin 1849. At this point, the tissue cutting head 1190 is prevented from moving any further in the distal direction "DD" by virtue of the locking system 1840. Thus, the surgeon may move the anvil assembly 1020 to capture and manipulate tissue in the end effector 1012 without risk of actually "firing" the end effector 1012 (i.e., or cutting the tissue and forming the staples).

[0282] Once the surgeon desires to cut tissue and form staples, a second actuation force is applied to the locking trigger 1842. When the locking trigger 842 is depressed, the locking bar portion 1844 pivots to a forward position which thereby permits the locking member 1848 to continue to pivot in the counterclockwise direction as the surgeon continues to apply the actuation force to the trigger 1822. Such actuation of the firing trigger 1822 results in the axial displacement of the tissue cutting head 1190 through the anvil assembly 1020 and the elongated jaw channel 1014. At this point, the upper tab portions 1196 and the lower foot 1198 on the tissue cutting head 1190 serves to space the anvil assembly 1020 relative to the elongated jaw channel 1014 such that the staples 10032 in the staple cartridge 10030 are formed into the tissue on each side of the tissue cut line.

[0283] After completing the cutting and stapling process, the firing trigger 1822 may be released. A return spring (not shown) attached to the firing trigger 1822 returns the firing trigger 1822 to the unactuated position. Alternative, the user can use the hook feature of the trigger to "pull" open the trigger if no spring is used. As the firing trigger 1822 moves in the clockwise "CW" direction, the firing carriage 1814 is moved in the proximal direction "PD" which also moves the knife bar assembly 1180 in the proximal direction "PD". As the tissue cutting head 1190 returns to its starting position, the upper tabs 1196 on the tissue cutting head 1190 contact an arcuate opening surface 1027 on the underside of the anvil cap 1023 as shown in FIG. 18. Continued movement of the tissue cutting head 1190 in the proximal direction "PD" causes the anvil assembly 1020 to pivot open by virtue of its contact with the arcuate surface 1027.

[0284] The surgical instrument 1010 also provides advantages over prior surgical instruments. For example, the unique and novel floating anvil arrangement is able to automatically adjust the anvil gap between the undersurface of the anvil and the staple cartridge or elongated channel. Thus, the floating anvil arrangement can automatically compensate for different thickness of tissue while enabling the staple forming undersurface(s) of the anvil to remain parallel to the staple cartridge and elongated channel. This is all accomplished without sacrificing anvil stability.

[0285] FIGS. 20-26 depict another surgical instrument 3010 that is capable of practicing several unique benefits of the present invention. The surgical instrument 3010 is designed to manipulate and/or actuate various forms and sizes of end effectors 3012 that are operably attached to an elongated shaft assembly 3100

of the surgical instrument. In the depicted embodiment, for example, the end effector 3012 comprises a surgical stapling device that has openable and closable jaws 3013 and 3015. More specifically, the end effector 3012 includes an elongated channel 3014 that forms a lower jaw 3013 of the end effector 3012. See FIGS. 21 and 10022. In the illustrated arrangement, the elongated channel 3014 is configured to operably support a staple cartridge 10030 of the type and construction described herein. For example, the surgical staple cartridge includes a cartridge body 10031 that operably supports a plurality of unformed surgical staples 10032 therein. The elongated channel 3014 also movably supports an anvil assembly 3020 that functions as an upper jaw 3015 of the end effector 3012.

[0286] In various implementations, the end effector 3012 is configured to be coupled to an elongated shaft assembly 3100 that protrudes from a handle assembly or housing 3400. See FIG. 20. The handle assembly 3400 may be similar to one of the handle assemblies disclosed herein and/or in U.S. Patent Application Publication No. US 2012/0074200 A1 except for the differences discussed herein.

[0287] Referring to FIG. 23, the elongated channel 3014 may comprise an elongated trough 3016 that is configured to removably support a surgical staple cartridge 10030 thereon. In various implementations, for example, the elongated channel 3014 may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and be formed with spaced side walls 3018. The body 10031 of staple cartridge 10030 is sized to be removably supported within the elongated channel 3014 as shown such that each staple 10032 therein is aligned with corresponding staple forming pockets in the anvil assembly 3020 when the anvil assembly 3020 is driven into forming contact with the staple cartridge 10030. The elongated channel 3014 may further include a proximal end 3200 that includes a pair of spaced side walls 3202. In at least one implementation, the end effector 3012 is configured to be articulated relative to the elongated shaft assembly 3100 about an articulation and pivot axis A-A about which the anvil assembly 3020 is pivoted relative to the elongated channel 3014. The elongated shaft assembly 3100 defines a longitudinal tool axis LT-LT. The articulation and pivot axis A-A is transverse to the longitudinal tool axis LT-LT. The elongated shaft assembly 3100 comprises a hollow outer shaft 3300 and serves to function as the shaft spine of the elongated shaft assembly 3100. The proximal end of the outer shaft 3300 may be rotatably supported by the handle assembly 3400 so that the clinician may selectively rotate the elongated shaft assembly 3100 and the end effector 3012 attached thereto about the longitudinal tool axis LT-LT. For example, the proximal end of the elongated shaft assembly may be operably coupled to a nozzle assembly 3250 that is rotatably supported on the handle assembly 3400. Rotation of nozzle assembly 3250 relative to the handle assembly 3400 (represented by arrow "R") will result in rotation of the elongated shaft assembly 3100 as well as the end effector 3012 coupled thereto. See FIG. 20.

[0288] Referring again to FIG. 23, the distal end 3302 of the outer shaft 3300 is formed with a clevis arrangement 3304 that comprises a pair of spaced attachment tabs 3306. Each attachment tab 3306 has a mounting hole 3308 therein that is adapted to receive a corresponding pivot pin 3204 that is formed on each

upstanding side wall 3202. Thus, the elongated channel 3014 is selectively pivotable or articulatable about the pivot axis A-A relative to the elongated shaft assembly 3100. The anvil assembly 3020 includes a distal anvil portion 3022 and a proximal anvil mounting portion 3030. The distal anvil portion 3022 may, for the most part, be substantially coextensive with the portion of the elongated channel 3014 that supports the staple cartridge 10030 and be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. The distal anvil portion 3022 comprises two spaced apart anvil arms 3024 that protrude distally from the anvil mounting portion 3030 to define an elongated slot 3026 therebetween. Each of the spaced-apart anvil arms 3024 has a staple forming undersurface, generally labeled as 3028 that has a plurality of staple forming pockets (not shown) formed therein.

[0289] The anvil mounting portion 3030 has a pair of mounting holes 3032 (only one is shown in FIG. 23) that are adapted to pivotally receive therein the corresponding pivot pins 3204 that protrude from the side walls 3202 of the proximal end 3200 of the elongated channel 3014. Such arrangement serves to pivotally mount the anvil assembly 3020 to the elongated channel 3014 for selective pivotal travel about pivot axis A-A between an open position (FIGS. 24 and 25) and a closed position (FIGS. 21, 22 and 26).

[0290] Articulation of the end effector 3012 about the pivot axis A-A as well as actuation of the anvil assembly 3020 between open and closed positions may be controlled by a single firing system generally designated as 3500. In at least one implementation, for example, the firing system 3500 includes an actuation pivot 3510 that is movably supported between the upstanding side walls 3202 of the elongated channel 3014. The actuation pivot 3510 includes a distal cam surface 3512 and a proximal cam surface 3514. The distal cam surface 3512 is configured to operably interface with an inwardly protruding distal anvil pin 3034 that protrudes from the anvil mounting portion 3030. The proximal cam surface 3514 is configured to operably interface with an inwardly protruding proximal anvil pin 3036 that also protrudes inwardly from the anvil mounting portion 3030. As can be seen in FIG. 23, the distal anvil pin 3034 extends inwardly through the corresponding elongated distal slots 3206 in the upstanding side walls 3202 of the proximal end 3200 of the elongated channel 3014. Likewise, the proximal anvil pin 3036 extends inwardly through corresponding elongated slots 3208 in the upstanding side walls 3202 of the proximal end 3200 of the elongated channel 3014.

[0291] The firing system 3500 may be controlled, for example, by a closure trigger arrangement on a handle assembly 3400 of the type disclosed in U.S. Patent Application Publication No. US 2012/0074200 A1. For example, the firing system 3500 may include an actuation bar 3520 that is movably coupled to the actuation pivot 3510. The actuation bar 3520 may have, for example, an attachment ball member 3522 formed on the distal end thereof that is rotatably received within a semi-circular groove 3516 in the actuation pivot 3510. Such arrangement permits the actuation pivot 3510 to pivot or otherwise move relative to the actuation bar 3520. Other methods of movably coupling the actuation bar 3520 to the actuation pivot 3510 may also be employed. The actuation bar 3520 may extend through the hollow outer shaft 3300 and be

operably coupled to, for example, the closure carriage arrangement disclosed in the aforementioned published patent application such that actuation of the trigger 10440 will result in the axial travel of the actuation bar 3520 within the outer shaft 3330. In various implementations, a series of support collars 3530, 3532, 3534 may be provided in the outer shaft 3300 to provide support to the actuation bar 3520 within the outer shaft 3300.

[0292] In use, the end effector 3012 is articulated into a desired position prior to closing the anvil assembly 3020. Of course, if the end effector 3012 must be inserted through a trocar or other opening in the patient, the clinician can move the anvil assembly 3020 to the closed position (FIG. 21) without articulating the end effector 3012 so that the end effector 3012 is coaxially aligned with the elongated shaft assembly 3100. The clinician manipulates the trigger 10440 to position the actuation pivot 3510 so that the cam surfaces 3512 and 3514 interact with the pins 3034, 3036 to result in the closure of the anvil assembly 3020 without articulating the end effector 3012. Once the end effector 3012 has been inserted through the trocar or other opening, the clinician may actuate the trigger 10440 to move the actuation pivot 3510 to the position shown in FIG. 24. When in that position, the actuation pivot 3510 causes the anvil assembly 3520 to move to the open position without being articulated. The clinician may then articulate the end effector 3012 about the pivot axis A-A relative to the elongated shaft assembly 3100 by further actuating the trigger 10440 to move the actuation pivot 3510 to the position shown, for example, in FIG. 25. As can be seen in that Figure, the end effector 3012 has pivoted in a first direction "FD" which is the same general direction that the anvil assembly 3020 moves when it moves from a closed position to the open position (referred to herein as the "opening direction 'OD'"). If desired, the user may actuate the trigger 10440 to thereby cause the end effector 3012 to move in a second direction "SD" that is the same general direction that the anvil assembly 3020 moves when it is moved from the open position to a closed position (referred to herein as the "closing direction "CD'"). Once the user has positioned the end effector 3012 in the desired position, the user further actuates trigger 10440 to manipulate the actuation pivot to the position illustrated in FIG. 26 to thereby clamp the target tissue "T" between the anvil assembly 3020 and the staple cartridge 10030.

[0293] The surgical instrument 3010 further includes a knife bar assembly 3600 that can be attached to the firing bar and firing rack arrangement disclosed herein and/or in U.S. Patent Application Publication No. US 2012/0074200 A1 such that it can be controlled by actuating the secondary trigger 10460. In various embodiments, the knife bar assembly 3600 may comprise an upper bar segment 3602 and a lower bar segment 3604. Such arrangement may enable the knife bar assembly 3600 to flex as the end effector 3012 is articulated, while remaining sufficiently rigid to be driven distally through the shaft assembly 3100. In the depicted embodiment, the upper and lower knife bar segments 3602, 3604 are each attached to a cutting head 3610. In the depicted configuration, the cutting head 3610 includes a vertically oriented body portion 3612 that has an upper portion 3615 and a lower portion 3617. A bottom foot 3614 is formed on or attached to the lower portion 3617. Similarly, an upper tab 3616 is formed on or otherwise attached to the upper portion

3615 of the vertically oriented body portion 3612. In addition, as can be seen in FIG. 23, the vertically oriented body portion 10612 further includes a tissue cutting edge 3620.

[0294] Referring to FIG. 23, the vertically oriented body portion 3612 extends through a longitudinally extending slot 3210 in the elongated channel 3014 and the longitudinally extending slot 3026 in the anvil assembly 3020. When assembled, the upper portion 3615 of the cutting head 3610 extends through a proximal upper opening 3031 in the anvil mounting portion 3030 of the anvil assembly 3020. Thus, when the cutting head 3610 is distally advanced, the upper tab portions 3616 ride on the anvil arms 3024. Likewise the bottom foot 3614 protrudes through a lower opening 3212 in the elongated channel 3014 such that it rides below the elongated channel as the cutting head 3610 is advanced distally. As the cutting head 3610 is advanced distally, the cutting edge 3620 thereon severs the tissue clamped in the end effector 3012. The surgical staple cartridge 10030 is crushed between the anvil assembly 3020 and the elongated channel 3014 thereby causing the staples 10032 supported therein to be formed on both sides of the tissue cut line as they are brought into contact with the staple forming underside of the anvil assembly 3020. After the cutting head 3610 has been advanced to the distal end of the end effector, 3012, the user retracts the cutting head 3610 to the starting position in the manner discussed herein and the trigger 10440 is actuated to open the anvil assembly 3020 to release the staple cartridge and stapled tissue.

[0295] As was discussed in detail above, by having the articulation axis also be the axis about which the anvil pivots, the surgeon has a much more reliable frame of reference regarding the location of the pivot axis when viewing the endocutter's anvil through the camera. Stated another way, when using the end effector arrangement of the surgical instrument 10010 the surgeon can determine where the elongated channel is going to pivot relative to the elongated shaft by viewing where the anvil is pivotally mounted to the elongated channel.

[0296] FIGS. 27-35 illustrate another surgical instrument arrangement 4010 that may employ various components of other surgical instruments disclosed herein except for the differences discussed below. The surgical instrument 4010 is designed to manipulate and/or actuate various forms and sizes of end effectors 4012 that are operably attached to an elongated shaft assembly 4100 of the surgical instrument. In the depicted embodiment, for example, the end effector 4012 comprises a surgical stapling device that has openable and closable jaws 4013 and 4015. More specifically, the end effector 4012 includes an elongated channel 4014 that forms a lower jaw 4013 of the end effector 4012. See FIG. 28. In the illustrated arrangement, the elongated channel 4014 is configured to operably support a staple cartridge 10030 and also movably supports an anvil assembly 4020 that functions as an upper jaw 4015 of the end effector 4012.

[0297] In various implementations, the end effector 4012 is configured to be coupled to an elongated shaft assembly 4100 that protrudes from a handle assembly or housing 4400. See FIG. 27. The handle assembly 4400 may be similar to one of the handle assemblies disclosed herein and/or in U.S. Patent Application Publication No. US 2012/0074200 A1 except for any differences discussed below. Alternative

embodiments, however, may be employed with and actuated by robotic systems as was discussed hereinabove.

[0298] Referring to FIGS. 28 and 29, the elongated channel 4014 may comprise an elongated trough 4016 that is configured to removably support a surgical staple cartridge 10030 thereon. In various implementations, for example, the elongated channel 3014 may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and be formed with spaced side walls 4018. The body 10031 of staple cartridge 10030 is sized to be removably supported within the elongated channel 3014 as shown such that each staple 10032 therein is aligned with corresponding staple forming pockets in the anvil assembly 4020 when the anvil assembly 4020 is driven into forming contact with the staple cartridge 10030. The elongated channel 4014 may further include a somewhat box-like proximal end 4200 that includes a pair of spaced side walls 4202 that have a top flap 4203 protruding inwardly therefrom to define a slot 4205 therebetween. The sidewalls 4202 are coupled together by a support bar 4207 that extends therebetween. See FIGS. 29, 31 and 32.

[0299] In at least one implementation, the elongated channel 4014 is configured to be moved or articulated relative to the elongated shaft assembly 4100 and the anvil assembly 4020 about a pivot axis A-A about which the anvil assembly 4020 is also pivotally mounted. The elongated shaft assembly 4100 defines a longitudinal tool axis LT-LT. The pivot axis A-A is transverse to the longitudinal tool axis LT-LT. The elongated shaft assembly 4100 comprises a hollow outer shaft 4300 and serves to function as the shaft spine of the elongated shaft assembly 4100. The proximal end of the outer shaft 4300 may be rotatably supported by the handle assembly 4400 so that the clinician may selectively rotate the elongated shaft assembly 4100 and the end effector 4012 attached thereto about the longitudinal tool axis LT-LT.

[0300] Referring again to FIG. 29, the distal end 4302 of the outer shaft 4300 is formed with a clevis arrangement 4304 that comprises a pair of spaced attachment tabs 4306. Each attachment tab 4306 has a mounting hole 4308 therein that is adapted to receive a corresponding pivot pin 4310 that defines the pivot axis A-A. The pivot pins 4310 also extend through corresponding openings 4210 in the upstanding side walls 4202 of the proximal mounting end 4200 of the elongated channel 4014. Thus, the elongated channel 4014 is selectively pivotable or articulatable about the pivot axis A-A relative to the elongated shaft assembly 4100 and the anvil assembly 4020. The anvil assembly 4020 includes a distal anvil portion 4022 and an proximal anvil mounting portion 4030. The distal anvil portion 4022 may, for the most part, be substantially coextensive with the portion of the elongated channel 3014 that supports the staple cartridge 10030 and be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. The distal anvil portion 4022 comprises two spaced apart anvil arms 4024 that protrude distally from the anvil mounting portion 4030 to define an elongated slot 4026 therebetween. Each of the spaced-apart anvil arms 4024 has a staple-forming undersurface, generally labeled as 4028 that has a plurality of staple forming pockets (not shown) formed therein. The anvil mounting portion 4030 has a pair of mounting holes 4032

that are adapted to pivotally receive therein the corresponding pivot pins 4310. Such arrangement serves to pivotally mount the anvil assembly 4020 to the outer shaft 4300 for selective pivotal travel about pivot axis A-A between an open position (FIGS. 32 and 33) and a closed position (FIGS. 28, 30 and 31) relative to the elongated channel assembly 4014.

[0301] Initial closure of the anvil assembly 4020 relative to the elongated channel assembly 4014 and the surgical staple cartridge 10030 operably supported therein may be accomplished by a unique and novel closure system, generally designated as 4110. The closure system 4110 may also be referred to herein as the "second jaw closure system". In one implementation, the closure system 4110 includes an anvil closure rod 4112 that has a proximal end that may be operably coupled to the closure carriage in the handle assembly 4400 in the various manners discussed herein and also disclosed in further detail in U.S. Patent Application Publication No. US 2012/0074200 A1. For example, the proximal end of the closure rod 4112 may have a flange (not shown) that is configured to be rotatably attached to a closure carriage that is operably supported within the housing assembly 4400. Thus, actuation of the trigger 10440 will result in the axial advancement of the anvil closure rod 4112 within the outer shaft 4300.

Such arrangement also enables the elongated shaft assembly 4100 and the end effector 4012 that is operably coupled thereto may be selectively rotated about the longitudinal tool axis LT-LT relative to the housing assembly 4400. The anvil closure rod 4112 may also be referred to herein as the "second jaw actuator bar."

[0302] Referring again to FIG. 29, a distal end 4118 of the anvil closure rod 4112 is configured to be pinned to an anvil closure link 4120. The anvil closure link 4120 is pivotally pinned to an anvil pin slide 4122 by a pin 4123. The anvil pin slide 4122 includes two spaced side walls 4124 that define a space 4125 therebetween that is configured to receive a portion of a tissue cutting head 4610 as will be discussed in further detail below. An anvil cam pin 4034 is mounted to the anvil mounting portion 4030 and extends through elongated slots 4208 in the upstanding side walls 4202 of the proximal end 4200 of the elongated channel 4014 as well as through cam slots 4126 provided through the side walls 4124 of the anvil pin slide 4122. FIG. 32 illustrates the positions of the anvil slide 4122 and the anvil cam pin 4034 when the anvil assembly 4020 is in the open position. To move the anvil assembly 4020 to a closed position relative to the elongated channel assembly 4014(FIG. 31), the clinician can actuate the trigger 10440 which drives the anvil closure rod 4112 in the distal direction "DD". Such movement of the anvil closure rod 4112 in the distal direction also moves the anvil pin slide 4122 in the distal direction "DD". As the anvil pin slide 4122 moves in the distal direction, the camming action of the anvil pin 4034 in the slots 4126 and 4208 cams the anvil assembly 4020 in the closing direction "CD" to the closed position as shown in FIG. 31. Movement of the anvil closure rod 4112 in the proximal direction "PD" will cause the anvil assembly 4020 to move in the opening direction "OD".

[0303] In various arrangements, the end effector 4012 may be configured to be selectively articulated relative to the longitudinal tool axis LT-LT. Stated another way, the elongated channel assembly 4014 may

be selectively articulatable or movable relative to the anvil assembly 4020. As described above, the elongated channel 4014 is pivotally coupled to the distal end 4302 of the outer tube 4300 by pivot pins 4310. Such attachment arrangement permits the end elongated channel assembly 4014 to articulate in a first direction "FD" about the articulation and pivot axis A-A which is essentially the same direction that the anvil assembly 4020 moves in when the anvil assembly 4020 is moved from a closed position to an open position (the anvil opening direction "OD"). Such arrangement further facilitates articulation or movement in a second articulation direction "SD" that is essentially the same as the direction that the anvil assembly 4020 moves from an open position to a closed position (the anvil closing direction "CD"). To facilitate such movement of the elongated channel assembly 4014 relative to the anvil assembly 4020, a reciprocatable articulation rod 4150 is employed. The articulation rod 4150 may also be referred to herein as the "first jaw actuator bar". More specifically and with reference to FIG. 29, the articulation rod 4150 is sized to be movably received with the outer tube 4300 and has a distal end 4152 that is pivotally pinned to a pair of articulation links 4160. The articulation links 4160 are pivotally pinned to the proximal portion of the elongated channel 4014 by an articulation pin 4161. As can be seen in FIG. 34, a proximal end 4154 of the articulation rod 4150 has an articulation rack 4156 formed thereon that drivingly interfaces with an articulation control system 10200 of the type described hereinabove. As indicated above, the articulation control system 10200 may also be referred to herein as the "first jaw closure system". Ratcheting rotation of the actuator 10210 of the articulation transmission 10200 causes articulation of the elongated channel assembly 4014 in the first or second directions relative to the anvil assembly 4020. FIGS. 28, 30, 31 and 31 illustrate the elongated channel assembly 4014 in an unarticulated position. When the drive gear 10240 on the articulation body 10220 of the articulation transmission 10200 is rotated to thereby push the articulation rod 4150 in the distal direction "DD", the elongated channel assembly 4014 will move in the first articulation direction "FD" relative to the anvil assembly 4020 as shown in FIG. 33. When the drive gear 10240 on the articulation body 10220 of the articulation transmission 10200 has been rotated to thereby pull the articulation rod 10112 in the proximal direction "PD", the elongated channel assembly 4014 will pivot in a second direction "SD" relative to the anvil assembly 4020. The second direction "SD" is the same as the closure direction "CD". See FIG. 33.

[0304] The surgical instrument 4010 as illustrated in FIG. 27 may further include an firing system of the type described herein and/or in U.S. Patent Application Publication No. US 2012/0074200 A1 that may be controlled by actuating trigger 10460. Referring to FIG. 34, a firing rack 10500 is coupled to a firing rod 10530 that is attached to the proximal end of a knife bar assembly 4600. In various forms, the knife bar assembly 4600 includes a distal knife bar portion 4602 that includes an upper knife bar 4604 and a lower knife bar 4606 that are attached to an I-beam cutting head 4610. The upper knife bar 4604 and the lower knife bar 4606 are configured to flex as the end effector 4012 is articulated. As can be seen in FIG. 29, for example, the I-beam cutting head 4610 includes a vertically oriented body portion 4612 that has a bottom

foot 4614 and an upper tab 4616 formed thereon. A tissue cutting edge 4620 is formed on the vertically oriented body portion 4612.

[0305] Still referring to FIG. 29, the vertically oriented body portion 4612 extends through a longitudinally extending slot 4704 in the elongated channel 4014 and the longitudinally extending slot 4026 in the distal anvil portion 4024. The distal anvil portion 4024 further has a trough 4025 formed in the upper surface for slidably receiving the upper tab 4616 therein. The distal end of the upper tab 6616 may be sloped to interface with sloped surfaces 4027 formed on the anvil arms 4024 of the distal anvil portion 4022. The flexible firing bars 4604, 4606 extend through the elongated shaft assembly 4100 to be coupled to a distal end portion 10532 of a firing rod 10530 by a coupler member 10650. As was discussed above, actuation of the trigger 10460 will result in the axial advancement of the firing rod 10530 within the elongated shaft assembly 4100 to apply firing and retraction motions to the knife bar assembly 4600.

[0306] Operation of the surgical instrument 4010 will now be described. To initiate the closure process, a first stroke is applied to the trigger assembly 10430. That is, the trigger assembly 10430 is initially pivoted toward the pistol grip 10406. Such pivoting action serves to drive the closure carriage in the distal direction "DD". Such distal movement of the closure carriage also axially advances the anvil closure rod 4112 in the distal direction "DD". As the anvil closure rod 4112 moves distally, the closure link 4120 moves the anvil pin slide 4122 distally. As the anvil pin slide 4122 moves distally, the anvil assembly 4020 is pivoted to the closed position by virtue of the camming interaction of the anvil pin 4034 within the slots 4208, 4126. See FIG. 31. In the various manners discussed herein, if the surgeon desires to simply grasp and manipulate tissue prior to clamping it between the anvil assembly 4020 and the surgical staple cartridge 10030, the trigger assembly 10430 may be pivoted to open and close the anvil assembly 4020 without fully pivoting the trigger assembly 10430 to the fully closed position. Once the trigger assembly 10430 has been initially fully compressed into the closed position, the anvil assembly 4020 will be retained in the locked or clamped position by the closure locking assembly which prevents the proximal movement of the closure carriage as was discussed above. To drive the knife bar assembly 4600 distally through the tissue clamped in the end effector 4012, the surgeon again pivots the primary trigger 10440 toward the pistol grip 10406 of the housing assembly 10400. As the primary trigger 10440 is pivoted, the firing rack 10500, the firing rod 10530, and the knife bar assembly 4600 are driven in the distal direction "DD". As the knife bar assembly 4600 is driven in the distal direction, the cutting head 4610 also moves distally. As the cutting head 4610 moves distally, the sloped surface on the upper tab 4616 travels up the sloped surfaces 4027 on the distal anvil portion 4022 moving the floating distal anvil portion 4022 in the down direction "D". As the distal anvil portion 4022 is driven downwardly towards the clamped tissue and the staple cartridge 10030, the clamping or crushing action causes the staples to be formed against the underside of the distal anvil portion 4022. Thus, as the cutting head 4610 is driven distally through the end effector 4012, the tissue cutting surface 4620 thereon severs the clamped tissue while forming the staples in the staple cartridge which are situation

on both sides of the cut tissue. After the knife bar assembly 4600 has been driven through the tissue clamped in the end effector 4012, the surgeon then releases the primary trigger 10440 to thereby permit the primary trigger 10440 to pivot to its unactuated position under the bias of the firing spring. As the primary trigger 10440 pivots back to the starting position, the firing rack 10500, firing rod 10530, and knife bar assembly 4600 are drawn proximally back to their respective starting positions. The end effector 4012 remains in its clamped position as shown in FIG. 31. The anvil assembly 4020 may then be unlocked and moved to the open position in the manner discussed above.

[0307] As was discussed in detail above, by having the articulation axis also be the axis about which the anvil pivots, the surgeon has a much more reliable frame of reference regarding the location of the pivot axis when viewing the endocutter's anvil through the camera. Stated another way, when using the end effector arrangement of the surgical instrument 10010 the surgeon can determine where the elongated channel is going to pivot relative to the elongated shaft by viewing where the anvil is pivotally mounted to the elongated channel.

[0308] The surgical instrument 4010 also employs separate control systems for moving the end effector jaws 4013 and 4015. For example, the clinician may elect to move or articulate the lower jaw 4013 (elongated channel 10014) about the pivot axis A-A toward or way from the upper jaw 4015 without actuating the upper jaw 4015 (anvil assembly 4020). This may be accomplished by actuating the articulation control system 10200 without actuating the closure system 4110. Thus, the elongated channel 4014 may be selectively pivoted about the pivot axis A-A while the anvil assembly 4020 is open or closed. Similarly, the anvil assembly 4020 may be actuated or moved without moving the elongated channel 4014 by actuating the closure system 4110 without actuating the articulation control system 10200. Such unique and novel arrangement provides the clinician with more flexibility when positioning the end effector jaws within the patient.

[0309] FIGS. 36-42 depict another surgical instrument 5010 that is capable of practicing several unique benefits of the present invention. The surgical instrument 5010 is designed to manipulate and/or actuate various forms and sizes of end effectors 5012 that are operably attached to an elongated shaft assembly 5100 of the surgical instrument. In the depicted embodiment, for example, the end effector 5012 comprises a surgical stapling device that has openable and closable jaws 5013 and 5015. More specifically, the end effector 5012 includes an elongated channel 5014 that forms a lower jaw 5013 of the end effector 5012. See FIG. 37. In the illustrated arrangement, the elongated channel 5014 is configured to operably support a staple cartridge 10030 of the type and construction described herein. For example, the surgical staple cartridge includes a cartridge body 10031 that operably supports a plurality of unformed surgical staples 10032 therein. The elongated channel 5014 also movably supports an anvil 3020 that functions as an upper jaw 5015 of the end effector 5012.

[0310] In various implementations, the end effector 5012 is configured to be coupled to an elongated shaft assembly 5100 that protrudes from a handle assembly or housing 5400. See FIG. 36. The handle assembly 5400 may be similar to one of the handle assemblies disclosed herein and/or in U.S. Patent Application Publication No. US 2012/0074200 A1 except for the differences discussed below.

[0311] Referring to FIG. 38, the elongated channel 5014 may comprise an elongated trough 5016 that is configured to removably support a surgical staple cartridge 10030 thereon. In various implementations, for example, the elongated channel 5014 may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and be formed with spaced side walls 5018. The body 10031 of staple cartridge 10030 is sized to be removably supported within the elongated channel 5014 as shown such that each staple 10032 therein is aligned with corresponding staple forming pockets in the anvil 5020 when the anvil 5020 is driven into forming contact with the staple cartridge 10030. The elongated channel 5014 may further include a proximal end 5200 that includes a pair of spaced side walls 5202 and 5204. Each side wall 5202, 5204 has a hole 5205, 5207, respectively therethrough for attachment to the elongated shaft assembly 5100 by corresponding pivot pins 5310R and 5310L.

[0312] In at least one implementation, for example, the end effector 5012 is configured to be articulated relative to the elongated shaft assembly 5100 about an articulation and pivot axis A-A about which the anvil assembly 5020 is pivoted relative to the elongated channel 5014. The elongated shaft assembly 5100 defines a longitudinal tool axis LT-LT. The articulation and pivot axis A-A is transverse to the longitudinal tool axis LT-LT. The elongated shaft assembly 5100 comprises a hollow outer shaft 5300 and serves to function as the shaft spine of the elongated shaft assembly 5100. The proximal end of the elongated shaft assembly 5100 may be rotatably supported by the handle assembly 5400 so that the clinician may selectively rotate the elongated shaft assembly 5100 and the end effector 5012 attached thereto about the longitudinal tool axis LT-LT. For example, the proximal end of the elongated shaft assembly 5100 may be operably coupled to a nozzle assembly 5250 that is rotatably supported on the handle assembly 5400. Rotation of nozzle assembly 5250 relative to the handle assembly 5400 (represented by arrow "R") will result in rotation of the elongated shaft assembly 5100 as well as the end effector 5012 coupled thereto. See FIG. 36.

[0313] Referring again to FIG. 38, the distal end 5302 of the outer shaft 5300 is formed with a clevis arrangement 5304 that comprises a pair of spaced attachment tabs 5306R and 5306L. Each attachment tab 5306R, 5306L has a mounting hole 5308R, 5308L, respectively therein that is adapted to receive a corresponding pivot pin 5310R, 5310L, respectively. Thus, the elongated channel 5014 is selectively pivotable or articulatable about the pivot axis A-A relative to the elongated shaft assembly 5100. The anvil assembly 5020 includes a distal anvil portion 5022 and a proximal anvil mounting portion 5030. The distal anvil portion 5022 may, for the most part, be substantially coextensive with the portion of the elongated channel 5014 that supports the staple cartridge 10030 and be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. The distal anvil portion 5022 comprises two spaced apart anvil

portions 5024 that protrude distally from the anvil mounting portion 5030 to define an elongated slot 5026 therebetween. Each of the spaced-apart anvil portions 5024 has a staple forming undersurface, generally labeled as 5028 that has a plurality of staple forming pockets (not shown) formed therein. The anvil mounting portion 5030 includes a right mounting wall 5032 and a left mounting wall 5034. Each mounting wall 5032, 5034 has a mounting hole 5036 extending therethrough that are adapted to pivotally receive therein the corresponding pivot pins 5310R, 5310L. Such arrangement serves to pivotally mount the anvil assembly 5020 to the elongated channel 5014 for selective pivotal travel about pivot axis A-A between an open position and a closed position.

[0314] The anvil assembly 5020 is selectively movable between open and closed positions by means of an anvil bar 5110. The anvil bar 5110 may be coupled to a closure carriage of the type disclosed herein and/or in U.S. Patent Application Publication No. US 2012/0074200 A1 such that actuation of a trigger mounted on the handle assembly will result in the axial movement of the anvil bar 5110 within elongated shaft assembly 5100. The anvil bar 5110 is configured for movable attachment to an actuator cam 5510 that is pivotally journaled on an anvil pin 5038 that protrudes inwardly from the left mounting wall 5034 of the anvil mounting portion 5030. See FIGS. 39 and 40. As can be seen in FIG. 41, for example, the anvil pin 5034 is rotatably received within a corresponding anvil cam slot 5512 within the actuator cam 5510. The distal end 5112 of the anvil bar 5110 is pivotally pinned to the actuator cam 5510 by a pivot pin 5114 defines an anvil actuation axis B-B. See FIG. 40.

[0315] The end effector 5012 may also be articulatable or pivotable relative to the elongated shaft assembly 5100 about the pivot axis A-A by an articulation system of the type described herein and/or in U.S. Patent Application Publication No. US 2012/0074200 A1. The articulation system may be employed to axially actuate an articulation bar 5150 that is pivotally coupled to the actuator cam 5510. Referring to FIGS. 38 and 39 for example, the distal end 5152 of the articulation bar 5150 pin is rotatably mounted on a pin hub 5514 protruding from the actuator cam 5510. The pin hub 5514 has a cavity 5516 therein for rotatably receiving an inwardly protruding channel pin 5209 for selective rotation relative thereto about a channel axis C-C. See FIG. 40.

[0316] FIGS. 41 and 42 illustrate the position of the end effector 5012 in a neutral or unarticulated position with the anvil assembly 5020 thereof in an open position. When the user desires to close the anvil assembly 5020, the anvil rod 5110 is advanced distally in the distal direction "DD". Movement of the anvil rod 5110 in the distal direction causes the actuator cam 5510 to interact with the anvil pin 5038 to pivot the anvil assembly 5020 to a closed position about the pivot axis A-A. When the clinician desires to articulate the end effector 5012, the articulation rod 5150 is moved axially within the elongated shaft 5100. Movement of the articulation rod in the distal direction "DD" will, for example, cause the end effector 5012 to pivot in a first direction "FD" that is essentially the same direction in which the anvil assembly 5020 is moved from a closed position to an open position (referred to herein as the opening direction "OD"). Movement of the

articulation rod in a proximal direction "PD" will cause the end effector 5012 to pivot in a second direction "SD" about the pivot axis A-A which is essentially the same direction in which the anvil assembly 5020 moves when moving from an open position to a closed position (referred to herein as the closing direction "CD").

[0317] As can also be seen in FIGS. 38 and 39, the surgical instrument 5010 further includes a knife bar assembly 5600 that can be attached to the firing bar and firing rack arrangement disclosed herein and/or in U.S. Patent Application Publication US 2012/0074200 A1 such that it can be controlled by actuating the secondary trigger in the various manners described herein460. The knife bar assembly 5600 may comprise a knife bar 5602 that may flex as the end effector 5012 is articulated, while remaining sufficiently rigid to be driven distally through the shaft assembly 5100. In the depicted embodiment, the knife bar 5602 is attached to a cutting head 5610. In the depicted configuration, the cutting head 5610 includes a vertically oriented body portion 5612 that has an upper portion 5615 and a lower portion 5617. A bottom foot 5614 is formed on or attached to the lower portion 5617. Similarly, an upper tab 5616 is formed on or otherwise attached to the upper portion 5615 of the vertically oriented body portion 5612. In addition, as can be seen in FIGS. 38 and 39, the vertically oriented body portion 5612 further includes a tissue cutting edge 5620. The vertically oriented body portion 5612 extends through a longitudinally extending slot 5210 in the elongated channel 5014 and the longitudinally extending slot 5026 in the anvil assembly 5020. Thus, when the cutting head 5610 is distally advanced, the upper tab portions 5616 ride on the anvil arms 5024. Likewise the bottom foot 5614 protrudes through a lower opening in the elongated channel 5014 such that it rides below the elongated channel 5014 as the cutting head 5610 is advanced distally. As the cutting head 5610 is advanced distally, the cutting edge 5620 thereon severs the tissue clamped in the end effector 5012. The surgical staple cartridge 10030 is crushed between the anvil assembly 5020 and the elongated channel 5014 thereby causing the staples 10032 supported therein to be formed on both sides of the tissue cut line as they are brought into contact with the staple forming underside of the anvil assembly 5020. After the cutting head 5610 has been advanced to the distal end of the end effector 5012, the user retracts the cutting head 5610 to the starting position in the manner discussed herein and the trigger is actuated to open the anvil assembly 5020 to release the staple cartridge and stapled tissue.

[0318] As was discussed in detail above, by having the articulation axis also be the axis about which the anvil pivots, the surgeon has a much more reliable frame of reference regarding the location of the pivot axis when viewing the endocutter's anvil through the camera. Stated another way, when using the end effector arrangement of the surgical instrument 10010 the surgeon can determine where the elongated channel is going to pivot relative to the elongated shaft by viewing where the anvil is pivotally mounted to the elongated channel.

[0319] In various implementations, when employing surgical end effectors of the types disclosed herein, the end effector is configured to be coupled to an elongated shaft assembly that protrudes from a housing.

The housing may comprise a hand-manipulatable handle arrangement or it may, for example, comprise a portion of a robotic system or other automated control system arrangement. The end effector and elongated shaft may typically be introduced to the surgical site within the patient through a trocar tube or working channel in another form of access instrument. In at least some surgical procedures, it is desirable and indeed, even sometimes necessary, to limit the size of trocar tubes/access tubes that are employed. This limits the size of end effector and elongated shaft arrangements that may be employed. For example, if a trocar is employed that has a 5mm diameter opening through the trocar tube, the end effector as well as the elongated shaft must be sized to enable them to be passed through that opening. When employing cutting and stapling end effectors that essentially comprise jaws that are moveable between open and closed positions, the clinician passes the end effector through the trocar when the jaws are in their closed position. Typically when the jaws are in their fully closed position, the end effector is in its smallest cross-sectional shape to facilitate such insertion through the tube or access opening. Once the end effector has been passed through the tube or opening, the clinician may then open the jaws to grasp and manipulate the target tissue. Once the target tissue is properly positioned between the jaws, the clinician may cause the jaws to be closed onto or clamped onto the tissue in preparation for firing the instrument (i.e., causing the instrument to cut and staple the tissue). Thus, the size of the end effector that may be employed to complete a surgical procedure may necessarily be limited by the size of access opening or access tube that it must pass through. Such limitations can become problematic, however, in instances wherein the jaws cannot sufficiently accommodate the target tissue due to the thickness of the target tissue to be cut and stapled. In some applications, for example, the tissue may be over compressed by the jaws if the tissue is thicker than anticipated.

[0320] Over the years, a variety of end effector arrangements have been developed to effectively accommodate various tissue thicknesses. For example, U.S. Patent No. 7,665,647, entitled SURGICAL CUTTING AND STAPLING DEVICE WITH CLOSURE APPARATUS FOR LIMITING MAXIMUM TISSUE COMPRESSION, and issued on February 23, 2010, the entire disclosure of which is hereby incorporated by reference herein discloses cutting head configurations referred to as "E-Beam" arrangements that are configured to limit an amount of compression applied to the tissue as the E-beam is fired down the end effector. While effective, there is a need for an end effector that has a fully closed height that is smaller than a closed "operating height" or "stapling height" when stapling tissue.

[0321] FIGS. 43-46 illustrate a cutting beam assembly 6610 that may be employed with various end effectors 6012 of the type, for example, disclosed herein as well as those disclosed in U.S. Patent No. 7,665,647. As can be seen in FIGS. 43 and 44, the cutting beam assembly 6610 may include a firing bar 6620 that has a proximal portion 6622 that is attached to a distal cutting beam head 6630 that translates within a staple cartridge 6670. See FIGS. 45 and 46. The distal cutting beam head 6630 may also be referred to as a "firing member". The staple cartridge 6670 may comprise a staple cartridge of the type disclosed in U.S. Patent No. 7,665,647 and be configured to be operably supported in the elongated channel

6014 of the end effector 6012. As discussed therein, the staple cartridge 6670 includes a series of staple drivers 6642 that operably support the surgical staples 6674 thereon. The drivers 6672 are driven upwardly toward the anvil 6020 as a wedge sled 6676 is advanced distally through the staple cartridge 6670.

[0322] Referring to FIGS. 43 and 44, the distal cutting beam head 6630 includes a body portion 6632 that is attached to the proximal portion 6622 of the firing bar 6620. The firing bar 6622 may be actuated by any of the firing arrangements disclosed herein including those firing arrangements disclosed in U.S. Patent No. 7,665,647. As can be seen in those Figures, the body portion includes an upper portion 6640 and a lower portion 6650. The upper portion 6640 includes a flexible extension arm 6642 that protrudes from the lower portion 6650. Essentially, the extension arm 6642 comprises a cantilever-type beam arrangement that includes a distally protruding nose 6644 that includes upper pins or tabs 6645 that protrude laterally therefrom. The upper portion 6640 further includes a lower tab portion 6646 that includes a distally-protruding lower nose portion 6647 and a proximally-protruding hook, bumper, or catch formation 6648 that is designed to engage a complementary body hook 6654 formed on the lower portion 6650 as shown in FIG. 44. As can be most particularly seen in FIGS. 43 and 44, a cutting surface 6649 is provided on the movable upper portion 6640 and is oriented such that it located proximal to the end of the upper nose 6644 and the end of the lower nose portion 6647 such that a tissue-capturing pocket 6659 is established between the upper nose 6644 and the lower nose 6647. Such pocket 6659 enables tissue to be captured therein just distal of cutting surface 6649. As can be appreciated from reference to FIGS. 43 and 44, the cutting surface 6649 as well as the upper nose portion 6644 and upper tabs 6645 move as a unit (e.g., they move together) relative to the lower portion 6650 of the cutting beam head 6630. As will be discussed in further detail below, such arrangement enables the cutting beam head 6630 to assume a compressed state that facilitates passage of the cutting beam head 6630 through, for example, an access opening or a trocar port that has a somewhat limited cross-sectional area, while still being able to accommodate various thicknesses of tissue when the end effector has exited though the opening and has been clamped onto the tissue in preparation for firing.

[0323] The lower portion 6650 of the cutting beam head 6630 further includes lower foot tabs 6652 that protrude laterally from the lower portion 6650. As can be seen in FIGS. 45 and 46, the elongated channel 6014 includes an elongated slot 6016 that corresponds with an elongated slot 6678 in the staple cartridge 6670 for accommodating the body portion 6632 of the cutting beam head 6630. The elongated channel further has a channel track 6018 that is configured to receive the lower foot tabs 6652. Likewise, the anvil assembly 6020 includes an elongated slot 6022 that accommodates the body portion 6632 and an upper anvil track 6024 that accommodates the upper tabs 6645 therein.

[0324] FIG. 43 illustrates the cutting beam head 6630 in its compressed state. The overall maximum height of the cutting beam head in this compressed state is represented by "H1". FIG. 44 illustrates the cutting beam head 6630 in its uncompressed maximum height state. The overall maximum height of the cutting beam head in this uncompressed state is represented by "H2". It will be understood that the overall

height of the E-beam 6630 can vary between H1 and H2 depending upon the cutting beam head's compressed state. Referring now to FIG. 45, the end effector 6012 is illustrated in its most cross-sectionally compact state which may be referred to herein as its insertion state or position. The overall height (or diameter) of the end effector 6012 is represented in FIG. 45 by "E1". This would be the state, for example, in which the end effector 6012 might be inserted through an access opening or a trocar port. Once the end effector 6012 has been inserted through the opening or trocar port to the surgical site, the clinician may open and close the anvil assembly 6020 as needed to grasp and manipulate the target tissue T. Once the target tissue T has been captured between the anvil assembly 6020 and the staple cartridge 6670, the clinician may lock the anvil assembly 6020 in the closed position in the various manners disclosed herein or otherwise known. The unique and novel cutting beam head 6630 enables the over all height of the end effector 6012 to increase to accommodate various thicknesses of tissue and or different surgical staple cartridges that have different lengths/sizes of staples/fasteners. FIG. 46 illustrates the target tissue T after it has been "fully clamped" in the end effector 6012 and the end effector 6012 has been fired to cut and sever the tissue T. The overall height of the end effector 6012 is represented by "E2". Such cutting beam head arrangement is capable of assuming a compressed insertion height for insertion into the surgical site and then automatically reconfiguring to a firing height. Such reconfiguration is accomplished by the extension arm 6642 which acts as a spring and which is normally biased into its uncompressed state as illustrated in FIG. 44. Thus, the cutting beam head 6630 has a range of operating heights extending between H1 and H2. This range may be represented by "H3" and may be equal to the distance between the lower edge of the extension arm 6642 and the upper-most edge of the body hook portion 6636. See FIG. 44.

[0325] FIGS. 47-54 depict another surgical instrument 7010 that is capable of practicing several unique benefits of the present invention. The surgical instrument 7010 depicted in the FIG. 47 comprises a housing 7020 that consists of a handle 7022 that is configured to be grasped, manipulated and actuated by a clinician. The handle 7022 may comprise a pair of interconnectable housing segments 7024, 7026 that may be interconnected by screws, snap features, adhesive, etc. As the present Detailed Description proceeds, however, it will be understood that the various unique and novel arrangements of the various forms of shaft arrangements and end effector arrangements disclosed herein may also be effectively employed in connection with robotically-controlled surgical systems such as those robotic systems and arrangements disclosed in U.S. Patent Application Serial No. 13/536,323, entitled ROBOTICALLY POWERED SURGICAL DEVICE WITH MANUALLY ACTUATABLE REVERSING SYSTEM, and filed June 28, 2012, the entire disclosure of which is has been herein incorporated by reference..

[0326] As can be seen in FIG. 48, the surgical end effector 7100 may comprise an elongated channel 7102 that is configured to receive a surgical fastener cartridge 7110 therein. The surgical fastener cartridge 7110 may include a cartridge body 7112 that has a centrally disposed elongated slot 7114 therein. The cartridge body 7112 may further include rows of fastener pockets 7116 that are located on each side of the elongated

slot 7114 and which are configured to support corresponding surgical fasteners 7120 therein. The elongated channel 7102 may further operably support a "firing member" in the form of a tissue-cutting member or knife assembly 7150. The knife assembly 7150 is configured to axially travel in the slot 7114 in the cartridge body 7112 when the cartridge body 7112 has been installed in the elongated channel 7102. The knife assembly 7150 may be configured with a tissue cutting edge 7152 that is centrally disposed between a lower foot 7154 and an upper foot or tab 7156. In a preferred arrangement, the knife assembly 7150 has the same construction and features as cutting head assembly 6610 described in detail above. As will be discussed in further detail below, the knife assembly 7150 is configured to be axially driven within the elongated channel 7102 and the surgical fastener cartridge 7110 in response to motions applied thereto by a firing drive system 7300.

[0327] As can also be seen in FIG. 48, the surgical end effector 7100 may further include an anvil assembly 7130 that is supported for movement relative to the elongated channel 7102. The anvil assembly 7130 may be movable relative to the surgical fastener cartridge 7110, for example, in response to "actuation motions" which may comprise, for example, closing and opening motions that are transferred thereto from a closure drive system 7200. In one arrangement, for example, the anvil assembly 7130 includes an anvil body portion 7132 that has a fastener forming surface 7134 formed on the underside thereof. The fastener forming surface 7134 may comprise a series of forming pockets (not shown) that correspond to the surgical fasteners 7120 supported in the surgical fastener cartridge 7110. As the legs of the surgical fasteners 7120 are driven into forming contact with the corresponding forming pockets in the anvil assembly 7130, they are formed into a desired tissue-retaining configuration. The anvil assembly 7130 may further includes an anvil mounting portion 7136 that has a pair of trunnions 7138 protruding therefrom that are received within corresponding trunnion slots 7610 formed in a U-shaped control insert 7602 that is movably supported in a proximal mounting portion 7104 of the elongated channel 7102. In various arrangements, the surgical fasteners 7120 are driven out of their respective fastener pockets 7116 in the surgical fastener cartridge 7110 by corresponding sled assemblies 7160 and 7170 that are movably supported within the elongated channel 7102 and are movable in response to firing motions applied thereto by the firing drive system 7300.

[0328] As indicated above, the anvil assembly 7130 is also responsive to actuation motions in the form of opening and closing motions that are applied thereto by a closure drive system 7200. Various details regarding the certain aspects of the construction and operation of the closure drive system 7200 may be found in U.S. Patent Application Serial No. 13/803,097, filed March 14, 2013, and entitled ARTICULATABLE SURGICAL INSTRUMENT COMPRISING A FIRING DRIVE, the entire disclosure of which is incorporated by reference herein. As discussed in that reference and as shown in FIG. 49 herein, the closure drive system 7200 includes a closure trigger 7202 that is configured to cooperate with a closure release assembly 7220 that is pivotally coupled to a frame 7030. In at least one form, the closure release assembly 7220 may comprise a release button assembly 7222 that may be pivoted in a counterclockwise

direction by a release spring (not shown). As the clinician depresses the closure trigger 7202 from its unactuated position towards the pistol grip portion 7028 of the handle 7022, the closure release assembly 7220 serves to lock the closure trigger 7202 in the fully actuated position. When the clinician desires to unlock the closure trigger 7202 to permit it to be biased to the unactuated position, the clinician simply pivots the closure release button assembly 7220 to cause it to disengage the closure trigger arrangement and thereby permit the closure trigger 7202 to pivot back to the unactuated position. Other closure trigger locking and release arrangements may also be employed.

[0329] Referring to FIGS. 49-50, the closure drive system 7200 may further comprise a proximal closure tube segment 7210 that has a proximal end 7212 that is adapted to be rotatably coupled to a closure tube attachment yoke 7230. The proximal end 7212 of the proximal closure tube segment 7210 is configured to be received within a cradle 7232 (FIG. 49) in the closure tube attachment yoke 7230 to permit relative rotation relative thereto. The proximal closure tube segment 7210 may be rotatably attached to the closure tube attachment yoke 7230 by a U-shaped connector (not shown) that is configured to be received in an annular slot 7214 in the proximal end 7212 of the proximal closure tube segment 7210 and be seated in a slot 7234 (FIG. 49) in the closure tube attachment yoke 7230. Such arrangement serves to rotatably couple the proximal closure tube segment 7210 to the closure tube attachment yoke 7230 such that the proximal closure tube segment 7210 may rotate relative thereto. More specifically, such arrangement facilitates manual rotation of the elongated shaft assembly 7050 relative to the handle 7022 about a longitudinal tool axis "LT-LT" defined by the elongated shaft assembly 7050 to enable the clinician to rotate the surgical end effector 7100 in the manner represented by arrow "R" in FIG. 47.

[0330] In various arrangements, the closure tube attachment yoke 7230 is movably mounted on a proximal articulation tube 7402 of an articulation system 7400 which will be discussed in further detail below. Such arrangement permits the closure tube attachment yoke 7230 to move axially on the proximal articulation tube 7402 in response to actuation of the closure trigger 7202. In particular, the closure tube attachment yoke 7230 may be pivotally coupled to the closure trigger 7202 by a closure linkage bar 7240. See FIG. 49. Thus, when the clinician pivots the closure trigger 7202 inward toward the pistol grip portion 7028 of the handle 7022, the closure tube attachment yoke 70230 will be advanced in the distal direction "DD". When the firing trigger 7202 is returned to the unactuated position, the closure tube attachment yoke 7230 will be advanced proximally (direction "PD") on the proximal articulation tube 7402 to a starting position.

[0331] The closure drive system 7200 may further include an intermediate tube segment 7250 that is configured for attachment to the distal end 7218 of the proximal closure tube segment 7210. As can be seen in FIG. 50, the intermediate tube segment 7250 may include a flexible articulation portion 7260 and an attachment stem portion 7252. The attachment stem portion 7252 may be sized to extend into the open distal end 7218 of the proximal closure tube segment 7210 in frictional engagement therewith. The flexible articulation portion 7260 may be integrally formed with the attachment stem portion 7252 and include an

articulation spine 7262 that includes proximal end portions 7264 (only one can be seen in FIG. 50) that are configured to be received in corresponding notches 7219 in the distal end 7218 of the proximal closure tube segment 7210 to prevent relative rotation between the proximal closure tube segment 7210 and the intermediate tube segment 7250. The intermediate tube segment 7250 may be non-rotatably (i.e., attached to prevent relative rotation between these components) attached to the proximal closure tube segment 7210 by, for example, screws, detents, adhesive, etc.

[0332] The closure drive system 7200 may further include a distal closure tube segment 7280 that is configured to axially engage and apply opening and closing motions to the anvil assembly 7130. The distal closure tube segment 7280 may be attached to the distal end of intermediate tube segment 7250 for axial travel therewith. The articulation spine 7262 may further include distal end portions 7266 that are configured to be received in corresponding notches 7284 in the proximal end 7282 of the distal closure tube segment 7280 to prevent relative rotation between the distal closure tube segment 7280 and the intermediate tube segment 7250. See FIG. 50. The proximal end 7282 of the distal closure tube segment 7280 may inwardly extending attachment tabs 7286 that are adapted to be bent into corresponding notches 7266 in the intermediate tube segment 7250. See FIG. 50. Such arrangement serves to facilitate attachment of the distal closure tube segment 7280 to the intermediate tube segment 7250 for axial travel therewith.

[0333] The distal closure tube segment 7280 is configured to apply opening and closing motions to the anvil assembly 7130. The anvil mounting portion 7136 may be formed with an anvil tab 7142. The distal end 7288 of the distal closure tube segment 7280 has an inwardly extending actuation tab 7290 formed therein that is configured to interact with the anvil tab 7142. For example, when the distal closure tube segment 7280 is in the open position, the actuation tab 7290 is in biasing contact with the anvil tab 7142 which serves to pivot the anvil assembly 7130 to the open position.

[0334] Operation of the closure drive system 7200 will now be described. The anvil assembly 7130 may be moved relative to the surgical fastener cartridge 7110 by pivoting the closure trigger 7202 toward and away from the pistol grip portion 7028 of the handle 7022. Thus, actuating the closure trigger 7202 causes the proximal closure tube segment 7210, the intermediate tube segment 7250 and the distal closure tube segment 7280 to move axially in the distal direction "DD" to contact the end wall 7144 of the anvil body portion 7132 to pivot or otherwise move the anvil assembly 7130 toward the surgical fastener cartridge 7110. The clinician may grasp and manipulate tissue between the anvil assembly 7130 and the fastener cartridge 7110 by opening and closing the anvil assembly 7130. Once the target tissue is captured between the anvil assembly 7130 and fastener cartridge 7110, the clinician may pivot the closure trigger 7202 to the fully actuated position wherein it is locked in place for firing.

[0335] Referring again to FIG. 49, the frame 7030 may also be configured to operably support the firing drive system 7300 that is configured to apply firing motions to corresponding portions of the elongated shaft assembly 7050 and ultimately to the knife assembly 7150 and the sled assemblies 7160, 7170. As can be

seen in FIG. 49, the firing drive system 7300 may employ an electric motor 7302 that is supported in the pistol grip portion 7028 of the handle 7022. In various forms, the motor 7302 may be a DC brushed driving motor having a maximum rotation of, approximately, 25,000 RPM, for example. In other arrangements, the motor 7302 may include a brushless motor, a cordless motor, a synchronous motor, a stepper motor, or any other suitable electric motor. A battery 7304 (or "power source" or "power pack"), such as a Li ion battery, for example, may be coupled to the handle 7022 to supply power to a control circuit board assembly 7306 and ultimately to the motor 7302.

[0336] The electric motor 7302 can include a rotatable shaft 7308 that operably interfaces with a gear reducer assembly 7310 that is mounted in meshing engagement with a with a set, or rack, of drive teeth 7322 on a longitudinally-movable drive member 7320. The gear reducer assembly 7310 can include, among other things, a housing and an output pinion gear 7314. In certain embodiments, the output pinion gear 7314 can be directly operably engaged with the longitudinally-movable drive member 7320 or, alternatively, operably engaged with the drive member 7320 via one or more intermediate gears. In use, the electric motor 7302 can move the drive member distally, indicated by an arrow "DD", and/or proximally, indicated by an arrow "PD", depending on the direction in which the electric motor 7302 rotates. For example, a voltage polarity provided by the battery can operate the electric motor 7302 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 7302 in a counter-clockwise direction. When the electric motor 7302 is rotated in one direction, the drive member 7320 will be axially driven in the distal direction "DD". When the motor 7302 is driven in the opposite rotary direction, the drive member 320 will be axially driven in a proximal direction "PD". The handle 7022 can include a switch which can be configured to reverse the polarity applied to the electric motor 7302 by the battery. The handle 7022 can also include a sensor that is configured to detect the position of the movable drive member 7320 and/or the direction in which the movable drive member 7320 is being moved.

[0337] Actuation of the motor 7302 can be controlled by a firing trigger 7330 that is pivotally supported on the handle 7022. The firing trigger 7330 may be pivoted between an unactuated position and an actuated position. The firing trigger 7330 may be biased into the unactuated position by a spring (not shown) or other biasing arrangement such that when the clinician releases the firing trigger 7330, it may be pivoted or otherwise returned to the unactuated position by the spring or biasing arrangement. In at least one form, the firing trigger 7330 can be positioned "outboard" of the closure trigger 7202 as discussed in further detail in U.S. Patent Application Serial No. 13/803,097 which has been previously incorporated by reference in its entirety herein. In at least one form, a firing trigger safety button 7332 may be pivotally mounted to the closure trigger 7202. The safety button 7332 may be positioned between the firing trigger 7330 and the closure trigger 7202 and have a pivot arm (not shown) protruding therefrom. When the closure trigger 7202 is in the unactuated position, the safety button 7332 is contained in the handle housing where the clinician

cannot readily access it and move it between a safety position preventing actuation of the firing trigger 7330 and a firing position wherein the firing trigger 7330 may be fired. As the clinician depresses the closure trigger 7202, the safety button 7332 and the firing trigger 7330 pivot down to a position wherein they can then be manipulated by the clinician.

[0338] As indicated above, in at least one form, the longitudinally movable drive member 7320 has a rack of teeth 7322 formed thereon for meshing engagement with a corresponding drive gear of the gear reducer assembly 7310. At least one form may also include a manually-actuatable "bailout" assembly that is configured to enable the clinician to manually retract the longitudinally movable drive member 7320 should the motor become disabled. U.S. Patent Application Serial No. 13/803,097 contains further details of one form of bailout assembly that may be employed. U.S. Patent Application Publication No. US 2010/0089970 also 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, filed on October 10, 2008, now U.S. Patent Application Publication No. 2010/0089970, is incorporated by reference in its entirety.

[0339] Referring to FIG. 50, various forms of the elongated shaft assembly 7050 may include a firing member assembly 7060 that is supported for axial travel within an articulation shaft assembly 7400 that essentially functions as shaft frame or spine. The firing member assembly 7060 may further include a proximal firing shaft 7062 that has a proximal end portion 7064 that is configured to be rotatably received in a distal cradle 7326 provided in a distal end 7324 of the movable drive member 7320. Such arrangement permits the proximal firing shaft 7062 to rotate relative to the movable drive member 7320 while also axially moving therewith. The proximal firing shaft 7062 may further have a slot 7068 formed in its distal end for receiving a proximal end 7072 of a flexible distal firing shaft assembly 7070 therein. See FIG. 50. As can be seen in that Figure, the proximal end 7072 of the distal firing shaft assembly 7070 may be received within the slot 7068 in the distal firing shaft 7062 and may be pinned thereto with a pin 7073.

[0340] The distal firing shaft assembly 7070 may include a central firing beam 7074 that is located between a right sled pusher beam 7076 and a left sled pusher beam 7078. The central firing beam 7074 and the pusher beams 7076, 7078 may, for example, each be fabricated from metal that facilitates axial actuation of the sled assemblies 7160, 7170 in the surgical end effector 7100 while also facilitating flexing thereof when the end effector 7100 is articulated. In at least one arrangement, the central pusher beam 7074, the right sled pusher beam 7076 and the left sled pusher beam 7078 may extend through a slot 7146 in the anvil mounting portion 7136. The right sled pusher beam 7076 corresponds to the right sled assembly 7160 and the left sled pusher beam 7078 corresponds to the left sled assembly 7170 movably supported within the elongated channel 7102. Axial movement of the right sled pusher beam 7076 and the left sled pusher beam 7078 will result in the axial advancement of the right and left sled assemblies 7160, 7170, respectively,

within the elongate channel 7102. As the right sled assembly 7160 is axially advanced within the elongated channel 7102, it drives the surgical fasteners 7120 supported in the cartridge body 7112 on the right side of the slot 7114 out of their respective pockets 7116 and as the left sled assembly 7170 is axially advanced within the elongated channel 7102, it drives the surgical fasteners 7120 supported within the cartridge body 7112 on the left side of the slot 7114 out of their respective pockets 7116.

[0341] The central firing beam 7074 has a distal end 7080 that may be configured to be received within a slot provided in the body portion 7155 of the knife assembly 7154 and retained therein by, for example, a frictional fit, adhesive, welding, etc. In at least one form, the elongated channel 7102 is formed with a right upstanding wall 7107 and a left upstanding wall 7108 that define a centrally-disposed channel slot 7109. Once the knife assembly 7150 is inserted into the bottom window in the elongated channel 7102, the body portion 7151 of the knife assembly 7150 may be inserted into the channel slot 7109 and advanced proximally in the elongated channel 7102 to be coupled with the distal end 7080 of the central firing beam 7074. A lower channel cover 7111 may be attached to the bottom of the elongated channel 7102 to prevent tissue, body fluids, etc. from entering into the elongated channel 7102 which might hamper the movement of the knife assembly 7150 therein.

[0342] The surgical instrument 7010 may also include an articulation system 7400 of the type described in detail in U.S. Patent Application Serial No. 13/803,097. In one implementation, for example, the articulation system 7400 includes an articulation shaft assembly 7430 that may be operably controlled by an articulation control system 7460. In one form, for example, the articulation shaft assembly 7430 may include a right articulation shaft segment 7440 and a left articulation shaft segment 7450. The right articulation shaft segment 7440 includes a proximal end 7442 that has a right passage segment 7444 formed therein. Likewise the left articulation shaft segment 7450 includes a proximal end portion 7452 that has a left passage segment 7454 formed therein. When the right articulation shaft segment 7440 and the left articulation shaft segment 7450 are installed within the proximal closure tube segment 7210, they form the articulation shaft assembly 7430. The right passage segment 7444 and the left passage segment 7454 cooperate to receive a portion of the proximal firing shaft 762 therein. The right articulation shaft segment 7440 and the left articulation shaft segment 7450 may be, for example, composed of a plastic, especially a glass fiber-reinforced amorphous polyamide, sold commercially under the trade name Grivory GV-6H by EMS-American Grilon.

[0343] Still referring to FIG. 50, the articulation shaft assembly 7430 may further include a right articulation band 7490 and a left articulation band 7500. In one form, a proximal end portion 7492 of the right articulation band 7490 may be attached to a distal portion 7448 of the right articulation shaft segment such that a distal portion 7494 of the right articulation band 7490 protrudes out of a right passage 7449 therein. The proximal end portion 7492 of the right articulation band 7490 may include holes or cavities 7493 that are configured to receive corresponding lugs (not shown) in the right articulation shaft segment 7440 to facilitate attachment of the right articulation band 7490 to the right articulation shaft segment 7440.

Likewise, a proximal end portion 7502 of the left articulation band 7500 may have holes or cavities 7503 therein that are configured to receive lugs (not shown) in the distal portion 7458 of the left articulation shaft segment 7450 to facilitate attachment of the left articulation band 7500 to the articulation shaft segment 7450. The articulation bands 7490 and 5700 may be composed of a metal, advantageously full hard 301 stainless steel or its equivalent. The distal end of the left articulation band 7500 may have a left hook portion 7506 that is adapted to be coupled to a left attachment portion 7507 of the elongated channel 7102. Likewise, the distal end of the right articulation band 7494 has a right hook portion 7496 for attachment to a right attachment portion 7497. As discussed in further detail in U.S. Patent Application Serial No. 13/803,097, when the clinician wishes to articulate the end effector 7100 to the right relative to the longitudinal tool axis LT-LT, the clinician simply rotates the articulation control knob 7570 in the appropriate direction.

[0344] The surgical instrument 7010 may be used in a minimally invasive procedure wherein it is inserted through a trocar port that has been installed in a patient. In such applications, it is generally advantageous to minimize the overall cross-sectional shape of the end effector during insertion into the patient in order to minimize the size of the trocar port that must be employed. The smallest cross-sectional configuration that the end effector 7100 may adopt is achieved when the upper jaw or anvil assembly 7130 is in its a "first insertion position" relative to the lower jaw or more specifically relative to the surgical staple cartridge 7110 installed in the elongated channel 7102. Thus, to facilitate insertion of the end effector 7100 through the trocar port, the cross-sectional area or footprint is sized relative to the cross-sectional size of the port opening in the trocar port to permit the end effector 7110 to slidably pass therethrough.

[0345] In at least one implementation, the end effector 7100 employs an active anvil control system 7600 that is configured to enable the anvil assembly 7130 to move to the first insertion position to enable the end effector 7100 to be inserted through the trocar port and then once the end effector 7100 has passed through the trocar port, enables the anvil assembly 7130 to assume an operating configuration for stapling tissue. Referring to FIGS. 48 and 51-54, one form of anvil control system 7600 includes a U-shaped control insert 7602 that is movably supported on the elongated channel 7102 and is attached to a control bar 7604. The control bar 7604 extends through the elongated shaft assembly 7050 and is movably supported for axial travel therein. The control bar 7604 may be attached to a movable actuator slide 7606 or other form of actuator arrangement supported on the handle assembly. See FIG. 47. Movement of the actuator slide 7606 in the distal direction "DD" will cause the control bar 7604 to move in the distal direction "DD". Similarly, movement of the actuator slide 7606 in the proximal direction "PD" will cause the control bar 7604 to move in the proximal direction "PD".

[0346] As can be seen in FIG. 48, the U-shaped control insert 7602 is formed with two upstanding walls 7608 that each have a somewhat L-shaped trunnion slot 7610 therein. More specifically, each trunnion slot 7610 has a vertical slot portion 7612 and a horizontal slot portion 7614. The trunnion slots 7610 are sized to

movably receive a corresponding anvil trunnion 7138 therein. FIG. 51 illustrates the anvil assembly 7130 in its first insertion position. As can be seen in that Figure, for example, the anvil assembly 7130 is being inserted through a distal end portion of a trocar port 7630. To enable the anvil assembly 7130 to assume that first insertion position, the clinician moves the control bar 7604 in the distal direction "DD" to cause the movable anvil trunnions 7130 to be retained within the horizontal slot portions 7614 as shown. When in that position, the anvil mounting portion 7136 is in is lowest position within the elongated channel 7102.

[0347] The elongated channel 7102 is equipped with an elastic "biasing means" 7620 that serves to bias the anvil body portion 7132 away from the elongated channel 7102. In various embodiments, the elastic biasing means 7620 may comprise any form of resilient member(s) and/or spring(s) that are attached directly to the elongated channel 7102. For example, in the depicted arrangement, the biasing means comprises strips of compressible or elastic foam material 7622 attached along the sides of the elongated channel 7102. When the anvil assembly 7130 is inside the trocar port 7630, the foam strips 7622 will be compressed as shown in FIG. 51. After the end effector 7100 has passed through the trocar port 7630, the clinician may move the control bar 7604 in the proximal direction "PD" such that the control insert 7602 is also moved proximally to the position illustrated in FIG. 52. When in that position, the foam strips 7622 bias the anvil assembly 7130 upward (represented by arrow "U" in FIG. 52) to a "primary opened position" thereby causing the anvil trunnions 7138 to move to the upper end of the vertical trunnion slots 7612 as shown. When the anvil assembly 7130 is in that "primary opened position", the clinician may then actuate the closure trigger to move the distal closure tube 7280 in the proximal direction "PD" to cause the anvil assembly 7130 to move to a "fully open position" as illustrated in FIG. 53. Once the clinician has positioned the target tissue between the anvil assembly 7130 and the staple cartridge 7110, the anvil assembly 7130 can be closed using the closure trigger 7202 to move the anvil assembly 7130 to the closed or fully clamped position illustrated in FIG. 54.

[0348] FIGS. 55 and 56 illustrates a "passive" anvil control arrangement 7650 that is configured to enable the anvil assembly 7130 to move to the first insertion position for insertion through a hollow trocar port 7630 and then, once the end effector 7100 has passed through the hollow trocar port 7630, to be biased into a "primary opened position" whereupon further actuation motions may be applied to the anvil assembly 7130 for acquiring and clamping the target tissue. In this arrangement, for example, the anvil control arrangement 7650 includes a U-shaped control insert 7652 that is movably supported on the elongated channel 7102 for vertical travel therein. One form of control insert 7652 is depicted in FIG. 57. As can be seen in that Figure, the control insert includes a pair of vertical side walls 7654 that are spaced from each other and connected together by an upper bar 7655. Each vertical side wall has an arcuate trunnion slot 7656 therein. Referring again to FIGS. 55 and 56, the control insert 7652 is movable relative to the elongated channel 7102 along an insert axis "IA-IA" which is transverse to the longitudinal tool axis "LT-LT" that is defined by the elongated shaft assembly 7050. The control insert 7652 may movably interface with vertically extending guide ribs

7660 formed in the elongated channel 7102 to guide the control insert 7652 as it moves up and down along the insert axis IA-IA between a first lower position that corresponds to the insert position of the anvil assembly 7130 and a second upper position that corresponds to the "primary opened position" wherein actuation motions may be applied to the anvil assembly 7130. As can be seen in FIGS. 55 and 56, the anvil trunnions 7138 are received within the trunnion slots 7656. Control member biasing means 7662 is provided between the control insert 7652 and the bottom of the elongated channel 7102 to bias the control insert 7652 in the upward direction "U" to the second or upper-most position. As shown in FIG. 55, the control member biasing means 7662 comprises leaf springs 7664. However, other biasing materials, members, springs, materials, etc. may be employed.

[0349] FIG. 55 illustrates the end effector 7100 wherein the upper jaw or anvil assembly 7130 is in the insertion position as it is being and being inserted through the trocar port 7630. As can be seen in that Figure, the control insert 7652 is compressed into its lowest position within the elongated channel 7102 referred to herein as the first position. After the end effector 7100 has been inserted through the trocar port 7630, the "biasing means" 7620 serves to bias the anvil body portion 7132 away from the elongated channel 7102 to the primary opened position as shown in FIG. 56. As can be seen in that Figure, when the anvil assembly 7130 is in that position, the springs 7664 bias the control insert 7652 to its upper-most or second position and the clinician may then operate the closure system to apply an actuation motion to the anvil assembly 7130 to move the anvil assembly 7130 relative to the elongated channel 7102 to a fully opened position for receiving the target tissue therebetween. The clinician may then again operate the closure system to move the anvil assembly to the fully clamped position wherein the end effector is ready for firing.

[0350] FIGS. 58 and 59 illustrate another anvil control configuration that facilitates initial positioning of the anvil assembly in a fully compressed, first insertion position wherein the end effector 7720 can be inserted through the trocar port and then once the end effector 7100 has passed through the trocar port, enables the anvil assembly 7730 to assume a primary opened position whereupon application of an actuation motion to the anvil assembly 7730 may cause the anvil assembly 7730 to move to a fully opened position. As shown in those Figures, the end effector 7720 is coupled to a surgical instrument 7710 of the types and construction disclosed herein. The anvil assembly 7730 may be similar in construction to other anvil assemblies disclosed herein. For example, the anvil assembly 7730 may include an anvil body portion 7732 and an anvil mounting portion 7736 that has a pair of trunnions 7738 protruding therefrom as well as an upstanding anvil tab 7742. The anvil tab 7742 is configured to interact with the actuation tab 7290 of the distal closure tube segment 7280 has in the various manners described herein.

[0351] As can be seen in FIGS. 58 and 59, the end effector 7720 includes an elongated channel 7721 that is similar in construction and operation to other elongated channel arrangements described herein. The elongated channel 7721 is configured to operably support a surgical staple cartridge therein and includes a proximal mounting portion 7722 that comprises two upstanding wall portions 7723 that each has a trunnion

slot 7724 therein. In at least one implementation, each trunnion slot 7724 has a distal portion 7726 that allows the trunnions to be parked therein during the initial insertion process. Each trunnion slot 774 further has an arcuate portion 7727 that facilitates travel of the trunnions 7738 during opening and closing of the anvil assembly 7730.

[0352] In various implementations, biasing means 7750 are provided on portions of the underside 7733 of the anvil body portion 7732 as well as on the sides of the elongated channel 7721 and/or on portions of the surgical staple cartridge. For example, anvil biasing member(s) 7752 may be provided on the anvil body portion 7732 in confronting arrangement with anvil biasing member(s) 7756 on the elongated channel 7721. The biasing means 7752, 7754 may comprise any form of resilient member(s) and/or spring(s). For example, in the depicted arrangement, the biasing means comprises strips of compressible or elastic foam material. When the anvil assembly 7730 is inside the trocar port 7630, the biasing members 7752, 7754 will be compressed as shown in FIG. 58. After the end effector 7720 has passed through the trocar port 7630, the biasing members 7752, 7754 bias the anvil assembly 7730 upward to a "primary opened position" as shown in FIG. 59. When the anvil assembly 7730 is in that "primary opened position", the clinician may then actuate the closure trigger to move the distal closure tube 7280 in the proximal direction "PD" to cause the anvil assembly 7730 to move to a "fully open position". Once the clinician has positioned the target tissue between the anvil assembly 7730 and the staple cartridge, the anvil assembly 7730 can be moved to the closed or fully clamped position. The amount of resistance and biasing forces generated by the biasing members may be altered by employing different biasing members having different durometers or spring members with different spring compression characteristics. Another method is to alter the geometry of the biasing members. FIGS. 60 and 61 depict different biasing member configurations 7752', 7754' (FIG. 60) and 7752", 7754" (FIG. 61).

[0353] FIGS. 62 and 63 illustrate use of the end effector 7720 with an alternative distal closure tube arrangement 7280' that is essentially identical as distal closure tube 7280 except that a biasing member 7292 is mounted on the inwardly extending actuation tab 7290. In the illustrated embodiment, the biasing member 7292 comprises a leaf-type spring. It will be appreciated however, that the biasing member could comprise an elastic material that is attached, for example, to the anvil mounting portion 7736 (distal from the anvil tab 7742). FIG. 62 illustrates the end effector 7720 the insertion position as it is being inserted through the trocar port 7630. As can be seen in that Figure, the anvil body portion 7732 is compressed into its lowest position relative to the elongated channel 7102 by trocar portion 7630 which also places a biasing force or motion on the biasing member 7292. After the end effector 7100 has been inserted through the trocar port 7630, the biasing member 7292 biases the anvil body portion 7132 away from the elongated channel 7102 to the primary opened position as shown in FIG. 63. The clinician may then again operate the closure system to move the anvil assembly 7730 to the fully clamped position wherein the end effector is ready for firing.

[0354] FIG. 64 illustrates an exemplary surgical instrument 7810 which can include a housing 7820, an elongated shaft assembly 7850 that operably protrudes from the housing 7820 and which is operably coupled to a surgical end effector 7900. The surgical instrument 7810 depicted in the FIG. 64 comprises a housing 7820 that consists of a handle 7822 that is configured to be grasped, manipulated and actuated by a clinician. As the present Detailed Description proceeds, however, it will be understood that the various unique and novel arrangements of the various forms of shaft arrangements and end effector arrangements 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 various forms of surgical end effectors attached thereto. 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, U.S. Patent Application Serial No. 13/536,323, entitled ROBOTICALLY POWERED SURGICAL DEVICE WITH MANUALLY ACTUATABLE REVERSING SYSTEM, filed June 28, 2012, the entire disclosure of which is incorporated by reference herein discloses various robotic system arrangements that may also be effectively employed. Furthermore, as will be discussed in further detail below, the surgical instrument 7810 depicted in at least some of the accompanying drawings employs a motor for generating control motions for actuating various components and features of the surgical end effector. As the present Detailed Description proceeds, however, those of ordinary skill in the art will appreciate that certain features and advantages of the present invention may also be effectively attained in connection with surgical instruments that are equipped with manually generated (i.e., non-motor generated) actuation and control motions.

[0355] As illustrated in FIGS. 64 and 66, the handle 7822 may comprise a pair of interconnectable housing segments 7824, 7826 that may be interconnected by screws, snap features, adhesive, etc. As used herein, the term "snap feature" includes, but is not limited to, for example, a tab that has a protrusion thereon that is configured to retainingly engage a corresponding mating portion of another component. Such features may be designed to releasably engage the mating portion or it may not be designed or intended to be removed. In the illustrated arrangement, the handle housing segments 7824, 7826 cooperate to form a pistol grip portion 7828 that can be gripped and manipulated by the clinician. As will be discussed in further detail below, the handle 7822 operably supports a plurality of drive systems or control systems therein that are configured to generate and apply various control motions to corresponding component portions of the elongated shaft assembly 7850 that is operably attached to the surgical end effector 7900. In the illustrated embodiment, the surgical end effector 7900 is configured to cut and fasten tissue, for example.

[0356] FIG. 65 illustrates one form of surgical end effector 7900 that may be employed. As can be seen in that Figure, the surgical end effector 7900 may comprise an elongated channel 7902 that is configured to

receive a surgical fastener cartridge 7910 therein. The surgical fastener cartridge 7910 may include a cartridge body 7912 that has a centrally disposed elongated slot 7914 therein. The cartridge body 7912 may further include rows of fastener pockets 7916 that are located on each side of the elongated slot 7914 and which are configured to support corresponding surgical fasteners 7920 therein. The elongated channel 7902 may further operably support a tissue-cutting member or knife assembly 7950 therein that is configured to axially travel in the slot 7914 in the cartridge body 7912 when installed in the elongate channel 7902. The knife assembly 7950 may be configured with a tissue cutting edge 7952 that is centrally disposed between a lower foot 7954 and an upper foot or tab 7956. As will be discussed in further detail below, the knife assembly 7950 is configured to be axially driven within the elongated channel 7902 and the surgical fastener cartridge 7910 in response to motions applied thereto by a firing drive system 8100.

[0357] As can also be seen in FIG. 65, the surgical end effector 7900 may further include an anvil assembly 7930 that is movably supported on the elongate channel 7902. The anvil assembly 7930 may be movable relative to the surgical fastener cartridge 7910, for example, in response to closing and opening motions transferred thereto from a closure drive system 8000. In other arrangements, however, the anvil assembly may be fixed and the surgical fastener cartridge may be configured to move relative to the anvil assembly upon application of closure motions thereto. In one arrangement, for example, the anvil assembly 7930 includes an anvil body portion 7932 that has a fastener forming surface 7934 formed on the underside thereof. The fastener forming surface 7934 may comprise a series of forming pockets (not shown) that correspond to the surgical fasteners 7920 supported in the surgical fastener cartridge 7910. As the legs of the surgical fasteners 7920 are driven into forming contact with the corresponding forming pockets in the anvil assembly 7930, they are formed into a desired tissue-retaining configuration. The anvil assembly 7930 may further include an anvil mounting portion 7936 that has a pair of trunnions 7938 protruding therefrom that are received within corresponding arcuate slots 7906 formed in a proximal mounting portion 7904 of the elongated channel 7902. In various arrangements, the surgical fasteners 7920 are driven out of their respective fastener pockets 7916 in the surgical fastener cartridge 7910 by corresponding sled assemblies 7960 and 7970 that are movably supported within the elongated channel 7902 and are movable in response to firing motions applied thereto by the firing drive system 8100.

[0358] Referring now to FIG. 66, the handle 7822 may further include a frame 7830 that operably supports various components of the closure drive system 8000 and the firing drive system 8100. In at least one form, the closure drive system 8000 may include an actuator in the form of a closure trigger 8002 that is pivotally supported by the frame 7830. The closure trigger 8002 may be pivotally supported by frame 7830 such that when the clinician grips the pistol grip portion 7828 of the handle 7822, the closure trigger 8002 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 8002 may be biased into the unactuated position by spring or other biasing arrangement (not shown). Various details regarding the certain aspects of the

construction and operation of the closure drive system 8000 may be found in U.S. Patent Application Serial No. 13/803,097, filed March 14, 2013, and entitled ARTICULATABLE SURGICAL INSTRUMENT COMPRISING A FIRING DRIVE, the entire disclosure of which is incorporated by reference herein. As discussed in that reference and as shown in FIG. 66 herein, the closure trigger 8002 may be configured to cooperate with a closure release assembly 8020 that is pivotally coupled to the frame 7830. In at least one form, the closure release assembly 8020 may comprise a release button assembly 8022 that may be pivoted in a counterclockwise direction by a release spring (not shown). As the clinician depresses the closure trigger 8002 from its unactuated position towards the pistol grip portion 7828 of the handle 7822, the closure release assembly 8020 serves to lock the closure trigger 8002 in the fully actuated position. When the clinician desires to unlock the closure trigger 8002 to permit it to be biased to the unactuated position, the clinician simply pivots the closure release button assembly 8020 to cause it to disengage the closure trigger arrangement and thereby permit the closure trigger 8002 to pivot back to the unactuated position. Other closure trigger locking and release arrangements may also be employed.

[0359] Referring to FIGS. 66 and 67, the closure drive system 8000 may further comprise a proximal closure tube segment 8010 that has a proximal end 8012 that is adapted to be rotatably coupled to a closure tube attachment yoke 8030. The proximal end 8012 of the proximal closure tube segment 8010 is configured to be received within a cradle 8032 (FIG. 66) in the closure tube attachment yoke 8030 to permit relative rotation relative thereto. The proximal closure tube segment 8010 may be rotatably attached to the closure tube attachment yoke 8030 by a U-shaped connector 8036 that is configured to be received in an annular slot 8014 in the proximal end 8012 of the proximal closure tube segment 8010 and be seated in a slot 8034 (FIG. 66) in the closure tube attachment yoke 8030. Such arrangement serves to rotatably couple the proximal closure tube segment 8010 to the closure tube attachment yoke 8030 such that the proximal closure tube segment 8010 may rotate relative thereto. More specifically, such arrangement facilitates manual rotation of the elongated shaft assembly 7850 relative to the handle 7822 about a longitudinal tool axis "LT-LT" defined by the elongated shaft assembly 7850 to enable the clinician to rotate the surgical end effector 7900 in the manner represented by arrow "R" in FIG. 64.

[0360] In various arrangements, the closure tube attachment yoke 8030 is movably mounted on a proximal articulation tube 8202 of an articulation system 8200 which will be discussed in further detail below. Such arrangement permits the closure tube attachment yoke 8030 to move axially on the proximal articulation tube 8202 in response to actuation of the closure trigger 8002. In particular, the closure tube attachment yoke 8030 may be pivotally coupled to the closure trigger 8002 by a closure linkage bar 8040. See FIG. 66. Thus, when the clinician pivots the closure trigger 8002 inward toward the pistol grip portion 7828 of the handle 7822, the closure tube attachment yoke 8030 will be advanced in the distal direction "DD". When the firing trigger 8002 is returned to the unactuated position, the closure tube attachment yoke 8030 will be advanced proximally (direction "PD") on the proximal articulation tube 8202 to a starting position.

[0361] The closure drive system 8000 may further include an intermediate flexible tube segment 8050 that is configured for attachment to the distal end 8018 of the proximal closure tube segment 8010. As can be seen in FIG. 68, the intermediate tube segment 8050 may include a flexible articulation portion 8060 and an attachment stem portion 8052. The attachment stem portion 8052 may be sized to extend into the open distal end 8018 of the proximal closure tube segment 8010 in frictional engagement therewith. The flexible articulation portion 8060 may be integrally formed with the attachment stem portion 8052 and include an articulation spine 8062 that includes proximal end portions 8064 (only one can be seen in FIG. 5) that are configured to be received in corresponding notches 8019 in the distal end 8018 of the proximal closure tube segment 8010 to prevent relative rotation between the proximal closure tube segment 8010 and the intermediate tube segment 8050. The intermediate tube segment 8050 may be non-rotatably (i.e., attached to prevent relative rotation between these components) attached to the proximal closure tube segment 8010 by, for example, screws, detents, adhesive, etc.

[0362] The closure drive system 8000 may further include a distal closure tube segment 8080 that is configured to axially engage and apply opening and closing motions to the anvil assembly 7930. The distal closure tube segment 8080 may be attached to the distal end of intermediate tube segment 8050 for axial travel therewith. The articulation spine 8062 may further include distal end portions 8066 that are configured to be received in corresponding notches 8084 in the proximal end 8082 of the distal closure tube segment 8080 to prevent relative rotation between the distal closure tube segment 8080 and the intermediate tube segment 8050. See FIG. 68. The proximal end 8082 of the distal closure tube segment 8080 may inwardly extending attachment tabs 8086 that are adapted to be bent into corresponding notches 8067 in the intermediate tube segment 8050. See FIG. 68. Such arrangement serves to facilitate attachment of the distal closure tube segment 8080 to the intermediate tube segment 8050 for axial travel therewith.

[0363] The distal closure tube segment 8080 is configured to apply opening and closing motions to the anvil assembly 7930. As can be seen in FIG. 70, one form of the anvil mounting portion 7936 may be formed with a groove 7940 that defines an anvil tab 7942. As can be seen in FIGS. 69 and 71, the distal end 8088 of the distal closure tube segment 8080 has an inwardly extending actuation tab 8090 formed therein that is configured to interact with the anvil tab 7942. For example, when the distal closure tube segment 8080 is in the open position (FIGS. 69 and 71), the actuation tab 8090 is in biasing contact with the anvil tab 7942 which serves to pivot the anvil assembly 7930 to the open position. As shown in FIG. 72, when the anvil assembly 7930 is in an open position, the trunnions 7938 are located in the bottom of the trunnion slots 7906 in the proximal mounting portion 7904 of the elongated channel 7902. When the distal closure tube segment 8080 is advanced distally, the distal end 8088 contacts an upstanding end wall 7944 on the anvil body 7932 to cause the anvil assembly 7930 to pivot or otherwise move toward the surgical fastener cartridge 7910. When assembled, the trunnions 7938 each extend into a corresponding opening 8092 in the distal closure tube segment 8080. See FIG. 69.

[0364] Operation of the closure drive system 8000 will now be described. The anvil assembly 7930 may be moved relative to the surgical fastener cartridge 7910 by pivoting the closure trigger toward and away from the pistol grip portion 7828 of the handle 7822. Thus, actuating the closure trigger 8002 causes the proximal closure tube segment 8010, the intermediate tube segment 8050 and the distal closure tube segment 8080 to move axially in the distal direction "DD" to contact the end wall 7944 of the anvil body portion 7932 to pivot or otherwise move the anvil 7930 toward the surgical fastener cartridge 7910. The clinician may grasp and manipulate tissue between the anvil assembly 7930 and the fastener cartridge 7910 by opening and closing the anvil assembly 7930. Once the target tissue is captured between the anvil assembly 7930 and fastener cartridge 7910, the clinician may pivot the closure trigger 8002 to the fully actuated position wherein it is locked in place for firing.

[0365] As indicated above, the frame 7830 may also be configured to operably support the firing drive system 8100 that is configured to apply firing motions to corresponding portions of the elongated shaft assembly 7850 and ultimately to the knife assembly 7950 and the sled assemblies 7960, 7970. As can be seen in FIGS. 64 and 73, the firing drive system 8100 may employ an electric motor 8102 that is supported in the pistol grip portion 7828 of the handle 7022. In various forms, the motor 8102 may be a DC brushed driving motor having a maximum rotation of, approximately, 25,000 RPM, for example. In other arrangements, the motor 10302 may include a brushless motor, a cordless motor, a synchronous motor, a stepper motor, or any other suitable electric motor. A battery 8104 (or "power source" or "power pack"), such as a Li ion battery, for example, may be coupled to the handle 10022 to supply power to a control circuit board assembly 8106 and ultimately to the motor 8102. FIG. 66 illustrates a battery pack housing 8105 that is configured to be releasably mounted to the handle 7822 for supplying control power to the surgical instrument 7810. A number of battery cells connected in series may be used as the power source to power the motor 8102. In addition, the power source may be replaceable and/or rechargeable.

[0366] As outlined above with respect to other various forms, the electric motor 8102 can include a rotatable shaft 8108 that operably interfaces with a gear reducer assembly 8110 that is mounted in meshing engagement with a with a set, or rack, of drive teeth 8122 on a longitudinally-movable drive member 8120. The gear reducer assembly 8110 can include, among other things, a housing 8112 and an output pinion gear 8114. See FIG. 10. In certain embodiments, the output pinion gear 8114 can be directly operably engaged with the longitudinally-movable drive member 8120 or, alternatively, operably engaged with the drive member 8120 via one or more intermediate gears 8116. The intermediate gear, in at least one such embodiment, can be meshingly engaged with the set, or rack, of drive teeth 8122 defined in the drive member 8120. In use, the electric motor 8102 can move the drive member distally, indicated by an arrow "DD", and/or proximally, indicated by an arrow "PD", depending on the direction in which the electric motor 8102 rotates the intermediate gear. In use, a voltage polarity provided by the battery can operate the electric motor 8102 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 8102 in a counter-clockwise direction. When the electric motor 8102 is rotated in one direction, the drive member 8120 will be axially driven in the distal direction "DD". When the motor 8102 is driven in the opposite rotary direction, the drive member 8120 will be axially driven in a proximal direction "PD". The handle 7822 can include a switch which can be configured to reverse the polarity applied to the electric motor 8102 by the battery. The handle 7822 can also include a sensor that is configured to detect the position of the movable drive member 8120 and/or the direction in which the movable drive member 8120 is being moved.

[0367] Actuation of the motor 8102 can be controlled by a firing trigger 8130 that is pivotally supported on the handle 7822. The firing trigger 8130 may be pivoted between an unactuated position and an actuated position. The firing trigger 8130 may be biased into the unactuated position by a spring (not shown) or other biasing arrangement such that when the clinician releases the firing trigger 8130, it may be pivoted or otherwise returned to the unactuated position by the spring or biasing arrangement. In at least one form, the firing trigger 8130 can be positioned "outboard" of the closure trigger 8002 as discussed in further detail in U.S. Patent Application Serial No. 13/803,097 which has been previously incorporated by reference in its entirety herein. In at least one form, a firing trigger safety button 8132 may be pivotally mounted to the closure trigger 8002. The safety button 8132 may be positioned between the firing trigger 8130 and the closure trigger 8002 and have a pivot arm (not shown) protruding therefrom. When the closure trigger 8002 is in the unactuated position, the safety button 8132 is contained in the handle housing where the clinician cannot readily access it and move it between a safety position preventing actuation of the firing trigger 8130 and a firing position wherein the firing trigger 8130 may be fired. As the clinician depresses the closure trigger 8002, the safety button 8132 and the firing trigger 8130 pivot down to a position wherein they can then be manipulated by the clinician.

[0368] As indicated above, in at least one form, the longitudinally movable drive member 8120 has a rack of teeth 8122 formed thereon for meshing engagement with a corresponding drive gear of the gear reducer assembly 8110. At least one form may also include a manually-actuatable "bailout" assembly that is configured to enable the clinician to manually retract the longitudinally movable drive member 8120 should the motor become disabled. U.S. Patent Application Serial No. 13/803,097 contains further details of one form of bailout assembly that may be employed. U.S. Patent Application Publication No. US 2010/0089970 also 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, and filed on October 10, 2008, now U.S. Patent Application Publication No. 2010/0089970, is incorporated by reference in its entirety herein.

[0369] Referring to FIGS. 67 and 68, various forms of the elongated shaft assembly 7850 may include a firing member assembly 7860 that is supported for axial travel within an articulation shaft assembly 8230

that is part of the articulation system 8200 and which essentially functions as shaft frame or spine. The firing member assembly 7860 may further include a proximal firing shaft 7862 that has a proximal end portion 7864 that is configured to be rotatably received in a distal cradle 8126 provided in a distal end 8124 of the movable drive member 8120. Such arrangement permits the proximal firing shaft 7862 to rotate relative to the movable drive member 8120 while also axially moving therewith. The proximal firing shaft 7862 may further have a slot 7868 formed in its distal end 7866 for receiving a proximal end 7872 of a flexible distal firing shaft assembly 7870 therein. See FIG. 68. As can be seen in that Figure, the proximal end 7872 of the distal firing shaft assembly 7870 may be received within the slot 7868 in the distal firing shaft 7862 and may be pinned thereto with a pin 7873.

[0370] The distal firing shaft assembly 7870 may include a central firing beam 7874 that is located between a right sled pusher beam 7876 and a left sled pusher beam 7878. The central firing beam 7874 and the pusher beams 7876, 7878 may, for example, each be fabricated from metal that facilitates axial actuation of the sled assemblies 7960, 7970 in the surgical end effector 7900 while also facilitating flexing thereof when the end effector 7900 is articulated as will be discussed in further detail below. In at least one arrangement, the central pusher beam 7874, the right sled pusher beam 7876 and the left sled pusher beam 7878 may extend through a slot 7946 in the anvil mounting portion 7936. The right sled pusher beam 7876 corresponds to the right sled assembly 7960 and the left sled pusher beam 7878 corresponds to the left sled assembly 7970 movably supported within the elongated channel 7902. Axial movement of the right sled pusher beam 7876 and the left sled pusher beam 7878 will result in the axial advancement of the right and left sled assemblies 7960, 7970, respectively, within the elongated channel 7902. As the right sled assembly 7960 is axially advanced within the elongated channel 7902, it drives the surgical fasteners 7920 supported in the cartridge body 7912 on the right side of the slot 7914 out of their respective pockets 7916 and as the left sled assembly 7970 is axially advanced within the elongated channel 7902, it drives the surgical fasteners 7920 supported within the cartridge body 7912 on the left side of the slot 7914 out of their respective pockets 7916.

[0371] The central firing beam 7874 has a distal end 7880 that may be configured to be received within a slot 7951 provided in the knife assembly 7954 and retained therein by, for example, a frictional fit, adhesive, welding, etc. A bottom window 7905 may be formed in a distal end 7903 of the elongated channel 7902 to enable the knife assembly 7950 to be inserted therethrough. In at least one form, the elongated channel 7902 is formed with a right upstanding wall 7907 and a left upstanding wall 7908 that define a centrally-disposed channel slot 7909. Once the knife assembly 7950 is inserted into the bottom window 7905 in the elongated channel 7902, the body portion 7951 of the knife assembly 7950 may be inserted into the channel slot 7909 and advanced proximally in the elongated channel 7902 to be coupled with the distal end 7980 of the central firing beam 7874. A lower channel cover 7911 may be attached to the bottom of the elongated channel 7902

to prevent tissue, body fluids, etc. from entering into the elongated channel 7902 which might hamper the movement of the knife assembly 7950 therein.

[0372] In one form, the anvil assembly 7930 may be installed onto the elongate channel 7902 as follows. To commence the installation process, the anvil assembly 7930 is positioned over the elongated channel 7902 such that the trunnions 7938 may be inserted into notches 7913 in the proximal mounting portion 7904 of the elongated channel 7902 which enable the trunnions 7938 to enter the corresponding trunnion slots 7906 in the elongated channel 7902. See FIG. 65. This installation may be performed before the distal closure tube segment 8080 has been attached to the intermediate tube segment 8050 or after the distal closure tube segment 8080 has been moved sufficiently proximally to permit the anvil to be so positioned. Once the trunnions 8038 are received within their respective trunnion slots 7906, the distal closure tube segment 8080 may be moved to the position shown in FIGS. 71 and 72 wherein the distal closure tube segment 8080 retains the trunnions 7938 in their respective trunnion slots 7906 and the actuation tab 8090 is in biasing contact with the anvil tab 7942 which serves to pivot the anvil assembly 7930 to the open position. When in that position, each trunnion 7938 protrudes into a corresponding opening 8092 in the distal closure tube segment 8080. See FIG. 69. As shown in FIGS. 65 and 71, when the anvil assembly 7930 is in an open position, the upper end of the knife assembly 7950 enters a window 7933 in the anvil body portion 7932. Such window 7933 provides clearance for the anvil assembly 7930 to be moved to the closed positions while the knife assembly 7950 remains in the unactuated position. Once the anvil assembly 7930 has been installed with the knife assembly 7950 in place, an anvil cover 7935 may be attached to the anvil body 7934 to prevent tissue, body fluids, etc. from entering into the anvil body 7934 which might hamper the movement of the knife assembly 7950 therein. As the knife assembly 7950 is advanced distally in the end effector 7900, the upper tab 7956 of the knife assembly 7950 engages ledges in the anvil body and the lower foot 7954 engages portions 7915 of the elongated channel 7902 and serves to retain the anvil assembly 7930 in the closed position and essentially maintain the spacing between the anvil assembly 7930 and the fastener cartridge 7910.

[0373] FIGS. 70A and 70B illustrate an alternative distal closure tube arrangement 8080' that may work with an anvil assembly 7930' that may be substantially identical to anvil assembly 7930 except that anvil assembly 7930' lacks an anvil tab. In such an arrangement, for example, each trunnion 7938 extends into a corresponding opening 8092' in the distal closure tube segment 8080'. The distal closure tube segment 8080' further includes an inwardly extending gill tab 8094 that protrudes inward for contact with the corresponding anvil trunnion 7938. When the distal closure tube segment 8080' is drawn in the proximal direction "PD", each gill tab 8094 contacts the corresponding trunnion 7938 to cause the trunnion to move downwardly in its corresponding trunnion slot 7906 in the elongated channel 7902 to pivot or otherwise move the anvil assembly 7930' into open positions. FIG. 70C illustrates yet another distal closure tube

arrangement 8080" wherein the actuation tab is formed by an indentation 8090" in the distal closure tube segment 8080" for interaction with the anvil tab 7942 in the above-described manner.

[0374] FIG. 70D illustrates an alternative anvil assembly 7930" wherein the anvil tab 7942' is removably attached to the anvil mounting portion 7936. In one arrangement for example, the anvil tab 7942' is configured with a snap tab 7943 arranged to retainingly engage an opening 7941 in the anvil mounting portion 7936. The anvil assembly 7930" may otherwise be the same as anvil assembly 7930 described above and be opened and closed in similar manners by the distal closure tube segment 8080. FIG. 70E illustrates yet another anvil assembly 7930" wherein the anvil tab is formed by a screw 7948 that is removably attachable to the anvil mounting portion 7936. Such removable anvil tab/screw arrangements may facilitate ease of installation of the anvil assembly 7930".

[0375] Referring to FIGS. 67 and 68, one form of articulation system 8200 includes an articulation shaft assembly 8230 that may be operably controlled by an articulation control system 8260. In one form, for example, the articulation shaft assembly 8230 may include a right articulation shaft segment 8240 and a left articulation shaft segment 8250. The right articulation shaft segment 8240 includes a proximal end 8242 that has a right passage segment 8244 formed therein. Likewise the left articulation shaft segment 8250 includes a proximal end portion 8252 that has a left passage segment 8254 formed therein. When the right articulation shaft segment 8240 and the left articulation shaft segment 8250 are installed within the proximal closure tube segment 8010, they form the articulation shaft assembly 8230. The right passage segment 8244 and the left passage segment 8254 cooperate to receive a portion of the proximal firing shaft 7862 therein. The right articulation shaft segment 8240 and the left articulation shaft segment 8250 may be, for example, composed of a plastic, especially a glass fiber-reinforced amorphous polyamide, sold commercially under the trade name Grivory GV-6H by EMS-American Grilon.

[0376] In various arrangements, for example, the articulation control system 8260 may include a nozzle assembly 8262 that is supported for rotational travel relative to the handle 7822. As can be seen in FIG. 67, the nozzle assembly 8262 may comprise an upper nozzle segment 8264 and a lower nozzle segment 8266 that are attached together by a series of fasteners (e.g., screws) 8268. The upper nozzle segment 8264 may be configured to rotatably support an articulation control knob 8270 thereon. In one arrangement, for example, the articulation control knob 8270 extends through an opening (not shown) in the upper nozzle segment 8264 and is coupled to an articulation gear member 8272 by screws 8274. The articulation gear member 8272 may include articulation spur gear 8276 that extends into an opening 8016 in the proximal end portion 8012 of the proximal closure tube segment 8010. As can be further seen in FIG. 67, the articulation system 8200 further includes a right actuation tube adapter 8278 and a left articulation tube adapter 8280. The right articulation tube adapter 8278 has a right recess 8279 formed therein that is adapted to receive a right adapter lug 8246 formed on the proximal end 8242 of the right articulation shaft segment 8240. Likewise, the left articulation tube adapter 8280 includes a left recess 8282 that is adapted to engage a left

adapter lug 8256 formed on the proximal end 8252 of the left articulation shaft segment 8250. The right articulation tube adapter 8278 further has a series of right articulation drive gears 8281 that are configured for meshing engagement with the articulation spur gear 8276. The left articulation tube adapter 8280 has a series of left articulation drive gears 8284 formed therein that are adapted to intermesh with the articulation spur gear 8276. Thus, when the articulation control knob 8270 is rotated about a control axis CA-CA that is transverse to the longitudinal tool axis LT-LT relative to the handle 7822 (FIG. 64), the left articulation shaft segment 8250 is, for example, driven axially in the distal direction "DD" within the proximal closure tube segment 8010 and the right articulation shaft segment 8240 is simultaneously axially driven in the proximal direction "PD".

[0377] Still referring to FIG. 68, the articulation shaft assembly 8230 may further include a right articulation band 8290 and a left articulation band 8300. In one form, a proximal end portion 8292 of the right articulation band 8290 may be attached to a distal portion 8248 of the right articulation shaft segment such that a distal portion 8294 of the right articulation band 8290 protrudes out of a right passage 8249 therein. The proximal end portion 8292 of the right articulation band 8290 may include holes or cavities 8293 that are configured to receive corresponding lugs (not shown) in the right articulation shaft segment 8240 to facilitate attachment of the right articulation band 8290 to the right articulation shaft segment 8240. Likewise, a proximal end portion 8302 of the left articulation band 8300 may have holes or cavities 8303 therein that are configured to receive lugs (not shown) in the distal portion 8258 of the left articulation shaft segment 8250 to facilitate attachment of the left articulation band 8300 to the articulation shaft segment 8250. The articulation bands 8290 and 8300 may be composed of a metal, advantageously full hard 301 stainless steel or its equivalent.

[0378] Referring now to FIGS. 75-78, as was briefly discussed above, the intermediate tube segment 8050 may have an attachment stem portion 8052 and a flexible articulation portion 8060. In various arrangements, the intermediate tube segment 8050 may be fabricated from, for example, rigid thermoplastic polyurethane sold commercially as ISOPLAST grade 2510 by the Dow Chemical Company and include a centrally disposed, vertically-extending articulation spine 8062. The articulation spine 8062 includes a proximal spine end 8064 and a distal spine end 8066 that facilitate attachment to the proximal closure tube segment 8010 and the distal closure tube segment 8080, respectively as was discussed above. The articulation spine 8062 further includes a centrally disposed component or knife slot 8070 for facilitating the passage of various control components therethrough. In the illustrated arrangement, the slot 8070 movably supports the central firing beam 7874, the right pusher beam 7876 and the left pusher beam 7878. In various forms, the centrally disposed slot 8070 is substantially enclosed to retard or prevent infiltration of body fluids and tissue therein which might otherwise hamper the movement of the control components operably passing therethrough.

[0379] As can be most particularly seen in FIG. 78, the flexible articulation portion 8060 further includes a plurality of right ribs 8310 and a plurality of left ribs 8320 that may be integrally-formed with, and laterally

protrude from, the articulation spine 8062. In various forms, for example, each right rib 8310 may comprise a rib body portion 8312 that is spaced from the articulation spine 8062 by a corresponding right rib neck portion 8316. Likewise, each left rib 8320 may comprise a left rib body portion 8322 that is spaced from the articulation spine 8062 by a left rib neck portion 8326. As can be seen in FIG. 76, the left and right rib body portions 8312, 8322 have an arcuate shape to provide the flexible articulation portion 8060 of the intermediate tube segment 8050 with a substantially-circular cross-sectional shape. Such shape may facilitate easy passage of the intermediate tube segment 8050 through a circular passage such as, for example, an appropriately sized trocar.

[0380] In various arrangements, each of the right rib neck portions 8016 serves to define a right articulation passage 8318 for movably receiving the right articulation band 8290 therethrough. The right articulation band 8290 may extend through the right articulation passage 8318 and be coupled to the proximal mounting portion 7904 of the elongate channel 7902. For example, the distal end 8294 of the right articulation band 8290 may have a right hook portion 8296 that is adapted to be coupled to a right attachment portion 8297 of the elongated channel 7902. See FIG. 65. Similarly, each of the left rib neck portions 8326 serves to define a left articulation passage 8328 for movably receiving the left articulation band 8300 therethrough. The left articulation band 8300 may extend through the left articulation passage 8328 and be coupled to the proximal mounting portion 7904 of the elongated channel 7902. For example, the distal end 8304 of the left articulation band 8300 may have a left hook portion 8306 that is adapted to be coupled to a left attachment portion 8307 of the elongated channel 7902.

[0381] One method of operating the articulation system 8200 will now be described. When the clinician wishes to articulate the end effector 7900 to the right relative to the longitudinal tool axis LT-LT (the right direction is represented by arrow "RD" in FIG. 78), the clinician simply rotates the articulation control knob 8270 in the appropriate direction. For example, turning the control knob 8270 in a clockwise direction (when viewed from above) causes the left articulation band to be pushed in the distal direction "DD" and the right articulation band 8290 is drawn in the proximal direction "PD" which serve to apply an articulation motion to the elongated channel 102. As the articulation motion is applied to the elongated channel 7902, the flexible articulation portion 8060 flexes to accommodate the movement of the surgical end effector 7900 in the "right" direction. Conversely, if the clinician wishes to articulate the end effector 7900 in the left direction "LD", the clinician simply rotates the control knob 8270 in a counterclockwise direction which causes the right articulation band 8290 to be pushed in the distal direction "DD" and the left articulation band 8300 to be drawn in the proximal "PD" direction thereby causing the surgical end effector 7900 to move to the left. The end effector 7900 may also be articulated by a robotic system (not shown) that is configured to apply control motions to the articulation bands 8290, 8300.

[0382] Upon application of the above-described articulation motions to the surgical end effector 7900, it may be desirable to avoid twisting or torquing the flexible articulation portion 8060 of the intermediate tube

segment 8050. If such torque or twisting were to occur, the possibility exists for hampering or, in instances of severe twisting, completely jamming the operation of the central firing beam 7874 and the right and left sled pusher beams 7876, 7878. To avoid this problem, the right and left ribs 8310, 8320 may be uniquely configured to prevent twisting between the ribs.

[0383] In at least one arrangement, for example, each rib body 8312 has lateral ends that are arranged in spaced, confronting relationship with the lateral ends of the rib bodies of adjacent ribs. Referring again to FIG. 78, for example, the rib body 8312 of each right rib 8310 has a first right lateral end 8313 and a second right lateral end 8314. With the exception of the proximal-most right rib 8310P and the distal-most right rib 8310D, the first right lateral end 8313 of one right rib 8310 is in confronting relationship with the second right lateral end 8314 of an adjacent right rib 8310. When the flexible articulation portion 8060 of the intermediate tube segment 8050 is unarticulated (e.g., the flexible articulation portion 8060 is substantially axially aligned on the longitudinal tool axis LT-LT), the first right lateral end 8313 of each right ribs 8310 is spaced from the second right lateral end 8314 of the adjacent right rib 8310 by a right rib space 8315. In the arrangement depicted in FIG. 78, for example, all of the right rib spaces 8315 have substantially the same space width "SWR". Likewise, the rib body 8322 of each left rib 8320 has a first left lateral end 8323 and a second left lateral end 8324. With the exception of the proximal-most left rib 8320P and the distal most left rib 8320D, the first left lateral end 8323 of one left rib 8320 is in confronting relationship with the second left lateral end 8324 of an adjacent left rib 8320. When the flexible articulation portion 8060 of the intermediate tube segment 8050 is unarticulated, the first left lateral end 8323 of each left rib 8320 is spaced from the second left lateral end 8324 of the adjacent left rib 8320 by a left rib space 8325. In the arrangement depicted in FIG. 78, for example, all of the left rib spaces 8325 have substantially the same space width "SWL". In at least one form, the right rib space widths SWR are substantially the same as the left rib space widths SWL. However, the right and left rib space widths may differ from each other.

[0384] Still referring to FIG. 78, each rib may be provided with a twist-preventing configuration, generally designated as 8330. In at least one arrangement, for example, an anti-twist protrusion 8332 may be formed on each of the first right lateral ends 8313 of the right rib bodies 8312 and on each of the first left lateral ends 8323 of each of the left rib bodies 8322. Each anti-twist protrusion 8332 corresponds with a substantially complementary-shaped recces 8334 formed in the rib that is immediately adjacent and in confronting relationship therewith. FIG. 77 illustrates this arrangement on the left ribs 8320. In at least one arrangement, the right ribs 8310 employ an identical configuration. In at least one form, the protrusions 8332 may be substantially aligned along a lateral axis. That is, the protrusions 8332 formed on the right ribs 8310 may be substantially aligned along a right lateral axis RLA-RLA on the right side of the articulation spine 8062 and the protrusions 8332 formed on the left ribs 8320 may be substantially aligned on the left side of the articulation spine 8062 along a left lateral axis LLA-LLA. When the flexible portion 8060 is unarticulated, the right lateral axis RLA-RLA, the left lateral axis LLA-LLA and the longitudinal tool axis LT-LT may be

substantially parallel to each other. As can be see in FIG. 78, the right lateral axis RLA-RLA and the left lateral axis LLA-LLA are spaced from the longitudinal tool axis LT-LT.

[0385] As the flexible articulation portion 8060 is articulated in the right direction "RD", at least some of the protrusions 8332 on the right ribs 8310 will frictionally engage a portion of a corresponding recess 8332 in an adjacent right rib 8310 to prevent the flexible portion 8060 from twisting. Similarly, as the flexible articulation portion 8060 is articulated in the left direction "LD", at least some of the protrusions 8332 on the left ribs 8320 will engage a portion of the recess 8332 in an adjacent left rib 8320 in a "twist-preventing orientation" to prevent the flexible portion 8060 from twisting. This engagement/orientation between the protrusion 8332 and the bottom of the cavity 8334 in an adjacent left rib 8320, for example, is illustrated in FIG. 79. As can be seen in that Figure, in that example, the first left lateral end 8323 of one of the second rib 8320 is in abutting contact with the second left lateral end 8324 of an adjacent left rib 8320 to thereby prevent or retard twisting of the flexible portion 8060 of the intermediate tube segment 8050.

[0386] Various alternative anti-twist arrangements are also contemplated. For example, the anti-twist features may not provided on, for example, the proximal-most four ribs. In still other arrangements, the anti-twist features may be provided in a plurality of ribs comprising a central area of the flexible segment, but not in the proximal-most and distal most ribs. In, other arrangements, the ant-twist features may be employed on every other pair of ribs along the length of the flexible segment. For example, the proximal-most pair of adjacent ribs may have anti-twist features, then the next rib or ribs (distal to those ribs) may not have anti-twist features and the next ribs (distal thereto) may have the anti-twist features and so on. These alternative arrangements may be applied only to the ribs on one side of the articulation spine or they may be employed on the ribs on both sides of the articulation spine. By altering the number, location and/or spacing of the ribs with the anti-twist features, as well as the space widths between the ribs (with and without anti-twist features), as well as the geometric shape of the articulation spine, one can advantageously adjust the overall flexibility of the flexible segment, its degree of articulation, its degree of stiffness and its rate of articulation.

[0387] Referring to FIGS. 75 and 76, in the illustrated arrangement, the articulation spine 8062 is elongated and has a height, generally designated as "H". In at least one arrangement, the height "H" is substantially consistent for the length "L" of the articulation spine 8062. In addition, the articulation spine 8062 may decreasingly taper from the proximal end portion 8064 to the distal end portion 8066. More specifically, as can be seen in FIG. 75, the proximal end portion 8064 has a proximal width "PW" and the distal end portion 266 has a distal width "DW". In the illustrated embodiment, the "PW" is greater than the distal width "DW" and the width of the articulation spine 8062 gradually tapers in width (as opposed to height) from the proximal end 8064 to the distal end 8066 along length "L". Such tapered articulation spine arrangement further serves to retard twisting during articulation of the surgical end effector while facilitating increased articulation of the distal end of the flexible portion 8060 relative to the proximal end of the flexible portion

8060 and while facilitating movable passage of various control components (e.g., central firing beam 7874, right sled pusher beam 7876, left sled pusher beam 7878, etc.) therethrough.

[0388] Further, in one arrangement, when the flexible portion 8060 is in an unarticulated or flexed position, all of the right rib spaces 8315 and left rib spaces 8325 have the same starting width. Thus, in that configuration, SWR=SWL. FIGS. 80 and 81 illustrate another intermediate tube segment 8050' that may be substantially identical to the intermediate tube segment 8050 described above, except that the right rib spaces 8315 and the left rib spaces 8325 decrease in magnitude going from the proximal end of the flexible articulation portion 8060' to the distal end of the flexible articulation portion 8060'. That is, the proximal-most right rib space 8315P' is the widest right rib space and the distal most right rib space 8315D' is the narrowest right rib space with the right rib spaces 8315' getting successively narrower going in the distal direction "DD". Similarly, the proximal-most left rib space 8325P' is the widest left rib space and the distal-most left rib space 8325D' is the narrowest left rib space with the left rib spaces 8325' getting successively narrower going in the distal direction. In such arrangement, when the articulation motion is applied to the surgical end effector, the flexible portion 8060 will have a faster rate of flexure at its distal end. That is, a distal portion of flexible segment 8060' will flex or articulate at a rate that is greater than a rate at which another portion of 8060' that is proximal to that distal segment will articulate upon application of an articulation motion to the end effector. Stated another way, relative movement between the ribs on the distal end will stop before the relative movement between the more proximal ribs stops because the spaces between the distal ribs are smaller than the spaces between the proximal ribs. In the illustrated arrangement the widths of the right and left rib spaces 8315' and 8325' that are laterally aligned with each other may be equal in magnitude. Such rib space width arrangements may enable the flexible articulation portion 8060' to assume a substantial "U"- shape if desired. See e.g., FIG. 82. It will be understood, however, that various other slot width arrangements, sizes and configurations may be employed to achieve a desired amount/range of articulation while preventing the intermediate tube from inadvertently twisting about the longitudinal tool axis.

[0389] FIG. 83 depicts another surgical instrument 8410 that is capable of practicing several unique benefits of the present invention. The surgical instrument 8410 is designed to manipulate and/or actuate various forms and sizes of end effectors 8412 that are operably attached to an elongated shaft assembly 8500 of the surgical instrument. In the depicted embodiment, for example, the end effector 8412 comprises a surgical stapling device that has openable and closable jaws 8413 and 8415. More specifically, the end effector 8412 includes an elongated channel 8414 that forms a lower jaw 8413 of the end effector 8412. See FIG. 84. In the illustrated arrangement, the elongated channel 8414 is configured to operably support a staple cartridge 8430 and also movably supports an anvil 8420 that functions as an upper jaw 8415 of the end effector 8412.

[0390] Referring now to FIGS. 84 and 85, the anvil 8420 may have a mounting portion 8422 that protrudes from its proximal end 8421. The mounting portion 8422 may have lateral mounting holes 8424 therethrough that enable the mounting portion 8422 to be pivotally pinned to an upstanding pivot boss 8417 formed in the elongated channel 8414 by an anvil pin 8418. The anvil 8420 may be selectively "moved" towards the surgical staple cartridge 8430 mounted in the elongated channel 8414 by axially advancing a distal closure tub segment 8590 in the distal direction "DD" as will be discussed in further detail below. In various implementations, for example, a first anvil actuation member in the form of an anvil camming pin 8419 may extend through a camming slot 8423 provided in the anvil mounting portion 8422. The camming pin 8419 is mounted in holes 8591 provided in the distal closure tube segment 8590 such that movement of the distal closure tube segment 8590 in the distal and proximal directions will result in the movement of the camming pin 8419 in the camming slot 8423. In addition, the distal closure tube segment 8590 may further include a second anvil actuation member in the form of, for example, an actuation pin 8593 that is positioned to interact with an angled actuation surface 8425 formed on the proximal end of the anvil mounting portion 8522. FIGS. 89-91 illustrate the anvil 8420 in a first or open position. The anvil 8420 may be moved to a closed position by moving the distal closure tube segment 8590 in the distal direction "DD". Movement of the distal closure tube segment 18590 in the distal direction "DD" causes the first camming pin 8419 to move within the camming slot 8423 in the anvil mounting portion 8422 which thereby causes the anvil 8420 to pivot about the anvil pin 8418 to the closed position as illustrated in FIGS. 86-88. To return the anvil 10020 to the open position (FIGS. 89-91), the distal closure tube segment 8590 is moved in the proximal direction "PD" which causes the first camming pin 8419 to move in the camming slot 8423 in an opposite direction and cam the anvil 8420 to the open position. Such closure tube arrangement differs from prior closure tube arrangements wherein the distal end of the closure tube segment is configured to contact the anvil and pivot it to a closed position. Use of the present camming pin arrangements does not require use of an anvil that has a more robust portion configured for actuation contact with the closure tube segment.

[0391] In various arrangements, the end effector 8412 may be configured to be selectively articulated about a longitudinal tool axis LT-LT that is defined by the elongated shaft assembly 8500. For example, the elongated shaft assembly 8500 may include a flexible neck assembly 8510 that enables the end effector 8412 to articulate in a first direction "FD" that is essentially the same direction that the anvil 8420 moves in when the anvil 8420 is moved from an open position to a closed position (hereinafter referred to as the anvil closing direction "CD"). See FIGS. 86 and 90. The flexible neck assembly 8510 will further facilitate articulation of the end effector 8412 in a second articulation direction "SD" that is essentially the same as the direction that the anvil moves from a closed position to an open position (hereinafter referred to the anvil opening direction "OD"). See FIGS. 86, 89 and 90.

[0392] Various flexible neck assemblies are disclosed in U.S. Provisional Patent Application Serial No. 61/386,117, entitled ARTICULATING SURGICAL DEVICE, and filed September 24, 2010, the entire

disclosure of which is herein incorporated by reference. Other flexible neck assemblies are disclosed in U.S. Patent Application Publication No. 2012/0074200, entitled SURGICAL INSTRUMENT WITH SELECTIVELY ARTICULATABLE END EFFECTOR, and filed September 23, 2011, the entire disclosure of which is hereby incorporated by reference herein. The flexible neck assembly 110 may, for example, be composed of rigid thermoplastic polyurethane sold commercially as ISOPLAST grade 2510 by the Dow Chemical Company. The flexible neck assembly 8510 may have a flexible neck segment 8511 that comprises a first or upper flexible neck portion 8512 and a second or lower flexible neck portion 8514. These neck portions 8512, 8514 may be separated by a longitudinal rib portion 8516. The neck portions 8512, 8514 may each have a plurality of neck ribs 8518 that are configured essentially as semi-circular disks which together generally form a cylindrical configuration. An upper slot 8520 extends through each of the neck ribs 8518 of the first or upper flexible neck portion 8512 to form a passage through the first flexible neck portion 8512 for receiving a first flexible transmission band assembly 8550 therethrough. Similarly, a lower slot 8521 extends through each of the neck ribs 8518 in the second or lower flexible neck portion 8514 to form a passage for receiving a second flexible transmission band assembly 8570 therethrough. See, for example, FIG. 86. The flexible neck assembly 8510 may include guide surfaces 8524 (only one can be seen in FIG. 92) that extend proximally from the flexible neck segment 8511 for supporting the reciprocating movement of the flexible transmission band assemblies 8550, 8570.

[0393] As can be seen in FIG. 92, the first or upper transmission band assembly 8550 may include a first transmission band 8552 and the second transmission band assembly 8570 may include a second transmission band 8572. In addition, the first transmission band 8550 may have a first elongated structural portion 8554 and the second transmission band 8570 may have a second elongated structural portion 8574. When the first and second transmission bands 8550, 8570 are brought into contact with each other during assembly of the instrument, they form an elongated cylinder which has a longitudinal cavity 8560 extending concentrically through it to operably receive a firing rod 10530 therethrough. See FIGS. 93 and 94. The first structural portion 8554 of the first transmission band 8552 has a first articulation rack 8556 formed thereon and the second structural portion 8574 of the second transmission band 8572 has a second articulation rack 8576 formed thereon which, as will be discussed in further detail below, drivingly interface with an articulation transmission assembly 8600.

[0394] Referring again to FIG. 92, the first transmission band 8552 may have a first exterior reinforcement band portion 8557 that extends distally from the first structural portion 8554. Likewise, the second transmission band 8572 may have a second exterior reinforcement band portion 8577 that extends distally from the second structural portion 8576. Each exterior reinforcement band portion 8557, 8577 may have a plurality of attachment lugs 8562 for securing first and second interior articulation bands 8558, 8578 thereto. For example, the first transmission band 8552 has a first interior articulation band 8558 attached thereto and the second transmission band 8572 has a second interior articulation band 8578 attached thereto. The first

and second transmission bands 8552, 8572 may be composed of a plastic, especially a glass fiber-reinforced amorphous polyamide, sold commercially under the trade name Grivory GV-6H by EMS-American Grilon. In contrast, the interior articulation bands 8558, 8578 of the transmission band assembly may be composed of a metal, advantageously full hard 301 stainless steel or its equivalent. The attachment lugs 8562 on the exterior reinforcement band portions 8557, 8577 of the transmission bands 8552, 8572, respectively, are received into and secured within a plurality of lug holes 8564 on the corresponding interior articulation band 8558, 8578. See FIG. 92.

[0395] In at least one implementation, the proximal end of the elongated cartridge channel 8414 is provided with a pair of upper and lower band connector ears 8450. See FIGS. 84 and 86-88. These band connector ears 8450 are inserted into and through connector loops 8559, 8579 on the distal end of the interior articulation bands 8558, 8578, respectively. In this manner, the cartridge channel 8414 is coupled to the interior articulation bands 8558, 8578 of the flexible neck assembly 8510. Specifically, the reciprocation of the first and second flexible transmission band assemblies 8550, 8570 in opposite directions causes the interior articulation bands 8558, 8578 received in the upper and lower slots 8520, 8521 on the flexible neck segment 8511 to reciprocate in a like manner. Upon reciprocation of the interior articulation bands 8558, 8578, in particular when the first band 8558 is moved proximally in tandem with the second band 8578 moving distally, the first and second flexible neck portions 8514, 8516 bend as the neck ribs 8518 of the first flexible neck portion 8514 move toward each other and the neck ribs 8518 of the second flexible neck rib portion 8516 concurrently move away from each other. The coupling of the interior articulation bands 8558, 8578 to the exterior reinforcement band portions 8557, 8577 of the transmission bands 8552, 8572, respectively prevents the interior articulation bands 8558, 8578 from buckling between adjacent neck ribs.

[0396] In various arrangements, the distal closure tube segment 8590 is slid over the channel guide 8528 of the flexible neck assembly 8510. The proximal end 8591 of the distal closure tube segment 8590 has a pair of diametrically opposed slots 8592 therein (only one can be seen in FIGS. 83 and 92) for receiving distally protruding lugs 8513 protruding from the flexible neck portion 8511 to prevent rotation of the distal closure tube segment 8590 relative to the flexible neck portion 8511. In various embodiments, the distal closure tube segment 8590 may be retained on the channel guide 8528 by a retention tab (not shown) that extends into the fastener hole (not shown) in the channel guide 8528. However, other fastening arrangements may be employed, for example. Such arrangement causes the distal closure tube segment 8590 to move axially with the flexible neck assembly 8510.

[0397] Movement of the first and second transmission bands 8552, 8572 may be controlled by an articulation transmission assembly 8600. The component parts of one form of articulation transmission assembly 8600 are illustrated in FIG. 92. In one form, the articulation transmission assembly 8600 may include an actuator 8610, an articulation body 8620 and a nozzle 8650 (FIGS. 83 and 94). Rotational movement of the actuator 8610 causes corresponding rotation of the articulation body 8620 within the nozzle

8650. The first and second elongated transmission bands, 8552 and 8572, consequently reciprocate axially in opposite directions parallel to the longitudinal tool axis LT-LT of the elongated shaft assembly 10100 to cause the remote articulation of the end effector 8412.

[0398] Still referring to FIG. 92, the articulation body 8620 has a deck 8622 consisting of first and second spaced-apart, semicircular deck halves, 8624, 8626. The deck halves are mutually opposed to each other and essentially represent mirror images of each other. The first and second deck halves 8624, 8626 have protruding from their surfaces mutually opposed first and second detents 8625, 8627, respectively. Each deck half 8624, 8626 has a set of deck teeth 8628 spaced about 180 degrees from the set of deck teeth on the other deck half. The articulation body 8620 has a pair of rotation stops 8630 protruding from its surface as well as a pair of finger recesses 8632. A drive gear 8640 protrudes laterally from the articulation body 8622. The drive gear 8640 has a flared opening 8642 through it, and a lateral pivot 8644. Within the flared opening 8642 of the drive gear 8640, there is a firing rod orifice (not shown) for receiving a firing rod 8930 therethrough enabling the application of a firing motion to the end effector 8412. The drive gear 8640 is configured to intermesh with the first and second drive racks 8556, 8576, respectively to effect the desired reciprocating movement of the first and second transmission bands 8552, 8572. See FIG. 94.

[0399] The nozzle 8650 of the articulation transmission assembly 8600 may include a nozzle body 8652. The nozzle body 8652 may have an axial bore 8654 therethrough that facilitates the passage of the first transmission band assembly 8550 and the second transmission band assembly 8570 as well as for the firing rod 8930 and other operative components of the instrument 8410 including a the proximal end 8706 of a proximal outer shaft segment 8700. See FIG. 94. The nozzle body 8652 may also have a frame groove 8656 and flange 8658 to rotatably fasten the nozzle body 8652 to a housing 8800. In various forms, a detent housing 8660 comprises a portion of the nozzle body 8652. See FIG. 95. An annular array of detent teeth (not shown) is formed within the detent housing 8660. A detent housing floor is spaced from the detent teeth. The floor may have a pair of ledges which interact within the rotation stops 8630 of the articulation body 8620 to limit the degree of rotation. When the articulation body 8620 is inserted into the detent housing 8660, the base of the articulation body 8620 is supported on the floor within the detent housing 8660, and the deck teeth 8628 of the first and second deck halves, 8624, 8626 are aligned for meshing engagement with the detent teeth of the detent housing 8660. A spring member 8668 is supported within the articulation body to bias the deck teeth 8628 into meshing engagement with the detent teeth.

[0400] Referring again to FIG. 92, the actuator 8610 may consist of a lever arm 8612, a cap 8614 and a pair of retaining fingers 8616. The lever arm 8612 is mounted on the top of the cap 8614. The pair of retaining fingers 8616 protrudes laterally from the underside of the cap 8614. Each of the retaining fingers 8616 has a retaining clip. The retaining fingers 8616 are received within the finger recesses 8632 of the articulation body 8620. First and second detents, 8625, 8627, on the deck halves of the articulation body are inserted into a slot depression within the underside of the circular cap 8614. Advantageously, each of the three significant

components of the articulation transmission assembly, namely the actuator, articulation body and nozzle, may be injection molded components. Such components, for example, may be fabricated from a glass fiber-reinforced amorphous polyamide, sold commercially under the trade name Grivory GV-4H by EMS--American Grilon 150.

[0401] Ratcheting rotation of the actuator 8610 causes articulation of the end effector 8412 in the first or second directions relative to the longitudinal tool axis LT-LT. FIG. 86 illustrates the end effector 8412 in an unarticulated position in solid lines and exemplary ranges of articulation in broken lines. When the drive gear 8640 on the articulation body 8620 of the articulation transmission 8600 is rotated to thereby drive the first transmission band assembly 150 distally in the "DD" direction and the second transmission bar assembly 8570 proximally in the proximal direction "PD", the end effector 8412 will articulate in the first articulation direction "FD" relative to the longitudinal tool axis LT-LT. When the drive gear 8640 on the articulation body 8620 of the articulation transmission 8600 has been rotated to thereby drive the second articulation band assembly 8570 in the distal direction "DD" and the first articulation band assembly 8550 in the proximal direction "PD", the end effector 8412 will pivot in a second direction "SD" relative to the longitudinal tool axis LT-LT.

[0402] As can be seen in FIG. 93, the elongated shaft assembly 8500 further includes a proximal outer shaft segment 8700 that is attached to the flexible neck assembly 8510. The proximal outer shaft segment 8700 is substantially rigid and may be attached to the flexible neck portion 8511 of the flexible neck assembly 8510 by, for example, a press fit, adhesive or other suitable fastener arrangement. As can be seen in FIG. 94, in at least one embodiment, the distal end 8702 of the proximal outer shaft segment 8700 has a pair of opposed notches 8704 therein that are adapted to receive corresponding lugs 8515 protruding from the flexible neck portion 8511 such that rotation of the proximal outer shaft segment 8700 results in rotation of the flexible neck assembly 8510 and ultimately of the end effector 8412.

[0403] Still referring to FIG. 92, the proximal outer shaft segment 8700 has a proximal end 8706 that has a slot 8708 for receiving the drive gear 8640 therethrough such that the proximal outer shaft segment 8700 may move axially relative thereto. In addition, the proximal end 8706 of the proximal outer shaft segment 8700 has a flange 8710 formed thereon that facilitates rotational attachment to a closure carriage 8820 of an actuation system that is operably supported within the housing assembly 8800. The closure carriage and actuation system may be of the same or similar type, construction and operation as the closure carriage and actuation system disclosed in U.S. Patent Application Publication No. 2012/0074200 which has been incorporated by reference herein in its entirety.

[0404] Referring now to FIG. 96, the closure carriage 8820 may comprise two carriage segments 8822 (only one is illustrated) that are interconnected together by adhesive, snap features, screws, etc. As used herein, the term "snap feature" includes, but is not limited to, for example, a tab that has a protrusion thereon that is configured to retainingly engage a corresponding mating portion of another component. Such features

may be designed to releasably engage the mating portion or it may not be designed or intended to be removed. In at least one form, the closure carriage 8820 has a distal end 8824 that has a groove arrangement 8826 that is adapted to receive the flanged end 8710 of the proximal outer shaft segment 8700. Such arrangement serves to attach the proximal end 8706 of the proximal outer shaft segment 8700 to the closure carriage 8820 while facilitating its selective rotation of the proximal outer shaft segment 8700 relative to the closure carriage 8820. Therefore, the elongated shaft assembly 8500 and the end effector 8412 that is operably coupled thereto may be selectively rotated about the longitudinal tool axis LT-LT relative to the housing assembly 8800.

[0405] In various implementations, the housing assembly 8800 comprises a pistol-shaped handle housing that may be fabricated in two or more pieces for assembly purposes. For example, the housing assembly 8800 as shown comprises a right hand case member 8802 and a left hand case member 8804 (FIG. 83) that are molded or otherwise fabricated from a polymer or plastic material and are designed to mate together. Such case members 8802 and 8804 may be attached together by snap features, pegs and sockets molded or otherwise formed therein and/or by adhesive, screws, etc. When assembled, the housing assembly 8800 movably supports the closure carriage 8820 for selective axial travel therein in response to actuation motions from a trigger, generally designated as 8830. As the present Detailed Description proceeds, however, it will be understood that the various unique and novel aspects and attributes of the various implementations of the present invention may be effectively attained when employed with robotically controlled or otherwise remotely controlled systems. Thus, the term "housing" or "housing assembly" may also encompass a housing or similar portion of a robotic system that houses or otherwise operably supports at least one drive system that is configured to generate and apply at least one control motion which could be used to actuate various forms of surgical end effectors attached thereto. For example, various implementations of the surgical instrument described herein may be used in connection with those robotic systems and arrangements disclosed in U.S. Patent Application Serial No. 13/536,323, entitled ROBOTICALLY POWERED SURGICAL DEVICE WITH MANUALLY ACTUATABLE REVERSING SYSTEM, and filed June 28, 2012, the entire disclosure of which is incorporated by reference herein.

[0406] The trigger assembly 8830 may, for example, comprise a primary trigger 8840 and a secondary trigger 8860. The primary and secondary triggers 8840 and 8860 are pivotally journaled on a pivot pin assembly 8831 formed in the housing assembly 8800 such that the triggers 8840 and 8860 may essentially move relative to each other. Such arrangement permits the trigger assembly 8830 to pivot relative to the housing assembly 8800 about a pivot axis PA-PA. See FIG. 96. The primary trigger 8840 has an elongated, grippable primary trigger paddle 8842 that protrudes from a primary drive portion 8844 that has a firing rack 8846 formed thereon. In one embodiment, the secondary trigger 8860 has a secondary trigger paddle 8862 that protrudes from a secondary drive portion 8864 as discussed in further detail that is pivotally journaled on the pivot pin assembly 8831. The primary drive portion 8844 has a slot 8848 that is adapted to receive the

secondary drive portion 8864 of the secondary trigger 8860 therein as the primary trigger paddle 8842 is pivoted towards a pistol grip portion 8806 of the housing assembly 8800. Such arrangement essentially enables the secondary trigger 8860 to "nest" within the primary trigger 8840 during actuation. As will be discussed in detail below, the secondary trigger 8860 is pivotally actuated by pivoting the primary trigger 8840. Thus, in other embodiments, the secondary trigger 8860 may lack the secondary trigger paddle 8842. In various forms, the trigger assembly 8830 may be biased into the unactuated position by a trigger spring (not shown).

[0407] As can be seen in FIG. 96, the secondary drive portion 8864 of the secondary trigger 8860 may have a closure gear segment 8866 formed thereon that is configured for meshing engagement with a carriage gear rack 8823 formed on the underside of the closure carriage 8820. Thus, when the secondary trigger 8860 is pivoted toward the pistol grip 8806, the closure carriage 8820 is driven in the distal direction "DD".

[0408] In various implementations, the actuation system 8810 may further include an actuation bar 8870. The actuation bar 8870 has a first actuation rack 8872 formed thereon that is configured for meshing engagement with the primary gear segment 8846 on the primary trigger 8840. Thus, when the primary gear segment 8846 is in meshing engagement with the first actuation rack 8872, the actuation bar 8870 is driven in the distal direction "DD" when the primary trigger 8840 is pivoted toward the pistol grip 8806. The actuation bar 8870 has a second actuation rack 8874 formed thereon configured to meshingly engage clutch teeth 8884 on a clutch shaft 8882 of a clutch assembly 8880. In various embodiments, the clutch shaft 8882 is rotatably is supported within the housing assembly 8800 and is also laterally movable therein. The clutch shaft 8882 has a hub portion 8886 that has a plurality of spaced teeth 8888 that are configured to drivingly engage teeth openings 8892 in a drive gear 8890 that is rotatably supported on the clutch shaft 8882. The drive gear 8890 has a segment of drive gears 8894 thereon that are adapted for meshing engagement with a firing rack 8900 that is movably supported in the housing assembly 8800.

[0409] Various embodiments of the clutch assembly 8880 may further comprise a clutch plate 8910 that is slidably journaled on a clutch pin 8849 provided on the primary drive portion 8844 of the primary trigger 8840. The clutch pin 8849 may be movably received within a vertical slot 8912 in the clutch plate 8910. The clutch plate 8910 also has a distally-extending clutch arm 8914 that is adapted to actuatably engage a bevel plate 8889 formed on the clutch shaft 8882. In addition, a clutch spring 8920 is employed to bias the clutch shaft 8880 laterally such that the teeth 8888 on the clutch shaft 8882 are brought into meshing engagement with the teeth openings 8892 in the drive gear 8890.

[0410] As can be seen in FIGS. 92 and 96, the firing rack 8900 is coupled to a firing rod 8930 that is attached to the proximal end of the knife bar assembly 8970. In various embodiments, the knife bar assembly 8970 may comprise an upper bar segment 8971 and a lower bar segment 8972. Such arrangement may enable the knife bar assembly 8970 to flex as the end effector 8412 is articulated, while remaining sufficiently rigid to be driven distally through the shaft assembly 8500. In the depicted embodiment, the

upper and lower knife bar segments 8971, 8972 are each attached to an "E-beam" cutting head 8973. In the depicted configuration, the E-beam cutting head 8973 includes a vertically oriented body portion 8974 that has an upper portion 8975 and a lower portion 8976. A bottom foot 8977 is formed on or attached to the lower portion 8976. In alternative embodiments, the bottom foot may essentially comprise laterally extending lower tabs that protrude laterally from the lower portion. Similarly, at least one upper tab 8977' is formed on or otherwise attached to the upper portion 8975 of the vertically oriented body portion 8974. In addition, as can be seen in FIG. 84, the vertically oriented body portion 8974 further includes at least one intermediate tab portion 8978 (only one is shown) as well as a tissue cutting edge 8979.

[0411] Referring to FIG. 84, the vertically oriented body portion 8974 extends through a longitudinally extending slot 8980 in the elongated channel 8414 and a longitudinally extending slot 8981 in the anvil 8420. When assembled, portions of the elongated channel 8414 are received between the bottom foot 8977 and the intermediate tab portions 8978. The, upper tab portion 8977' is arranged to be received within the anvil 8420 above portions 8982 of the anvil 8420 that define the anvil slot 8981. To facilitate ease of assembly, the anvil 8420 may be provided with a movable anvil cover 8983 and the elongated channel 8414 may be provided with a removable channel cover 8984. Once assembled, the anvil cover 8983 and the channel cover 8984 may be installed to prevent tissue, body fluids, etc. from entering the anvil 8420 and the elongated channel 8414, respectively which may hamper operation of the cutting head 8973.

[0412] In various arrangements, each staple cartridge 8430 includes a cartridge body 8431 that has a sled assembly 8985 operably supported therein. The sled assembly 8985 may have a mounting portion 8986 that is configured to extend into a sled slot 8987 formed in the vertically oriented body portion 8974 of the cutting head 8973. See FIGS. 84 and 86. The sled assembly 8985 may be configured with wedges 8988 that are arranged to contact staple drivers 8989 that are operably supported within the staple cartridge 8430. The staple drivers 8989 may support one or more staples 8990 thereon in a known manner. As the sled assembly 8985 is driven in the distal direction DD through the staple cartridge 8430, the wedges 8988 drive the drivers 8989 upward within the cartridge 8430 in a known manner. The upwardly moving drivers 8989 drive the staples 8990 into forming contact with a staple forming undersurface of the anvil 8420. The undersurface may, for example, include staple-forming pockets that correspond to each staple.

[0413] The end effector 8412 may also employ a cutting head lockout system, generally designated as 8991 that serves to prevent distal advancement of the cutting head 8973 when a new staple cartridge 8430 is not present within the elongated channel 8414. In at least one arrangement, for example, the cutting head lockout system 8991 may comprise a lockout spring 8992 that is mounted to the bottom of elongated channel 8414. The lockout spring 8992 may be configured to contact the bottom foot 8977 of the cutting head assembly 8973 when the cutting head assembly 8974 is in the starting position. See FIGS. 86, 88 and 91. An opening 8993 may be provided through the bottom of the elongated channel 8414 such that when in that position, the lockout spring 8992 biases the bottom foot 8977 such that it interferes with the bottom of the

elongated channel 8414. Thus, when the bottom foot 8977 is in that position, if the clinician were to try advance the cutting head 8973 distally through the elongated channel 8414, the bottom foot portion 8977 will contact a portion of the elongated channel 8414 to prevent such advancement of the cutting head 8973. When a cartridge 8430 has been properly installed with the elongated channel 8414, the mounting portion 8986 of the sled assembly 8985 extends into the sled slot 8987 and serves to move the cutting head assembly 8973 into a position whereby the foot portion 8977 is moved out of interfering contact with the bottom of the elongated channel 8414. When in that position, the cutting head assembly 8973 is free to be advanced distally through the elongated channel 8414. Such arrangement serves to prevent the clinician from inadvertently firing the end effector when a new cartridge is not present which could otherwise result in the tissue being cut but not stapled. As the cutting head 8973 is advanced distally, the bottom foot 8977, the intermediate tab portions 8978 and the upper tab 8977' cooperate to orient the anvil 8420 relative to the staple cartridge deck at a desired spaced relationship relative to each other. A distally presented tissue-cutting edge 8979, which is between the upper tab 8977' and intermediate tab portions 8978, severs clamped tissue while causing the staples 8990 within the staple cartridge 8430 to be formed into the tissue clamped within the end effector 8412.

[0414] As can be seen in FIG. 84, the upper firing bar 8971 is attached to the upper end portion 8975 and the lower firing bar 8972 is spaced from the upper firing bar 8971 and is attached to the lower end portion 8976 of the vertically-extending 8974 of the cutting head 8973. Such arrangement serves to transmit the firing motions to the upper and lower portions of the cutting head 8973 in an equivalent manner to facilitate aligned movement of the cutting head through the anvil 8420, the surgical staple cartridge 8430 and the elongated channel 8414. In various arrangements, for example, the upper firing bar 8971 may be attached to the upper end portion directly behind the upper tabs(s) 8977' such that the upper firing bar 8971 is essentially axially aligned with point(s) from which the upper tab(s) 8977' protrude laterally from the upper end portion 8975. Similarly, the lower firing bar 8972 may be attached to the bottom end portion 8976 directly behind the bottom foot 8977or the point(s) from which the laterally protruding bottom tabs protrude laterally from the bottom end portion 8976 such that the lower firing bar 8972 is axially aligned therewith. The upper and lower firing bars 8971, 8972 may be welded to the vertical extending portion 8974 in those locations. For example, the welds may be applied to the firing bars from one side or from both lateral sides of the firing bars. In at least one implementation, the upper and lower firing bars 8971, 8972 are not directly attached to each other. The portions of the upper and lower firing bars 8971, 8972 that extend through the elongated shaft assembly 8500 to be coupled to a distal end portion 8932 of the firing rod 8930 are supported in a contiguous orientation relative to each other. The proximal ends of the upper and lower firing bars 8971, 8972 may be attached to the distal end portion 8932 of the firing rod 8930 by a coupler member 8994. See FIG. 92. As will be discussed in further detail below, the firing rod 8930 facilitates the application of firing and retraction motions to the knife bar assembly 10600 by the actuation system 8810. In at least one

implementation, the anvil mounting portion 8422 has a wedge-like formation 8427 thereon that serves to separate the upper firing bar 8971 and lower firing bar 8972 as the knife bar assembly 8970 is driven in the distal direction "DD". See, for example, FIG. 91.

[0415] In various arrangements, the firing rod 8930 extends through a closure bushing 8940 that is mounted within the housing assembly 8800. In at least one form, a pair of mounting studs 8807 protrude from the handle casings 8802, 8804 and extend through corresponding slots in the closure carriage 8820 to be received in a retaining slot in the bushing 8840. A closure spring 8950 that is attached to a retainer clip 8952 is journaled on the closure bushing 8940. The closure spring 8950 extends between the nozzle body 8652 and an internal wall 8825 in the closure carriage 8820. Thus, the closure spring 8950 serves to bias the closure carriage 8820 in the proximal direction "PD".

[0416] Various embodiments may also include a releasable closure locking assembly 8960 that interfaces with the closure carriage 8820 to selectively retain the closure carriage 8820 in its distal-most closed or clamped position. In at least one form, the closure locking assembly 8960 includes a locking button 8962 that is pivotally supported in the housing assembly 8800. The locking button 8862 has a latch arm 8964 that is configured to abut a locking ledge 8826 formed on the closure carriage 8820 when the button 8962 is in the locked position. In addition, the latch arm 8964 has a catch 8966 formed thereon that is configured to releasably latch with a locking latch 8902 on the proximal end of the firing rack 8900. A locking spring 8968 serves to bias the locking button 8962 into the locked position.

[0417] Operation of the surgical instrument 8410 will now be described. FIGS. 89-91 illustrate the jaws 8413 and 8415 of the end effector 8412 in an open position. When the end effector 8412 is in the open position, the latch arm 8964 is located on top of the locking ledge 8826 formed on the closure carriage 8820 such that the catch 8966 of the latch arm 894 is in retaining engagement with the locking latch 8902 on the firing rack 8900. Thus, when in this initial starting position, the knife bar assembly 8790 cannot be inadvertently actuated. The clutch plate 8910, as well as the closure carriage, are each in their proximal-most unactuated positions. When in those positions, the clutch drive bevel 8889 on the clutch shaft 8882 is in contact with a portion of the closure carriage 8820, which prevents the clutch shaft 8882 from laterally moving into meshing engagement with the drive gear 8890 under the bias of the clutch spring 8920.

[0418] To initiate the closure process, a first stroke is applied to the trigger assembly 8830. That is, the trigger assembly 8830 is initially pivoted toward the pistol grip 8806. Such pivoting action serves to drive the closure carriage 8820 in the distal direction "DD" by virtue of the meshing engagement between the closure gear segment 8866 on the secondary trigger 8860 and the carriage rack 8823 formed on the underside of the closure carriage 8820. Such distal movement of the closure carriage 8820 also axially advances the proximal outer shaft segment 8700 and the distal closure tube segment 8590 in the distal direction "DD". As the distal closure tube segment 8590 moves distally, the pin 8419 which extends through the slots 8423 in the anvil mounting portion 8422, travels from the position illustrated in FIGS. 90 and 91 to the position

illustrated in FIGS. 86-88 to pivot the anvil 8420 to the closed position. If the surgeon desires to simply grasp and manipulate tissue prior to clamping it between the anvil 8420 and the surgical staple cartridge 8430, the trigger assembly 8830 may be pivoted to open and close the anvil 8420 without fully pivoting the trigger assembly 8830 to the fully closed position.

[0419] Those of ordinary skill in the art will understand that, as the trigger assembly 8830 is pivoted toward the pistol grip 8806, the actuation bar 8870 will necessarily also be driven distally by virtue of the meshing engagement between the primary gear segment 8846 on the primary trigger 8840 and the first actuation rack 8872 on the actuation bar 8870. The distal movement of the actuation bar 8870 will also result in the an application of a rotary actuation motion to the clutch shaft 8882 by virtue of the meshing engagement between the clutch teeth 10484 on the clutch shaft 8882 and the second actuation rack 8874 on the actuation bar 8870. However, such rotary motion is not applied to the drive gear 8890 because the clutch arm 8914 of the clutch plate 8910, in contact with the clutch drive bevel 8889 on the clutch shaft 8882, prevents the axial movement of the clutch shaft 8882 into meshing engagement with the drive gear 8890. Thus, the clutch shaft 8882 freely rotates relative to the drive gear 8890. Accordingly, the clutch assembly 8880 automatically prevents the activation of the firing rack 8900 during the initial actuation of the trigger assembly 8830.

[0420] Once the trigger assembly 8830 has been initially fully compressed into the closed position, the anvil 8420 will be retained in the locked or clamped position by the closure locking assembly 8960 which prevents the proximal movement of the closure carriage 8820. To drive the knife bar assembly 8970 distally through the tissue clamped in the end effector 8412, the surgeon again pivots the primary trigger 8840 toward the pistol grip 8806 of the housing assembly 8800. As the primary trigger 8840 is pivoted, the firing rack 8900, the firing rod 8930, and the knife bar assembly 10600 are driven in the distal direction "DD". After the knife bar assembly 8970 has been driven through the tissue clamped in the end effector 8412, the surgeon then releases the primary trigger 8840 to thereby permit the primary trigger 8840 to pivot to its unactuated position under the bias of the firing spring 8832. As the primary trigger 8840 pivots back to the starting position, the firing rack 8900, firing rod 8930, and knife bar assembly 8970 are drawn proximally back to their respective starting positions. The end effector 10012 remains in its clamped position as shown in FIG. 88. As can also be seen in that Figure, the sled assembly 8985 remains in the distal end of the cartridge 8430 while the knife bar assembly 8970 is returned to the starting position.

[0421] To unlock the closure carriage 8820 and the secondary trigger 8860, the surgeon depresses the locking button 8962. As the locking button 8962 is depressed, the locking arm 8964 is pivoted out of abutting engagement with the locking ledge 8826 on the closure carriage 8820. Further details regarding the operation of the firing and closure systems may be found in U.S. Patent Application Publication No. US 2012/0074200 which has been herein incorporated by reference in its entirety. As the closure carriage 8820 moves proximally, the proximal outer shaft segment 8700, the flexible neck assembly 8510, and the distal

closure tube segment 8590 are drawn proximally. As the distal closure tube segment 8590 moves proximally, the shaft 8419 travels proximally within the slot 8423 in the anvil mounting portion 8422 to move the anvil 8420 to an open position.

[0422] As can be appreciated from the foregoing, the various surgical instruments disclosed herein afford the clinician with improved maneuverability and various other advantages that are not available when using prior surgical instruments that are configured to cut and fasten tissue. For example, in various implementations disclosed herein, the end effector is selectively articulatable in the same directions in which the jaws are movable relative to each other. Stated another way, the jaws of the surgical end effector are constrained to move in one plane. In various implementations disclosed herein, the end effector is also capable of moving in that same plane. Prior end effectors are commonly constrained to move in planes that differ from the plane in which the jaws move.

[0423] Another advantage provided by many of the present implementations is the use of a firing bar that comprises at least an upper firing bar and at least a lower firing bar that form a laminated structure. The upper and lower bars may at some point be attached to each other or they may be unattached and just be contiguous with each other. In either arrangement, the upper bar is attached to an upper end of the cutting head and the lower bar may be attached to the lower head such that they are spaced from each other at their points of attachment to the cutting head. Such arrangement serves to provide for a more stable cutting head arrangement that may be less likely to twist and/or buckle during actuation. In addition, the cutting head may be equipped with laterally protruding upper tab(s) that engage a portion of the anvil and lower tab(s) that engage the elongated channel. The upper firing bar may be attached directly behind the point where the upper tabs are attached such that it is axially aligned therewith. Likewise the lower firing bar may be attached to the bottom portion directly behind the points where the bottom tab(s) are attached such that it is axially aligned therewith. Such axial alignment facilitates transfer of the driving or actuation motions to the cutting head at the points where the cutting head engages the anvil and the elongated channel which may further prevent and buckling and/or twisting of the cutting head during actuation.

[0424] The various surgical instruments arrangements disclosed herein that employ tissue cutting and staple firing systems, jaw opening and closing systems and end effector articulation systems that essentially employ components that are axially reciprocated during actuation may be actuated by manually generated actuation motions, For example, the firing systems may be housed in a handle that includes trigger arrangements that are configured to generate actuation motions when the clinician manipulate the triggers. It will be appreciated, however, that such actuation motions may likewise be generated by motors that are supported in a handle or are supported or comprise a portion of a robotic system. Thus, the various surgical instruments disclosed herein should not be limited to use solely in connection with hand-held housings and manually generated actuation motions.

[0425] Powered surgical instruments are disclosed in U.S. Patent Application Publication No. 2009/0090763, filed on August 12, 2008, and entitled POWERED SURGICAL STAPLING DEVICE to Zemlok et al. (hereinafter "Zemlok '763"), the entire disclosure of which is hereby incorporated by reference herein. Powered surgical instruments are also disclosed in U.S. Patent Application Publication No. 2011/0278344, filed on March 9, 2011, and entitled POWERED SURGICAL INSTRUMENT to Zemlok et al. (hereinafter "Zemlok '344"), now U.S. Patent No. 8,201,721, the entire disclosure of which is hereby incorporated by reference herein. FIG. 97 illustrates a powered surgical instrument 9010 that, in many ways, may be similar to those surgical instruments (including various features, components and subcomponents thereof) disclosed in, for example, Zemlok '763 and/or Zemlok '344, which have each been incorporated by reference herein in their respective entireties. Likewise, the surgical instrument 9010 may be similar to those surgical instruments disclosed in U.S. Patent Application Serial No. 13/974,166, filed August 23, 2013, and entitled FIRING MEMBER RETRACTION DEVICES FOR POWERED SURGICAL INSTRUMENTS to Shelton et al. (hereinafter, "Shelton '166") the entire disclosure of which is hereby incorporated by reference herein. The surgical instrument 9010 depicted in FIG. 97 includes a housing 9012 that has a handle portion 9014 for facilitating manual manipulation and operation of the instrument. Thus, the term "housing" as used herein may encompass a handheld or otherwise hand-manipulatable arrangement. However, the term "housing" may also encompass portions of an automated surgical instrument system such as a robotically-controlled system that is not intended to be handheld but is otherwise manipulated and actuatable by various components, portions, and/or actuators of the system. For example, various implementations of the surgical instrument described herein may be used in connection with those robotic systems and arrangements disclosed in U.S. Patent Application Serial No. 13/536,323, entitled ROBOTICALLY POWERED SURGICAL DEVICE WITH MANUALLY ACTUATABLE REVERSING SYSTEM, and filed June 28, 2012, the entire disclosure of which is incorporated by reference herein. Furthermore, the coupling arrangements and end effector arrangement disclosed herein may also be effectively employed with non-powered hand held surgical instruments. Thus, the end effector arrangements and coupling arrangements disclosed herein should not be limited to use in connection with powered instruments, whether they be hand-held or otherwise automated.

[0426] An elongated shaft assembly 9116 in the form of an endoscopic portion protrudes from the housing 9012 and is configured for operable attachment to a surgical end effector that is constructed to perform at least one surgical procedure in response to applications of firing motions thereto. The surgical end effector may comprise a device configured to cut and staple tissue such as a "loading unit" 9020 as shown in FIGS. 98-105. Surgical end effectors, such as loading unit 9020, for example, can be releasably attached to the elongated shaft assembly 9116 of the powered surgical instrument 9010, as described in greater detail herein.

[0427] FIGS. 98-105 illustrate one exemplary form of end effector or loading unit 9020 that may be employed with the surgical instrument 9010. As can be seen in FIG. 100, the loading unit 9020 includes an

anvil assembly 9220 that is supported for pivotal travel relative to a carrier 9240 that operably supports a staple cartridge 9260 therein. The staple cartridge 9260 may comprise a surgical staple cartridge that is designed to be "implanted" within the patient. For example, the implantable surgical staple cartridge 9260 may comprise any of the various surgical staple cartridge arrangements disclosed in U.S. Patent Application Publication No. 2012/0080484, filed September 30, 2010, and entitled SURGICAL STAPLING INSTRUMENT WITH A VARIABLE STAPLE FORMING SYSTEM, the entire disclosure of which is hereby incorporated by reference herein. In at least one implementation for example, the staple cartridge 9260 includes a body portion 9261 that consists of a compressible hemostat material such as, for example, oxidized regenerated cellulose ("ORC") or a bio-absorbable foam in which lines of unformed metal staples are supported. In at least some embodiments, in order to prevent the staple from being affected and the hemostat material from being activated during the introduction and positioning process, the entire cartridge may be coated or wrapped in a biodegradable film such as a polydioxanon film sold under the trademark PDS.RTM. or with a Polyglycerol sebacate (PGS) film or other biodegradable films formed from PGA (Polyglycolic acid, marketed under the trade mark Vicryl), PCL (Polycaprolactone), PLA or PLLA (Polylactic acid), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone 25, sold under the trademark Monocryl) or a composite of PGA, PCL, PLA, PDS that would be impermeable until ruptured. The body 9261 of staple cartridge 9260 is sized to be removably supported within the carrier 9240 as shown such that each staple therein is aligned with corresponding staple forming pockets in the anvil assembly 9220.

[0428] The anvil assembly 9220 has a pair of trunnions 9221 formed thereon that are adapted to be pivotally received within trunnion slots 9242 in a proximal end 9241 of the carrier 9240 such that the anvil assembly 9220 may move or pivot between an open position and a closed position relative to the carrier 9240 about an anvil pivot axis ANV-ANV. The anvil pivot axis ANV-ANV is transverse to a longitudinally extending tool axis LA-LA defined by the elongated shaft assembly 9116. When the anvil assembly 9220 is pivoted from an open position to a closed position, the anvil assembly 9220 is moving in a closing direction "CD" about anvil pivot axis ANV-ANV. Conversely, when the anvil assembly 9220 is moving from a closed position to an open position, the anvil assembly 9220 is moving in an opening direction "OD" about anvil pivot axis ANV-ANV.

[0429] The loading unit 9020 employs a unique and novel articulation joint 9270 that facilitates articulation of the carrier 9240 and anvil assembly 9220 to pivot about an articulation axis "AA-AA" that is transverse to a longitudinal tool axis "LA-LA". For example, the loading unit 9020 may include an end effector housing 9400 that is configured to be received within an outer casing 9450. The distal end 9402 of the end effector housing 9400 may have a clevis 9404 formed thereon by two distally protruding tabs 9406. Each tab 9406 has a pivot hole 9408 formed therein that is adapted to receive therein a corresponding pivot pin 9274 formed on an articulation ball assembly 9272. See FIG. 100. The articulation ball assembly 9272 may be rigidly affixed to the proximal end 9241 of the carrier 9240 by, for example, welding or other suitable fastening

arrangement. As will be discussed in further detail below, when assembled together, the carrier 9240 and anvil assembly 9220 can selectively articulate as a unit about the articulation axis AA-AA in a first direction "FD" which is the same direction as the anvil closing direction "CD" and in a second direction "SD" which is the same as the anvil opening direction "OD". See FIG. 105.

[0430] Still referring to FIG. 100, the end effector housing 9400 may be provided with a channel 9410 for slidably receiving an articulation link 9420 therein. The articulation link 9420 includes a proximal end portion 9422 and a distal end 9424. Fixedly attached to the distal end portion 9424 is an articulation tube 9426. The articulation tube 9426 may comprise a hollow tube and be attached to the distal end 9424 by, for example, welding or other suitable means. As can be seen in FIG. 102, the articulation tube 9426 may have a series of articulation teeth 9428 formed therein that are configured to meshingly engage sets of distal articulation teeth 9276 formed on the articulation ball 9272. Thus, movement of the articulation link 9420 in the distal direction "DD" will cause the carrier 9240 and anvil assembly 9220 to pivot in the first direction "FD" about the articulation axis AA-AA. Conversely, movement of the articulation link 9420 in the proximal direction "PD" will cause the carrier 9240 and anvil assembly 9220 to pivot as a unit in the second direction "SD" about the articulation axis AA-AA. The articulation link 9420 and the articulation tube 9426 may be collectively referred to herein as the articulation link assembly 9425. See FIG. 100.

[0431] The loading unit 9020 may also be equipped with a drive assembly 9460 that is configured to axially move through the end effector housing 9400. In at least one implementation, the drive assembly 9460 includes a drive beam assembly 9461 that includes an upper drive beam 9462 and a lower drive beam 9464 that are attached to a cutting head 9470. The cutting head 9470 may include a body portion 9471 that has a tissue cutting edge 9472 formed thereon. An upper portion 9473 of the body portion 9471 has an upper tab 9474 formed thereon. A bottom foot or tab 9476 is formed on a lower portion 9475 of the body portion 9471. The vertically oriented body portion 9471 extends through a longitudinally extending slot 9245 in the carrier 9240 and a longitudinally extending slot 9222 in the anvil assembly 9220. When assembled, the bottom foot 9476 is configured to slide along the bottom of the carrier 9240. The, upper tab portion 9474 is arranged to be slidably received within an elongated channel 9223 formed in the anvil assembly 9220.

[0432] As can be seen in FIG. 100, the upper firing bar 9462 is attached to the upper end portion 9473 and the lower firing bar 9464 is spaced from the upper firing bar 9462 and is attached to the lower end portion 9475 of the vertically-extending portion 9471 of the cutting head 9470. Such arrangement serves to transmit the firing motions to the upper and lower portions of the cutting head 9470 in an equivalent manner to facilitate aligned movement of the cutting head 9470 through the anvil assembly 9220, the surgical staple cartridge 9260 and the carrier 9240. In various arrangements, for example, the upper firing bar 9462 may be attached to the upper end portion 9473 directly behind the upper tabs(s) 9474 such that the upper firing bar 9462 is essentially axially aligned with point(s) from which the upper tab(s) 9474 protrude laterally from the upper end portion 9473. Similarly, the lower firing bar 9464 may be attached to the bottom end portion 9475

directly behind the bottom foot 9476 or the point(s) from which the laterally protruding bottom tabs 9476 protrude laterally from the bottom end portion 9475 such that the lower firing bar 9464 is axially aligned therewith. The upper and lower firing bars 9462, 9464 may be welded to the vertical extending portion 9471 in those locations. For example, the welds may be applied to the firing bars from one side or from both lateral sides of the firing bars. As the cutting head 9470 is driven distally in the distal direction "DD", the anvil assembly 9220 is pivoted closed between the upper tabs(s) 9474 and the lower tab(s) or foot 9476. Further advancement of the cutting head assembly 9470 causes the surgical staple cartridge 9260 to be crushed between the anvil assembly 9220 and the carrier 9240 thereby causing the surgical staples supported therein to be formed on both sides of the tissue cut line as they are brought into contact with the staple forming underside of the anvil assembly 9220. After the cutting head assembly 9470 has been advanced to the distal end of the carrier 9240, the user retracts the cutting head assembly 9470 to the starting position whereupon the anvil assembly 9220 may be opened to release the staple cartridge 9260 and stapled tissue. In one implementation, for example, the upper tab(s) 9474 are configured to interact with the upper surface of the anvil assembly 9220 to cam or pivot the anvil assembly 9220 back to the open position. In alternative arrangements, a spring or other biasing member (not shown) may be employed to bias the anvil assembly 9220 to the open position when the cutting head assembly 9470 is in a starting position.

[0433] The drive beam assembly 9460 may further include a proximal engagement member 9467 that includes a pair of engagement fingers 9468 that are configured to operably engage a distal end 9522 of a firing rod 9104 as will be discussed in further detail herein. As can be seen in FIG. 100, for example, the proximal engagement member 9467 is pivotally coupled to the upper and lower firing bars 9462, 9464 to facilitate articulation and flexing thereof during articulation of the carrier 9240 about the articulation axis AA-AA without binding the drive beam assembly 9461. In at least one implementation, for example, the proximal engagement member 9467 is pivotally coupled to the upper and lower firing bars 9462, 9464 by a pair of pivot links 9466. Such links 9466 enable the upper firing bar 9462 to pivot relative to the proximal engagement member 9467 independent form the lower firing bar 9464 and visa versa.

[0434] As can be seen in FIG. 97, the surgical instrument 9010 may include a motor 9100 that is configured to generate rotary actuation motions that may be employed, for example, to apply firing motions to the loading unit 9020 as will be discussed in further detail below. In at least one form, for example, the motor 9100 is configured to apply rotary actuation motions to a firing member assembly, generally designated as 9082. In one arrangement, for example, the firing member assembly 9082 includes a drive tube 9102 that is rotatably supported within the housing 9012 and has an internal thread (not shown) formed therein. A proximal threaded portion of a firing member or firing rod 9104 is supported in threaded engagement with the drive tube 9102 such that rotation of the drive tube 9102 results in the axial movement of the firing rod 9104. The firing rod 9104 may interface with the interior of the drive assembly 9460 in the loading unit 9020. As discussed in further detail in the aforementioned incorporated Zemlok '763 and

Zemlok '344, rotation of drive tube 9102 in a first direction (e.g., counter-clockwise) causes the firing rod 9104 to advance the drive assembly 9460 in the distal direction.

[0435] As can be further seen in FIG. 97, the surgical instrument 9010 may include an articulation system generally designated as 9109. However, surgical instrument 9010 may include various other articulation system arrangements disclosed in detail herein. In at least one form, the articulation system 9109 may include an articulation mechanism 9110 that includes an articulation motor 9112 and a manual articulation knob 9114. The articulation motor 9112 may be actuated by a powered articulation switch 9116 or by pivoting the manual articulation knob 9114. Actuation of the articulation motor 9112 serves to rotate an articulation gear 9118 of the articulation mechanism 9110. Actuation of articulation mechanism 9110 may cause the end effector (e.g., the cartridge/anvil portion of the loading unit 9020) to move from its first position, wherein its axis is substantially aligned with longitudinal tool axis "LA-LA" of the elongated shaft assembly 9116 to a position in which the axis of the end effector is disposed at an angle relative to the longitudinal tool axis "LA-LA" of the elongated shaft assembly about, for example, articulation axis "AA-AA". Further discussion regarding various aspects of the articulation mechanism 9110 may be found in Zemlok '763 which was previously incorporated by reference herein in its entirety. In addition, U.S. Patent No. 7,431,188, entitled SURGICAL STAPLING APPARATUS WITH POWERED ARTICULATION, and filed March 15, 2007, the entire disclosure of which is hereby incorporated by reference herein, discloses motor-powered articulatable end effectors which may be employed in connection with surgical instrument 9010. Those of ordinary skill in the art will understand, however, that the unique and novel coupling and end effector arrangements disclosed herein may also be effectively employed with manually-operated (i.e., non-powered) articulation systems that are known in the art.

[0436] In various embodiments, the surgical instrument can include at least one motor, which can apply firing motions to the loading unit 9020 and/or articulation motions to the articulation system 9109, as described elsewhere in greater detail. The motor 9100 may, for example, be powered by a power source 9200 of the type described in further detail in Zemlok '763. For example, the power source 9200 may comprise a rechargeable battery (e.g., lead-based, nickel-based, lithium-ion based, etc.). It is also envisioned that the power source 9200 may include at least one disposable battery. The disposable battery may, for example, be between about 9 volts and about 30 volts. However, other power sources may be employed. FIG. 97 illustrates one example wherein the power source 9200 includes a plurality of battery cells 9202. The number of battery cells 9202 employed may depend upon the current load requirements of the instrument 9010.

[0437] Referring to FIG. 97, a power source such as, for example, the power source 9200 can supply power for operation of the surgical instrument 9010. For example, the power source 9200 can supply power for a motor such as, for example, motor 9100 to cause rotation of the drive tube 9102 in a first direction and ultimately the axial advancement of the firing rod 9104 which drives the drive assembly 9460 distally

through the loading unit 9020. Alternatively, the power source 9200 can supply power for the motor 9100 to cause rotation of the drive tube 9102 in a second direction opposite the first direction and ultimately the axial retraction of the firing rod 104 which can move the drive beam 9060 proximally to its starting and/or default position.

[0438] Surgical end effectors, such as a disposable loading unit 9020, for example, can be operably coupled to the elongated shaft assembly 9116 of the powered surgical instrument 10010 (FIG. 1). In various embodiments, the surgical instrument 9010 can include an elongated shaft assembly 9116, which can engage the loading unit 9020, for example. In various embodiments, a coupling assembly 9115 that includes a rotatable coupling collar 9500, for example, can releasably lock the loading unit 9020 relative to the elongated shaft assembly 9116. Furthermore, in various embodiments, rotation of the coupling collar 9500 can facilitate attachment and/or alignment of a firing assembly and/or an articulation assembly, as described herein. In various embodiments, the loading unit 9020 can include a distal attachment portion 9480 and the elongated shaft assembly 9116 can include an outer tube 9030 and a distal attachment portion 9032. The distal attachment portion 9480 of the loading unit 9020 can receive the distal attachment portion 9032 of the shaft assembly 9116 when the loading unit 9020 is secured to the elongated shaft assembly 9116 (FIG. 107). Furthermore, the rotatable coupling collar 9500 can be positioned around the distal attachment portion 9032 of the shaft assembly 9116, such that the distal attachment portion 9480 of the loading unit 9020 can also be positioned within the rotatable coupling collar 9500. The rotatable coupling collar 9500 can be secured to the elongated shaft assembly 9116 and/or the proximal attachment portion 9480, and, in certain embodiments, can be rotatably fixed to the distal attachment portion 9032 of the shaft assembly 9116, for example. In certain embodiments, a proximal attachment portion of the shaft assembly 9116 can receive a distal attachment portion 9480 of the loading unit 9020 when the loading unit 9020 is secured to the shaft assembly 9116. Furthermore, in certain embodiments, a coupling collar 9500 can be rotatably fixed to the loading unit 9020.

[0439] Referring to FIGS. 106 and 107, as the loading unit 9020 moves between a non-attached position and an attached position relative to the elongated shaft assembly 9116 of the surgical instrument 9010, the loading unit 9020 can translate along a longitudinal tool axis LA-LA as defined by the elongated shaft assembly 9116. The distal attachment portion 9480 of the loading unit 9020 can be inserted into the distal attachment portion 9032 of the elongated shaft assembly 9116 as the loading unit 9020 moves from the non-attached position to the attached position. For example, the loading unit 9020 can translate in proximal direction "PD" (FIG. 107) when the loading unit 9020 is moved between the non-attached position and the attached position. In certain embodiments, a groove-and-slot engagement between the distal attachment portion 9480 and the distal attachment portion 9032 can guide the loading unit 10020 along the longitudinal tool axis LA-LA defined by the elongated shaft assembly 9116. Referring primarily to FIG. 110, the distal attachment portion 9480 can include a guide rail 9482. Furthermore, referring primarily to FIG. 112, the

distal attachment portion 9032 can include a guide slot 9034. The guide slot 9034 can be dimensioned and structured to receive and guide the guide rail 9482 as the proximal attachment portion 9480 of the loading unit 9020 is inserted into the distal attachment portion 9032 of the elongated shaft assembly 9116. For example, the guide slot 9034 can comprise a longitudinal slot, and the guide rail 9482 can comprise a longitudinal ridge, for example. In certain embodiments, the guide slot 9034 and guide rail 9482 can prevent twisting and/or rotating of the loading unit 9020 relative to the longitudinal tool axis LA-LA.

[0440] Referring primarily to FIG. 106, the distal attachment portion 9480 can include a first alignment indicia 9484, such as a first arrow, for example, and the elongated shaft assembly 9116 and/or the coupling collar 9500 can include a second alignment indicia 9502, such as a second arrow, for example. Alignment of the first and second alignment indicia 9484, 9502 can align the guide rail 9482 and the guide slot 9034, which can facilitate attachment of the distal attachment portion 9480 to the distal attachment portion 9032. As described herein, translation of the loading unit 9020 along a longitudinal path toward the elongated shaft assembly 9116 can releasably lock the loading unit 9020 relative to the elongated shaft assembly 9116. In such embodiments, rotation of the loading unit 9020 relative to the elongated shaft assembly 9116 may not be required to attach the loading unit 9020 relative to the elongated shaft assembly 9116. In fact, rotation of the loading unit 9020 relative to the elongated shaft assembly 9116 can be restrained and/or prevented by a groove-and-slot engagement between the distal attachment portion 9032 and the distal attachment portion 9480, as described herein. In various embodiments, the coupling collar 9500 can rotate relative to the loading unit 9020 and/or the elongated shaft assembly 9116 to releasably lock the loading unit 9020 to the elongated shaft assembly 9116. For example, as described herein, the coupling collar 9500 can rotate from an initial orientation (FIG. 120) toward a secondary orientation (FIG. 121) and then return toward the initial orientation (FIG. 124) to lock the loading unit 9020 to the elongated shaft assembly 9116.

[0441] Referring primarily to FIGS. 110 and 111, the proximal portion 9480 of the loading unit 9020 can include a rotation key or rib 9486. As the loading unit 9020 is moved in the proximal direction "PD" (FIG. 106) between a non-attached position (FIG. 106) and an attached position (FIG. 107), the rotation key 9486 can affect rotation of the coupling collar 9500. For example, the rotation key 9486 can rotate and/or bias the coupling collar 9500 in direction B (FIG. 107) from the initial orientation to the secondary orientation. The distal attachment portion 9480 can be inserted into the distal attachment portion 9032 when the coupling collar 9500 is biased into the secondary orientation. Furthermore, when the distal attachment portion 9480 is fully inserted into the distal attachment portion 9032, the rotation key 9486 can permit the coupling collar 9500 to rotate in direction C (FIG. 107) from the secondary orientation toward the initial orientation. As used herein the term "fully inserted" as used with respect to the coupling of the loading unit 9020 to the elongated shaft assembly 9116 means that the distal attachment portion 9480 of the loading unit 9020 has been fully inserted in mating or operational engagement with the distal attachment portion 9032 of the elongated shaft assembly 9116. Direction C can be opposite to direction B, for example. As described

herein, when the coupling collar 9500 returns to the initial orientation, the coupling collar 9500 can lock the distal attachment portion 9480 relative to the distal attachment portion 9032. Referring to FIGS. 110 and 111, the rotation key 9486 can include a rotation ramp 9488 at the proximal end thereof. The rotation ramp 9488 can engage an element of the shaft assembly 9116 to effect rotation of the rotation coupling collar 9500, for example.

[0442] In various embodiments, the rotation ramp 9488 can affect rotation of a firing shaft 9104 positioned within the elongated shaft assembly 9116. For example, referring primarily to FIGS. 115-118, the firing shaft 9104 can include a firing shaft rotator 9600 which can extend radially outward from the firing shaft 9104. The rotation ramp 9488 of the rotation key 10486 can engage the firing shaft rotator 9600 when the loading unit 9020 is inserted into the elongated shaft assembly 9116. In various embodiments, the rotation ramp 9448 can rotate the firing shaft rotator 9600, which can rotate the firing shaft 9104. For example, the firing shaft 104 and the firing shaft rotator 9600 can rotate in direction B between a first orientation (FIG. 121) and a second orientation (FIG. 122). Referring still to FIGS. 115-118, the firing shaft 9104 can be engaged with the rotatable coupling collar 9500. For example, the rotatable coupling collar 9500 can include a rotator groove 9502, which can be structured and dimensioned to receive and/or hold the firing shaft rotator 9600. The firing shaft rotator 9600 can be held by the rotator groove 9600, such that the rotation of the firing shaft rotator 9600 rotates the rotatable coupling collar 9500. In such embodiments, insertion of the loading unit 9020 into the elongated shaft assembly 9116, can affect rotation of the rotatable coupling collar 9500 in direction B (FIG. 122) via rotation of the firing shaft rotator 9600 in direction B, for example.

[0443] Referring primarily to FIGS. 112 and 113, the distal attachment portion 9032 can include a rotation key slot 9510, which can receive the rotation key 9486 when the distal attachment portion 9480 is inserted into the distal attachment portion 9032. In various embodiments, the rotation key slot 9510 can include a clearance notch 9512 for receiving the firing shaft rotator 9600. For example, the rotation ramp 9488 at the proximal end of the rotation key 9486 can rotate the firing shaft rotator 9600 to the second orientation and into the clearance notch 9512 (FIG. 122). The rotation key 9486 can continue to move along the rotation key slot 9510 as the loading unit 9020 is inserted into the elongated shaft assembly 9116. Furthermore, when the distal end 9490 of the rotation key 9486 moves past the firing shaft rotator 9600, the firing shaft rotator 9600 can rotate back toward the first orientation (FIG. 126), which can corresponding rotate the rotatable coupling collar 9500 back toward the initial orientation thereof.

[0444] In various embodiments, the rotatable coupling collar 9500 can be biased into the initial orientation relative to the elongated shaft assembly 9116 and/or the distal attachment portion 9032. For example, a spring 9514 can bias the coupling collar 9500 into the initial orientation. The spring 9514 can include a proximal end 9516 that can be secured relative to the elongated shaft assembly 9116, and a distal end 9550 that can be secured relative to the coupling collar 9500. For example, the proximal end 9516 of the spring 9514 can be retained in a proximal spring slot 9556 (FIG. 119) of the shaft assembly 9116, and the distal end

9550 of the spring 9514 can be retained in a distal spring slot 9552 (FIG. 114) of the rotatable coupling collar 9500, for example. In such embodiments, rotation of the coupling collar 9500 can displace the distal end 9550 of the spring 9514 relative to the proximal end 9516 of the spring 9514, which can generate a torsional force. Accordingly, the coupling collar 9500 can resist rotation from the initial orientation to the secondary orientation, and, when the coupling collar is rotated to the secondary orientation, the spring 9514 can bias the coupling collar 9500 back toward the initial orientation. Because the firing shaft rotator 9600 is engaged with the coupling collar 9500, the spring 9514 can also bias the firing shaft 9104 toward the first orientation thereof.

[0445] In various embodiments, the rotatable coupling collar 9500 can include a locking detent 9518 that releasably locks the loading unit 9020 to the elongated shaft assembly 9116. Referring primarily to FIG. 114, the locking detent 9518 can extend radially inward from the inner perimeter of the rotatable coupling collar 9500. In various embodiments, the locking detent 9518 can extend into a detent slot 9520 (FIG. 112) in the distal attachment portion 9032. Referring primarily to FIG. 112, the detent slot 9520 can form a notch in the guide slot 9034. In various embodiments, the detent slot 9520 can extend from the guide slot 9034, and can be perpendicular or substantially perpendicular to the guide slot 9034, for example. Further, the locking detent 9518 can move along the detent slot 9520 when the rotatable coupling collar 9500 rotates between the initial orientation and the secondary orientation relative to the elongated shaft assembly 9116.

[0446] In various embodiments, the locking detent 9518 can engage the distal attachment portion 9480 of the loading unit 9020 to lock the loading unit 9020 relative to the elongated shaft assembly 9116. For example, referring again to FIG. 110, the distal attachment portion 9480 can include the guide rail 9482, which can have a lock notch 9489 defined therein. The lock notch 9489 can be structured and dimensioned to receive the locking detent 9518 of the rotatable coupling collar 9500 when the loading unit 9020 is fully inserted into the distal attachment portion 9032. For example, when the distal attachment portion 9480 is fully inserted into the distal attachment portion 9032, the lock notch 9489 of the distal attachment portion 9480 can be aligned with the detent slot 9520 of the distal attachment portion 9032. Accordingly, the locking detent 9518 can slide along the detent slot 9520 in the distal attachment portion 9032 and into the lock notch 9489 in the distal attachment portion. Furthermore, the locking detent 9518 can be biased toward engagement with the lock notch 9489 by the torsion spring 9514. For example, after the firing shaft rotator 9600 clears the distal end 9490 of the rotation key 9486, the firing shaft 9104 can be biased back toward the first orientation and the rotatable coupling collar 9500 can be biased back toward the initial orientation by the torsion spring 9514. Furthermore, when the coupling collar 9500 is rotated from the secondary orientation back to the initial orientation, the locking detent 9518 thereof can be aligned and engaged with the lock notch 9489 in the guide rail 9482.

[0447] In various embodiments, rotation of the coupling collar 9500 can facilitate attachment and/or alignment of a firing assembly. For example, the firing shaft 9104 can extend between a proximal end 9524

and a distal end 9522. The proximal end 9524 can have a rotation joint, which can permit rotation of the firing shaft 9104 between the first configuration and the second configuration. Furthermore, the distal end 9522 can have a coupler for attaching the proximal engagement member 9467 of the drive beam assembly 9461 to the firing shaft 104. Rotation of the firing shaft 9104 can facilitate attachment of the proximal engagement member 9467. For example, as the coupler at the distal end 9522 of the firing shaft 9104 rotates, the distal end 9522 is operably coupled to the proximal engagement member 9467. In certain embodiments, the coupler can include a bayonet mount, which can engage a corresponding bayonet receiver of the cutting element in the loading unit 9020. Referring primarily to FIGS. 108 and 109, the firing assembly can further include a sleeve 9526 positioned around the firing shaft9 104 between the proximal end 9524 and the distal end 9522, for example.

[0448] In various embodiments, when the firing shaft 9104 rotates within the elongated shaft assembly 9116, the firing shaft 9104 can rotate into alignment with a firing shaft slot 528 in the loading unit 9020. For example, the firing shaft rotator 9600 can be aligned with the firing shaft slot 9528 when the loading unit 9020 is fully inserted and attached to the elongated shaft assembly 9116. However, in various embodiments, when the loading unit 9020 is only partially inserted into the elongated shaft assembly 9116, the firing shaft rotator 9600 can be rotated, via the rotation key 9486, out of alignment with the firing shaft slot 9528. In other words, the firing shaft rotator 9600 can be aligned with the firing shaft slot 9482 when the firing shaft 9104 is in the first orientation, and can be misaligned with the firing shaft slot 9482 when the firing shaft 9104 rotates toward the second orientation. In such embodiments, when the loading unit is only partially inserted into the elongated shaft assembly 9116 and/or before the loading unit 9020 is releasably locked to the elongated shaft assembly 9116 by the rotatable coupling collar 9500, the firing path of the firing shaft rotator 9600 can be blocked by the distal attachment portion 9480. Integration of the firing shaft 9104 and the coupling collar 9500 can ensure the loading unit 9020 is securely attached to the elongated shaft assembly 9116 before the firing shaft 9104 can fire and/or advance. For example, the surgical instrument may be unable to fire until the cutting element in the loading unit 9020 is coupled to the firing shaft 9104, and/or until the firing shaft 9104 is properly aligned within the elongated shaft assembly 9116, for example.

[0449] In certain embodiments, rotation of the coupling collar 9500 can facilitate attachment and/or alignment of an articulation assembly 9530. Referring primarily to FIGS. 108 and 109, the articulation assembly 9530 can include a proximal articulation bar 9538, a distal articulation bar 9420, and an articulation connector 9532. Furthermore, the shaft assembly 9116 can include a proximal articulation bar slot 9534, and the loading unit 9020 can include a distal articulation bar slot 9410, for example. In certain embodiments, the proximal articulation bar 9538 can be aligned with the proximal articulation bar slot 9534, and the distal articulation bar 9420 can be aligned with the distal articulation bar slot 10410. Referring now to FIG. 114, the articulation connector 9532 can be housed in the rotatable coupling collar 9500. For example, the

rotatable coupling collar 9500 can include an articulation connector slot 9536, and the articulation connector 9532 can be moveably positioned therein.

[0450] In various embodiments, referring again to FIGS. 108 and 109, the proximal articulation bar 9538 can have a proximal notch 9540, and the distal articulation bar 9420 can have a distal notch 9423. Furthermore, the articulation connector 9532 can include a proximal articulation lug 9533 and a distal articulation lug 9540. The proximal articulation lug 9533 can be retained in the proximal notch 9540 of the proximal articulation bar 9538. In certain embodiments, the distal articulation lug 9535 can operably engage the distal notch 9423 of the distal articulation bar 9420. As described herein, the rotatable coupling collar 9500 can rotate between the initial configuration and the secondary configuration. As the coupling collar 9500 rotates, the articulation connector 9532 housed therein can also rotate relative to the longitudinal axis defined by the shaft assembly 9116. In various embodiments, the proximal articulation lug 9533 of the articulation connector 9532 can remain positioned in the proximal notch 9540 of the proximal articulation bar 9538 as the articulation connector 9532 rotates. Furthermore, the distal articulation lug 9535 of the articulation connector 9532 can move into engagement with the distal notch 9423 of the distal articulation bar 9420 as the articulation connector 9532 rotates with the coupling collar 9500 from the secondary orientation toward the initial orientation. For example, when the loading unit 9020 is fully inserted into the shaft 9488, the distal notch 9423 of the distal articulation bar 9420 can be aligned with the distal articulation lug 9533 of the articulation connector 9532. In such embodiments, when the rotatable collar 9500 rotates back to the initial configuration, the distal articulation lug 9533 can slide into the distal notch 9423 of the distal articulation bar 9420. When the distal articulation lug 9533 is positioned in the distal notch 9423, the articulation assembly 9530 can be fully assembled.

[0451] Referring primarily to FIG. 113, in various embodiments, the proximal articulation bar slot 9534 can include a first clearance 9542 and a second clearance 9544. The proximal and distal articulation lugs 9533, 9535 of the articulation connector 9532 can extend into the first and second clearances 942, 9544, respectively. In certain embodiments, the first and second clearances 9542, 9544 can provide a space for the proximal and distal articulation lugs 9533, 9535 to move as the collar 9500 rotates and/or as the articulation assembly 9530 articulates, for example.

[0452] Referring now to FIGS.119-126, to connect the loading unit to the elongated shaft assembly 9116 of the surgical instrument, a user can align the alignment indicia 9484 of the loading unit 9020 with the alignment indicia 9502 of the elongated shaft assembly 9116 and/or the coupling collar 9500 (FIG. 119). While maintaining alignment of the alignment indicia 9484, 9502, the user can move the loading unit 9020 relative to the elongated shaft assembly 9116 along the longitudinal axis LA-LA. The user can move the loading unit 9020 along a straight or substantially straight path, and, in various embodiments, need not rotate the loading unit 9020 relative to the elongated shaft assembly 9116, for example. Referring primarily to FIG. 121, the loading unit 9020 can continue to translate relative to the elongated shaft assembly 9116, and the

guide rail 9482 of the distal attachment portion 9480 can fit into the guide slot 9034 (FIG. 112) in the distal attachment portion 9032 of the elongated shaft assembly 9116. As the distal attachment portion 9480 moves into the distal attachment portion 9032, the guide slot 9034 can guide the guide rail 9482, and can maintain alignment of the alignment indicia 9484, 9502, for example. In other words, the guide slot 9034 and the guide rail 9482 can prevent rotation of the loading unit 9020 relative to the longitudinal axis of the elongated shaft assembly 9116. Referring primarily to FIG. 120, the proximal articulation lug 9533 of the articulation connector 9032 can extend into the first clearance 9542 and can be positioned in the proximal notch 9540 of the proximal articulation bar 9420, and the distal articulation lug 9535 of the articulation connector 9032 can extend through the second clearance 9544, for example.

[0453] Referring primarily to FIG. 122, as the distal attachment portion 9480 is inserted into the distal attachment portion 9032, the rotation key ramp 9488 of the rotation key 9486 can abut the firing shaft rotator 9600. The rotation key ramp 9488 can guide and/or direct the firing shaft rotator 9600 into the clearance notch 9512 extending from the rotation key slot 9510. Furthermore, as the firing shaft rotator 9600 moves into the clearance notch 9512, the firing shaft 9104 can rotate in the direction B. The firing shaft 9104 can rotate from the first orientation to the second orientation. Such rotation of the firing shaft 9104 can facilitate attachment of the distal end 9522 of the firing shaft 9104 with the proximal engagement member 9467 that is pivotally coupled to the drive beam assembly 9461. Furthermore, rotation of the firing shaft rotator 9600 can rotate the coupling collar 9500 in the direction B via the engagement between the firing shaft rotator 9600 and the firing shaft rotator groove 9600 in the coupling collar 9500. The coupling collar 9500 can rotate from the initial orientation to the secondary orientation, for example. Additionally, the locking detent 9518 can move along the detent slot 9520 in the shaft assembly 9116 as the coupling collar 9500 rotates. Additionally, rotation of the coupling collar 9500 can rotate the distal end 9550 of the spring 9514 because the distal end 9550 of the spring 9514 can be retained in the distal spring slot 9552 (FIG. 114) in the coupling collar 9500. Displacement of the distal end 9550 relative to the proximal end 9516 can generate a torsional springback force, which can bias the coupling collar 9500 from the secondary orientation toward the initial orientation, for example, and can bias the firing shaft 9104 from the second orientation toward the first orientation, for example.

[0454] Referring primarily to FIG.123, as the coupling collar 9500 rotates toward the secondary orientation, the proximal articulation lug 9533 can remain engaged with the proximal notch 9540 in the proximal articulation bar 9538. Furthermore, the distal articulation lug 9535 can rotate such that the distal articulation lug 9535 provides a clearance for the distal articulation bar 9420 of the loading unit 9020. Referring to FIG. 124, the loading unit 9020 can be fully inserted into the elongated shaft assembly 9116 when the coupling collar 9500 and the articulation connector 9532 positioned therein are rotated to the secondary orientation. In various embodiments, the distal articulation bar 9420 can clear the distal articulation lug 9535 of the articulation connector 9532 when the articulation connector 9532 is rotated to the

secondary orientation. Furthermore, the distal articulation lug 9535 can be rotatably aligned with the distal notch 9423 in the articulation connector 9532. Referring still to FIG. 124, when the loading unit 9020 is fully inserted into the elongated shaft assembly 9116, the firing rod rotator 9600 can clear the distal end 9490 of the rotation key 9486.

[0455] Referring now to the FIG. 125, the firing shaft rotator 9600 can rotate in the direction C when the distal end 9490 of the rotation key 9486 passes the firing shaft rotator 9600. For example, the firing shaft rotator 9600 can rotate in direction C from the second orientation toward the first orientation. Furthermore, rotation of the firing shaft rotator 9600 can affect rotation of the coupling collar 9500 in the direction C from the secondary orientation toward the initial orientation. In various embodiments, the spring 9514 can bias the firing rod 9104 toward the first orientation thereof and the collar 9500 toward the initial orientation thereof. For example, the firing shaft rotator 9600 can be positioned in the firing shaft rotator groove 9602 (FIG. 114) in the coupling collar 9500 such that rotation of the firing shaft rotator 9600 rotates the coupling collar 9500. Due to the alignment of the distal articulation lug 9535 of the articulation connector 9532 and the distal notch 9423 of the distal articulation bar 9420, the articulation connector 9532 can rotate as the coupling collar 9500 rotates, and the distal articulation lug 9535 can rotate into engagement with the distal notch 9423. The articulation assembly 9530 can be assembled when the distal articulation lug 9535 engages the distal notch 9423. Furthermore, as the firing shaft rotator 9600 rotates in direction C, the distal end 9522 of the firing shaft 9104 can rotate in direction C, which can facilitate attachment of a the proximal engagement member 9467 of the drive beam assembly 9461 to the distal end 9522 of the firing shaft 9104.

[0456] Referring now to FIG. 126, rotation of the coupling collar 9500 can also rotate the locking detent 9518 of the collar 9500 into the lock notch 9489 in the guide rail 9482 of the distal attachment portion 9480. For example, when the loading unit 9020 is fully inserted into the elongated shaft assembly 9116, the lock notch 9489 can be aligned with the detent slot 9520 such that the locking detent 9518 can rotate through the detent slot 9520 and into the lock notch 9489. As described herein, the spring 9514 can bias the coupling collar 9500 to rotate in the direction C (FIG. 125) after the firing shaft rotator 9600 clears the distal end 9490 of the rotation key 9486. Referring still to FIG.126, when the firing shaft rotator 9600 rotates in direction C, the firing shaft rotator 9600 can move into alignment with the firing shaft slot 9528 in the loading unit 9020. Alignment of the firing shaft rotator 9600 with the firing shaft slot 9528 can permit the firing shaft 9104 to be advanced distally to fire the loading unit 9020, for example.

[0457] As described herein, the rotatable coupling collar 9500 can releasably lock the loading unit 9020 relative to the elongated shaft assembly 9116. Furthermore, rotation of the coupling collar 9500 can facilitate simultaneous attachment and/or alignment of the articulation assembly 9530, as well as attachment and/or alignment of the firing shaft 9104 with a cutting head assembly in the loading unit 9020, for example. Furthermore, rotation of the coupling collar 9500 can also simultaneously unlock the loading unit 9020 from the elongated shaft assembly 9116, disconnect the articulation assembly 9530, and/or disconnect the firing

shaft 104 from the cutting element in the loading unit 9020. For example, when the coupling collar 9500 is again rotated from the initial orientation toward the secondary orientation, the locking detent 9518 can disengage the lock notch 9489 in the distal attachment portion 9480. Accordingly, the distal attachment portion 9480 can be withdrawn from the distal attachment portion 9032 along the longitudinal axis defined by the elongated shaft assembly 9116, for example. In various embodiments, the loading unit 9020 can be unattached from the elongated shaft assembly 9116 without rotating the loading unit 9020 relative to the elongated shaft assembly 9116. However, the coupling collar 9500 can rotate relative to the elongated shaft assembly 9116, which can disconnect the distal articulation bar 9420 from the articulation connector 9532 in the coupling collar 9500, and can disconnect the firing shaft 9104 from the cutting element or drive beam assembly in the loading unit 9020, for example.

[0458] Thus, as can be appreciated from the foregoing, at least one surgical instrument embodiment of the present invention includes a surgical end effector that comprises a lower jaw and an upper jaw. In one implementation, the upper jaw comprises a proximal upper jaw portion that is pivotally coupled to the lower jaw for selective pivotal travel relative thereto about a pivot axis between open and closed positions upon application of closing and opening motions to the proximal upper jaw portion. A distal upper jaw portion may be movably coupled to the proximal upper jaw portion and is supported for parallel movement toward and away from the lower jaw when the proximal upper jaw portion is in the closed position. A firing member may be operably supported for operable travel within the surgical end effector relative to the upper and lower jaws when the proximal upper jaw portion is in the closed position and firing motions are applied to the firing member.

[0459] In at least one implementation, the surgical instrument may employ a lockout system that is configured to not only prevent actuation of the firing system or stated another way, advancement of the cutting head through the elongated channel when a cartridge is not present, but also to prevent such firing system actuation unless a new cartridge has been properly supported within the elongated channel. In such implementations, each new cartridge has a sled assembly supported in a starting position. When a cartridge has been properly installed within the elongated channel, the sled assembly interfaces with the lockout system to thereby enable the cutting head to be advanced distally through the cartridge. If, however, a spent cartridge has been inadvertently installed in the elongated channel, the lockout system will prevent actuation of the cutting head, because the sled assembly will be located in the distal end of the cartridge and thereby unable to interface with the lockout system. Such system will prevent re-actuation of the firing system, should the clinician fail to replace a spent cartridge and attempt to actuate the firing system.

[0460] In at least one other implementation, there is provided a surgical instrument that comprises an elongated shaft assembly and a surgical end effector that includes an elongated channel that is coupled to the elongated shaft assembly. A surgical staple cartridge may be operably supported in the elongated channel. The end effector may further comprise an anvil assembly that includes a proximal anvil portion that is

pivotally coupled to the elongated channel about a pivot axis. The proximal anvil portion is selectively movable between open and closed positions upon application of closing and opening motions thereto. The anvil assembly may further comprise a distal anvil portion that is slidably coupled to the proximal anvil portion such that when the proximal anvil portion is in the closed position, the distal anvil portion is movable relative thereto while remaining parallel to the elongated channel. A firing member may be operably supported for operable movement within the surgical end effector upon application of firing and retraction motions thereto. A firing system may be configured to selectively apply the firing and retraction motions to the firing member. The instrument may further include a closure system for applying the opening and closing motions to the proximal anvil portion.

[0461] In accordance with at least one other general form, there is provided a surgical method for treating target tissue within a patient. In various implementations, the method may comprise installing a hollow trocar port into a patient and providing a surgical end effector. The surgical end effector may comprise an elongated shaft assembly that defines a longitudinal tool axis and includes a lower jaw that is operably coupled to the elongated shaft assembly. The lower jaw may include elastic biasing means. An upper jaw may be supported for movement relative to the lower jaw upon application of actuation motions thereto. The upper jaw may be movable between a first insertion position wherein the upper jaw is compressible against the biasing means on the lower jaw to provide the surgical end effector with a smallest cross-sectional shape to facilitate passage of the surgical end effector through the hollow trocar port into the patient and a primary opened position. When in the primary open position the upper jaw may be movable into a fully open position for admitting target tissue between the upper and lower jaws. Upon application of another actuation motion to the upper jaw, the upper jaw may be moved to a fully clamped position wherein a target tissue may be clamped between the upper and lower jaws. A firing member may be operably supported for selective operable travel within the surgical end effector upon application of a firing motion thereto. The surgical method may further comprise inserting the surgical end effector into the hollow trocar port such that an inner surface of the hollow trocar port compresses the upper jaw into the insertion position until the surgical end effector has exited the distal end of the trocar port whereupon the biasing means moves the upper jaw into the primary opened position. The method may also comprise applying the actuation motion to the upper jaw to move the upper jaw to the fully opened position and manipulating the end effector such that the target tissue is positioned between the upper and lower jaws. The method may further include applying the another actuation motion to the upper jaw to move the upper jaw into the fully clamped position and applying the firing motion to the firing member to cause the firing member to travel from a starting position to an ending position within the end effector.

[0462] In accordance with another general form, there may be provided a surgical method for treating target tissue within a patient. In various implementations, the method may comprise installing a hollow trocar port into a patient and providing a surgical end effector. The surgical end effector may comprise an

elongated shaft assembly that has a lower jaw operably coupled thereto. The lower jaw may include elastic biasing means. An upper jaw may be supported for movement relative to the lower jaw upon application of actuation motions thereto. The upper jaw may be movable between a first insertion position wherein the upper jaw is compressible against the elastic biasing means to provide the surgical end effector with a smallest cross-sectional shape to facilitate passage of the surgical end effector through the trocar port into the patient and a primary opened position. When in the primary opened position, an application of an actuation motion to the upper jaw may move the upper jaw into a fully open position for admitting target tissue between the upper and lower jaws. Upon application of another actuation motion to the upper jaw may move the upper jaw to a fully clamped position wherein the target tissue is clamped between the upper and lower jaws. A control insert may operably support a portion of the upper jaw therein and be selectively movably supported in the lower jaw for travel between a first position corresponding to the insertion position and a second position corresponding to the primary opened position. The surgical end effector may further comprise means for moving the control insert between the first and second positions and a firing member that is operably supported for selective operable travel within the surgical end effector upon application of a firing motion thereto. The surgical method may further comprise moving the control insert into the first position and inserting the surgical end effector through the hollow trocar port into the patient. The method may also comprise moving the control insert to the second position to enable the biasing means to move the upper jaw into the primary opened position and applying the actuation motion to the upper jaw to move the upper jaw to the fully opened position. The surgical method may also include manipulating the end effector such that the target tissue is positioned between the upper and lower jaws and applying another actuation motion to the upper jaw to move the upper jaw into the fully clamped position. The surgical method may include applying the firing motion to the firing member to cause the firing member to travel from a starting position to an ending position within the end effector.

[0463] In accordance with another general form, there is provided a surgical method for treating target tissue within a patient. In various implementations, the method comprises installing a hollow trocar port into a patient and providing a surgical end effector. The surgical end effector may comprise a lower jaw and an upper jaw that is supported for movement relative to the lower jaw between a first insertion position wherein the upper jaw is compressible against the lower jaw to provide the surgical end effector with a smallest cross-sectional shape to facilitate passage of the surgical end effector through the hollow trocar port into the patient and a primary opened position. When in the primary opened position, upon application of an actuation motion to the upper jaw, the upper jaw may be movable into a fully open position for admitting target tissue between the upper and lower jaws. Upon application of another actuation motion to the upper jaw, the upper jaw may be moved to a fully clamped position wherein the target tissue is clamped between the upper and lower jaws. A firing member may be operably supported for selective operable travel within the surgical end effector upon application of a firing motion thereto. The surgical method may further comprise operably

coupling an elongated shaft assembly to the surgical end effector wherein the elongated shaft assembly defines a longitudinal tool axis and includes a distal closure tube portion that is supported for axial travel relative to the upper jaw to apply the actuation motions thereto. The distal closure tube portion may include biasing means to automatically bias the upper jaw to the primary opened position upon exiting of the upper jaw from the trocar port. The surgical method may also include inserting the surgical end effector into the hollow trocar port such that an inner surface of the hollow trocar port compresses the upper jaw into the insertion position until the surgical end effector has exited the distal end of the trocar port whereupon the biasing means moves the upper jaw into the primary opened position. The surgical method may also comprise applying the actuation motion to the upper jaw to move the upper jaw to the fully opened position and manipulating the end effector such that the target tissue is positioned between the upper and lower jaws. The surgical method may also include applying the another actuation motion to the upper jaw to move the upper jaw into the fully clamped position and applying the firing motion to the firing member to cause the firing member to travel from a starting position to an ending position within the end effector.

[0464] Referring to an exemplary embodiment depicted in FIGS. 127-129, a surgical instrument 100 can include a handle assembly 104, a shaft 114 extending from the handle assembly 104, and an end effector 120 extending from the shaft 114. Referring primarily to FIG. 129, a staple cartridge 140 can be loaded into an elongate channel 122 of a first jaw 123 of the end effector 120. In certain embodiments, the staple cartridge 140 can be disposable and/or replaceable, for example. Additionally or alternatively, the staple cartridge 140 can be integrated into the end effector 120, for example, and/or the end effector 120 can be disposable and/or replaceable, for example. In various embodiments, the surgical instrument 100 can be motor-driven. For example, referring primarily to FIG. 128, a motor 106 can be positioned in the handle assembly 104. The handle assembly 104 of the surgical instrument 100 can also include a trigger 108. Actuation of the trigger 108 can affect closure of the jaws 123, 124 of the end effector 120, firing of staples 160 from the staple cartridge 140, and/or translation of a firing bar 156 and cutting element 158 through the end effector 120, for example.

[0465] Referring primarily to FIG. 129, staples 160 can be ejectably positioned in the staple cartridge 140. For example, at least one sled 190 can translate through the staple cartridge 140 to eject the staples 160 from the staple cartridge 140. The firing bar 156 having the cutting element or knife 158 can also translate through the staple cartridge 140 to cut tissue captured between the end effector jaws, 123, 124, for example. As depicted in FIG. 129, the firing bar 156 and cutting element 158 can move from a proximal position in the first jaw 123 to a distal position in the first jaw 123. In various embodiments, tissue positioned intermediate the staple cartridge 140 and the anvil 124 can be stapled by the staples 160, and then cut by the cutting element 158, for example. Referring primarily to FIGS. 130 and 131, the staple cartridge 140 can include a cartridge body 142 and staple cavities 144 defined in the cartridge body 142. Staples, such as staples 160, for example, can be removably positioned in the staple cavities 144. In certain embodiments, each staple

cavity 144 can removably store a single staple 160. Each staple cavity 144 can have a proximal end 146 and a distal end 148, for example, and longitudinal sidewalls 150 can extend between the proximal end 146 and the distal end 148 of each staple cavity 144. As described in greater detail herein, the proximal ends 146, the distal ends 148, and/or the longitudinal sidewalls 150 of the staple cavity 144 can guide and/or support the staple 160 during deployment from the staple cavity 144.

[0466] Referring now to FIGS. 132-139, the staple 160 can include a base 162, a first staple leg 164 extending from the base 162, and a second staple leg 166 extending from the base 162. The base 162 can have a proximal portion 168 and a distal portion 170, for example, and an intermediate portion 172 of the base 162 can be positioned between the proximal portion 168 and the distal portion 170, for example. As depicted in FIGS. 132-139, the first staple leg 164 can extend from the proximal portion 168 of the base 162, and the second staple leg 166 can extend from the distal portion 170 of the base 162. The staple legs 164, 166 can include a tip 174, for example, which can have a pointed or substantially pointed end. In various embodiments, the tip 174 can facilitate piercing into and/or through tissue, for example. In certain embodiments, the staple legs 164, 166 can include corner edges 176, which can be sharp, or substantially sharp, for example, and can also facilitate piercing into and/or through tissue, for example. In other embodiments, the staple legs 164, 166 can include rounded corner edges.

[0467] Referring still to FIGS. 132-139, chamfers 184, 186 can be positioned between the staple legs 164, 166 and the base 162. For example, an upper chamfer 184 can extend between the staple legs 164, 166 and the base 162, and/or a lower chamfer 186 can extend between the staple legs 164, 166 and the base 162. When tissue is captured by the staple 160, the tissue can be compressed between the base 162 and the deformed staple legs 164, 166, and the chamfers 184, 186 may contact the compressed tissue. In various embodiments, the chamfers 184, 186 can compress the captured tissue, for example, and may prevent the base 162 from unintentionally piercing and/or cutting the captured tissue, for example.

[0468] In various embodiments, the base 162 of the staple 160 may be asymmetrical relative to the staple legs 174, 176. For example, referring primarily to FIG. 136, a first axis A may be defined between the first and second staple legs 174, 176, and the base 162 can be asymmetrical relative to the first axis A. The base 162 can be non-linear, for example, and can include at least one laterally contoured portion 178 that bends or curves away from the axis A. The base 162, or at least a portion of the base 162, can be defined by a second axis B. The contoured portion 178 can be include straight and/or curved regions, and may be generally non-parallel to the first axis A and the second axis B, for example. For example, the contoured portion 178 can bend or curve away from the first axis A, include a straight or substantially straight portion, and bend or curve toward the second axis B (FIG. 136).

[0469] Referring still to FIG. 136, the center of mass (COM) of the staple 160 can be offset from the first axis A. In various embodiments, a portion of the base 162 can extend along the second axis B, for example, which can be parallel or substantially parallel to the first axis A. For example, the intermediate portion 172

of the base 162 can be parallel or substantially parallel to the first axis A. A contoured portion 178 can be positioned between the proximal portion 168 and the intermediate portion 172, for example, and another contoured portion 178 can be positioned between the distal portion 170 and the intermediate portion 172, for example. The contoured portions 178 can laterally offset the intermediate portion 172 of the base 162 from the staple legs 164, 166 and from the first axis A, for example. In certain embodiments, the staple legs 164, 166 can be positioned in a first plane defined by the first axis A, for example, and the intermediate portion 172 of the base 162 can be positioned in a second plane defined by the second axis B. The second plane can be parallel, or substantially parallel, to the first plane, for example, and the center of mass (COM) of the staple 160 can be positioned between the first plane and the second plane. In such embodiments, the staple 160 can include a leg formation plane, *e.g.*, the plane defined by the first axis A, which can be offset from the COM of the staple 160. For example, deformation of the staple 160 can form a modified "B-form", for example, and the staple legs 164, 166 may be non-coplanar and/or laterally offset from the intermediate portion 172 of the staple base 162. In various instances, the modified "B-form" staple formation can engage, capture, compress, and/or affect a greater volume of tissue, for example. Additionally, in certain instances, the modified "B-form" staple formation can exert forces on the engaged tissue in different and/or divergent directions, for example. Modified "B-form" can define a tissue entrapment area extending in three different directions. For instance, a portion of the tissue entrapment area can be defined in two directions by the legs 164 and 166 and another portion of the tissue entrapment area can be defined in a third direction between the base 162 and the legs 164, 166.

[0470] In various embodiments, the intermediate portion 172 of the staple base 162 can include a longitudinal guide surface 173. For example, as described in greater detail herein, the longitudinal guide surface 173 can slide and/or move against a guide surface 150 in the staple cavity 144 (FIGS. 130 and 131) as the staple 160 is fired and/or ejected from the cartridge body 142 (FIGS. 130 and 131), for example. In such embodiments, the longitudinal guide surface 173 can balance and/or stabilize the staple 160 during deployment. Furthermore, the intermediate portion 172 of the staple base 162 can include a tissue-contacting surface 175 (FIG. 135), which can be flat or substantially flat, for example. In various instances, the tissue-contacting surface 175 of the base 162 can form a flat surface for contacting captured tissue, which can provide a broad and/or smooth surface for applying and/or distributing pressure on the captured and/or compressed tissue. In such embodiments, tissue tearing and/or trauma within the staple 160 may be reduced and/or minimized, for example.

[0471] In various embodiments, the base 162 of the staple 160 can include one of more drive surfaces. For example, the base 162 can include an initial drive surface 180 and a secondary drive surface 182. Referring still to FIGS. 132-139, the proximal portion 168 of the base 162 can include the initial drive surface 180, for example, and/or the intermediate portion 172 of the base 172 can include the secondary drive surface 182. For example, the proximal portion 168 can include a nub having the first drive surface 180. The nub of the

first drive surface 180 can include a rounded and/or sloped surface, for example. The secondary drive surface 182 can comprise a ramp on the intermediate portion 172 of the base 162. For example, the secondary drive surface 182 can be positioned distal to the initial drive surface 180 and/or between the proximal portion 168 and the distal portion 170 of the base 162, for example. The secondary drive surface 182 can include an inclined surface or plane, for example, and can slope downward in the direction of the distal portion 170 (see FIGS. 133 and 134).

[0472] Referring primarily to FIGS. 133 and 134, a staple midline M can be defined intermediate the first staple leg 164 and the second staple leg 166. The staple midline M can bisect the staple 160, and can pass through the center of mass (COM) of the staple 160, for example. In various embodiments, the secondary drive surface 182 can extend across the midline M. For example, the secondary drive surface 182 can extend along the intermediate portion 172 of the base 162, and can cross from a proximal side of the midline M to a distal side of the midline M. In such embodiments, during deployment of the staple 160 via the sled 190, as described in greater detail herein, a ramp 192 of the sled 190 can drive the staple 160 at and/or near the midline M of the staple 160 during a portion of the staple's deployment. In various embodiments, the distal end of the secondary drive surface 182 can also include a staple overdrive 188, which is described in greater detail herein. Referring primarily to FIG. 133, the staple overdrive 188 can include the lowest point of the intermediate portion 172 of the base 162 and, in some embodiments, can be vertically aligned with the lowest point of the proximal portion 168 and/or the distal portion 170 of the base 162, for example. In other embodiments, the staple overdrive 188 may be positioned vertically below or above the lowest portion of the proximal portion 168 and/or the distal portion 170 of the base 162.

[0473] In various embodiments, the drive surfaces 180, 182 of the staple 160 can be separate and distinct. For example, the drive surfaces 180, 182 can be laterally and/or longitudinally offset, such that the drive surfaces 180, 182 are unconnected and/or nonadjacent. Each drive surface can be discrete, for example. The initial drive surface 180 can overlap a first plane (*see* axis A in FIG. 136), for example, and the secondary drive surface 182 can overlap a second plane (*see* axis B in FIG. 136), for example. In certain embodiments, the drive surfaces 180, 182 can be parallel. For example, the initial drive surface 180 can extend along the first axis A (FIG. 136), and the secondary drive surface 180 can extend along the second axis B (FIG. 136). In various embodiments, a lateral gap having a width x (FIGS. 136 and 137) can be defined between the initial drive surface 180 and the secondary drive surface 182, for example. In some embodiments, a longitudinal gap having a width y (FIG. 136) can be defined between the initial drive surface 180 and the secondary drive surface 182, for example. The initial drive surface 180 can be proximal to the secondary drive surface 182, for example. Furthermore, a non-driven portion of the base, such as the lower chamfer 186 of the contoured portion 178 between the proximal portion 168 and the intermediate portion 172, for example, can separate the initial drive surface 180 and the secondary drive surface 182, for example. In

various embodiments, the contoured portions 178 can traverse between the first plane defined by axis A and the second plane defined by axis B, for example.

[0474] Referring still to FIGS. 132-139, at least one of the drive surfaces 180, 182 of the staple 160 can be integrally formed with the staple 160. For example, the drive surfaces 180, 182 can be defined in the base 162 of the staple 160. The staple 160 can comprise a single, unitary piece, for example, which may integrally include the drive surfaces 180, 182. The drive surfaces 180, 182 can comprise a boundary or perimeter surface of the single, unitary piece, for example. In various circumstances, the staple 160 can be seamless, for example, and many not include any adhered and/or overmolded features, for example. Furthermore, the base 162 and the staple legs 164, 166 can be a contiguous part, and the base 162 can integrally define the drive surfaces 180, 182, for example. In certain instances, as described in greater detail herein, the staple 160 can be stamped or otherwise formed from a single piece of material, for example, and can remain a single piece of material, for example. In various instances, the drive surfaces 180, 182 can comprise a surface or flat of the formed piece.

[0475] Referring now to FIGS. 140-143, the sled 190 can drive the staples 160 from the cavities 144 in the cartridge body 142 (FIG. 129). In various instances, the sled 190 can directly contact the staples 160 and/or can directly drive the staples 160. For example, the sled 190 can include a ramp or inclined surface 192, which can contact at least one drive surface 180, 182 of the staple 160. As the sled 190 translates relative to the staple 160, the ramp 192 can push the drive surfaces 180, 182 to lift the staples 160. In various embodiments, the degree of incline of the ramp 192 can vary along the length thereof. For example, the ramp 192 can be designed to lift the staple 160 faster and/or slower during at least part of the staple's deployment. Moreover, the degree of incline of the ramp 192 can be designed and/or selected based on the degree of incline of a staple drive surface 180, 182. For example, the ramp 192 can define an incline that is greater than, less than, and/or equal to the incline of the initial drive surface 180 and/or the secondary drive surface 182. The relationship between the ramp 192 incline and the drive surface 180, 182 incline can affect the speed of staple deployment, for example.

[0476] Referring still to FIGS. 140-143, the sled 190 can include at least one lateral portion 191a, 191b. For example, the sled 190 can include a single lateral portion, a pair of lateral portions, and/or more than two lateral portions. In various instances, each lateral portion 191a, 191b can correspond to a row of staples 160 removably positioned in the cartridge body 142. As further depicted in FIGS. 140-143, the lateral portions 191a, 191b can be longitudinally staggered. For example, in certain embodiments, the first lateral portion 191a can lag behind or follow the second lateral portion 191b by a length of distance L (FIGS. 140 and 142). In other embodiments, the lateral portions 191a, 191b can be longitudinally aligned and/or the second lateral portion 191b can lag or follow the first lateral portion 191a, for example. In embodiments where the sled 190 comprises multiple lateral portions 191a, 191b, an intermediate portion 193 can connect and/or bridge the lateral portions 191a, 191b, for example.

[0477] Referring primarily to FIGS. 140-143, the sled 190 can transfer between the drive surfaces 180, 182 of the staple 160. Stated differently, the sled 190 can exert a driving force on the initial driving surface 180 of the staple 160, for example, and can then transition to exert a driving force on the second, or secondary, driving surface 182 of the staple 160. In certain embodiments, the sled ramp 192 can include a leading surface 194 and a trailing surface 196. The leading surface 194 can be adjacent to and/or connected to the trailing surface 196, for example, and the staple 160 can smoothly transition between the leading surface 194 and the trailing surface 196. For example, the leading surface 194 can contact the staple 160 and begin to lift the staple 160, and the trailing surface 196 can move into contact with the staple 160 and continue to lift the staple 160. In certain instances, the trailing surface 196 can smoothly lift the staple 160 out of and/or away from engagement with the leading surface 194, for example.

[0478] Referring still to FIGS. 140-143, the leading surface 194 can be aligned with the initial drive surface 180 and the trailing surface 196 can be aligned with the secondary drive surface 182, for example. In operation, the leading surface 194 of the ramp 192 can initially contact the staple 160. For example, referring to FIGS. 140 and 141, as the sled 190 translates, the leading surface 194 can contact the initial drive surface 180 of the staple 160. The inclined leading surface 194 can exert a driving force on the initial drive surface 180, which can begin to the lift the base 162 of the staple 160. For example, the staple 160 can be lifted a first distance or height by the leading surface 194. As the sled 190 continues to translate, referring now to FIGS. 142 and 143, the trailing surface 196 can move into contacting engagement with the secondary drive surface 182 of the staple 160, for example. The inclined trailing surface 196 can exert a driving force on the secondary drive surface 182, for example, which can continue to the lift the base 162 of the staple 160. For example, the staple 160 can be lifted a second distance or height by the trailing surface 194.

[0479] In various instances, the trailing surface 196 can lift the initial drive surface 180 away from and/or out of contact with the leading surface 194 of the ramp 192, for example. For example, the trailing surface 196 can contact the secondary drive surface 182 and immediately lift the staple 160 such that the primary drive surface 180 is moved out of driving contact with the leading surface 194. In other embodiments, the leading surface 194 can drive the initial drive surface 180 and the trailing surface 196 can drive the secondary drive surface simultaneously for at least a portion of the staple's deployment. As the sled 190 continues to translate, the trailing surface 196 can lift the base 162 out of the staple cavity 144 (FIGS. 130 and 131) and/or can eject the staple 160 from the cartridge 140 (FIGS. 130 and 131). For example, the proximal portion of the trailing surface 196 can include a sled overdrive 198. In various embodiments, the sled overdrive 198 can extend out of the staple cavity 144 and can lift the staple overdrive 188, *i.e.*, the lowest portion of the intermediate portion 172 of the base 162 (see FIG. 133), out of the staple cavity 144.

[0480] Deployment of multiple staples 160 according to an exemplary application of the present disclosure is depicted in FIGS. 144-147. In certain embodiments, multiple rows of staple cavities 144 can be defined in the cartridge body 142. For example, multiple rows of staple cavities 144 can be defined on a first side of the

cartridge slot 143 (FIG. 129), and multiple rows of staple cavities 144 can be defined on a second side of the cartridge slot 143. FIGS. 144-147 depict two rows of staples 160 positioned in two rows of staples cavities 144 in the cartridge body 142. Referring still to FIGS. 144-147, the staples 160a, 160c, and 160e can be positioned in a more inner row of staple cavities 144, for example, and the staples 160b, 160d, and 160f can be positioned in a more outer row of staple cavities 144, for example. In various embodiments, the first inner staple 160a can be positioned nearer to the cartridge slot 143 than the first outer staple 160b. For example, the first inner staple 160a can be adjacent to the cartridge slot 143, and the first outer staple 160b can be intermediate the first inner staple 160a and the side of the cartridge body 142, for example. In various embodiments, additional rows of staples 160 can be defined in the cartridge body 142. For example, at least one row of staples can be positioned intermediate the first staple 160a and the cartridge slot 143, and/or at least one row of staples 160 can be positioned intermediate the first outer staple 160b and the side of the cartridge body 142, for example.

[0481] Referring primarily to FIG. 144, as the sled 190 moves distally, the second lateral portion 191b can contact the first inner staple 160a. The leading surface 194 (FIGS. 140-143) of the second lateral portion 191b can begin to lift the first inner staple 160a, for example. Referring now to FIG. 145, as the sled 190 continues to move distally, the trailing surface 196 (FIGS. 140-143) of the second lateral portion 191b can continue to lift the first inner staple 160a, and can move the first inner staple 160a into forming contact with the anvil 152 of the end effector 120, for example. Additionally, the leading surface 194 of the second lateral portion 191b can move into contact with the second inner staple 160c, for example. In various instances, the first lateral portion 191a can move into contact with the first outer staple 160b at the same time that the second lateral portion 191b moves into contact with the second inner staple 160c, for example. In certain embodiments, the longitudinal lag or offset between the first lateral portion 191a and the second lateral portion 191b can correspond to the longitudinal distance between the first outer staple 160b and the second inner staple 160c. For example, the first lateral portion 191a can lag behind the second lateral portion 191b a length L (FIGS. 140 and 142), and the first outer staple 160b can be longitudinally offset from the second inner staple 160c by the length L. In such embodiments, deployment of the first outer staple 160b and the second inner staple 160c can be simultaneous and/or synchronized, for example.

[0482] Referring now to FIG. 146, as the sled 190 continues to progress, the trailing surface 196 of the second lateral portion 191b can continue to lift the first inner staple 160a toward the anvil 152. The staple forming pockets 154 defined in the anvil 152 can catch the staple legs 164, 166, and can deform the first inner staple 160a. Furthermore, the second lateral portion 191b can continue to lift the second inner staple 160c, and the first lateral portion 191a can continue to lift the first outer staple 160b, for example. Referring now to FIG. 147, as the sled 190 continues to move distally, the second lateral portion 191b can eject the first inner staple 160a from the staple cavity 144. In various instances, the sled overdrive 198 (FIGS. 140-143), can lift the staple overdrive 188 to clear the staple base 162 over the cartridge body 142,

for example. As the staple forming pockets 154 of the anvil 124 continue to form the first inner staple 160a, the second lateral portion 191b can continue to lift the second inner staple 160c, for example, and the first lateral portion 191a can continue to lift the first outer staple 160b. Additionally, the second lateral portion 191b can move into contact with the third inner staple 160e, for example, and the first lateral portion 191a can move into contact with the second outer staple 160d, for example. In various instances, similar to the above, the second outer staple 160d can be longitudinally offset from the third inner staple 160e by the length L (FIGS. 140 and 142).

[0483] As described herein, the staples 160 can be sequentially fired from the cartridge 140. For example, as the sled 190 moves distally, the sled 190 can sequentially fire staples 160 from a proximal portion of the cartridge body 142 toward a distal portion of the cartridge body 142. As described herein, the sled 190 can fire a first, more proximal, inner staple 160a before firing a second, more distal, inner staple 160c. In other embodiments, the sled 190 may translate proximally to fire staples 160 from a staple cartridge. In such embodiments, the sled 190 can sequentially fire staples 160 from a distal portion of the staple cartridge 140 toward a proximal portion of the staple cartridge 140. Moreover, firing of the staples 160 from the staple cartridge 140 can be paced or synchronized. For example, the first outer staple 160b and the second inner staple 160c can be fired simultaneously, and/or the second outer staple 160d and the third inner staple 160e can be fired simultaneously, for example. For example, the longitudinal offset between the first lateral portion 191a of the sled 190 and the second lateral portion 191b of the sled 190 can correspond to the longitudinal distance between a staple 160 in a first row of staple cavities and a staple 160 in a second, different row of staple cavities. In such embodiments, deployment of the staples 160 can be timed such that a staple 160 in the first row of staple cavities is fired at the same time as a staple 160 in the second row of staple cavities. The timing or pacing of staple deployment can improve tissue positioning and/or placement during firing. For example, sections of the tissue can be held in position by the end effector jaws 123, 124 (FIG. 129), and the sections can be stapled simultaneously. In other instances though, the offset between 191a and 191b may not be the same as the offset between the staples in the staple rows.

[0484] An exemplary embodiment of staple deployment is further illustrated in FIGS. 148-157. For example, the staples 160a, 160b, 160c, and 160d can be positioned on both sides of the cartridge slot 140, and can be ejectably positioned in staple cavities 144 defined in the cartridge body 142. Referring primarily to FIGS. 148 and 149, the staples 160a, 160b, 160c, and 160d can be unfired, and the sleds 190 can be positioned proximal to the cartridge body 142. The sleds 190 can be aligned with the rows of staple cavities 144 in the cartridge body 142. For example, a first sled 190 can be aligned with the staples 160a, 160c in the first inner row of staple cavities 144 and with the staples 160b, 160d in the first outer row of staple cavities 144, and a second sled 190 can be aligned with the staples 160a, 160c in the second inner row of staple cavities 144 and with the staples 160b, 160d in the second outer row of staple cavities 144. The first lateral

portions 191a of each sled 190 can be aligned with the outer staples 160b, 160d, and the second lateral portions 191b of each sled 190 can be aligned with the inner staples 160a, 160c, for example.

[0485] Referring primarily to FIGS. 150 and 151, the first inner staples 160a can be moved or lifted to partially fired positions relative to the cartridge body 142. For example, the second lateral portions 191b of each sled 190 can move into engagement with the first inner staples 160a. The leading surfaces 194 of the second lateral portions 191b can lift the first inner staples 160a a first distance. Subsequently, the trailing surfaces 196 can move into engagement with the first inner staples 160a to further lift the first inner staples 160a. In various embodiments, distal translation of the sleds 190 can be coordinated, and the first inner staples 160a on each side of the slot 143 can be fired simultaneously, for example. As the first inner staples 160a are lifted, a portion of each staple 160a can slide or move against a longitudinal guide surface 150 of the staple cavity 144, and the longitudinal guide surface 150 can support and/or balance the torque generated by the sled 190, as described in greater detail herein.

[0486] Referring now to FIGS. 152 and 153, as the sleds 190 continue to translate relative to the cartridge 140, the sleds 190 can move into engagement with the first outer staples 160b and the second inner staples 160c. In various instances, the sleds 190 can contact the first outer staples 160b and the second inner staples 160c simultaneously. For example, the first lateral portions 191a of sleds 190 can contact the first outer staples 160b as the second lateral portions 191b of the sleds 190 contact the second inner staples 160c, for example. Referring primarily to FIG. 153, the leading surfaces 194 of the first lateral portions 191a and the second lateral portions 191b of the sleds 190 can engage the initial drive surfaces 180 of the staples 160b, 160c, and can lift the staples 160b, 160c relative to the cartridge body 142. Additionally, the trailing surfaces 196 of the second lateral portions 191b of the sleds 190 can continue to lift the first inner staples 160a, for example. As the first inner staples 160a continue to move out of the staple cavities 144, an anvil 152 (FIGS. 144-147) can begin to deform the first inner staples 160a. For example, staple forming pockets 154 (FIGS. 144-147) can catch, turn and/or bend the legs 164, 166 of the first inner staples 160a. As described herein, the anvil 152 can deform the staples 160a into modified "B-forms", for example.

[0487] Referring now to FIGS. 154 and 155, as the sleds 190 continue to translate relative to the staple cartridge 140, the second lateral portions 191b of the sleds 190 can continue to lift the first inner staples 160a, for example, and the anvil 152 (FIGS. 144-147) can continue to deform the first inner staples 160a, for example. In various instances, the sleds 190 can also continue to lift the first outer staples 160b and the second inner staples 160c. For example, the trailing surfaces 196 of the sleds 190 can move into engagement with the secondary drive surfaces 182 of the first outer staples 160b and the second inner staples 160c, and can lift the staple bases 162 upward, for example, such that the staples legs 164, 166 continue to move out of the cartridge body 142.

[0488] Referring now to FIGS. 156 and 157, as the sleds 190 continue to translate relative to the cartridge 140, the second lateral portions 191b of the sleds 190 can continue to simultaneously lift the first inner

staples 160a. For example, the sled overdrives 198 (FIGS. 142 and 143), can lift the first inner staples 160a entirely out of the cartridge body 142, such that the first inner staples 160a are entirely ejected from the staple cartridge 140. In various instances, the anvil 152 (FIGS. 144-147) can continue to deform the first inner staples 160a, for example, and the first inner staples 160a can be fully deformed when lifted entirely out of the cartridge body 142. Additionally, the trailing surfaces 196 of the sleds 190 can also continue to simultaneously lift the first outer staples 160b and the second inner staples 160c. For example, the trailing surfaces 196 of the first lateral portions 191a can lift or drive the first outer staples 160b, and the trailing surfaces 196 of the second lateral portions 191b can lift or drive the second inner staples 160c, for example. Moreover, as the first outer staples 160b and the second inner staples 160c continue to move out of the staple cavities 144, the anvil 152 (FIGS. 144-147) can begin to deform the first outer staples 160b and the second inner staples 160c. For example, staple forming pockets 154 (FIGS. 144-147) can catch, turn and/or bend the legs 164, 166 of the first outer staples 160b and the second inner staples 160c. In various instances, the sleds 190 can continue to translate relative to the cartridge body 142, and the first and second lateral portions 191a, 191b of the sleds 190 can continue to pace and/or time the deployment of the staples 160 from adjacent and/or neighboring staple rows. The sleds 190 can sequentially fire staples 160 from the proximal portion of the staple cartridge 140 to the distal portion of the staple cartridge 140. In other embodiments, the sleds 190 can move proximally, and can fire staples 160 from the distal portion of the staple cartridge 140 toward a proximal portion of the staple cartridge 140, for example. Moreover, in certain instances, the spacing between the staples and the lateral sled portions can affect non-synchronized deployment of the staples, for example.

[0489] Referring now to FIGS. 182-190, in various instances, the staple cavity 144 can guide the staple 160 as the sled 190 moves the staple 160 through a firing progression. For example, in various instances, the leading surface 194 of the sled 190 can contact the initial drive surface 180 of the staple 160, and can exert a driving force D_1 (FIG. 184) on the staple 160 via the initial drive surface 180 (FIGS. 182-184). The leading surface 194 can lift the staple 160 upward along a plane defined by axis E (FIG. 183) and axis F (FIG. 184). As indicated in FIGS. 183 and 184, the staple's center of mass (COM) can be offset from the axes E and F and, in such embodiments, the driving force D_1 (FIG. 184) exerted on the initial drive surface 180 in the plane defined by axes E and F can generate a torque T_1 (FIG. 184). As described in greater detail herein, the staple cavity 144 can include a longitudinal sidewall 150 between the proximal end 146 and the distal end 148 of the staple cavity 144. In certain embodiments, the staple cavity 144 can include a first sidewall 150a and a second sidewall 150b. Moreover, as described herein, the sidewalls 150a, 150b can resist torsion of the staple 160 during firing. For example, when the leading surface 194 of the sled 190 drives the initial drive surface 180 of the staple 160 along the plane defined by axes E and F, the second sidewall 150b can resist the counterclockwise torque T_1 (FIG. 184) corresponding to the driving force D_1 generated by the sled 190. As the staple 160 is lifted a first distance by the leading surface 194 of the sled 190, the second sidewall 150b

can guide and support the intermediate portion 172 of the staple base 162. For example, the flat surface 173 of the intermediate portion 172 of the staple base 162 can slide along and/or move against the second sidewall 150b.

[0490] Referring now to FIGS. 185-187, when the sled 190 transitions between the initial drive surface 180 and the secondary drive surface 182, as described herein, the trailing surface 196 of the sled 190 can exert a driving force D_2 (FIG. 187) on the staple 160 via the secondary drive surface 182. In various instances, the trailing surface 196 of the sled 190 can lift the base 162 of the staple 160 upward along a plane defined by axis I (FIG. 186) and axis J (FIG. 187). As indicated in FIGS. 186 and 187, the staple's center of mass (COM) can be offset from the plane defined by axes I and J and, in such embodiments, the driving force D_2 (FIG. 187) exerted on the secondary drive surface 182 by the trailing surface 196 of the sled 190 can generate a torque T_2 (FIG. 187). Upon comparing FIGS. 184 and 187, it can be seen that the driving force D_1 is applied to the staple 160 on a first side of the COM and the driving force D_2 is applied on the opposite side of the COM. In various instances, the torque T_1 can be in a first direction, and the torque T_2 can be in second direction, and the second direction can be opposite to the first direction, for example. When the trailing surface 196 drives the secondary drive surface 182 of the staple 160 along the plane defined by axes I and J, the first sidewall 150a can resist the clockwise torque T_2 (FIG. 187). As the staple 160 is lifted the second distance by the trailing surface 194, the first sidewall 150a can guide and support the proximal and distal ends 168, 170 of the staple base 162. For example, the proximal and distal ends 168, 170 of the base 162 can slide along and/or move against the first sidewall 150a.

[0491] The reader will appreciate that, in certain embodiments, various staples and/or features thereof, which are described herein with respect to the staple's COM, can be similarly applicable to the staple's center of geometry. In various instances, a staple, such as staple 160, for example, can comprise a single material and/or can have a uniform composition. In such embodiments, the COM of the staple can correspond to the center of geometry of the staple. In other embodiments, a staple can comprise multiple materials and/or a non-uniform composition. For example, the staple can be formed from multiple pieces and/or materials that have been welded and/or otherwise joined together. In certain embodiments, multiple sheets of at least two different materials can be welded together, for example, and the staple can be cut from a portion of the welded sheet comprising more than one material. In other embodiments, multiple sheets of at least two different materials can be layered, rolled and/or sealed together, for example, and the staple can be cut from a portion of the sheet comprising more than one material. In such embodiments, the COM of the staple can be offset from the center of geometry of the staple. For example, the COM of the staple can be laterally and/or longitudinally offset from the staple's center of geometry.

[0492] As depicted in FIGS. 184 and 187, the sled 190 can exert a vertical driving force D_1, D_2 on the staple 160 during deployment. The reader will appreciate that a driving force generated by the sled 190 can also comprise a horizontal component. In various embodiments, the proximal and/or distal ends 146, 148 of

the staple cavity 144 can guide and support the staple legs 164, 166, as the staple 160 is lifted by the sled 190. In various embodiments, the proximal and/or distal ends 146, 148 of the staple cavity 144 can balance the torque generated by the horizontal component of the driving force. For example, as the sled 190 moves distally, the distal end 148 of the staple cavity 144 can resist rotation and/or torqueing of the staple 160 during deployment. Referring now to FIGS. 188-190, the trailing surface 196 can continue to lift the staple 160 out of the staple cavity 144. For example, the sled overdrive 198 can contact the staple overdrive 188 to lift the base 162 of the staple 160 out of the cartridge body 140.

[0493] Referring now to FIGS. 171-173, a staple cartridge, such as a staple cartridge 240, for example, can be loaded into the elongate channel 122 of the end effector 120 (FIG 129). Staples, such as staples 160, for example, can be ejectably positioned in the staple cartridge 240. For example, sleds 190 (FIGS. 140-143) can translate through the staple cartridge 240 to eject the staples 160 therefrom. In various instances, the staple cartridge 240 can include a cartridge body 242 and cavities 244 defined in the cartridge body 242. Staples 160 can be removably positioned in the staple cavities 244, for example. For example, each staple cavity 244 can removably store a single staple 160. Moreover, each staple cavity 244 can have a proximal end 246 and a distal end 248, for example, and longitudinal sidewalls 250 can extend between the proximal end 246 and the distal end 248 of each staple cavity 244. Similar to the cavities 144 described herein, the proximal ends 246, distal ends 248, and/or longitudinal sidewalls 250 can guide and/or support the staples 160 during firing. For example, the longitudinal sidewalls 250 can counterbalance the torque exerted on the staple 160 by the translating sled 190. In various instances, the cavities 244 can also include diagonal guide surfaces 251 between the sidewalls 250. For example, a proximal diagonal guide surface 251a can extend between the proximal end 246 of the cavity 244 and a sidewall 250 of the cavity 244. Additionally or alternatively, a distal diagonal guide surface 251b can extend between the distal end 248 of the cavity 244 and a sidewall 250 of the cavity 244. The diagonal guide surfaces 251a, 251b can guide and/or support the contoured portions 178 (FIGS. 132-139) of the staple 160, for example, as the staple 160 is lifted within the staple cavity 244. For example, a portion of the contoured portion 178 can slide along and/or move against the diagonal guide surfaces 251a, 251b. In such an arrangement, the diagonal guide surfaces 251a, 251b can balance the torque exerted on the staple 160, for example.

[0494] Referring now to FIGS. 158A-158C, staples, such as the staples 160, for example, can be cut, formed and/or stamped from a sheet of material, such as a sheet of material 130, for example. The sheet of material 130 can be metallic, for example, and can comprise stainless steel and/or titanium, for example. In various instances, the sheet of material 130 can be substantially flat and/or smooth. Moreover, in certain instances, the sheet of material 130 can be bent, folded, contoured and/or crimped at various regions, such as a first region 134 and a second region 136, for example. The sheet of material 130 can be bent using a punch and/or stamp, for example. Flat or substantially flat portions 135a, 135b, and 135c of the sheet of material 130 can be positioned intermediate the regions 134, 136, for example. The first region 134 can be

intermediate the flat portions 135a and 135b, for example, and the second region 136 can be intermediate the flat portions 135b and 135c, for example. In various instances, the flat portions 135a and 135c can be coplanar, for example, and/or the flat portion 135b can be parallel and/or substantially parallel to the flat portions 135a and/or 135c, for example. Referring primarily to FIG. 158A, multiple flat sheets 130a, 130b, 130c, 130d, 130e, 130f can be stacked, and then bent at the regions 134 and 136 simultaneously. In other embodiments, the sheets 130a, 130b, 130c, 130d, 130e, 130f can be individually bent, for example, and then stacked.

[0495] In various instances, the staples 160 can be cut, formed and/or stamped from the bent sheets 130. For example, referring primarily to FIG. 158B, a staple outline 132 can be traced, etched, and/or cut into the bent sheets 130. The staple outline 132 can be machined and/or laser cut into the bent sheets 130, for example. In various instances, an electron discharge machining (EDM) wire 138 can be used to cut the staple outline 132. Furthermore, in certain instances, multiple stacked sheets 130 can be cut simultaneously. In certain embodiments, referring primarily to FIG. 158C, the staple outline 132 can form the boundary or perimeter of the staple 160. For example, the staple outline 132 can form the staple 160 (FIGS. 132-139 and 159-162), and/or can form a staple having various similar features to the staple 160, for example. In various instances, multiple staple outlines 132 can be cut into the sheet of material 130, and multiple staples 160 can be formed from a single sheet of material 130. As illustrated in FIGS. 158B and 158C, the EDM wire 138 can pass through more than one sheet of material 130 at a time to cut more than one staple 160 at a time. While six sheets 130 are being simultaneously cut by the EDM wire 138, any suitable number of sheets 130 can be cut at the same time. For instance, a wire 138 can cut less than six sheets 130 at the same time or more than six sheets 130 at the same time.

[0496] For example, referring to FIGS. 158C and 159-162, the staple outline 132 can form the base 162 and/or the staple legs 164, 166, for example. Furthermore, the staple outline 132 can include at least one integrally-formed staple drive surface. For example, the staple outline 132 can include the initial drive surface 180 and/or the secondary drive surface 182. In other words, the initial drive surface 180 and/or the secondary drive surface 182 can be machined and/or formed at the time the staple 160 is cut from the sheet of material 130. In certain instances, the bent or contoured regions 134, 136 of the sheet 130 (FIGS. 158A and 158B) can form the contoured portions 178 of the staple 160. Moreover, the lateral flat portions 135a and 135c of the sheet 130 (FIGS. 158A and 158B) can correspond to the staple legs 164 and 166, and the intermediate flat portion 135b of the sheet 130 (FIGS. 158A and 158B) can correspond to the intermediate portion 172 of the base 162, for example.

[0497] In various instances, the depth D_1 (FIGS. 160 and 162) of the staple 160 can determined by the depth of the sheet of material 130. For example, the sheet of material 130 can be selected based on the depth thereof, and the staple 160 formed from that sheet of material 130 can have the same depth as the sheet of material 130. Furthermore, the height H_1 (FIG. 161), and width W_1 (FIG. 161) of the base 162 and the staple

legs 164, 166 can be determined by the staple outline 132. In various instances, the staple outline 132 can provide variations in the height and/or width of the staple components along the length of each component. For example, the height H_1 of the base 162 and/or the width W_1 of the staple legs 164, 166 can vary along the length thereof. Furthermore, tapers, steps, and/or other variations can be defined by the staple outline 132, and thus, the geometry of the staple 160 can be selected and/or manipulated based on the purpose, application, and/or design of the staple 160 and/or the end effector 120 with which the staple 160 may be used.

[0498] Referring primarily to FIGS. 159-162, in various instances, the staple 160 can be cut such that the height H_1 of the base 162 is independent of and/or different than the depth D_1 of the staple legs 164, 166. For example, the depth D_1 of the staple legs 164, 166 can correspond to the depth of the sheet of material 130, and the base 162 can be cut to an appropriate height H_1, which can be independent of the depth of the sheet of material 130 and/or the corresponding leg depth D_1, for example The appropriate height H_1 can be based on the purpose, application, and/or design of the staples 160 and/or the end effector 120 (FIG. 129) with which the staple 160 may be used, for example. Furthermore, the height H_1 of the base 162 can also vary along the length thereof. For example, the height H_1 can vary at and/or near a drive surface of the staple 160, and/or at a gusset between one of the staple legs 164, 166 and the base 162, for example. The staple outline 132 can provide at least one taper and/or step along the length of the base 162, for example. The staple outline 132 can comprise a taper or ramp, for example, which can form the secondary drive surface 182 of the base 162. The degree of incline of the secondary drive surface 182 can be selected, designed and implemented via the staple outline 132. In certain embodiments, the height H_1 of the base 162 can be greater than the depth D_1 of the staple legs 164, 166. In other embodiments, the height H_1 of the base 162 can be equal to or less than the depth D_1 of the staple legs 164, 166. Comparatively, the geometry of a staple that is formed from a bent wire may be constrained and/or limited based on the dimensions of the initial wire. For example, in a wire-formed staple, the height of the staple base typically corresponds to the width of the staple legs, which typically corresponds to the diameter of the wire. Though drawing and/or rolling, for example, can modify the diameter of the wire, the volume of material limits and/or restrains the permissible modifications.

[0499] In various instances, the width W_1 of the staple legs 164, 166 can also be independent of the depth D_1 of the staple legs 164, 166 and the height H_1 of the base 162, for example. The staple legs 164, 166 can be cut to an appropriate width W_1 based on the application, purpose and/or design of the staple 160 and/or the end effector 120 (FIG. 129) with which the staple 160 may be used, for example. In certain embodiments, the staple legs 164, 166 can comprise different widths, for example, and/or the width of the staple legs 164, 166 can taper, step, or otherwise vary along the length thereof. For example, the staple legs 164, 166 can taper at the tips 174 to form a piercing edge or point.

[0500] Referring now to FIGS. 163-166, a staple outline 232 can be traced, cut, etched, and/or machined into the sheet of material 130 (FIGS. 158A and 158B), and a staple 260, similar to the staple 160 (FIGS. 159-162), for example, can be formed from the sheet of material 130. For example, the staple 260 can include a base 262 and staple legs 264, 266 extending from the base 262. In various embodiments, the staple 260 can include contoured portions 278, which can correspond to the bent and/or contoured regions 134, 136 of the sheet of material 130 (FIGS. 158A and 158B) from which the staple 260 was formed. In certain embodiments, the staple 260 can include an intermediate portion 272 between the contoured portions 278, for example. Moreover, at least one drive surface 280, 282 can be formed along the perimeter of the staple 260 via the staple outline 232.

[0501] Similar to the staple 160, the depth D_1 of the staples legs 264, 266 can correspond to the depth of the sheet of material 130. Furthermore, in various instances, the height H_2 of the staple base 262 can be independent of the depth D_1 of the staple legs 264, 266 and/or independent of the depth of the sheet of material 130. For example, as depicted in FIGS. 163-166, the height H_2 of the staple base 262 is less than the height H_1 of the staple base 162 (FIGS. 159-162), and the depth D_2 of the staples legs 264, 266 is equal to the depth D_1 of the staple legs 164, 166, for example. In various embodiments, the width W_2 of the staple legs 264, 266 can also be independent of the depth D_2 of the staple legs 264, 266. The height H_1 of the staple base 262 and the width W_2 of the staple legs 264, 266 can be selected based on the purpose, application, and/or design of the staple 260 and/or the end effector 120 (FIG. 129), for example.

[0502] Referring now to FIGS. 167-170, a staple outline 332 can be traced, cut, etched, and/or machined into the sheet of material 130 (FIGS. 158A and 158B), and a staple 360, similar to the staples 160 and 260 (FIGS. 159-166), for example, can be formed from the sheet of material 130. For example, the staple 360 can include a base 362 and staple legs 364, 366 extending from the base 362. In various embodiments, the staple 360 can include contoured portions 378, which can correspond to the bent and/or contoured regions 134, 136 of the sheet of material 130 (FIGS. 158A and 158B) from which the staple 360 was formed. In certain embodiments, the staple 360 can include an intermediate portion 372 between the contoured portions 378, for example. Moreover, at least one drive surface 380 and 382 can be formed along the perimeter of the staple 360 via the staple outline 332.

[0503] Similar to the staples 160 and 260, the depth D_3 of the staples legs 364, 366 can correspond to the depth of the sheet of material 130. Furthermore, in various instances, the height H_3 of the staple base 362 can be independent of the depth D_3 of the staple legs 364, 366 and/or independent of the depth of the sheet of material 130. For example, as depicted in FIGS. 167-170, the height H_3 of the staple base 362 is greater than the height H_1 of the staple base 162 (FIGS. 159-162) and greater than the height H_2 of the staple base 262 (FIGS. 163-166), and the depth D_3 of the staples legs 364, 366 is equal to the depth D_1 of the staple legs 164, 166 and equal to the depth D_2 of the staple legs 264, 266, for example. In various embodiments, the width W_3 of the staple legs 364, 366 can also be independent of the depth D_3 of the staple legs 364, 366. The

height H_3 of the staple base 362 and the width W_3 of the staple legs 364, 366 can be selected based on the purpose, application, and/or design of the staple 360 and/or the end effector 120 (FIG. 129), for example.

[0504] Referring now to FIGS. 174-177, a staple, such as a staple 460, for example, can be used in a staple cartridge, such as the staple cartridge 140 (FIGS. 129-131) and/or the staple cartridge 240 (FIGS. 171-173), for example. The staple 460 can include a base 462 having a proximal portion 468 and a distal portion 470. An intermediate base portion 472 can be positioned between the proximal portion 468 and the distal portion 470, for example. As depicted in FIGS. 174-177, a first staple leg 464 can extend from the proximal portion 468 of the base 462, and a second staple leg 466 can extend from the distal portion 470 of the base. In various instances, the staple legs 464, 466 can be cylindrical or substantially cylindrical, for example, and can include a staple tip 474, which can be tapered and/or include a sharp edge or point for piercing tissue, for example. In other embodiments, the staple legs 464, 466 can include a rounded and/or polygonal perimeter, for example. The intermediate portion 472 of the staple base 462 can include a tissue-contacting surface 473, which can be flat or substantially flat, for example. In various instances, the staple 460 can be formed from a wire, for example, which can be bent, twisted, and/or otherwise manipulated to form the staple legs 464, 466 and/or the staple base 462, for example. In various embodiments, the diameter of the wire can define the width and depth of the staple legs 464, 466, for example. In some embodiments, the wire can be drawn and/or rolled to modify the dimensions of the staple 460. In certain instances, the intermediate portion 462 of the wire base 462 can be formed and/or flattened to form the tissue-contacting surface 473. In various instances, the base 462 can be flattened between two parallel or substantially parallel plates, for example, such that the tissue-contacting surface 473 and a bottom surface 475 of the base 462 are flat or substantially flat and/or parallel or substantially parallel. Modifications to the base 162 may be limited and/or constrained by the volume of material of the wire, for example.

[0505] Referring still to FIGS. 174-177, the staple 460 can include chamfers and/or gussets. For example, a chamfer 484 can extend between the first staple leg 464 and the base 462, and/or a chamfer 484 can extend between the second staple leg 466 and the base 462. In certain embodiments, the chamfers 484 can be asymmetrical relative to a longitudinal axis G (FIG. 175) extending between the first staple leg 464 and the second staple leg 466, and/or relative to a vertical axis H (FIG. 177) extending along the length of the staple legs 464, 466, for example. The chamfers 484 can extend away from the axis G and/or the axis H, for example, and thus, in certain embodiments, the intermediate portion 472 of the base 462 can be offset from the axis G and/or the axis H. For example, the center of mass of the base 462 can be offset from the plane defined by the axis G and the axis H. In various instances, the offset intermediate portion 472 of the base 462 can form a wide and/or flat surface for contacting captured tissue, which can provide a broad and/or smooth surface for applying and/or distributing pressure on the captured tissue. In such embodiments, tissue tearing and/or trauma within the staple 460 may be reduced and/or minimized. Moreover, similar to the staples 160, 260, and/or 360 described herein, the staple 460 can include a leg formation plane, *e.g.*, the plane

defined by the axis G and the axis H, which can be offset from the center of mass of the base 462 of the staple 460, for example.

[0506] Referring now to FIGS. 178-181, a staple, such as a staple 560, for example, can be used in a staple cartridge, such as the staple cartridge 140 (FIGS. 129-131) and/or the staple cartridge 240 (FIGS. 171-173), for example. The staple 560 can include a base 562 having a proximal portion 568 and a distal portion 570. An intermediate base portion 572 can be positioned between the proximal portion 568 and the distal portion 570, for example. As depicted in FIGS. 178-181, a first staple leg 564 can extend from the proximal portion 568 of the base 562, and a second staple leg 566 can extend from the distal portion 570 of the base 562. In certain embodiments, the intermediate portion 572 of the base 560 can extend along an axis D (FIG. 179), which can be parallel and/or substantially parallel to an axis C (FIG. 179) defined between the first staple leg 564 and the second staple leg 566, for example.

[0507] In various instances, the staple legs 564, 566 can be cylindrical or substantially cylindrical, for example, and can include a staple tip 574, which can be tapered and/or include a sharp edge or point for piercing tissue, for example. In various instances, the staple 560 can be formed from a wire. For example, a wire can be bent, twisted and/or otherwise manipulated to form the staple 560. Referring still to FIGS. 178-181, the wire can be manipulated at curves 579a, 579b, 579c, and/or 579d. For example, the staple base 562 can include angled portions 578, which can be angularly oriented relative to the intermediate portion 572 of the staple base 562 and/or relative to the axis C defined between the first and second staple legs 564, 566, for example. In various embodiments, the wire forming the staple 560 can curve at 579a between the first staple leg 564 and the angled portion 578a, curve at 579b between the angled portion 578a and the intermediate portion 572, curve at 579c between the intermediate portion 572 and the angled portion 578b, and/or curve at 579d between the angled portion 578b and second staple leg 566, for example. For example, the intermediate portion 572 of the base 562 can be laterally offset from the axis C (FIG. 179) extending between the first staple leg 564 and the second staple leg 566.

[0508] In various embodiments, the diameter of the wire can define the width and depth of the staple legs 564, 566 and/or the staple base 562, for example. In some embodiments, the wire and/or portions thereof can be drawn and/or rolled to modify the dimensions of the staple 560 and/or elements of the staple 560. Furthermore, the wire can have a rounded and/or polygonal perimeter. In certain embodiments, the wire can be cut at an angle to form the staple tips 574, for example. Similar to the staples 160, 260, 360 and/or 460 described herein, the staple 560 can include a leg formation plane, *e.g.*, the plane defined by the axis C, which can be offset from the center of mass of the base 562 of the staple 560, for example.

[0509] Further to the above, turning now to FIG. 191, an end effector, such as end effector 120, for example, can include a staple cartridge 240 positioned within an elongate channel 122 and, in addition, an anvil 124 positionable opposite the staple cartridge 240. In various instances, the cartridge 240 can include a plurality of staple cavities 244, a fastener, such as staple 460, for example, positioned in each of the staple

cavities 244, and a longitudinal slot 243 configured to slidably receive a knife 158 therein. While staples 460 are depicted in connection with the embodiment depicted in FIG. 191, any suitable staple or fastener could be used with this embodiment, such as staples 160, for example. Referring generally to FIGS. 199 and 200, the end effector 120 can extend from a shaft 114 which can include a closure tube 115. When the closure tube 115 is advanced distally, the closure tube 115 can contact the anvil 124 and rotate the anvil 124 between an open position (FIG. 199) and a closed position (FIG. 200). Once the anvil 124 has been closed, the knife 158 can be advanced distally to transect tissue captured between the anvil 124 and the cartridge 240. In certain end effectors disclosed herein, the cartridge positioned within the end effector 120 can further include a fastener firing actuator, such as sled 190, for example, which is pushed distally by the knife 158 to deploy staples from the cartridge at the same time that the knife 158 transects the tissue. With regard to the embodiment depicted in FIG. 191, a staple cartridge can include a fastener firing actuator, such as sled assembly 790, for example, which can be advanced distally with, or alongside, the knife 158 to eject the staples 460 from the cartridge 240. For instance, the shaft 114 of the stapler can include a firing bar 157 configured to advance the knife 158 and, in addition, pusher bars 159 configured to advance the sled assembly 790. While the firing bar 157 and the pusher bars 159 may be advanced concurrently, in various circumstances, their operation can be timed in such a way that their initial distal movement can be staggered relative to one another, as described in greater detail further below. In addition to the initial relative movement between the firing bar 157 and the pusher bars 159, the sled assembly 790 can include two or more portions which can move relative to one another, as will also be described in greater detail further below.

[0510] Referring primarily to FIGS. 192-195, the sled assembly 790 can include a first sled portion 792 and a second sled portion 793. The first sled portion 792 can include an inner ramp portion 791a and an outer ramp portion 791b. As illustrated in FIGS. 192 and 193, the outer ramp portion 791b is positioned laterally with respect to the inner ramp portion 791a. The outer ramp portion 791b also extends distally with respect to the inner ramp portion 791a. Similarly, the second sled portion 793 can include an inner ramp portion 794a and an outer ramp portion 794b. As illustrated in FIGS. 194 and 195, the outer ramp portion 794b is positioned laterally with respect to the inner ramp portion 794a. The outer ramp portion 794b also extends distally with respect to the inner ramp portion 794a. In various instances, the inner ramp portion 791a can be configured to lift, or at least partially lift, an inner row of staples while the outer ramp portion 791b can be configured to lift, or at least partially lift, an outer row of staples. As primarily depicted in FIG. 193, the inner ramp portion 791a and the outer ramp portion 791b can each include a ramp surface, such as ramp surfaces 795a and 795b, respectively, which can slide underneath the staples in the inner row of staples and the outer row of staples, respectively. The ramp surfaces 795a and 795b of the inner ramp portion 791a and the outer ramp portion 791b can be configured to lift staples from an unfired position to an at least partially-fired position. In various instances, the ramp surfaces 795a and 795b of the inner ramp portion

791a and the outer ramp portion 791b can each comprise at least one inclined surface, curved surface, actuate surface, and/or convex surface, for example.

[0511] Further to the above, the inner ramp portion 794a of the second sled portion 793 can include an inner ramp surface 796a and, similarly, the outer ramp portion 794b of the second sled portion 793 can include an outer ramp surface 796b. In various instances, the inner ramp surface 795a of the first sled portion 792 can be configured to co-operate with the inner ramp surface 796a of the second sled portion 793 to lift the staples in the inner row of staples from their unfired positions and their fully-fired positions. More particularly, the inner ramp portion 791a can lift the staples in the inner row of staples from an unfired position to a partially-fired position wherein the inner ramp portion 794a can then lift the staples from their partially-fired positions to a fully-fired position, for instance. In such circumstances, the lifting motion of the staples in the inner row of staples can be initiated by the inner ramp portion 791a of the first sled portion 792, transferred to the inner ramp surface 796a of the second ramp portion 793, and then completed by the second ramp portion 793. Similarly, the outer ramp surface 795b of the first sled portion 792 can be configured to co-operate with the outer ramp surface 796b of the second sled portion 793 to lift the staples in the outer row of staples from their unfired positions and their fully-fired positions. More particularly, the outer ramp portion 791b can lift the staples in the outer row of staples from an unfired position to a partially-fired position wherein the outer ramp portion 794b can then lift the staples from their partially-fired positions to a fully-fired position, for instance. In such circumstances, the lifting motion of the staples in the outer row of staples can be initiated by the outer ramp portion 791b of the first sled portion 792, transferred to the outer ramp surface 796b of the second ramp portion 793, and then completed by the second ramp portion 793. The firing, or lifting, motion of the staples in the inner row of staples can be completed once the apex 798 of the inner ramp portion 794a has passed underneath the staples. Similarly, the firing, or lifting, motion of the staples in the outer row of staples can be completed once the apex 798 of the outer ramp portion 794b has passed underneath the staples.

[0512] Referring again to FIG. 191, the sled assembly 790 can include more than one first sled portion 792 and/or more than one second sled portion 793. In various instances, the sled assembly 790 can comprise a first set of sled portions comprising a first sled portion 792 and a second sled portion 793 and a second set of sled portions comprising a first sled portion 792 and a second sled portion 793. In certain instances, the second set of sled portions can constitute a mirror image of the first set. For the purposes of simplifying the description of the sled assembly 790 herein, reference may be made to only one set of sled portions; however, the reader should appreciate that the description regarding the operation of one set of sled portions could also apply to the concurrent operation of any suitable number sets of sled portions.

[0513] Further to the above, the outer staple rows of the cartridge 240, i.e., the rows furthest away from the channel 243, can lead the inner staple rows, i.e., the rows closest to the channel 243. Stated another way, the deformation of the staples in the outer row can begin before, or at least slightly before, the deformation of the

laterally adjacent staples in the inner row. In other instances, the outer staple rows of the cartridge 240, i.e., the rows furthest away from the channel 243, can lag the inner staple rows, i.e., the rows closest to the channel 243. Stated another way, the deformation of the staples in the inner row can begin before, or at least slightly before, the deformation of the laterally adjacent staples in the outer row. Moreover, while two staples rows are disclosed on each side of the channel 243 defined in the cartridge 240, other embodiments are envisioned in which more than two staple rows, such as three staple rows, for example, are present on each side of the channel 243. In such embodiments, the sled assemblies can be configured to deploy an additional row of staples at the same time as the inner row of staples, at the same time as the outer row of staples, and/or at a time which is staged sequentially with respect to the inner row of staples and the outer row of staples.

[0514] As mentioned above, the first sled portion 792 is movable relative to the second sled portion 793 of the sled assembly 790. Turning now to FIGS. 196-198, the sled assembly 790 is movable between an initial, unfired configuration (FIG. 196) and a second, extended configuration (FIGS. 197 and 198). In the initial, unfired configuration of sled assembly 790, referring primarily to FIG. 196, the first sled portion 792 is collapsed within, or retracted relative to, the second portion 793. In at least one such instance, the distal end of the first sled portion 792 may not extend beyond the distal end of the second sled portion 793. In other instances, although not illustrated, the distal end of the first sled portion 792 may extend beyond the distal end of the second sled portion 793 when the first sled portion 792 is collapsed within the second portion 793. With further reference to FIG. 196, the reader will further appreciate that the staples 460 are in an unfired position as they have not yet been lifted toward the anvil 124. Upon comparing FIGS. 196 and 197, the reader will notice that the first sled portion 792 has been extended relative to the second sled portion 793. In such circumstances, the distal end of the first sled portion 792 is positioned distally with respect to the distal end of the second sled portion 793. The movement of the first sled portion 792 from its initial, unfired position to its extended position can position the inner ramp portion 791a and/or the outer ramp portion 791b of the first sled portion 792 underneath one or more staples 460. In other configurations, the movement of the first sled portion 792 from its initial, unfired position to its extended position may not position the inner ramp portion 791a and/or the outer ramp portion 791b underneath one or more staples 460. In any event, as illustrated in FIG. 197, the extension of the first sled portion 792 can at least partially lift at least one staple 460 toward the anvil 124 and/or at least partially deform at least one staple 460 against the anvil 124. In certain instances, the extension of the first sled portion 792 can completely lift, or completely deform, at least one staple 460 against the anvil 124. In various circumstances, the second sled portion 793 may not be advanced distally when the first sled portion 792 is moved into its extended position; however, in certain circumstances, at least some distal movement of the second sled portion 793 may occur when the first sled portion 792 is moved into its extended position.

[0515] Upon comparing FIGS. 197 and 198, it can be noted that the first sled portion 792 and the second sled portion 793 have been advanced distally to lift staples 460 toward the anvil 124. The first sled portion 792 and the second sled portion 793 can then be advanced to the distal end of the end effector 120 to complete the firing stroke of the end effector 120, which will be discussed in greater detail further below. In any event, the initial progression of the sled assembly 790 during the firing stroke of the end effector 120 is depicted in FIGS. 196-198. FIG. 196 depicts the sled assembly 790 in a retracted, unfired position; FIG. 197 depicts the sled assembly 790 in an extended, partially-fired position; and FIG. 198 depicts the sled assembly 790 in an extended, fired position. As outlined above, the pusher bar, or bars, 159 can be moved distally in order to advance the sled assembly 790 through the progression depicted in FIGS. 196-198. With reference to FIG. 196, a pusher bar 159 is illustrated in an initial, unfired position in which it is in contact with the proximal end of the first sled portion 792. In various embodiments, the pusher bar 159 can include a contact flange 155 extending from the distal end thereof which can engage the first sled portion 792. With further reference to FIG. 196, the pusher bar 159 may not be in contact with the second sled portion 793 when the pusher bar 159 is in its initial, unfired position. As the pusher bar 159 is advanced distally, the pusher bar 159 can move the first sled portion 792 distally until the contact flange 155 comes into contact with the proximal end of the second sled portion 793, as illustrated in FIG. 197. It is this relative motion between the first sled portion 792 and the second sled portion 793 which extends the sled assembly 790 as discussed above. Thereafter, the pusher bar 159 can be advanced distally in order to advance the first sled portion 792 and the second sled portion 793 distally at the same time, as illustrated in FIG. 198.

[0516] As discussed above, the end effector 120 can be configured to staple and transect tissue at the same time. Referring again to FIG. 191, the end effector 120 can include a firing member, or knife bar, 156 comprising a knife edge 158 configured to transect the tissue as the knife bar 156 is advanced distally. Referring again to FIGS. 196 and 197, the initial distal movement of the pusher bar, or bars, 159 may not be transferred to the knife bar 156. Stated another way, the knife bar 156 may remain stationary, or at least substantially stationary, while the sled assembly 790 is moved between its retracted position (FIG. 196) and its extended position (FIG. 197). In such circumstances, relative movement between the pusher bars 159 and the knife bar 156 can occur, at least during the initial portion of the end effector firing stroke. Upon comparing FIGS. 200 and 203, it can be seen that, one, the pusher bars 159 have been advanced distally to extend the sled assembly 790 and, two, the knife bar 156 has not been advanced distally. Particular attention can be paid to the proximal ends of the knife bar 156 and the pusher bars 159. More particularly, the pusher bars 159 can include a drive pin 759 extending therebetween which extends through a drive slot 757 defined in the drive bar 157 extending proximally from the knife bar 156. When the pusher bars 159 are in their proximal unfired position, as illustrated in FIG. 200, the drive pin 759 is positioned in the proximal end of the drive slot 757. When the pusher bars 159 are advanced distally, as illustrated in FIG. 203, the drive pin 759 can slide distally within the drive slot 757 until the drive pin 759 reaches the distal end of the drive slot

757. In such a position, the sled 790 has been fully extended and the knife bar 156 has not yet been advanced distally with the pusher bars 159. Once the drive pin 759 is in contact with the distal end of the drive slot 757, as illustrated in FIGS. 204 and 205, the pusher bars 156 and the knife bar 159 can be advanced distally together.

[0517] Further to the above, the knife bar 156 can include flanges 153 and 155 which can be configured to engage the anvil 124 and the staple cartridge channel 123, respectively. When the knife bar 156 is in its proximal, unadvanced position, as illustrated in FIG. 203, the flange 153 can be positioned proximally with respect to a slot 121 defined in the anvil 124. In such a position of the knife bar 156, the flange 155 may or may not be positioned within a slot defined within and/or in the exterior of the cartridge channel 123. As the knife bar 156 is advanced distally, the flange 153 can enter into the anvil slot 121 and the flange 155 can be positioned within the cartridge channel slot. In such circumstances, the knife bar 156 can set the gap, or tissue gap distance, between the anvil 124 and the staple cartridge positioned within the cartridge channel 123. In various circumstances, the knife bar 156 can control the forming height and/or the compression of the tissue within the end effector 120 as the knife bar 156 is advanced distally.

[0518] The arrangement described above in which the pusher bars 159 move the sled assembly 790 before the pusher bars 159 advance the knife 158 can be advantageous in many circumstances. For instance, it is often desirable to staple tissue before it is incised and, thus, the formation of the staples leads, or at least sufficiently leads, the transection of the tissue by the knife bar 156. The staggered deployment of the sled 790 and the knife bar 156 can facilitate such a relative progression between the staple formation and the tissue incision. Moreover, the sled 790 can be compactly stored in the end effector 120 in its retracted, unfired configuration in order to permit a shorter proximal-to-distal, or longitudinal, length of the end effector 120. Stated another way, less longitudinal room may be required for a sled assembly that can begin its firing stroke in at least partially collapsed state. Furthermore, owing to the longitudinal extendibility of the sled assembly 790, the staple lifting surfaces of the sled assembly 790 can be longer and can include a shallower, or less aggressive, ramp angle than a unitary sled, for instance. Stated another way, the mechanical advantage of the sled assembly 790 can be improved owing to longer longitudinal lengths available for the ramps of the sled assembly 790.

[0519] Turning now to FIGS. 206-208, the sled assembly 790 and the knife bar 156 can be advanced distally toward the distal end of the end effector 120 to complete the firing stroke of the end effector 120. As the sled 790 approaches the distal end of the end effector 120, in various instances, the first sled portion 792 can contact a distal end 245 of the staple cartridge and retract relative to and/or within the second sled portion 793. More particularly, the distal end 245 can block the distal movement of the first sled portion 792 while the second sled portion 793 is advanced distally relative to the first sled portion 792 in order to complete the firing stroke. In various instances, the second sled portion 793 can be advanced distally until it also contacts the distal end 245 of the staple cartridge while, in other instances, the firing stroke can be

completed before the second sled portion 793 contacts the distal end 245. In either event, in embodiments where the distal flanges 155 of the pusher bars 159 push the first sled portion 792 and the second sled portion 793 toward the distal end of the end effector 120, the first sled portion 792 may become disengaged from the pusher bars 159 when the first sled portion 792 reaches the distal end so that that the pusher bars 159 can push the second sled portion 793 relative to the first sled portion 792. In at least one such instance, referring primarily to FIG. 203, the distal end of the staple cartridge can include a boss 241 which can be configured to lift the first sled portion 792 upwardly toward the anvil 124 so that the pusher bars 159 can slide underneath the first sled portion 792. In such circumstances, the first sled portion 792 can be operatively disengaged from the second sled portion 793 and the pusher bars 159. In various instances, the boss 241 can be positioned and arranged such that the first sled portion 792 is lifted upwardly after all of the staples of the staple cartridge have been deployed and/or transferred to the second sled portion 793, as discussed above. Moreover, further to the above, the distal end of the staple cartridge can include a first boss 241 configured to lift a first sled portion 792 and a second boss 241 configured to lift an additional first sled portion 792. In various instances, the bosses 241 can be configured to synchronously lift the first sled portions 792 at the same time. In some instances, the bosses 241 can be configured to lift the first sled portions 792 sequentially.

[0520] Referring now to FIGS. 211-214, FIG. 211 depicts the sled assembly 790 in its initial, unfired configuration. Further to the above, a pusher bar 159 can contact a proximal end 789 of the first sled portion 792 and push the first sled portion 792 distally until the proximal end 789 of the first sled portion 792 is flush with a proximal end 787 of the second sled portion 793, as illustrated in FIG. 212. At such point, the first sled portion 792 can be fully extended relative to the second sled portion 793. Thereafter, the pusher bar 156 can push on the proximal end 787 and the proximal end 789 simultaneously to advance the sled assembly 790 distally. As also discussed above, referring now to FIG. 213, the first sled portion 792 can be stopped by the distal end 245 of the staple cartridge and lifted upwardly by the boss 241 of the staple cartridge, for instance. At such point, the first sled portion 792 can be elevated relative to the second sled portion 793, and the distal flange 155, such that the second sled portion 793 can be slid relative to, and at least partially underneath, the first sled portion 792, in order to collapse the sled assembly 790, as illustrated in FIG. 214. Upon comparing FIGS. 213 and 214, it can be seen that the second sled portion 793 is moved closer toward ledge 788 defined in the bottom surface of the first sled portion 792 and that the distal end 789 of the first sled portion 792 is no longer aligned with the distal end 787 of the second sled portion 793.

[0521] After the firing stroke has been completed, referring now to FIGS. 209 and 210, the knife bar 156 and the pusher bars 159 can be retracted proximally. In various circumstances, the knife bar 156 can be pulled proximally by the pusher bars 159. More particularly, the pusher bars 159 can be retracted proximally relative to the knife bar 159 until the drive pin 759 contacts the proximal end of the drive slot 759. At such point, the pusher bars 159 can pull the knife bar 156 proximally until the flange 153 of the knife bar 156 is no

longer positioned within the slot 121 of the anvil 124. Thereafter, the anvil 124 can be moved into its open position when the closure tube 115 is pulled proximally. In certain instances, the staple cartridge can comprise a replaceable staple cartridge. In such instances, the spent staple cartridge can be removed from the cartridge channel 122 and, if desired, an unspent staple cartridge can be positioned within the cartridge channel 122 so that the surgical instrument can be used once again.

[0522] As illustrated in FIGS. 209 and 210, the collapsed sled assembly 790 can be left behind in the distal end of the end effector 120 when the knife bar 156 and the pusher bars 159 are retracted. In the event that the spent staple cartridge is removed from the cartridge channel 122, the collapsed sled assembly 790 can be removed from the end effector 120 with the cartridge. In certain instances, a staple cartridge may not be completely spent before the pusher bars 159 and the knife bar 156 are retracted. In such instances, the sled assembly 790 may only be partially advanced within the staple cartridge and may not be collapsed back into its unextended configuration. When the staple cartridge is then removed from the cartridge channel 123, some of the staples may still be positioned within their staple cavities.

[0523] As discussed herein, a firing actuator, or sled, of a staple cartridge and/or stapling instrument can include one or more inclined ramp surfaces configured to lift, or deploy, staples between an unfired position and a fired position. For instance, a sled can include a first inclined ramp surface configured to deploy a first row of staples, a second inclined ramp surface configured to deploy a second row of staples, and so forth. Each inclined ramp surface can comprise a contiguous surface which is configured to engage each staple in the corresponding row of staples and lift the staples until they have been fully deformed against an anvil positioned opposite the staple cartridge. The contiguous surface which defines each inclined ramp surface can include any suitable number of contours such as, for instance, one or more linear surfaces and/or one or more curved surfaces. In various instances, the contiguous surface can directly engage each staple in the corresponding row of staples and can remain continuously engaged with a staple in that row as it moved from its unfired position to its fully-fired position. After a staple has reached its fully-fired position, the inclined ramp surface may become disengaged from that staple. This arrangement can be possible for sleds with relatively movable components, such as sled assembly 790, for instance, and/or sleds that are not comprised of relatively movable components, such as sleds comprised of a unitary piece of material, for example.

[0524] In various circumstances, a firing actuator, or sled, can comprise one or more inclined ramp surfaces, wherein each inclined ramped surface is comprised of two or more co-operating drive surfaces. For instance, turning now to FIG. 218, a sled 890 can include a first inclined ramp surface 891a which is comprised of an initial, or first, drive surface 895a and a second, or final, drive surface 896a. The initial drive surface 895a and the final drive surface 896a of the first inclined ramp surface 891a can be configured to co-operatively lift the staples in a first staple row between an unfired position and a fired position. As the sled 890 is moved distally through a staple cartridge, referring to FIGS. 215-218, the initial drive surface

895a can contact a staple 160, for instance, and lift the staple 160 from its unfired position (FIG. 215) to a partially-fired position (FIG. 216). Thereafter, the sled 890 can be advanced distally such that the final drive surface 896a can lift the staple 160 between its partially-fired position and its fully-fired position. In various instances, the initial drive surface 895a can contact the initial drive surfaces 180 of the staples 160 to lift the staples 160 into their partially-fired positions and the final drive surface 896a can contact the second drive surfaces 182 of the staples 160 to lift the staples 160 into their finally-fired positions. In such instances, the staples 160 can be transferred from the initial drive surface 895a to the final drive surface 896a to complete the deployment, or firing, thereof. Referring to FIG. 218, the deployment, or firing, of a staple 160 can be complete once the apex 898 of the first inclined ramp surface 891a has passed under the second drive surface 182 of the staple 160.

[0525] Further to the above, referring again to FIG. 218, the initial drive surface 895a and the final drive surface 896a of the first inclined ramp surface 891a can be configured to co-operatively deploy staples within a first row of staples. The sled 890 can include additional inclined ramp surfaces to deploy additional rows of staples. For instance, the sled 890 can include a second inclined ramp surface 891b comprising an initial drive surface 895b and a final drive surface 896b which can be configured to co-operatively deploy staples within a second row of staples. In various instances, the sled 890 can further include any suitable number of inclined ramp surfaces, such as a third inclined ramp surface, similar to first inclined ramp surface 891a, configured to deploy staples within a third row of staples and a fourth inclined ramp surface, similar to second inclined ramp surface 891b, configured to deploy staples within a fourth row of staples, for example. In any event, the drive surfaces of an inclined drive surface, such as drive surfaces 895a, 895b, 896a, and 896b, for example, can include any suitable configuration such as a linear profile and/or a curved profile, for example. With further reference to FIG. 218, the first inclined ramp surface 891a can include a transition drive surface 897a intermediate the initial drive surface 895a and the final drive surface 896a. Similarly, the second inclined ramp surface 891b can include a transition drive surface 897b intermediate the initial drive surface 895b and the final drive surface 896b. In various instances, a transition drive surface can comprise a transition between one drive surface and another drive surface. In some instances, a transition drive surface can comprise a surface which simultaneously drives the initial drive surface 180 and the second drive surface 182 of a staple 160, for example. In various instances, an inclined ramp surface can include any suitable number of drive surfaces.

[0526] In various instances, further to the above, the initial drive surface 895a can be positioned laterally with respect to the final drive surface 896a. In certain instances, the initial drive surface 895a and the final drive surface 896a can be connected to one another. In other instances, the initial drive surface 895a and the final drive surface 896a may not be connected to one another. In various circumstances, the initial drive surface 895a can be defined by a first height and the final drive surface 896a can be defined by a second height which is taller than the first height. In certain circumstances, the initial drive surface 895a can be

defined along a first longitudinal axis and the final drive surface 896a can be defined along a second longitudinal axis. In certain instances, the first longitudinal axis and the second longitudinal axis can be parallel. In some instances, the initial drive surface 895a can be defined by a first plane and the final drive surface 896a can be defined by a second plane which is parallel to the first plane. In other instances, the first longitudinal axis and the second longitudinal axis can be non-parallel. In some instances, the first longitudinal axis and the second longitudinal axis can extend in directions which converge. In other instances, the first longitudinal axis and the second longitudinal axis can extend in directions which do not converge. In various instances, further to the above, the transition drive surface 897a of the first inclined surface 891a can be defined along an axis which is parallel to the first longitudinal axis and/or the second longitudinal axis. In certain instances, the transition drive surface 897a can be defined along an axis which is not parallel to the first longitudinal axis and/or the second longitudinal axis. In various instances, further to the above, the transition drive surface 897a of the first inclined surface 891a can be defined within a plane which is parallel to the first plane and/or the second plane. In some instances, the transition drive surface 897a can be co-planar with the initial drive surface 895a and/or the final drive surface 896a. In certain instances, the transition drive surface 897a can be defined within a plane which is different than the first plane and/or the second plane. In various instances, further to the above, the transition drive surface 897a can connect the initial drive surface 895a to the final drive surface 896a.

[0527] The discussion provided above in connection with inclined ramp surface 891a, initial drive surface 895a, final drive surface 896a, and transition drive surface 897a can be equally applicable to inclined ramp surface 891b, initial drive surface 895b, final drive surface 896b, and transition drive surface 897b, for example.

[0528] In various circumstances, further to the above, the first inclined ramp surface 891a can be parallel to the second inclined ramp surface 891b. In other instances, the first inclined ramp surface 891a may not be parallel to the second inclined ramp surface 891b. In various instances, the first inclined ramp surface 891a can be defined by a first height and the second inclined ramp surface 891b can be defined by a second height. In some instances, the first height can be the same as the second height. In such instances, a first row of staples formed by the first inclined ramp surface 891a and a second row of staples formed by the second inclined ramp surface 891b can be formed to the same height. In other instances, the first height can be different that the second height. In such instances, a first row of staples formed by the first inclined ramp surface 891a and a second row of staples formed by the second inclined ramp surface 891b can be formed to different heights. The disclosure of U.S. Patent No. 8,317,070, entitled SURGICAL STAPLING DEVICES THAT PRODUCE FORMED STAPLES HAVING DIFFERENT LENGTHS, which issued on November 27, 2012, is incorporated by reference in its entirety.

[0529] As discussed above, a sled can directly drive and deploy a staple and/or any other suitable fastener stored within a cartridge. Stated another way, the sled can directly contact the staples wherein a driver is not

present intermediate the sled and the staples. Such an arrangement is different than arrangements which include a plurality of drivers which support the staples. In such arrangements, the sled engages the drivers to lift the staples. In these arrangements, the drivers are often configured to completely eject the staples from the staple cavities in which they are stored. More particularly, the drivers are configured to lift the staples such that the staples are completely positioned above the top surface, or deck, of the staple cartridge when the staples are in their fully-fired position. In order to completely lift the staples above the deck of the staple cartridge, the drivers may also be at least partially lifted above the deck. Such an arrangement can be characterized as overdriving the staples. Many of the teachings discussed herein can be applied to embodiments including one or more sleds which directly drive staples and, in addition, embodiments including a plurality of drivers which are driven by one or more sleds in order to drive the staples. For instance, sled 890 is discussed in connection with embodiments in which it directly drives staples 160; however, sled 890 could also be used in embodiments which include drivers configured to deploy staples from the staple cavities. In such embodiments, each driver could include a first drive surface similar to first drive surface 180 configured to be engaged by the initial drive surface 895a, for instance, and a second drive surface similar to second drive surface 182 configured to be engaged by the final drive surface 896a, for instance.

[0530] In the embodiments disclosed herein in which the staples are driven directly by the sled, i.e., without the use of drivers, further to the above, the staples can be completely lifted above the deck, or overdriven, by the sled itself. Turning now to FIGS. 217-220, the sled 890 is configured to partially extend above the deck surface 141 of the cartridge 142. More particularly, the apex 898 of the first inclined ramp surface 891a and the apex 898 of the second inclined ramp surface 891b can extend above the deck surface 141 as the inclined ramp surfaces 891a and 891b pass through and/or between the cavities 144 to eject the staples 160, for example, from the staple cavities 144. In such circumstances, the sled 890 is configured to partially extend above the staple cavity openings defined in the deck surface 141. In various instances, the cartridge 142 can further comprise a plurality of coverings 145 positioned within and/or aligned with the rows of staple cavities 144. For instance, a covering 145 can be positioned intermediate adjacent staple cavities 144 within a staple cavity row. In certain instances, a covering 145 can be positioned proximally and/or distally with respect to a staple cavity 144. In various instances, referring primarily to FIG. 220, the apexes 898 of the inclined ramp surfaces 891 can pass underneath the coverings 145. In such instances, each covering 145 can include a bottom surface, such as an arched bottom surface 147, for example, configured to permit the inclined ramp surfaces 891 to pass thereunder. With further reference to FIG. 220, the cartridge 142 can include a first longitudinal slot 149 configured to slidably receive the first inclined ramp surface 891a therein and a second longitudinal slot 149 configured to receive the second inclined ramp surface 891b, for example. In various instances, the cartridge 142 can include a plurality of longitudinal slots 149 configured to receive the inclined ramp surfaces of the sled 890. In certain instances, the longitudinal slots

149 can be defined by the coverings 145 and the staple cavities 144. In some circumstances, each longitudinal slot 149 can correspond to a longitudinal row of staple cavities 144 wherein a longitudinal slot 149 can place the staple cavities 144 within a staple cavity row in communication with each other such that an inclined ramp surface passing through the longitudinal slot 149 can pass through the staple cavities 144 as outlined above.

[0531] In various instances, the deck of a cartridge can be configured to directly contact the tissue being fastened and/or support the tissue being fastened. In certain circumstances, a cartridge assembly can include a layer positioned on the deck, such as a tissue thickness compensator, for example, which is disclosed in U.S. Patent Application Serial No. 12/894,369, entitled IMPLANTABLE FASTENER CARTRIDGE COMPRISING A SUPPORT RETAINER, now U.S. Patent Application Publication No. 2012/0080344, which was filed on September 30, 2010, U.S. Patent Application Serial No. 13/097,856, entitled STAPLE CARTRIDGE COMPRISING STAPLES POSITIONED WITHIN A COMPRESSIBLE PORTION THEREOF, now U.S. Patent Application Publication No. 2012/0080336, which was filed on April 29, 2011, and U.S. Patent Application Serial No. 13/242,066, entitled CURVED END EFFECTOR FOR A STAPLING INSTRUMENT, now U.S. Patent Application Publication No. 2012/0080498, which was filed on September 23, 2011. The entire disclosures of U.S. Patent Application Serial No. 12/894,369, entitled IMPLANTABLE FASTENER CARTRIDGE COMPRISING A SUPPORT RETAINER, now U.S. Patent Application Publication No. 2012/0080344, which was filed on September 30, 2010, U.S. Patent Application Serial No. 13/097,856, entitled STAPLE CARTRIDGE COMPRISING STAPLES POSITIONED WITHIN A COMPRESSIBLE PORTION THEREOF, now U.S. Patent Application Publication No. 2012/0080336, which was filed on April 29, 2011, and U.S. Patent Application Serial No. 13/242,066, entitled CURVED END EFFECTOR FOR A STAPLING INSTRUMENT, now U.S. Patent Application Publication No. 2012/0080498, which was filed on September 23, 2011, are incorporated herein by reference. In various instances, referring again to FIG. 219, the deck 141 and the coverings 145 can be configured to directly contact tissue. In such instances, coverings 145 can extend above the deck 141 and, as a result, the deck 141 and the coverings 145 can comprise an uneven support surface. The coverings 145, in various instances, can apply an additional compressive pressure to the tissue positioned directly above and/or adjacent to each longitudinal row of staples. This additional compressive pressure can push fluids present within the tissue away from the staple lines prior to, during, and/or after the staple forming process which, as a result, can promote better staple formation and/or staple retention within the tissue. The coverings 145 can also be configured to grip the tissue positioned between a staple cartridge and an anvil, especially along the staple lines where the staple formation occurs. The coverings can also be configured to support the staples as the staples are being ejected from the staple pockets to provide a localized control over the staple forming process. The entire disclosures of U.S. Patent Application Serial No. 12/893,461, entitled STAPLE CARTRIDGE, now U.S. Patent Application Publication No. 2012/0074198, which was filed on September

29, 2010, and U.S. Patent Application Serial No. 13/851,676, entitled TISSUE THICKNESS COMPENSATOR COMPRISING A CUTTING MEMBER PATH, which was filed on March 27, 2013, are incorporated by reference herein.

[0532] As discussed above, referring primarily to FIGS. 184, 187, and 190, a staple cavity, such as staple cavity 144, for example, can include a first sidewall 150a and a second sidewall 150b which can be configured to guide a staple, such as a staple 160, for example, as it is lifted between an unfired position and a fired position. In various instances, the sidewalls 150a, 150b can be configured and arranged such that the entirety of the staple 160 is positioned intermediate the sidewalls 150a, 150b when the staple 160 is in its unfired position. In other circumstances, referring primarily to FIGS. 148-157, the sidewalls 150 of the staple cavity 144 may be configured such that less than the entirety of the staple 160 is positioned intermediate the sidewalls 150 when the staple 160 is in its unfired position. For instance, the base 162 of the staples 160 in the outermost rows of staple cavities 144 defined in the cartridge body 142 may be unsupported by at least one of the sidewalls 150 when the staples 160 are in their unfired positions. As the staples 160 are lifted upwardly, however, the bases 162 of the staples 160 may then be supported by both of the sidewalls 150. Turning now to FIGS. 219 and 220, some of the staple cavities 144 of the cartridge 142, such as cavities 144a, for example, may only support both sides of the bases 162 at the end of their lifting motion. In any event, even though the sidewalls of the staple cavities 144 defined in the cartridge body 142 may not entirely support the staples 160 in their unfired positions, the cartridge channel 123 of jaw 122, referring again to FIGS. 129 and 191, may at least partially support the staples 160. Stated another way, the cartridge body 142 and the cartridge channel 123 may co-operate to define the staple cavities 144 in order to support and/or surround the staples 160 throughout the lifting motion of the staples 160. For instance, the cartridge body 142 and the cartridge channel 123 can co-operate to support and/or surround a staple 160 when the staple 160 is in its unlifted position. At some point during the lifting motion of the staple 160, in some circumstances, the cartridge channel 123 may no longer support and/or the staple 160 and, in such circumstances, the cartridge body 142 may entirely support the staple 160 for the remainder of the lifting motion. In at least one embodiment, the cartridge channel 123 and the cartridge body 142 may co-operate to support the staple 160 for half, or approximately half, of the lifting motion. In other embodiments, the cartridge channel 123 and the cartridge body 142 may co-operate to support the staple 160 for less than half or more than half of the lifting motion. In some instances, the cartridge body 142 and the cartridge channel 123 may co-operatively support and/or surround the staple 160 throughout the entire lifting motion of the staple 160.

[0533] Various embodiments described herein are described in the context of linear end effectors and/or linear fastener cartridges. Such embodiments, and the teachings thereof, can be applied to non-linear end effectors and/or non-linear fastener cartridges, such as, for example, circular and/or contoured end effectors. For example, various end effectors, including non-linear end effectors, are disclosed in U.S. Patent

Application Serial No. 13/036,647, filed February 28, 2011, entitled SURGICAL STAPLING INSTRUMENT, now U.S. Patent Application Publication No. 2011/0226837, which is hereby incorporated by reference in its entirety. Additionally, U.S. Patent Application Serial No. 12/893,461, filed September 29, 2012, entitled STAPLE CARTRIDGE, now U.S. Patent Application Publication No. 2012/0074198, is hereby incorporated by reference in its entirety. U.S. Patent Application Serial No. 12/031,873, filed February 15, 2008, entitled END EFFECTORS FOR A SURGICAL CUTTING AND STAPLING INSTRUMENT, now U.S. Patent No. 7,980,443, is also hereby incorporated by reference in its entirety. The entire disclosure of U.S. Patent No. 7,845,537, entitled SURGICAL INSTRUMENT HAVING RECORDING CAPABILITIES, which issued on December 7, 2010, is incorporated by reference herein. The entire disclosure of U.S. Application Serial No. 13/118,241, entitled SURGICAL STAPLING INSTRUMENTS WITH ROTATABLE STAPLE DEPLOYMENT ARRANGEMENTS, now U.S. Patent Application Publication No. 2012/0298719, which was filed on May 27, 2011, is incorporated by reference herein.

[0534] 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.

[0535] Preferably, the invention described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

[0536] 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.

[0537] 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. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

WHAT IS CLAIMED IS:

1. A surgical method for treating target tissue within a patient, the method comprising the steps of:

installing a hollow trocar port into a patient;

providing a surgical end effector comprising:

an elongated shaft assembly defining a longitudinal tool axis;

a lower jaw operably coupled to the elongated shaft assembly, the lower jaw including elastic biasing means;

an upper jaw supported for movement relative to the lower jaw upon application of actuation motions thereto, the upper jaw being movable between a first insertion position wherein the upper jaw is compressible against the biasing means on the lower jaw to provide the surgical end effector with a smallest cross-sectional shape to facilitate passage of the surgical end effector through the hollow trocar port into the patient and a primary opened position whereupon application of an actuation motion thereto, the upper jaw is movable into a fully open position for admitting target tissue between the upper and lower jaws and upon application of another actuation motion to the upper jaw, the upper jaw is moved to a fully clamped position wherein the target tissue is clamped between the upper and lower jaws; and

a firing member operably supported for selective operable travel within the surgical end effector upon application of a firing motion thereto and wherein the surgical method further comprises:

inserting the surgical end effector into the hollow trocar port such that an inner surface of the hollow trocar port compresses the upper jaw into the insertion position until the surgical end effector has exited the distal end of the trocar port whereupon the biasing means moves the upper jaw into the primary opened position;

applying the actuation motion to the upper jaw to move the upper jaw to the fully opened position;

manipulating the end effector such that the target tissue is positioned between the upper and lower jaws;

applying the another actuation motion to the upper jaw to move the upper jaw into the fully clamped position; and

applying the firing motion to the firing member to cause the firing member to travel from a starting position to an ending position within the end effector.

2. The surgical method of claim 1 wherein the firing member comprises a body that includes an upper portion that is configured to engage the upper jaw and a lower portion that is configured to engage the

lower jaw and wherein the upper portion is movable relative to the lower portion between a collapsed position when the surgical end effector has the smallest cross-sectional shape and an operating position when the surgical end effector has exited the trocar port to enable the firing member to move from the starting position to the ending position upon application of the firing motion thereto.

3. The surgical method of claim 2 wherein the upper portion of the firing member includes a tissue cutting edge.

4. The surgical method of claim 3 wherein the lower jaw supports a surgical staple cartridge including a plurality of unformed surgical staples operably supported therein and wherein the upper jaw comprises an anvil and wherein the firing member cuts the target tissue clamped between the anvil and the surgical staple cartridge and drives the unformed surgical staples within the surgical staple cartridge into forming contact with the anvil as the firing member travels from the starting position to the ending position within the end effector.

5. The surgical method of claim 4 wherein the anvil comprises an anvil body including an anvil mounting portion, the anvil mounting portion movably engaging a control insert movably supported in the lower jaw for travel along an insert axis that is transverse to the longitudinal tool axis between a first position corresponding to the insertion position and a second position corresponding to the primary opened position, the anvil mounting portion automatically moving along the insert axis from the first position to the second position after the surgical end effector has exited the trocar port.

6. The surgical method of claim 5 wherein the control insert is biased into the second position by a biasing member supported on the lower jaw.

7. The surgical method of claim 4 further comprising the step of applying a retraction motion to the firing member to move the firing member from the ending position back to the starting position.

8. The surgical method of claim 7 further comprising the step of re-applying the actuation motion to the anvil to enable the target tissue to be released from the end effector.

9. The surgical method of claim 8 further comprising the steps of:

discontinuing the re-application of the actuation motion to the anvil to enable the anvil to return to the primary opened position; and

withdrawing the surgical end effector back through the trocar port such that the inner surface of the trocar port compresses the anvil into the first insertion position.

10. The surgical method of claim 1 wherein the elastic biasing means comprises compressible foam attached to the lower jaw.

11. A surgical method for treating target tissue within a patient, the method comprising the steps of:

installing a hollow trocar port into a patient;

providing a surgical end effector comprising:

an elongated shaft assembly;

a lower jaw operably coupled to the elongated shaft assembly, the lower jaw including elastic biasing means;

an upper jaw supported for movement relative to the lower jaw upon application of actuation motions thereto, the upper jaw being movable between a first insertion position wherein the upper jaw is compressible against the elastic biasing means to provide the surgical end effector with a smallest cross-sectional shape to facilitate passage of the surgical end effector through the trocar port into the patient and a primary opened position and whereupon application of an actuation motion thereto, the upper jaw is movable into a fully open position for admitting target tissue between the upper and lower jaws and upon application of another actuation motion thereto, the upper jaw is moved to a fully clamped position wherein the target tissue is clamped between the upper and lower jaws;

a control insert operably supporting a portion of the upper jaw therein and being selectively movably supported in the lower jaw for travel between a first position corresponding to the insertion position and a second position corresponding to the primary opened position;

means for moving the control insert between the first and second positions; and

a firing member operably supported for selective operable travel within the surgical end effector upon application of a firing motion thereto and wherein the surgical method further comprises:

moving the control insert into the first position;

inserting the surgical end effector through the hollow trocar port into the patient;

moving the control insert to the second position to enable the biasing means to move the upper jaw into the primary opened position;

applying the actuation motion to the upper jaw to move the upper jaw to the fully opened position;

manipulating the end effector such that the target tissue is positioned between the upper and lower jaws;

applying the another actuation motion to the upper jaw to move the upper jaw into the fully clamped position; and

applying the firing motion to the firing member to cause the firing member to travel from a starting position to an ending position within the end effector.

12. The surgical method of claim 11 wherein the firing member comprises a body that includes an upper portion that is configured to engage the upper jaw and a lower portion that is configured to engage the lower jaw and wherein the upper portion is movable relative to the lower portion between a collapsed position when the surgical end effector has the smallest cross-sectional shape and an operating position when the surgical end effector has exited the trocar port to enable the firing member to move from the starting position to the ending position upon application of the firing motion thereto.

13. The surgical method of claim 12 wherein the upper portion of the firing member includes a tissue cutting edge.

14. The surgical method of claim 13 wherein the lower jaw supports a surgical staple cartridge including a plurality of unformed surgical staples operably supported therein and wherein the upper jaw comprises an anvil and wherein the firing member cuts the target tissue clamped between the anvil and the surgical staple cartridge and drives the unformed surgical staples within the surgical staple cartridge into forming contact with the anvil as the firing member travels from the starting position to the ending position within the end effector.

15. The surgical method of claim 14 further comprising the step of applying a retraction motion to the firing member to move the firing member from the ending position back to the starting position.

16. The surgical method of claim 15 further comprising the step of re-applying the actuation motion to the anvil to enable the target tissue to be released from the end effector.

17. The surgical method of claim 16 further comprising the steps of:

discontinuing the re-application of the actuation motion to the anvil to enable the anvil to return to the primary opened position;

returning the control insert to the first position; and

withdrawing the surgical end effector back through the trocar port.

18. A surgical method for treating target tissue within a patient, the method comprising the steps of:

installing a hollow trocar port into a patient;

providing a surgical end effector comprising:

a lower jaw;

an upper jaw supported for movement relative to the lower jaw between a first insertion position wherein the upper jaw is compressible against the lower jaw to provide the surgical end effector with a smallest cross-sectional shape to facilitate passage of the surgical end effector through the hollow trocar port into the patient and a primary opened position whereupon application of an actuation motion thereto, the upper jaw is movable into a fully open position for admitting target tissue between the upper and lower jaws and upon application of another actuation motion to the upper jaw, the upper jaw is moved to a fully clamped position wherein the target tissue is clamped between the upper and lower jaws; and

a firing member operably supported for selective operable travel within the surgical end effector upon application of a firing motion thereto and wherein the surgical method further comprises:

operably coupling an elongated shaft assembly to the surgical end effector, the elongated shaft assembly defining a longitudinal tool axis and including a distal closure tube portion supported for axial travel relative to the upper jaw to apply the actuation motions thereto, the distal closure tube portion including biasing means to automatically bias the upper jaw to the primary opened position upon exiting of the upper jaw from the trocar port;

inserting the surgical end effector into the hollow trocar port such that an inner surface of the hollow trocar port compresses the upper jaw into the insertion position until the surgical end effector has exited the distal end of the trocar port whereupon the biasing means moves the upper jaw into the primary opened position;

applying the actuation motion to the upper jaw to move the upper jaw to the fully opened position;

manipulating the end effector such that the target tissue is positioned between the upper and lower jaws;

applying the another actuation motion to the upper jaw to move the upper jaw into the fully clamped position; and

applying the firing motion to the firing member to cause the firing member to travel from a starting position to an ending position within the end effector.

19. The surgical method of claim 18 wherein the firing member comprises a body that includes an upper portion that is configured to engage the upper jaw and a lower portion that is configured to engage the lower jaw and wherein the upper portion is movable relative to the lower portion between a collapsed position when the surgical end effector has the smallest cross-sectional shape and an operating position when the surgical end effector has exited the trocar port to enable the firing member to move from the starting position to the ending position upon application of the firing motion thereto.

20. The surgical method of claim 19 wherein the upper portion of the firing member includes a tissue cutting edge.

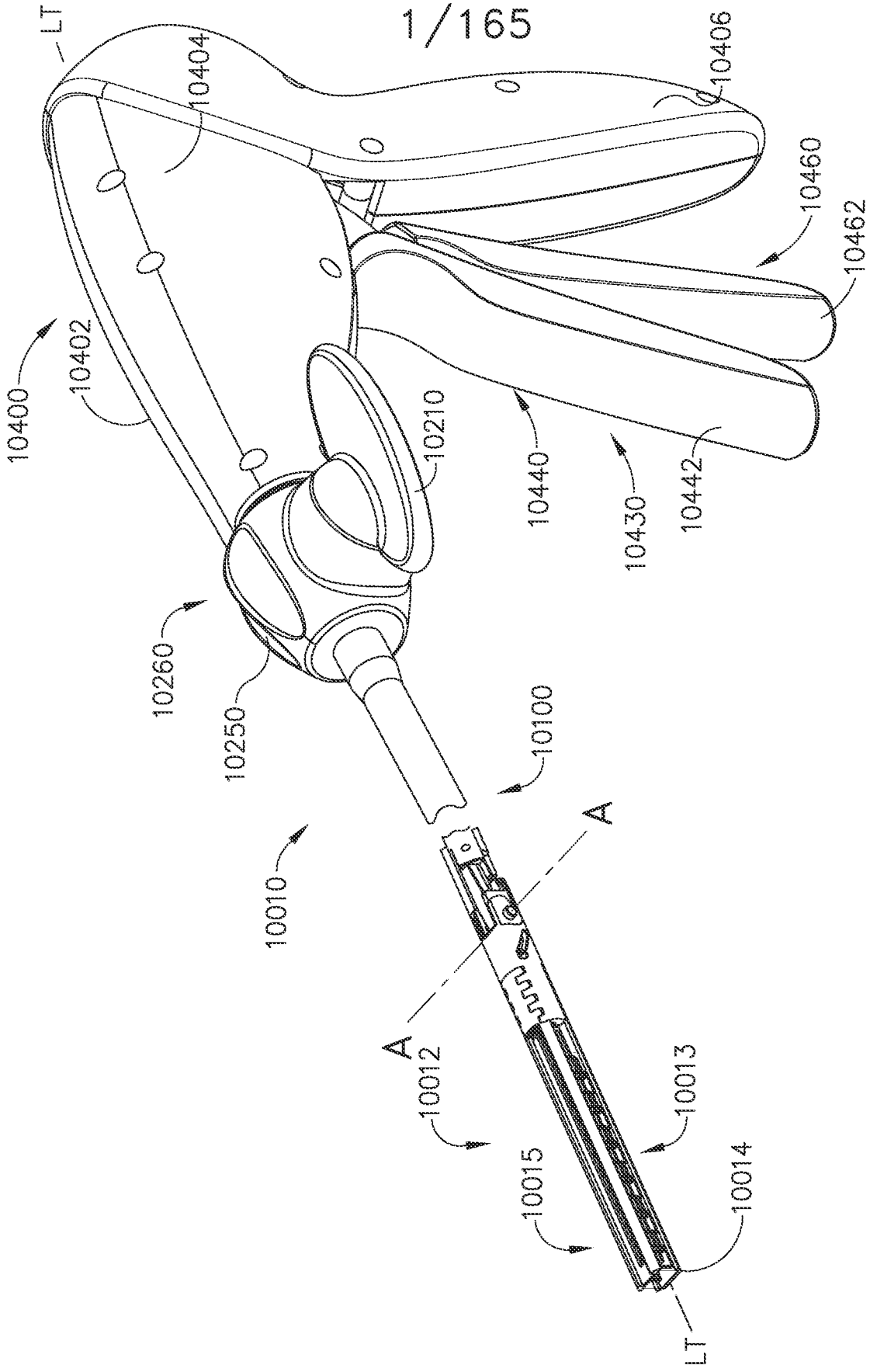

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FIG. 1

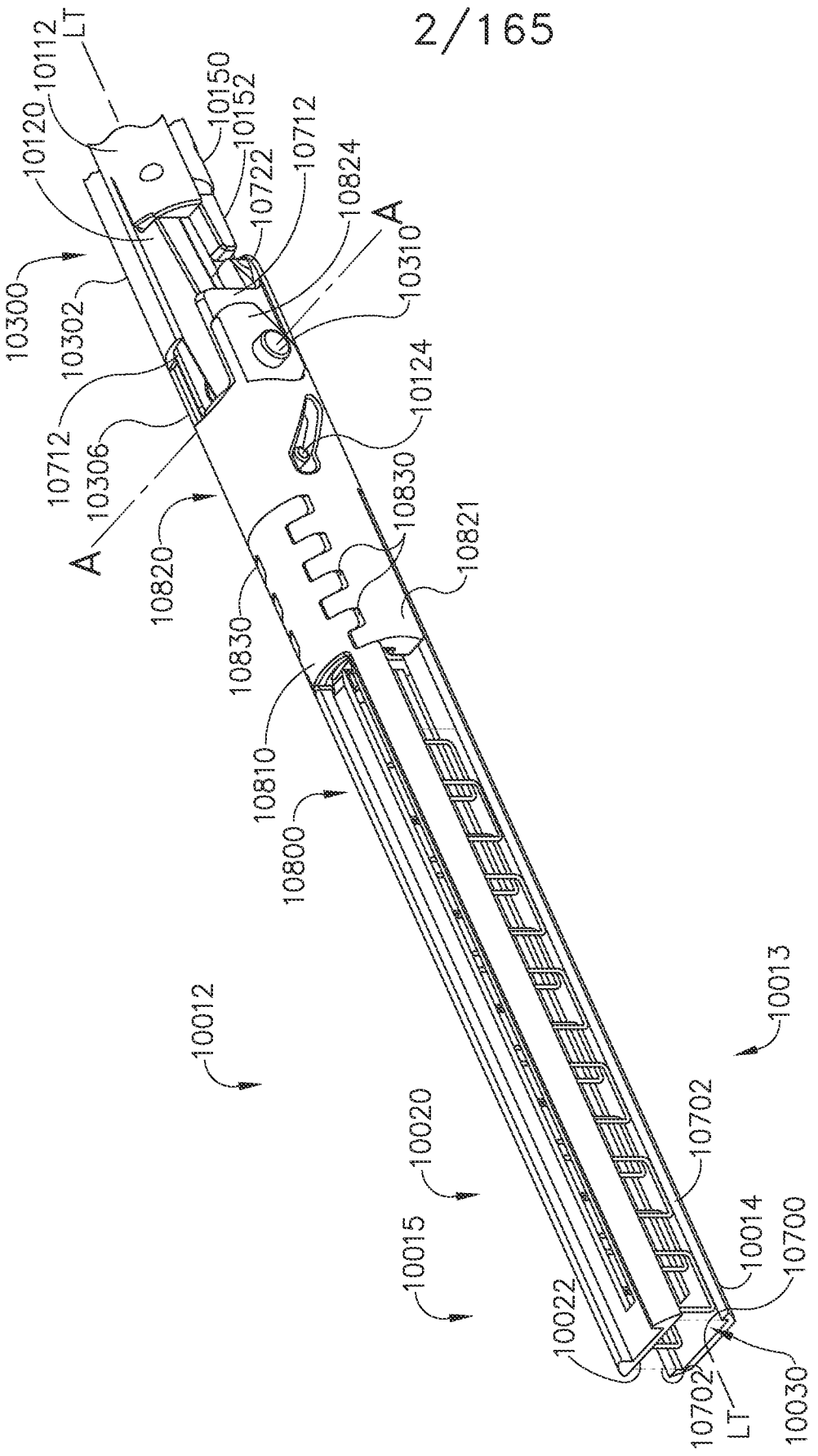

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FIG. 2

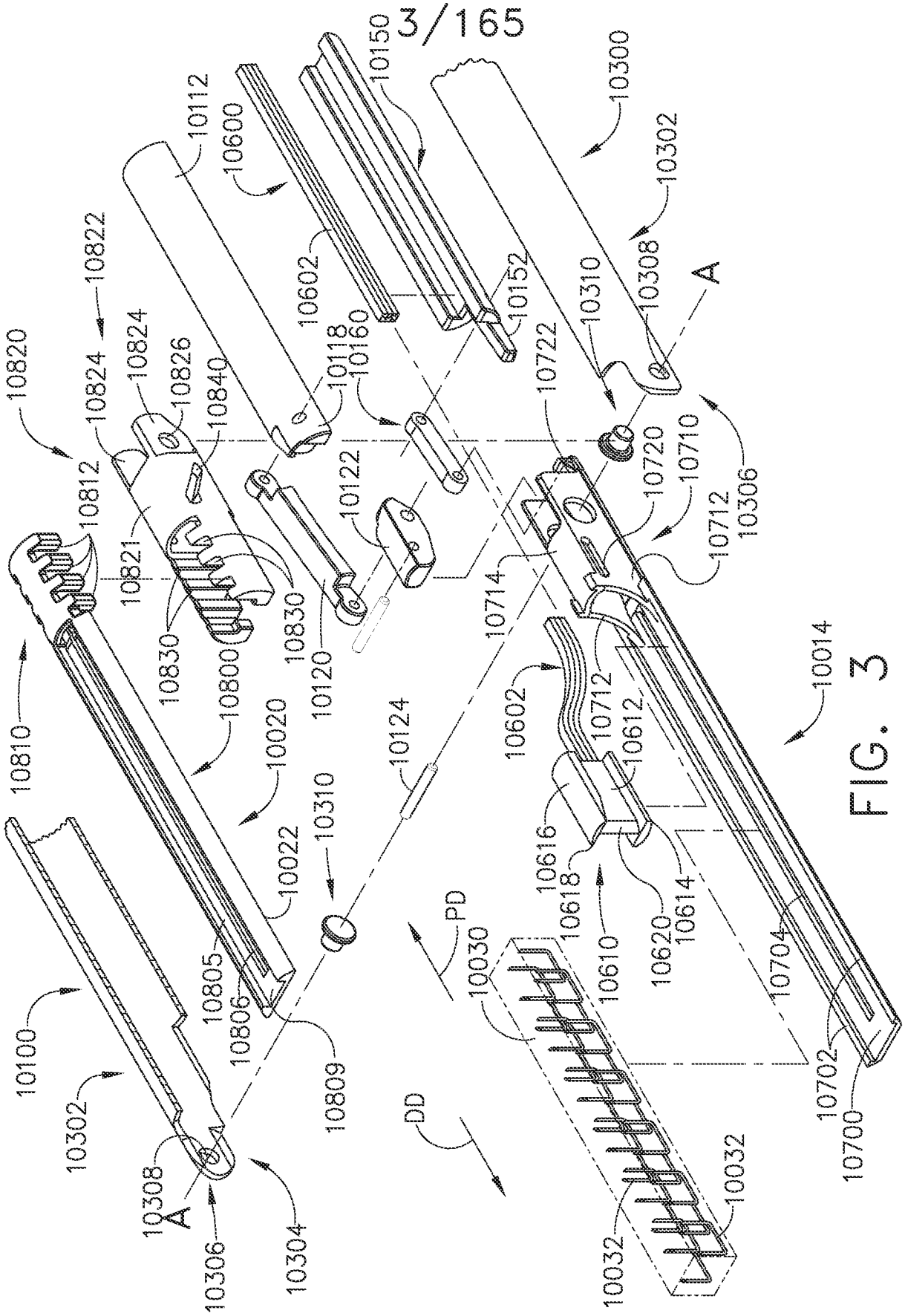

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FIG. 3

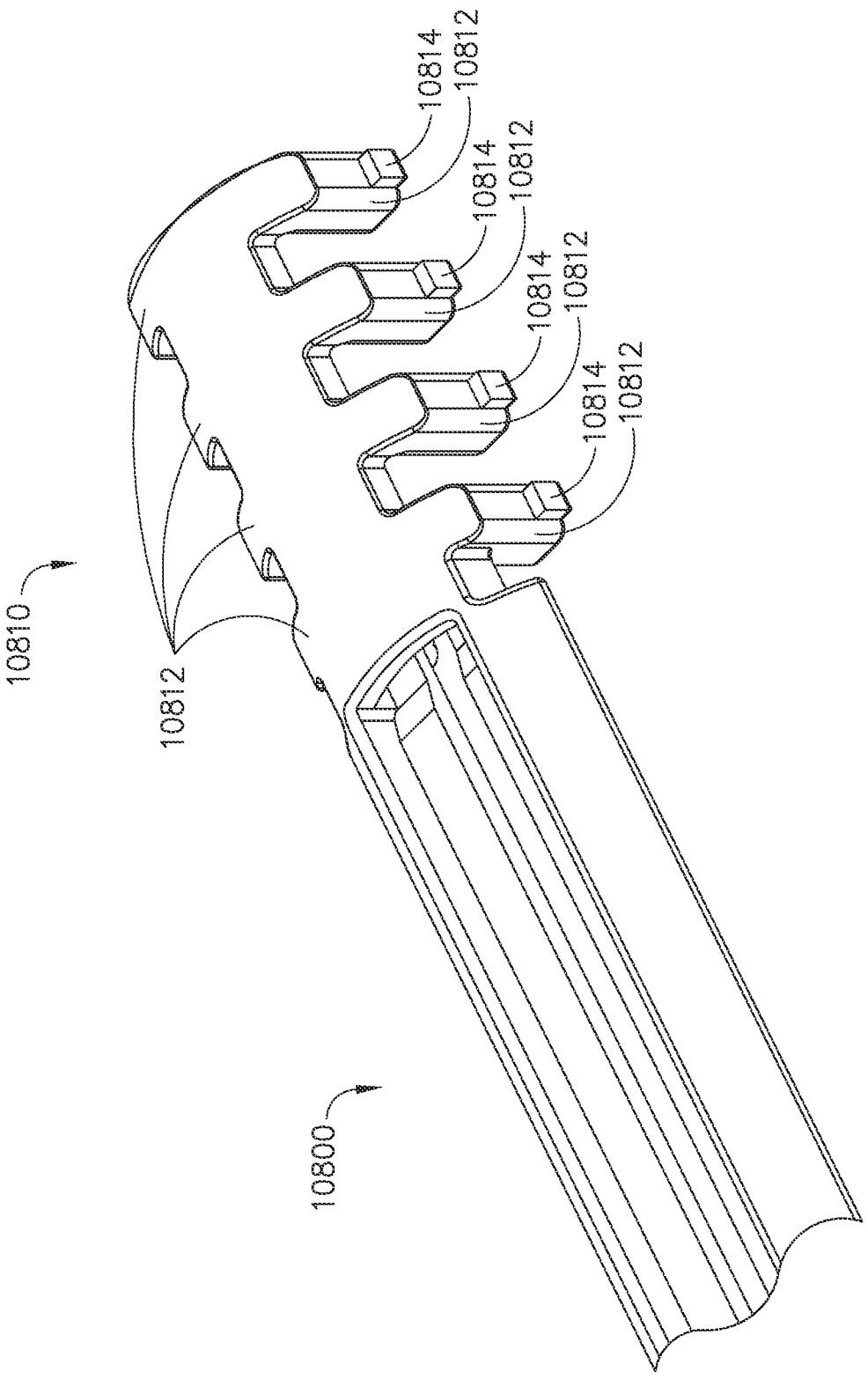

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FIG. 4

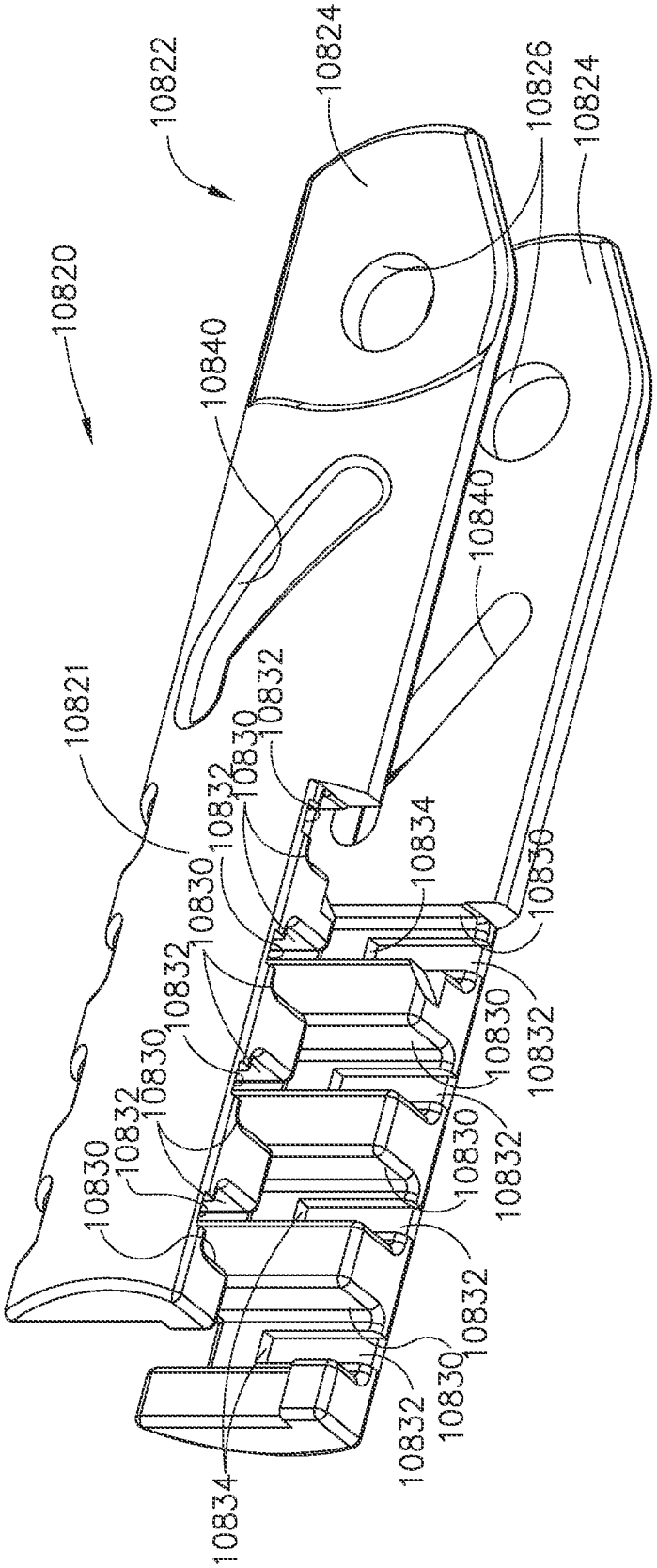

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FIG. 5

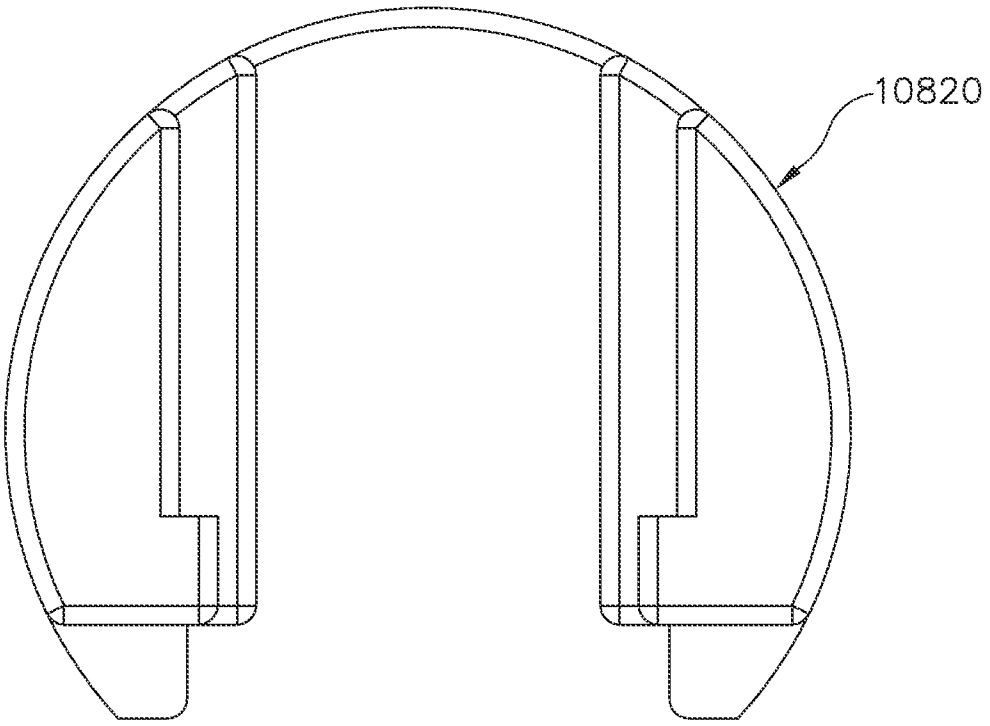

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FIG. 6

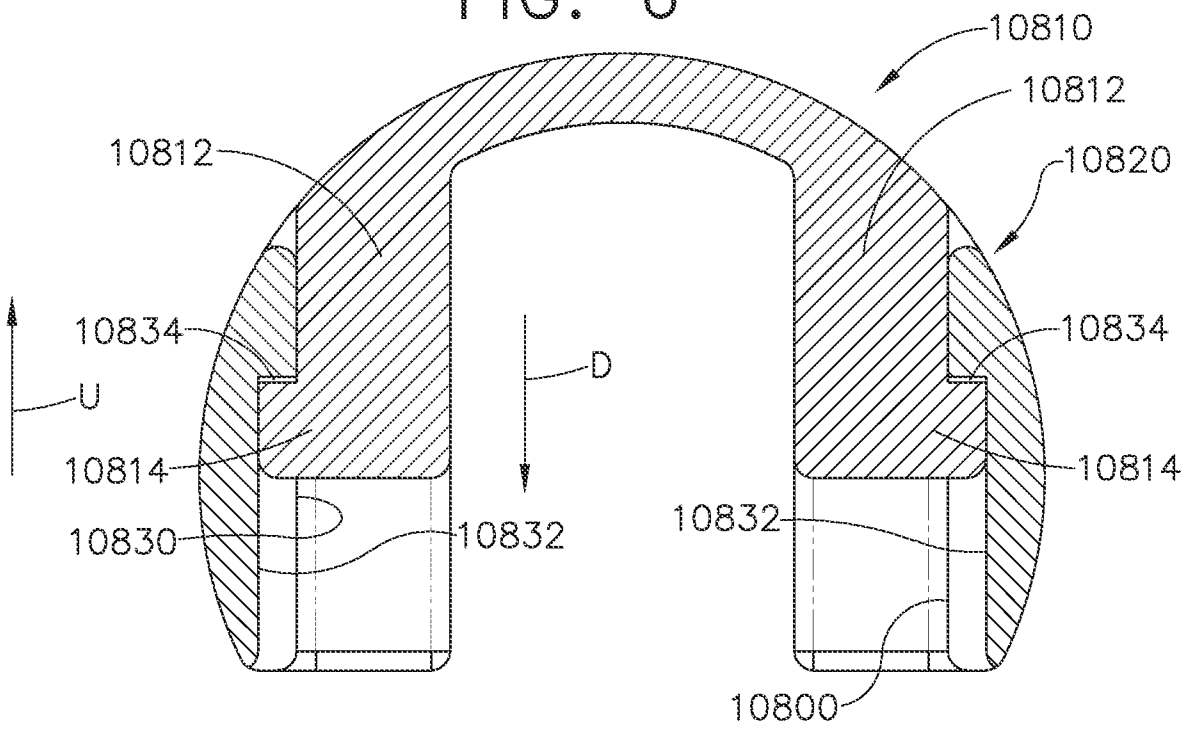

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FIG. 7

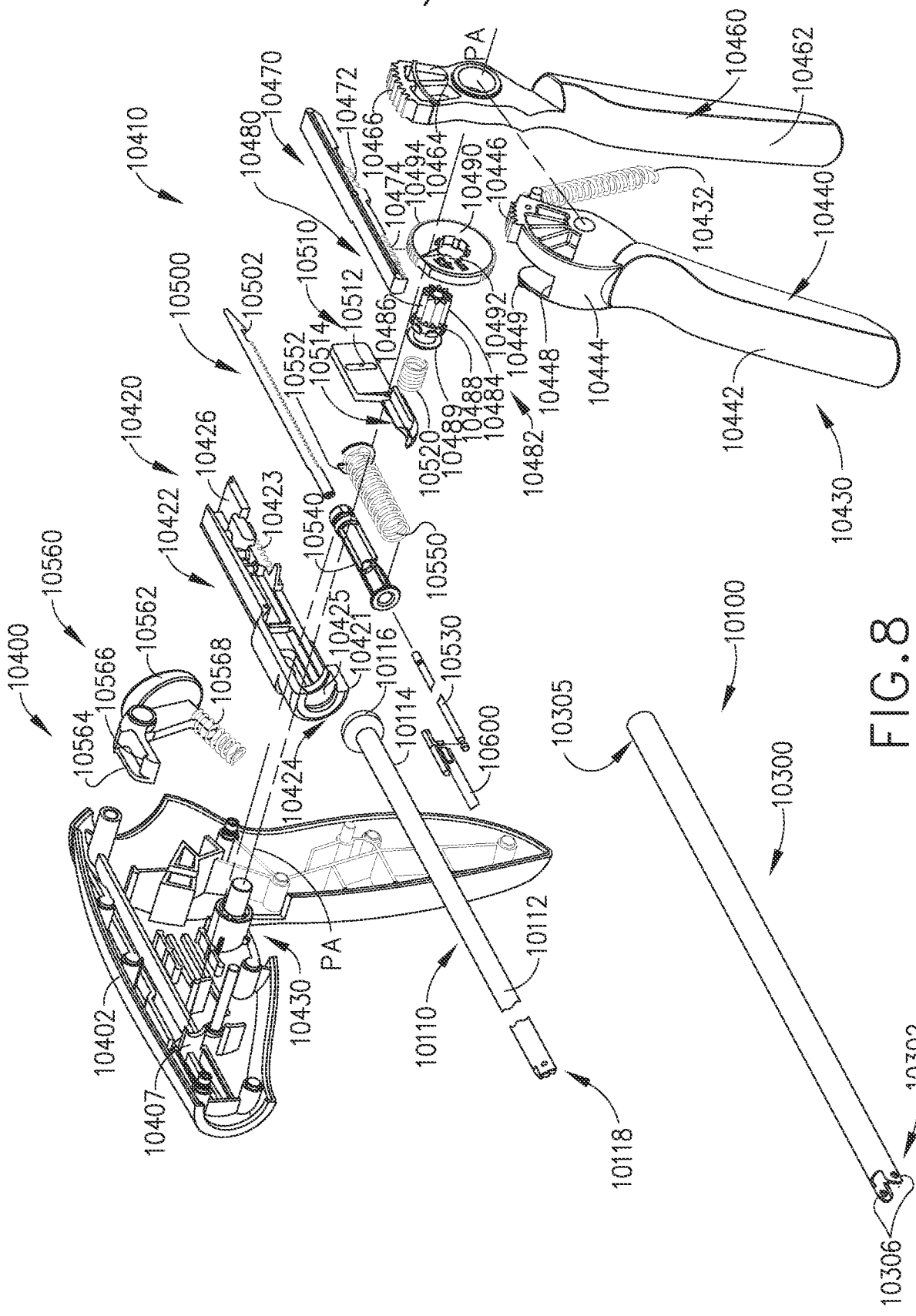

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FIG. 8

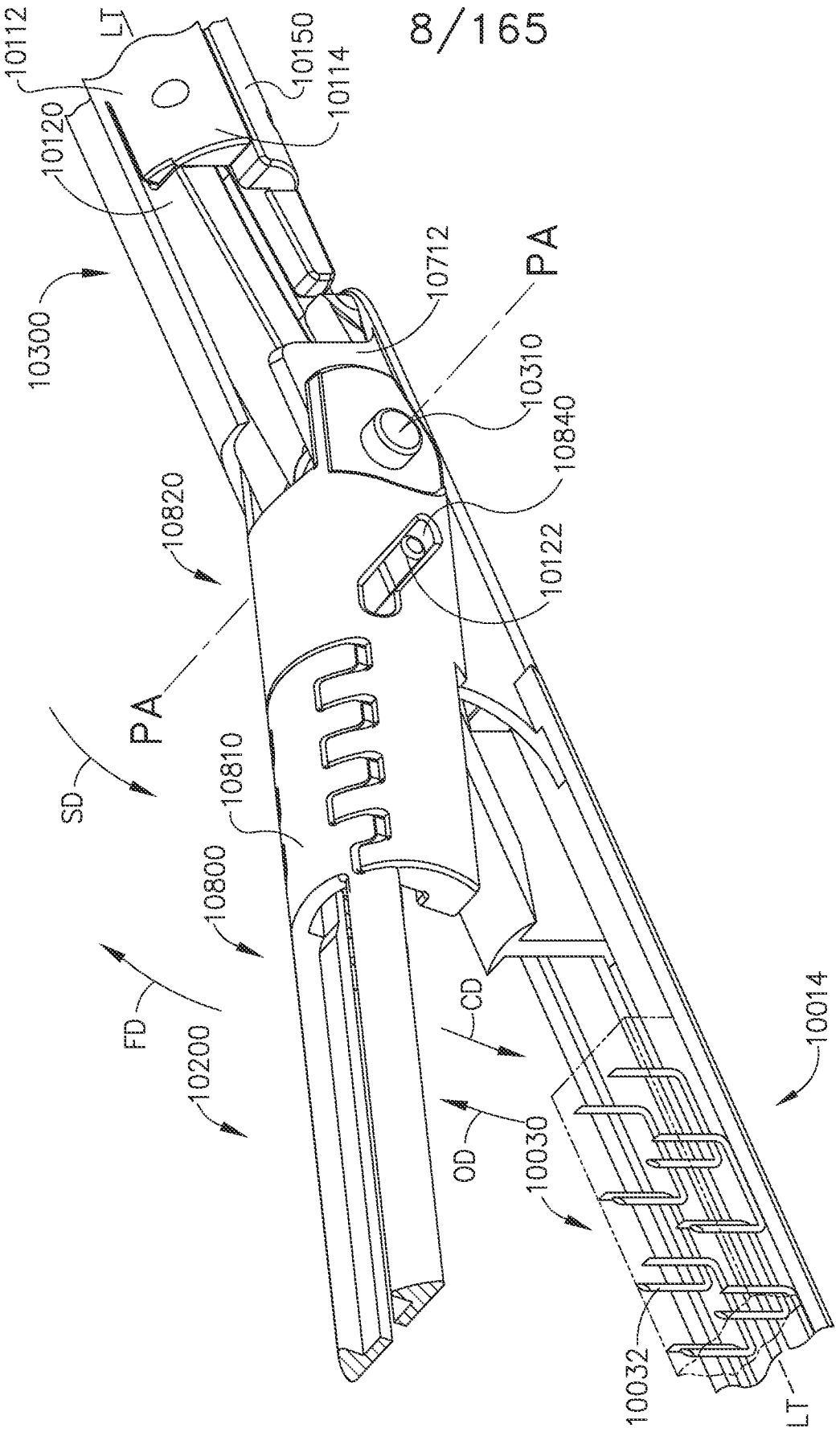

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FIG. 9

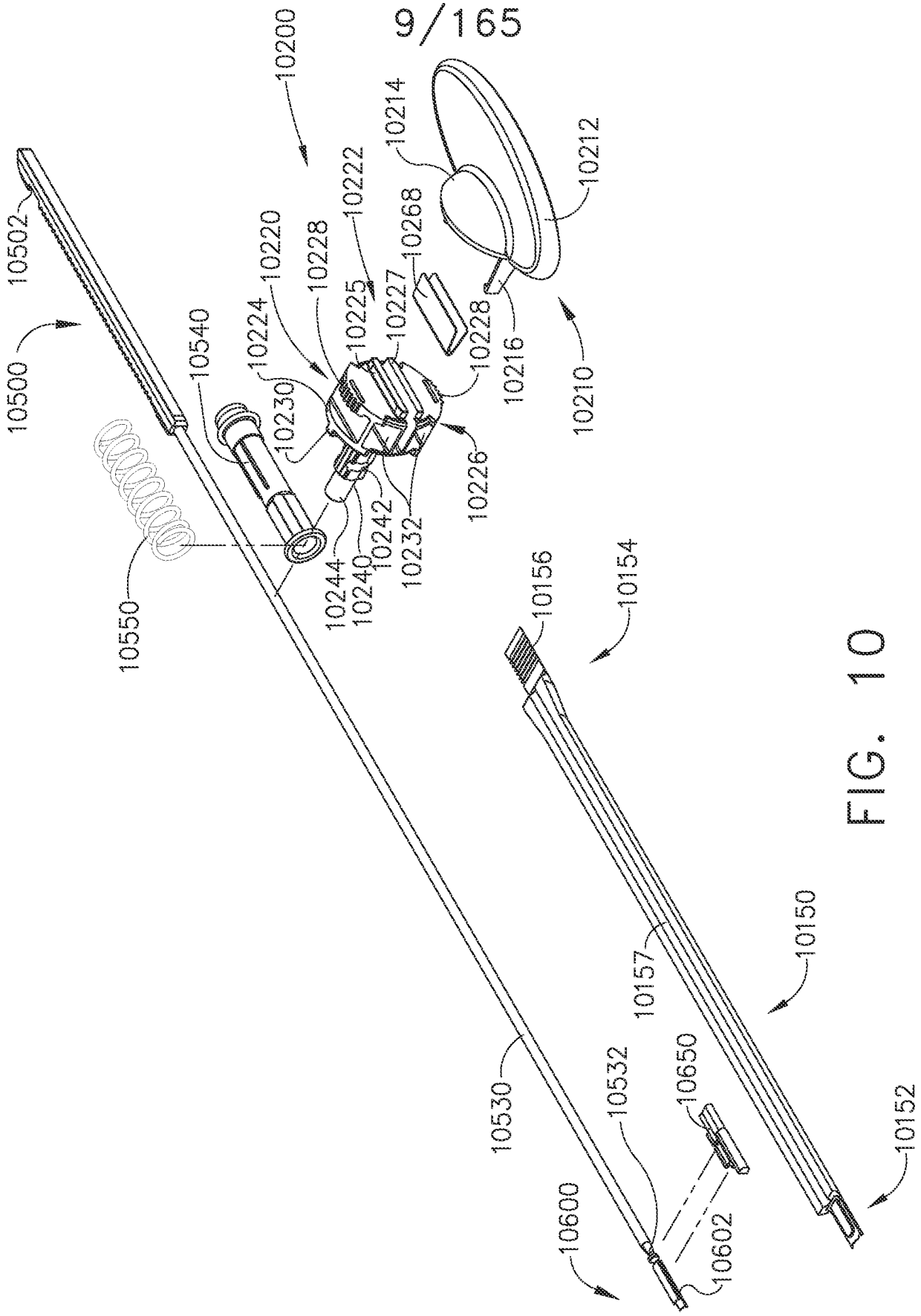

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FIG. 10

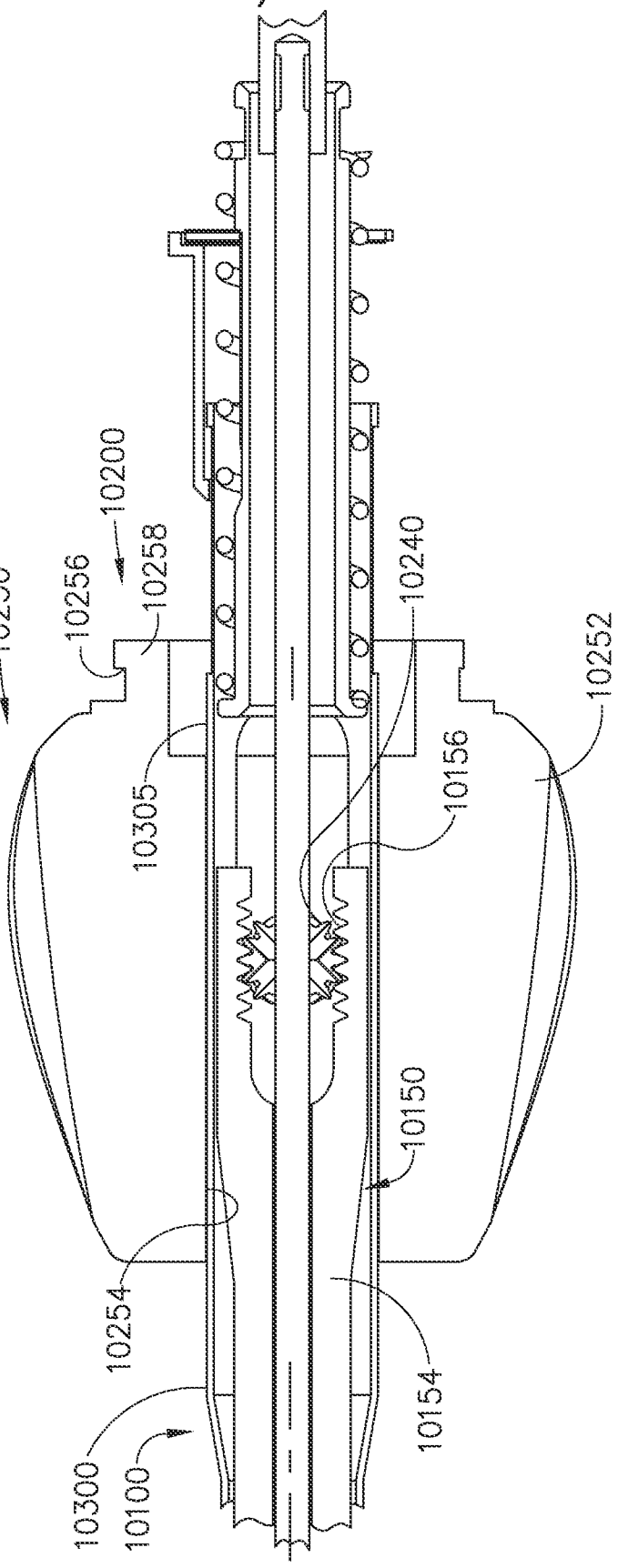

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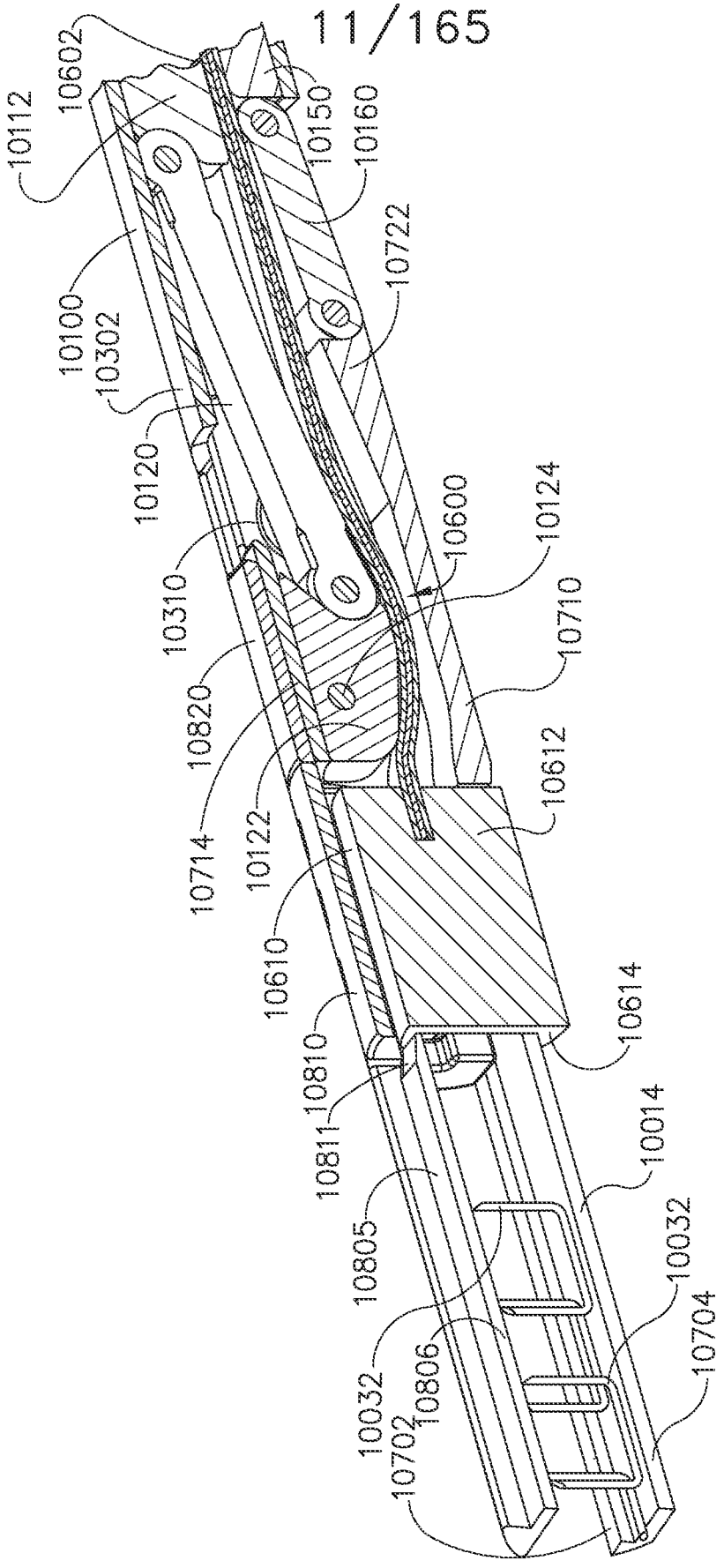

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FIG. 12

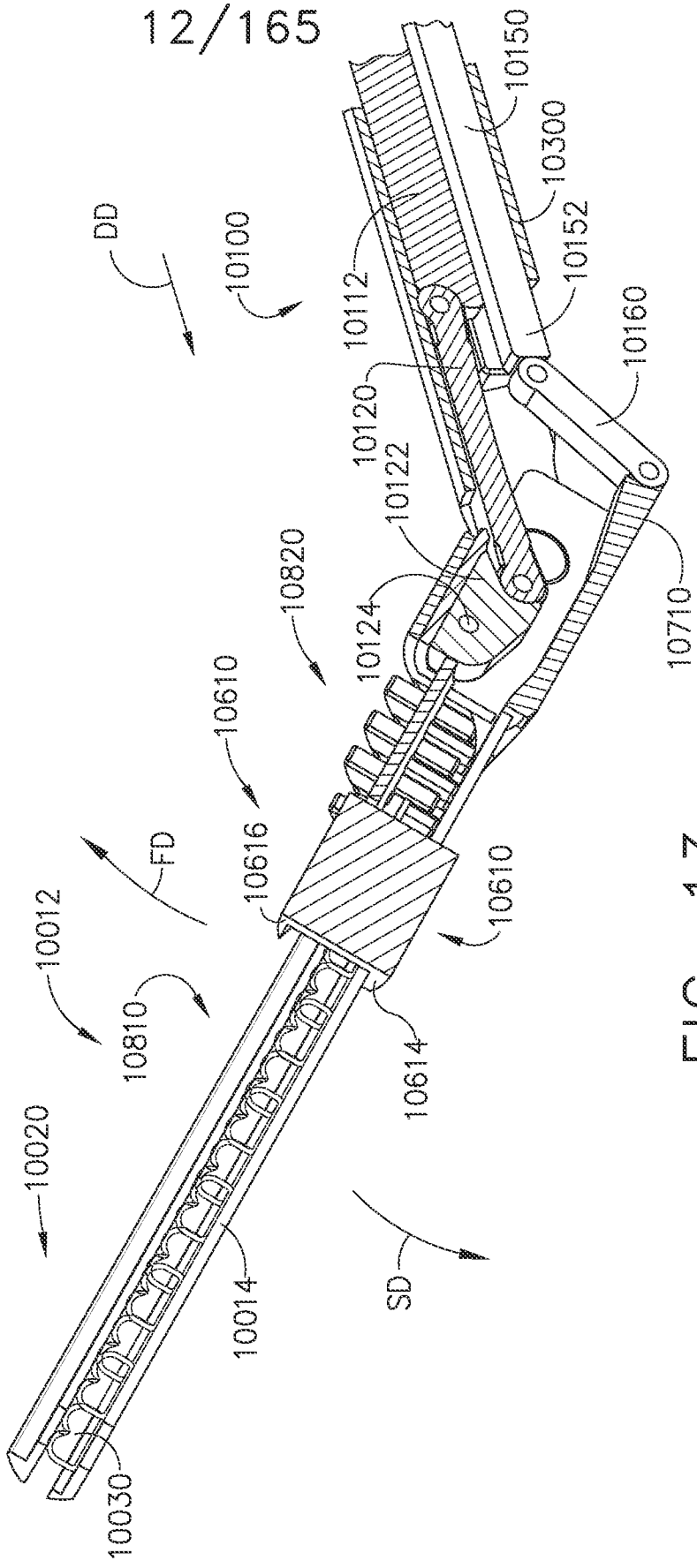

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FIG. 13

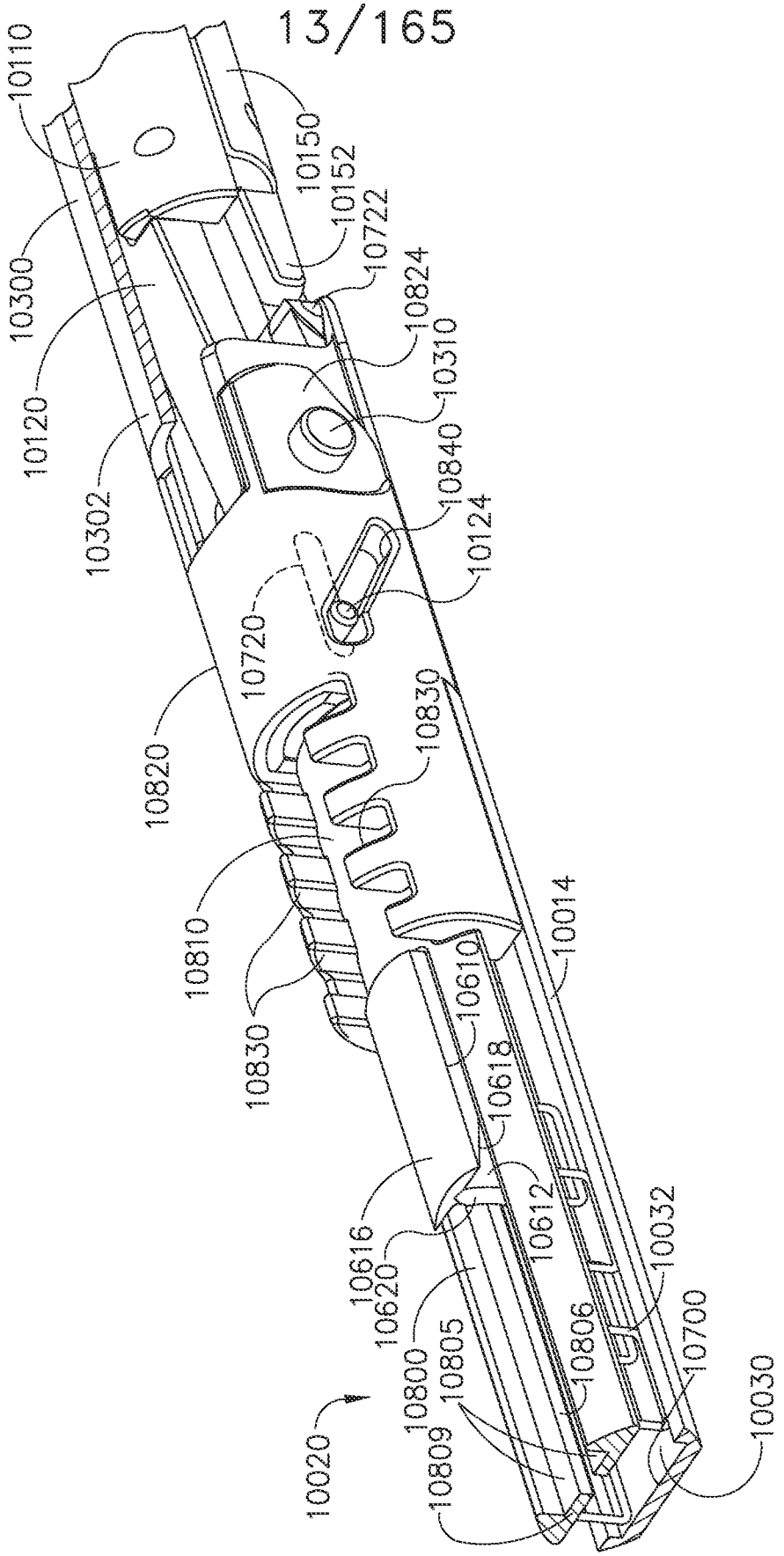

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FIG. 14

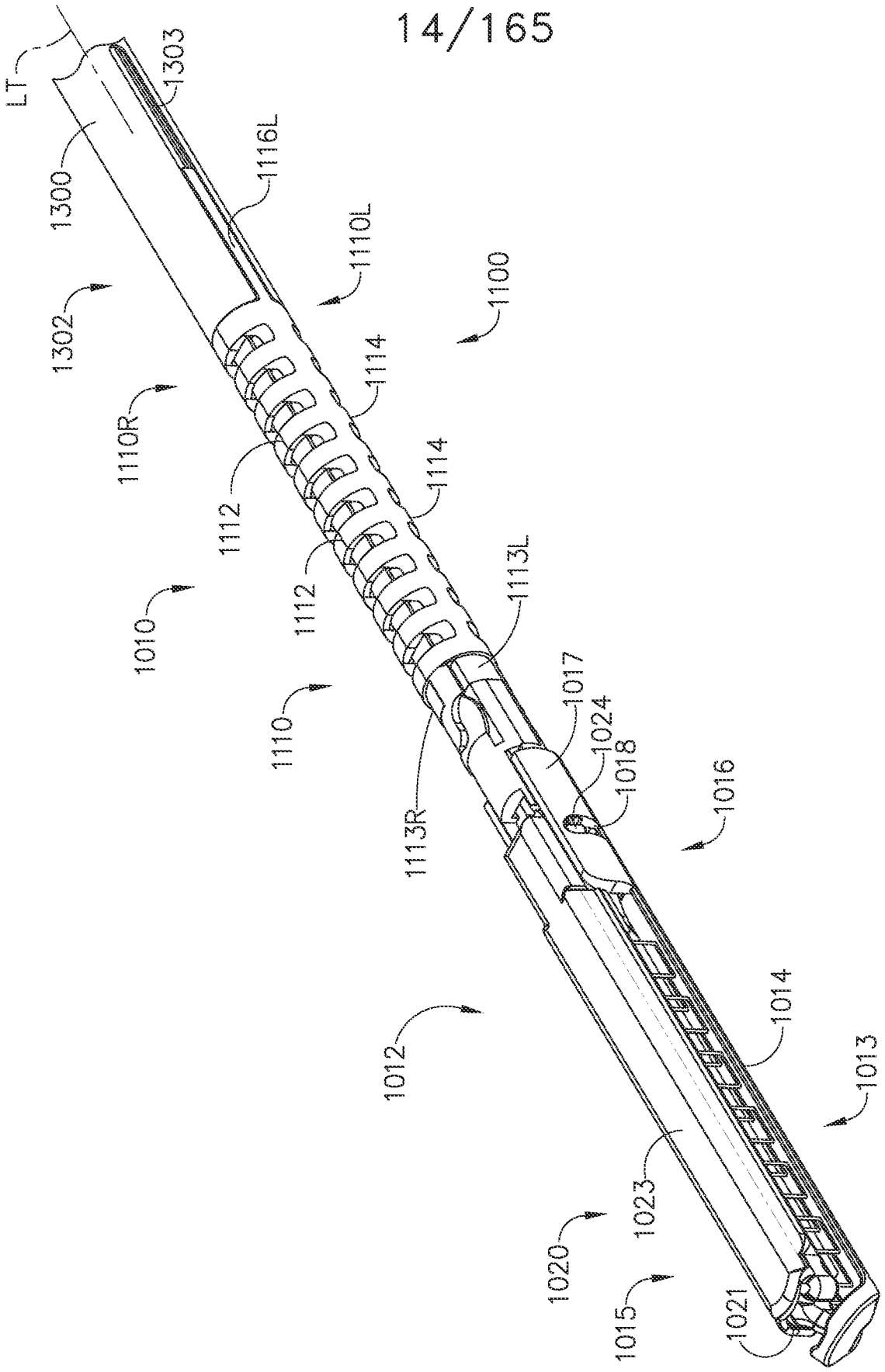

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FIG. 15

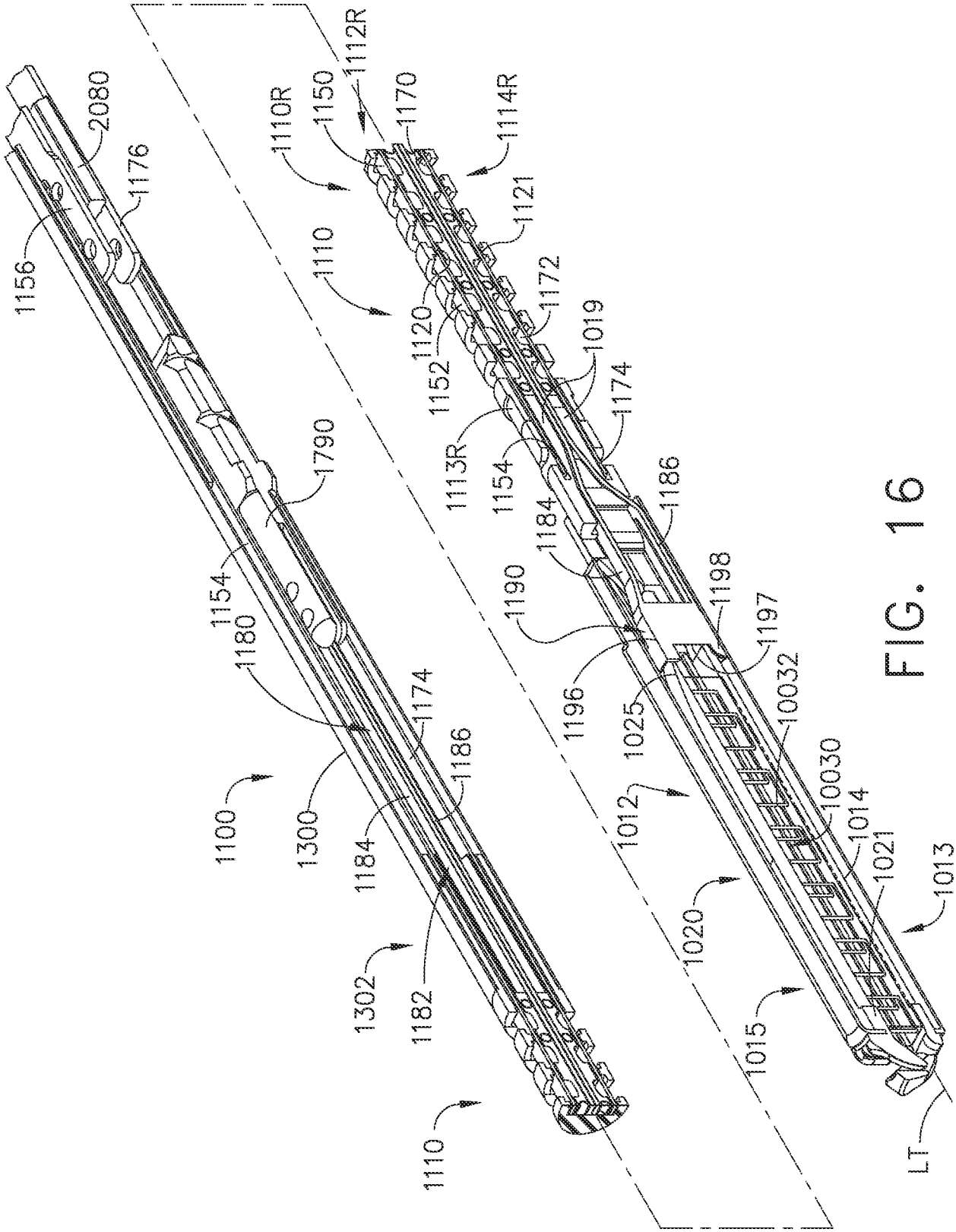

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FIG. 16

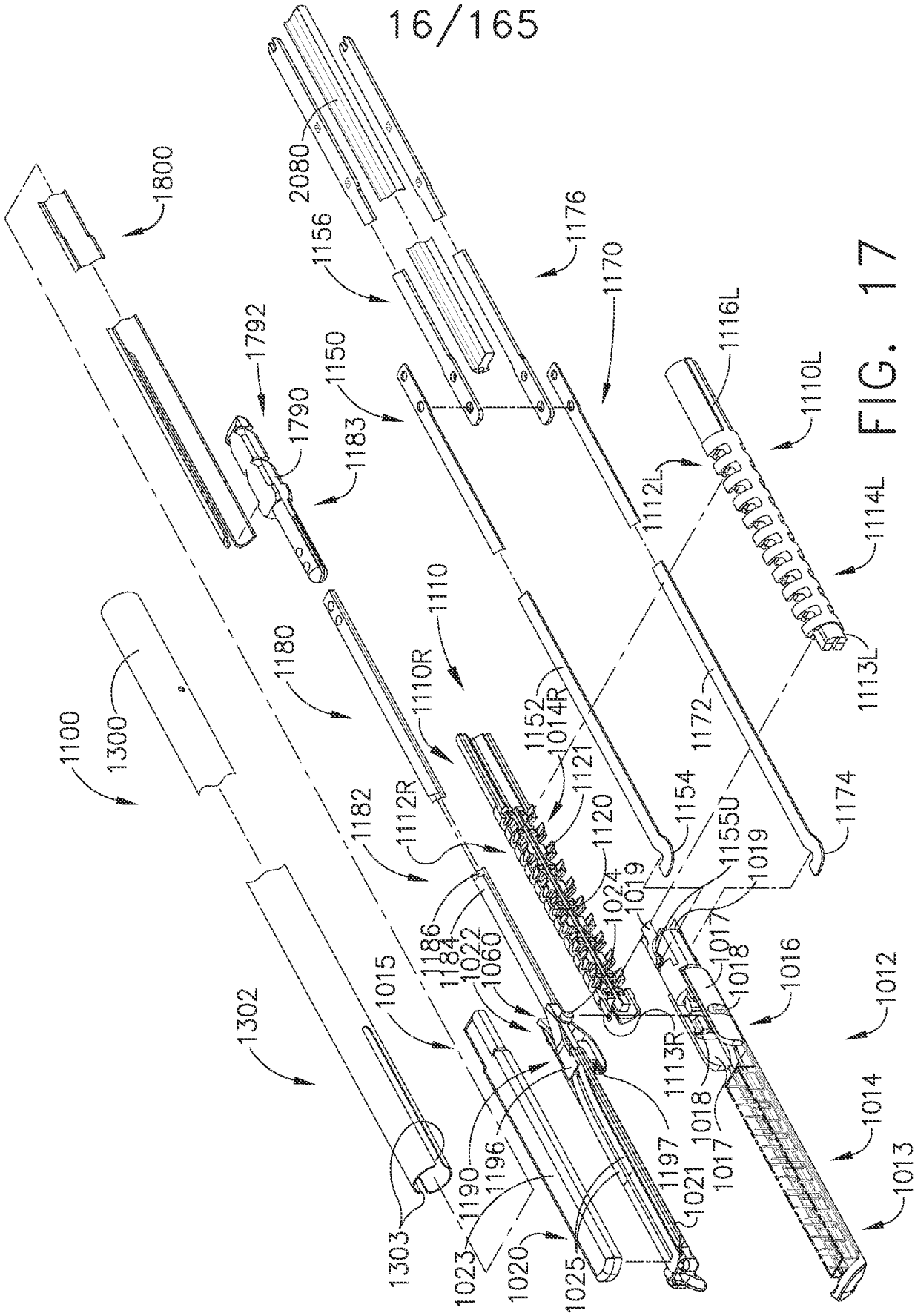

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FIG. 17

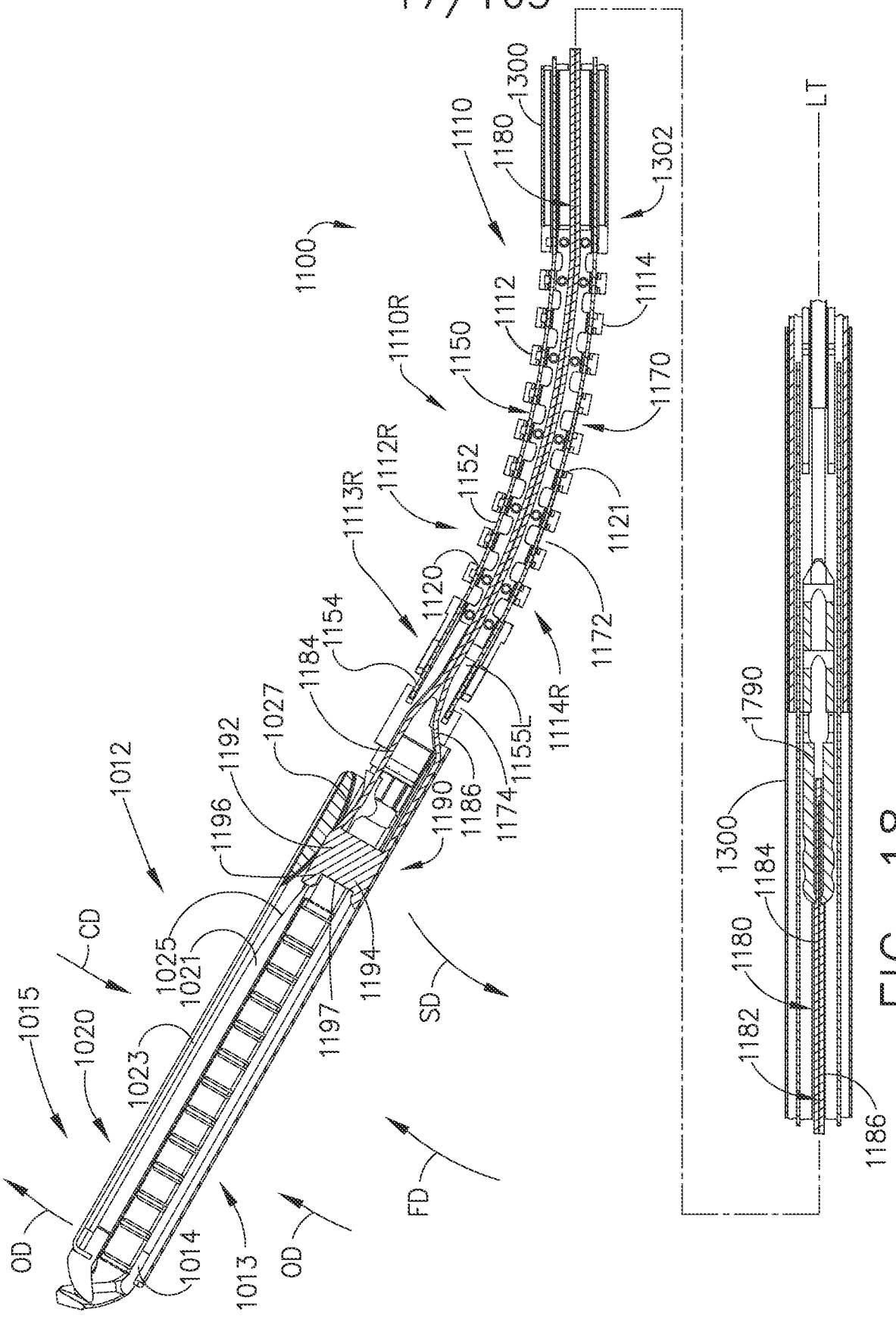

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1186

FIG. 18

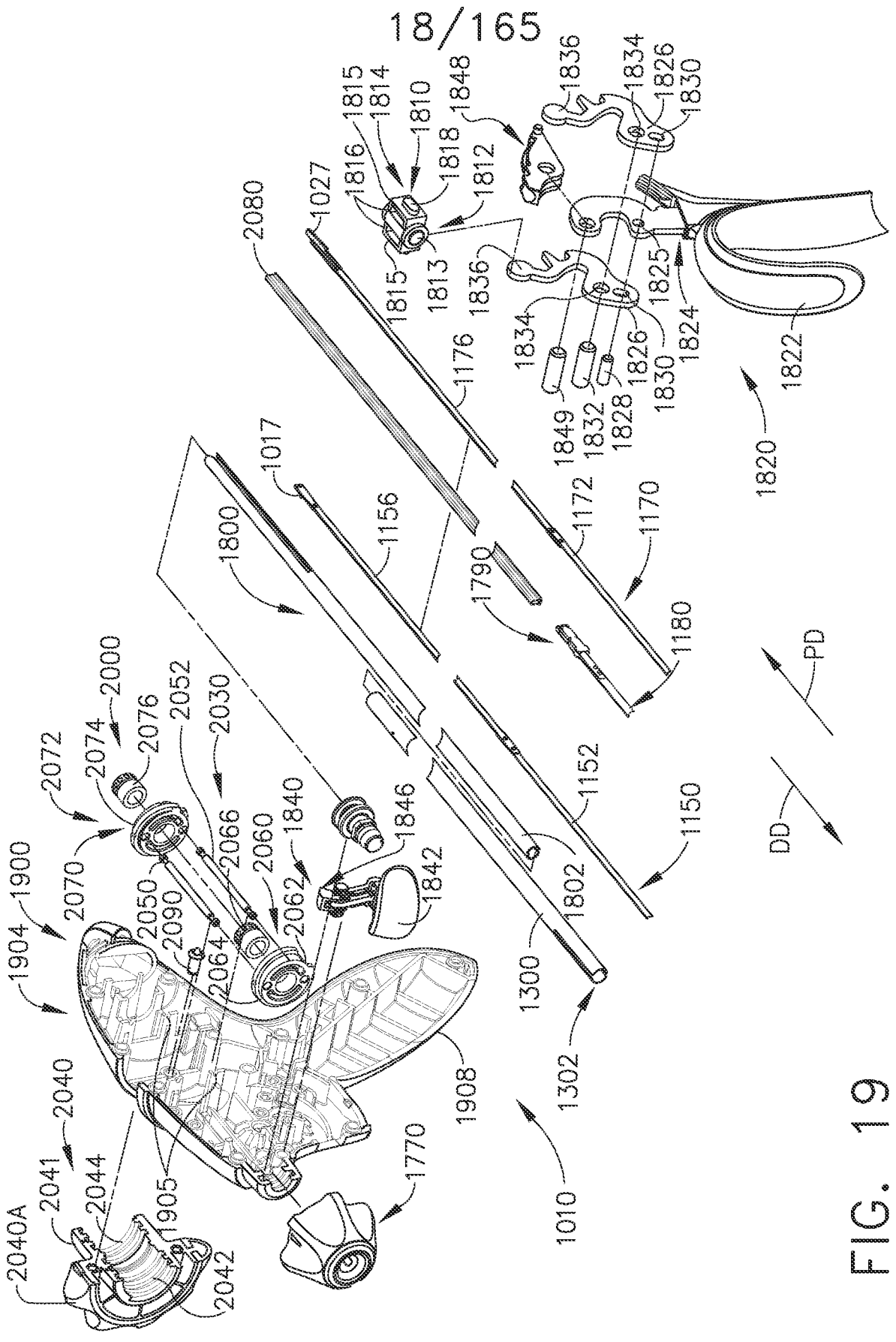

2080
1027
1816
1815
1814
1810
1848
1836
1834
1826
1830
1818
1812
1813
1825
1824
1822
1820
1176
1849
1832
1828
1017
1800
1156
1172
1170
1790
1180
2000
2076
2052
2030
2072
2074
1840
1846
2066
2060
1842
2062
2070
2050
2090
2064
1904
1900
1152
1150
1802
1300
1302
1908
1010
2040
2041
2044
1905
2040A
2042
1770
PD
DD

FIG. 19

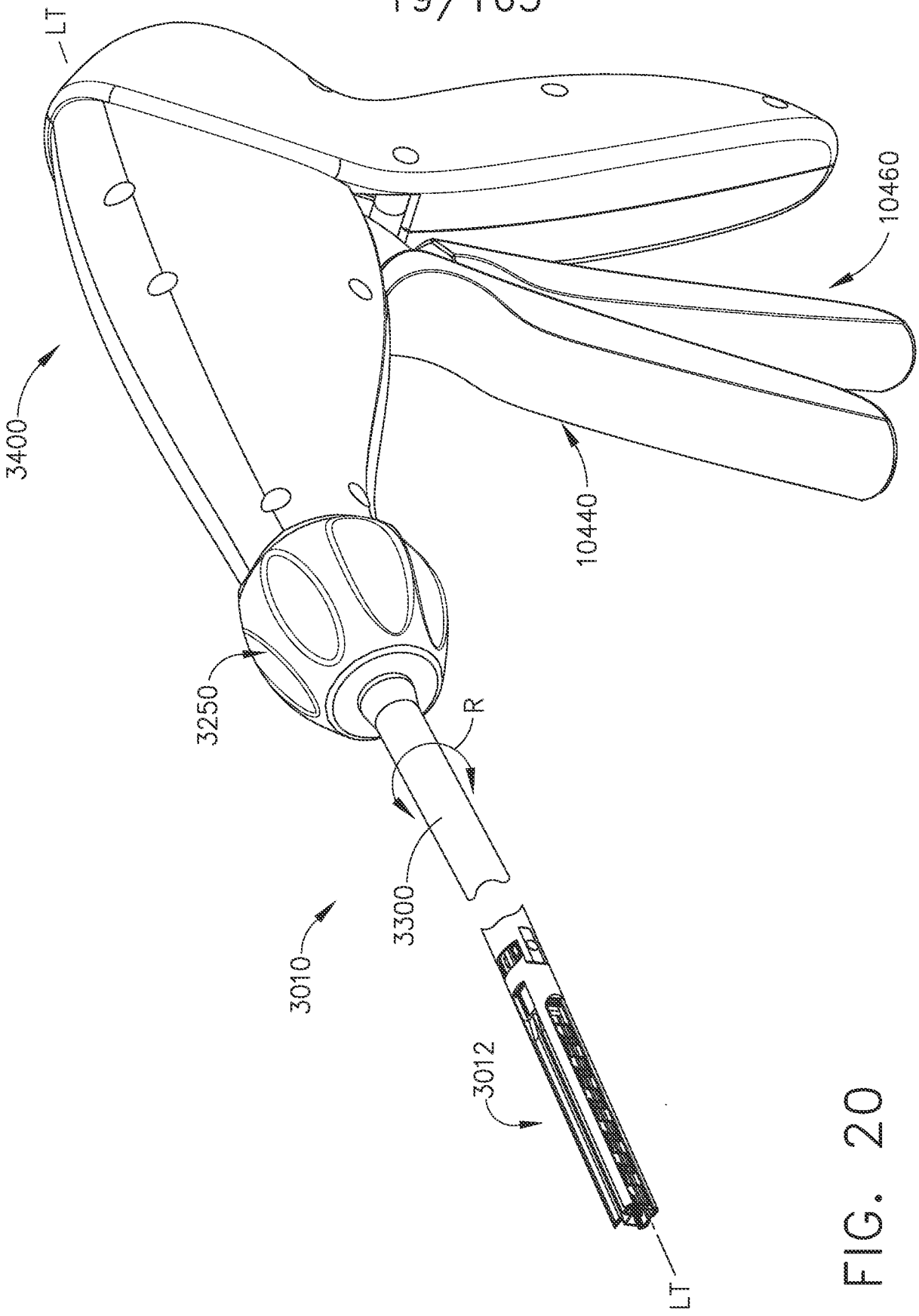


FIG. 20

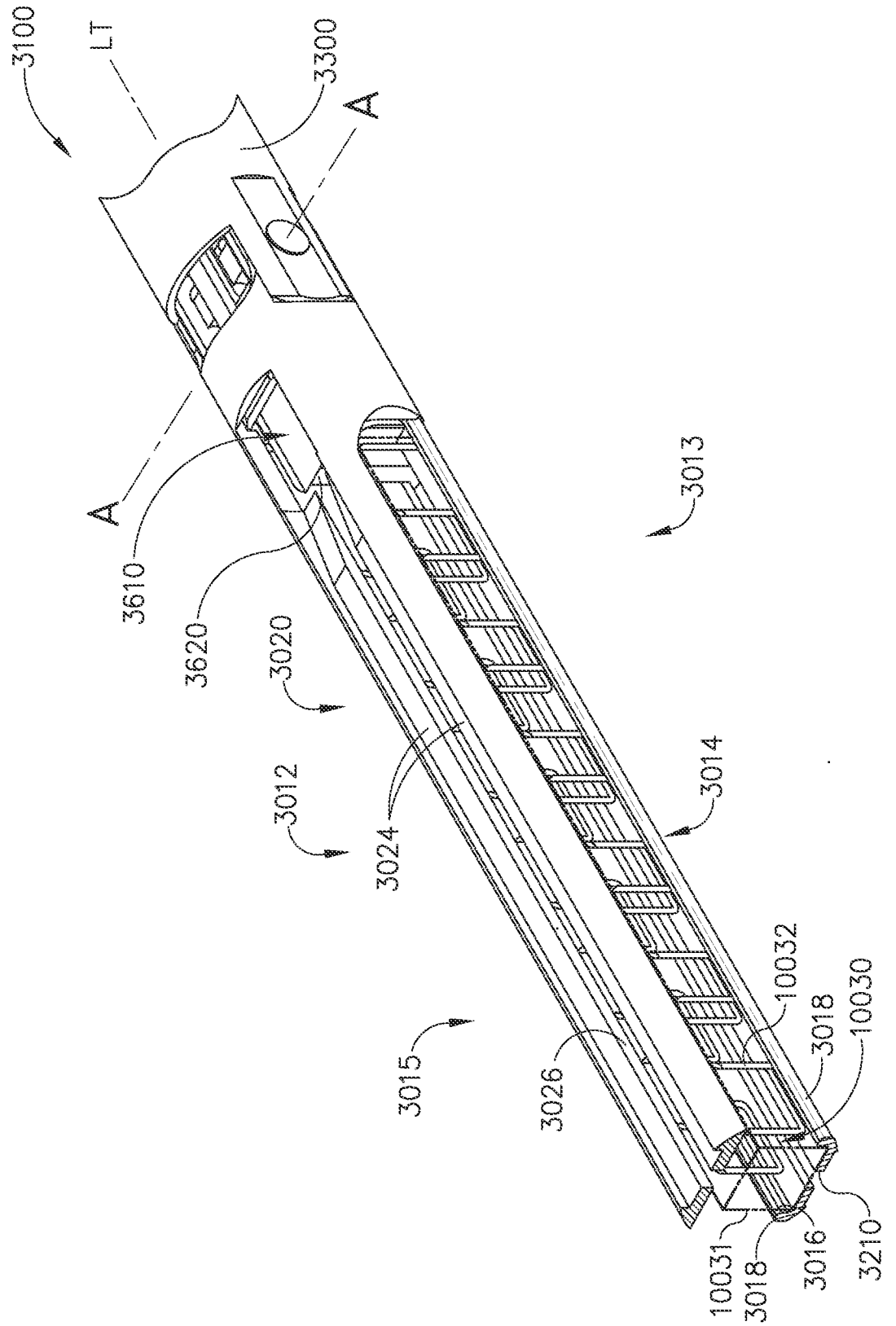

3100
LT
3300
A
A
3610
3620
3020
3012
3024
3013
3014
3015
3026
10032
3018
10030
10031
3018
3016
3210

FIG. 21

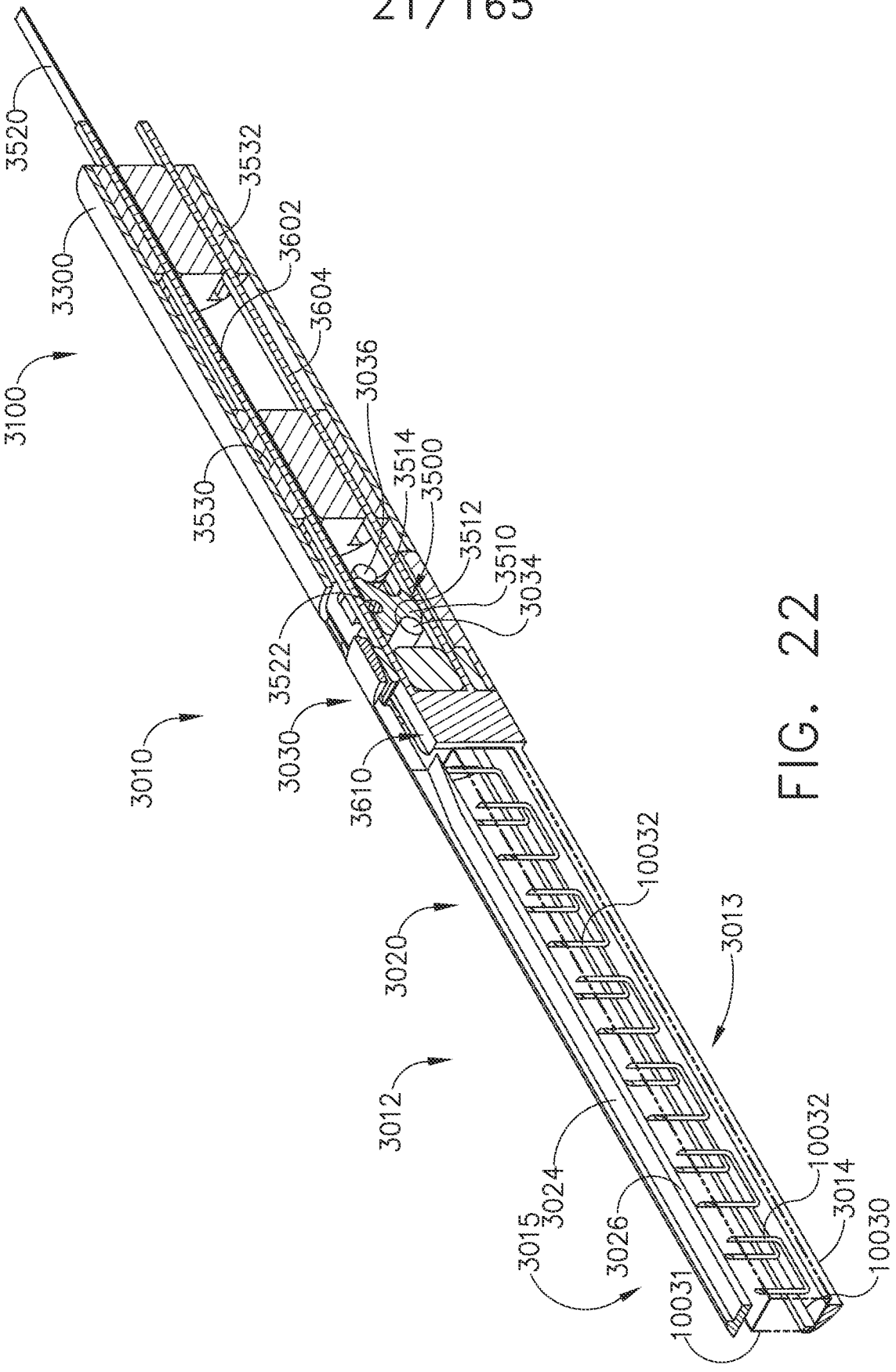

3520
3532
3602
3300
3604
3036
3100
3514
3500
3530
3512
3510
3034
3522
3030
3010
3610
10032
3020
3013
3012
3024
10032
3014
3015
3026
10030
10031

FIG. 22

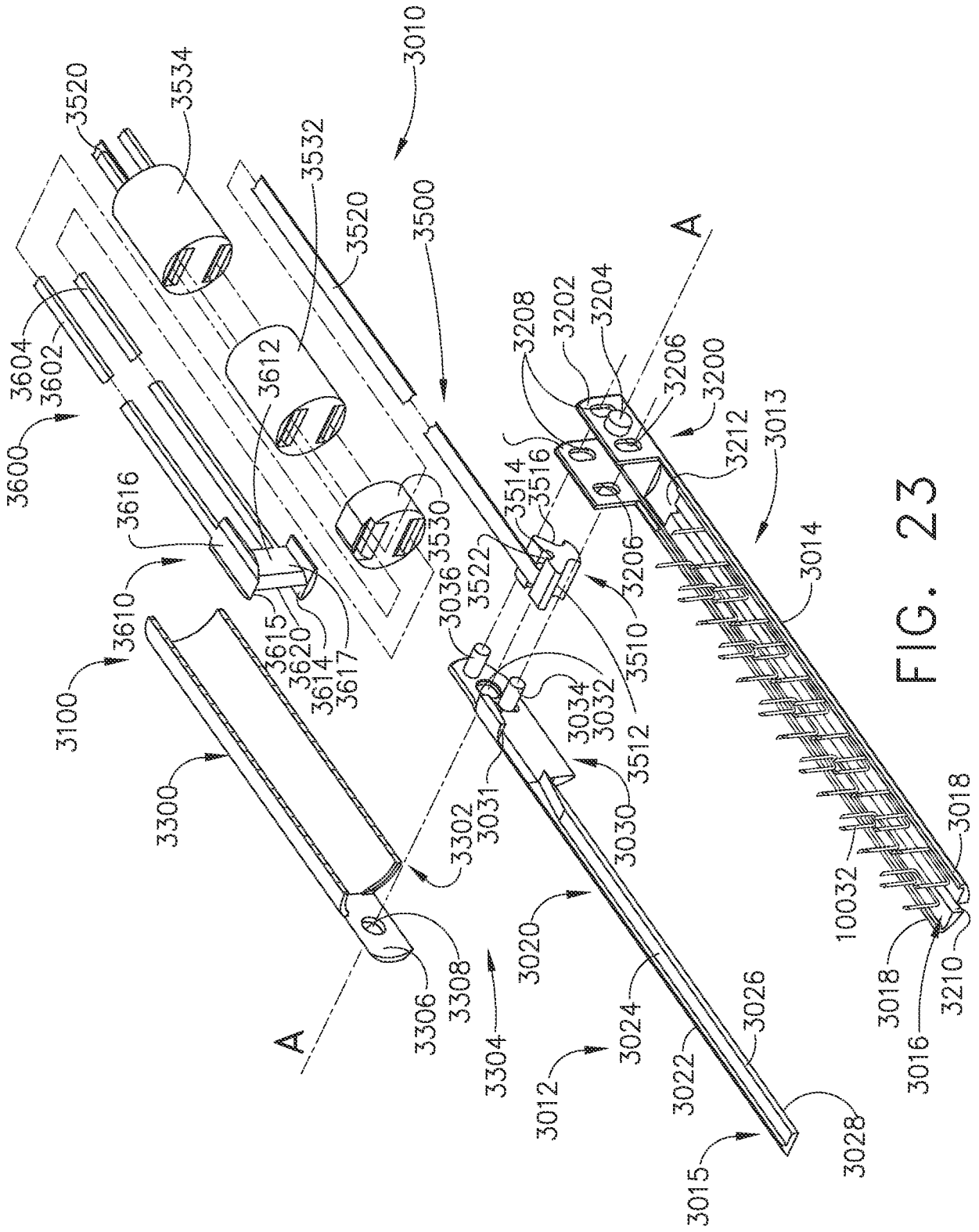

3010
3520
3534
3532
3520
3500
3604
3602
3600
3612
3616
3610
3100
3615
3620
3614
3617
3530
3036
3522
3514
3516
3208
3202
3204
3206
3200
3212
3013
3014
3206
3510
3512
3034
3032
3030
3031
3302
3300
3306
3308
3304
3012
3020
3024
3022
3026
3028
3015
A
A
10032
3018
3016
3210
3018

FIG. 23

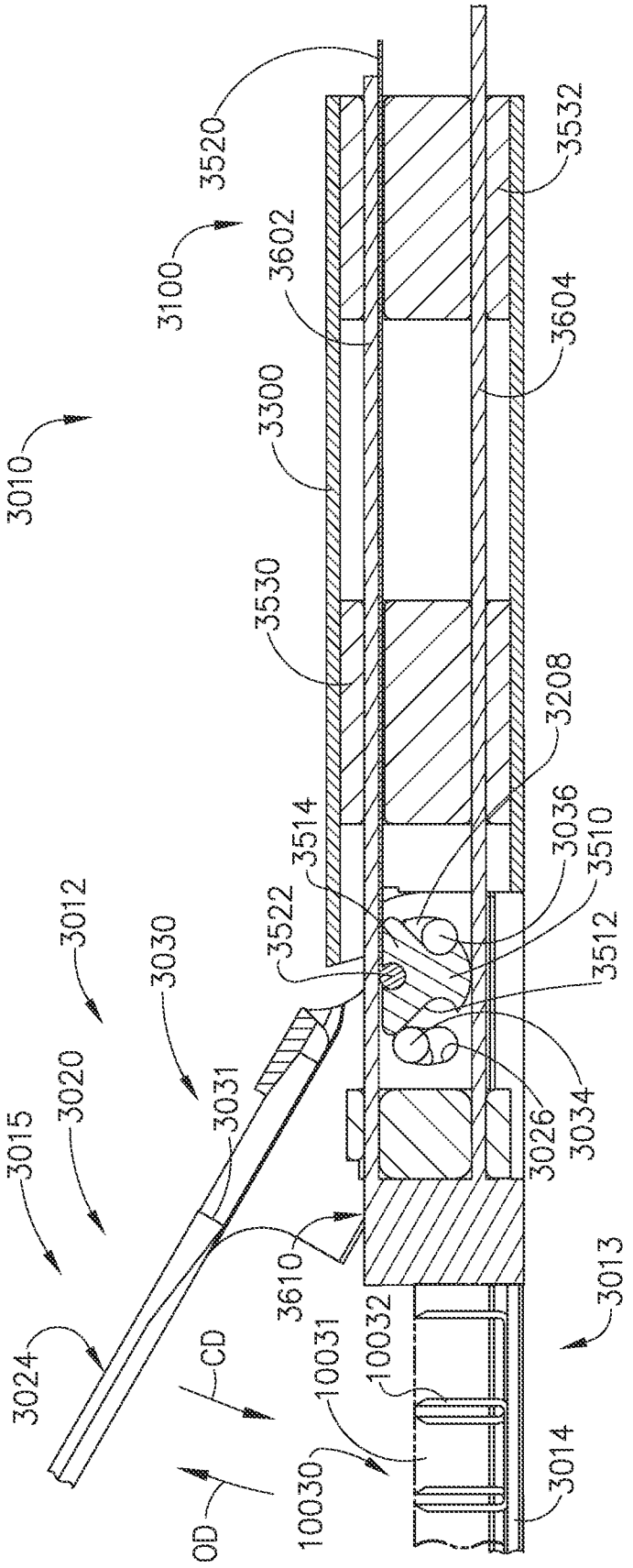

3520
3532
3100
3602
3604
3300
3010
3530
3208
3514
3036
3510
3522
3512
3012
3030
3031
3020
3026
3034
3015
3610
3013
3024
CD
10031
10032
10030
3014
OD

FIG. 24

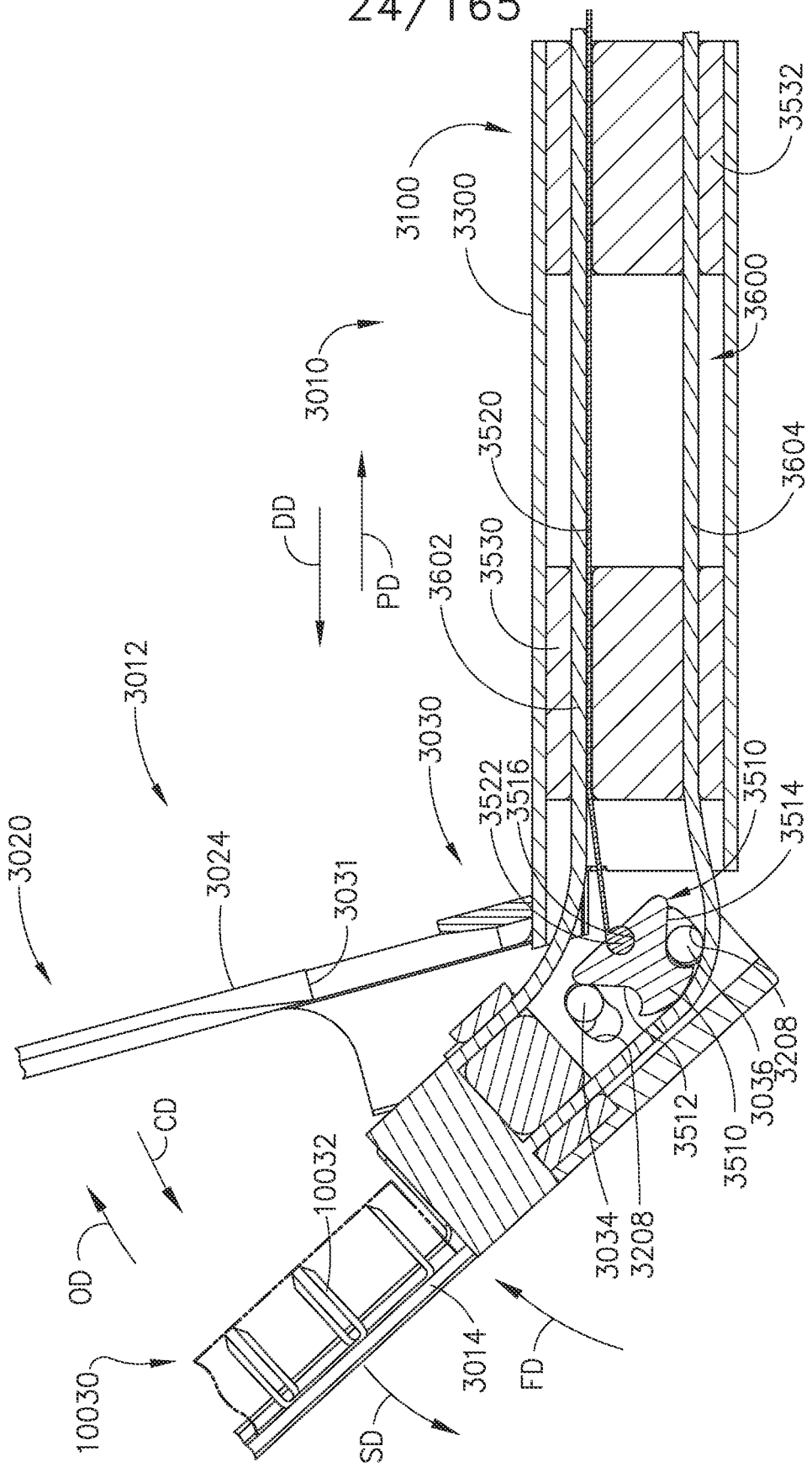

3532
3100
3300
3600
3010
3520
3604
DD
PD
3602
3530
3012
3030
3522
3516
3510
3514
3020
3024
3031
3208
3036
3512
3510
CD
10032
OD
3034
3208
10030
3014
FD
SD

FIG. 25

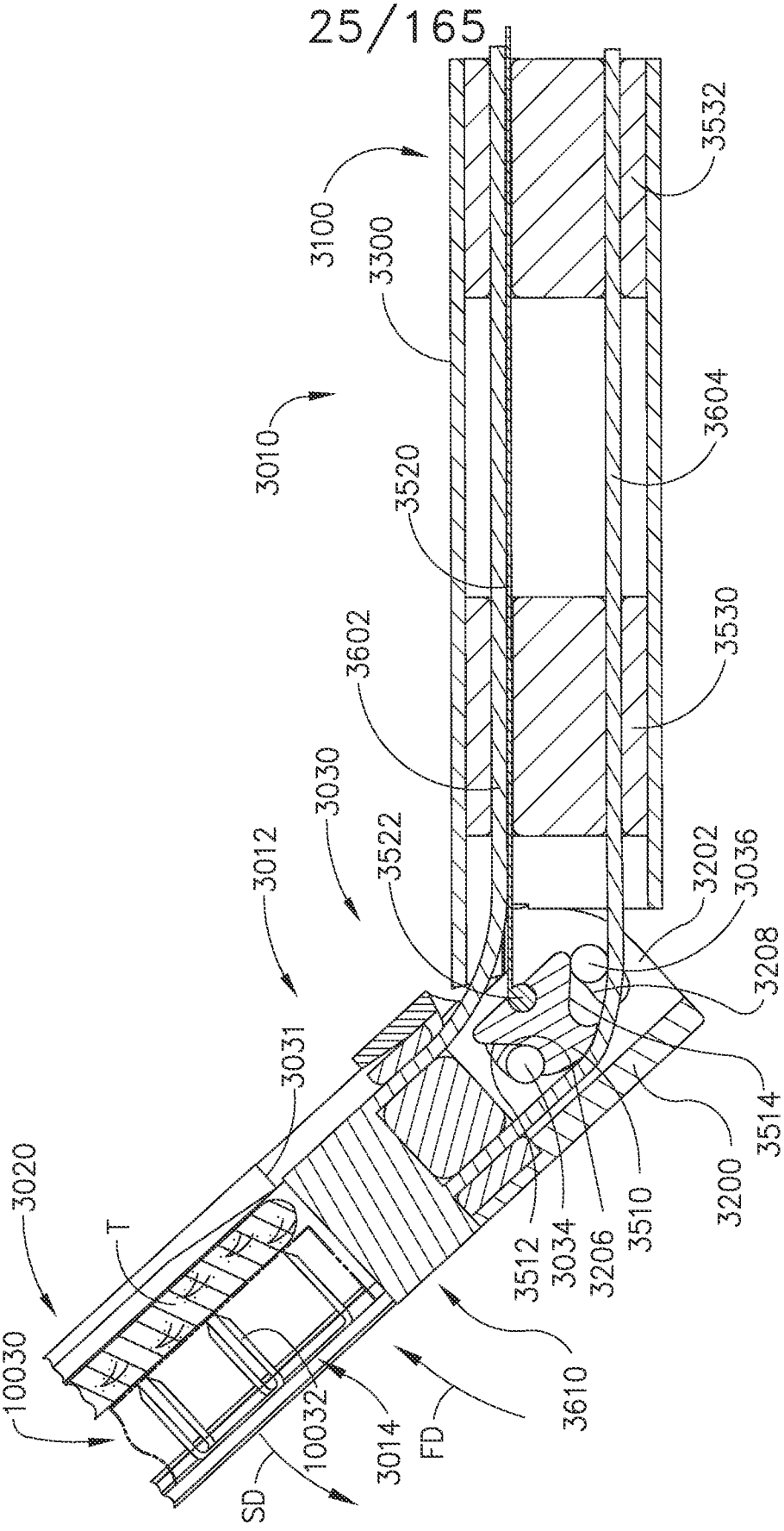

3532
3100
3300
3604
3010
3520
3602
3530
3030
3012
3522
3202
3036
3208
3031
3514
3020
T
3200
3512
3034
3206
3510
10030
3610
10032
3014
FD
SD

FIG. 26

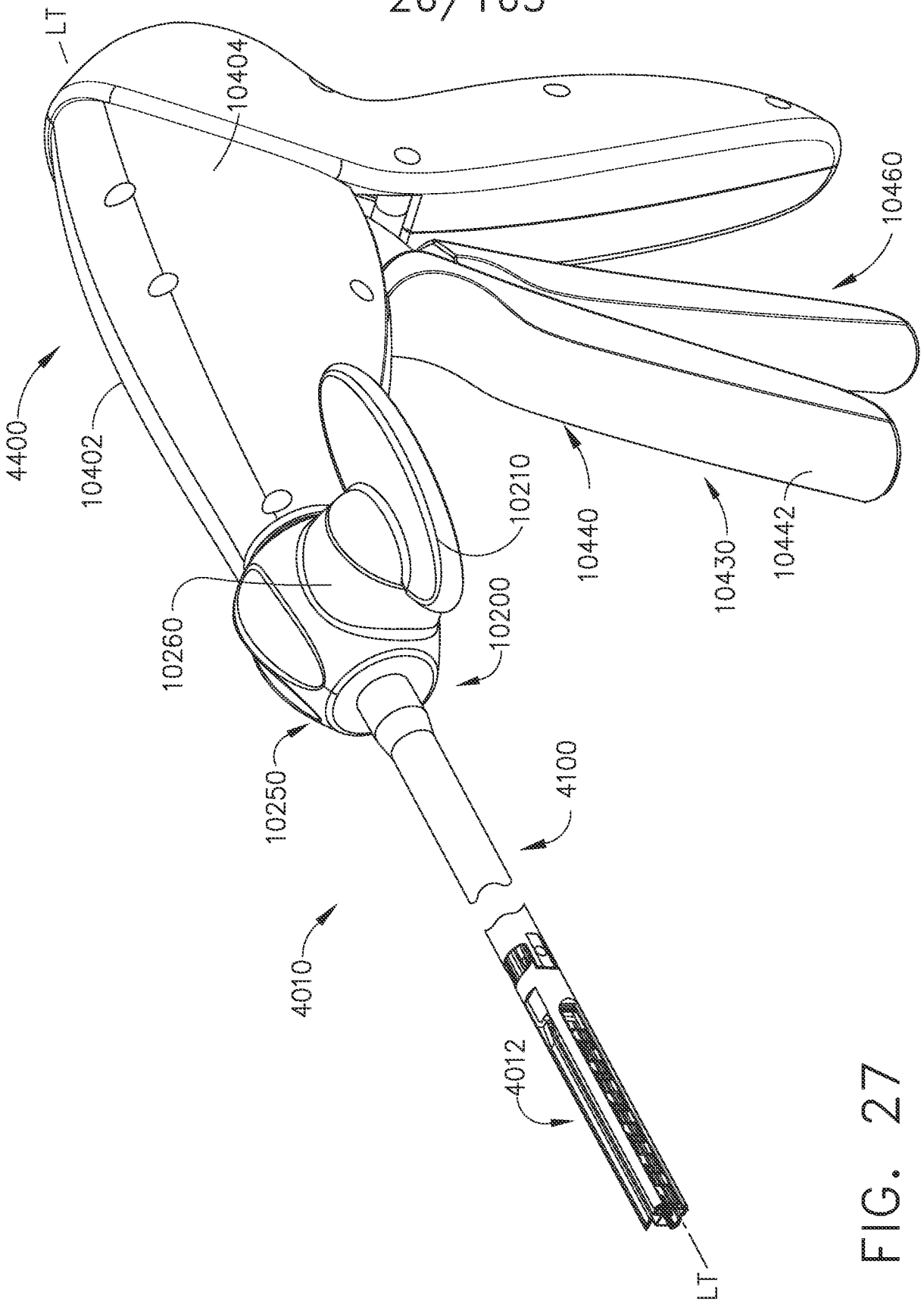

LT
10404
10460
4400
10402
10210
10440
10442
10430
10260
10200
10250
4100
4010
4012
LT

FIG. 27

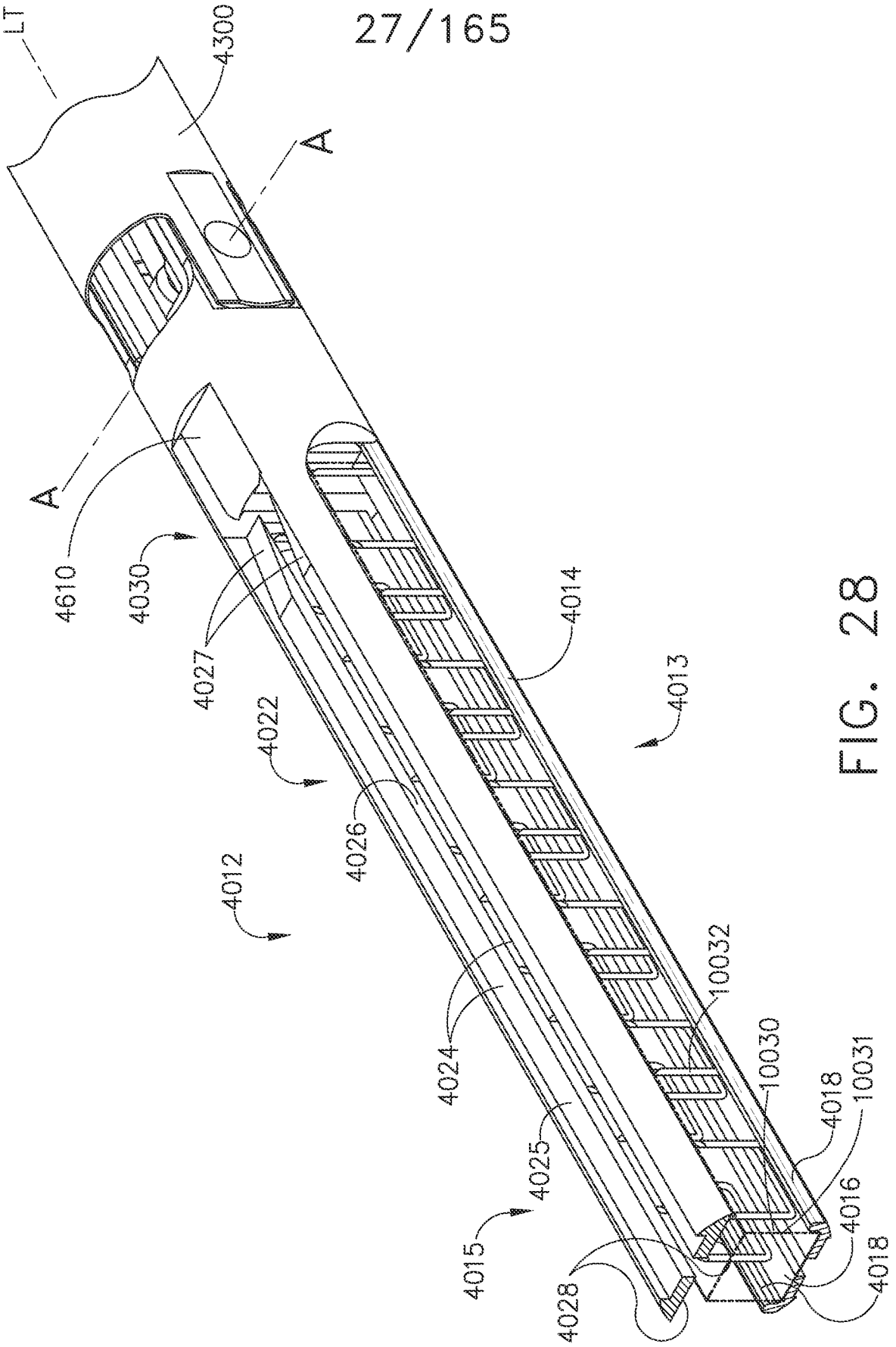

LT
4300
A
A
4610
4030
4027
4022
4026
4012
4014
4013
10032
10030
4018
10031
4016
4018
4024
4025
4015
4028

FIG. 28

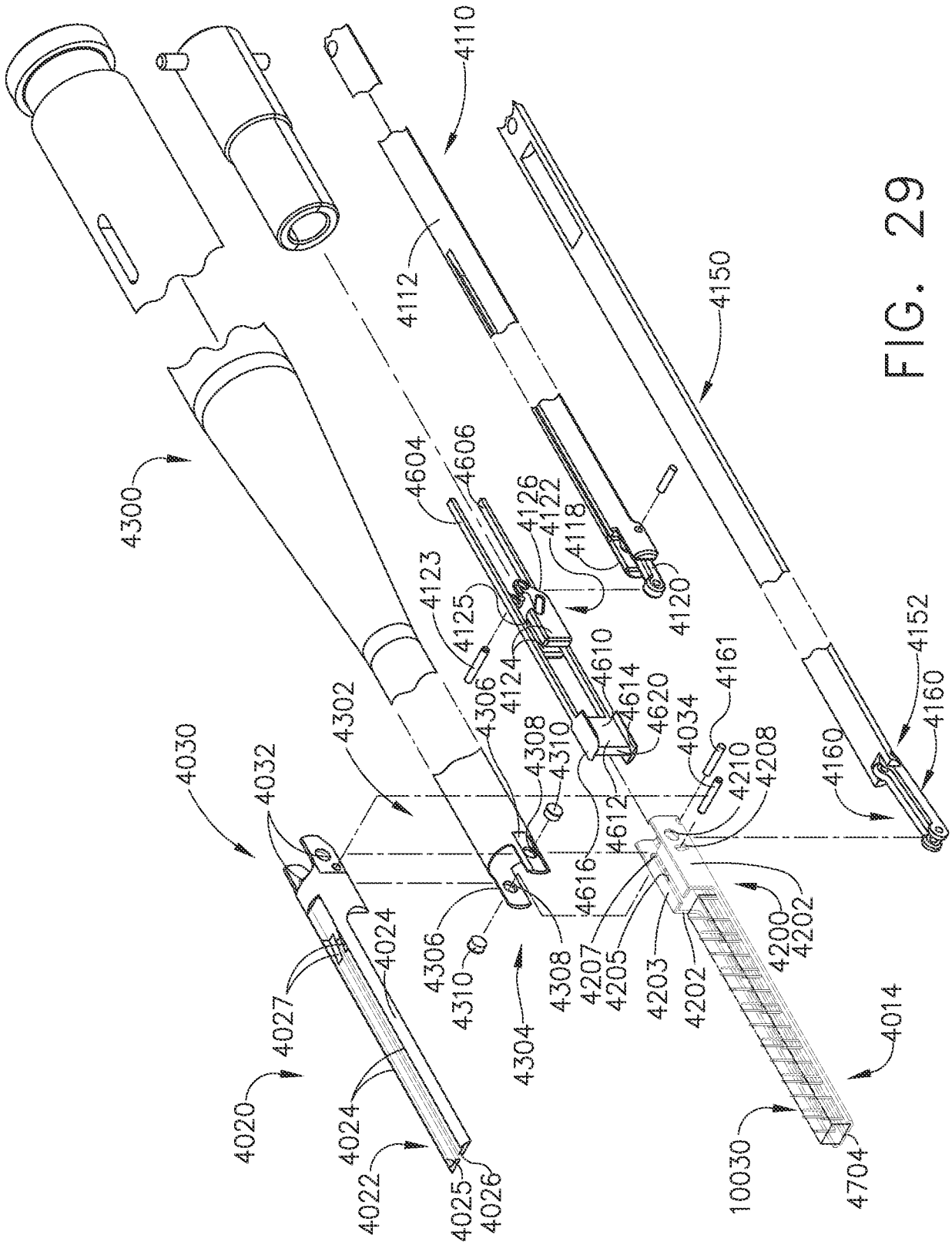

4110
4112
4150
4300
4604
4606
4126
4122
4118
4123
4125
4120
4124
4610
4614
4620
4034
4161
4152
4160
4302
4030
4032
4308
4310
4210
4208
4612
4616
4200
4202
4024
4306
4207
4205
4203
4202
4027
4310
4304
4308
4014
4020
4024
10030
4022
4704
4025
4026

FIG. 29

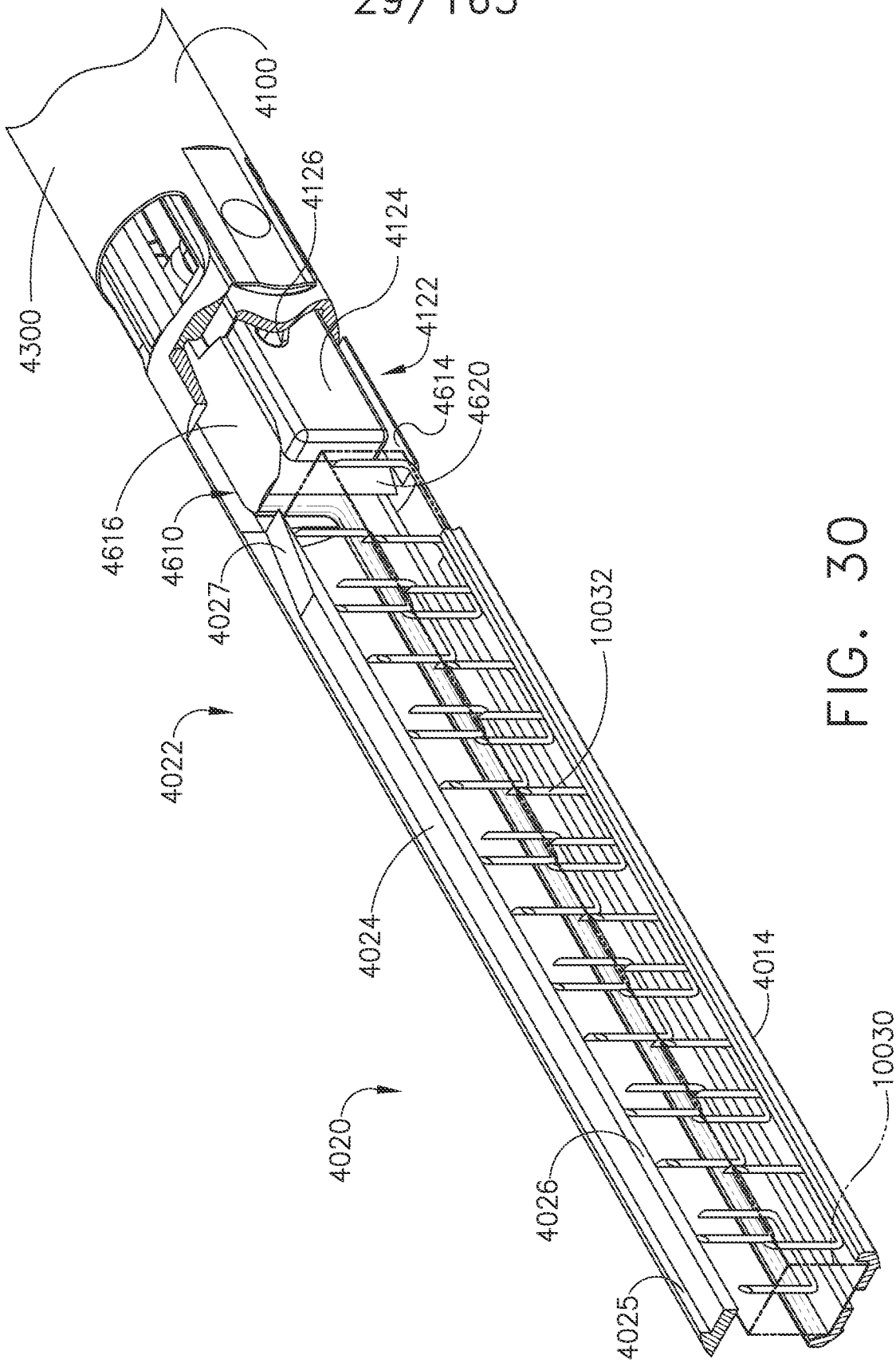

4100
4126
4124
4122
4300
4614
4620
4616
4610
4027
4022
10032
4024
4014
4020
10030
4026
4025

FIG. 30

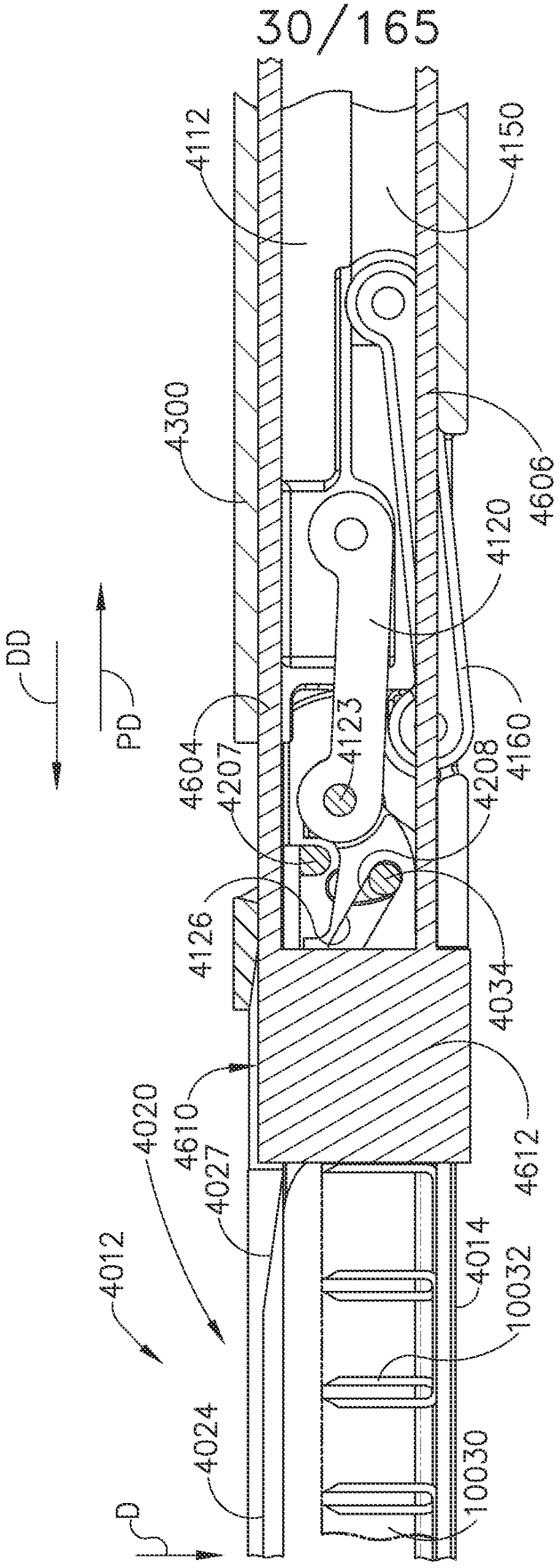

4112
4150
4300
4606
4120
DD
PD
4604
4207
4123
4208
4160
4126
4034
4020
4610
4027
4612
4012
4014
10032
4024
10030
D

FIG. 31

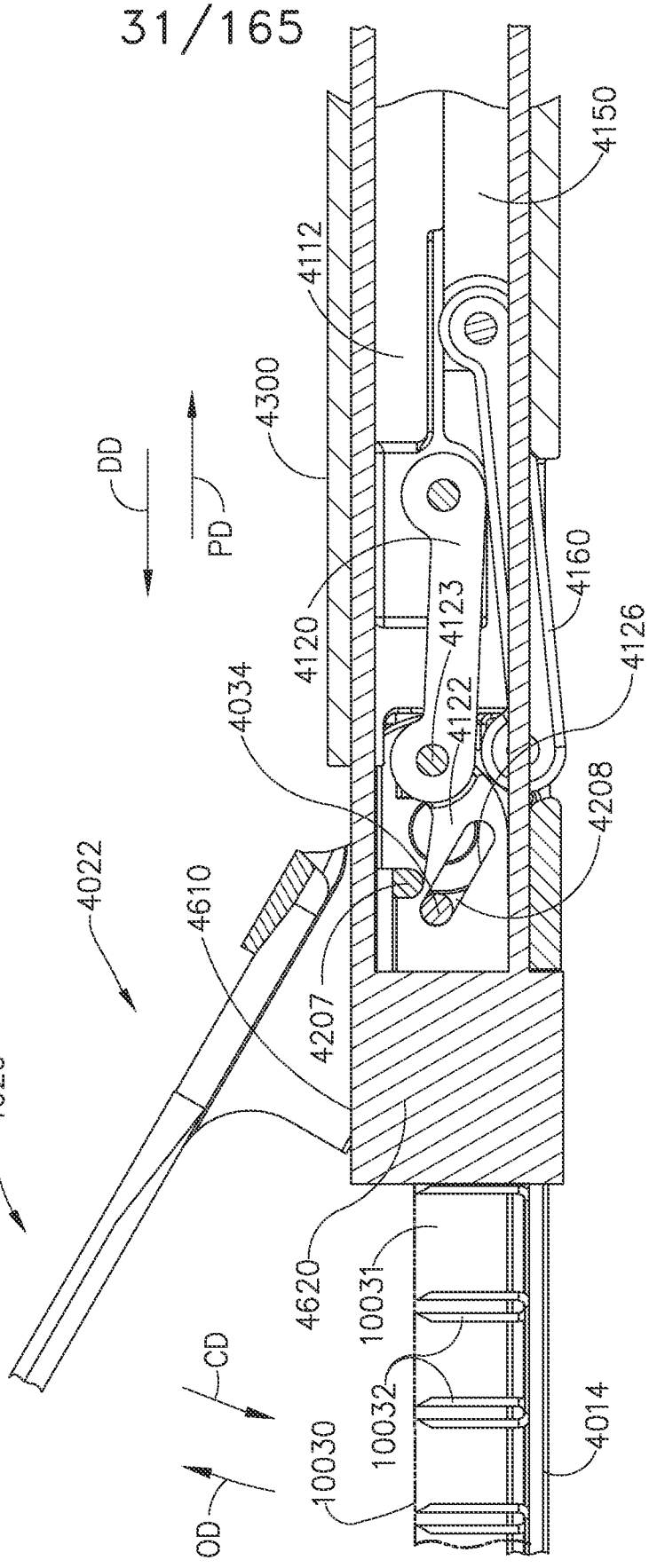

4150
4112
4300
DD
PD
4160
4120
4123
4126
4122
4034
4208
4022
4610
4207
4020
4620
10031
CD
10032
4014
10030
OD

FIG. 32

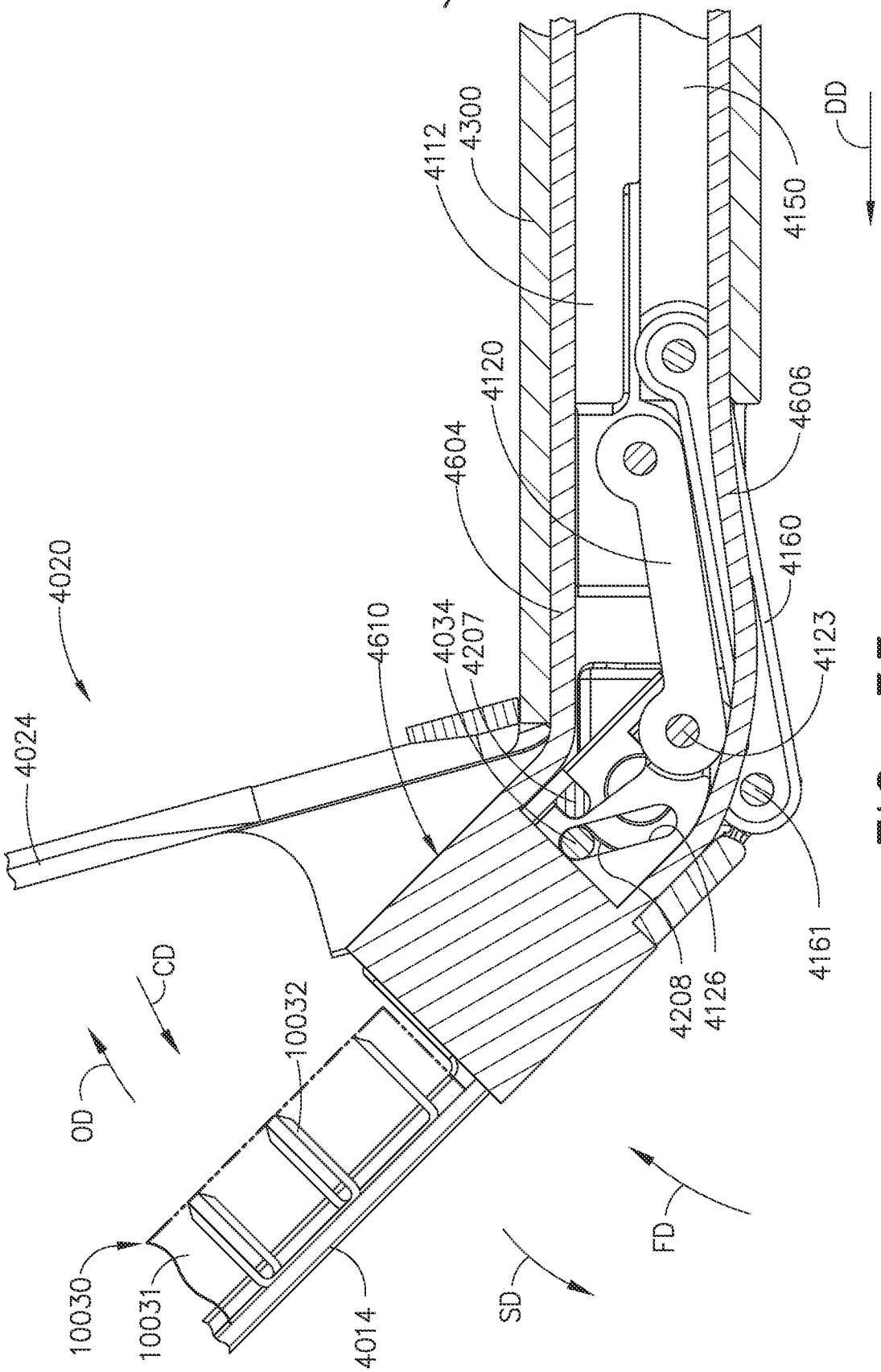

4020
4024
4610
4034
4207
4112
4300
4120
4604
4606
4150
DD
4160
4123
4161
4208
4126
CD
OD
10032
10030
10031
4014
SD
FD

FIG. 33

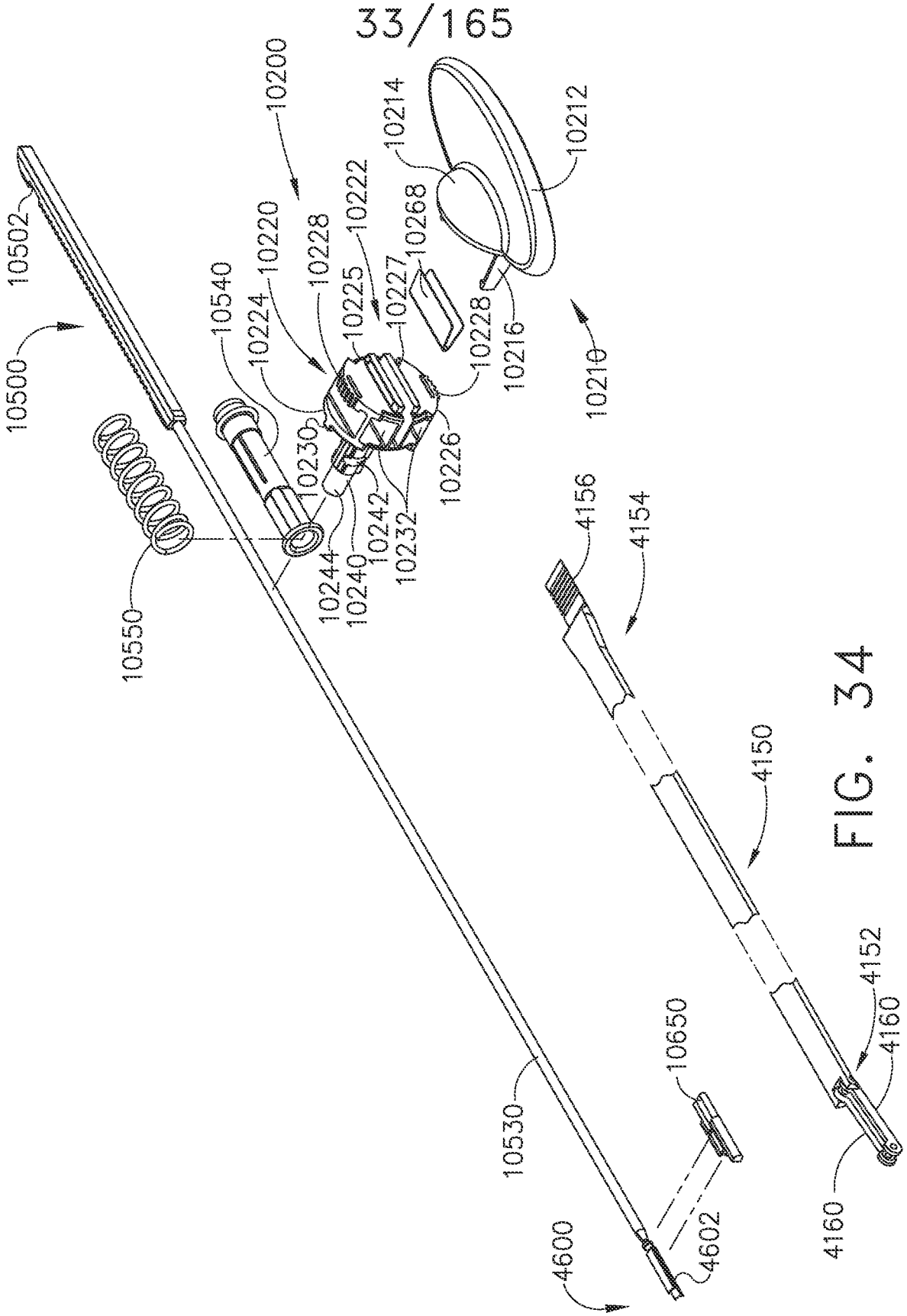

10200
10214
10212
10502
10222
10220
10268
10228
10540
10225
10227
10224
10228
10500
10216
10210
10230
10226
10242
10232
10244
10240
10550
4156
4154
4150
10530
10650
4152
4160
4160
4600
4602

FIG. 34

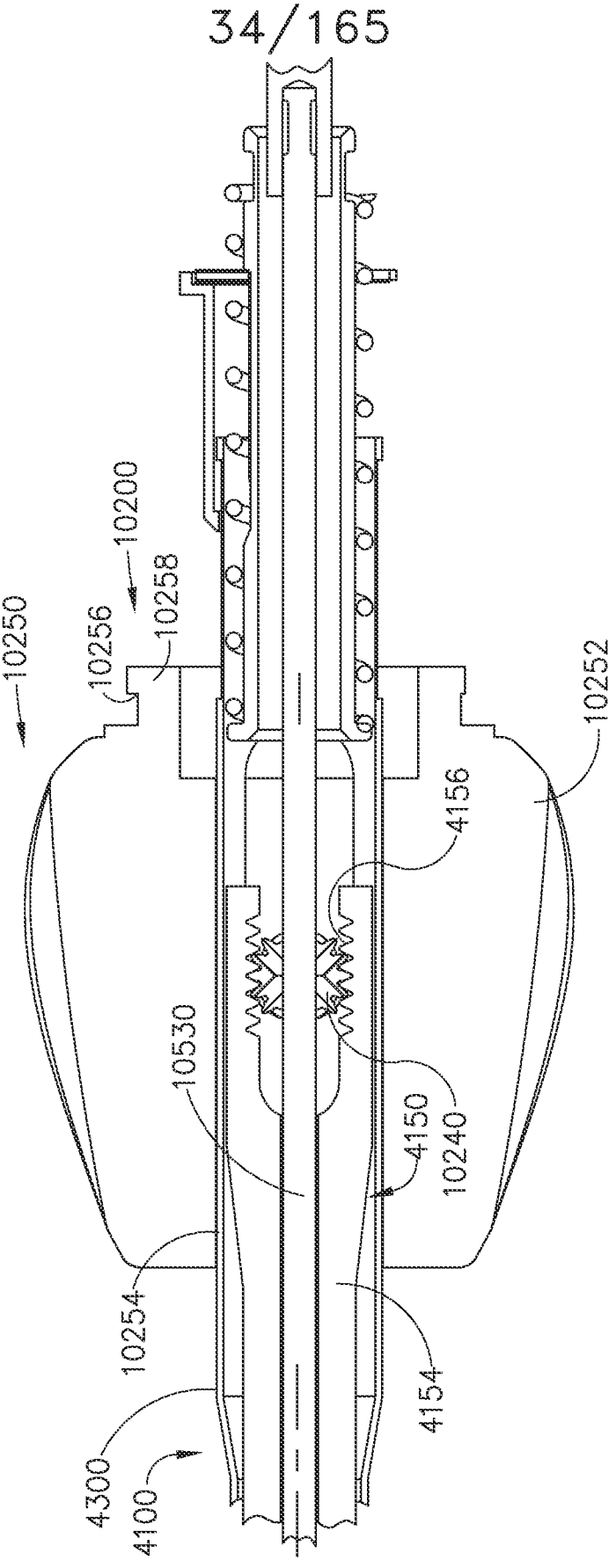

10250
10256
10258
10200
10252
4156
10530
4150
10240
10254
4154
4300
4100

FIG. 35

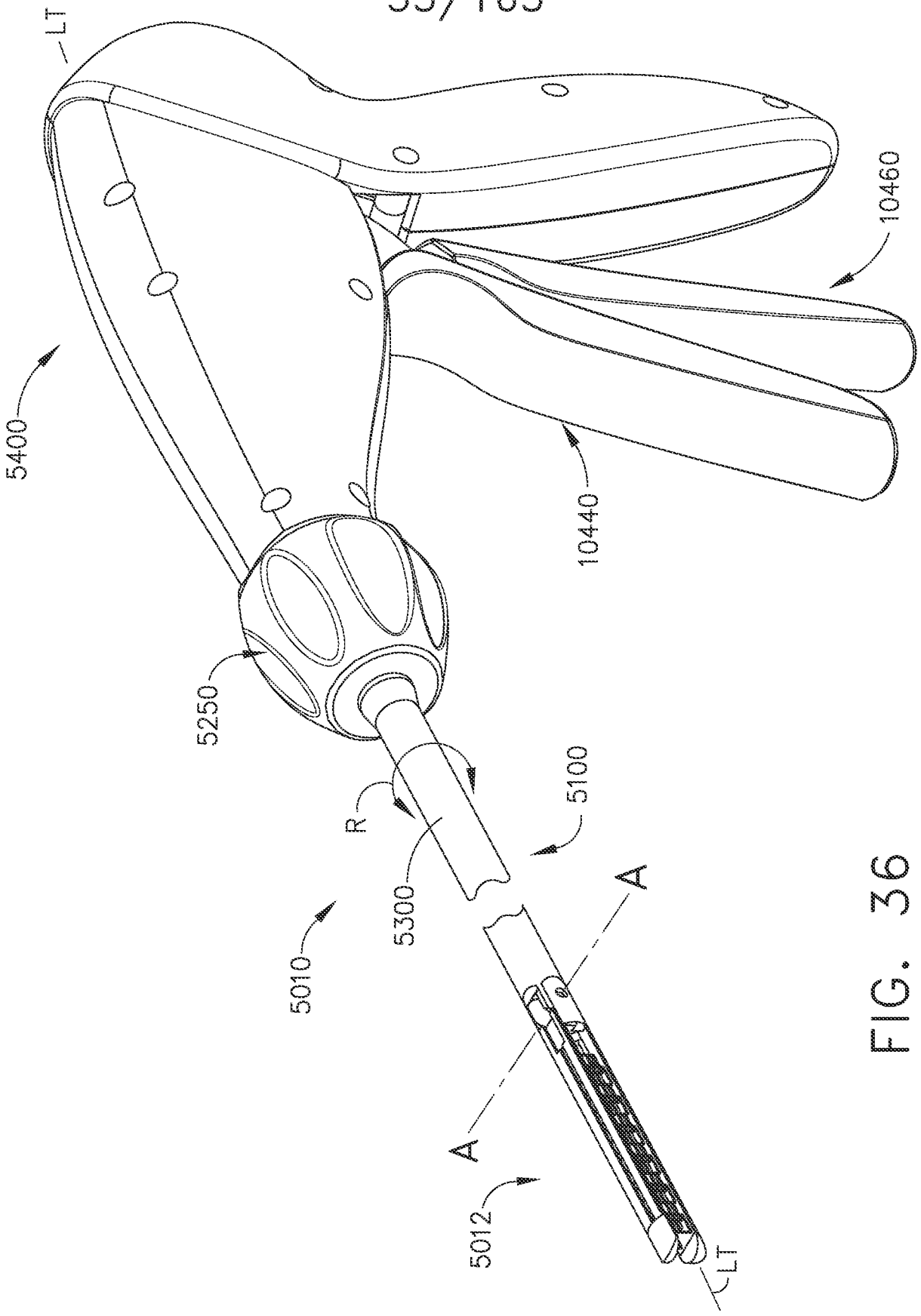


FIG. 36

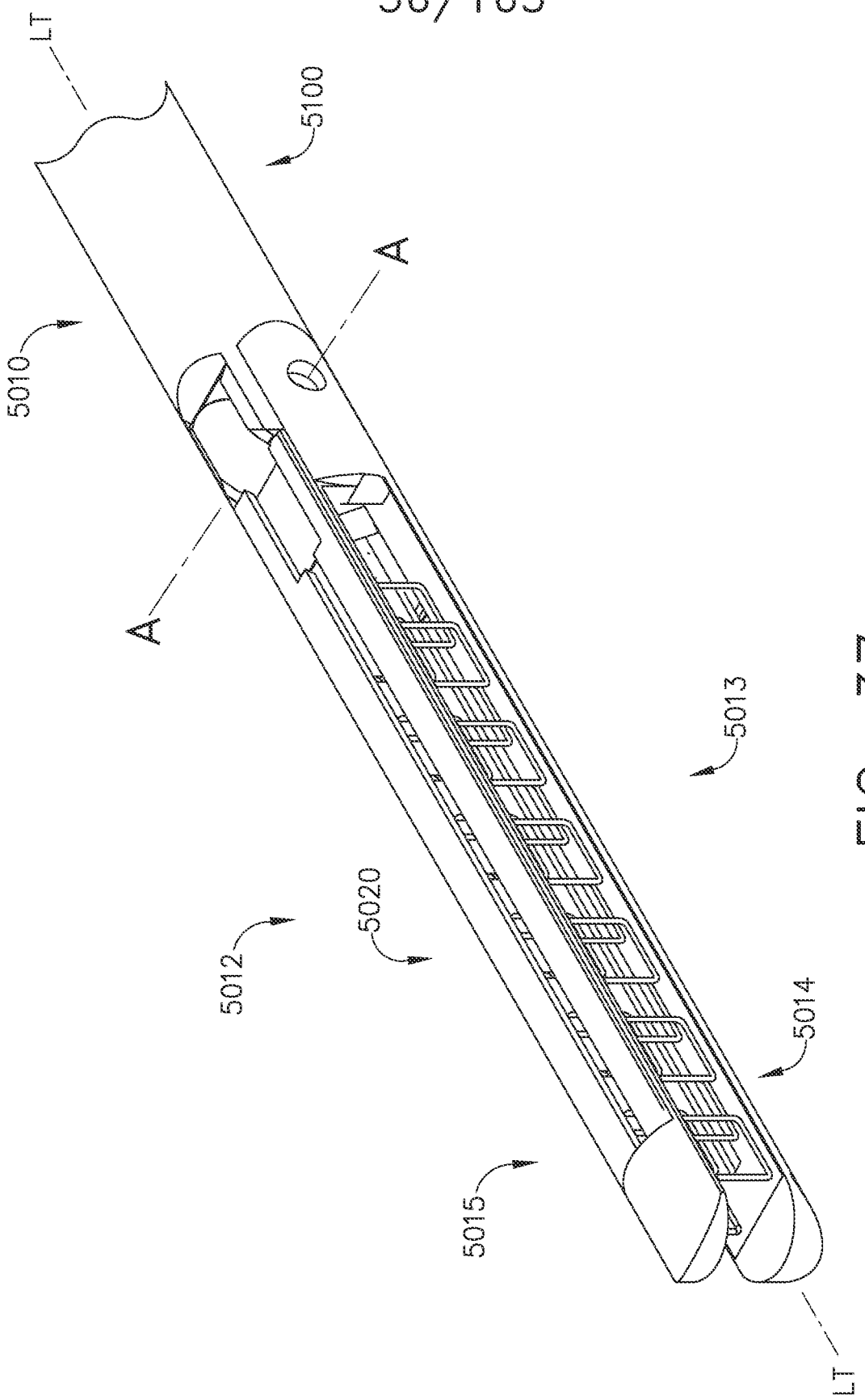


FIG. 37

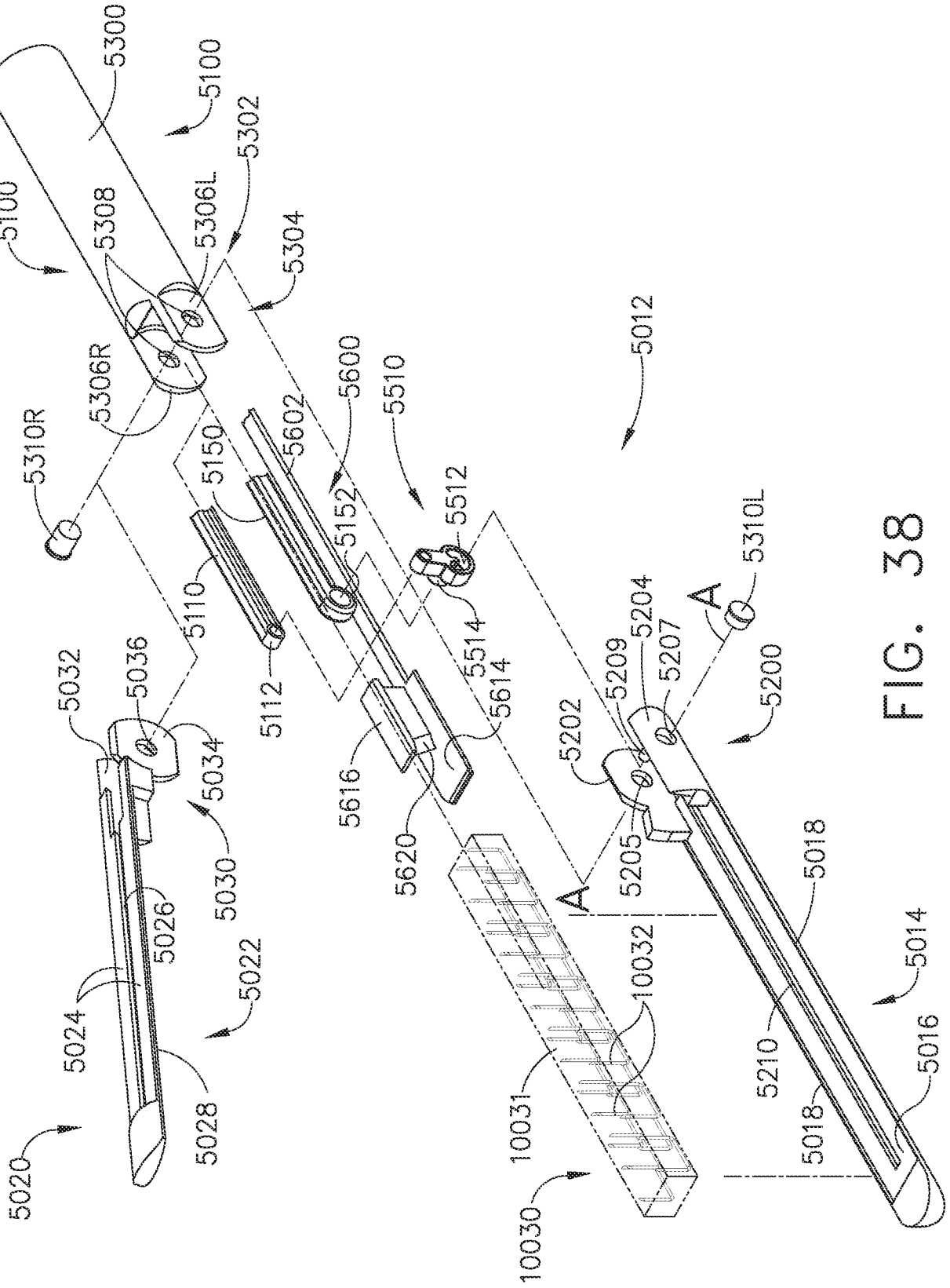

5300
5100
5302
5100
5308
5306L
5304
5306R
5310R
5012
5600
5510
5602
5150
5512
5152
5110
5514
5112
5614
5032
5036
5616
5034
5620
5030
5026
5022
5024
5028
5020
5202
5209
5204
5207
5310L
A
5200
5205
A
5018
5014
10032
10031
5210
5016
5018
10030

FIG. 38

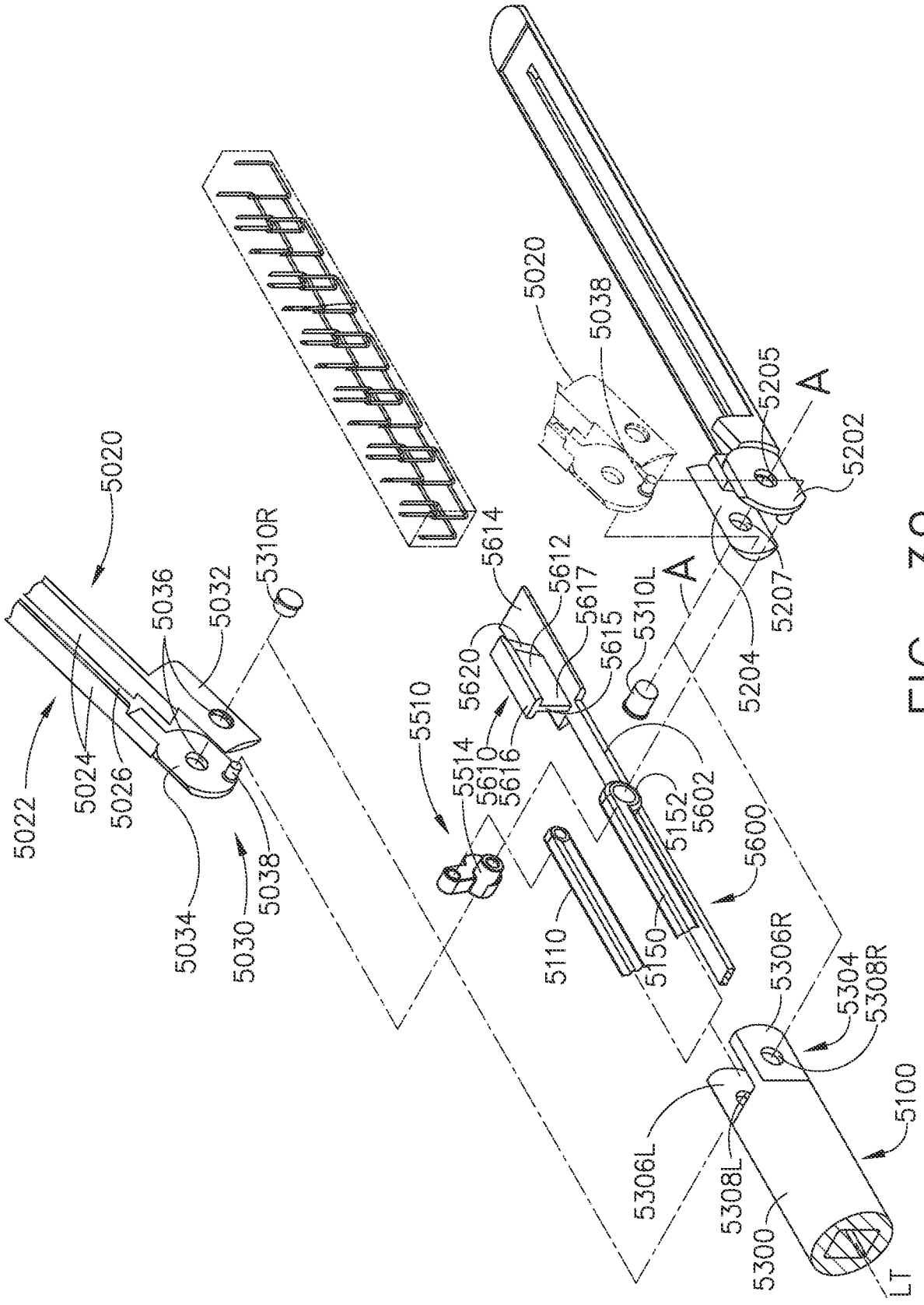

5020
5038
5205
A
5202
5020
5310R
5036
5032
5614
5612
5617
5615
5620
5310L
A
5207
5204
5022
5024
5026
5034
5030
5038
5510
5514
5610
5616
5602
5152
5600
5110
5150
5306R
5304
5308R
5306L
5308L
5100
5300
LT

FIG. 39

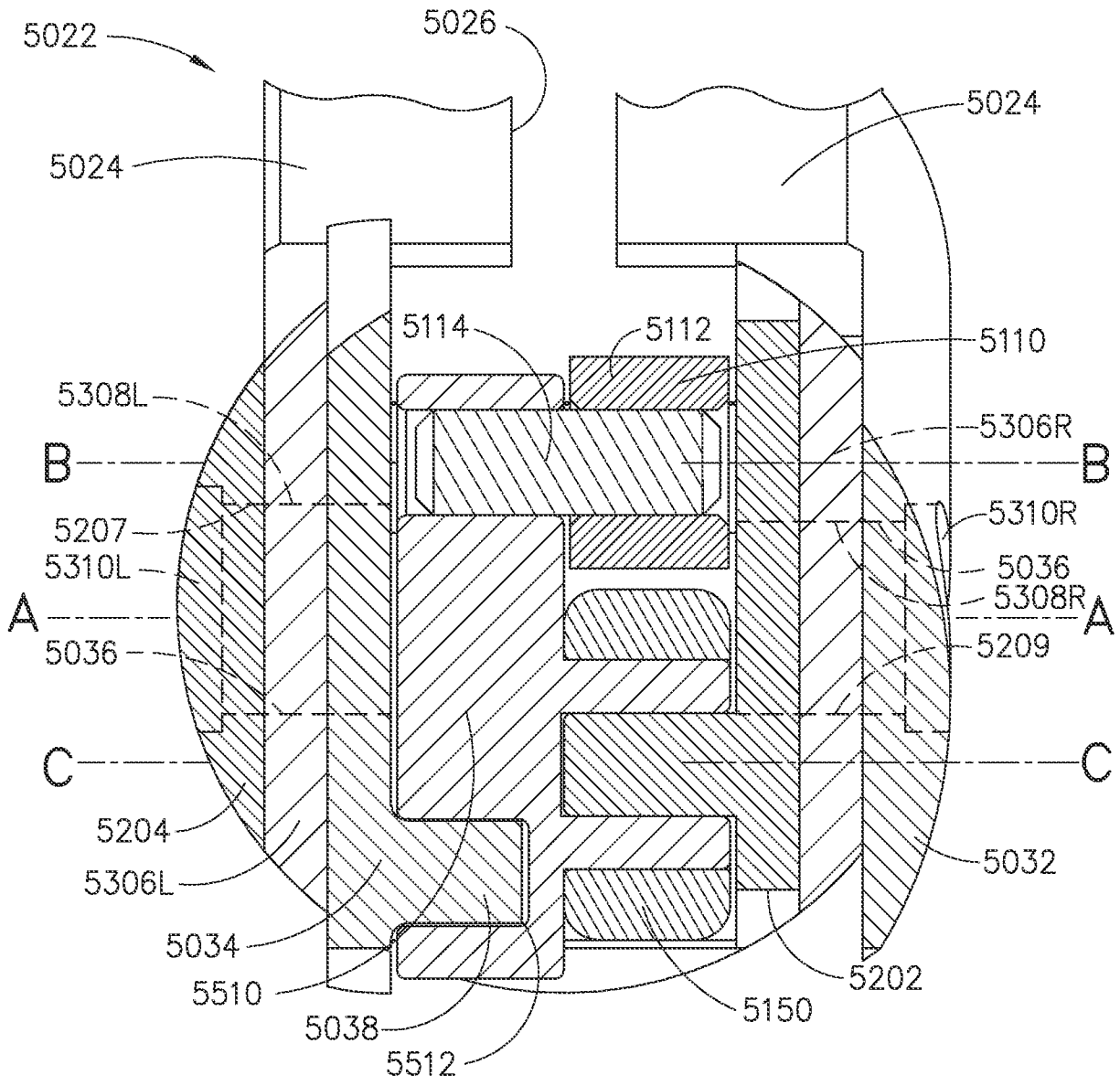

5022
5026
5024
5024
5114
5112
5110
5308L
5306R
B
B
5207
5310R
5310L
5036
5308R
A
A
5036
5209
C
C
5204
5306L
5032
5034
5510
5202
5150
5038
5512

FIG. 40

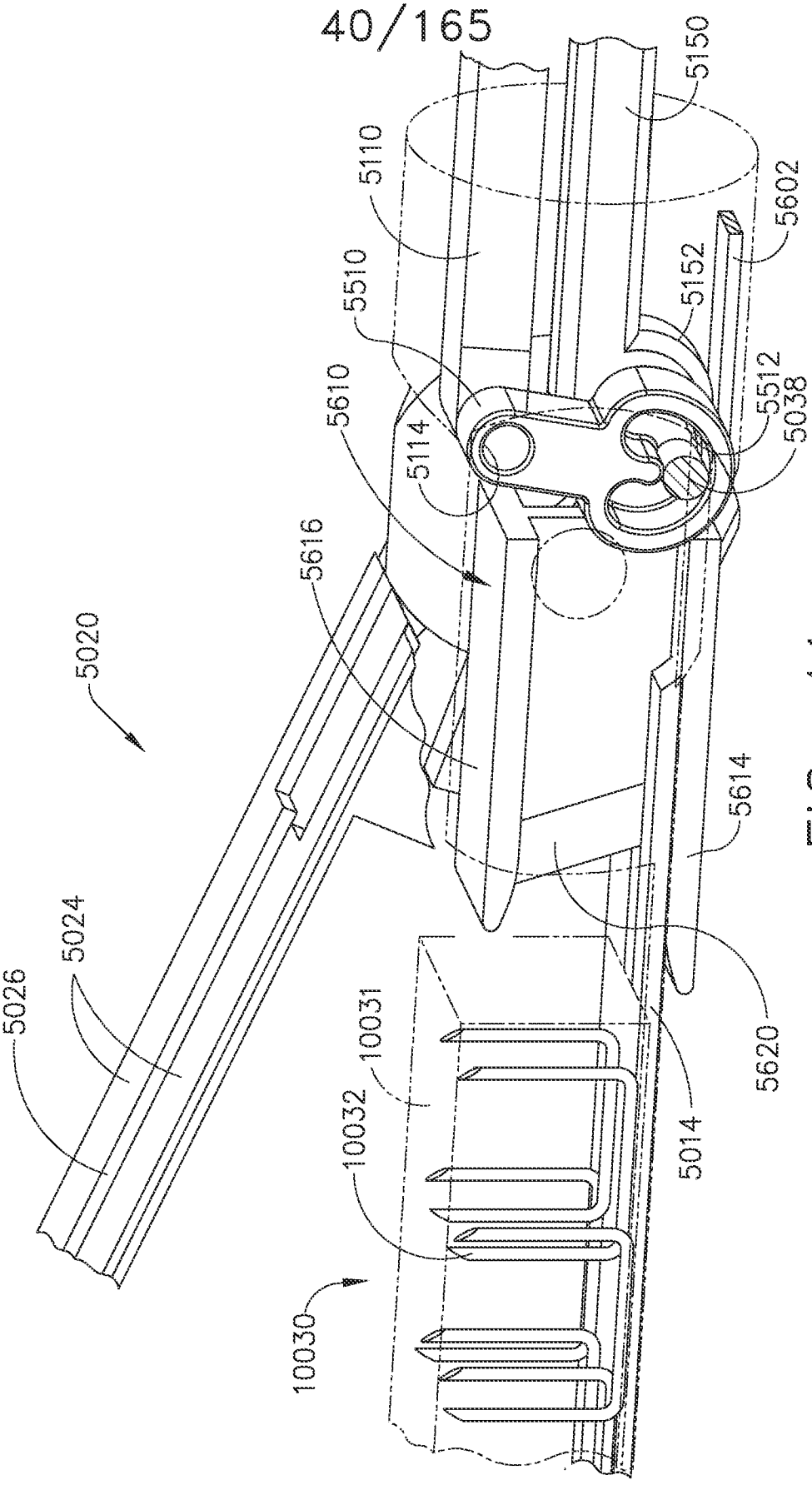

5150
5110
5602
5510
5152
5512
5610
5038
5114
5616
5020
5614
5024
5026
5620
10031
10032
5014
10030

FIG. 41

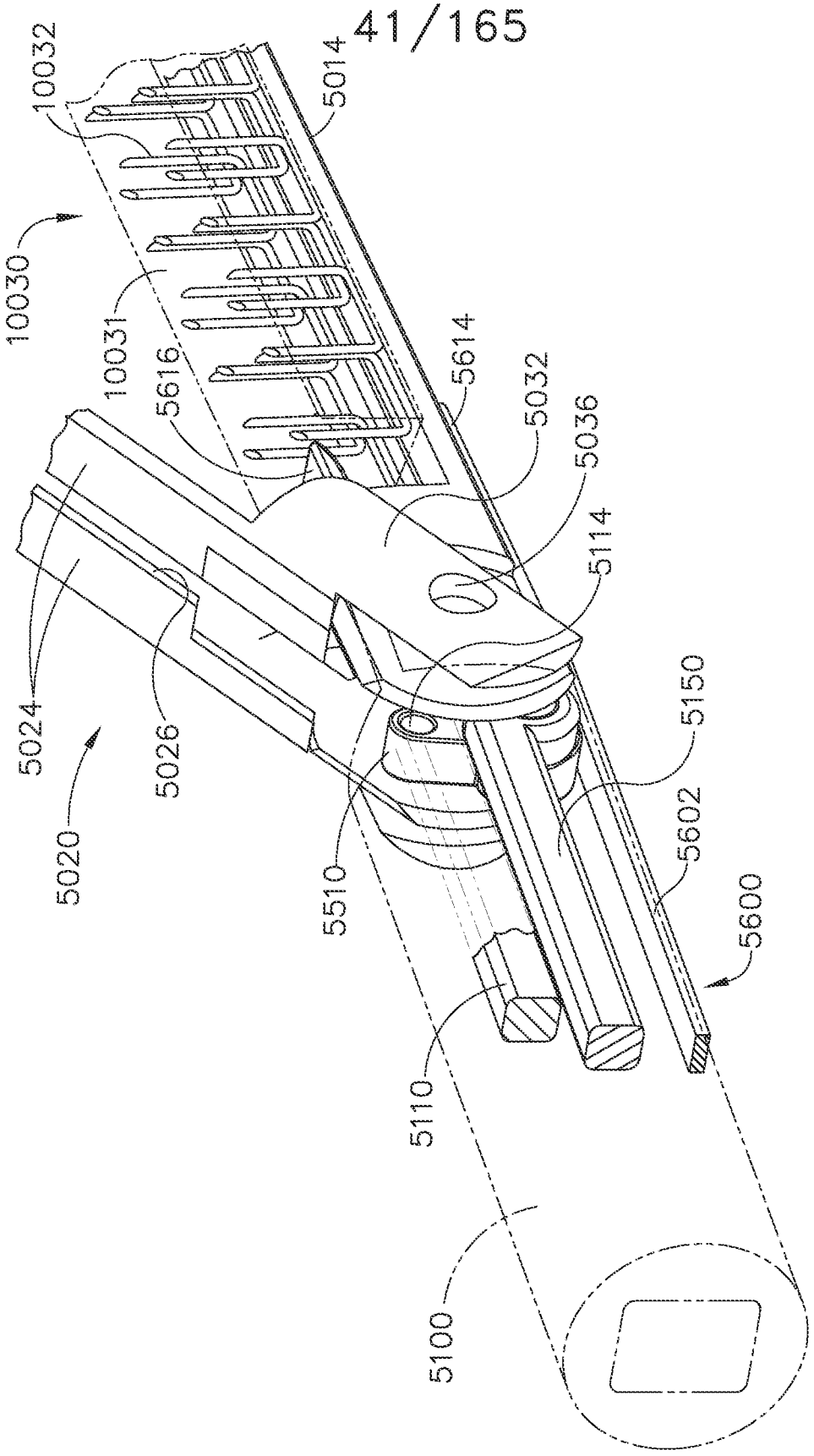

10032
5014
10030
10031
5616
5614
5032
5036
5114
5024
5026
5150
5020
5602
5510
5600
5110
5100

FIG. 42

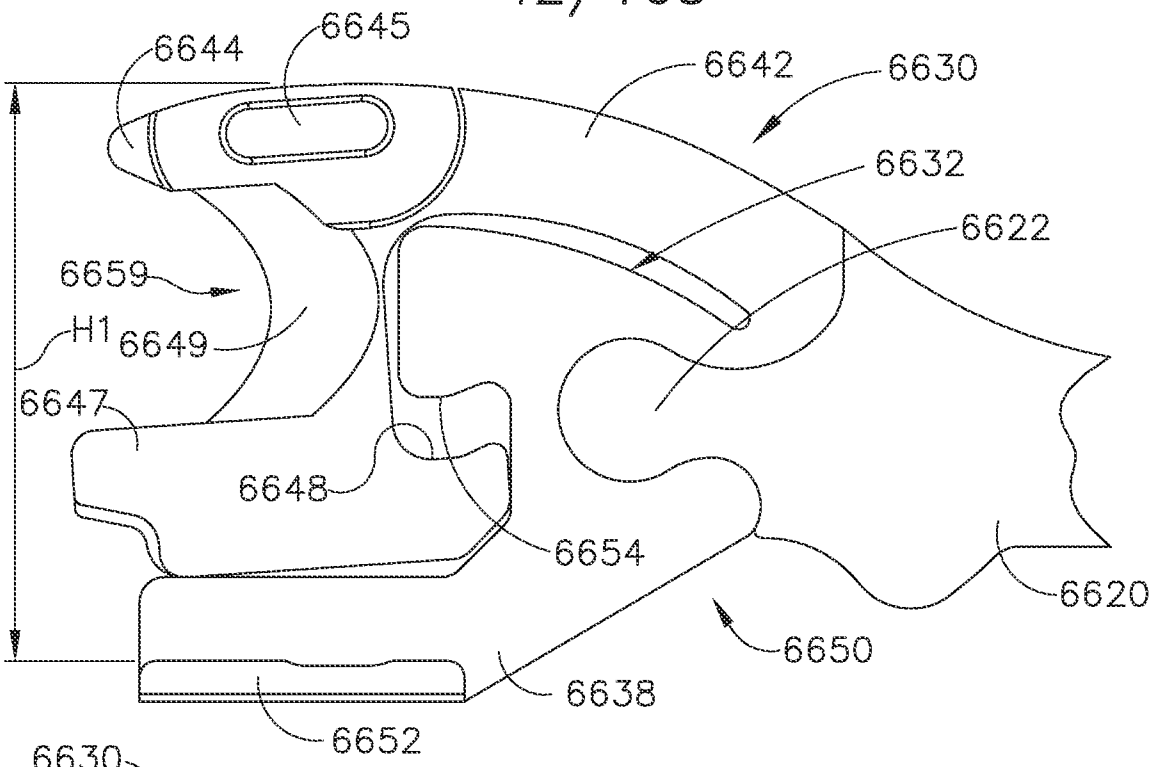

6644
6645
6642
6630
6632
6622
6659
H1
6649
6647
6648
6654
6620
6650
6638
6652

FIG. 43

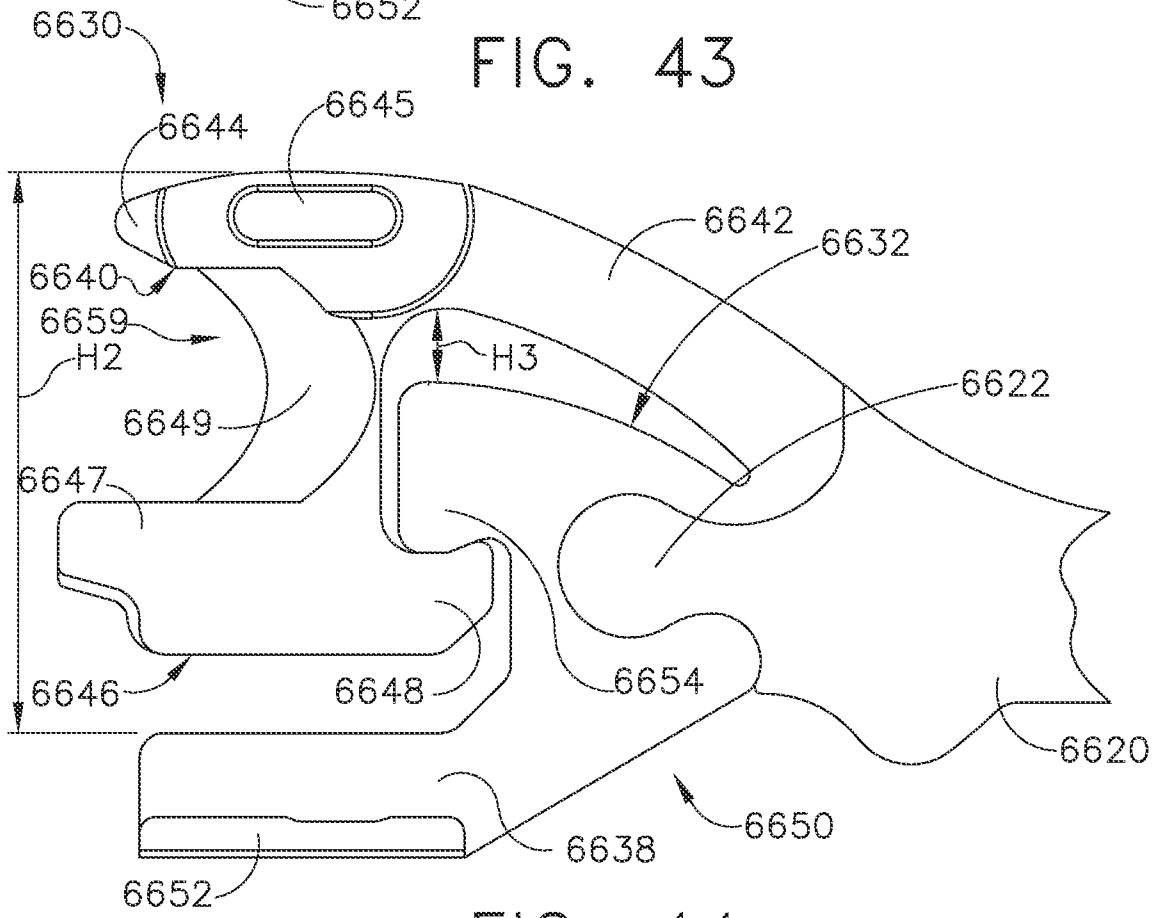

6630
6644
6645
6642
6632
6640
6659
H2
H3
6622
6649
6647
6646
6648
6654
6620
6650
6638
6652

FIG. 44

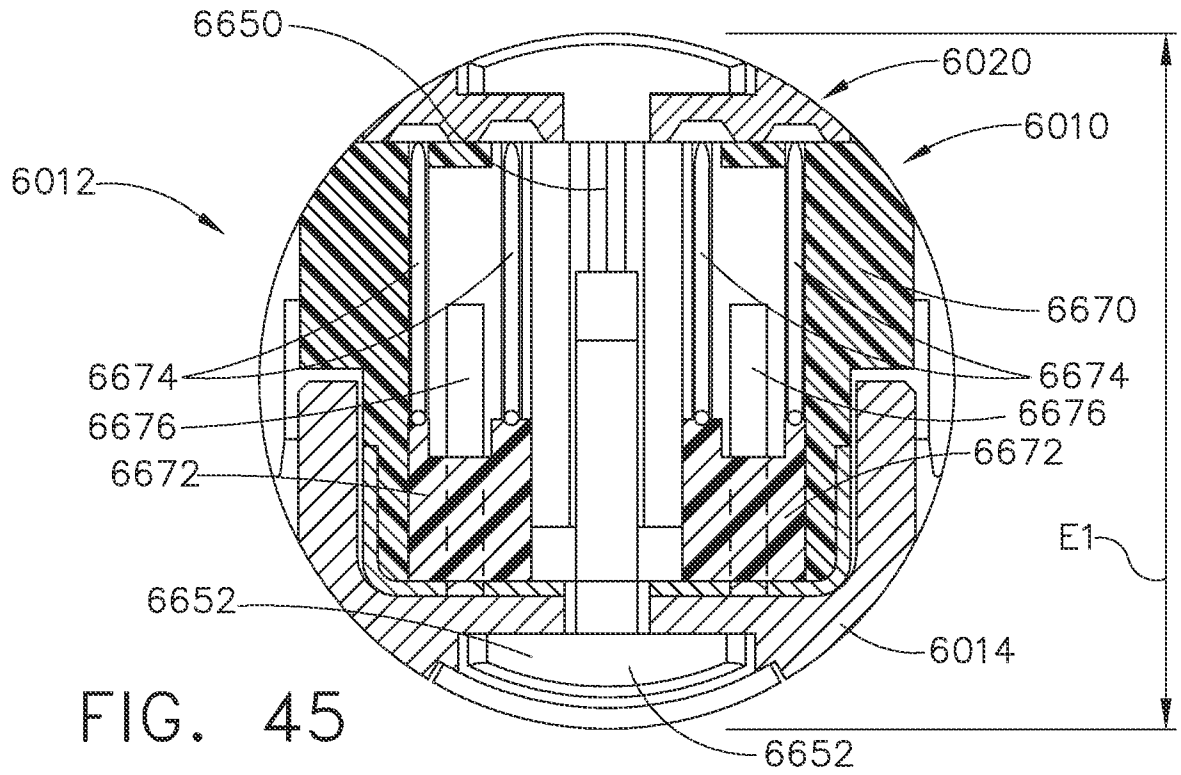

6650
6020
6010
6012
6670
6674
6674
6676
6676
6672
6672
E1
6652
6014
6652

FIG. 45

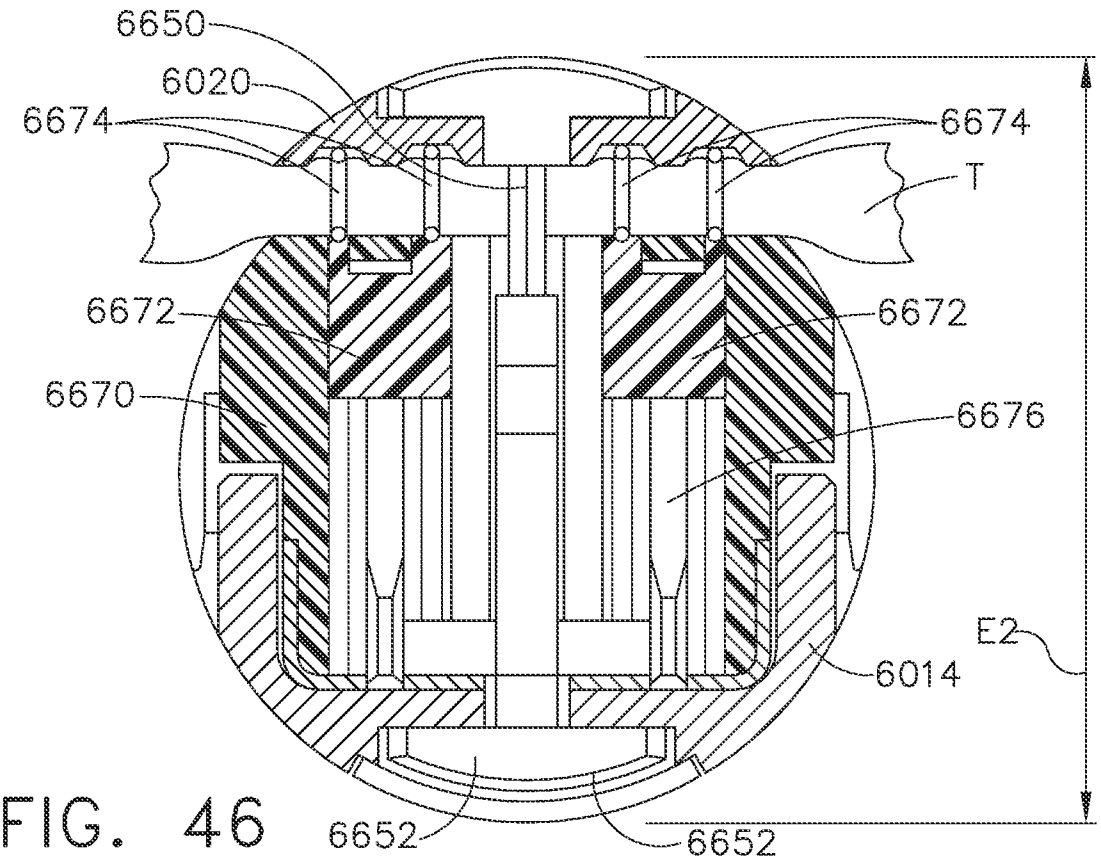

6650
6020
6674
6674
T
6672
6672
6670
6676
E2
6014
6652
6652

FIG. 46

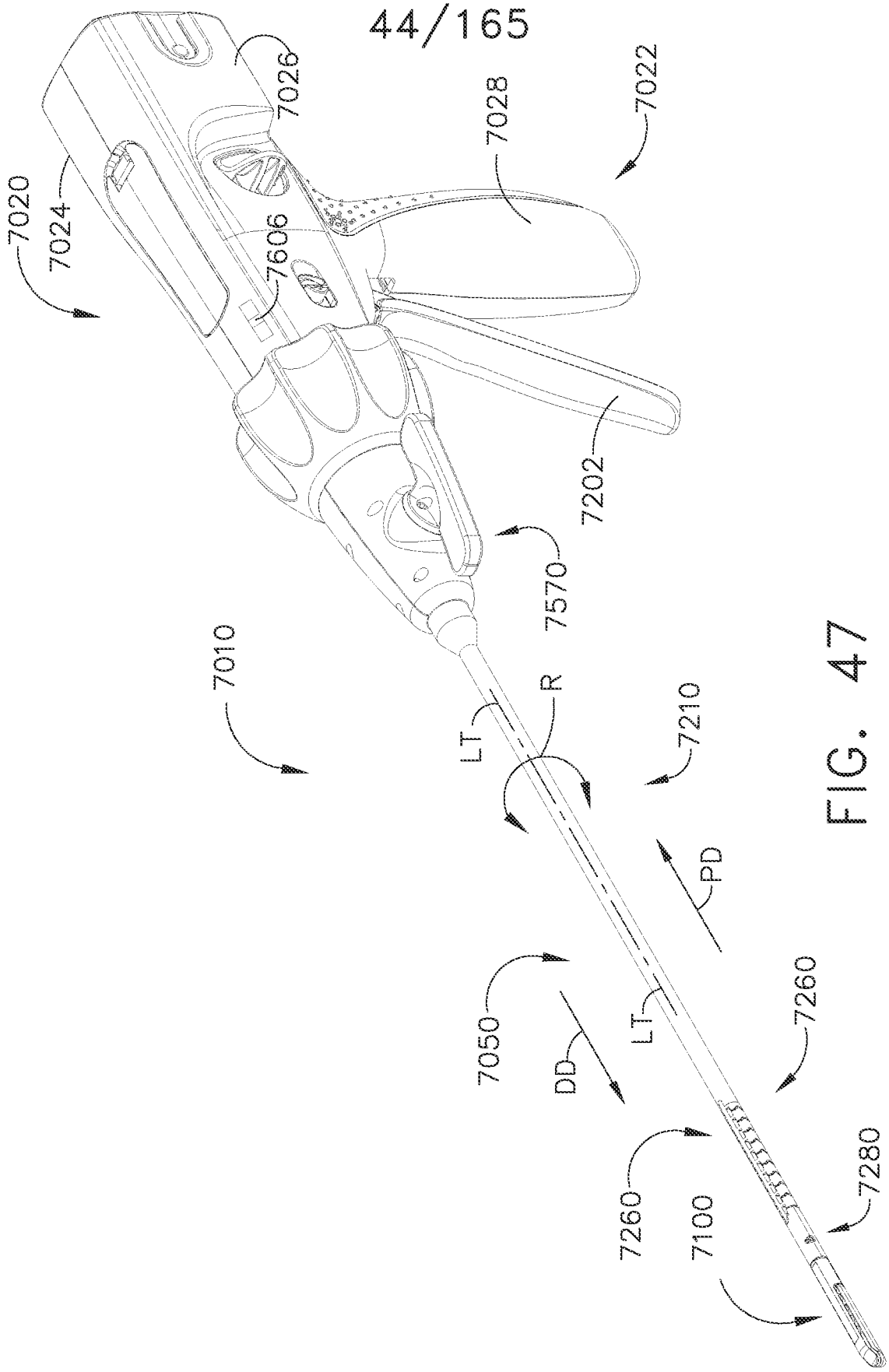

7020
7024
7026
7028
7022
7606
7202
7570
7010
LT
R
7210
PD
7050
DD
LT
7260
7260
7100
7280

FIG. 47

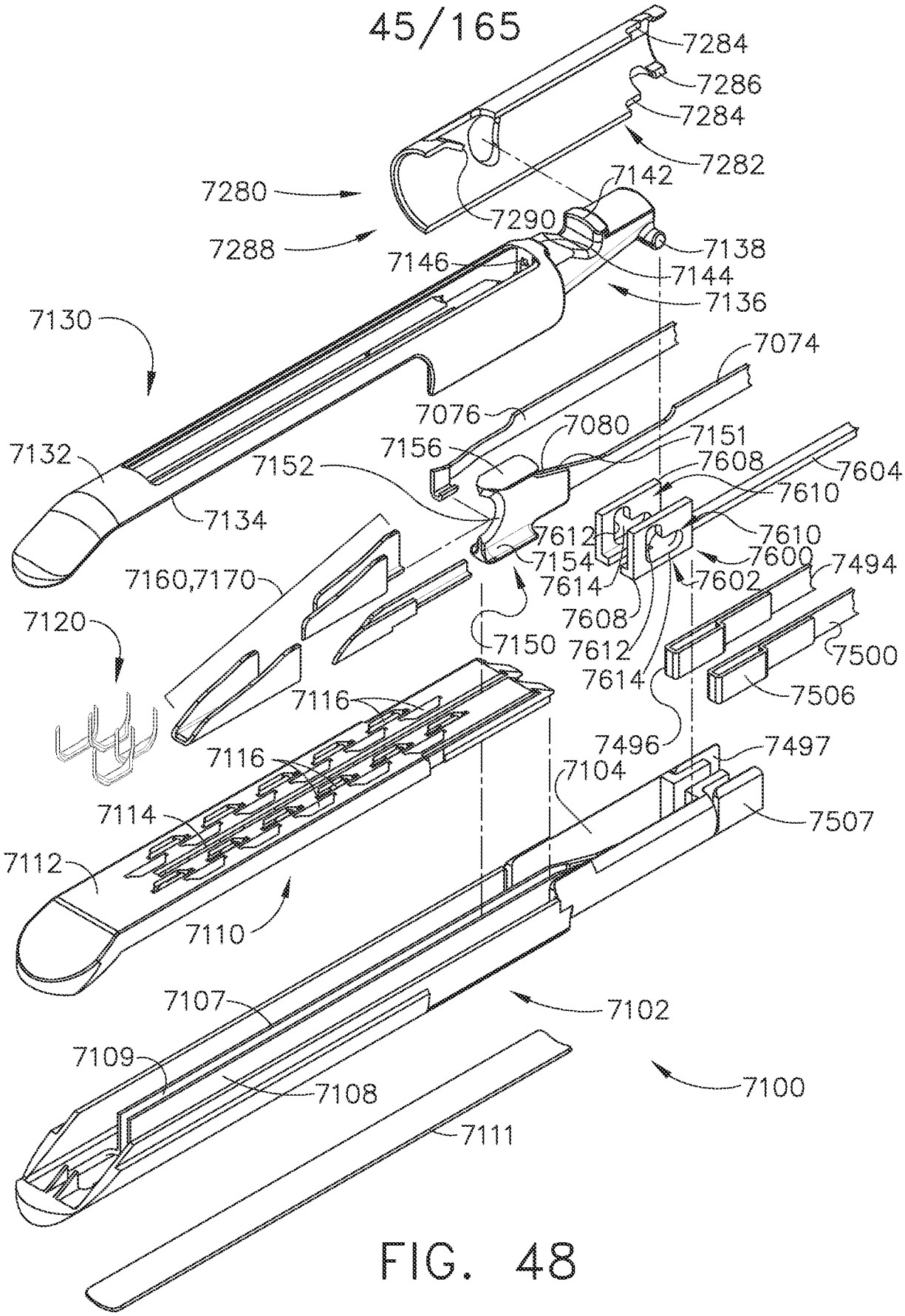

7284
7286
7284
7282
7142
7280
7290
7288
7138
7146
7144
7136
7130
7074
7076
7080
7151
7156
7608
7604
7132
7152
7610
7134
7612
7610
7154
7600
7494
7160,7170
7614
7602
7120
7608
7150
7612
7500
7614
7116
7506
7496
7497
7116
7104
7114
7507
7112
7110
7107
7102
7109
7100
7108
7111

FIG. 48

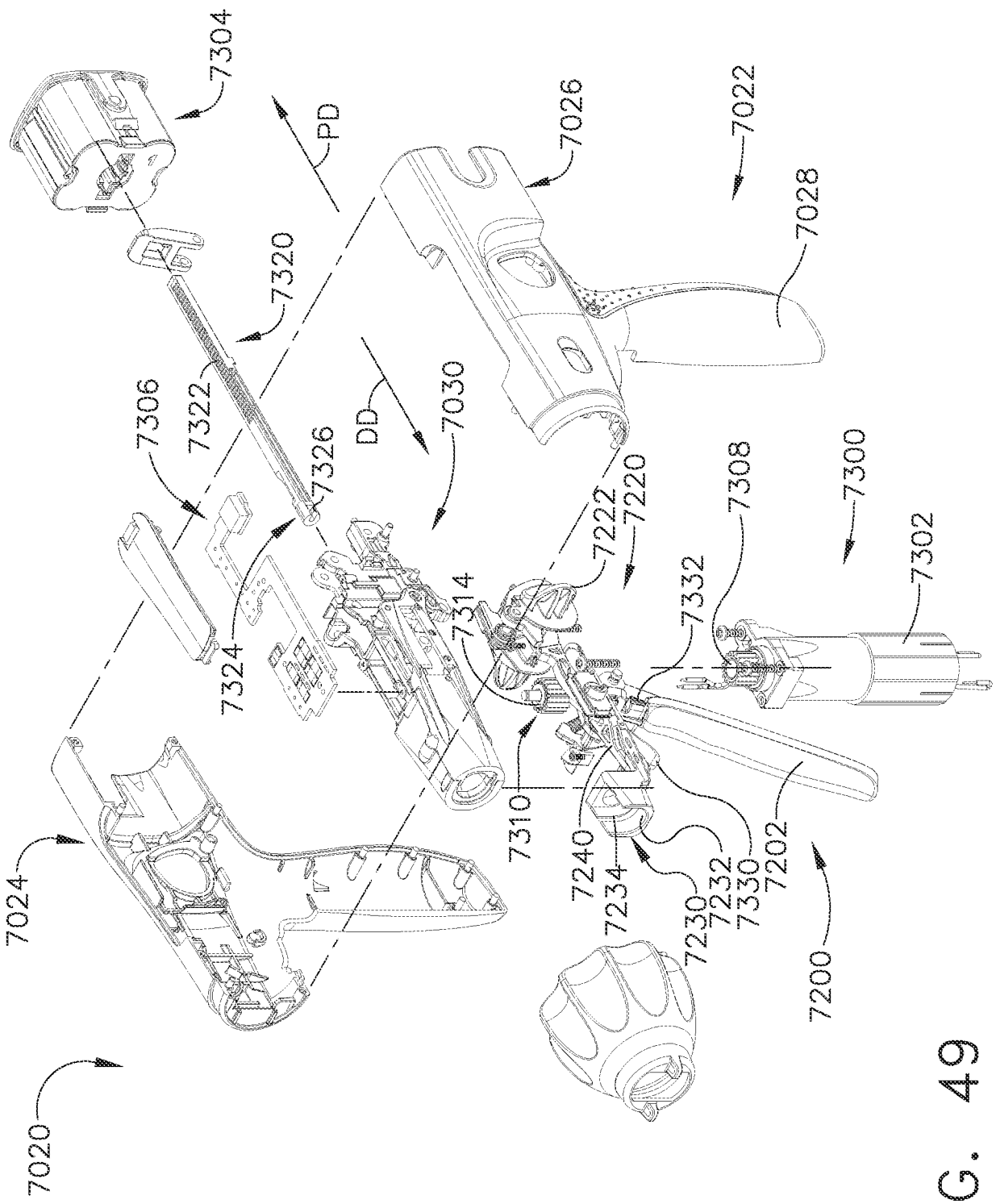

7304
PD
7026
7022
7028
7320
7306
7322
7326
DD
7030
7324
7220
7222
7308
7300
7314
7332
7302
7310
7240
7234
7230
7232
7330
7202
7200
7024
7020

FIG. 49

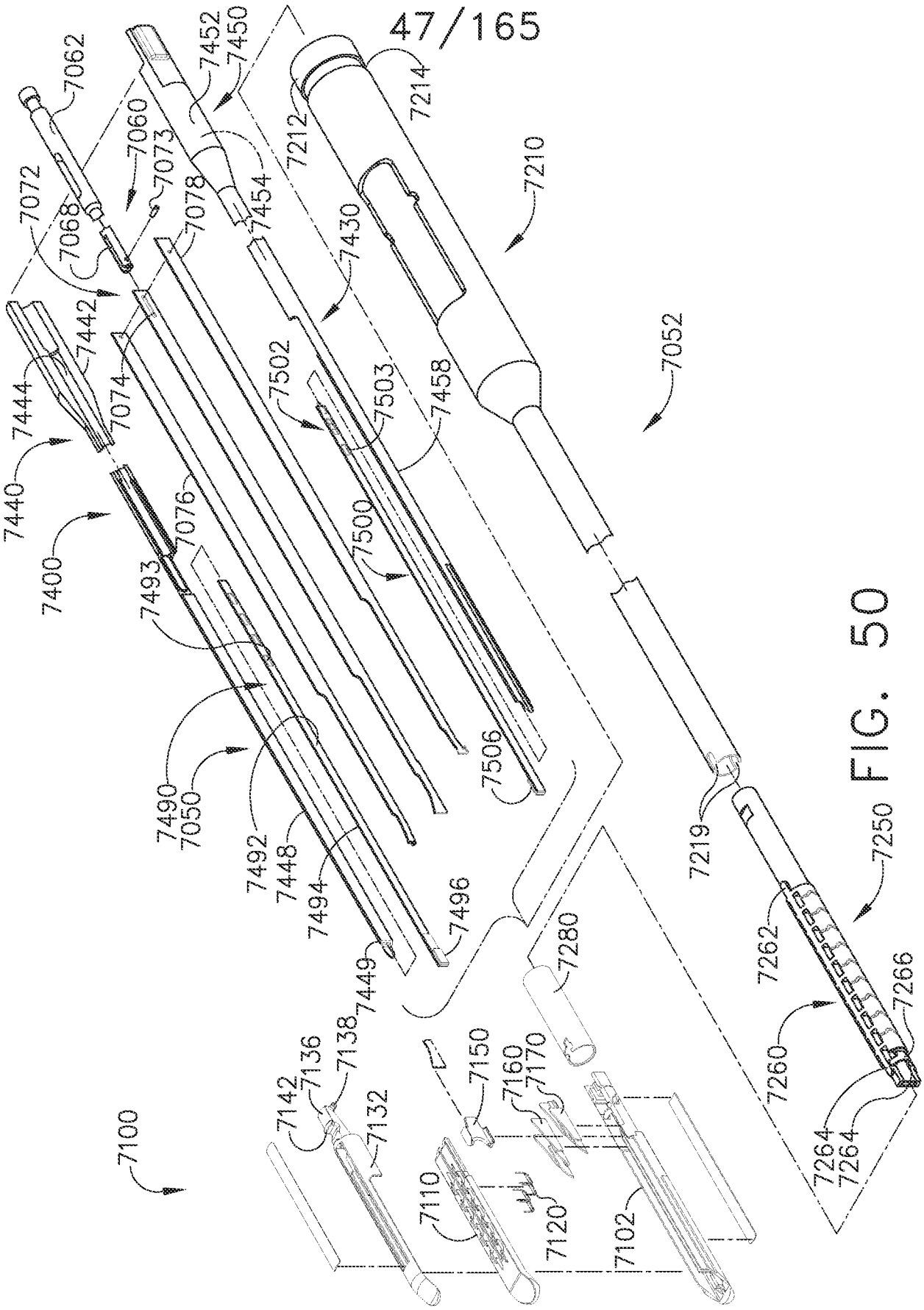

7062
7060
7072
7073
7068
7078
7452
7450
7454
7212
7214
7210
7430
7442
7444
7074
7502
7503
7458
7052
7440
7400
7076
7500
7493
7506
7490
7050
7492
7448
7494
7496
7449
7219
7250
7280
7262
7266
7260
7264
7264
7138
7136
7142
7132
7150
7160
7170
7110
7120
7102
7100

FIG. 50

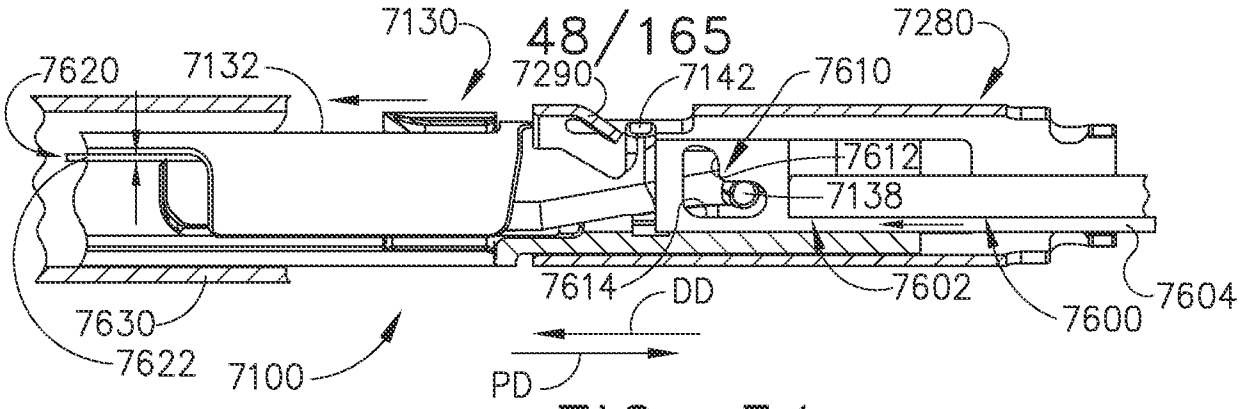


FIG. 51

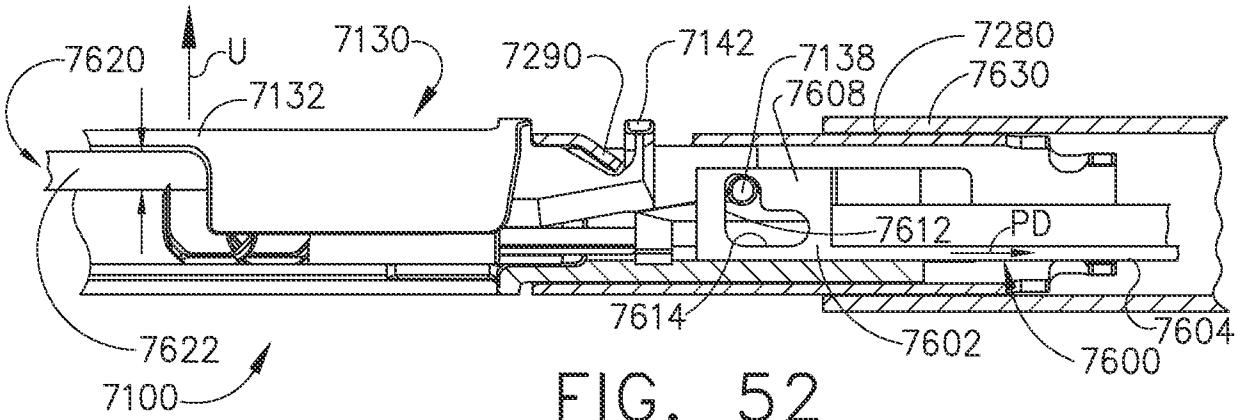


FIG. 52

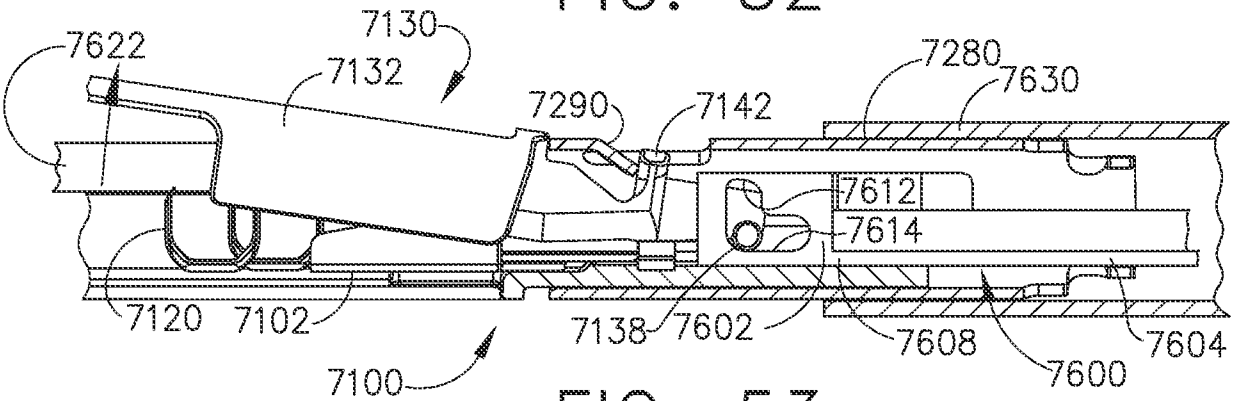


FIG. 53

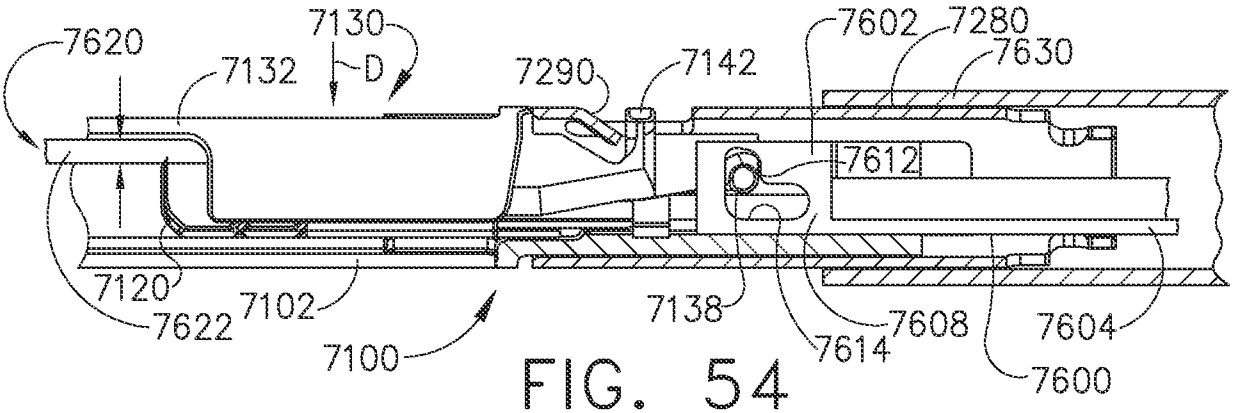


FIG. 54

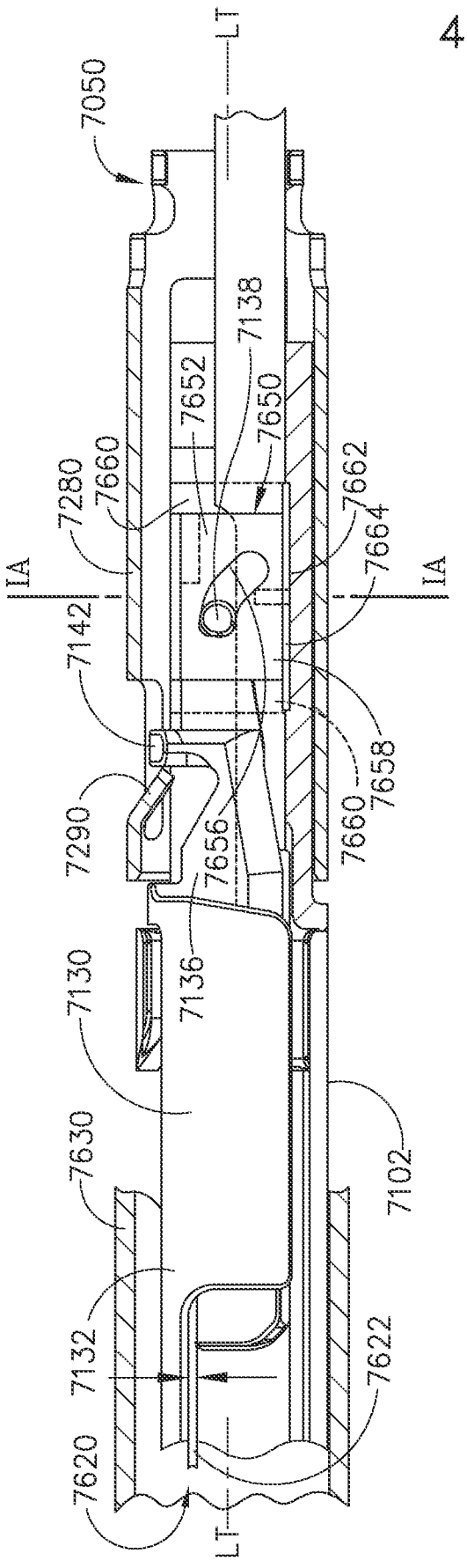

LT
7050
7138
7652
7650
7660
7280
7662
7664
IA
IA
7142
7658
7290
7656
7660
7136
7130
7630
7102
7132
7622
7620
LT

FIG. 55

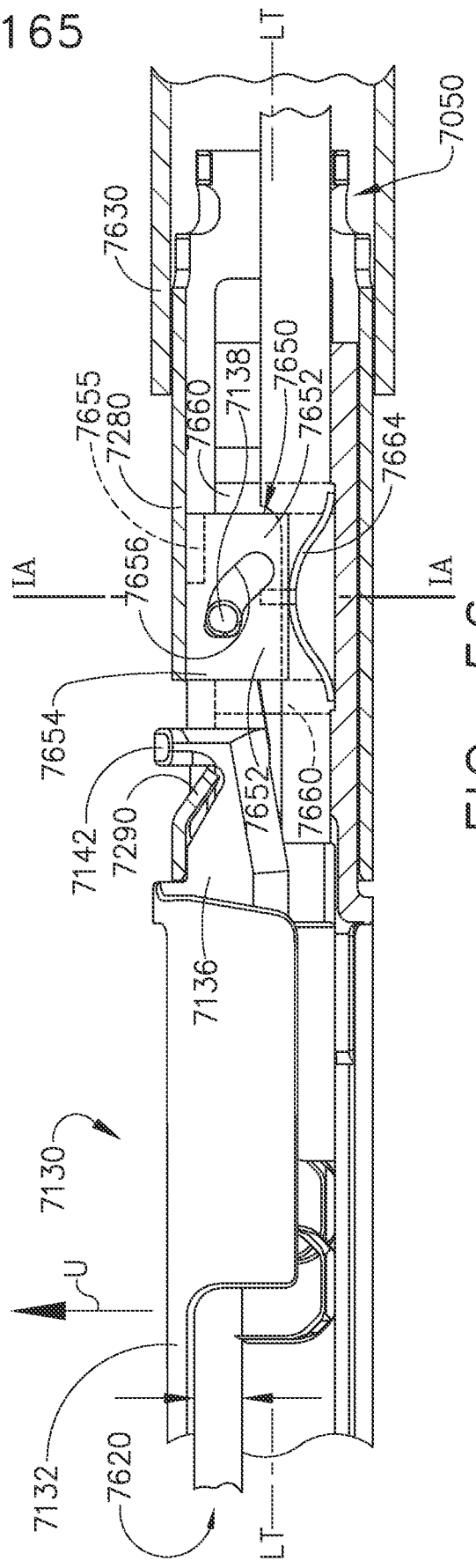

LT
7050
7630
7655
7280
7660
7138
7650
7652
7664
IA
IA
7656
7654
7142
7290
7652
7660
7136
7130
U
7132
7620
LT

FIG. 56

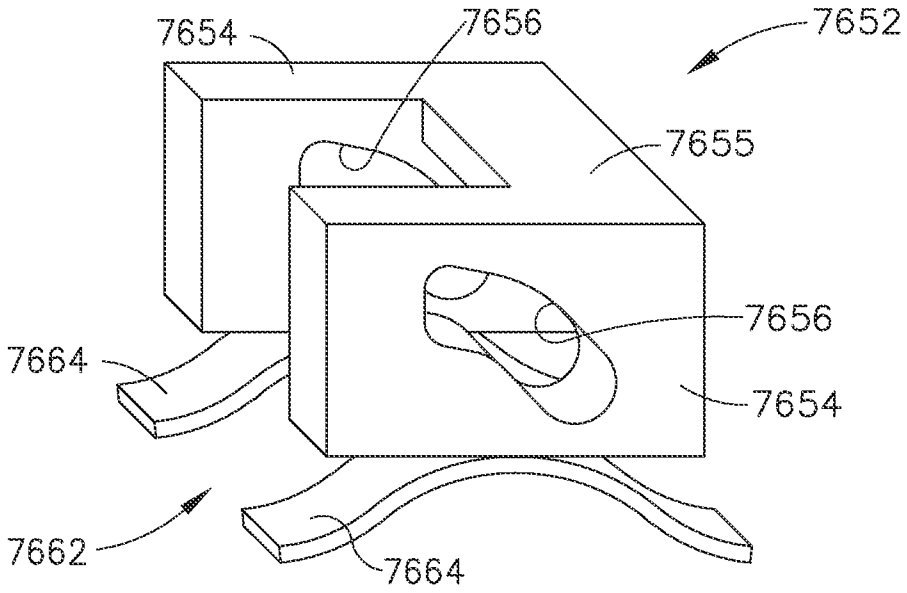


FIG. 57

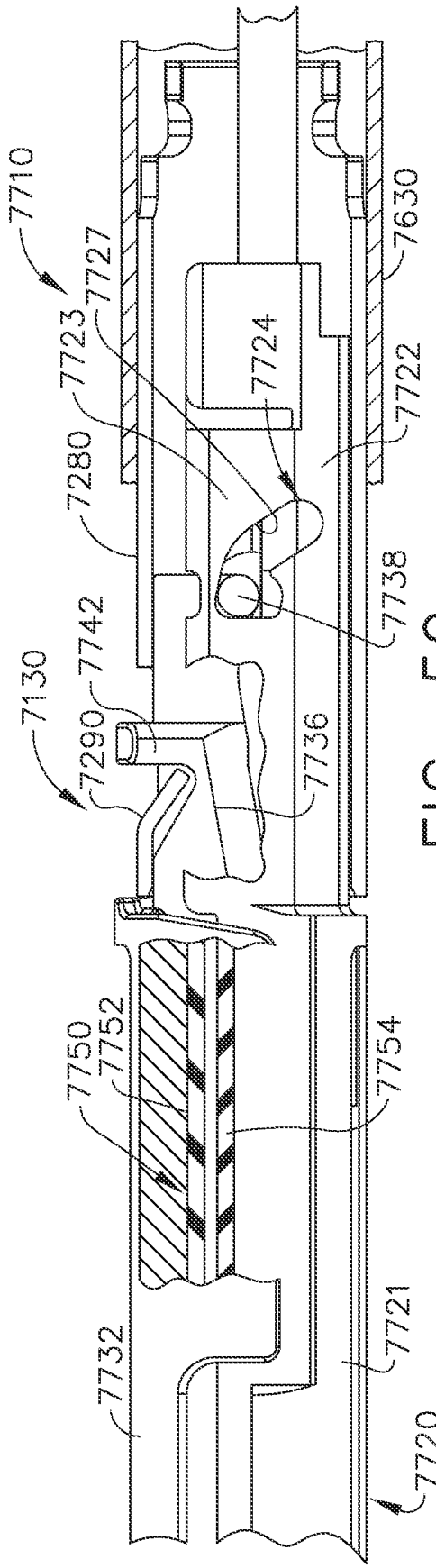

7710
7727
7723
7280
7724
7630
7722
7738
7742
7130
7290
7736
7750
7752
7754
7732
7721
7720

FIG. 59

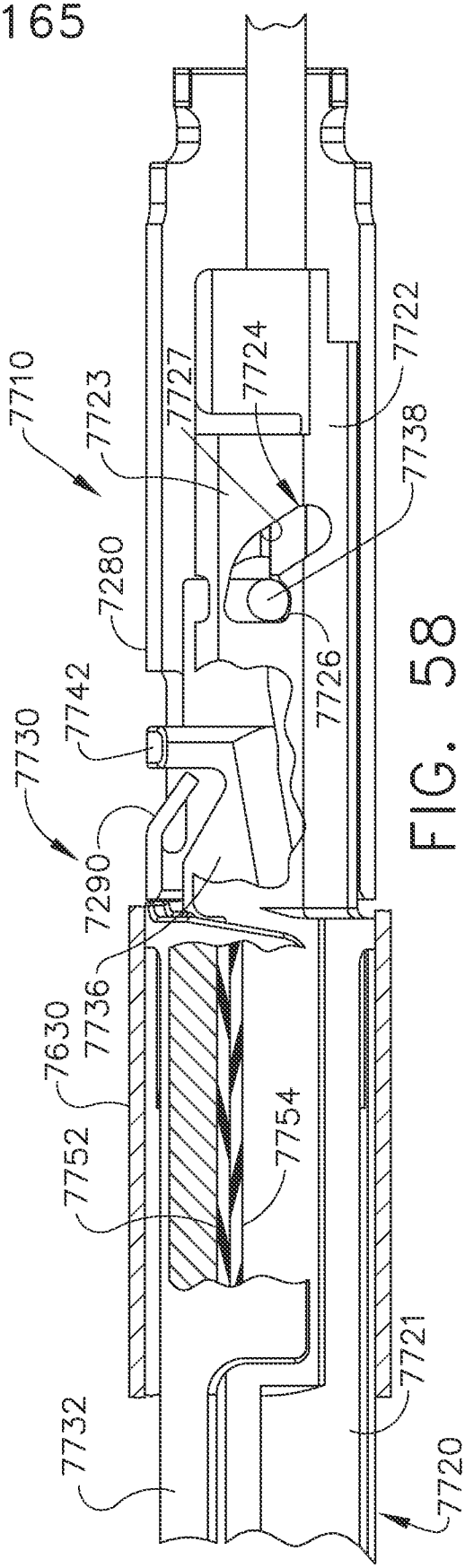

7710
7723
7727
7724
7722
7738
7280
7726
7742
7730
7290
7630
7736
7752
7754
7732
7721
7720

FIG. 58

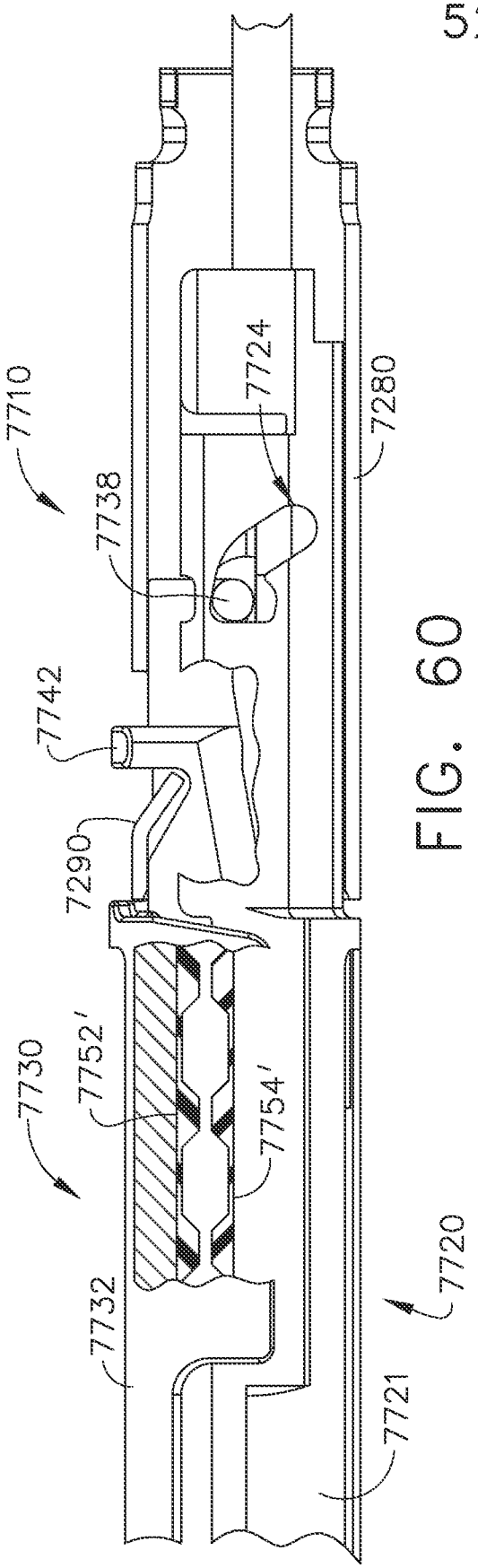

7710
7738
7724
7280
7742
7290
7730
7752'
7754'
7732
7720
7721

FIG. 60

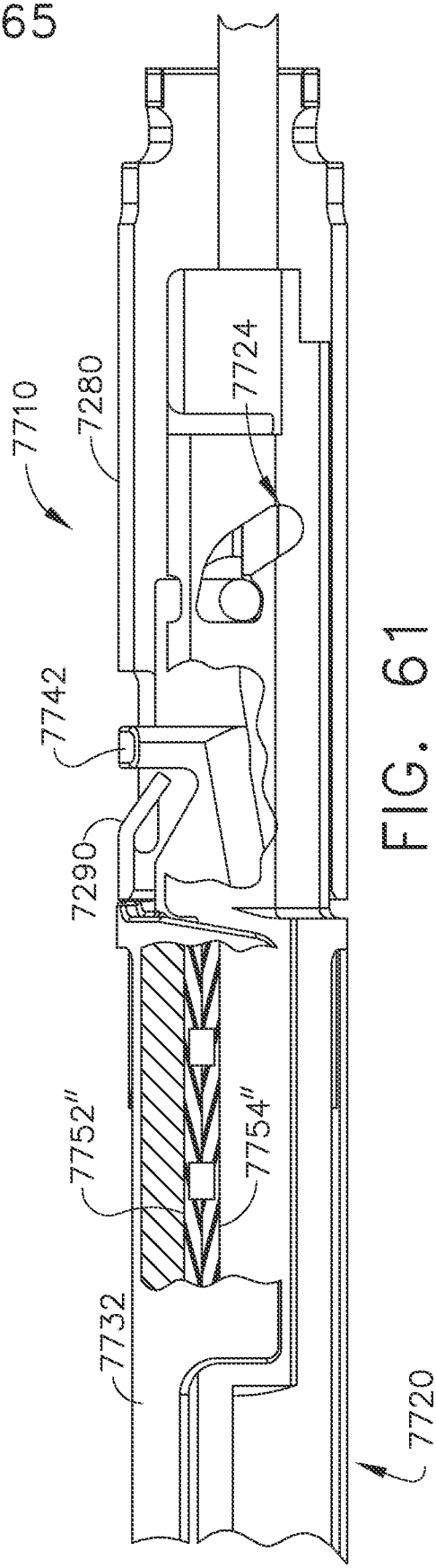

7710
7280
7724
7742
7290
7752"
7754"
7732
7720

FIG. 61

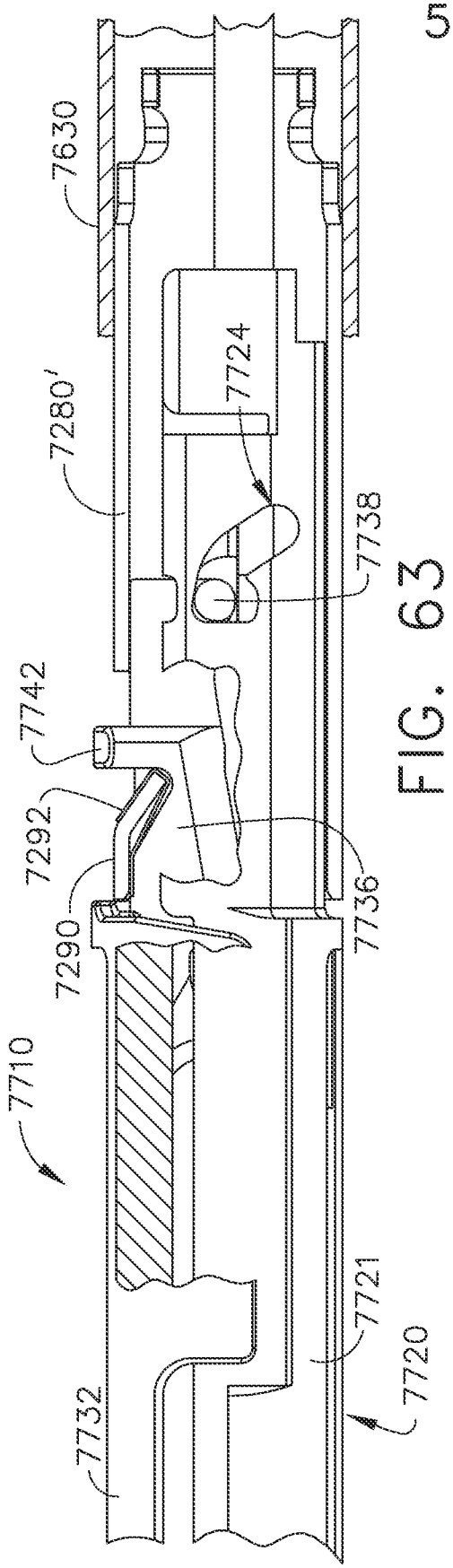

7630
7280'
7724
7738
7742
7292
7290
7736
7710
7721
7720
7732

FIG. 63

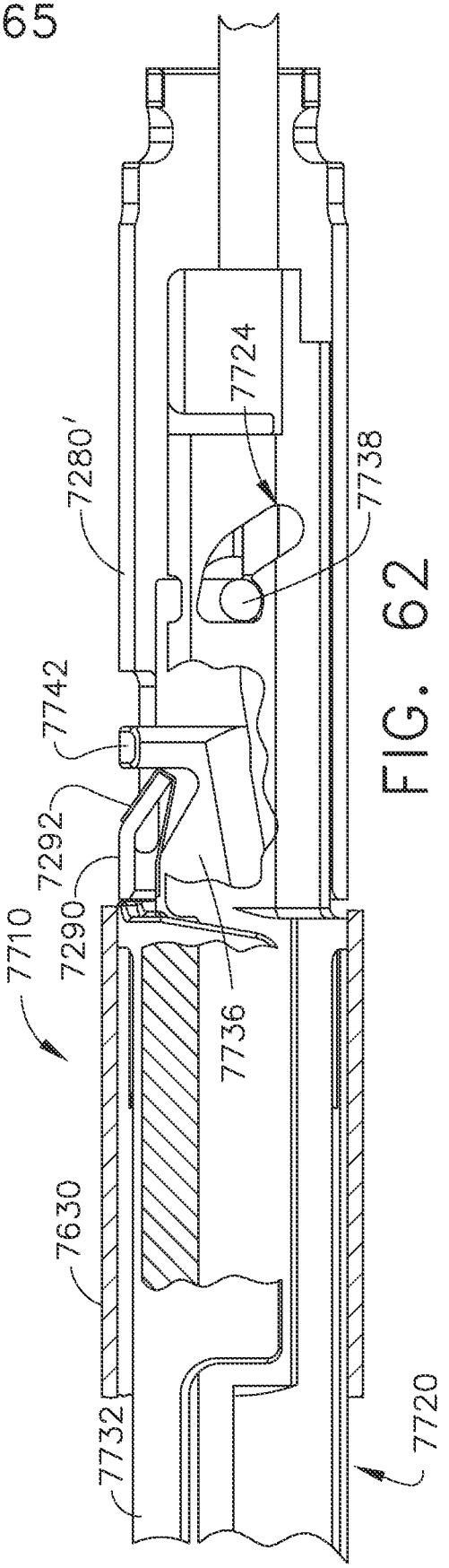

7280'
7724
7738
7742
7292
7290
7710
7736
7630
7732
7720

FIG. 62

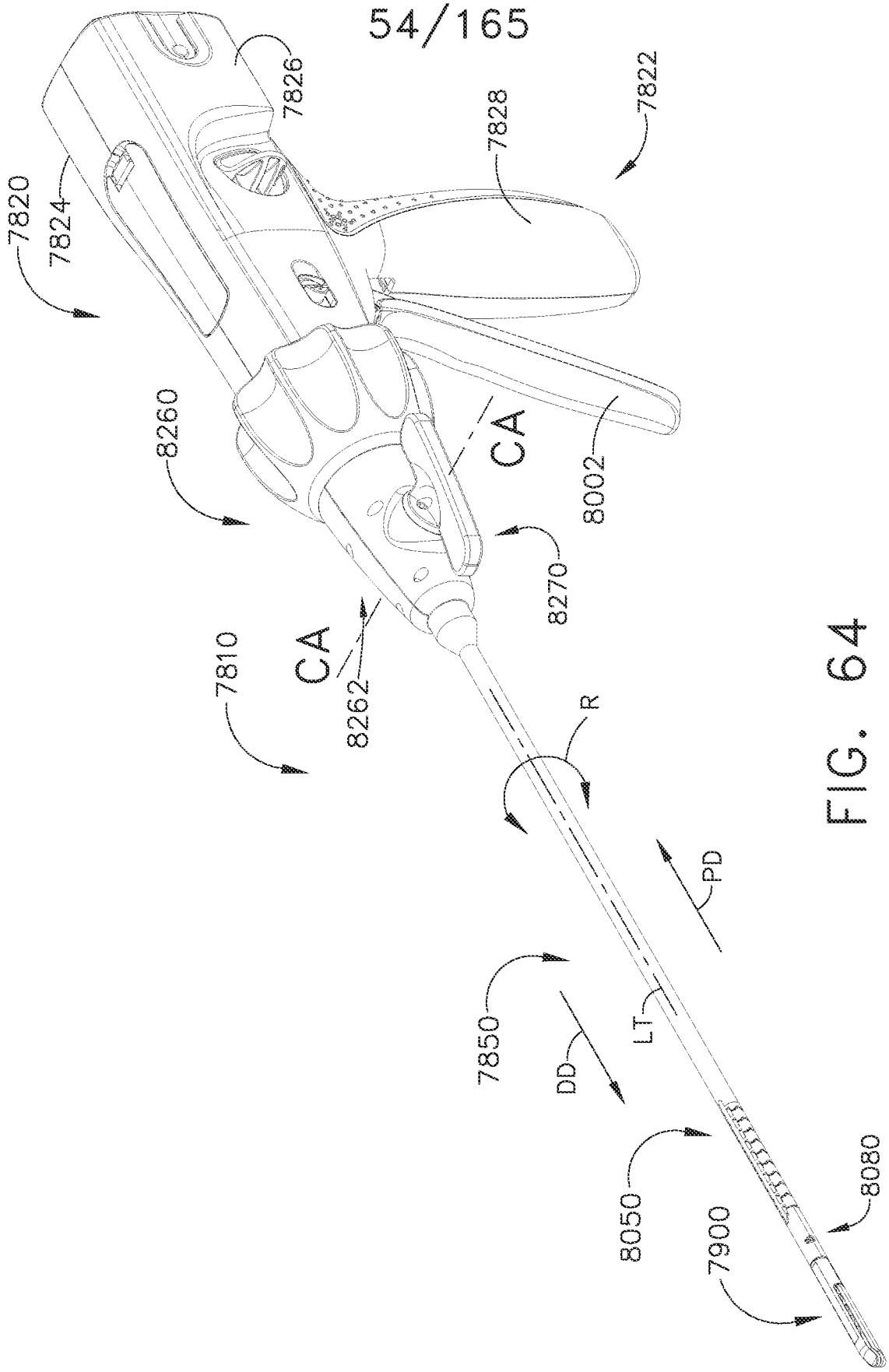

7826
7828
7822
7820
7824
8260
CA
CA
8002
8270
7810
8262
R
PD
7850
DD
LT
8050
7900
8080

FIG. 64

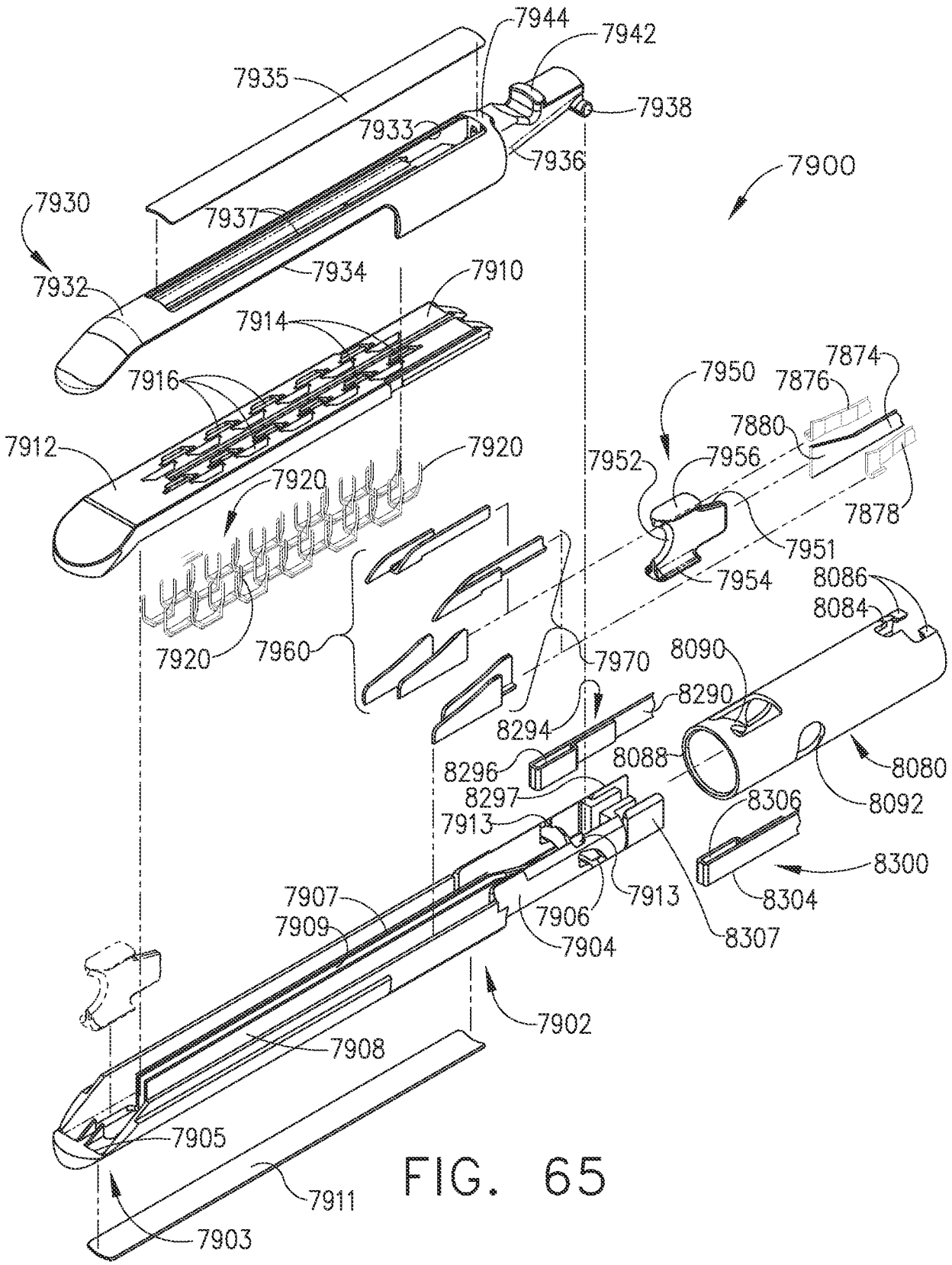

7944
7942
7935
7938
7933
7936
7900
7930
7937
7932
7934
7910
7914
7916
7912
7920
7920
7920
7960
7950
7874
7876
7880
7952
7956
7878
7951
7954
8086
8084
8090
7970
8290
8294
8296
8088
8080
8297
8092
7913
8306
8300
7907
7913
8304
7909
7906
7904
8307
7902
7908
7905
7911
7903

FIG. 65

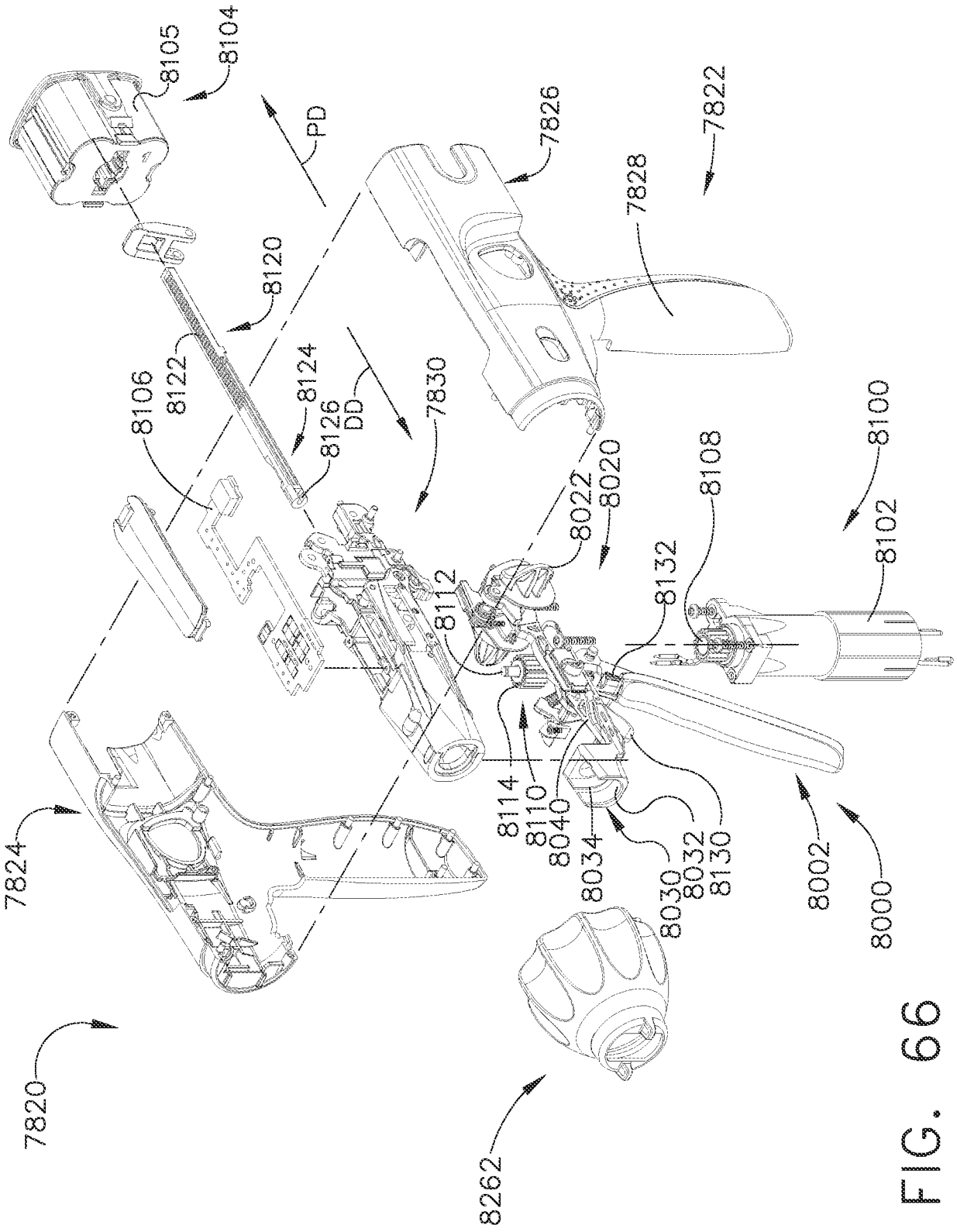

8105
8104
PD
7826
7822
7828
8120
8106
8122
8124
8126
DD
7830
8100
8108
8020
8022
8102
8132
8112
7824
8114
8110
8040
8034
8030
8032
8130
8002
8000
7820
8262

FIG. 66

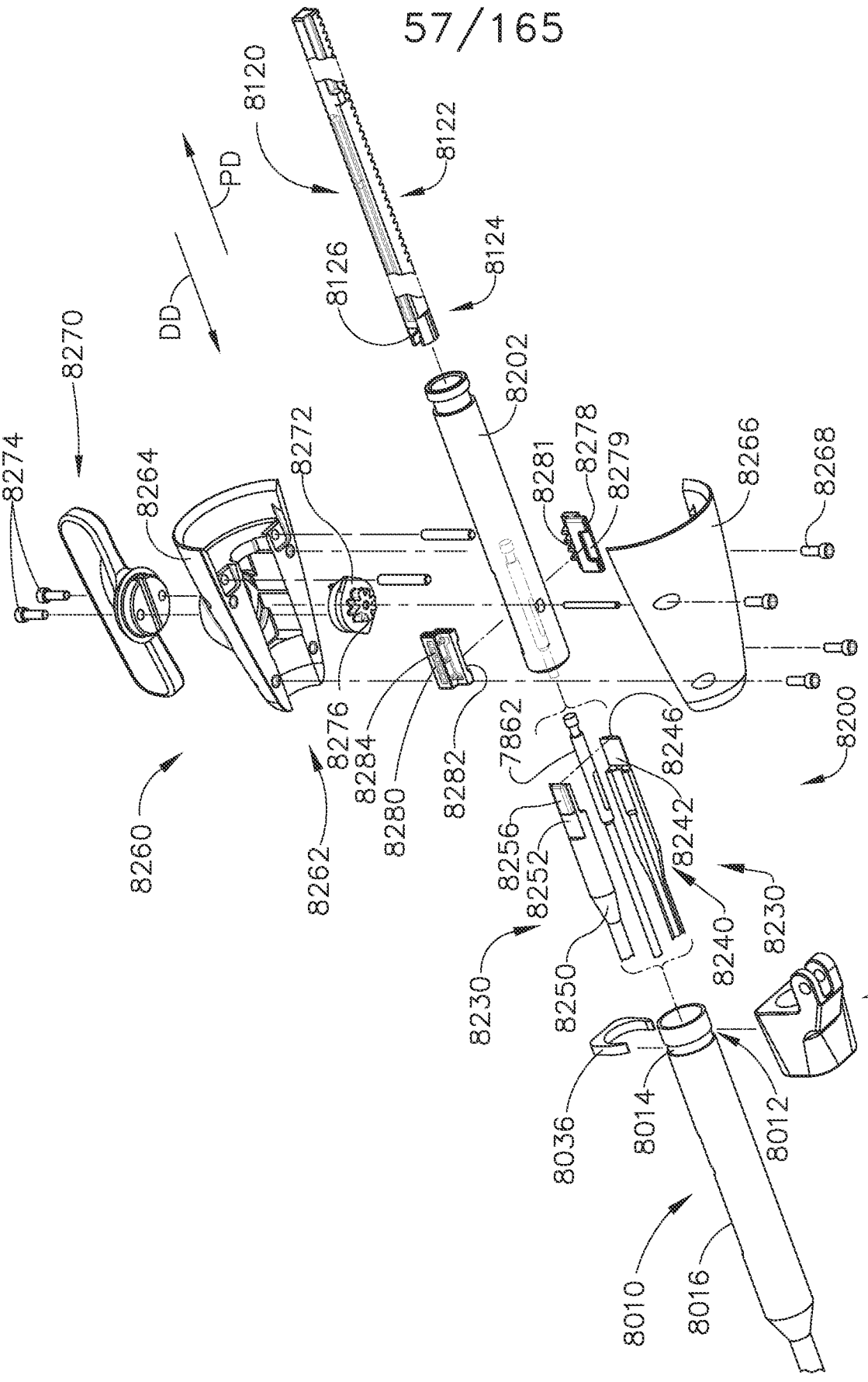

8120
8122
PD
DD
8124
8126
8270
8202
8274
8264
8272
8278
8281
8279
8266
8268
8276
8284
8280
8282
7862
8246
8200
8260
8262
8256
8252
8242
8240
8230
8230
8250
8030
8036
8014
8012
8010
8016

FIG. 67

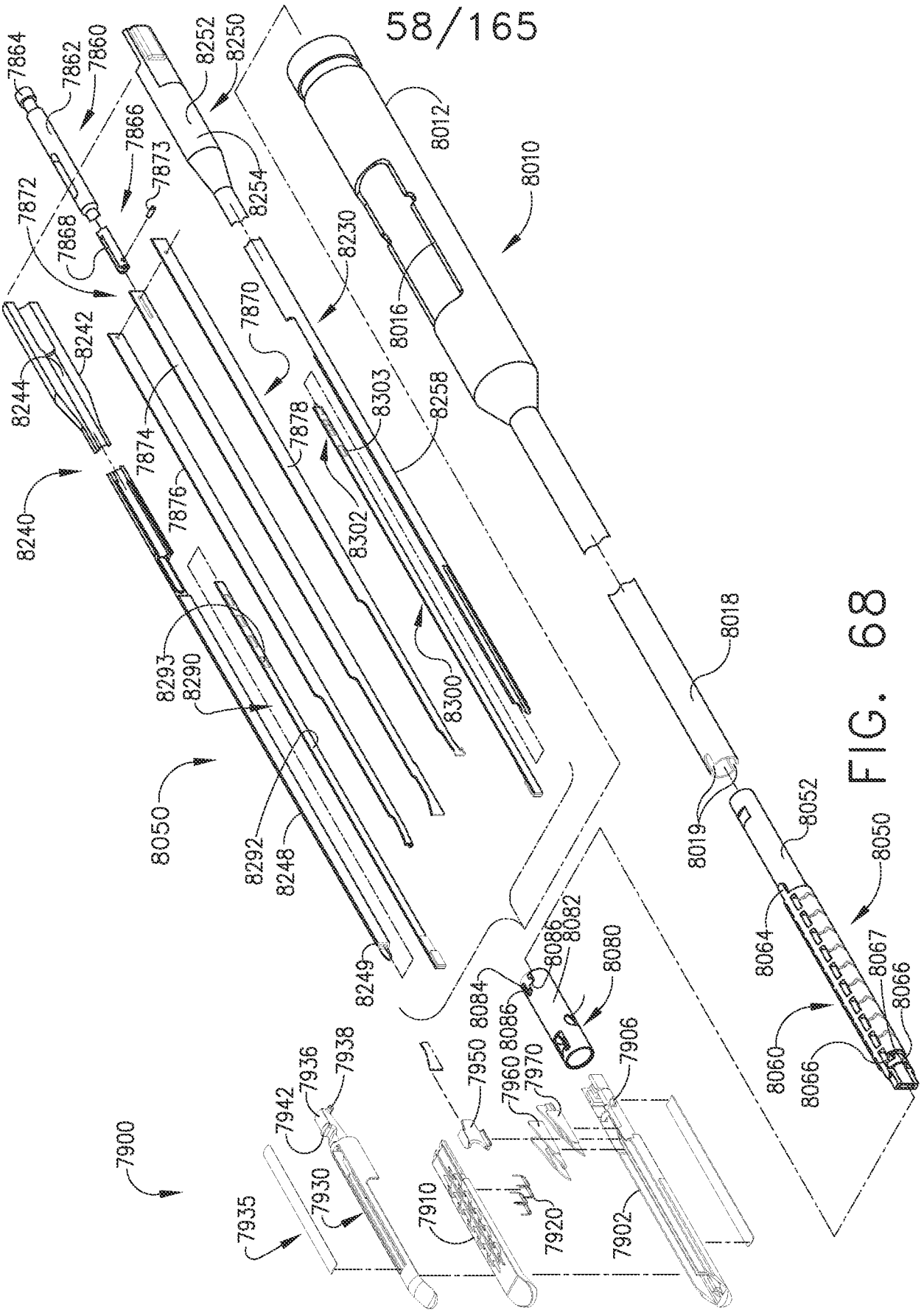

7864
7862
7860
7866
7873
7872
7868
8252
8250
8254
8012
8010
8230
7870
8016
8242
8244
8303
8258
7878
7874
7876
8302
8240
8293
8290
8300
8018
8050
8292
8248
8019
8052
8249
8064
8050
8086
8082
8080
8084
8067
8066
8060
8066
7950
8084
8086
7960
7970
7906
7936
7938
7942
7900
7930
7935
7910
7920
7902

FIG. 68

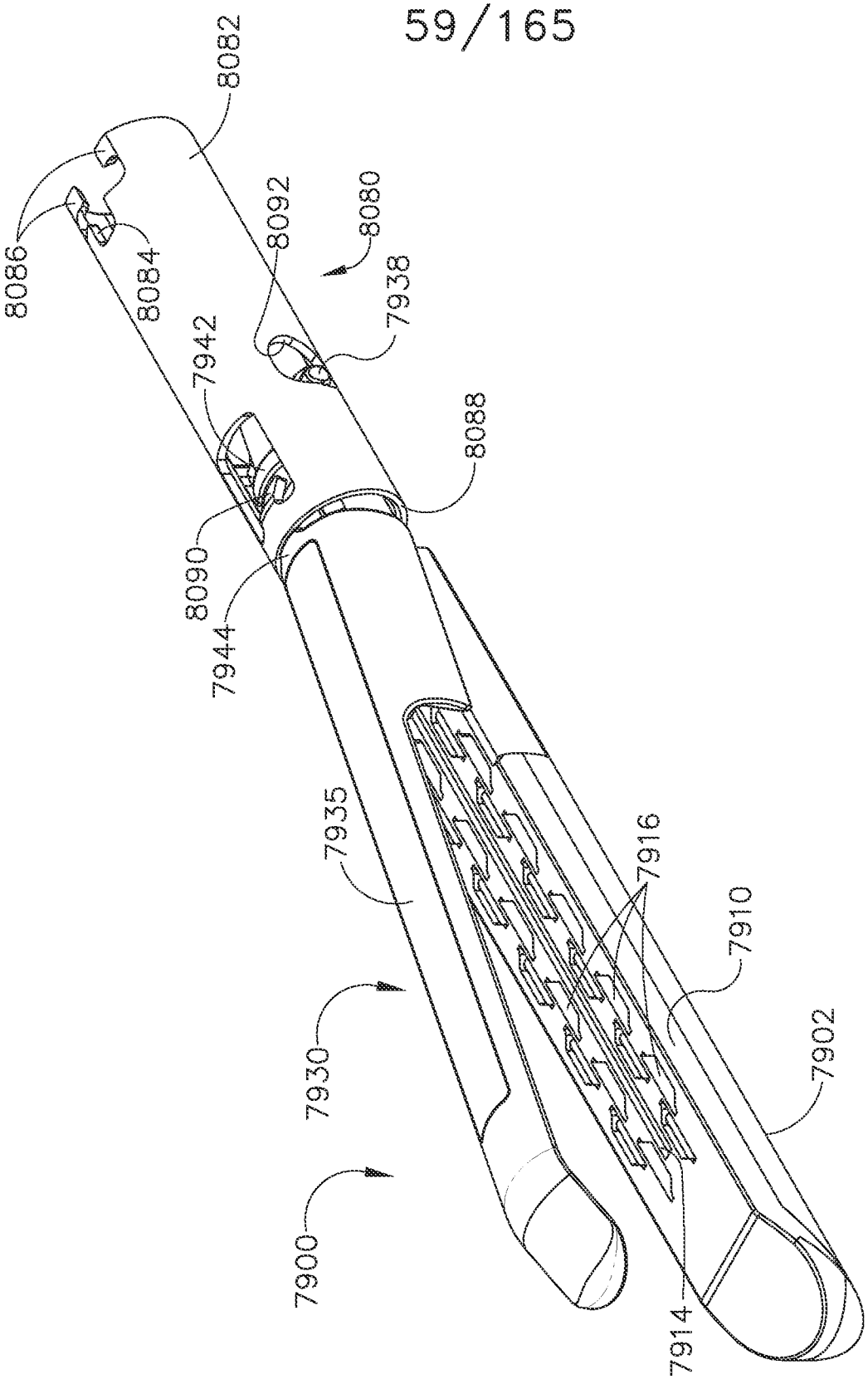

8082
8086
8084
8092
8080
7938
7942
8088
8090
7944
7935
7916
7910
7930
7902
7900
7914

FIG. 69

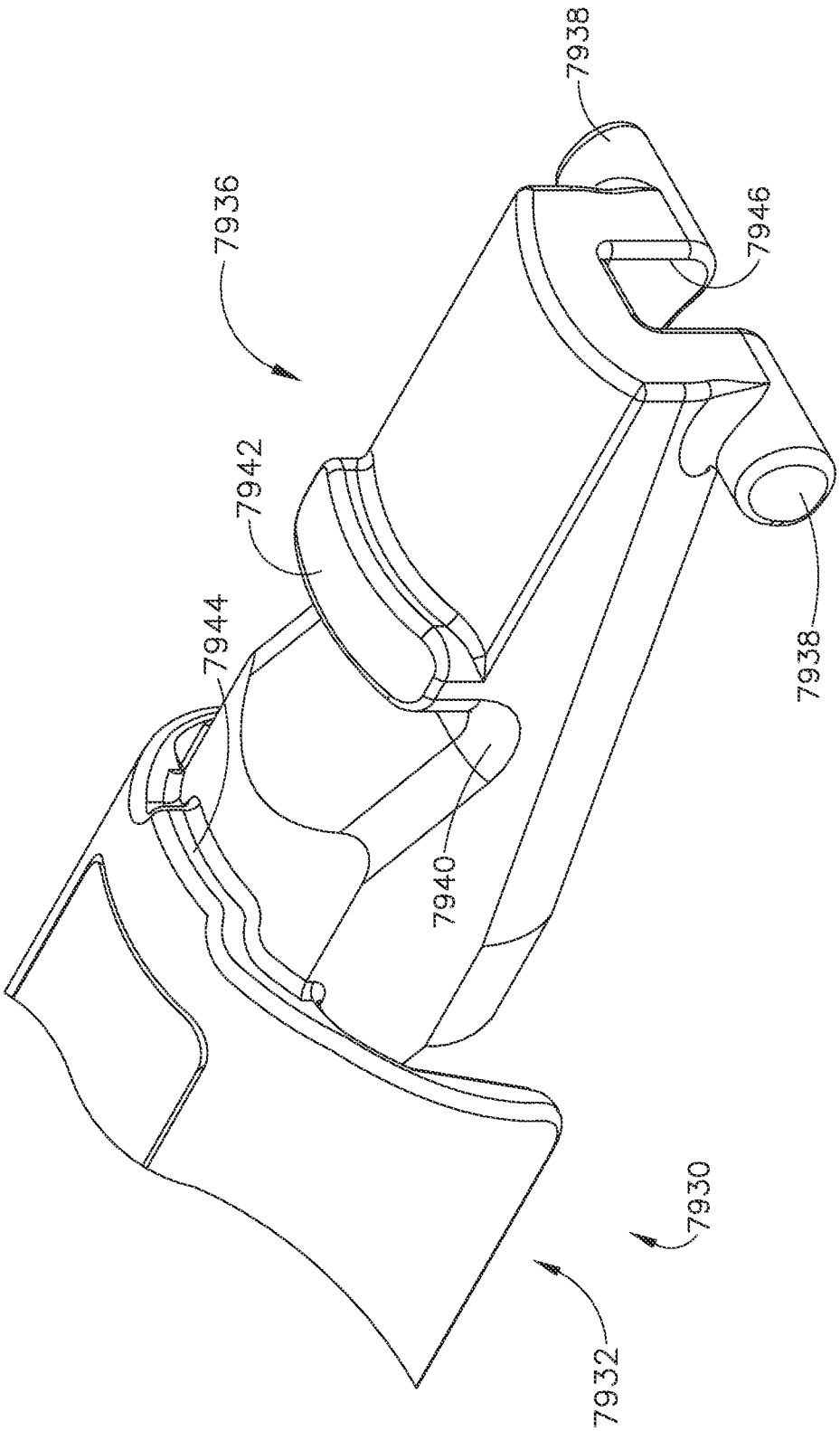


FIG. 70

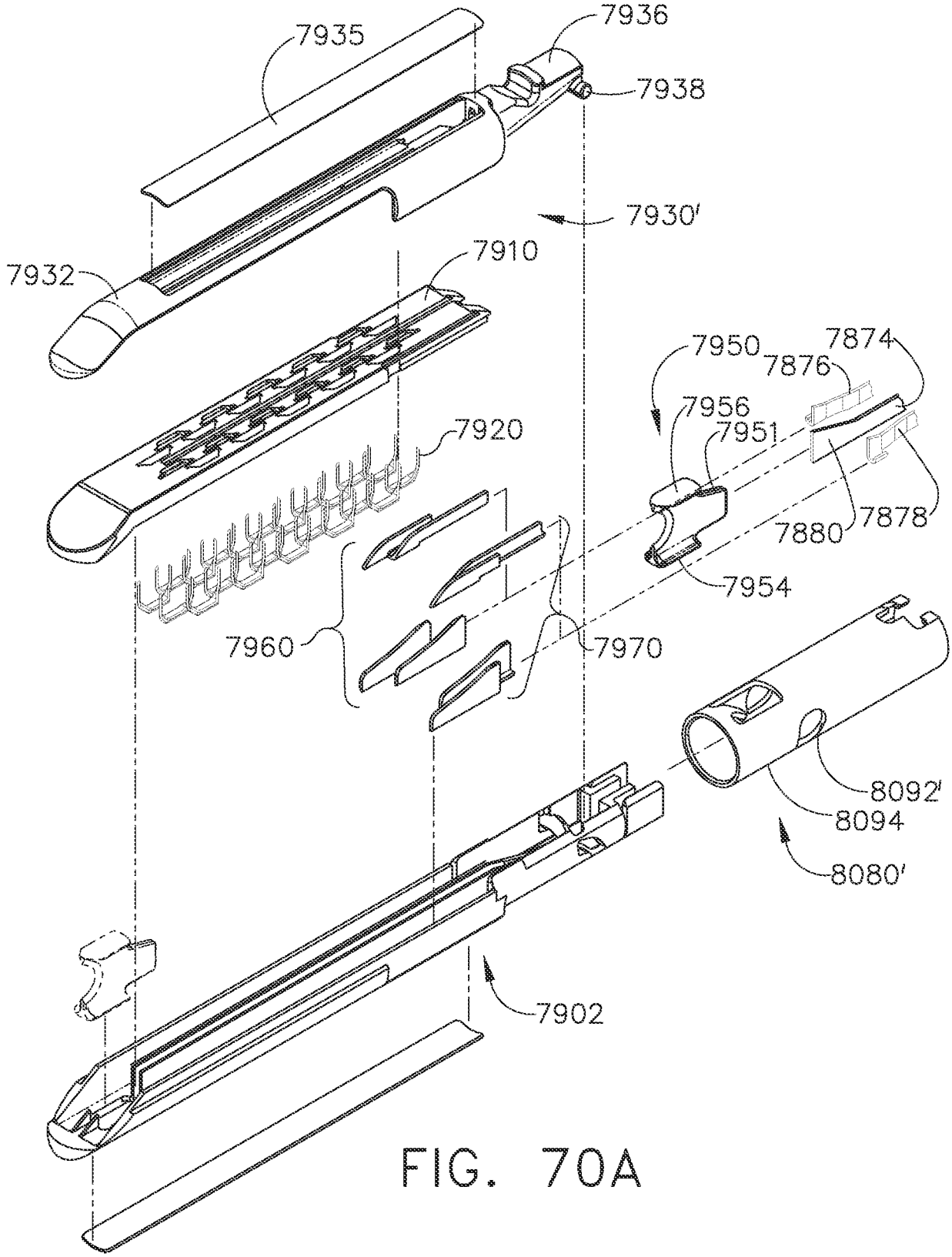

7935
7936
7938
7930'
7910
7932
7950
7874
7876
7956
7951
7920
7880
7878
7954
7960
7970
8092'
8094
8080'
7902

FIG. 70A

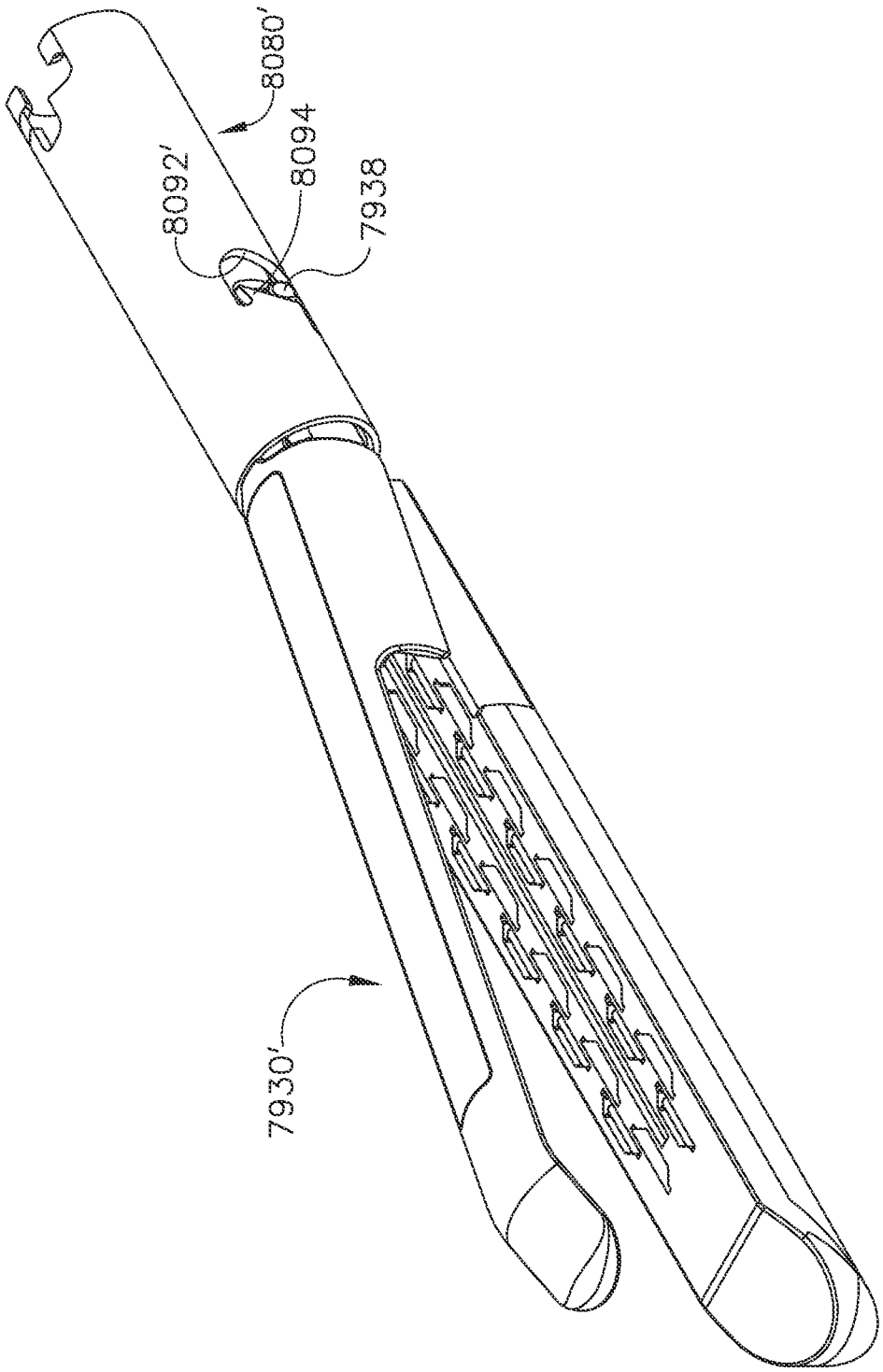


FIG. 70B

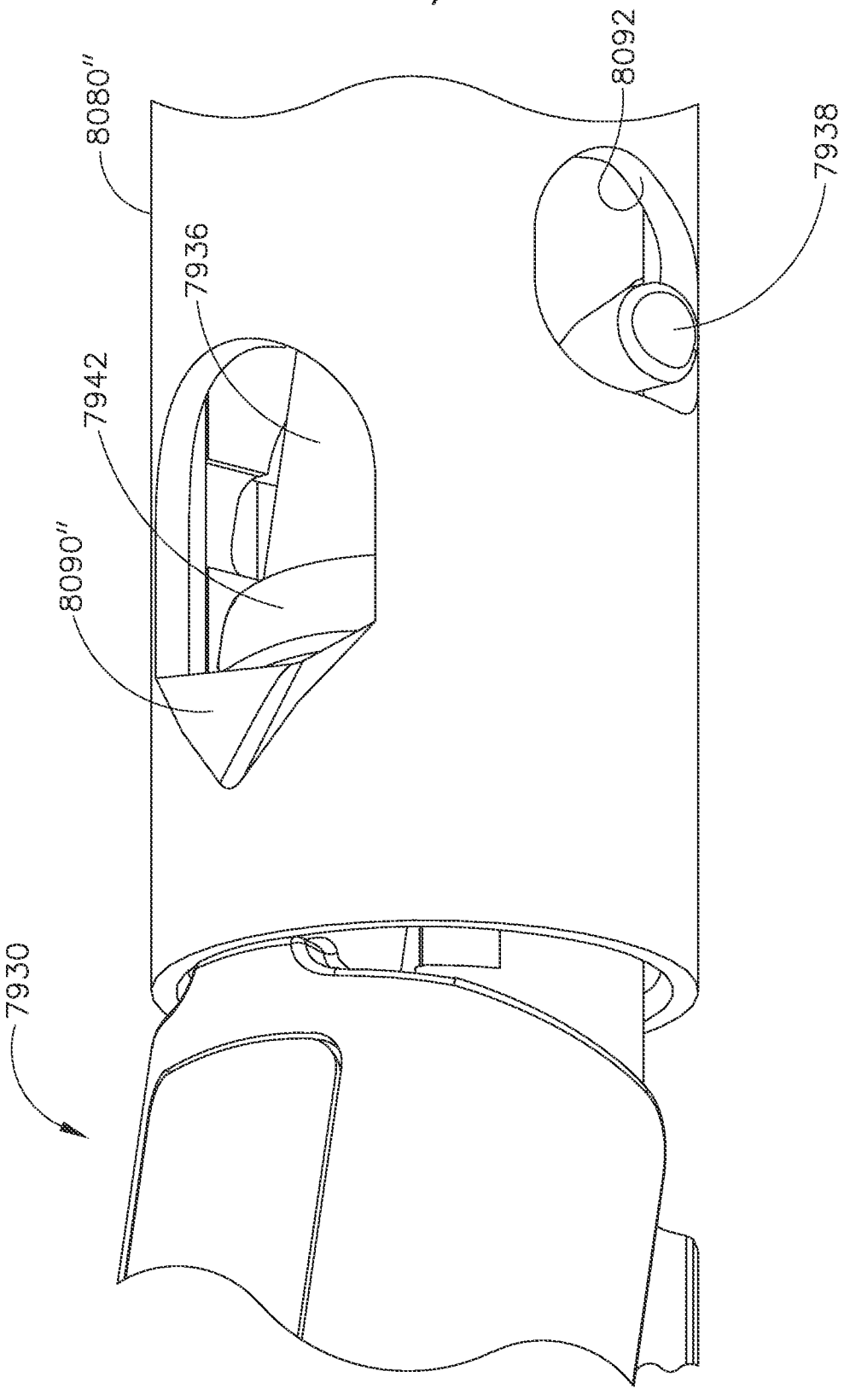


FIG. 70C

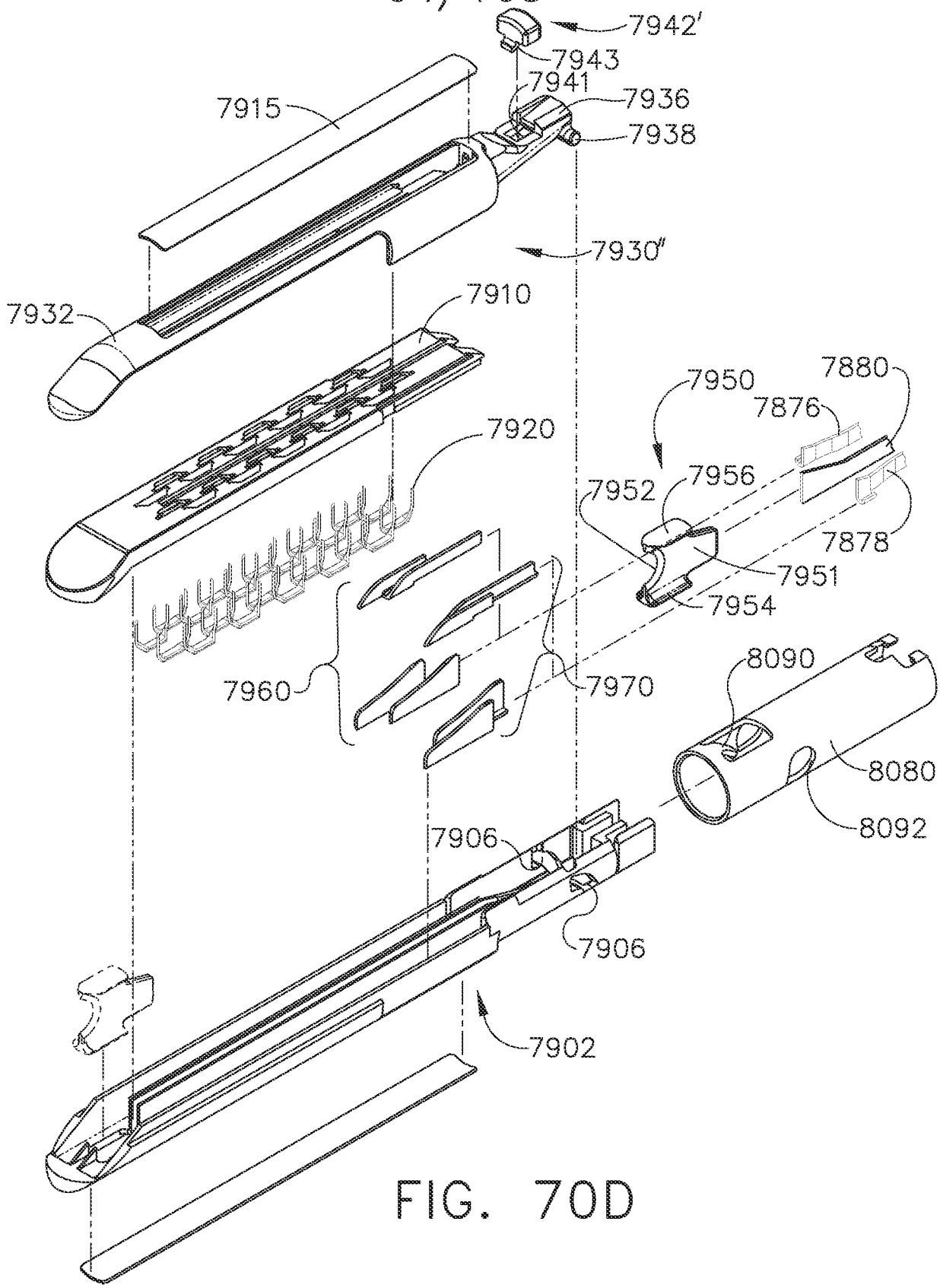

7942'
7943
7941
7936
7938
7915
7930"
7910
7932
7880
7950
7876
7920
7956
7952
7878
7951
7954
7960
7970
8090
8080
8092
7906
7906
7902

FIG. 70D

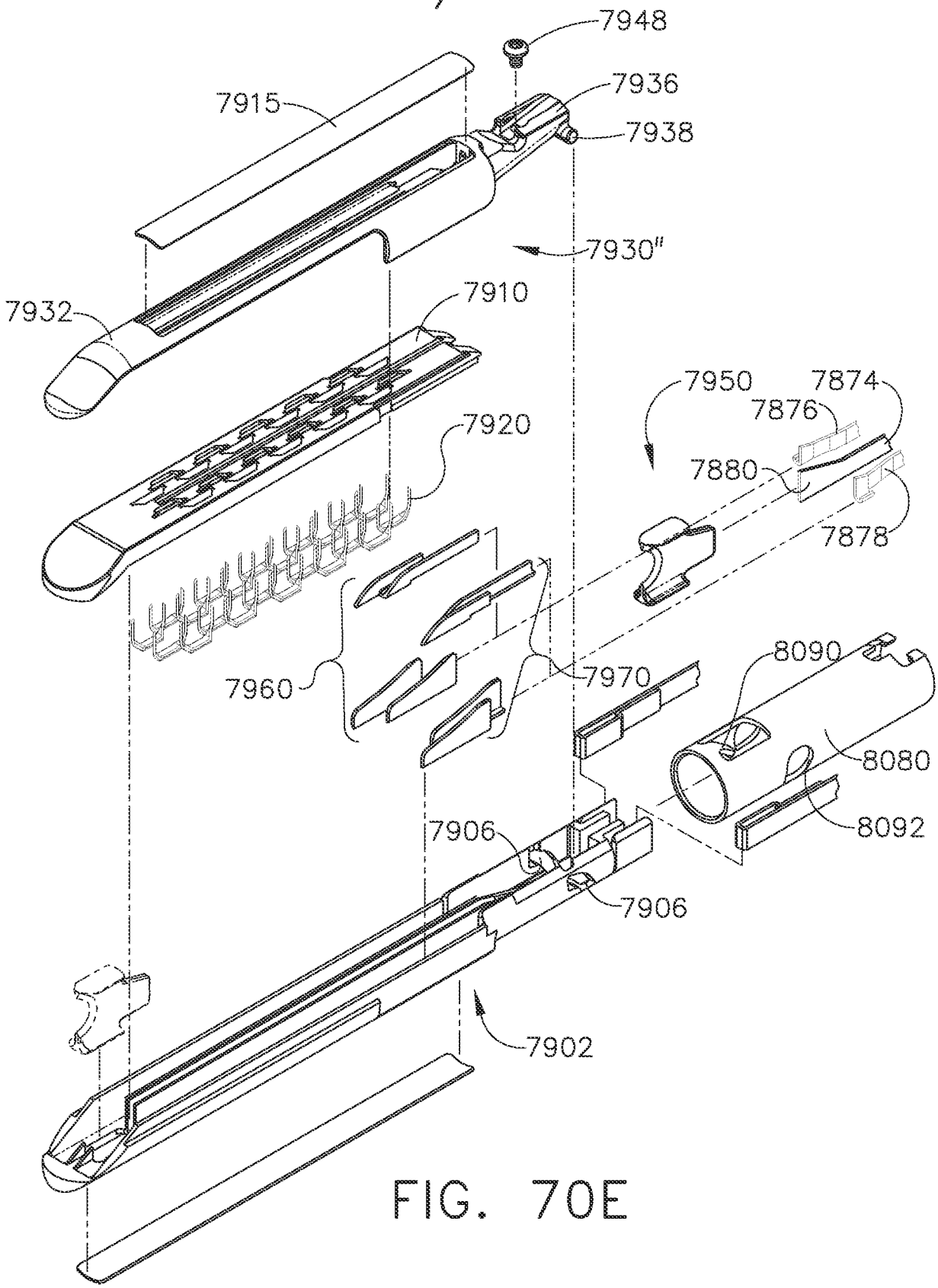

7948
7936
7915
7938
7930"
7910
7932
7950
7874
7876
7920
7880
7878
7960
7970
8090
8080
8092
7906
7906
7902

FIG. 70E

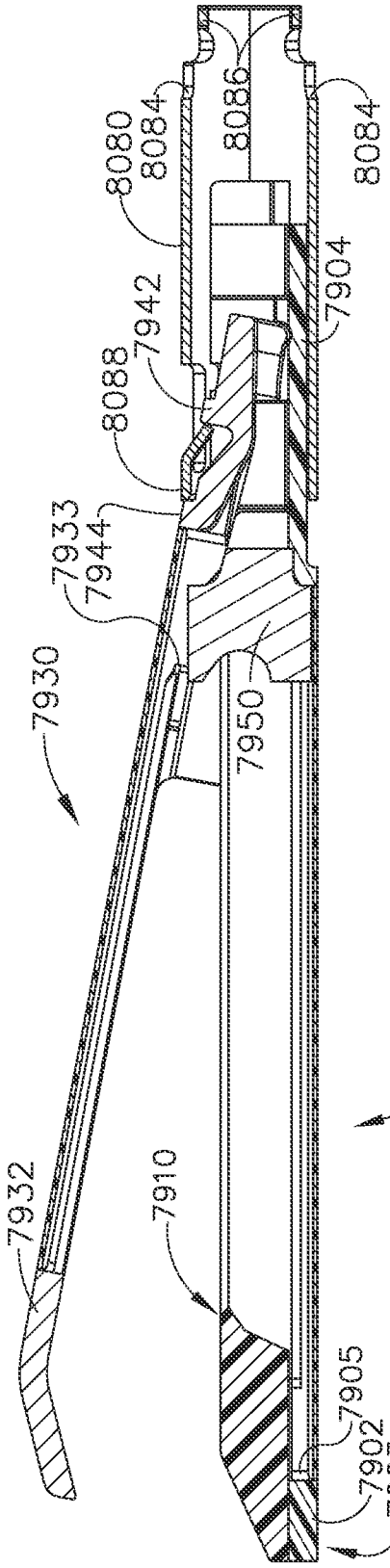

8080
8084
8086
8084
7904
7942
8088
7933
7944
7930
7950
7900
7932
7910
7905
7902
7903

FIG. 71

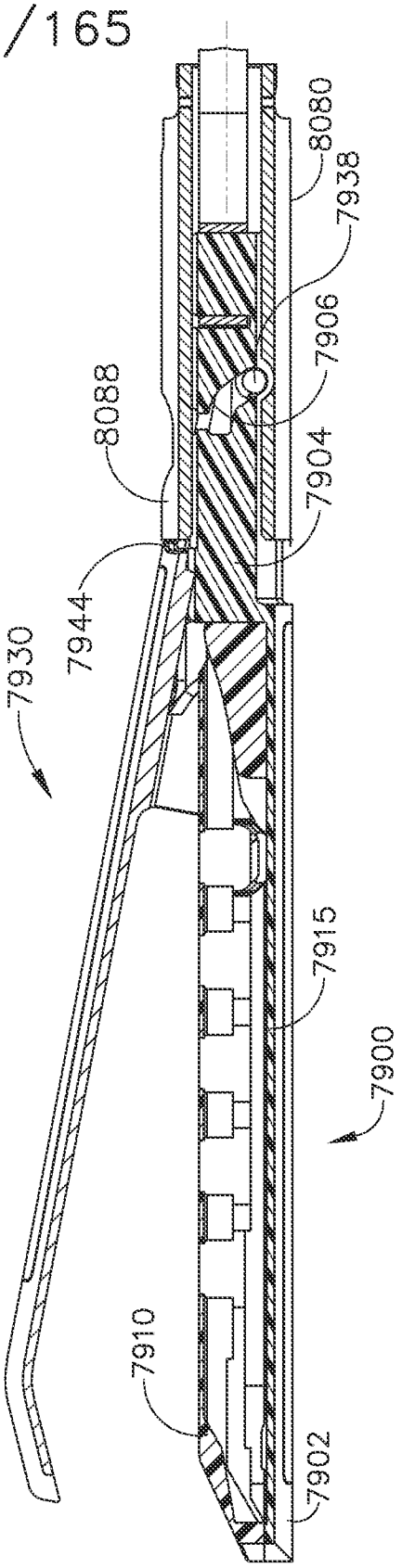

8080
7938
7906
8088
7904
7944
7930
7915
7900
7910
7902

FIG. 72

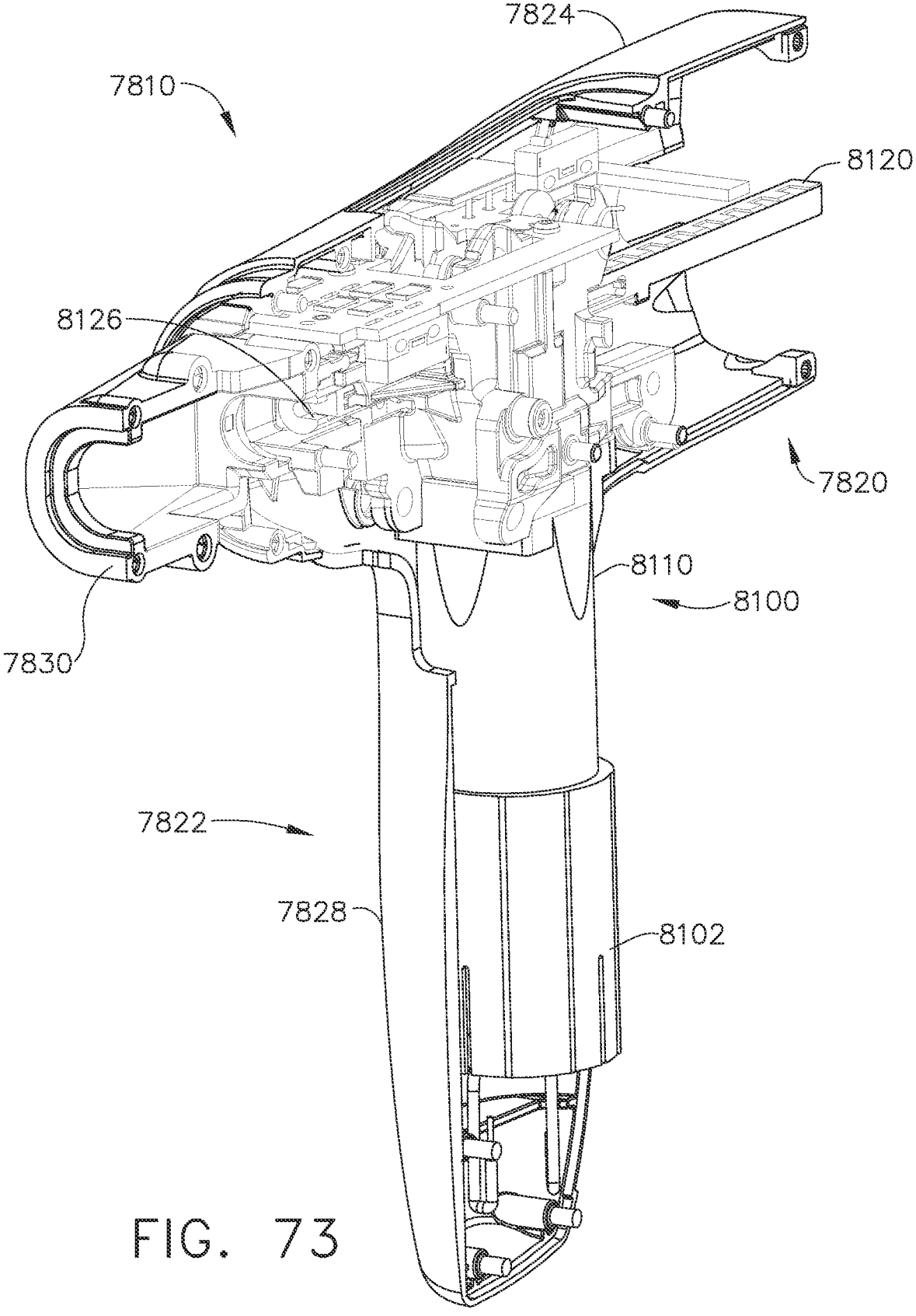


FIG. 73

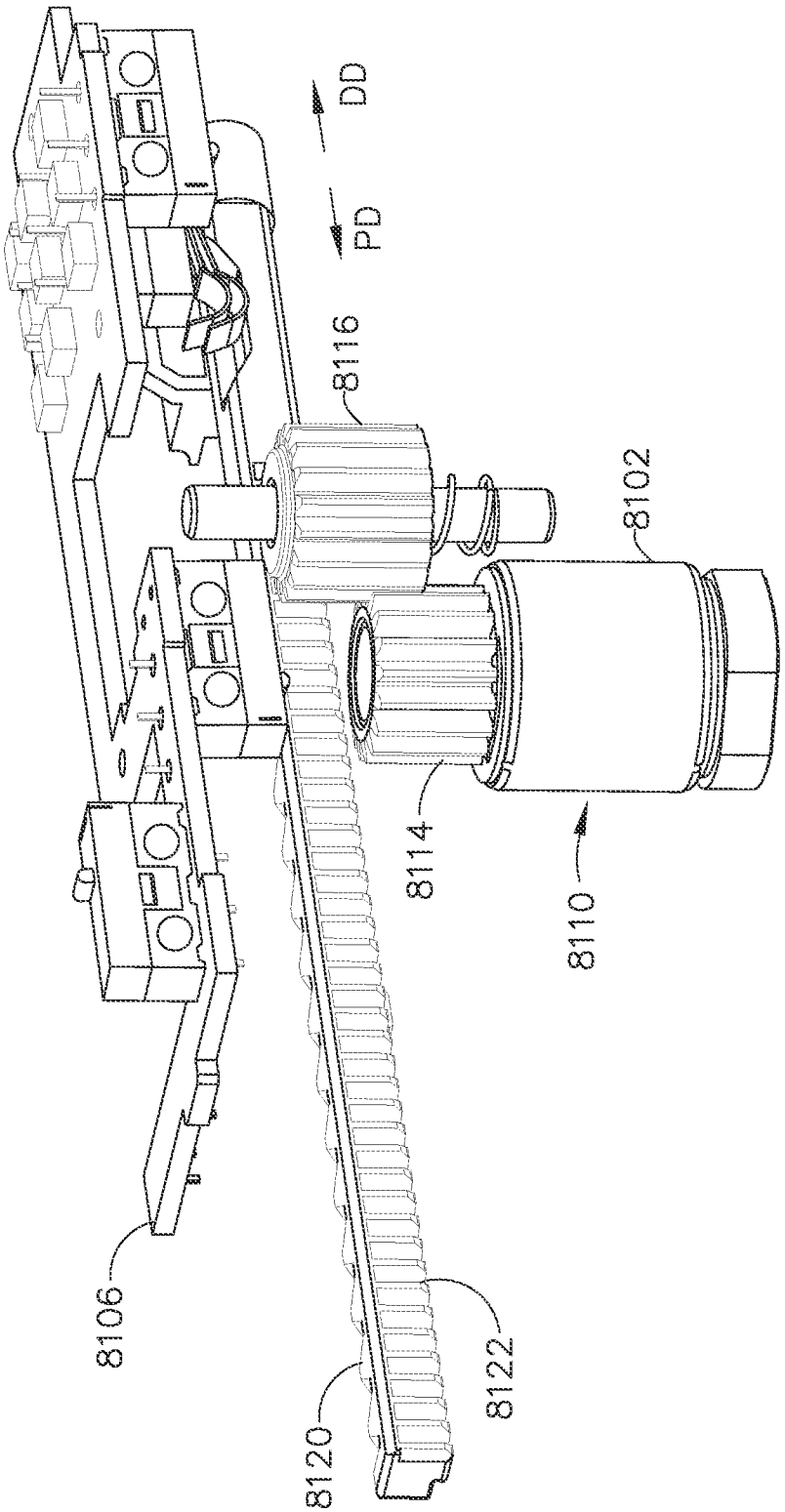


FIG. 74

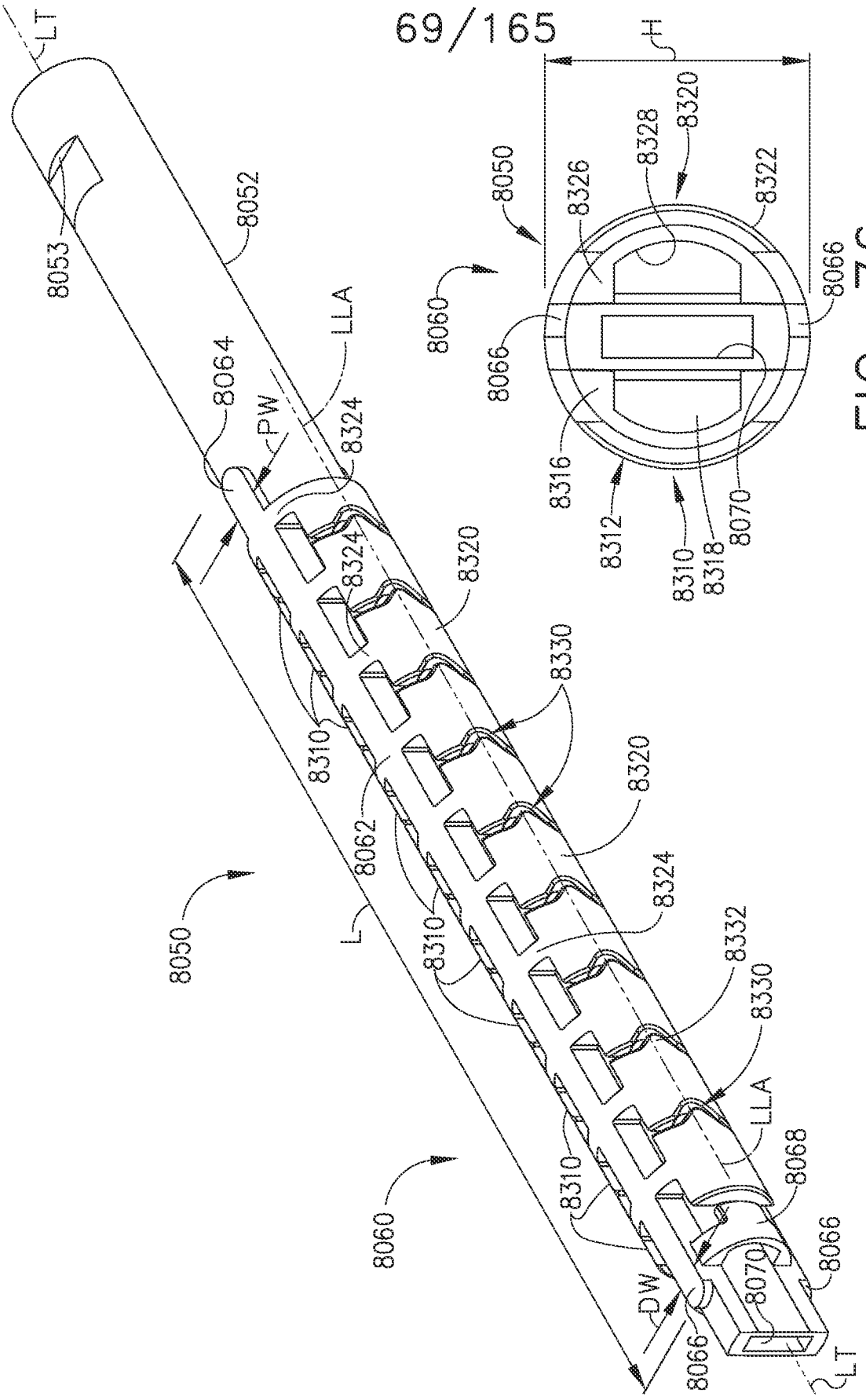

LT
8053
8052
8064
PW
LLA
8324
8320
8330
8310
8062
8050
L
8060
8332
8068
DW
8066
8070
H
8326
8328
8322
8316
8312
8310
8318

FIG. 75

FIG. 76

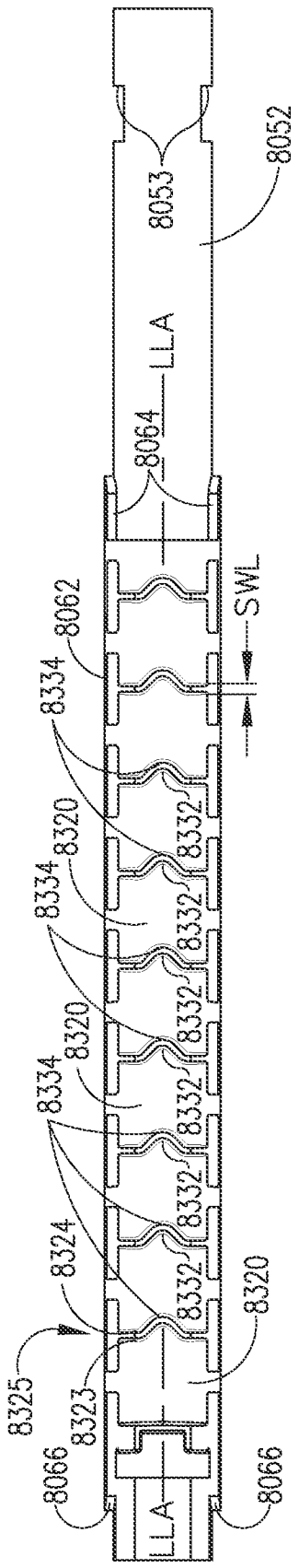

8052
8053
LLA
8064
SWL
8062
8334
8320
8332
8324
8325
8323
8066
LLA
8066
8320

FIG. 77

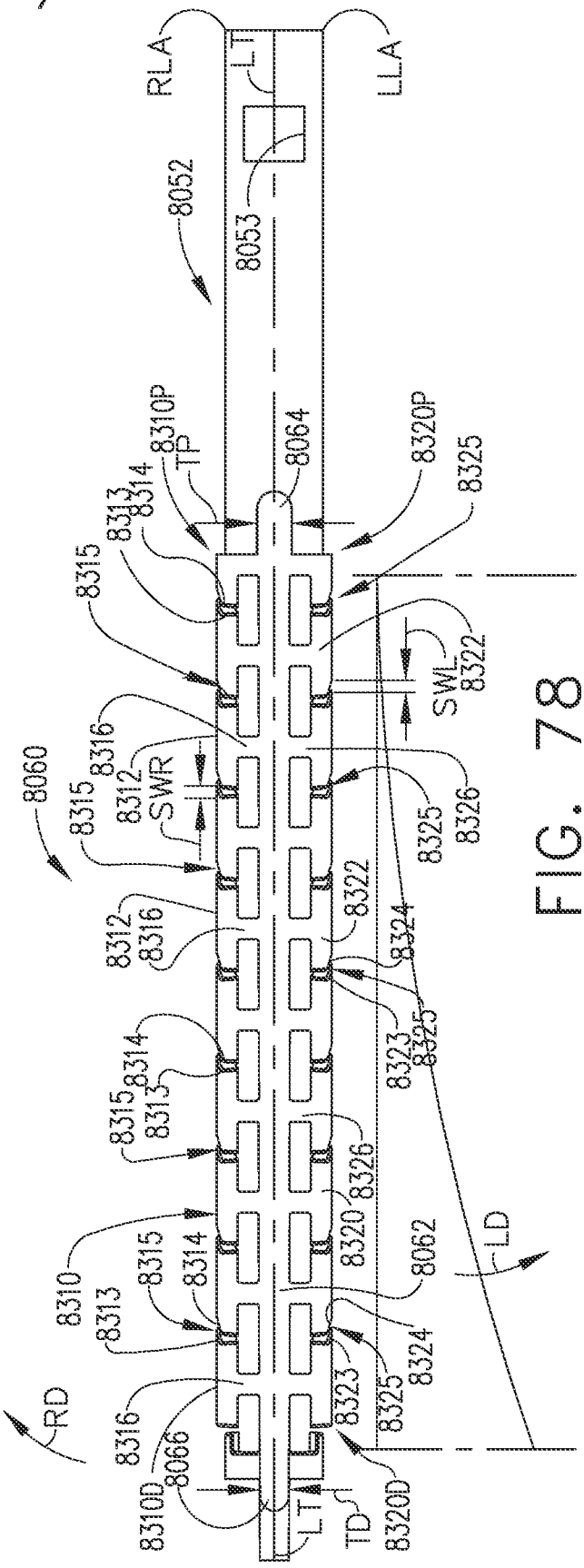

RLA
LT
LLA
8052
8053
8064
8310P
TP
8313
8314
8315
8320P
8325
8322
SWL
8316
8312
SWR
8060
8326
8324
8323
8310
8062
LD
RD
8310D
8066
LT
TD
8320D

FIG. 78

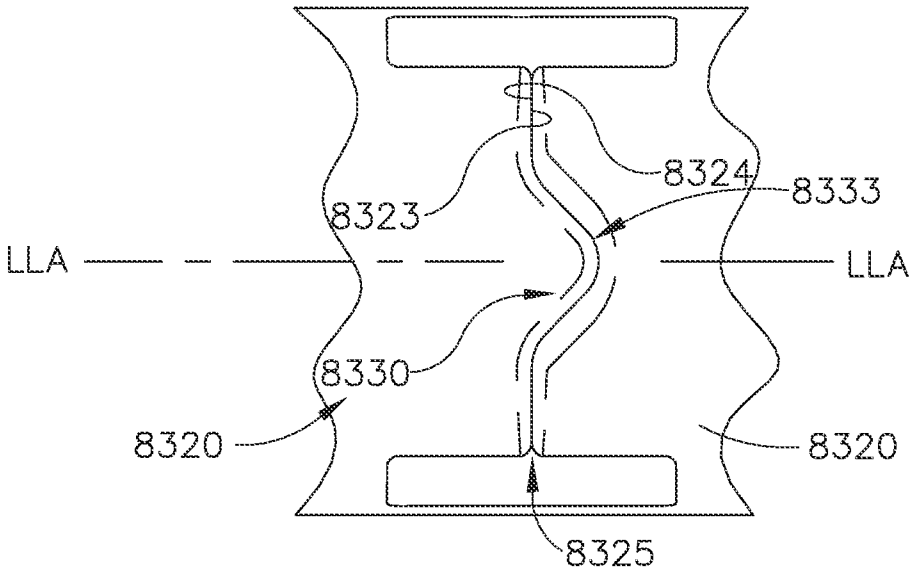


FIG. 79

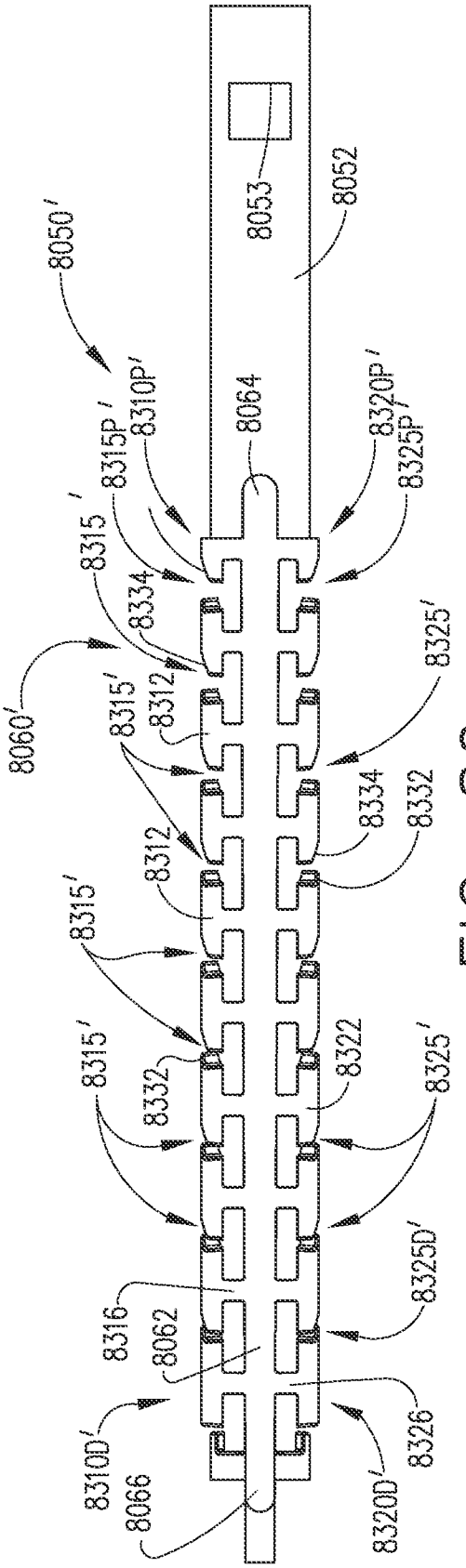

8050'
8053
8052
8064
8315P'
8310P'
8320P'
8325P'
8315'
8334
8060'
8312
8325'
8332
8322
8325D'
8316
8062
8310D'
8066
8326
8320D'

FIG. 80

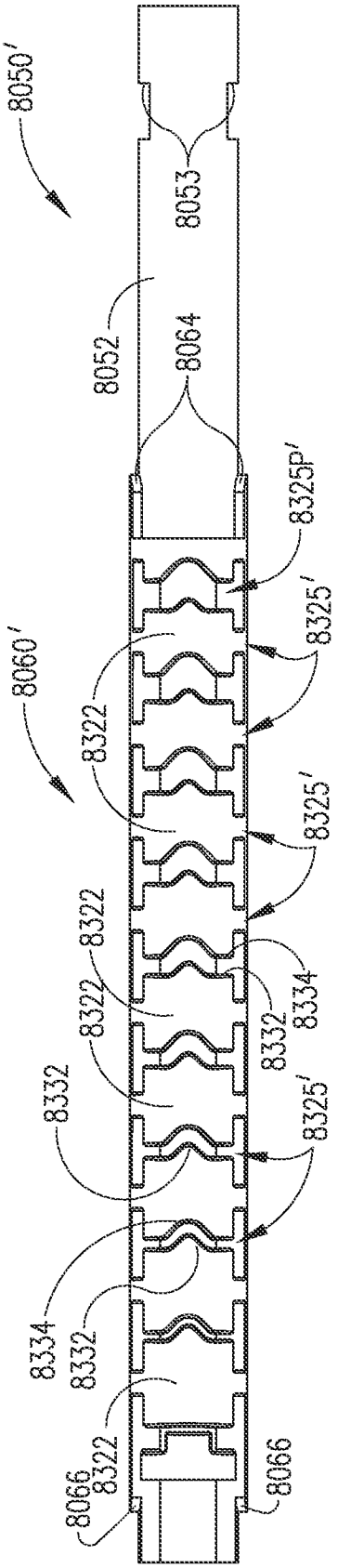

8050'
8053
8052
8064
8325P'
8325'
8060'
8322
8334
8332
8066

FIG. 81

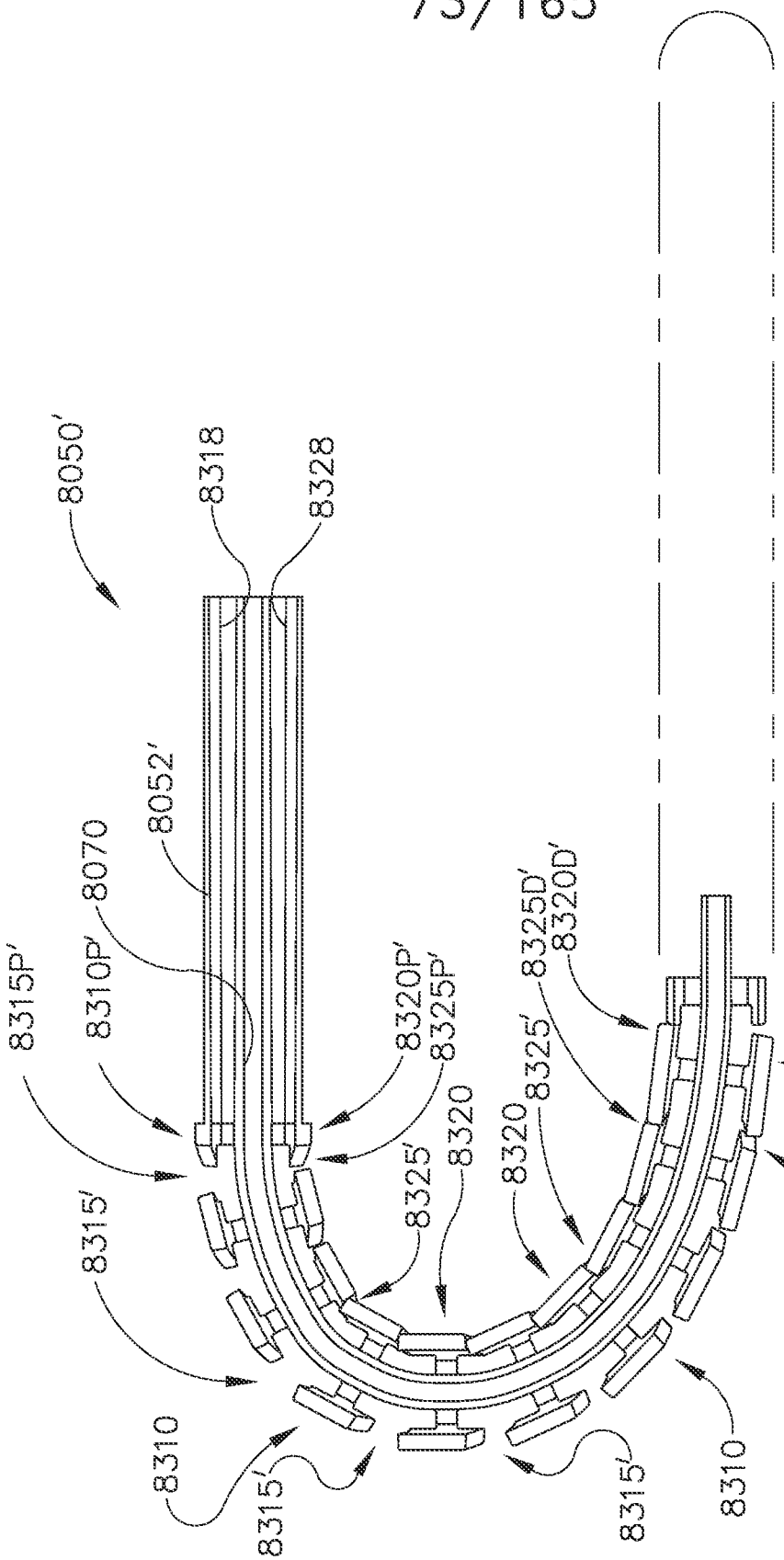

8050'
8318
8328
8052'
8070
8310P'
8315P'
8320P'
8325P'
8325D'
8320D'
8310D'
8325'
8320
8315'
8310
8315'
8315'
8310
8310D'

FIG. 82

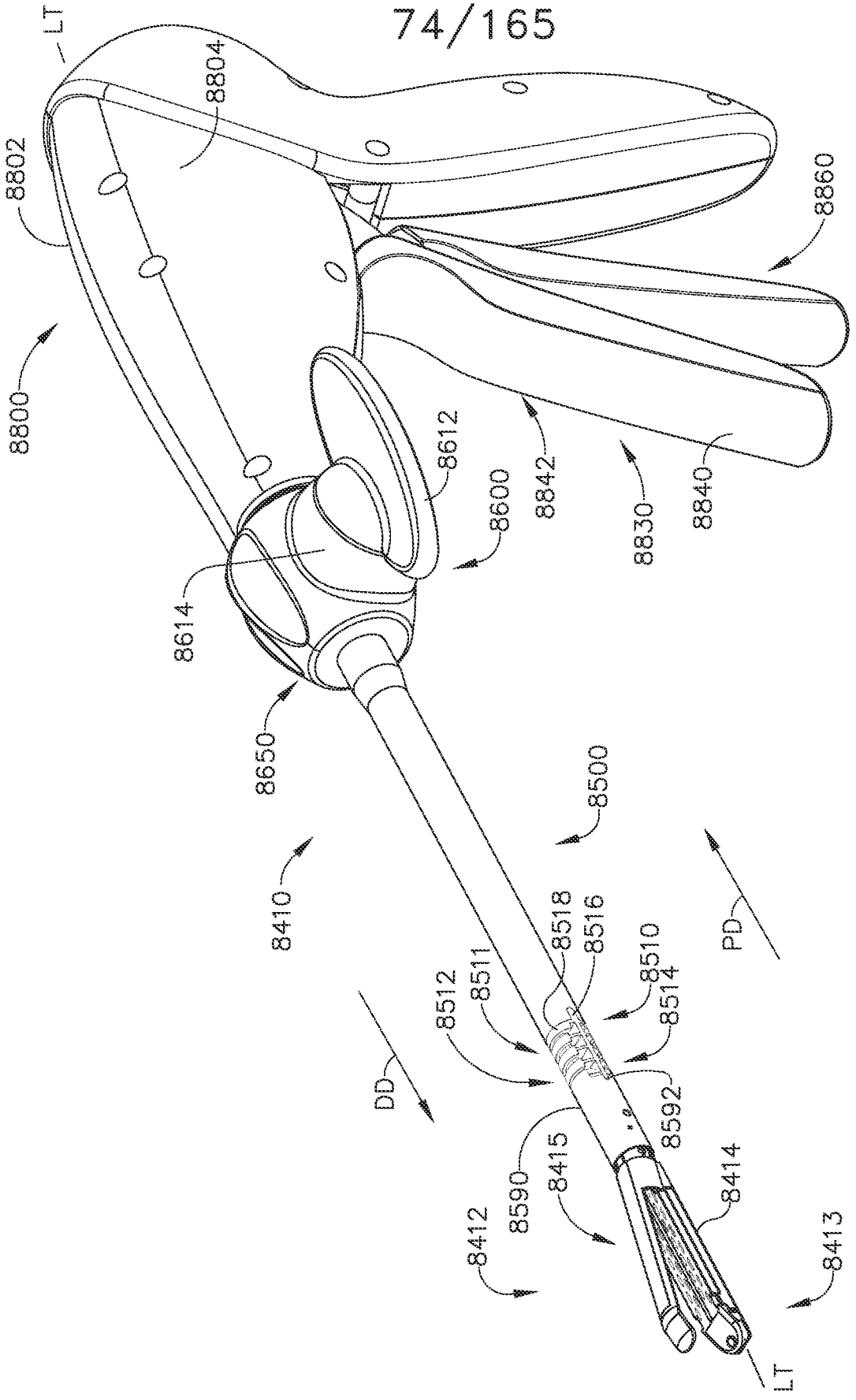

LT
8804
8802
8860
8800
8612
8600
8842
8840
8830
8614
8650
8500
8410
PD
8518
8516
8510
8511
8512
8514
DD
8592
8590
8415
8414
8412
8413
LT

FIG. 83

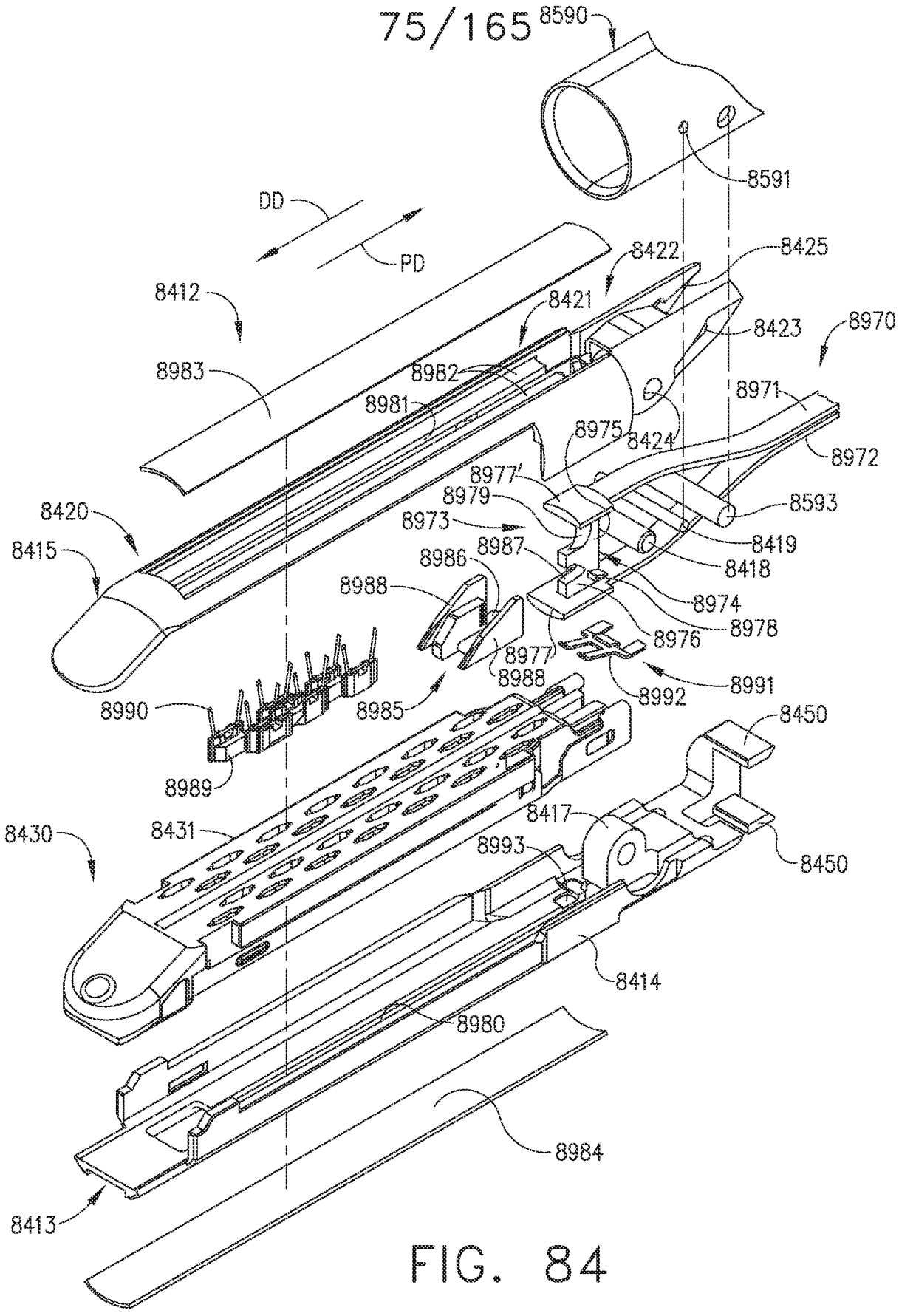

8590
8591
DD
PD
8422
8425
8412
8421
8423
8970
8983
8982
8971
8981
8975
8424
8972
8977
8979
8593
8420
8973
8419
8415
8987
8986
8418
8988
8974
8978
8976
8977
8988
8991
8990
8985
8992
8450
8989
8417
8430
8431
8993
8450
8414
8980
8984
8413

FIG. 84

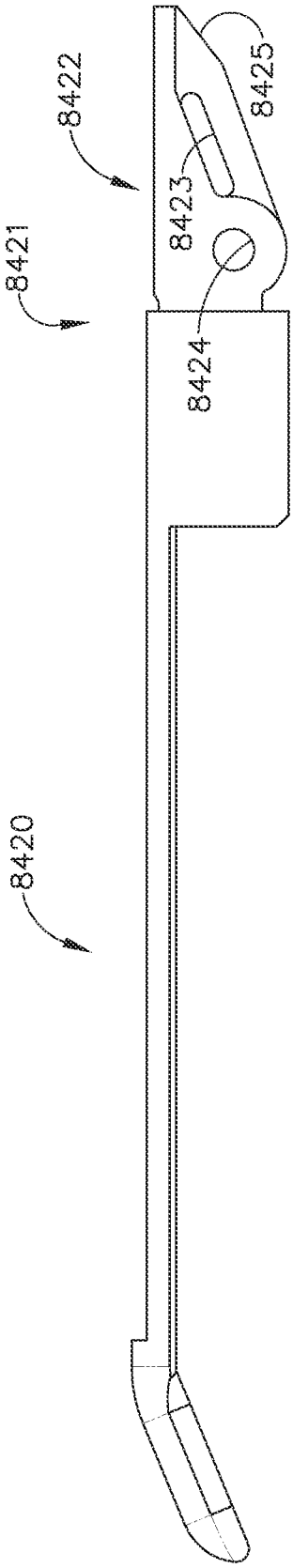


FIG. 85

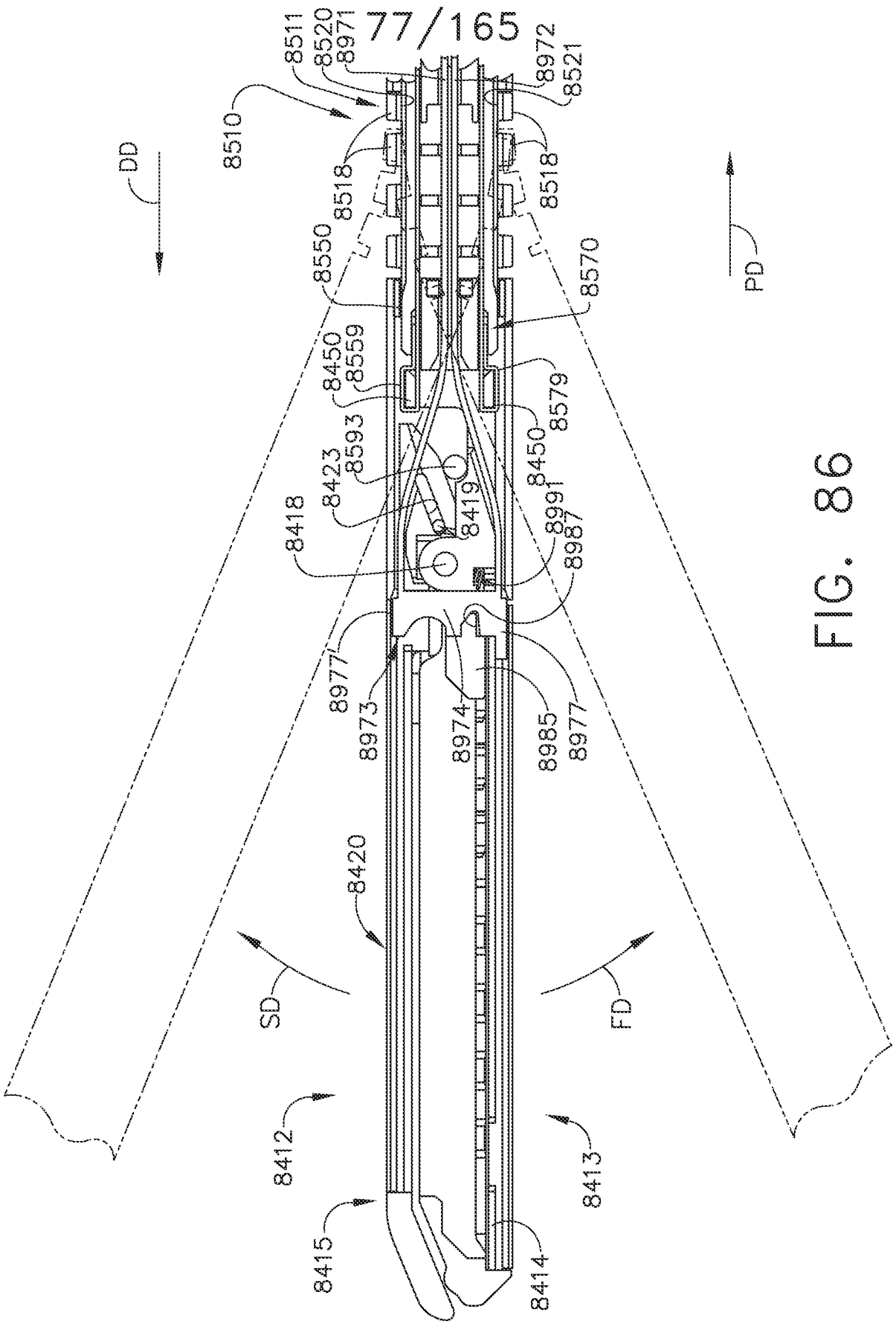

8511
8520
8971
8510
8972
8521
DD
PD
8518
8518
8550
8570
8450
8559
8579
8593
8450
8423
8419
8991
8418
8987
8977
8973
8974
8985
8977
8420
SD
FD
8412
8413
8415
8414

FIG. 86

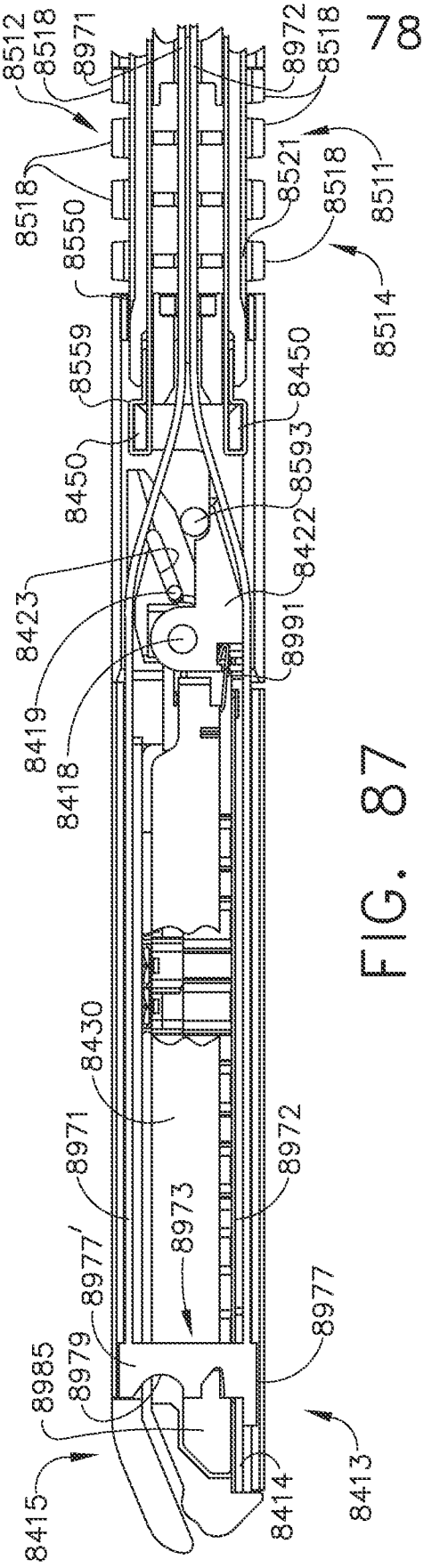

8512
8518
8971
8518
8972
8518
8521
8518
8511
8514
8550
8559
8450
8450
8593
8422
8423
8991
8419
8418
8430
8971
8972
8973
8977'
8977
8979
8985
8415
8414
8413

FIG. 87

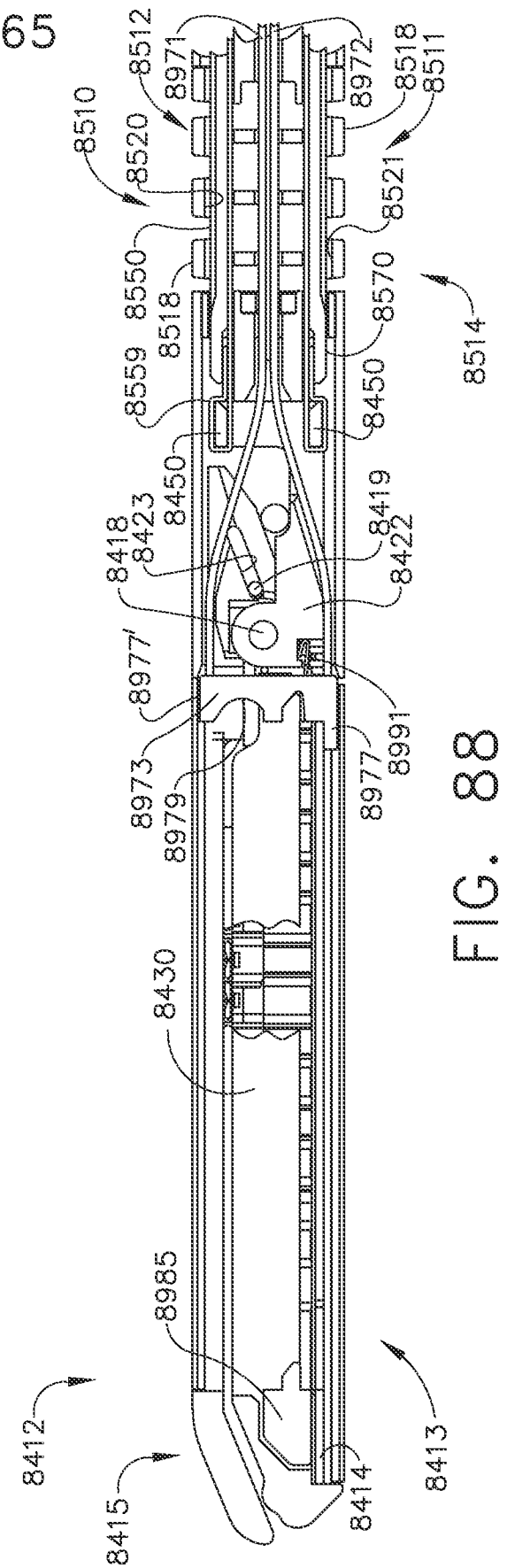

8510
8520
8512
8971
8972
8518
8511
8521
8550
8570
8514
8559
8518
8450
8450
8423
8418
8419
8422
8977'
8973
8979
8991
8977
8430
8985
8412
8415
8414
8413

FIG. 88

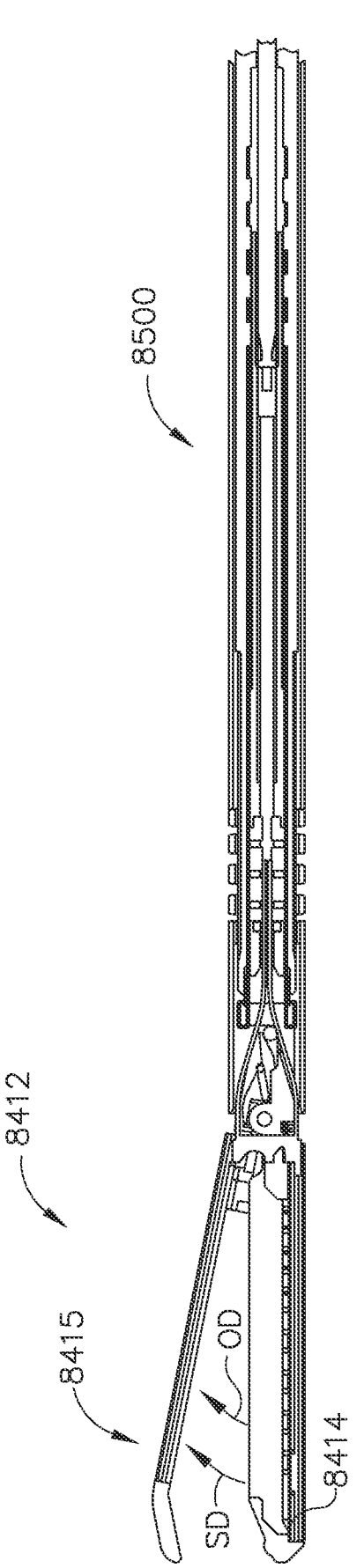

8500
8412
8415
OD
SD
8414

FIG. 89

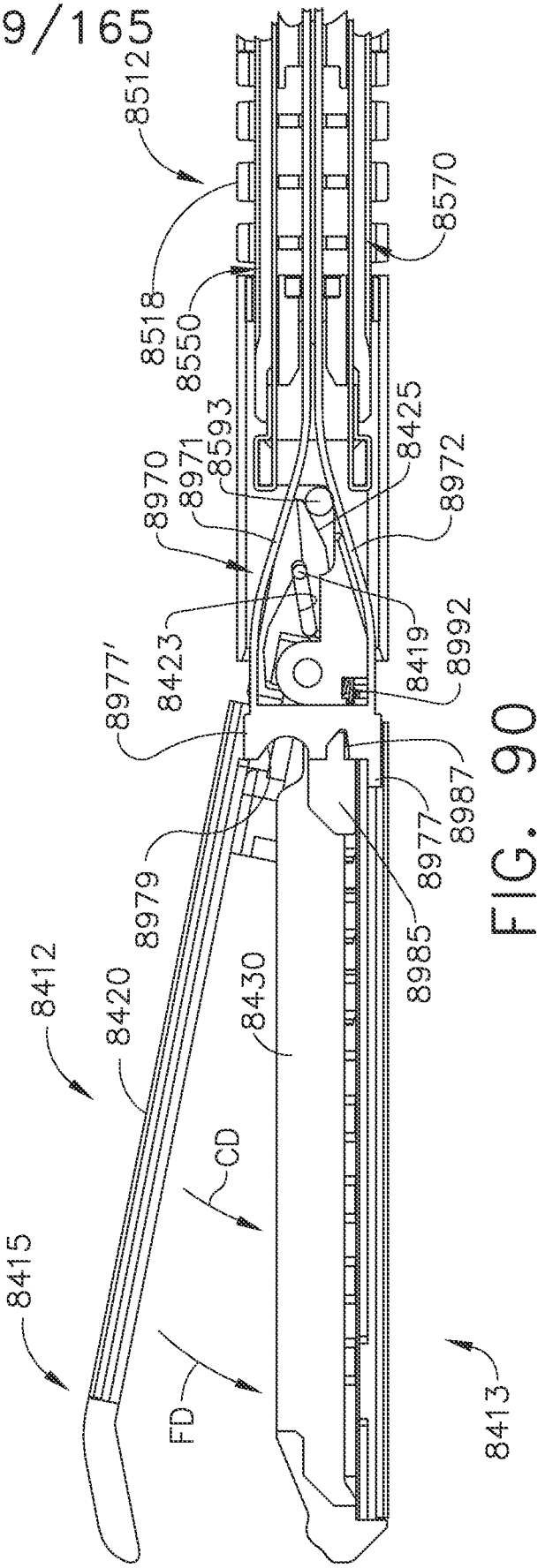

85125
8570
8518
8550
8593
8425
8970
8971
8972
8977'
8423
8419
8992
8987
8977
8985
8979
8412
8420
8430
CD
8415
FD
8413

FIG. 90

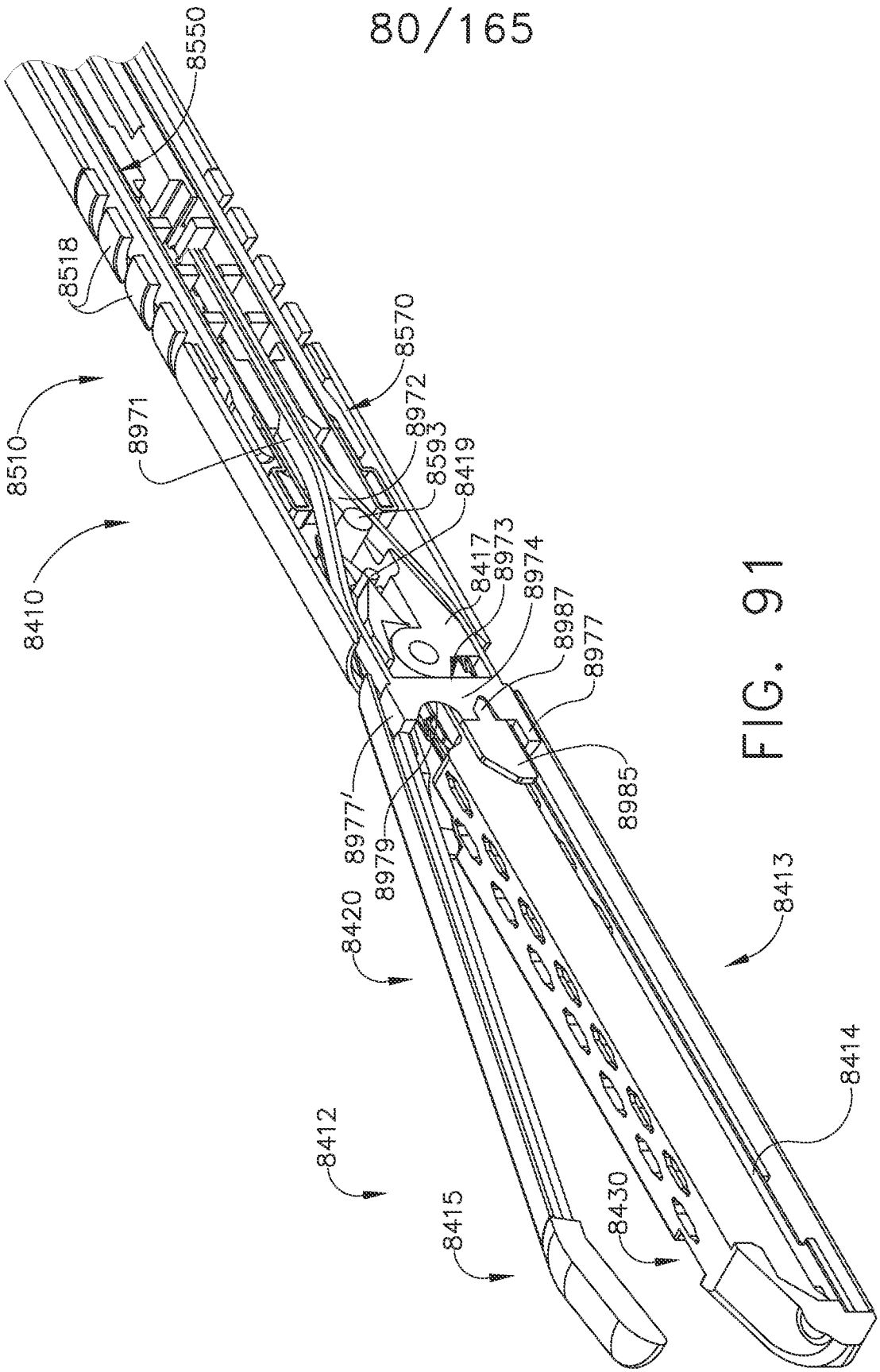

8550
8518
8570
8510
8971
8972
8593
8419
8410
8417
8973
8974
8987
8977
8985
8977'
8979
8420
8413
8414
8412
8430
8415

FIG. 91

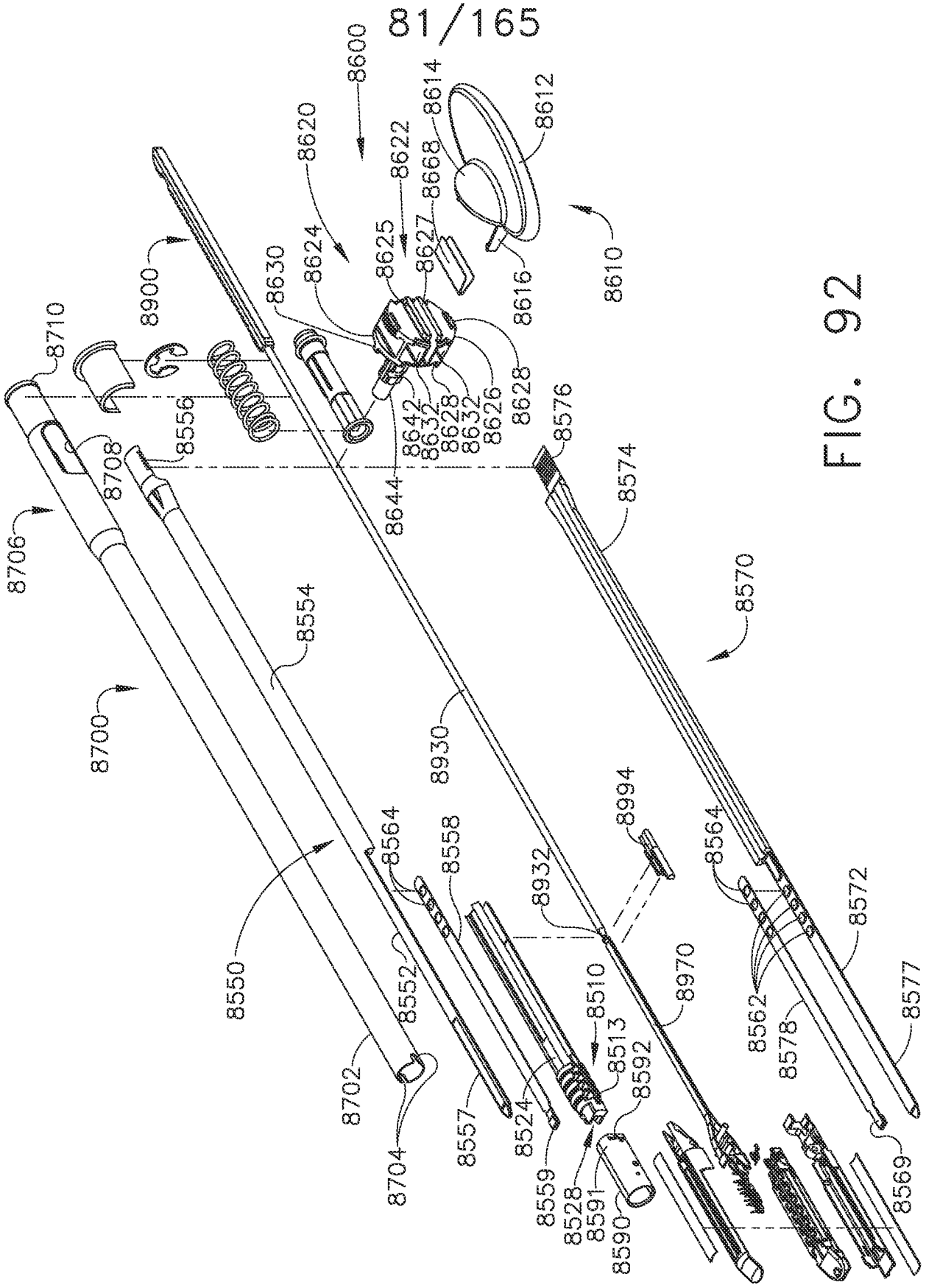

8600
8620
8622
8614
8612
8668
8624
8625
8627
8630
8900
8616
8610
8710
8628
8626
8632
8642
8644
8556
8708
8576
8574
8706
8554
8570
8700
8930
8994
8564
8558
8932
8572
8550
8552
8510
8970
8562
8513
8592
8577
8578
8702
8704
8557
8524
8559
8528
8591
8590
8569

FIG. 92

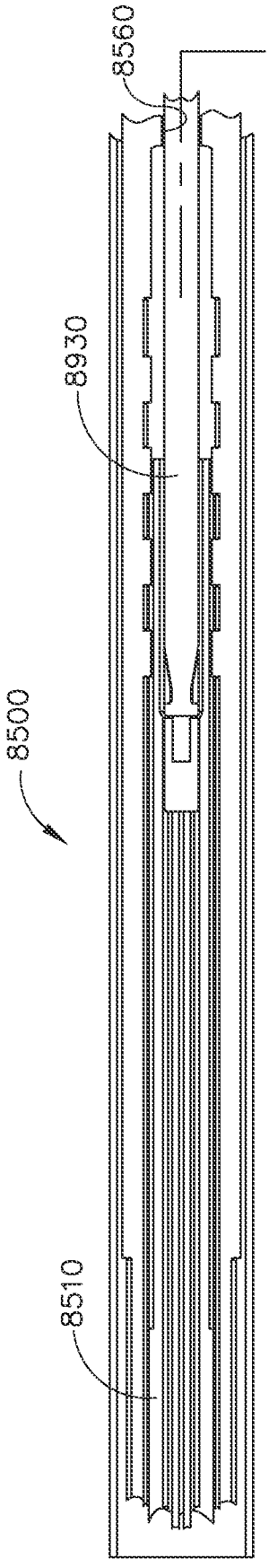

8560
8930
8500
8510

FIG. 93

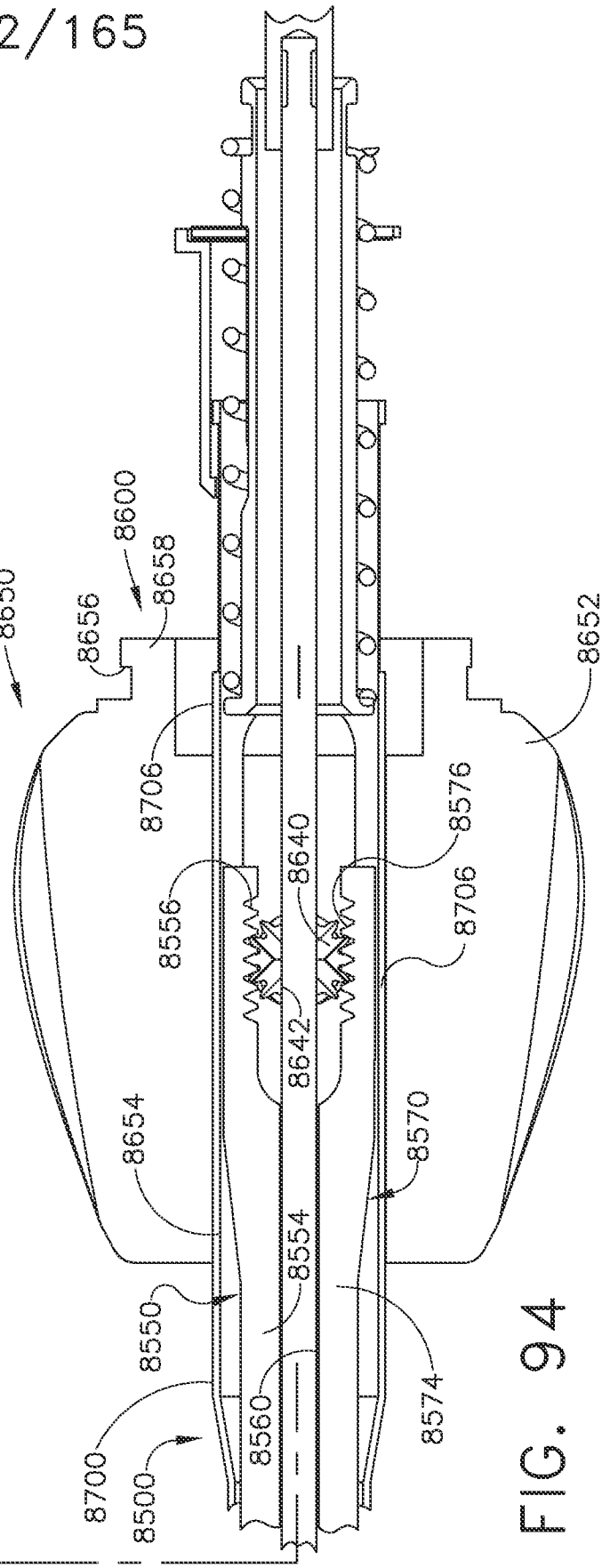

8650
8600
8658
8656
8652
8706
8576
8640
8556
8706
8642
8654
8570
8554
8550
8574
8560
8700
8500

FIG. 94

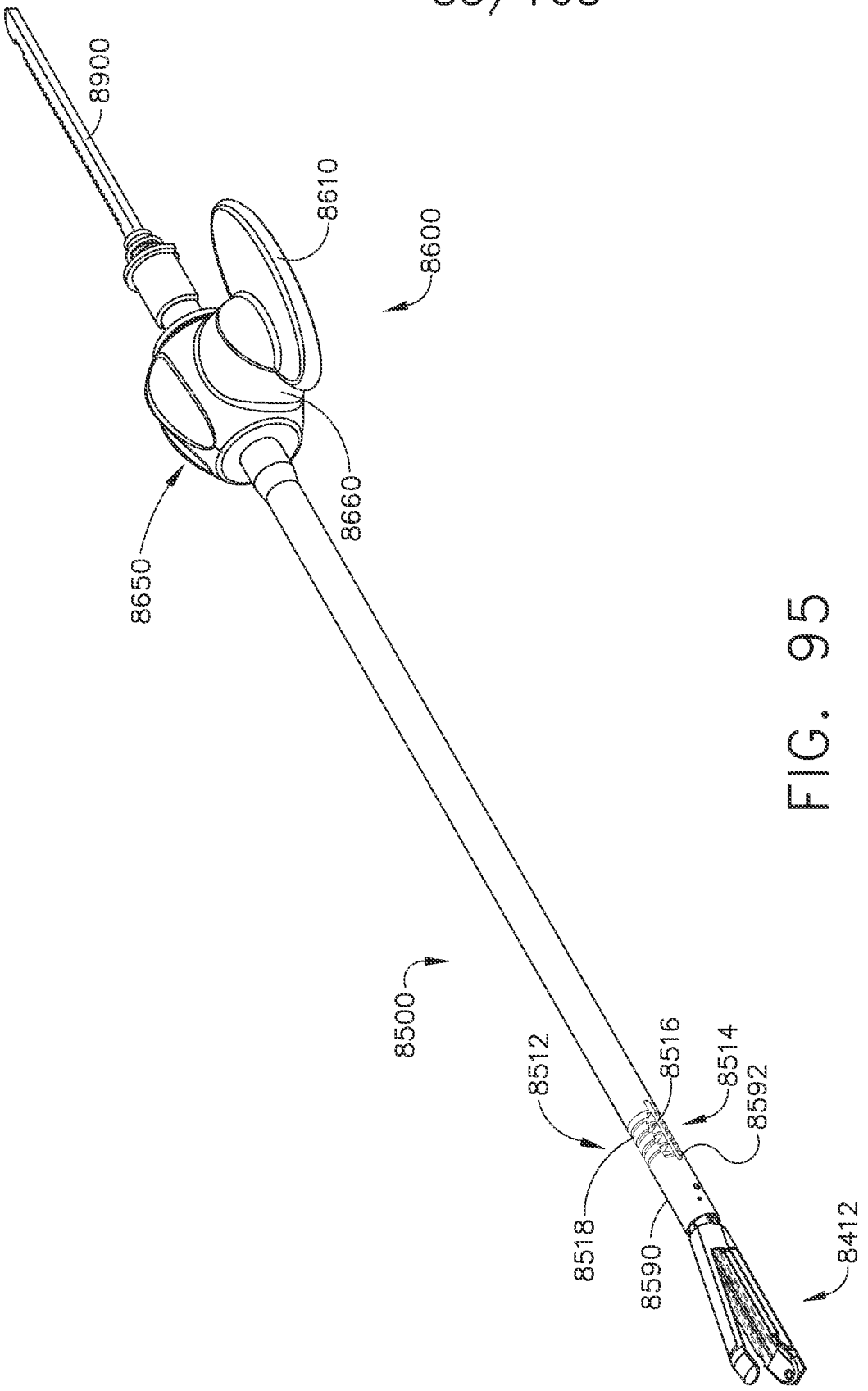

8900
8610
8600
8660
8650
8500
8512
8516
8514
8592
8518
8590
8412

FIG. 95

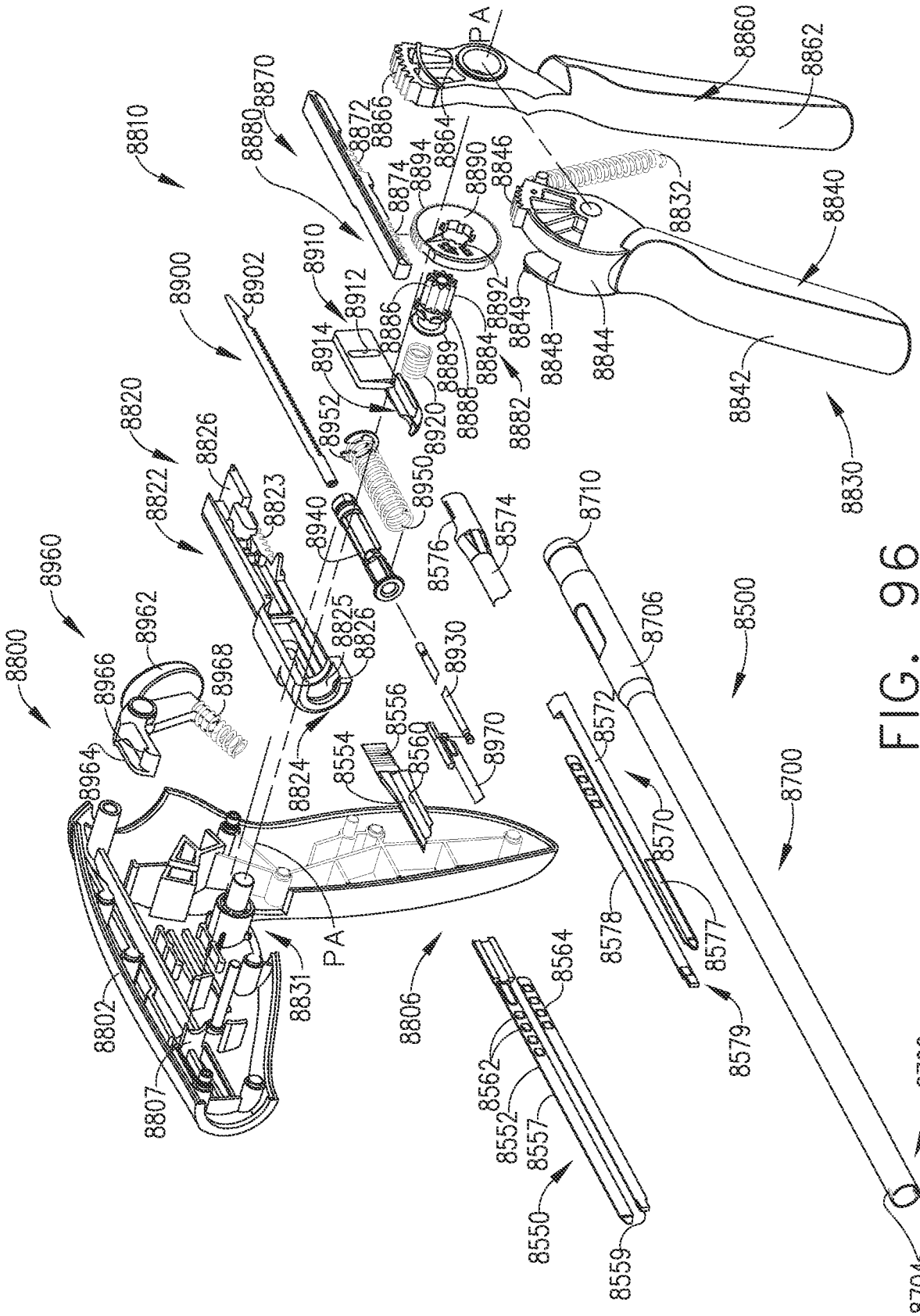

8800
8802
8806
8807
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8840
8842
8844
8846
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8860
8862
8864
8866
8870
8872
8874
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8884
8886
8888
8889
8890
8892
8894
8900
8902
8910
8912
8914
8920
8930
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8950
8952
8960
8962
8964
8966
8968
8970
8500
8550
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8554
8556
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8559
8560
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8564
8570
8572
8574
8576
8577
8578
8579
8700
8702
8704
8706
8710
PA

FIG. 96

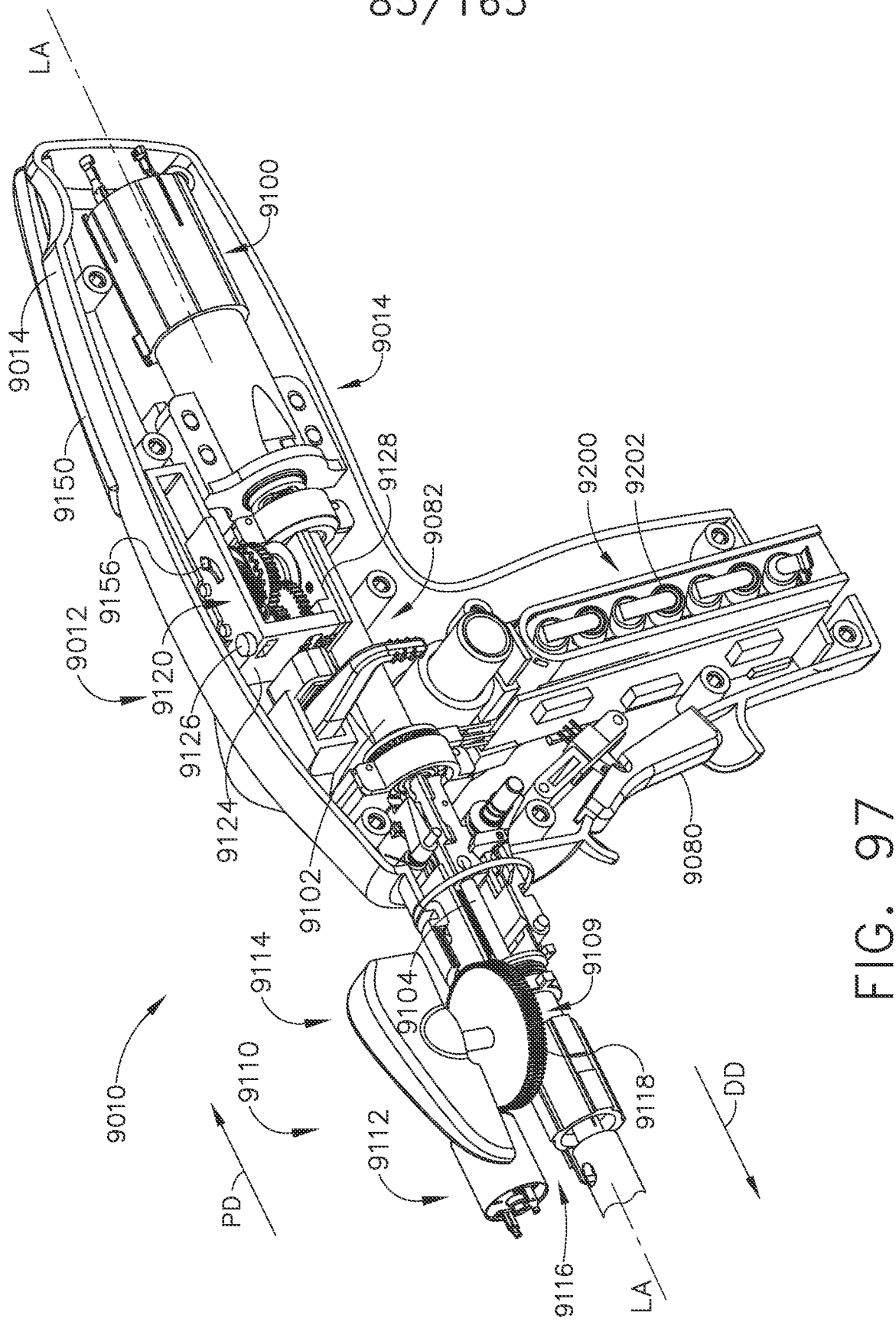

LA
9100
9014
9014
9150
9128
9082
9200
9202
9156
9012
9120
9126
9124
9102
9080
9114
9104
9109
9010
9110
9118
DD
9112
PD
9116
LA

FIG. 97

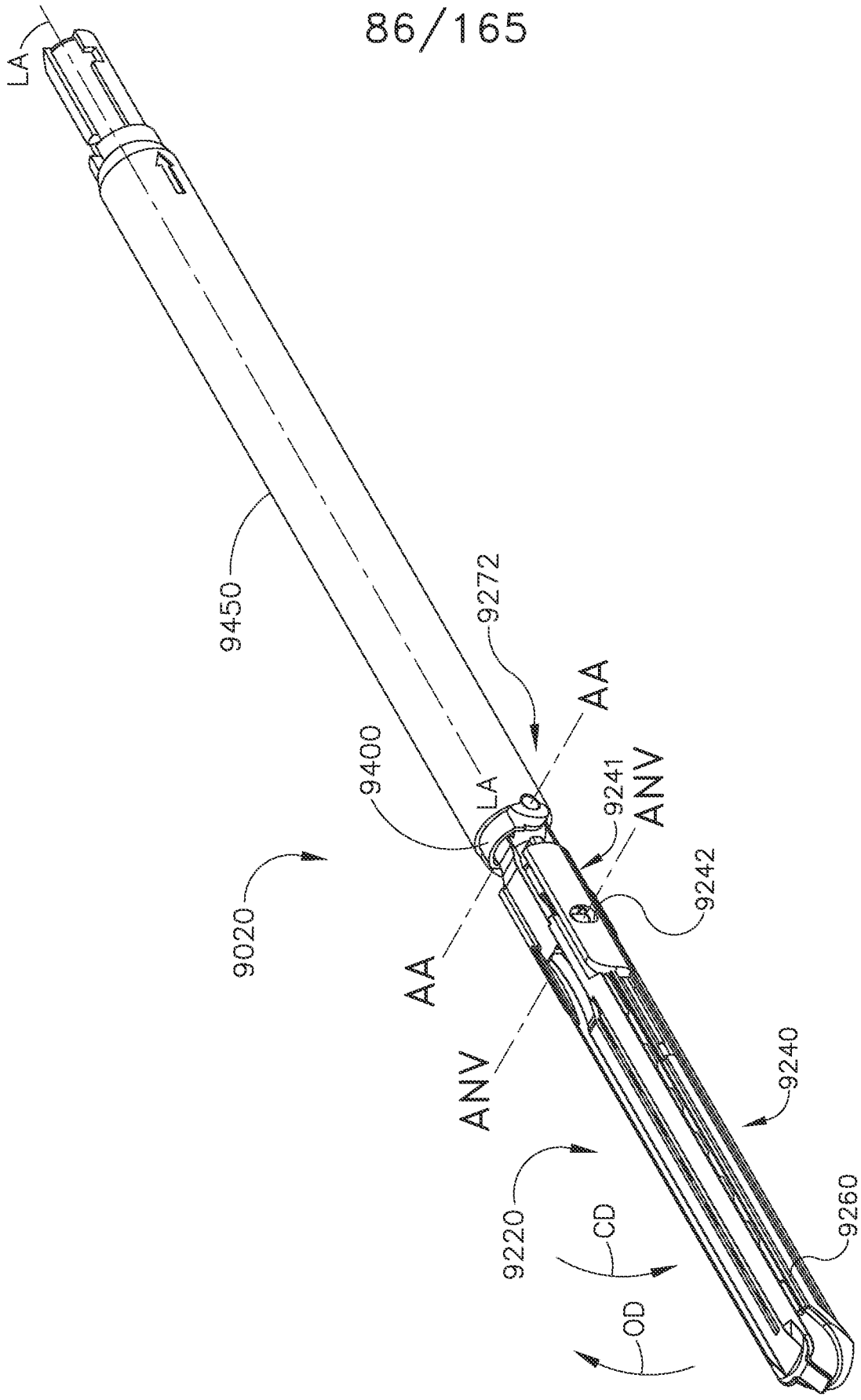

LA
9450
9272
AA
9400
LA
9241
ANV
9242
9020
AA
ANV
9240
9220
CD
OD
9260

FIG. 98

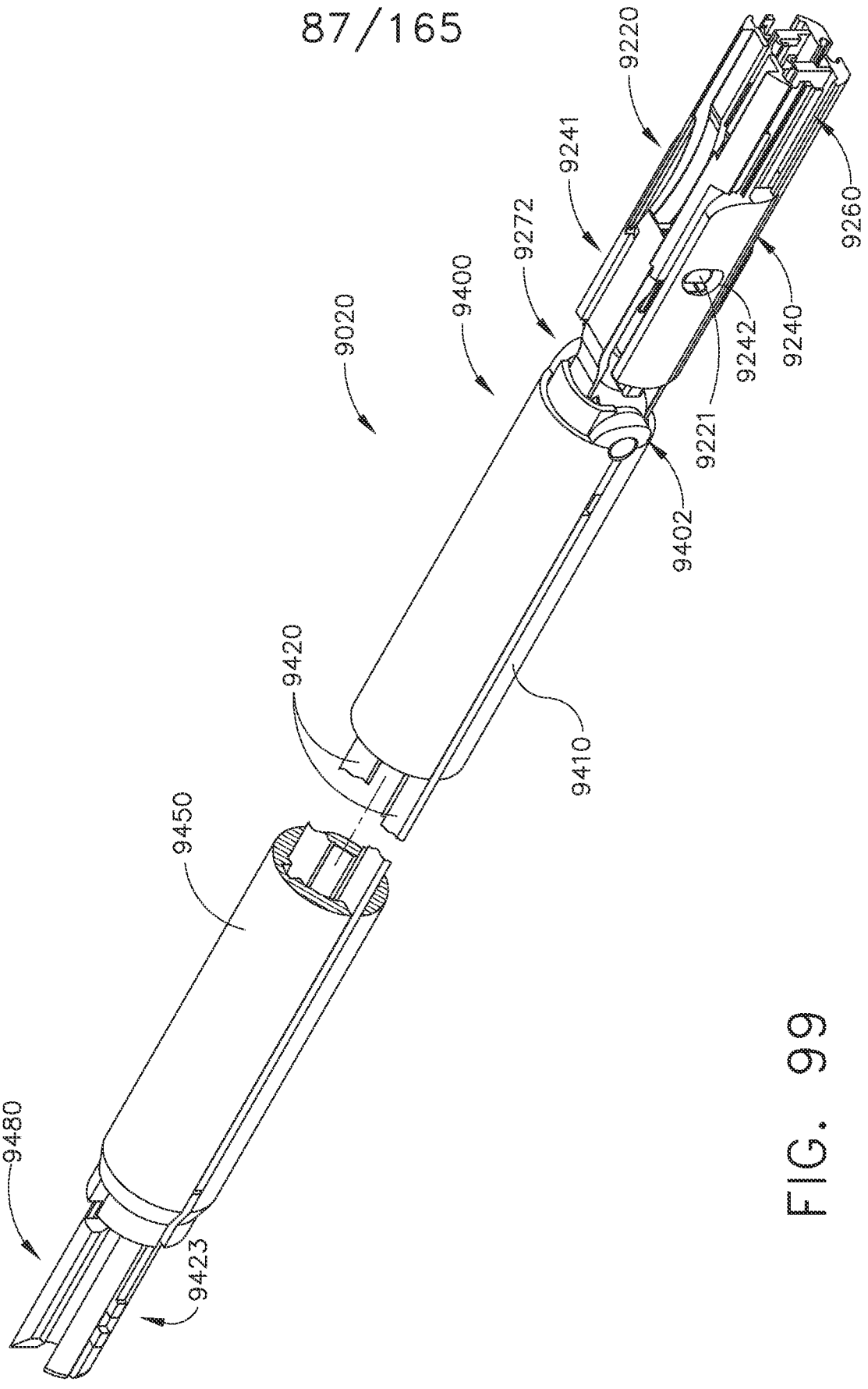

9220
9241
9260
9272
9400
9240
9020
9242
9221
9402
9420
9410
9450
9480
9423

FIG. 99

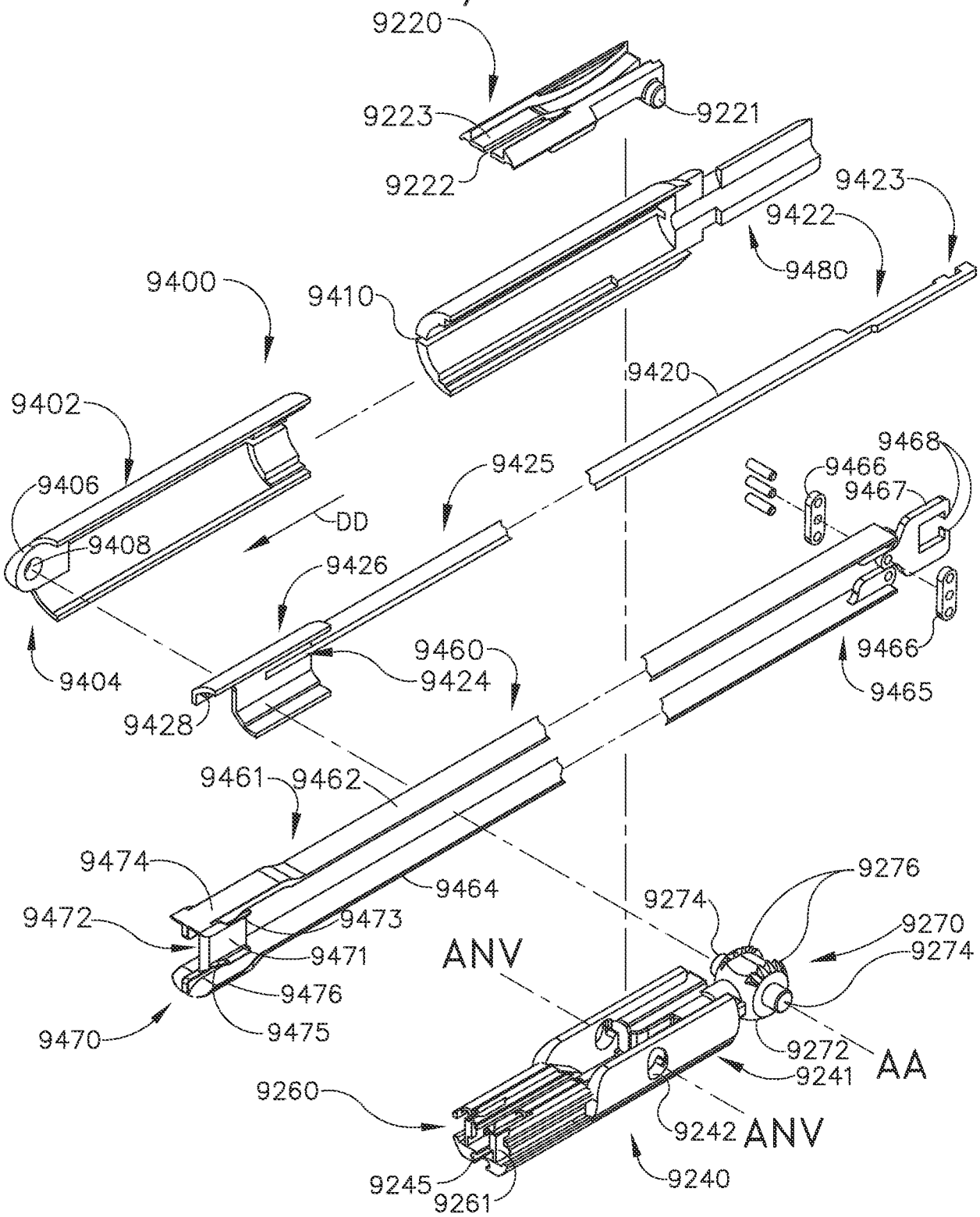

9220
9223
9221
9222
9423
9422
9480
9400
9410
9420
9402
9406
9425
9468
9466
9467
DD
9408
9426
9404
9460
9424
9466
9465
9428
9461
9462
9474
9464
9276
9274
9472
9473
9270
9274
ANV
9471
9476
9470
9475
9272
AA
9241
9260
9242
ANV
9245
9261
9240

FIG. 100

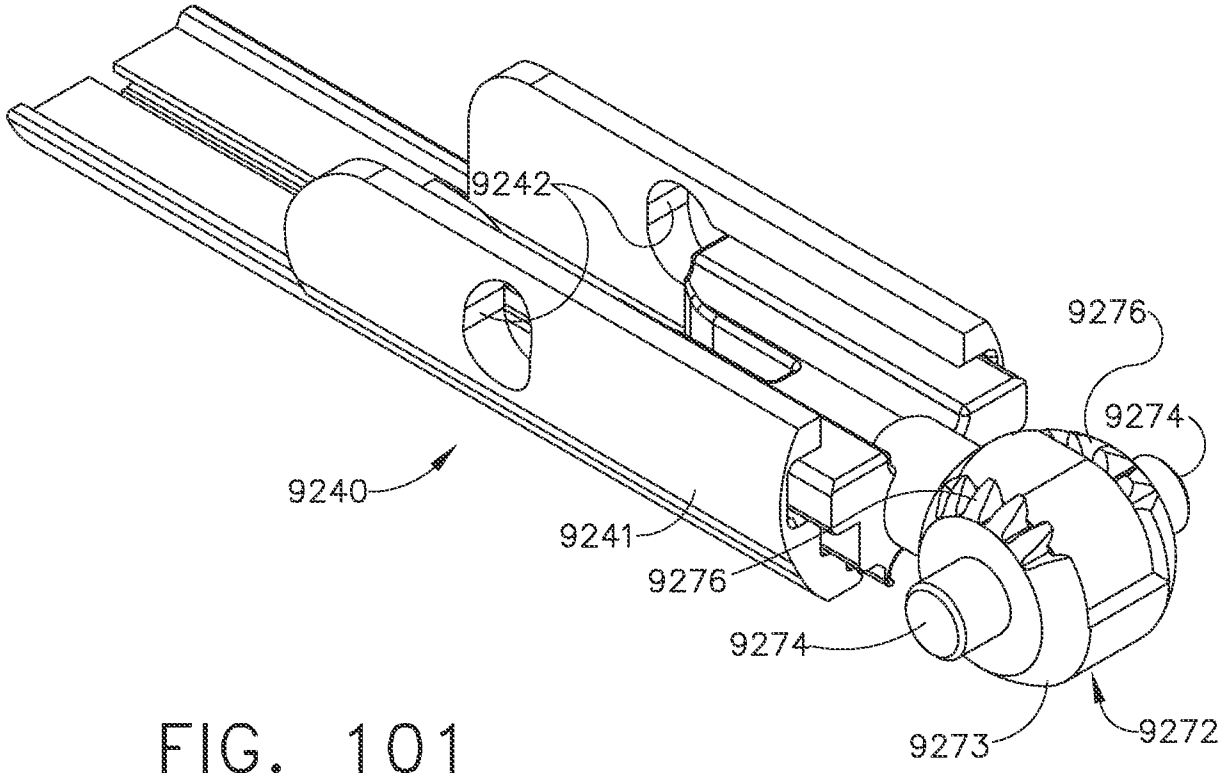


FIG. 101

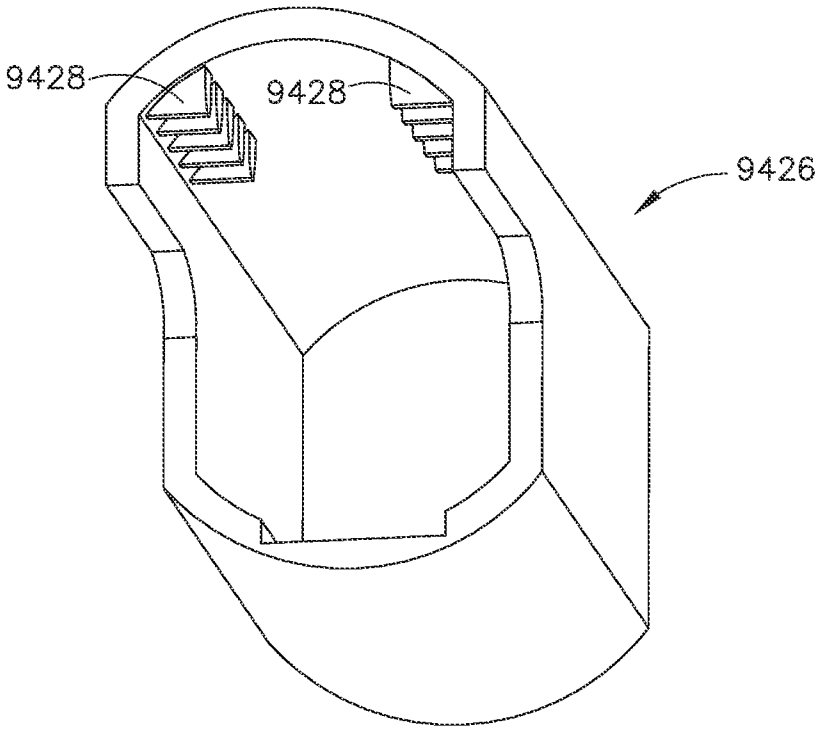


FIG. 102

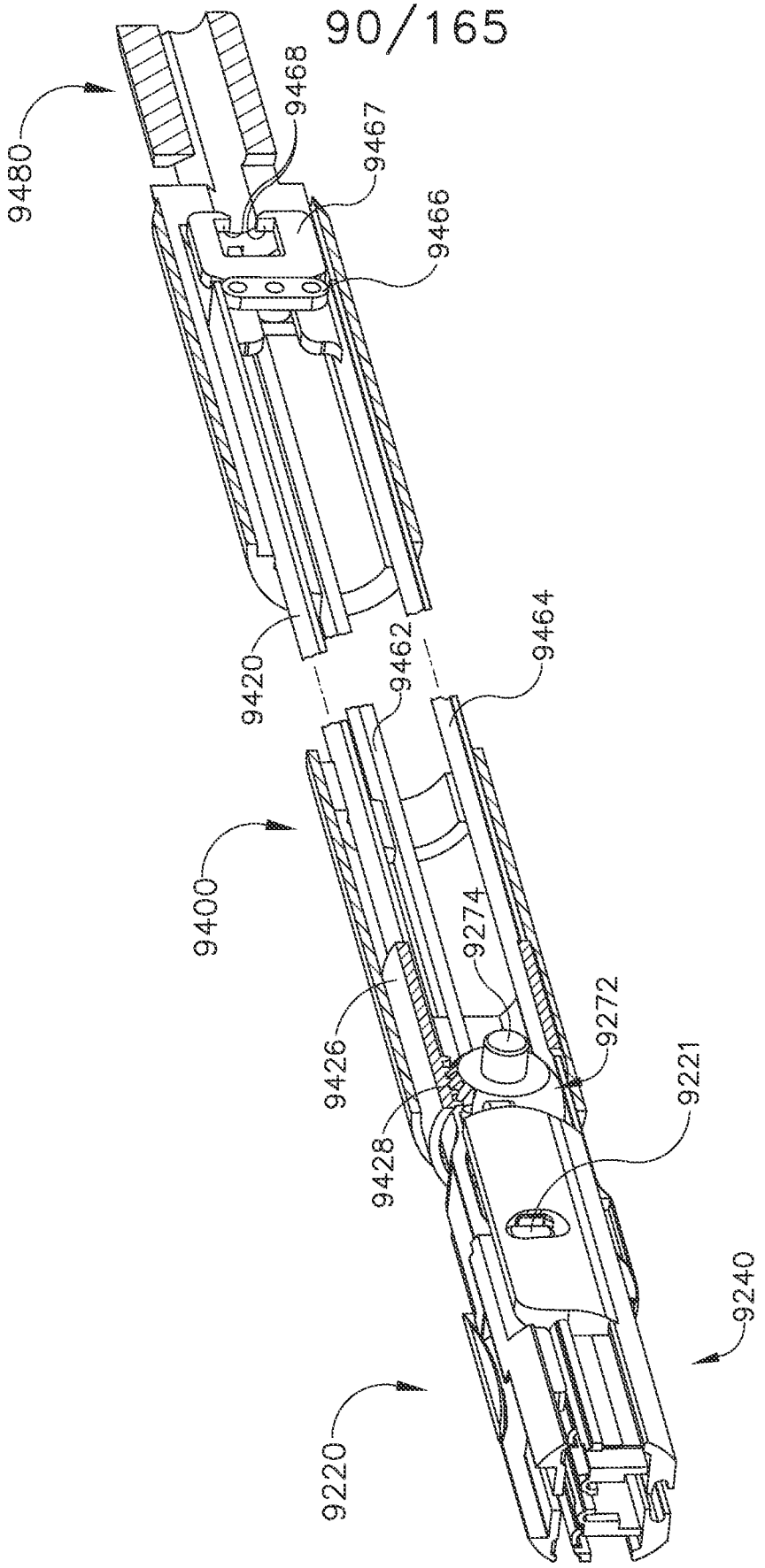

9480
9468
9467
9466
9420
9462
9464
9400
9274
9272
9426
9221
9428
9240
9220

FIG. 103

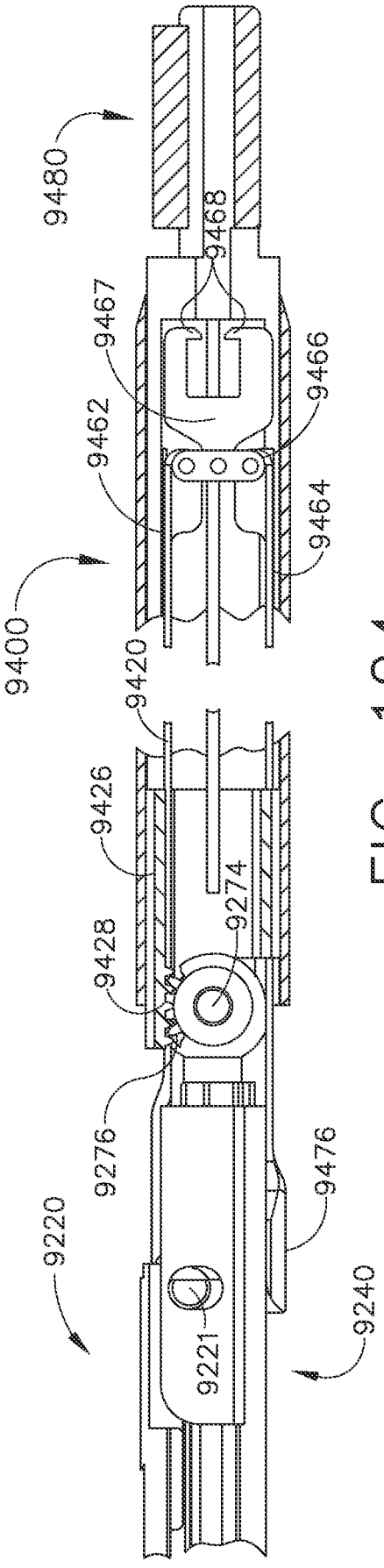


FIG. 104

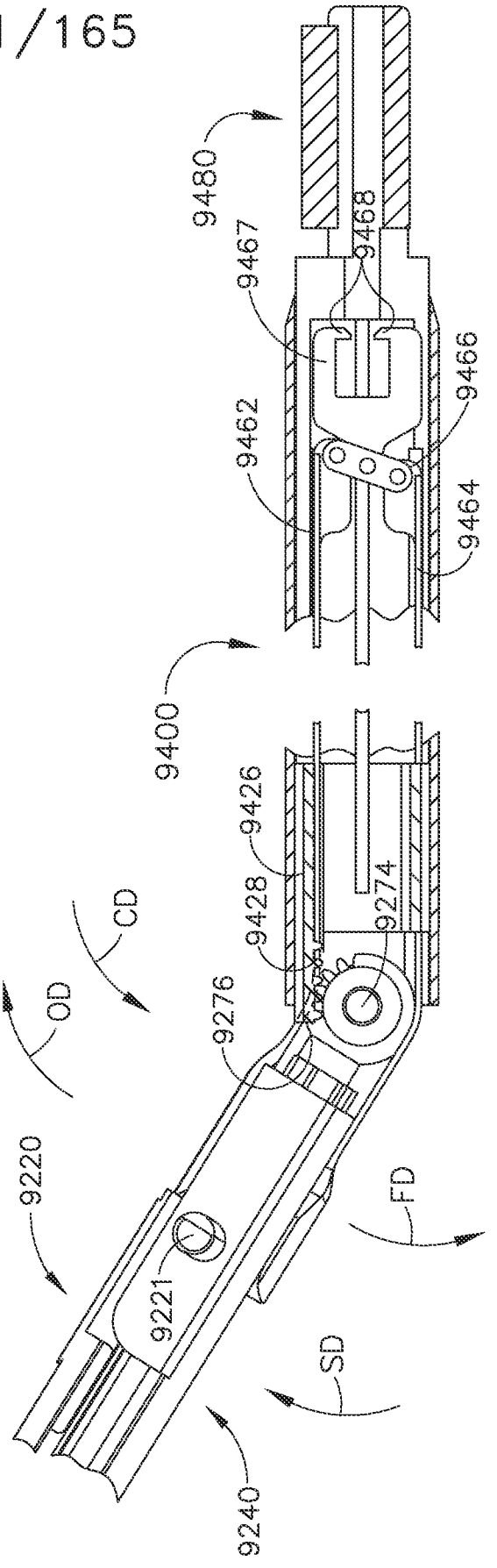


FIG. 105

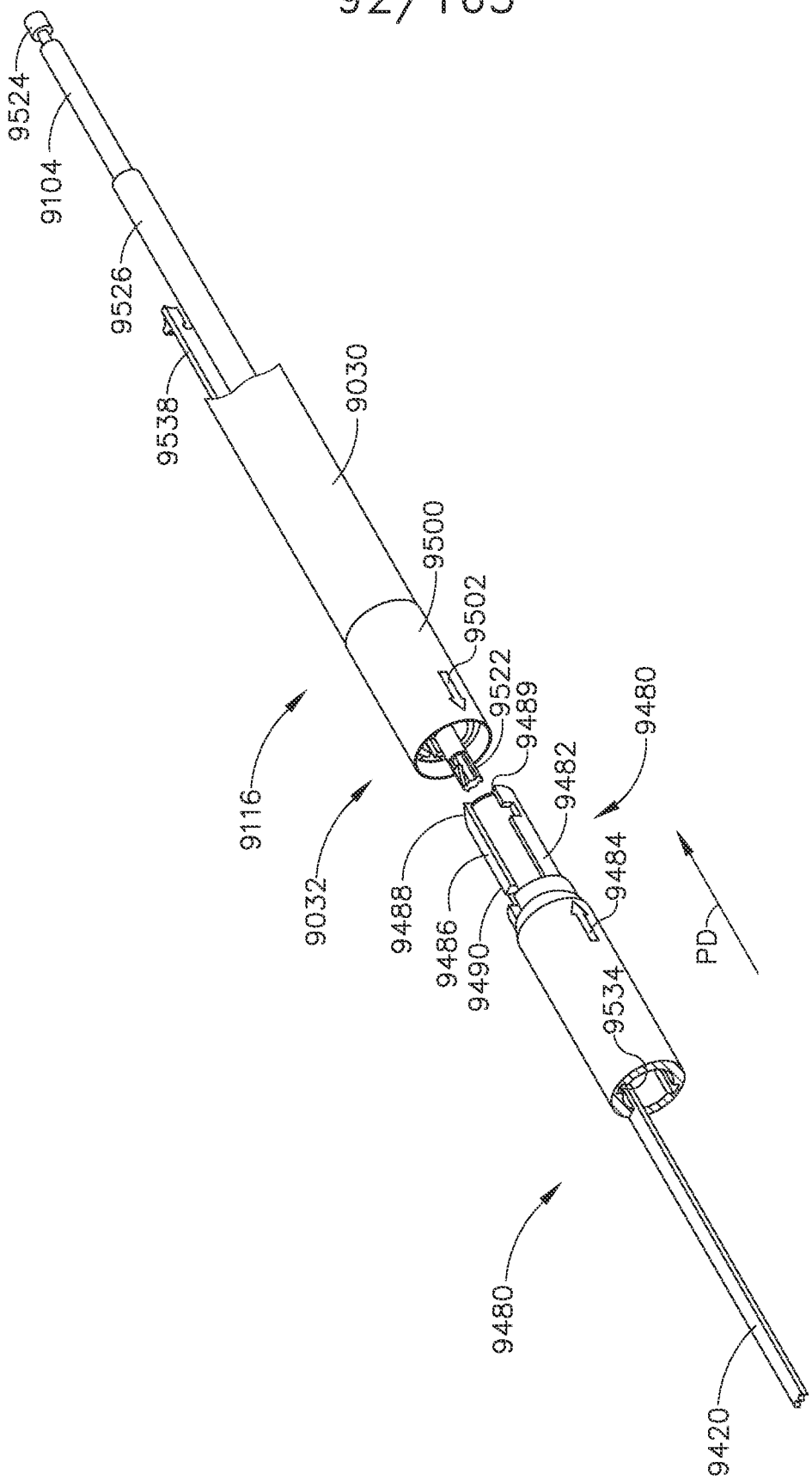

9524
9104
9526
9538
9030
9500
9502
9522
9489
9480
9482
9484
9116
9032
9488
9486
9490
9534
PD
9480
9420

FIG. 106

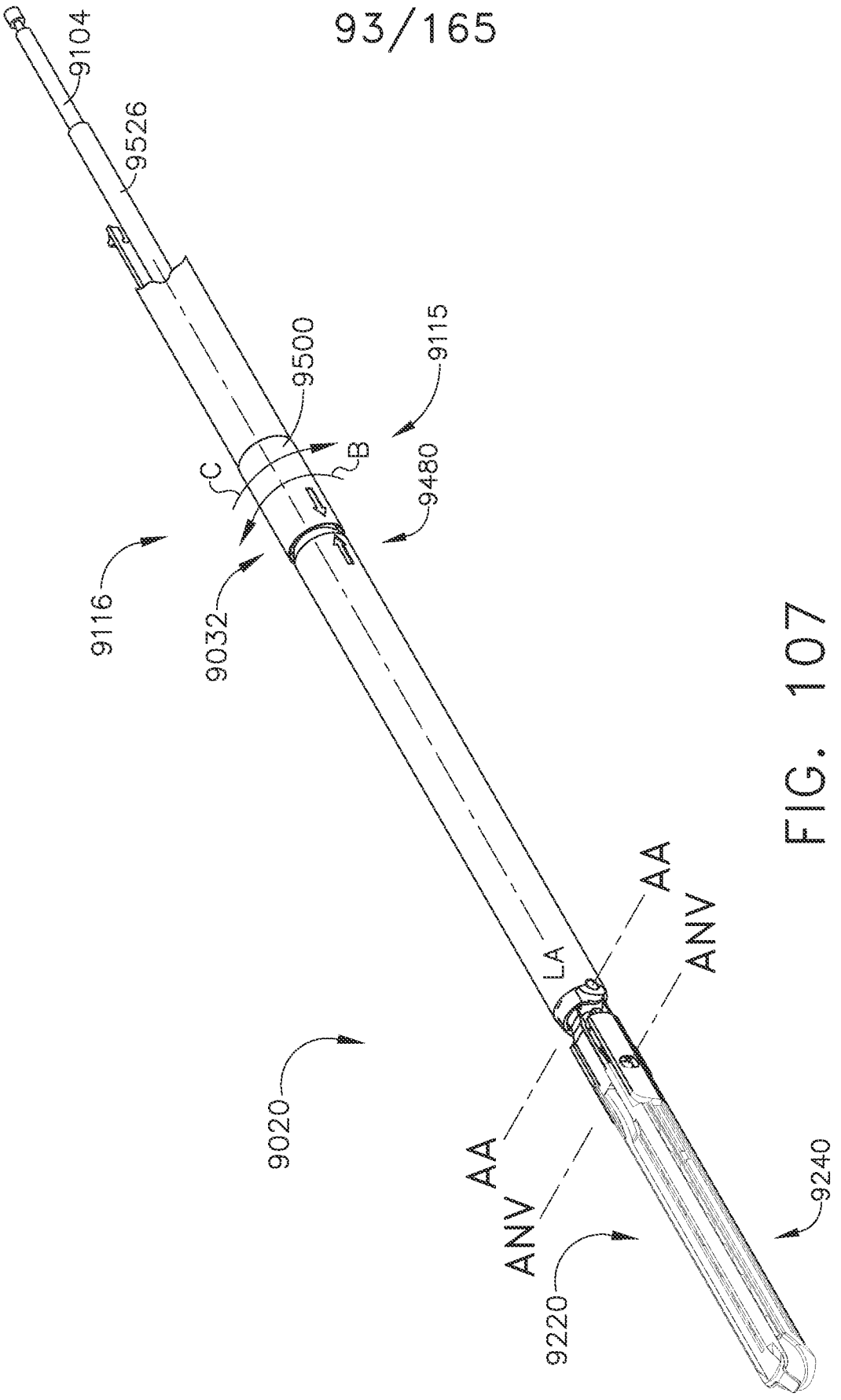

9104
9526
9500
9115
C
B
9480
9116
9032
9020
LA
AA
ANV
AA
ANV
9240
9220

FIG. 107

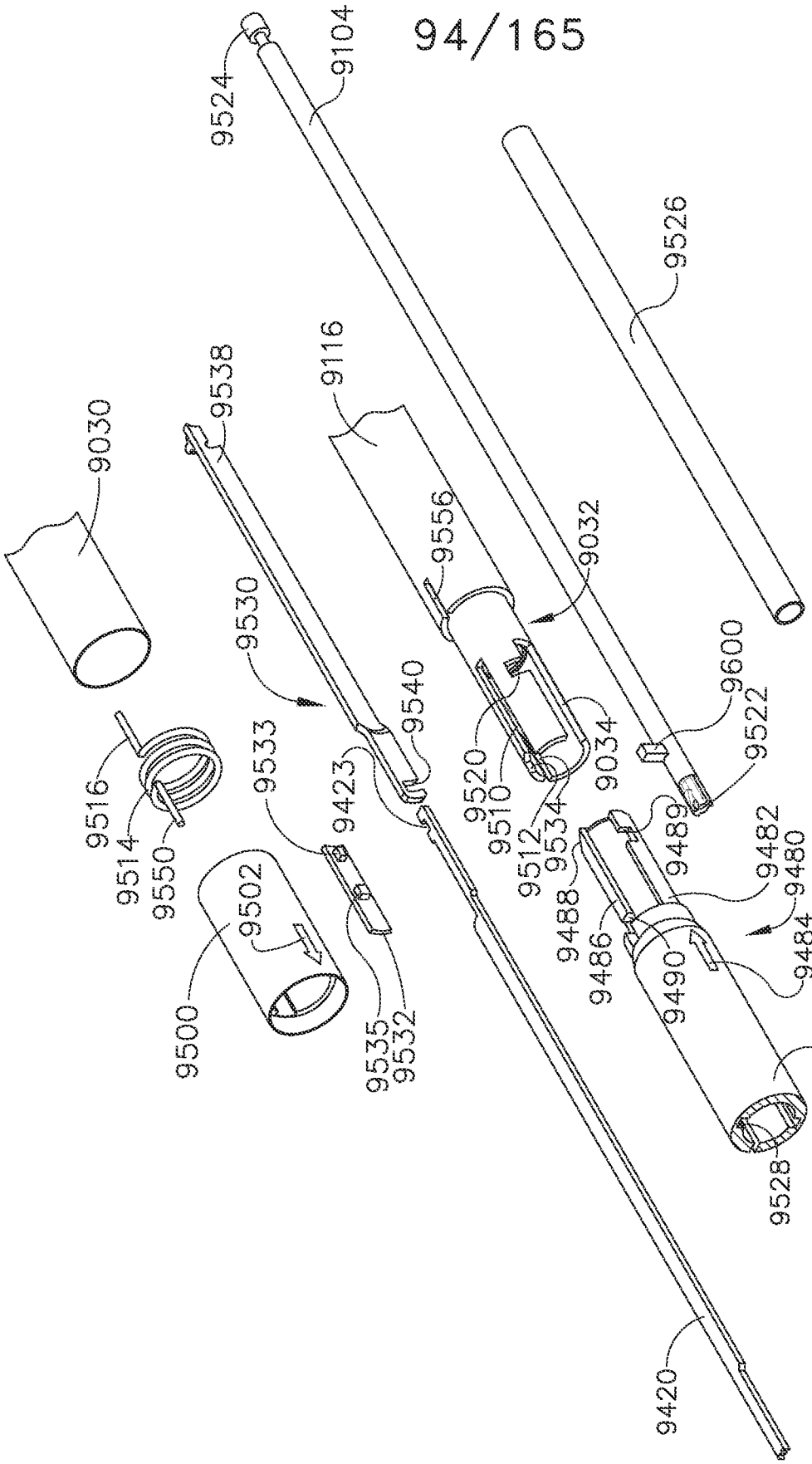

9524
9104
9526
9538
9116
9030
9556
9032
9530
9540
9600
9533
9423
9522
9516
9520
9034
9514
9510
9512
9534
9550
9489
9482
9502
9488
9480
9486
9484
9500
9490
9020
9535
9532
9528
9420

FIG. 108

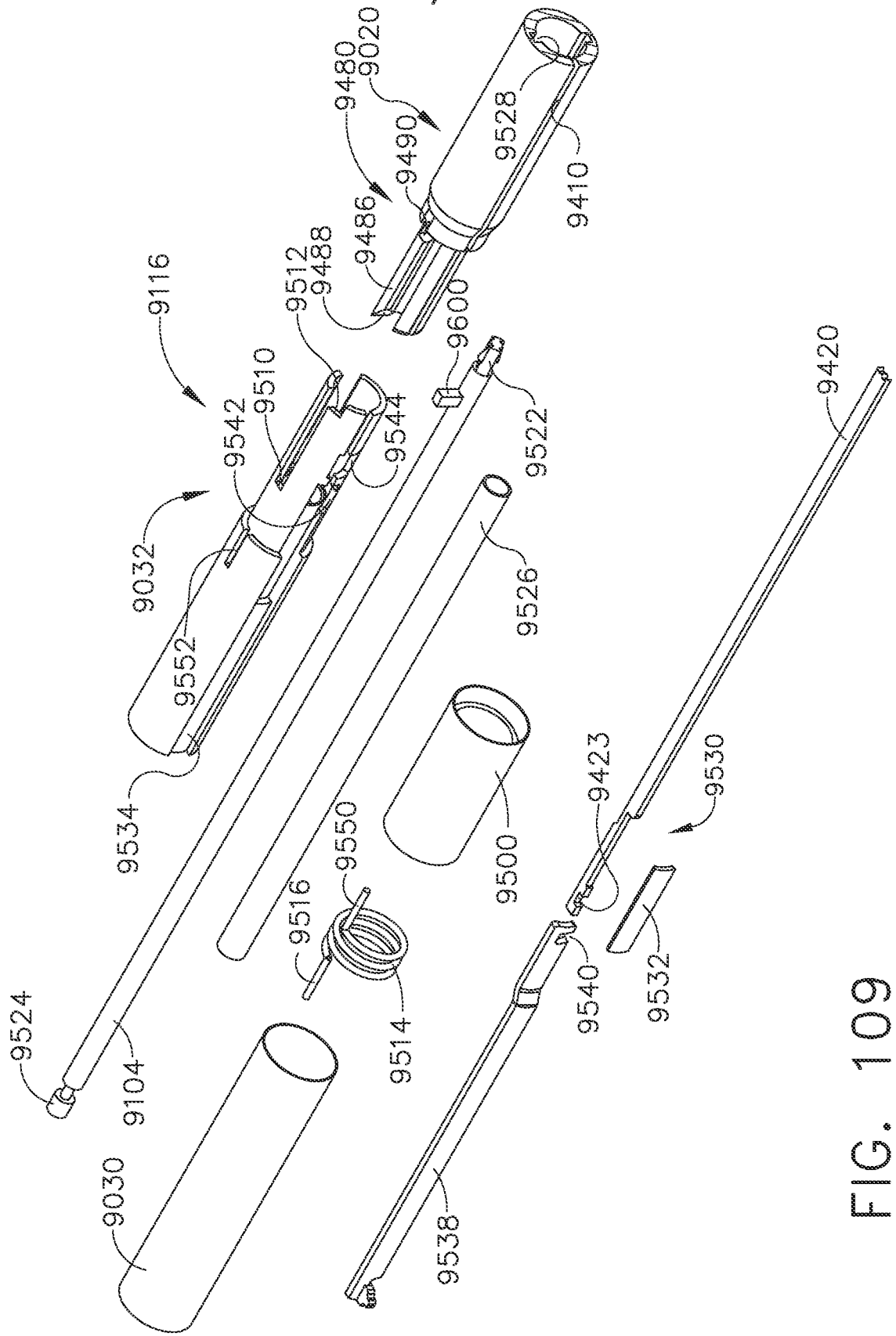

9480
9020
9490
9528
9410
9486
9488
9512
9600
9116
9510
9542
9544
9522
9032
9552
9526
9534
9420
9423
9530
9550
9500
9516
9514
9540
9532
9524
9104
9030
9538

FIG. 109

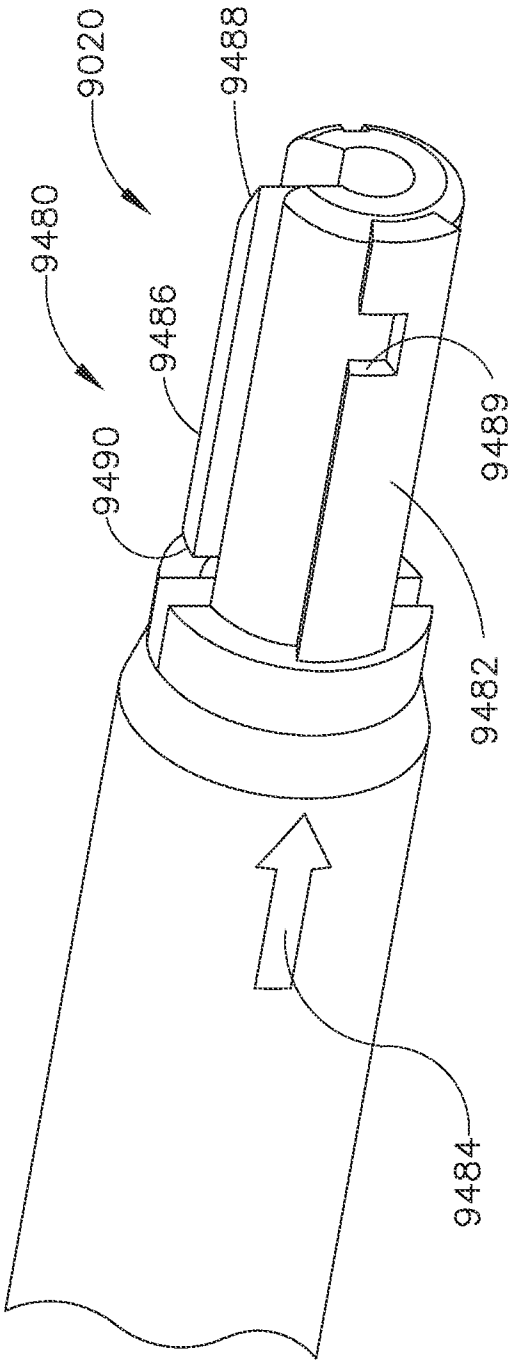


FIG. 110

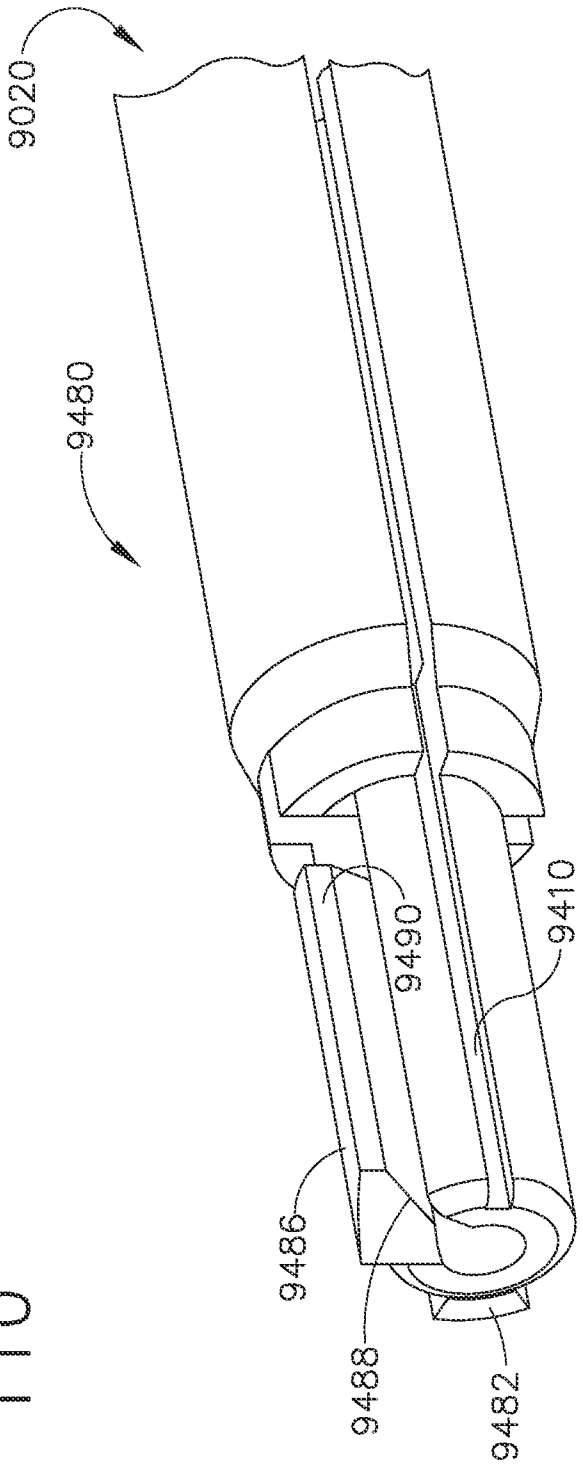


FIG. 111

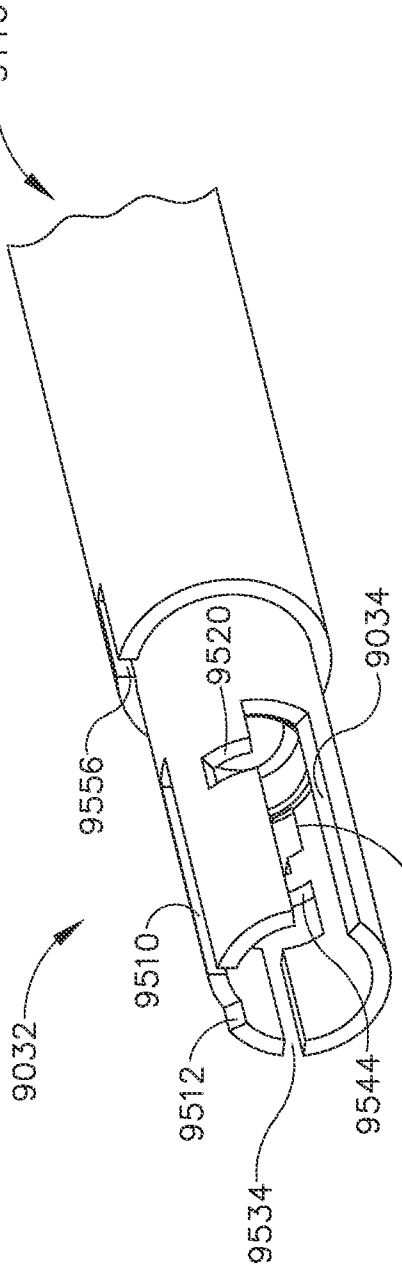


FIG. 112

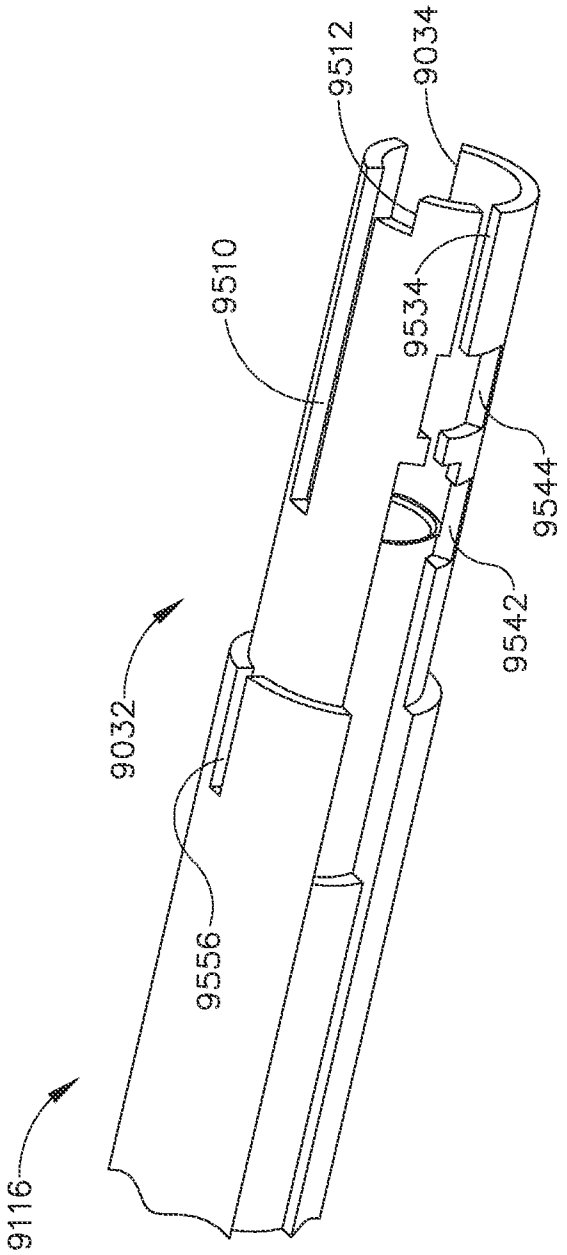


FIG. 113

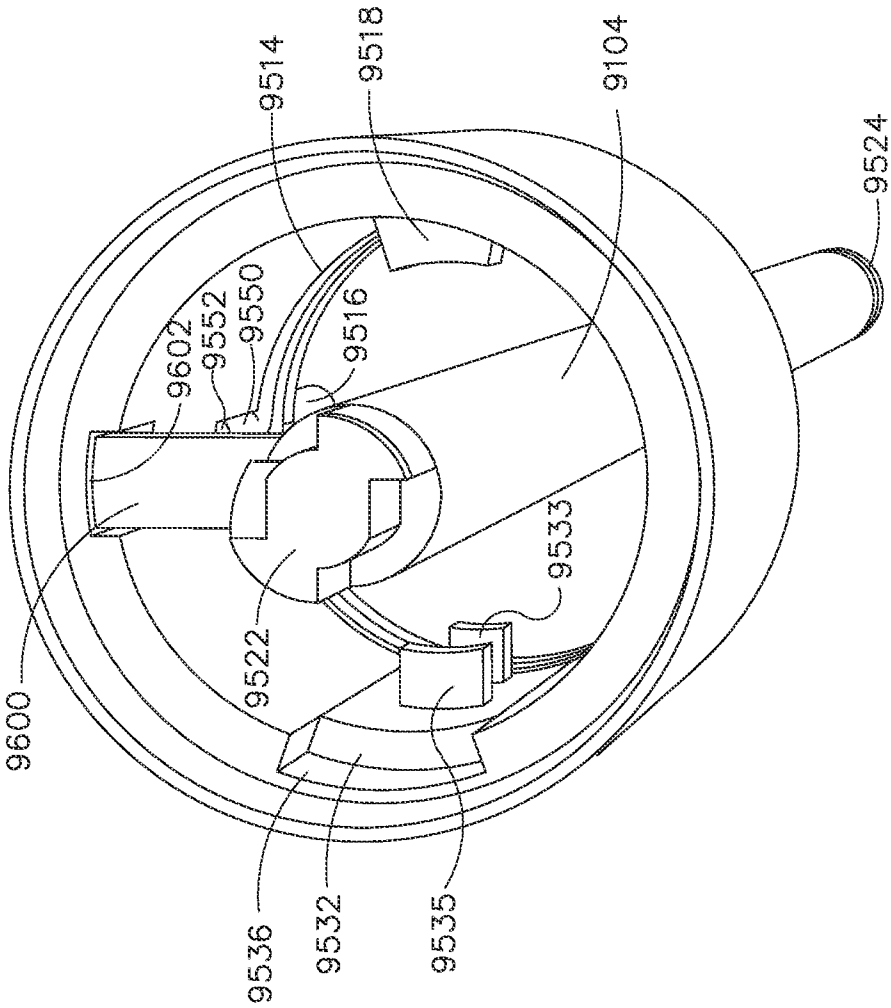

9514
9518
9104
9524
9602
9552
9550
9516
9533
9522
9600
9536
9532
9535

FIG. 114

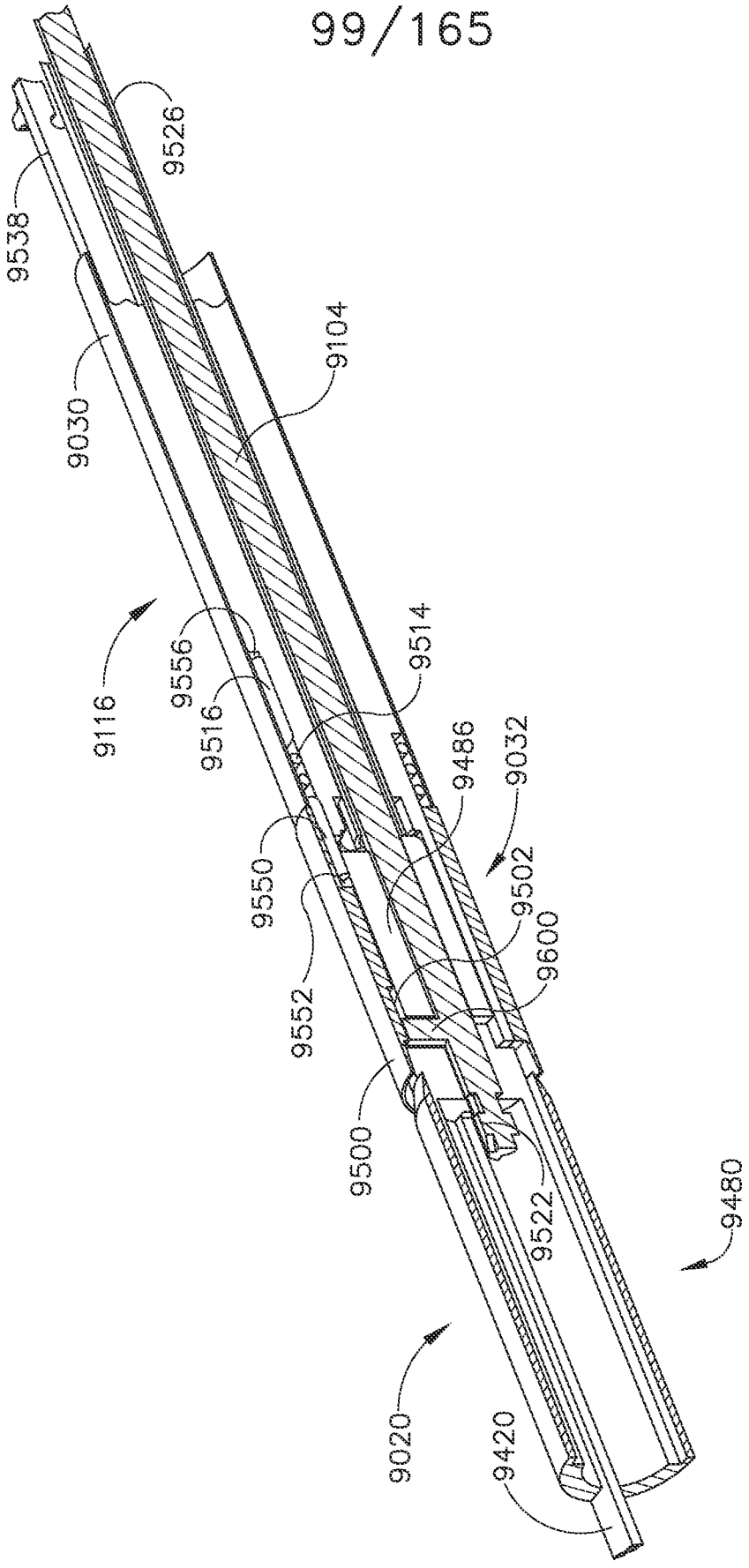

9526
9538
9104
9030
9116
9556
9516
9514
9486
9032
9550
9502
9600
9552
9500
9522
9480
9020
9420

FIG. 115

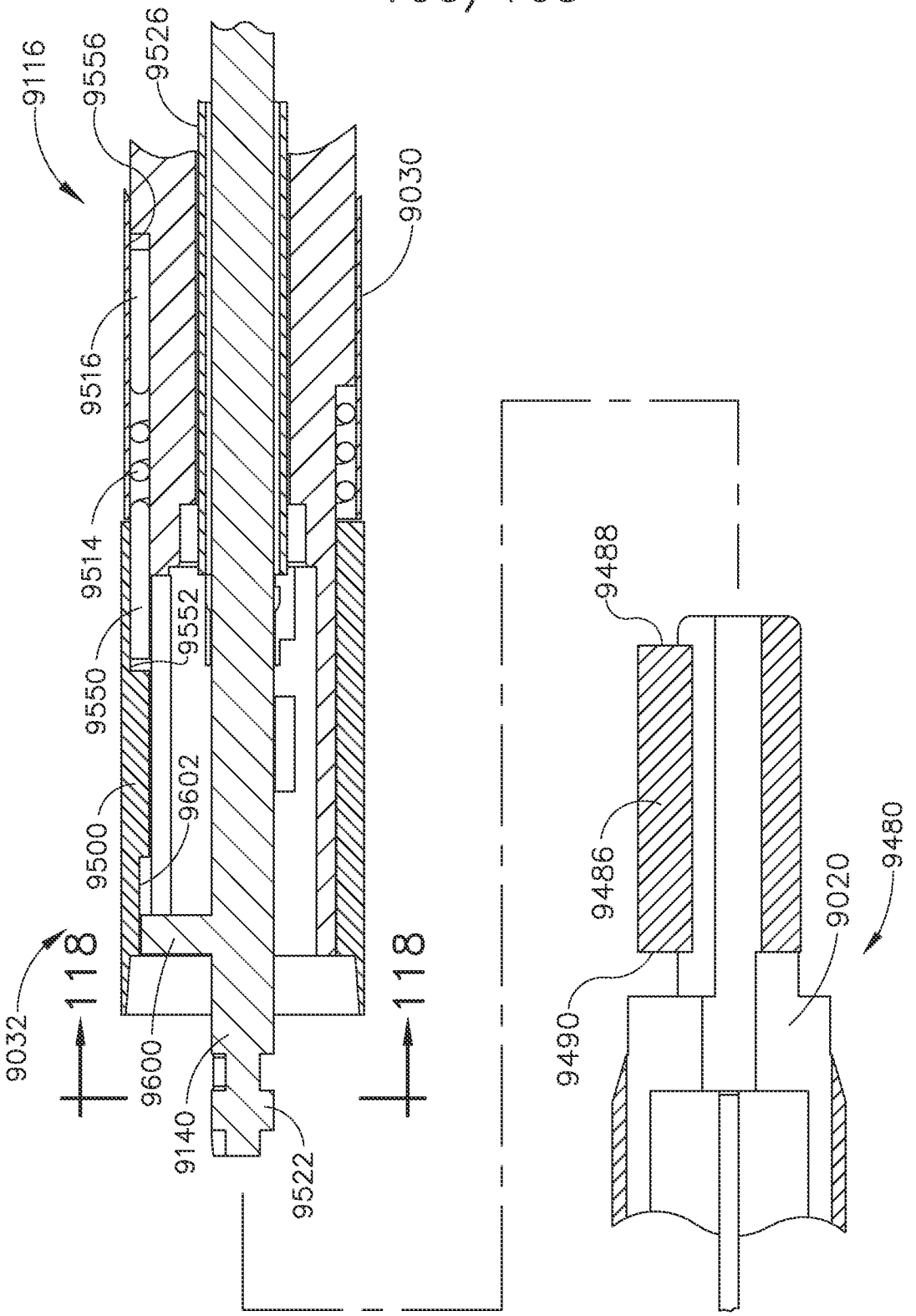

9116
9556
9526
9030
9516
9514
9552
9550
9602
9500
9032
118
9600
9140
9522
118
9488
9486
9020
9480
9490

FIG. 116

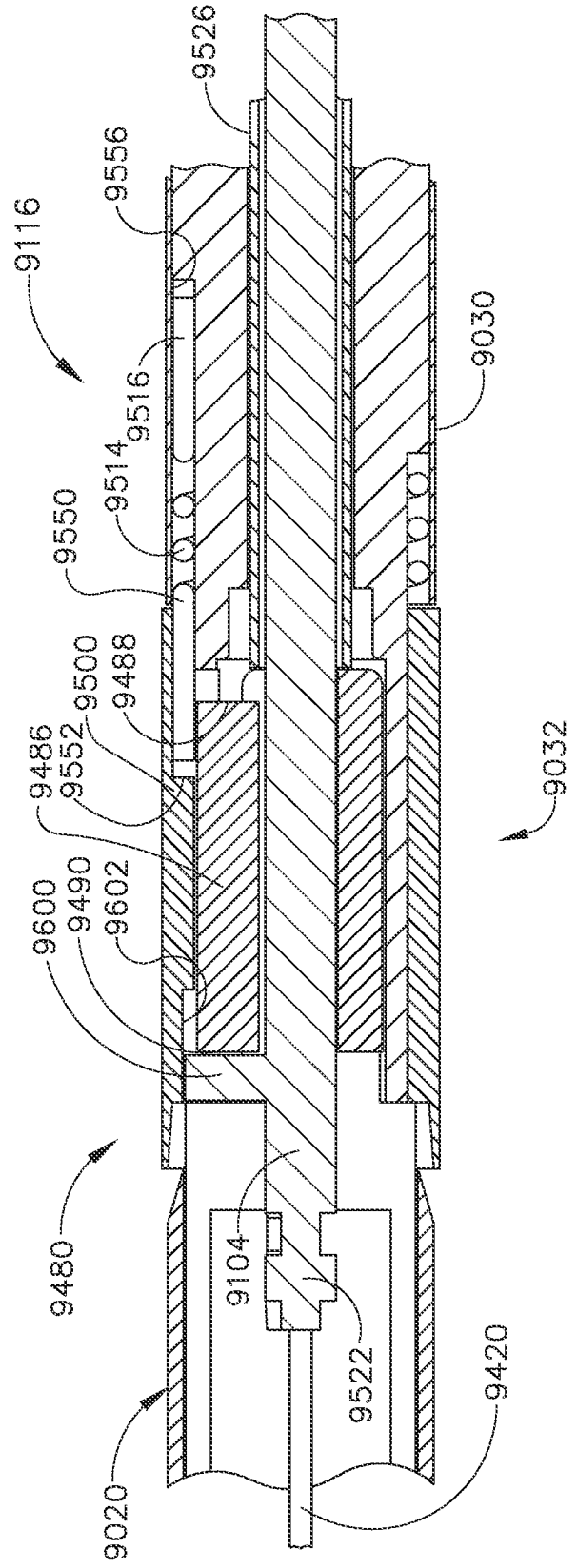

9526
9556
9116
9030
9516
9514
9550
9500
9488
9486
9552
9032
9600
9490
9602
9480
9104
9522
9420
9020

FIG. 117

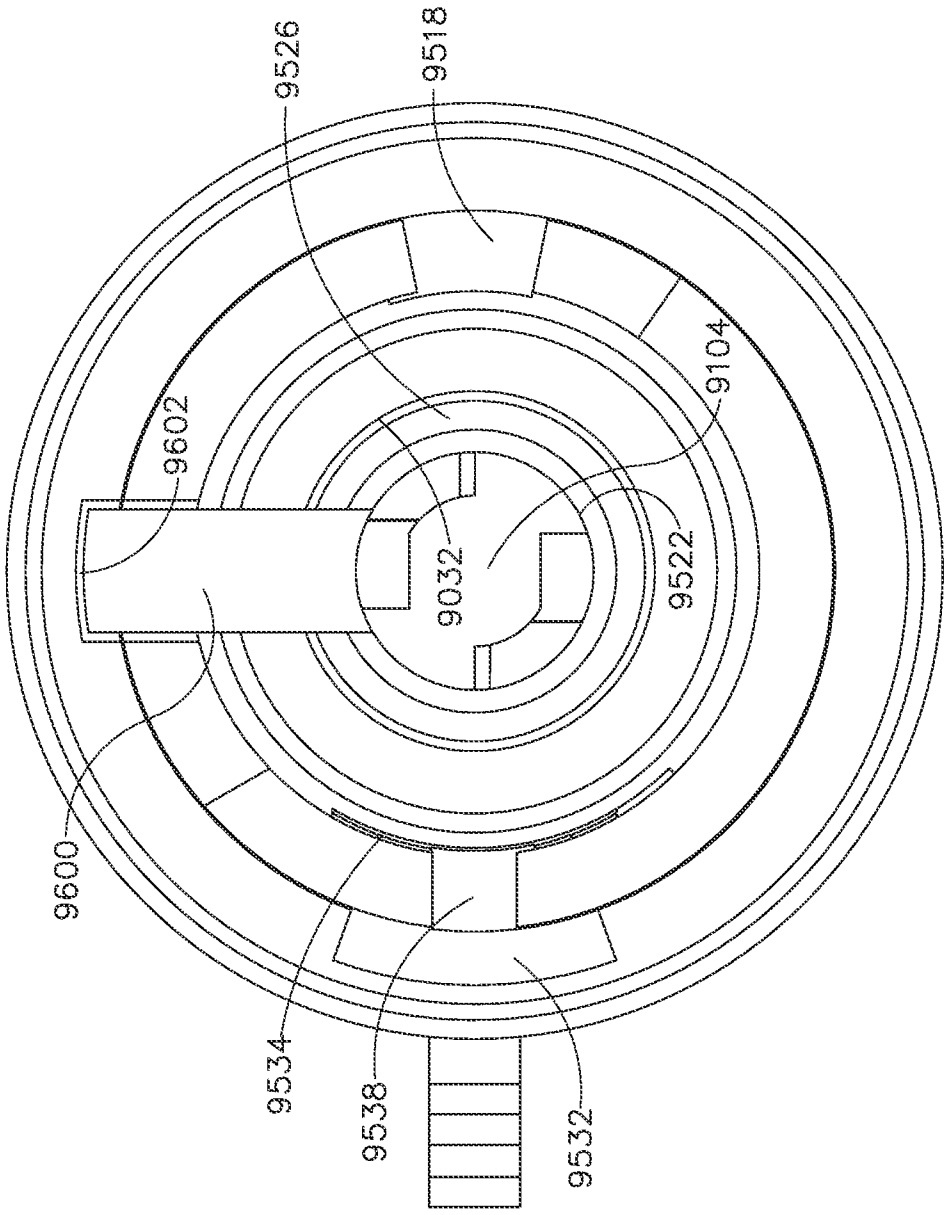


FIG. 118

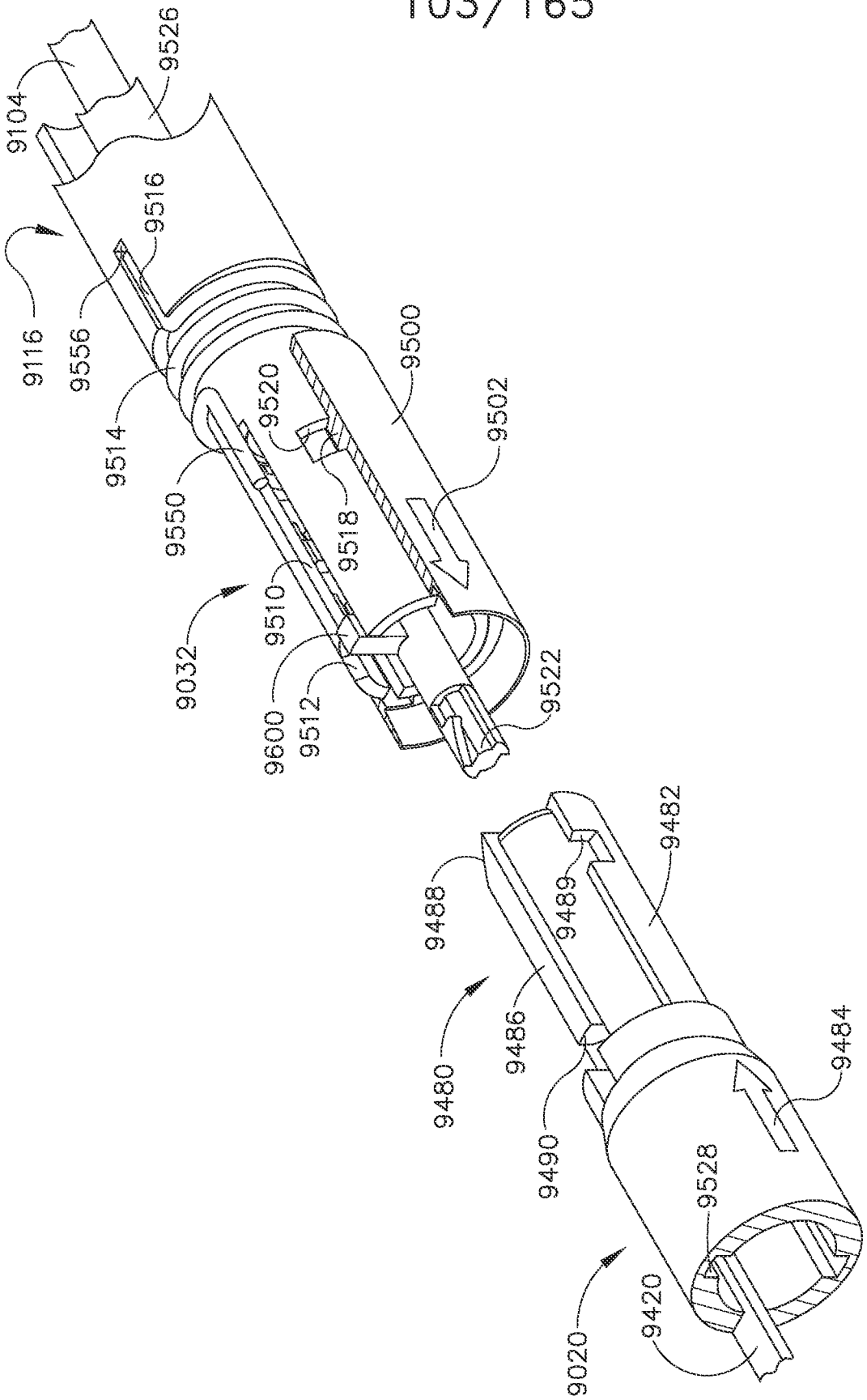

9104
9526
9516
9116
9556
9514
9520
9500
9502
9550
9518
9510
9032
9600
9512
9522
9482
9488
9489
9480
9486
9484
9490
9528
9420
9020

FIG. 119

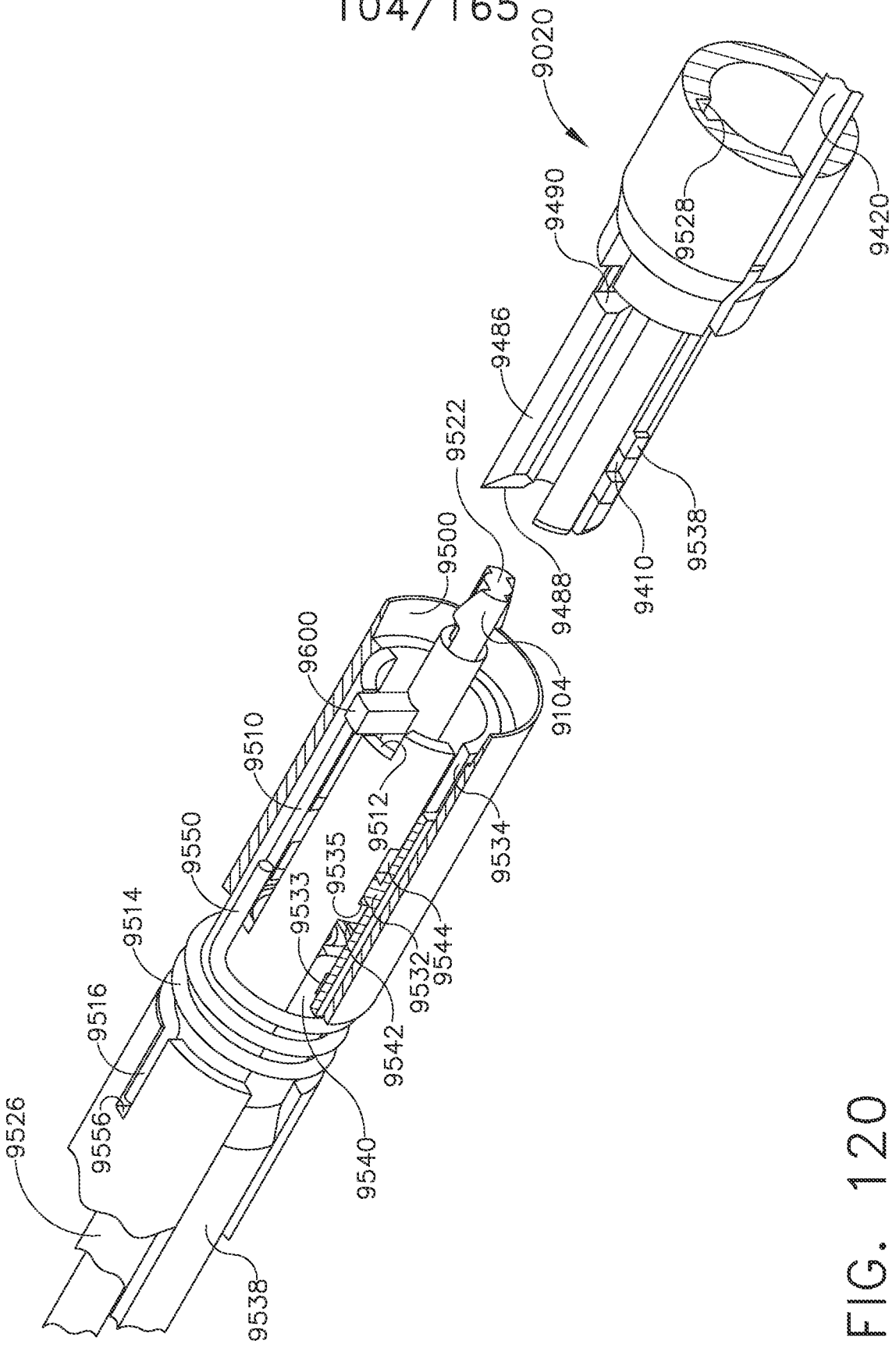

9020
9490
9528
9420
9486
9522
9500
9488
9410
9538
9600
9104
9510
9512
9534
9550
9535
9533
9544
9532
9514
9542
9516
9540
9556
9526
9538

FIG. 120

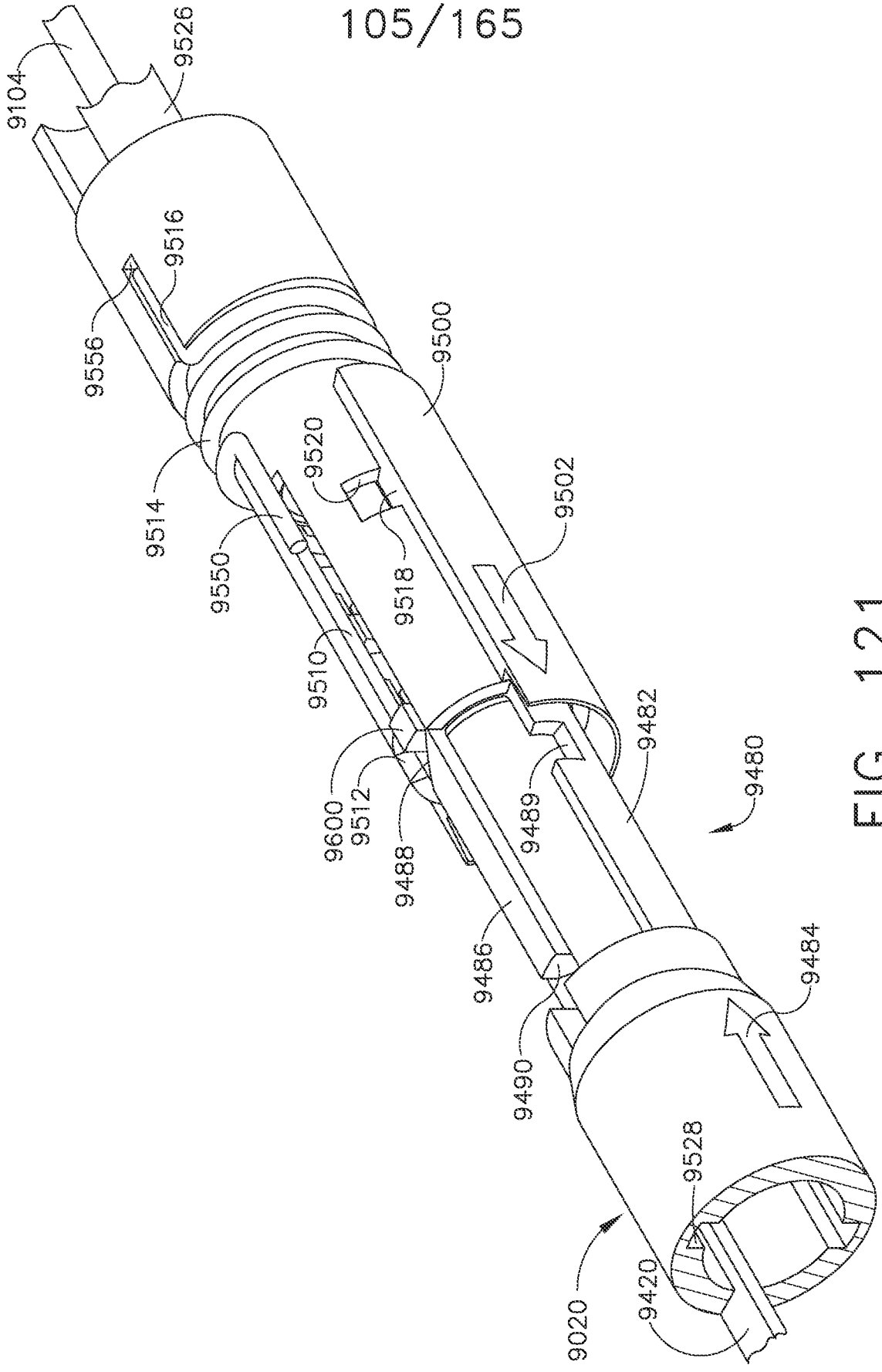

9104
9526
9516
9556
9500
9520
9514
9502
9550
9518
9510
9482
9480
9600
9512
9489
9488
9486
9484
9490
9528
9420
9020

FIG. 121

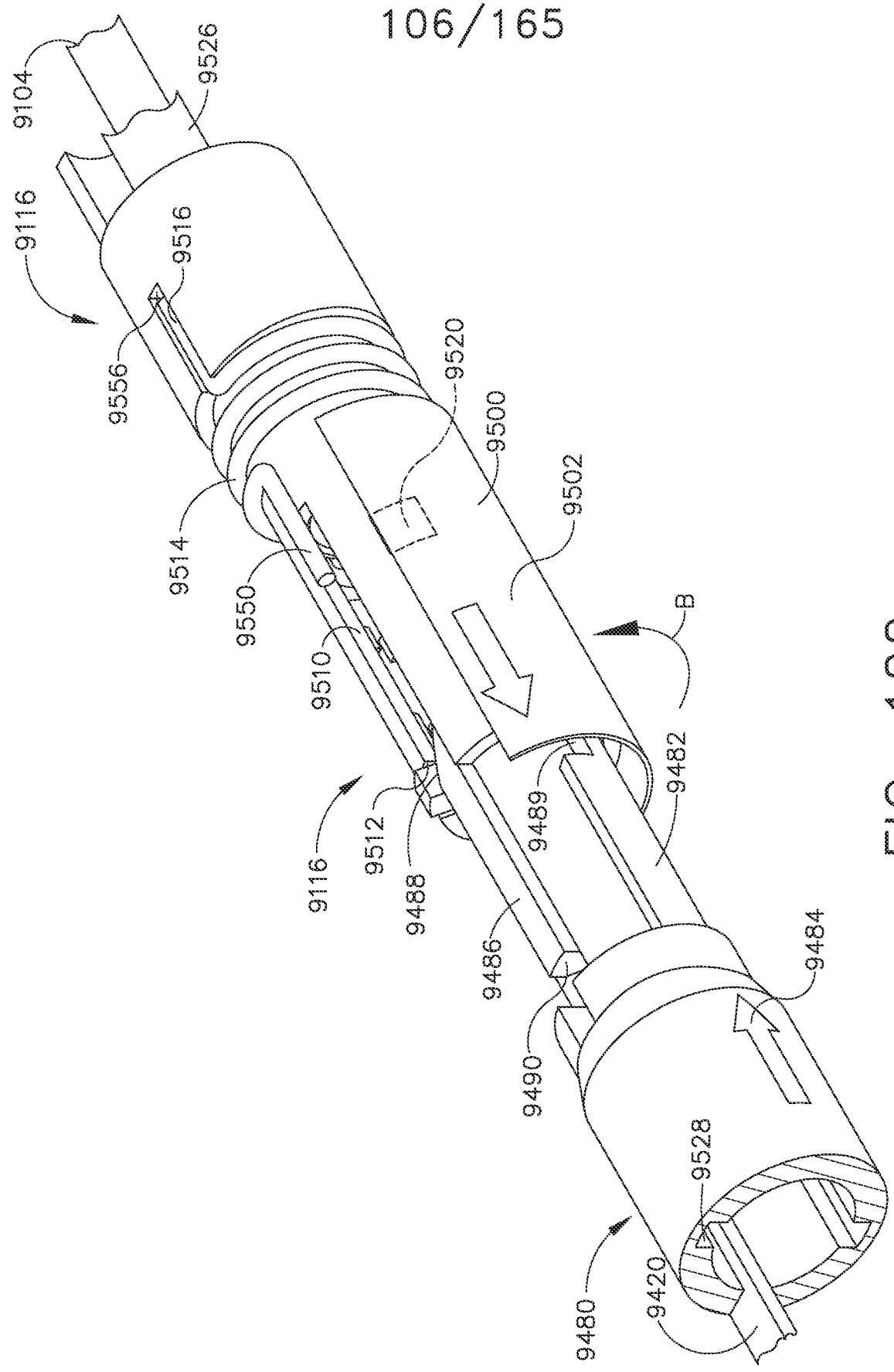

9104
9526
9116
9516
9556
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FIG. 122

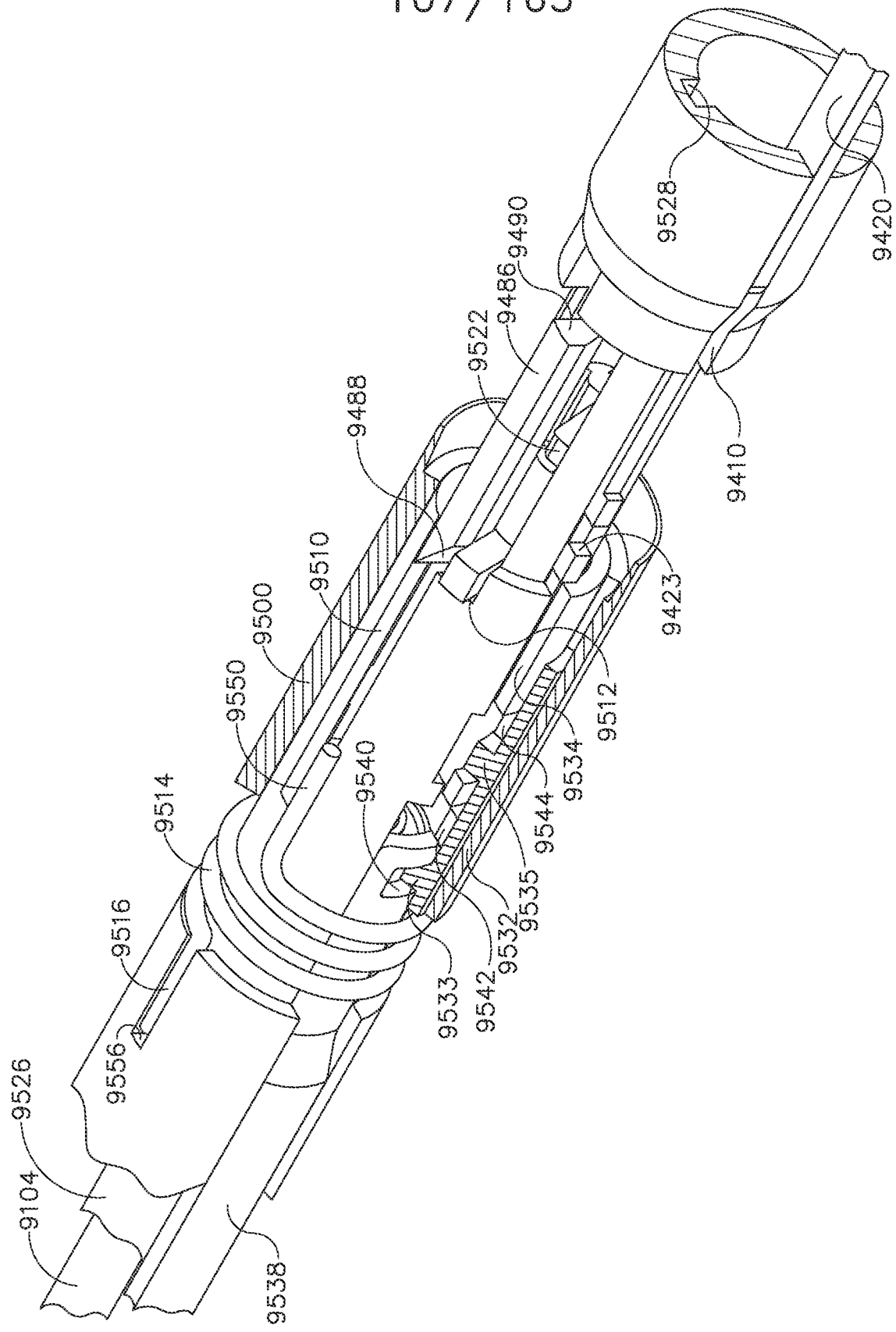

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FIG. 123

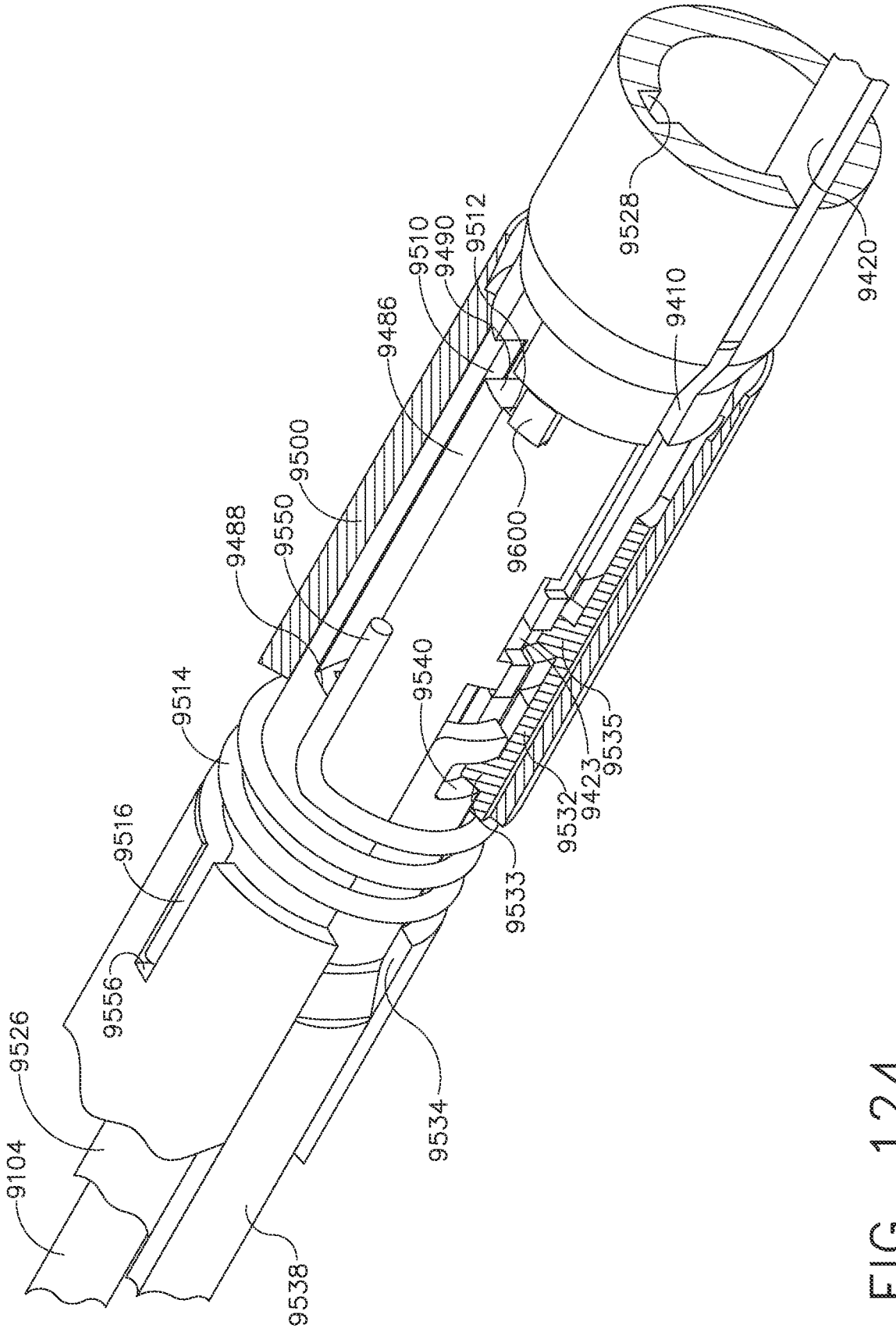

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FIG. 124

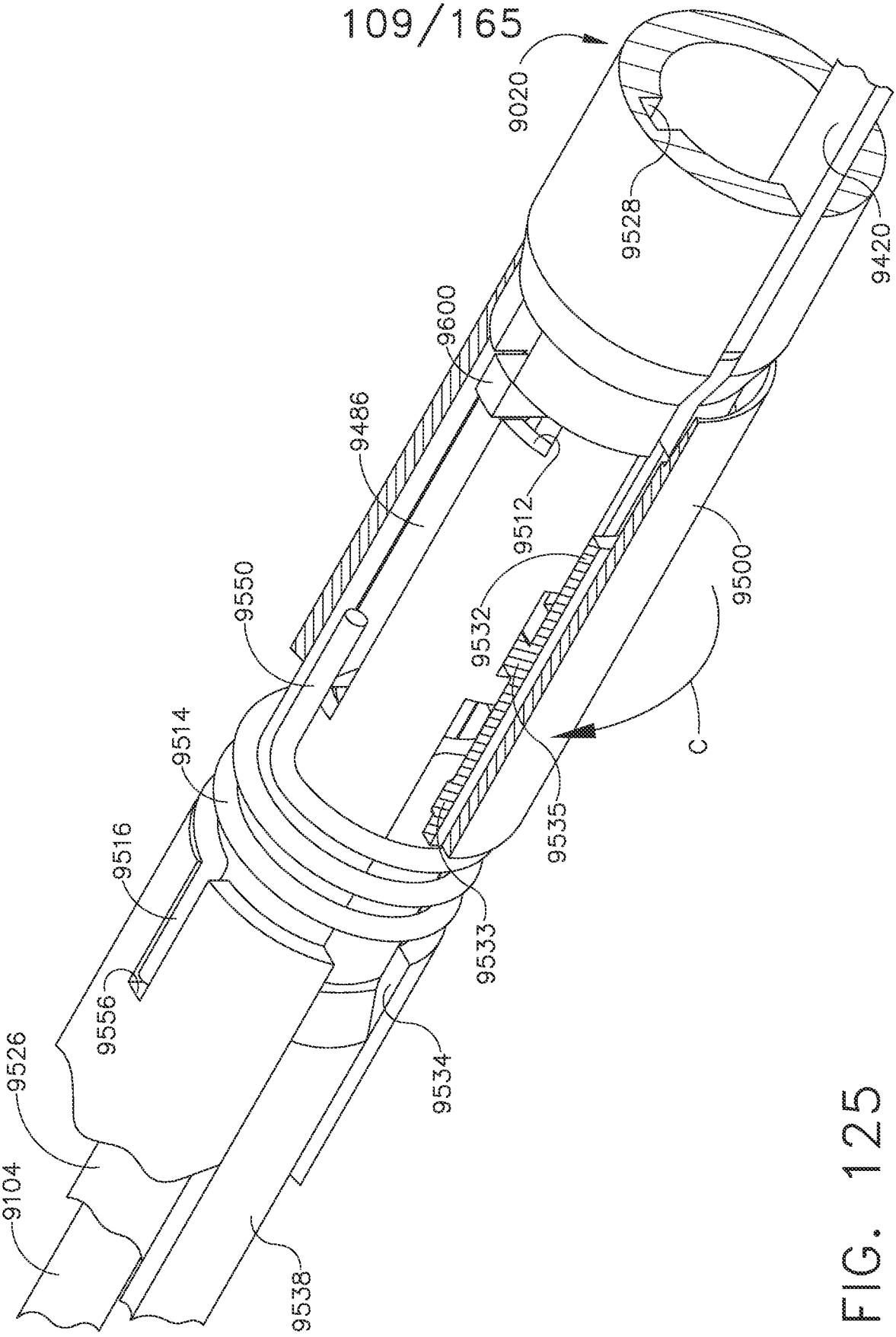

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FIG. 125

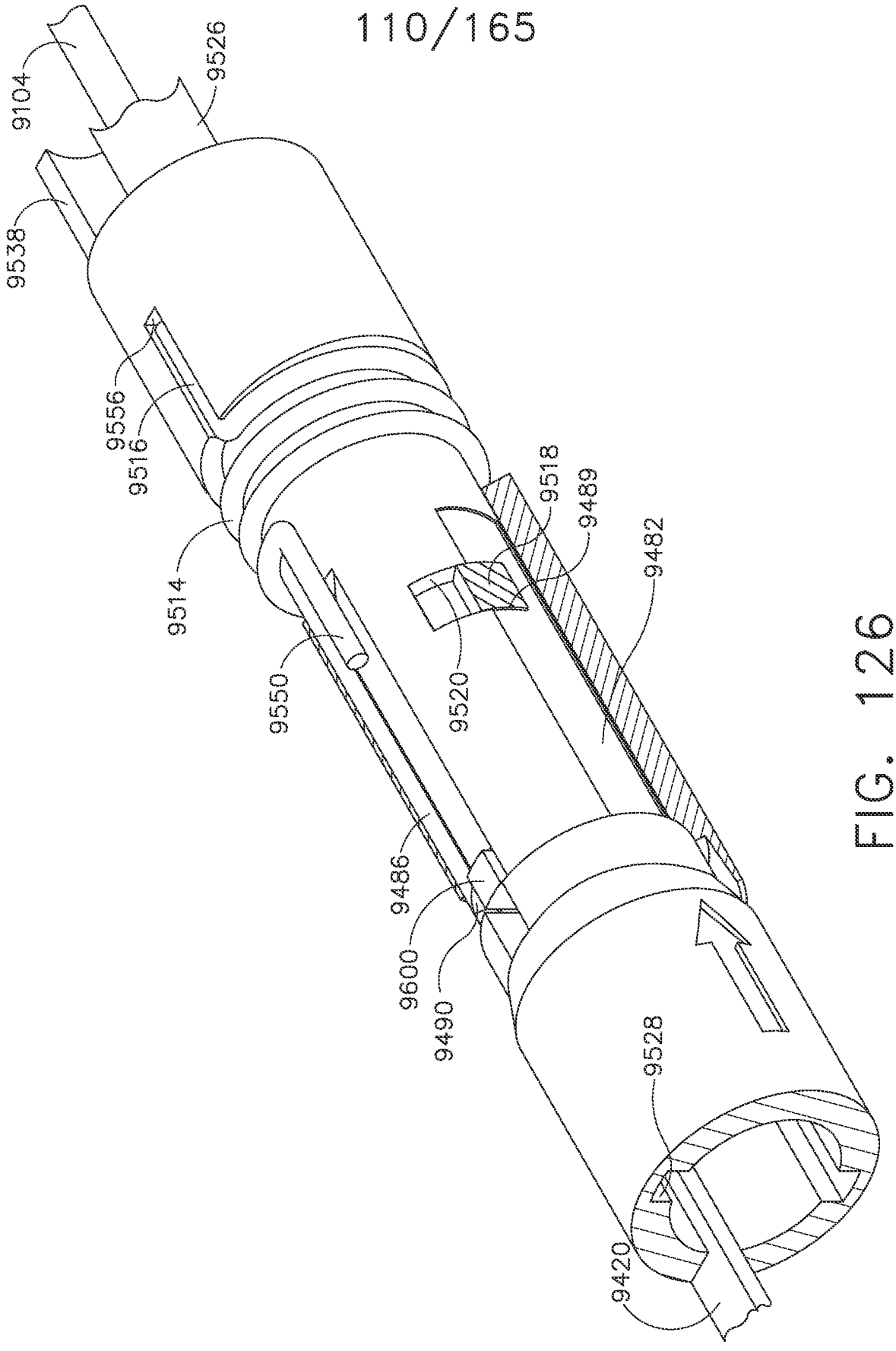

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FIG. 126

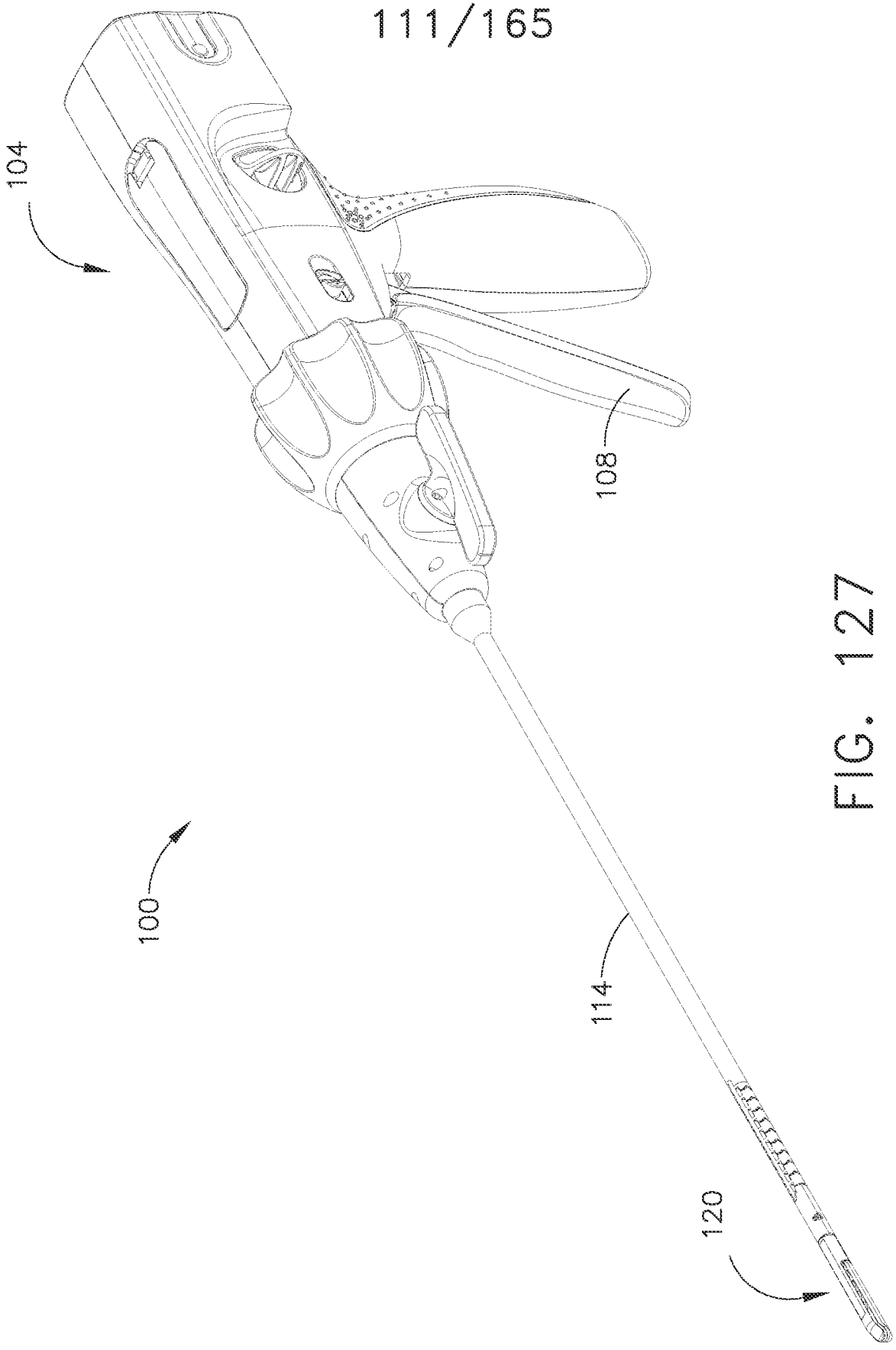


FIG. 127

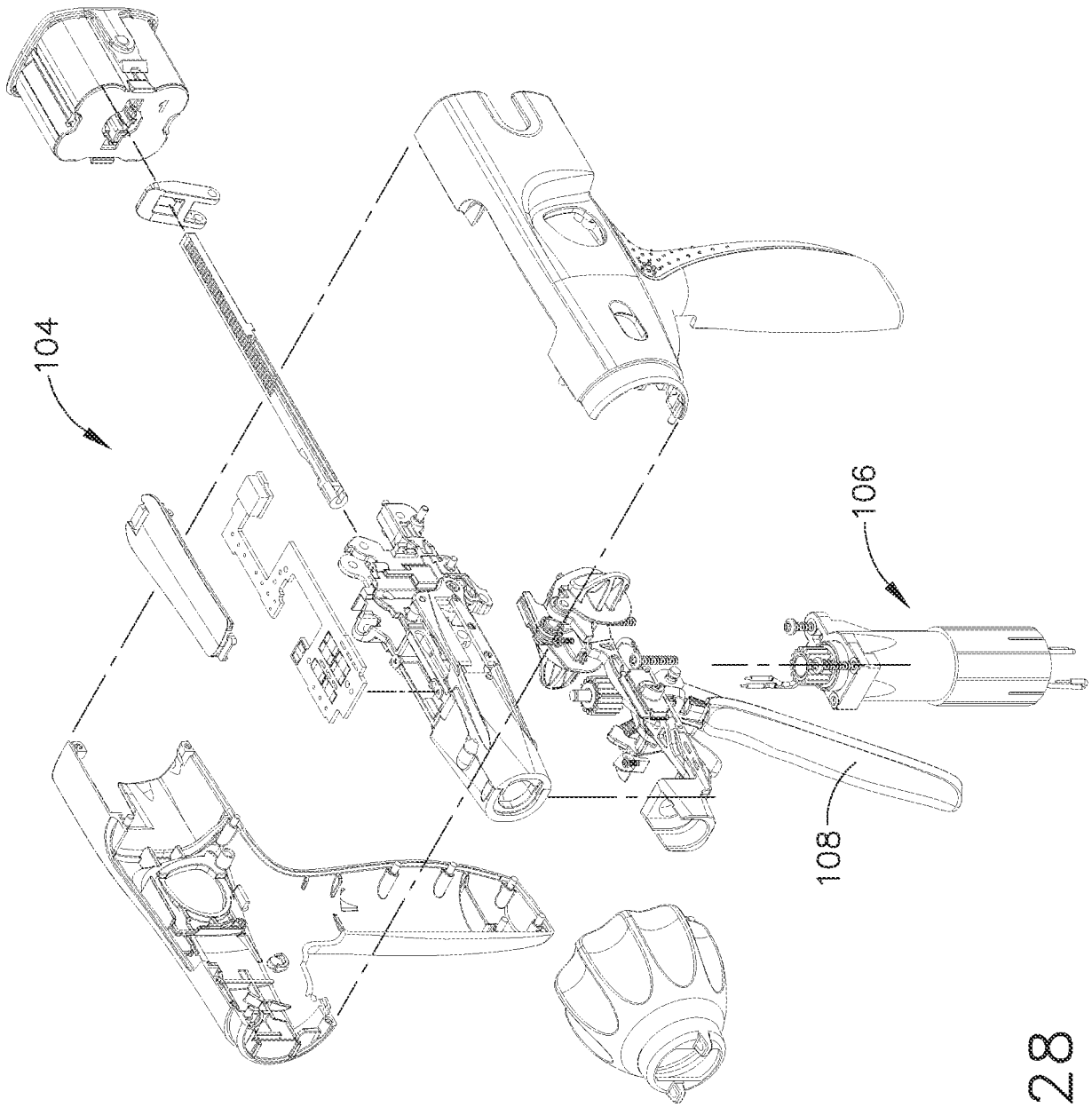


FIG. 128

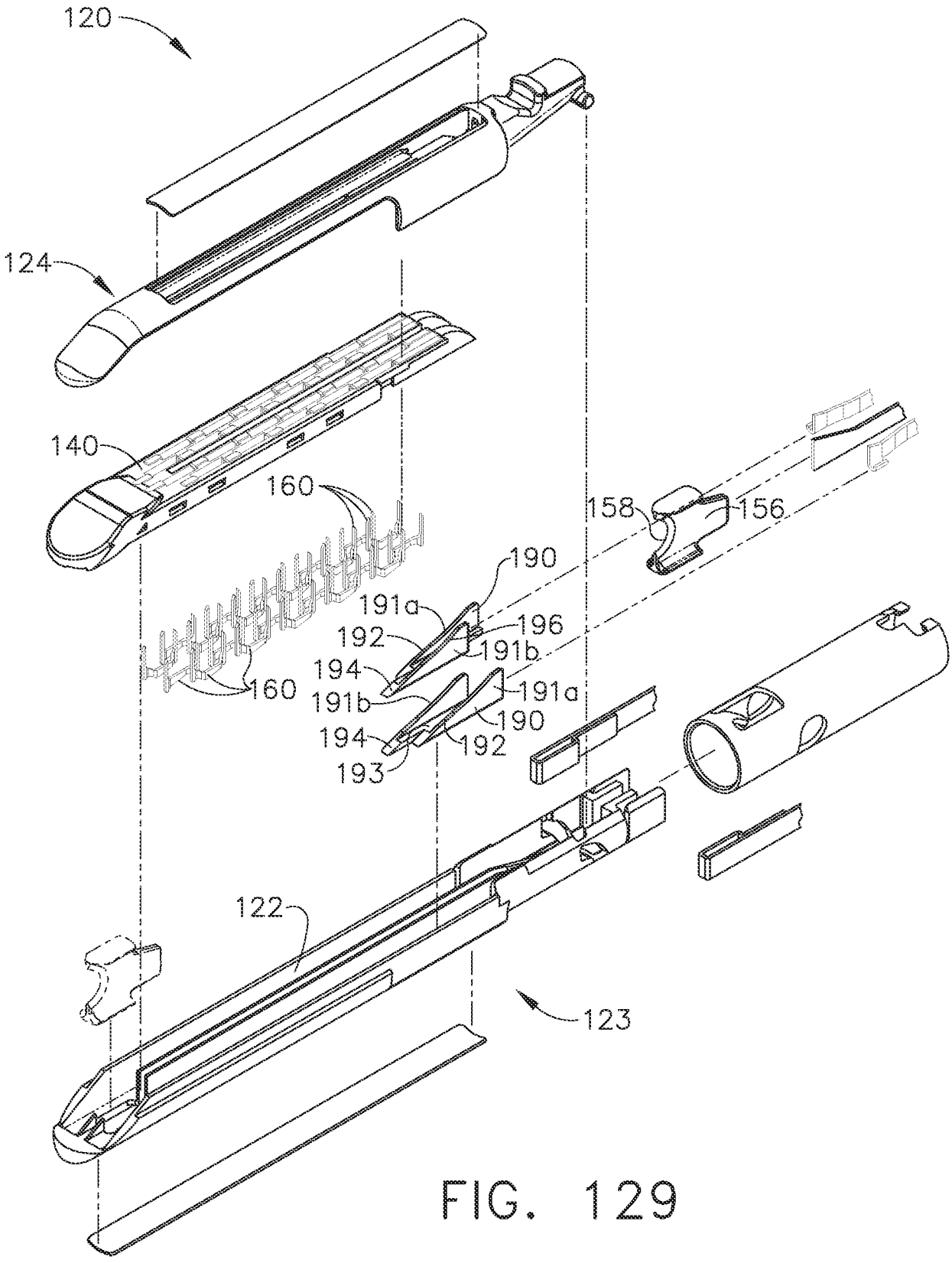

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FIG. 129

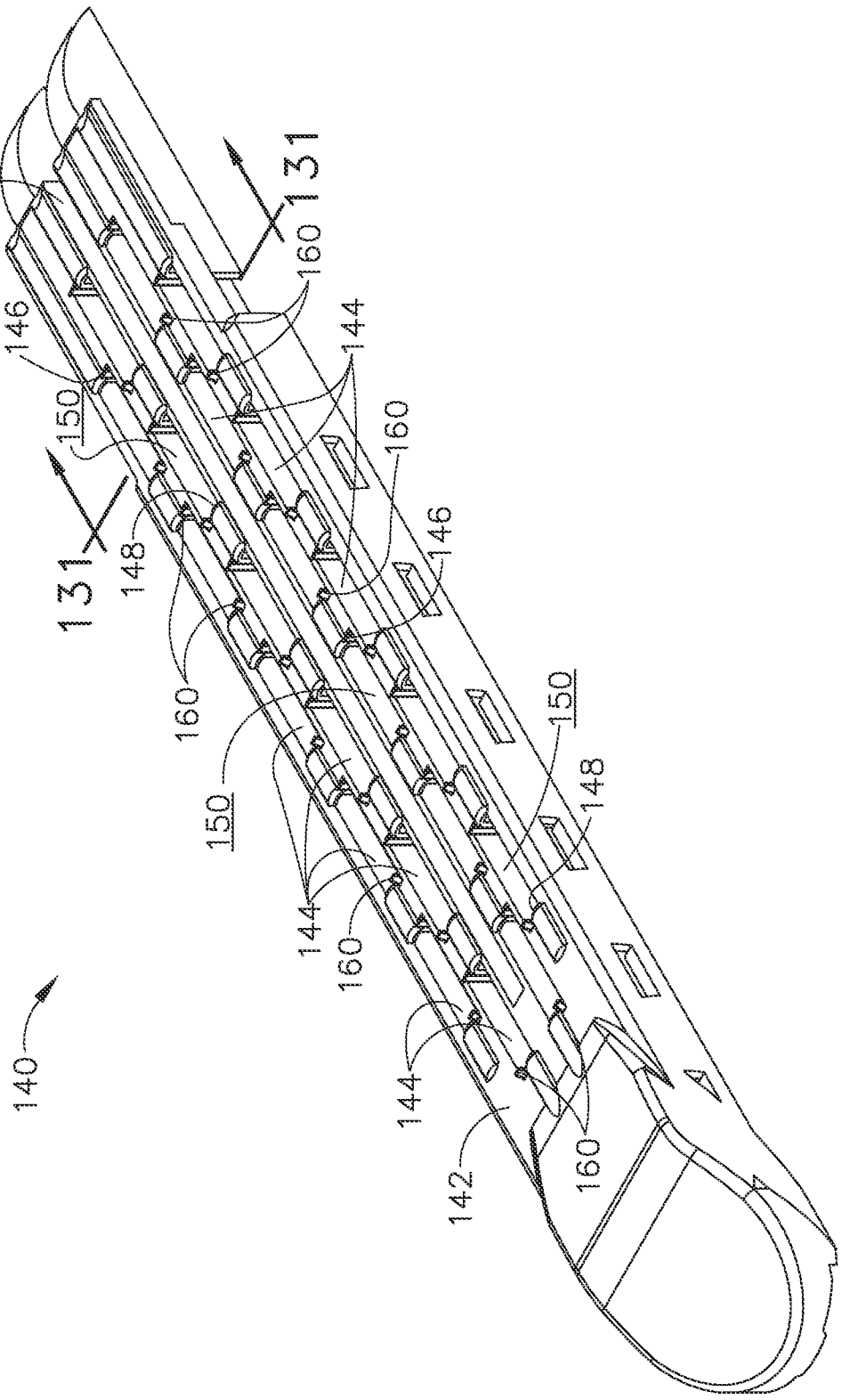

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FIG. 130

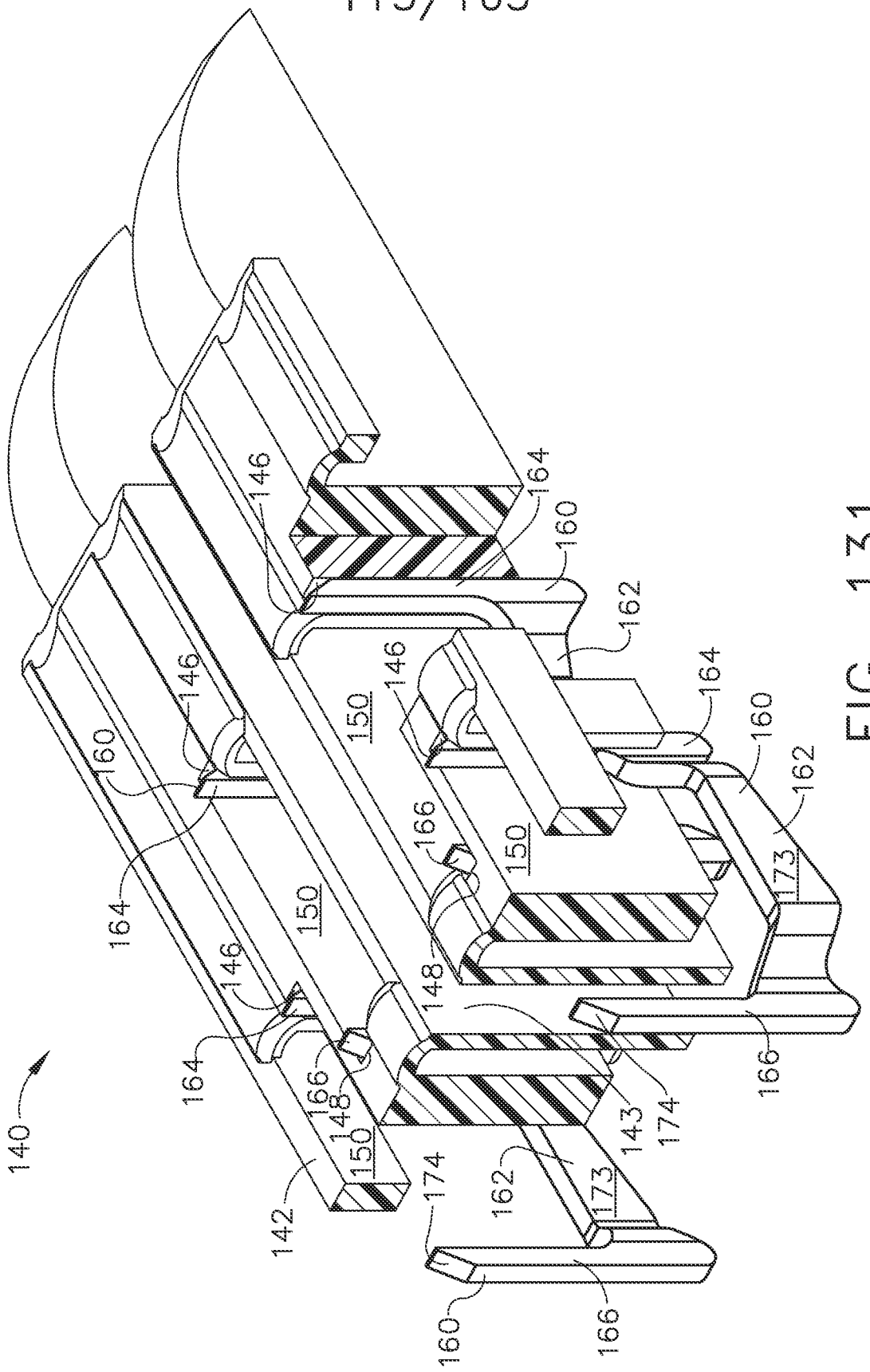


FIG. 131

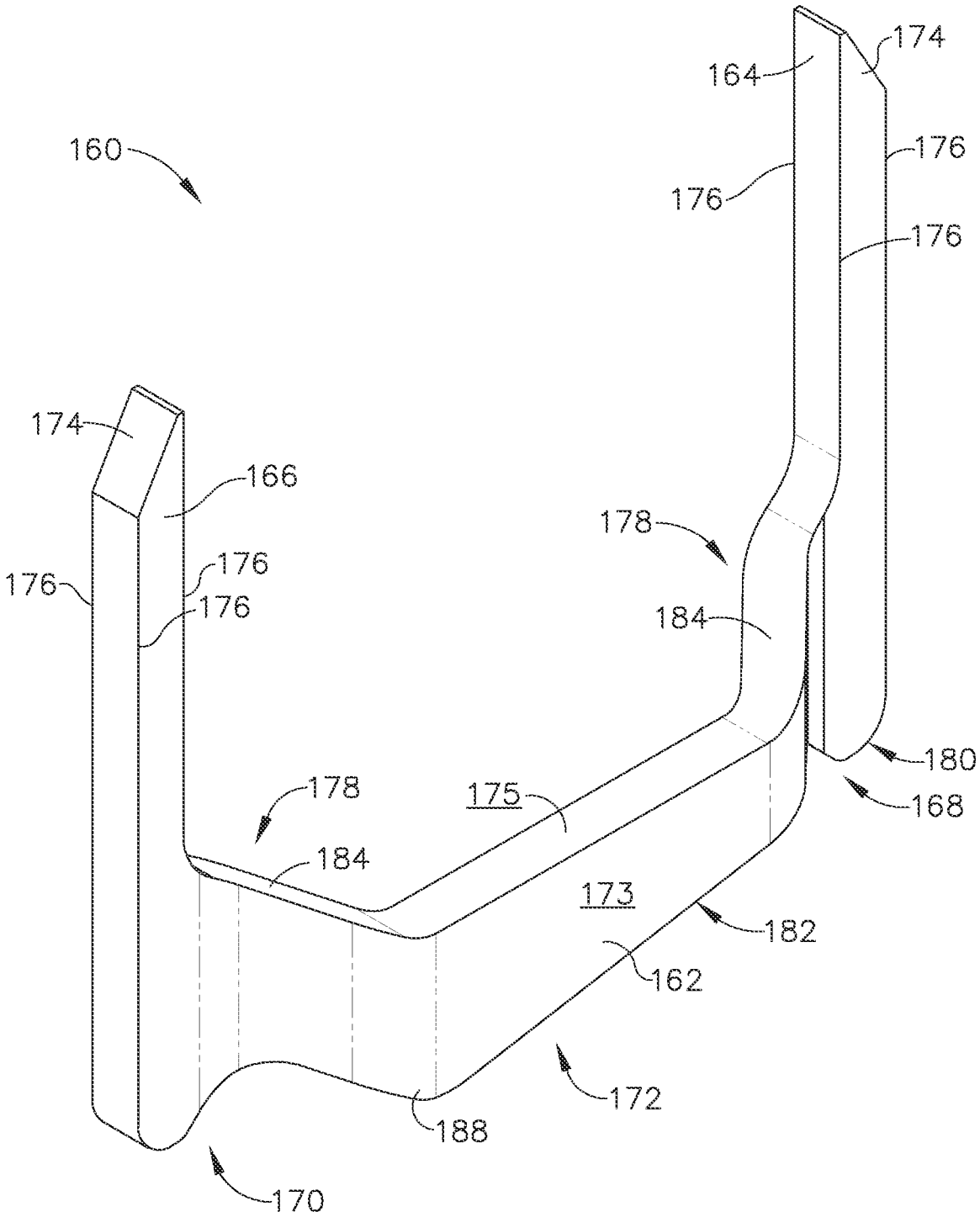

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FIG. 132

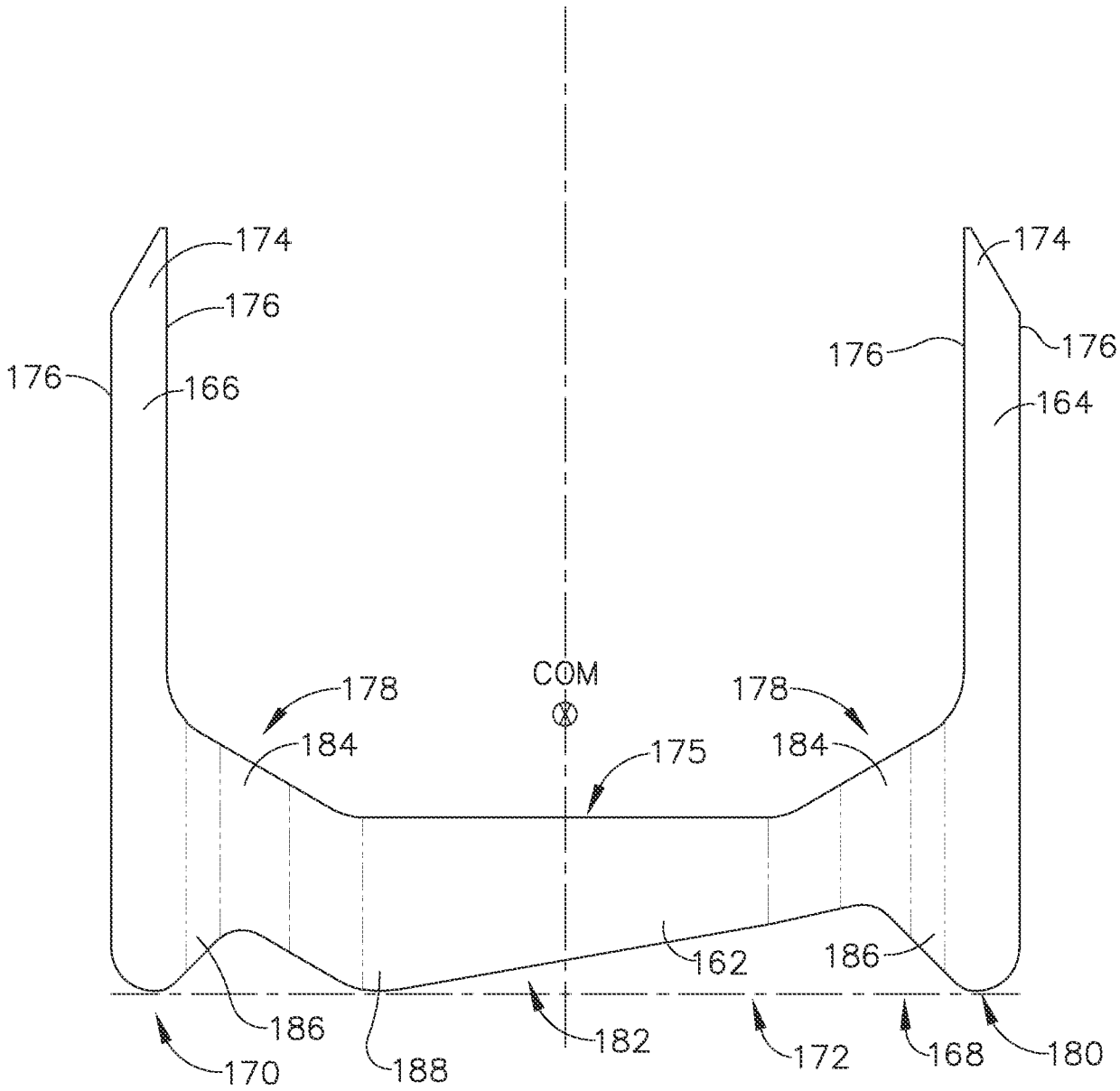

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FIG. 133

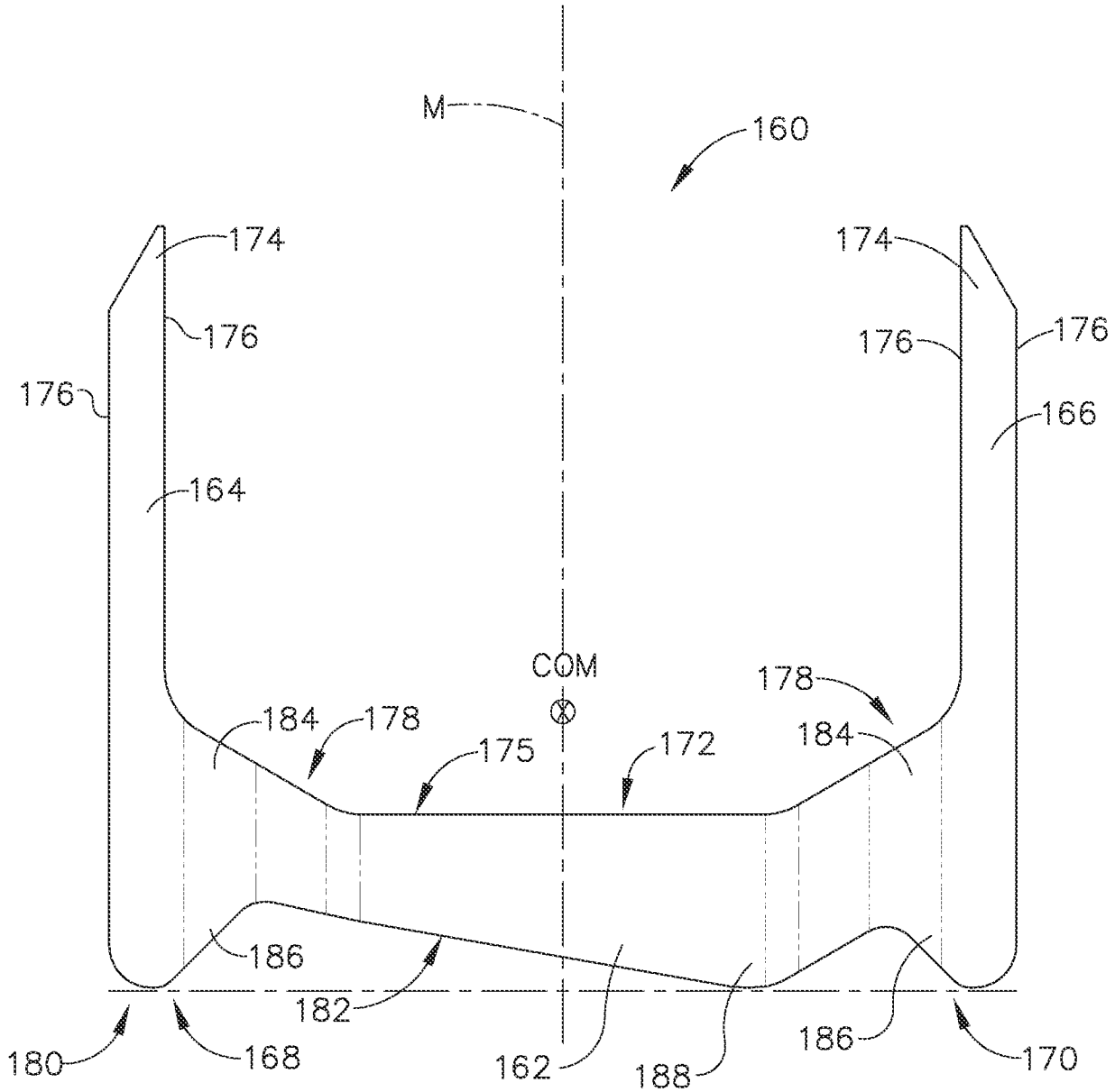

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FIG. 134

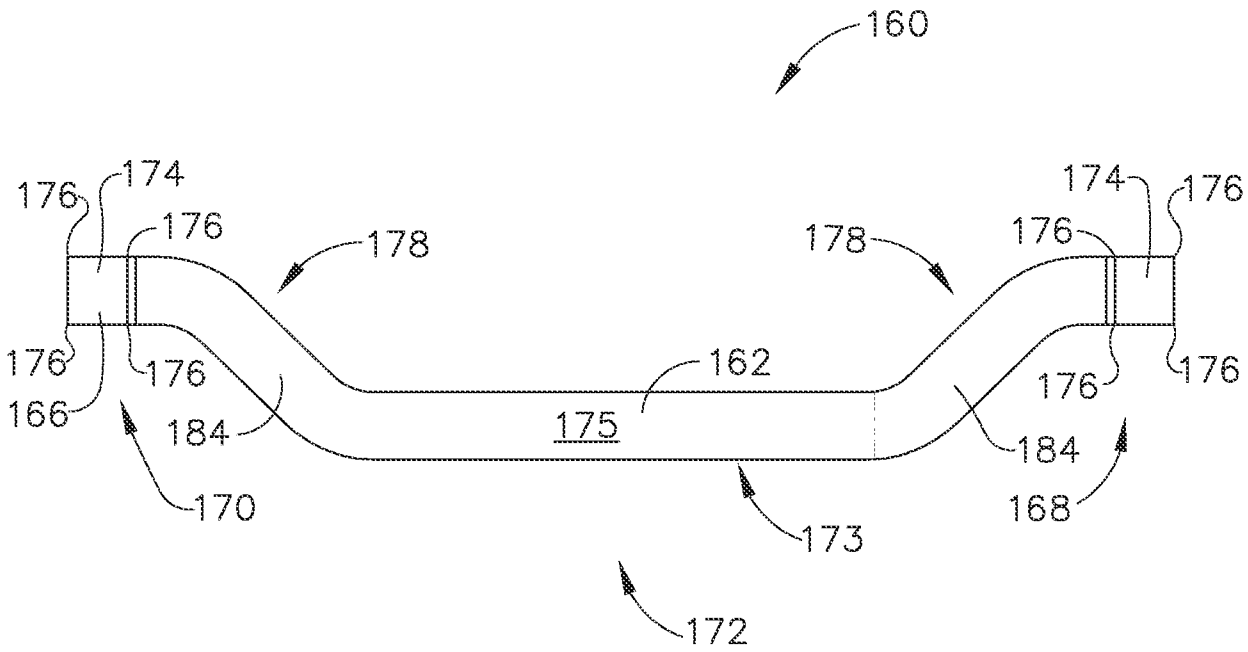

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FIG. 135

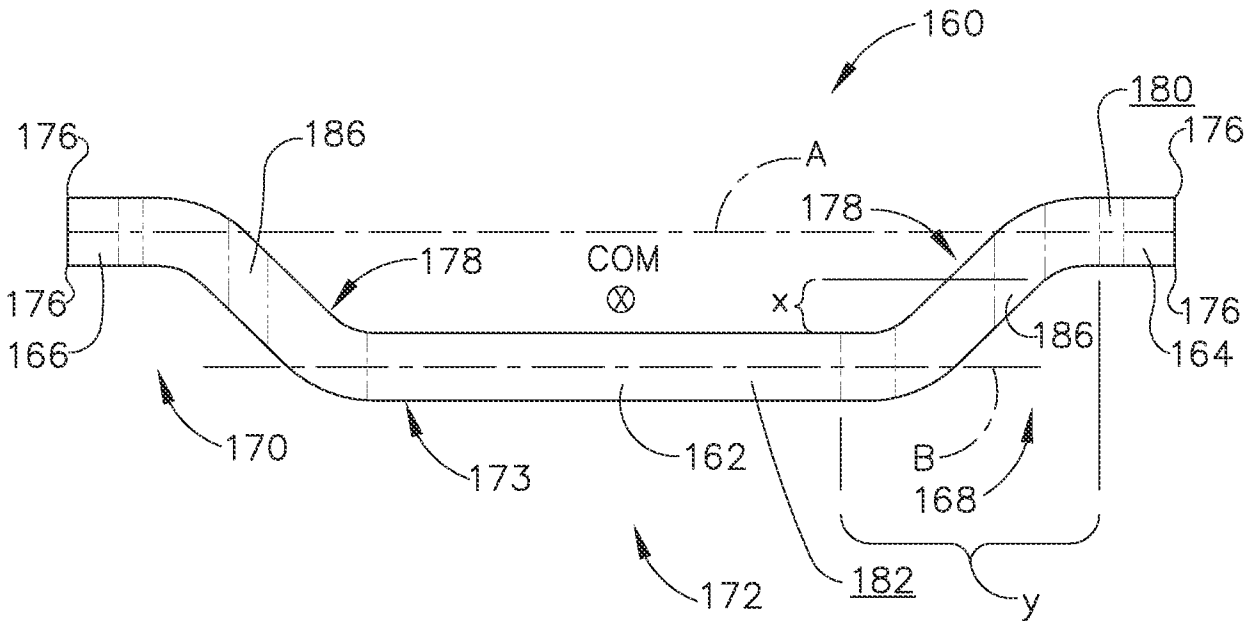

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FIG. 136

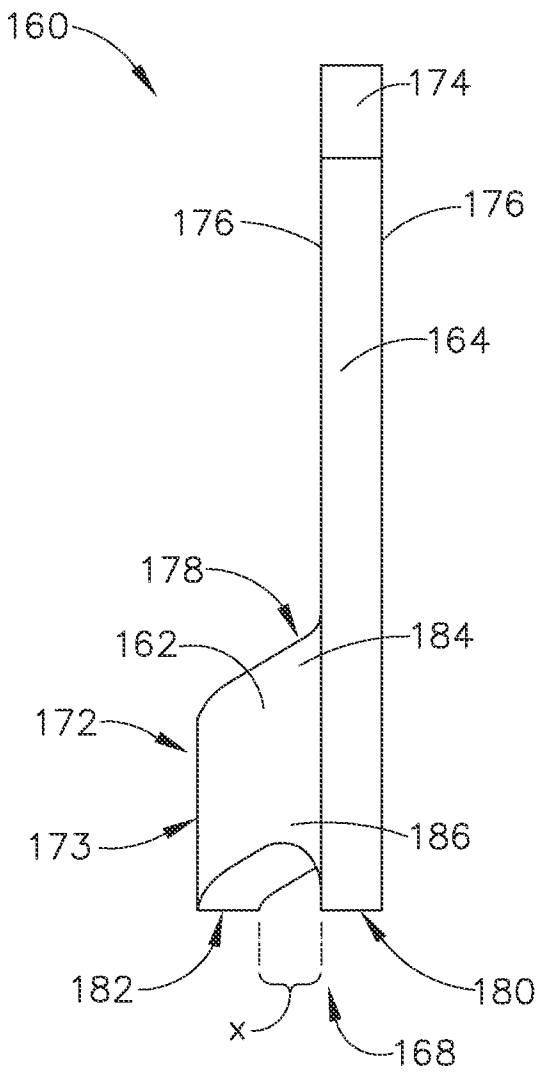


FIG. 137

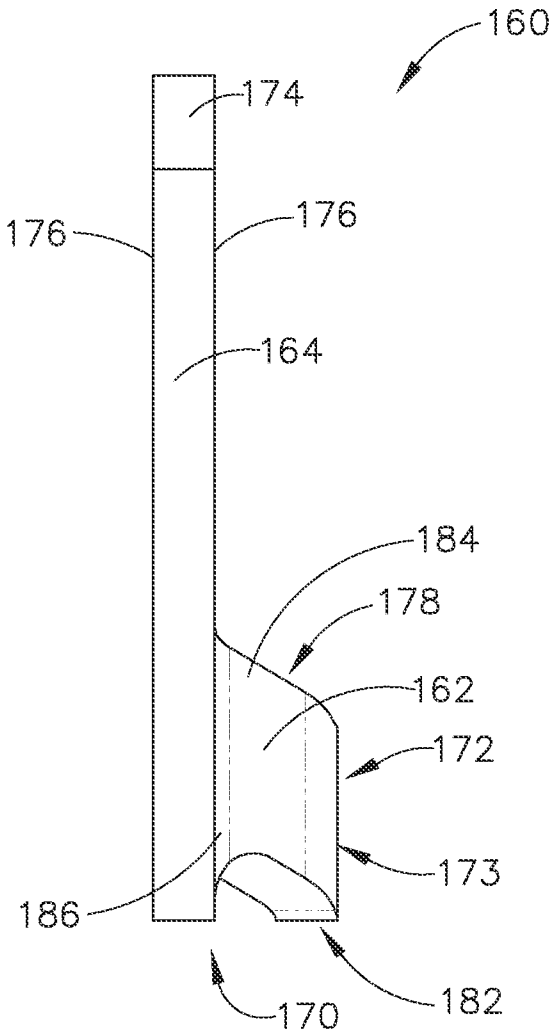


FIG. 138

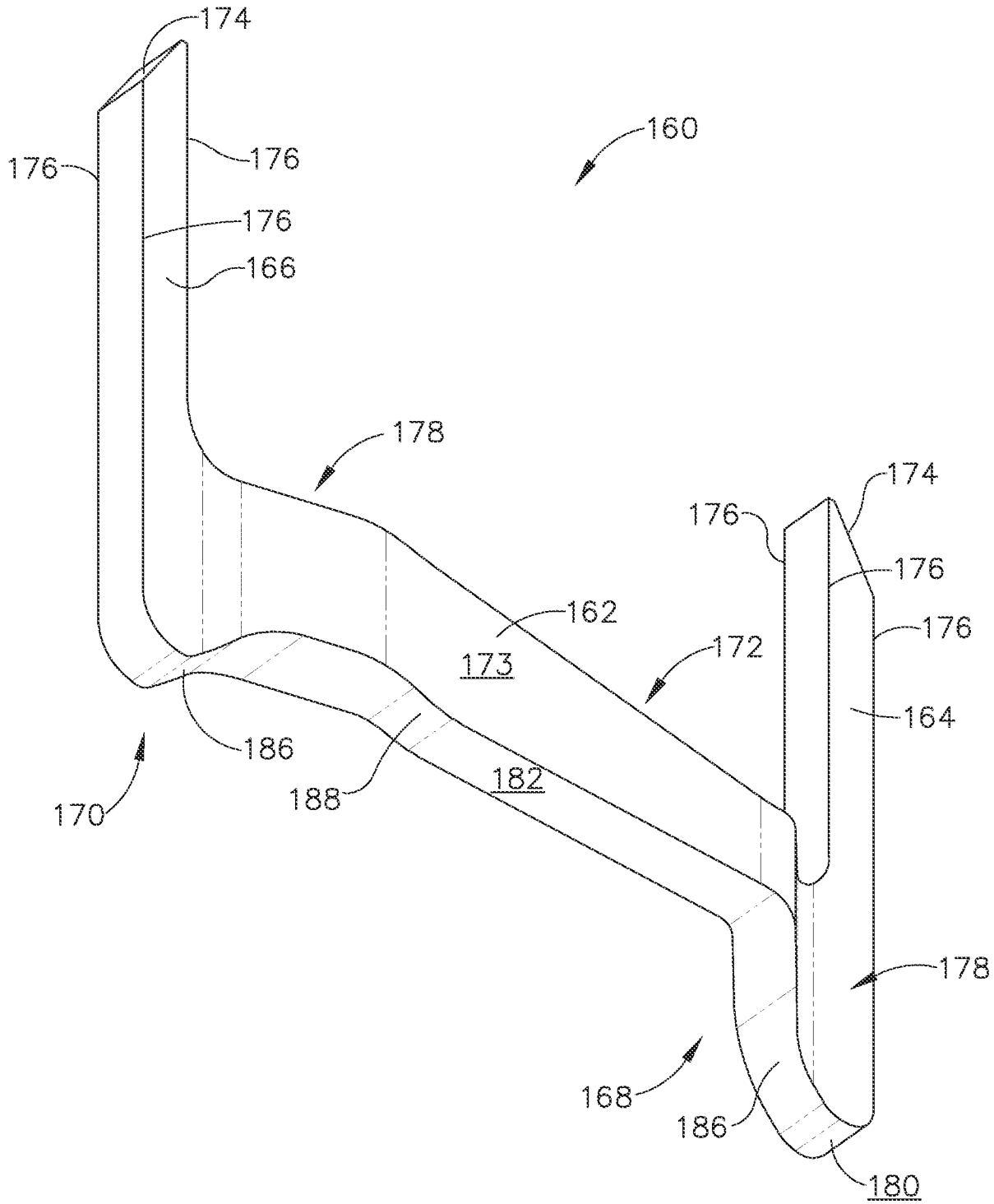

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FIG. 139

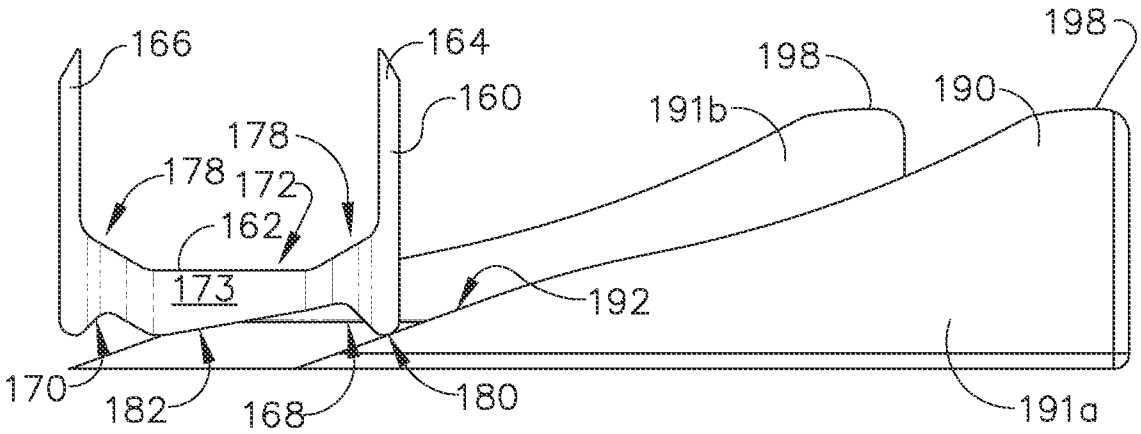


FIG. 140

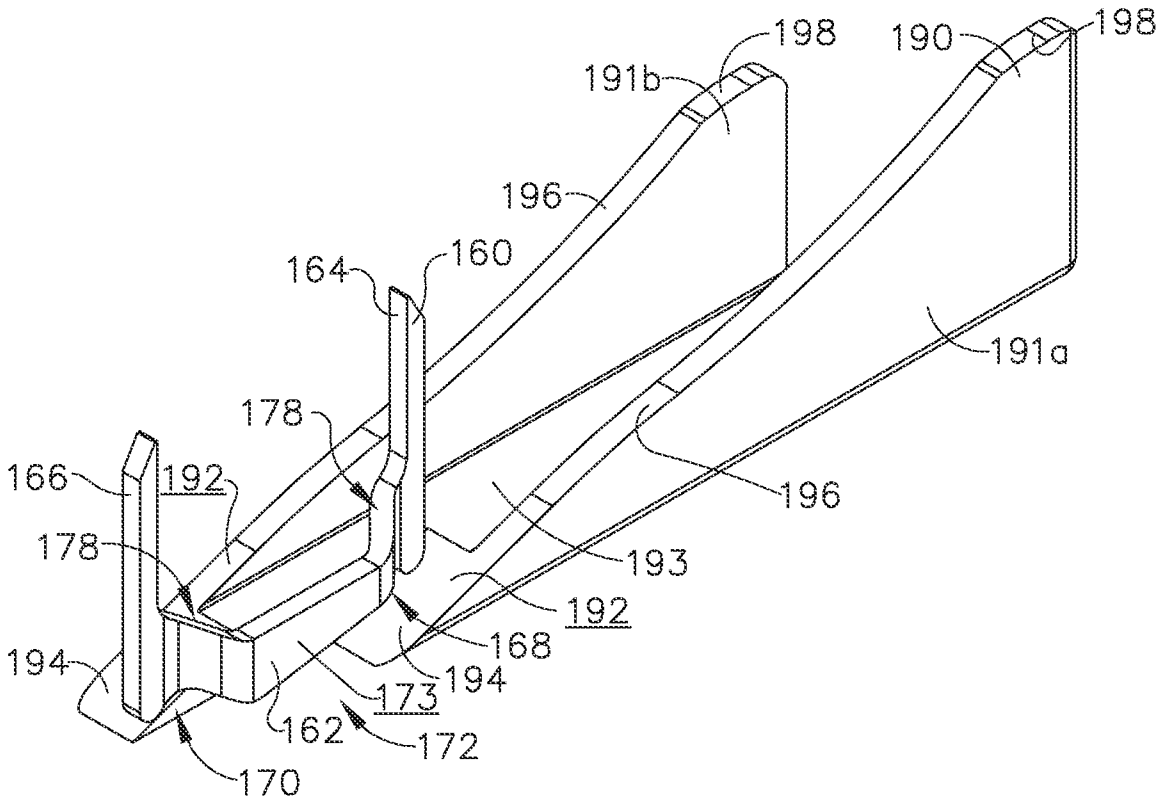


FIG. 141

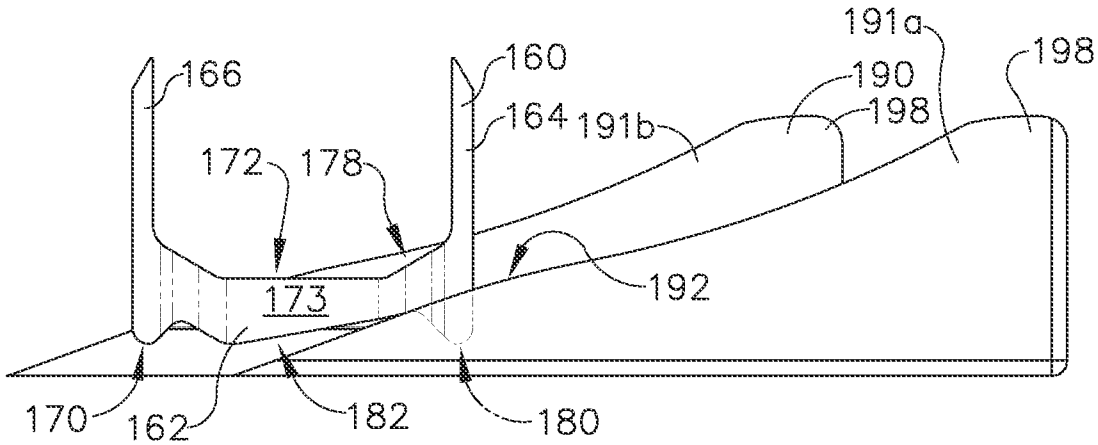


FIG. 142

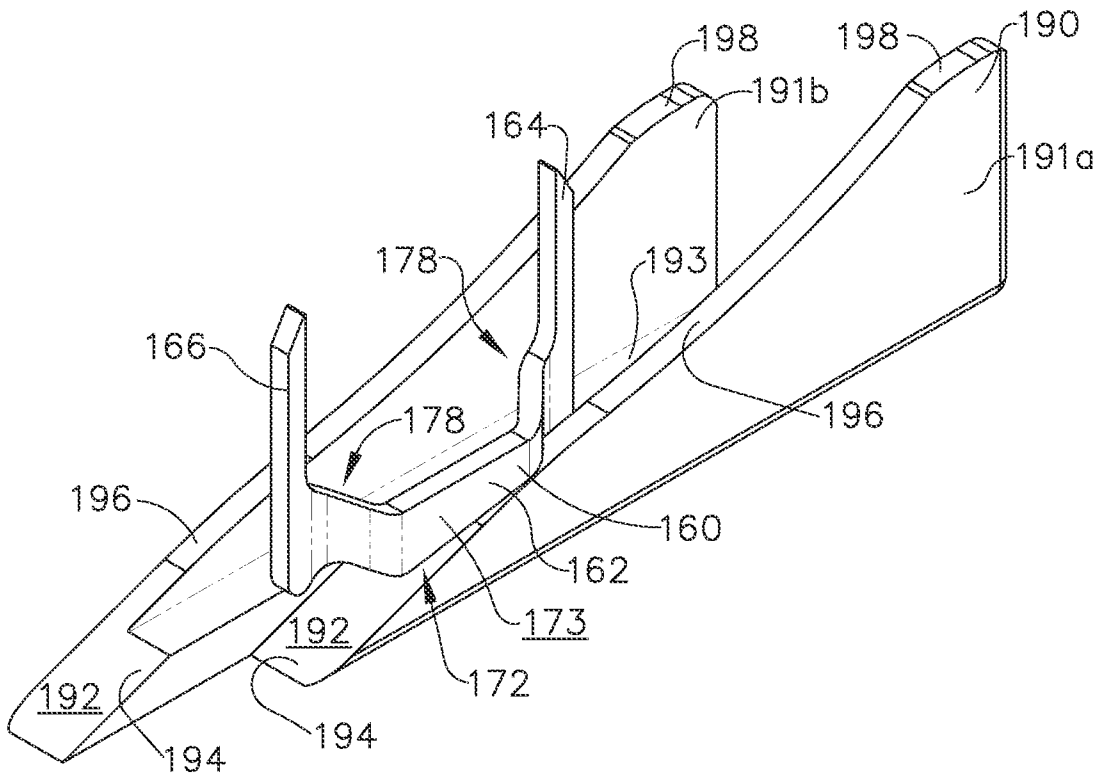


FIG. 143

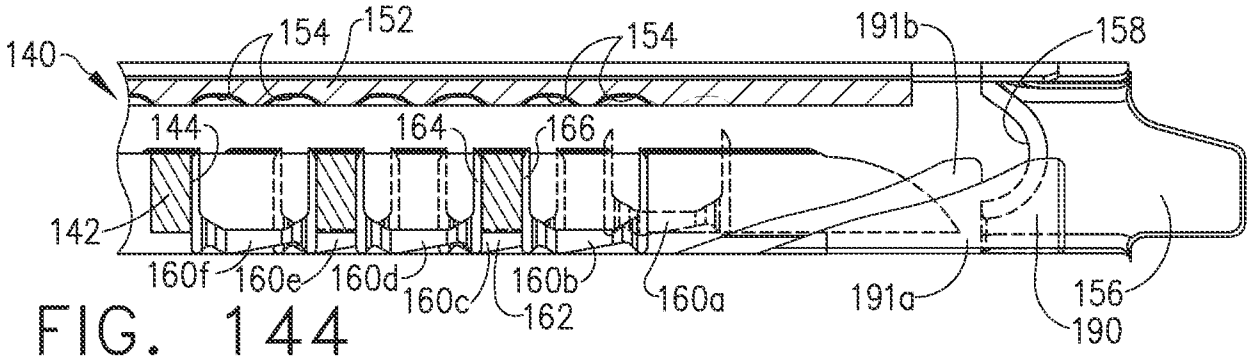


FIG. 144

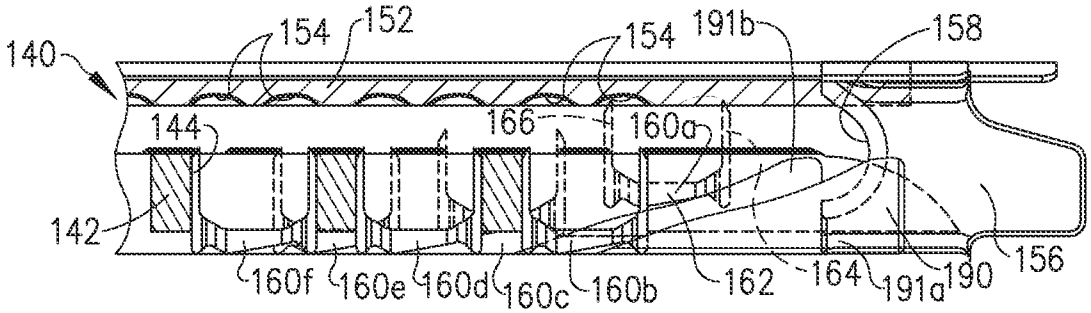


FIG. 145

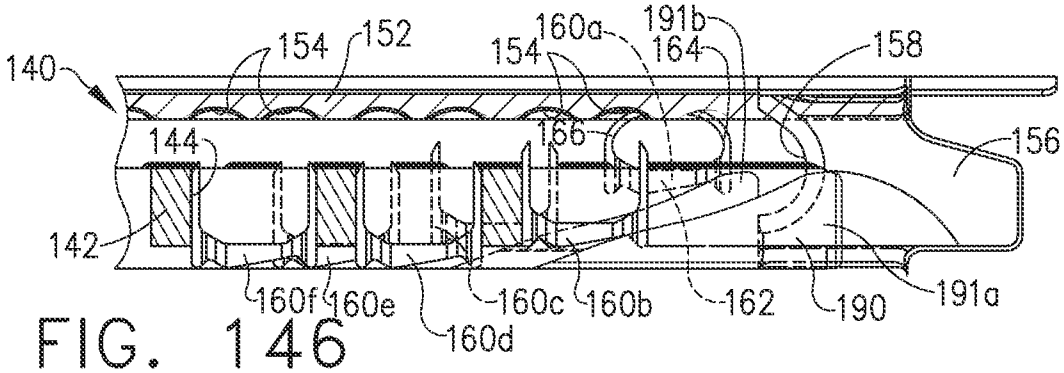


FIG. 146

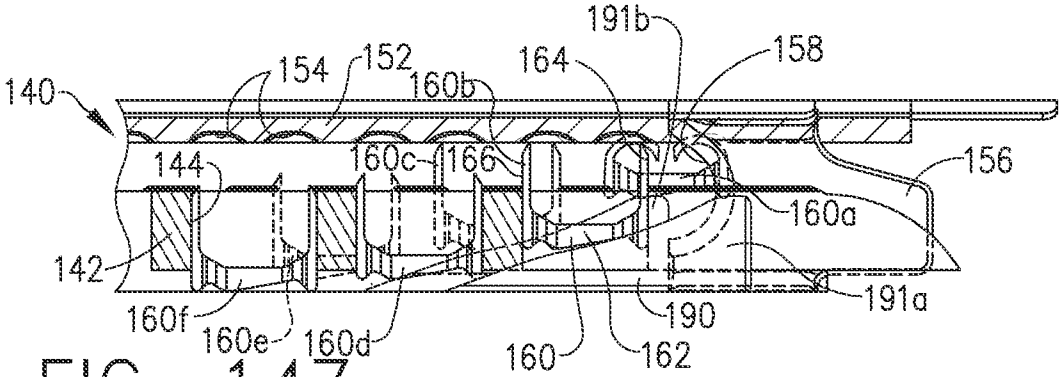


FIG. 147

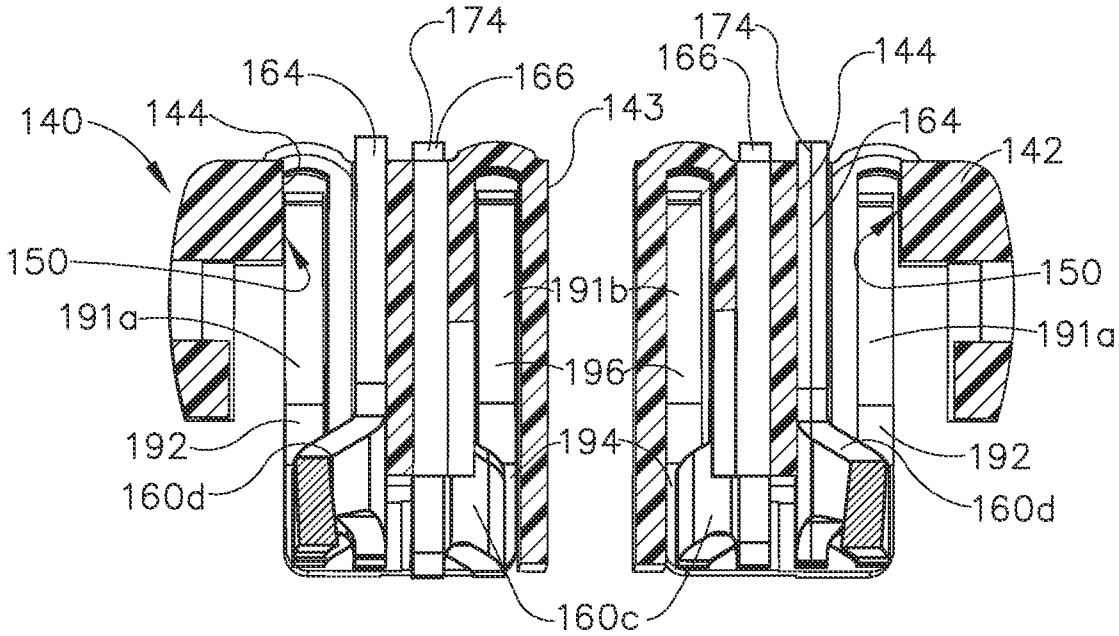


FIG. 148

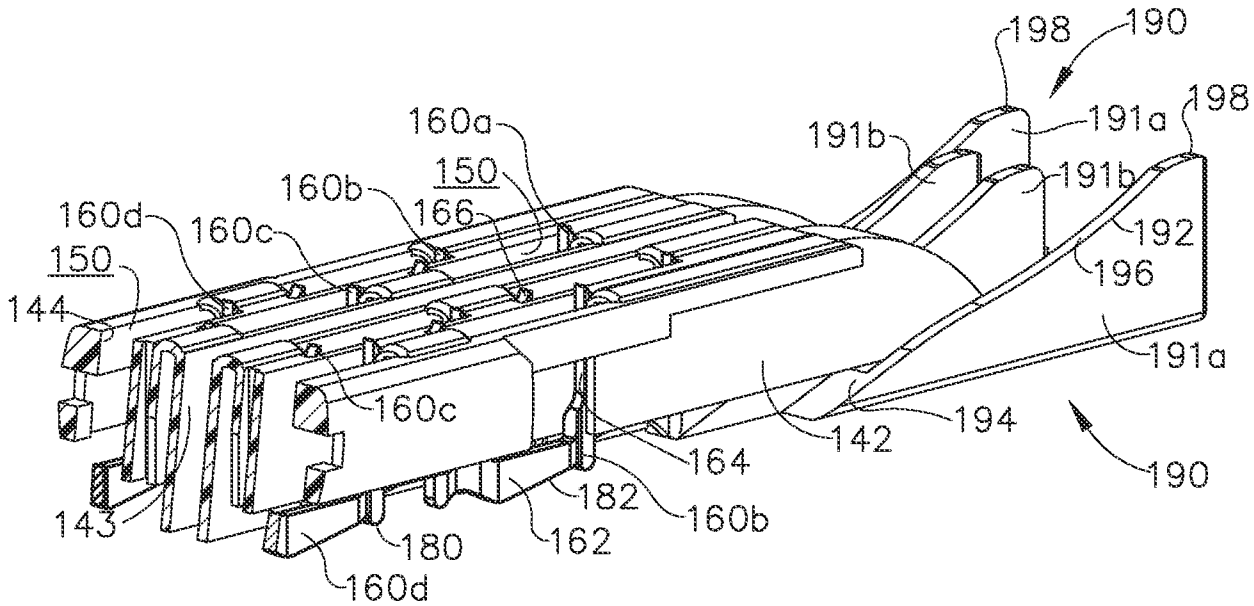


FIG. 149

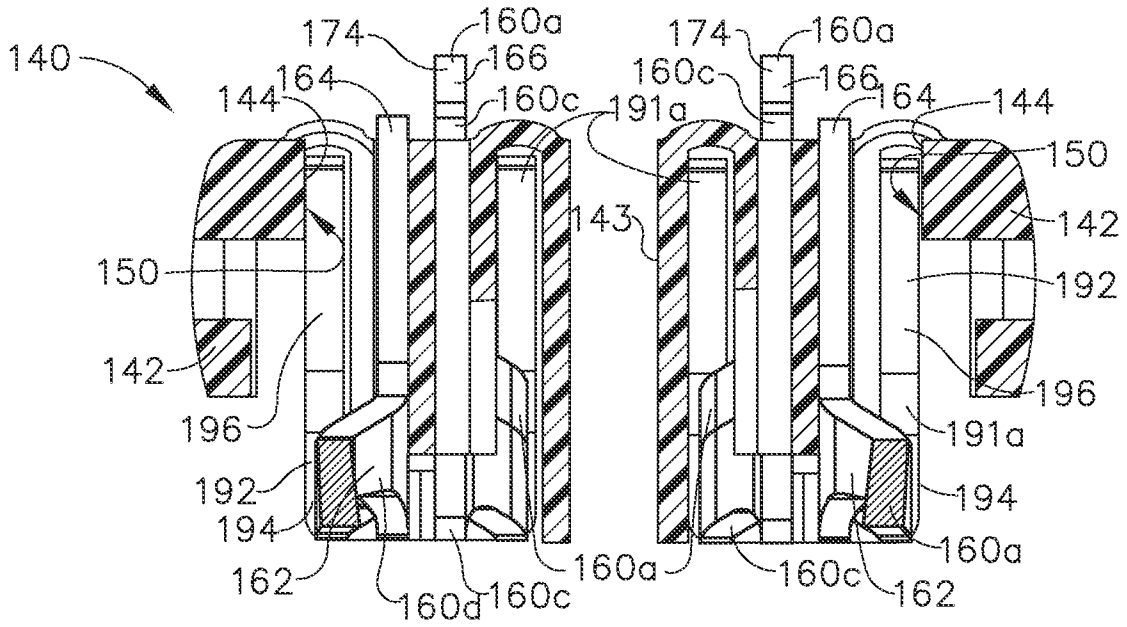


FIG. 150

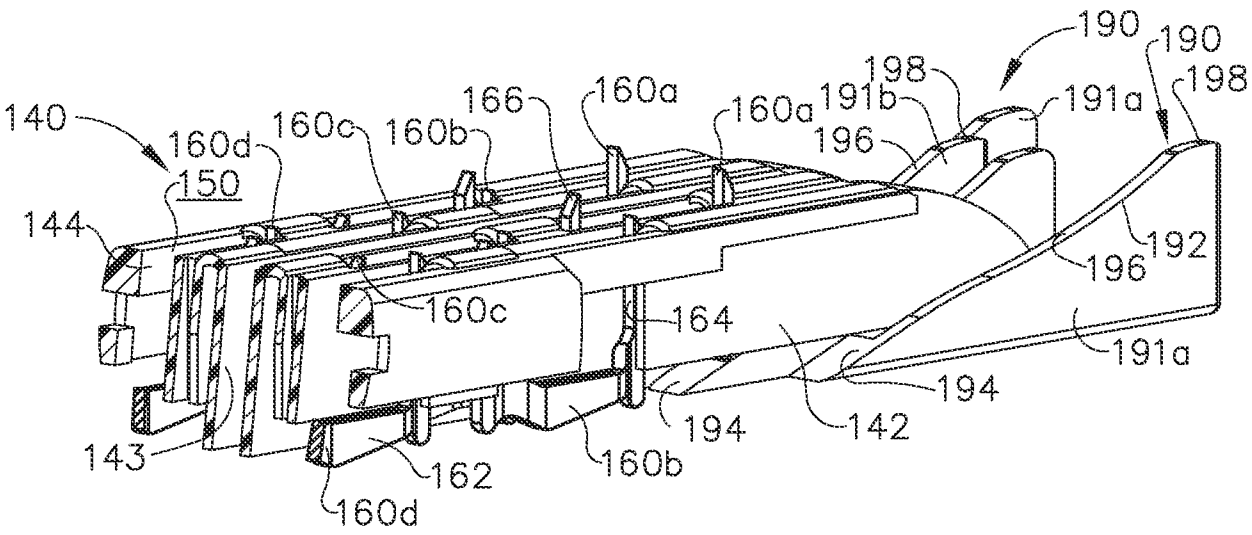


FIG. 151

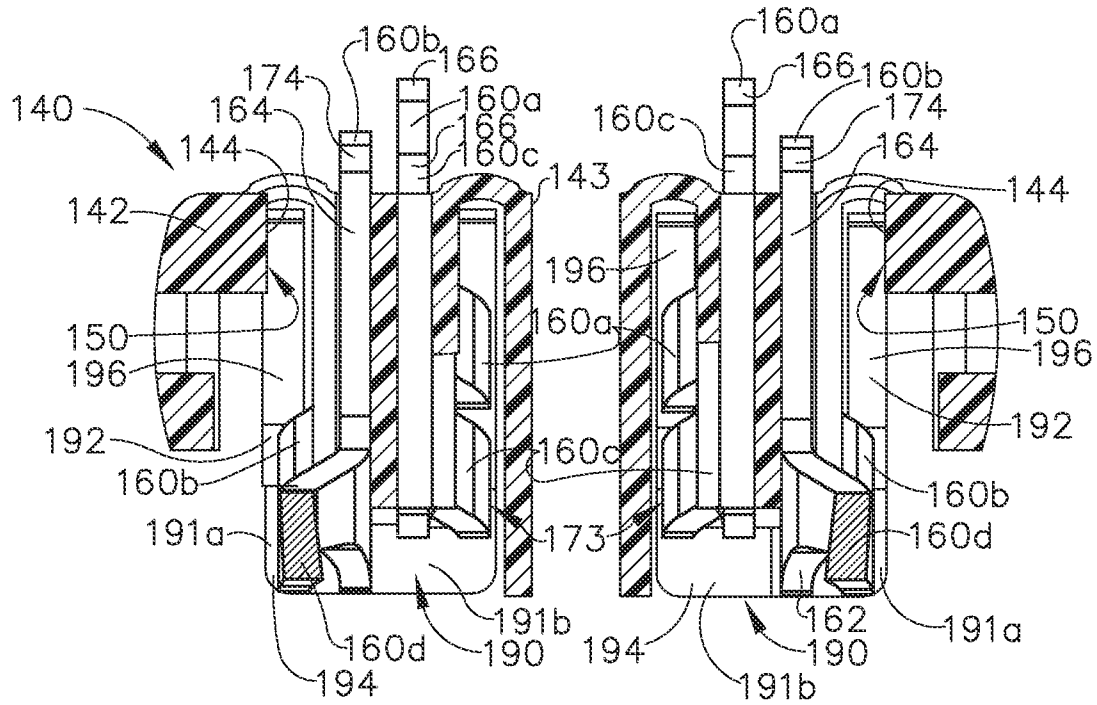


FIG. 152

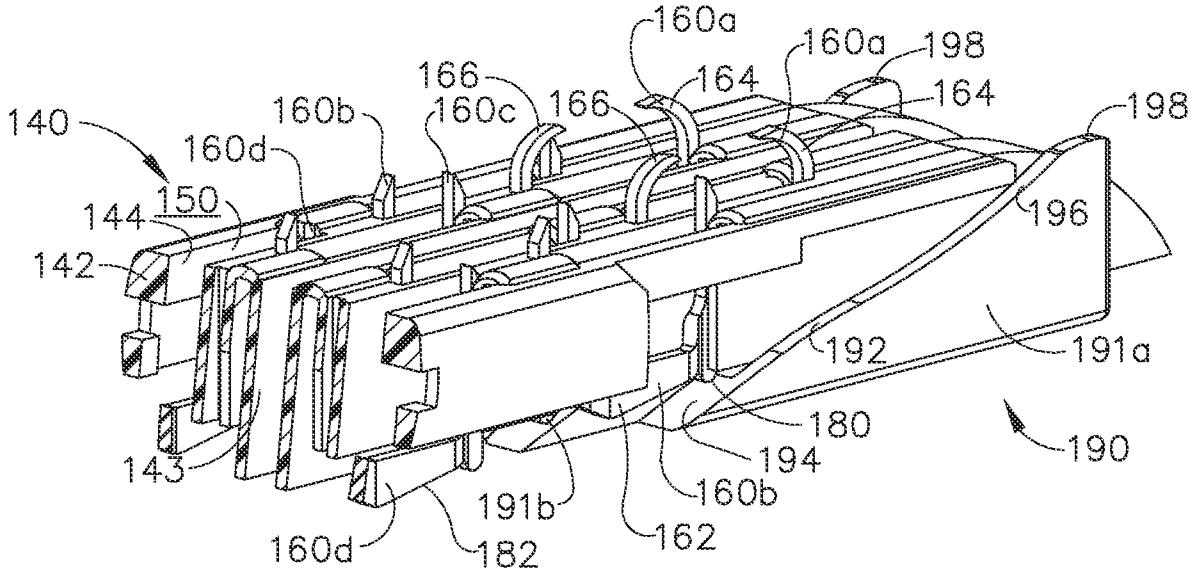


FIG. 153

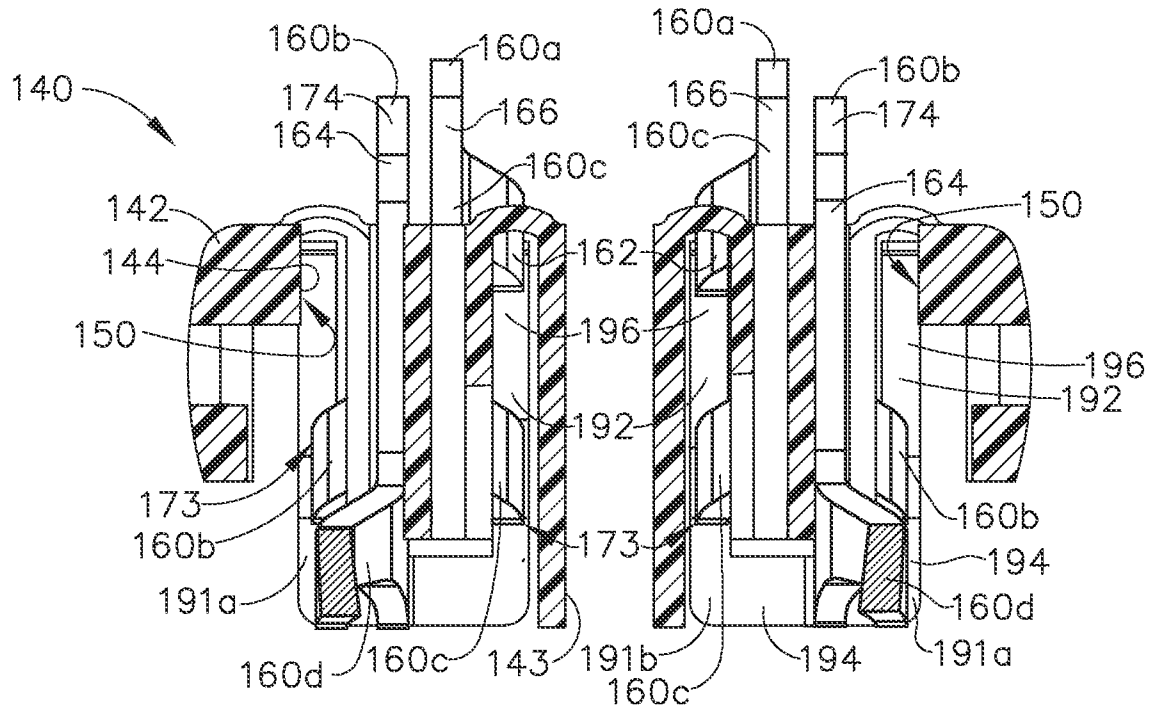


FIG. 154

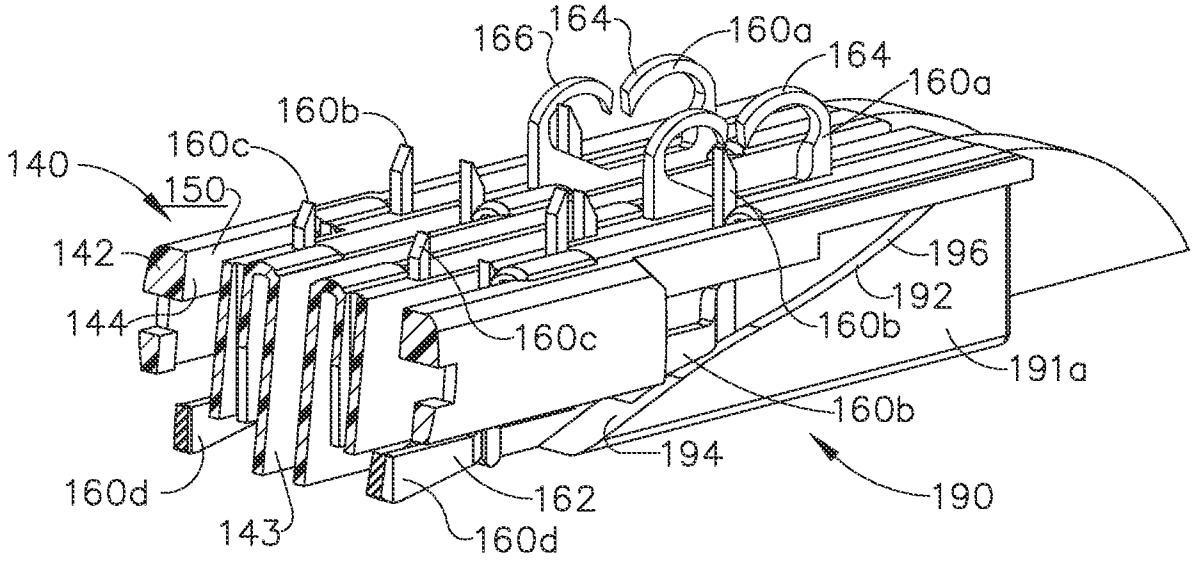


FIG. 155

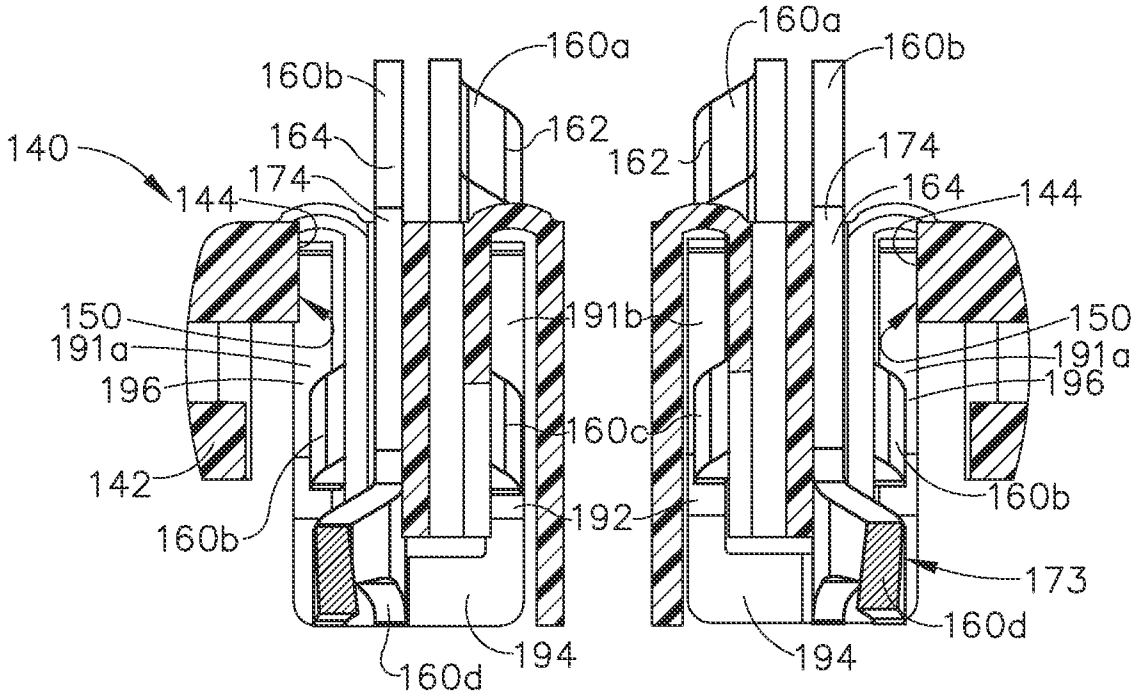


FIG. 156

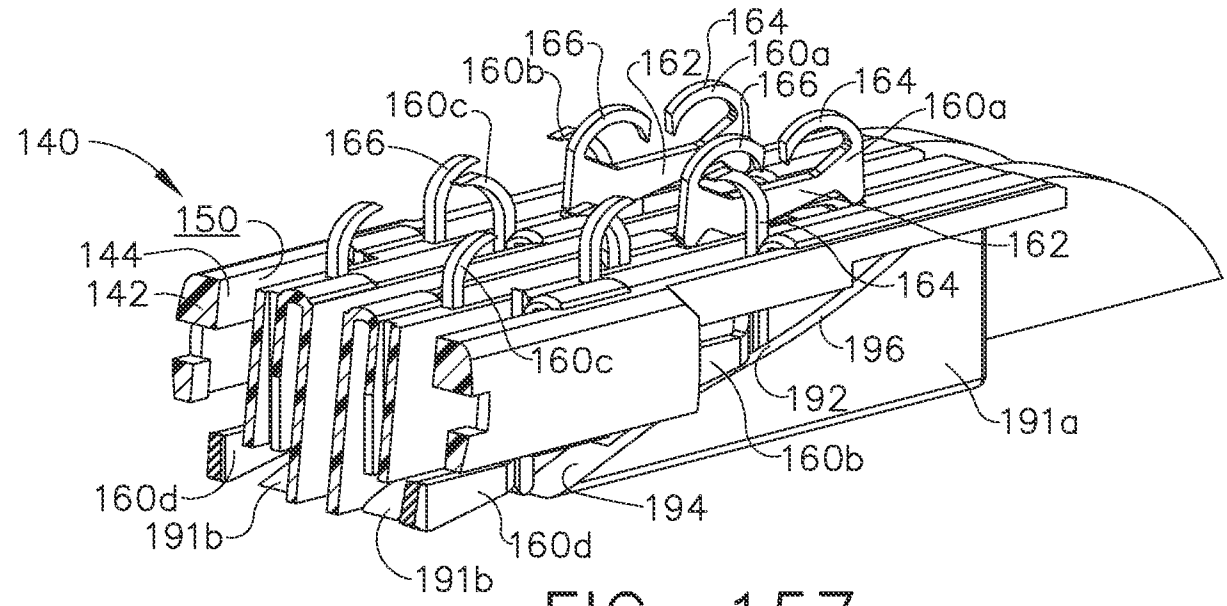


FIG. 157

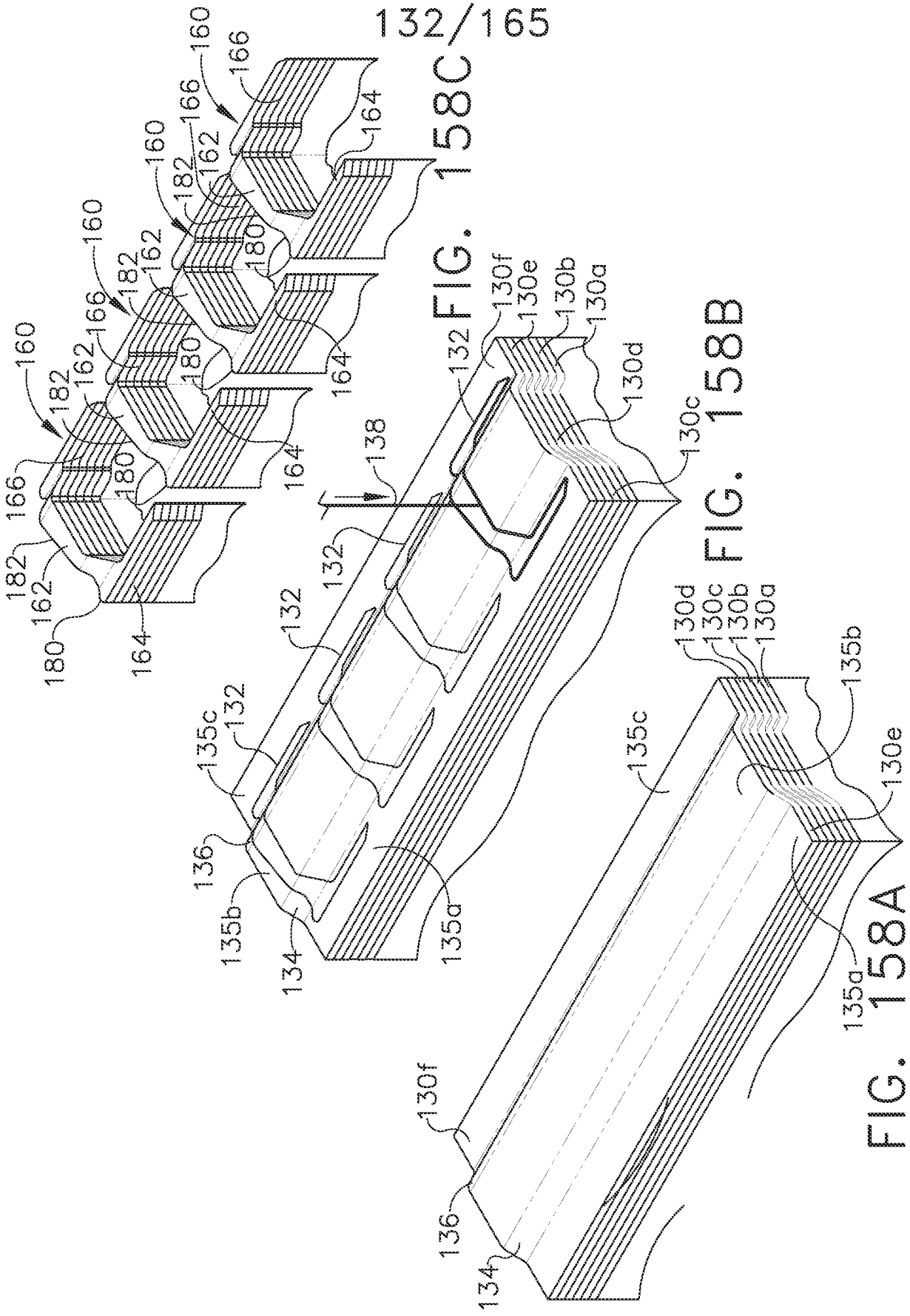


FIG. 158C

FIG. 158B

FIG. 158A

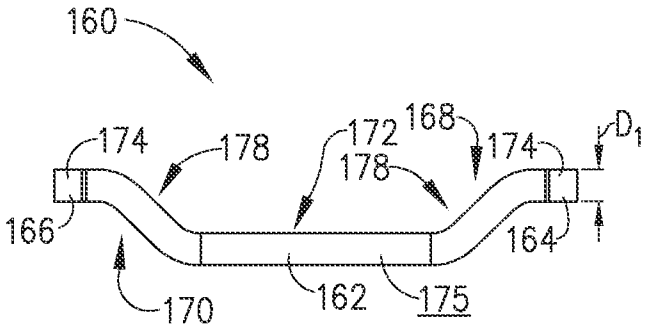


FIG. 160

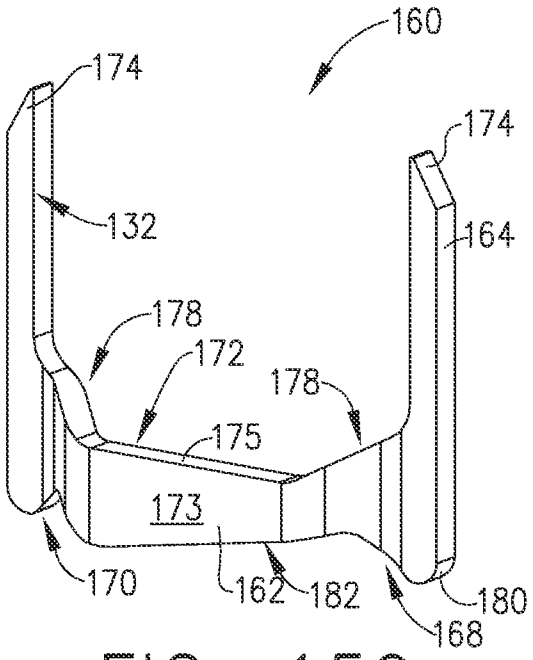


FIG. 159

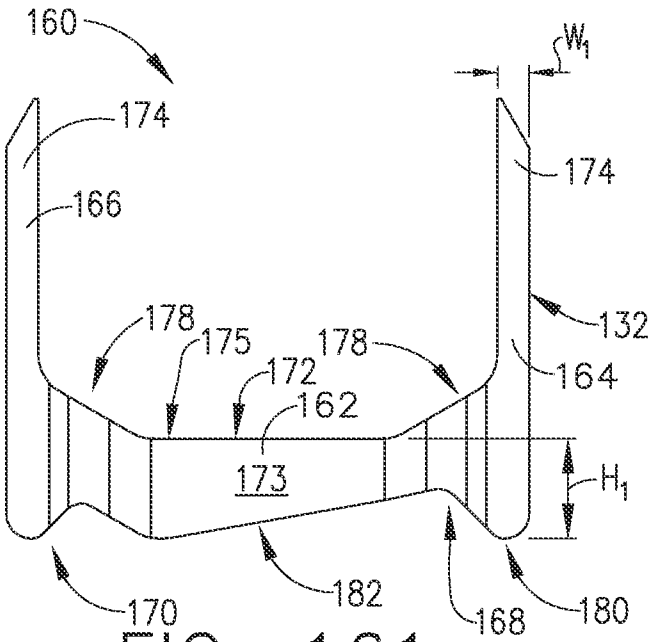


FIG. 161

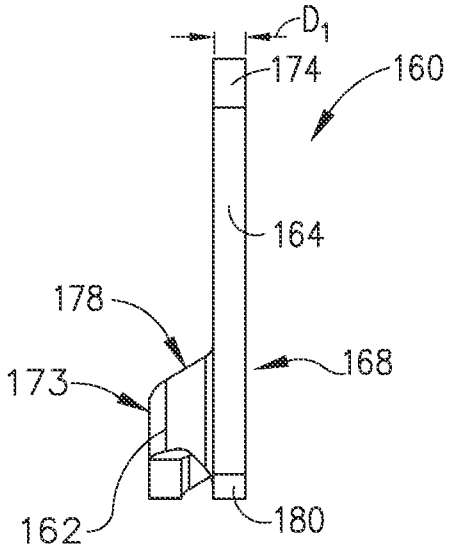


FIG. 162

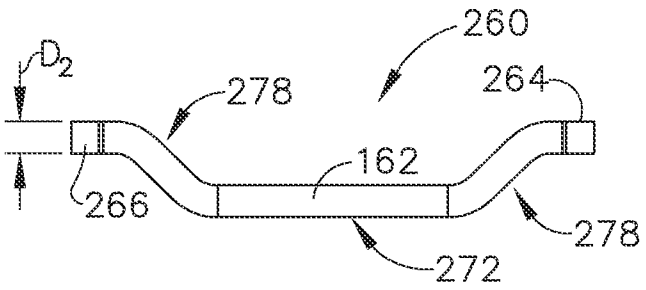


FIG. 164

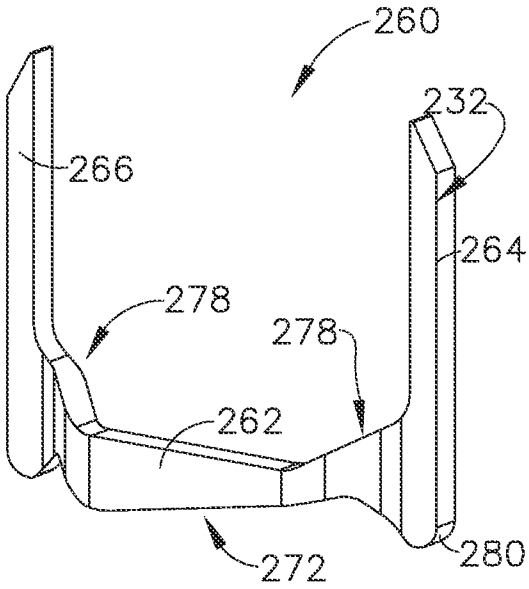


FIG. 163

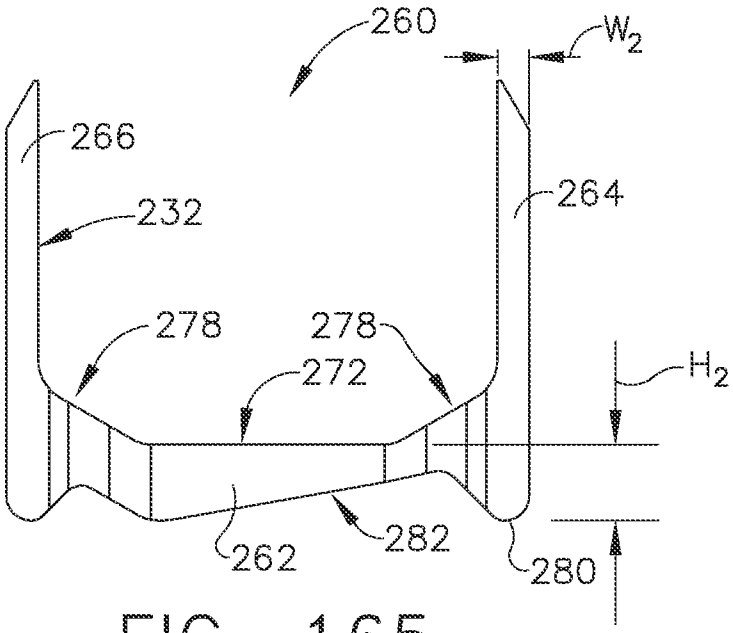


FIG. 165

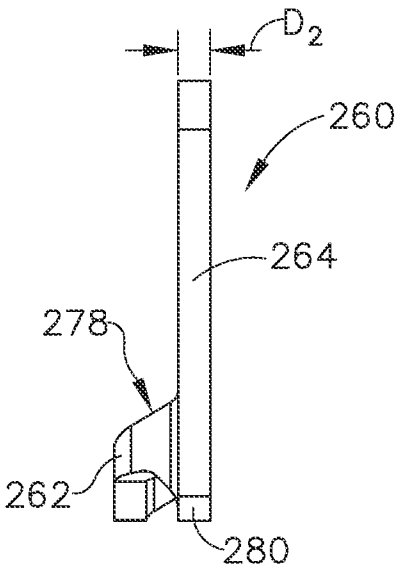


FIG. 166

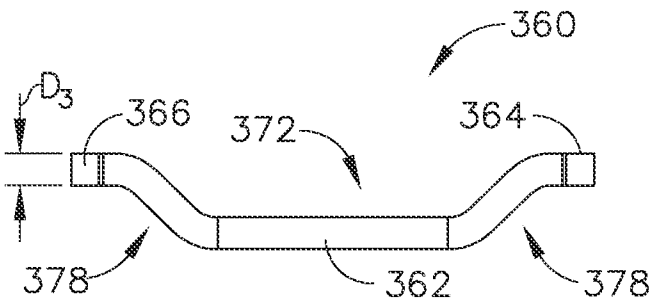


FIG. 168

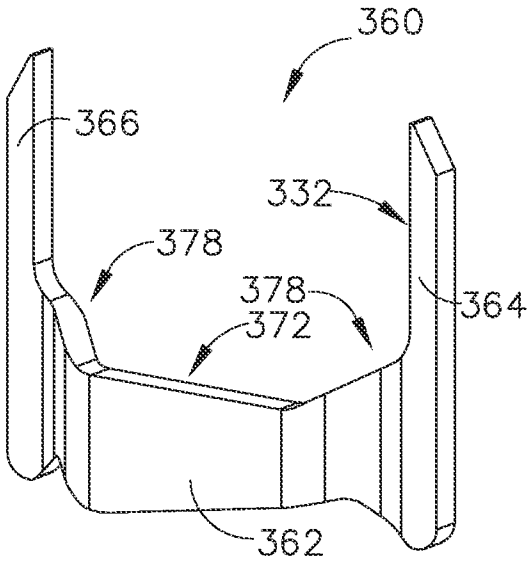


FIG. 167

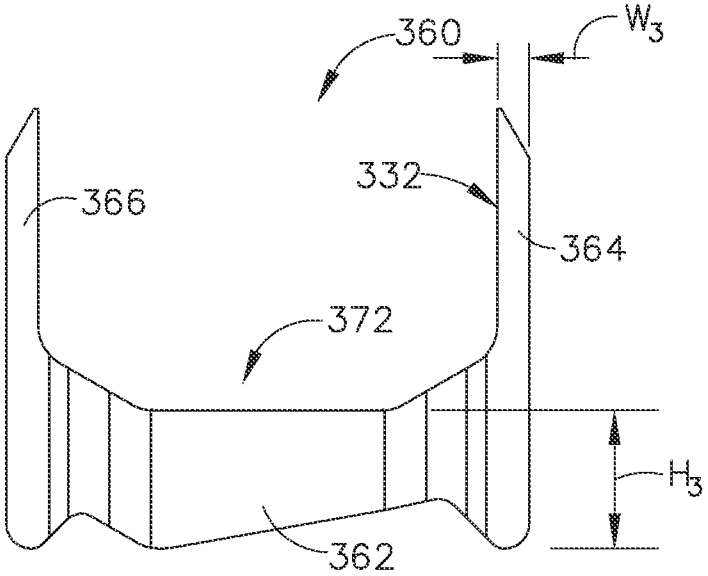


FIG. 169

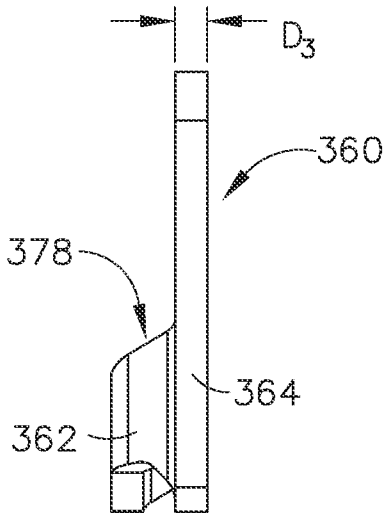


FIG. 170

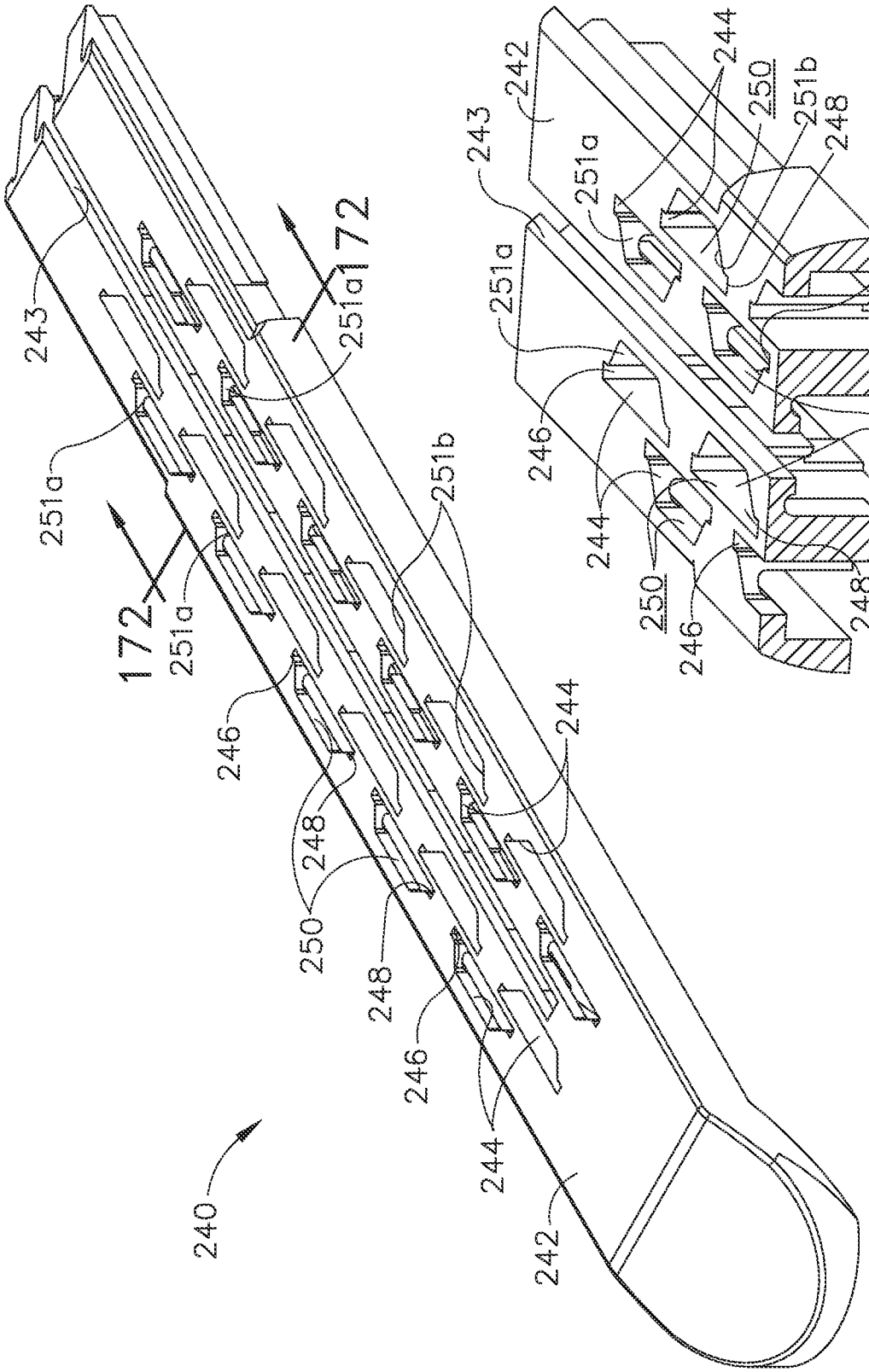


FIG. 171

FIG. 172

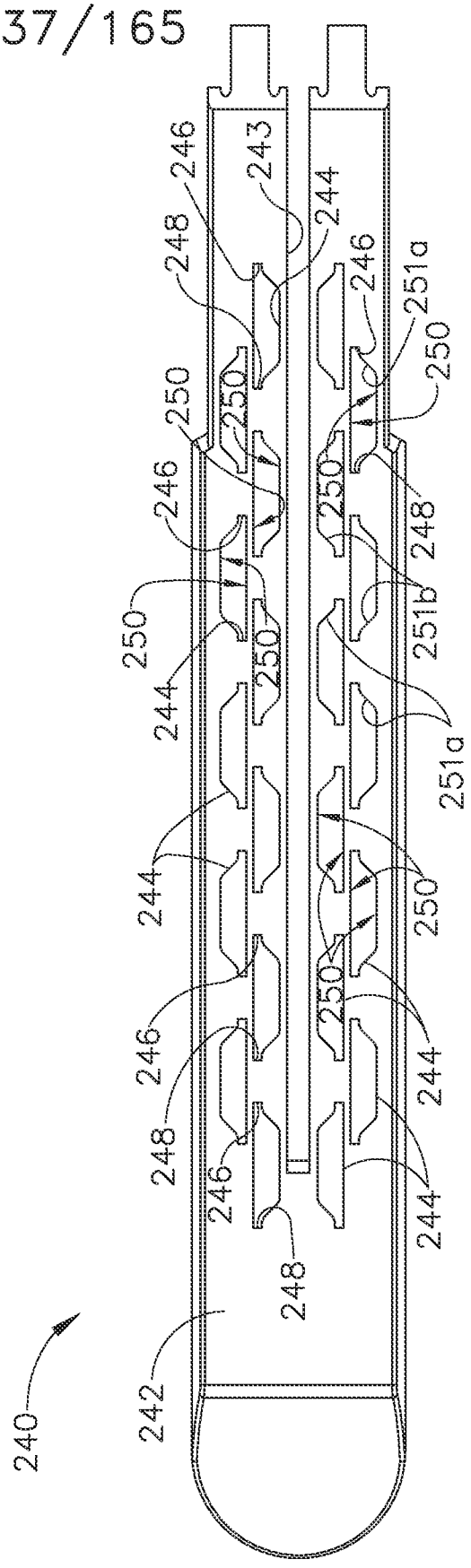


FIG. 173

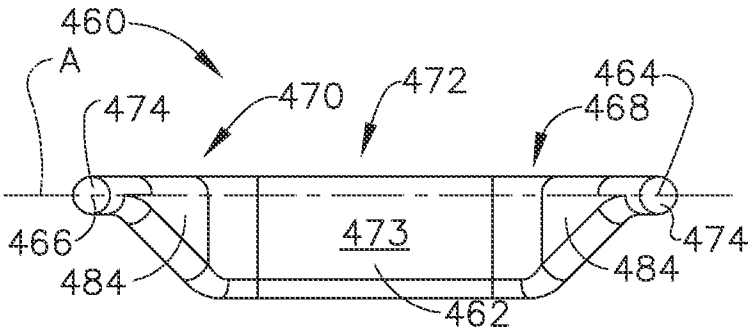


FIG. 175

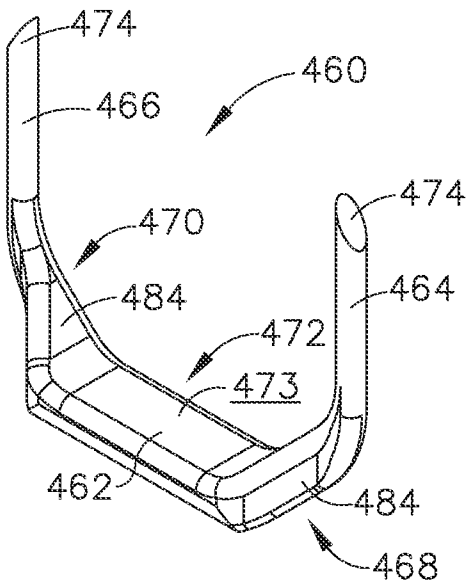


FIG. 174

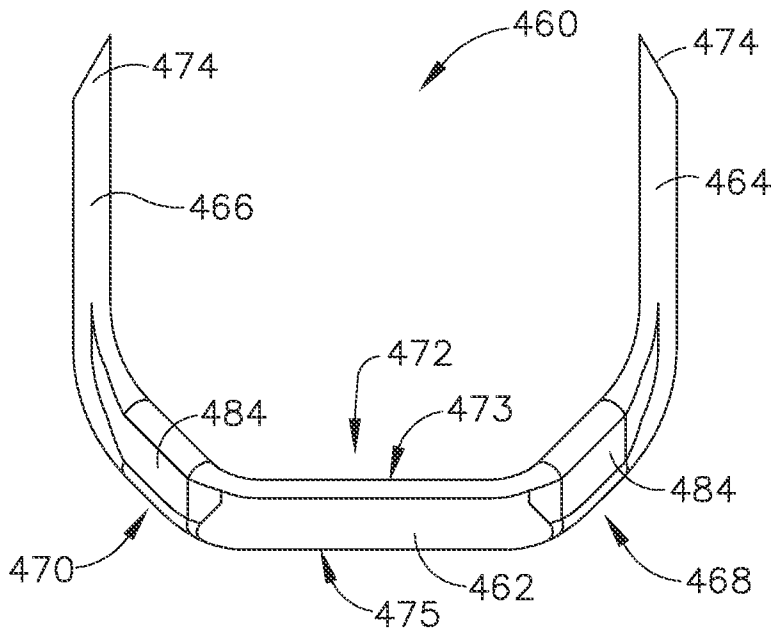


FIG. 176

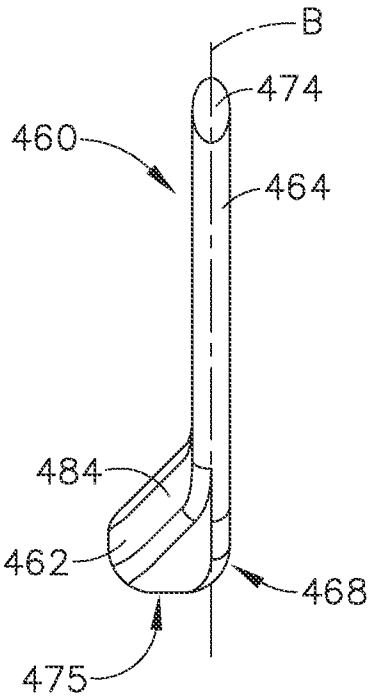


FIG. 177

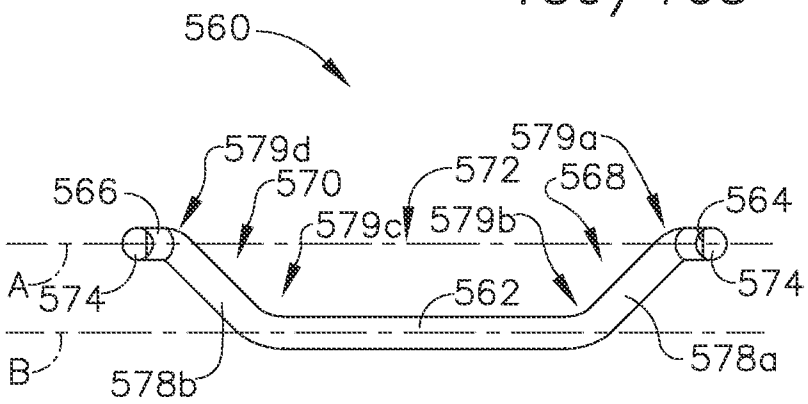


FIG. 179

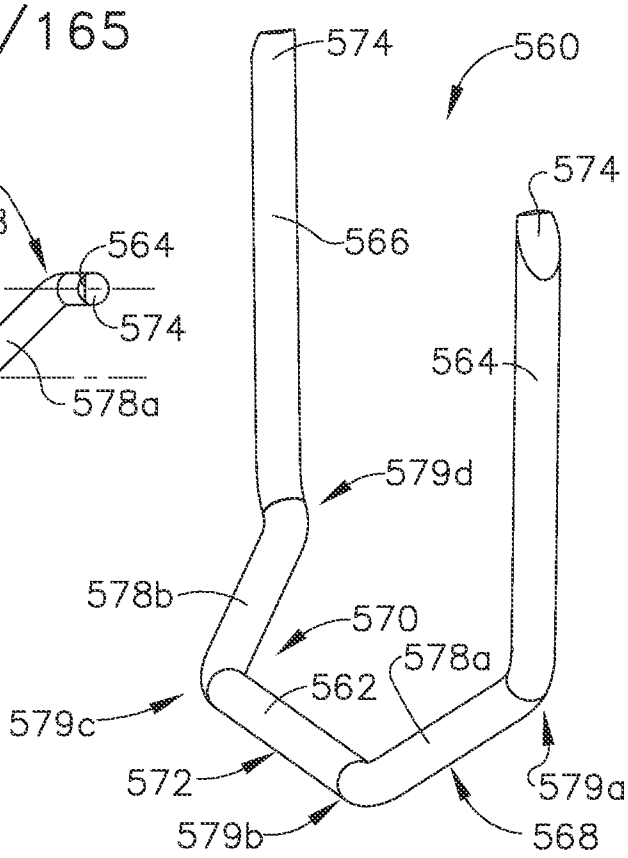


FIG. 178

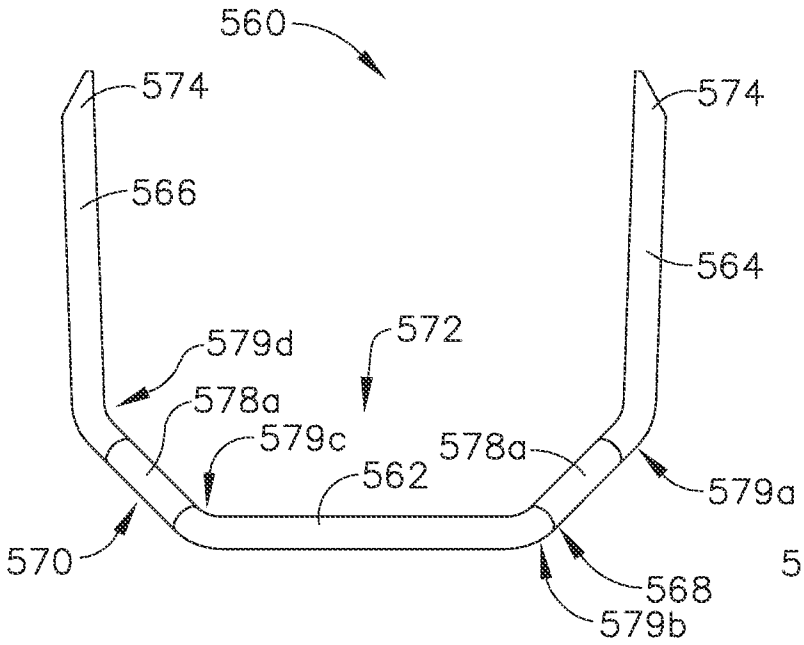


FIG. 180

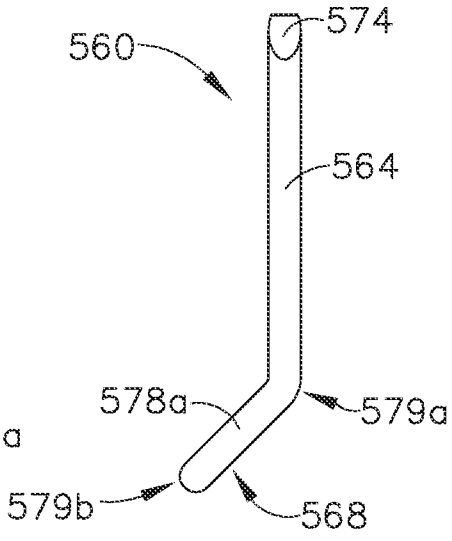


FIG. 181

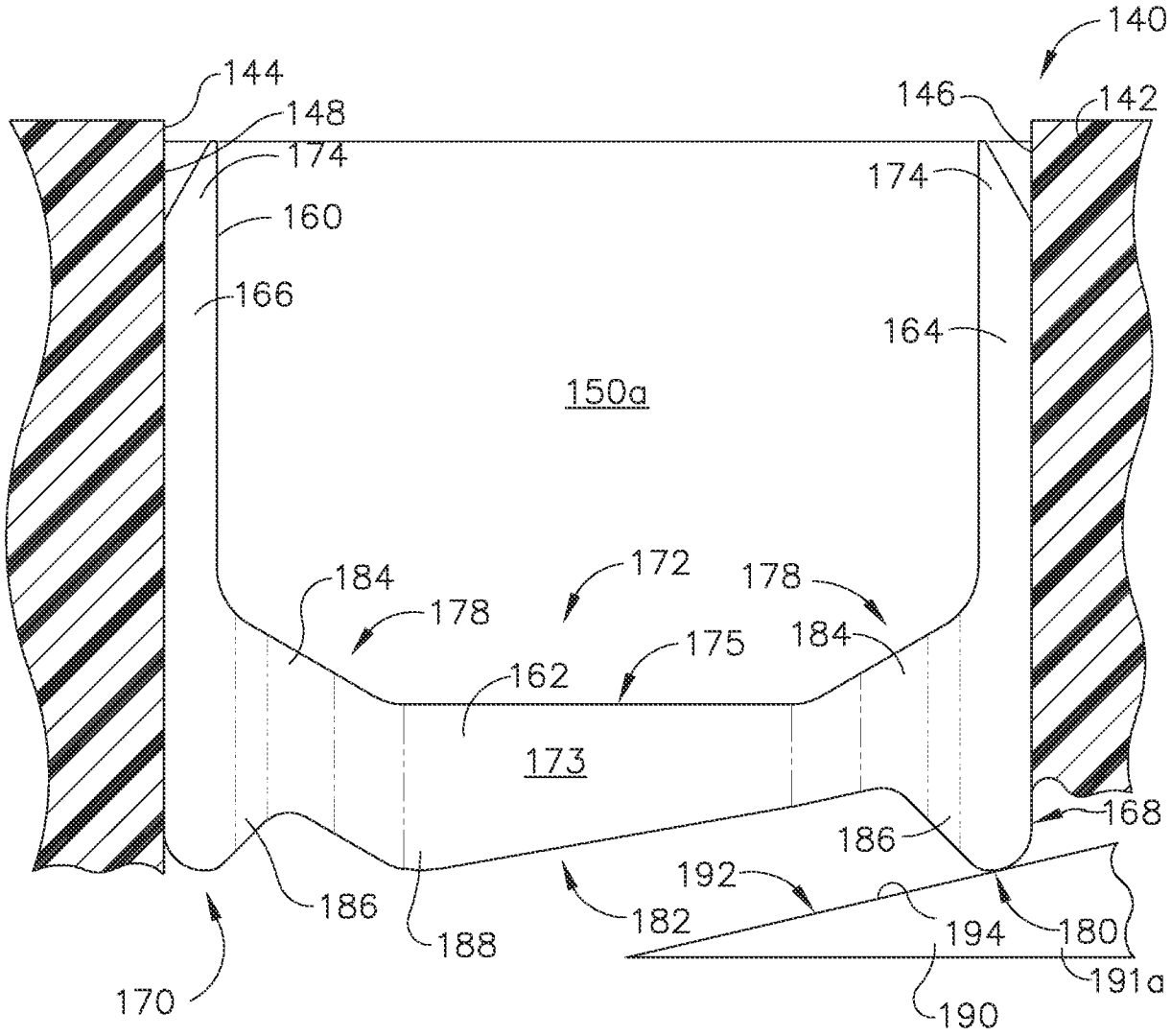

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FIG. 182

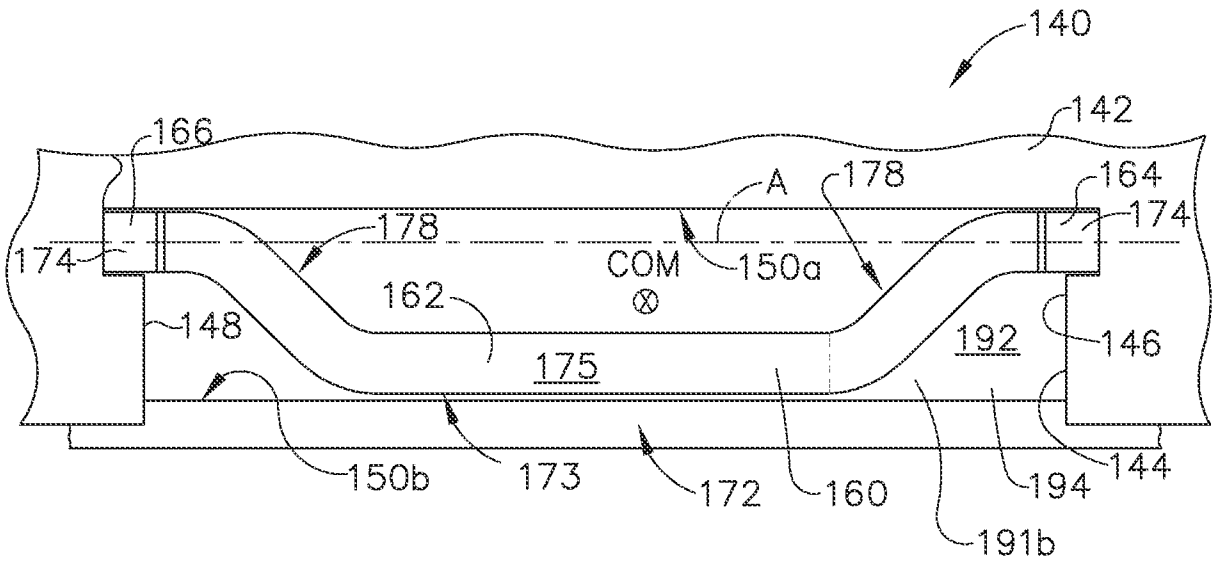

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FIG. 183

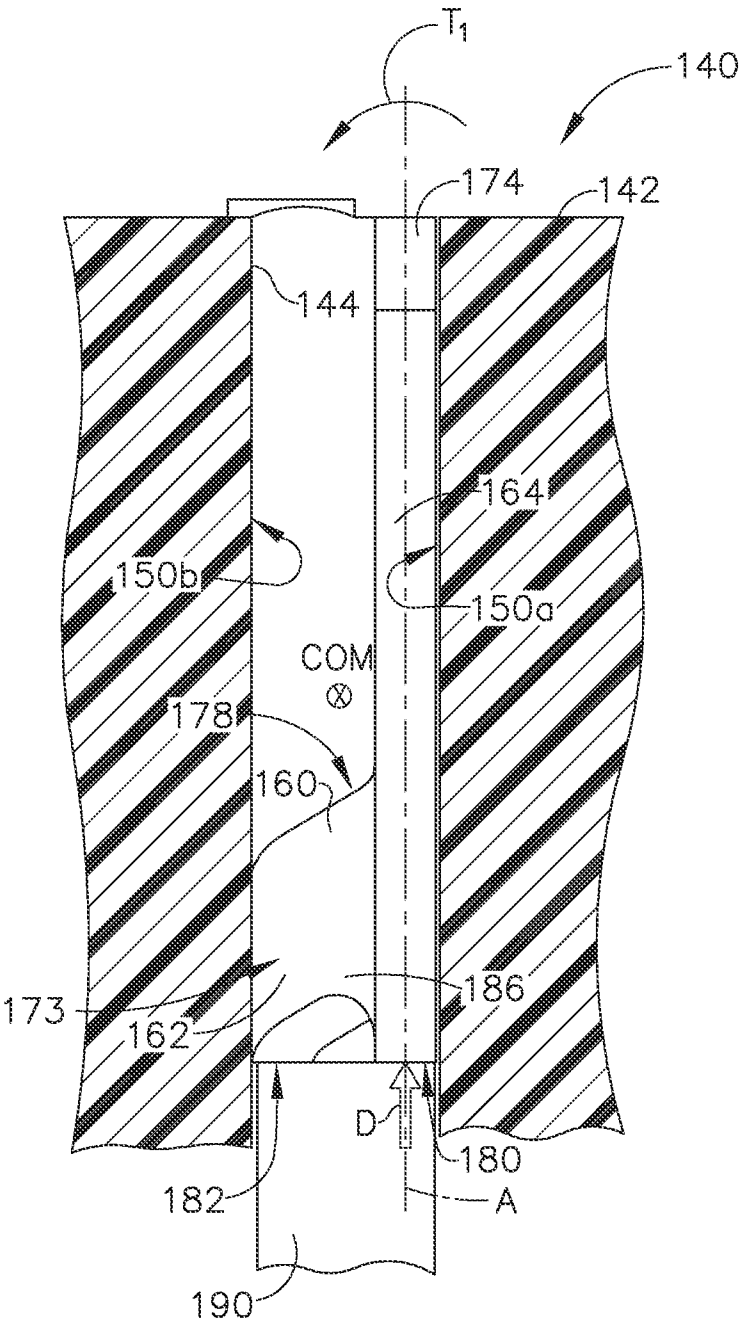

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FIG. 184

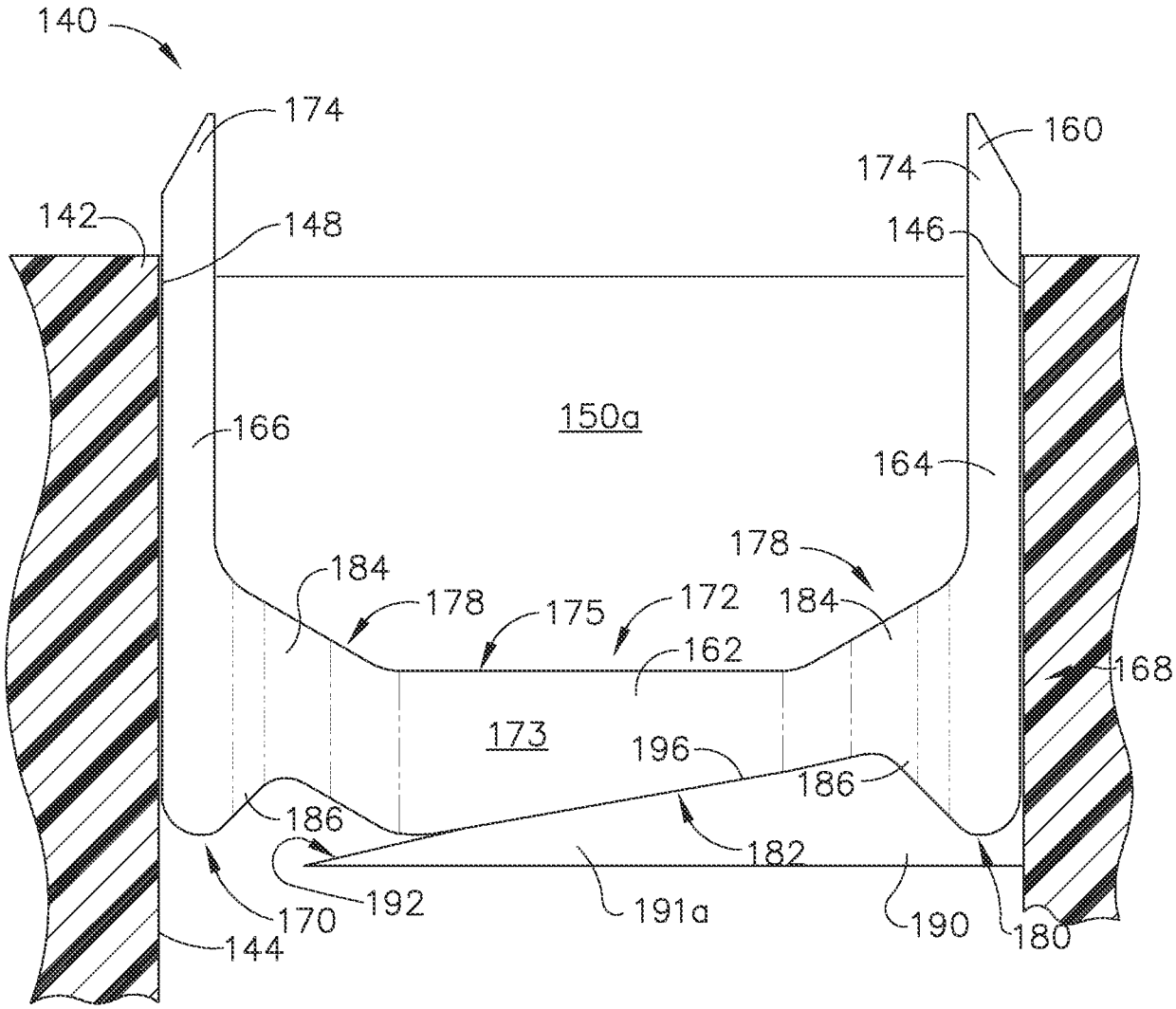

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FIG. 185

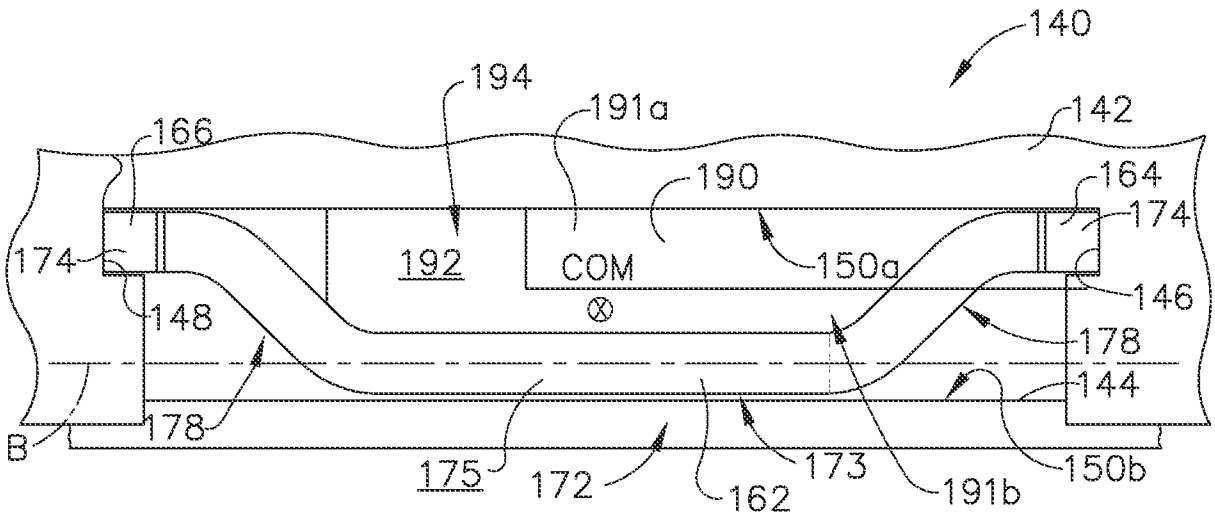

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FIG. 186

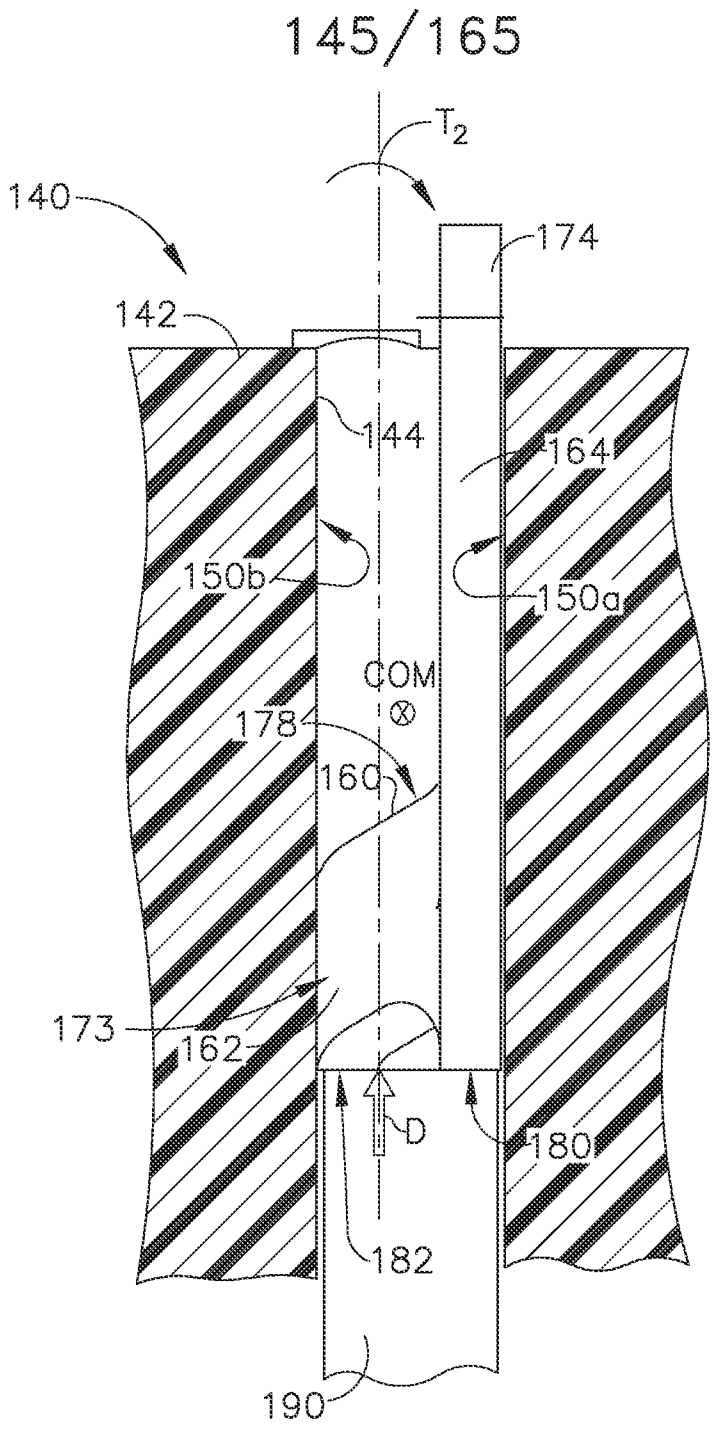

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FIG. 187

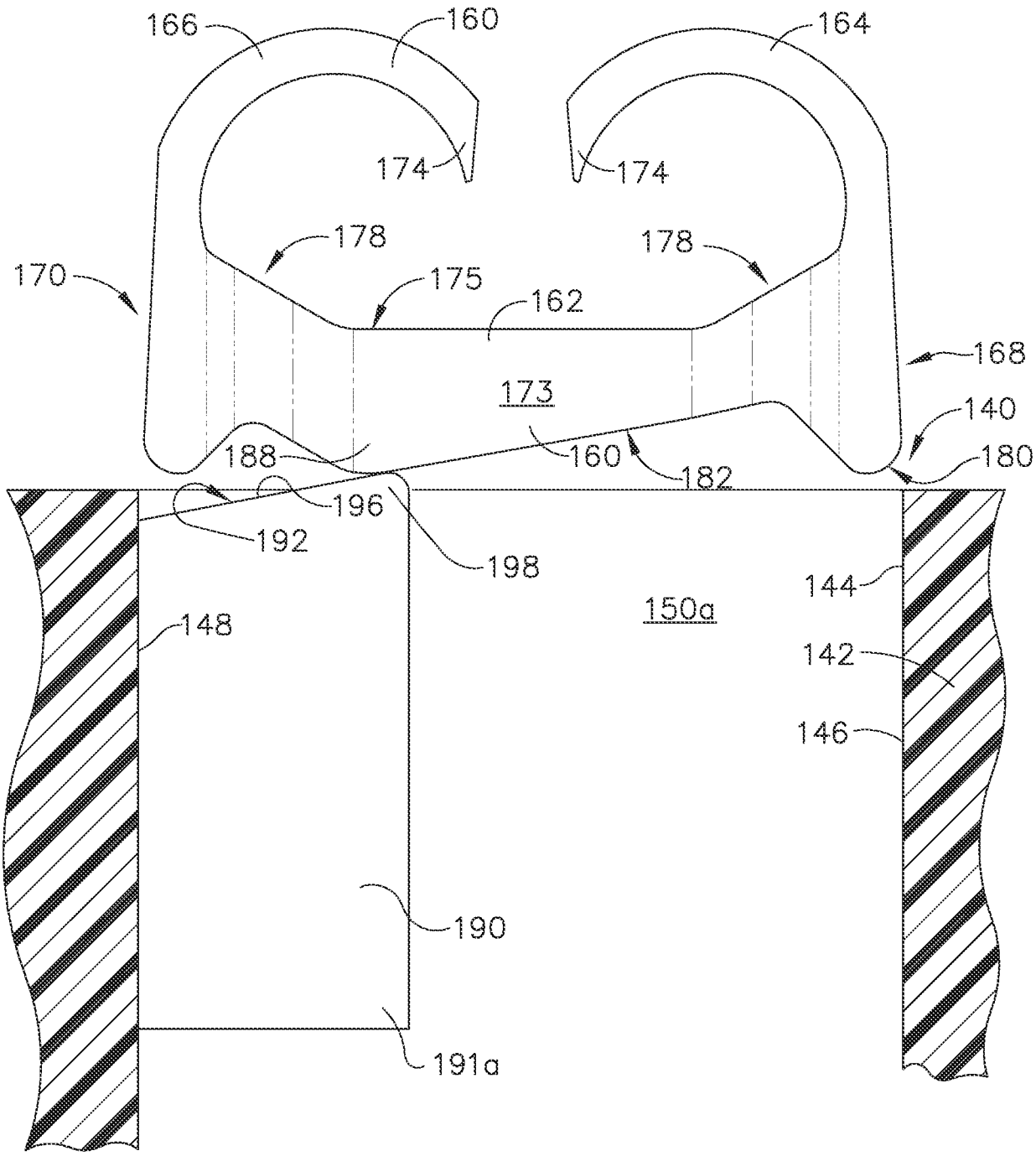

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FIG. 188

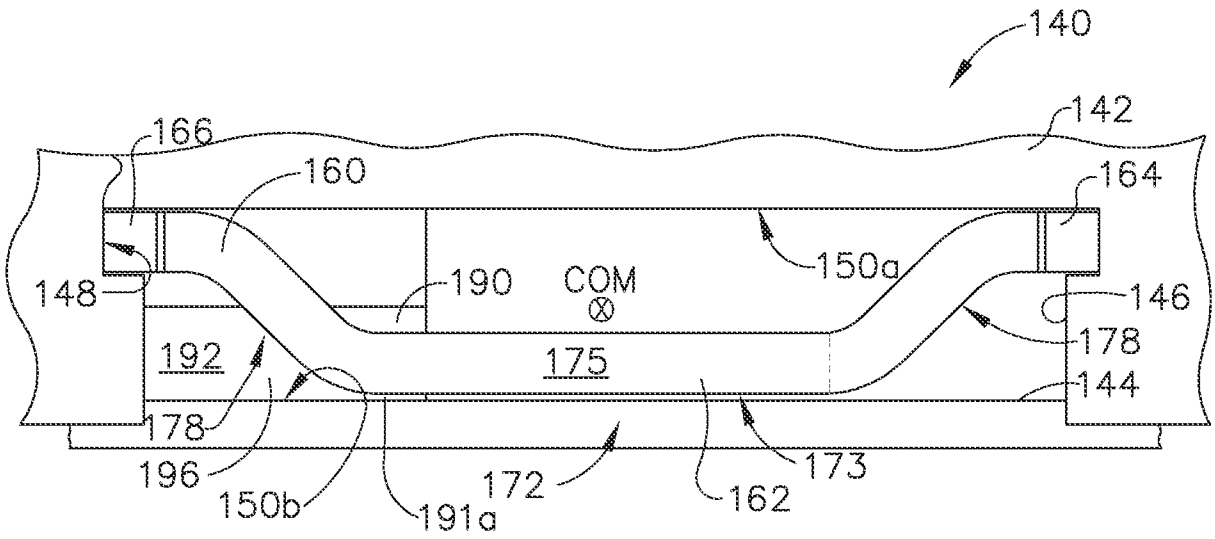

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FIG. 189

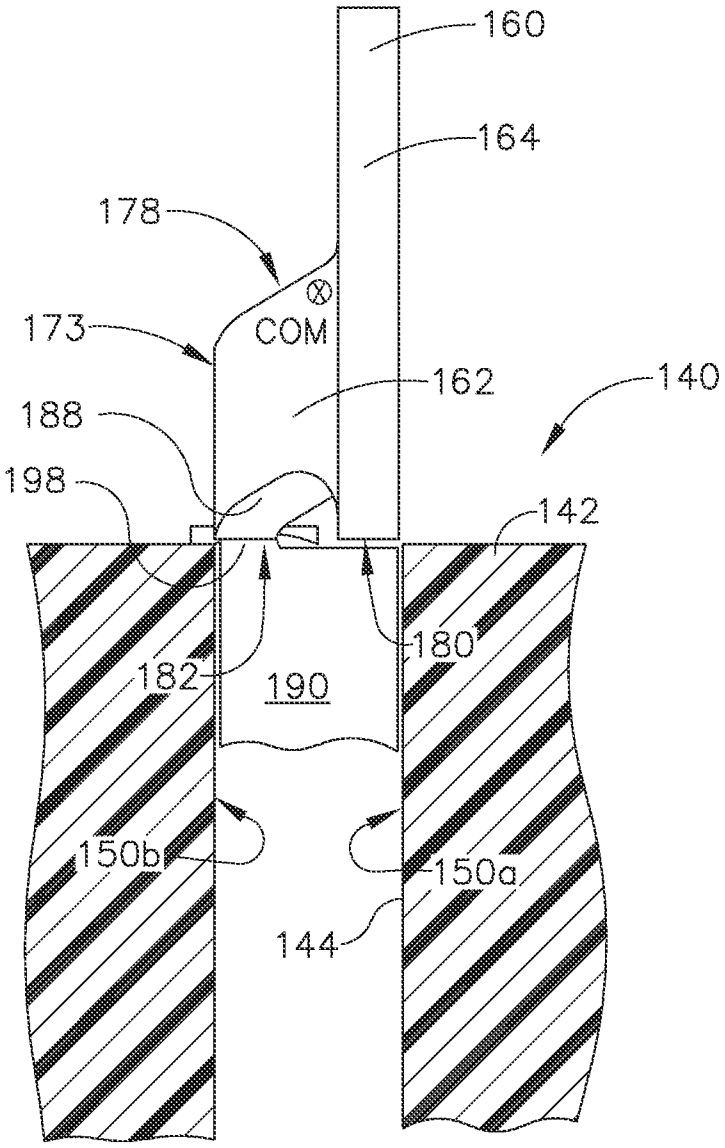

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FIG. 190

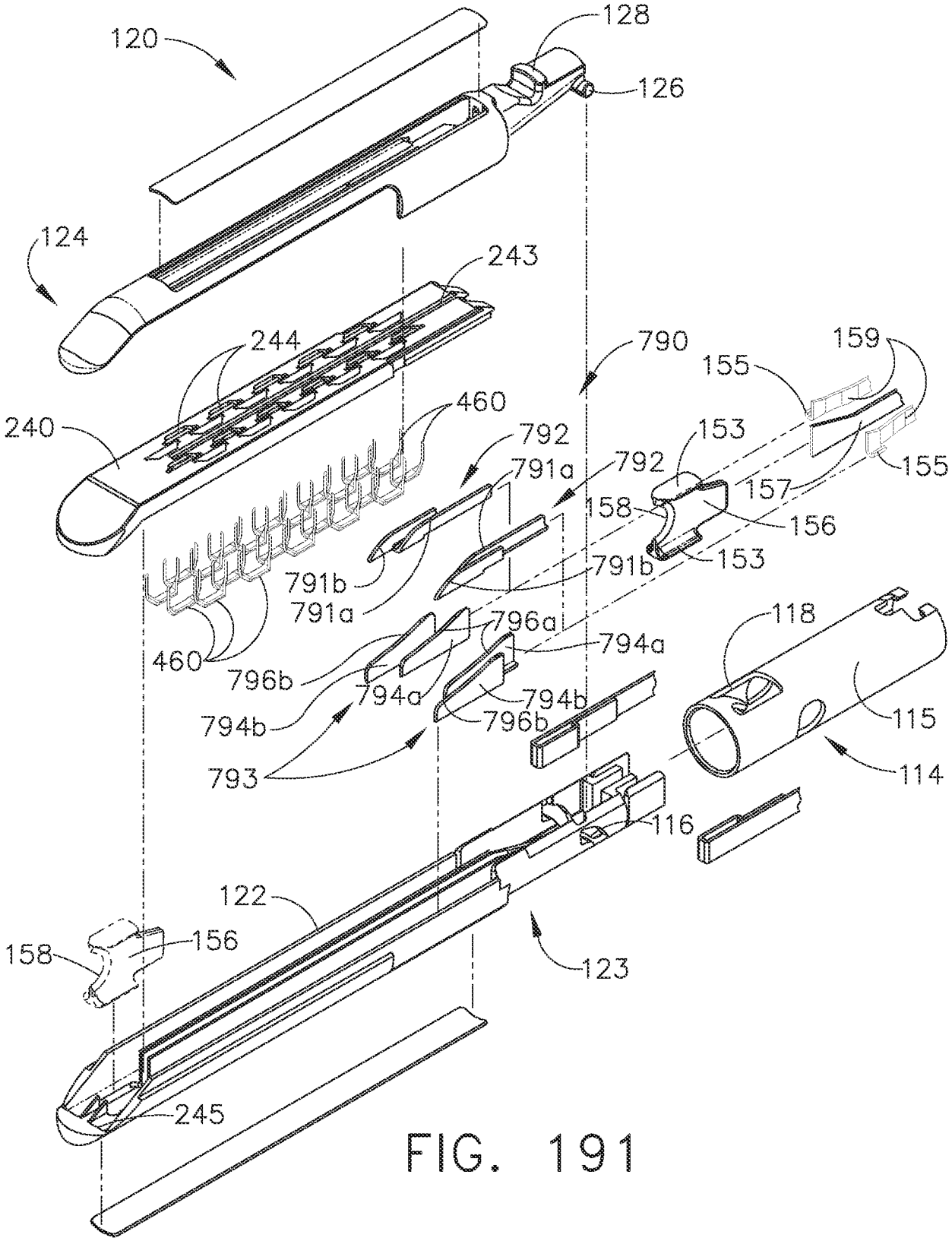

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FIG. 191

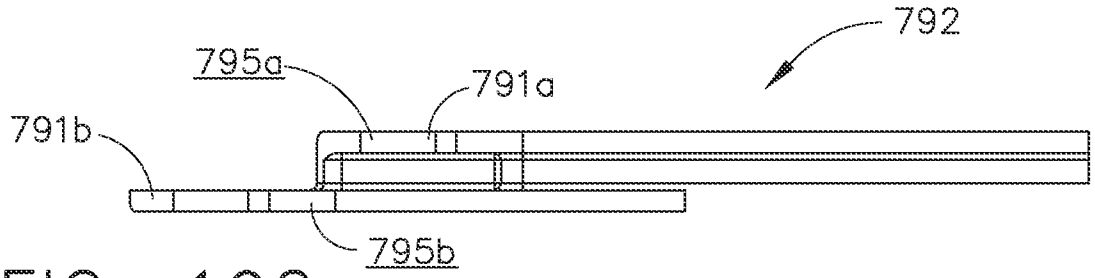


FIG. 192

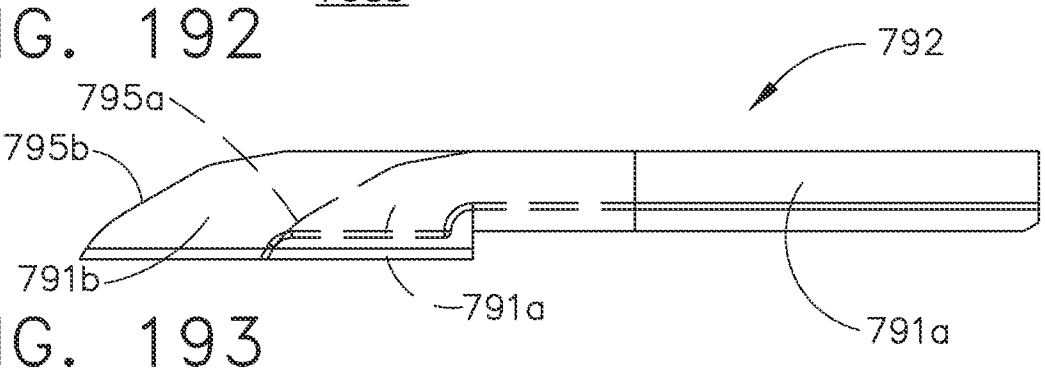


FIG. 193

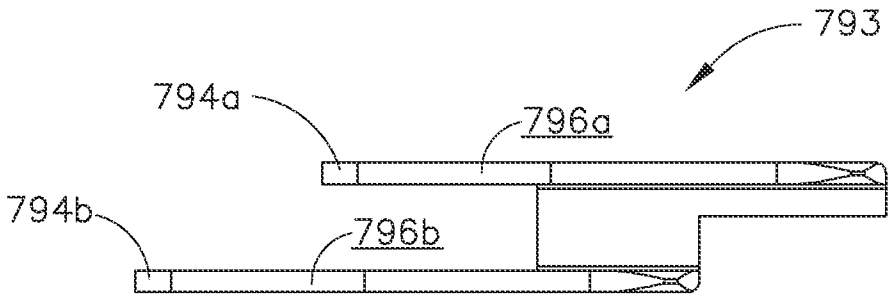


FIG. 194

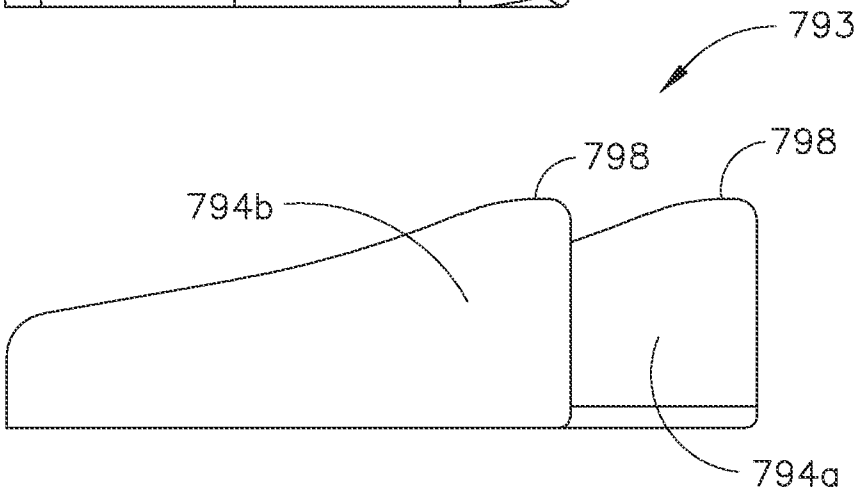


FIG. 195

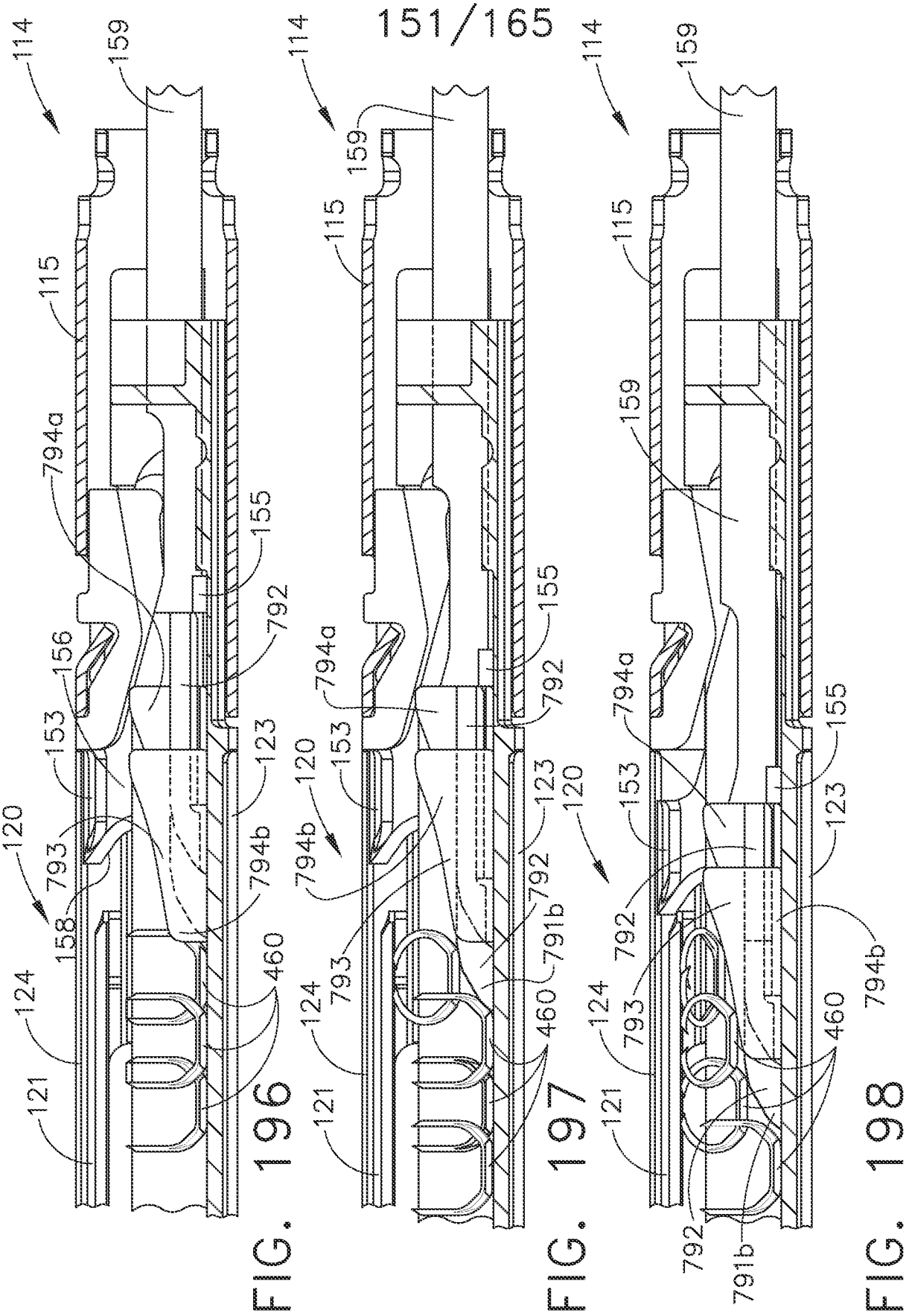


FIG. 196

FIG. 197

FIG. 198

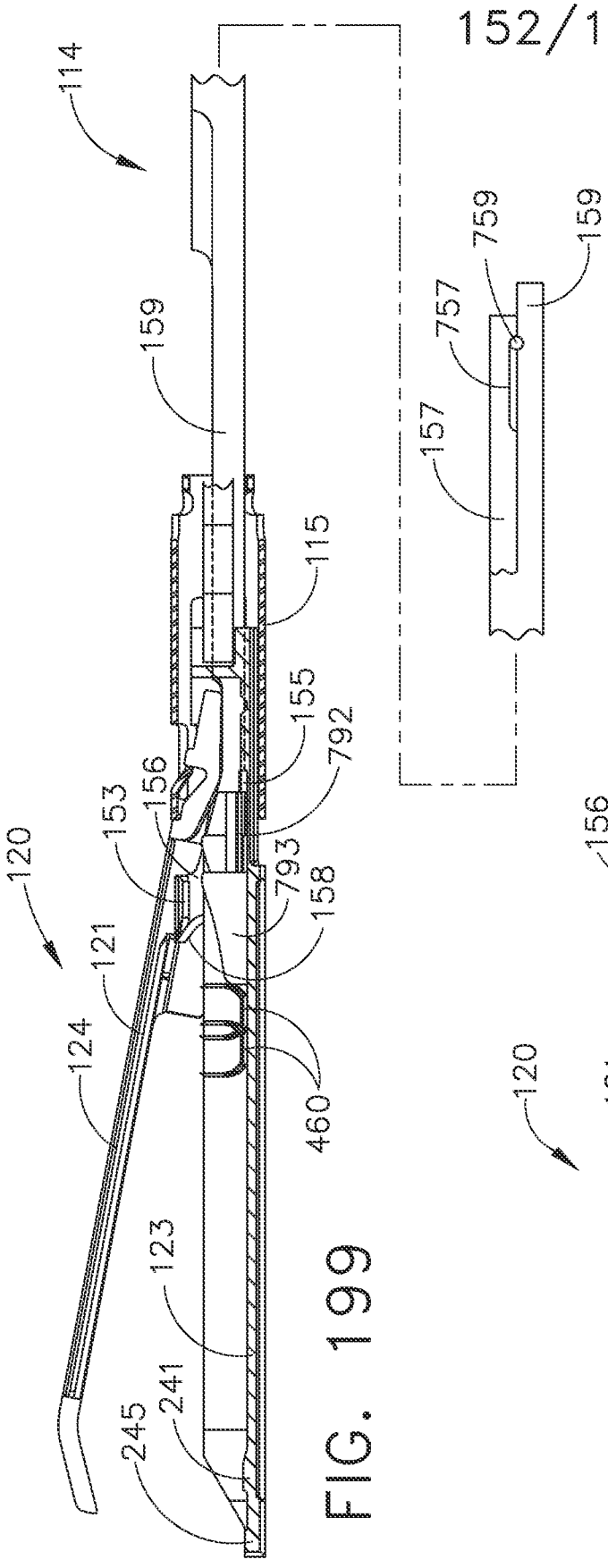


FIG. 199

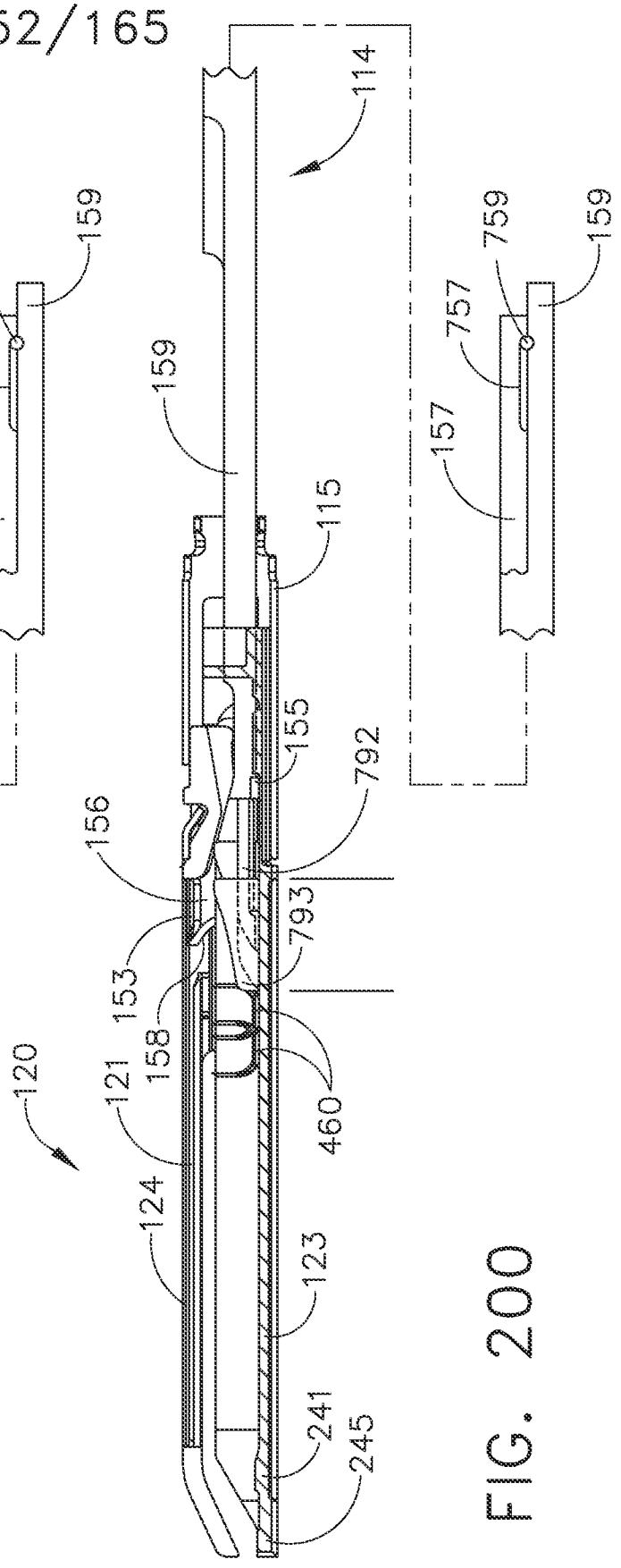


FIG. 200

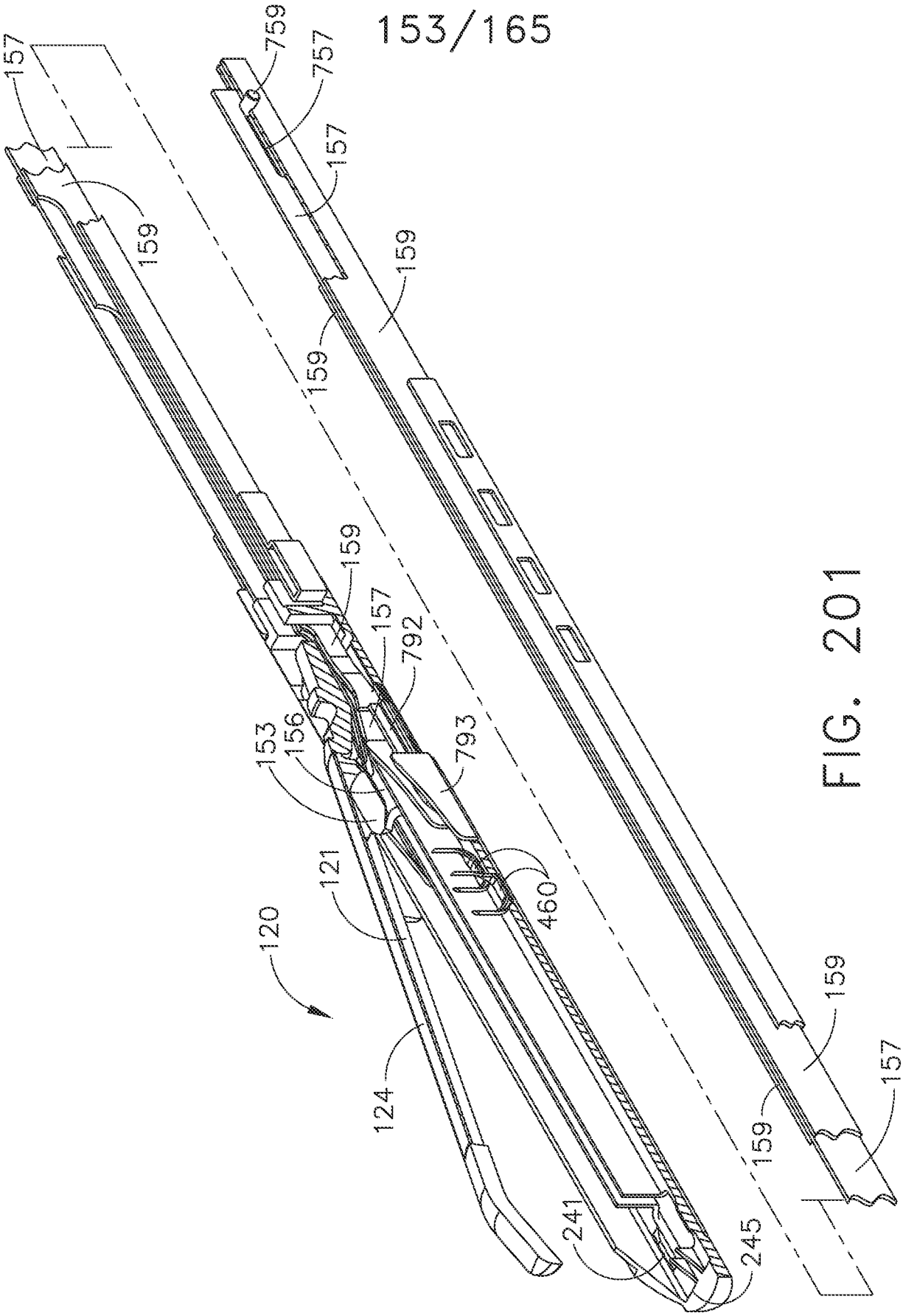

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FIG. 201

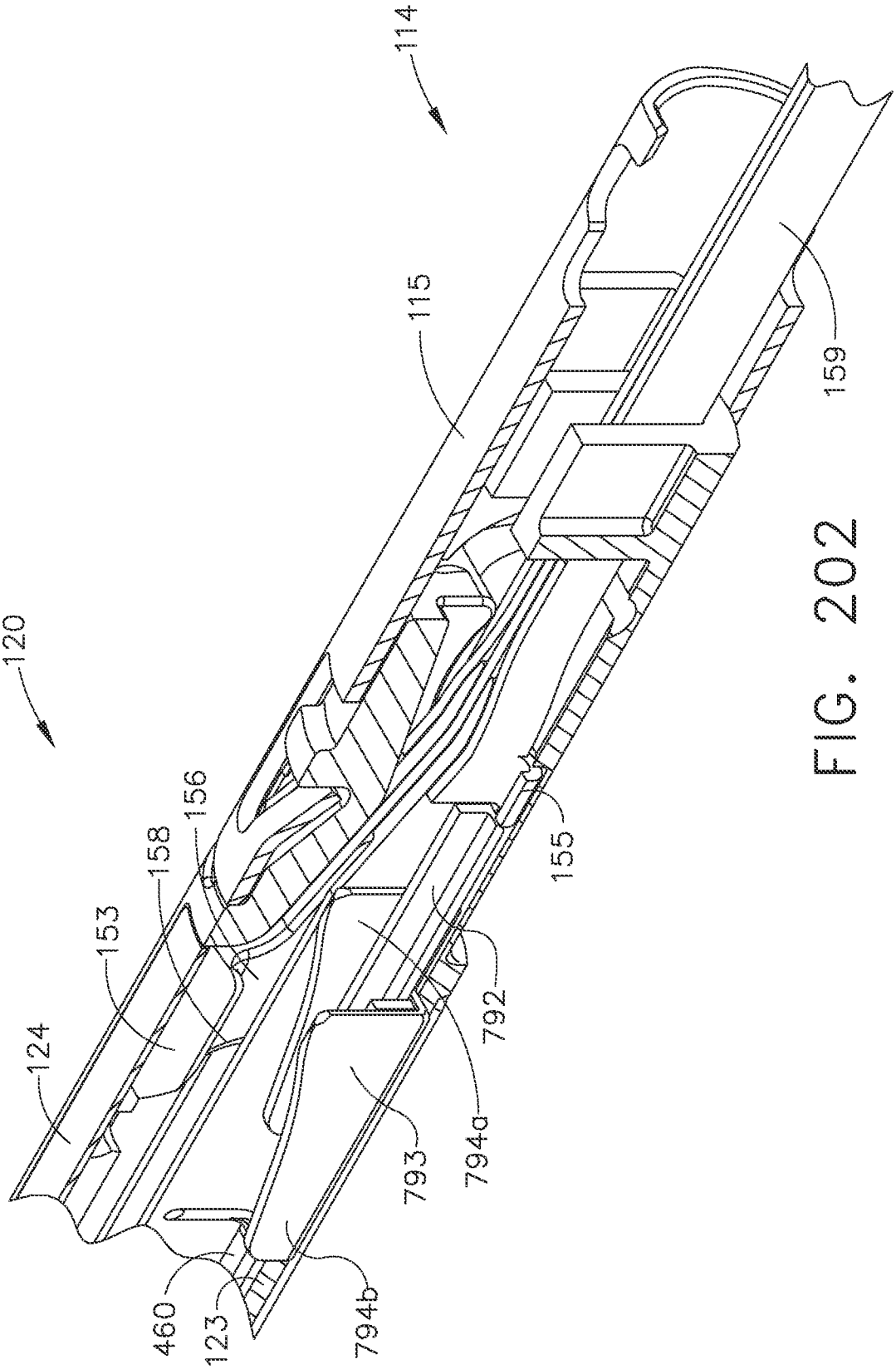


FIG. 202

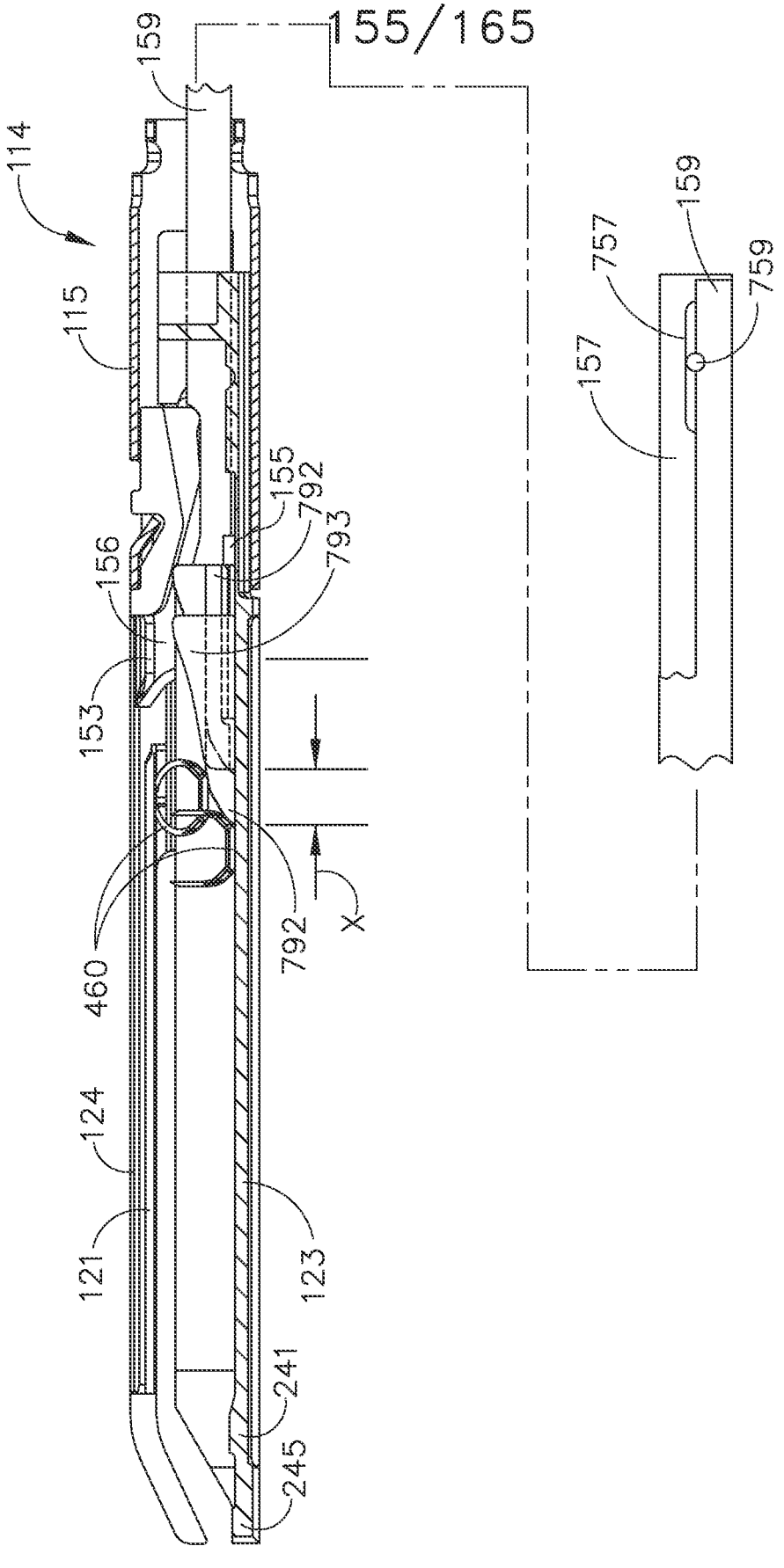

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FIG. 203

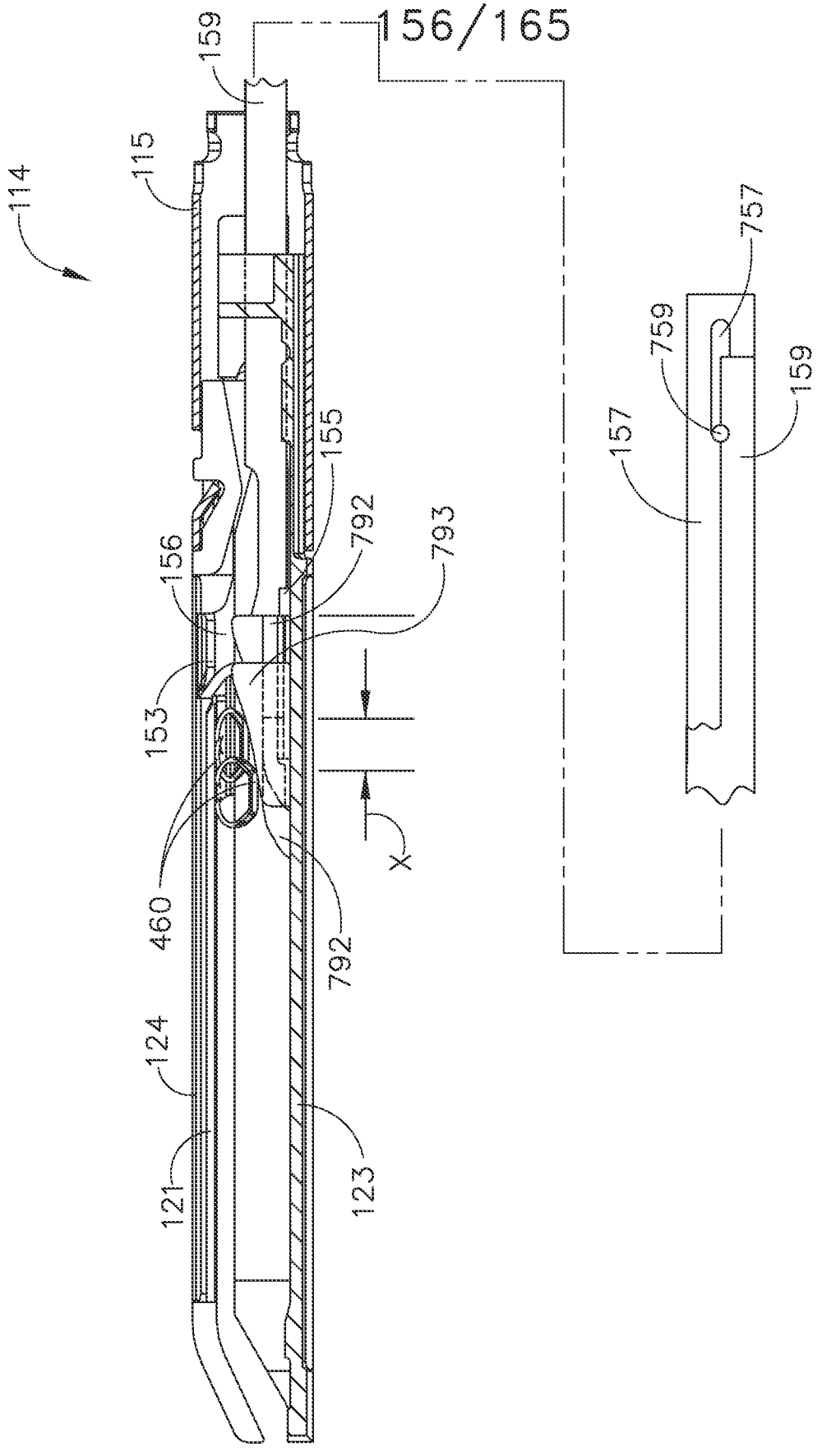

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FIG. 204

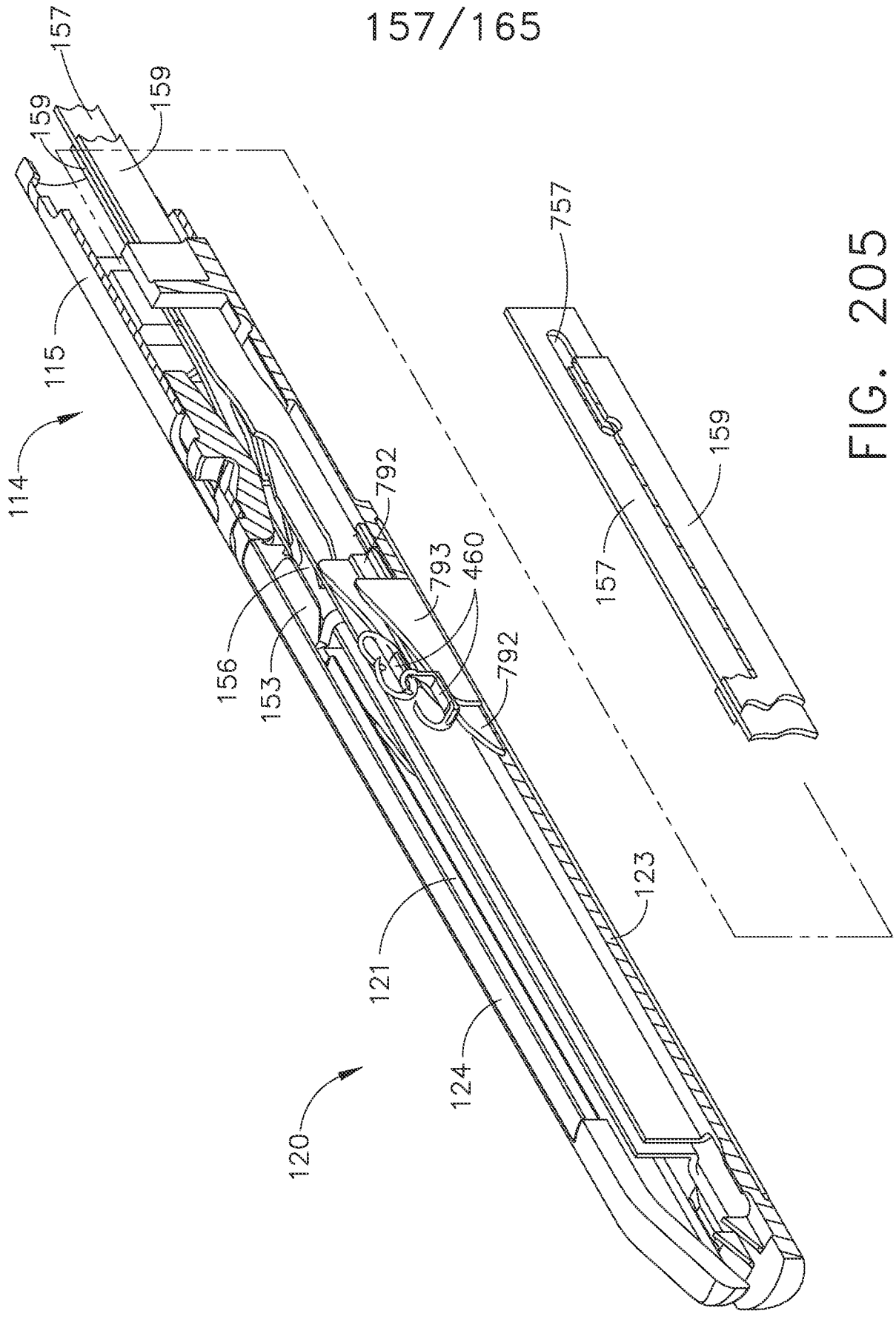

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FIG. 205

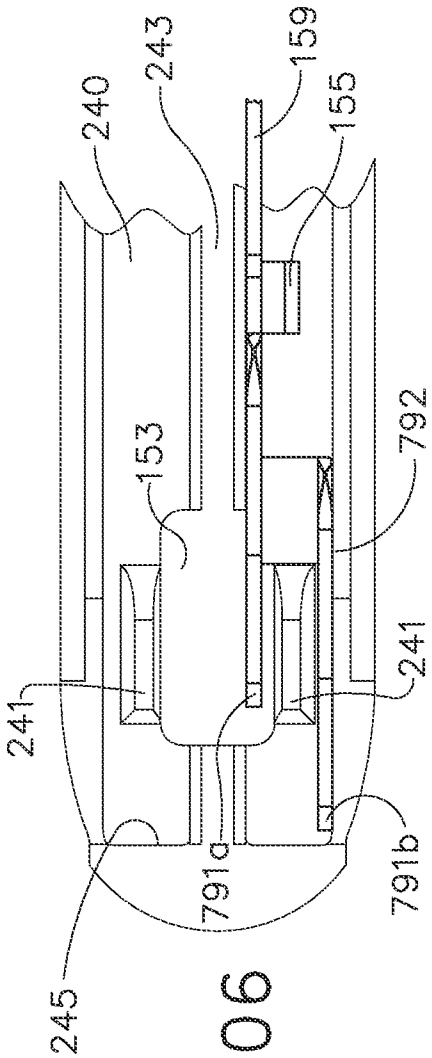


FIG. 206

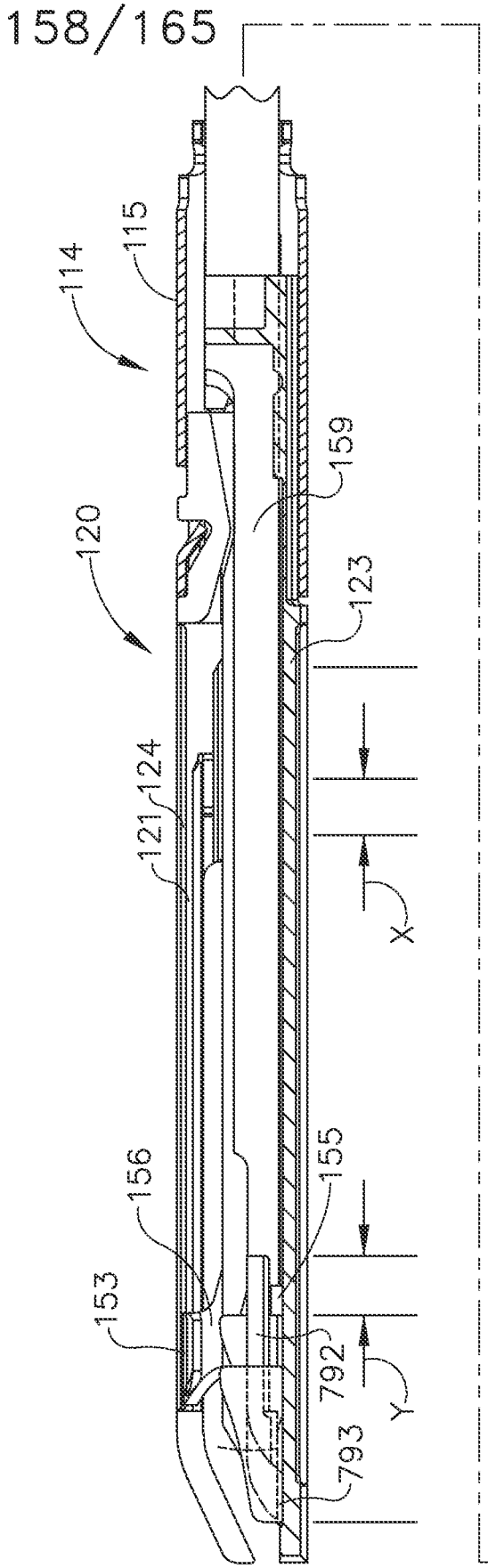


FIG. 207

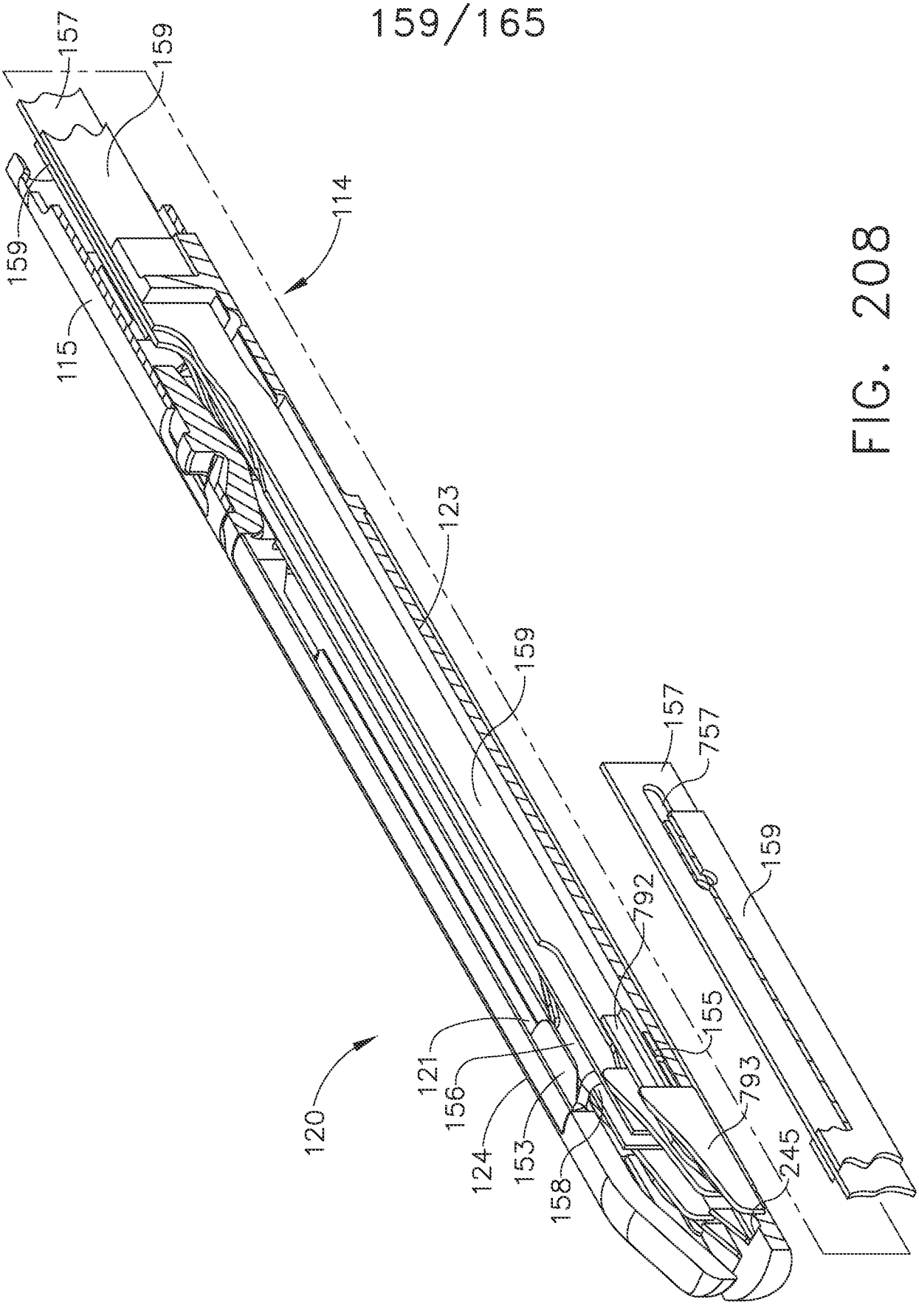

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FIG. 208

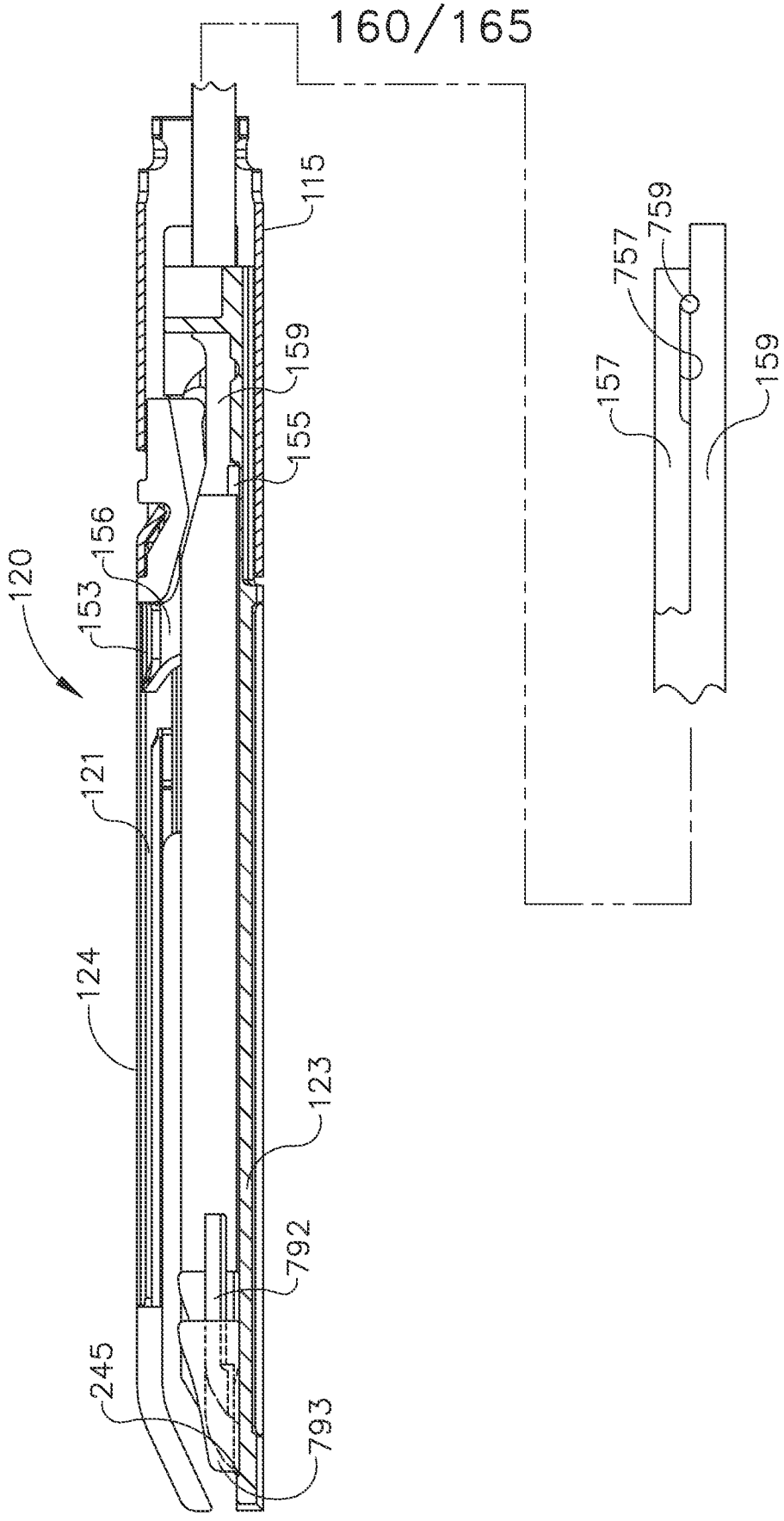

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FIG. 209

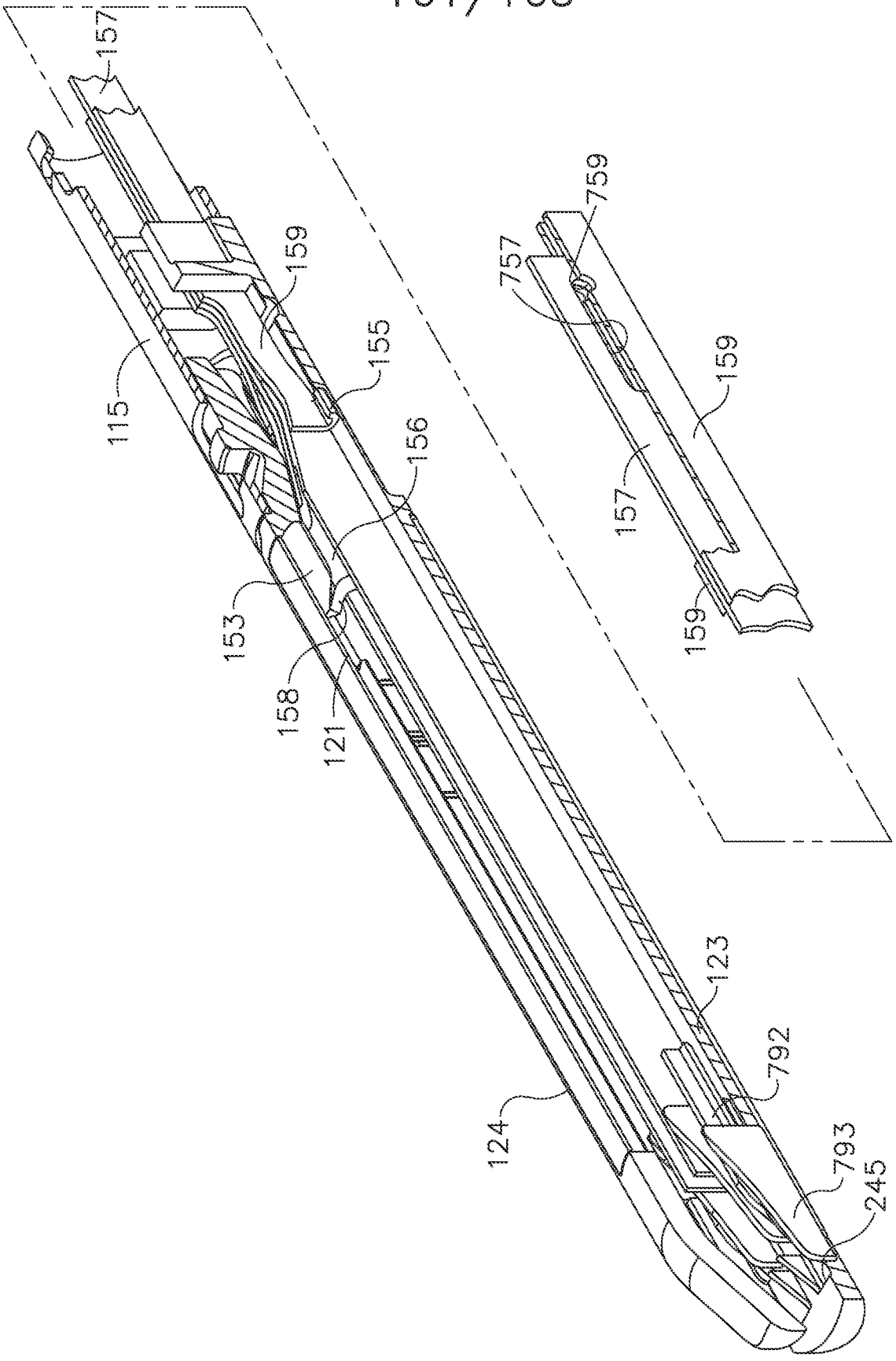

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FIG. 210

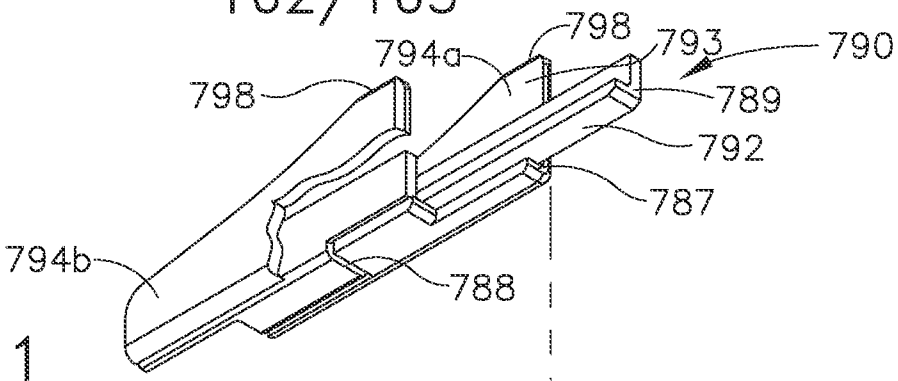


FIG. 211

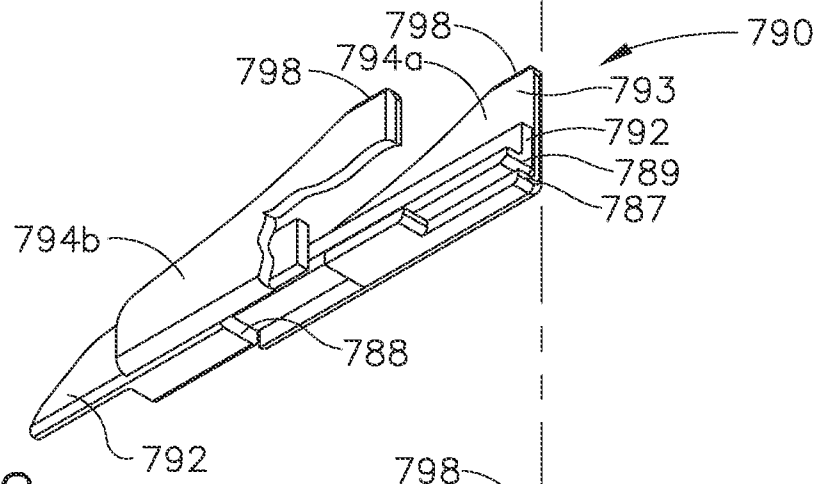


FIG. 212

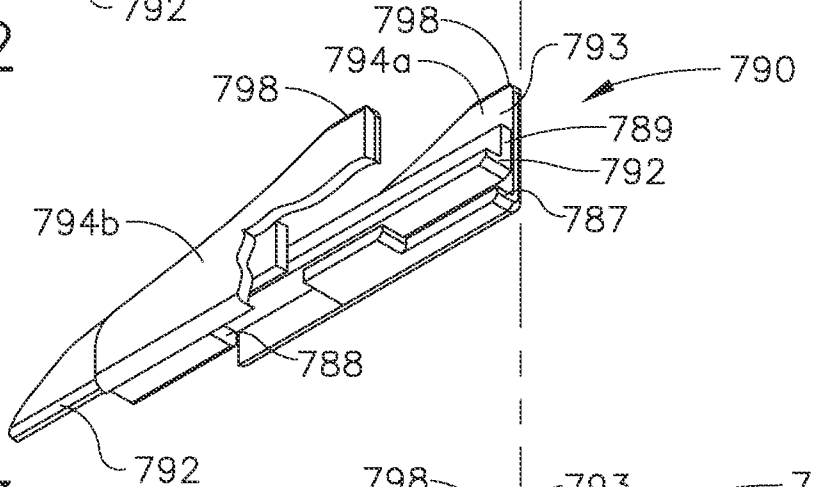


FIG. 213

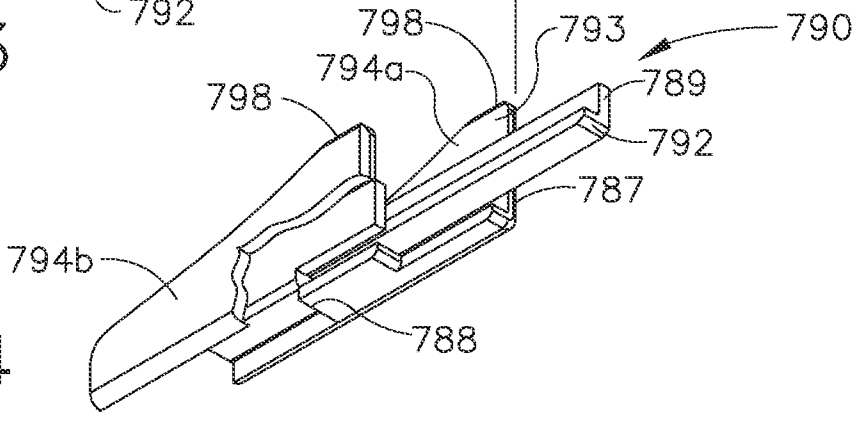


FIG. 214

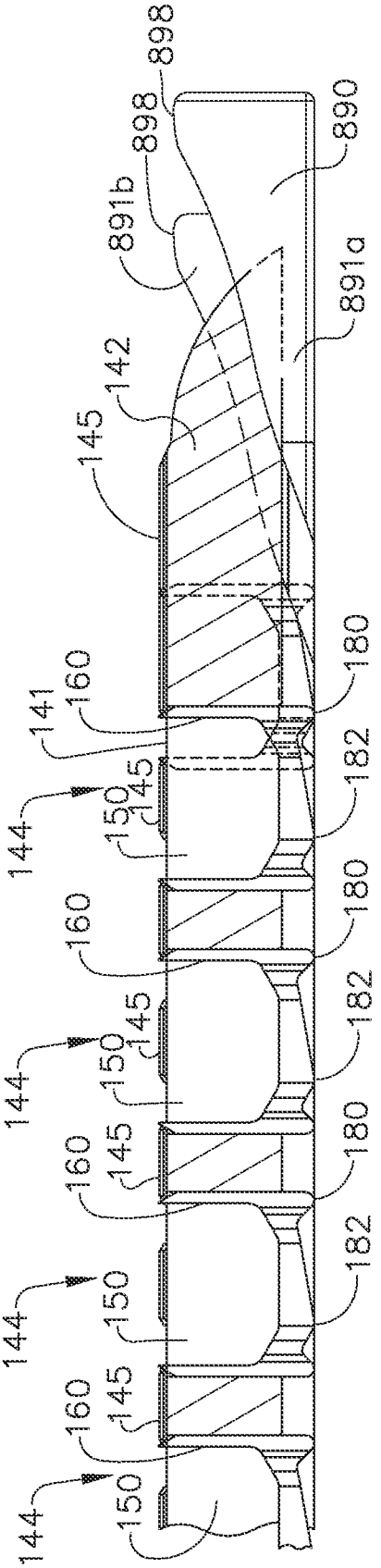


FIG. 215

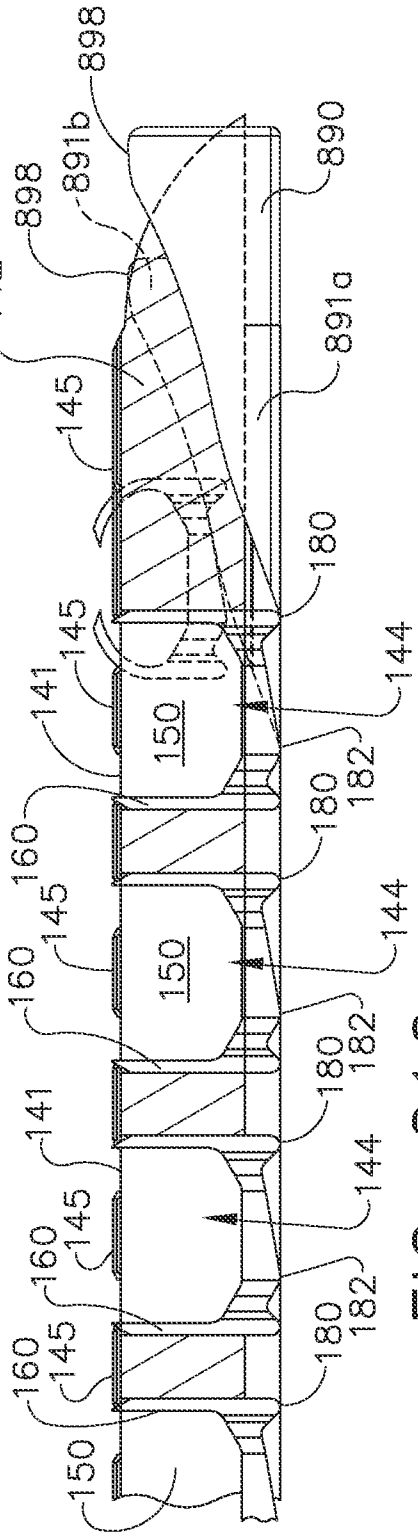


FIG. 216

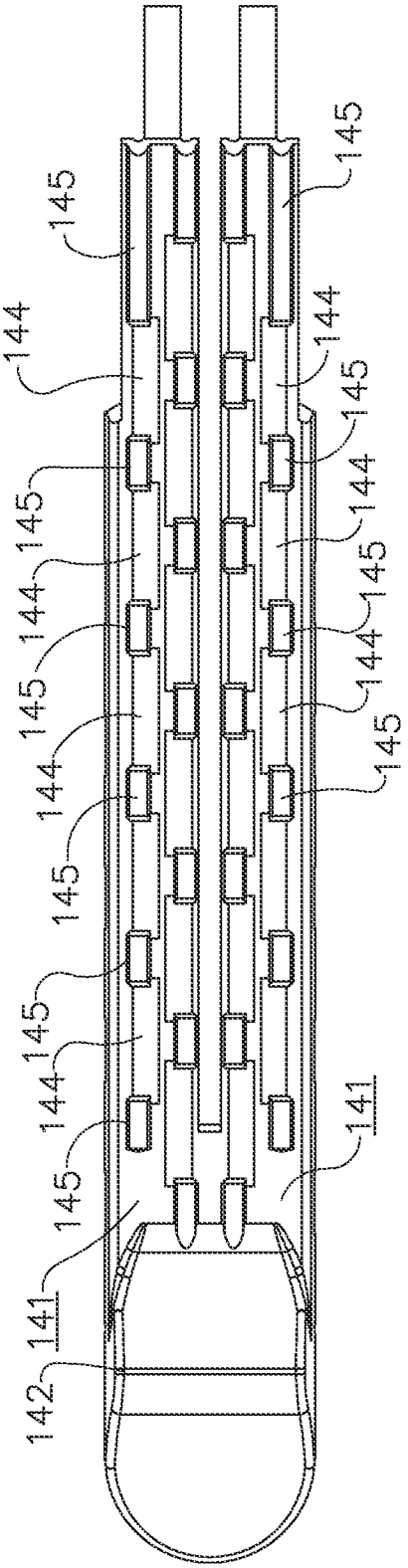


FIG. 217

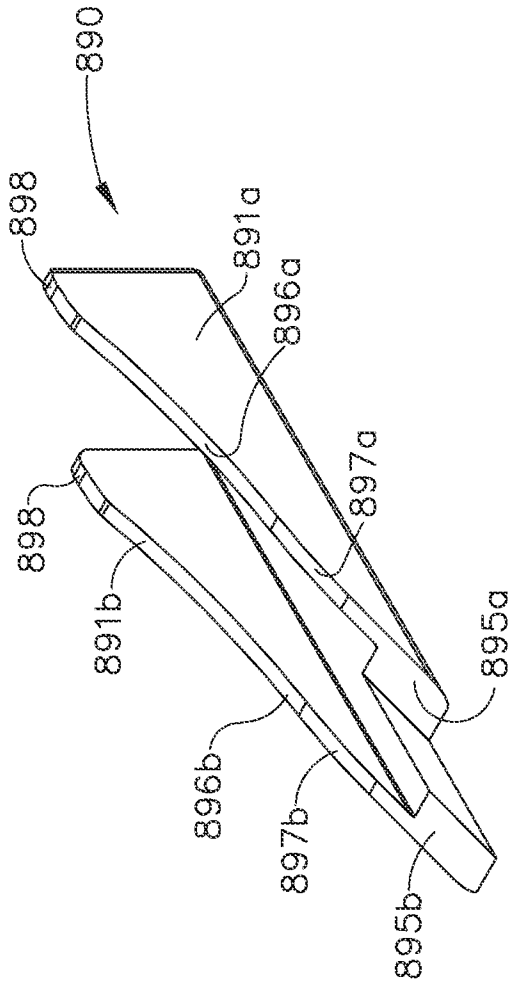


FIG. 218

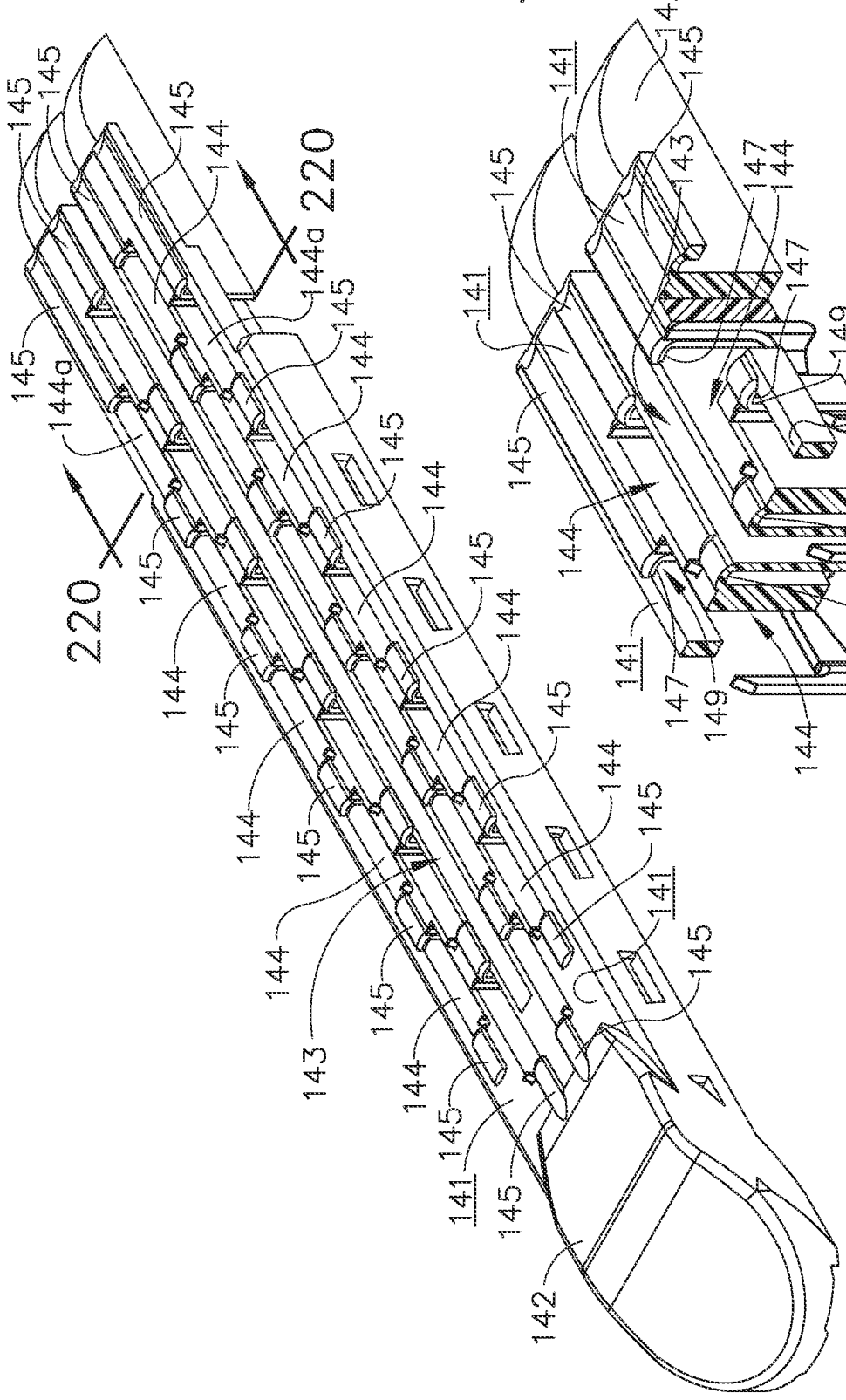


FIG. 219

FIG. 220

PATENT COOPERATION TREATY

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT

(PCT Article 17(2)(a), Rules 13ter.1(c) and Rule 39)

Applicant's or agent's file reference END7330WOPCT	IMPORTANT DECLARATION	Date of mailing *(day/month/year)* 13 May 2015 (13-05-2015)
International application No. PCT/US2014/069256	International filing date *(day/month/year)* 9 December 2014 (09-12-2014)	(Earliest) Priority date *(day/month/year)* 23 December 2013 (23-12-2013)
International Patent Classification (IPC) or both national classification and IPC A61B17/068 A61B17/07207 A61B2017/07271 A61B2017/07278		
Applicant ETHICON ENDO-SURGERY, INC.		

This International Searching Authority hereby declares, according to Article 17(2)(a), that **no international search report will be established** on the international application for the reasons indicated below

1. [X] The subject matter of the international application relates to:
   - a. [ ] scientific theories.
   - b. [ ] mathematical theories
   - c. [ ] plant varieties.
   - d. [ ] animal varieties.
   - e. [ ] essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes.
   - f. [ ] schemes, rules or methods of doing business.
   - g. [ ] schemes, rules or methods of performing purely mental acts.
   - h. [ ] schemes, rules or methods of playing games.
   - i. [X] methods for treatment of the human body by surgery or therapy.
   - j. [ ] methods for treatment of the animal body by surgery or therapy.
   - k. [ ] diagnostic methods practised on the human or animal body.
   - l. [ ] mere presentations of information.
   - m. [ ] computer programs for which this International Searching Authority is not equipped to search prior art.

2. [X] The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:
   [X] the description [X] the claims [ ] the drawings

3. [ ] The failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions prevents a meaningful search from being carried out:
   - [ ] the written form has not been furnished or does not comply with the standard.
   - [ ] the computer readable form has not been furnished or does not comply with the standard.

4. Further comments:

Name and mailing address of the International Searching Authority
European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040
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Authorized officer
ULLRICH, Josef
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A meaningful search is not possible on the basis of all claims because all claims are directed to methods for treatment of the human or animal body by surgery (Rule 39.1(iv) PCT).

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.