US010383664B2

(12) **United States Patent**
Donner et al.

(10) **Patent No.: US 10,383,664 B2**
(45) **Date of Patent: Aug. 20, 2019**

(54) **IMPLANTS, SYSTEMS, AND METHODS FOR FUSING A SACROILIAC JOINT**

(71) Applicant: **JCBD, LLC**, Fort Collins, CO (US)

(72) Inventors: **Edward Jeffrey Donner**, Fort Collins, CO (US); **Christopher Thomas Donner**, Fort Collins, CO (US)

(73) Assignee: **JCBD, LLC**, Fort Collins, CO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/662,045**

(22) Filed: **Jul. 27, 2017**

(65) **Prior Publication Data**

US 2017/0319240 A1 Nov. 9, 2017

Related U.S. Application Data

(63) Continuation of application No. 14/567,956, filed on Dec. 11, 2014, now Pat. No. 9,717,539, which is a (Continued)

(51) **Int. Cl.**
A61B 17/70 (2006.01)
A61B 17/17 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61B 17/7055*** (2013.01); ***A61B 17/1735*** (2013.01); ***A61B 17/1739*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61B 17/17–1796; A61B 17/705; A61B 17/7055; A61F 2/44–447; A61F 2/4611; A61F 2002/30995
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,669,698 B1 * 12/2003 Tromanhauser ... A61B 17/1615 606/104
6,743,256 B2 * 6/2004 Mason A61F 2/447 623/17.11
(Continued)

OTHER PUBLICATIONS

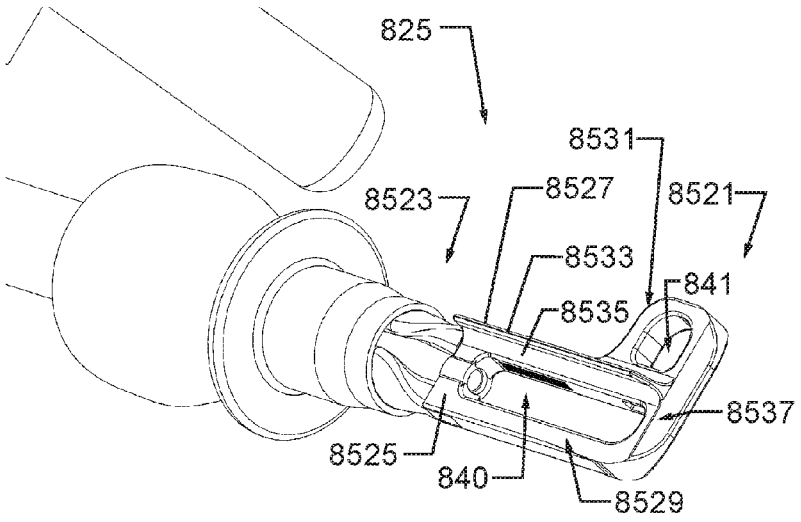
Globus Medical. Secure-C Cervical Artificial Disc. Copyright 2014.
(Continued)

Primary Examiner — Nicholas J Plionis
Assistant Examiner — Steven J Cotroneo
(74) *Attorney, Agent, or Firm* — Polsinelli PC; Joshua J. Pranckun; Samuel Wade Johnson

(57) **ABSTRACT**

A method of fusing a dysfunctional sacroiliac joint with an additively manufactured joint implant comprising a plurality of openings extending from a top surface into an inner portion of the joint implant via a plurality of channels, and an orifice extending from an exterior surface of the proximal end into the inner portion, wherein the orifice is in fluid communication with the plurality of channels via the inner portion; delivering the joint implant into the sacroiliac joint space through an access region and injecting an amount of biocompatible material at an initial stage of an injection process into the inner portion via the orifice and with a delivery tool; and, at a subsequent stage of the injection process the amount of biocompatible material moves from the inner portion through the plurality of channel via a second path and into the sacroiliac joint space immediately adjacent a top surface.

50 Claims, 67 Drawing Sheets



Related U.S. Application Data

continuation-in-part of application No. 14/514,221, filed on Oct. 14, 2014, now Pat. No. 9,826,986, and a continuation-in-part of application No. 14/447,612, filed on Jul. 31, 2014, now Pat. No. 9,700,356.

(60) Provisional application No. 61/914,409, filed on Dec. 11, 2013, provisional application No. 61/891,330, filed on Oct. 15, 2013, provisional application No. 61/891,345, filed on Oct. 15, 2013, provisional application No. 61/912,494, filed on Dec. 5, 2013, provisional application No. 61/954,594, filed on Mar. 17, 2014, provisional application No. 61/979,857, filed on Apr. 15, 2014, provisional application No. 61/955,126, filed on Mar. 18, 2014, provisional application No. 61/860,185, filed on Jul. 30, 2013.

(51) **Int. Cl.**
A61F 2/30 (2006.01)
A61B 90/00 (2016.01)

(52) **U.S. Cl.**
CPC .. ***A61B 17/7074*** (2013.01); *A61B 2090/3966* (2016.02); *A61F 2002/30995* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,837,732	B2 *	11/2010	Zucherman	A61F 2/4455 623/17.11
7,935,116	B2	5/2011	Michelson	
7,942,903	B2	5/2011	Moskowitz et al.	
8,882,818	B1	11/2014	Vestgaarden	
9,039,765	B2	5/2015	Trieu	
9,119,732	B2	9/2015	Schifano	
9,149,286	B1	10/2015	Greenhalgh et al.	
9,186,155	B2	11/2015	Katzman et al.	
9,254,130	B2	2/2016	Hollis	
9,452,065	B1	9/2016	Lawson	
9,480,511	B2	11/2016	Butters	
9,486,264	B2	11/2016	Reiley	
9,820,783	B2	11/2017	Donner et al.	
9,833,265	B2	12/2017	Donner et al.	
9,931,212	B1	4/2018	Donner et al.	
9,936,983	B2	4/2018	Mesiwala	
9,949,835	B2	4/2018	Donner	
9,949,843	B2	4/2018	Reiley	
2002/0068941	A1	6/2002	Hanson	
2002/0103487	A1	8/2002	Errico	
2004/0193271	A1	9/2004	Fraser	
2004/0220668	A1 *	11/2004	Eisermann	A61B 17/1642 623/17.11
2004/0260286	A1	12/2004	Ferree	
2005/0149192	A1 *	7/2005	Zucherman	A61B 17/1671 623/17.11
2005/0261775	A1	11/2005	Baum	
2006/0036251	A1	2/2006	Reiley	
2007/0179610	A1	8/2007	Biedermann	
2007/0239278	A1	10/2007	Heinz	
2007/0299445	A1	12/2007	Shadduck	
2008/0021461	A1	1/2008	Barker et al.	
2008/0133016	A1	6/2008	Heinz	
2009/0099659	A1	4/2009	Oh	
2009/0204215	A1	8/2009	McClintock	
2009/0306671	A1 *	12/2009	McCormack	A61B 17/025 606/90
2010/0168798	A1	7/2010	Clineff	
2010/0168861	A1	7/2010	Yundt	
2010/0185292	A1	7/2010	Hochschuler	
2010/0191088	A1	7/2010	Anderson	
2010/0191100	A1	7/2010	Anderson	
2010/0204796	A1	8/2010	Bae	
2010/0217086	A1	8/2010	Deshmukh	
2011/0160866	A1	6/2011	Laurence	
2011/0184519	A1 *	7/2011	Trieu	A61B 17/7055 623/17.11
2011/0213221	A1	9/2011	Roche	
2011/0230966	A1 *	9/2011	Trieu	A61B 17/562 623/17.12
2011/0230968	A1	9/2011	Perisic	
2011/0238181	A1 *	9/2011	Trieu	A61B 17/1735 623/17.11
2011/0264229	A1 *	10/2011	Donner	A61F 2/30988 623/18.11
2012/0032808	A1	2/2012	Cherubini	
2012/0065548	A1	3/2012	Morgan	
2012/0101582	A1	4/2012	Raiszadeh et al.	
2012/0215315	A1	8/2012	Hochschuler et al.	
2012/0253406	A1	10/2012	Bae	
2013/0035724	A1	2/2013	Fitzpatrick	
2013/0144393	A1	6/2013	Mutchler	
2013/0173004	A1	7/2013	Greenhalgh	
2013/0238093	A1	9/2013	Mauldin	
2013/0245763	A1	9/2013	Mauldin	
2014/0046380	A1	2/2014	Asfora	
2014/0277463	A1	9/2014	Yerby	
2014/0336763	A1 *	11/2014	Donner	A61F 2/30988 623/17.11
2015/0105828	A1	4/2015	Reckling	
2015/0250612	A1	9/2015	Schifano	
2016/0081809	A1	3/2016	Schneider	
2016/0081810	A1	3/2016	Reiley	
2016/0120661	A1	5/2016	Schell	
2016/0128838	A1	5/2016	Assell	
2016/0157897	A1	6/2016	Vaidya	
2017/0007409	A1	1/2017	Mauldin	
2017/0135733	A1	5/2017	Donner et al.	
2017/0164979	A1	6/2017	Donner et al.	
2017/0325845	A1	11/2017	Donner et al.	
2017/0325846	A1	11/2017	Donner et al.	
2018/0035893	A1	2/2018	Donner et al.	
2018/0036017	A1	2/2018	Donner et al.	
2018/0055521	A1	3/2018	Donner	
2018/0085223	A1	3/2018	Donner	
2018/0092669	A1	4/2018	Donner et al.	
2018/0092748	A1	4/2018	Donner et al.	
2018/0104071	A1	4/2018	Reckling	
2018/0185157	A1	7/2018	Donner et al.	
2018/0193154	A1	7/2018	Donner et al.	
2018/0193155	A1	7/2018	Donner et al.	
2018/0271662	A1	9/2018	Donner et al.	
2018/0271663	A1	9/2018	Donner et al.	
2018/0318091	A1	11/2018	Donner	
2018/0325675	A1	11/2018	Donner	
2018/0325676	A1	11/2018	Donner	

OTHER PUBLICATIONS

Synthes Spine. ProDisc-L Total Disc Replacement. For replacement of a diseased and/or degenerated intervertebral disc of the lumbosacral regions. Technique Guide. Copyright 2006.

Amendment Under 1.312, U.S. Appl. No. 14/681,882, dated Aug. 10, 2017.

Australian Examination Report, AU2016204937, dated May 21, 2018.

Canadian Office Action, CA2849095, dated May 28, 2018.

China Office Action, CN201510622898.0, dated Feb. 1, 2018 (English translation).

China Office Action, CN201510622898.0, dated Sep. 1, 2017 (English translation).

EP Examination Report, EP12799773.2, dated Jun. 4, 2018.

Final Office Action, U.S. Appl. No. 14/344,876, dated Apr. 13, 2018.

Final Office Action, U.S. Appl. No. 14/660,784, dated Jul. 20, 2018.

Non-Final Office Action, U.S. Appl. No. 14/344,876, dated Jun. 2, 2017.

Non-Final Office Action, U.S. Appl. No. 14/660,784, dated Mar. 5, 2018.

Non-Final Office Action, U.S. Appl. No. 15/178,244, dated May 16, 2017.

(56) **References Cited**

OTHER PUBLICATIONS

Non-Final Office Action, U.S. Appl. No. 15/178,291, dated May 16, 2017.
Non-Final Office Action, U.S. Appl. No. 15/385,446, dated Jul. 24, 2018.
Non-Final Office Action, U.S. Appl. No. 15/729,273, dated May 2, 2018.
Notice of Allowance, U.S. Appl. No. 14/127,119, dated Apr. 21, 2017.
Notice of Allowance, U.S. Appl. No. 14/216,975, dated Apr. 5, 2017.
Notice of Allowance, U.S. Appl. No. 14/344,876, dated May 18, 2018.
Notice of Allowance, U.S. Appl. No. 14/514,221, dated Jun. 16, 2017.
Notice of Allowance, U.S. Appl. No. 14/681,882, dated May 10, 2017.
Notice of Allowance, U.S. Appl. No. 14/723,384, dated Jun. 7, 2017.
Notice of Allowance, U.S. Appl. No. 15/061,524, dated Jul. 26, 2017.
Notice of Allowance, U.S. Appl. No. 15/178,244, dated Sep. 12, 2017.
Notice of Allowance, U.S. Appl. No. 15/178,291, dated Oct. 11, 2017.
Notice of Allowance, U.S. Appl. No. 15/828,556, dated Feb. 7, 2018.
Notice of Allowance, U.S. Appl. No. 15/828,677, dated Jan. 19, 2018.
Notice of Allowance, U.S. Appl. No. 15/910,753, dated May 21, 2018.
Notice of Allowance, U.S. Appl. No. 15/912,216, dated Jun. 20, 2018.
Notice of Allowance, U.S. Appl. No. 15/912,260, dated May 10, 2018.
Response to Final Office Action, U.S. Appl. No. 14/344,876, dated Apr. 27, 2018.
Response to Non-Final Office Action, U.S. Appl. No. 14/344,876, dated Sep. 5, 2017.
Response to Non-Final Office Action, U.S. Appl. No. 14/660,784, dated Jun. 4, 2018.
Response to Non-Final Office Action, U.S. Appl. No. 15/178,244, dated Aug. 15, 2017.
Response to Non-Final Office Action, U.S. Appl. No. 15/178,291, dated Aug. 16, 2017.
Response to Restriction, U.S. Appl. No. 14/660,784, dated Nov. 28, 2017.
Response to Restriction, U.S. Appl. No. 15/216,472, dated Jun. 4, 2018.
Restriction Requirement, U.S. Appl. No. 14/660,784, dated Sep. 28, 2017.
Restriction Requirement, U.S. Appl. No. 15/216,472, dated Apr. 2, 2018.
Amendment Under 1.312, U.S. Appl. No. 15/828,622, dated Oct. 26, 2018.
Amendment Under 1.312, U.S. Appl. No. 15/992,987, dated Sep. 26, 2018.
Amendment Under 1.312, U.S. Appl. No. 15/993,170, dated Sep. 26, 2018.
Corrected Notice of Allowability, U.S. Appl. No. 15/992,987, dated Oct. 9, 2018.
Corrected Notice of Allowability, U.S. Appl. No. 15/993,170, dated Oct. 9, 2018.
Non-Final Office Action, U.S. Appl. No. 15/216,472, dated Sep. 25, 2018.
Non-Final Office Action, U.S. Appl. No. 15/418,633, dated Aug. 7, 2018.
Non-Final Office Action, U.S. Appl. No. 15/664,862, dated Oct. 3, 2018.
Non-Final Office Action, U.S. Appl. No. 15/789,515, dated Oct. 29, 2018.
Notice of Allowance, U.S. Appl. No. 15/828,622, dated Aug. 9, 2018.
Notice of Allowance, U.S. Appl. No. 15/992,987, dated Aug. 16, 2018.
Notice of Allowance, U.S. Appl. No. 15/993,170, dated Aug. 8, 2018.
Preliminary Amendment, U.S. Appl. No. 15/831,589, dated Jul. 27, 2018.
Response to Final Office Action, U.S. Appl. No. 14/660,784, dated Oct. 22, 2018.
Response to Non-Final Office Action, U.S. Appl. No. 15/385,446, dated Oct. 24, 2018.
Response to Non-Final Office Action, U.S. Appl. No. 15/418,633, dated Nov. 7, 2018.
Response to Non-Final Office Action, U.S. Appl. No. 15/729,273, dated Aug. 1, 2018.
Restriction Requirement, U.S. Appl. No. 15/664,608, dated Oct. 5, 2018.
Amendment Under 1.312, U.S. Appl. No. 15/993,277, dated Feb. 28, 2019.
Corrected Notice of Allowability, U.S. Appl. No. 15/828,622, dated Nov. 19, 2018.
Final Office Action, U.S. Appl. No. 15/418,633, dated Feb. 4, 2019.
Final Office Action, U.S. Appl. No. 15/729,273, dated Nov. 20, 2018.
Non-Final Office Action, U.S. Appl. No. 15/785,997, dated Nov. 29, 2018.
Non-Final Office Action, U.S. Appl. No. 15/789,602, dated Nov. 29, 2018.
Non-Final Office Action, U.S. Appl. No. 15/993,277, dated Nov. 26, 2018.
Notice of Allowance, U.S. Appl. No. 14/660,784, dated Nov. 15, 2018.
Notice of Allowance, U.S. Appl. No. 15/993,277, dated Dec. 4, 2018.
Notice of Allowance, U.S. Appl. No. 15/385,446, dated Feb. 21, 2019.
Response to Non-Final Office Action, U.S. Appl. No. 15/216,472, dated Dec. 19, 2018.
Response to Non-Final Office Action, U.S. Appl. No. 15/664,862, dated Jan. 2, 2019.
Response to Non-Final Office Action, U.S. Appl. No. 15/785,997, dated Feb. 28, 2019.
Response to Non-Final Office Action, U.S. Appl. No. 15/789,515, dated Nov. 21, 2018.
Response to Restriction, U.S. Appl. No. 15/664,608, dated Dec. 5, 2018.

* cited by examiner

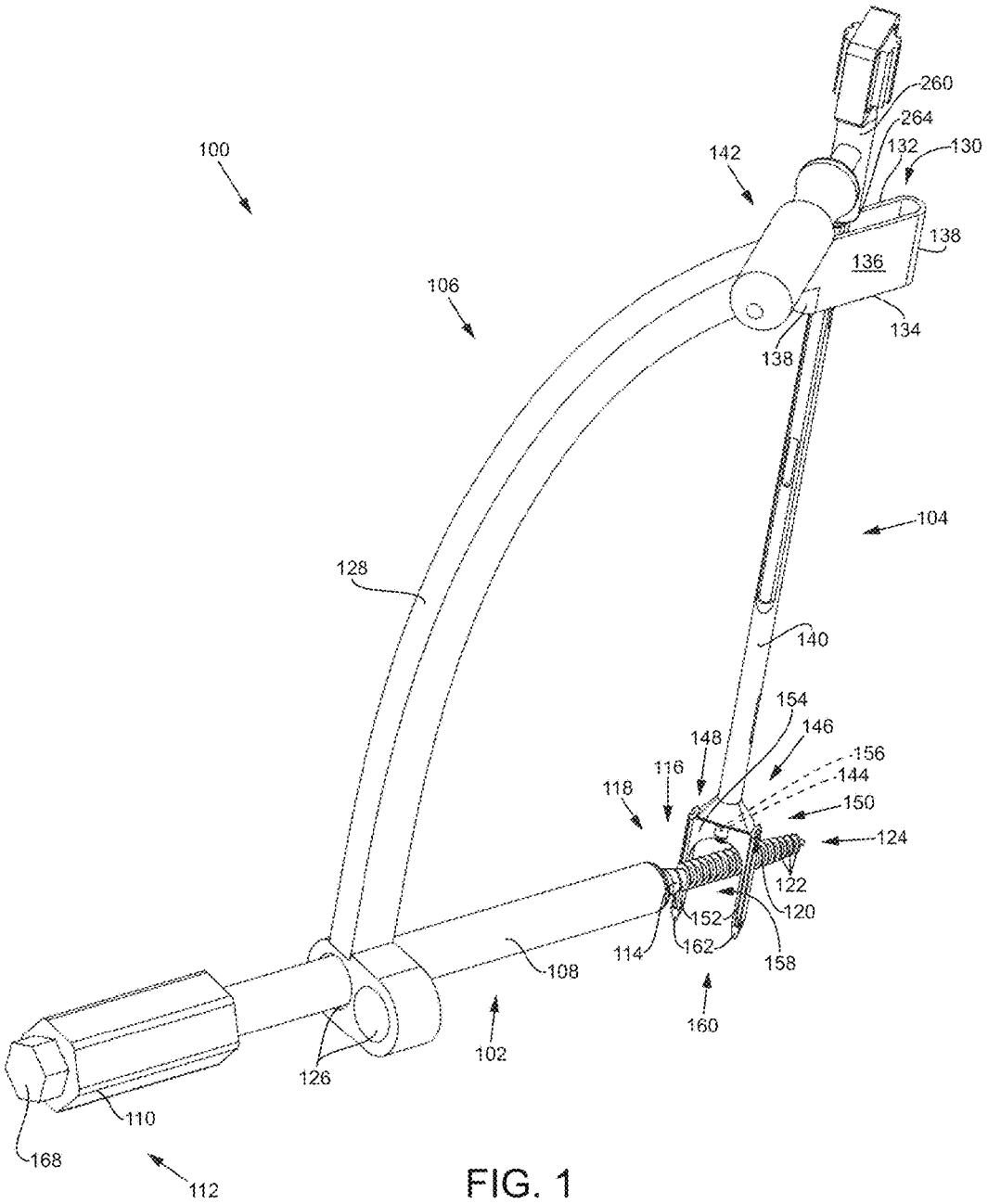

100
142
260
264
132
130
138
136
106
134
138
104
128
140
154
146
148
156
144
116
118
150
124
122
120
152
162
114
158
108
160
102
126
110
168
112

FIG. 1

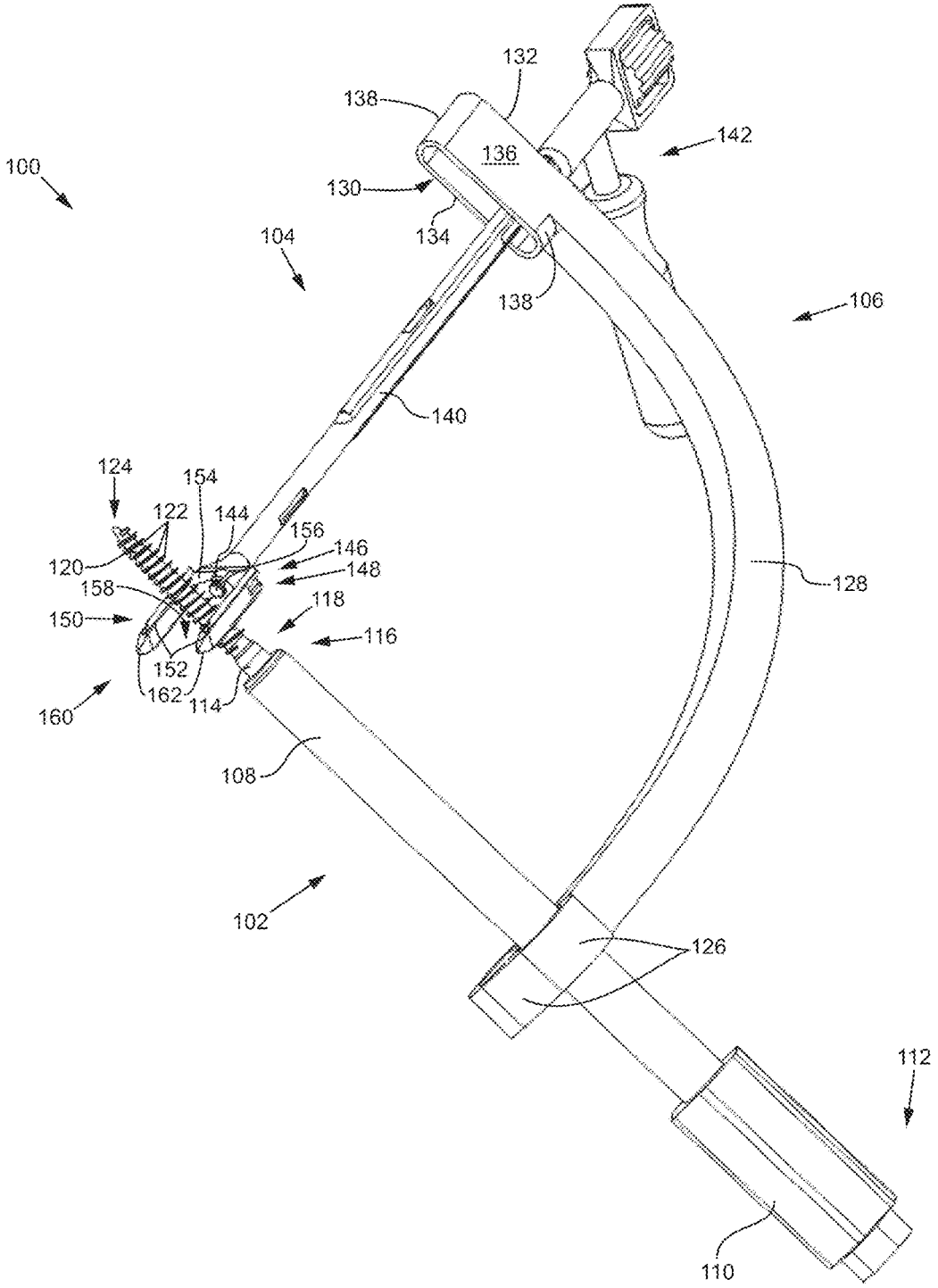

100
102
104
106
108
110
112
114
116
118
120
122
124
126
128
130
132
134
136
138
140
142
144
146
148
150
152
154
156
158
160
162

FIG. 2

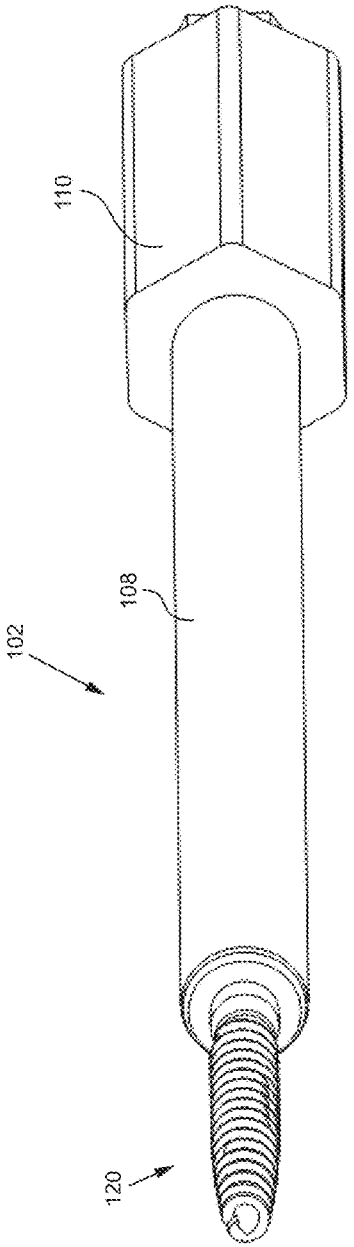

110
108
102
120

FIG. 3A

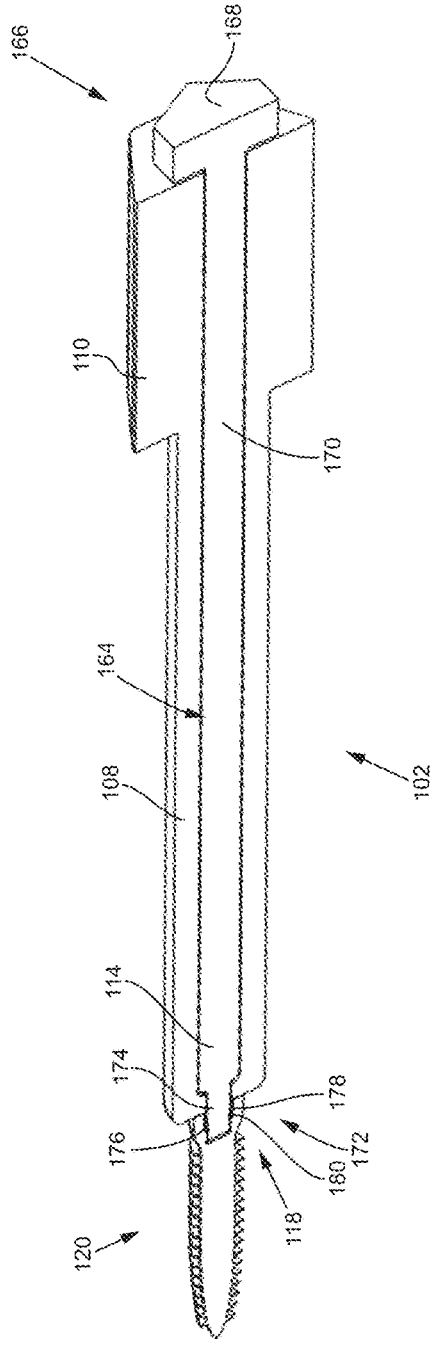

166
168
110
170
164
108
102
114
174
178
176
172
180
118
120

FIG. 3B

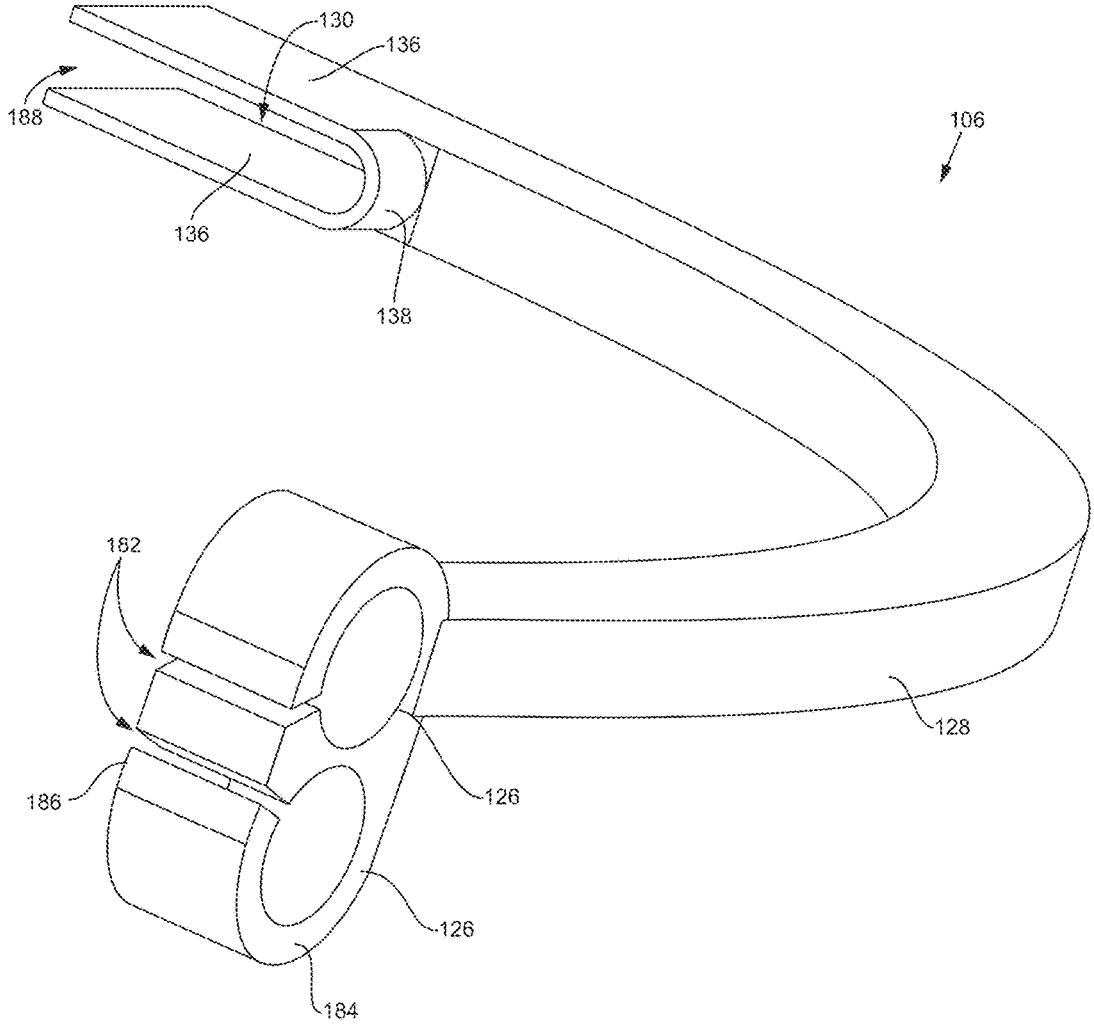


FIG. 4

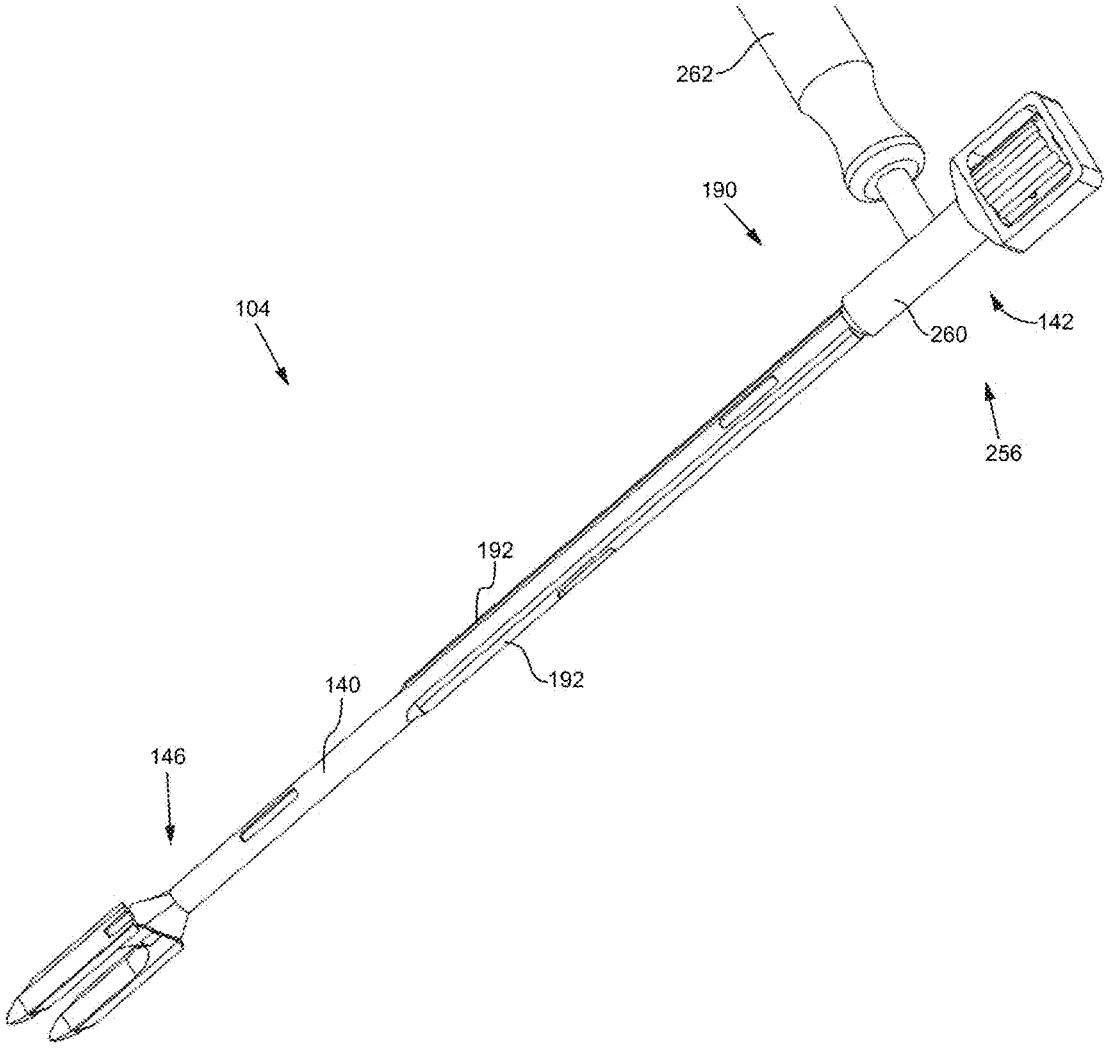


FIG. 5A

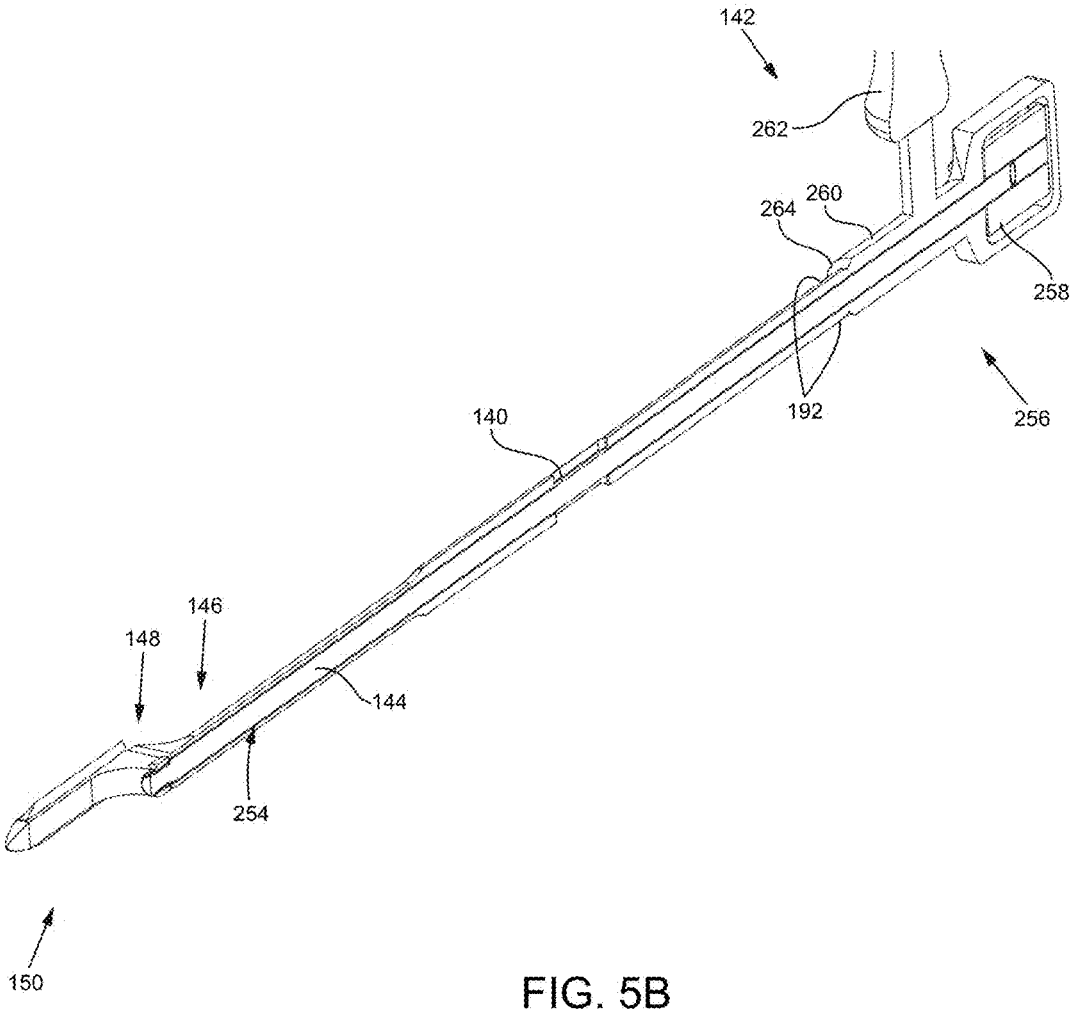


FIG. 5B

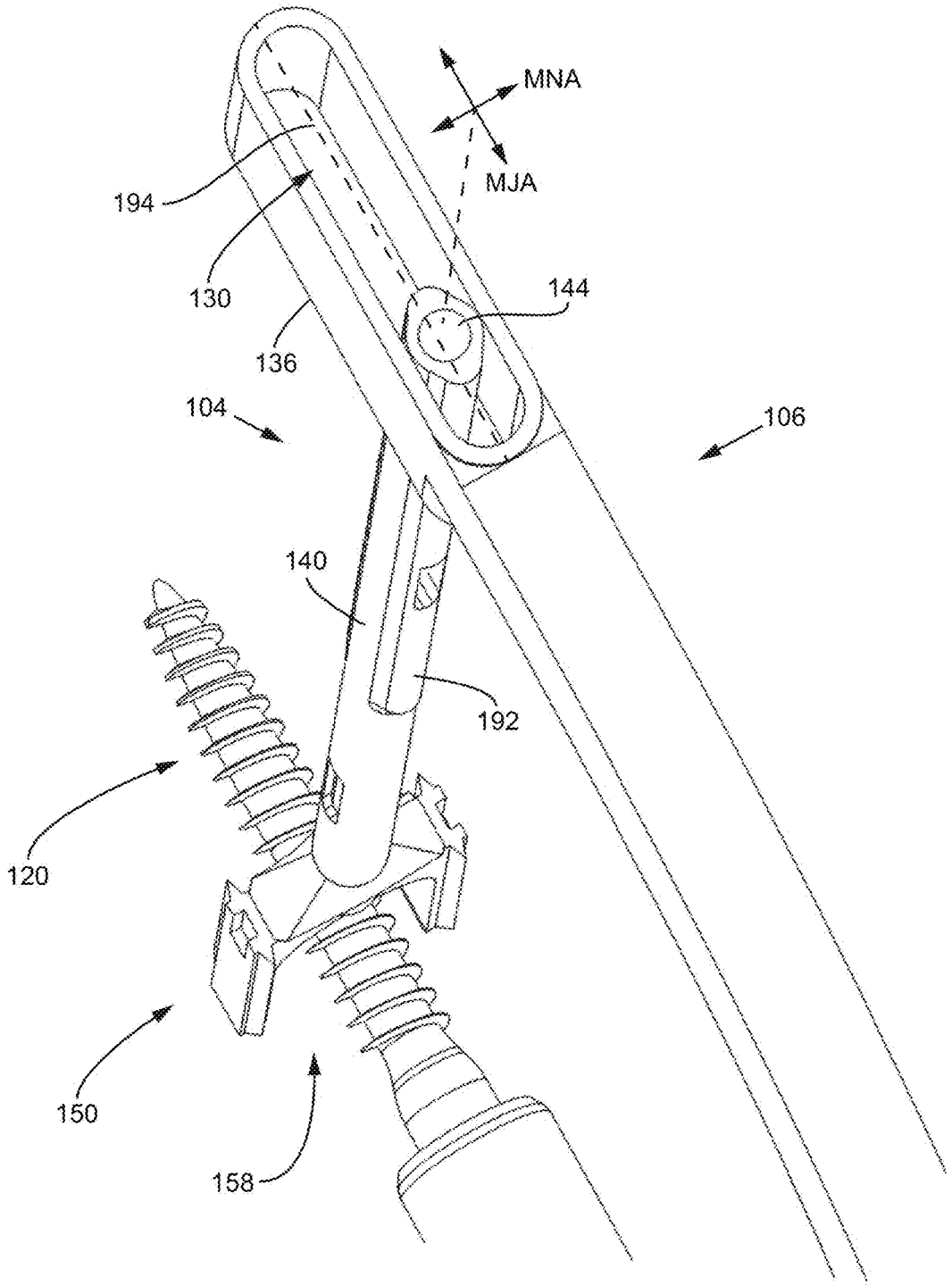


FIG. 6

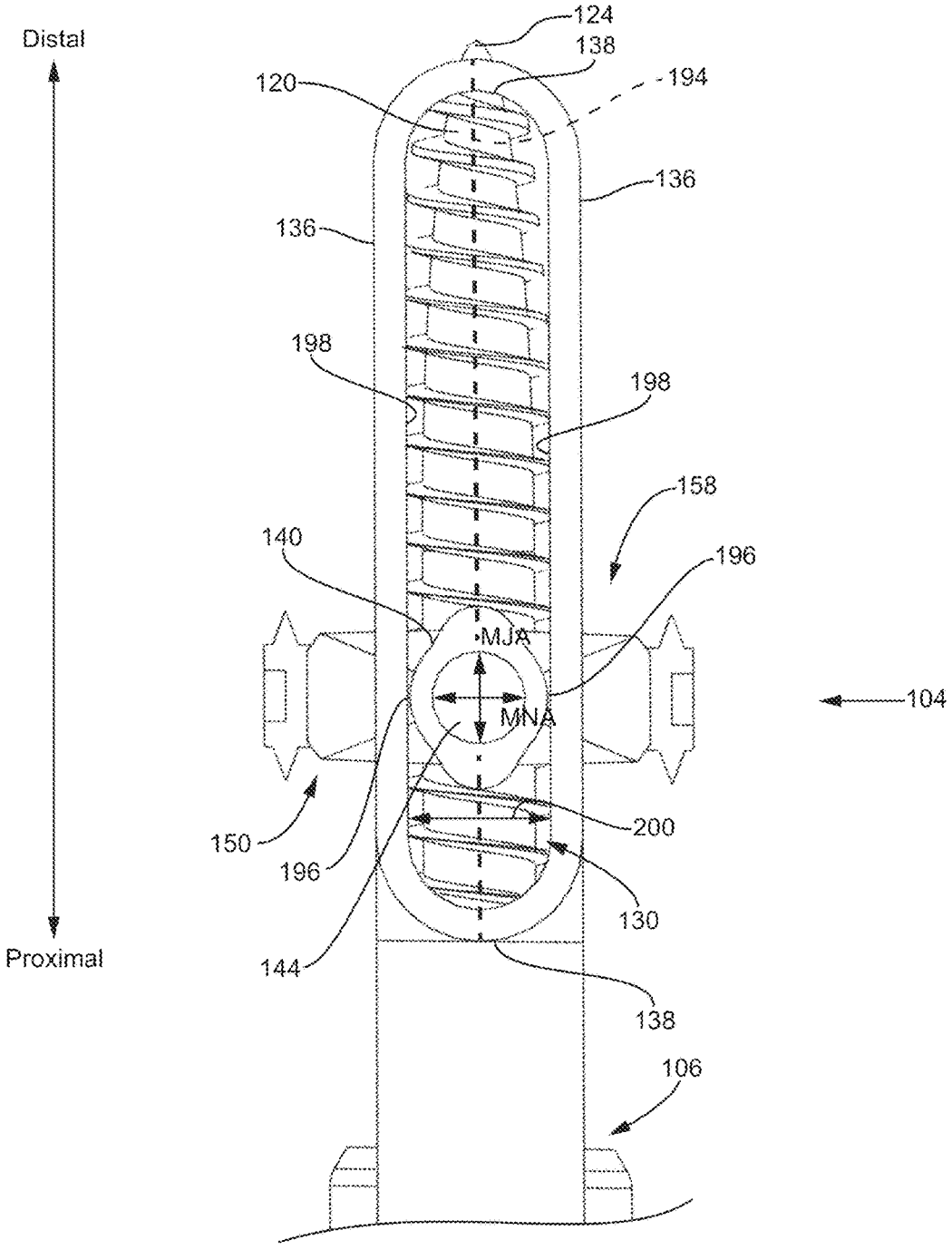

Distal
Proximal
124
138
120
194
136
136
198
198
158
140
196
MJA
MNA
104
150
196
200
130
144
138
106

FIG. 7

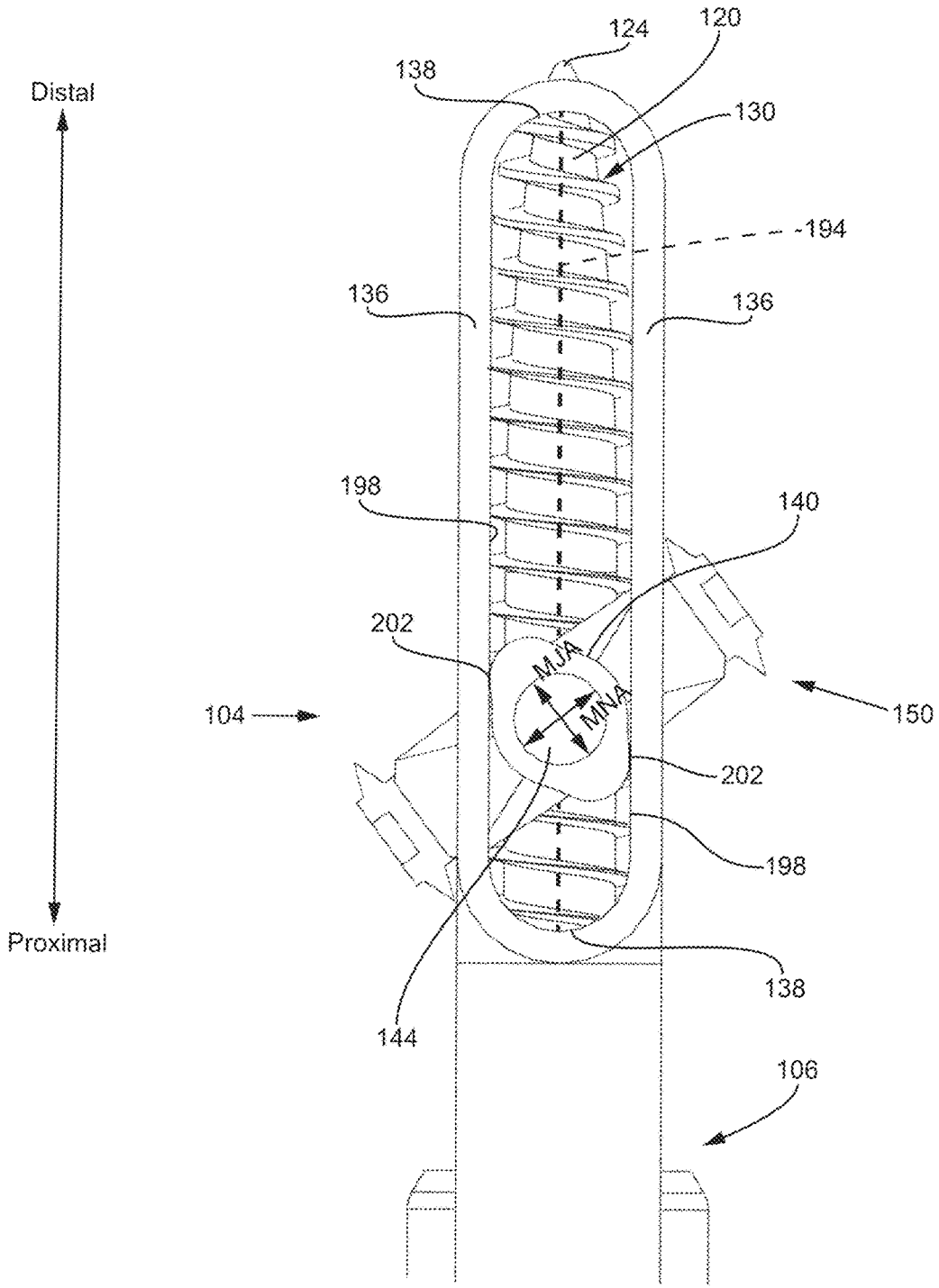

Distal
Proximal
124
120
138
130
194
136
136
198
140
202
MJA
MNA
104
150
202
198
138
144
106

FIG. 8

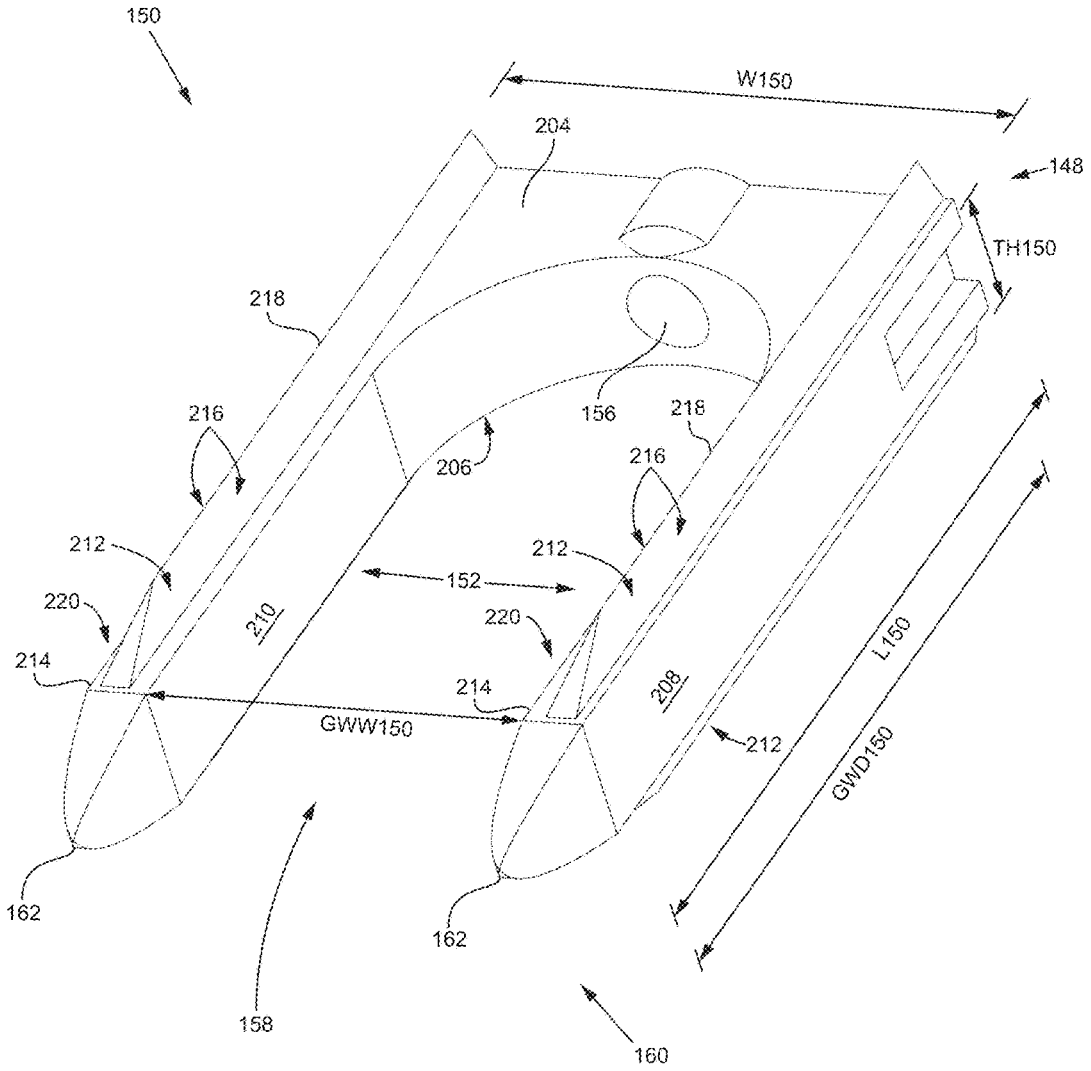

150
W150
204
148
TH150
218
216
156
218
206
216
212
212
152
220
220
210
214
214
208
GWW150
212
L150
GWD150
162
162
158
160

FIG. 9

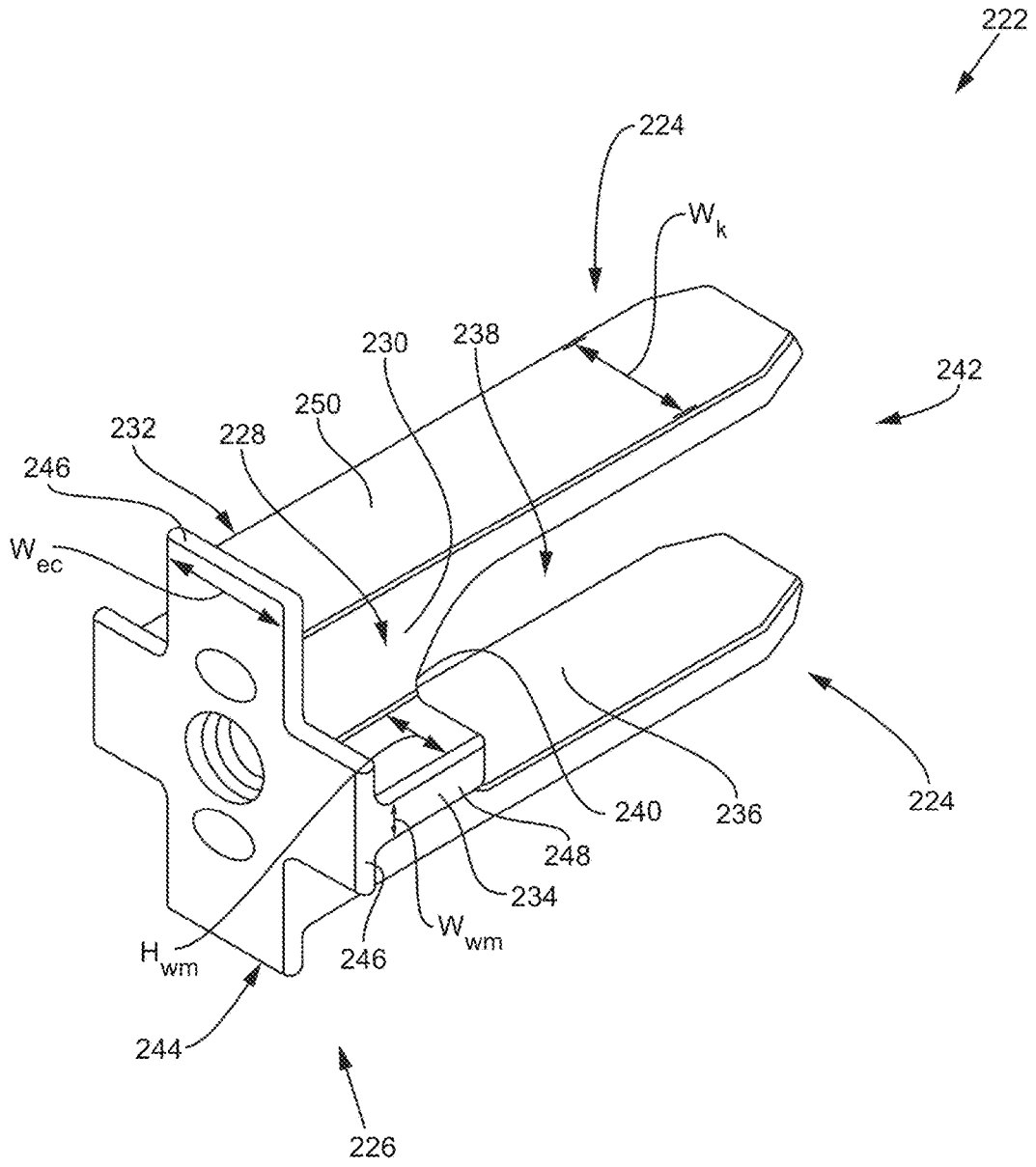

222
224
W_k
230
238
242
250
232
228
246
W_{ec}
240
236
224
248
234
W_{wm}
H_{wm}
246
244
226

FIG. 10

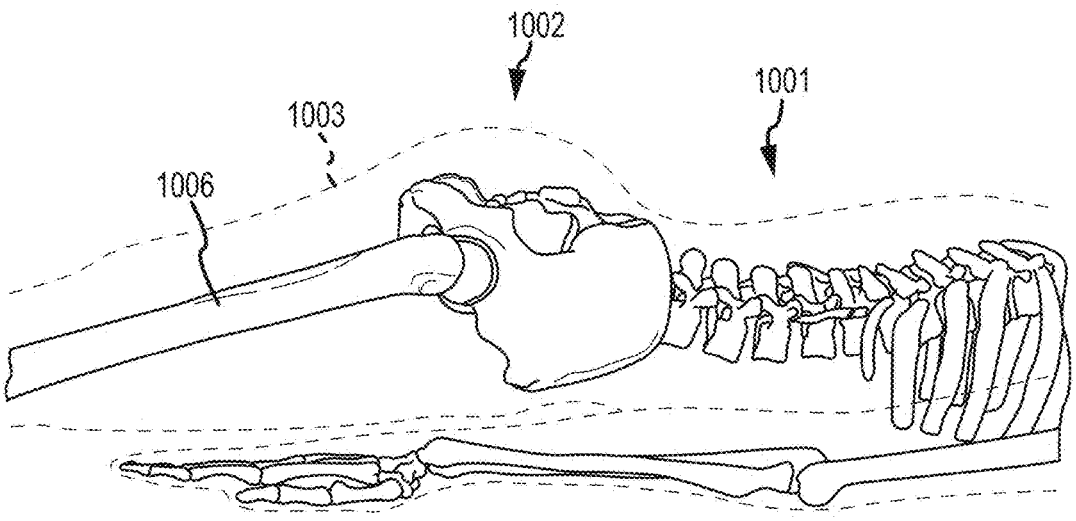


FIG. 11A

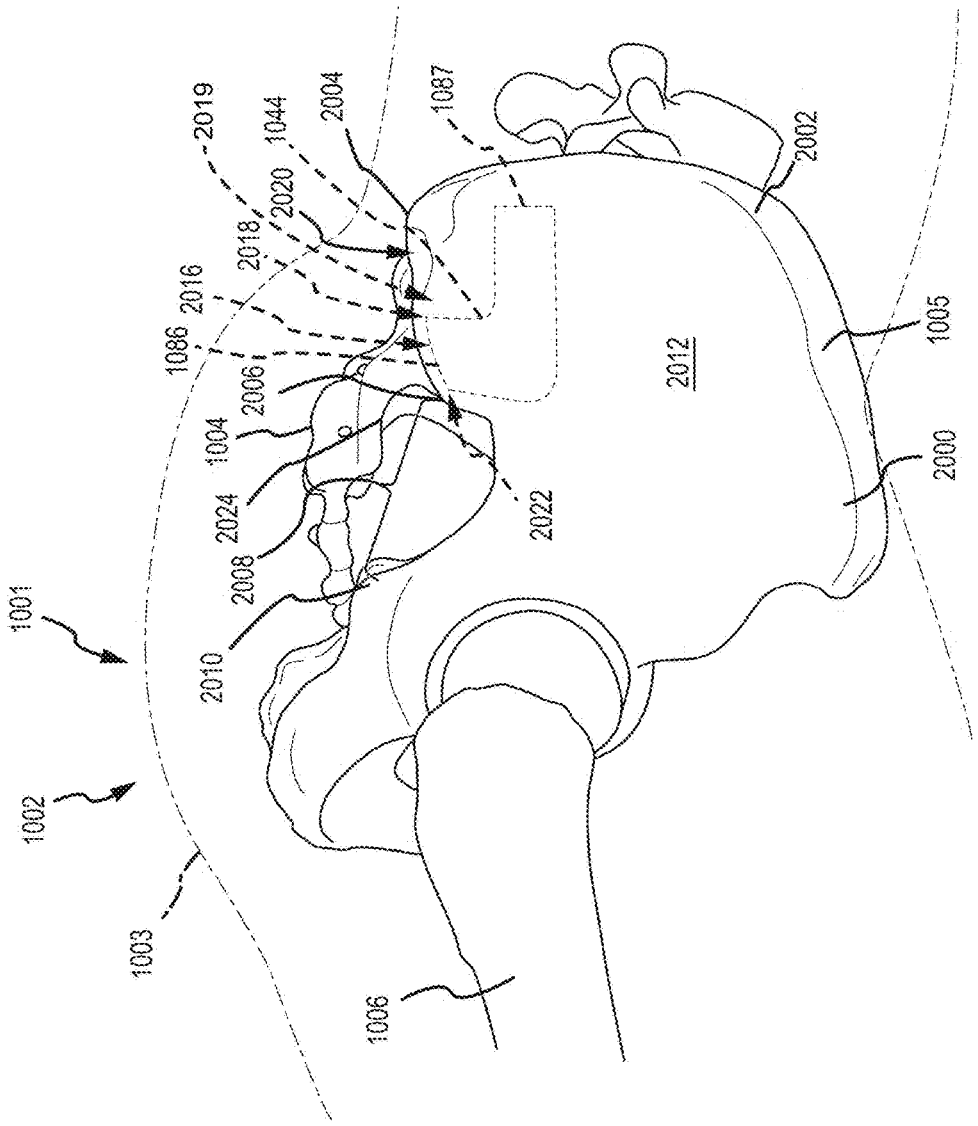

1001
1002
1003
1006
2010
2008
2024
1004
2006
1086
2016
2018
2020
1044
2019
2004
1087
2002
1005
2000
2012
2022

FIG. 11B

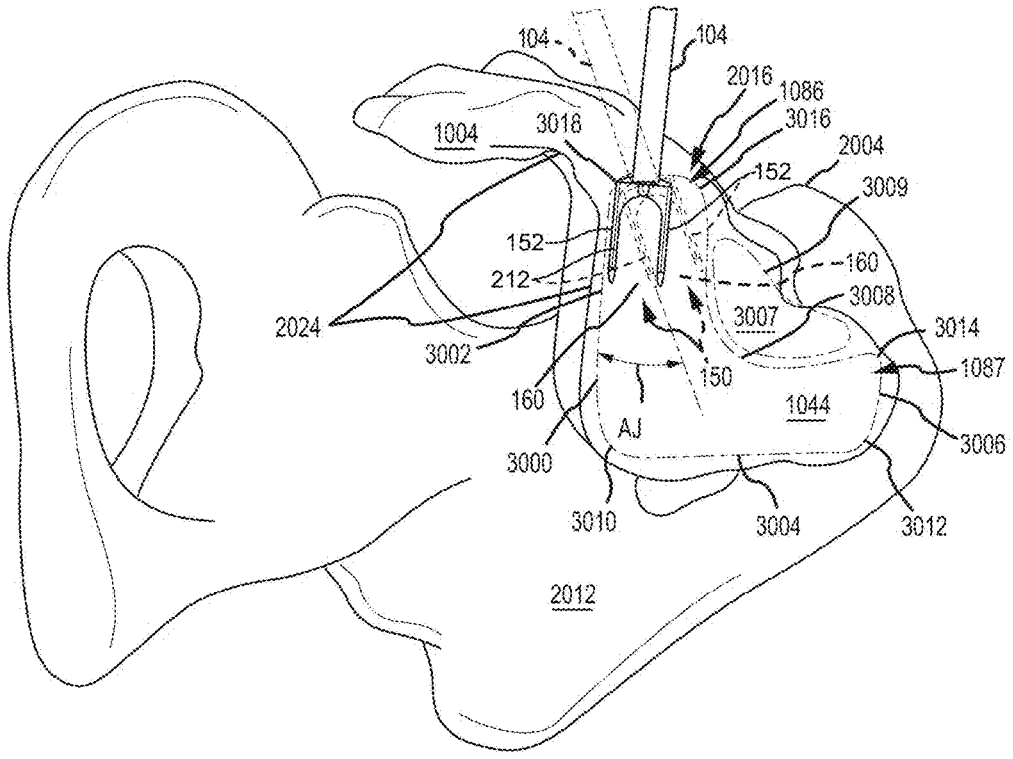

104
104
2016
1086
3016
1004
3018
2004
152
3009
152
160
212
3008
3007
2024
3014
3002
150
1087
160
1044
AJ
3006
3000
3010
3004
3012
2012

FIG. 11C

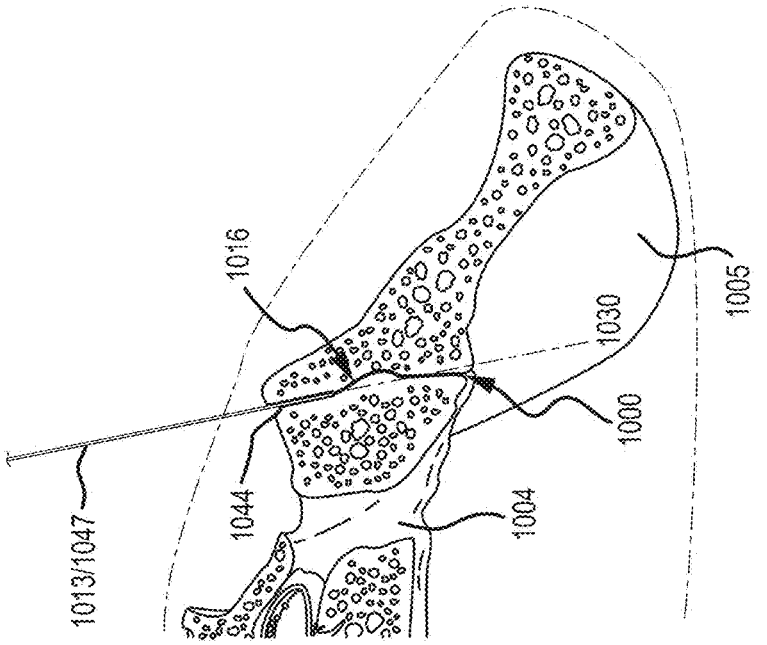


FIG. 12B

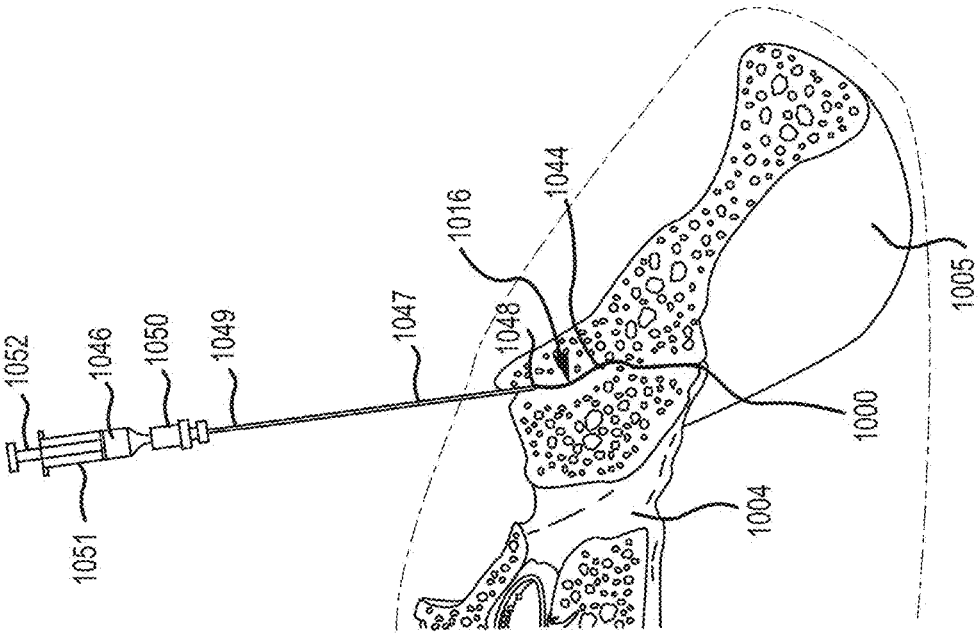


FIG. 12A

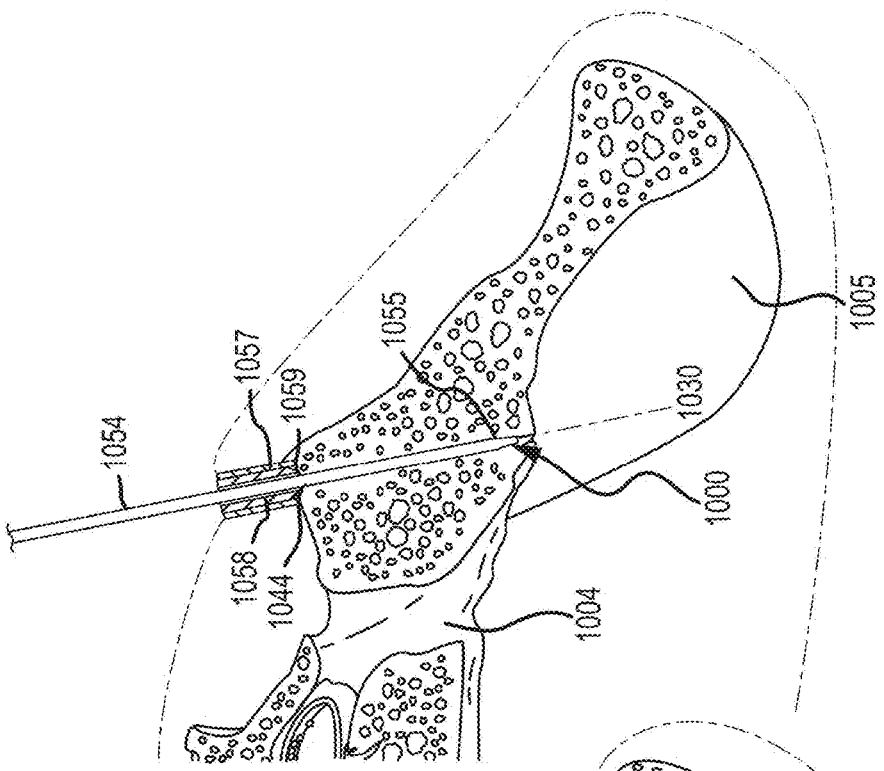


FIG. 12D

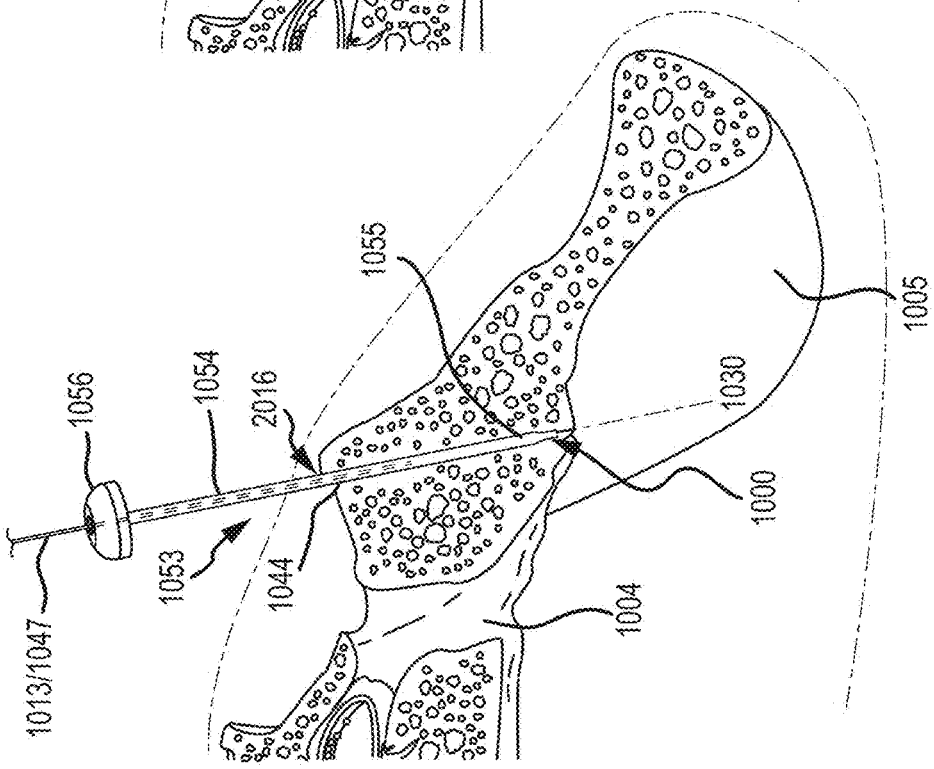


FIG. 12C

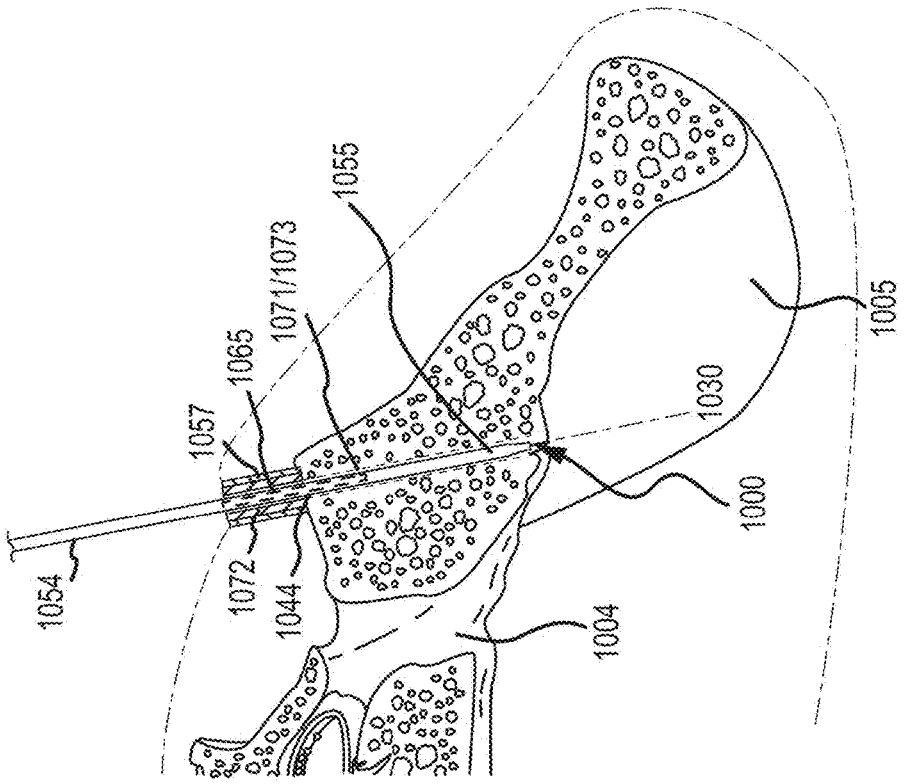


FIG. 12F

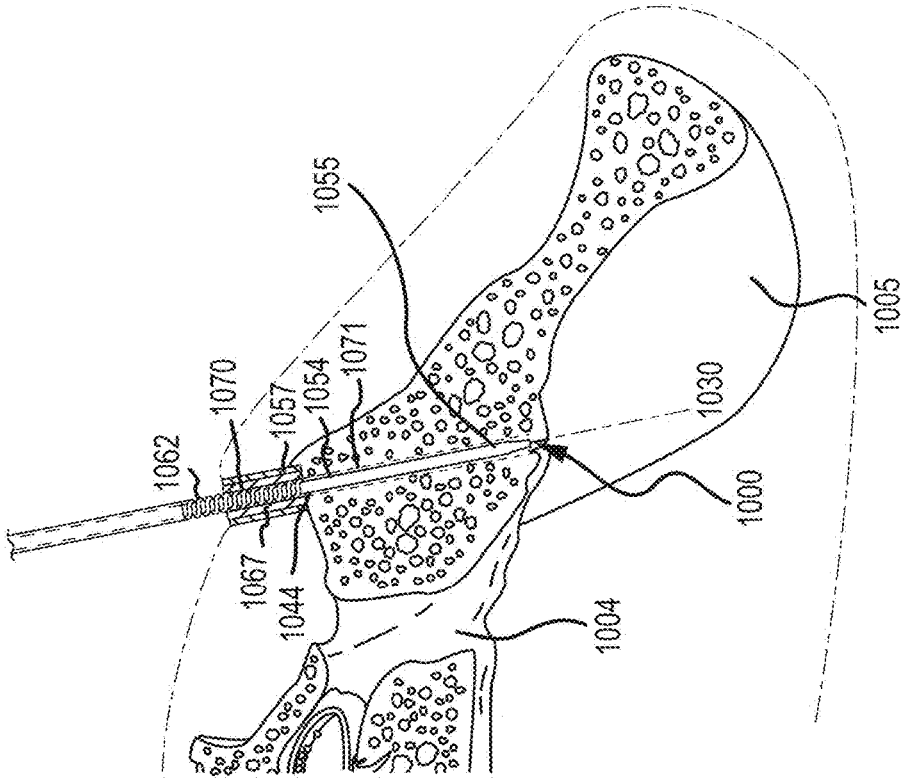


FIG. 12E

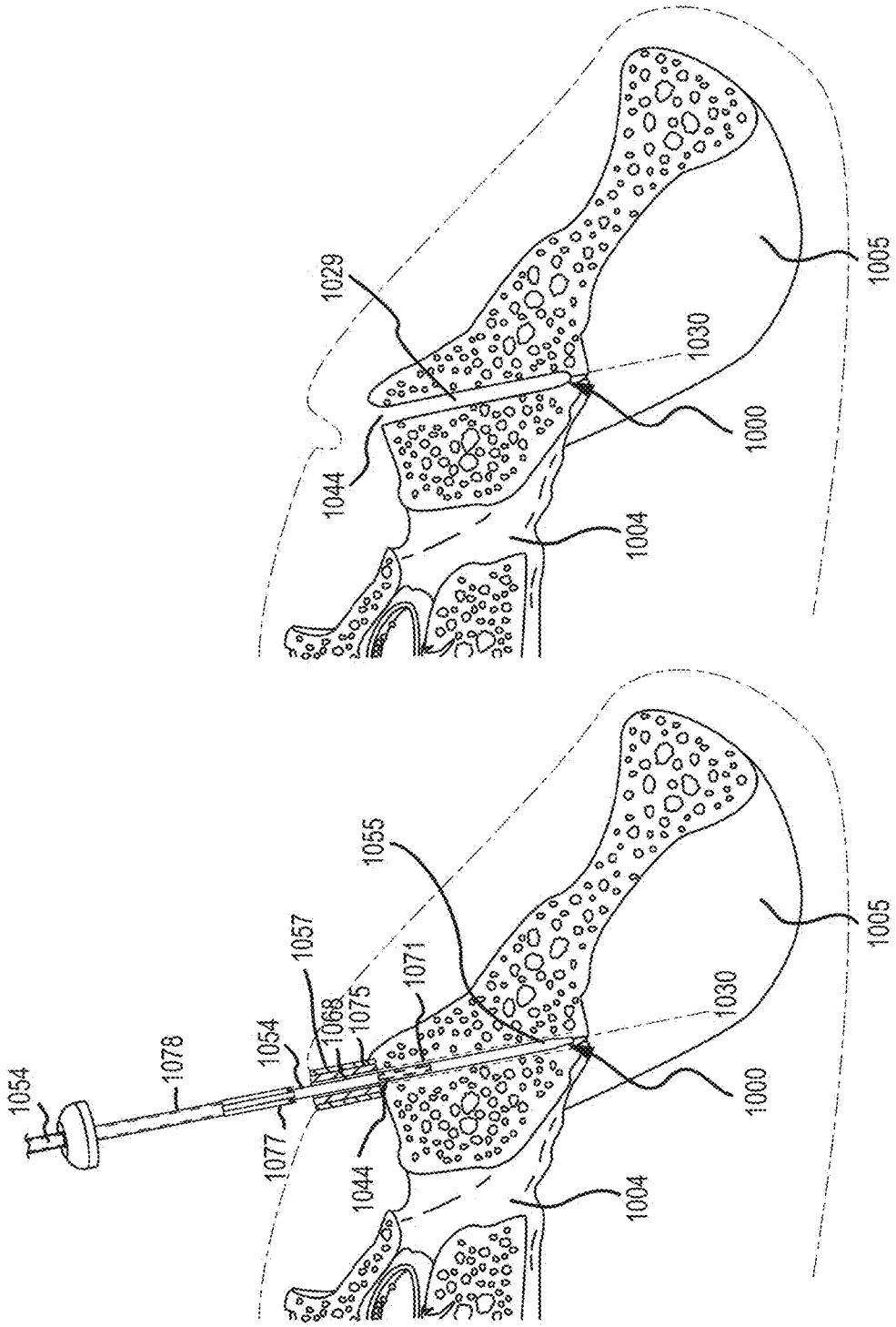


FIG. 12H

FIG. 12G

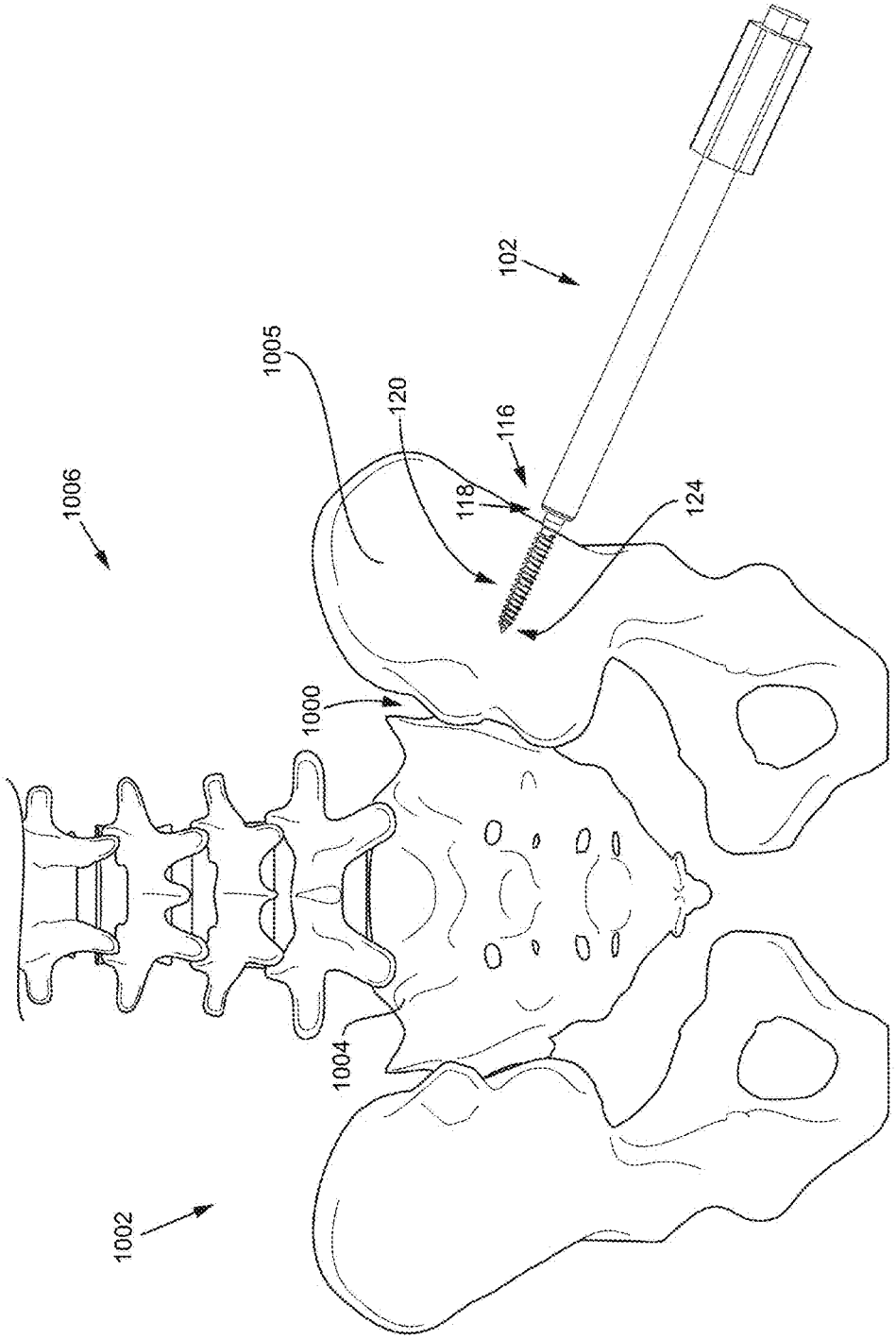


FIG. 13A

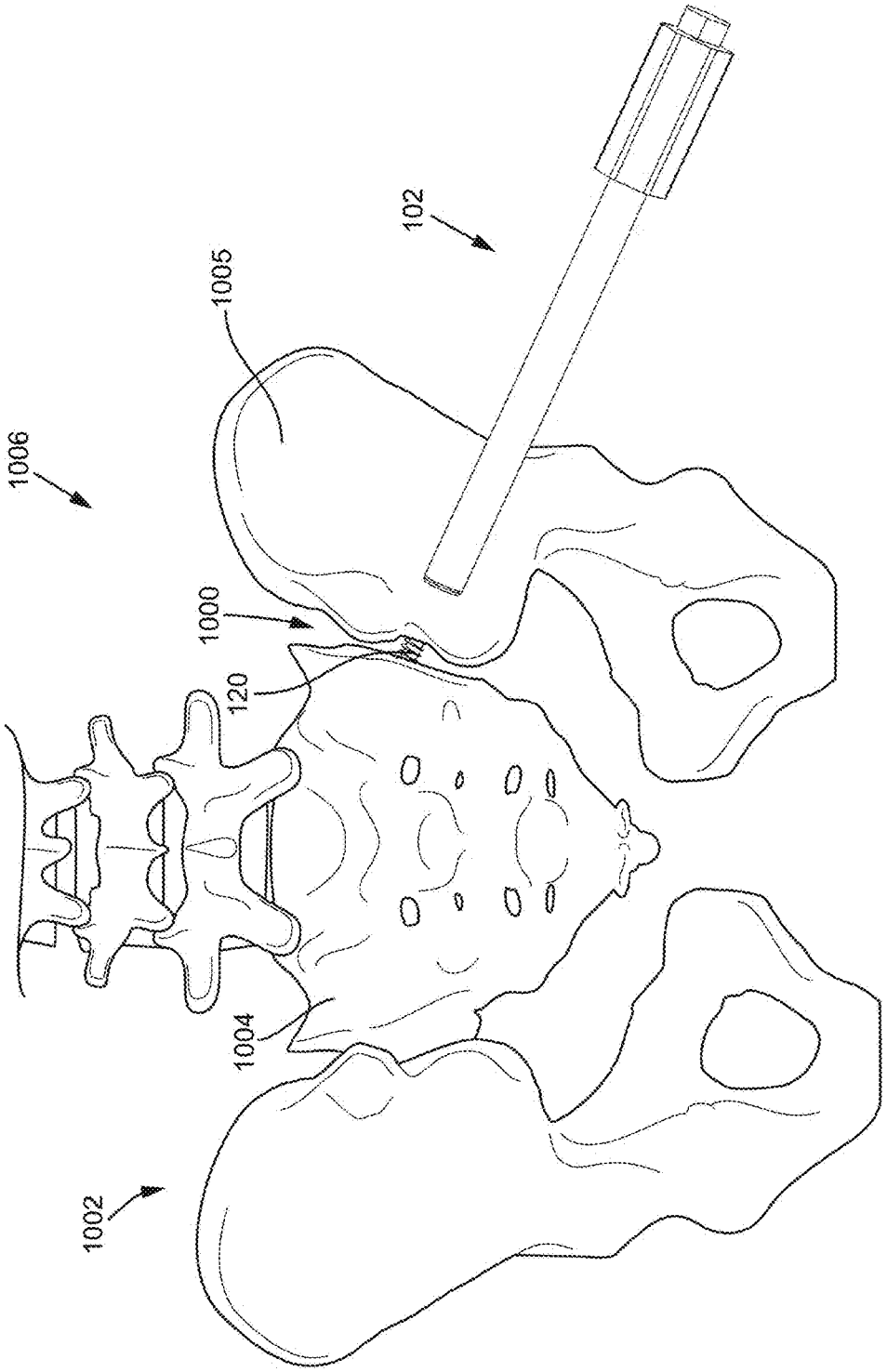


FIG. 13B

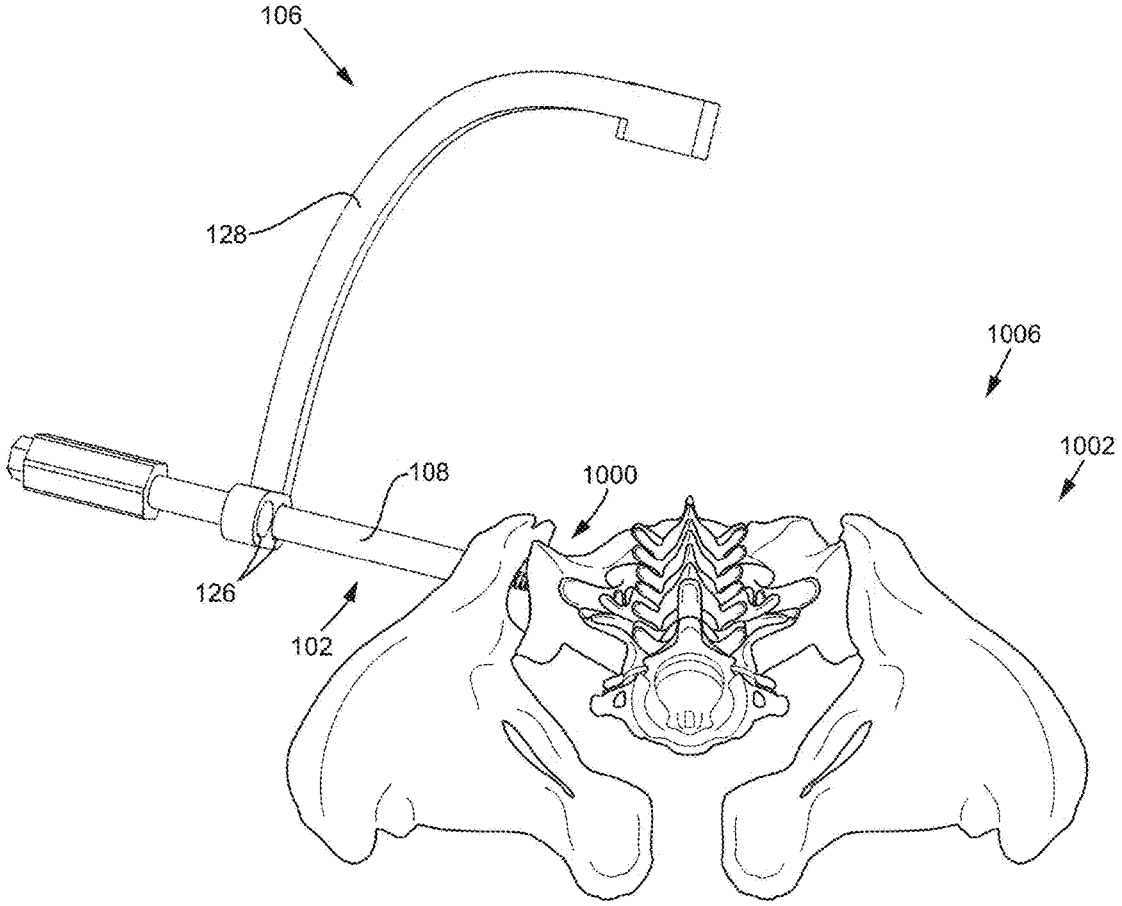


FIG. 13C

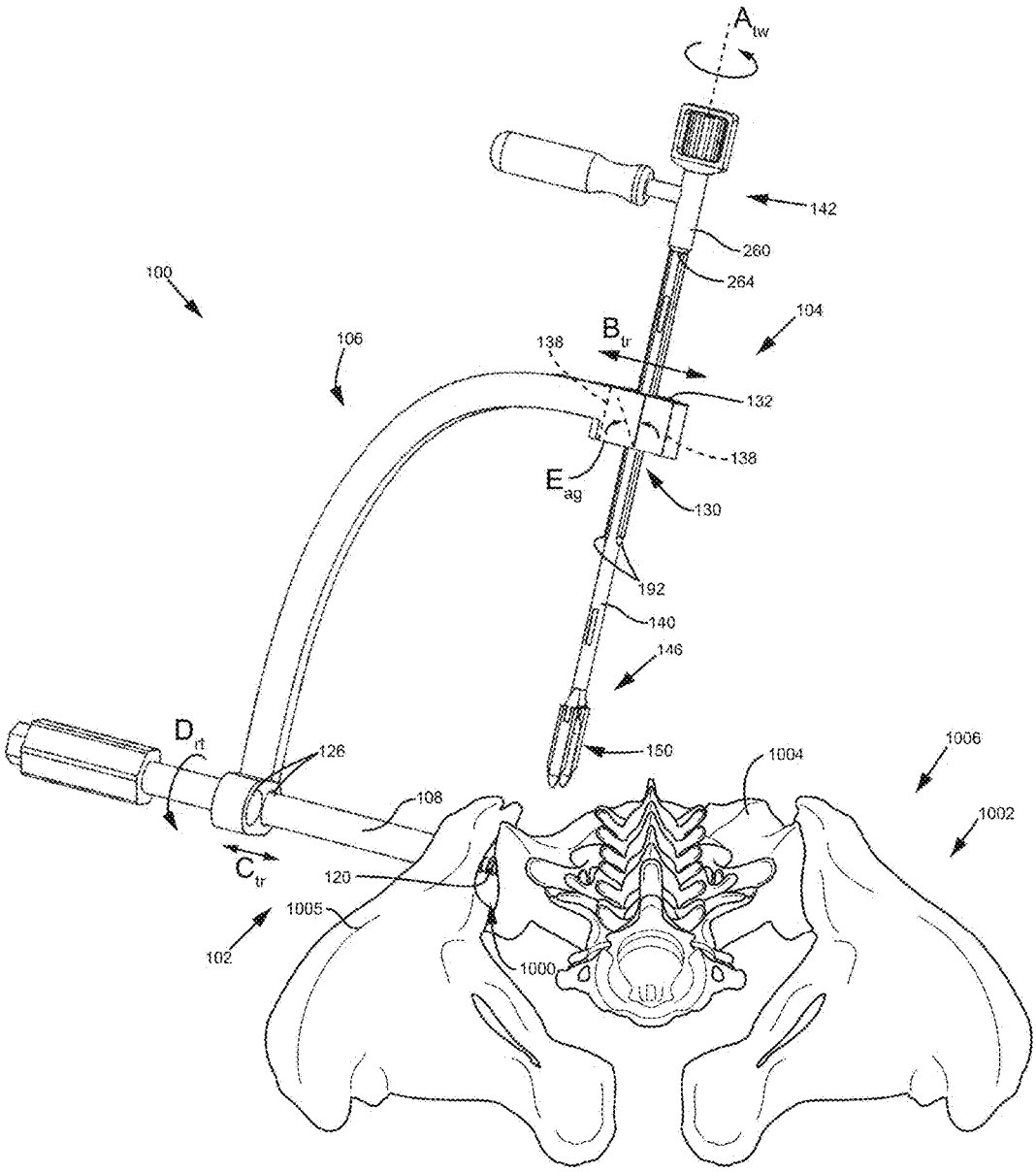

A_{tw}
142
260
264
100
104
106
138
B_{tr}
132
138
E_{ag}
130
192
140
146
D_{rt}
126
150
1004
1006
108
1002
C_{tr}
120
1005
102
1000

FIG. 13D

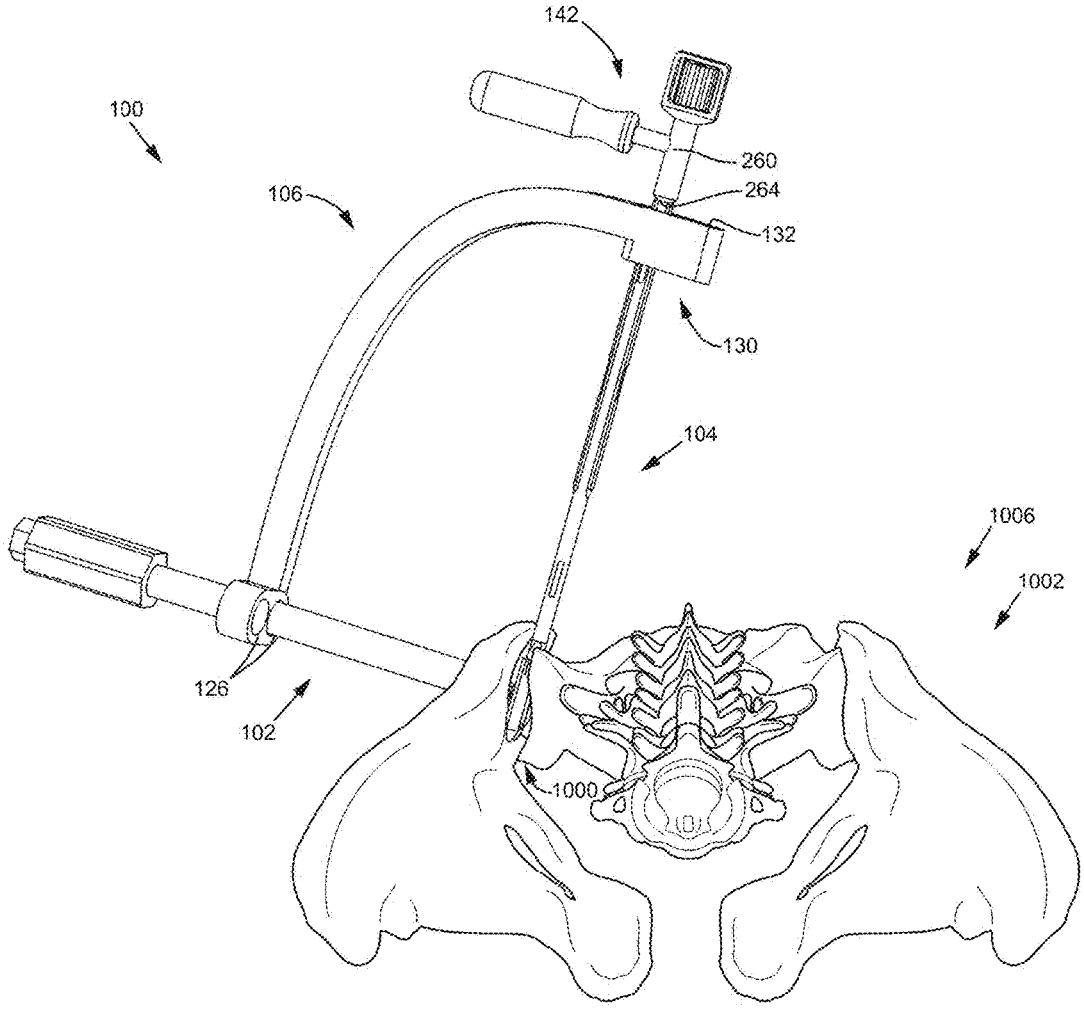


FIG. 13E

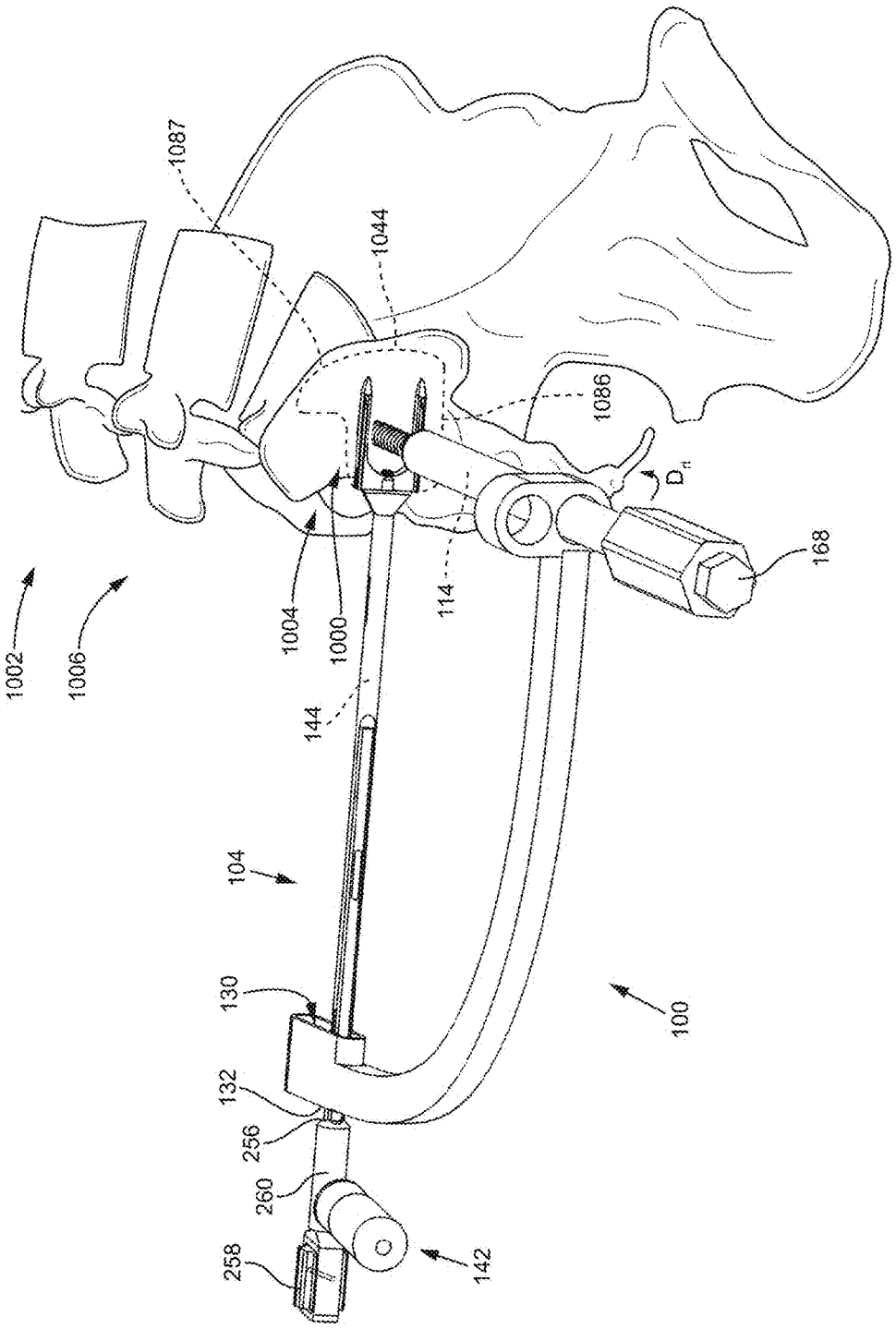

1087
1044
1086
D_n
168
114
1004
1000
1002
1006
144
104
130
132
256
260
258
142
100

FIG. 13F

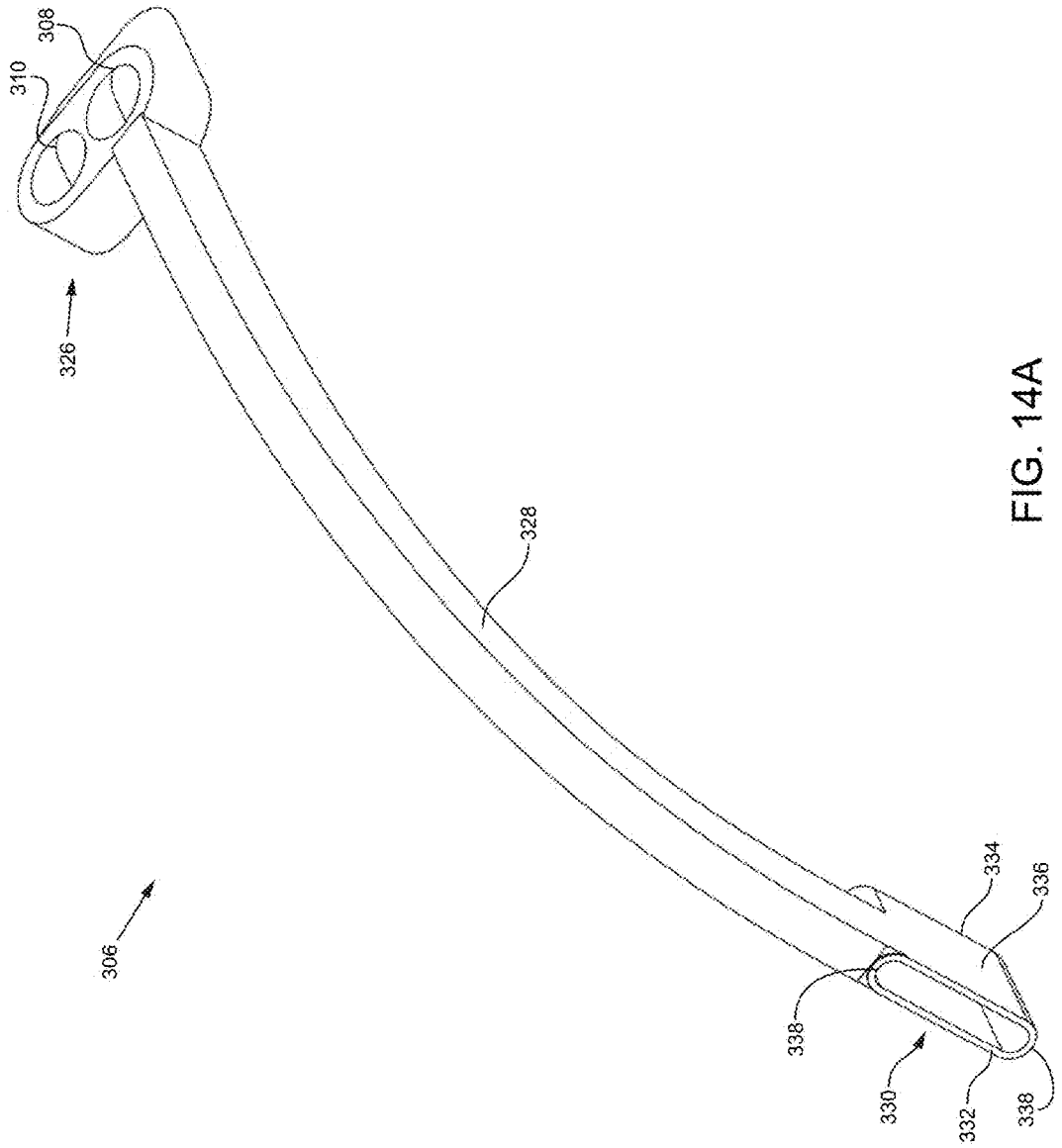


FIG. 14A

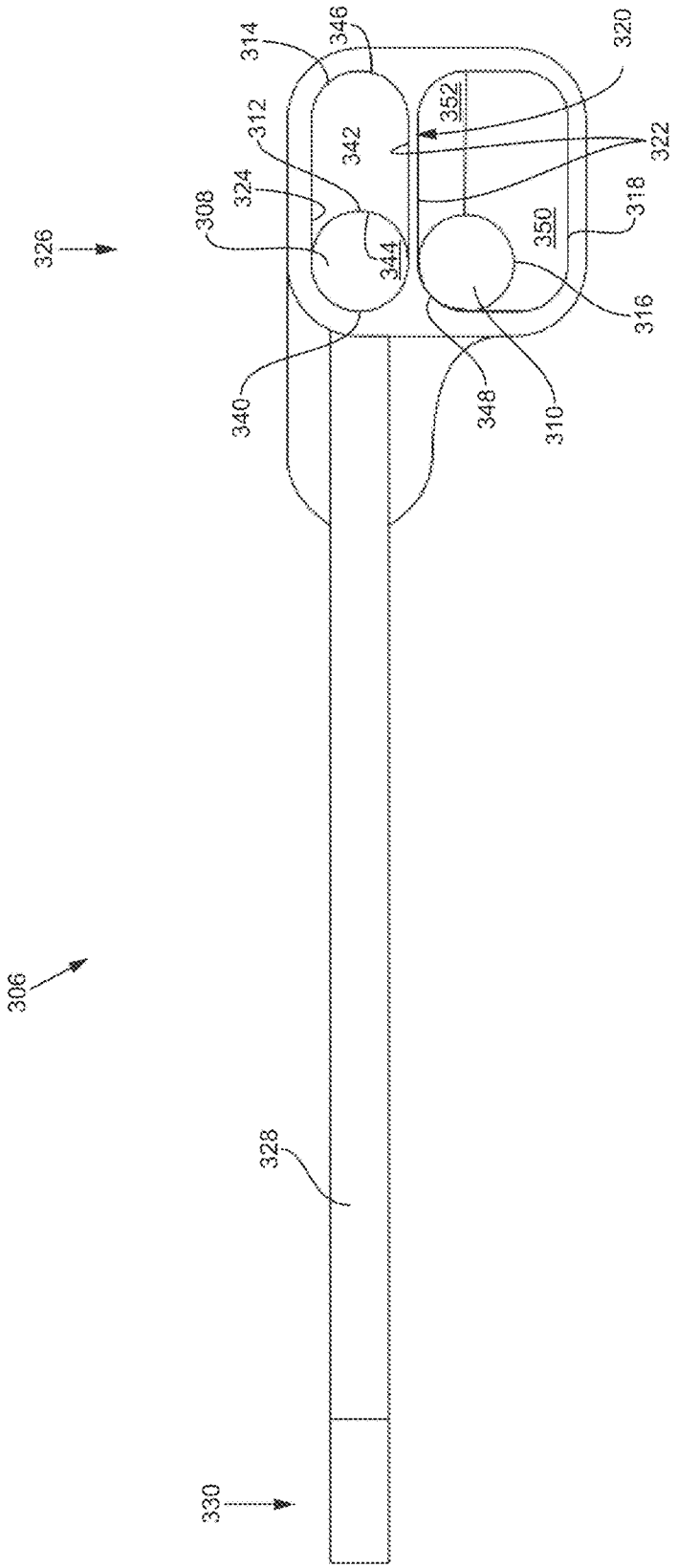

314
346
320
312
352
342
322
324
308
318
326
344
350
316
340
348
310
306
328
330

FIG. 14B

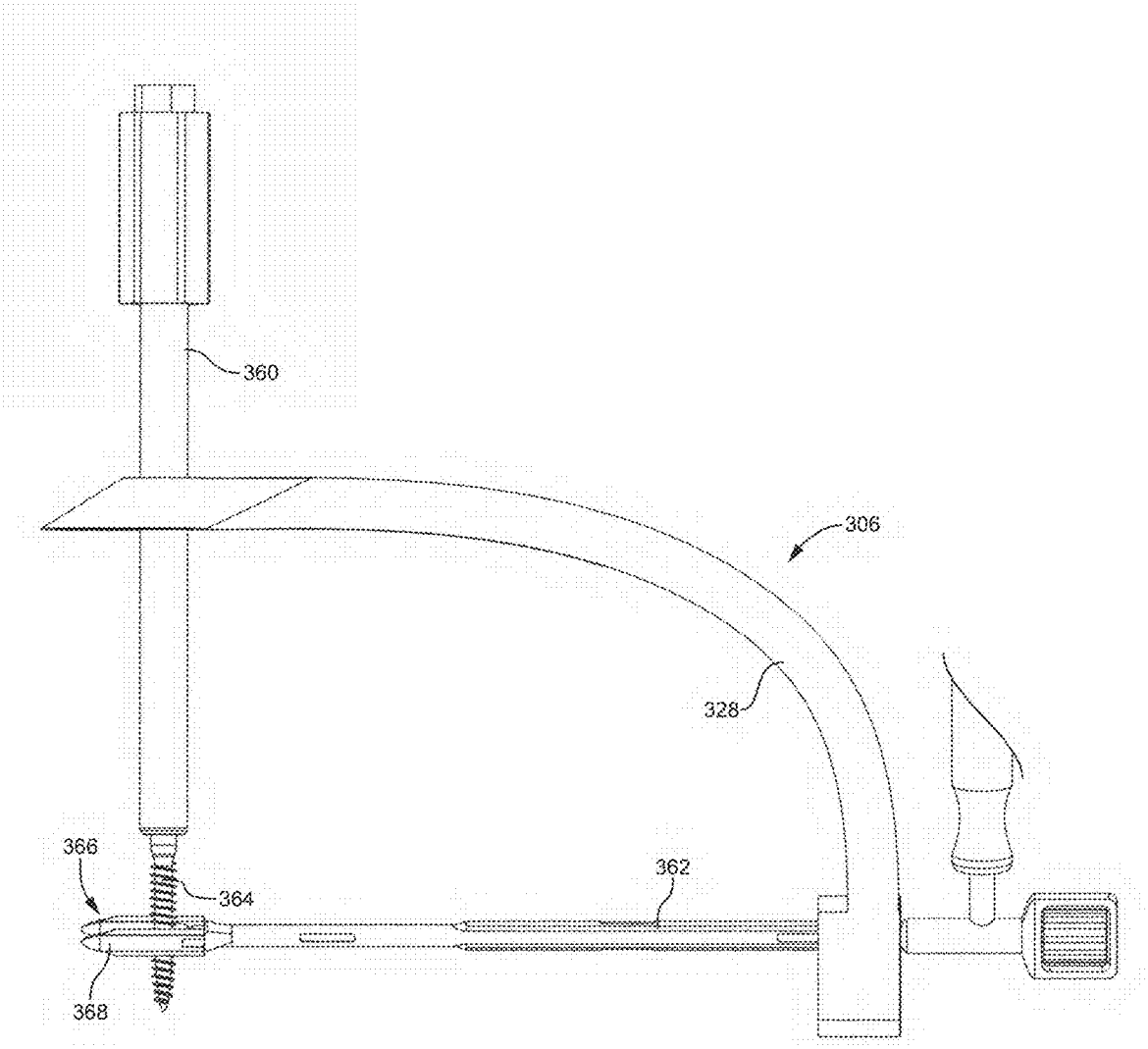


FIG. 14C

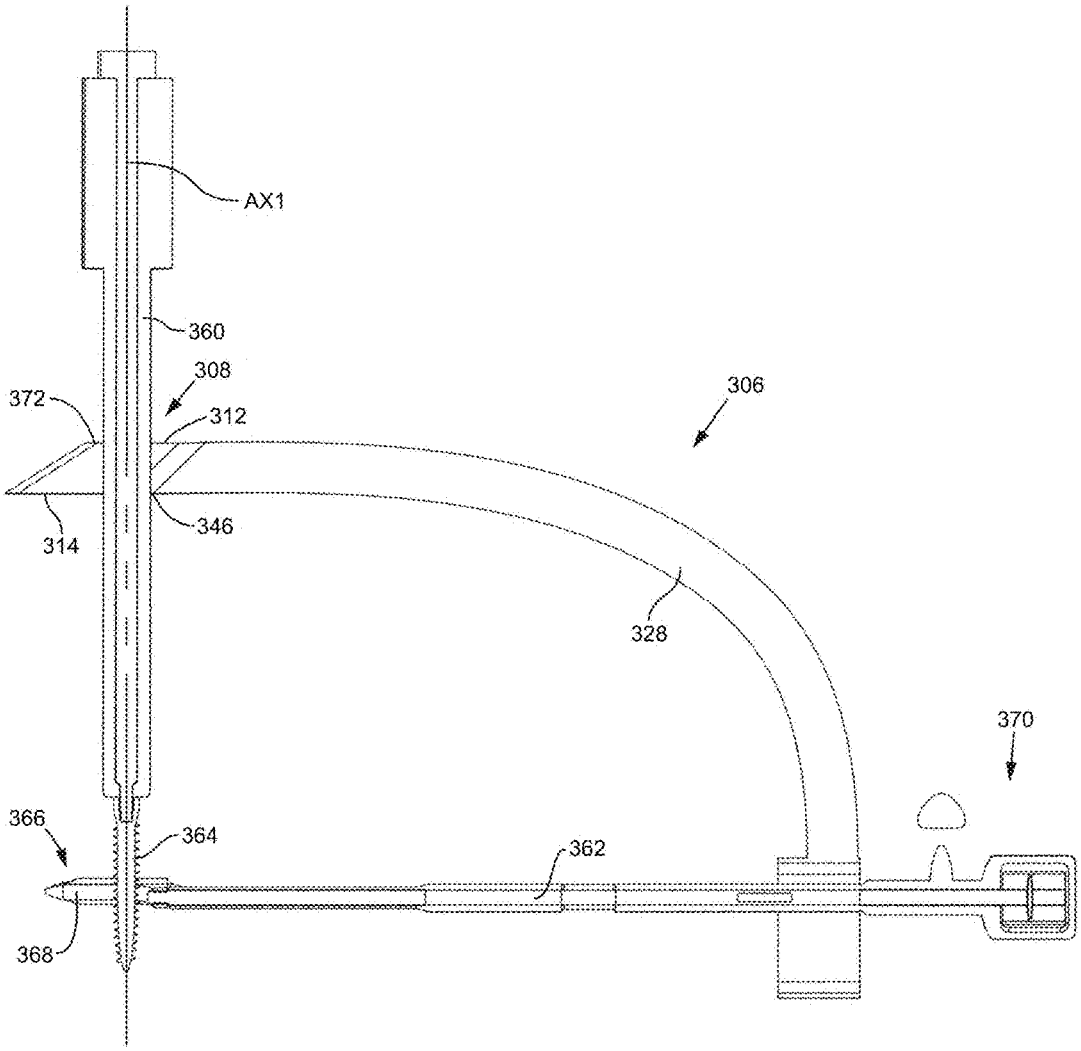


FIG. 14D

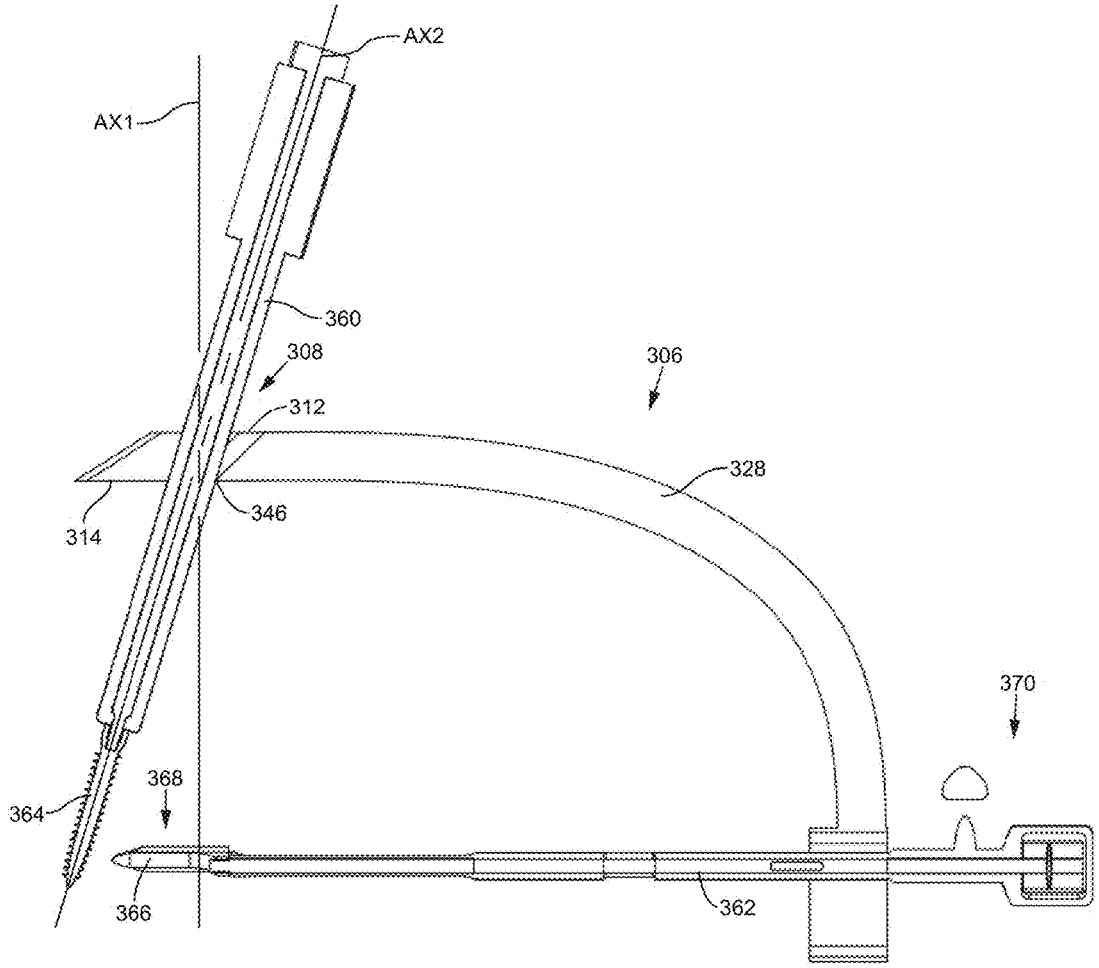


FIG. 14E

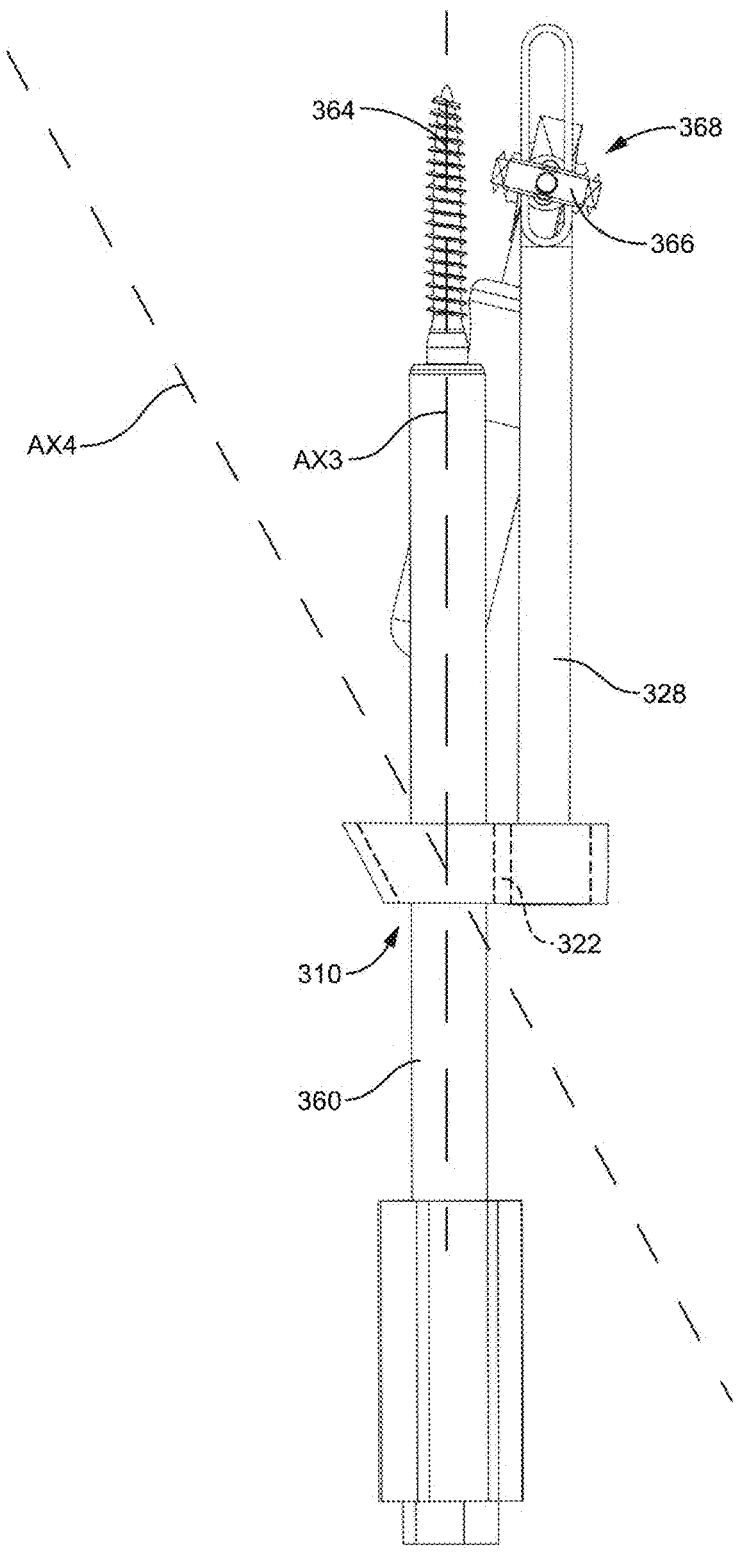


FIG. 14F

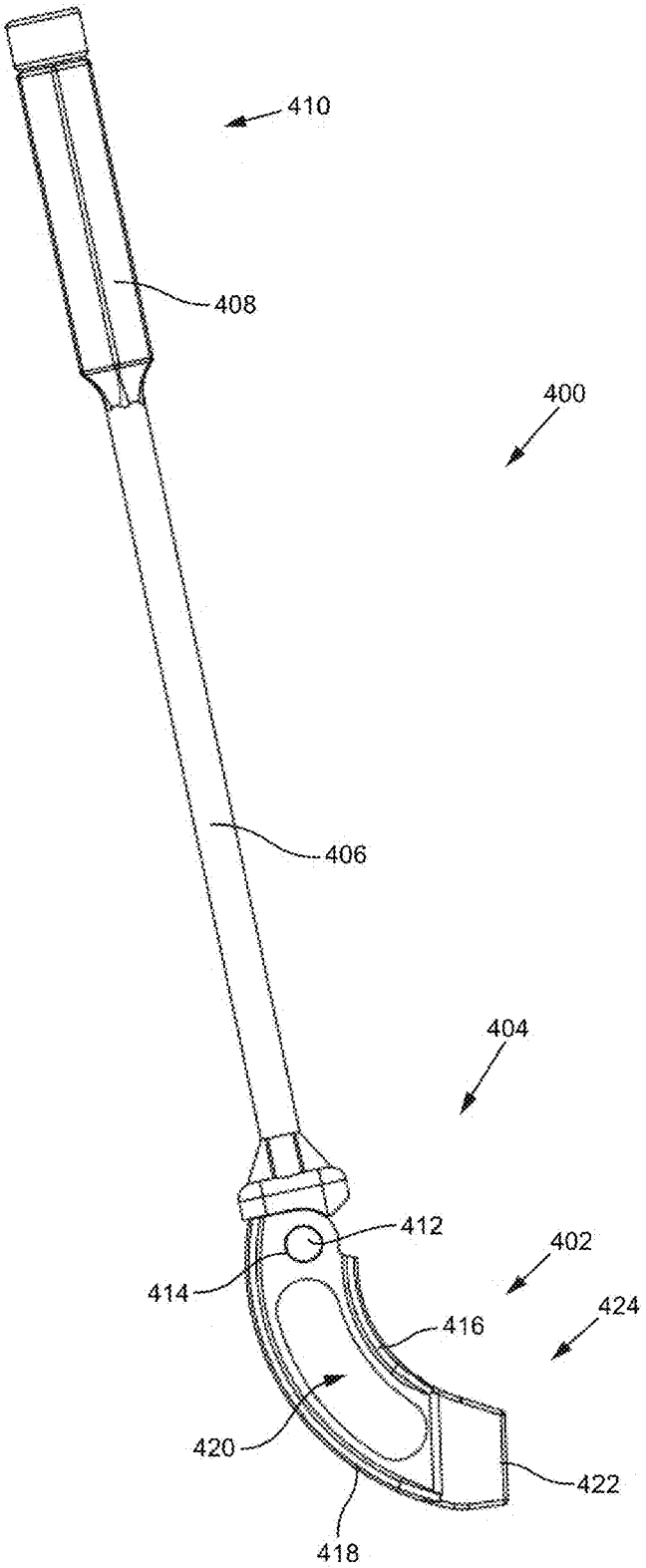


FIG. 15A

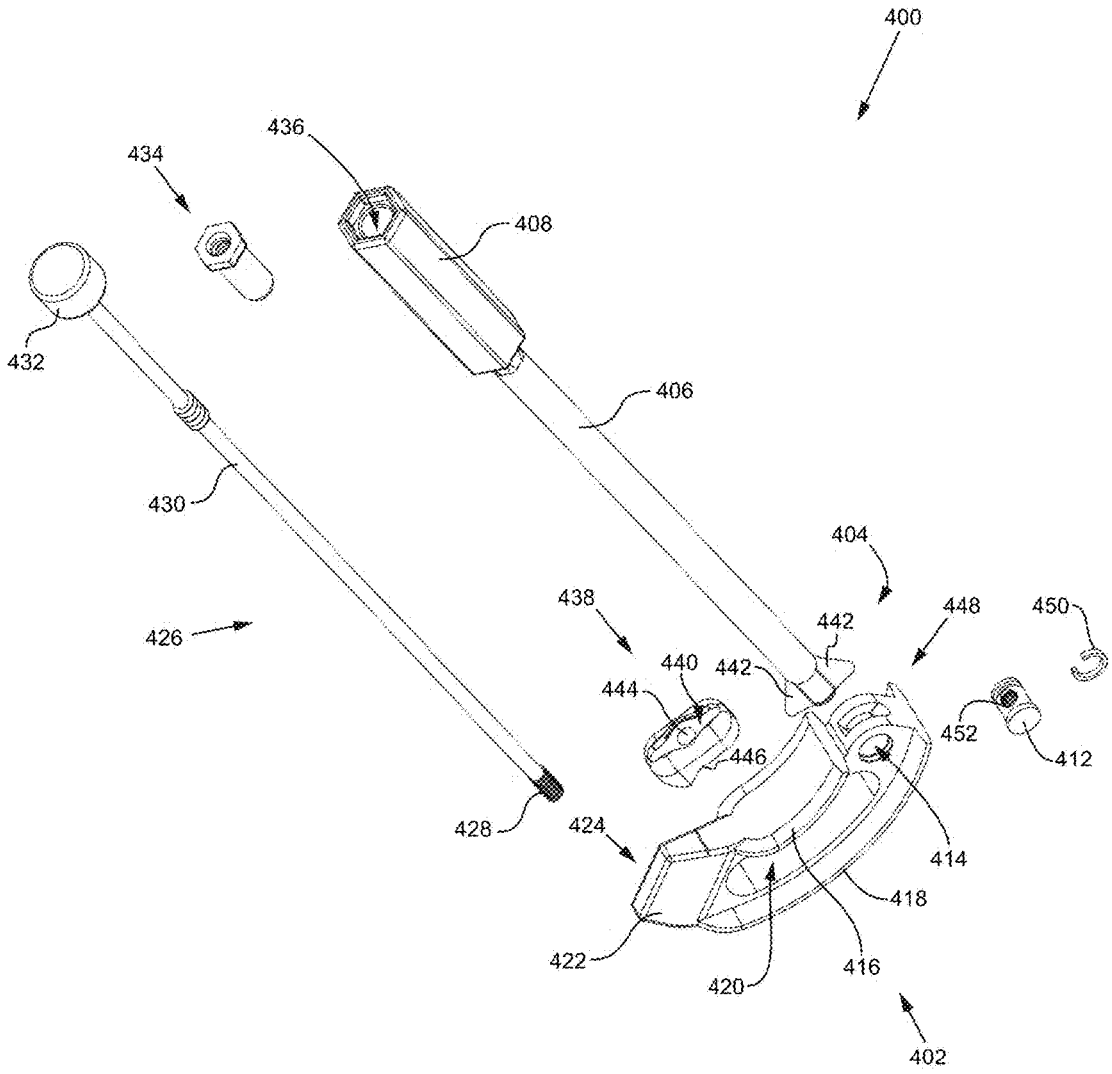

400
436
434
408
432
406
430
404
438
448
450
426
442
440
442
444
452
412
446
428
424
414
418
422
416
420
402

FIG. 15B

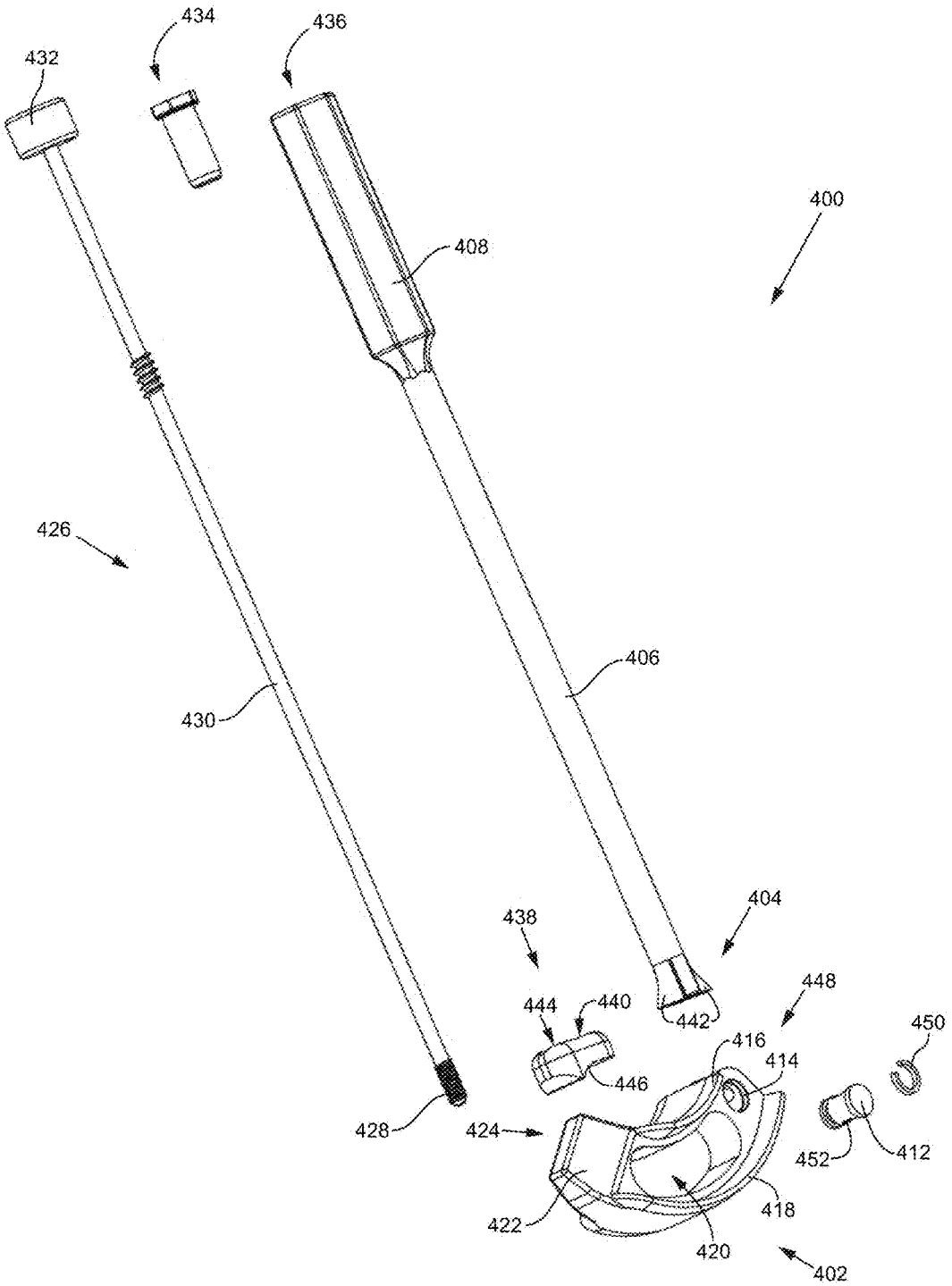

434
436
432
400
408
426
406
430
404
438
448
444
440
442
450
416
414
446
428
424
452
412
418
422
420
402

FIG. 15C

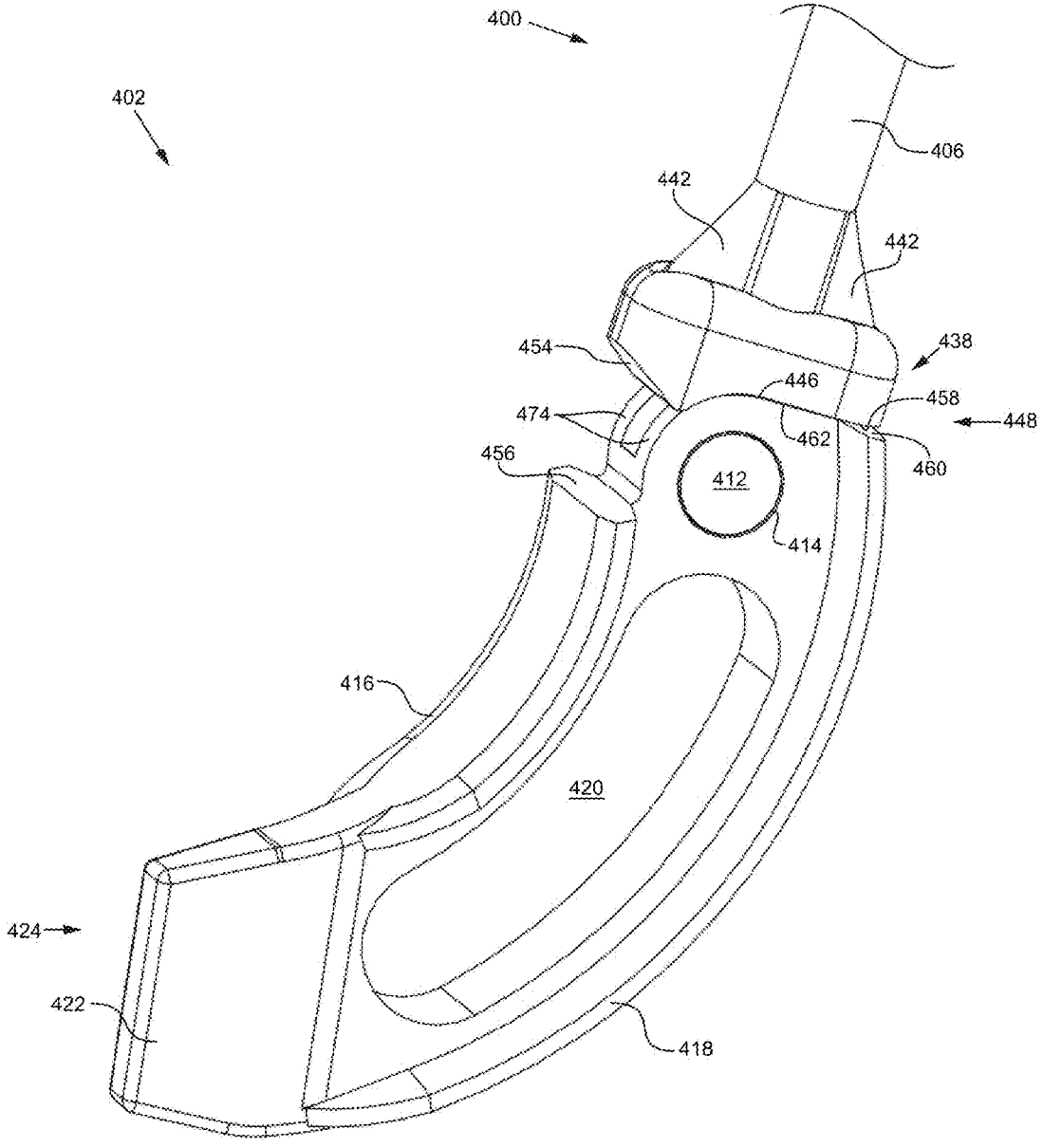

400
402
406
442
442
454
438
446
458
474
448
462
456
460
412
414
416
420
424
422
418

FIG. 15D

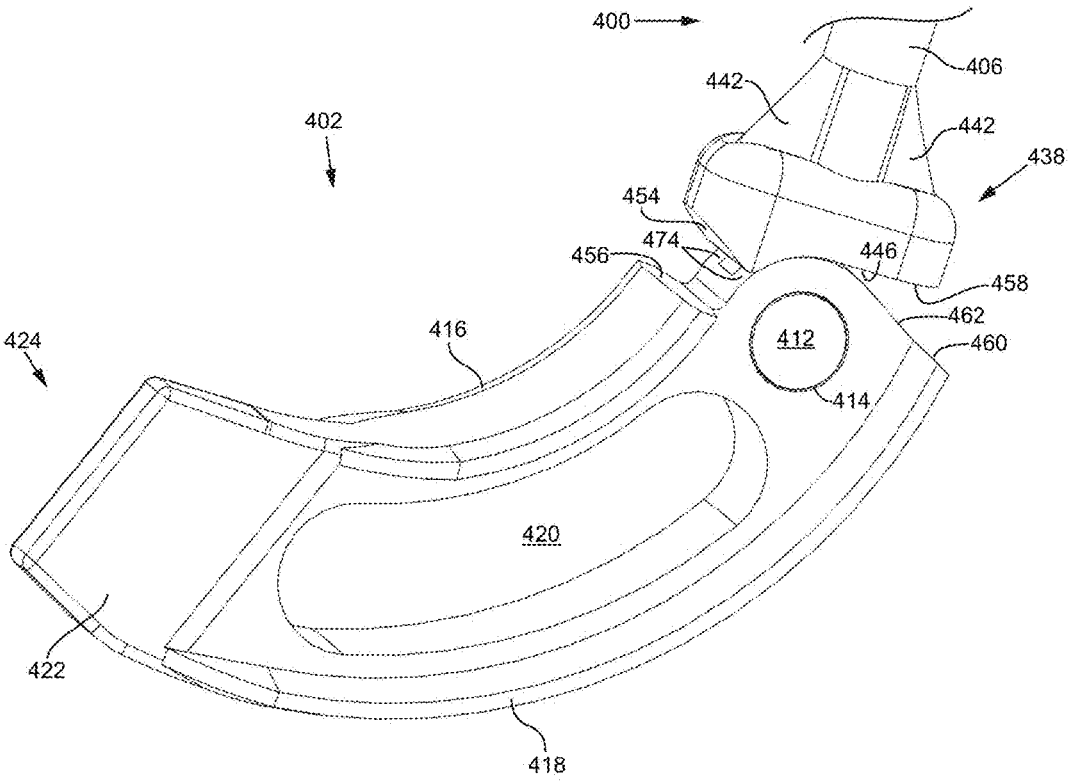

400
406
442
442
438
402
454
474
456
446
458
462
460
424
416
412
414
420
422
418

FIG. 15E

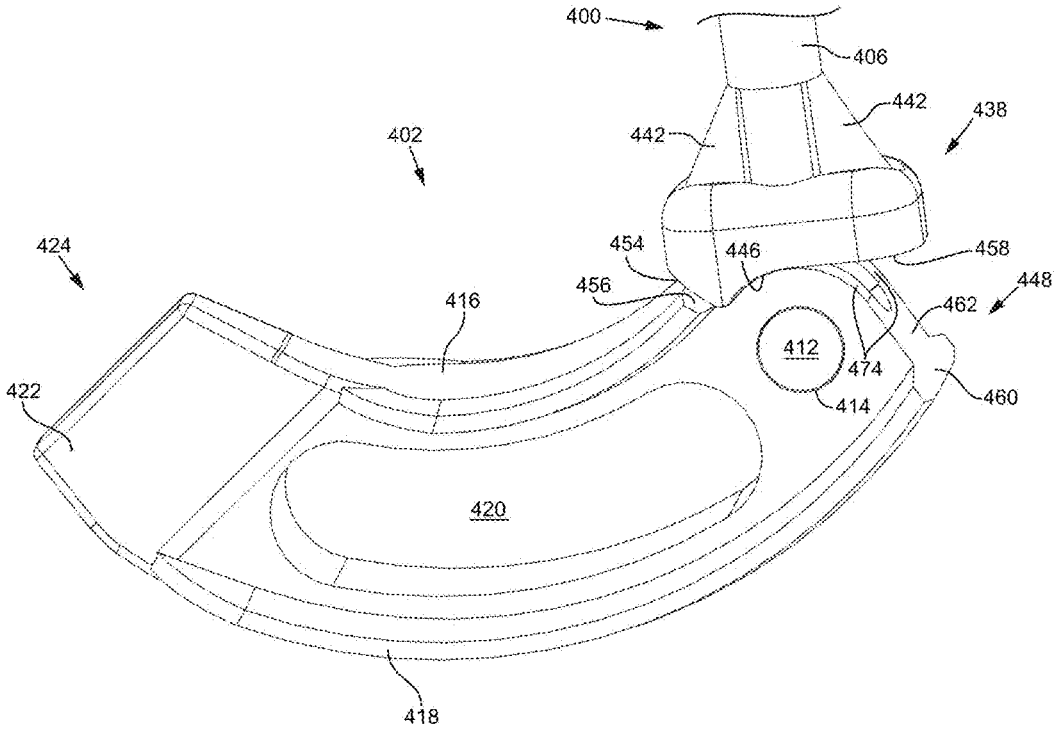

400
406
442
438
402
442
424
454
446
458
456
448
416
462
412
474
422
460
414
420
418

FIG. 15F

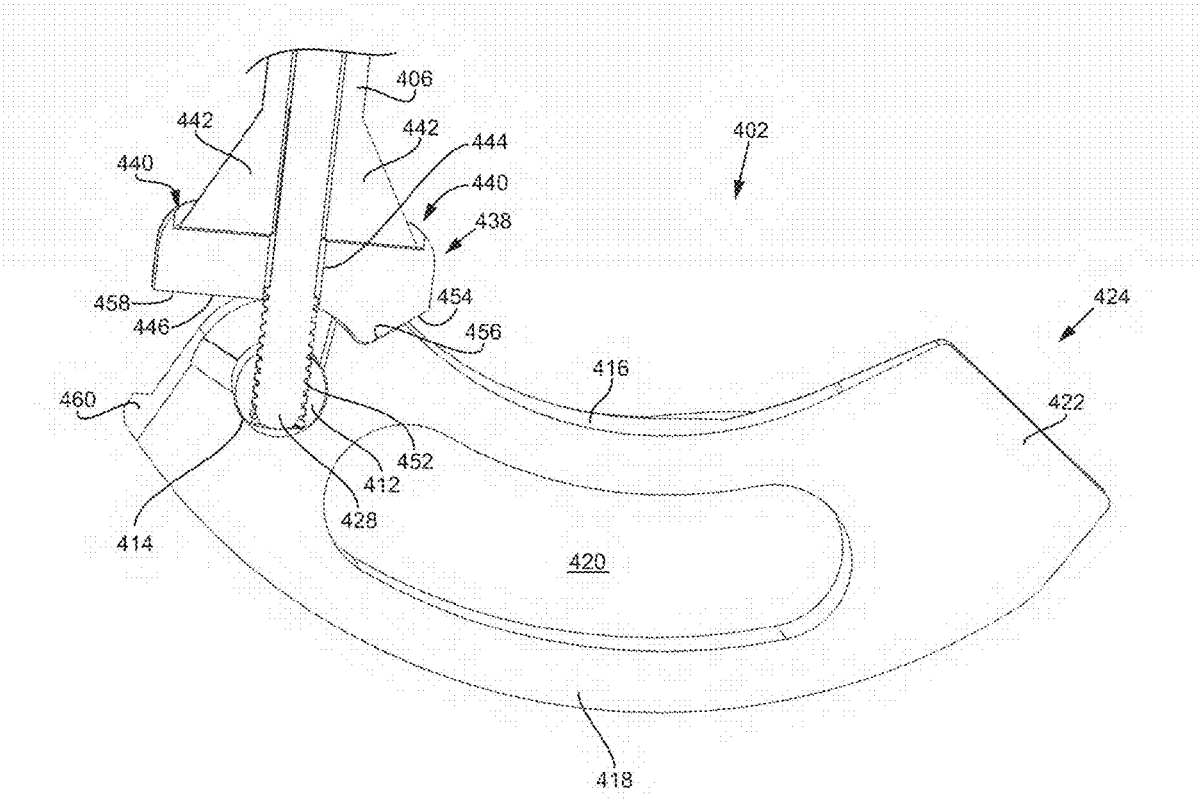

406
442
442
444
402
440
440
438
458
454
424
446
456
416
460
422
452
412
428
414
420
418

FIG. 15G

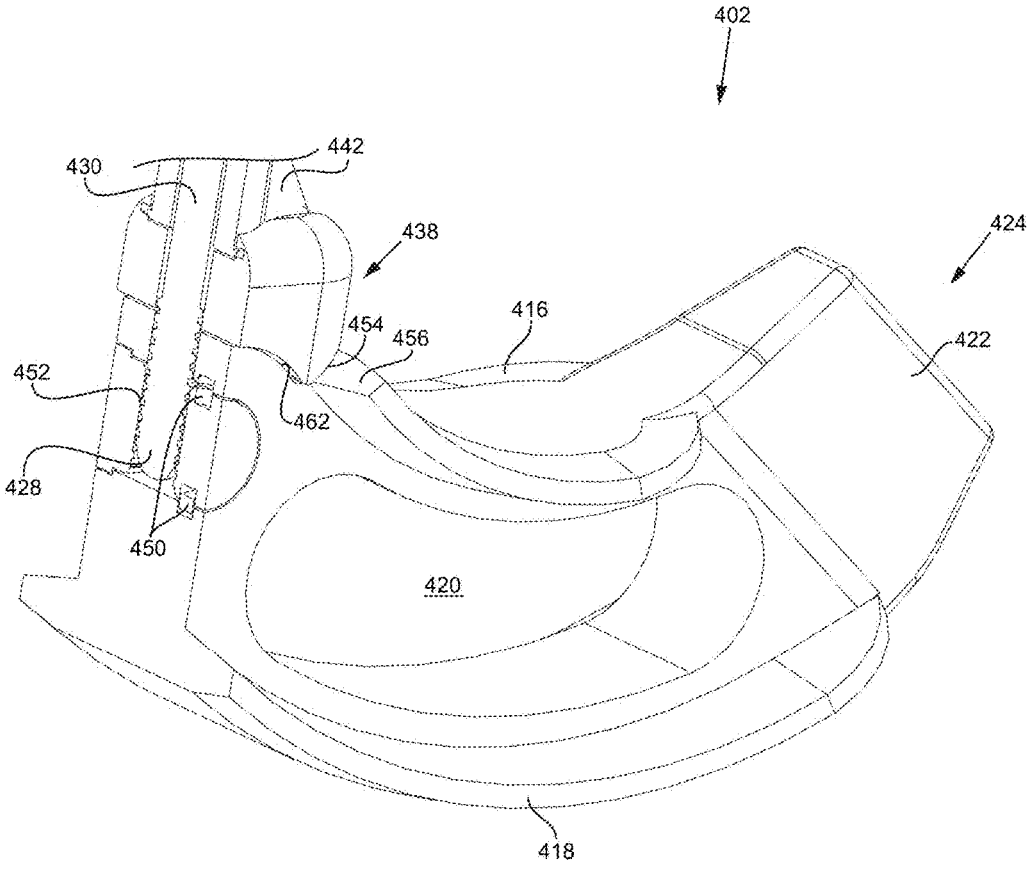


FIG. 15H

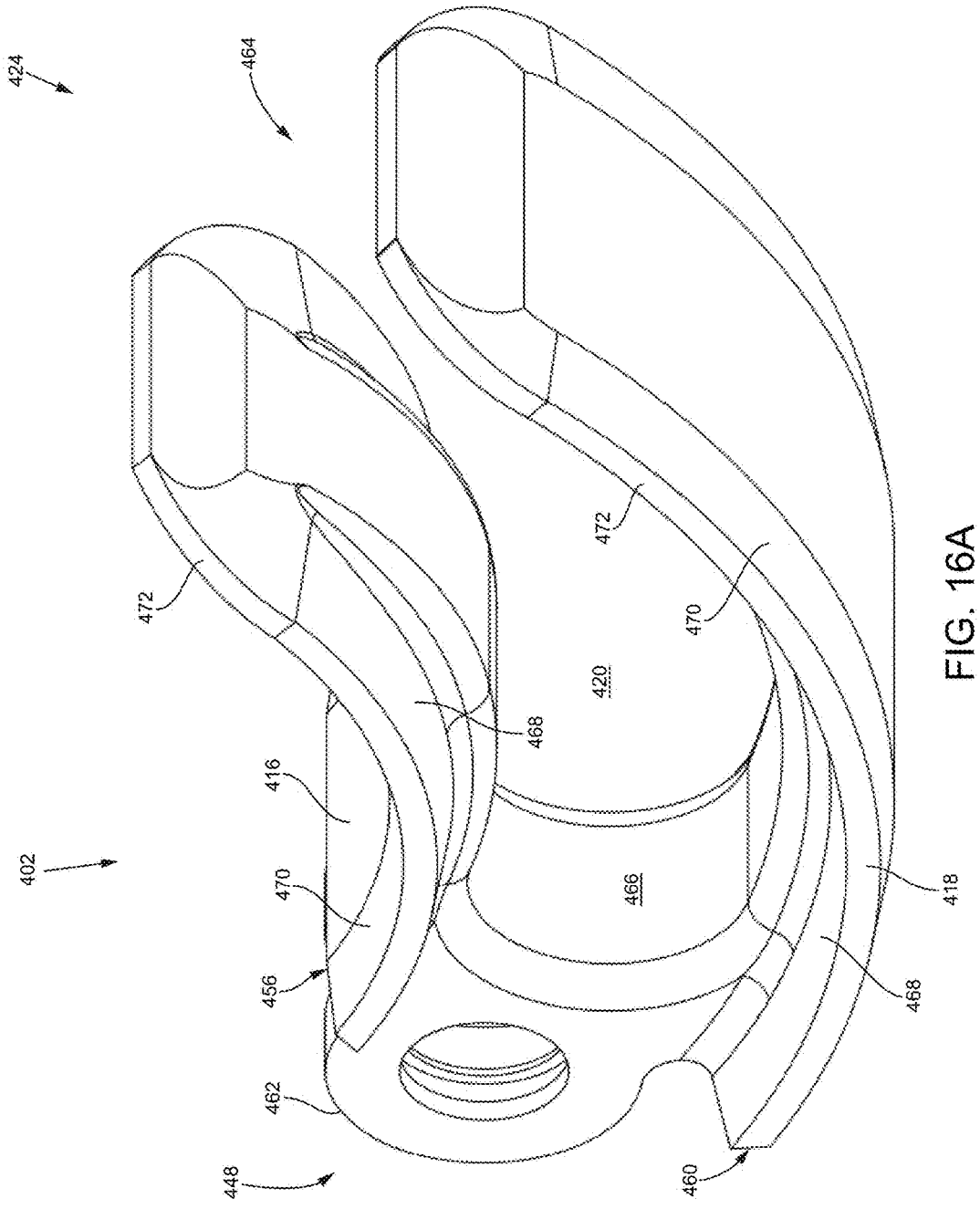

424
464
472
472
470
420
468
416
402
470
466
418
456
468
462
448
460

FIG. 16A

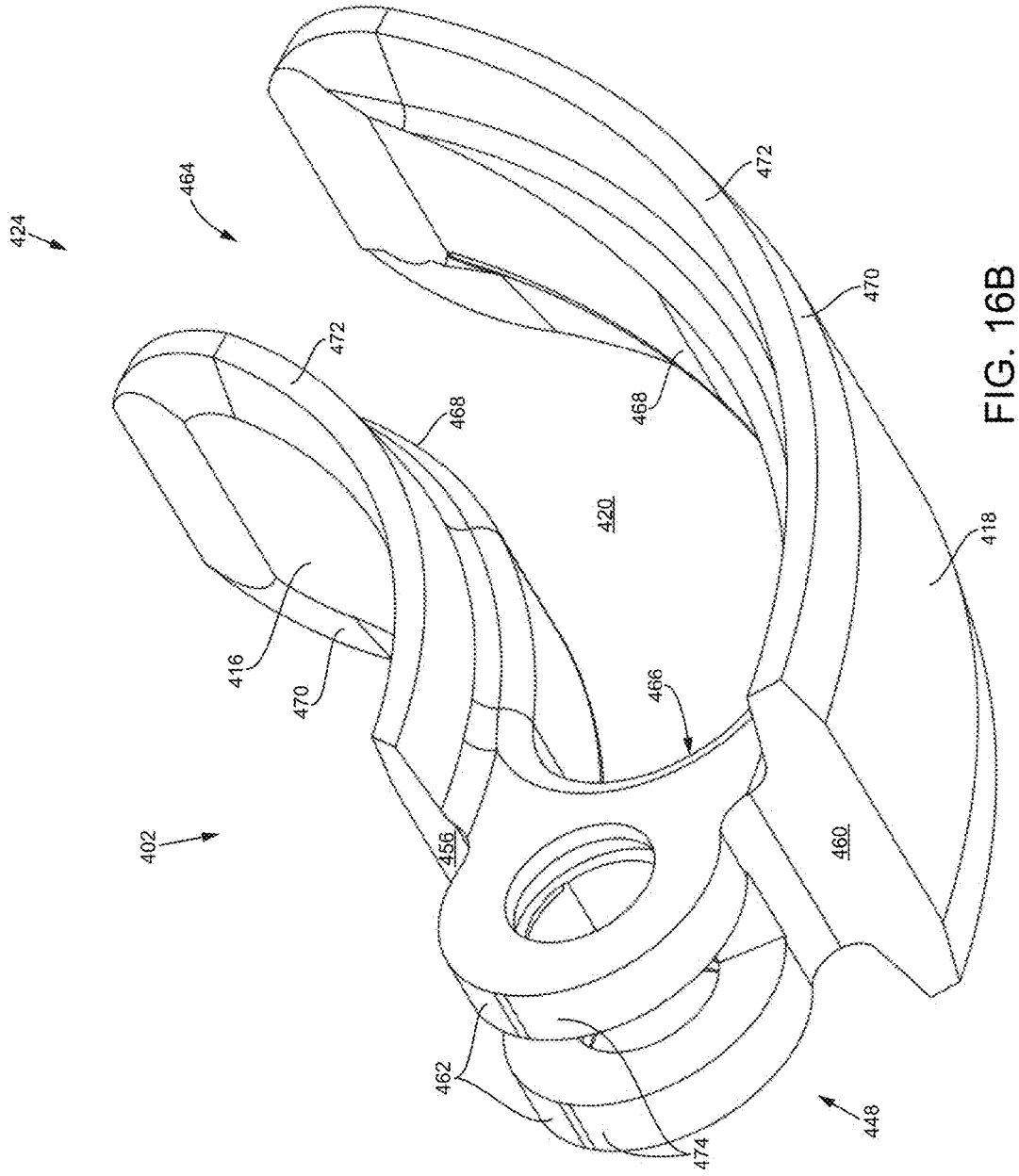

424
464
472
470
468
472
468
420
418
416
470
466
402
456
460
462
448
474

FIG. 16B

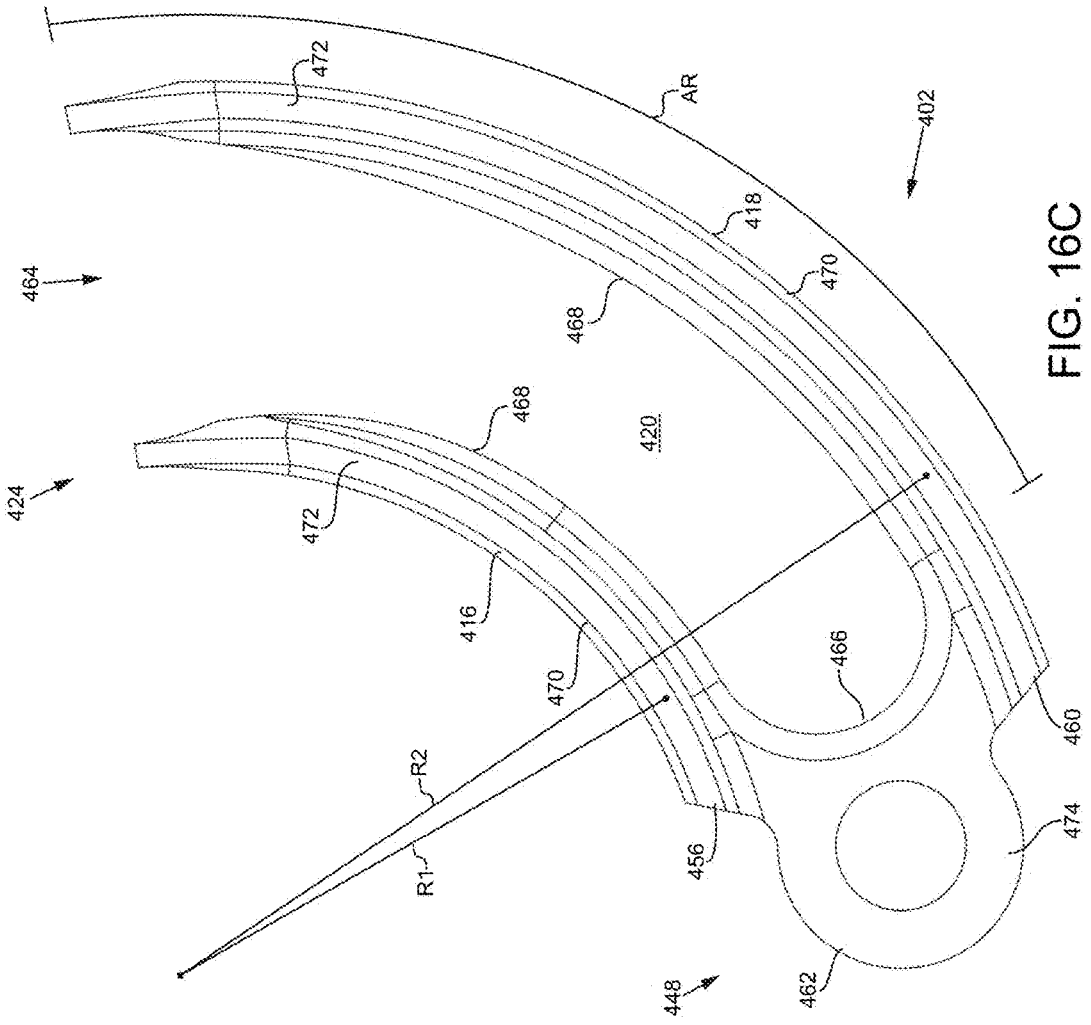

472
AR
402
418
470
464
468
468
420
424
472
416
470
466
460
R2
R1
456
474
448
462

FIG. 16C

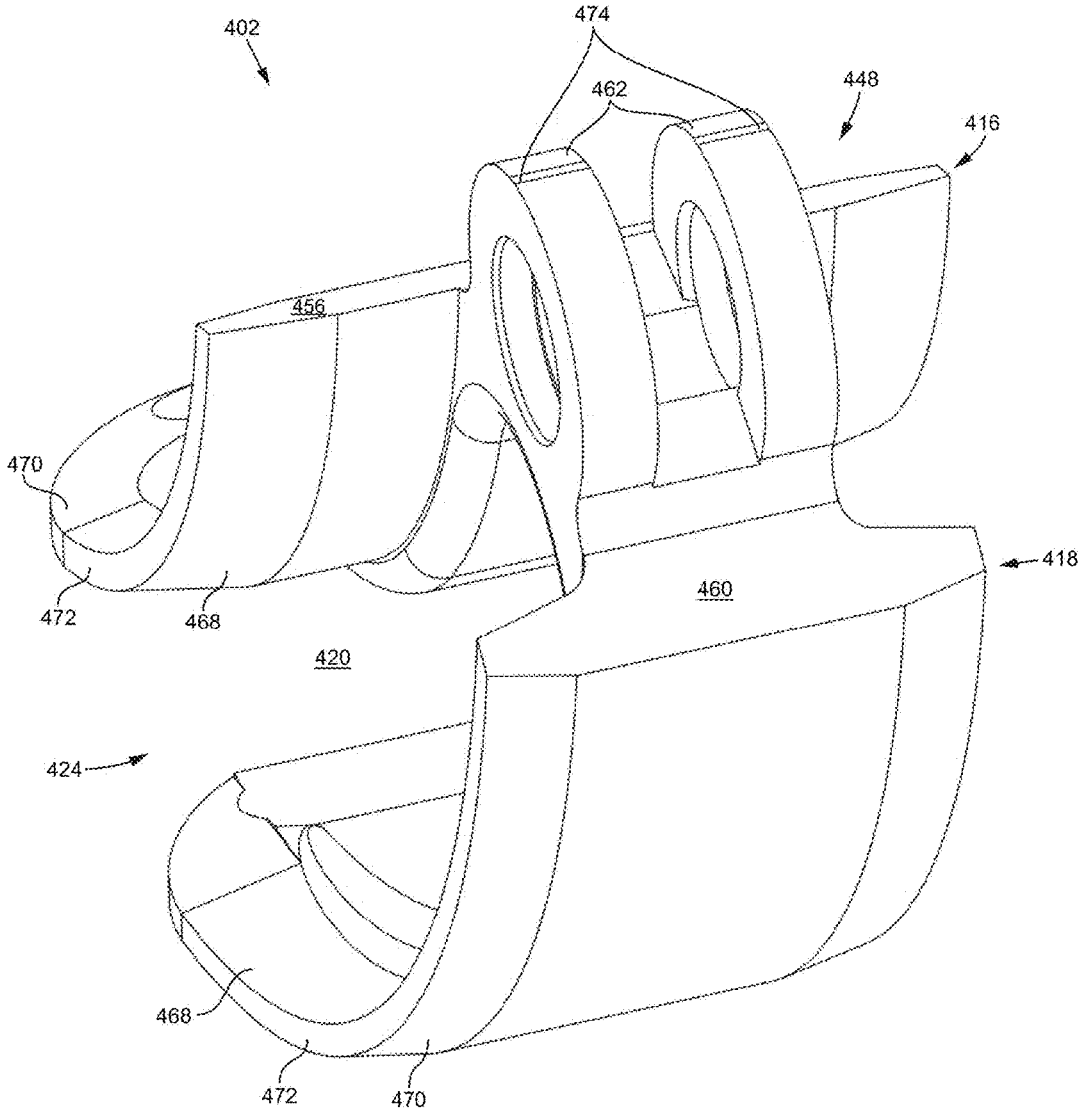


FIG. 16D

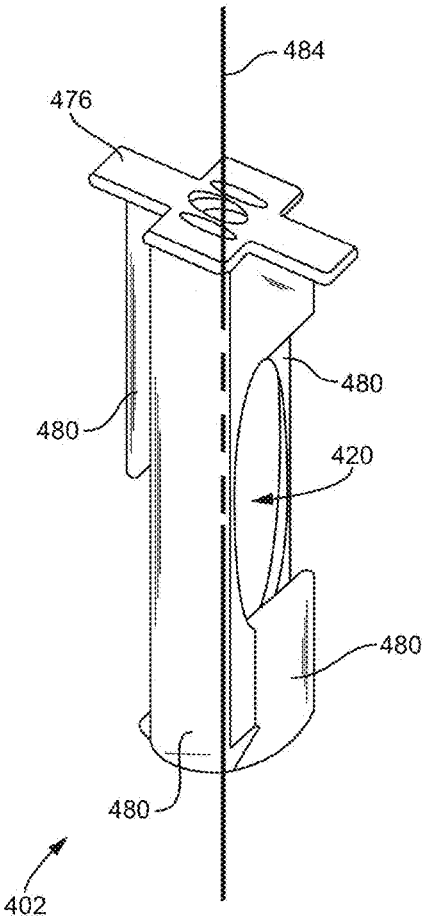


FIG. 17A

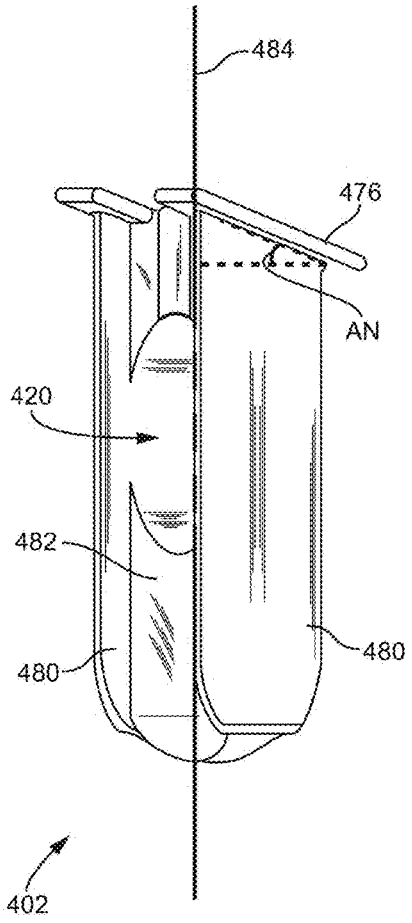


FIG. 17B

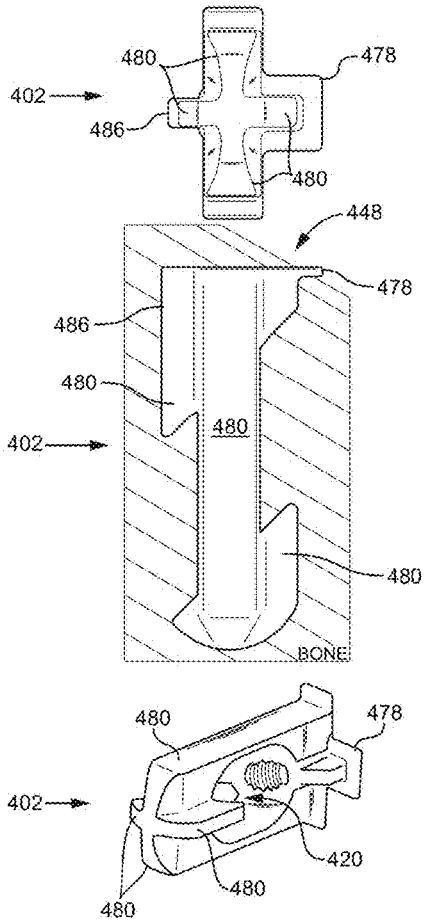


FIG. 17C

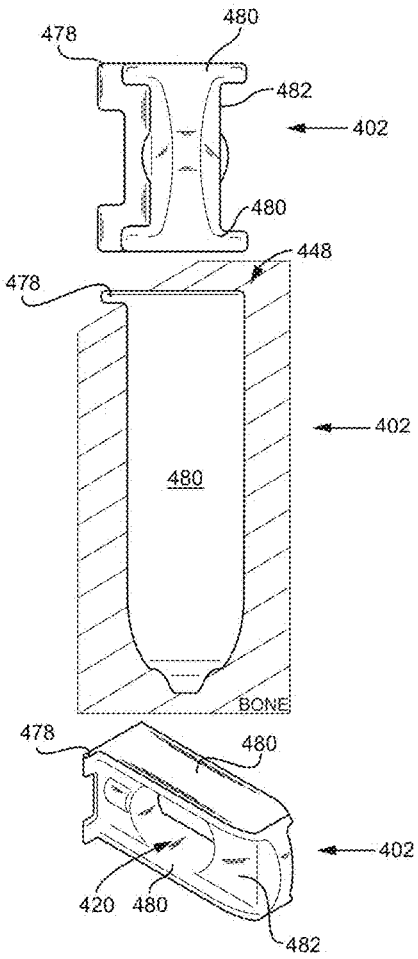


FIG. 17D

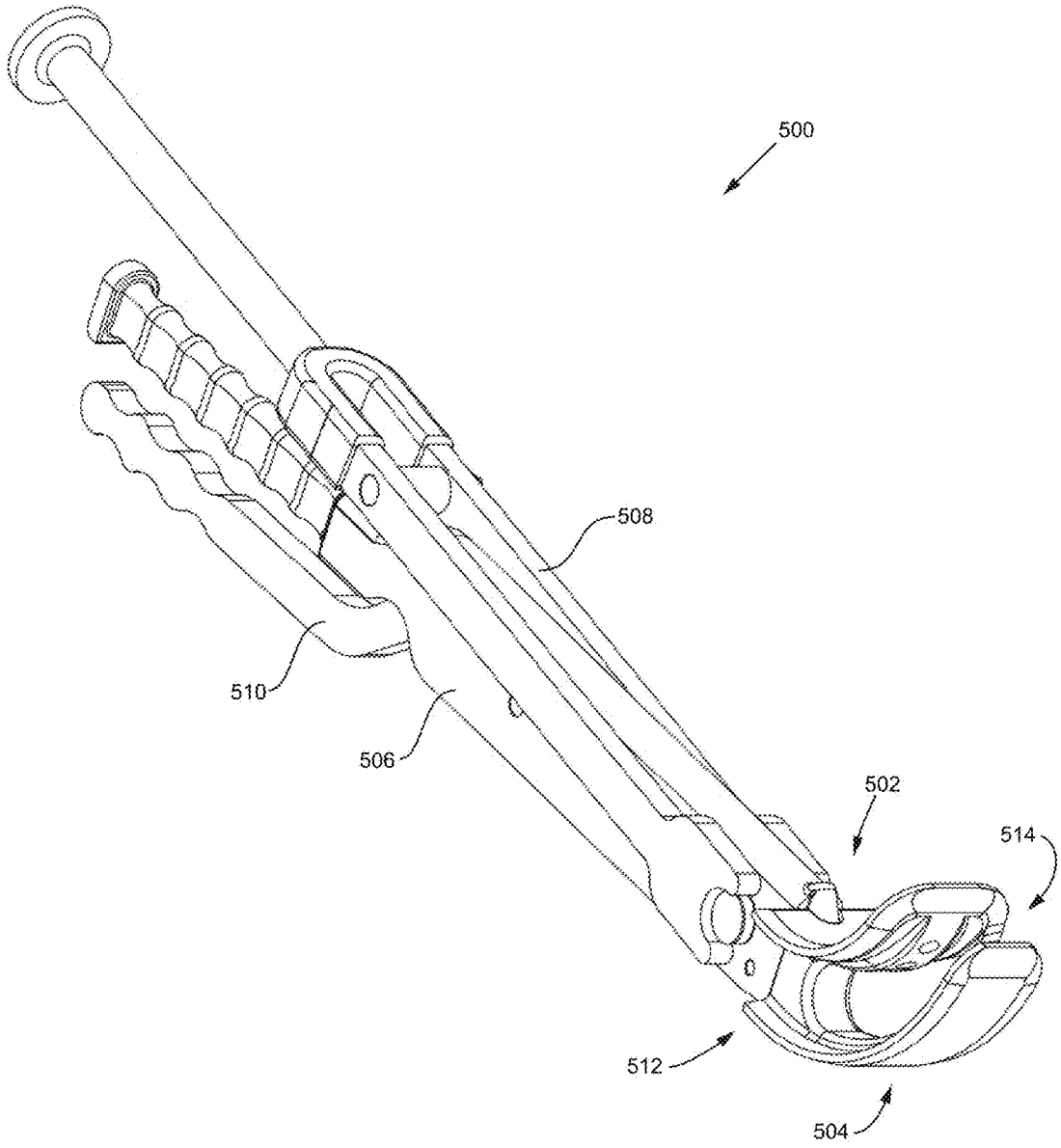


FIG. 18A

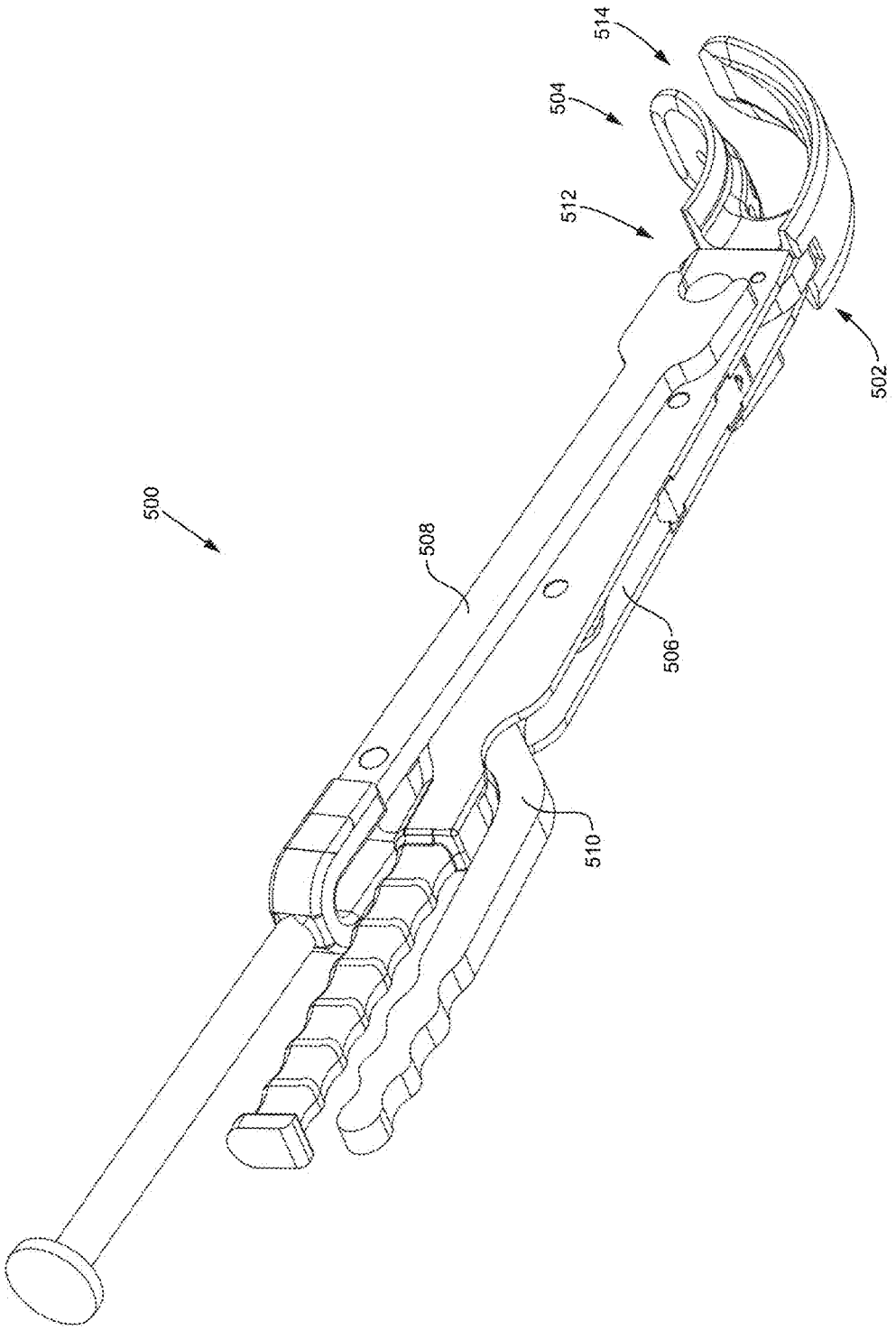


FIG. 18B

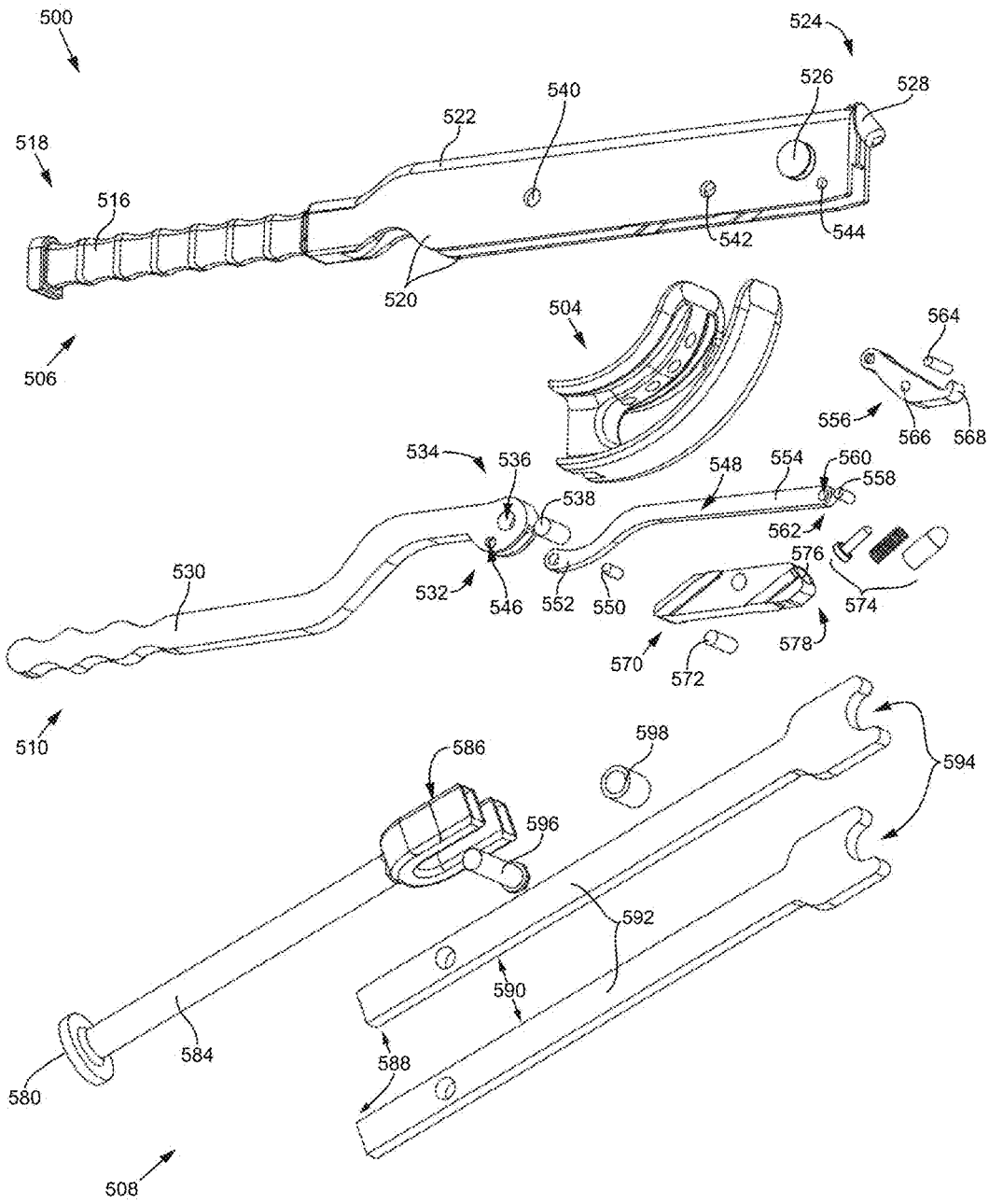

500
524
526
528
540
522
518
516
542
544
520
504
564
506
556
566
568
534
536
548
554
560
558
538
562
530
576
532
546
552
550
574
570
572
578
510
586
598
594
596
592
590
584
588
580
508

FIG. 18C

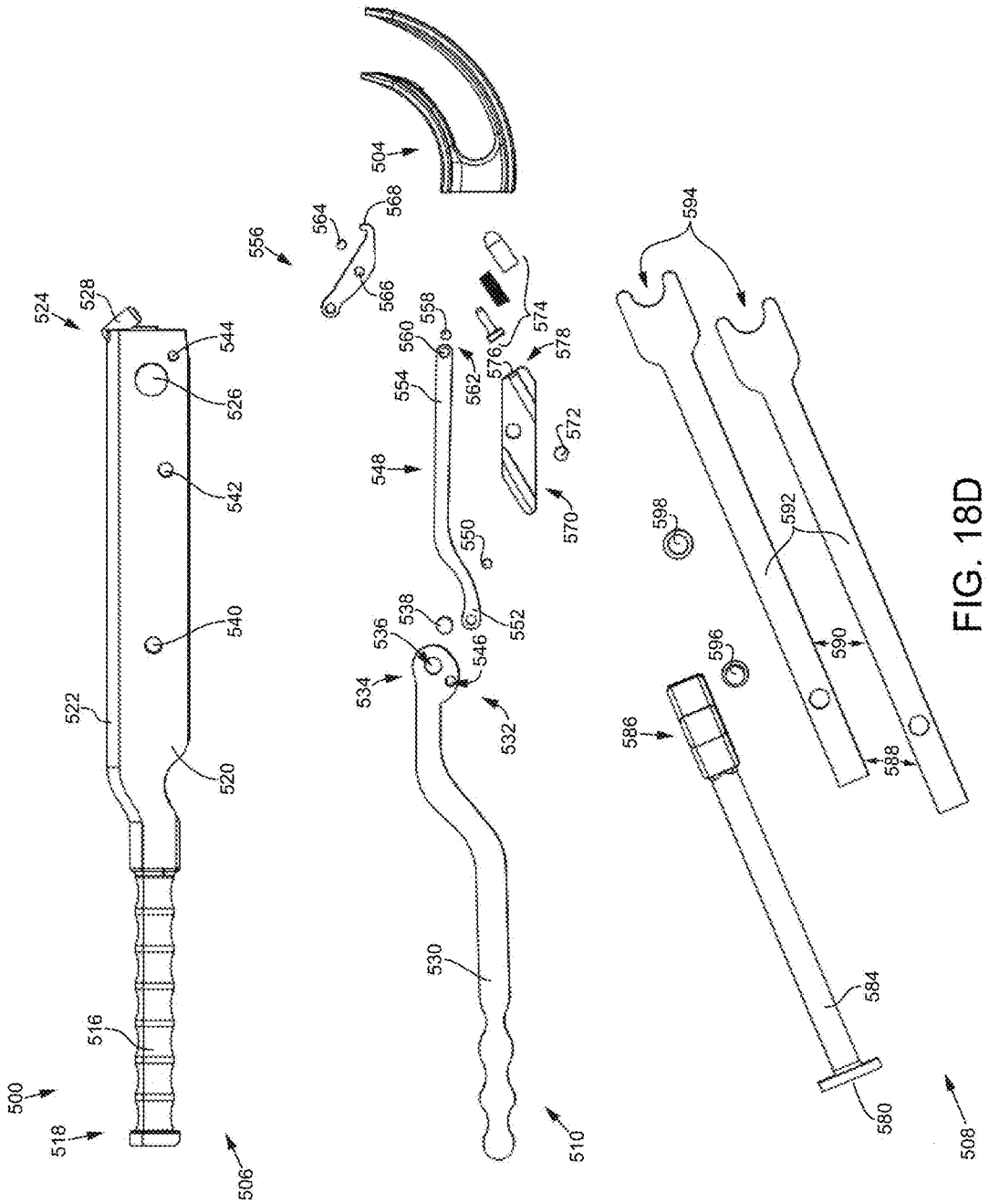

500
502
504
506
508
510
516
518
520
522
524
526
528
530
532
534
536
538
540
542
544
546
548
550
552
554
556
558
560
562
564
566
568
570
572
574
576
578
580
584
586
588
590
592
594
596
598

FIG. 18D

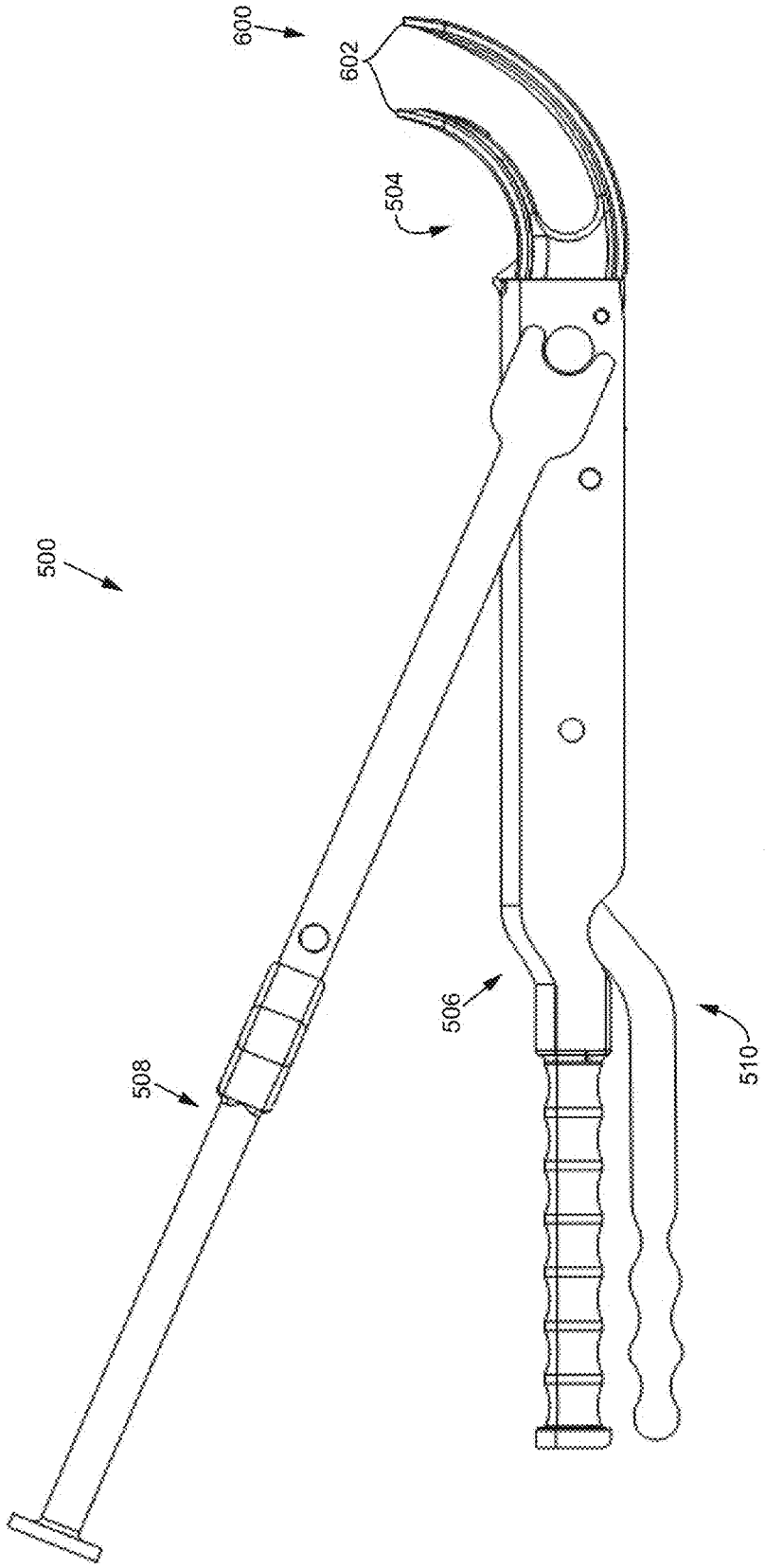


FIG. 18E

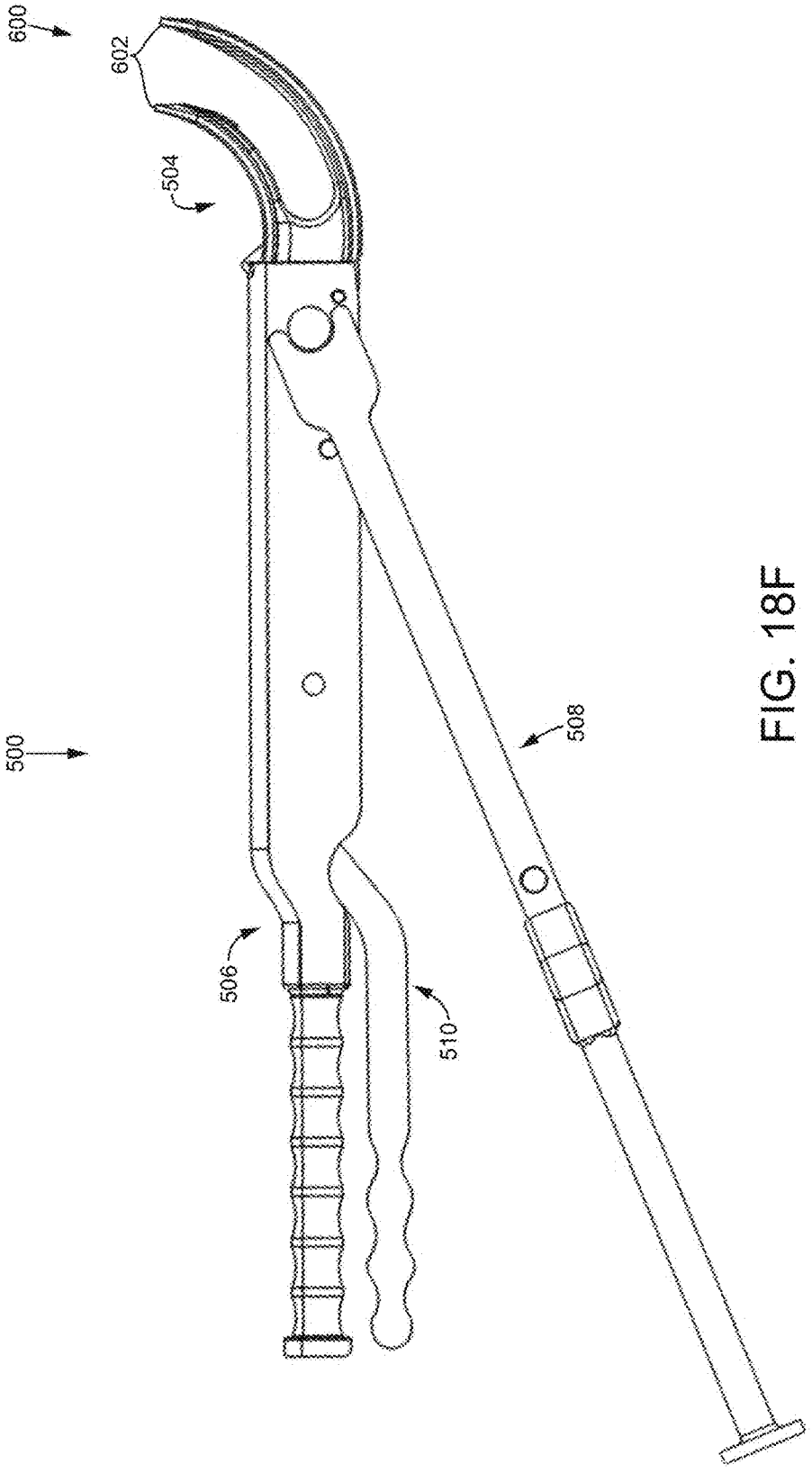


FIG. 18F

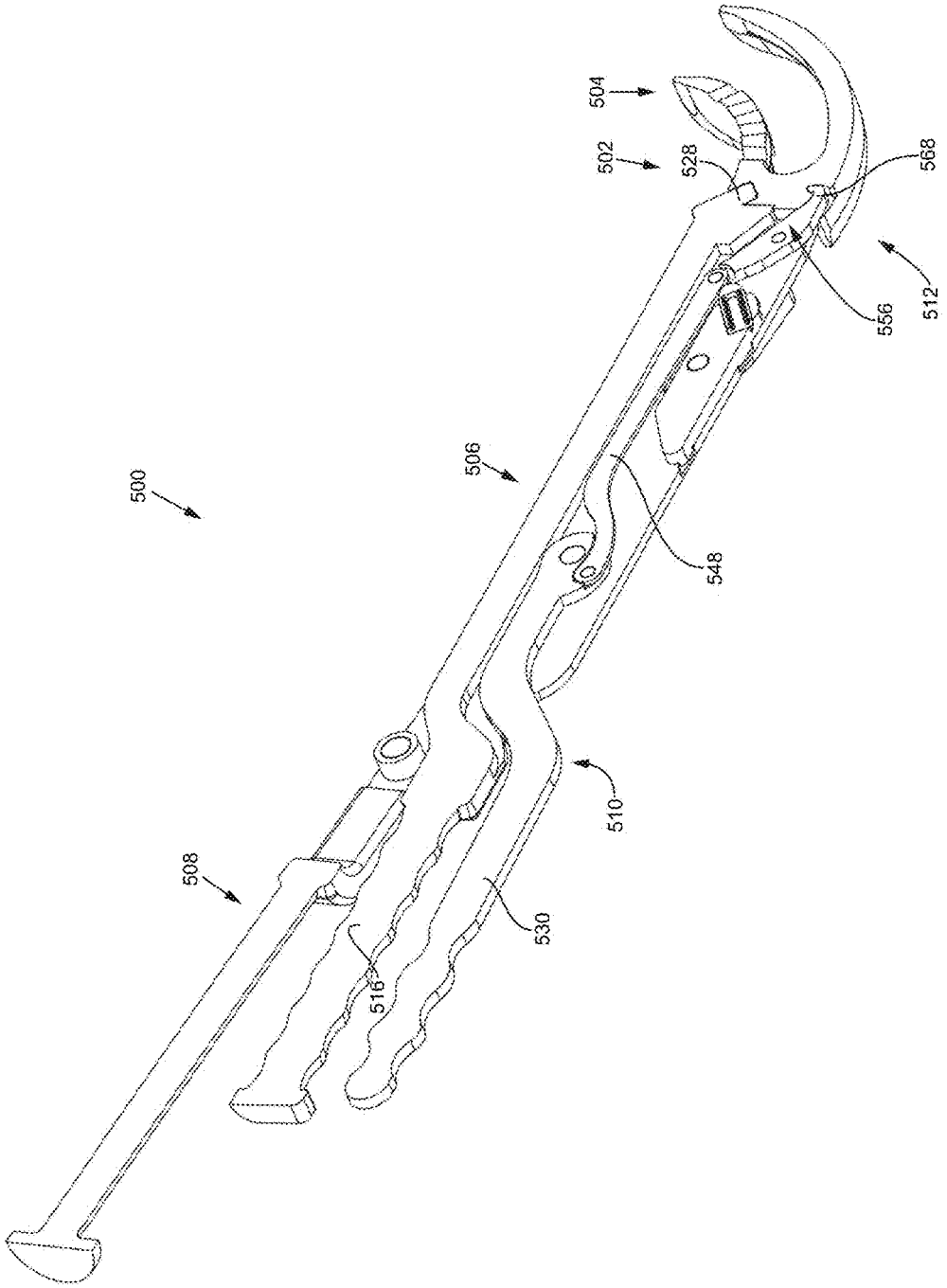


FIG. 18G

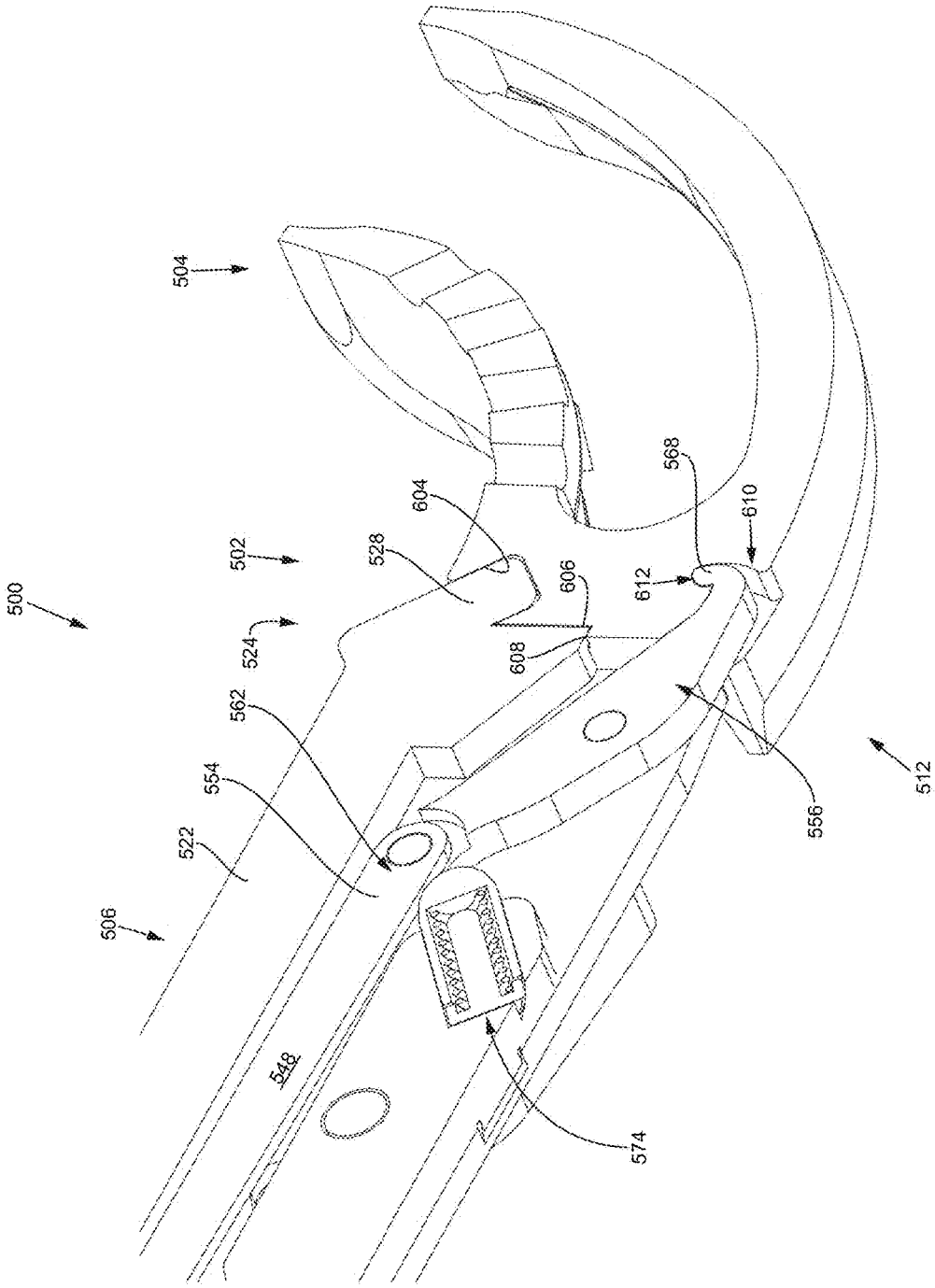

500
502
504
506
512
522
524
528
548
554
556
562
568
574
604
606
608
610
612

FIG. 18H

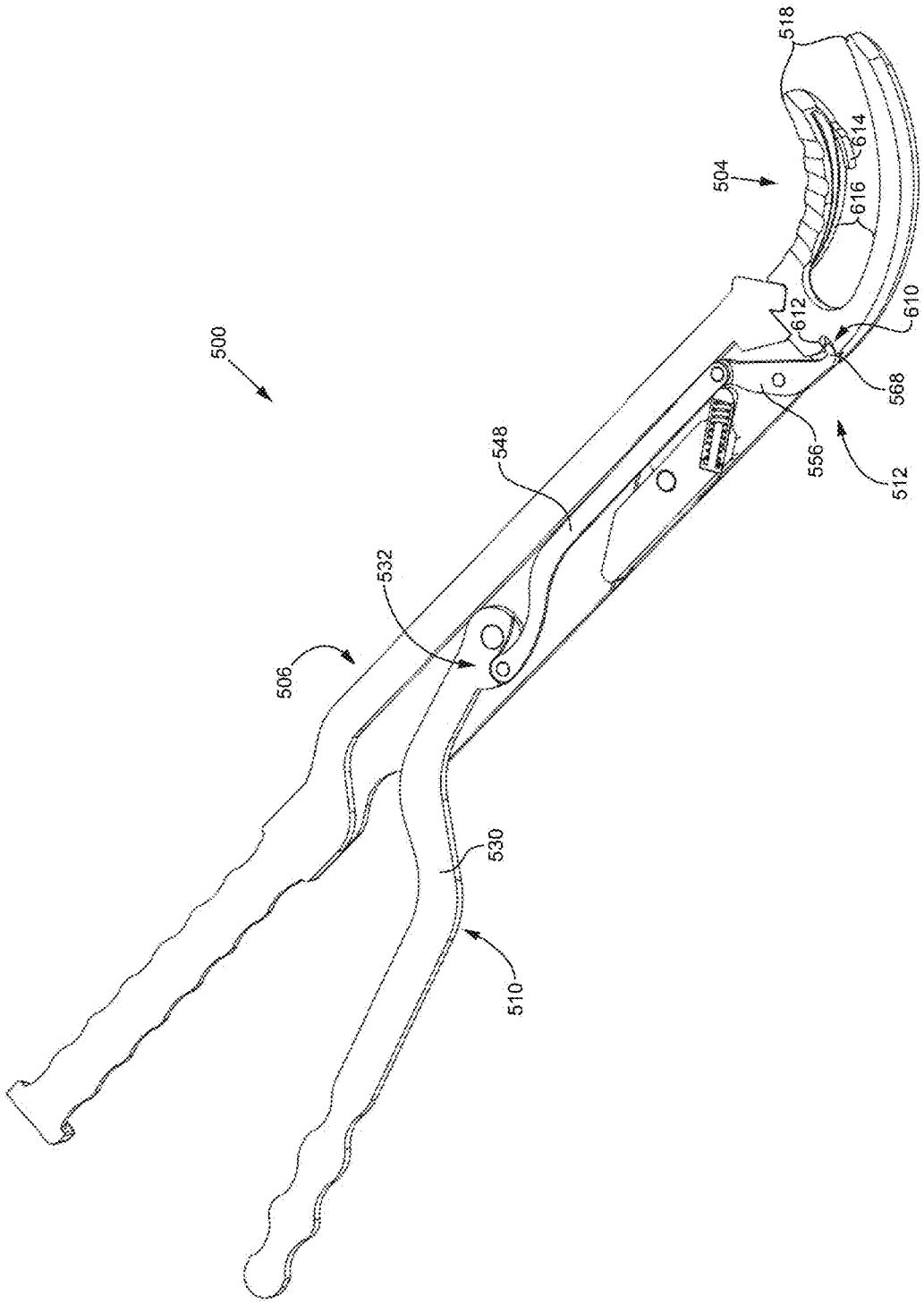


FIG. 18I

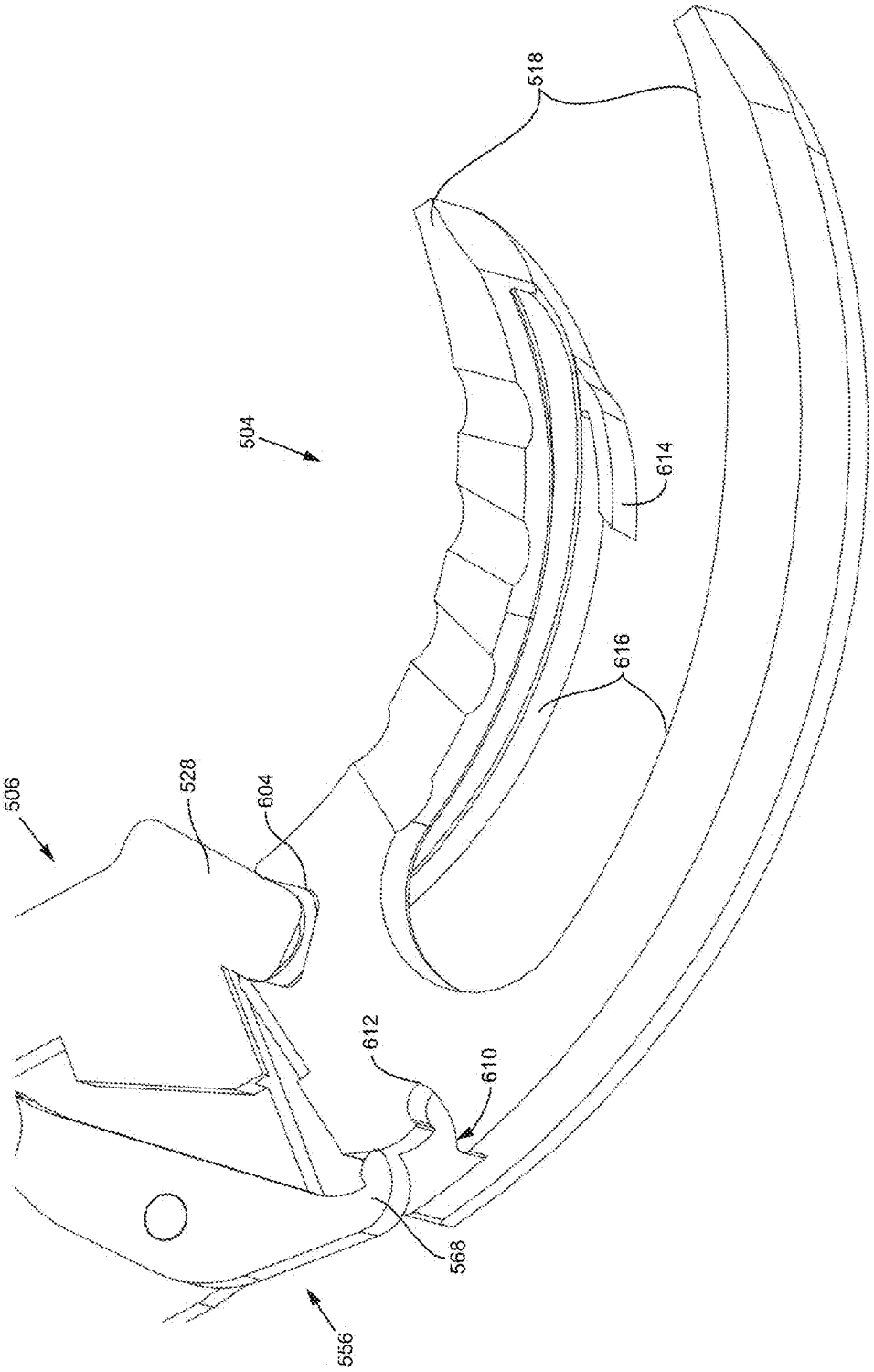


FIG. 18J

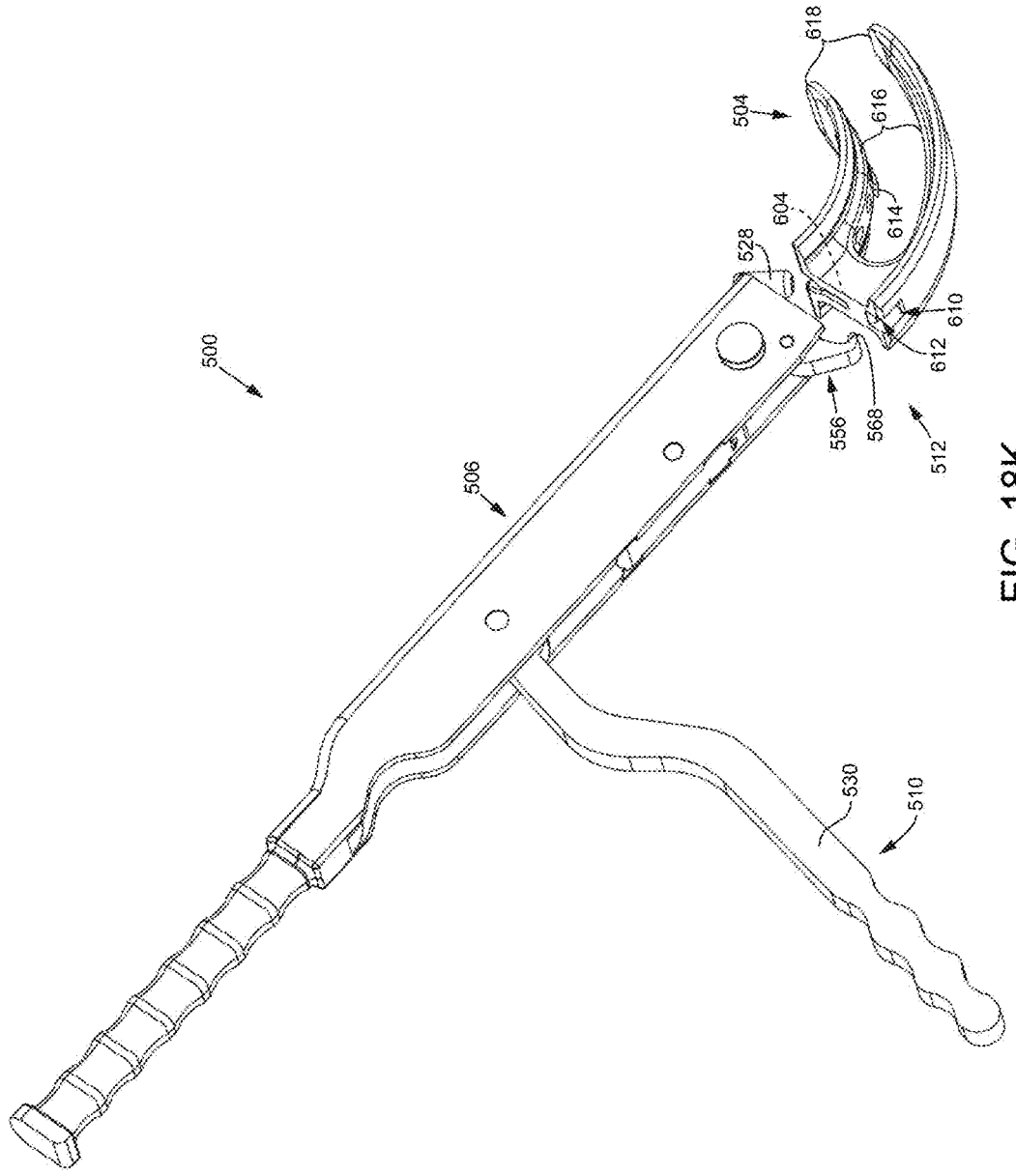


FIG. 18K

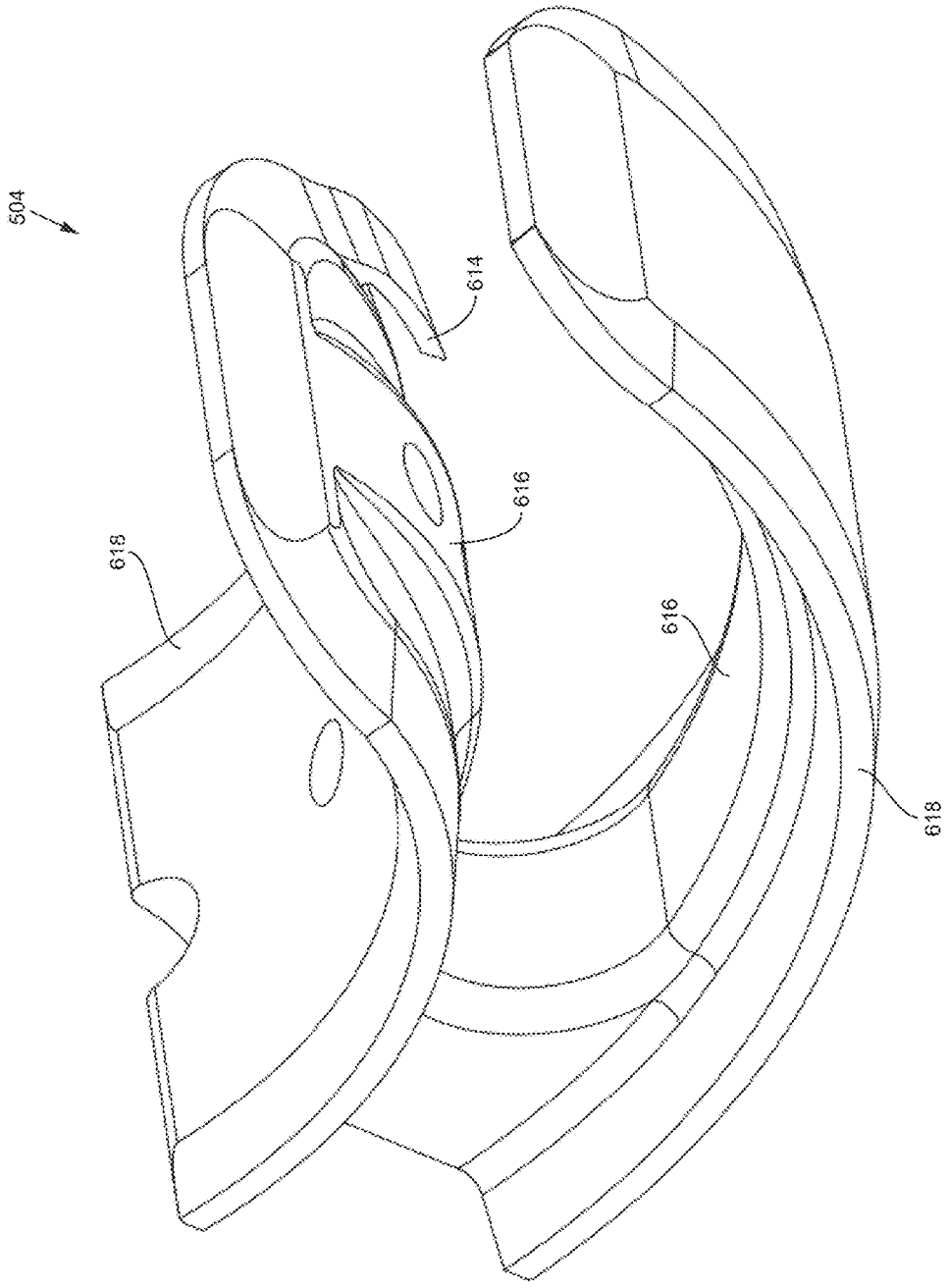


FIG. 18L

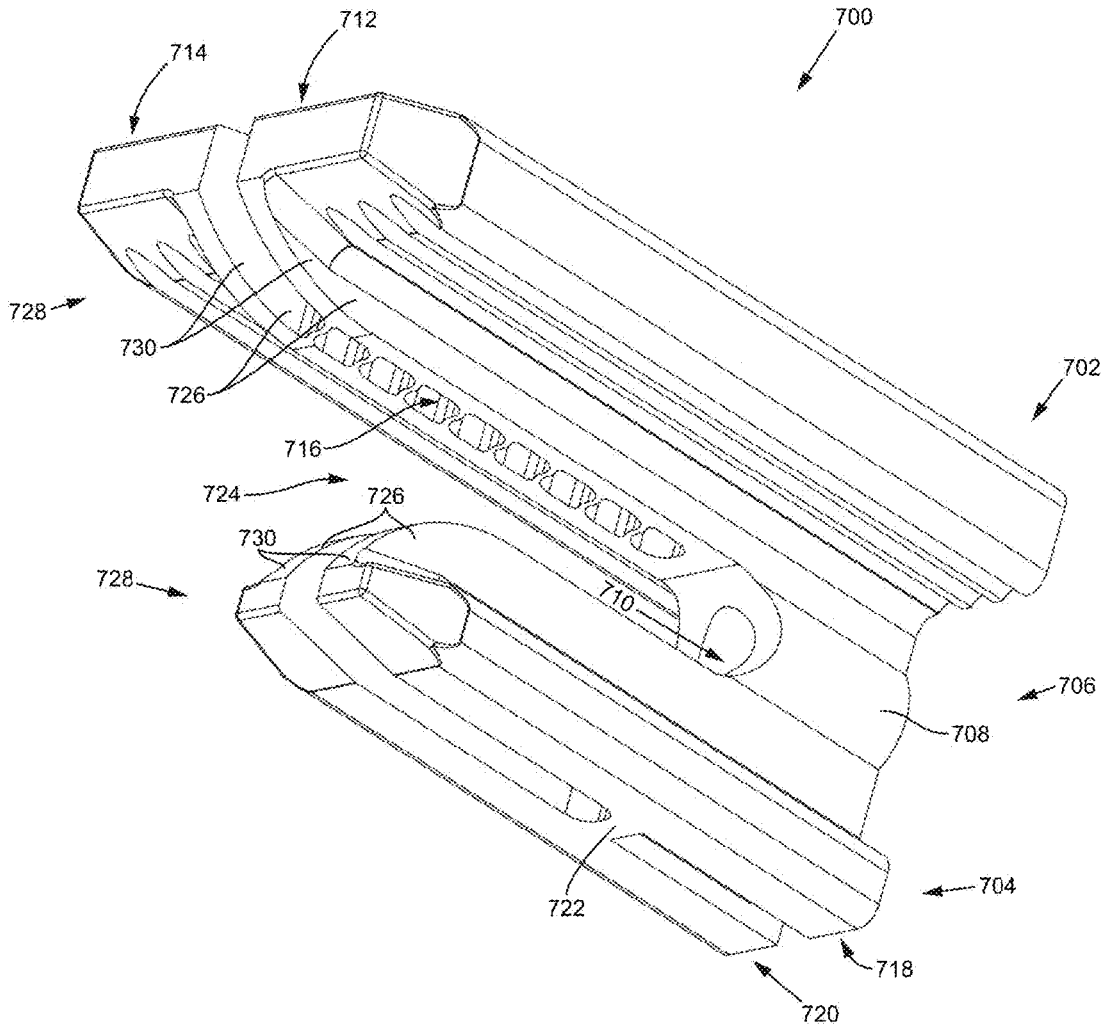

712
700
714
728
730
726
702
716
724
726
730
728
710
706
708
704
722
718
720

FIG. 19A

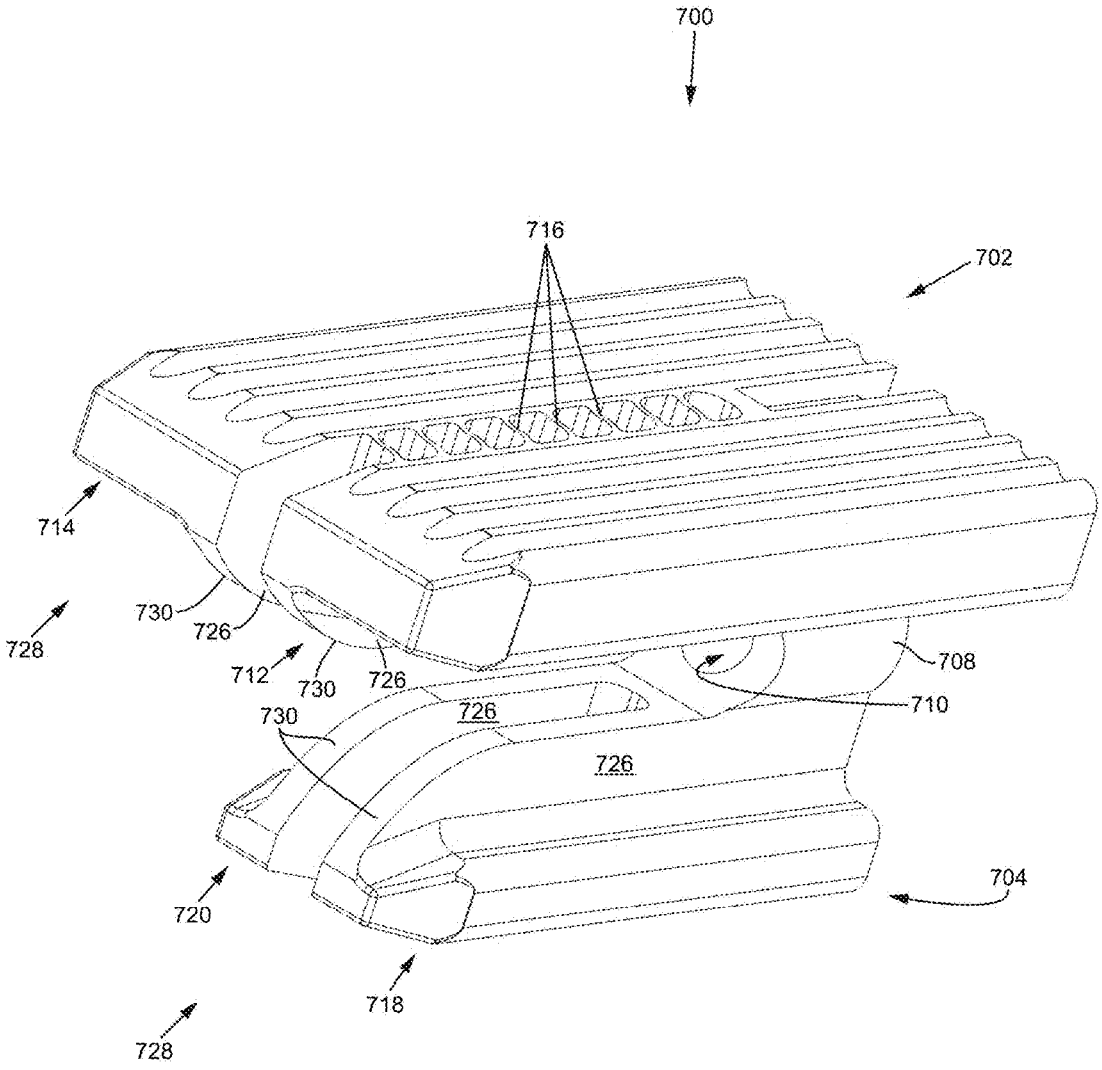

700
716
702
714
730
726
728
712
730
726
708
710
730
726
726
704
720
718
728

FIG. 19B

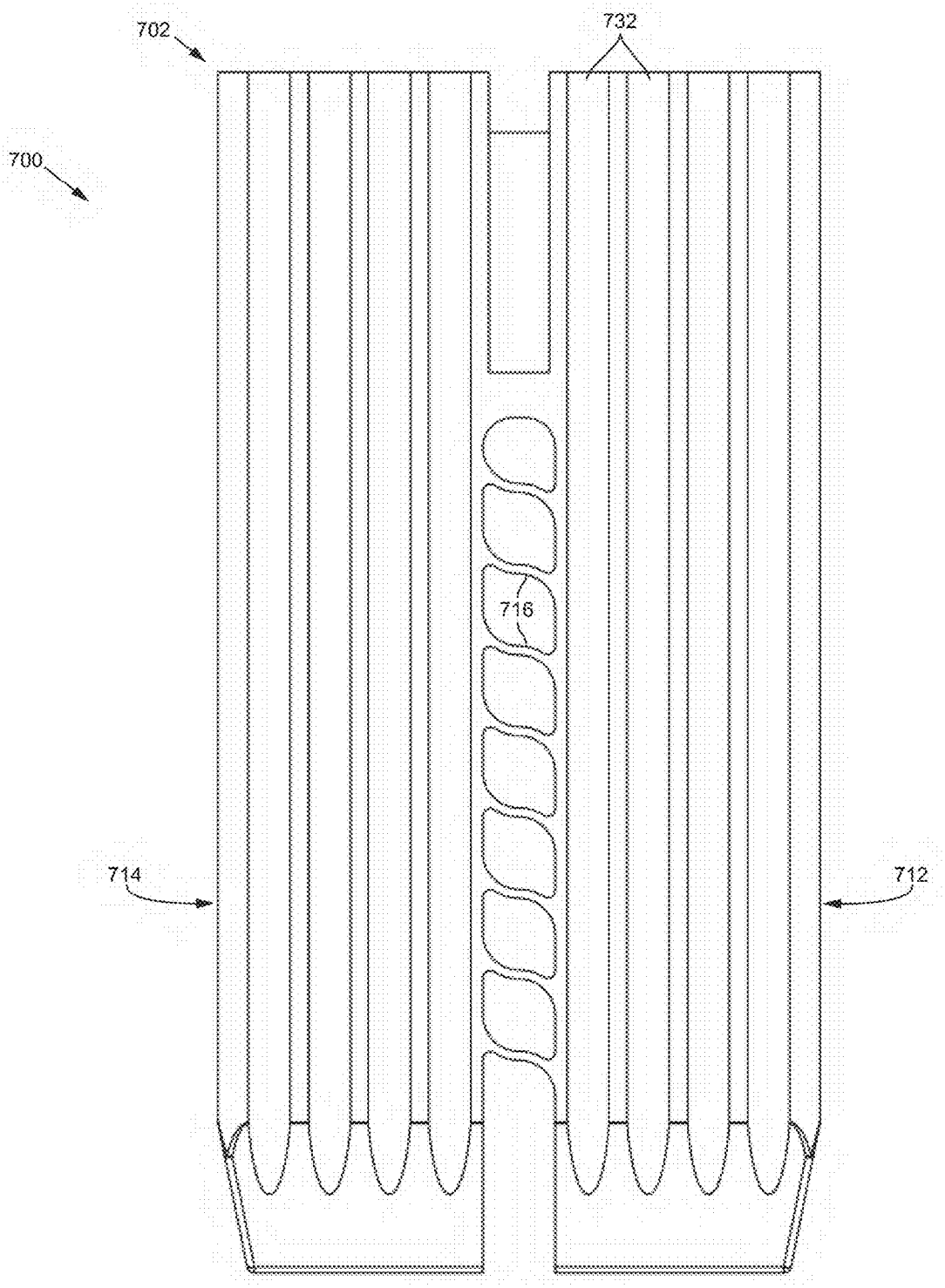


FIG. 19C

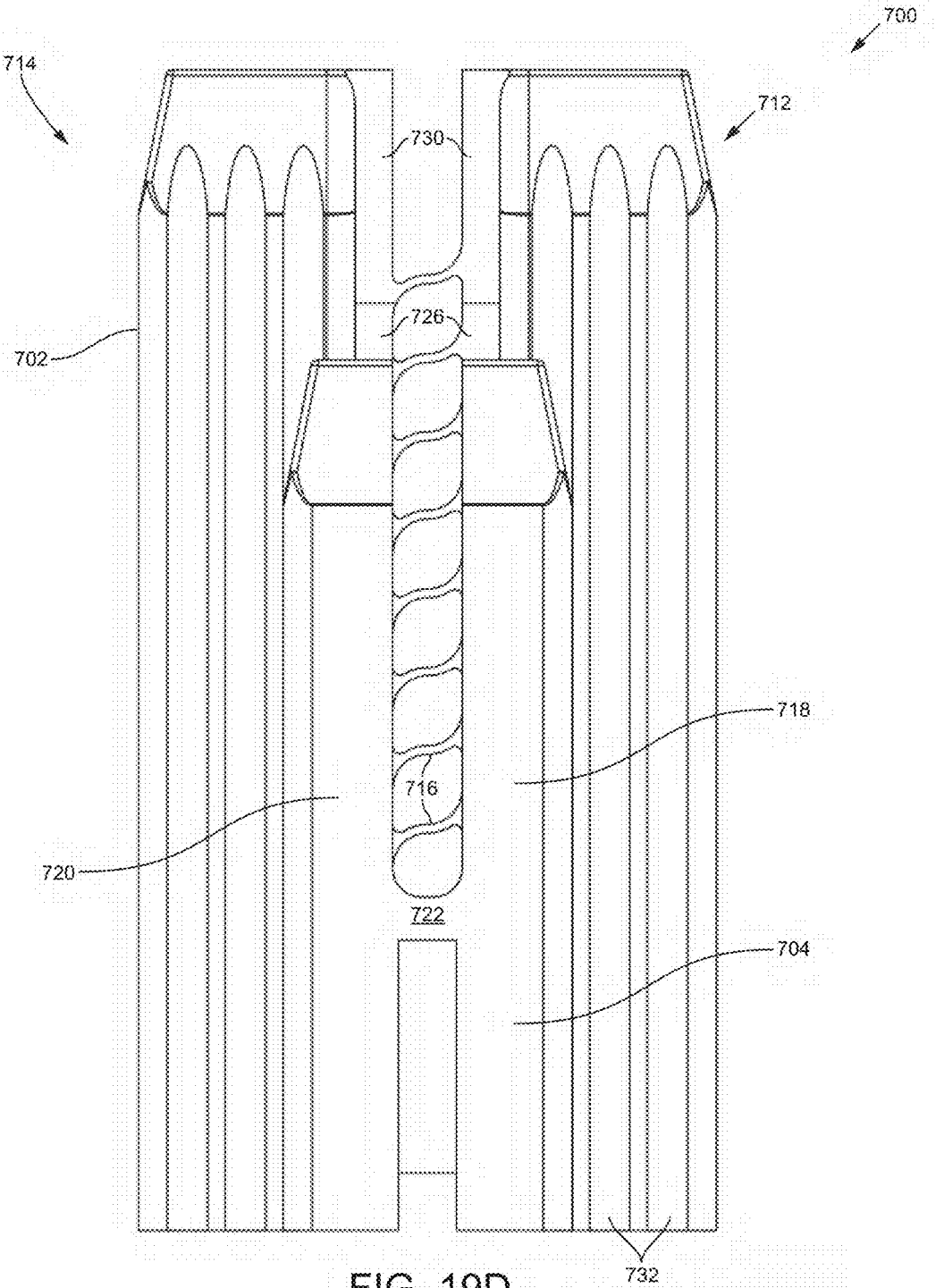


FIG. 19D

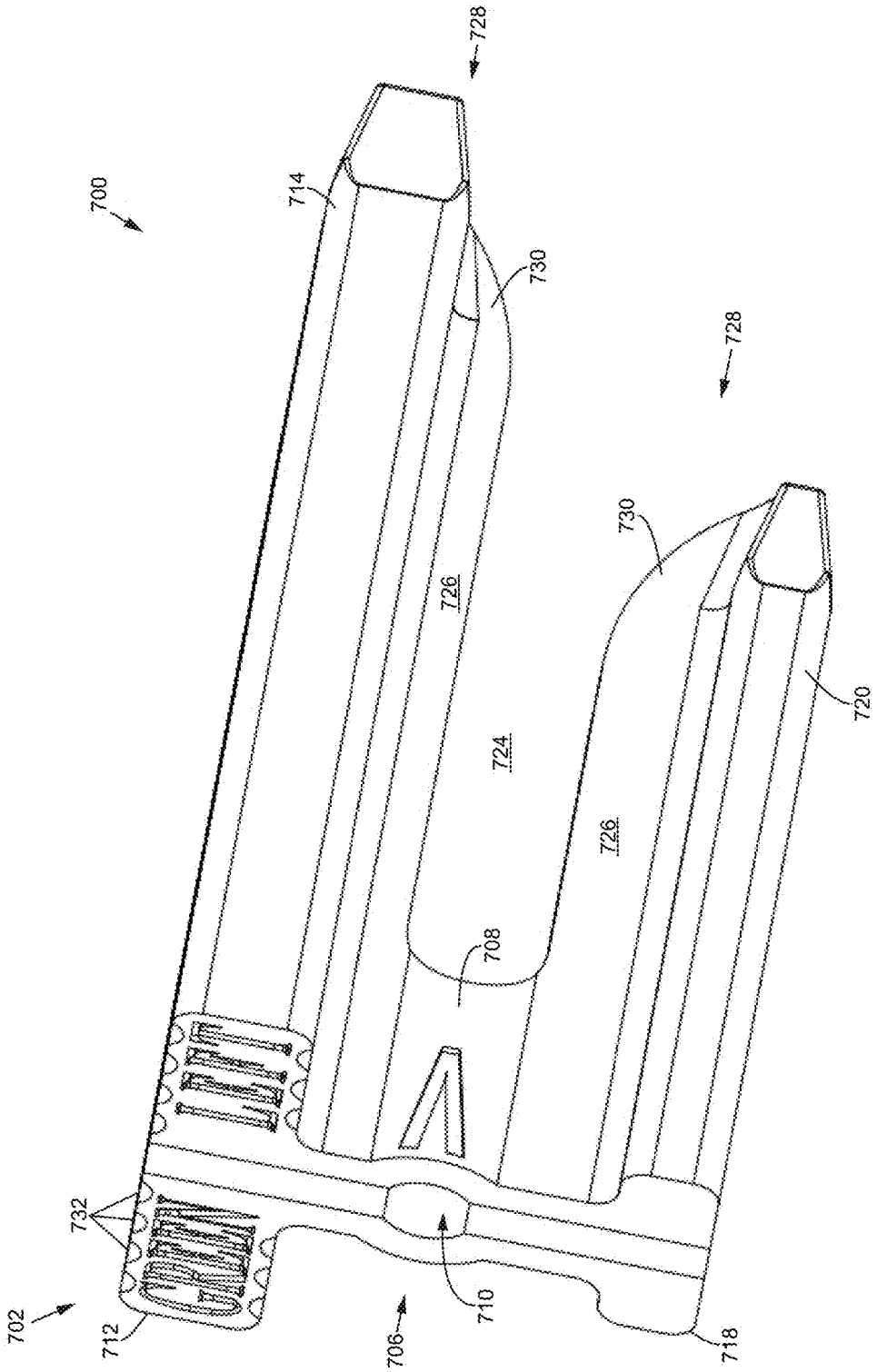


FIG. 19E

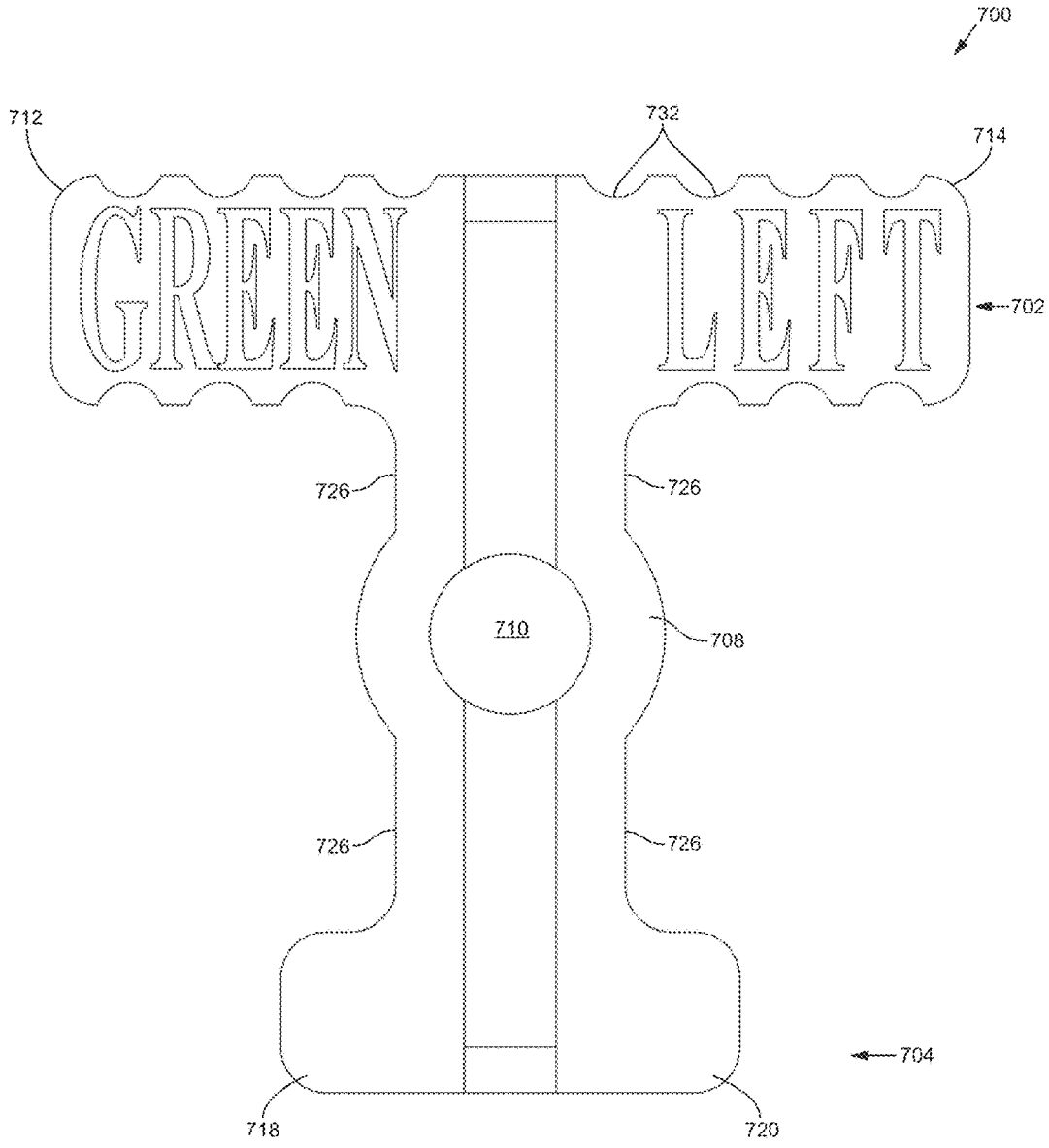

700
712
732
714
GREEN
LEFT
702
726
726
710
708
726
726
704
718
720

FIG. 19F

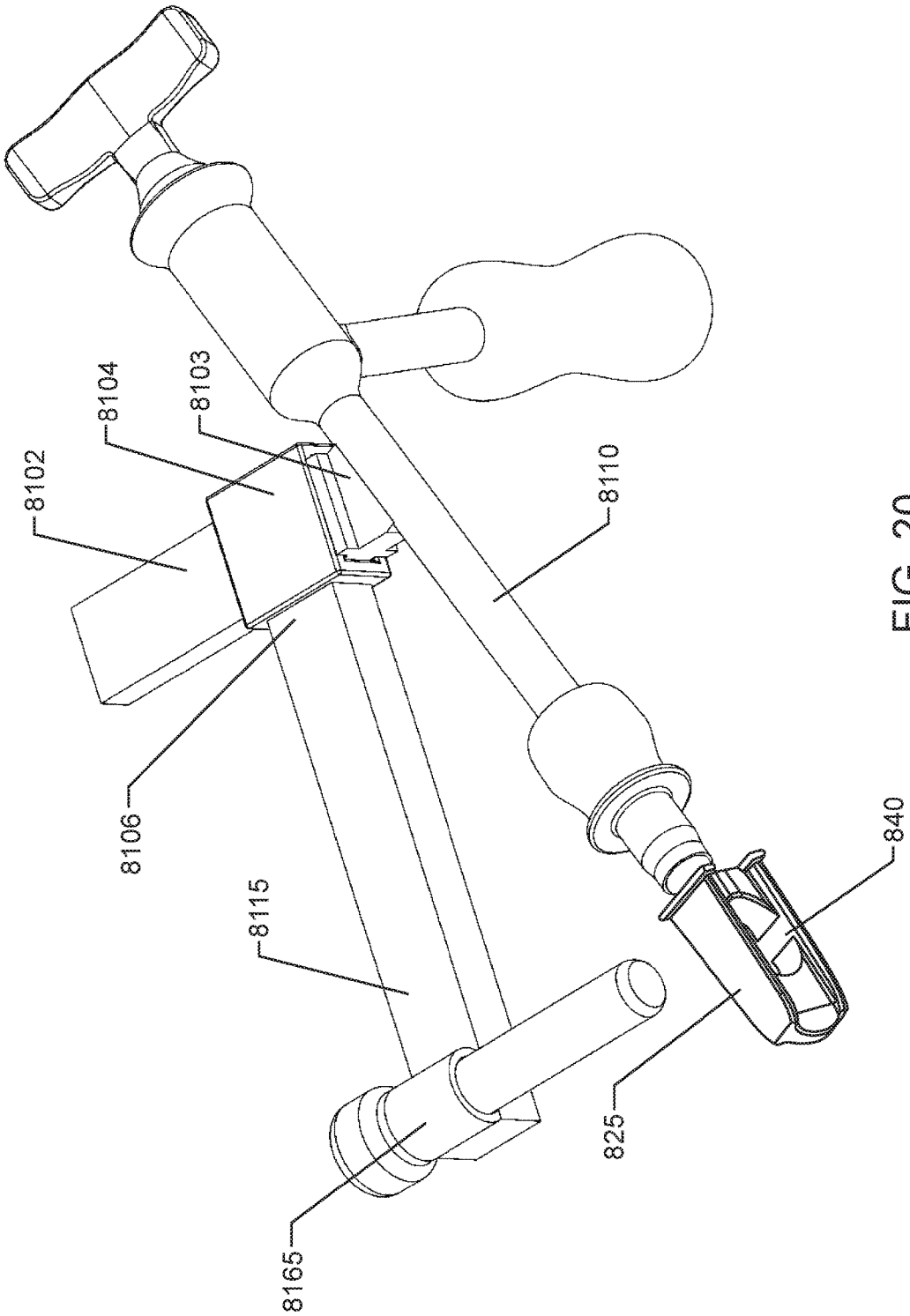


FIG. 20

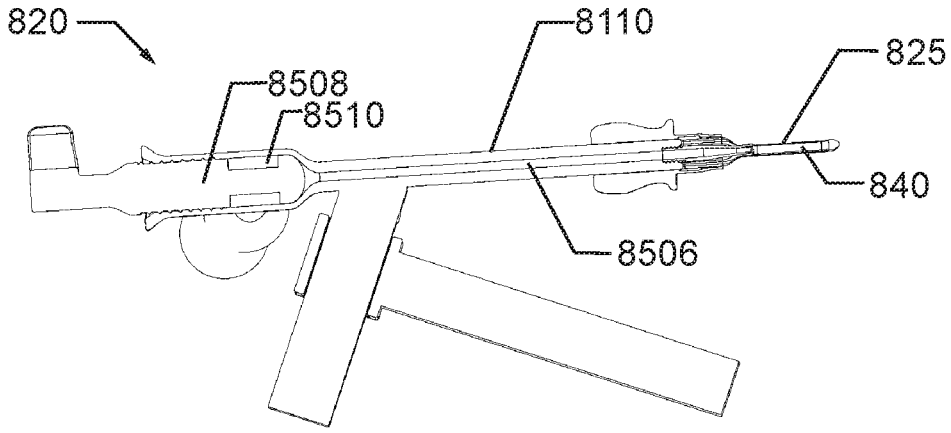

820
8508
8510
8110
825
840
8506

FIG. 21

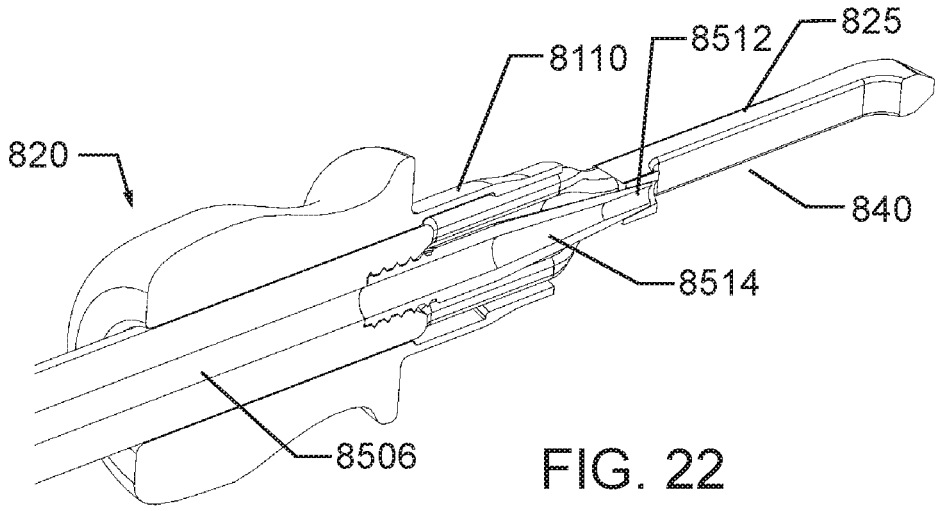

820
8110
8512
825
840
8514
8506

FIG. 22

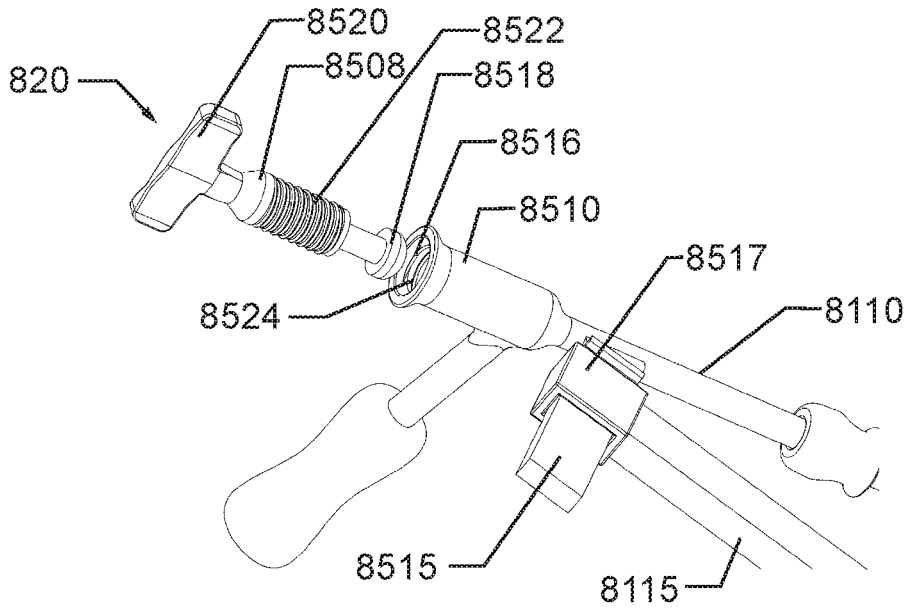

820
8520
8508
8522
8518
8516
8510
8517
8524
8110
8515
8115

FIG. 23

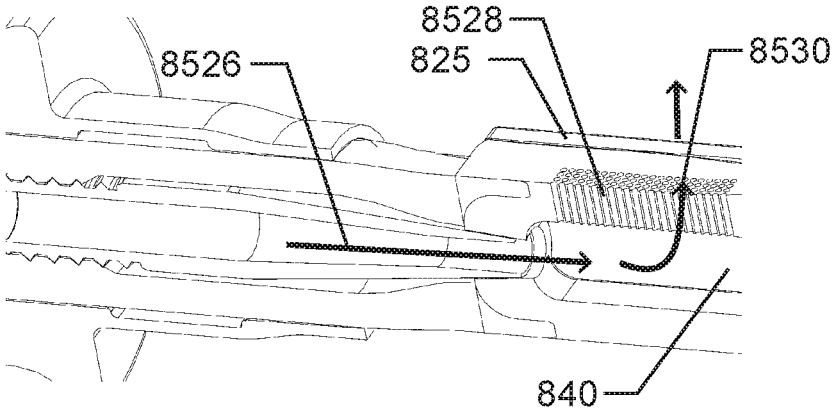

8528
8526
825
8530
840

FIG. 24

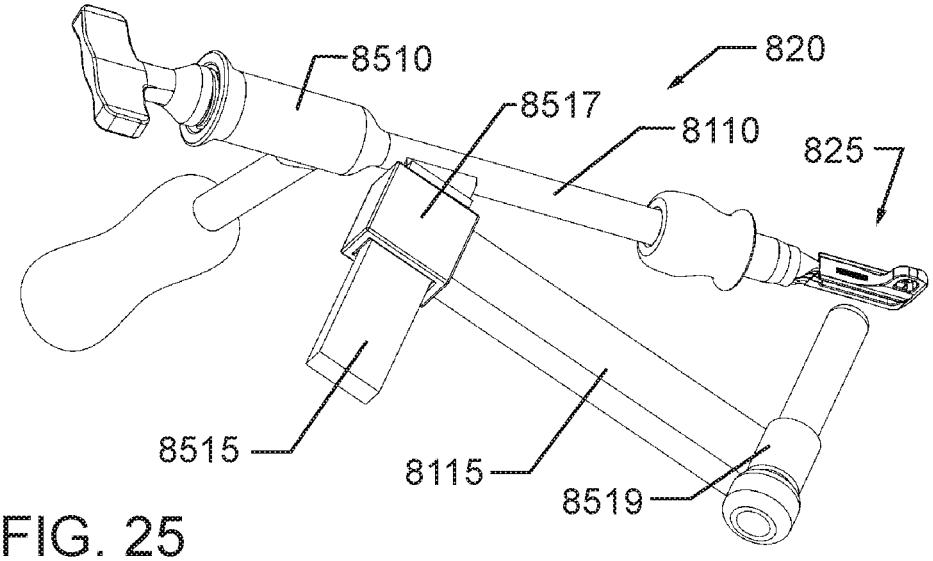

8510
820
8517
8110
825
8515
8115
8519

FIG. 25

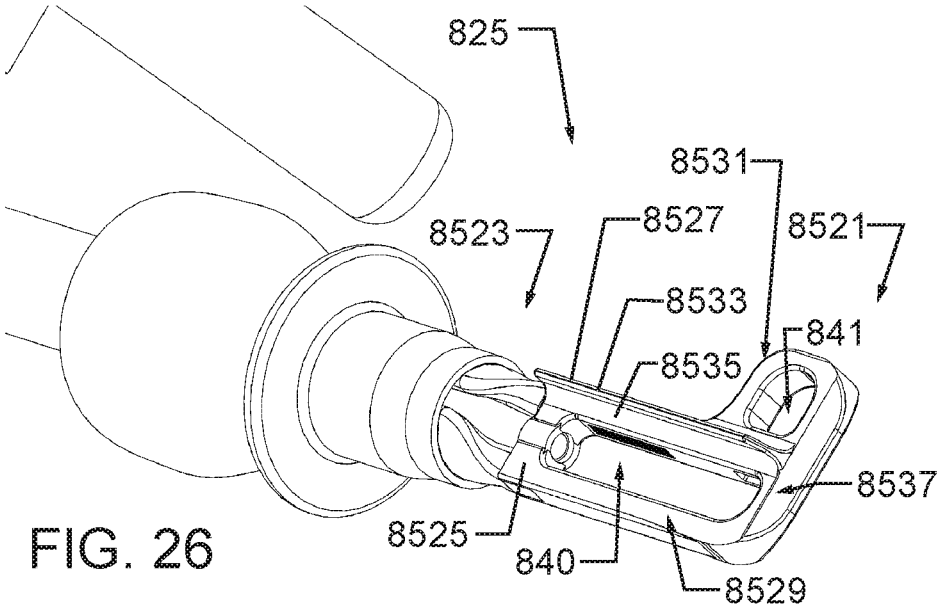

825
8531
8523
8527
8521
8533
841
8535
8537
8525
840
8529

FIG. 26

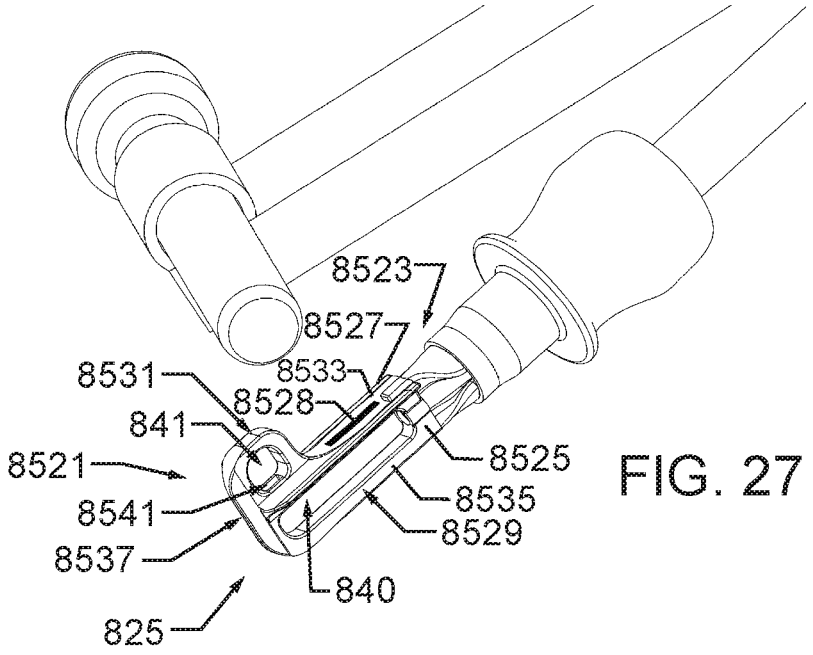

8523
8527
8531
8533
8528
841
8521
8525
8535
8541
8529
8537
840
825

FIG. 27

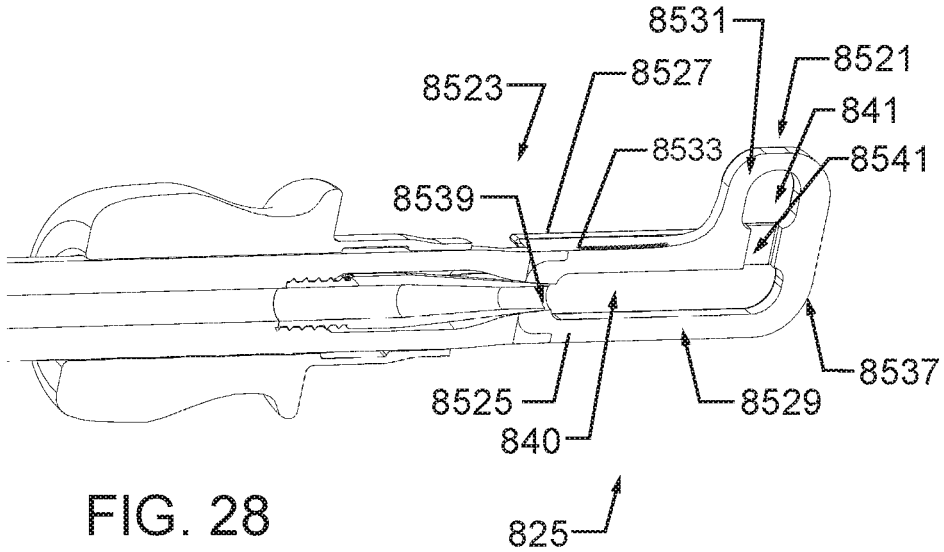

8531
8521
8523
8527
841
8533
8541
8539
8537
8525
8529
840
825

FIG. 28

IMPLANTS, SYSTEMS, AND METHODS FOR FUSING A SACROILIAC JOINT

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a continuation application of U.S. application Ser. No. 14/567,956 filed Dec. 11, 2014, which application claims priority under 35 U.S.C. § 119 to U.S. Provisional Patent Application 61/914,409, which was filed Dec. 11, 2013, entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT," and is hereby incorporated by reference in its entirety into the present application.

U.S. application Ser. No. 14/567,956 is also a continuation-in-part ("CIP") application of, and claims priority to, U.S. patent application Ser. No. 14/514,221 ("the '221 application"), which was filed Oct. 14, 2014, entitled "SYSTEMS FOR AND METHODS OF PREPARING A SACROILIAC JOINT FOR FUSION." The '221 application claims priority under 35 U.S.C. § 119 to: 1) U.S. Provisional Patent Application 61/891,330, which was filed Oct. 15, 2013, entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT"; 2) U.S. Provisional Patent Application 61/891,345, which was filed Oct. 15, 2013, entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT"; 3) U.S. Provisional Patent Application 61/912,494, which was filed Dec. 5, 2013, entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT"; 4) U.S. Provisional Patent Application 61/914,409, which was filed Dec. 11, 2013, entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT"; and 5) U.S. Provisional Patent Application 61/954,594, which was filed Mar. 17, 2014, entitled "SYSTEMS AND METHODS FOR FUSING A SACROILIAC JOINT AND ANCHORING AN ORTHOPEDIC APPLIANCE". The '221 application and all Provisional Patent Applications to which it claims priority are hereby incorporated by reference in their entireties into the present application.

U.S. application Ser. No. 14/567,956 is also a continuation-in-part ("CIP") application of, and claims priority to, U.S. patent application Ser. No. 14/447,612 ("the '612 application"), which was filed Jul. 31, 2014, entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT," now U.S. Pat. No. 9,700,356. The '612 application claims priority under 35 U.S.C. § 119 to: 1) U.S. Provisional Patent Application 61/979,857, which was filed Apr. 15, 2014, entitled "SACROILIAC JOINT IMPLANT"; 2) U.S. provisional application 61/955,126, which was filed Mar. 18, 2014, entitled "SACROILIAC JOINT IMPLANT"; 3) U.S. Provisional Patent Application 61/914,409, which was filed Dec. 11, 2013, entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT"; and 4) U.S. Provisional Patent Application 61/860,185, which was filed Jul. 30, 2013, entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT". The '612 application and all Provisional Patent Applications to which it claims priority are hereby incorporated by reference in their entireties into the present application.

TECHNICAL FIELD

Aspects of the present disclosure relate to medical apparatus and methods. More specifically, the present disclosure relates to devices, systems, and methods for fusing a sacroiliac joint.

BACKGROUND

The sacroiliac joint is the joint between the sacrum and the ilium of the pelvis, which are joined by ligaments. In humans, the sacrum supports the spine and is supported in turn by an ilium on each side. The sacroiliac joint is a synovial joint with articular cartilage and irregular elevations and depressions that produce interlocking of the two bones.

Pain associated with the sacroiliac joint can be caused by traumatic fracture dislocation of the pelvis, degenerative arthritis, sacroiliitis an inflammation or degenerative condition of the sacroiliac joint, osteitis condensans ilii, or other degenerative conditions of the sacroiliac joint. Currently, sacroiliac joint fusion is most commonly advocated as a surgical treatment for these conditions. Fusion of the sacroiliac joint can be accomplished by several different conventional methods encompassing an anterior approach, a posterior approach, and a lateral approach with or without percutaneous screw or other type implant fixation. However, while each of these methods has been utilized for fixation and fusion of the sacroiliac joint over the past several decades, substantial problems with respect to the fixation and fusion of the sacroiliac joint remain unresolved.

A significant problem with certain conventional methods for fixation and fusion of the sacroiliac joint including the anterior approach, posterior approach, or lateral approach may be that the surgeon has to make a substantial incision in the skin and tissues for direct access to the sacroiliac joint involved. These invasive approaches allow the sacroiliac joint to be seen and touched directly by the surgeon. Often referred to as an "open surgery", these procedures have the attendant disadvantages of requiring general anesthesia and can involve increased operative time, hospitalization, pain, and recovery time due to the extensive soft tissue damage resulting from the open surgery.

A danger to open surgery using the anterior approach can be damage to the L5 nerve root, which lies approximately two centimeters medial to the sacroiliac joint or damage to the major blood vessels. Additionally and as seen in FIG. **1**, which depicts a conventional fusion procedure (immobilization of the articular surfaces of the sacroiliac joint in relation to one another) on a sacroiliac joint **1**, one or more screws or implants **2** are implanted transversely across the articular surfaces **3** and through the sacrum **4** and the ilium bones **5**. That is, the joint **1** is immobilized by placement of a fusion device **2** transverse to or across a plane defined by articular surfaces **3** of the sacroiliac joint space.

Use of trans-sacroiliac and S1 pedicle-iliac bone implants can also involve the risk of damage to the lumbosacral neurovascular elements. Damage to the lumbosacral neurovascular elements as well as delayed union or non-union of the sacroiliac joint by use of these procedures may require revision surgery to remove all or a portion of the implants or repeat surgery as to these complications.

Another significant problem with conventional procedures utilizing minimally invasive small opening procedures can be that the procedures are technically difficult, requiring biplanar fluoroscopy of the articular surfaces of the sacroiliac joint and extensive surgical training and experience. Despite the level of surgical training and experience, there is a substantial incidence of damage to the lumbosacral neurovascular elements. Additionally, sacral anomalies can further lead to mal-placement of implants leading to damage of surrounding structures. Additionally, these procedures are often performed without fusion of the sacroiliac joint, which does not remove the degenerative joint surface and thereby

may not address the degenerative condition of the sacroiliac joint, which may lead to continued or recurrent sacroiliac joint pain.

Another significant problem with conventional procedures can be the utilization of multiple trans-sacroiliac elongate implants, which do not include a threaded surface. This approach requires the creation of trans-sacroiliac bores in the pelvis and nearby sacral foramen, which can be of relatively large dimension and which are subsequently broached with instruments, which can result in bone being impacted into the pelvis and neuroforamen.

The creation of the trans-sacroiliac bores and subsequent broaching of the bores requires a guide pin, which may be inadvertently advanced into the pelvis or sacral foramen, resulting in damage to other structures. Additionally, producing the trans-sacroiliac bores, broaching, or placement of the elongate implants may result in damage to the lumbosacral neurovascular elements, as above discussed. Additionally, there may be no actual fusion of the articular portion of the sacroiliac joint, which may result in continued or recurrent pain requiring additional surgery.

Another substantial problem with conventional procedures can be that placement of posterior extra-articular distracting fusion implants and bone grafts may be inadequate with respect to removal of the articular surface or preparation of cortical bone, the implant structure and fixation of the sacroiliac joint. The conventional procedures may not remove sufficient amounts of the articular surfaces or cortical surfaces of the sacroiliac joint to relieve pain in the sacroiliac joint. The conventional implant structures may have insufficient or avoid engagement with the articular surfaces or cortical bone of the sacroiliac joint for adequate fixation or fusion. The failure to sufficiently stabilize and fuse the sacroiliac joint with the conventional implant structures and methods may result in a failure to relieve the condition of sacroiliac joint being treated. Additionally, conventional methods of driving apart a sacrum and ilium may lead to mal-alignment of the sacroiliac joint and increased pain.

Improvements to sacroiliac joint fusion involve systems and methods for non-transverse delivery of an implant into the sacroiliac joint are described in U.S. patent applications: Ser. No. 12/998,712, filed May 23, 2011 entitled SACROILIAC JOINT FIXATION FUSION SYSTEM; Ser. No. 13/236,411, filed Sep. 19, 2011 entitled SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT; and Ser. No. 13/475,695, filed May 18, 2012, entitled SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT; and Ser. No. 13/945,053, filed Jul. 18, 2013, entitled SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT; and Ser. No. 13/946,790, filed Jul. 19, 2013, entitled SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT; and Ser. No. 14/216,975, filed Mar. 17, 2014, entitled SYSTEMS AND METHODS FOR FUSING A SACROILIAC JOINT AND ANCHORING AN ORTHOPEDIC APPLIANCE; and Ser. No. 14/447,612, filed Jul. 31, 2014, entitled SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT. All of application Ser. Nos. 12/998,712, 13/236,411, 13/475,695, 13/945,053, 13/946,790, 14/216,975, and 14/447,612 are herein incorporated by reference in their entirety.

The systems and methods discussed herein address the challenges in fusing the sacroiliac joint.

SUMMARY

One implementation of the present disclosure may take the form of a sacroiliac joint fusion system. In certain embodiments, the system may include a joint implant, an anchor element and a delivery tool.

In certain embodiments, the joint implant may include a proximal end, a distal end, a longitudinal axis extending between the proximal and distal ends of the joint implant, and a graft window extending non-parallel to the longitudinal axis. The anchor element may include a proximal end and a distal end. The anchor element may be configured to be received in the graft window of the joint implant.

In certain embodiments, the delivery tool may include an implant arm, an anchor arm, and a positioning arm. In certain embodiments, the implant arm may include an implant shaft extending between a proximal end and a distal end of the implant arm, and a longitudinal axis extending between the proximal and distal ends of the implant arm. The distal end of the implant arm may be configured to releasably couple to the proximal end of the joint implant. In certain embodiments, the anchor arm may include an anchor shaft extending between a proximal end and a distal end of the anchor arm, and a longitudinal axis extending between the proximal and distal ends of the anchor arm. The distal end of the anchor arm may be configured to releasably couple to the proximal end of the anchor element.

In certain embodiments, the positioning arm may be coupled with the implant arm at a first end and coupled with the anchor arm at a second end. The implant arm may be configured to rotate relative to the first end along the longitudinal axis of the implant arm within a fixed range of rotation. When the implant arm is coupled to the first end and the anchor arm is coupled to the second end, a delivery arrangement may automatically exist such that the anchor element and the joint implant align in a trajectory such that the anchor element will be received within the graft window upon convergence of the anchor element and the joint implant.

In certain implementations, the anchor element may be configured to be received within the graft window of the joint implant in any rotational orientation of the implant arm that is within the fixed range of rotation.

In certain implementations, the fixed range of rotation may be about 60 degrees of rotation.

In certain implementations, the fixed range of rotation may be about 45 degrees of rotation.

In certain implementations, the fixed range of rotation may be between about 45 degrees and about 60 degrees of rotation.

In certain implementations, the graft window may extend to the distal end of the joint implant and define an opened distal end. In this and other implementations, the joint implant may further include a pair of generally parallel keels extending from the proximal end to the distal end, and a spanning member extending between the pair of generally parallel keels at the proximal end of the joint implant. The graft window may extend between the spanning member and the pair of generally parallel keels.

In certain implementations, the implant shaft may be longitudinally and slidably displaceable relative to the first end of the positioning arm.

In certain implementations, the implant shaft may be laterally and slidably displaceable relative to the first end of the positioning arm, wherein lateral displacement is transverse to the longitudinal axis of the implant arm.

In certain implementations, the first end may include a channel defined in the positioning arm and the implant arm may include a cam feature that interacts with the channel when the implant arm is coupled to the first end. In this and other implementations, a cross-sectional shape of the

implant shaft defines the cam feature. In this and other implementations, the cam feature may be configured to rotate within the channel between a pair of locked positions that define the fixed range of rotation.

In certain implementations, the anchor arm may include an anchor retainer extending through a passageway of the anchor shaft, a distal end of the anchor retainer configured to releasably couple to the proximal end of the anchor element. In this and other implementations, a proximal end of the anchor retainer may include a first head that is configured to be rotationally engaged so as to releasably couple the distal end of the anchor retainer with the proximal end of the anchor element.

In certain implementations, the implant arm includes an implant retainer extending through a passageway of the implant shaft, a distal end of the implant retainer configured to releasably couple to the proximal end of the joint implant. In this and other implementations, a proximal end of the implant retainer includes a second head that is configured to be rotationally engaged so as to releasably couple the distal end of the implant retainer with the proximal end of the joint implant.

In certain implementations, the implant arm includes the cam mechanism and the positioning arm includes a channel, wherein the cam mechanism includes a cam-shape that is configured to only partially rotate within the channel to define the fixed range of rotation.

In certain implementations, longitudinal displacement of the implant arm relative to the first end is fixed beyond a certain point so as to inhibit contact between a surface of the joint implant and the anchor element. In this and other implementations, the positioning arm includes an opening at the first end that is configured to receive the implant shaft therethrough, the implant arm comprising a stop feature that is configured to contact the positioning arm during longitudinal displacement and inhibit further displacement.

Another implementation of the present disclosure may take the form of a method for fusing a sacroiliac joint having a sacrum and an ilium. In certain embodiments, the method may include providing a joint implant and a delivery tool.

In certain embodiments, the joint implant may include a body and a graft window. The body may extend between an implant proximal end and an implant distal end. The graft window may extend non-parallel through the body and extend proximally from the implant distal end to define at least a portion of an opened distal end.

In certain embodiments, the delivery tool may include an implant arm, an anchor arm, and a positioning arm. The implant arm may extend between a proximal implant arm end and a distal implant arm end. The distal implant arm end may be configured to releasably couple to the implant proximal end of the joint implant. The anchor arm may extend between a proximal anchor arm end and a distal anchor arm end. The distal anchor arm end may be configured to releasably couple to a proximal end of an anchor element.

In certain embodiments, the positioning arm may couple the implant arm and the anchor arm such that, when coupled, a delivery arrangement automatically exists such that the anchor element and the joint implant align in a trajectory such that the anchor element will be received within the graft window upon convergence of the anchor element and the joint implant. The implant arm may be configured to rotate relative to the positioning arm about a longitudinal axis of the implant arm within a fixed range of rotation.

In certain embodiments the method may further include releasably coupling the implant proximal end to the distal implant arm end and releasably coupling the proximal end of the anchor to the distal anchor arm end.

In certain embodiments, the method may further include, first, delivering the anchor element transversely through the sacroiliac joint and, second, delivering the joint implant non-transversely into the sacroiliac joint such that the anchor element is positioned within the graft window of the joint implant. The joint implant may be in an orientation within the sacroiliac joint such that the body and the graft window are a generally within a plane defined by the sacroiliac joint.

In certain embodiments, the method may further include uncoupling the distal implant arm end from the implant proximal end and uncoupling the distal anchor arm end from the proximal end of the anchor element.

In certain implementations, the method may include rotating the implant arm about the longitudinal axis and within the fixed range of rotation to select a final implant trajectory that will result in delivery of the joint implant into the sacroiliac joint in the orientation.

In certain implementations, the fixed range of rotation may be about 60 degrees of rotation.

In certain implementations, the fixed range of rotation may be between about 20 degrees and about 90 degrees.

In certain implementations, the body of the joint implant may further include a first keel, a second keel opposite the first keel, and a spanning member coupling and extending between the first and second keels at the implant proximal end. The graft window may be defined between the first and second keels and the spanning member. In this and other implementations, the body of the joint implant may further include a pair of wing members coupled with the spanning member and extending generally perpendicularly from a surface of the spanning member that extends between the first and second keels. In this and other implementations, the surface of the spanning member may be a planar surface.

In certain implementations, the step of uncoupling the distal implant arm end from the implant proximal end may entail rotationally engaging a proximal portion of an implant retainer. The implant retainer may extend through a passageway that extends through the implant arm and define the distal implant arm end that releasably couples with the implant proximal end.

In certain implementations, the step of uncoupling the distal anchor arm end from the proximal end of the anchor element entails rotationally engaging a proximal portion of an anchor retainer, the anchor retainer extending through a passageway that extends through the anchor arm and defining the distal anchor arm end that releasably couples with the proximal end of the anchor element.

In certain implementations, the implant arm may include a cam mechanism and the positioning arm includes a channel. The cam mechanism may include a cam-shape that is configured to only partially rotate within the channel to define the fixed range of rotation.

In certain implementations, a distal-most depth of delivery of the joint implant may be fixed so as to inhibit contact between a surface of the joint implant and the anchor element.

In certain implementations, a proximal portion of the implant arm includes a stop feature that is configured to contact the positioning arm when the distal-most depth is reached.

In certain implementations, an implant may be inserted into the sacroiliac joint region along a generally arcuate path. Accordingly, a surgical preparation technique and tools may be utilized while operating in the arcuate path. The implant arcuate path may follow and generally match the

surgical preparation arcuate path and a path arc may include a radius of between approximately 3 cm to 6 cm. The portion of the path having an arcuate path including a radius of between approximately 3 cm to 6 cm may reside substantially in the plane of the sacroiliac joint or in a plane in close proximity and generally parallel thereto. Furthermore, the arcuate path may generally or substantially reside in a sacroiliac joint articular region. Additionally, an implant may be selected for use during the procedure which substantially matches the radius or curvature of the arcuate or curved insertion path or surgical preparation path.

In certain implementations, a curved implant may include: 1) a proximal end region configured to couple with an inserter; 2) a first distally extending member coupled to the implant proximal region; 3) a second distally extending member coupled to the implant proximal region and spaced apart from the first distally extending member, and 4) a gap between the first and second distally extending members at a distal end region such that the first and second distally extending members are connected to one another only at the proximal end region; wherein the proximal end region further includes a first and second bone contact surface generally opposed to one another and where said contact surfaces extend distally from a proximal end region contact surface extreme proximal first and second edge, respectively, toward an implant distal end; and wherein a superior end of the proximal end region defines a coupling location of the first distally extending member, and the superior end extends between the contact surfaces; and where an inferior end of the proximal end region defines a coupling location of the second distally extending member, and the inferior end extends between the contact surfaces; and wherein each the first and second distally extending members comprise a first and second longitudinally extending axis, respectively, and the first and second longitudinal axes curve along a length of the implant such that the first and second curved axes are concentrically aligned.

Furthermore, the first and second distally extending members may further include a first and second maximum thickness and a first and second maximum width, respectively, the first maximum thickness defined between a point on a superior most surface and an inferior most surface of a lateral end region of the first distally extending member; the second maximum thickness defined between a point on a superior most surface and an inferior most surface of a lateral end region of the second distally extending member; the first maximum width defined between a first extreme lateral edge of a first lateral edge region of the first distally extending member and a second extreme lateral edge of a second lateral edge region of the first distally extending member; the second maximum width defined between a first extreme lateral edge of a first lateral edge region of the second distally extending member and a second extreme lateral edge of a second lateral edge region of the second distally extending member, wherein the first and second lateral edge regions of both the first and second distally extending members extend lateral beyond the first and second contact surfaces, respectively; and wherein the first maximum thickness is greater than the second maximum thickness and the first maximum width is greater than the second maximum width and wherein the extreme lateral edges of the first distally extending member extend a greater distance from the first and second contact surfaces versus the distance between the extreme lateral edges of the second distally extending members and the first and second contact surfaces. Additionally, at a distal end region of the first distally extending member, the superior and/or inferior surfaces may taper toward one another. Said taper may be configured in different manners; e.g., the distal end region of the superior surface may have a curvature which is concentrically aligned with the first axis while the inferior surface may taper toward an extreme distal edge of the superior surface such that when implanted the first distally extending member may transition from a neutral condition to an expanded condition; the neutral condition is such that the first axis is substantially concentrically aligned with a central curved longitudinal axis of the implant; and the expanded condition is such that the distal end region of the first distally extending member is displaced further from the central axis versus the neutral condition. Alternatively, the taper may be configured where both the superior and inferior surfaces taper toward one another such that the first distally extending member remains in a generally neutral condition when advanced into the joint. Said curved implant may be positioned into the sacroiliac joint such that a point of concentricity (as defined by the first and second curved axes) is generally posterior and/or dorsal the implant body after final implant placement such that the second distally extending member is in proximity to a sacroiliac joint ventral boundary (a combination of the inferior boundary segment, anterior-inferior corner and anterior boundary segment).

While multiple embodiments are disclosed, still other embodiments of the present disclosure will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the disclosure. As will be realized, the various embodiments of the present disclosure are capable of modifications in various aspects, all without departing from the spirit and scope of the present disclosure. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top isometric view of a delivery system with an anchor arm, an implant arm, and a positioning arm coupled therebetween.

FIG. **2** is a bottom isometric view of the delivery system of FIG. **1**.

FIG. **3**A is a side isometric view of the anchor arm coupled with an anchor.

FIG. **3**B is a cross-sectional side isometric view of the anchor arm coupled with the anchor.

FIG. **4** is an isometric view of the positioning arm.

FIG. **5**A is an isometric side view of the implant arm and handle assembly.

FIG. **5**B is a cross-sectional view of the implant arm and the handle assembly.

FIG. **6** is an isometric, cross-sectional view of a channel and a proximal end of the implant arm.

FIG. **7** is a top view of the cross-sectional illustration of FIG. **6** depicting the implant arm in a particular rotational orientation.

FIG. **8** is another top view of the cross-sectional illustration of FIG. **6** depicting the implant arm in another particular rotational orientation.

FIG. **9** is an isometric view of the implant.

FIG. **10** is an isometric view of another implant.

FIG. **11**A is a right lateral view of a hip region of a patient lying prone.

FIG. **11**B is an enlarged view of the hip region of FIG. **11**A.

FIG. **11**C is a close-up lateral side view of the hip region with the nearest ilium removed in order to show an implant positioned within the joint region

FIGS. **12**A-**12**H are steps in the methodology and illustrated in the same transverse cross-section taken along a plane extending medial-lateral and anterior-posterior.

FIG. **13**A is a posterior view of a hip region of a skeletal structure and an isometric view of an anchor arm approaching a lateral surface of an ilium.

FIG. **13**B is the same view of the hip region of FIG. **13**A but with the anchor arm advanced relative to the ilium.

FIG. **13**C is a top view of the hip region of the skeletal structure looking caudal with the positioning arm coupled with the anchor arm.

FIG. **13**D is the same view of the hip region of the skeletal structure of FIG. **13**C but with the implant arm coupled to the positioning arm.

FIG. **13**E is the same view of the hip region of the skeletal structure of FIGS. **13**C-**13**D but the implant is positioned within the sacroiliac joint.

FIG. **13**F is a side view of the hip region of the skeletal structure with the nearest ilium removed to show the implant and anchor positioned within the sacroiliac joint.

FIG. **14**A is an isometric top view of a positioning arm.

FIG. **14**B is a bottom view of the positioning arm of FIG. **14**A.

FIG. **14**C is a side view of the positioning arm of FIG. **14**A coupled with an implant arm and an anchor arm.

FIG. **14**D is a cross-sectional view of the positioning arm, implant arm, and anchor arm of FIG. **14**C with an anchor positioned within a graft window of an implant.

FIG. **14**E is a cross-sectional view of the positioning arm, implant arm, and anchor arm of FIG. **14**C with the anchor positioned distal of the graft window of the implant.

FIG. **14**F is a bottom view of the positioning arm, implant arm, and anchor arm with the anchor arm positioned in an offset collar of the positioning arm.

FIG. **15**A is a side view of a delivery tool rotatably coupled with a curved implant.

FIG. **15**B is an isometric top and exploded view of the delivery tool and implant of FIG. **15**A.

FIG. **15**C is an isometric bottom and exploded view of the delivery tool and implant of FIG. **15**A.

FIGS. **15**D-**15**F are close-up views of the implant rotatably coupled with the delivery tool with the implant in various degrees of rotation relative to the delivery tool.

FIG. **15**G is a side cross-sectional view of the implant rotatably coupled with the delivery tool with the cross-section along a longitudinal axis of the implant.

FIG. **15**H is a side cross-sectional view of the implant rotatably coupled with the delivery tool with the cross-section along an axis perpendicular to the longitudinal axis of the implant.

FIG. **16**A is a front isometric view of another embodiment of an implant.

FIG. **16**B is a back isometric view of the implant of FIG. **16**A.

FIG. **16**C is a side view of the implant of FIG. **16**A.

FIG. **16**D is a back isometric view of the implant of FIG. **16**A with wider upper keels and narrower lower keels.

FIG. **17**A is a side isometric view of a first embodiment of an implant with an angled end cap.

FIG. **17**B is a side isometric view of a second embodiment of an implant with an angled end cap.

FIG. **17**C is a series of views of a first embodiment of an implant with an asymmetric end cap.

FIG. **17**D is a series of views of a second embodiment of an implant with an asymmetric end cap.

FIG. **18**A is a front isometric view of a delivery tool coupled with an implant via a gripping mechanism.

FIG. **18**B is a back isometric view of the delivery tool and implant of FIG. **18**A.

FIG. **18**C is an isometric side and exploded view of the various components of the delivery tool and implant of FIG. **18**A.

FIG. **18**D is a side and exploded view of the various components of the delivery tool and implant of FIG. **18**A.

FIG. **18**E is a side view of the delivery tool and implant of FIG. **18**A with an impactor positioned superior of an implant arm.

FIG. **18**F is a side view of the delivery tool and implant of FIG. **18**A with an impactor positioned inferior of the implant arm.

FIG. **18**G is a side isometric and cross-sectional view of the delivery tool and implant where the cross-section is along a longitudinal axis of the delivery tool and implant and where the lever handle is in a closed position.

FIG. **18**H is a close-up view of the gripping mechanism shown in FIG. **18**G.

FIG. **18**I is a side isometric and cross-sectional view of the delivery tool and implant where the cross-section is along a longitudinal axis of the delivery tool and implant and where the lever handle is in an opened position.

FIG. **18**J is a close-up view of the implant coupled with the delivery tool shown in FIG. **18**I.

FIG. **18**K is an isometric side view of the delivery tool and implant in an uncoupled state with the lever handle in an opened position.

FIG. **18**L is an isometric front view of the implant showing an anti-migration element.

FIG. **19**A is an isometric front and bottom view of another implant embodiment.

FIG. **19**B is an isometric front and top view of the implant shown in FIG. **19**A.

FIG. **19**C is a top view of the implant shown in FIG. **19**A.

FIG. **19**D is a bottom view of the implant shown in FIG. **19**A.

FIG. **19**E is an isometric side and back view of the implant shown in FIG. **19**A.

FIG. **19**F is a back view of the implant shown in FIG. **19**A.

FIG. **20** is a perspective view of an adjustable delivery system with a slidable anchor arm and a bone paste insertion element.

FIG. **21** is a side cross-sectional view of a delivery tool with a bone paste insertion element.

FIG. **22** is a perspective cross-sectional view of a delivery tool with a bone paste insertion element.

FIG. **23** is a perspective view of a delivery tool with a bone paste insertion element.

FIG. **24** is a cross-sectional close-up view of a delivery tool with a bone paste insertion element and an implant with a plurality of bone paste channels.

FIG. **25** is another perspective view of the delivery tool with the bone paste insertion element.

FIG. **26** is a close-up perspective view of the implant coupled to a distal end of the delivery tool.

FIG. **27** is a close-up perspective view of the implant coupled to the distal end of the delivery tool from the opposite side as FIG. **26**.

FIG. **28** is a cross-sectional side view of the implant and distal end of the delivery tool.

DETAILED DESCRIPTION

I. Delivery Tool for Fusion of the Sacroiliac Joint

Implementations of the present disclosure involve a delivery tool for fusing a sacroiliac joint involving an implant delivered within a plane of the joint and an anchor delivered transversely (i.e., across) the joint. The delivery tool is configured to deliver the anchor prior or subsequent to delivery of the implant. The delivery tool, in particular, may include an anchor arm coupled to an implant arm via a positioning arm. The positioning arm is removably, rotationally, and slidably coupled with both the anchor arm and the implant arm. The positioning arm includes a rotating joint at the connection with the implant arm such that the implant arm may rotate within a "window" of orientations that are configured to allow an anchor at a distal end of the anchor arm to be positioned within a graft window or opening of an implant at a distal end of the implant arm. The rotational "window" of orientations may be mechanically fixed at the rotating joint such that rotational movement of the implant arm is restrained to orientations within the "window." Such a configuration of a delivery tool with a range of allowable orientations of the implant arm relative to the anchor arm allows for blind delivery of an implant or anchor (i.e., depending on the order of delivery) that ensures positioning of the anchor within the graft window of the implant.

To begin, reference is made to FIG. **1**, which depicts a delivery tool **100** in an isometric view. As seen in the figure, the delivery tool **100** includes an anchor arm **102**, an implant arm **104**, and a positioning arm **106** coupled between the anchor arm **102** and implant arm **104**. The anchor arm **102** may include an anchor shaft **108** with a handle **110** at a proximal end **112** and an anchor retainer **114** at a distal end **116**. The anchor retainer **114** may releasably couple with a proximal end **118** of an anchor element **120**. The anchor retainer **114** may include a shaft (as seen in FIG. **3**B) that extends through an internal passageway in the anchor shaft **108**. The anchor retainer **114** may include a head **168** at the proximal end **112** of the anchor arm **102**. The head **168** may be rotationally engaged by a user to releasably couple the anchor retainer **114** and the anchor element **120**. The anchor element **120** may be a bone screw or anchor or similar device configured to be delivered through a patient's bone (e.g., sacrum, ilium). The anchor element **120** may have a threading **122** on its outer surface and may include a tapered distal end **124**.

Referring to the positioning arm **106**, it includes a pair of collars **126** that are each configured to receive the anchor shaft **108** and orient the anchor shaft **108** such that it may rotate and translate; however, angling of the anchor arm **102** relative to the positioning arm **106** is restrained. Angling is restrained because the collars include a diameter that is slightly larger than an outer diameter of the anchor shaft **108**.

Extending away from and coupled to the pair of collars **126** is an arcuate positioning member **128**. As seen in FIG. **1**, the positioning member **128** is positioned directly above one of the collars **126** while the other one of the collars **126** is offset from the positioning member **128**. A channel **130** is formed in the positioning member **128** on an end opposite the pair of collars **126**. The channel **130** defines a stadium-shaped opening that extends from a proximal edge **132** to a distal edge **134** of the channel **130**. The channel **130** is bounded by generally perpendicular side walls **136** and rounded end walls **138** that are positioned between the side walls **136**. The channel **130** is configured to receive the implant arm **104** and restrain its rotation to a limited, predetermined range. As will be discussed later, the channel **130** and the implant arm **104** form a rotating joint about which the implant arm **104** may be rotated relative to positioning arm **106** and the anchor arm **102**, or vice versa.

While the positioning member **128** is depicted as being arcuate, other designs are possible and contemplated herein. The positioning member **128** may, for example, be a single straight member or may include multiple members of differing shapes. As another example, the positioning member **128** may include telescoping members that enable retraction and extension of an inner telescoping member.

As seen in FIG. **1**, when the anchor arm **102** is positioned in the particular collar **126** that lies in a common plane with the positioning member **128**, the anchor element **120** is configured to be positioned in a central portion of a graft window **158** of an implant **150**. That is, one of the collars **126** lies in a common plane with the positioning member **128**, the channel **130**, and, thus, the shaft **140** of the implant arm **104**. The other collar **126** is offset such that, when the anchor arm **102** is positioned in the other collar **126**, the anchor element **120** will be positioned outside the graft window **158** of the implant **150** (e.g., caudal or cranial of the implant **150**).

Still referring to FIG. **1**, the implant arm **104** includes an implant shaft **140** extending between a handle assembly **142** and an implant retainer **144** at a distal end **146** of the implant arm **104**. The implant retainer **144** is configured to releasably couple with a proximal end **148** of an implant **150**. In this embodiment, the implant **150** is fork-shaped and includes a pair of keels **152** extending distally from a proximally positioned spanning member **154** that couples with and extends between the pair of keels **152**. Turning to FIG. **2**, which is bottom isometric view of the delivery tool **100**, the spanning member **154** includes a bore **156** to receive the implant retainer **144**. In this embodiment, the bore **156** and the implant retainer **144** include complementary threading; however, other mechanisms are possible to releasably couple the implant **150** and the implant retainer **144**. Referring back to the implant **150**, a distal opening or graft window **158** is defined between the pair of keels **152**. The graft window **158** is open at a distal end **160** of the implant **150**. Thus, the distal end **160** of the implant **150** is defined by distal tips **162** of the keels **152** and the graft window **158** extending between the distal tips **162**.

As illustrated in FIGS. **1-2**, the implant arm **104** is limited to certain rotational arrangements such that the anchor element **120** will remain positioned within the graft window **158**. Conversely, the anchor arm **102** and positioning arm **106** are limited to certain rotational arrangements relative to the implant arm **104** such that the anchor element **120** will remain positioned within the graft window **158**. That is, either the implant arm **104** may be rotated or the anchor arm **102** and positioning arm **106** may be rotated; this will depend on whether the implant **150** or the anchor element **120** is delivered into a patient's body first (i.e., in a fixed position). In this way, for example, a surgeon may choose to initially deliver the anchor element **120** into the patient's body. Subsequently, the surgeon may choose to deliver the implant **150**. Prior to delivery of the implant **150**, the surgeon may rotate the implant arm **104** relative to the positioning arm **106** and anchor arm **102** until a trajectory is chosen to deliver the implant **150** into the joint space. The surgeon is able to rotate the implant arm **104** relative to the positioning arm **106** and the anchor arm **102** because they

are in a fixed position (i.e., anchored to the patient's bone) relative to the implant arm **104**. Thus, any rotational position of the implant arm **104** chosen by the surgeon will ensure that, when delivered into the joint space, the anchor **150** will be positioned within the graft window **158** of the implant **150**.

Alternatively, for example, a surgeon may choose to initially deliver the implant **150** into the surgical area. Subsequently, the surgeon may choose to deliver the anchor element **120**. Prior to delivery of the anchor element **120**, the surgeon may rotate the anchor arm **102** and the positioning arm **106** relative to the implant arm **104** until a trajectory is chosen to deliver the anchor element **120** transversely across the joint space. The surgeon is able to rotate the anchor arm **102** and positioning arm **106** as an assemblage relative to the implant arm **104** because the implant arm is in a fixed position (i.e., implanted in the patient's joint) relative to the anchor arm **102** and positioning arm **106**. Thus, any rotational position chosen by the surgeon will ensure that, when delivered transversely across the joint space, the anchor **150** will be positioned within the graft window **158** of the implant **150**.

Reference is now made to FIG. **3**A, which is an isometric side view of the anchor arm **102** coupled to the anchor element **120**. As seen in the figure, the anchor shaft **108** is a tubular member that couples to the handle **110** at the proximal end **112** of the anchor arm **102**. The handle **110** includes a hexagonal cross-section, although other cross-sectional shapes are possible. As illustrated in FIG. **3**B, which is a longitudinal cross-section view of the anchor arm **102** and the anchor element **120**, the anchor retainer **114** is a cylindrical member (similar to a bolt) that extends through and is slidingly received within an internal passageway **164** of the shaft **108** of the anchor arm **102**. A proximal end **166** of the implant retainer **114** includes the head **168** that may be shaped to fit a surgical tool configured to rotate the implant retainer **114**. In this embodiment, the head **168** is a hexagonal bolt-type head. The head **168**, however, may be differently shaped. Referring still to FIG. **3**B, the head **168** distally transitions to a smooth shank **170**. At a distal end **172** of the implant retainer **114** is a reduced diameter section **174** that includes a threaded section **176**. The reduced diameter section **174** is configured to protrude through a distal opening **178** in the shaft **108** of the anchor arm **102**. The distal opening **178** is sized to permit the reduced diameter section **174** from extending therethrough, but not the shank **170**, which has a diameter that is larger than the reduced diameter section **174**.

As seen in FIG. **3**B, the threaded section **176** is a male-end that is configured to threadably engage with a female-end **180** at the proximal end **118** of the anchor element **120**. In operation, the implant retainer **114** may be slidingly engaged and received within the internal passageway **164** in the anchor arm **102**. The implant retainer **114** may be distally advanced such that the reduced diameter section **174** extends through the distal opening **178** in the shaft **108** of the anchor arm **102**. At this point, the proximal end **118** of the anchor element **120** may be threadably engaged with the threaded section **176** by rotating the implant retainer **114** relative to the anchor element **120**. When the anchor element **120** is fully, threadably engaged with the implant retainer **114**, the proximal end **118** of the anchor element **120** abuts the distal end **116** of the anchor arm **116**.

Referring back to FIGS. **1**-**2**, once the anchor element **120** is fully secured to the anchor arm **102** via the implant retainer **114**, the assemblage may be positioned within one of the collars **126** of the positioning arm **106**. Or, if the anchor element **120** is to be delivered into the patient's body prior to the implant **150**, the anchor arm **102** may be utilized by itself. In either situation, the anchor arm **102** may be distally advanced and rotationally driven into the patient's bone by rotating the assemblage of the anchor arm **102** coupled with the anchor until the anchor element **120** is sufficiently positioned within the patient's bone. At that point, the implant retainer **114** may be rotationally disengaged with the anchor element **120** and the anchor arm **102** may be removed from contact with the anchor element **120**, which is left in place in the patient's bone. Alternatively, the anchor arm **102** may remain coupled with the anchor element **120** such that the positioning arm **106** and the implant arm **104** may be coupled with the anchor arm **102** for the subsequent delivery of the implant **150** into the joint space.

Reference is now made to FIG. **4**, which depicts an isometric view of the positioning arm **106**. In this embodiment of the positioning arm **106**, the collars **126** include an expansion slit **182** extending from a proximal edge **184** to a distal edge **186**. In this way, the collars **126** may expand and provide a friction or interference fit against the anchor shaft **108** of the anchor arm **102** when it is received within the collars **126**. Also in this embodiment of the positioning arm **106**, the channel **130** is formed by the generally parallel side walls **136** and a single end wall **138**. That is, a distal end **188** of the channel **130** is open. In other embodiments (e.g., FIGS. **1**-**2**), the distal end **188** of the channel **130** is closed and bounded by another end wall **138**.

Turning now to the implant arm **104**, reference is made to FIG. **5**A, which depicts an isometric side view of the implant arm **104** and handle assembly **142**. At the proximal end **190** of the implant arm **104**, the implant shaft **140** includes a pair of members **192** that extend from a surface of the implant shaft **140**. As will be seen in FIGS. **6**-**7**, the pair of members **192** define a cam-shaped cross-section that is received within the channel **130** (not shown) of the positioning arm **106** (not shown). Distal of the pair of members **192**, the implant shaft **140** defines a circular cross-section. The proximal end **190** of the implant arm **104** is configured to be releasably secured to the handle assembly **142**. Alternatively, the handle assembly **142** may be fixedly secured to the implant arm **104**.

As seen in FIG. **5**B, which is a cross-sectional view of the implant arm **104** and the handle assembly **142**, the implant retainer **144** extends through a passageway **254** that extends though the implant shaft **140** from a proximal end **256** to the distal end **146** of the implant arm **104**. At the distal end **146** of the implant arm **104**, the implant retainer **144** threadably couples to the proximal end **148** of the implant **150**. At the proximal end **256** of the implant arm **104**, the implant retainer **144** couples with a rotationally engageable head **258** that is configured to be rotated in order to couple and decouple the implant retainer **144** and the implant **150**. As seen in FIGS. **5**A-**5**B, the handle assembly **142** includes an enlarged body **260** at the proximal end **256** of the implant arm **104**. The handle assembly **142** also includes a handle **262** extending generally perpendicularly off of the enlarged body **260** that is configured to be grasped by a surgeon during a surgical procedure.

The enlarged body **260** at the proximal end **256** of the implant arm **104** includes an increased diameter compared with the implant shaft **140** and the pair of members **192**. The enlarged body **260** is sized such that it will not extend through the channel **130** of the positioning arm **106** as the implant arm **104** is distally advanced, as seen in FIG. **1**, which ensures that the implant **150** will remain in a predefined orientation relative to the anchor element **120**. In

operation, the implant **150** may be distally advanced until a distal end **264** of the enlarged body **260** contacts the proximal edge **132** of the channel **130**. In this orientation, the anchor element **120** will be positioned within the graft window **158** of the implant **150**.

As seen in FIG. **6**, which is an isometric, cross-sectional view of the channel **130** and the proximal end **190** of the implant arm **104**, the portion of the implant shaft **140** having the pair of members **192** and the implant retainer **144** are configured to be received within the channel **130** of the positioning arm **106** to form a rotating joint. In this figure, the cross-section is taken along the channel **130** and perpendicular to the extension of the implant arm **104**. As seen in the figure, the pair of members **192** define a cam-shape that is semi-elliptic or similar to a rhombus or lozenge with rounded corners. Other cam-shapes are possible such as, for example, an egg-shaped or elliptic shape. As illustrated in this figure, the implant shaft **140** is positioned within the channel **130** such that a minor axis MNA of the cam-shaped cross-section of the implant shaft **140** generally extends across the channel **130** and in between the parallel side walls **136**. And, the major axis MJA of the cam-shaped cross-section of the implant shaft **140** generally extends along a longitudinal axis **194** of the channel **130**. In this way, the implant shaft **140** is configured to rotate within a range of degrees relative to the channel **130** (and, thus, the implant is configured to rotate within the same range relative to the anchor element **120**) where the range of degrees is fixed by the size and orientation of the cam-shaped cross-section of the pair of members **192** on the implant shaft **140**.

In certain embodiments, the implant shaft **140** may rotate with a range of about 70 degrees. In certain embodiments, the range of degrees may be 40, 50, or 60, among others. Such a range may depend on a size or orientation of an anchor element **120** or implant **150**. That is, a particular implant **150** may have a relatively small graft window **158** such that a corresponding implant arm **104** must be used with an implant shaft **140** having a smaller range of rotation. Conversely, a particular implant **150** having a relatively larger graft window **158** may allow for an implant arm **104** having an implant shaft **140** that allows for a larger range of rotation.

Reference is now made to FIG. **7**, which is a close-up, top view of the cross-sectional illustration of FIG. **6**. As seen in the figure, the implant shaft **140** is neutrally positioned within the channel **130** of the positioning arm **106**. That is, the major axis MJA is generally parallel with a longitudinal axis **194** of the channel **130** and with the side walls **136**. In the neutral position, outer surfaces **196** on the implant shaft **140** that are on the minor axis MNA abut inner walls **198** of the channel **130**. Between these outer surfaces **196** define a diameter that is similar to a length **200** defined between the inner walls **198** of the channel **130**. As seen in the figure, the implant shaft **140** may rotate clockwise or counterclockwise within the range of degrees determined by the geometric orientation of the cam-shaped cross-section of the implant shaft **140**. Within the range of degrees, the implant shaft **140** is configured to rotate the implant **150** relative to the anchor element **120** such that the anchor element **120** will remain positioned within the graft window **158** of the implant **150**.

Turning to FIG. **8**, which is another close-up, top view of the cross-sectional illustration of FIG. **6**, the implant shaft **140** is in a locked position within the channel **130**. That is, the implant shaft **140**, in FIG. **8**, has been rotated counterclockwise from the neutral position (as shown in FIG. **7**) such that the geometric configuration of the cam-shaped cross-section of the implant shaft **140** is locked or prevented from further rotation within the channel **130**. In this position, camming surfaces **202** of the implant shaft **140** contact opposing inner walls **198** of the channel **130** and are prevented from further counterclockwise rotation by the force exerted on the camming surfaces **202** by the inner walls **198**. Further rotation is restricted because the diameter of the implant shaft **140** increases and causes the camming surfaces **202** to contact the inner walls **198** of the channel **130**. While FIG. **8** only shows the implant shaft **140** in a counterclockwise rotation, the implant shaft **140** will similarly lock in a clockwise rotation by camming surfaces **202** contacting the inner walls **198** of the channel. Generally, the range of degrees of allowable rotation of the implant shaft **140** relative to the channel **130** will be equally split between clockwise and counterclockwise rotation on either side of the neutral position; however, the implant shaft **140** may be shaped such that rotation is unequally split between clockwise and counterclockwise rotation.

As seen in FIGS. **7-8**, the implant shaft **140** may be positioned within the channel **130** at any point along the longitudinal axis **194** of the channel **130**. That is, the implant arm **104** or, more particularly, the implant shaft **140** may translate distal-proximal within the channel **130**. Thus, as the implant shaft **140** is distally translated, the implant **150** is positioned closer to the tapered distal end **124** of the anchor element **120**. And, as the implant shaft **140** is proximally translated, the implant **150** is positioned closer to the proximal end **118** of the anchor element **120**. In addition, the implant shaft **140** may extend through the channel **130** at an angle such that the implant shaft **140** is not parallel to the end walls **138** of the channel **130**. In other words, the implant shaft **140** may extend at angles other than perpendicular relative to the anchor arm (not shown in FIGS. **7-8**). Alternatively, the implant shaft **140** may be restrained from such angling relative to the anchor arm.

Moving on, reference is made to FIG. **9**, which is an isometric view of the implant **150**. As seen in the figure, the implant **150** includes a pair of keels **152** extending distally from the proximal end **148** of the implant **150**. Extending between the keels **152** at the proximal end **148** is the spanning member **154** that includes the bore **156** for receiving the implant retainer **144** (not shown in FIG. **9**). And, extending between the keels **152** at the distal end **160** and extending proximally to the spanning member **154** is the graft window **158**. The pair of keels **152** include distal tips **162** that converge to a point.

The implant **150** further includes a top surface **204** and a bottom surface **206** generally opposite the top surface **204**. The top and bottom surfaces **204**, **206** extend onto each of the keels **152**. The top and bottom surfaces **204**, **206** are also generally perpendicular to outer surfaces **208** and inner surfaces **210** of the keels **152**. On the top and bottom surfaces **204**, **206** of each of the keels **152** is a fin **212** that extend from the proximal end **148** of the implant **150** to a distal end **214** of the keels **152** where the keels **152** begin tapering towards the distal tip **162**. The fins **212** extend outward from the top and bottom surfaces **204**, **206** and include opposite side surfaces **216** that converge at a blade-like edge **218** that extends from a length of the fin **212**. The distal end **220** end of the fin **212** is beveled. While the blade-like edge **218** is shown with a straight-edge, the edge may include serrations, grooves, or other features.

In certain embodiments, the implant **150** may have the following dimensions. A length L**150** of the implant **150** may be within a range of about 25 mm to about 60 mm. In certain embodiments, the length L**150** may be about 30 mm, 40 mm, or 50 mm. A width W**150** of the implant **150** may

be within a range of about 15 mm to about 40 mm. In certain embodiments, the width W**150** may be about 20 mm, 27.5 mm, or 35 mm. A thickness TH**150** of the implant **150** defined between the top and bottom surfaces **204**, **206** may be within a range of about 2.5 mm to about 10 mm. In certain embodiments, the thickness TH**150** may be about 3 mm, 5 mm, or 7 mm. Furthermore, the thickness TH**150** may vary between the distal and proximal end; e.g., the proximal end region may have a substantially smaller TH**150**, e.g., between 2 mm and 4 mm, versus a substantially larger TH**150** at a proximal end region which may have a TH**150** of approximately 5 mm to about 8 mm. A graft window width GWW**150** of the implant **150** defined between the inner walls **210** of the keels **152** may be within a range of about 7 mm to about 30 mm. In certain embodiments, the graft window width GWW**150** may be about 10 mm, 15 mm, or 20 mm. The graft window width GWW**150** may extend about 20% to about 80% of the width W**150** of the implant **150**. In certain embodiments, the graft window width GWW**150** may extend between about 30%, 50%, or 70% of the width W**150** of the implant **150**. A graft window depth GWD**150** of the implant **150** defined between the opened distal end **160** of the implant **150** and a distal surface of the spanning member **154** may be within a range of about 22 mm to about 57 mm. In certain embodiments, the graft window depth GWD**150** may be about 25 mm, 35 mm, or 45 mm. The graft window depth GWD**150** may extend about 30% to about 90% of the length L**150** of the implant **150**. In certain embodiments, the graft window depth GWD**150** may extend between about 50%, 65%, or 80% of the length L**150** of the implant **150**.

Other implant designs for use with the delivery tool **100** are possible and contemplated by the present disclosure. For example, FIG. **10** depicts an isometric view of another embodiment of an implant **222**. As seen in the figure, the implant **222** includes a pair of keels **224** extending distally from a proximal end **226** of the implant **222**. A spanning member **228** extends between the keels **224** at the proximal end **226** of the implant **222**. Extending between inner surfaces **236** of the keels **224** and the spanning member **228** is a graft window **238** that extends from a distal end **240** of the spanning member **228** to a distal end **242** of the implant **222**. The graft window **238** is open at the distal end **242** such that the implant **222** may be delivered subsequently to delivery of an anchor (not shown) into a joint space where the anchor is positioned within the graft window **238**.

Referring still to FIG. **10**, the spanning member **228** further includes a top surface **230** and a bottom surface **232** generally opposite the top surface **230**. Extending generally perpendicularly from the top and bottom surfaces **230**, **232** of the spanning member **228** are wing members **234** that are centrally positioned between the keels **224**. The wing members **234** extend from the proximal end **226** to the distal end **240** of the spanning member **228**. The implant **222** may include an end cap **244** at the proximal end **226** of the implant **222**. As seen in the figure, the end cap **244** is cross-shaped and plate-like and is coupled to the keels **224** and wing members **234**. Extending through the end cap **244** and a portion of the spanning member **228** is a bore **252** that is configured to releasably couple with the implant retainer **144**. An outer edge **246** of the end cap **244** lies flush with a top surface **248** of the wing members **234**. And, the outer edge **246** also extends beyond a top surface **250** of the keels **224**. A width W_k of the keels **224** is about equal to a width W_{ec} of the end cap **244**. A width W_{wm} of the wing members **234** is smaller than the width W_{ed} of the end cap **244**.

Example dimensions for the implant **222** may be the same or similar to those described in reference to the implant **150** of FIG. **9**. Additional dimensions regarding the wing member **234** may be as follows. The wing members **234** may extend a height H_{wm} of about 3 mm to about 15 mm from the top and bottom surfaces **230**, **232** of the spanning member **228**. In certain embodiments, the height H_{wm} of the wing members **234** may extend about 5 mm, 8 mm, or 10 mm from the top and bottom surfaces **230**, **232**. The wing members **234** may include a width W_{wm} of about 2 mm to about 7 mm. In certain embodiments, the width W_{wm} may be about 2.5 mm, 3.5 mm, or 4.5 mm. The end cap **244** may include a width W_{ec} of about 6 mm to about 15 mm. In certain embodiments, the width W_{ec} of the end cap **244** may be about 7 mm, 9 mm, or 11 mm.

II. Methods of Fusing the Sacroiliac Joint with the Delivery Tool

The following discussion will focus on various methods of accessing and fusing a sacroiliac joint utilizing the tools and devices discussed previously. While the discussion focuses on fusing the sacroiliac joint, the methods discussed herein are not limiting; rather, the methods are applicable to the fusion of other joints as well.

A. Preoperative Planning for a Surgical Fusion Procedure

Prior to any joint preparation, a surgeon or other medical person may select a suitable procedure to fuse the sacroiliac joint. The procedure may include fusing the joint with or without delivering an implant in the joint space. If the surgeon selects a procedure involving delivery of an implant within the joint space, the surgeon will select an implant configuration for delivery into the sacroiliac joint of the patient based on preoperative or intraoperative data. The data may be the result of post-processing of raw or other imaging data (e.g. CT or MRI DICOM files). The post-processing may include the use of a software program (e.g., 3DSLICER available from http://www.slicer.org) that may be used for medical image processing and 3D visualization of image data. Other data may include the patient's weight, activity level, and general health.

The preoperative or intraoperative data may assist in the planning and selecting of desirable anchor trajectories (e.g., starting and stopping points on patient's soft tissue and near or within bone tissue), anchor dimensions (e.g., length, diameter, head size, washer, thread pitch), implant types and dimensions, and joint preparation tool types, dimensions, and configurations. A particularly system for preparing and fusing the sacroiliac joint may be selected, for example, for a hypermobile joint, which may include an implant or fusion system that is resistant to the expected forces present at that particular patient's sacroiliac joint. The determination of fixation sufficiency may be calculated based on the patient's data and also on the performance results of various bench and/or finite element analysis ("FEA") tested implant assembly configurations. For example, a calculated anchor and/or implant trajectory may be considered and determined from certain patient imaging and post-processing data with an overlaid implant assembly. Further, the implant assembly footprint within the joint plane may be selected as a lower percent of total joint surface to permit sufficient bony fusion across the joint while maintaining a sufficient implant sacral and iliac face surface area to prevent implant subsidence.

Specific measurements and characteristics of the patient's anatomy may influence the selection of a particular joint fusion system. For example, the patient's bone density may be measured at numerous locations in proximity to and surrounding the elements of the implant assembly. Lower bone density (e.g., osteopenia, osteoporosis) corresponding

to a T-score lower than −1, sacroiliac joint instability, or hypermobility may require the use of an implant assembly with a greater amount of keel (i.e., the material cross section as defined by thickness of the keel and its length along implant longitudinal axis and also keels extending a greater distance into both bones defining the sacroiliac joint) and anchor extending across the sacroiliac joint and into the ilium and sacrum. Additionally, the relative angles between the implant longitudinal axis and anchor or anchors, and also the relative angles between multiple anchors (e.g., parallel, divergent, convergent) may be preselected based on the patient's anatomy.

A comparison of the preoperative or intraoperative data (e.g., sacroiliac joint surface area, joint surface contours, joint space volume (and related dimensions), joint boundaries, joint mobility, loading, bone density, desirable anatomic pathways) and the selected implant assembly and joint preparation tools may be conducted to ensure or validate compatibility before the manufacture ships the implant system and/or before the surgeon employs the system in a surgical procedure. After implant assembly and preparation tools validation, the selected assemblies may be shipped to the surgeon and the surgeon may proceed with the surgical fusion procedure utilizing the selected assemblies.

B. Anatomical Overview and Positioning of an Implant Non-Transversely within the Sacroiliac Joint

To begin, reference is made to FIGS. **11**A-**11**B, which depict various bone landmarks adjacent, and defining, the sacroiliac joint **1000** of a patient **1001**.

Reference is first made to FIG. **11**A, which is a right lateral view of a hip region **1002** of a patient **1001** lying prone, wherein the soft tissue **1003** surrounding the skeletal structure **1006** of the patient **1001** is shown in dashed lines. Delivery of an implant into the sacroiliac joint **1000** is via a posterior approach to the hip region **1002**. FIG. **11**B, which is an enlarged view of the hip region **1002** of FIG. **11**A, depicts a lateral view of the patient's hip region **1002** reveals certain features of the ilium **1005**, including the anterior superior iliac spine **2000**, the iliac crest **2002**, the posterior superior iliac spine **2004**, the posterior inferior iliac spine **2006**, the greater sciatic notch **2008** extending from the posterior inferior iliac spine **2006** to the ischial spine **2010**, and the tubercle of iliac crest **2012**.

The sacroiliac joint articular region **1044** is shown in dashed lines. A posterior inferior access region **2016** of the sacroiliac joint articular region **1044** has a superior end **2018** on the sacroiliac joint line **2019** that is between approximately 0 mm and approximately 40 mm inferior the posterior inferior overhang **2020** of the posterior superior iliac spine **2004**. The posterior inferior access region **2016** of the sacroiliac joint articular region **1044** has an inferior end **2022** on the sacroiliac joint line that is at approximately the intersection of the posterior inferior iliac spine **2006** with the lateral anterior curved boundary **2024** of the sacrum **1004**. In other words, the posterior inferior access region **2016** of the sacroiliac joint articular region **1044** has an inferior end **2022** on the sacroiliac joint line that is at approximately the superior beginning of the greater sciatic notch **2008**.

Still referring to FIG. **11**B, the sacroiliac joint articular region **1044** roughly defines an L-shape that includes a caudal region **1086** and a cranial region **1087**. Access into the caudal region **1086** of the sacroiliac joint is via the posterior inferior access region **2016** that extends between corners defined by the superior end **2018** and the inferior end **2022**. Access into the cranial region **1087** may be accomplished by continual, anterior travel in the caudal region **1086** until the articular region **1044** turns superiorly into the cranial region **1087**.

To begin a discussion of implant delivery into the sacroiliac joint articular region **1044**, reference is made to FIG. **11**C, which is a close-up lateral side view of the hip region **1002** of a patient **1001** with a nearest ilium **1005** removed in order to show the sacroiliac joint boundary **3000** defined along the sacrum **1004** and outlining the sacroiliac joint articular region **1044**, and an implant **150** positioned for implantation within the sacroiliac joint articular region **1044**.

As seen in FIG. **11**C, boundaries along the sacroiliac joint articular region **1044** include an inferior boundary segment **3002**, an anterior boundary segment **3004**, a superior boundary segment **3006**, and a posterior boundary segment **3008**. The inferior boundary segment **3002** is immediately adjacent, and extends along, the sciatic notch **2024**.

The inferior boundary segment **3002** and anterior boundary segment **3004** intersect to form an anterior-inferior corner **3010**. The anterior boundary segment **3004** and superior boundary segment **3006** intersect to form an anterior-superior corner **3012**. The superior boundary segment **3006** and posterior boundary segment **3008** intersect to form a superior-posterior corner **3014**. The posterior boundary segment **3008** and posterior inferior access region **2016** intersect to form a superior-posterior corner **3016** of the posterior inferior access region **2016**. The inferior boundary segment **3002** and posterior inferior access region **2016** intersect to form an inferior-posterior corner **3018** of the posterior inferior access region **2016**.

The inferior boundary segment **3002** extends between corners **3010** and **3018**. The anterior boundary segment **3004** extends between corners **3010** and **3012**. The superior boundary segment **3006** extends between corners **3012** and **3014** and provides an access into the cranial portion **1087** of the sacroiliac joint. The posterior boundary segment **3008** extends between corners **3014** and **3016**. The posterior inferior access region **2016** extends between corners **3016** and **3018** and provides an access into the caudal region **1086** of the sacroiliac joint. The posterior boundary segment **3008** separates articular region **1044** and extra-articular region **3007**, which includes the sacral fossa on the sacrum **1004** and the corresponding iliac tuberosity on the ilium **1005** and defined by the extra-articular region boundary **3009**.

In one aspect and as seen in FIG. **11**C, the implant **150** may be delivered via an implant arm **104** of a delivery tool into the caudal region **1086** of the sacroiliac joint articular region **1044**. As shown via the implant **150** and implant arm **104** shown in solid lines, in one embodiment, the implant **150** enters the posterior inferior access region **2016**, and is further advanced into the caudal region **1086** of the sacroiliac joint articular region **1044**, in an orientation such that the implant top and bottom surfaces **204**, **206** (as shown in the implant **150** of FIG. **9**) contact an articular surface of an ilium and sacrum, respectively, and the portion of the implant in between said implant surfaces resides generally in a plane of the sacroiliac joint while at least a portion of keels **152** and/or fins **212** extend across the joint plane into the bones defining the joint. In particular, keels and fins **152**, **212** are generally parallel to and (the inferior of the pair are) immediately adjacent the inferior boundary segment **3002**. Thus, the opened distal end **160** of the implant **150** is heading generally perpendicular to, and towards, the anterior boundary segment **3004**.

As shown in FIG. **11**C via the implant **150** and implant arm **104** shown in dashed lines, in one embodiment, the

implant **150** enters the posterior inferior access region **2016**, and is further advanced into the caudal region **1086** of the sacroiliac joint articular region **1044**, in an orientation such that the implant arm **104** and keels **152** are in the joint plane and the fin **212** of the keels **152** next to the inferior boundary segment **3002** are somewhere between being generally parallel to the inferior boundary segment **3002** (as illustrated by the solid-lined implant **150** in FIG. **11**C) or forming an angle AJ with the inferior boundary segment **3002** of up to approximately 50 degrees. Thus, the distal end **160** of the implant shown in dashed lines can be said to head anywhere from generally perpendicular to, and towards, the anterior boundary segment **3004** to heading generally towards the superior-anterior corner **3012**, or points in between.

In one embodiment, the implant **150** may be first directed into the joint space as illustrated by the solid-lined implant **150** in FIG. **11**C after which the implant **150** is rotated within the joint space to be positioned somewhere between, and including, angled position depicted by the dashed-lined implant **150**. In other embodiments, the implant **150** may be first directed into the joint space as illustrated by the dashed-lined implant **150** in FIG. **11**C after which the implant **150** is rotated within the joint space to be positioned somewhere between, and including, the parallel position depicted by the solid-lined implant **150**. Thus, an implant **150** may be delivered non-transversely (i.e., within the joint and not across the joint) into the caudal region **1086**, the cranial portion **1087**, or partially within each of the caudal and cranial regions **1086**, **1087** of the sacroiliac joint articular region **1044**. Further details of the implant delivery can be found in related applications, such as U.S. patent application Ser. No. 12/998,712, filed Jan. 13, 2011, entitled "SACROILIAC JOINT FIXATION FUSION SYSTEM," which is incorporated by reference herein in its entirety.

C. Accessing and Preparing the Sacroiliac Joint for Implant and/or Anchor Delivery

Now that an overview of the relevant anatomical landmarks and positioning of an implant non-transversely within the sacroiliac joint has been described, the discussion may now focus on delivery of an anchor and/or and implant into the surgical site. In doing so, reference will be made to FIGS. **12**A-**12**H, among additional figures, which are steps in the methodology and illustrated in the same transverse cross section taken in along a plane extending medial-lateral and anterior posterior. In this cross section, articular surfaces **1016** are covered by a thick layer of articular cartilage with a joint space existing between them, the FIGS. **12**A-**12**H are simplified for illustrative purposes and do not show these features to scale.

Now referring primarily to FIG. **12**A, an embodiment of the method can include the step of placing a patient under sedation prone on a translucent operating table (or other suitable surface). The sacroiliac joint **1000** can be locally anesthetized to allow for injecting a radiographic contrast **1046** (as a non-limiting example, Isoview **300** radiographic contrast) under fluoroscopic guidance into the inferior aspect of the sacroiliac joint **1000** to outline the articular surfaces **1016** of the sacroiliac joint **1000**) defined between the sacrum **1004** and ilium **1005**, the sacroiliac joint **1000** having an interarticular region **1044**. Injection of the radiographic contrast **1046** within the sacroiliac joint **1000** can be accomplished utilizing a tubular member **1047** (e.g., a syringe needle) having first tubular member end **1048** which can be advanced between the articulating surfaces **1016** of the sacroiliac joint **1000** and having a second tubular member end **1049** which removably couples to a hub **1050**. The hub **1050** can be configured to removably couple to a syringe barrel **1051** or other device to contain and deliver an amount of radiographic contrast **1046**. In the example of a syringe barrel **1051**, the syringe barrel **1051** can have an internal volume capable of receiving an amount of the radiographic contrast **1046** sufficient for outlining the articular surfaces **1016** of the sacroiliac joint **1000**, for example, under lateral fluoroscopy. A plunger **1052** can be slidingly received within the barrel **1051** to deliver the radiographic contrast **1046** through the tubular member **1047** into the sacroiliac joint **1000**. The tubular member **1047** can have a gauge in the range of about 16 gauge and about 20 gauge and can further be incrementally marked on the external surface to allow determination of the depth at which the first needle end **1048** has advanced within the sacroiliac joint **1000**. As the first needle end **1048** advances into the sacroiliac joint **1000** the radiographic dye **1046** can be delivered from within the syringe barrel **1051** into the sacroiliac joint **1000** to allow visualization of the sacroiliac joint **1000** and location of the tubular needle **1047** within the sacroiliac joint **1000**.

Now referring primarily to FIG. **12**B, once the first tubular member end **1048** has been sufficiently advanced into the sacroiliac joint **1000** and the articular surfaces **1016** of the sacroiliac joint **1000** have been sufficiently visualized, the hub **1050** can be removed from the tubular member **1047** leaving the tubular member **1047** fixed within the sacroiliac joint **1000** as an initial guide for tools subsequently used to locate or place the sacroiliac joint implant non-transversely between the articulating surfaces **1016** of the sacroiliac joint **1000** (e.g., locate the implant non-transversely to the joint plane **1030** generally defined by the articulating surfaces **1016** of the interarticular region **1044** of the sacroiliac joint **1000**) or in removal of a portion of the sacroiliac joint **1000** within the region defined by the articular surfaces **1016** to generate an implant receiving space **1029** (shown in FIG. **12**H). Alternately, one or more guide pins **1013** can be inserted along substantially the same path of the tubular member **1047** for fixed engagement within the sacroiliac joint **1000** and used in subsequent steps as a guide(s).

Now referring primarily to FIG. **12**C, a small incision **1053** can be made in the skin at the posterior superior, or as to certain embodiments inferior, aspect of the sacroiliac joint **1000**, extending proximal and distal to the tubular member **1047** along the line of the sacroiliac joint **1000** to provide a passage to access the interarticular space between the articulating surfaces **1016** (see FIG. **12**B) of the sacroiliac joint **1000**. More specifically, the small incision **1053** can be made along the joint line of the sacroiliac joint **1000** in the tissue covering the posterior inferior access region **2016** of the sacroiliac joint articular region **1044**. A cannulated probe **1054** can be slidingly engaged with the tubular member **1047** (or guide pin **1013**) extending outwardly from the sacroiliac joint **1000** (while the sacroiliac joint may be shown in the figures as being substantially linear for illustrative purposes, it is to be understood that the normal irregular features of the sacroiliac joint have not been removed). The cannulated probe **1054** can have a probe body **1054** of generally cylindrical shape terminating in a spatulate tip **1055** at the end advanced into the sacroiliac joint **1000**. A removable cannulated probe handle **1056** couples to the opposed end of the probe body **1054**. The spatulate tip **1055** can be guided along the tubular needle **1047** or guide wire **1013** into the posterior portion of the sacroiliac joint **1000** and advanced to the anterior portion of the sacroiliac joint **1000** under lateral fluoroscopic visualization. The cannulated probe handle **1056** can then be removed providing the generally cylindrical probe body

1054 extending outwardly from the sacroiliac joint 1000 through the incision 1053 made in the skin.

Alternatively, the probe 1054 can be used to guide, advance or place a needle, guide wire or other instrument up to, near, or into the joint.

Additionally, in particular embodiments, probe handle 1056 or the opposed end of the probe body 1054, or both, can be configured to have an interference fit or a luer lock hub to communicate with a syringe barrel 1051 in order to advance contrast, in situ curable biocompatible materials, stem cells, or etc. through the cannulated probe 1054 or cannulated probe handle 1056.

Now referring primarily to FIG. 12D, a passage from the incision 1053 (see FIG. 12C) to the sacroiliac joint 1000 can be generated by inserting a cannula 1057 into the incision. A soft tissue dilator 1058 having a blunt end 1059 can be advanced over the probe body 1054, or a plurality of soft tissue dilators of increasing size, until the blunt end 1059 of the soft tissue dilator 1058 and the corresponding cannula end contact the posterior aspect of the sacroiliac joint 1000. More specifically, in one embodiment, the ends of the dilator 1058 and cannula 1057 contact the joint line 2019 of the sacroiliac joint 1000 at the posterior inferior access region 2016 of the sacroiliac joint articular region 1044. The soft tissue dilator 1058 can be removed from within the cannula 1057. The external surface of the cannula 1057 can be sufficiently engaged with the surrounding tissue to avoid having the tissue locate with in the hollow inside of the cannula 1057. A non-limiting embodiment of the cannula 1057 provides a tubular body having substantially parallel opposed side walls which terminate in a radius at both ends (lozenge shape) into which a plurality of different jigs can be inserted. Alternatively, as a non-limiting example, according to particular embodiments, cannula 1057 and corresponding dilators 1058 and alignment jigs 1060 can be configured to have tubular bodies with an elliptical or circular cross section.

In some embodiments, the cannula 1057 may be additionally configured to have within or near its walls a light source such as, for example, a fiberoptic or a LED light source to assist in visualization of the working area. Also, in some embodiments, irrigation and suction tubing may communicate with the inside passage of cannula 1057.

At this stage or at other stages of the methodology, additional tools and methods may be employed to provide access to the sacroiliac joint 1000 as described in U.S. patent application Ser. No. 13/475,695 filed May 18, 2012 entitled "SYSTEMS FOR AND METHODS OF FUSING A SACROILIAC JOINT," which is hereby incorporated by reference in its entirety. Additionally, at this stage or others, the sacroiliac joint 1000 may be surgically prepared for a fusion procedure using various tools and methods described in U.S. patent application Ser. No. 14/514,221 filed Oct. 14, 2014 entitled "SYSTEMS FOR AND METHODS OF PREPARING A SACROILIAC JOINT FOR FUSION," which is hereby incorporated by reference in its entirety.

Now referring to FIG. 12E, a cannulated drill bit 1070 can be advanced over the probe body 1054 and within a drill guide hole of the first drill jig 1067. The cannulated drill bit 1070 under fluoroscopic guidance can be advanced into the interarticular region 1044 between the articulating surfaces 1016 of the sacroiliac joint 1000 to produce a first bore 1071 (shown in broken line) to a determined depth. As to certain embodiments of the method, an amount of articular cartilage or other tissues from between the articular surfaces 1016 of the sacroiliac joint 1000 can be removed sufficient to allow embodiments of the sacroiliac joint implant 150 to be implanted in replacement of the removed articular cartilage or tissue. Because the method removes the degenerative articular cartilage or tissue between the articular surfaces 1016 of the sacroiliac joint 1000, the articular surfaces 1016 of the sacroiliac joint 1000 can remain intact or substantially intact allowing the sacroiliac joint implant 150 to be non-transversely located between the articular surfaces 1016 of the sacroiliac joint 1000. Understandably, other instruments can be utilized separately or in combination with a cannulated drill bit 1062 for the removal of articular cartilage or tissue between articular surfaces 1016 such as: box chisels, side cutting router bits, burs, flexible burs and bits, hole saws, curettes, lasers (such as CO2, Neodymium/YAG (yttrium-aluminum-garnet), argon, and ruby), electrosurgical equipment employing electromagnetic energy (the cutting electrode can be a fine micro-needle, a lancet, a knife, a wire or band loop, a snare, an energized scalpel, or the like) where the energy transmitted can be either monopolar or bipolar and operate with high frequency currents, for example, in the range of about 300 kHz and about 1000 kHz whether as pure sinusoidal current waveform where the "crest factor" can be constant at about 1.4 for every sinus waveform, and a voltage peak of approximately 300 V to enable a "pure" cutting effect with the smallest possible coagulation effect or as amplitude modulated current waveforms where the crest factor varies between 1.5 and 8, with decreasing crest factors providing less of a coagulation effect. Electrosurgical waveforms may be set to promote two types of tissue effects, namely coagulation (temperature rises within cells, which then dehydrate and shrink) or cut (heating of cellular water occurs so rapidly that cells burst). The proportion of cells coagulated to those cut can be varied, resulting in a "blended" or "mixed" effect. Additionally, a fully rectified current, or a partially rectified current, or a fulguration current where a greater amount or lateral heat is produced can be employed to find the articular surfaces of the joint and aid in advancing a probe or guide wire into a position in between the articulating surfaces. These currents can effectively degrade the cartilage and allow advance into the joint without grossly penetrating much beyond the cartilage.

Now referring to FIG. 12F, as to certain embodiments, the first drill jig 1067 can be removed from within the cannula 1057 and a second drill jig 1072 can be advanced over the probe body 1054 and received within the cannula 1057; however, the methodology is not limited to any particular number of drill jigs and as to certain embodiments of the method the first drill jig 1067 can include all the required drill guide hole(s) 1068 (or slots or other configurations of the drill guide) and as to other embodiments of the method a plurality of drill jigs can be utilized in serial order to provide all the drill guide holes 1068. As to the particular embodiment shown by the Figures, the first drill jig 1067 can provide one or more additional drill guide holes 1068 which guide in relation to the first bore 1071*a* second or more cannulated drills 1062 of the same or different configuration to be inserted within and advanced into the sacroiliac joint 1000 to produce a second bore 1073 (generally shown in broken line as 1071/1073) or a plurality of bores within the sacroiliac joint 1000 spaced apart in predetermined pattern to allow removal of sufficient articular cartilage 1016 or other tissue from the interarticular space of sacroiliac joint 1000 for placement of embodiments of the sacroiliac joint implant 150 within the region defined by and between the paired articular surfaces 1016 of the sacroiliac joint 1000. As to certain methods described herein, the first drill jig 1067 or the second drill jig 1072 or a plurality of drill jigs can be utilized in serial order to remove a portion of the sacroiliac

joint **1000** for generation of an implant receiving space **1029** (shown in FIG. **12**H). As these embodiments of the method, articular cartilage or other tissues and sufficient subchondral bone can be removed from between the articular surfaces **1016** of the sacroiliac joint **1000** sufficient to allow placement of certain embodiments of the sacroiliac joint implant **150** and one or more keel or fin **152**, **212** receiving channels **1074** can be cut into at least one of the articular surfaces **1016** of said sacroiliac joint **1000** sufficient to receive other embodiments of the sacroiliac implant **150**. The one or more keel or fin receiving channels **1074** can be cut a depth into the subchondral, cortical bone or cancellous bone of the sacrum **1004** or ilium **1005**.

Now referring primarily to FIG. **12**G, in a subsequent step, the last in the serial presentation of drill jigs **1067**, **1072** can be removed from within the cannula **1057** and a broach jig **1075** can be advanced over the probe body **1054** to locate within the cannula **1057**. The broach jig **1075** can include a broach guide hole **1076** which receives a first broach end **1077** of a cannulated broach **1078** advanced over the probe body **1054**. The first broach end **1077** can have a configuration which can be advanced into the sacroiliac joint **1000**. As to certain embodiments of the method, the first broach end **1077** can be adapted to remove an amount of articular cartilage and other tissue from between the articular surfaces **1016** within the articular region **1044** of the sacroiliac joint **1000** for non-transverse placement of a sacroiliac joint implant **150** As to other embodiments of the method, the cannulated broach **1078** can remove a sufficient portion of the sacroiliac joint **1000** to generate an implant receiving space **1029** to receive embodiments of the sacroiliac joint implant **150**.

As a non-limiting example, FIG. **12**G shows a broach **1078** configured to remove a portion of the sacroiliac joint **1000** to produce an implant receiving space **1029** (shown in FIG. **12**H) to receive embodiments of the sacroiliac joint implant **150** such that the broach has an outer surface and outer surface cross section along its length which may generally or substantially match the implant **150** outer surface profile including the keels and fins **152**, **212**.

D. Utilizing the Delivery Tool Described Herein to Deliver an Anchor and/or Implant into the Surgical Site

As mentioned previously, the delivery tool described herein may be used to deliver an anchor transversely across the plane of the sacroiliac joint and to subsequently deliver an implant non-transversely within the plane of the joint such that the anchor is positioned within the graft window of the implant. The delivery tool described herein may also be used to deliver the implant and to subsequently deliver the anchor in the described orientation. While the method discussed herein will focus on the delivery of the anchor and then the implant, the steps of the method may be modified to first deliver the implant and then the anchor.

To begin, reference is made to FIG. **13**A, which is a posterior view of a hip region **1002** of a skeletal structure **1006** and an isometric view of an anchor arm **102** approaching a lateral surface of an ilium **1005**. As seen in the figure, the distal end **116** of the anchor arm **102** may be coupled with a proximal end **118** of an anchor element **120** and the distal end **124** of the anchor element **120** may be positioned to be delivered non-transversely or across the sacroiliac joint **1000**. In this case, the distal end **124** of the anchor element **120** is positioned to be delivered first through the ilium **1005** and then through the sacrum **1004**. The anchor arm **102** may, however, be positioned to deliver the anchor element **120** non-transversely first through the sacrum **1004** and then through the ilium **1005**.

Although not shown in FIG. **13**A, a sleeve may extend through an incision in the patient's soft tissue such that a distal end of the sleeve is positioned generally against the lateral surface of the ilium **1005**. The anchor arm may then be positioned within the sleeve and guided to the surface of the ilium **1005**. In this arrangement, a longitudinal axis of the sleeve may be such that it is generally coaxial with a longitudinal axis of the anchor arm **102**.

The anchor arm **102** may be positioned to deliver the anchor element **120** through the sacroiliac joint articular region **1044** (as seen in FIG. **11**B). And, since the delivery tool **100** described herein includes a rotating joint at the connection of the positioning arm **106** and the implant arm **104** (as seen in FIG. **1**), the exact trajectory of the anchor arm **102** relative to the sacroiliac joint **1000** need not be exact. That is, the rotating joint allows for adjustment such that the anchor element **120** may be delivered in a range or orientations relative to the sacroiliac joint and the delivery tool may be adjusted via the rotating joint so that the implant may be delivered into the joint with the anchor positioned within the graft window of the implant.

Turning now to FIG. **13**B, which is the same view of the hip region **1002** as in FIG. **13**A, once the anchor arm **102** is positioned relative to the sacroiliac joint **1000**, the anchor arm **102** may be advanced relative to the ilium **1005** to deliver the anchor element **120** through the ilium **1005**, the sacroiliac joint **1000**, and sacrum **1004**. The anchor element **120** may be rotationally advanced by a surgeon rotating the anchor arm **102** by hand or by a drill (not shown). Additionally, a drill may be used to predrill a pilot hole in which the anchor arm **102** will subsequently be used to deliver the anchor element **120** within the pilot hole.

Once the anchor element **120** is delivered, the positioning arm **106** may be coupled with the anchor arm **102**, as illustrated in FIG. **13**C, which is a top view of the hip region **1002** of the skeletal structure **1006** looking caudal. As seen in the figure, the positioning arm **106** is slidably coupled with the anchor arm **102**. In particular, the anchor shaft **108** is received within one of the collars **126** of the positioning arm **106**. In this particular arrangement, the anchor shaft **108** is positioned within the particular collar **126** that is in-plane with the positioning member **128**.

Turning to FIG. **13**D, which is the same view of the hip region **1002** of the skeletal structure **1006** as FIG. **13**C, the implant arm **104** is coupled with the positioning arm **106**. One method of coupling the implant arm **104** and the positioning arm **106** is by extending the distal end **146** implant arm **104**, being uncoupled with the implant **150**, through the channel **130** of the positioning arm **106** and, then, coupling the implant **150** with the implant arm **104**. Other methods may include extending the implant arm **104**, being coupled with the implant **150**, through the channel of the positioning arm **106**; that is, if the implant **150** is of a small enough size to fit through the channel **130**.

As seen in FIG. **13**D, the portion of the implant shaft **140** having the pair of members **192** is positioned within the channel **130**. And, the amount of distal movement of the implant arm **104** relative to the channel **130** is limited by the enlarged body **260** of the handle assembly **142**, which is configured to contact the proximal edge **132** of the channel **130** and restrict further distal movement of the implant arm **104**.

Once the implant arm **104** is positioned within the channel **130** of the positioning arm **106**, the implant arm **104** may be aligned to deliver the implant **150** within the sacroiliac joint **1000**. Various adjustments to the various components of the delivery tool **100** may be made while keeping the anchor

arm **102** in place. As an example, the rotation or twist A_{tw} along a longitudinal axis of the implant arm **104** and, thus, the implant **150** may be adjusted to align the implant **150** with the plane of the sacroiliac joint **1000**. More particularly, the twist A_{tw} of the implant **150** may be adjusted so that the keels **152** are positioned within the plane of the joint. The amount of twist A_{tw} is restricted to the geometric configuration of the members **192** extending off the implant shaft **140**. Thus, if the implant arm **104** is able to twist into a particular orientation without being "locked" or restricted from further movement within the channel **130**, then the particular orientation is such that it will deliver the implant **150** into an appropriate orientation relative to the pre-delivered anchor element **120**.

As another example of an adjustment to the components of the delivery tool **100**, the implant arm **104** may translate B_{tr} within the channel **130** towards either of the opposite end walls **138**. A similar translational adjustment C_{tr} may be performed by translating the positioning arm **106** via sliding the collar **126** on the anchor shaft **108** of the anchor arm **102**. As stated previously, the positioning arm **106** may be secured in position on the anchor shaft **108** by, for example, fasteners (e.g., set screw, clamp). Or, the positioning arm **106** may freely translate C_{tr} and rotate D_{rt} on the anchor shaft **108**. If the translation C_{tr} and rotation D_{rt} is secured in position on the anchor shaft **108**, the implant arm **104** may be translationally adjusted B_{tr} within the channel **130** to accomplish a similar or the same function.

Another example of an adjustment to the components of the delivery tool **100** includes adjusting an angle E_{ag} of delivery of the implant **150**. The implant arm **104** may be angled within the channel **130** to align the implant **150** in a trajectory that will position the implant **150** within the sacroiliac joint **1000**. Such an adjustment may be necessary depending on the relative angle of delivery of the anchor element **120** with respect to the lateral surface of the ilium **1005**.

Once the implant arm **104** is aligned in a trajectory that will align the implant **150** within the sacroiliac joint **1000**, the implant arm **104** may be distally advanced relative to the sacroiliac joint **1000**, as illustrated in FIG. **13**E, which is the same view of the hip region **1002** of the skeletal structure **1006** as FIG. **13**C-**13**D. As seen in FIG. **13**E, the implant arm **104** is distally advanced such that the distal end **264** of the enlarged body **260** of the handle assembly **142** abuts the proximal edge **132** of the channel **130** of the positioning arm **106**. In this orientation, as shown in FIG. **13**F, which is a side view of the hip region **1002** of the skeletal structure **1006** with the ilium removed to show the sacroiliac joint **1000** and sacrum **1004**, the anchor element **120** is positioned within the graft window **158** of the implant **150**. Also as seen in FIG. **13**F, the implant **150** is inserted into the caudal region **1086** of the articular region **1044** of the sacroiliac joint **1000** such that the keels **152** are positioned within a plane of the joint. In this way, the graft window **158** allows for bone growth through the implant **150** (i.e., through the graft window **158**) and across the joint **1000**.

In certain embodiments, the implant **150** may be first directed in the joint space as illustrated in FIG. **13**F after which the implant **150** is rotated D_{rt} within the joint space to be positioned somewhere between the cranial and caudal portions **1087**, **1086** of the articular region **1044**. In other embodiments, the implant **150** is not rotated, but simply inserted into the articular region **1044**.

Once the implant **150** and anchor element **120** are delivered into their respective locations, the implant arm **104** and the anchor arm **102** may be decoupled from the implant **150** and the anchor element **120**. The implant **150** may be decoupled from the implant arm **104** by rotationally engaging the head **258** on the handle assembly **142**. This engagement threadably releases the implant retainer **144** from the implant **150**. The anchor element **120** may be decoupled from the anchor arm **102** by rotationally engaging the head **168** of the anchor retainer **114**. This engagement threadably releases the anchor retainer **114** from the anchor element **120**. Once disengaged, the anchor arm **102**, the implant arm **104**, and the positioning arm **106** may be removed and the surgical procedure may continue.

III. Additional Embodiments of the Delivery Tool and Implants

A. Positioning Arm with Angulating Collars

Various modifications to the delivery tool **100** discussed herein are possible and contemplated by the present disclosure. One such modification to the positioning arm **306** is illustrated in FIGS. **14**A-**14**F. As seen in FIG. **14**A, the positioning arm **306** is similar to the positioning arm previously described in that it includes an arcuate positioning member **328** extending between a channel **330** and a pair of collars **326**. The channel **330** is identical to previously described embodiments in that it is formed by generally parallel side walls **336** and rounded end walls **338** that extend from a proximal edge **332** to a distal edge **334**. The channel **330** is configured to receive an implant arm (not shown in FIG. **14**A) and restrain its rotation to a limited, predetermined range. The channel **330** and the implant arm form a rotating joint about which the implant arm may be rotated relative to positioning arm **306** and an anchor arm (not shown in FIG. **14**A), or vice versa.

Opposite the channel **330**, the collars **326** are configured to allow certain predefined angulation of an anchor arm positioned within the collars **326**. The collars **326** include an in-line collar **308** that is positioned in a common plane with the positioning member **328** and an offset collar **310** that is positionally or laterally offset from a plane of the positioning member **328**. While in previously described embodiments of the positioning arm **306** the angling of the anchor arm relative to the positioning arm was restrained, in the present embodiment of the positioning arm **306**, as seen in FIG. **14**A, the collars **326** allow for angulation of an anchor arm positioned within one of the collars **326**.

As illustrated in FIG. **14**B, which is a bottom view of the positioning arm **106**, the in-line collar **308** includes a circular proximal edge **312** and a stadium-shaped distal edge **314**. The offset collar **310** includes a circular proximal edge **316** and a rounded-rectangle-shaped distal edge **318**. As seen in FIG. **14**B, a partition wall **320** having generally parallel side walls **322** separates the in-line collar **308** and the offset collar **310**. The in-line collar **308** also includes an inner side wall **324** that is opposite of and generally parallel with the partition wall **320**. Extending between the inner side wall **324** and the side wall **322** of the partition wall **320** is a rounded wall **340**. Opposite the rounded wall **340** is a sloped wall **342** that extends from a forward end **344** of the circular proximal edge **312** to a forward end **346** of the stadium-shaped distal edge **314**. In this way, an anchor arm positioned within the in-line collar **310** is restrained from angling outside a plane defined by the positioning member **328** by the side wall **322** of the partition wall **320** and the inner side wall **324**. The anchor arm may, however, angulate within the plane that is common to the positioning member **328**.

Turning to the offset collar **310**, as seen in FIG. **14**B, the collar **310** includes a rounded wall **348** that is adjacent the side wall **322** of the partition wall **320**. The offset collar **310**

additionally includes a sloped side wall **350** that is opposite the side wall **322** of the partition wall **320** and a sloped front wall **352** that is opposite the rounded wall **348**. In this way, an anchor arm may be positioned within the offset collar **310** and angled such that an anchor shaft of the anchor arm is positioned against one of the sloped walls **350**, **352**. The offset collar **310** permits more angulation of the anchor arm, as compared with the in-line collar **308**, because the offset collar **310** is configured to position an anchor element at a distal end of an anchor arm outside of a graft window of an implant. Thus, a surgeon has fewer limitations as to where to place the anchor when it is positioned outside the confines of a graft window of the implant. When using the in-line collar **308**, however, there are more limitations because the in-line collar **308** is configured to align an anchor at a distal end of the anchor arm within the graft window of an implant. The angulation of the anchor arm within the in-line collar **308** allows for angulation that will either position the anchor within the graft window of the implant or distal of the graft window of the implant while restricting angulations that would allow the anchor to contact the body of the implant.

Reference is now made to FIG. **14**C, which is an side view of the positioning arm coupled between an anchor arm **360** and an implant arm **362** with a longitudinal cross section down the plane of the positioning member **328**. As seen in the figure, an anchor **364** is positioned within a graft window **366** of an implant **368**. Turning to FIG. **14**D, which is the same view as of FIG. **14**C, except shown in cross section, the proximal edge **312**, in this embodiment, is elongated as opposed to circular. In this arrangement, the anchor arm **360** may be positioned within the in-line collar **308** in a number of orientations. For example, the anchor arm **360** may be positioned along axis AX**1** where the anchor **364** is oriented generally perpendicular to the implant arm **362** and the implant **368**. Further angling of the anchor **364** towards a handle **370** of the implant arm **362** is restricted by the anchor arm **360** contacting a forward edge **372** of the proximal edge **312** and a rear edge **346** of the distal edge **314** of the in-line collar **308**. As seen in FIG. **14**, the anchor arm **360** may angulate away from the implant **366** (i.e., distal of the graft window **368**) along an axis AX**2**. As seen in the figure, the anchor arm **360** may angulate even further past axis AX**2** and will be limited by the particular geometry of the distal and proximal edges **314**, **312**. In this and other embodiments of the positioning arm **306**, an anchor arm **360** positioned within the in-line collar **308** may be configured to angulate between about 0 degrees to about 30 degrees. In certain embodiments, an anchor arm **360** may be configured to angulate from a generally perpendicular orientation relative to an implant arm **362** about 5, 10, or 15 degrees.

Reference is now made to FIG. **14**F, which is a bottom view of the positioning arm **306** with an anchor arm **360** coupled to the offset collar **310** of the positioning arm **306**. As seen in the figure, the anchor arm **360** is positioned along an axis AX**3** that is adjacent and generally parallel with the partition wall **322** and the positioning member **328** such that the anchor **364** is positioned lateral of the graft window **368** of the implant **366**. In this orientation, the anchor **364** avoids contact with the implant **366** in all rotational orientations of the implant **366**. Because of the sloped surfaces on the interior of the offset collar **310**, the anchor arm **360** may pivot about the offset collar **310** and angulate away from implant **366** between axes AX**3** and AX**4**, for example. While not illustrated in FIG. **14**F, when the anchor arm **360** is positioned within the offset collar **310**, the anchor arm **360** may angulate in the manner as described in reference to the in-line collar **308** in FIG. **14**E, among other possible angulations. In this and other embodiments of the positioning arm **306**, an anchor arm **360** positioned within the offset collar **310** may be configured to angulate between: about 0 degrees to about 30 degrees in a plane parallel to the positioning member **328**; and about 0 degrees to about 30 degrees in a plane perpendicular to a plane parallel to the positioning member **328**.

B. Curved Implants with Uni-Planar Rotation and Associated Delivery Tools

The following discussion will focus on FIGS. **15**A-**16**D, which illustrate a delivery tool and implants that are configured for uni-planar rotation relative to the delivery tool. Because of the unique shape of the sacroiliac joint, an implant having a curved shape that generally matches the shape of the sacroiliac joint may be beneficial in a joint fusion, or other, procedure. To facilitate delivery of a curved implant, among other implants, into the sacroiliac joint, a delivery tool allowing for certain rotation of the implant relative to the delivery tool may be desirable.

As illustrated in FIG. **15**A, which is a side view of a delivery tool **400**, a curved implant **402** is coupled to a distal end **404** of the delivery tool **400**. The delivery tool **400** includes a tubular shaft **406** extending proximally from the distal end **404** and includes a handle **408** at a proximal end **410** of the delivery tool **400**. As seen in the figure, the implant **402** is rotationally coupled with the delivery tool **400** via a cylindrical insert **412** that is fitted within a transverse bore **414** to form a plain bearing for the implant **402** to rotate relative to the delivery tool **400**. The implant **402** further includes an upper keel **416** separated from a lower keel **418** by a graft window **420** extending transversely or across the implant **402**. In this embodiment, the upper and lower keels **416**, **418** converge to form a distal tip **422**; however, in other embodiments of the implant **402**, a distal end **424** of the implant **402** may be opened with no convergence of the keels **416**, **418**.

Referring to FIGS. **15**B-**15**C, which are isometric top and bottom views of the delivery tool **400** in an exploded view, the remaining components of the delivery tool **400** are shown. More particularly, the delivery tool **400** further includes an implant retainer **426** having a threaded distal end **428**, a shaft **430** extending proximally from the threaded distal end **428**, and a proximal handle **432**. The delivery tool **400** also includes a proximal insert **434** that is positioned within a proximal opening **436** of the handle **408**.

Coupled between the distal end **402** of the delivery tool **400** and the implant **402** is a coupler **438** that includes a recess **440** on its top surface that matingly receives a pair of spreader members **442** on the distal end **404** of the delivery tool **400**. As seen in the figures, the coupler **438** includes a bore **444** extending therethrough that is coaxially aligned with an internal passageway extending through the tubular shaft **406** when the spreader members **442** of the delivery tool **400** are matingly received in the recess **440** of the coupler **438**. The bottom surface of the coupler **438** includes a curved bearing surface **446** that abuts against a proximal end **448** of the implant **402**. As will be shown in later figures, the shape of the bottom surface of the coupler and the proximal end **448** of the implant are configured to limit the rotation of the implant **402**.

In operation, once the proximal insert **434** is positioned within the proximal opening **436**, the implant retainer **426** may be distally inserted into and through the tubular shaft **406** such that the threaded distal end **428** extends out a distal opening **448** of the tubular shaft **406**. The coupler **438** may be engaged with the spreader members **442** and the threaded distal end **428** of the implant retainer **426** may extend

through the bore **444**. The cylindrical insert **412** may be positioned within the transverse bore **414** and a retainer ring **450** may secure the insert **412** within the bore **414**. As seen in the figures, the cylindrical insert **412** includes a threaded bore **452** that is configured to threadably receive the threaded distal end **428** of the implant retainer **426** to thereby couple the implant **402** and the delivery tool **400**.

As illustrated in FIGS. **15**D-**15**F, which are a close-up, isometric top views of the implant **402** coupled to the delivery tool **400** in different degrees of rotation, the curved bearing surface **446** of the coupler **438** matingly abuts against a proximal surface **462** of the proximal end **448** of the implant **402**. The proximal surface **462** is defined on a proximal surface of each of a pair of bearing members **474**. The pair of bearing members **474** includes a gap defined therebetween such that the threaded distal end **428** may extend through the gap to engage with the bore **452** of the cylindrical insert **412**. As mentioned previously, the geometry of the bottom surface of the coupler **438** influences the amount of possible rotation of the implant **402** relative to the delivery tool **400**. More particularly, in addition to the curved bearing surface **446**, the bottom portion of the coupler **438** includes a first planar surface **454** that extends from the curved bearing surface **446**. The first planar surface **454** acts as a stop feature and is configured to contact a proximal end surface **456** of the upper keel **416** when the implant **402** is rotated in a clockwise direction, as shown in FIGS. **15**D-**15**F. Opposite the first planar surface **454** is a second planar surface **458** that also acts as a stop feature and is configured to contact a proximal end surface **460** of the lower keel **418** when the implant **402** is rotated in a counterclockwise direction, as shown in FIGS. **15**D-**15**F. Thus, the total amount of rotation of the implant **402** relative to the delivery tool **400** is fixed between the first planar surface **454** contacting the proximal end surface **456** of the upper keel **416** and the second planar surface **458** contacting the proximal end surface **460** of the lower keel **418**. As can be understood from the previous discussion, the same delivery tool **400** may be used with different couplers **438** (i.e., having differently shaped curved bottom surfaces and first and second planar surface **454**, **458** arrangements) and corresponding implants **402** to facilitate different degrees of rotation between the implant **402** and the delivery tool **400**. In this and other embodiments, the amount of rotation of the implant **402** relative to the delivery tool **400** may be between about 10 degrees and about 180 degrees. In certain embodiments, the rotation may be about 30, 50, or 90 degrees.

Referring now to FIG. **15**G, which is a cross-sectional view of FIG. **15**F taken along a longitudinal axis of the implant **402**, the first planar surface **454** abuts the proximal end surface **456** of the upper keel **416** such that further rotation is inhibited. As seen in the figure, the threaded distal end **428** extends through the tubular shaft **406** of the delivery tool **400** and through the bore **444** of the coupler **438** to threadably engage with the threaded bore **452** of the cylindrical insert **412**. As seen in FIG. **15**H, which is another cross-sectional view of FIG. **15**F, except the cross-section in the present figure is perpendicular to the longitudinal axis of the implant **402** and bisecting the cylindrical insert **412**, the retainer ring **450** supports a position of the cylindrical insert **412** within the implant **402** when before and after the implant retainer **426** is coupled with the insert **412**.

Referring now another embodiment of an implant **402**, reference is made to FIGS. **16**A-**16**C. As seen in the figures, the implant **402** is similar to the implant **402** shown in FIGS. **15**A-**15**E, except that the distal end **424** of the implant **402** includes an opening **464** such that the upper and lower keels **416**, **418** are cantilevered off of the proximal end **448** of the implant **402** as opposed to coupled together by with a convergent distal tip. Additionally, the present embodiment of the implant **402** differs from that shown in FIGS. **15**A-**15**E in that the proximal surface **462** of the proximal end **448** of the implant **402** allows for increased rotation of the implant **402** relative to the delivery tool **400** because the proximal surface **462** extends circumferentially further between the proximal end surface **456** of the upper keel **416** and the proximal end surface **460** of the lower keel **418**. In this way, when the implant **402** is coupled with the delivery tool **400**, the proximal surface **462** provides increased bearing contact with the curved bottom surface **446** of the coupler **438** such that the implant **402** can rotate further relative to the delivery tool **400** than in the previously described embodiment. In this and other embodiments, the amount of rotation of the implant **402** relative to the delivery tool **400** may be between about 10 degrees and about 200 degrees. In certain embodiments, the rotation may be about 30, 60, or 110 degrees.

As seen in FIG. **16**C, which is a side view of the implant **402** shown in FIGS. **16**A-**16**B, the upper and lower keels **416**, **418** extend outwardly the proximal end **448** of the implant **402** and are separated by a rounded proximal wall **466**. The keels **416**, **418** are generally equidistant from each other from the rounded proximal wall **466** to their termination at the distal end **424** of the implant **402**. As seen in FIGS. **16**A-**16**C, inner and outer surfaces **468**, **470** of the upper and lower keels **416**, **418** are beveled along edges **472** that extend around the keels **416**, **418**. In the embodiment of FIGS. **16**A-**16**C, the lower keel **418** extends a further distance, distally, from the rounded proximal wall **466** in order for the curvature of the top and bottom keels **416**, **418** to match. In this and other embodiments, the curvature of the upper and lower keels **416**, **418** are defined by an arc AR of about 80 degrees with a radius R**1** of about 25 mm to 35 mm and a radius R**2** of about 50 mm to 55 mm. In certain embodiments, the arc AR may be about 40, 50, 60, 70, 80, 90, 100, 110, or 120 degrees and may even be up to 180 degrees, radius R**1** may be about 2, 2.5, 3 or 3.5 cm, and radius R**2** may be about 4, 5, or 6 cm. A width of the keels may be about 1, 1.5, or 2 cm.

While the keels **416**, **418** of the implant **402** shown in FIGS. **16**A-**16**C are of generally equal width, the upper and lower keels **416**, **418** may be of different widths, as shown in FIG. **16**D, which is an isometric view of the proximal end **448** of the implant **402**. As seen in the figure, the upper keel **416** is wider than the lower keel **418**. In certain embodiments, the upper keel **416** may be about 2 cm wide and the bottom keel **418** may be about 1 cm wide.

When implanted into a sacroiliac joint, the implant **402** is configured to extend non-transversely into the joint such that a portion of the upper keel **416** extends into the ilium and an opposite portion of the upper keel **416** extends into the sacrum. Similarly, a portion of the lower keel **418** extends into the ilium and an opposite portion of the lower keel **418** extends into the sacrum. In this way, the graft window **420** of the implant **402** lies within the plane of the joint such that bone growth may pass through the graft window **420**, along with an anchor, to fuse the sacrum and ilium. In certain instances, it may be beneficial to deliver an implant having keels of different widths. And, since the sacrum and ilium are structurally thinner and generally less robust at the inferior boundary segment **3002**, as seen in FIG. **11**C, including an implant **402** with narrower keels at the bottom of the implant **402** may cause less material from the implant to extend into the sacrum and ilium along the thinner and

less robust sections of the bones. In contrast, superior aspects of the sacrum and ilium are thicker and more robust than portions of the sacrum and ilium at the inferior boundary segment **3002**. Thus, the superior portions of the sacrum and ilium may be better suited to receive keels **416** that are relatively wider than keels **418** that are positioned near the inferior boundary segment **3002** of the joint.

C. Implants Having Angled and/or Asymmetrically Shaped End Caps

Reference is now made to FIGS. **17**A-**17**D, wherein FIGS. **17**A-**17**B depict implants **402** with angled end caps **476** and FIGS. **17**C-**17**D depict implants **402** with asymmetrically positioned end caps **478**. First, reference is made to FIGS. **17**A-**17**B. As seen in the FIG. **17**A, the implant **402** includes a cross-shaped cross-section with a pair of keels **480** positioned generally perpendicular to each other. The implant **402** further includes a graft window **420** extending transversely across the implant **402** and intersecting the keels **480**. As seen in FIG. **17**B, the implant **402** includes a pair of keels **480** and a spanning member **482** extending between and generally perpendicular to the pair of keels **480**. A graft window **420** extends transversely across the spanning member **482**. In both embodiments of the implant **402**, there is an angled end cap **476** that extends across the implant non-perpendicularly from a longitudinal axis **484** extending along a length of the implant **402**. Such an orientation of an angled end cap **476** may be useful since, in certain instances, the sacroiliac joint is not perpendicularly aligned with the posterior surfaces of the sacrum and the ilium. As such, with an implant **402** having an angled end cap **476** that is non-perpendicularly aligned with the longitudinal axis **484** of the implant **402** may cause the end cap to lie flush with the posterior surfaces of the sacrum and the ilium. The angle AN, as seen in FIG. **17**A, may be such that when the implant **402** is positioned non-transversely in the sacroiliac joint, the angled end cap **476** lies flush against the posterior surfaces of the sacrum and ilium. In certain embodiments, the angle AN may be about 15, 25, or 35, or be in a range of about 10 to about 50.

Reference is now made to FIGS. **17**C-**17**D, which are the respective implants **402** shown in FIGS. **17**A-**17**B, except the embodiments of the present discussion include asymmetrically positioned end caps **478**. That is, the implants **402** include end caps **478** that do not extend over the entirety of the proximal end **448** of the implant **402**. Instead, the end cap **478** only extends over a portion of the proximal end **448** of the implant. A purpose of the asymmetrically positioned end caps **478** is so that the end cap **478** will contact a posterior surface of either the sacrum or the ilium and, thus, prevent the implant **402** from further extending into the sacroiliac joint while allowing an opposite portion of the proximal end **448** of the implant to extend further into the joint.

As shown in FIG. **17**C, the end cap **478** extends laterally over three of the four keels **480**, but does not extend outward beyond a top surface **486** of one of the keels **480**. As shown in FIG. **17**D, the end cap **478** extends laterally from one half of the implant **402**. In this way, when the implant **402**, of either FIG. **17**A or **17**B, is delivered into the sacroiliac joint such that the graft window **420** is positioned within the plane of the joint such that an anchor may be received through the sacrum, ilium, and graft window **420**, the asymmetrically positioned end cap **478** will inhibit further distal delivery of the implant **402** into the joint by the end cap **478** abutting either the posterior surface of the sacrum or ilium. It is noted that in the implants **402** of FIGS. **17**A-**17**D, it may be desirable to utilize implants **402** that are specific to the procedure because the implants **402** cannot be rotated around the longitudinal axis **484** prior to implantation without changing the orientation of the angled or asymmetrically positioned end cap **478**.

D. Curved Implants with Delivery Tooling Having a Gripping Implant Retainer

The following discussion will focus on FIGS. **18**A-**18**L, which depict the various components of a delivery tool **500** having a gripping mechanism **502** coupling an implant **504** to the delivery tool **500**. As illustrated in FIG. **18**A-**18**B, which are respective front and back isometric views of the delivery tool **500**, the tool **500** includes an implant arm **506**, an impactor **508**, and a lever assembly **510**. The implant arm **506** and the lever assembly **510** work in conjunction with each other to grip a proximal end **512** of the implant **504**. More particularly, the gripping mechanism **502** includes portions of the implant arm **506** and the lever assembly **510** that function to releasably couple with the implant **504**. The implant **504** is curved along a longitudinal axis of the implant **504** and includes an opened distal end **514** as described previously with respect to FIGS. **16**A-**16**D. This and other features of the implant **504** may be similar or different to previously described embodiments.

Reference is now made to FIGS. **18**C-**18**D, which are respective isometric side perspective and isometric side views of the delivery tool **500**. Referring first to the implant arm **506**, it includes a handle **516** at a proximal end **518** that is coupled to a pair of planar, plate-like members **520** that are coupled together by a top wall member **522**. The plate-like members **520** and the top wall member **522** extend to a distal end **524** of the implant arm **506** and define an open interior space that houses a portion of the lever mechanism **510**. The plate-like members **520** include a first, second, and third through holes **540**, **542**, **544** extending transversely across the plate-like member **520** and are configured to rotatably couple portions of the lever mechanism **510**, as will be subsequently described. Near the distal end **524** of the implant arm **506** and extending outwardly from the plate-like members **520** are a pair of cylindrical protrusions **526** that are configured to be engaged with the impactor **508** to distally drive the delivery tool **500** and, thus, the implant **504** into a joint. At the extreme distal end **524** of the implant arm **506** is a fixed retainer member **528** that is cylindrically-shaped, although other shapes are possible for the fixed retainer member **528**. Additionally, the fixed retainer member **528** may articulate, in which case the member would not be fixed. Continuing on, the fixed retainer member **528** is configured to be matingly received within a reciprocally shaped cavity in the proximal end **512** of the implant. The fixed retainer member **528** is a part of the gripping mechanism **502** and will be subsequently discussed in more detail.

Moving on to the lever mechanism **510**, the mechanism includes a lever handle **530** that includes a cramming head **532** at a distal end **534** of the lever handle **530**. The camming head **532** includes a first axle bore **536** extending generally through a central portion of the camming head **532**. The camming head **532** is rotatably coupled to the implant arm **506** by a first shaft **538** (e.g., pin, rod, rivet) that extends through the first axle bore **536** and through the first through hole **540** to anchor the lever handle **530** to the implant arm **506**. The camming head **532** further includes a second axle bore **546** positioned proximal-inferior of the first axle bore **536**. The camming head **532** is rotatably coupled to a distal lever member **548** by a second shaft **550** extending through the second axle bore **546** in the camming head **532** and a through hole in the distal lever member **548**. The distal lever member **548** includes a curved proximal section **552** and a

straight distal section **554** that is rotatably coupled to a gripper member **556** by a third shaft **558** extending through a third axle bore **560** at the distal end **562** of the straight distal section **554** and a through hole on the gripper member **556**.

The gripper member **556** is pivotally coupled to the implant arm **506** at the third through hole **544** by a fourth shaft **564** extending through a fourth axle bore **566** positioned in a central portion of the gripper member **556**. The gripper member **556** includes a distal lip **568** that is configured to grip the proximal end **512** of the implant **504**. In this way, translation of the distal lever member **548** causes the gripper member **556** to pivot about the fourth shaft **564** and, thus, pivot the distal lip **558** in a gripping motion to engage the proximal end **512** of the implant **504**.

Positioned within the implant arm **506** is a lever retaining member **570** that is anchored to the second through hole **542** in the implant arm **506** via a fifth shaft **572**. The lever retaining member **570** is positioned inferior of the straight distal section **554** of the distal lever member **548** and is configured to maintain a level orientation of the distal lever member **548** when the lever handle **530** is rotated about the first shaft **538**. The level retaining member **570** includes a spring-biased pin **574** that is positioned in a recess **576** near a distal end **578** of the member **570** and is configured to support the straight distal section **554** in the level orientation.

Reference is now made to the impactor **508** in FIGS. **18**C-**18**D. As seen in the figures, the impactor **508** includes an impact plate **580** at a proximal end **582** of the impactor **508**. Moving distally from the impact plate **580** is a shaft **584** that couples to a tubular U-shaped member **586**. A proximal portion **588** of impacting arms **590** are configured to be positioned within and secured to the U-shaped members **586**. The impacting arms **590** include a shaft **592** that extends distally and terminates in a semi-circular bearing surface **594** that is configured to contact the cylindrical protrusions **526** on the implant arm **506**. The impactor **508** also includes a sixth shaft **596** and a spacer **598** that couples between the pair of impacting arms **590** near the proximal portion **588** of the impacting arms **590**.

Turning now to FIGS. **18**E-**18**F, which are side views of the delivery tool **500**, the impactor **508** is positioned in various orientations relative to the implant arm **506**. More particularly, in FIG. **18**E, the impactor **508** is shown in a superior position relative to the implant arm **506**, and, in FIG. **18**F, the impactor **508** is shown in an inferior position relative to the implant arm **506**. As seen in the figures, the impactor **508** may be used in these and other orientations to assist in driving the implant **504** into a patient's joint. For example, upon initial delivery of the distal end **600** of the implant into the joint, the surgeon may place the impactor **508** in an inferior position, as in FIG. **18**F, because the impactor **508** is then in line with a trajectory of the distal tips **602** as they enter the joint. At other points in a surgical procedure, the surgeon utilize the impactor **508** in the superior position, as in FIG. **18**E.

Reference is now made to FIG. **18**G, which is an isometric side view of the delivery tool **500** with a cross section down a longitudinal axis of the tool **500**. As seen in the figure, the implant **504** is locked within the gripping mechanism **502** by complementary action of the fixed retainer member **528** and the distal lip **568** of the gripping member **556**. In this locked position, the lever handle **530** is generally parallel to the handle **516** of the implant arm **506**, the distal lever member **548** is in a proximal-most position, and the gripping member **556** is pivoted in a counterclockwise-most direction to cause the distal lip **568** to retain the proximal end **512** of the implant **504** in abutting contact with the delivery tool **500**.

As seen in FIG. **18**H, which is a close-up view of the gripping mechanism **102** shown in FIG. **18**G, the implant **504** includes a cylindrically shaped recess **604** on a top portion of the proximal end **512** of the implant **504** that is configured to receive the fixed retaining member **528**. The cylindrically shaped recess **604** extends into the proximal end **512** of the implant **504** at an approximate 45 degree angle. Inferior to the cylindrically shaped recess **604** is a notch **606** that is configured to receive a corresponding corner edge **608** of the distal end **524** of the implant arm **506**. At a bottom portion of the proximal end **512** of the implant **504** is an elongated recess **610** having a superiorly and proximally extending terminal end **612**. In this way, the distal lip **568** of the gripping mechanism **556** may extend in the elongated recess **610** and grasp the superiorly and proximally extending terminal end **612** upon closure of the lever handle **530**, which causes counterclockwise pivoting of the gripping member **556** and gripping of the implant **504**. Also, as shown in FIG. **18**H, the spring-biased pin **574** urges the distal end **562** of the straight distal section **554** into a parallel orientation with the top wall **522** of the implant arm **506**. The spring-biased pin **574** may also function as a stop feature to inhibit further counterclockwise pivoting of the gripping member **556**.

Referring now to FIG. **18**I, which depicts a cross-sectional side view of the delivery tool **500**, the lever handle **530** is opened by counterclockwise rotation of the lever handle **530**. As seen in the figure, as the lever handle **530** is rotated, the camming head **532** rotates, which causes the distal lever member **548** to translate distally. The distal movement of the distal lever member **548** causes the gripping member **556** to pivot clockwise and, thus, release the distal lip **568** from its grip on the terminal end **612** of the elongated recess **610** on the bottom portion of the proximal end **512** of the implant **504**.

As the distal lip **568** further releases from the elongated recess **610**, as seen in FIG. **18**J, the implant **504** pivots relative to the distal end **524** of the implant arm **506** to release the fixed retainer member **528** from engagement with the cylindrical recess **604**. As the implant **504** is fully released from coupling with the gripping mechanism **102**, as shown in FIG. **18**K, the lever handle **530** is in a fully opened position. The delivery tool **500** is then ready to releasably couple with the implant **504**, if desired, by positioning the fixed retainer member **528** within the cylindrical recess **604** of the proximal end **512** of the implant **504** and closing the lever handle (i.e., clockwise rotation), which will cause the distal lip **568** of the gripper mechanism **556** to pivot counterclockwise and grip the superiorly and proximally extending terminal end **612** of the elongated recess **610** of the implant **504**. At that point, the impactor **508** (not shown) may be used and positioned in a superior or inferior position relative to the implant arm **506**.

As illustrated in FIGS. **18**I-**18**L, the implant **504** may include anti-migration elements **614** on inner walls **616** of the keels **618**. The anti-migration elements **614** may include ramped structures, surface deformities, or any other feature to inhibit proximal, or other, migration of the implant **504** once implanted into the joint. Multiple anti-migration elements **614** may positioned on the inner walls **616** of the keels **618**. Additionally, the anti-migration elements **614** may be positioned on outer walls of the keels **618** or on the outer and inner walls **616** of the keels **618**.

E. Alternative Implant Embodiments

Reference is now made to FIGS. **19**A-**19**F, which depict various views of an implant **700** for use with delivery tools described herein, among other delivery tools. Initially referring to FIGS. **19**A-**19**B, which are respective isometric top and bottom views of the implant **700**, the implant **700** includes a top planar keel member **702** and a bottom planar keel member **704** that are coupled together at a proximal end **706** of the implant **700** by a tubular member **708** defining a bore **710** therein. The top planar keel member **702** includes a sacrum section **712** and an ilium section **714** that are separated by an elastically deformable structural element **716**. Similarly, the bottom planar keel member **704** includes a sacrum section **718** and an ilium section **720** that is separated by an elastically deformable structural element **722**. In this or other embodiments, the structural elements **716**, **722** may be inelastically deformable.

Still referring to FIGS. **19**A-**19**B, the top planar keel member **702** extends distally further than the bottom planar keel member **704**. A graft or anchor window **724** is formed distal of the tubular member **708** and in between inner surfaces of the top and bottom planar keel members **702**, **704**. Projecting inward from the inner surfaces of the top and bottom planar keel members **702**, **704** are generally perpendicular flanges **726** the run the length of the members **702**, **704**. At a distal end **728** of the keel members **702**, **704**, the flanges **726** include a rounded taper **730**.

As illustrated in FIGS. **19**C-**19**D, which are respective top and bottom views of the implant **700**, the implant **700** is symmetric about the sacrum sections **712**, **718** and ilium sections **714**, **720**. And, when delivered into the sacroiliac joint such that the sacrum sections **712**, **718** are positioned within the sacrum and the ilium sections **714**, **720** are positioned within the ilium, the deformable structural elements **716**, **722** lie in the plane of the joint. In this way, inward pressure from the sacrum or ilium can cause deformation of the deformable structural elements **716**, **722** and, thus, provide some "give" to the implant **504** without driving apart the sacrum or ilium. As seen in these figures, the top and bottom planar keel members **702**, **704** include longitudinally extending cylindrical grooves **732** extending the length of the implant **700**. FIG. **19**E depicts a back isometric view of the implant **700** illustrating the features previously described. And, FIG. **19**F depicts a back view of the implant **700** further illustrating the features described herein.

The following discussion will focus on FIGS. **20**-**28**, which depict the various components of a delivery tool **820** having an adjustable delivery system with a slidable anchor arm and configured to inject a bone paste material, or any other biocompatible material into an implant **825**.

As illustrated in FIG. **20**, according to certain aspects, the anchor arm **8115** may be adjustable to accommodate patients of different sizes and/or fine-tune the anchor element trajectory while still maintaining the angular relationships between the components of a system within a predefined range to allow the anchor element **120** to be delivered relative to the implant **825**, for example, through the graft window **840** without any further adjustment to the delivery tool **820**. As illustrated in FIG. **20**, the anchor arm **8115** may be slidably attached at one end to a guide beam **8102**. The guide beam **8102** may be attached to the implant arm **8110** at one end **8103** and protrude from the implant arm **8110** in a cantilevered configuration, wherein the protrusion angle of the guide beam **8102** is configured to result in a predetermined anchor entry angle through the implant **825**. The anchor arm **8115** may be provided with a slidable fitting **8104** at an end **8106** opposite to the anchor arm collar **8165**. In this aspect, the slidable fitting **8104** may be translated along the guide beam **8102** to adjust the distance between anchor arm collar **8165** and implant **825**, while maintaining the angular relationships maintained between the implant arm **8110**, anchor arm **8115**, anchor arm collar **8165**, and the graft window **840**.

Referring now to FIG. **21**, the delivery tool **820** may be configured to inject a bone paste material, or any other biocompatible material into an implant **825**. In one aspect, the implant arm **8110** may be provided with a conduit **8506** that opens into the graft window **840** of the implant **825**. As illustrated in FIG. **21**, the proximal end of the conduit **8506** may be provided with a plunger **8508** that may be depressed distally within a close-fitting barrel **8510** formed within the proximal end **880** of the implant arm **8110**. The plunger **8508** may provide a pressure that may cause the bone paste material or other biocompatible material to flow distally through the conduit **8506** and out into the graft window **840** of the implant **825**.

Referring now to FIG. **22**, the conduit **8506** may terminate distally at a distal opening **8512** that provides a path for the bone paste material to pass into the graft window **840** of the implant **825**. In an aspect, the conduit **8506** may narrow in a nozzle **8514** ending distally at the distal opening **8512**. The nozzle **8514** may be sized to fit within an orifice within the implant **825** including, but not limited to the bore **710** illustrated, for example at FIGS. **19**A and **19**F. In this other aspect, the nozzle **8514** may be sized to fit closely within the bore **710**. In an aspect, the nozzle **8514** may be provided with threads configured to mesh within threads of a threaded bore **710**.

Referring now to FIG. **23**, the barrel **8510** may include a lumen **8516** within which the bone paste material may be inserted prior to injection into the graft window **840**. The plunger **8508** may further include a distal end **8518** configured to fit closely within the lumen **8516** in order to develop pressure within the lumen when the plunger **8508** is advanced distally into the lumen **8516**. In one aspect, the plunger **8508** may be advanced by applying a distally directed force to the plunger handle **8520**. In another aspect, the plunger **8508** may further include a threaded portion **8522** configured to mesh with corresponding threads **8524** formed within the barrel **8510**. In this aspect, the plunger may be advanced distally by twisting the threaded portion **8522** into the corresponding threads **8524**.

Referring to FIG. **24**, the bone paste material may advance outward into the graft window **840** of the implant **825** at the initial stage of the injection process, along a path **8526**. As the graft window **840** fills with bone paste material and the pressure within the graft window increases, additional bone paste material may enter the joint space (not shown) surrounding the implant **825**. In an aspect, the implant **825** may be provided with a plurality of channels **8528** connecting the volume within the graft window **840** to the joint space surrounding the implant **825**. In this aspect, additional bone paste material may travel through the plurality of channel **8528** to the joint space along a path **8530**. In various aspects, an amount of bone paste material sufficient to fill the graft window as well as the joint space surrounding the implant may be introduced using the delivery tool in the various aspects described herein above.

Reference is made to FIGS. **25**-**28**, which depict additional views of the implant **825**. In particular, FIG. **25** illustrates a top isometric view of the delivery tool **820** and implant **825**, FIG. **26** illustrates a close-up isometric view of the implant **825** and distal end of the delivery tool **820**, FIG. **27** illustrates a close-up isometric view of the implant **825**

and the delivery tool **820** from an opposite side as FIG. **26**, and FIG. **28** illustrates a cross-sectional side view of the distal end of the delivery tool **820** and the implant **825**.

As seen in FIG. **23**, the anchor arm **8115** may be slidably coupled with a guide beam **8515** of the implant arm **8110**. The guide beam **8515** may be attached to the implant arm **8110** at one end and protrude from the implant arm **8110** in a cantilevered configuration, wherein the protrusion angle of the guide beam **8515** is configured to result in a predetermined anchor entry angle relative to the implant, for example, through the implant **825**. The anchor arm **8115** may be provided with a slidable fitting **8517** at an end opposite the anchor arm collar **8519**, as seen in FIG. **25**. In this way, the slidable fitting **8517** may be translated along the guide beam **8515** to adjust the distance between the anchor arm collar **8519** and the implant **825**, while maintaining the angular relationship between the arms **8110**, **8115**, the collar **8519**, and the implant bore **840**.

Referring to the implant **825**, as shown in FIGS. **21-22** and FIGS. **24-28**, it includes a distal or leading end **8521**, a proximal or trailing end **8523**, a longitudinally extending body or intra-articular member **8525**, a first and second bore or void **840**, **841** extending across the body **8525**, and keels, fins, or planar members **8527** that extend outwardly away from the body **8525**. The shape of the body **8525** is L-shaped, boot-shaped, or generally a shape matching a sacroiliac joint of a human. More particularly, the body **8525** includes a rectangular body portion **8529** and a projection **8531** at the distal end **8521** of the body **8525** of the implant **825**. The first void **840** extends through the rectangular body portion **8529** and the second void **841** extends through the projection **8531**. As best seen in FIGS. **26**, **27** and **28**, the keels **8527** extend outward from a superior or top edge **8533** of the rectangular body portion **8529** of the body **8525** of the implant **825**. The keels **8527** extend from the proximal end **8523** to the distal end **8521** and bisect the rectangular body portion **8529** and the projection **8531**.

The implant **825** includes opposite side surfaces **8535** that are generally parallel with each other. The void **840** through the rectangular body portion **8529** is elongate and generally extends from near the proximal end **8523** to near the distal end **8521**. The portion of the body **8525** of the implant **825** defining the distal end **8521** of the implant **825** is tapered to an edge **8537**. At the proximal end **8523** of the implant **825** is a bore **8539** for coupling with the delivery tool **820** and also through which the bone paste material may be injected into the void **840** of the implant **825**.

As seen in FIG. **28**, the first and second voids **840**, **841** are connected by a passageway **8541** so bone paste material injected into the void **840** of the implant **825** can then travel through the passageway **8541** and into the second void **841** in the projection **8531** at the distal end **8521** of the implant **825**.

The foregoing merely illustrates the principles of the embodiments described herein. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein. It will thus be appreciated that those skilled in the art will be able to devise numerous systems, arrangements and methods which, although not explicitly shown or described herein, embody the principles of the embodiments described herein and are thus within the spirit and scope of the present disclosure. From the above description and drawings, it will be understood by those of ordinary skill in the art that the particular embodiments shown and described are for purposes of illustrations only and are not intended to limit the scope of the present disclosure. References to details of particular embodiments are not intended to limit the scope of the disclosure.

What is claimed is:

1. A method of fusing a sacroiliac joint having a sacrum, an ilium, and a sacroiliac joint space defined therebetween, the method comprising:

a) approaching a posterior aspect of the sacroiliac joint space with a joint implant comprising:
  a distal end opposite a proximal end;
  a first side opposite a second side, wherein each of the first and second sides extend between the distal end and the proximal end;
  a top surface extending between both the distal end and the proximal end and the first side and the second side;
  a pattern of openings defined on the top surface, the pattern of openings extending a pattern length between the distal end and the proximal end and extending a pattern width between the first side and second side, the pattern of openings comprising a plurality of openings extending from the top surface into an inner portion of the joint implant via a plurality of channels, respectively;
  an orifice extending from an exterior surface of the proximal end into the inner portion, wherein the orifice is in fluid communication with the plurality of channels via the inner portion;
  an intra-articular member extending away from the top surface;
  a first bone graft window extending between opposite faces of the intra-articular member; and
  a second bone graft window extending between opposite faces of the intra-articular member, wherein the first bone graft window is in fluid communication with the second bone graft window via a passageway so that an amount of biocompatible material is configured to travel from the first bone graft window through the passageway and into the second bone graft window;

b) delivering the joint implant into the sacroiliac joint space through an access region, the joint implant being oriented in the sacroiliac joint space such that the plurality of channels and the orifice are positioned within the sacroiliac joint space thereby bringing the orifice and sacroiliac joint space into fluid communication via the plurality of channels; and

c) injecting the amount of biocompatible material at an initial stage of an injection process into the inner portion via the orifice and with a delivery tool, the delivery tool comprising:
  an implant arm configured to couple with the joint implant;
  a conduit having a proximal opening opposite a distal opening; and
  a plunger configured to force the amount of biocompatible material to flow distally through the conduit, wherein the amount of biocompatible material is sufficient to fill the inner portion.

2. The method of claim **1**, wherein the amount of biocompatible material is advanced outwardly from the distal opening of the conduit and into the inner portion of the joint implant at the initial stage of the injection process along a first path; and, at a subsequent stage of the injection process, the amount of biocompatible material moves from the inner

portion through the plurality of channels via a second path and into the sacroiliac joint space immediately adjacent the top surface.

3. The method of claim **1**, wherein the conduit narrows at the distal opening and is sized to fit closely within the orifice.

4. The method of claim **1**, wherein a distal end of the implant arm comprises a pair of alignment protrusions configured to engage corresponding complementary voids of the joint implant on opposite sides of the orifice.

5. The method of claim **1**, wherein the joint implant comprises a bottom surface opposite the top surface and wherein at least a portion of the intra-articular member extends away from the bottom surface, the intra-articular member comprising a sacral surface opposite an iliac surface, wherein the first side extends away from the sacral surface and the second side extends away from the iliac surface.

6. The method of claim **5**, wherein, when the joint implant is oriented in the sacroiliac joint space such that the intra-articular member is coplanar with the joint plane of the sacroiliac joint space, the first side extends into the sacrum and the second side extends into the ilium.

7. The method of claim **5**, wherein both the first and the second bone graft window extend between the sacral surface and iliac surface.

8. The method of claim **7**, wherein the first bone graft window comprises a proximal end, a top side and a bottom side wherein a junction between the proximal end and the top side comprises a transition slope having a radiused surface.

9. The method of claim **8**, wherein the pattern of openings is positioned distal to the transition slope.

10. The method of claim **9**, wherein the first bone graft window comprises a length extending between the proximal end and distal end of the joint implant and a height extending between the top side and the bottom side of the first bone graft window, the length being greater than the height.

11. The method of claim **10**, wherein the first bone graft window comprises a distal end opposite the first bone graft window proximal end, wherein a distal portion of the joint implant distal to the first bone graft window distal end is configured such that the sacral surface and the iliac surface transition to a tapered wedge arrangement at a distal most end of the joint implant.

12. The method of claim **11**, wherein a distal most tip of the joint implant distal most end extends further distally than the top surface.

13. The method of claim **1**, wherein the plurality of openings are staggered as they extend the pattern length such that a second opening of the plurality of openings is offset from first and third openings of the plurality of openings towards the first side and defining the pattern width.

14. The method of claim **13**, wherein a fourth opening of the plurality of openings is offset from the first and third openings toward the second side.

15. The method of claim **1**, wherein the pattern length is greater than the pattern width.

16. The method of claim **1**, wherein the first bone graft window is positioned inferior to the top surface while the second bone graft window is positioned superior to the top surface.

17. The method of claim **1**, wherein the passageway is sized larger than any of the plurality of openings.

18. The method of claim **1**, wherein the joint implant comprises an anti-migration element comprising a ramped structure coupled to a surface of the joint implant, the anti-migration element configured to inhibit migration of the joint implant once implanted.

19. The method of claim **1**, wherein the intra-articular member has an L-shaped or boot-shaped configuration, or a shape matching the sacroiliac joint of a human.

20. The method of claim **1**, wherein the plurality of openings comprises a first, a second and a third opening, and wherein each of the first, second, and third openings comprises a circular perimeter.

21. The method of claim **1**, wherein the plurality of openings comprises a first, a second and a third opening and wherein each of the first, second, and third openings comprises a perimeter having a pair of parallel sides.

22. The method of claim **1**, wherein the plurality of openings comprises a first, a second and a third opening, and wherein the first and second openings are separated by a strut extending between the first and second sides of the joint implant, wherein the strut comprises a first termination and a second termination opposite the first termination, and wherein at least one of the first and second terminations is positioned in closer proximity to the proximal end of the joint implant while at least one of the second and first terminations is positioned in closer proximity to the distal end of the joint implant.

23. The method of claim **22**, wherein the strut is configured such that the strut is deformable in response to inward pressure from the sacrum or ilium.

24. The method of claim **23**, wherein the strut is elastically deformable.

25. The method of claim **23**, wherein the strut is inelastically deformable.

26. A method of fusing a sacroiliac joint having a sacrum, an ilium, and a sacroiliac joint space defined therebetween, the method comprising:

a) approaching a posterior access region of the sacroiliac joint space with a joint implant comprising:
   a first keel defining a plurality of openings therein, the plurality of openings extending through the first keel to opposite sides of the first keel via a plurality of channels, respectively;
   an intra-articular member coupled with the first keel, the intra-articular member defining an inner cavity therein, wherein one of the opposite sides of the first keel defines at least a portion of the inner cavity;
   an orifice extending from an exterior surface of the joint implant into the inner cavity, wherein the orifice is in fluid communication with the plurality of channels via the inner cavity;
   a first bone graft window extending between opposite faces of the intra-articular member; and
   a second bone graft window extending between opposite faces of the intra-articular member, wherein the first bone graft window is in fluid communication with the second bone graft window via a passageway so that an amount of biocompatible material is configured to travel from the first bone graft window through the passageway and into the second bone graft window;
b) delivering the joint implant into the sacroiliac joint space through the posterior access region, the joint implant being oriented in the sacroiliac joint space such that: the intra-articular member is positioned within a joint plane of the sacroiliac joint space; and, the plurality of channels and the orifice are positioned within the sacroiliac joint space thereby bringing the orifice and sacroiliac joint space into fluid communication via the plurality of channels; and

c) injecting the amount of biocompatible material into the inner cavity via the orifice and with a delivery tool.

27. The method of claim **26**, wherein the delivery tool comprises:

an implant arm configured to couple with the joint implant;

a conduit having a proximal opening opposite a distal opening; and

a plunger configured to force the biocompatible material to flow distally through the conduit, wherein the biocompatible material is sufficient to fill the inner cavity.

28. The method of claim **26**, wherein the joint implant comprises an anti-migration element comprising a ramped structure coupled to a surface of the joint implant, the anti-migration element configured to inhibit migration of the joint implant once implanted.

29. The method of claim **28**, wherein the anti-migration element is coupled to the first keel.

30. The method of claim **26**, wherein the plurality of openings are staggered as they extend between a joint implant proximal end and a joint implant distal end such that a second opening of the plurality of openings is offset from first and third openings of the plurality of openings towards a first keel edge.

31. The method of claim **30**, wherein a fourth opening of the plurality of openings is offset from the first and third openings toward a second keel edge opposite the first keel edge.

32. The method of claim **26**, wherein the first bone graft window comprises a proximal end, a top side and a bottom side wherein a junction between the proximal end and the top side comprises a transition slope having a radiused surface.

33. The method of claim **32**, wherein the plurality of openings is positioned distal to the transition slope.

34. The method of claim **33**, wherein the first bone graft window comprises a length extending between a proximal end and a distal end of the joint implant and a height extending between the top side and the bottom side of the first bone graft window, the length being greater than the height.

35. The method of claim **26**, wherein the first bone graft window is positioned inferior to the first keel while the second bone graft window is positioned superior to the first keel.

36. The method of claim **26**, wherein the passageway is sized larger than any of the plurality of openings.

37. The method of claim **26**, wherein the plurality of openings includes first, second and third openings each comprising a perimeter having a pair of parallel sides.

38. The method of claim **26**, wherein the plurality of openings includes first, second and third openings and the first and second openings are separated by a strut extending between first and second keel edges, wherein the strut comprises a first termination and a second termination opposite the first termination, and wherein at least one of the first and second terminations is positioned in closer proximity to a proximal end of the joint implant while at least one of the second and first terminations is positioned in closer proximity to a distal end of the joint implant.

39. The method of claim **38**, wherein the strut is configured such that the strut is deformable in response to inward pressure from the sacrum or ilium.

40. A method for fusing a sacroiliac joint having an ilium, a sacrum and a plane therebetween with an implant, the method comprising:

providing an implant having a top surface, wherein the top surface comprises a proximal end, a distal end opposite the proximal end, a first lateral side extending between the distal end and proximal end, and a second lateral side extending between the distal end and proximal end and positioned opposite the first lateral side, a plurality of spaced apart openings defined on the top surface in a pattern, the plurality of spaced apart openings comprising first, second and third openings, wherein the first, second, and third openings each extend an opening length from the top surface into an inner portion of the implant, wherein the pattern is arranged such that: the second opening is positioned between the first and third openings; the first opening is positioned between the proximal end and the second opening; and, the third opening positioned between the distal end and the second opening, the implant further comprising:

an intra-articular member extending away from the top surface;

a first bone graft window extending between opposite faces of the intra-articular member; and

a second bone graft window extending between opposite faces of the intra-articular member, wherein the first bone graft window is in fluid communication with the second bone graft window via a passageway so that an amount of biocompatible material is configured to travel from the first bone graft window through the passageway and into the second bone graft window;

positioning the implant up to the sacroiliac joint;

aligning the implant such that the first lateral side is aligned with a sacrum, the second lateral side is aligned with the ilium and the opening lengths of each of the first, second, and third openings lies in the plane of the joint; and

delivering the implant into the sacroiliac joint such that the first lateral side is positioned within the sacrum, the second lateral side is positioned within the ilium and the opening lengths of each of the first, second, and third openings lies in the plane of the joint.

41. The method of claim **40**, wherein each of the first, second, and third openings comprises a circular perimeter.

42. The method of claim **40**, wherein each of the first, second, and third openings comprises a perimeter having a pair of parallel sides.

43. The method of claim **40**, wherein the first and second openings are separated by a strut extending between the first and second lateral sides wherein the strut comprises a first termination and a second termination opposite the first termination and wherein at least one of the first or second terminations is positioned in closer proximity to the proximal end of the top surface while at least one of the second or first terminations is positioned in closer proximity to the distal end of the top surface.

44. The method of claim **43**, wherein the strut is configured such that the strut is deformable in response to inward pressure from the sacrum or ilium.

45. The method of claim **44**, wherein the strut is elastically deformable.

46. The method of claim **44**, wherein the strut is inelastically deformable.

47. The method of claim **40**, wherein the implant comprises an anti-migration element comprising a ramped structure coupled to a surface of the implant, the anti-migration element configured to inhibit migration of the implant once implanted.

48. The method of claim **40**, wherein the first bone graft window is positioned inferior to the top surface while the second bone graft window is positioned superior to the top surface.

49. The method of claim **40**, wherein the passageway is sized larger than any of the plurality of spaced apart openings.

50. The method of claim **40**, wherein the implant is oriented in the sacroiliac joint such that the intra-articular member is within the joint plane.

* * * * *