US 20250261978A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2025/0261978 A1
(43) Pub. Date: Aug. 21, 2025
Shiner et al.

(54) BONE STABILIZATION SYSTEMS

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(21) Appl. No.: 19/183,986

(22) Filed: Apr. 21, 2025

Related U.S. Application Data

(63) Continuation of application No. 17/509,526, filed on Oct. 25, 2021, now Pat. No. 12,279,795, which is a continuation-in-part of application No. 16/031,066, filed on Jul. 10, 2018, now Pat. No. 11,096,730, which is a continuation-in-part of application No. 15/925,846, filed on Mar. 20, 2018, now Pat. No. 10,856,920, which is a continuation-in-part of application No. 15/703,345, filed on Sep. 13, 2017, now abandoned.

Publication Classification

(51) Int. Cl.

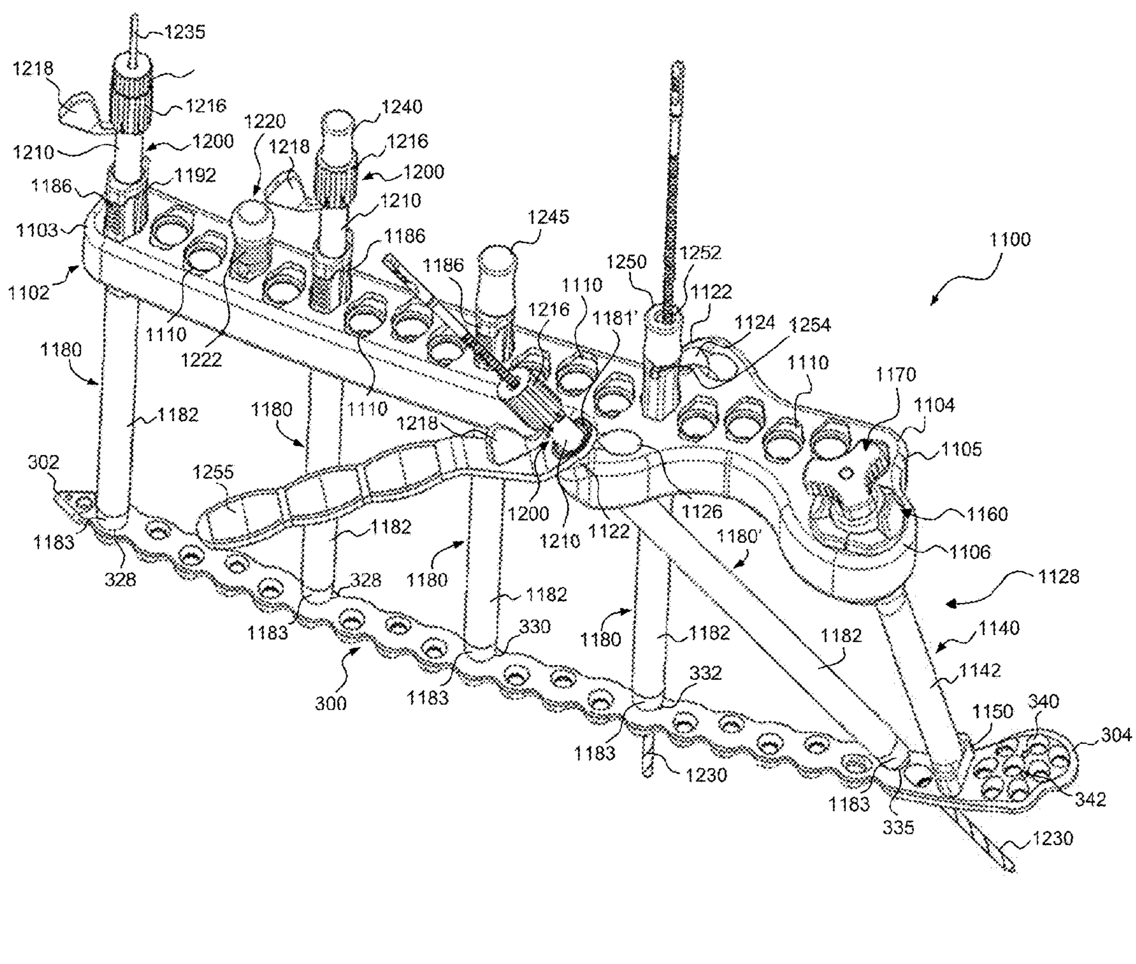
A61B 17/80	(2006.01)
A61B 17/17	(2006.01)
A61B 17/34	(2006.01)
A61B 17/68	(2006.01)
A61B 17/84	(2006.01)
A61B 17/86	(2006.01)
A61B 90/00	(2016.01)

(52) U.S. Cl.

CPC ***A61B 17/8061*** (2013.01); ***A61B 17/1728*** (2013.01); ***A61B 17/3468*** (2013.01); ***A61B 17/3496*** (2013.01); ***A61B 17/8014*** (2013.01); ***A61B 17/8057*** (2013.01); ***A61B 17/808*** (2013.01); ***A61B 17/84*** (2013.01); ***A61B 17/846*** (2013.01); ***A61B 17/86*** (2013.01); ***A61B 17/8665*** (2013.01); ***A61B 17/8695*** (2013.01); *A61B 2017/347* (2013.01); *A61B 2017/681* (2013.01); *A61B 2090/0808* (2016.02)

(57) **ABSTRACT**

An aiming guide system configured for connection to a bone plate including an aiming arm and a connection assembly. The aiming arm has a rigid body extending from a proximal end to a distal end with a plurality of aiming holes defined through the rigid body between the proximal end and the distal end thereof. The distal end defines an attachment slot through the body. The connection assembly is configured to engage an attachment screw hole of the bone plate and the attachment slot such that the aiming arm is fixed in position relative to the bone plate with each of the aiming holes aligned with a respective hole along the bone plate.



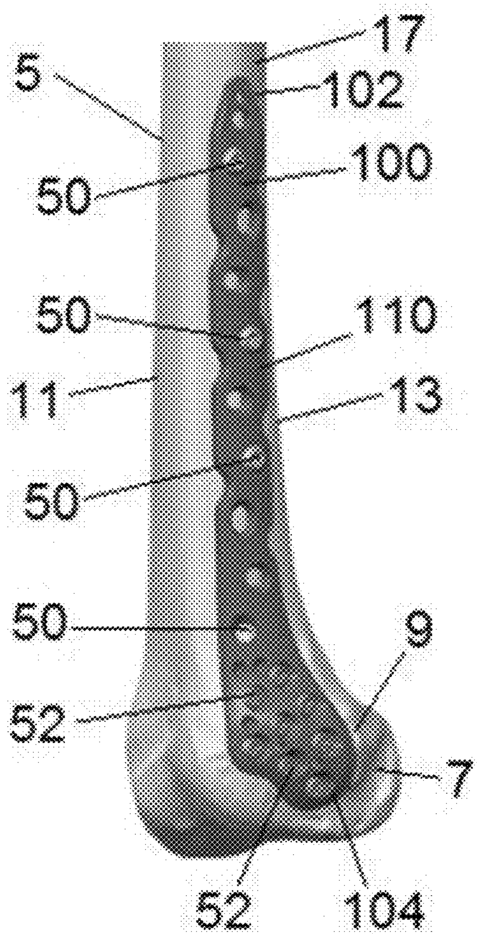


FIG. 1

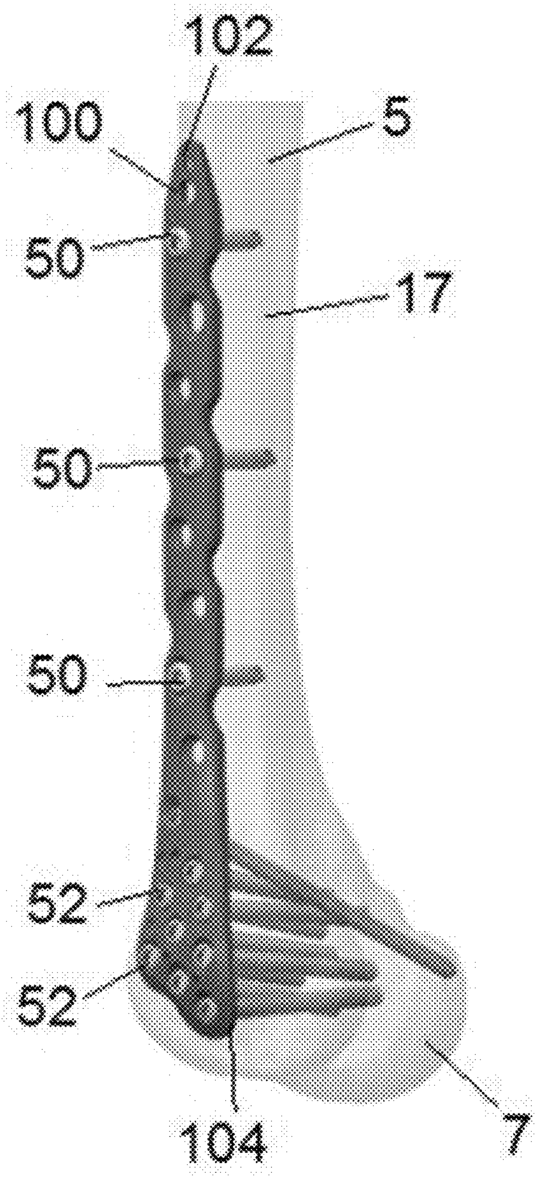
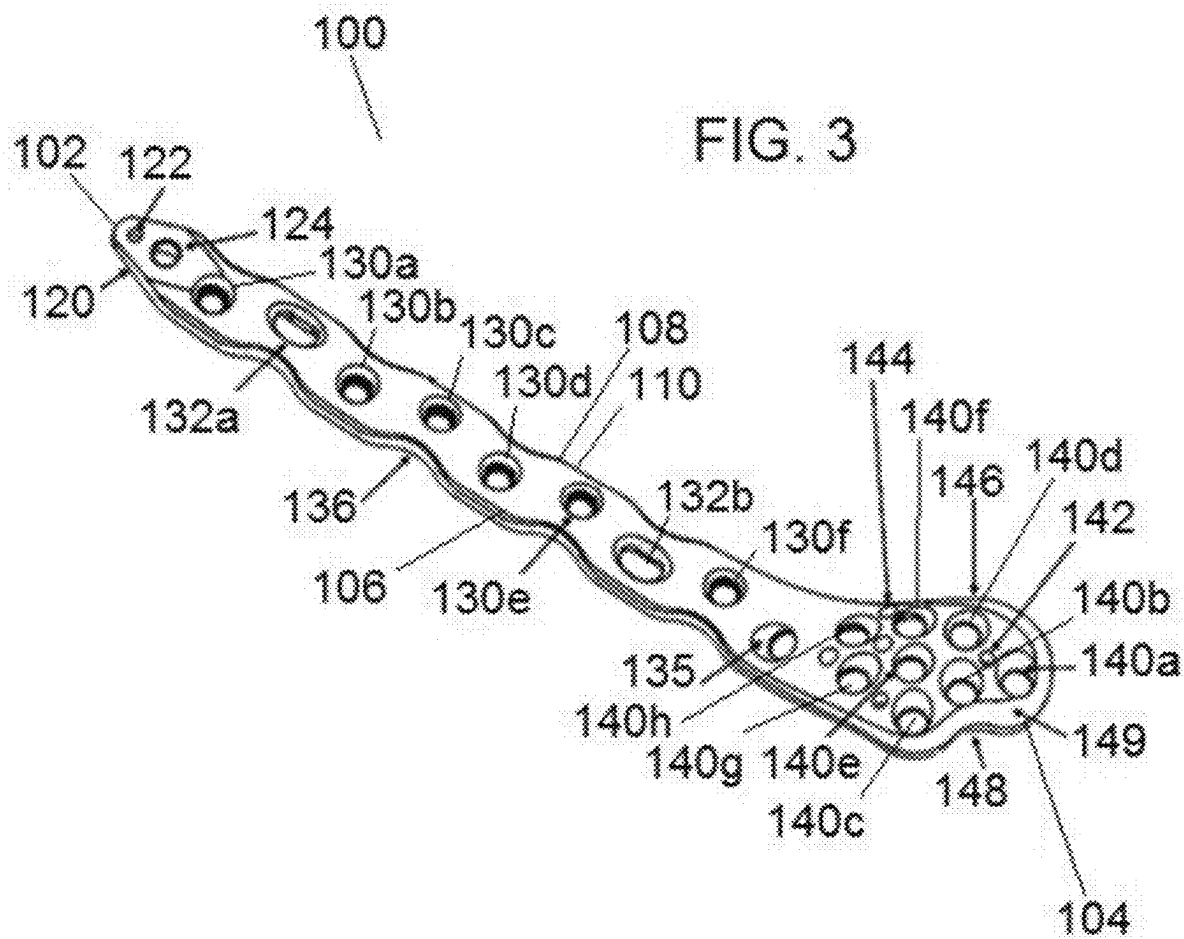


FIG. 2

FIG. 3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140c
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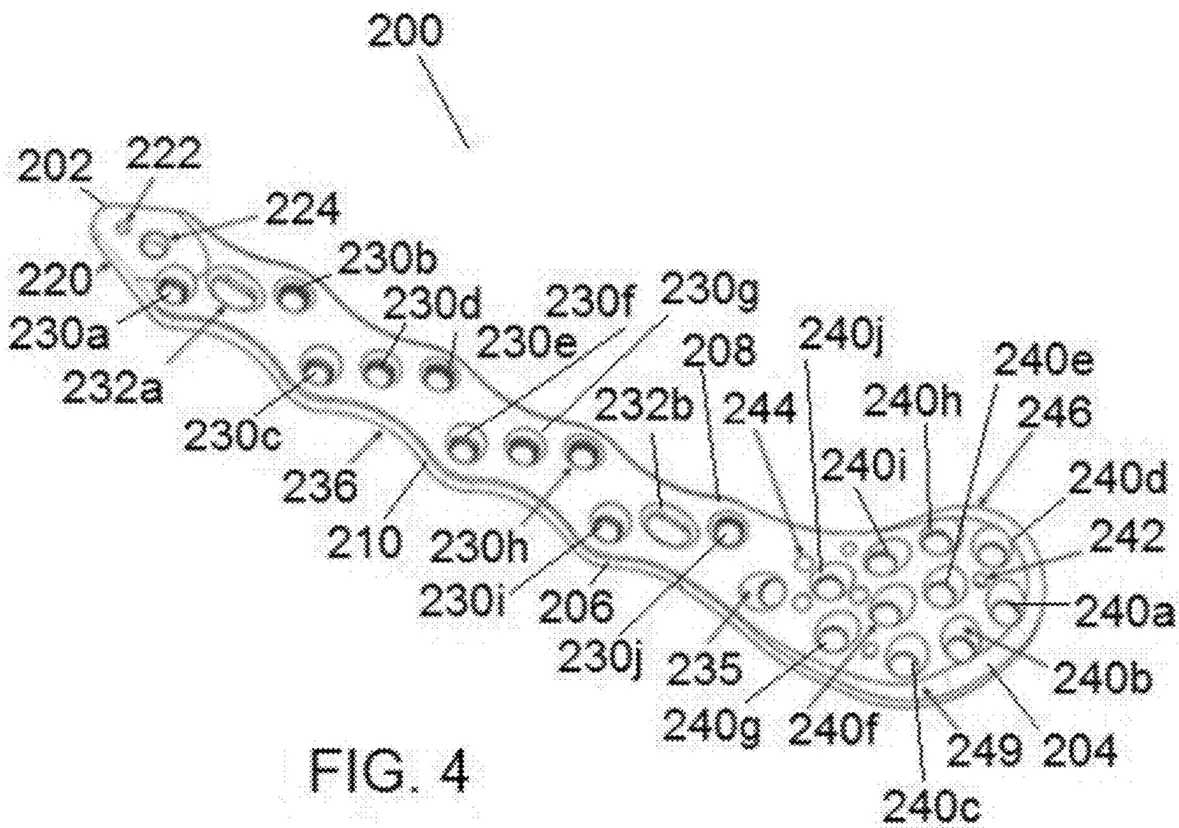
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232b
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240b
240g
240f
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240c

FIG. 4

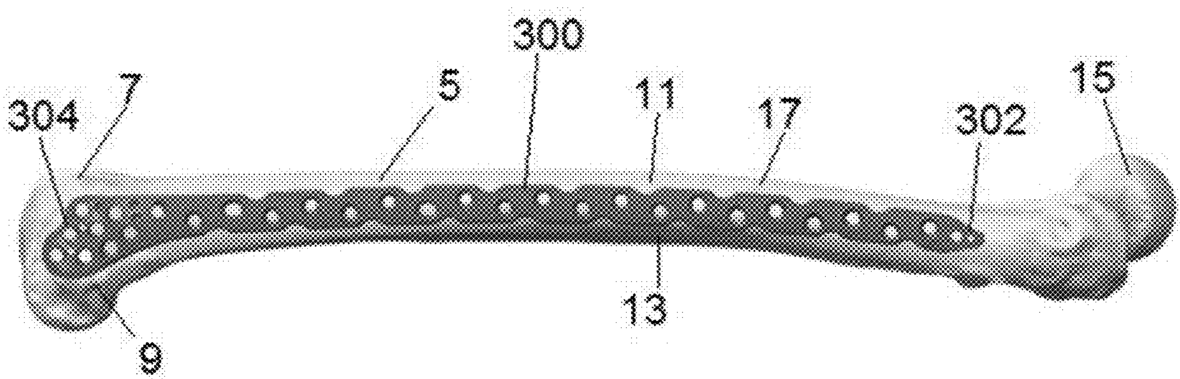
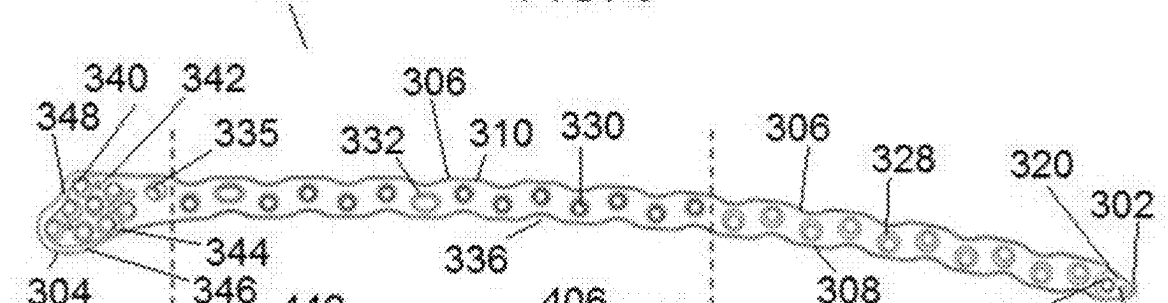


FIG. 5

FIG. 6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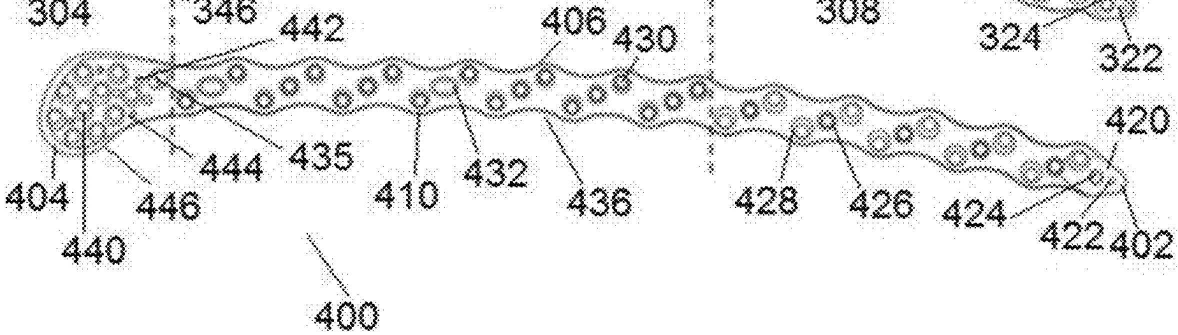
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FIG. 7

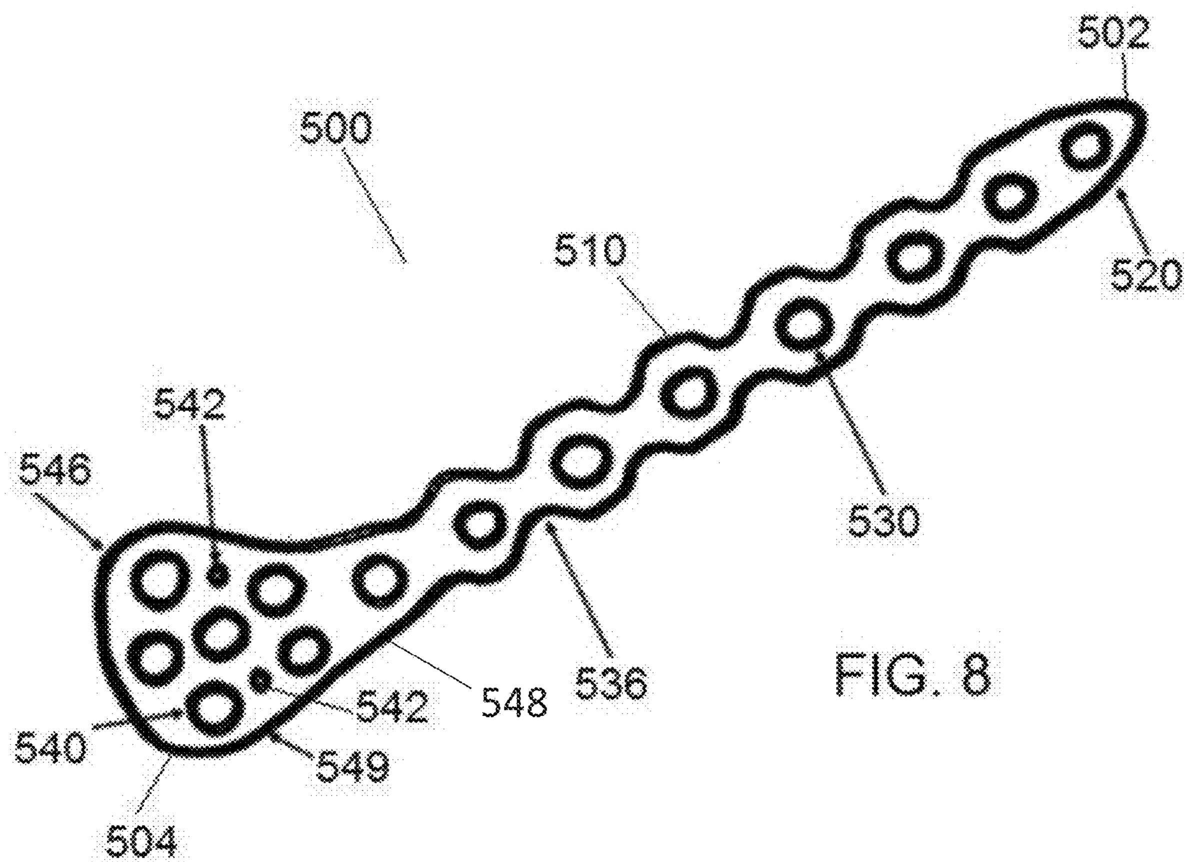


FIG. 8

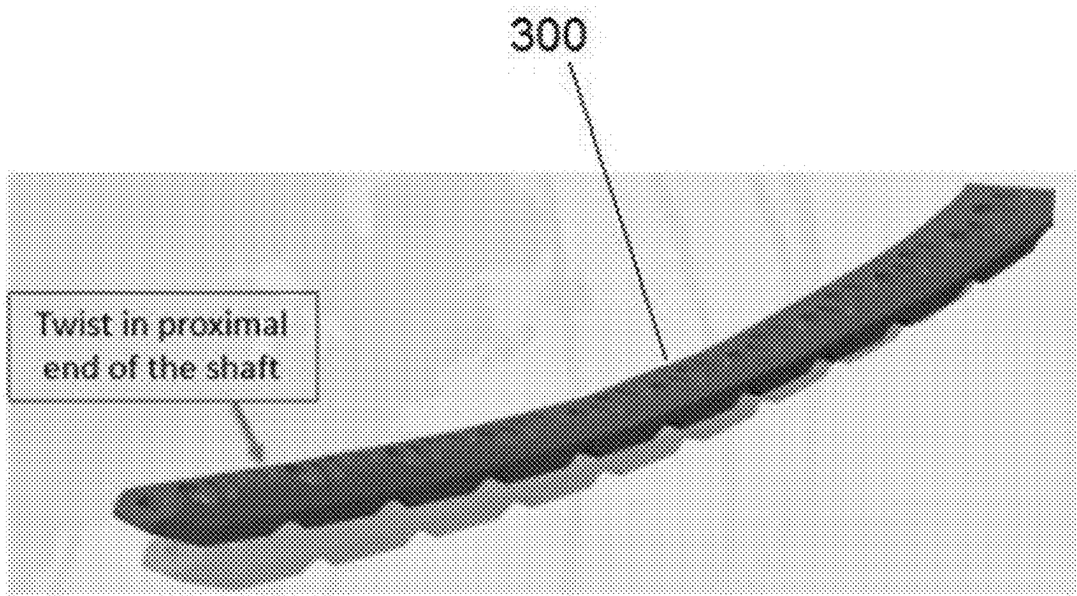
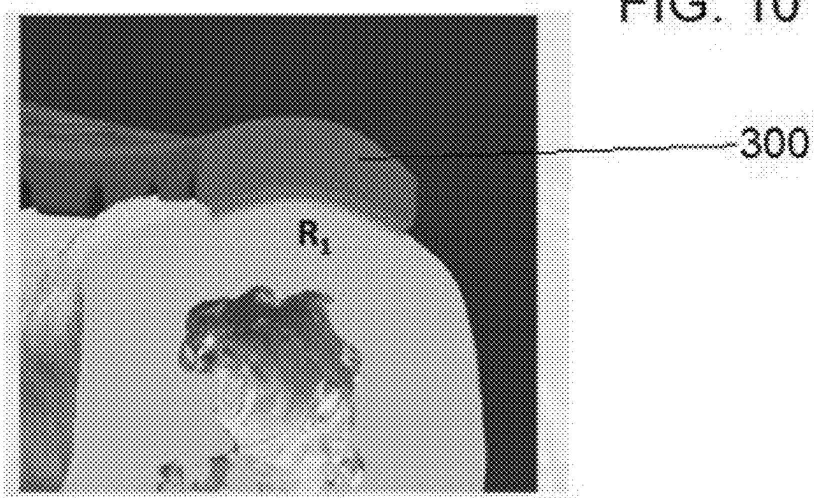


FIG. 9

FIG. 10



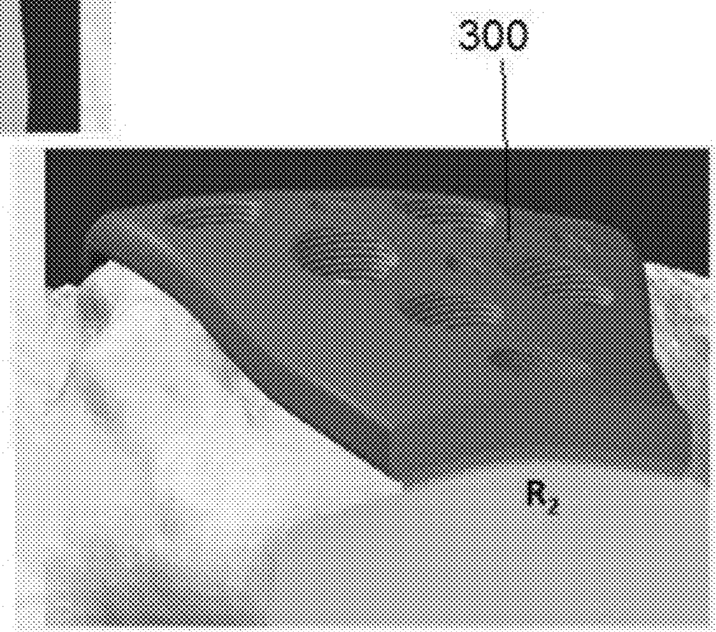
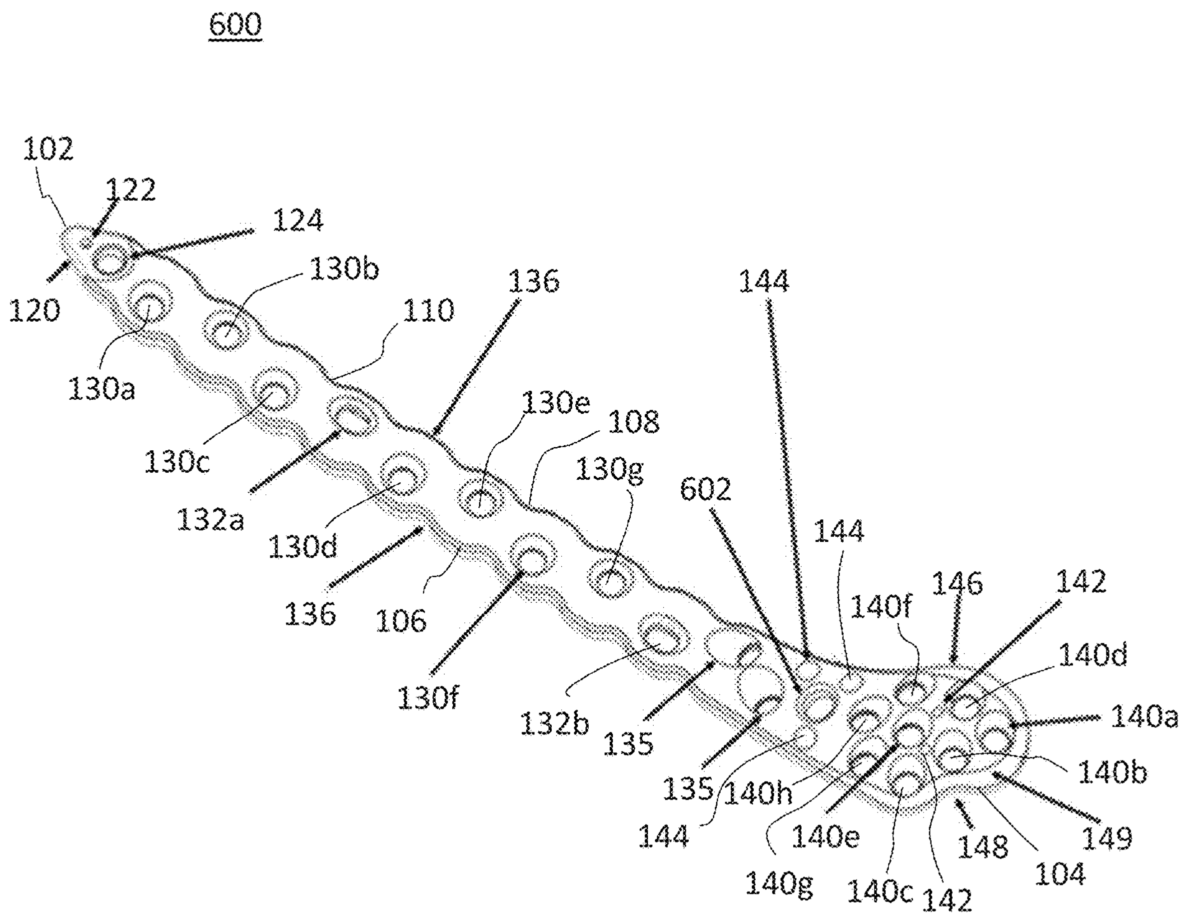


FIG. 11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140f
146
142
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140a
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140h
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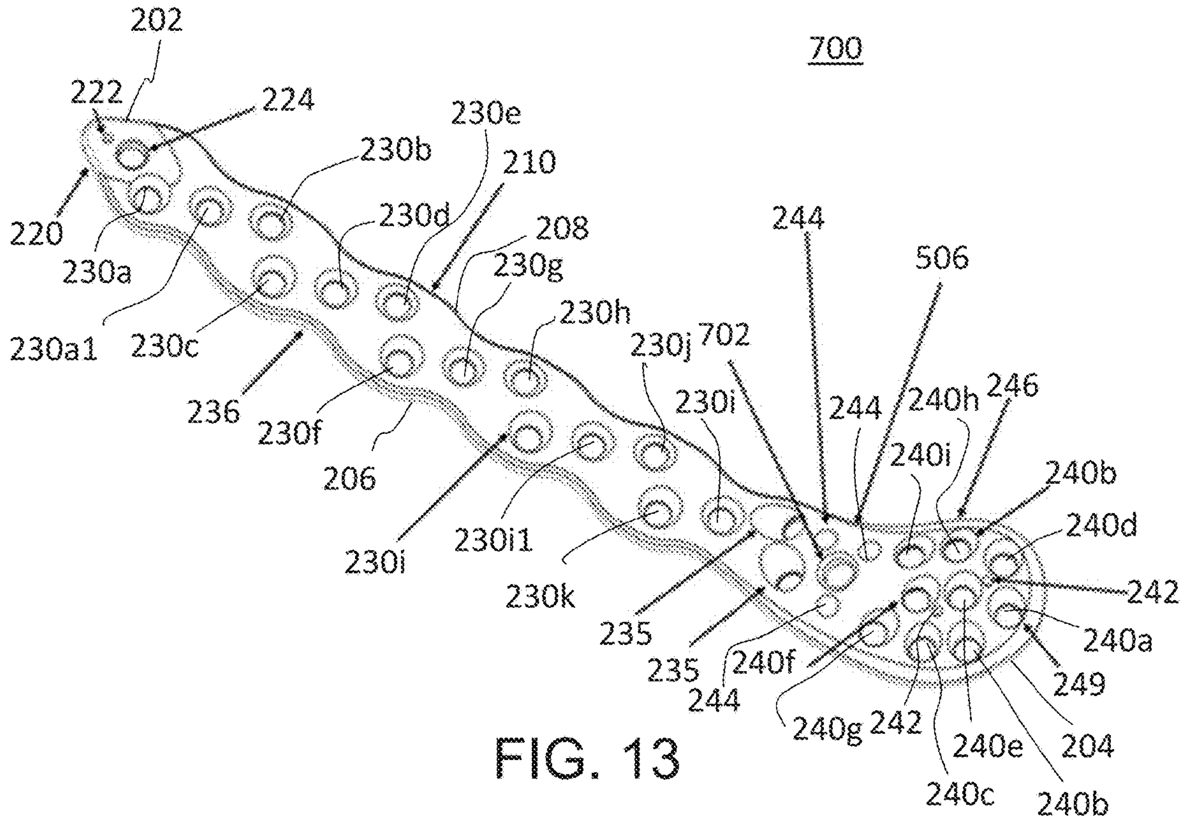
140e
148
149
104
140g
140c
142

FIG. 12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230i
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240h
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240i
240b
240d
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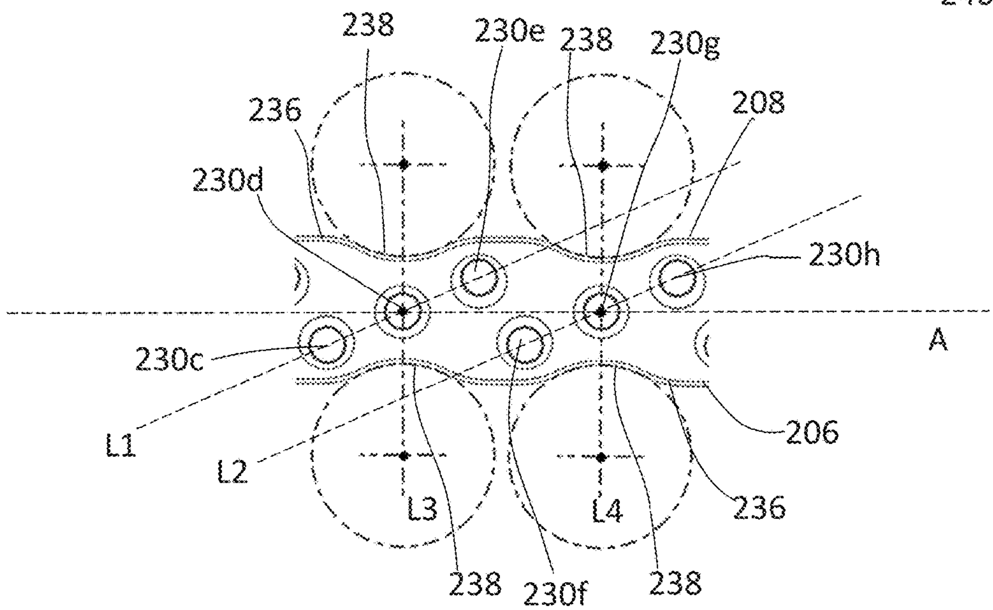
240c
240b

FIG. 13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L1
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L3
L4
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230f
238

FIG. 14

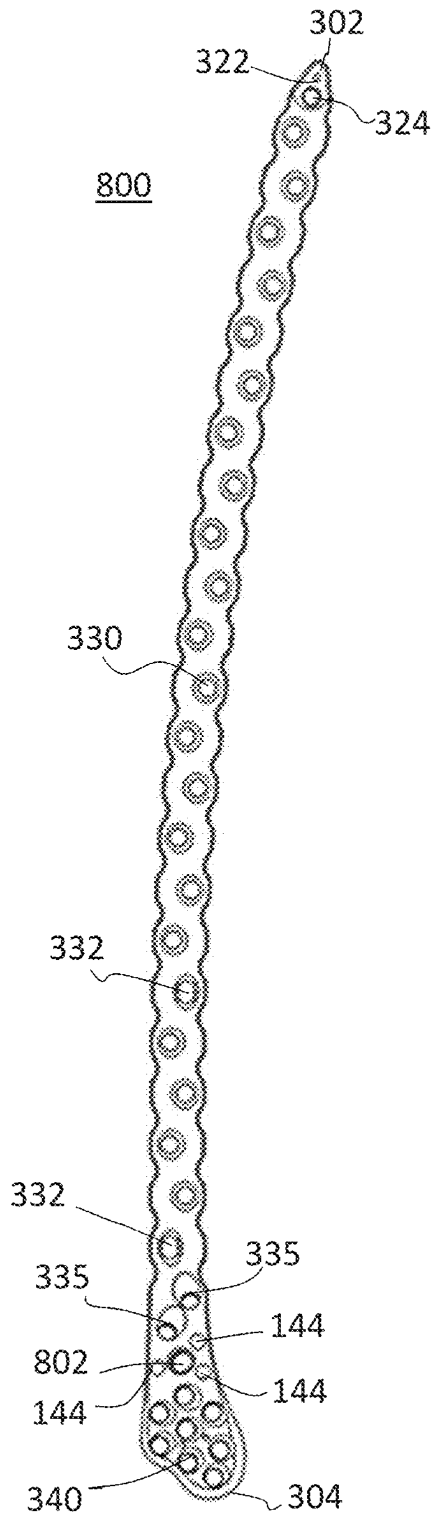
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FIG. 15

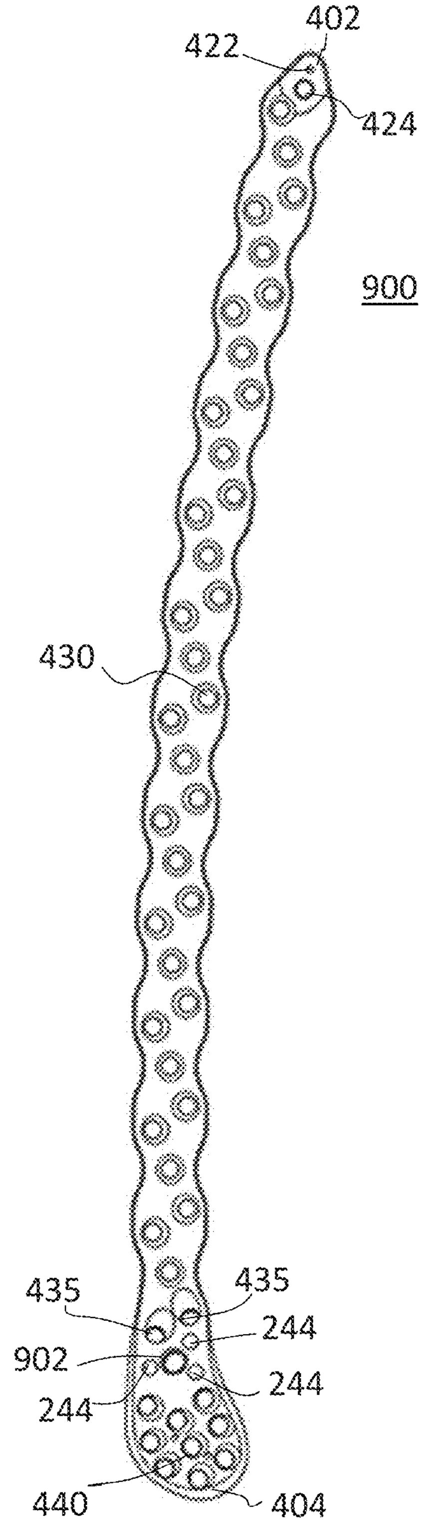
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FIG. 16

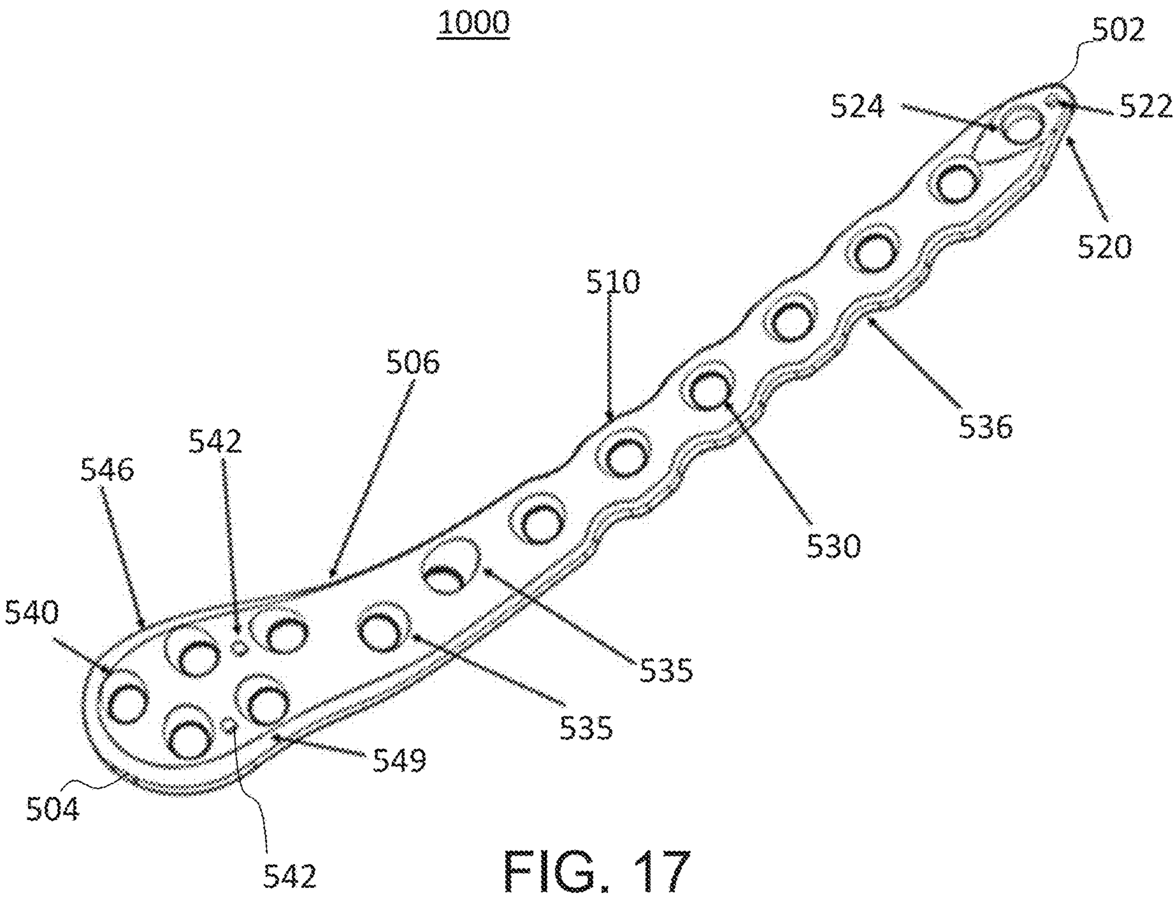
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FIG. 17

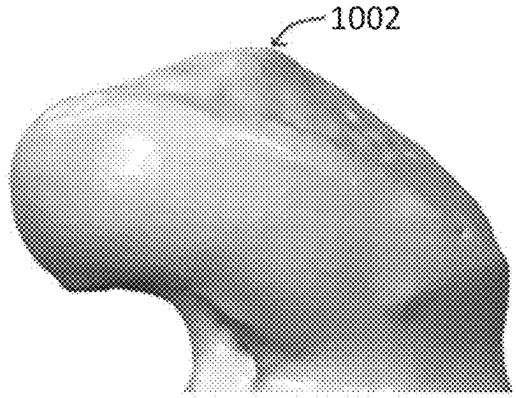


FIG. 18

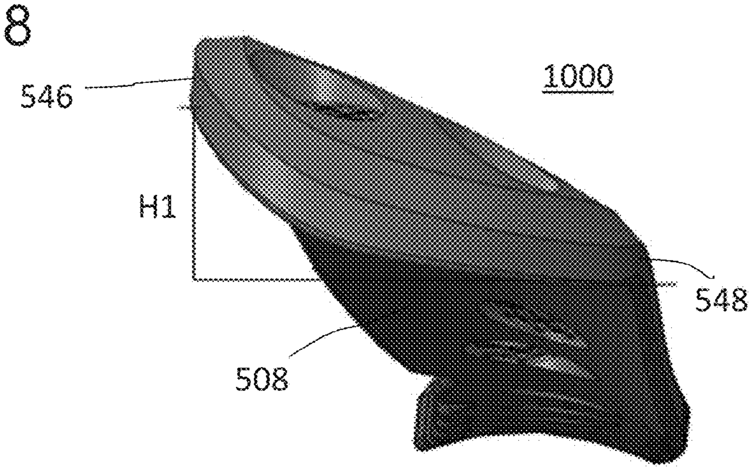


FIG. 19

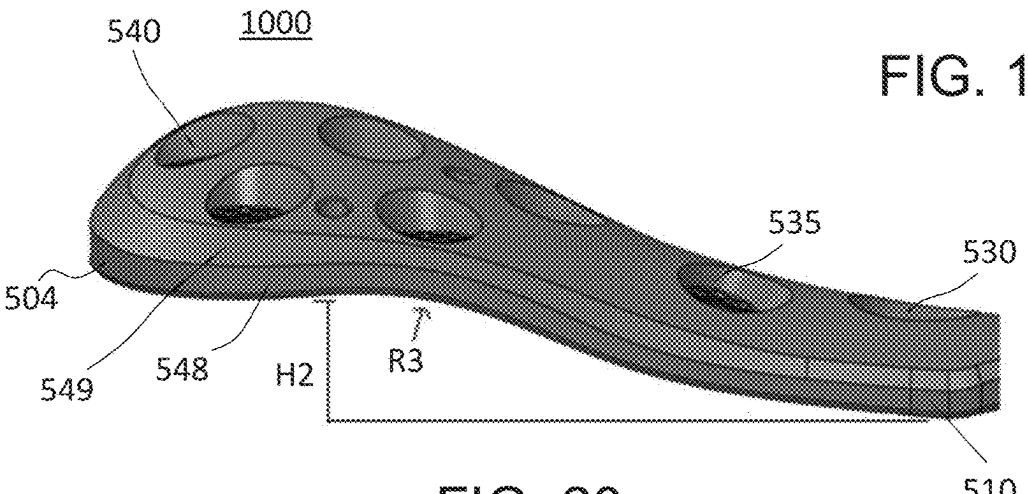
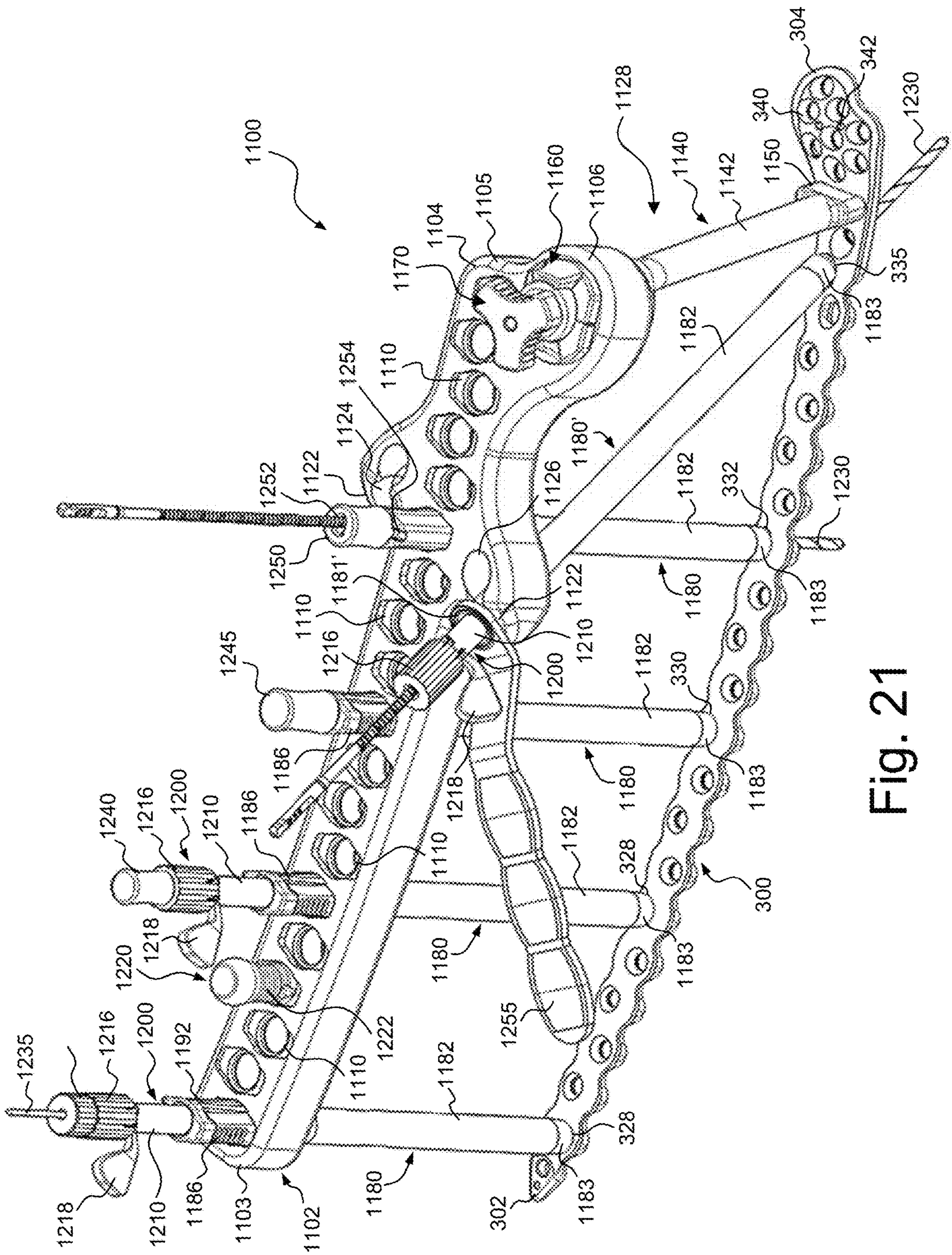


FIG. 20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1124
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1252
1180'
1126
332
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1103
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302
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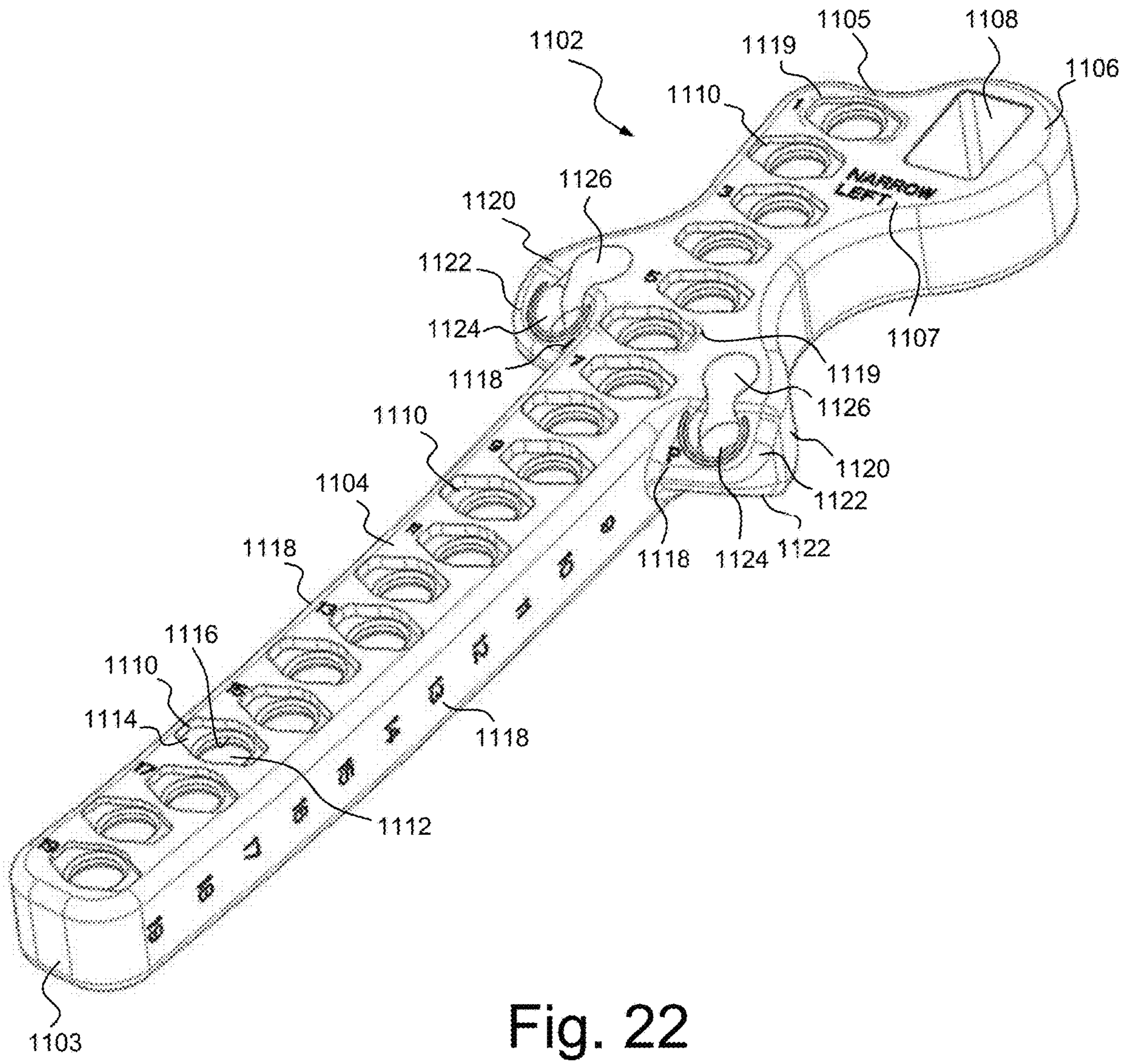
Fig. 21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1118
1103

Fig. 22

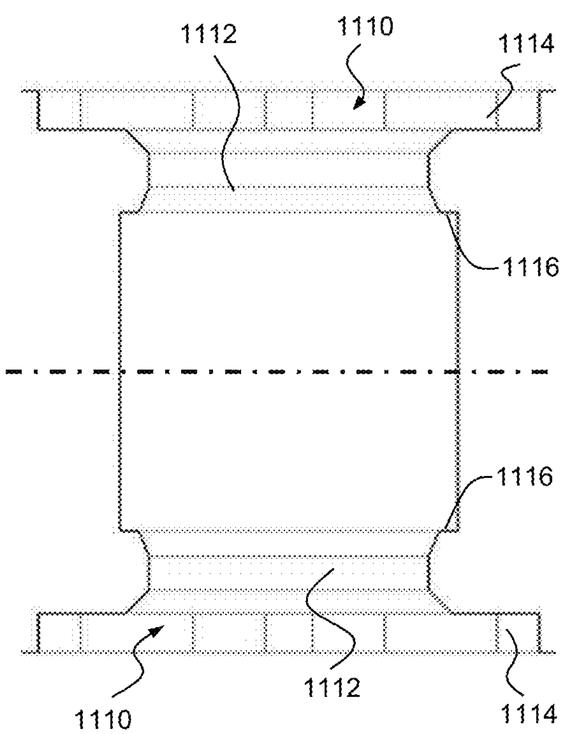
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Fig. 23

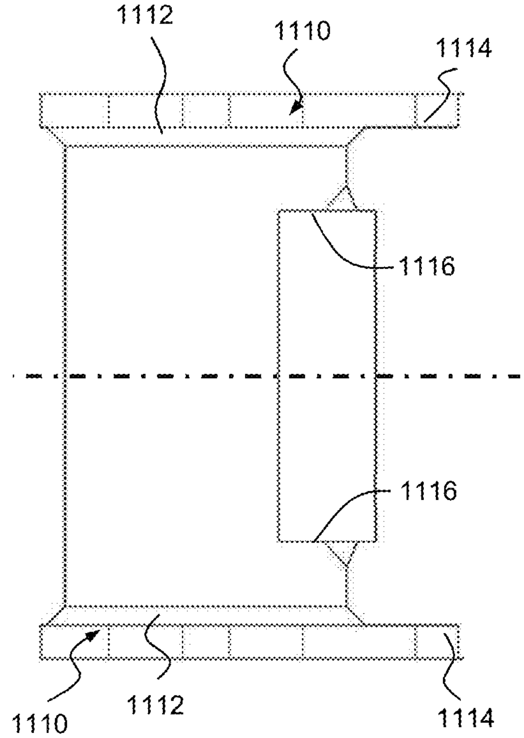
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Fig. 24

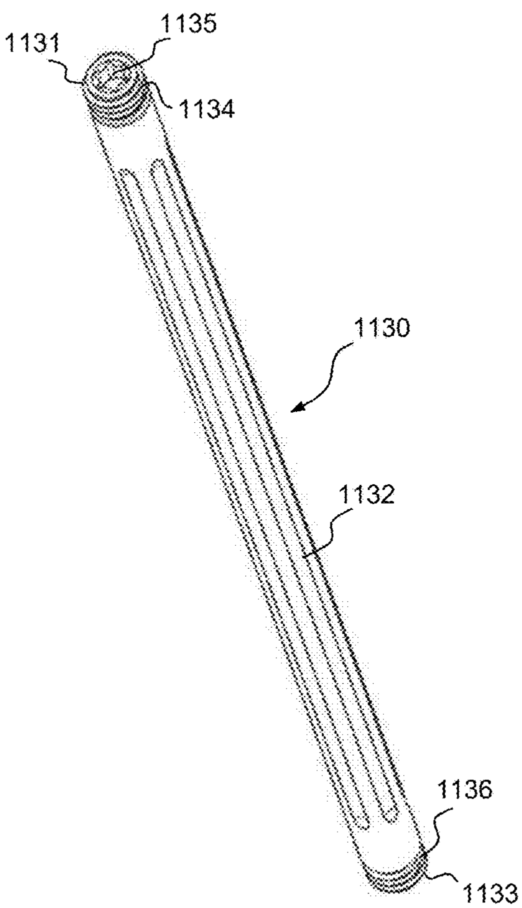
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Fig. 25

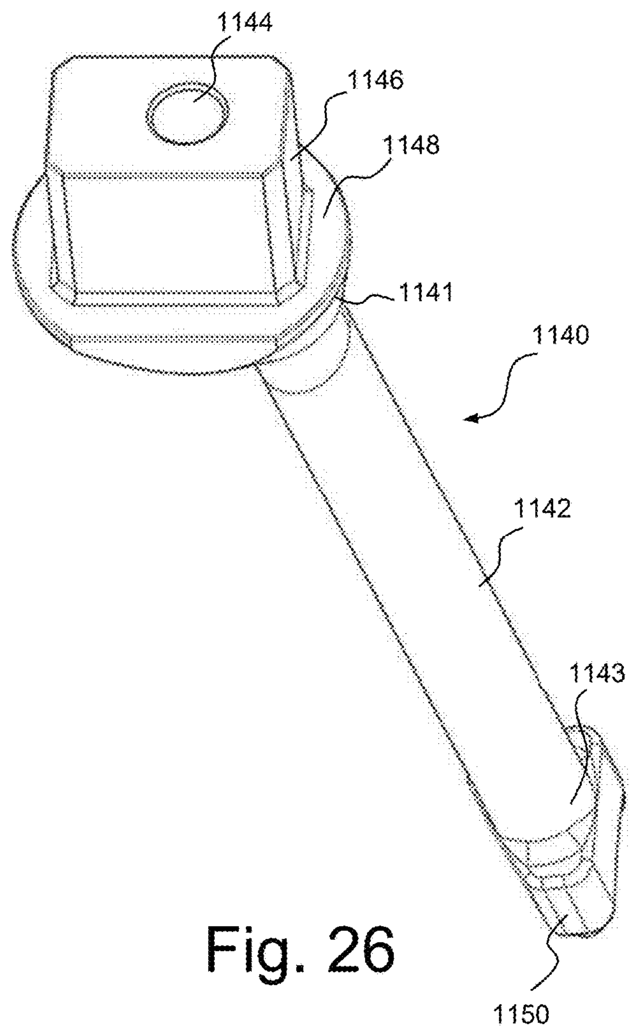
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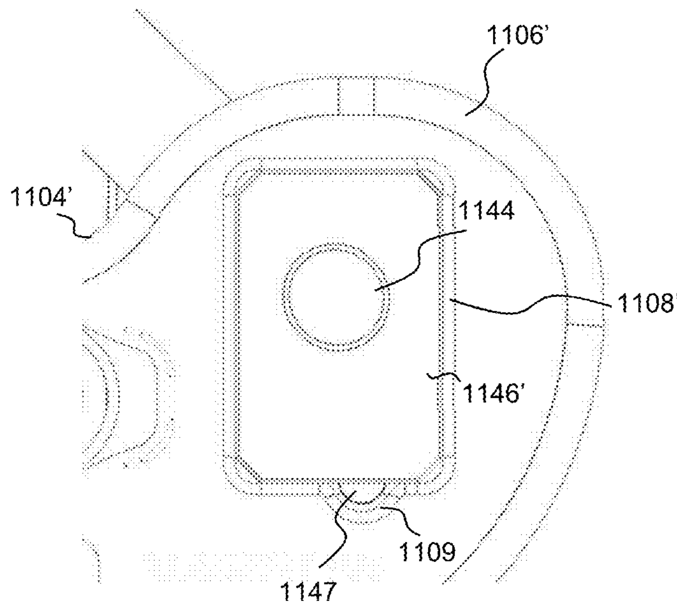
Fig. 26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1108'
1146'
1109
1147

Fig. 27

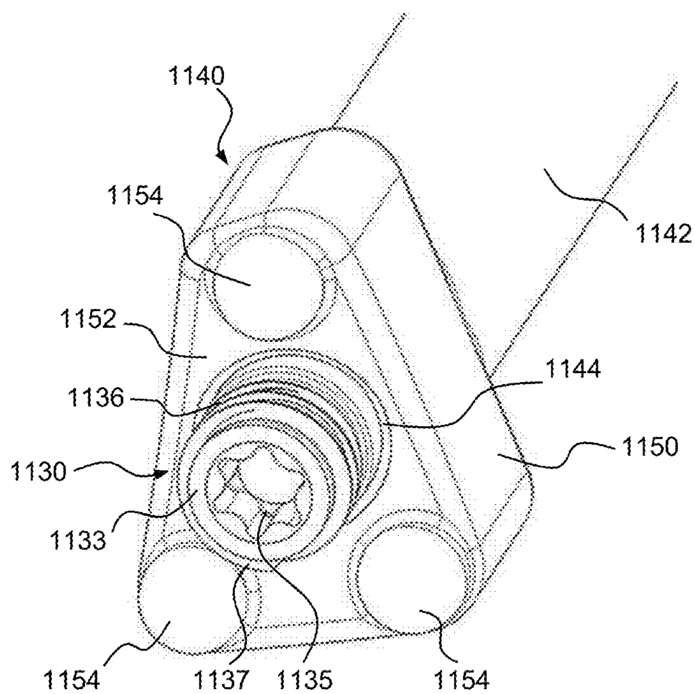
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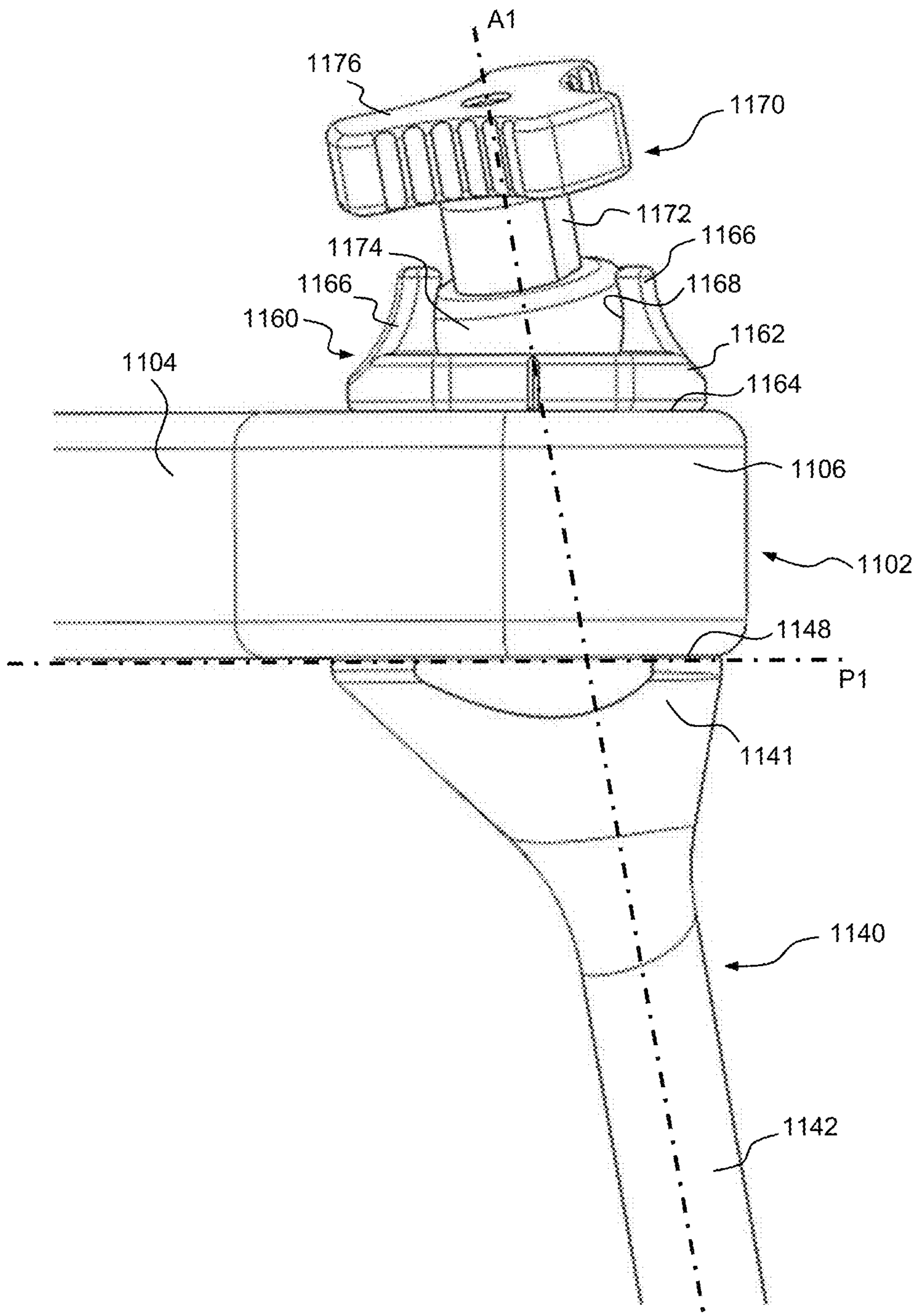
Fig. 28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P1
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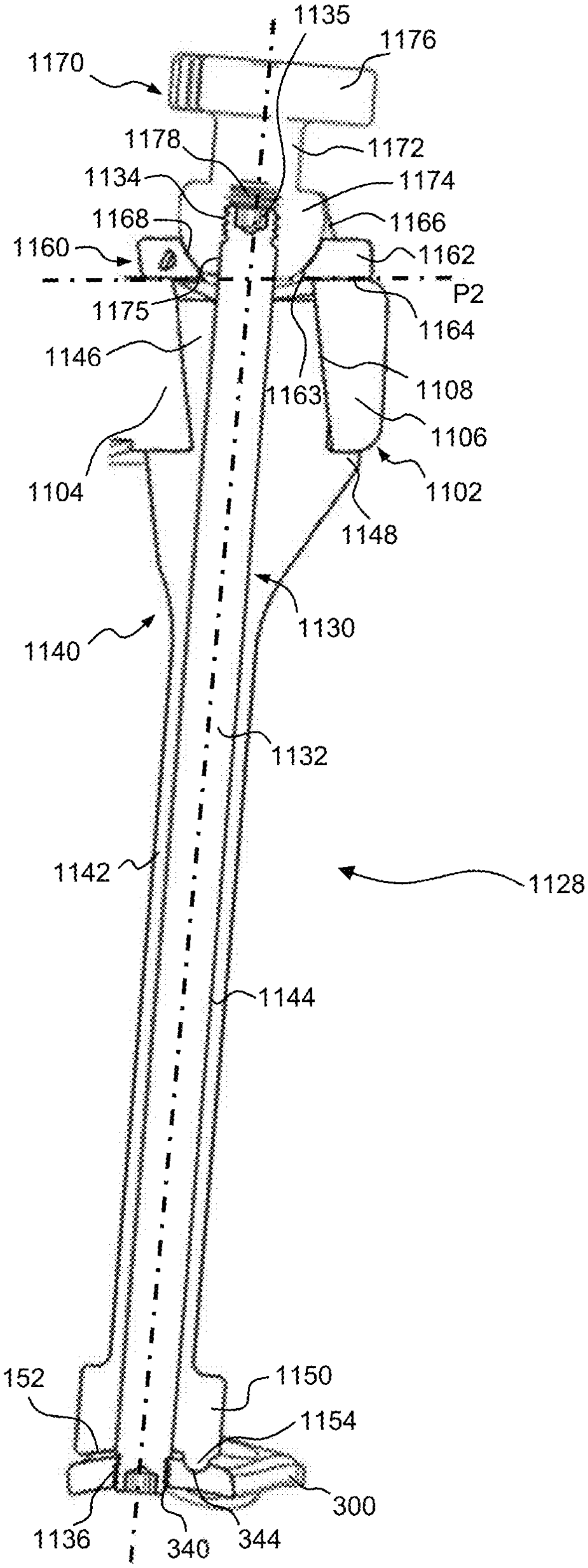
1142

Fig. 29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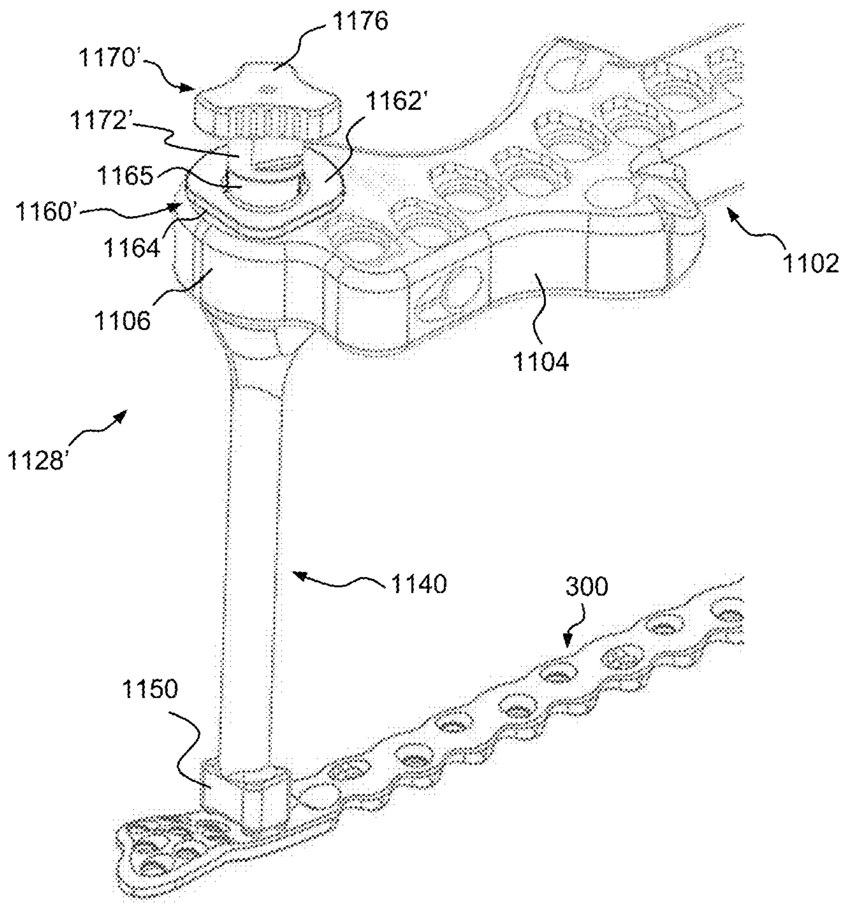
344

Fig. 30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1128'
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300
1150

Fig. 31

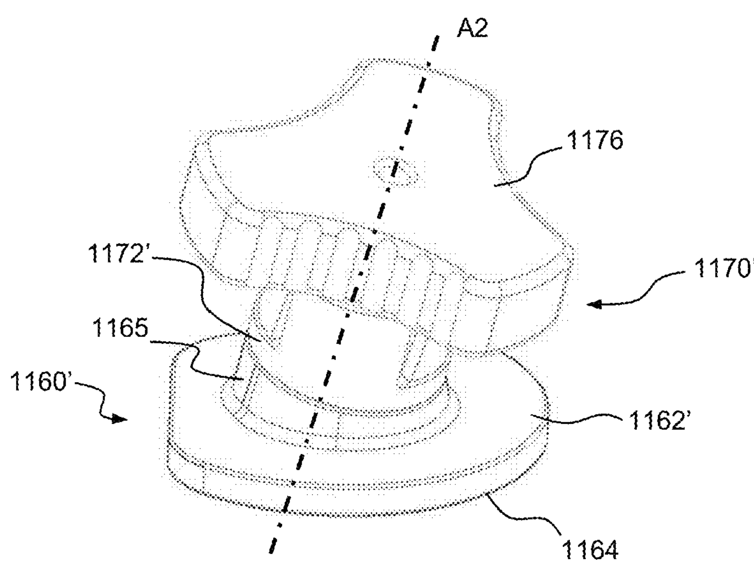
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Fig. 32

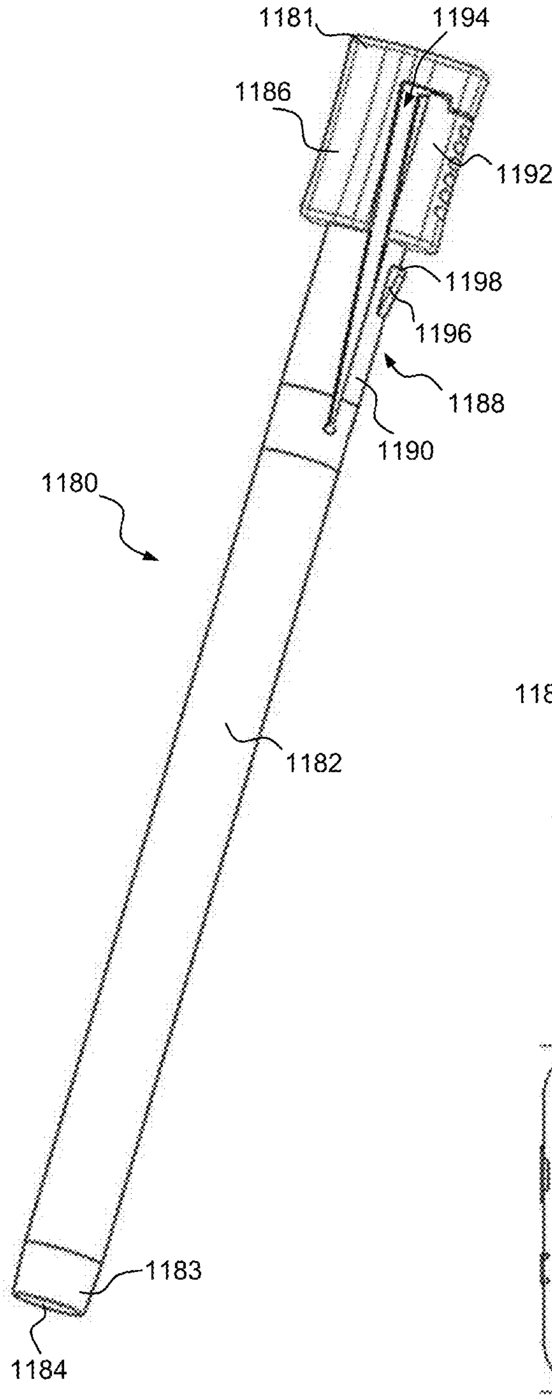
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Fig. 33

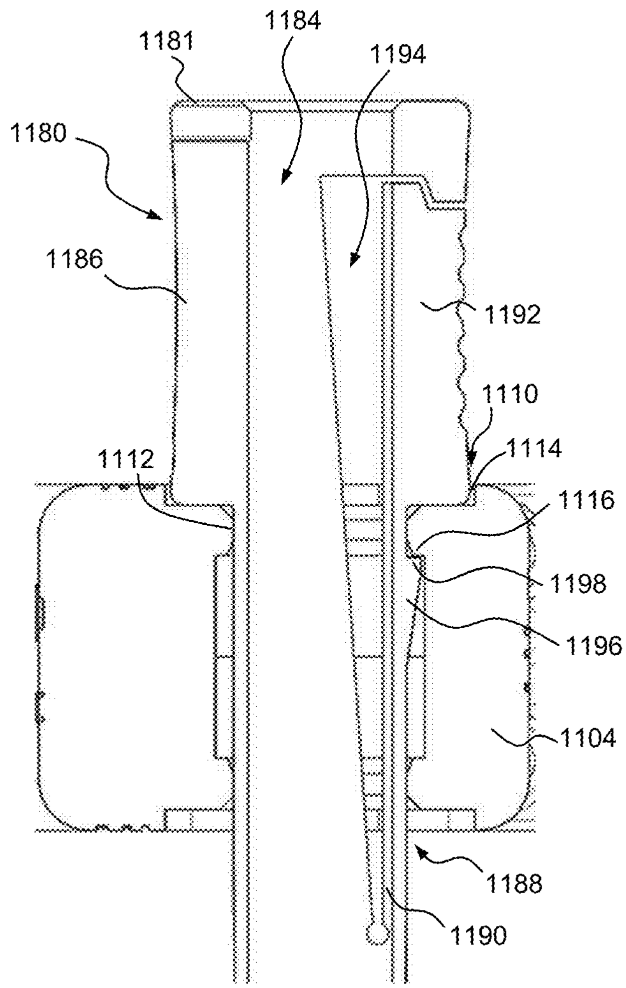
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Fig. 34

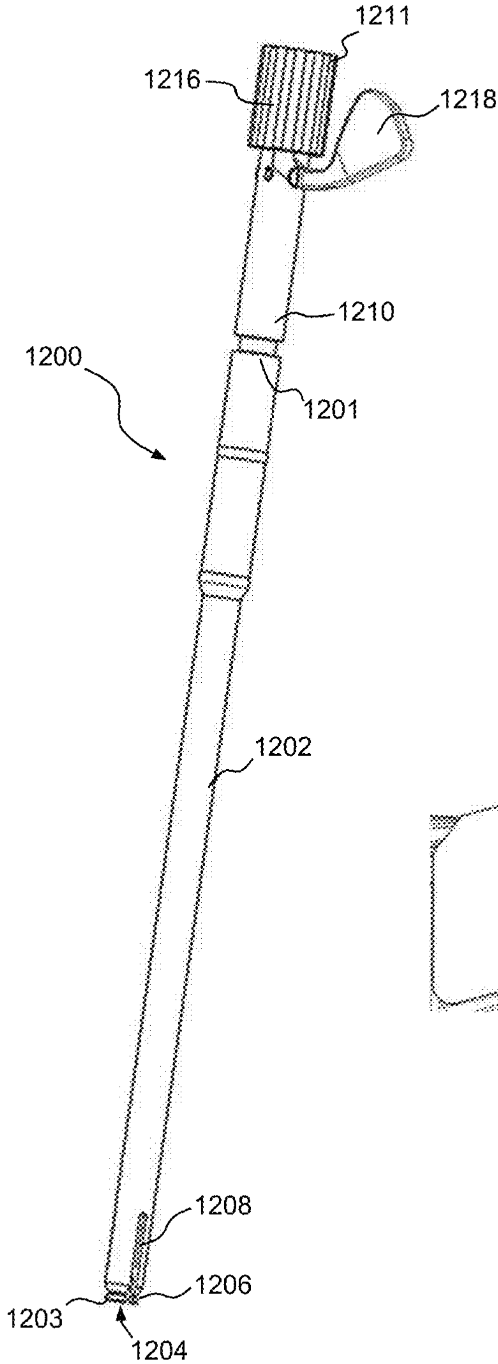
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Fig. 35

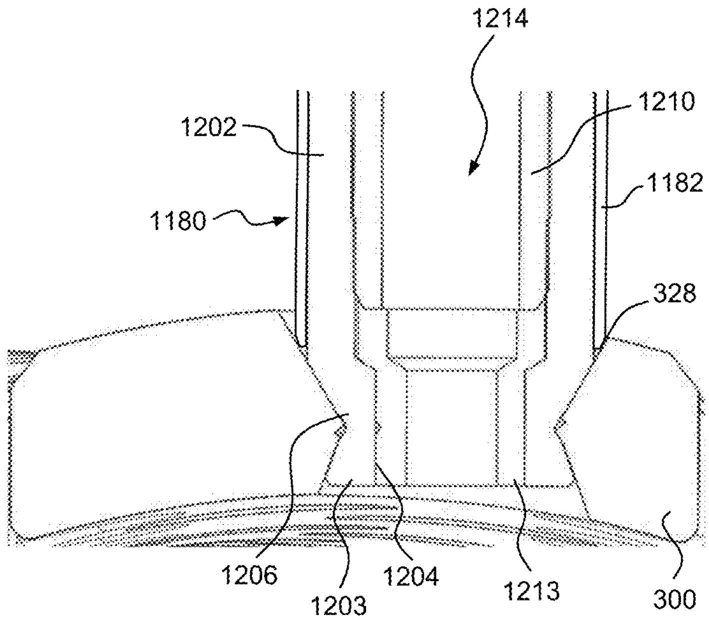
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Fig. 36

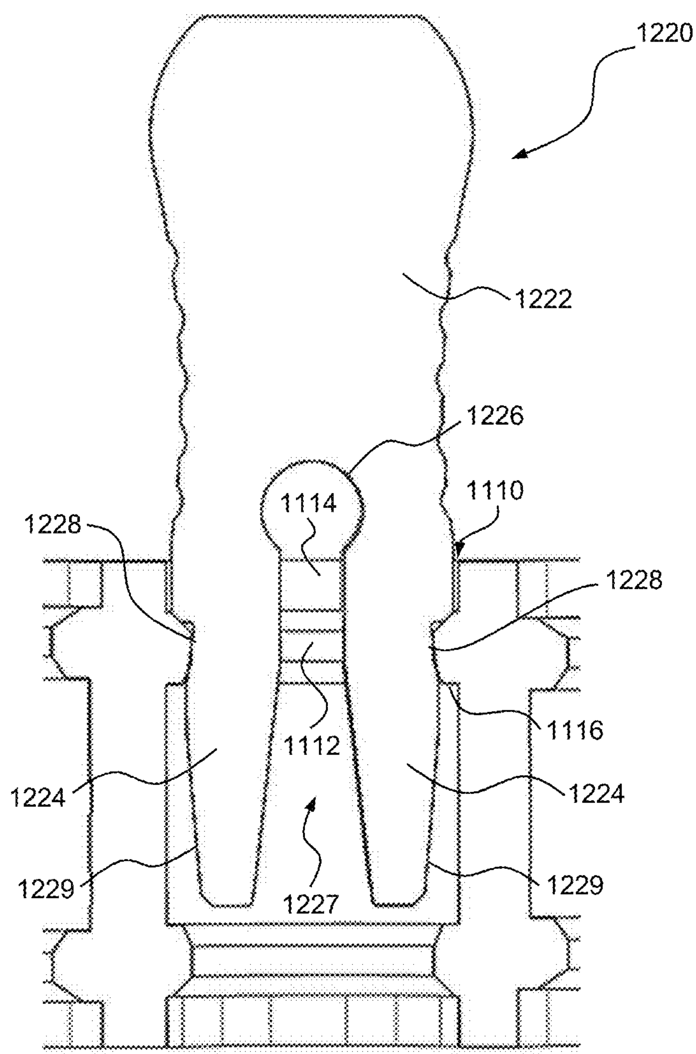
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Fig. 37

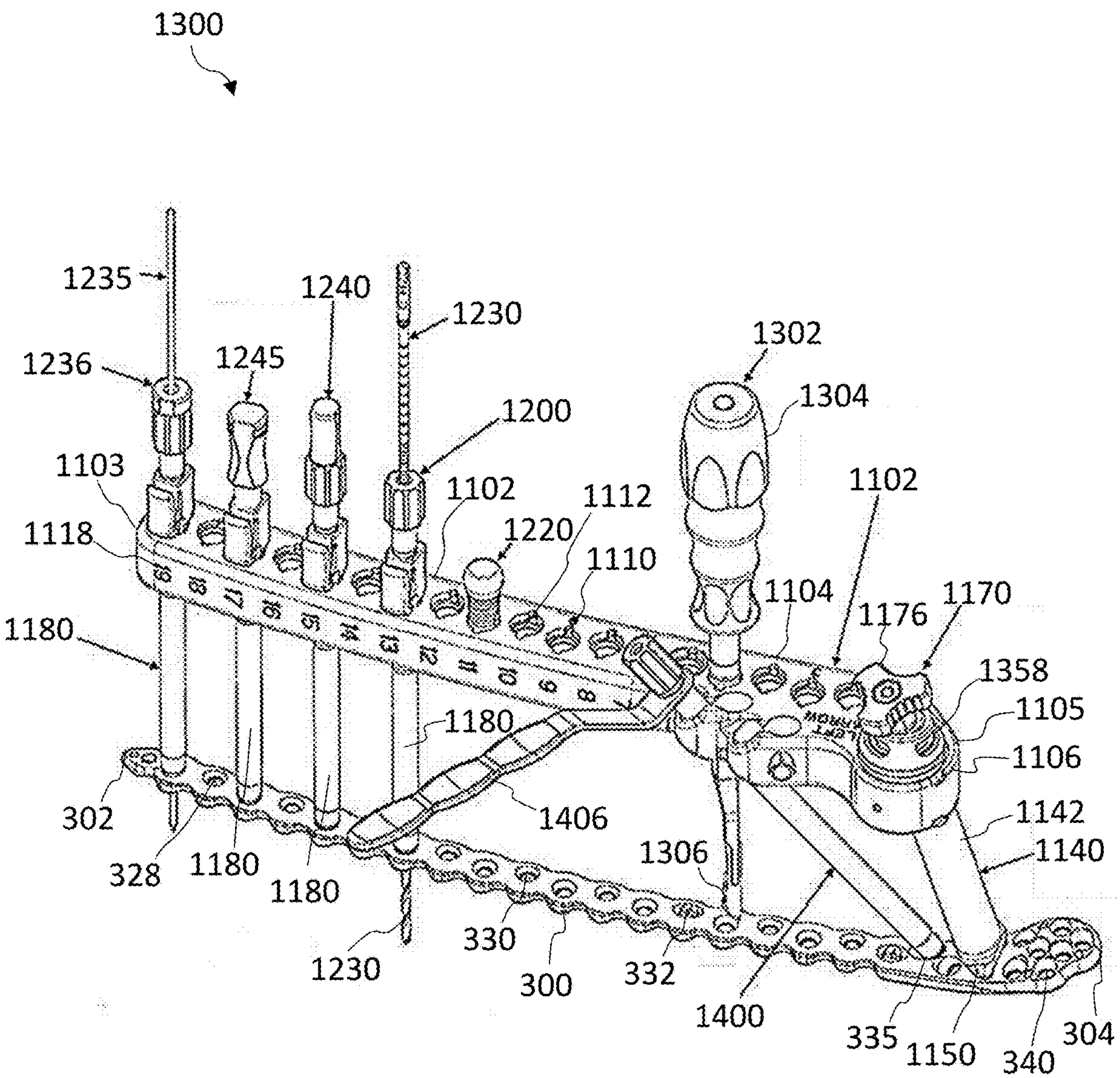
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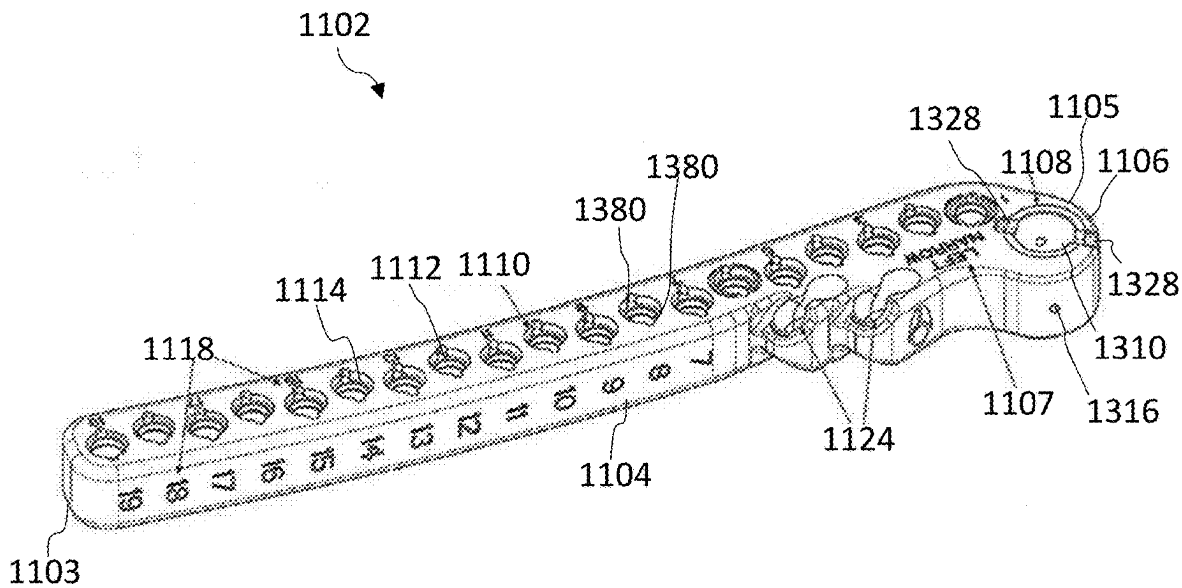
FIG. 38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1103

FIG. 39

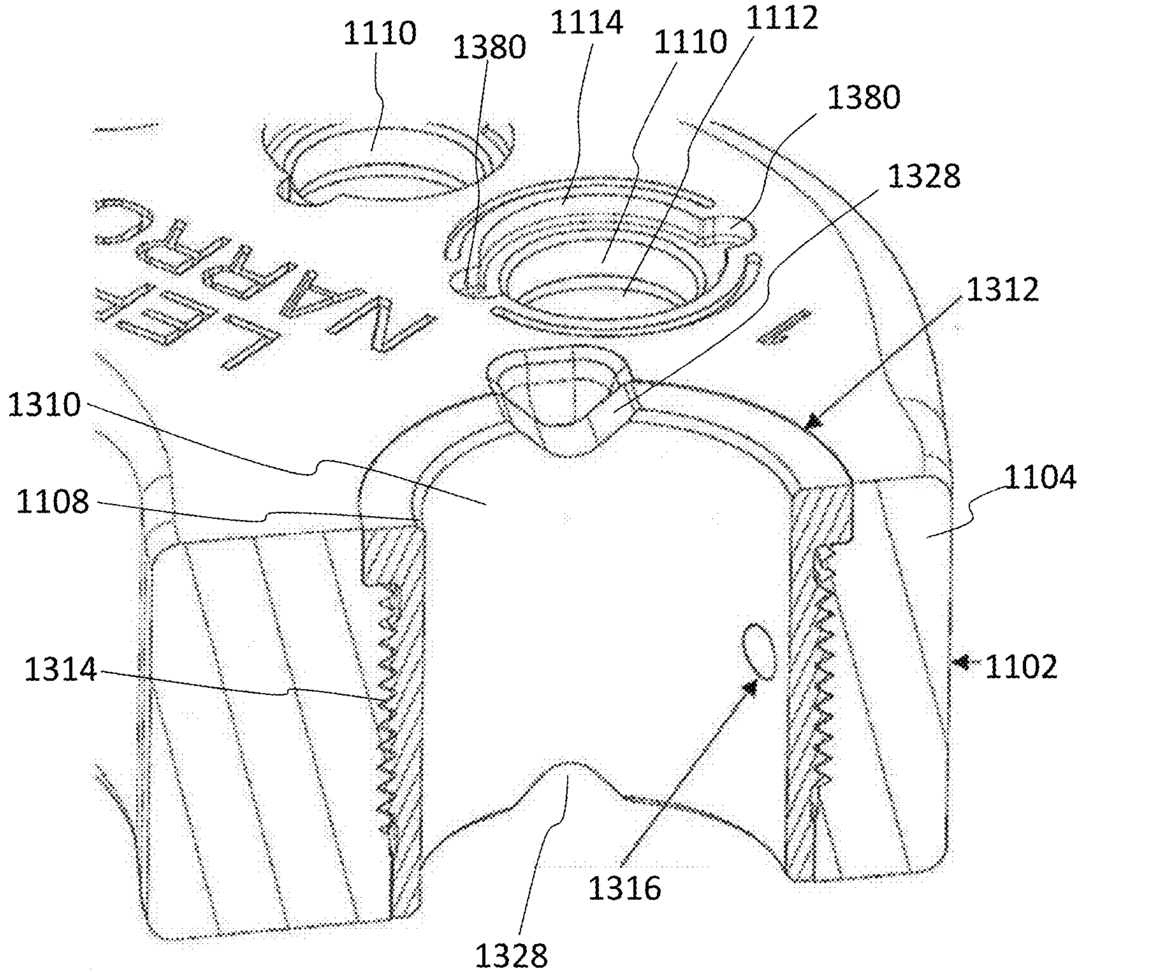
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FIG. 40

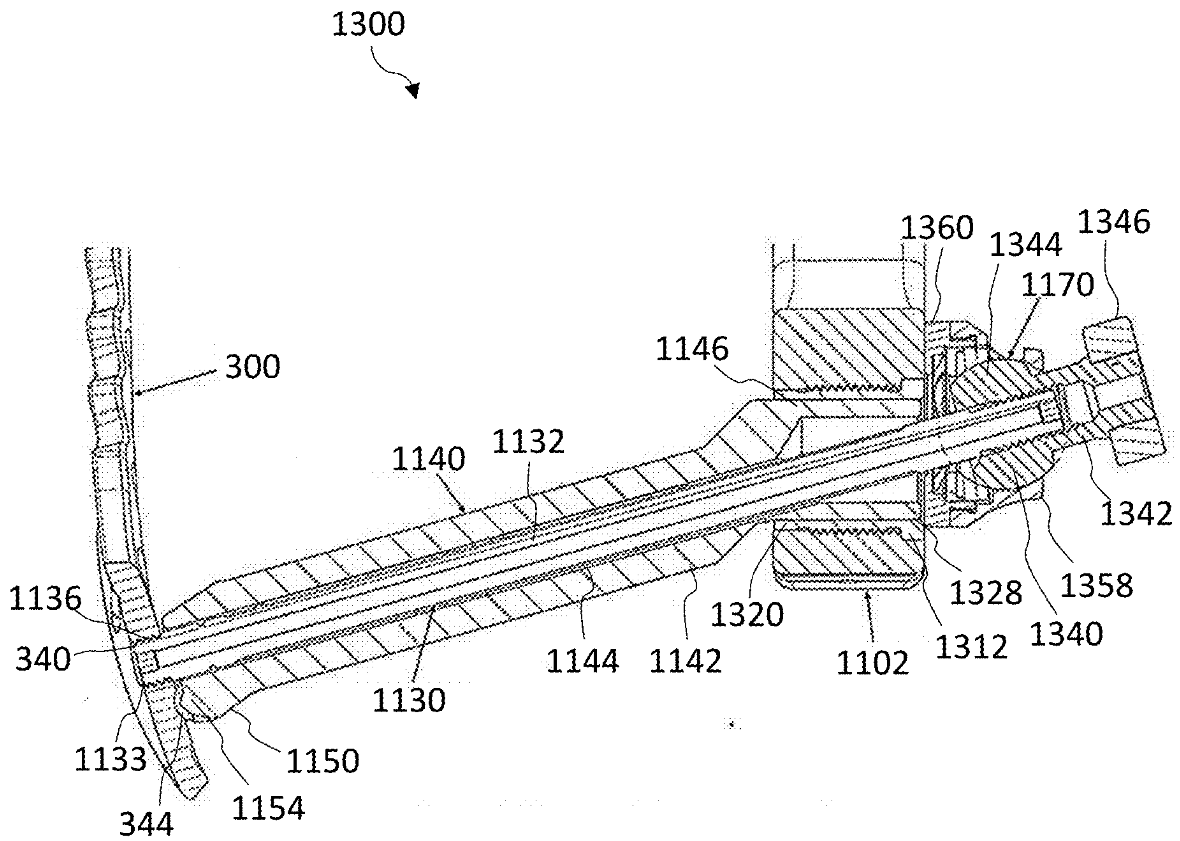
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FIG. 41

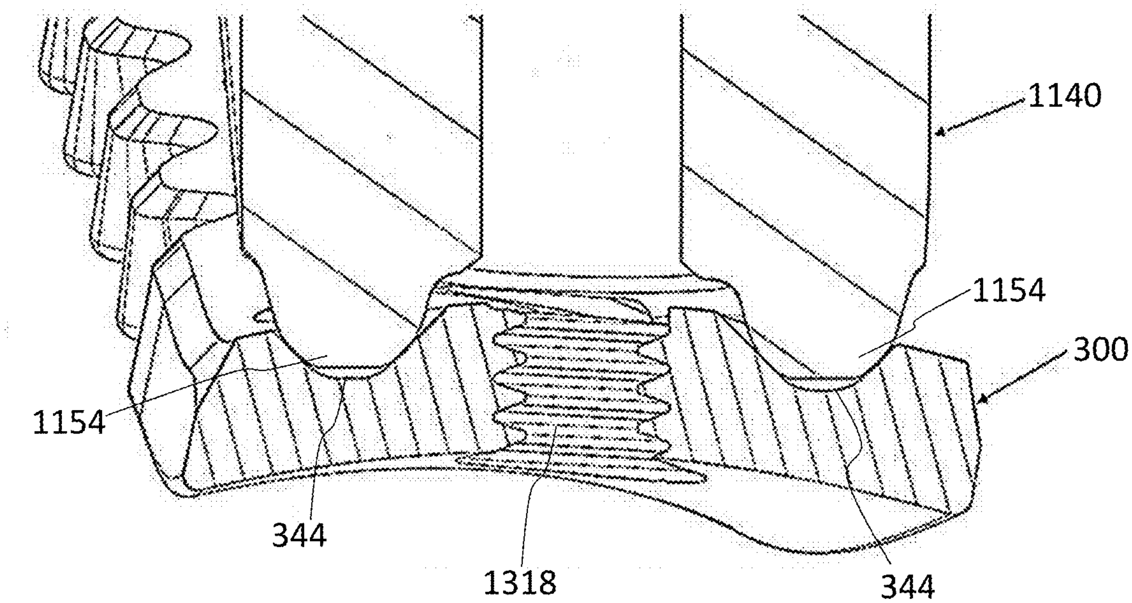


FIG. 42

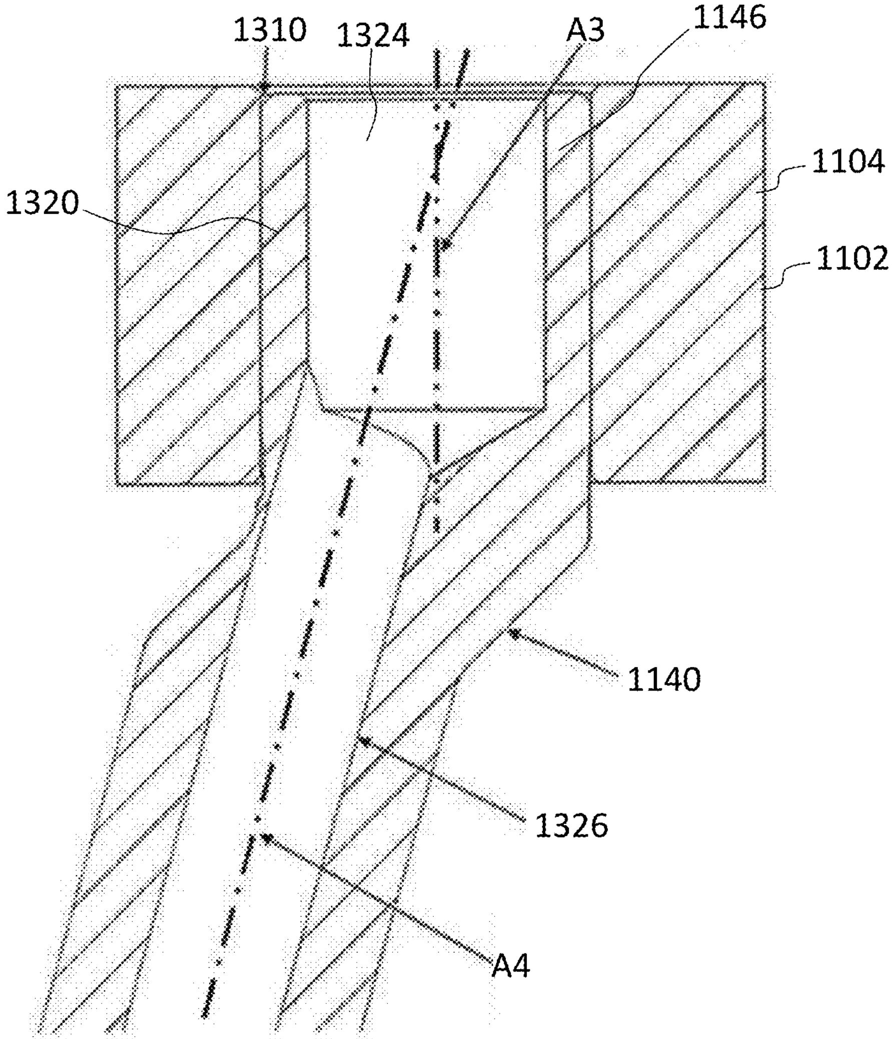


FIG. 43

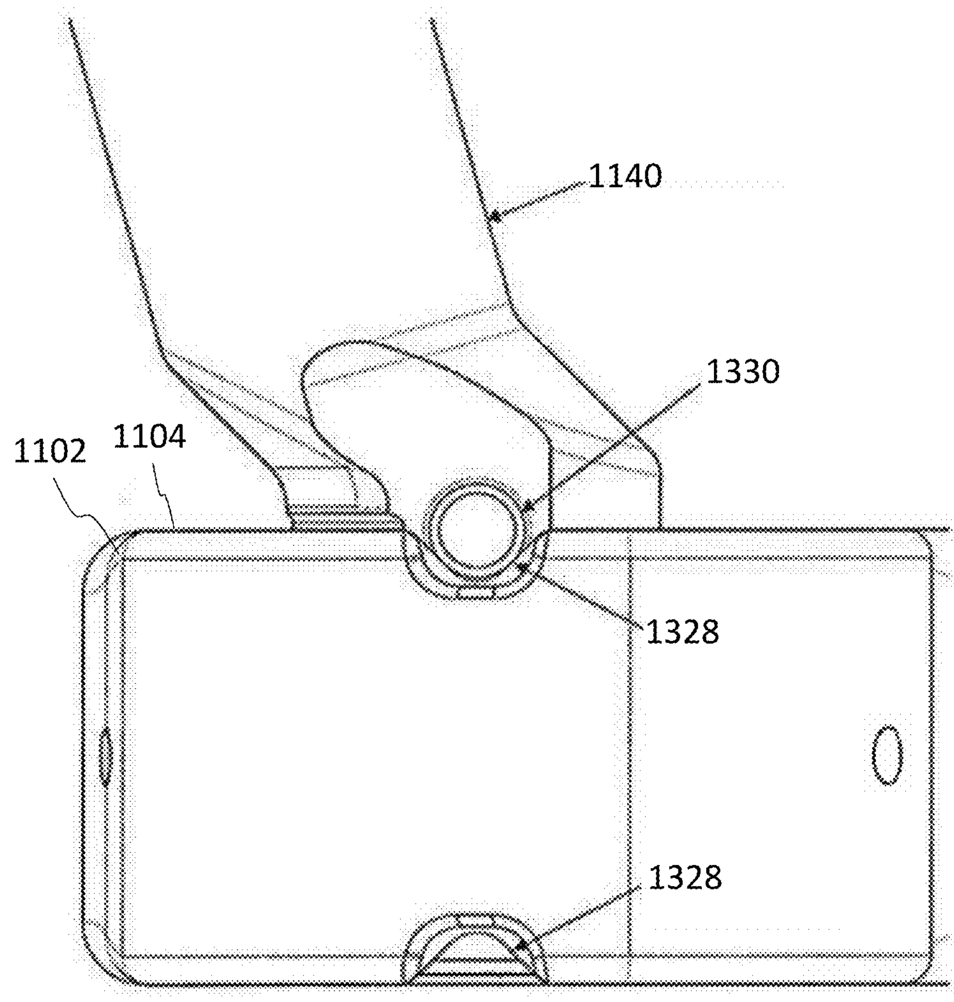
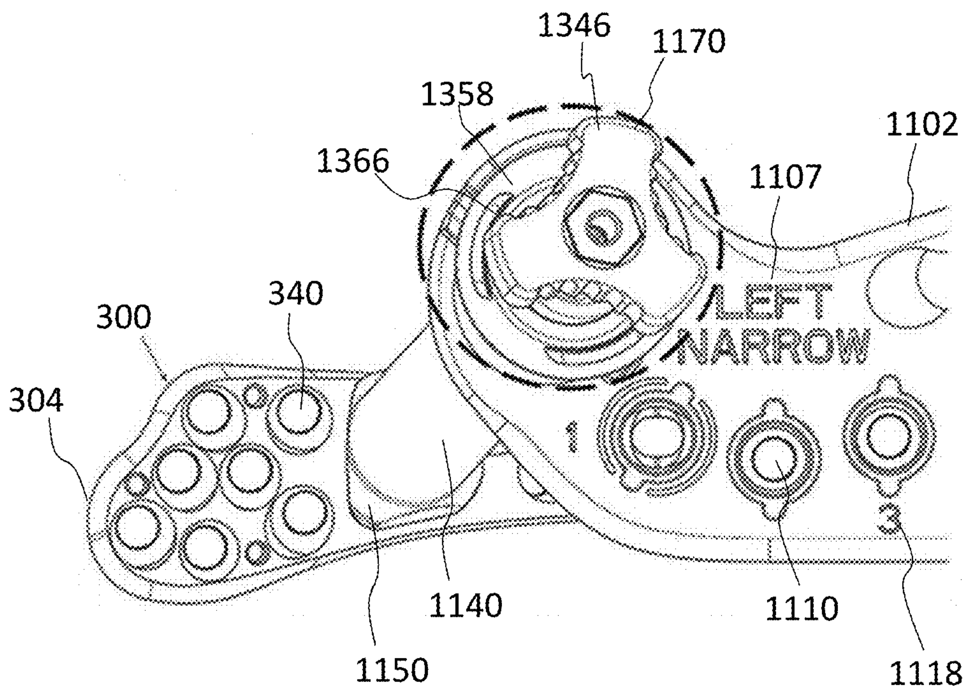


FIG. 44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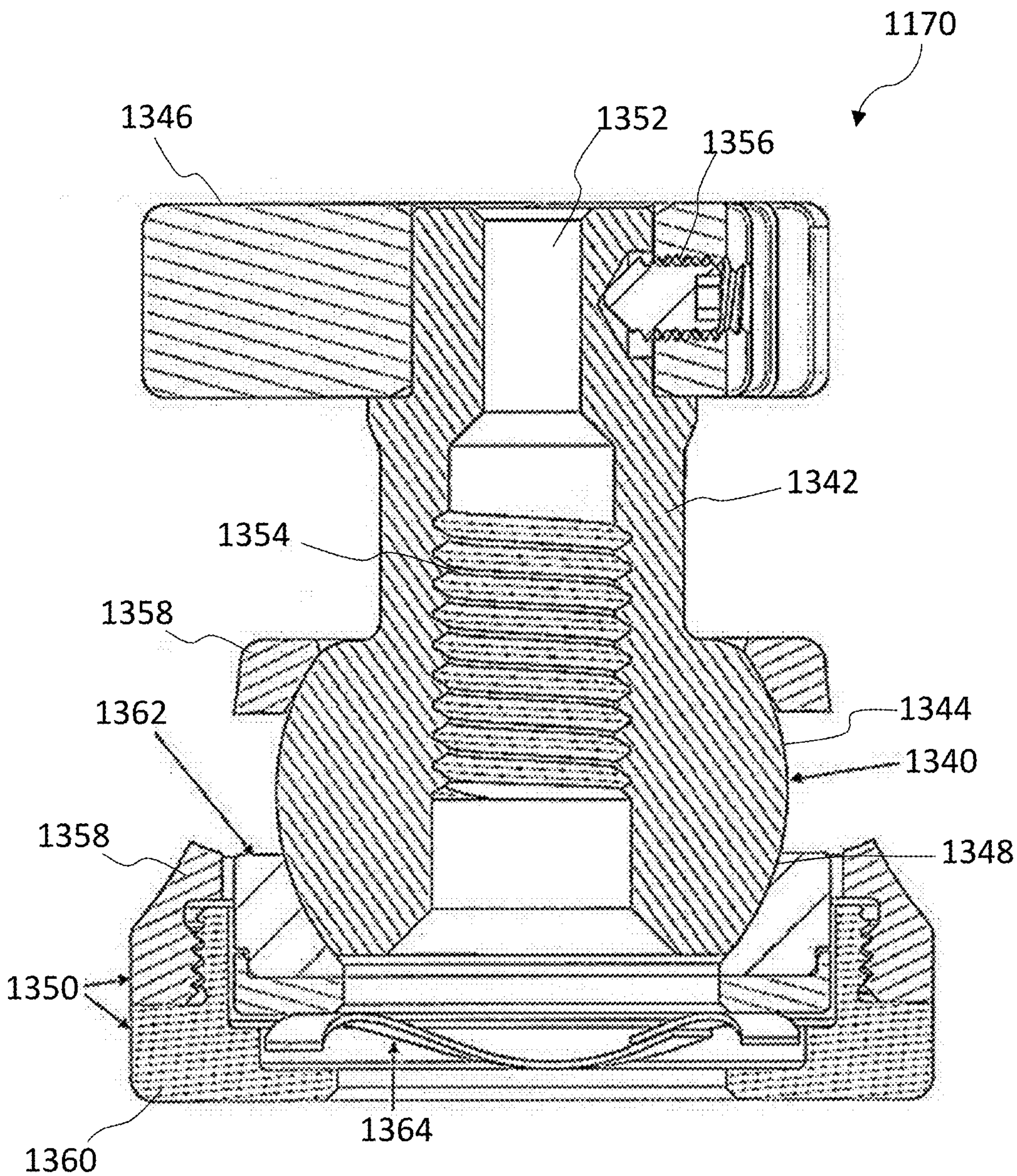
1366
1107
340
300
LEFT
NARROW
304
1
3
1140
1110
1150
1118

FIG. 45


1170
1346
1352
1356
1342
1354
1358
1362
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1340
1358
1348
1350
1360
1364

FIG. 46

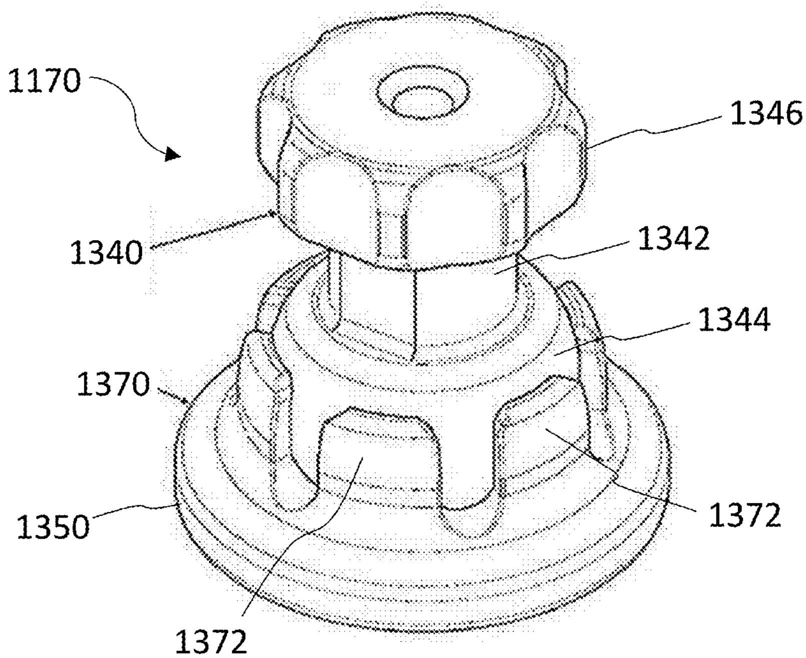
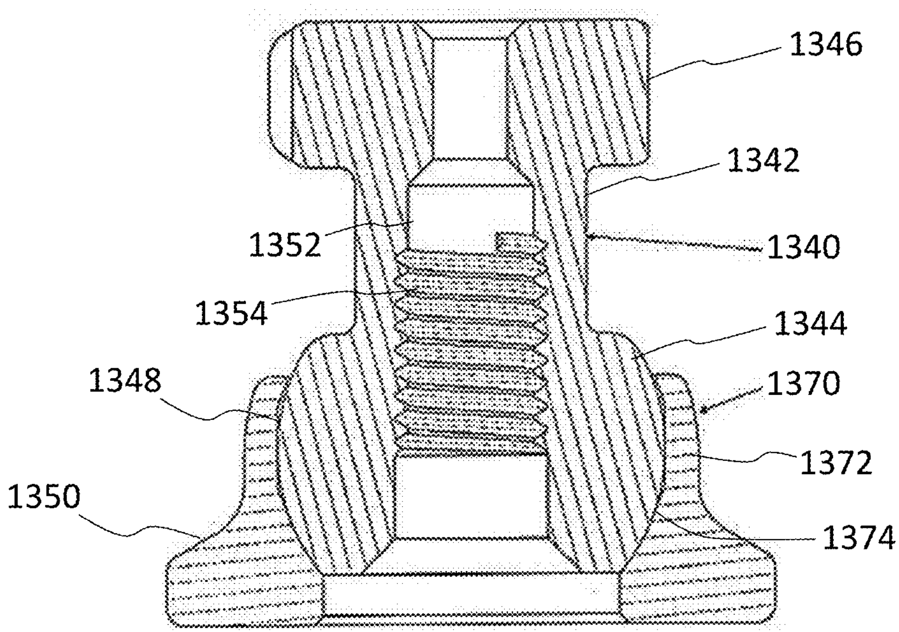

1170
1346
1340
1342
1344
1370
1350
1372
1372

FIG. 47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1348
1370
1372
1350
1374

FIG. 48

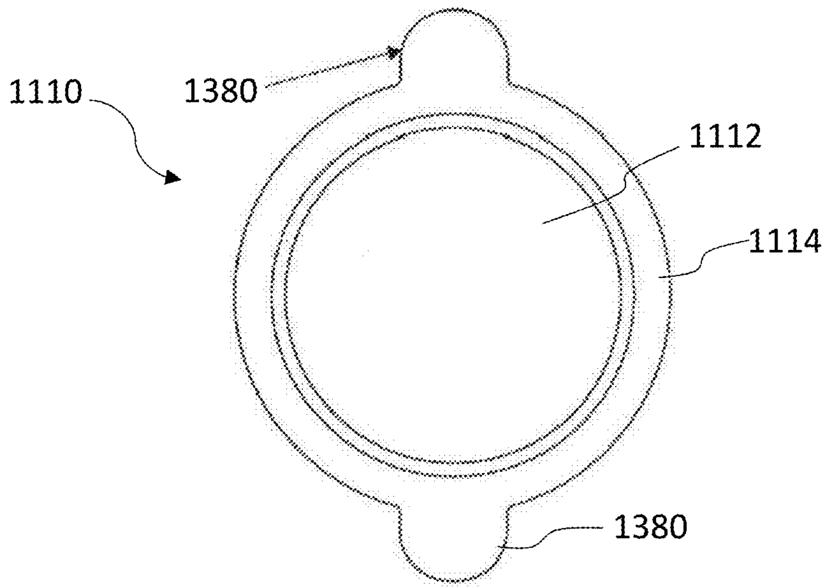


FIG. 49A

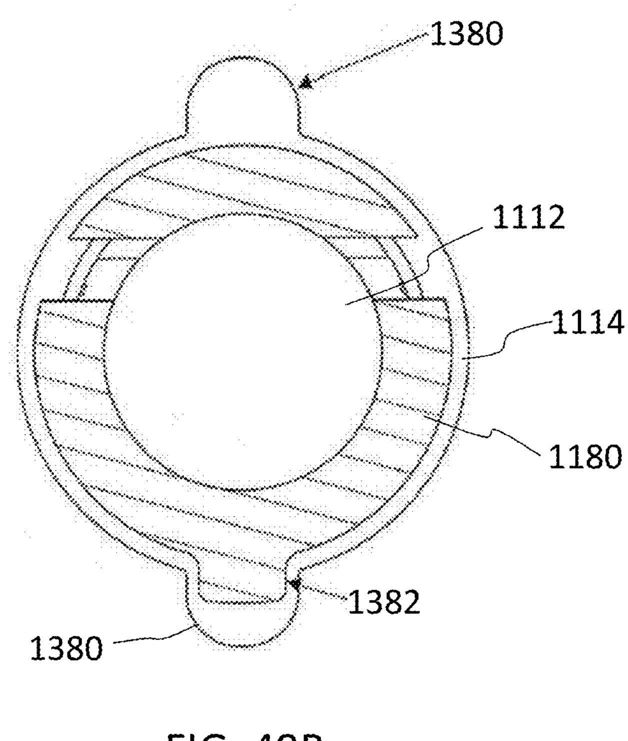


FIG. 49B

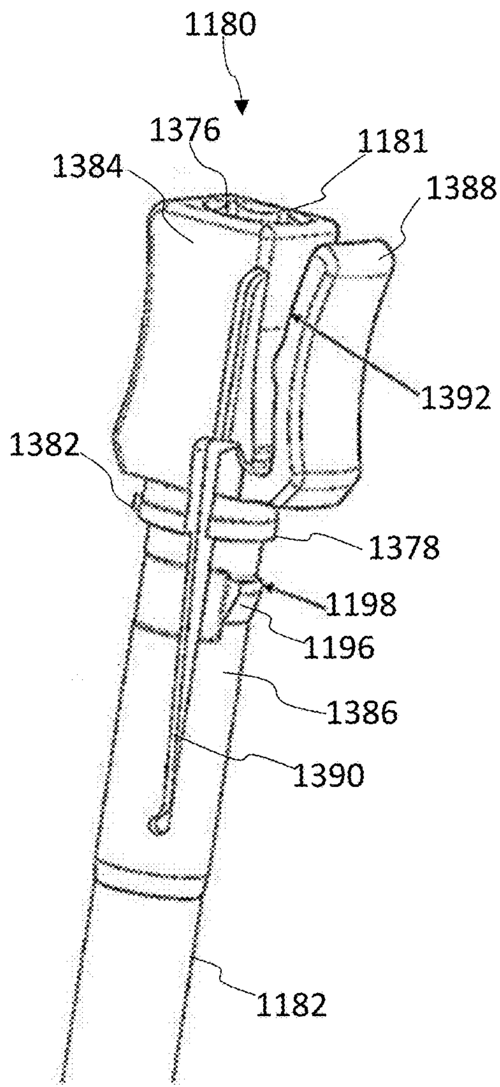


FIG. 50A

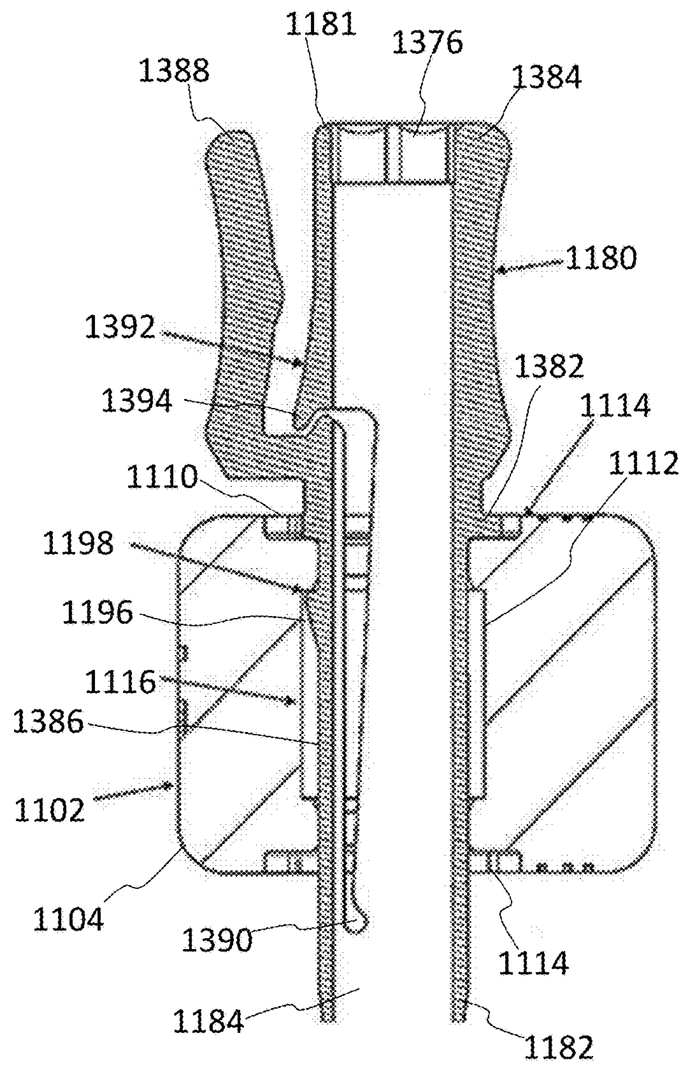
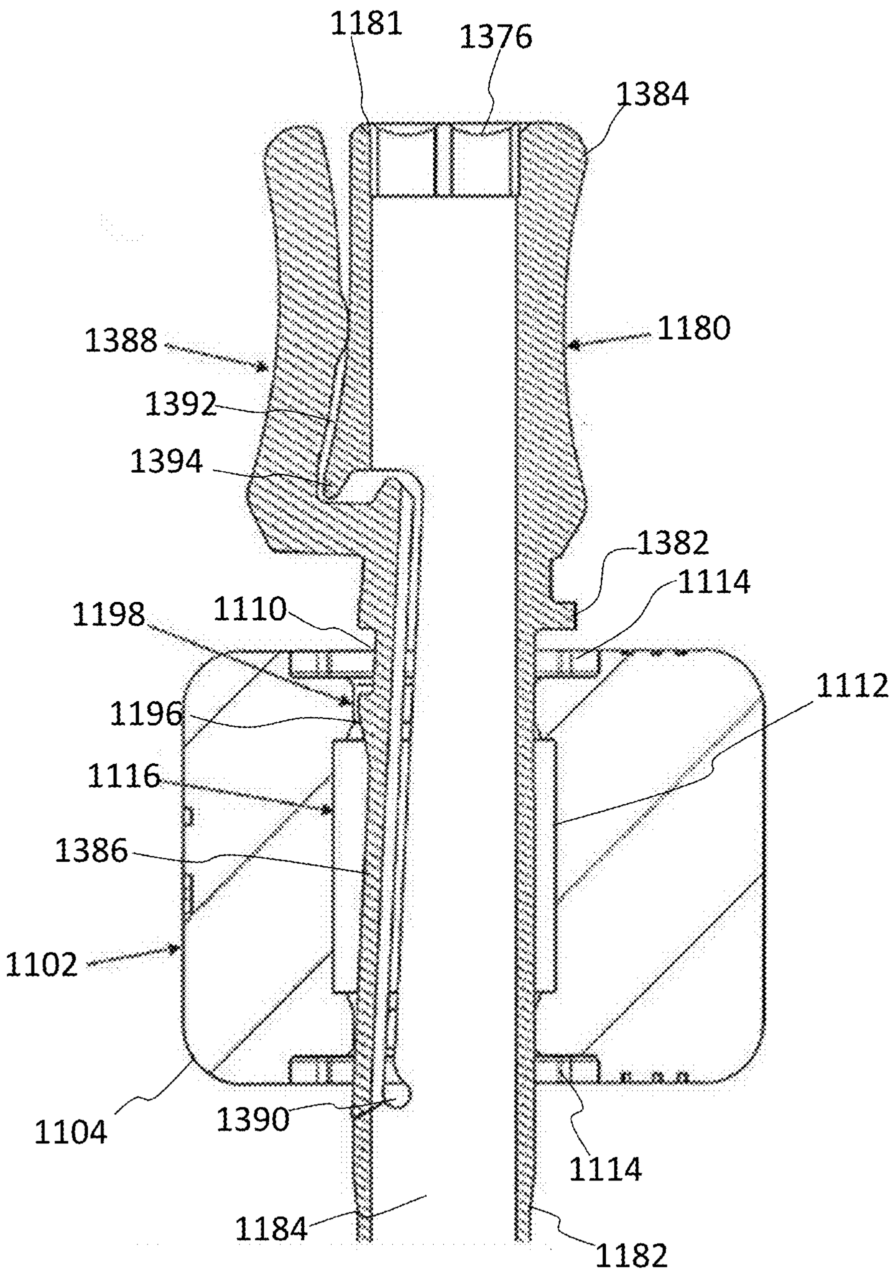


FIG. 50B


1181
1376
1384
1388
1180
1392
1394
1382
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1198
1110
1112
1196
1116
1386
1102
1104
1390
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1184
1182

FIG. 50C

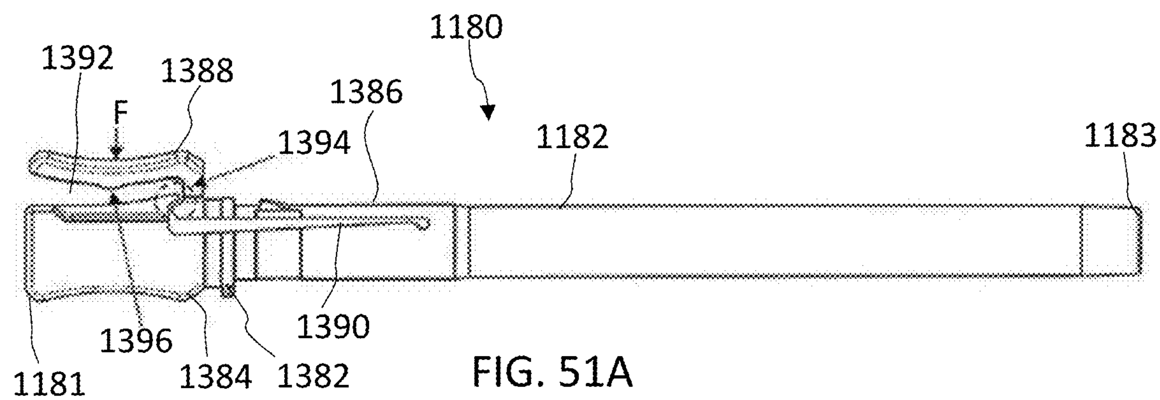


FIG. 51A

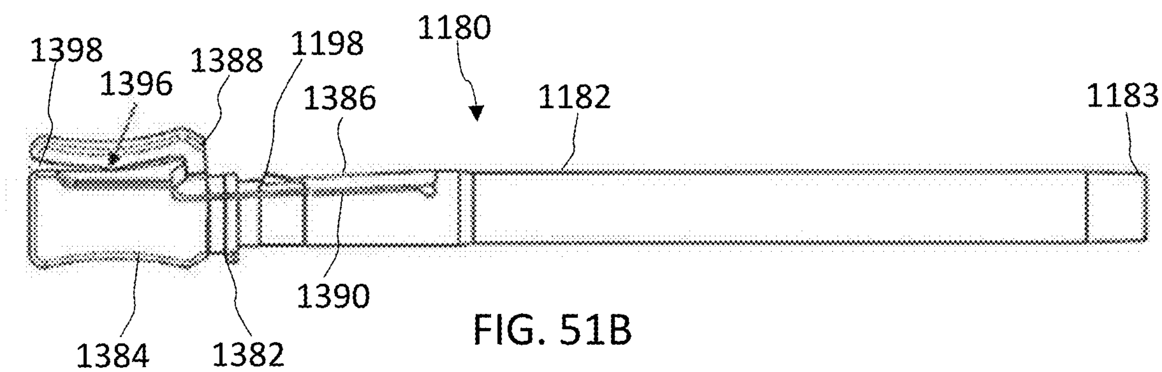


FIG. 51B

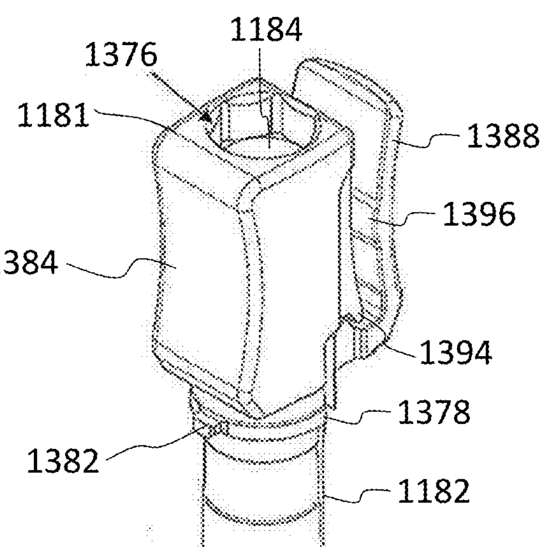


FIG. 52

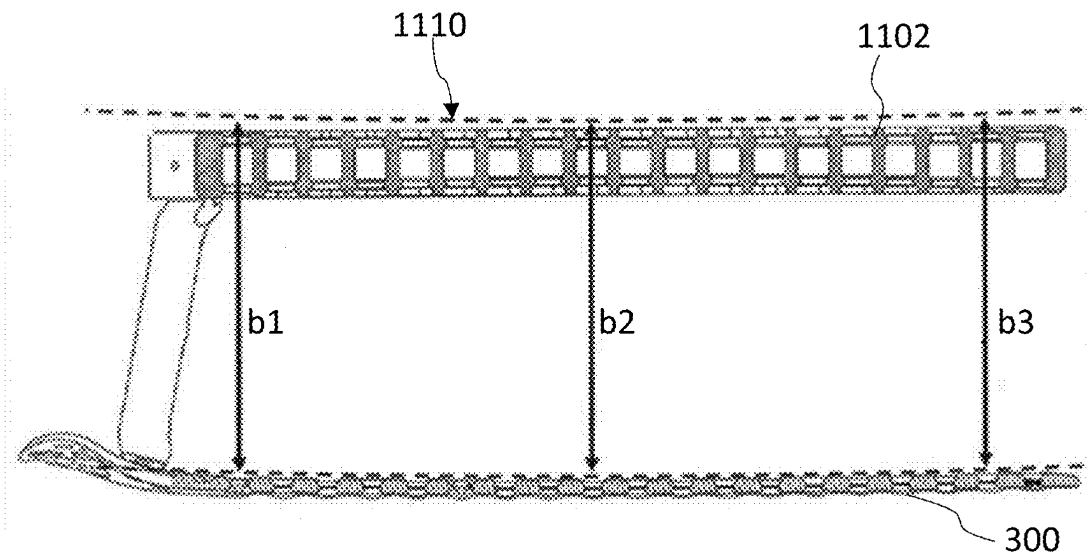

1110
1102
b1
b2
b3
300

FIG. 53

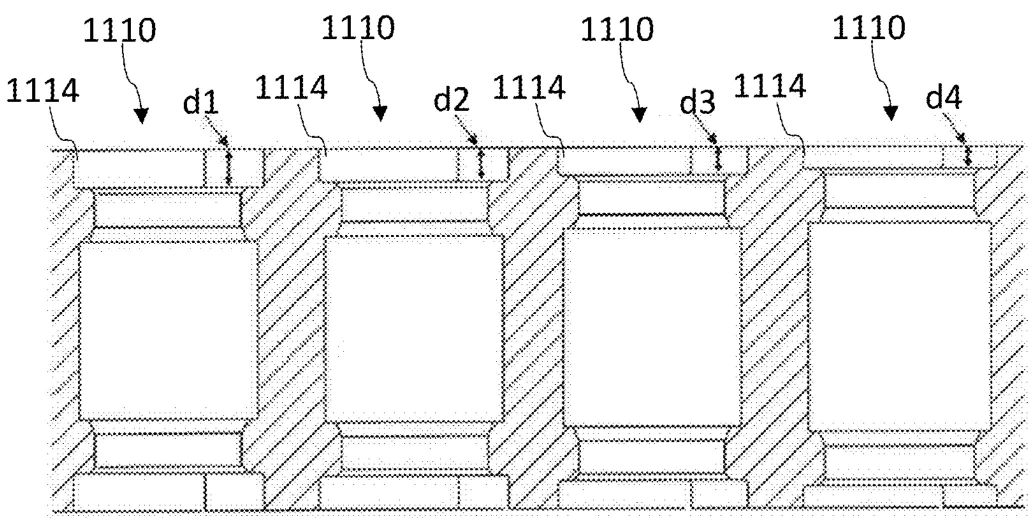

1110
1114
d1
1110
1114
d2
1110
1114
d3
1110
1114
d4

FIG. 54

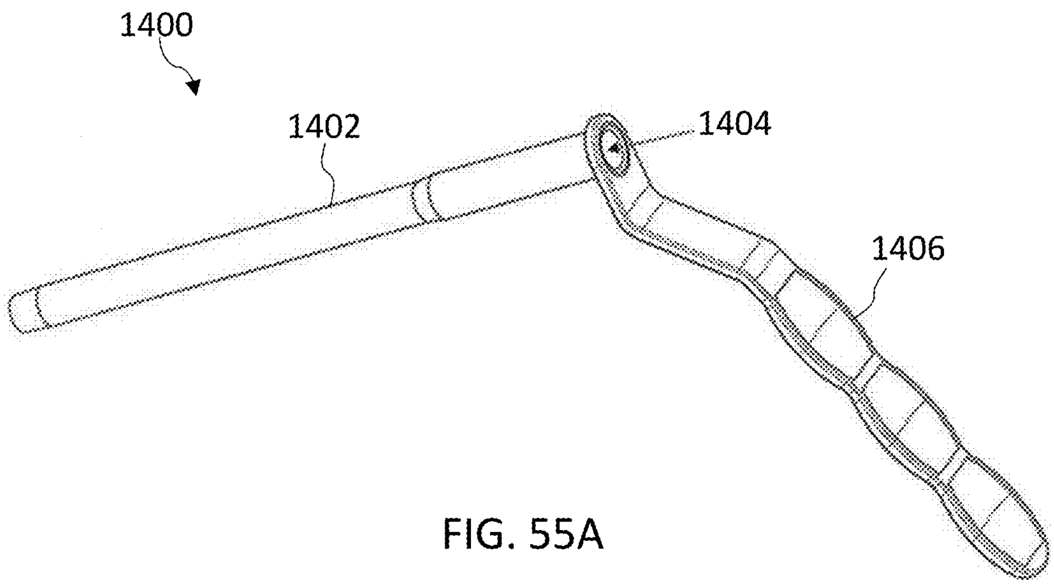


FIG. 55A

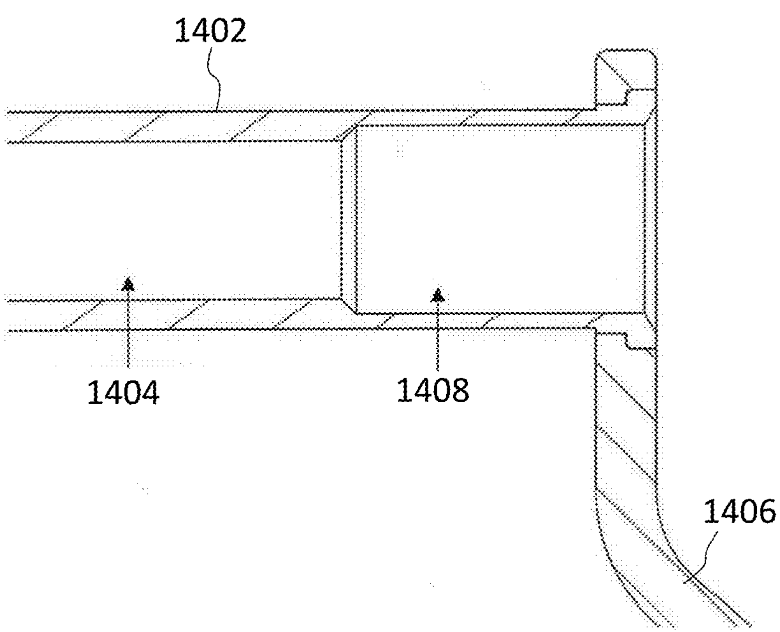
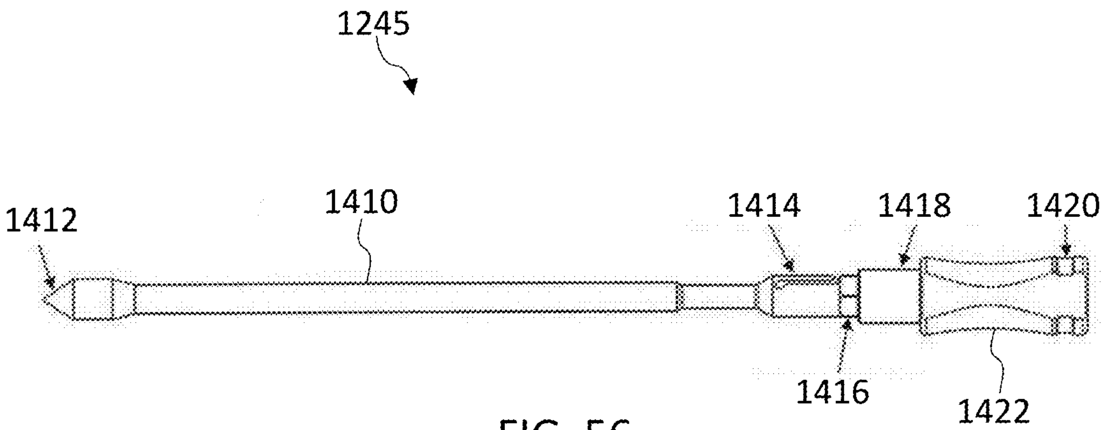


FIG. 55B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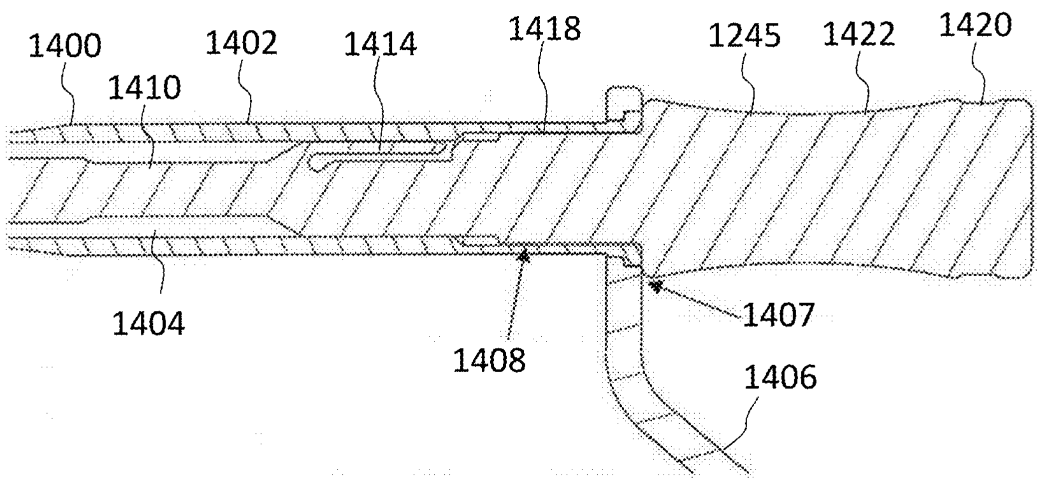
1412
1410
1414
1418
1420
1416
1422

FIG. 56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1410
1402
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1418
1245
1422
1420
1404
1408
1407
1406

FIG. 57

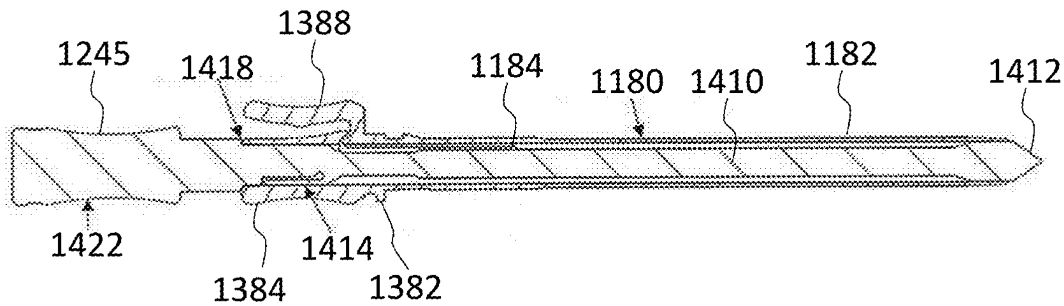

1388
1245
1418
1184
1180
1410
1182
1412
1422
1414
1384
1382

FIG. 58

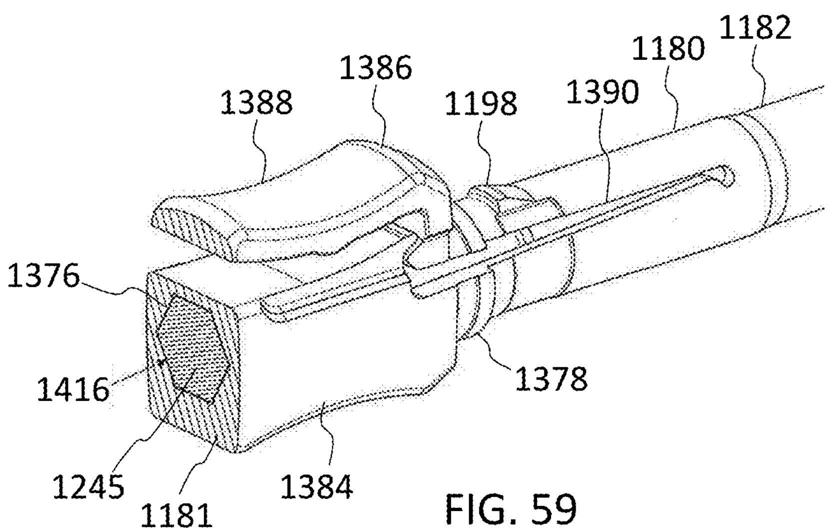
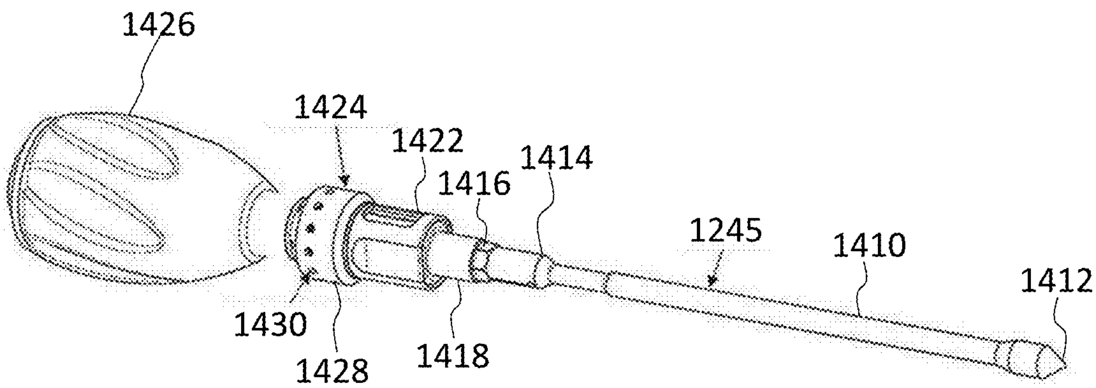

1182
1180
1386
1388
1198
1390
1376
1378
1416
1245
1181
1384

FIG. 59


1426
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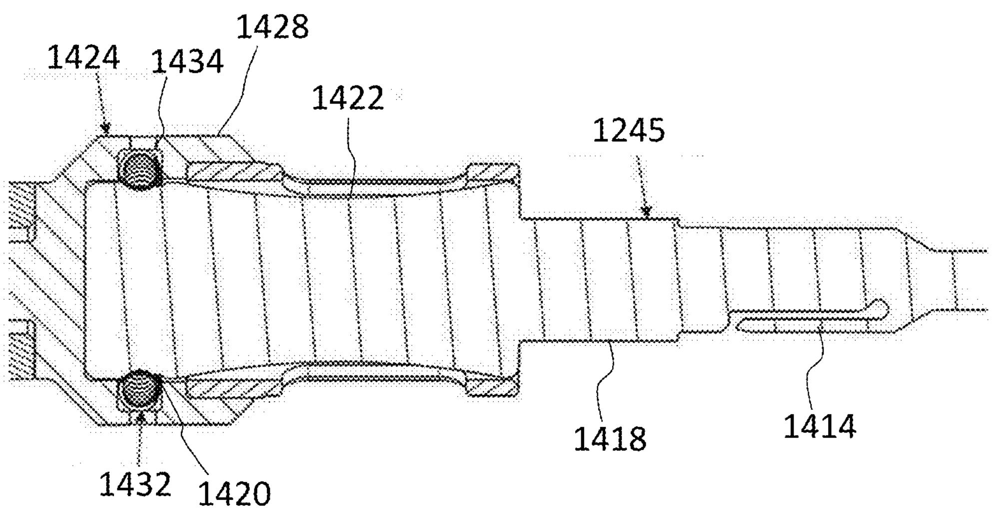
1414
1245
1410
1412
1430
1428
1418

FIG. 60


1428
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1434
1422
1245
1418
1414
1432
1420

FIG. 61

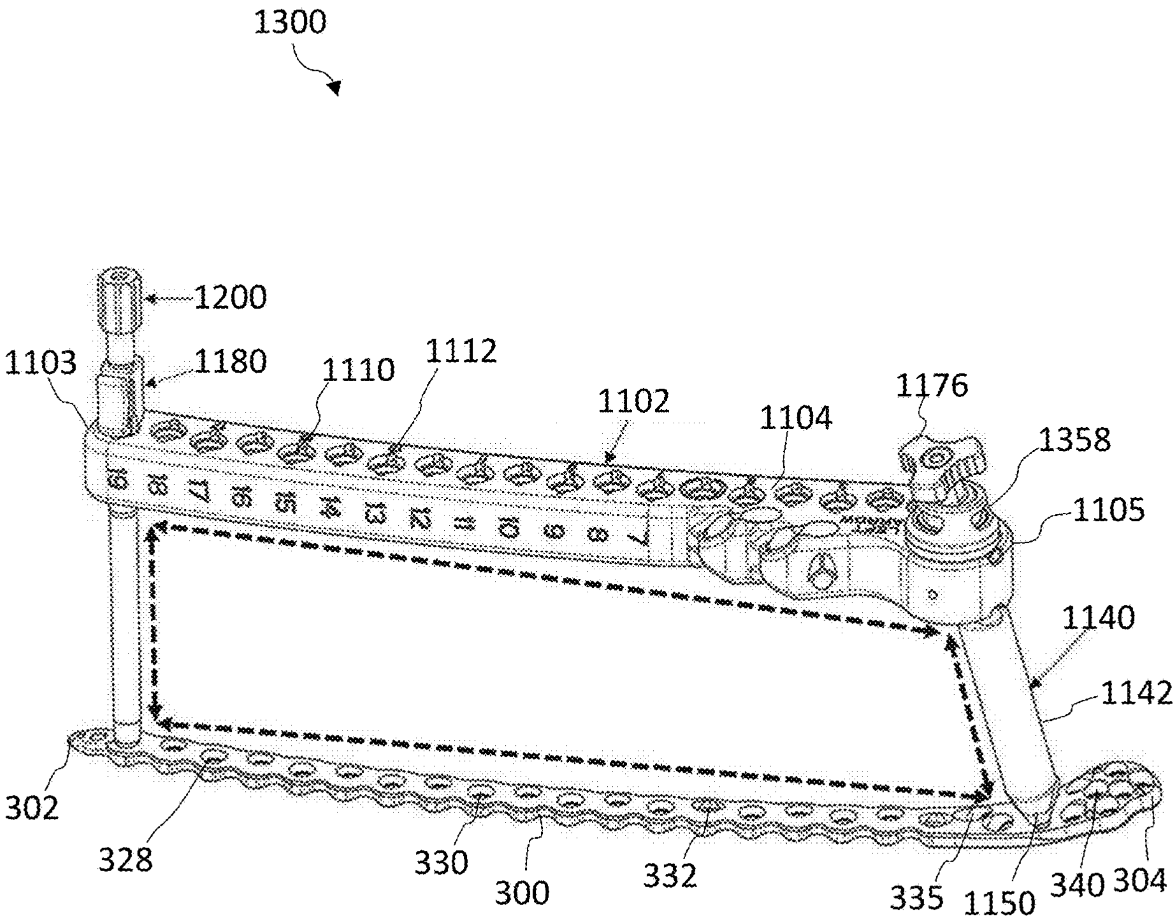
1300
1200
1103
1180
1110
1112
1102
1104
1176
1358
1105
1140
1142
302
328
330
300
332
335
1150
340
304

FIG. 62

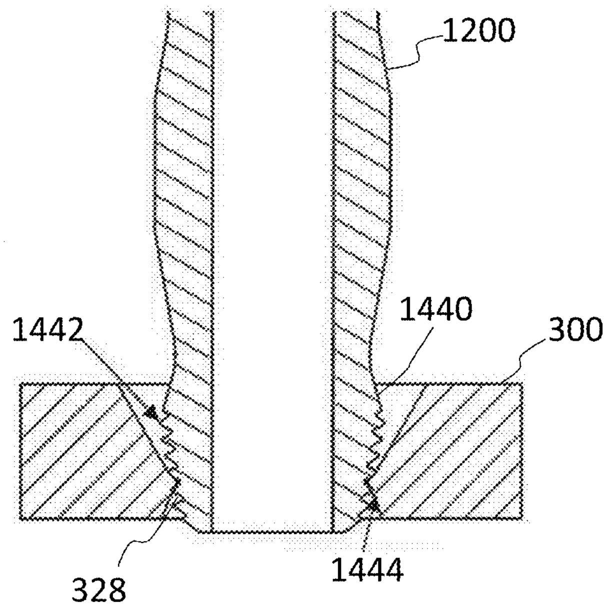

FIG. 63A

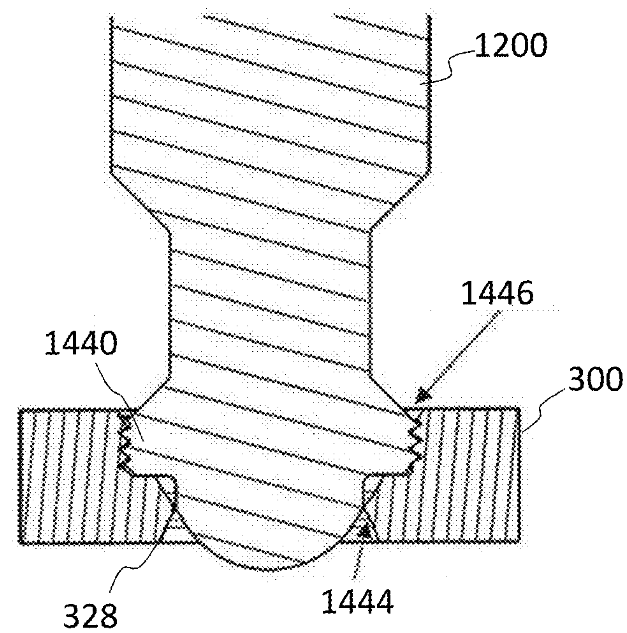

FIG. 63B

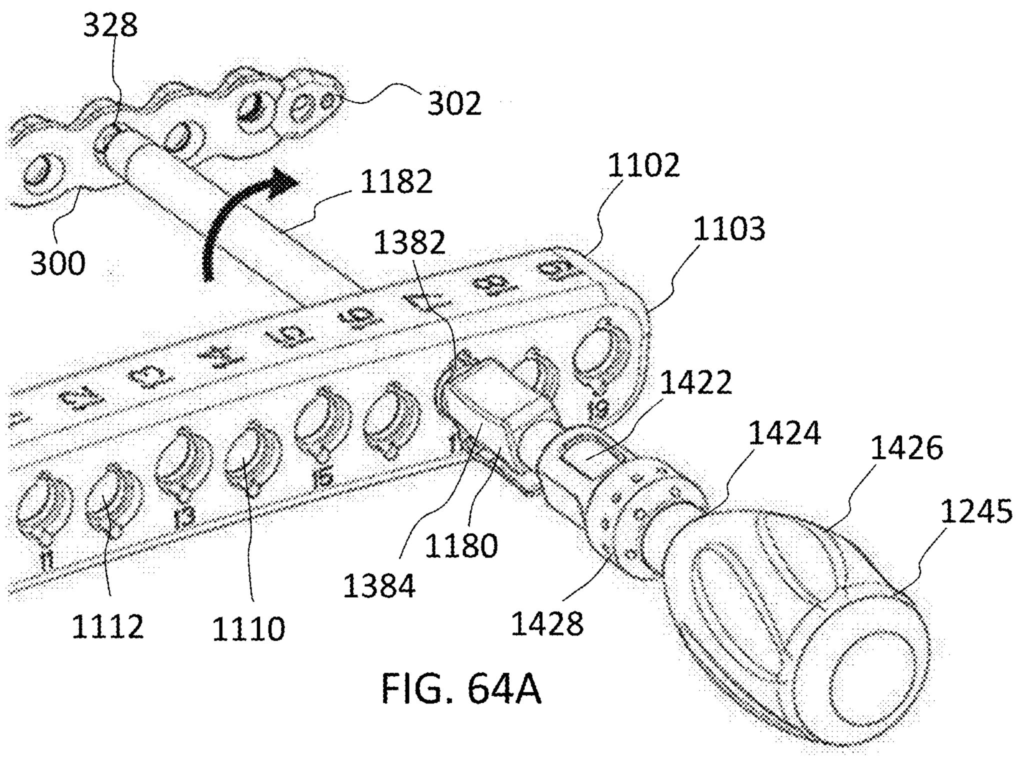

FIG. 64A

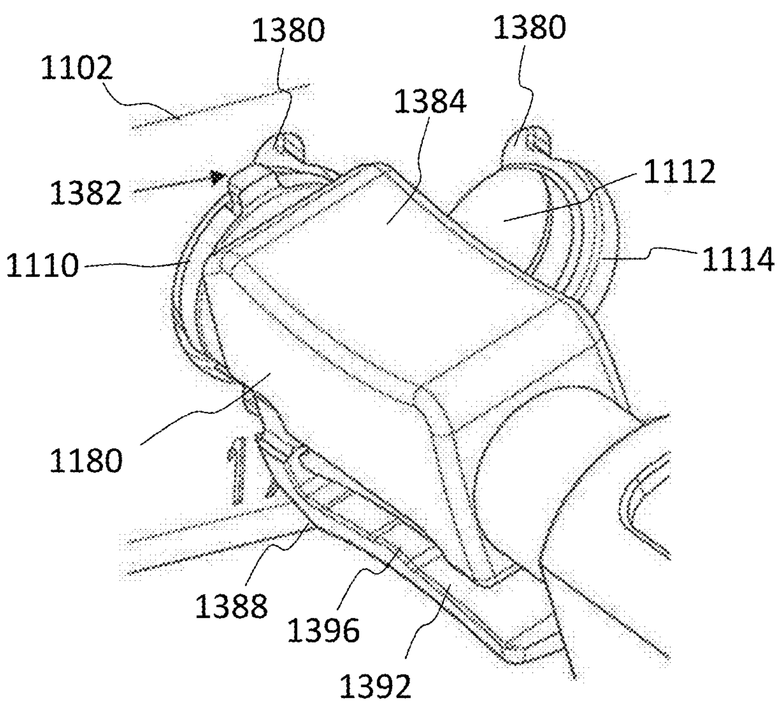

FIG. 64B

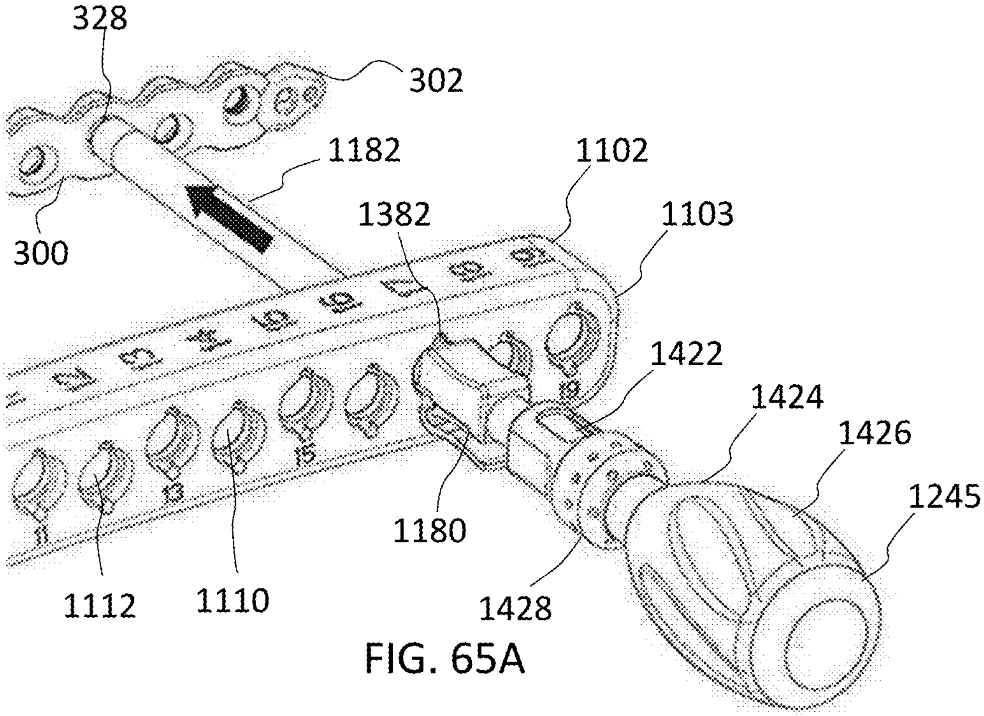

FIG. 65A

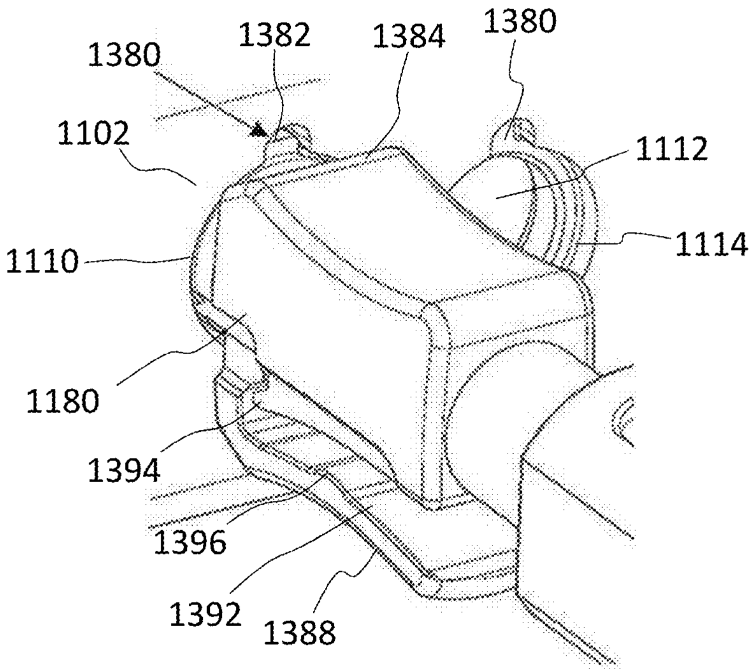

FIG. 65B

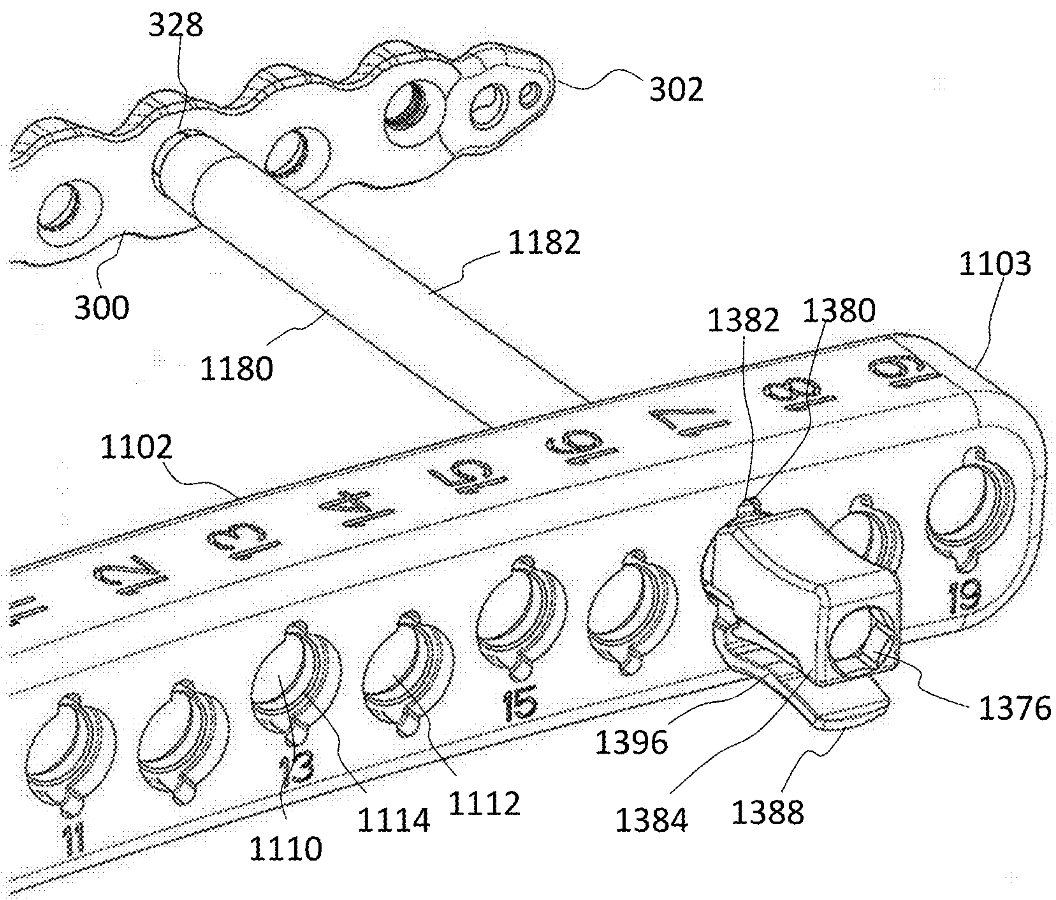
328
302
300
1182
1180
1103
1382
1380
1102
1376
1396
1384
1388
1110
1114
1112

FIG. 66

BONE STABILIZATION SYSTEMS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 17/509,526, filed on Oct. 25, 2021, which is a continuation-in-part of U.S. patent application Ser. No. 16/031,066, filed on Jul. 10, 2018, which is a continuation-in-part of U.S. patent application Ser. No. 15/925,846, filed Mar. 20, 2018, which is a continuation-in-part of U.S. patent application Ser. No. 15/703,345 filed Sep. 13, 2017, which are incorporated by reference herein in their entireties for all purposes.

FIELD OF THE INVENTION

[0002] The present disclosure relates to surgical devices, and more particularly, stabilization systems including plates, for example, for trauma applications.

BACKGROUND OF THE INVENTION

[0003] Bone fractures can be healed using plating systems. During treatment, one or more screws are placed on either side of a fracture, thereby causing compression and healing of the fracture. There is a need for improved plating systems as well as mechanisms for accurate use of the plating systems.

[0004] Full open reduction and internal fixation (ORIF) of distal femur plates often requires an incision that would span much of the length of the femur, increasing the potential for excessive stripping of the soft tissue and/or periosteum and a higher chance of wound complications. Lateral distal femur plates are often inserted with an aiming guide assembly to assist in performing a minimally invasive (MIS) surgical approach. With an aiming guide, a surgeon can place and direct a plate through one small incision at the knee as well as target the location of shaft holes with small incisions up the femur. However, there is a need for a guide system that provides an easy to use, distal connection with the plate.

SUMMARY OF THE INVENTION

[0005] In accordance with the application, in some embodiments, a system is provided for treating a fracture in a bone. The system comprises a bone plate configured to engage the bone, the bone plate comprising a proximal portion, a shaft and a distal portion, wherein the proximal portion comprises a tapered tip, wherein the shaft comprises one or more holes, and wherein the distal portion comprises one or more distal holes and a posterior side and an anterior side, wherein the posterior side of the distal portion is raised relative to the anterior side of the distal portion. The system further comprises at least one fastener received through the one or more holes of the shaft and at least one fastener received through the one or more distal holes of the distal portion.

[0006] In other embodiments, a system is provided for treating a fracture in a bone. The system comprises a bone plate configured to engage the bone, the bone plate comprising a proximal portion, a shaft and a distal portion, wherein the proximal portion comprises a tapered tip, wherein the shaft comprises one or more holes, and wherein the distal portion comprises one or more distal holes and a posterior side and an anterior side, wherein the one or more holes in the shaft are fixed holes while the one or more distal holes in the distal shaft are polyaxial locking holes. The system further includes at least one fastener received through the one or more holes of the shaft and at least one fastener received through the one or more distal holes of the distal portion.

[0007] In yet another embodiment, a system for treating a fracture in a bone includes a bone plate configured to engage the bone, the bone plate extending along a longitudinal axis and comprising a proximal portion, a shaft, and a distal portion, the shaft comprises a plurality of holes (e.g., polyaxial holes), the plurality of holes include a first repeating pattern of holes and a second repeating pattern of holes, the first repeating pattern of holes having a first virtual line segment connecting center points of all of the first repeating pattern of holes, the second repeating pattern of holes having a second virtual line segment connecting center points of all of the second repeating pattern of holes, wherein the first virtual line segment and the second virtual line segment are parallel, and the first virtual line segment and the second virtual line segment are angled relative to the longitudinal axis, and the distal portion comprises a plurality of distal holes and a posterior side and an anterior side, wherein the posterior side of the distal portion is raised relative to the anterior side of the distal portion.

[0008] According to yet another embodiment, a system for treating a fracture in a bone includes a bone plate configured to engage the bone, the bone plate extending along a longitudinal axis and comprising a proximal portion, a shaft, and a distal portion, the shaft comprises a plurality of holes (e.g., polyaxial holes), the plurality of holes include a first repeating pattern of holes and a second repeating pattern of holes, the first repeating pattern of holes having a first virtual line segment connecting center points of all of the first repeating pattern of holes, the second repeating pattern of holes having a second virtual line segment connecting center points of all of the second repeating pattern of holes, wherein the first virtual line segment and the second virtual line segment are parallel, and the first virtual line segment and the second virtual line segment are angled relative to the longitudinal axis, and wherein the first repeating pattern includes a first center hole and the second repeating pattern includes a second center hole, and the center point of the first and second center holes are aligned generally along the longitudinal axis of the plate.

[0009] Also provided are kits including plates of varying shapes and sizes, bone anchors, fasteners, insertion tools, and components for installing the same.

[0010] Also provided are aiming guide systems configured for connection to a bone plate. In at least one embodiment, the aiming guide system includes an aiming arm and a connection assembly. The aiming arm has a rigid body extending from a proximal end to a distal end with a plurality of aiming holes defined through the rigid body between the proximal end and the distal end thereof. The distal end defines an attachment slot through the body. The connection assembly is configured to engage an attachment screw hole of the bone plate and the attachment slot such that the aiming arm is fixed in position relative to the bone plate with each of the aiming holes aligned with a respective hole along the bone plate.

[0011] In at least one embodiment, the aiming guide system includes an aiming arm and a connection assembly. The aiming arm has a rigid body extending from a proximal end to a distal end with a plurality of aiming holes defined through the rigid body between the proximal end and the distal end thereof. The distal end defines an attachment slot through the body. The connection assembly is configured to engage an attachment screw hole of the bone plate and the attachment slot such that the aiming arm is fixed in position relative to the bone plate with each of the aiming holes aligned with a respective hole along the bone plate. The connection assembly includes an attachment post having a first end with an orienting boss extending from a mating surface. The orienting boss is configured to be received in the attachment slot such that the aiming arm rests on the mating surface and is maintained in a proper orientation. A second end of the attachment post has an attachment block having a distal surface which defines a plurality of ball end pins. Each ball end pin is configured to be received in a respective indentation on the plate surface about the attachment screw hole. A threaded shaft extends through a through bore of the attachment post with threads of at least one end of the shaft body configured to threadably engage the attachment screw hole. A fastener is configured to threadably engage threads on an opposite end of the threaded shaft to secure the attachment post between the aiming arm and bone plate.

[0012] Also provided is a method of connecting an aiming guide arm to a bone plate wherein the aiming guide arm has a rigid body extending from a proximal end to a distal end with a plurality of aiming holes defined through the rigid body between the proximal end and the distal end thereof and the distal end defining an attachment slot through the body. The bone plate extends along a longitudinal axis and includes a proximal portion, a shaft, and a distal portion, the bone plate defining a plurality of first screw holes along shaft, a plurality of second screw holes at the distal portion, an attachment screw hole proximate the distal portion and a plurality of indentations about the attachment screw hole. The method includes threadably engaging a first end of a threaded shaft in the attachment screw hole such that the threaded shaft extends from the bone plate at an oblique angle; sliding an attachment post over the threaded shaft such that ball end pins extending from an attachment block on one end of the attachment post seat within the indentations on the bone plate, the opposite end of the attachment post having an orienting boss extending from a mating surface; positioning the aiming guide arm with the orienting boss extending through the attachment slot with a first surface of the aiming guide arm seated on the mating surface; and securing a fastener to the second end of the threaded shaft, the fastener engaging a second surface of the aiming guide body opposite the first surface to secure the aiming guide body relative to the bone plate in a fixed orientation.

[0013] According to one embodiment, an aiming guide system configured for connection to a bone plate defining a plurality of screw holes includes an aiming arm, a connection assembly, and a tissue protection sleeve. The aiming arm may include a rigid body extending from a proximal end to a distal end with a plurality of aiming holes defined through the rigid body. The plurality of aiming holes each include a recess encircling each hole with at least one slot. The distal end of the aiming arm defines a cylindrical opening through the rigid body. The connection assembly is configured to engage the cylindrical opening and an attachment screw hole in the bone plate such that the aiming arm is fixed in position relative to the bone plate with each of the plurality of aiming holes aligned with a respective one of the screw holes. The connection assembly includes a cylindrical boss receivable in the cylindrical opening in the aiming arm and an attachment post. The tissue protection sleeve is configured to be positioned through one of the plurality of aiming holes such that the tissue protection sleeve defines a through bore from the aiming guide to a respective one of the screw holes in the bone plate. The tissue protection sleeve includes an outer tab configured to be received in one of the slots in the aiming hole, thereby keying the tissue sleeve to the aiming arm.

[0014] The aiming guide system may include one or more of the following features. The at least one slot may include a pair of slots oriented 180 degrees to each other. The tissue protection sleeve may include a releasable locking tab configured to engage an undercut in the aiming hole to releasably secure the tissue protection sleeve to the aiming arm. The connection assembly may include a threaded shaft having a shaft body extending between first and second ends, each end including a plurality of threads, the threaded shaft extending through a through bore of the attachment post with the threads of at least one of the first and second ends of the shaft body configured to threadably engage the attachment screw hole in the bone plate. Tension in the threaded shaft may be created by tightening a polyaxial nut assembly configured to self-center on the threaded shaft and match any angulation of the aiming guide. The polyaxial nut assembly may include a spherical nut with a shaft extending between a ball portion and a handle member. The spherical nut may be received in a base, thereby providing self-centering and angular flexibility of the polyaxial nut assembly. The attachment post may include an attachment block having a distal surface which defines a plurality of ball end pins. Each ball end pin may be configured to be received in a respective indentation on a surface of the bone plate about the attachment screw hole such that positioning of the ball end pins within the indentations properly aligns the attachment post relative to the bone plate. The attachment post may be configured to extend at an oblique angle with respect to the bone plate such that the attachment post and aiming arm do not overlie screw holes at a distal region of the bone plate. The system may include an instrument, such as a trocar configured to be positioned through the tissue protection sleeve. The trocar may have a shaft with a tip at a distal end and an enlarged grip base at a proximal end. The trocar may have a deformable retention tab to retain the trocar in the tissue protection sleeve, an external hexagon for rotational control, a stepped shoulder to accommodate different tissue sleeve lengths, and a retention groove on the end of the enlarged base to engage with a removeable handle. The aiming arm may be reversible, for example, with one or more indicators representing its orientation.

[0015] According to another embodiment, an aiming system includes a bone plate, an aiming arm, and a connection assembly. The bone plate may include a proximal portion, a shaft, and a distal portion. The bone plate may define a plurality of first screw holes along the shaft, a plurality of second screw holes at the distal portion, and an attachment screw hole proximate the distal portion. The aiming arm may have a rigid body extending from a proximal end to a distal end with a plurality of aiming holes defined through the rigid body. The plurality of aiming holes may each include a recess encircling each hole with at least one slot.

The distal end of the aiming arm may define a cylindrical opening through the rigid body. The connection assembly may be configured to engage the cylindrical opening and the attachment screw hole in the bone plate such that the aiming arm is fixed in position relative to the bone plate with each of the plurality of aiming holes aligned with a respective one of the first screw holes. The connection assembly may include a cylindrical boss receivable in the cylindrical opening in the aiming arm and an attachment post.

[0016] According to another embodiment, an aiming guide system configured for connection to a bone plate defining a plurality of screw holes includes an aiming arm and a connection assembly. The aiming arm may have a rigid body extending from a proximal end to a distal end with a plurality of aiming holes defined through the rigid body. The distal end of the aiming arm may define a cylindrical opening through the body. A face of the aiming guide may define a pair of notches about the cylindrical opening. The connection assembly may be configured to engage the cylindrical opening and an attachment screw hole in the bone plate such that the aiming arm is fixed in position relative to the bone plate with each of the plurality of aiming holes aligned with a respective one of the screw holes. The connection assembly may include a cylindrical boss receivable in the cylindrical opening in the aiming arm, an attachment post, and a cross pin receivable in the pair of notches to thereby secure the cylindrical boss in the cylindrical opening. The cylindrical boss may include a central opening having a hole axis and the attachment post defines a central cannulation having a central cannulation axis such that the central cannulation axis and the cylindrical boss axis are not aligned. The cylindrical opening may include a tubular insert (e.g., metallic) threadedly coupled to the aiming arm to reinforce the opening.

[0017] According to another embodiment, a method of securing an aiming guide arm relative to a bone plate may include on or more of the following steps in any suitable order: (1) positioning an instrument through a tissue protection sleeve, the instrument having a shaft with a tip at a distal end and an enlarged grip base at a proximal end; (2) positioning the tissue protection sleeve through an aiming hole in the aiming guide arm, the aiming hole defining a recess encircling the hole with a slot, the tissue protection sleeve having a head member and a hollow body with a central cannulation and an outer tab; and (3) rotating and pushing the tissue protection sleeve such that the outer tab is received in the slot in the aiming hole, thereby keying the tissue sleeve to the aiming arm.

[0018] The method may include one or more of the following features. The aiming hole may define a pair of slots oriented 180 degrees to each other, thereby permitting the tissue protection sleeve to be inserted in two orientations. The head member of the tissue protection sleeve may include a polygonal opening, and the instrument may include an external polygon configured to mate with the polygonal opening, thereby constraining rotation between the tissue protection sleeve and the instrument. The tissue protection sleeve may include a pivotal locking arm with a button for engaging and releasing a locking tab from an undercut in the aiming hole. The tissue protection sleeve may include a collar positioned between the button and the locking tab, and the outer tab may be positioned on the collar at a location opposite to the button. When the tissue protection sleeve is inserted properly, an audible click may indicate the pivotal locking arm elastically deforms and the locking tab snaps past the undercut in the aiming hole. The method may include removing the tissue protection sleeve by squeezing the button and head member together, temporarily elastically deforming the locking arm, releasing the locking tab from the undercut, and allowing the tissue protection sleeve to be pulled upward and free from the aiming arm. Deformation of the locking arm and the button may be bounded by one or more intentional mechanical stops. The instrument may include a deformable retention tab to retain the instrument in the tissue protection sleeve, a stepped shoulder to accommodate different tissue sleeve lengths, and a retention groove on an end of the enlarged grip base to engage with a removeable handle. The stepped shoulder of the instrument may bottom out when the shoulder contacts a proximal face of the head member of the tissue protection sleeve.

[0019] According to another embodiment, a method of securing an aiming guide arm relative to a bone plate may include one or more of the following steps in any suitable order: (1) securing an attachment post having a cylindrical boss to a distal region of the bone plate; (2) positioning the cylindrical boss in a cylindrical opening at a distal end of the aiming guide arm; (3) securing the attachment post to the aiming guide arm with a polyaxial nut assembly; (4) positioning a tissue protection sleeve through an aiming hole at a proximal end of the aiming guide arm and into an opening at a proximal region of the bone plate, wherein the tissue protection sleeve is positioned at the most-proximal holes possible for both the aiming guide arm and the bone plate. The aiming guide arm, the attachment post, the bone plate, and the tissue protection sleeve may form a lock the box construct configured to improve the rigidity and enhance targeting accuracy.

[0020] The method may include one or more of the following features. Before securing the attachment post, the method may include reversing and orienting the aiming guide arm based on indicators on the aiming arm to match the handedness of the bone plate. Securing the attachment post to the bone plate may include positioning a plurality of ball end pins in respective indentations on a surface of the bone plate, thereby properly aligning the attachment post relative to the bone plate. The attachment post may be secured to the bone plate with a threaded shaft having a plurality of threads by positioning the threaded shaft through a through bore of the attachment post and threadably engaging an attachment screw hole in the bone plate. Tension to the threaded shaft may be created by tightening the polyaxial nut assembly providing for self-centering on the threaded shaft and matching of any angulation of the aiming guide. The attachment post may be configured to extend at an oblique angle with respect to the bone plate such that the attachment post and aiming arm do not overlie screw holes at a distal region of the bone plate. The tissue protection sleeve may include a releasable locking tab, and when the locking tab engages an undercut in the aiming hole, the tissue protection sleeve is releasably secured to the aiming arm.

[0021] According to yet another embodiment, a method of securing an aiming guide arm relative to a bone plate may include one or more of the following steps in any suitable order: (1) threadably engaging a first end of a threaded shaft in an attachment screw hole in a bone plate such that the threaded shaft extends from the bone plate at an oblique angle; (2) sliding an attachment post over the threaded shaft such that ball end pins extending from an attachment block on one end of the attachment post seat within indentations on the bone plate, the opposite end of the attachment post having a cylindrical boss; (3) positioning the cylindrical boss into a cylindrical opening in the aiming guide arm; and (4) securing a polyaxial nut assembly to a second end of the threaded shaft, thereby creating tension to the threaded shaft. The polyaxial nut assembly may include a spherical nut with a shaft extending between a ball portion and a handle member. The spherical nut may be received in a base, thereby providing self-centering and angular flexibility of the polyaxial nut assembly. The cylindrical boss may include a central opening having a hole axis and the attachment post defines a central cannulation having a central cannulation axis. The central cannulation axis and the cylindrical boss axis may be mis-aligned such that the attachment post is on a non-normal axis relative to the aiming guide, thereby removing obstructions from a radiographic view of the plate.

[0022] Also provided are kits including aiming arm systems including their components and plates of varying shapes and sizes. The kits may further include other instruments, bone anchors, fasteners, and other components for performing the procedures described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] A more complete understanding of the present invention, and the attendant advantages and features thereof, will be more readily understood by reference to the following detailed description when considered in conjunction with the accompanying drawings, wherein:

[0024] FIG. **1** is a view of a bone plate on bone in accordance with some embodiments of the present application.

[0025] FIG. **2** is an alternate view of the bone plate on bone in FIG. **1**.

[0026] FIG. **3** is a top perspective view of a narrow bone plate in accordance with some embodiments of the present application.

[0027] FIG. **4** is a top perspective view of a broad bone plate in accordance with some embodiments of the present application.

[0028] FIG. **5** is a view of an alternative bone plate on bone in accordance with some embodiments of the present application.

[0029] FIG. **6** is a top view of a lengthened, narrow bone plate in accordance with some embodiments of the present application.

[0030] FIG. **7** is a top view of a lengthened, broad bone plate in accordance with some embodiments of the present application.

[0031] FIG. **8** is a top view of a medial plate in accordance with some embodiments of the present application.

[0032] FIG. **9** is a top perspective view of a representative plate including a twist up its shaft.

[0033] FIG. **10** is a cross-sectional view of a section of a representative plate showing an arced contour of an underside.

[0034] FIG. **11** is a cross-sectional view of a different section of a representative plate showing an arced contour of an underside.

[0035] FIG. **12** is a top perspective view of another embodiment of a narrow bone plate.

[0036] FIG. **13** is a top perspective view of another embodiment of a broad bone plate.

[0037] FIG. **14** is a close-up view of the geometry of the broad bone plate of FIG. **13**.

[0038] FIG. **15** is a top view of another embodiment of a narrow bone plate.

[0039] FIG. **16** is a top view of another embodiment of a broad bone plate.

[0040] FIG. **17** is a perspective view of another embodiment of a medial locking plate.

[0041] FIG. **18** is a perspective view of the epicondylar ridge on the end of a femur.

[0042] FIG. **19** illustrates the distal portion of the medial plate shown in FIG. **17**.

[0043] FIG. **20** is a side view of a portion of the medial plate shown in FIG. **17**.

[0044] FIG. **21** is a perspective view of an aiming guide system in accordance with an embodiment of the disclosure shown attached to an illustrative bone plate.

[0045] FIG. **22** is a perspective view of the aiming arm of the aiming guide system of FIG. **21**.

[0046] FIGS. **23** and **24** are cross-sectional views of aiming holes of narrow and broad aiming arms, respectively.

[0047] FIG. **25** is a perspective view of an illustrative threaded shaft of the connecting assembly of the aiming guide system of FIG. **21**.

[0048] FIG. **26** is a perspective view of an illustrative attachment post of the connecting assembly of the aiming guide system of FIG. **21**.

[0049] FIG. **27** is a top plan view illustrating an alternative embodiment of the attachment slot and orienting boss.

[0050] FIG. **28** is a perspective view of the distal attachment block of the attachment post of FIG. **26**.

[0051] FIG. **29** is a side elevation view illustrating connection of the connecting assembly with the aiming arm.

[0052] FIG. **30** is a cross-sectional view illustrating the connecting assembly fully assembled between the aiming arm and the bone plate.

[0053] FIG. **31** is a perspective view of an aiming guide system in accordance with another embodiment of the disclosure shown attached to an illustrative bone plate.

[0054] FIG. **32** is a perspective view of the fixed axis fastener of the aiming guide system of FIG. **31**.

[0055] FIG. **33** is a perspective view of an illustrative tissue protection sleeve according to an embodiment of the disclosure.

[0056] FIG. **34** is an expanded elevation view of the proximal portion of the tissue protection sleeve of FIG. **33** engaged within an aiming hole of the aiming arm.

[0057] FIG. **35** is a perspective view of an illustrative drill sleeve according to an embodiment of the disclosure.

[0058] FIG. **36** is a cross-sectional view of the distal portion of the drill sleeve of FIG. **35** extending into a bone plate hole.

[0059] FIG. **37** is a cross-sectional view of an illustrative hole marker engaged within an aiming hole of the aiming arm.

[0060] FIG. **38** is a perspective view of an aiming guide system in accordance with an embodiment of the disclosure shown attached to an illustrative bone plate.

[0061] FIG. **39** is a perspective view of the aiming guide arm of FIG. **38**.

[0062] FIG. **40** is a close-up partial cross-sectional view of an attachment location between the aiming guide arm and an attachment post according to one embodiment.
[0063] FIG. **41** is a cross-sectional view of the aiming guide system including the aiming arm attached to the bone plate with the attachment post and polyaxial nut assembly according to one embodiment.
[0064] FIG. **42** is a close-up cross-sectional view of a first kinematic mount between the bone plate and the distal attachment block of the attachment post shown in FIG. **28**.
[0065] FIG. **43** is a close-up cross-sectional view of the second kinematic mount between the aiming arm and the cylindrical boss of the attachment post.
[0066] FIG. **44** is a side view of the second kinematic mount between the aiming arm and attachment post.
[0067] FIG. **45** is a top-down perspective view of the aiming guide system providing an open view to the distal region of the plate and fracture site.
[0068] FIG. **46** is a cross-sectional view of the polyaxial nut assembly according to one embodiment.
[0069] FIG. **47** is a perspective view of the two-piece base of the polyaxial nut assembly according to another embodiment.
[0070] FIG. **48** is a cross-sectional view of the two-piece base of the polyaxial nut assembly shown in FIG. **47**.
[0071] FIGS. **49**A-**49**B show tissue sleeve keying features between the aiming holes in the aiming guide and the tissue protection sleeve according to one embodiment.
[0072] FIGS. **50**A-**50**C show perspective and cross-sectional views, respectively, of a tissue protection sleeve and the aiming arm interface for retaining the tissue sleeve according to one embodiment.
[0073] FIGS. **51**A-**51**B show side views of the tissue protection sleeve with the thumb lock in a relaxed state and a deformed state, respectively.
[0074] FIG. **52** shows a close-up top isometric view of the head member of the tissue protection sleeve according to one embodiment.
[0075] FIG. **53** shows a representation of the aiming arm aligned to the plate at equal distances such that the distance from the center of each hole of the plate to the bottom of the recess in each hole in the aiming arm is constant according to one embodiment.
[0076] FIG. **54** shows an example of varying recess depths in adjacent holes of the aiming guide according to one embodiment.
[0077] FIGS. **55**A-**55**B show a perspective view and close-up cross-sectional view, respectively, of a kickstand sleeve according to one embodiment.
[0078] FIG. **56** shows an example of a soft tissue trocar instrument according to one embodiment.
[0079] FIG. **57** shows a cross-sectional view of the trocar inserted through the kickstand sleeve.
[0080] FIG. **58** shows a cross-sectional view of the interaction between the trocar and the soft tissue sleeve.
[0081] FIG. **59** shows a close-up perspective view of the polygonal rotation control between the trocar and the head member of the tissue protection sleeve.
[0082] FIG. **60** shows an example of a trocar with removable handle according to one embodiment.
[0083] FIG. **61** is a cross-sectional view of the trocar-handle interconnection.
[0084] FIG. **62** shows a representation of a lock the box configuration for connection of the aiming arm to the plate including the attachment post and the tissue protection sleeve positioned through the furthest hole possible.
[0085] FIG. **63**A-**63**B show close-up cross-sectional views of different embodiments of a drill guide to plate interface.
[0086] FIGS. **64**A-**64**B show perspective and close-up views of insertion of the trocar through the soft tissue sleeve in the aiming guide with the tissue sleeve not fully seated in the aiming guide.
[0087] FIGS. **65**A-**65**B show perspective and close-up views of the tissue sleeve fully seated and engaged with the aiming guide and trocar positioned through the guide.
[0088] FIG. **66** shows the tissue protection sleeve fully and properly seated in the aiming guide arm.

DETAILED DESCRIPTION OF THE INVENTION

[0089] Embodiments of the present application are generally directed to devices, systems and methods for bone stabilization. In particular, embodiments are directed to bone plates that extend across bone members to treat one or more fractures.
[0090] The plates described herein may be adapted to contact one or more of a femur, a distal tibia, a proximal tibia, a proximal humerus, a distal humerus, a clavicle, a fibula, an ulna, a radius, bones of the foot, bones of the hand, or other suitable bone or bones. The bone plates may be curved, contoured, straight, or flat. The plates may have a head portion that is contoured to match a particular bone surface, such as a condylar region, metaphysis or diaphysis. In addition, the plates may have a shaft portion that is contoured to match a particular surface that flares out in the form of an L-shape, T-shape, Y-shape. The plates may be adapted to secure small or large bone fragments, single or multiple bone fragments, or otherwise secure one or more fractures. In particular, the systems may include a series of trauma plates and screws designed for the fixation of fractures and fragments in diaphyseal and metaphyseal bone. Different bone plates may be used to treat various types and locations of fractures.
[0091] The bone plates may be comprised of titanium, stainless steel, cobalt chrome, carbon composite, plastic or polymer-such as polyetheretherketone (PEEK), polyethylene, ultra-high molecular weight polyethylene (UHMWPE), resorbable polylactic acid (PLA), polyglycolic acid (PGA), combinations or alloys of such materials or any other appropriate material that has sufficient strength to be secured to and hold bone, while also having sufficient biocompatibility to be implanted into a body. Similarly, the bone plates may receive one or more screws or fasteners may be comprised of titanium, cobalt chrome, cobalt-chrome-molybdenum, stainless steel, tungsten carbide, combinations or alloys of such materials or other appropriate biocompatible materials. Although the above list of materials includes many typical materials out of which bone plates and fasteners are made, it should be understood that bone plates and fasteners comprised of any appropriate material are contemplated.
[0092] The bone plates described herein can include a combination of locking holes and non-locking holes, only locking holes, or only non-locking holes. Locking holes comprise one or more openings that accept one or more locking fasteners. The one or more openings can be partially or fully threaded, thread-forming, or otherwise configured to

allow locking attachment of the fastener to the hole. In some embodiments, the holes comprise stacked or polyaxial locking holes, which can accept both locking and non-locking fasteners. In some embodiments, the locking fasteners include heads that are at least partially threaded. The locking fasteners can be monoaxial or polyaxial. One non-limiting example of a locking fastener (among others) is shown in FIG. 6 of U.S. Ser. No. 15/405,368, filed Jan. 13, 2017, which is (along with any subsequent publication of the same application) hereby incorporated by reference in its entirety.

[0093] Non-locking holes comprise one or more openings for accepting one or more non-locking fasteners. The one or more openings are at least in part non-threaded. In some embodiments, these openings include non-threaded or stacked openings, which can accept both locking and non-locking fasteners. In some embodiments, the holes comprise stacked or polyaxial locking holes, which can accept both locking and non-locking fasteners. The non-locking fasteners can be monoaxial or polyaxial. One non-limiting example of a non-locking fastener (among others) is shown in FIG. 4 of U.S. Ser. No. 15/405,368, filed Jan. 13, 2017, which is (along with any subsequent publication of the same application) hereby incorporated by reference in its entirety. In some embodiments, the non-locking fasteners can include dynamic compression screws, which enable dynamic compression of an underlying bone.

[0094] In some embodiments, one or more of the plates described below include both locking and non-locking holes. Locking holes and locking fasteners may be useful for patients that have weaker bone. In addition, these may be helpful to prevent screw backout. Non-locking plates may be useful for patients that have strong bone.

[0095] In some embodiments, one or more of the plates described below can comprise improved distal femoral plates. These plates can be used by a surgeon as an internal fixation device for a variety of fracture patterns in the condylar region of the distal femur. Typical indications can include buttressing of comminuted/multi-fragmentary fractures, metaphyscal and supracondylar fractures, intra-articular and extra-articular femur fractures, periprosthetic fractures, fractures in osteopenic bone, osteotomies of the femur, and nonunions and malunions.

[0096] The one or more plates can provide a number of advantages, as will be discussed further below. In particular, the plates are designed to better accommodate anatomical features. For example, one or more plates can include a raised posterior sideline that accommodates an epicondylar protuberance. In addition, the plates have various holes or openings for receiving various types of screws or fasteners, such as one or more kickstand screws, fixed screws, and/or polyaxial screws, that provide excellent fixation while minimizing the risk of various deformities.

[0097] FIG. **1** is a view of a bone plate on bone in accordance with some embodiments of the present application. The bone plate **100** comprises a distal femur plate that is attached to a femur bone **5**. The femur bone **5** comprises a distal condylar region **7** and a shaft **17** having a lateral side **11** and a medial side **13**. The condylar region **7** includes a pair of medial and lateral condyles and a pair of medial and lateral epicondyles **9** positioned near the posterior edge of the condyles.

[0098] The bone plate **100** comprises a distal femur plate that comprises a proximal portion **102** and a distal portion **104**. The proximal portion **102** comprises a tapered insertion end that transitions into a shaft **110**. The distal end of the shaft **110** flares out into a wider portion that forms the head or distal portion **104** of the bone plate **100**. While the proximal portion **102** and shaft **110** of the bone plate **100** reside along the shaft **17** of the femur, the head or distal portion **104** of the bone plate **100** resides along the condylar region **7** of the femur.

[0099] The proximal portion **102** and shaft **110** of the bone plate **100** are configured to receive one or more screws or fasteners **50**. Likewise, the distal portion **104** of the bone plate **100** is configured to receive one or more screws or fasteners **52**. In some embodiments, the fasteners **50** on the proximal portion **102** and shaft **110** of the bone plate **100** comprise fixed angle fasteners, while the fasteners **52** on the distal portion **104** of the bone plate **100** comprise polyaxial fasteners. It has been found that while fixed angle fasteners are often stronger than polyaxial fasteners and provide greater stiffness to a bone plate attached to bone, at times, bone plate stiffness can be too great, thereby impeding proper bone healing. Accordingly, the present application provides a novel bone plate **100** that can accommodate both fixed angle fasteners **50** and polyaxial fasteners **52**, thereby providing a balance between adequate stiffness and proper healing. In other embodiments, the bone plate **100** can receive only fixed angle fasteners, thereby providing a bone plate of increased stiffness. In other embodiments, the bone plate **100** can receive only variable angle fasteners, thereby providing a bone plate of less stiffness. Moreover, polyaxial locking holes provide an opportunity to place a fastener at a variety of different angles relative to the bone plate, permitting the avoidance of other fasteners and/or implants that may already be in the bone. Therefore, the polyaxial locking holes provide more options for a surgical user. FIG. **2** is an alternate view of the bone plate on bone in FIG. **1**. From this view, one can see the bone plate **100** and its fasteners **50**, **52** through the femur **5**. As noted above, in some embodiments, fasteners **50** comprise fixed fasteners that enter through the shaft **17** of the femur **5**. These fasteners **50** are shorter relative to fasteners **52** and provide increased stiffness. In some embodiments, fasteners **52** comprise variable angle fasteners that enter through the condylar region **7** of the femur **5**. These fasteners **52** are longer relative to fasteners **50**. While these fasteners **52** can provide decreased stiffness relative to the other fasteners **50**, they also have more variability in their angle of placement relative to one another and the bone plate to provide more options for a surgical user.

[0100] FIG. **3** is a top perspective view of the narrow bone plate in accordance with some embodiments of the present application. The bone plate **100** comprises a proximal portion **102** and a distal portion **104**. In between the proximal portion **102** and distal portion **104** is a shaft **110** having an anterior sidewall **106** and a posterior sidewall **108**. Along the length of the bone plate **100** are a series of holes or openings for receiving screws or fasteners therein.

[0101] The proximal portion **102** of the bone plate **100** comprises a tapered tip **120**. In some embodiments, the tapered tip **120** serves as the lead portion of the bone plate **100** to enter into an incision. In some embodiments, the tapered tip **120** allows for simplified submuscular plate insertion to minimize incision length. The proximal portion **102** further comprises a k-wire hole **122** for receiving a k-wire therein to guide bone plate **100** to a desired surgical site. The k-wire hole **122** allows for temporary fixation of the bone plate **100** to bone via a k-wire. In some embodiments, the k-wire hole **122** is unthreaded. In addition, the proximal portion **102** further comprises an articulated tensioning device (ATD) slot **124**. The ATD slot **124** is configured to receive a portion of a tension or compression device (not shown) that can help to bring bone fragments together for healing. In some embodiments, the ATD slot **124** is composed of a through hole and a cylindrical shaped undercut on the bottom of the plate **100**.

[0102] The proximal portion **102** transitions into the shaft portion **110**. The shaft portion **110** comprises multiple holes or openings **130***a*, **130***b*, **130***c*, **130***d*, **130***e*, **130***f* that are configured to receive fasteners therein. In some embodiments, holes **130***a*-**130***f* are configured to be fixed angle, stacked locking holes that can accommodate screws (e.g., between 3.5-7.5 mm screws, such as 4.5 mm screws). The fixed angle, stacked locking holes advantageously allow for mono-axial insertion of fasteners that lock to the bone plate **100**. In some embodiments, these holes can also accommodate non-locking fasteners. In some embodiments, the holes **130***a*-**130***f* are arranged in series such that no two holes **130***a*-**130***f* overlap along a width of the shaft portion **110**.

[0103] In addition, the shaft portion **110** comprises one or more bi-directional dynamic compression slots **132***a*, **132***b* interspersed between the holes **130***a*-**130***f*. The slots **132***a*, **132***b* are elongated in length relative to the holes **130***a*-**130***f*, and are configured to receive one or more non-locking fasteners therein. While the present embodiment illustrates two dynamic compression slots **132***a*, **132***b*, in some embodiments, there can be three or more compression slots. In some embodiments, the dynamic compression slots **132***a*, **132***b* allow for static insertion of non-locking screws into the shaft portion **110** of the bone. In some embodiments, they also allow for compression (e.g., between 0.5-2 mm, such as 1 mm, of compression) along the shaft portion **110** of the bone through eccentric insertion of a non-locking screw. In some embodiments, the locations of the dynamic compression slots **132***a*, **132***b* are optimized for typical intercondylar splits and osteotomies.

[0104] In addition to the holes **130***a*-**130***f* and the compression slots **132***a*, **132***b*, the shaft **110** further comprises a kickstand hole **135**. In some embodiments, the kickstand hole **135** comprises a polyaxial locking hole for receiving a locking fastener therein. The kickstand hole **135** is advantageously designed to receive a fastener that targets the strong cortical bone in the posteromedial cortex of the condylar region, thereby promoting angular stability. Additionally, the kickstand hole is useful for providing enhanced fixation for comminuted fractures in the metaphyseal region of the bone, due to its oblique angle relative to the upper surface of the plate. In some embodiments, the kickstand hole **135** is angled between 23-33 degrees, or in some embodiments between 27-29 degrees, upwards from a normal plane of the upper surface of the plate.

[0105] The shaft portion **110** comprises an anterior side **106** and a posterior side **108** that form the edges of the shaft portion **110**. The anterior side **106** and posterior side **108** can include one or more waisted edge scallops **136**. Advantageously, the one or more waisted edge scallops **136** permit some bending of the shaft portion **110** without deforming the holes, thereby promoting uniform load transfer. In some embodiments, the shaft portion **110** can have a pre-contoured geometry. Advantageously, the pre-contoured geometry can allow an optimal fit along an entire lateral aspect of a femur. In lengthier versions of the plate **100**, there can be an anterior bow and slight shaft twist to mate with proximal femoral anatomy. In addition, in some embodiments, the underside of the bone plate **100** can be arced to mate with the cylindrical nature of the femoral shaft.

[0106] The distal end of the shaft portion **110** transitions into the wider, distal portion **104** of the bone plate **100**. The distal portion **104** of the bone plate **100** is configured to reside at or near the condylar region of the femur **5**. The distal portion **104** comprises holes or openings **140***a*, **140***b*, **140***c*, **140***d*, **140***c*, **140***f*, **140***g*, **140***h* that are configured to receive one or more fasteners or screws therein. In some embodiments, the holes **140***a*-**140***h* comprise polyaxial locking holes that can accommodate screws (e.g., between 3.5-7.5 mm screws, such as 4.5 mm screws). The locking holes may be thread-forming such that a thread is formed within the locking hole as the fastener is inserted therein. In some embodiments, the polyaxial locking holes **140***a*-**140***h* can have a cone of angulation of up to between 30 to 50 degrees, and more particularly 40 degrees, according to some embodiments. The polyaxial locking holes **140***a*-**140***h* thus accommodate fasteners of different angles. Advantageously, in some embodiments, the polyaxial locking holes are designed to accommodate multi-planar diverging trajectories to allow a surgeon to select optimal screw trajectories to avoid any existing hardware in the condylar region. In other words, fasteners inserted into the condylar region will avoid other similarly inserted fasteners or other pre-existing hardware that may have been inserted previously in the region. While the present embodiment includes eight polyaxial holes **140***a*-**140***h*, one skilled in the art will appreciate that the bone plate **100** can include less than eight polyaxial holes or greater than eight polyaxial holes. Furthermore, as the bone plate **100** can include both fixed angle fasteners (e.g., in the shaft **110** of the bone plate **100**) and polyaxial fasteners (e.g., in the distal portion **104** of the bone plate **100**), the bone plate **100** can be provided relative to an underlying with just enough stiffness to accommodate adequate healing.

[0107] In some embodiments, the holes **140***a*-**140***h* can include one or more holes that are nominally angled so that they are parallel to a knee joint. These holes can receive one or more fasteners or screws that are parallel to the knee joint, thereby helping in proper alignment of the bone plate **100** relative to bone. In the present embodiment, holes **140***b*, **140***d*, **140***e* can be parallel to a knee joint and can be considered to be condylar realignment holes. Advantageously, these condylar realignment holes can help to restore the anatomic alignment of the articular block to prevent varus/valgus deformities and post-traumatic arthritis. In other words, holes **140***b*, **140***d*, **140***e* (which are a subset of the polyaxial holes **140***a*-**140***h*) can help guide one or more fasteners therethrough that are parallel to the knee joint, thereby helping to ensure proper alignment between the bone plate and underlying bone. By providing proper alignment, this advantageously helps to prevent varus/valgus deformities and post-traumatic arthritis. One skilled in the art will appreciate that while holes **140***b*, **140***d*, **140***e* can be formed as condylar realignment holes, other holes in the distal end can also be used for similar purposes.

[0108] In addition to the holes **140***a*-**140***h*, the distal portion **104** of the plate **100** further comprises a distal pair of k-wire holes **142**. Like the proximal k-wire hole **122**, the k-wire holes **142** allow temporary fixation of the bone plate **100** to bone with k-wires.

[0109] In addition to the holes **140***a*-**140***h* and k-wire holes **142**, the distal portion **104** of the plate **100** further comprises three indentations **144**. In some embodiments, the indentations **144** are rounded or spherical. The purpose of the indentations **144** is to help accommodate a portion of an instrument (e.g., an attachment post of an associated aiming instrument, for example, as described with reference to FIGS. **21**-**34**). The instrument can be used to accurately guide fasteners or screws into respective holes in the bone plate **100**. The instrument can rest against one or more of the indentations **144**, thereby ensuring proper alignment and orientation between the instrument and the plate **100**. Unlike the holes **140***a*-**140***h* and k-wire holes **142**, the indentions **144** do not extend through the upper surface to the lower surface of the bone plate **100**. Rather, they are formed partially along the height of the bone plate **100**.

[0110] The distal portion **104** of the plate **100** can have a distinct contour. In particular, the distal portion **104** of the plate **100** can comprise a concave cutout or lag screw groove **148**. Screws or fasteners can sometimes be placed externally to the bone plate **100** to lag fragments of the articular block prior to plate placement. The lag screw groove **148** advantageously accommodates and/or permits placement of these external lag/compression screws.

[0111] In some embodiments, the distal portion **104** of the plate **100** further comprises a variable chamfered surface **149**. The variable chamfered surface **149** advantageously has different amounts of material removed from a top surface of the bone plate **100** at the distal end, thereby permitting a thinner surface in an area where soft tissue cover is minimal. This desirably helps to prevent irritation around the knee region.

[0112] In some embodiments, the distal portion **104** of the bone plate **100** further comprises an anterior side and a posterior side, wherein the posterior side has a raised contour relative to the anterior side in a vertical direction along the height of the bone plate **100**. As shown in FIG. **3**, the bone plate **100** comprises a raised posterior side **146** that can be between 2-10 mm higher than an anterior side. In some embodiments, the raised posterior side **146** has an underside that is between 2-10 mm higher than an underside of an opposing anterior side of the bone plate **100**. The purpose of the raised posterior side **146** is that it advantageously accommodates an anatomical ridge on the posterior side of the femoral condyle known as the epicondyle. The raised posterior side **146** is advantageously designed to reside or sit on the epicondyle, thereby providing a mechanism by which a surgeon can key the bone plate **100** into place on the condylar surface. Furthermore, the raised posterior side **146** helps to stabilize the bone plate **100** over a bone, which would likely be unsteady without the raised feature. In addition to the raised contour, the bone plate **100** also includes condylar contouring around its distal perimeter to mimic the metaphyscal and epiphyseal anatomy to guide plate placement.

[0113] In some embodiments, the overall height or thickness of the bone plate **100** can be variable along its length. In some embodiments, the height or thickness of the bone plate **100** can be greater in the shaft **110** than in the distal portion **104**. In some embodiments, the thickness in the shaft **110** can be between 3.0-6.0 mm, while the thickness in the distal portion **104** can be between 1.5-4.5 mm. The variable thickness advantageously provides ideal stiffness to the bone plate **100**, while also balancing the need to be careful around surrounding tissue around the bone plate. For example, a less thick distal portion **104** can help reduce unnecessary contact with adjacent tissue, thereby reducing irritation around a knee region.

[0114] FIG. **4** is a top perspective view of a broad bone plate in accordance with some embodiments of the present application. The broad bone plate **200** includes many similar features as the narrower bone plate **100**, but is wider than the narrower bone plate **100**. In some embodiments, a distal portion **204** of the bone plate **200** can be between 7-11 mm, or approximately 9 mm, wider than the narrower bone plate **100**. This additional width permits space for additional (e.g., two or more) polyaxial locking holes **240**, as well as one or more k-wire holes **242**. In some embodiments, a shaft portion **210** of the bone plate **200** can be between 5.5-9.5 mm, or approximately 7.5 mm, wider than the narrower bone plate **100**. This additional width permits space for additional fixed angle, stacked locking holes **230**. In some embodiments, the additional width of the shaft **210** provides space for two, three or more locking holes **230** along its width.

[0115] The bone plate **200** comprises a proximal portion **202** and a distal portion **204**. In between the proximal portion **202** and distal portion **204** is a shaft **210** having an anterior sidewall **206** and a posterior sidewall **208**. Along the length of the bone plate **200** are a series of holes or openings for receiving screws or fasteners therein.

[0116] The proximal portion **202** of the bone plate **200** comprises a tapered tip **220**. In some embodiments, the tapered tip **220** serves as the lead portion of the bone plate **200** to enter into an incision. In some embodiments, the tapered tip **220** allows for simplified submuscular plate insertion to minimize incision length. The proximal portion **202** further comprises a k-wire hole **222** for receiving a k-wire therein to guide bone plate **200** to a desired surgical site. The k-wire hole **222** allows for temporary fixation of the bone plate **200** to bone via a k-wire. In some embodiments, the k-wire hole **222** is unthreaded. In addition, the proximal portion **202** further comprises an articulated tensioning device (ATD) slot **224**. The ATD slot **224** is configured to receive a portion of a tension or compression device (not shown) that can help to bring bone fragments together for healing. In some embodiments, the ATD slot **224** is composed of a through hole and a cylindrical shaped undercut on the bottom of the plate **200**.

[0117] The proximal portion **202** transitions into the shaft portion **210**. The shaft portion **210** comprises multiple holes or openings **230***a*, **230***b*, **230***c*, **230***d*, **230***c*, **230***f*, **230***g*, **230***h*, **230***i*, **230***j* that are configured to receive fasteners therein. In some embodiments, holes **230***a*-**230***j* are configured to be fixed angle, stacked locking holes that can accommodate screws (e.g., between 3.5-7.5 mm screws, such as 4.5 mm screws). The fixed angle, stacked locking holes advantageously allow for mono-axial insertion of fasteners that lock to the bone plate **200**. In some embodiments, these holes can also accommodate non-locking fasteners. In some embodiments, the holes **230***a*-**230***j* are distributed such that no two holes **230***a*-**230***j* overlap along a width of the shaft portion **110**. However, one skilled in the art will appreciate that the shaft portion **210** is wide enough to accommodate two or more holes **230***a*-**230***j* side-by-side. In the present embodiment, the shaft includes distinct groups of three holes **230***a*-**230***j* side-by-side along the entire length of the plate.

[0118] In addition, the shaft portion **210** comprises one or more bi-directional dynamic compression slots **232***a*, **232***b* interspersed between the holes **230***a*-**230***j*. The slots **232***a*, **232***b* are elongated in length relative to the holes **230***a*-**230***j*, and are configured to receive one or more non-locking fasteners therein. While the present embodiment illustrates two dynamic compression slots **232***a*, **232***b*, in some embodiments, there can be three or more compression slots. In some embodiments, the dynamic compression slots **232***a*, **232***b* allow for static insertion of non-locking screws into the shaft portion **210** of the bone. In some embodiments, they also allow for compression (e.g., between 0.5-2 mm, such as 1 mm, of compression) along the shaft portion **210** of the bone through eccentric insertion of a non-locking screw. In some embodiments, the locations of the dynamic compression slots **232***a*, **232***b* are optimized for typical intercondylar splits and osteotomies. In the present embodiments, each of the dynamic compression slots **232***a*, **232***b* is positioned adjacent to a pair of locking holes **230**.

[0119] In addition to the holes **230***a*-**230***f* and the compression slots **232***a*, **232***b*, the shaft **210** further comprises a kickstand hole **235**. In some embodiments, the kickstand hole **235** comprises a polyaxial locking hole for receiving a locking fastener therein. The kickstand hole **235** is advantageously designed to receive a fastener that targets the strong cortical bone in the posteromedial cortex of the condylar region, thereby promoting angular stability. Additionally, the kickstand hole is useful for providing enhanced fixation for comminuted fractures in the metaphyseal region of the bone, due to its oblique angle relative to the upper surface of the plate.

[0120] The shaft portion **210** comprises an anterior side **206** and a posterior side **208** that form the edges of the shaft portion **210**. The anterior side **206** and posterior side **208** can include one or more waisted edge scallops **236**. Advantageously, the one or more waisted edge scallops **236** permit some bending of the shaft portion **210** without deforming the holes, thereby promoting uniform load transfer. The waisted edge scallops **236** are slightly larger than the waisted edge scallops **136** to take into account the wider shaft. In some embodiments, the shaft portion **210** can have a pre-contoured geometry. Advantageously, the pre-contoured geometry can allow an optimal fit along an entire lateral aspect of a femur. In lengthier versions of the plate **200**, there can be an anterior bow and slight shaft twist to mate with proximal femoral anatomy. In addition, in some embodiments, the underside of the bone plate **200** can be arced to mate with the cylindrical nature of the femoral shaft.

[0121] The distal end of the shaft portion **210** transitions into the wider, distal portion **204** of the bone plate **200**. The distal portion **204** of the bone plate **200** is configured to reside at or near the condylar region of the femur **5**. The distal portion **204** comprises holes or openings **240***a*, **240***b*, **240***c*, **240***d*, **240***c*, **240***f*, **240***g*, **240***h*, **240***i*, **240***j* that are configured to receive one or more fasteners or screws therein. In some embodiments, the holes **240***a*-**240***j* comprise polyaxial locking holes that can accommodate screws (e.g., between 3.5-7.5 mm screws, such as 4.5 mm screws). In some embodiments, the polyaxial locking holes **240***a*-**240***j* can have a cone of angulation of up to between 30 to 50 degrees, and more particularly 40 degrees, according to some embodiments. The polyaxial locking holes **240***a*-**240***j* thus accommodate fasteners of different angles. Advantageously, in some embodiments, the polyaxial locking holes are designed to accommodate several multi-planar diverging trajectories to allow a surgeon to select optimal screw trajectories to avoid any existing hardware in the condylar region. In other words, fasteners inserted into the condylar region will avoid other similarly inserted fasteners or other pre-existing hardware that may have been inserted previously in the region. While the present embodiment includes ten polyaxial holes **240***a*-**240***j*, one skilled in the art will appreciate that the bone plate **200** can include less than ten polyaxial holes or greater than ten polyaxial holes. Furthermore, as the bone plate **200** can include both fixed angle fasteners (e.g., in the shaft **210** of the bone plate **200**) and polyaxial fasteners (e.g., in the distal portion **204** of the bone plate **200**), the bone plate **200** can be provided relative to an underlying with just enough stiffness to accommodate adequate healing.

[0122] In some embodiments, the holes **240***a*-**240***j* can include one or more holes that are nominally angled so that they are parallel to a knee joint. These holes can receive one or more fasteners or screws that are parallel to the knee joint, thereby helping in proper alignment of the bone plate **200** relative to bone. In the present embodiment, holes **240***b*, **240***c*, **240***f* can be parallel to a knee joint and can be considered to be condylar realignment holes. Advantageously, these condylar realignment holes can help to restore the anatomic alignment of the articular block to prevent varus/valgus deformities and post-traumatic arthritis. In other words, holes **240***b*, **240***e*, **240***f* (which are a subset of the polyaxial holes **240***a*-**240***j*) can help guide one or more fasteners therethrough that are parallel to the knee joint, thereby helping to ensure proper alignment between the bone plate and underlying bone. By providing proper alignment, this advantageously helps to prevent varus/valgus deformities and post-traumatic arthritis. One skilled in the art will appreciate that while holes **240***b*, **240***c*, **240***f* are considered condylar realignment holes, these are only representative, and other holes in the distal portion can also be considered condylar realignment holes.

[0123] In addition to the holes **240***a*-**240***j*, the distal portion **204** of the plate **200** further comprises a distal pair of k-wire holes **242**. Like the proximal k-wire hole **222**, the k-wire holes **242** allow temporary fixation of the bone plate **200** to bone with k-wires.

[0124] In addition to the holes **240***a*-**240***j* and k-wire holes **242**, the distal portion **204** of the plate **200** further comprises three indentations **244**. In some embodiments, the indentations **244** are rounded or spherical. The purpose of the indentations **244** is to help accommodate a portion of an instrument (e.g., an attachment post of an associated aiming instrument). The instrument can be used to accurately guide fasteners or screws into respective holes in the bone plate **200**. The instrument can rest against one or more of the indentations **244**, thereby ensuring proper alignment and orientation between the instrument and the plate **200**. Unlike the holes **240***a*-**240***j* and k-wire holes **242**, the indentions **244** do not extend through the upper surface to the lower surface of the bone plate **200**. Rather, they are formed partially along the height of the bone plate **200**.

[0125] In some embodiments, the distal portion **204** of the plate **200** further comprises a variable chamfered surface **249**. The variable chamfered surface **249** advantageously has different amounts of material removed from a top surface of the bone plate **200** at the distal end, thereby permitting a thinner surface in an area where soft tissue cover is minimal. This desirably helps to prevent irritation around the knee region.

[0126] In some embodiments, the distal portion **204** of the bone plate **200** further comprises an anterior side and a posterior side, wherein the posterior side has a raised contour relative to the anterior side. As shown in FIG. **4**, the bone plate **200** comprises a raised posterior side **246** that can be between 2-10 mm higher than an anterior side. In some embodiments, the raised posterior side **246** has an underside that is between 2-10 mm higher than an underside of an opposing anterior side of the bone plate **200**. The purpose of the raised posterior side **246** is that it advantageously accommodates an anatomical ridge on the posterior side of the femoral condyle known as the epicondyle. The raised posterior side **246** is advantageously designed to reside or sit on the epicondyle, thereby providing a mechanism by which a surgeon can key the bone plate **200** into place on the condylar surface. Furthermore, the raised posterior side **246** helps to stabilize the bone plate **200** over a bone, which would likely be unsteady without the raised feature. In addition to the raised contour, the bone plate **200** also includes condylar contouring around its distal perimeter to mimic the metaphyseal and epiphyseal anatomy to guide plate placement.

[0127] FIG. **5** is a view of an alternative bone plate on bone in accordance with some embodiments of the present application. The bone plate **300** comprises a plate that is lengthier than the bone plates **100**, **200** in prior embodiments. The bone plate **300** is designed to extend along a majority of the length of a femur **5**. In some embodiments, as shown in FIG. **5**, the bone plate **300** extends from the distal condylar region **7** close to the proximal region **15** of the bone plate **300**. By spanning the extending length, the bone plate **300** may help heal and prevent fractures that are higher up the femur and near the proximal region **15**. Additionally, a lengthier bone plate can assist in providing a longer working length, which helps to modulate the stiffness of the plate and screw construct to promote faster healing.

[0128] FIG. **6** is a top view of a lengthened, narrow bone plate in accordance with some embodiments of the present application. While the bone plate **300** has a number of similar features to bone plates **100**, **200**, the bone plate **300** is much longer. In some embodiments, the bone plate **300** has a length of between 400 and 500 mm, such as approximately 460 mm.

[0129] The bone plate **300** can include three distinct regions, identified by the perforated lines. These regions include a proximal region **302**, a medial region **306** and a distal region **304**.

[0130] The proximal region **302** comprises a tapered distal end that includes a tapered tip **320**, k-wire hole **322** and ATD slot **324**. In addition, the proximal region **302** comprises a series of proximal holes **328**. In some embodiments, these proximal holes **328** are polyaxial and nominally angled toward the outer edge of the bone plate **300** in order to assist in dodging a hip stem in the proximal femur. While the present embodiment shows ten proximal holes **328**, in other embodiments, the proximal region **302** includes less than ten or greater than ten proximal holes **328**. In addition, while the present embodiment shows ten proximal holes **328** that are similar to one another (e.g., polyaxial), in some embodiments, the proximal holes **328** can be a combination of monoaxial and polyaxial locking holes, or just monoaxial holes.

[0131] The medial region **306** comprises a shaft region having a series of holes or openings for receiving fasteners or screws therein. As shown in FIG. **6**, some of the holes can be stacked holes **330** that can accept locking or non-locking screws, while some of the holes can be elongated dynamic compression slots **332** that can accept non-locking screws. In the present embodiments, the medial region **306** comprises twelve stacked holes **330** and two dynamic compression slots **332**. However, one skilled in the art will appreciate that in some embodiments, the medial region **306** can include less than or greater than twelve stacked holes **330** and two dynamic compression slots **332**.

[0132] The distal region **304** of the bone plate **300** comprises a flared out, wider region that resides on a condylar region of bone. In some embodiments, the distal region **304** includes a pair of distal k-wire holes **342** for receiving guiding k-wires therein. The distal region **304** further includes three indentations **344** that are configured to engage a portion of an instrument (e.g., an alignment post of an aiming guide). The distal region **304** further includes a series of holes or openings for receiving one or more fasteners or screws therein. These include one kickstand hole **335** and eight polyaxial locking holes **340**, which are advantageously designed such that fasteners that are inserted therethrough do not interfere with one another. In addition to these features, the distal region **304** can further include a lag screw groove **348** and a raised posterior side **346** that can accommodate an epicondylar flare.

[0133] As shown in FIG. **6**, the bone plate **300** comprises different types of holes in the three distinct regions-proximal region **302**, medial region **306** and distal region **304**. In some embodiments, the distal region **304**, which encompasses the condylar region, comprises polyaxial locking holes **328**. In the medial region **306**, the polyaxial locking holes **328** can transition into non-polyaxial or fixed holes **330**. In some embodiments, the fixed holes **330** can be stacked holes. In the proximal region **302**, the fixed holes **330** can transition into polyaxial locking holes **340**.

[0134] FIG. **7** is a top view of a lengthened, broad bone plate in accordance with some embodiments of the present application. Like the bone plate **300**, bone plate **400** has a number of similar features to bone plates **100**, **200**, but is much longer. In some embodiments, the bone plate **400** has a length of between 400 and 500 mm, such as approximately 460 mm. The bone plate **400** is also wider than the bone plate **300**, thereby accommodating a number of distinct hole patterns along its length.

[0135] The bone plate **400** can include three distinct regions, identified by the perforated lines. These regions include a proximal region **402**, a medial region **406** and a distal region **404**. All three regions (**402**, **404**, and **406**) can contain groups of two or more holes side-by-side along the length of the plate. In the present embodiments, the shaft includes distinct groups of three holes side-by-side along the entire length of the plate.

[0136] The proximal region **402** comprises a tapered distal end that includes a k-wire hole **422** and ATD slot **424**. In addition, the proximal region **402** comprises a series of proximal holes. In some embodiments, these proximal holes comprise polyaxial locking holes **428** that are nominally angled toward the outer edge of the bone plate **400** in order to assist in dodging a hip stem in the proximal femur. In between pairs of polyaxial locking holes **428** are stacked holes **426**. In some embodiments, both the polyaxial locking holes **428** and stacked holes **426** can receive locking or non-locking fasteners. In the present embodiment, the proximal region **402** comprises five sets of holes, whereby each set comprises a pair of polyaxial locking holes **428** and a stacked hole **426**.

[0137] The medial region **406** comprises a shaft region having a series of holes or openings for receiving fasteners or screws therein. As shown in FIG. **7**, some of the holes can be stacked holes **430** that can accept locking or non-locking screws, while some of the holes can be elongated dynamic compression slots **432** that can accept non-locking screws. In the present embodiments, the medial region **406** comprises seven sets of holes, whereby each set comprises two or more stacked holes **430**. In some of the sets, at least one dynamic compression slot **432** is provided between the two or more stacked holes.

[0138] The distal region **404** of the bone plate **400** comprises a flared out, wider region that resides on a condylar region of bone. In some embodiments, the distal region **404** includes a pair of distal k-wire holes **442** for receiving guiding k-wires therein. The distal region **404** further includes three indentations **444** that are configured to engage a portion of an instrument (e.g., an alignment post of an aiming guide). The distal region **404** further includes a series of holes or openings for receiving one or more fasteners or screws therein. These include one kickstand hole **435** and ten polyaxial locking holes **440**, which are advantageously designed such that fasteners that are inserted therethrough do not interfere with one another. In addition to these features, the distal region **404** can further include a raised posterior side **446** that can accommodate an epicondylar flare.

[0139] FIG. **8** is a top view of a medial plate in accordance with some embodiments of the present application. The medial plate **500** is inserted through an incision over the anteromedial of the distal femur or an S-shaped incision on the posterior side of the knee joint. The medial plate **500** includes similar features as the narrow and broad locking plates **100**, **200**. In some embodiments, the longest length of the medial plate will sit no less than 8 cm below the lesser trochanter in order to preserve the vessels and nerve pathways on the medial side of the femur. In some embodiments, the thickness of the plate **500** varies along a length of the plate **500**. For example, the plate **500** can be thicker in a proximal region (e.g., between 2.0-4.0 mm, such as approximately 3.0 mm) than in a distal region (e.g., between 1.5-3.0 mm, such as approximately 2.25 mm).

[0140] The medial plate **500** comprises a proximal portion **502** and a distal portion **504** and a shaft **510** therebetween **510**. The proximal portion **502** comprises a tapered insertion tip **520**. Along the proximal portion **502** and shaft **510** are a series of holes **530** for receiving fasteners therein. In some embodiments, the holes **530** are polyaxial locking holes. In other embodiments, the holes **530** are fixed angled stacked locking holes. In some embodiments, the holes **530** are a combination of polyaxial locking holes or fixed angle stacked locking holes. In some embodiments, the holes **530** accommodate screws of various sizes, such as between 3.5-7.5 mm screws, such as approximately 4.5 mm. The shaft **510** further includes waisted edge scallops **536**.

[0141] The distal portion **504** of the medial plate **500** comprises similar features as in prior embodiments, including a pair of distal k-wire holes **542** and six polyaxial locking holes **540**. The polyaxial locking holes **540** can accommodate fasteners or screws that are between 3.0 and 6.0 mm, or approximately 4.5 mm. Furthermore, the distal portion **504** comprises a raised posterior side **546** to accommodate an epicondylar flare, as well as condylar contouring **506** to accommodate distinct anatomy. In some embodiments, the distal portion **504** also comprises a variable chamfered surface **549**.

[0142] FIG. **9** is a top perspective view of a representative plate including a twist up its shaft. From this view, one can see how the proximal portion of the representative shaft **300** can have an upward twist from a more medial section of the plate. The advantage of the upward twist is that the plate is a better anatomical fit with bone.

[0143] FIG. **10** is a cross-sectional view of a section of a representative plate showing an arced contour of an underside. FIG. **11** is a cross-sectional view of a different section of a representative plate showing an arced contour of an underside. From these views, one can see how the arced surface varies in radius and centrality along the length of the plate. For example, the underside in FIG. **10** has a radius of R**1**, while the underside in FIG. **11** has a radius of R**2**, wherein R**1** is different from R**2**. By having different arced contours along different sections of the plate, this also helps to give the plate a better anatomical fit to bone. In some embodiments, R**1** and R**2** can have a dimension between about 25 mm to 250 mm, whereby R**1** is different from R**2**.

[0144] Turning now to FIG. **12**, a top perspective view of a narrow bone plate **600** according to yet another embodiment is shown. The narrow bone plate **600** is similar to narrow bone plate **100** shown in FIG. **3** and like elements are labeled the same. Similar to plate **100**, bone plate **600** comprises proximal portion **102** and distal portion **104** with shaft **110** extending therebetween having anterior sidewall **106** and posterior sidewall **108**.

[0145] Similar to holes or openings **130*a*-130*f*** in plate **100**, plate **600** includes a plurality of holes or openings **130*a*-130*g*** that are configured to receive fasteners therein. In some embodiments, holes **130*a*-130*g*** may be configured as locking holes, which may be able to accept locking or non-locking screws. The openings **130*a*-130*g*** may be in the form of 4.5 mm polyaxial locking holes. The openings **130*a*-130*g*** may be staggered to prevent new linear fracture lines in the metaphyseal and diaphyseal regions.

[0146] Similar to plate **100**, the shaft portion **110** of plate **600** comprises one or more bi-directional dynamic compression slots **132*a***, **132*b***. These slots **132*a***, **132*b*** may be configured to receive one or more non-locking fasteners therein and may allow for compression along the shaft portion **110** of the bone. The bi-directional dynamic compression slots **132*a***, **132*b*** may allow for static insertion of non-locking screws into the shaft of the bone and/or may allow for 1 mm of compression along the shaft of the bone through eccentric insertion of a non-locking screw. The locations of the dynamic compression slots **132*a***, **132*b*** were optimized for typical intercondylar splits and osteotomies.

[0147] The articulated tensioning device (ATD) hole **124** is composed of a through hole in the tip of the plate **600** and a cylindrical shaped undercut on the bottom surface of the plate **600**. The hole mates with an ATD and allows for compression or tensioning of fracture fragments.

[0148] Plate **600** further includes a plurality of kickstand holes **135**. For example, in this embodiment, the shaft portion **110** may include two kickstand holes **135** separated from one another and oriented in different directions. The kickstand holes **135** may each comprise a polyaxial locking hole for receiving a locking fastener therein. In the metaphyseal region of the lateral plates, the two kickstand strut screws permit fixation in the anteromedial and posteromedial cortices of the medial femoral condyle in the lateral plates. The screw targets the strong cortical bone of the posteromedial cortex in order to enhance screw fixation, prevent pull-out, and promote angular stability via triangular fixation.

[0149] The anterior side **106** and posterior side **108** can include one or more waisted edge scallops **136**. Advantageously, the one or more waisted edge scallops **136** permit some bending of the shaft portion **110** without deforming the holes, thereby promoting uniform load transfer.

[0150] The distal end of the shaft portion **110** transitions into the wider, distal portion **104** of the bone plate **600**. Similar to plate **100**, plate **600** includes holes or openings **140***a*-**140***h* that are configured to receive one or more fasteners or screws therein, including locking or non-locking screws. The holes **140***a*-**140***h* may comprise polyaxial locking holes, for example, with a cone of angulation. The cluster of holes **140***a*-**140***h* may be nominally targeted in several multi-planar diverging trajectories to allow the surgeon to select optimal screw trajectories to avoid any existing hardware in the condyle.

[0151] The distal portion **104** of the plate **600** may further comprises a distal pair of k-wire holes **142**. Like the proximal k-wire hole **122**, the k-wire holes **142** allow temporary fixation of the bone plate **600** to bone with k-wires.

[0152] The distal portion **104** of the plate **600** may include three indentations **144**, for example, or blind openings being rounded or spherical, to help accommodate a portion of an instrument (e.g., an attachment post of an associated aiming instrument).

[0153] In this embodiment, plate **600** further includes a dedicated aiming arm attachment hole **602**. The dedicated aiming arm attachment hole **602** may be a threaded hole, for example, for attaching the attachment post of an associated aiming instrumentation for the system.

[0154] The thickness of the plate **600** may vary from about 4.5 mm proximally to 3.6 mm distally, varying through the metaphyseal and epiphyseal regions. The transition in thickness may begin about 129 mm from the most distal edge of the plate **600**. The width of the plate **600** may vary from about 33 mm wide in the head of the plate **600** to about 17.5 mm wide in the shaft of the plate **600**. The transition in width may also begin about 129 mm from the most distal edge of the plate **600**.

[0155] Turning now to FIGS. **13** and **14**, a broad lateral bone plate **700** according to yet another embodiment is shown. The broad lateral bone plate **700** is similar to broad bone plate **200** shown in FIG. **4** and like elements are labeled the same. Similar to plate **200**, bone plate **700** comprises proximal portion **202** and distal portion **204** with shaft **210** extending therebetween having anterior sidewall **206** and posterior sidewall **208**. The broad lateral locking plate **700** may be inserted through an incision over the lateral aspect of the distal femur and may provide some of the same types of features as the narrow version **600**.

[0156] The shaft portion **210** comprises a plurality of holes or openings **230***a*, **230***a***1**, **230***b*, **230***c*, **230***d*, **230***c*, **230***f*, **230***g*, **230***h*, **230***i*, **230***i***1**, **230***j*, **230***k*, **230***l* that are configured to receive fasteners therein. As compared to plate **200**, plate **700** replaces dynamic compression slots **232***a*, **232***b* with openings **230***a***1** and **230***i***1** and additional openings **230**K and **230***l* are added. The plurality of openings **230***a*-**230***l* may be 4.5 mm polyaxial locking holes in the distal cluster that may be nominally targeted in several multi-planar diverging trajectories to allow the surgeon to select optimal screw trajectories to avoid any existing hardware in the condyle. The plurality of openings **230***a*-**230***l* may accept locking or non-locking screws. The plurality of openings **230***a*-**230***l* in the shaft **210** of the plate **700** may be staggered to prevent new linear fracture lines in the metaphyseal and diaphyseal regions. In particular, the plurality of openings **230***a*-**230***l* may be a repeating pattern of three holes (e.g., **230***a*, **230***a***1**, **230***b*).

[0157] As best seen in FIG. **14**, a first virtual line segment L**1** connecting a repeating pattern of three holes (e.g., **230***c*-**230***e*) through their respective center points may be angled relative to the longitudinal axis A of the plate **700**. Similarly, a second virtual line segment L**2** connecting a repeating pattern of three holes (e.g., **230***f*-**230***h*) through their respective center points may be angled relative to the longitudinal axis A of the plate **700**. Although two virtual line segments L**1**, L**2** are shown it is evident that the same repeating pattern of three holes repeats along the length of the plate **700**. Each line segment L**1**, L**2** connecting a repeating pattern of three holes through their respective center points may be generally aligned substantially parallel to one another.

[0158] The center point of the center hole **230***d*, **230***g* of each repeating pattern may be aligned generally along the longitudinal axis A of the plate **700**. In addition, indentations **238** of the scallop **236** along the anterior and posterior sidewalls **206**, **208** may be generally aligned with the center hole **230***d*, **230***g* of each repeating pattern. As best seen in FIG. **14**, the center of the scallops **236** on both of the side surfaces **206**, **208** are aligned with the center of the middle row of shaft holes. The indentations **238** of the scallop **236** along the side surfaces **206**, **208** lie on an axis which is perpendicular to the centered longitudinal axis A along the length of the shaft **210**. In particular, a virtual line segment L**3** connecting a center point for the radius of a first indentation **238** on anterior sidewall **206** to a center point for the radius of a second indentation **238** on the posterior sidewall **208** are generally aligned with the center of the center hole **230***d*. Similarly, a virtual line segment L**4** connecting a center point for the radius of a third indentation **238** on anterior sidewall **206** to a center point for the radius of a fourth indentation **238** on the posterior sidewall **208** are generally aligned with the center of the center hole **230***g*. It will again be appreciated that although two virtual line segments L**3**, L**4** are shown it is evident that the same repeating pattern of three holes repeats along the length of the plate **700**. The undulating scallops **236** result in a shaft profile which continually varies in overall width.

[0159] Plate **700** further includes a plurality of kickstand holes **235**. For example, in this embodiment, the shaft portion **210** may include two kickstand holes **235** separated from one another and oriented in different directions. The kickstand holes **235** may each comprise a polyaxial locking hole for receiving a locking fastener therein. The polyaxial locking kickstand strut holes **235** are designed to target the strong cortical bone in the anteromedial and posteromedial cortices of the medial condyle and promote angular stability.

[0160] Similar to plate **600**, plate **700** includes a dedicated aiming arm attachment hole **702** and a plurality of indentations **244** surrounding the attachment hole **702**. The dedicated aiming arm attachment hole **702** may be a threaded hole, for example, for attaching the attachment post of an associated aiming instrumentation for the system. As shown, the three indentations **244** or blind openings may be rounded or spherical, to help accommodate a portion of an instrument (e.g., an attachment post of an associated aiming instrument).

[0161] The distal portion **204** of the bone plate **700**, configured to reside at or near the condylar region of the femur **5**, may include a plurality of holes or openings **240***a*, **240***b*, **240***c*, **240***d*, **240***c*, **240***f*, **240***g*, **240***h*, **240***i*, such as polyaxial locking holes, that are configured to receive one or more fasteners or screws therein. This is substantially similar to plate **200** except hole **240***j* is omitted. One or more k-wire holes **242** may also be positioned in the distal portion **204** of the plate **700**.

[0162] The thickness of the plate **700** may vary from about 4.5 mm proximally to about 3.6 mm distally varying through the metaphyseal and epiphyseal regions. Like the narrow plate **600**, the transition in thickness may begin about 129 mm from the most distal edge of the plate. The width of the plate may vary from about 39 mm wide in the head of the plate **700** to about 24 mm wide in the shaft **210** of the plate **700**. The transition in width also begins about 129 mm from the most distal edge of the plate **700**.

[0163] The main differentiating qualities between the broad plate **700** and the narrow plate **600** are the overall size of the plates and the total number of each type of feature. The distal portion of the plate **700** is about 6 mm wider than that of the narrow plate **600**, thereby permitting space for one additional 4.5 mm polyaxial locking hole resulting in a total of 9 polyaxial holes in the distal cluster. As this plate **700** is designed to fill the majority of the lateral femoral condyle and/or abut against the femoral component of a total knee arthroplasty, the lag screw groove is eliminated in the broad plate **700**.

[0164] The shaft **210** of the broad plate **700** is about 6.5 mm wider than that of the narrow plate **600**. With more space, the alternating pattern of polyaxial locking holes in the shaft is increased from 2-wide to 3-wide. Additionally, the waisted edge scallops **236** are slightly larger to take into account the wider shaft **210**.

[0165] FIGS. **15** and **16** show the longest lengths for each of the two lateral plates **800**, **900**. These plates **800**, **900** are substantially the same as those shown in FIGS. **6** and **7**, respectively, and like elements are labeled the same. In these embodiments, the plates **800**, **900** further include an additional kickstand opening, **335**, **435**, respectively, and the associated indentations or blind openings **144**, **244**, respectively, to help accommodate a portion of an instrument (e.g., an attachment post of the associated aiming instrument). The total length of these plates **800**, **900** is about 458 mm and the radius of curvature (i.e., anterior bow) is about 1200 mm. Plate lengths decrease by approximately 31-33 mm, resulting in 11 lengths of each lateral plate and a shortest length of about 137 mm.

[0166] The pattern of staggered polyaxial holes **330**, **430** occurs in the shaft of both lateral plates. The staggered hole pattern in the shaft provides increased pull-out resistance and helps to prevent new linear fracture lines in the metaphyseal and diaphyseal regions. Two DCP slots **332** break the stacked hole pattern at the 1st and 6th holes in the narrow plate (FIG. **15**), which may be useful in non-unions and osteotomies.

[0167] In the broad plate **900**, the polyaxial holes **430** follow the three-hole diagonal pattern, described with reference to FIG. **14**, along the entire length of the shaft, nominally angled parallel to the center row of holes **430** but can be targeted inwards or outwards in order to dodge other implants such as total hip or knee arthroplastics.

[0168] Turning now to FIG. **17**, the medial locking plate **1000** is similar to plate **500** shown in FIG. **8** and like elements are numbered the same. Medial locking plate **1000** may be advantageous in that the bottom surface **508** of the plate **1000** in contact with bone is anatomically contoured to abut the corresponding contours of the adjacent bone. For example, FIG. **18** illustrates the epicondylar ridge **1002** of the medial condyle, which is a bony protrusion located on the medial side of the femur's distal end. In order to accommodate the epicondylar ridge **1002**, the plate **1000** may include one or more of a raised posterior edge H**1**, an anterior radius R**3**, and a raised height H**2**. As shown in FIG. **19**, the posterior edge **546** may be raised relative to the anterior edge **548** to conform to the average height of the epicondylar ridge **1002** of the medial condyle. For example, the posterior edge **546** may be higher than anterior edge **548** by a height H**1**. Height H**1** of the raised posterior edge **546** may be about 10-14 mm, or about 12 mm, as compared to the anterior edge **548**. Turning to FIG. **20**, the bottom surface **508** of the plate **1000** may include an anterior radius R**3**. The anterior radius R**3**, for example, along the anterior edge **548**, may be contoured to the distal end of the femur. For example, the radius R**3** may range from about 28-32 mm, or about 30 mm. In addition, the height H**2** of the distal portion **504** may be raised relative to the shaft **510** of the plate **1000**. For example, the height H**2** may be about 9-10 mm, or about 9.5 mm. The anterior radius R**3** and raised height H**2** relative to the plate shaft **510** are designed to conform to the average size of the anteromedial third of the medial condyle. These unique anatomic features provide for a better fit to the bone and may provide better patient outcomes.

[0169] Plate **1000** may include holes **530**, **540**, kickstand holes **535**, articulated tensioning device (ATD) hole **524**, and k-wire holes **522**, **542** as already described herein. The holes **530**, **540** may be locking holes, such as polyaxial locking holes. In particular, the locking holes may be thread-forming holes such that the fastener locks to the plate **1000** when inserted therein. The locking holes **530**, **540**, for example, provided in all portions of the plate **1000**, permit the creation of a fixed angle construct which helps to prevent both varus collapse and screw backout, even in cases of osteoporosis.

[0170] The medial locking plate **1000** may be inserted through an incision over the anteromedial aspect of the distal femur or an S-shaped incision on the posterior side of the knee joint. The plate **1000** is designed to sit on the most anterior third of the medial condyle, directly on top of the medial epicondyle. Plate **1000** may provide the same types of features as the narrow and broad lateral plates including all polyaxial locking holes **540** in the distal cluster and polyaxial locking holes **530** along the shaft **510** and two polyaxial locking kickstand strut holes **535** designed to target the strong cortical bone in the posterolateral cortex of the condyle and promote angular stability. The thickness of the plate **1000** may vary from about 3.0 mm proximally to about 2.25 mm distally with the transition occurring in the metaphyscal region of the plate **1000**.

[0171] Unlike other plates that may lead to misplacement or are improperly contoured, the plates described in embodiments herein may have raised contours on their respective posterior sides to sit more flush on the condylar anatomy and provide surgeons with a way to key in the plate in the correct location. By having a large number of options for fixation along the plates, helps in preventing varus collapse and loss of fixation in poor bone quality. Many options for points of fixation become even more important in highly comminuted articular blocks or when other existing implants may need to be avoided.

[0172] Referring to FIGS. **21-37**, an aiming guide system **1100** in accordance with an embodiment of the disclosure will be described. Generally, the aiming guide system **1100** includes an aiming arm **1102** that attaches to the bone plate **300** via a connection assembly **1128** that includes a single attachment post **1140** and threaded shaft **1130** engaged with the plate **300**. While the aiming guide system **1100** is shown and described with respect to bone plate **300**, it is understood that the system **1100** may be sized and configured to be utilized with various bone plates including the other plates described herein. The angle of the attachment post **1140** relative to the top surface of the plate **300** is designed such that the post **1140** and subsequent assembly items do not block access to the distal cluster of screw holes **340** in the plate. The aiming arm **1102** keys into place on the attachment post **1140** and is oriented with the proper side facing up (for a left femur procedure, the surface label "LEFT" should be facing up). A two-piece fastener completes the assembly of the aiming arm **1102** to the plate **300**, including a washer **1160** which lays flush against the upper surface of the aiming arm **1102** and a spherical nut **1170** that tightens onto the threaded shaft **1130**.

[0173] Referring to FIG. **21**, the aiming arm **1102** accepts tissue protection sleeves **1180**. The sleeves **1180** provide a portal into small incisions through which trocars **1245**, drill sleeves **1210**, k-wire sleeves **1236**, dynamic compression sleeves **1250**, drills **1230**, drivers, and screws may pass. The sleeves **1180** clip into place on either surface of the aiming arm **1102** (depending on whether the procedure is being performed on a right or left femur). The accurate and rigid interface of the sleeves **1180** with the aiming arm **1102** functions to properly align the sleeves **1180** to provide the nominal (0°) angle of the holes **328**, **330**, **332** in the shaft of the plate **300**. The kickstand sleeve **1180'** is another type of tissue protection sleeve, providing a similar portal for trocars, drill sleeves, and the like, but is designed to align with the two oblique "kickstand" screw holes **335** in the plate **300**.

[0174] Having generally described the aiming guide system **1100**, illustrative components, along with assembly and operation thereof, will be described. Referring to FIG. **22**, the aiming arm **1102** has a generally rigid body **1104** extending from a proximal end **1103** to a distal end **1105**. The arm body **1104** has a length shorter than the plate **300** such that the proximal end **1103** thereof is slightly distal of the proximal end **302** of the plate **300** and the distal end **1105** is proximal of the distal end **304** of the plate **300** such that the screw holes **340** remain unobstructed. An attachment area **1106** extends from the distal end **1105** of the arm body **1104** and defines an attachment slot **1108** extending through the arm body **1104**. The attachment slot **1108** is configured to receive the orienting boss **1146** on the attachment post **1140** as will be described in more detail hereinafter. As illustrated in FIG. **21**, upon connection of the aiming arm **1102** to the plate **300**, the attachment area **1106** is offset to the side of plate **300** and does not obstruct the plate **300**.

[0175] The arm body **1104** may be manufactured from a radiolucent material to prevent obstructing lateral imaging during the procedure. The aiming arm **1102** may be configured to be reversible, i.e., when one surface is facing upward, the arm **1102** is configured for a lefthanded plate and when the opposite surface is facing upward, the arm **1102** is configured for a righthanded plate. Additionally, the arm body **1104** may have different configurations for narrow lateral plates versus broad lateral plates. In at least one embodiment, there is one left-right reversible arm for the narrow lateral plate and one left-right reversible arm for the broad lateral plate. A plate identifier **1107** may be printed on each surface to identify to the user the arm configuration and orientation. Additionally, or alternatively, in at least one embodiment, the attachment location of the aiming arm **1102** to the attachment post **1140** may include a rounded groove or slot to accept a ball-end pin or the like in the orienting boss **1146** of the attachment post **1140** only when the aiming arm **1102** is assembled in the correct orientation, as described hereinafter with respect to FIG. **27**.

[0176] Referring to FIGS. **22-24**, a plurality of aiming holes **1110** are defined through the aiming arm **1102**. Each aiming hole **1110** has a through bore **1112** which extends through the arm body **1104** and aligns with a respective screw hole **328**, **330**, **332** of the plate **300** when the aiming arm **1102** is attached relative to the plate **300**. The aiming holes **1110** may be numbered with indicators **1118** on the side and/or each surface of the arm body **1104** to indicate the associated targeted hole **328**, **330**, **332** in the plate **300**.

[0177] Each aiming hole **1110** includes, on each surface of the arm body **1104**, a recess **1114** about the through bore **1112**. The recesses **1114** are configured to receive a portion of the head member **1186** of a tissue protection sleeve **1180**. The recess **1114** preferably has a non-round shape which complements the shape of the head member **1186** such that the head member **1186** is received and retained in a fixed position. An undercut **1116** is defined within each recess **1114** to receive a locking tab **1196** on the tissue protection sleeve **1180**, as will be described in more detail hereinafter.

[0178] In both the narrow and broad aiming arms, the recess **1114** and undercut **1116** features are mirrored about the mid-plane of the aiming arm **1102** such that tissue protection sleeves **1180** can be inserted from either side of the reversible embodiment of the aiming arm **1102**. The undercuts **1116** meet at the mid-plane of each bore **1112**, resulting in a continuous groove in which the retention ledge **1198** of the locking tab **1196** will sit. In the narrow aiming arm as illustrated in FIG. **23**, the undercut **1116** is fully circumferential about the central axis of each bore **1112**. In the broad aiming arm as illustrated in FIG. **24**, the axis of revolution of the undercut **1116** is offset by 2 mm, resulting in an undercut which only consumes about 35% of the circumference of each bore **1112**.

[0179] Referring again to FIG. **22**, a projection **1120** extends outwardly from each side of the arm body **1104**. Each projection **1120** defines upper and lower sloped surfaces **1122**. A kickstand targeting hole **1124** is through each sloped surface **1122** and has an axis generally perpendicular to the sloped surface **1122**. Each kickstand targeting hole **1124** exits the projection on the opposite surface of the arm body **1104** at an exit hole **1126**. The kickstand targeting holes **1124** permit nominal targeting of the two oblique kickstand screw holes **335** in the distal cluster of the plate **300**. Each kickstand targeting hole **1124** may have a visual indicator **1118** next to the hole. For example, the holes may be labeled A for anterior and P for posterior.

[0180] A connection assembly **1128** in accordance with an embodiment of the disclosure will be described with reference to FIGS. **25-30**. The connection assembly **1128** a threaded shaft **1130**, a single attachment post **1140**, and a two-piece fastener including a washer **1160** and a spherical nut **1170**. Referring to FIG. **25**, the threaded shaft **1130** includes a shaft body **1132** extending between ends **1131** and **1133**. Each end **1131**, **1133** includes threads **1134**, **1136**, respectively, and a driver-receiving bore **1135**, for example, configured to receive a hexalobe screwdriver. The threaded shaft **1130** is preferably reversible, with identical threads **1134**, **1136** at each end. In at least one embodiment, the tips of the threaded shaft contain a blunted first thread **1137** to promote self-centering of the shaft **1130** and help prevent cross-threading in the plate **300**. While not illustrated, it is recognized that the threaded shaft **1130** may be cannulated through its long central axis to permit the placement of a k-wire through the attachment slot **1108** of the aiming arm **1102** for preliminary fixation.

[0181] The attachment post **1140** includes a hollow tube **1142** extending from a proximal end **1141** to a distal end **1143**. A radial mating surface **1148** extends outwardly from the proximal end **1141** of the tube **1142** and the orienting boss **1146** extends upwardly from the mating surface **1148**. The mating surface **1148** extends at an acute angle relative to the axis of the hollow tube **1142**. The mating surface **1148** is oriented such that the aiming arm **1102** will lie flat on the mating surface **1148** when slid over the orienting boss **1146**. The orienting boss **1146** preferably has a configuration which dictates the orientation of the aiming arm **1102**. For example, in the illustrated embodiment, the orienting boss **1146** has a rectangular configuration such that when the orienting boss **1146** is engaged within the attachment slot **1108** of the aiming arm **1102**, the aiming arm **1102** must be properly aligned with the bone plate **300**. The orienting boss **1146** is not limited to a rectangular configuration, but may have other configurations, for example, oval shaped, trapezoidal, pentagonal.

[0182] Additionally, or alternatively, a keying feature may be provided between the attachment slot and the orienting boss. In the embodiment illustrated in FIG. **27**, one face of the orienting boss **1146'**, for example, the proximal side, includes a ball-end pin **1147** or other keying member extending therefrom. The ball-end pin **1147** is positioned some distance away from the center plane of the boss **1146'**. The attachment area **1106'** of the arm body **1104'** defines an attachment slot **1108'** with a corresponding groove **1109** positioned to receive the keying member **1147** provided the aiming arm **1102** is in the proper orientation. Since the keying member **1147** is off center, if the arm body **1104'** illustrated in FIG. **27** was flipped over, the groove **1109** would no longer align with the keying member **1147** and the orienting boss **1146'** would not be receivable in the attachment slot **1108'**.

[0183] An attachment block **1150** extends from the distal end **1143** of the hollow tube **1142**. The distal surface **1152** of the attachment block **1150** is offset and contoured to match the contour of the plate **300** at the attachment location. A plurality of ball end pins **1154** extend from the distal surface **1152**. The ball end pins **1154** are configured to align with and engage the indentations **344** in the plate **300** (see FIG. **6**). The engagement of the ball end pins **1154** in the indentations **344** ensures a proper orientation of the attachment post **1140** with the plate **300**, and thereby, a proper orientation of the aiming arm **1102** with the plate **300**. A continuous through bore **1144** extends through the attachment post **1140** from the orienting boss **1146**, through the hollow tube **1142** and through the attachment block **1150** such that the attachment post **1140** may be slid over the threaded shaft **1130**. The cannulation through the post **1140** matches the angle of the shaft **1130** relative to the top of the plate **300** as shown in FIG. **30**. As such, once assembled, the trajectories of the holes **1110** in the aiming arm **1102** will align with the trajectories of the holes **328**, **330**, **332** in the shaft of the plate **300**.

[0184] Referring to FIGS. **29** and **30**, the two-piece fastener includes the washer **1160** and the spherical nut **1170**. The purpose of the two-piece fastener is to provide a simplified, streamlined assembly mechanism that permits lagging of the plate **300**, post **1140**, and aiming arm **1102** together in one step. As the axis A1 of the threaded shaft **1130** and the plane P1 of the aiming arm's mating surface are not normal to one another, the fastener required to lag the guide system together must be able to be oriented to the shaft **1130** and the aiming arm **1102** individually. The washer **1160** and spherical nut **1170** described herein achieve such individual orientation. The pre-determined orientation would be fixed such that the bottom surface of the washer would lie flush with the top surface of the aiming arm and the central axis of the nut would lie co-axial with the central axis of the threaded shaft. The washer **1160** includes a base member **1162** with a contact surface **1164**. A hole **1163** extends through the base member **1162** such that the threaded shaft **1130** may pass therethrough. A plurality of fingers **1166** extend upward from the base member **1162**. The fingers **1166** along with the base member **1162** define a semi-spherical seat **1168** for the spherical nut **1170**.

[0185] The spherical nut **1170** includes a shaft **1172** extending between a ball portion **1174** and a handle member **1176**. The ball portion **1174** has a semi-spherical configuration which complements that of the seat **1168**. The fingers **1166** are configured to allow the ball portion **1174** of the spherical nut **1170** to be snapped into the seat **1168** and thereafter retain the ball portion **1174** within the seat **1168**. With such a configuration, the spherical nut **1170** can move freely within the washer **1160** but remains contained to avoid additional parts. A distal end of the ball portion **1174** defines an opening **1175** into a threaded bore **1178**. The threaded bore **1178** is configured to threadably engage the threads **1134**, **1136** at either end **1131**, **1133** of the threaded shaft **1130**. When the spherical nut **1170** is oriented with the threaded shaft **1130** and tightened, the washer **1160** self-aligns with the mating surface of the aiming arm **1102**, completing the rigid connection of the arm **1102** to the plate **300**.

[0186] Referring to FIGS. **31** and **31**, a guide assembly with an alternative embodiment of the connection assembly **1128'** will be described. In the present embodiment, the two-piece fastener is replaced with a fixed axis fastener including a washer **1160'** and nut **1170'** which are fixed together such that the nut **1170'** is rotatable about a singular axis A**2**. The angle of axis A**2** is selected to match the angle of the axis A**1** of the attachment post **1140**. The washer **1160'** includes a base member **1162'** which defines a contact surface **1164**. A nut attachment shaft **1165** extends from the base member **1162'** and is configured to receive and rotatably retain the shaft **1172'** of the nut **1170'**. The nut shaft **1172'** may be connected to the nut attachment shaft **1165** via radial tabs engaging a rim within the nut attachment shaft **1165** or any other suitable means for rotatably connecting the nut shaft **1172'** to the nut attachment shaft **1165**. The fixed orientation of the nut attachment shaft **1165**, only permits rotational motion of the nut **1170'** about the nut's central axis. The nut shaft **1172'** includes internal threads configured to threadably engage the threads **1134**, **1136** at either end **1131**, **1133** of the threaded shaft **1130**. With the angle of the axis A**2** of the nut **1170'** matching that of the attachment post axis A**1**, the contact surface **1164** of the washer **1160'** will be parallel to and lie against the surface of the arm body **1104**.

[0187] Having generally described the components of the connection assembly **1128**, attachment of the aiming arm **1102** to the plate **300** will be described with reference to FIGS. **29** and **30**. As a first step, the threaded shaft **1130** is assembled onto the plate **300**. The threads **1136** threadably engage the threads of one of the holes **340** in the plate **300**. The threaded shaft **1130** can be final tightened with a hexalobe screwdriver or the like engaged with the driver-engagement bore **1135**. The attachment post **1140** is slid over the threaded shaft **1130** and the ball end pins **1154** align with and engage the indentations **344** in the plate **300**. The aiming arm **1102** is then positioned such that the orienting boss **1146** is received in the attachment slot **1108**. The two-piece fastener is then positioned such that the contact surface **1164** of the washer **1160** sits on the upper surface of the aiming arm **1102** and the threaded shaft **1130** is received into the threaded bore **1178** of the spherical nut **1170**. The handle **1176** is then used to tighten the nut **1170** as the threaded bore **1178** engages the threads **1134**. As the spherical nut **1170** is tightened, the washer **1160** self-aligns with the mating surface of the aiming arm **1102**, completing the rigid connection of the arm **1102** to the plate **300**. As can be seen from FIGS. **29** and **30**, upon connection, the plane P**1** of the mating surface **1148** of the attachment post **1140** and the plane P**2** of the contact surface **1164** of the washer **1160** are parallel to one another. Accordingly, the trajectories of the holes **1110** in the aiming arm **1102** will align with the trajectories of the holes **328**, **330**, **332** in the shaft of the plate **300**.

[0188] Referring to FIGS. **33** and **34**, an embodiment of a tissue protection sleeve **1180** will be described. The tissue protection sleeve **1180** is configured to be inserted into one of the aiming holes **1110** with a 1-to-1 association with the holes **328**, **330**, **332** in either the narrow or broad lateral plates **300**. The tissue protection sleeve **1180** includes a shaft **1182** extending from a proximal end **1181** to a distal end **1183**. A through bore **1184** extends through the shaft **1182** from the proximal end **1181** to the distal end **1183**. The distal end **1183** may have a slight taper thereto to minimize tissue disruption.

[0189] As described above, a head member **1186** configured to seat in a desired orientation within the recess **1114** of one of the aiming holes **1110** is defined at the proximal end **1181** of the shaft **1182**. Additionally, the proximal end **1181** of the shaft **1182** defines the locking tab **1196** which is configured to engage in the undercut **1116** of the aiming hole **1110**. The locking tab **1196** is releasable such that the sleeve **1180** is removable from the aiming hole **1110**. To facilitate such, a slot **1194** is defined in the shaft **1182** such that a pivotal locking arm **1190** is defined. The free end of the pivotal locking arm **1190** defines an unlocking button **1192**. The locking tab **1196** is positioned along the locking arm **1190** distally of the unlocking button **1192**. The locking tab **1196** has a sloped surface extending to the retention ledge **1198**. Accordingly, as the tissue protection sleeve **1180** is inserted into the aiming hole **1110**, the sloped surface of the locking tab **1196** will contact the through bore **1112** and the locking arm **1190** will pivot radially inward, allowing the locking tab **1196** to pass through the bore **1112**. Once the locking tab **1196** passes the bore **1112** and is aligned with the undercut **1116**, the pivotal locking arm **1190** will automatically return to its initial position, with the retention ledge **1198** engaging the undercut **1116**, as shown in FIG. **34**. In at least one embodiment, when inserted properly, an audible click is heard as the retention ledge **1198** engages the aiming hole's undercut **1116**. To remove the tissue protection sleeve **1180**, the unlocking button **1192** is squeezed toward the head portion **1186** of the sleeve **1180**, releasing the ledge **1198** from the undercut **1116**. The sleeve **1180** can then be pulled free from the aiming arm **1102**. With reference to FIG. **21**, the tissue protection sleeve **1180** may receive instruments directly, for example, trocar **1245**, or may receive additional sleeves, for example, drilling sleeve **1200** or dynamic compression sleeve **1250**, which in turn receive instruments.

[0190] In the illustrated embodiment, the kickstand tissue protection sleeve **1180'** is substantially the same as the tissue protection sleeves **1180** described above except at the proximal end **1181'** thereof. Instead of a head member **1186** and locking arm **1190**, a handle **1255** extends radially from the proximal end **1181'**. The handle **1255** facilitates greater control and rotation of the kickstand tissue protection sleeve **1180'** as it is inserted at an angle relative to the bone plate **300**. In other aspects, the sleeve **1180'** is the same as in the previous embodiment and facilitates passage of drill sleeves, screws and the like as described herein.

[0191] Referring to FIGS. **35** and **36**, an embodiment of a drill sleeve **1200** positionable within one of the tissue protection sleeves **1180**, **1180'** will be described. The drill sleeve **1200** includes an outer sleeve body **1202** extending from a proximal end **1201** to a distal end **1203**. A through bore **1204** extends through the outer body sleeve **1202** from the proximal end **1201** to the distal end **1203**. A collet **1206** is defined at the distal end **1203** of the outer sleeve body **1202**. Slots **1208** on either side of the outer sleeve body **1202** allow the collet **1206** to collapse and return to its natural expanded position. The drill sleeve **1200** also includes an inner drill sleeve body **1210** which extends from a proximal end **1211** to a distal end **1213**. A through bore **1214** extends through the inner body sleeve **1210** from the proximal end **1211** to the distal end **1213**. The distal end **1213** of the inner drill sleeve **1210** is sized to be positioned within the bore **1204** of the outer sleeve body **1202**. The proximal end **1211** of the inner drill sleeve body **1210** includes a grippable head member **1216** and a rotation tab **1218**. In an initial position, the inner sleeve body **1210** is only partially inserted into the outer sleeve body **1202** such that the distal end **1213** thereof is clear of the collapsible collet **1206**.

[0192] The drill sleeve **1200** may be inserted into one of the tissue protection sleeves **1180**, **1180'** with the inner sleeve body **1210** in the initial position. The drill sleeve **1200** is advanced through the tissue protection sleeve **1180**, **1180'** until the collet **1206** of the outer sleeve body **1202** compresses and snaps into any of the holes **328**, **330**, **332**, **335** of the plate **300**. Once the outer sleeve body **1202** is fully seated, the collet **1206** is held in the expanded position by depressing the inner sleeve body **1210** until the distal end **1213** thereof is aligned with the collet **1206**, as illustrated in FIG. **36**. In the illustrated embodiment, the inner sleeve body **1210** is depressed by rotating the tab **1218**. In other embodiments of the drill sleeve, this can be achieved by pressing axially, rotating a nut, depressing a lever, or the like. With the drill sleeve **1200** locked in place, the inner sleeve through bore **1214** is configured to receive various instruments, for example, as shown in FIG. **21**, a drill **1230**, a k-wire **1235**, or a positioning pin **1240**.

[0193] Alternatively, a dynamic compression sleeve **1250** can be inserted into the tissue protection sleeve **1180** to allow off-axis predrilling and permit compression through a dynamic compression hole **332** in either direction in the long axis of the plate **300**. The dynamic compression sleeve has a bore **1252** with an axis that is offset a given distance, for example, by about 1 mm, from the central axis of the sleeve **1250**. With the sleeve **1250** in a first orientation, the off axis bore **1252** is offset the given distance in the proximal direction of the plate **300** and when rotated 180°, is offset the given distance in the distal direction of the plate **300**. The sleeve **1250** has a tab **1254** which is aligned and press-fit into a tab in the head member **1186** of the tissue protection sleeve **1180** to properly clock its orientation. The holes **1110** in the aiming arm **1102** that align with dynamic compression holes **332** in the plate **300** may be marked, for example, outlined with white paint **1119** on the aiming arm.

[0194] Referring to FIGS. **21** and **37**, a hole marker **1220** may also press-fit into one of the aiming holes **1110** to allow marking either the last hole in a plate being targeted or a hole which has already been filled with a screw. In the illustrated embodiment, the hole marker **1220** has a handle portion **1222** with a pair of legs **1224** depending therefrom. The legs **1224** are separated from one another by a gap **1227**. A circular cut **1226** adjacent the handle portion **1222** allows the legs **1224** to pivot toward one another upon application of an inward force, but then automatically return to the initial position upon removal of such force. The outer sides **1229** of each leg **1224** have a taper such that as the legs **1224** are moved into the through bore **1112** of one of the aiming holes **1110**, the legs **1224** will pivot toward one another and pass through. Each leg **1224** also has an outer notch defined therein **1228**. When the hole marker **1220** is completely seated in the recess **1114** of the aiming hole **1110**, the notch **1228** will receive and engage the wall of the through bore **1112** as the legs **1224** move back toward the initial position. The notches **1228** are sloped such that a sufficient removal force on the handle portion **1222** will cause the leg **1224** to again pivot toward one another and pass in the reverse direction through the through bore **1112**.

[0195] The aiming guide system **1100** described herein allows for improved lateral imaging and visualization of the fracture. Due to the oblique angle of the threaded shaft **1130**, fracture lines are clearly visible in the metaphyseal region of the femur, and access to the distal holes **340** in the head of the plate **300** is maintained. The system **1100** also has fewer components and fewer total assembly steps, allowing for simpler operation and a more streamlined procedure than some of the other available guides.

[0196] Attachment of the aiming arm **1102** to the plate **300** is achieved via a smaller rigid connection to the plate than most others on the market. This smaller connection is also located more distally in the plate than other competitive options. Therefore, a smaller incision placed more distally (closer to the articular surface of the knee) can be achieved. With a smaller MIS incision, excessive stripping of the soft tissue and/or periosteum can be avoided and there is a lower chance of wound complications.

[0197] Oblique "kickstand" screw holes in a distal femur plate are a unique way to engage the strong bone on the medial condyle of the femur and promote stabilization of the construct through triangular, off-axis fixation. Providing a way to target the nominal axis of the kickstand holes through the guide system allows an easier, MIS approach to placing locking or non-locking screws in these oblique holes.

[0198] Turning now to FIGS. **38-66**, an aiming guide system **1300** is shown in accordance with one embodiment. Aiming guide system **1300** is similar to aiming guide system **1100** and like elements will be labeled the same. The aiming guide arm **1102** attaches to the bone plate **300** via two kinematic mounts including a single attachment post **1140** and threaded shaft **1130** engaged with the plate **300**. In this embodiment, the attachment slot **1108** and boss **1146** may include a cylindrical interface and v-notches **1328** with a cross pin **1330** to control six degrees of freedom. The polyaxial nut assembly **1170** secures the connection assembly **1128** and provides for angular flexibility and self-centering properties. The aiming through holes **1110** in the aiming arm **1102** may include slots **1380** configured to engage with a tab **1382** on the tissue sleeve **1180**, thereby keying the tissue sleeve **1180** to the aiming arm **1102**. While the aiming guide system **1300** is shown and described with respect to bone plate **300**, it is understood that the system **1300** may be sized and configured to be utilized with various bone plates including the other plates described herein.

[0199] Referring to FIG. **38**, the aiming guide system **1300** includes aiming arm **1102** which is configured to attach to plate **300**. The aiming guide **1102** attaches to the plate **300** via the attachment post **1140** and threaded shaft **1130** engaged with the plate **300**. The post **1140** may be aligned with dedicated geometry on the plate **300**. The tilt and angle of the attachment post **1140** relative to the top surface of the plate **300** is designed such that the post **1140** and subsequent assembly items do not block access to the distal cluster of screws **340** in the plate **300**. The aiming arm **1102** keys into place on the attachment post **1140**. The aiming arm **1102** may be reversible to accommodate procedures on the left or right femur, for example. A polyaxial nut assembly **1170** completes the assembly of the guide **1102** to the plate **300**.

[0200] The aiming arm **1102** accepts one or more tissue protection sleeves **1180**. The tissue protection sleeves **1180** provide a portal into small incisions through which trocars **1245**, drill sleeves **1200**, k-wire sleeves **1236**, drills **1230**, drivers, and screws may pass. The sleeves **1180** may clip into place on either face of the aiming arm **1102** (depending on whether the procedure is being performed on a right or left femur). An accurate and rigid interface of the sleeve **1180** with the guide **1102** optimizes the function of the aiming guide **1102** as a whole since the sleeves **1180** provide the nominal (0) angle of the holes **328**, **330** in the shaft of the plate **300**. The kickstand sleeve **1400**, another type of tissue protection sleeve **1180**, provides a similar portal for the same items, but designed to interface with the two oblique kickstand screw holes **335** in the plate.

[0201] Prior to insertion of a tissue protection sleeve **1180**, a scalpel **1302** may be used to create accurately located and appropriately sized incisions through skin and tissue. The scalpel **1302** may include a scalpel blade handle **1304** with a standard surgical blade **1306** intraoperatively attached. The scalpel **1302** may be positioned through one or more aiming holes **1110** in the aiming arm **1102**. The scalpel blade handle **1304** may be guided by the same geometry in the aiming guide **1102** as the tissue sleeves **1180**. The scalpel **1302** may bottom out at an appropriate depth to prevent a collision between the blade **1306** and plate **300**.

[0202] A hole marker **1220** may be used to indicate or block a relevant position in the aiming guide **1102** which may enhance the surgical flow. Although the tissue sleeves **1180**, k-wire sleeve **1236**, trocar **1245**, positioning pin **1240**, drill **1230**, and scalpel **1302** are shown at a certain number or position along the aiming arm **1102**, it will be appreciated that the user may position these devices in any suitable aiming hole **1110** at any suitable position to align with the plate **300** and perform the desired procedure.

[0203] With emphasis on FIG. **39**, aiming arm **1102** includes a plurality of aiming holes **1110**, a pair of kickstand targeting holes **1124**, and an attachment location or attachment slot **1108** for coupling the attachment post **1140** to the plate **300**. In this embodiment, the attachment location **1108** defines a cylindrical hole **1310** configured to receive a cylindrical boss **1146** of the attachment post **1140**.

[0204] Each aiming arm **1102** may be configured to match the specific hole geometry of a particular family of plates. For example, for a distal femur system, there may be two plate geometries (broad and narrow) and two corresponding aiming arm geometries (broad and narrow). The aiming arms **1102** may be reversible, for example, to accommodate anatomic left/right plate variations. The aiming arms **1102** may be manufactured from a radiolucent material, such as carbon fiber reinforced with PEEK, to prevent obstructing lateral imaging during the procedure. The variety and hand of the aiming guide **1102** may be indicated through a guide indicator **1107** on the face of the aiming guide **1102** (e.g., "NARROW LEFT"). The shaft targeting holes **1110**, defined through the aiming arm **1102**, may be numbered with indicators **1118** on the side, top, and/or each surface of the arm body **1104** to indicate the associated targeted hole **328**, **330**, **332** in the plate **300**. The kickstand targeting holes **1124** permit nominal targeting of the two oblique kickstand screws in the distal cluster of the plate **300**. The tissue protection sleeves **1180**, drill sleeves **1200**, and other instrumentation are compatible with both the narrow and broad aiming arms **1102**.

[0205] The attachment location or slot **1108** is configured to form one part of a pair of reversible kinematic mounts. The attachment location **1108** may define a cylindrical hole **1310** configured to receive a corresponding cylindrical boss **1320** of the attachment post **1140**. The cylindrical hole **1310** extends through the aiming arm **1102** from a top face to a bottom face of the aiming arm **1102** near the distal end **1105** of the arm **1102**. As shown in FIG. **40**, the attachment location **1108** may include an optional tubular insert **1312**, such as a metallic insert. The tubular insert **1312** may have a threaded interface **1314** with the radiolucent aiming arm **1102**. The metallic insert **1312** may provide a hard bearing surface for the kinematic mount. The threaded insert **1312** may be permanently bonded to the aiming arm **1102**, for example, with epoxy and/or cross pinned **1316** in place to prevent rotation and removal. The insert **1312** may help with reinforcement and durability over the life of the instrument.

[0206] Turning now to FIGS. **41-46**, the aiming arm **1102** and plate **300** are precisely oriented with respect to each other to ensure accurate targeting of the holes **328**, **330** in the plate **300**. Accurate and repeatable connections between the aiming arm **1102** and plate **300** may be ensured by the pair of kinematic mounts. The first kinematic mount is between the plate **300** and attachment post **1140**, and the second kinematic mount is between the aiming arm **1102** and the attachment post **1140**.

[0207] With emphasis on FIG. **42**, the first kinematic mount between the plate **300** and attachment post **1140** is shown. This connection was previously described in detail with respect to FIG. **28**. For example, the first kinematic mount may include a set of three semi-spherical protrusions **1154** which engage in conical indentations **344** in the plate **300**. Each sphere **1154** has an accurate geometric location in the cone **344**. The three sphere-cone interfaces **344**, **1154** together constrain all six degrees of freedom between the attachment post **1140** and the plate **300**. The attachment post **1140** and the plate **300** may be held in contact by the tension created by the threaded shaft **1130**. The threaded shaft **1130** may be non-reversible and engages with machine threads **1318** into a dedicated hole in the plate **300**. The shaft **1130** passes through a central cannulation **1326** of the attachment post **1140** and its spherical protrusions **1154**. The tips of the threaded shaft **1130** may contain a blunted first thread to prevent cross-threading in the plate **300**. The threaded shaft **1130** may be cannulated through its long central axis to allow the passage of a k-wire **1235**.

[0208] Turning now to FIGS. **43-44**, the second kinematic mount between the aiming arm **1102** and attachment post **1140** is shown. The second kinematic mount includes a boss **1146** coupled to the attachment post **1140**. In this embodiment, the boss **1146** is a cylindrical boss **1320**, which is receivable in the cylindrical opening **1310** in the aiming arm **1102**. The cylindrical boss **1320** includes an annular body with a central opening **1324**. The central opening **1324** has a hole axis A3. When the boss **1320** is received in the cylindrical opening **1310**, the hole axis A3 may be aligned generally perpendicular to the body of the aiming arm **1102**. The attachment post **1140** includes a hollow tube **1142** defining a central cannulation or channel **1326**. The channel **1326** has a central cannulation axis A4. The boss opening **1324** is in fluid communication with the central channel **1326**. The attachment post **1140** may be constructed on a non-normal axis relative to the aiming guide **1102**. That is, the central cannulation axis A4 and the cylindrical boss axis A3 are not aligned. As best seen in FIG. **45**, this non-alignment allows the attachment post **140** and polyaxial nut **1170** to be located in a more favorable location (e.g., the segmented circle does not overlap the plate **300**) on the aiming guide **1102**, thereby removing obstructions from a radiographic view of the plate **300** and fracture site.

[0209] As best seen in FIGS. **40** and **44**, the face of the aiming guide **1102** may define a pair of notches **1328** about the opening **1310**. The notches **1328** are configured to receive a cross pin **1330**. The notches **1328** may form v-shaped notches or other suitable indentations for receiving the cross pin **1330**. The v-shaped notches may be oriented 180 degrees to each other about the cylindrical opening **1310**. A first set of v-shaped notches **1324** may be indented into a top face of the aiming arm **1102** and a second set of v-shaped notches **1324** may be indented on the opposite face of the aiming arm **1102** to allow the mechanism to be reversible and accommodate a mirrored attachment post **1140**. As best seen in FIG. **40**, when the insert **1312** is present, the v-shaped notches **1328** may be indented into the outer face(s) of the insert **1312**. The cylindrical boss **1320** and corresponding hole **1310** control four degrees of freedom and the cylindrical cross pin **1330** and v-shaped notches **1328** control the final two degrees of freedom. The arrangement of the pin **1330** and v-shaped notches **1328** together may eliminate tolerance-related toggle about the cylindrical boss **1320**.

[0210] Turning now to FIGS. **46-48**, the tension in the threaded shaft **1130** may be created by tightening a polyaxial nut assembly **1170**. The polyaxial nature of the nut **1170** allows it to self-center on the threaded shaft **1130** and match the angulation of the aiming guide **1102**. Any angulation error present in the attachment post **1140** or aiming guide **1102** is effectively absorbed by the flexibility in the nut **1170**. As best seen in FIG. **41**, the tension created passes through the following loop of components: plate **300** to attachment post **1140** to aiming arm **1102** to polyaxial nut **1170** to threaded shaft **1130**. The polyaxial nut assembly **1170** includes frictional elements such that nut **1170** will not tilt due to gravity and is able to connect to the aiming guide **1102** in a lateral orientation.

[0211] The polyaxial nut **1170** is an assembly of components that provide angular flexibility and self-centering properties. The polyaxial nut assembly **1170** includes a spherical nut **1340** with a shaft **1342** extending between a ball portion **1344** and a handle member **1346**. The ball portion **1344** has a semi-spherical configuration which complements that of a seat **1348** in a base **1350**. The spherical nut **1340** defines a central through opening **1352** into a threaded bore **1354**. The threaded bore **1354** is configured to threadably engage the threads **1134**, **1136** at either end **1131**, **1133** of the threaded shaft **1130**. The handle member **1346** may include a tri-lobe thumb nut (FIG. **46**), eight-lobed knob (FIG. **47**), or other suitable configuration with grips for providing torque or other movement to the polyaxial nut **1340**. The handle member **1346** may be integral with (FIG. **47**) or secured to the top of the shaft **1342** with a threaded screw **1356** (FIG. **46**), pin, adhesive, or other suitable means.

[0212] With emphasis on the embodiment shown in FIG. **46**, the base **1350** may include a two-piece captive base assembly with a first upper component **1358** and a second lower component **1360** threadedly interfaced with one another. The upper component **1358** may be configured to surround a top portion of the ball **1344** and may define a plurality of slits **1366** therethrough. The lower component **1360** may receive a lower portion of the ball **1344** and may be positioned between the ball **1344** and the upper face of the aiming arm **1102**. A bottom surface of the lower component **1360** may contact an upper face of the aiming arm **1102** and/or an upper face of the cylindrical boss **1320**.

[0213] In this embodiment, the two-piece washer base assembly **1358**, **1360** is configured to hold captive the spherical nut **1340**, a polymer washer **1362**, and a wave spring **1364**. The polymer washer **1362** is configured to fit around the base of the spherical ball portion **1344**. The wave spring **1364** may include a single turn wave spring with a gap or overlapping ends positioned in the lower base **1360** beneath the spherical ball portion **1344** of the spherical nut **1340**. The captive base **1350** contains the wave spring **1364** and polymeric washer **1362** which together provide friction and allow the spherical nut **1340** to retain its attitude regardless of physical orientation. A nut **1340** without one or more of these frictional elements could tilt due to gravity and may be difficult to assemble in the orientation shown in FIG. **41**. When the spherical nut **1340** is oriented with the threaded shaft **1130** and tightened, the lower component **1360** self-aligns with the mating surface of the aiming arm **1102**, completing the rigid connection of the arm **1102** to the plate **300**.

[0214] With emphasis on FIGS. **47-48**, another embodiment of the polyaxial nut assembly **1170** is shown with the wave spring **1364** and polymeric washer **1362** replaced by a flexible single-piece polymeric washer **1370**. The washer **1362** may include a base member **1350** with a lower contact surface for mating with the aiming guide **1102** and/or top of the cylindrical boss **1320**. A hole **1374** extends through the base member **1350**. A plurality of fingers **1372** extend upward from the base member **1350**. The fingers **1372** along with the base member **1350** define a semi-spherical seat **1348** for the spherical ball **1344**. The flexible polymeric washer **1370** and spherical nut **1340** may have an annular interference snap fit. The interference provides frictional resistance. The nut **1340** can be disassembled for cleaning by un-snapping the two components. This configuration may provide a simplified, streamlined assembly mechanism that permits lagging of the plate **300**, post **1140**, and aiming arm **1102** together in one step.

[0215] In this manner, attachment of the aiming guide **1102** to the plate **300** is achieved via a small rigid connection to the plate **300**. This small connection is located distally in the plate **300**. Therefore, a smaller incision placed more distally (closer to the articular surface of the knee) can be achieved. With a smaller MIS incision, excessive stripping of the soft tissue and/or periosteum can be avoided with a lower chance of wound complications.

[0216] Turning now to FIGS. **49-50**, the tissue protection sleeve **1180** may be inserted through any of the aiming guide holes **1110**. Each aiming hole **1110** includes, on each surface of the arm body **1104**, recess **1114** about the through bore **1112** and undercut **1116** defined within each recess **1114**. The recess **1114** is configured to receive a tab **1382** of the tissue protection sleeve **1180**, thereby orienting the sleeve **1180** in the aiming guide **1102**. The tissue protection sleeve **1180** may be secured in the aiming guide **1102** when the retention ledge **1198** of the sleeve **1180** seats in the undercut **1116** of the hole **1110**.

[0217] In this embodiment, as best seen in FIGS. **49**A-**49**B, the recess **1114** may include a round shape encircling the bore **1112** and at least one slot **1380** for receiving at least one tab **1382** on the tissue protection sleeve **1180**. The slot(s) **1380** may include a u-shaped recess positioned along a sector of the opening **1110** that protrudes outwardly past an outer diameter of the recess **1114**. In this embodiment, a pair of slots **1380** are oriented 180 degrees to each other which permits the tissue sleeve **1180** to be inserted in two orientations. It will be appreciated that any suitable type, number, and orientation of slots **1380** may be provided to orient the tissue protection sleeve **1180**. The tissue protection sleeve **1180** is keyed into place by seating the tab **1382** on the tissue protection sleeve **1180** into one or more slots **1380** about the aiming arm holes **1110**. The slots **1380** may be oriented on a hole-by-hole basis to reduce or eliminate the opportunity for adjacent sleeves **1180** to interfere with each other.

[0218] As previously described with respect to FIGS. **23-24**, the recess **1114** and undercuts **1116** may be mirrored about the mid-plane of the aiming arm **1102** such that tissue protection sleeves **1180** can be inserted from either side of the aiming arm **1102**. The undercuts **1116** meet at the mid-plane of each hole **1110**, resulting in a continuous groove in which the retention ledge **1198** will sit. The undercut **1116** may be fully circumferential about the central axis of each hole **1110**.

[0219] As shown in FIGS. **50**A-**50**C, the tissue protection sleeve **1180** may include a tubular shaft **1182** defining a through bore **1184**, a head member **1384** configured to sit above the opening **1110**, and a pivotal locking arm **1386** with a button or thumb lever **1388** for engaging and releasing the locking tab **1196** from the undercut **1116** in the aiming hole **1110**. The free end of the pivotal locking arm **1386** defines the unlocking button or thumb lever **1388**. To facilitate the pivotal locking arm **1386**, one or more cuts or slots **1390** are defined in the shaft **1182** such that the pivotal locking arm **1386** is defined and a relief cut **1392** separates the thumb lever **1388** from the head member **1384**. The thumb lever **1388** may have an L-shaped body with a first portion protruding outward from the tubular shaft **1182** and a second portion extending upward toward the proximal end **1181** of the shaft **1182**. A protrusion **1394** extending downwardly from the head **1384** may prevent the thumb lever **1388** from extending too far outward from the body **1182**.

[0220] The tissue protection sleeve **1180** may include a band or collar **1378** positioned between the thumb lever **1388** and the retention ledge **1198**. The collar **1378** may encircle the shaft body **1182** and may be configured to be positioned in the recess **1114** in the aiming hole **1110**. The tab **1382** may be positioned on the collar **1378** at a location 180 degrees opposite to the thumb lever **1388**. It will be appreciated that the tab or tabs **1382** may be located at any suitable position with respect to the thumb lever **1388** to orient the sleeve **1180** in the desired direction.

[0221] The locking tab **1196** is positioned along the locking arm **1386** distally of the unlocking button **1388** and the collar **1378**. The locking tab **1196** may include a sloped surface extending to the retention ledge **1198**. As the tissue protection sleeve **1180** is inserted into the aiming hole **1110**, the sloped surface of the locking tab **1196** will contact the through bore **1112** and the locking arm **1386** will pivot radially inward, allowing the locking tab **1196** to pass through the bore **1112**. Once the locking tab **1196** passes the bore **1112** and is aligned with the undercut **1116**, the pivotal locking arm **1386** will automatically return to its initial position, with the retention ledge **1198** engaging the undercut **1116**, as shown in FIG. **50**B. In at least one embodiment, when inserted properly, an audible click may be heard as the sleeve **1180** elastically deforms in the region of the relief cut **1392** and the retention ledge **1198** snaps past the aiming arm's undercut **1116**. As best seen in FIG. **50**C, to remove the tissue protection sleeve **1180**, the thumb lock **1388** and head **1384** of the sleeve **1180** are squeezed together, temporarily elastically deforming the locking arm **1386** of the tissue sleeve **1180**, releasing the ledge **1198** from the undercut **1116**, thereby allowing for the tissue sleeve **1180** to be pulled upward and free from the aiming arm **1102**.

[0222] With emphasis on FIGS. **51**A-**51**B, the thumb button **1388** may include one or more features to limit movement of the button **1388** toward or away from the head member **1384** of the tissue protection sleeve **1180**. As previously described, the locking arm **1386** of the tissue protection sleeve **1180** is a deformable component that snaps into the aiming arm **1102** at shaft hole locations along the aiming arm **1102**, as illustrated in FIGS. **38** and **49**A-**50**C. Deformation of locking arm **1386** and thumb lock **1388** is bounded by one or more intentional mechanical stops **1394**, **1396** in each direction, for example, to prevent permanent plastic deformation of the material. During normal use, the thumb lock **1388** of the sleeve **1180** is squeezed, typically at a central location on the thumb lock **1388** (e.g., labeled as an application of force F). A protruding travel bump stop **1396** may be provided on the underside of the thumb button **1388** to limit travel in the direction of force F. The bump stop **1396** may be located directly under the intended point of application of force F. The thumb lock **1388** may also be prevented from extending too far away from the head member **1384** in a direction opposite to force F. For example, integral interlocking geometry **1394** may prevent deformation in this opposite direction. The interlocking geometry, best seen in FIG. **50**B (locked configuration) and FIG. **50**C (unlocked configuration), may include protrusion **1394** which is translatable along a recess in the top of the first portion of the L-shaped lock **1388**. In addition, the geometry of the flexible portion of the tissue protection sleeve **1180** provides for a proximal gap **1398** that remains even when the thumb lock **1388** is fully squeezed against the head member **1384** of the tissue protection sleeve **1180** (as shown in FIG. **51**B), which reduces the likelihood of a pinched finger or glove.

[0223] With emphasis on FIG. **52**, the tissue protection sleeve **1180** has a hollow body and includes a central cannulation **1184** for receiving an instrument therethrough. The head member **1384** may include one or more planar faces to from a generally rectangular body. One or more of the planar faces may include a concave arch, for example, along the side facing the button **1388** and on the opposite side. The concave surface may help with gripping the head member **1384** during insertion and removal. The proximal end **1181** of the sleeve **1180** may include a shallow polygonal opening **1376** near the top face of the head member **1384**. In one embodiment, the polygonal opening **1376** may have a hexagonal cross-section. The hexagonal opening **1376** may be in fluid communication with the cannulation **1184**. The hexagonal opening **1376** may be used to constrain rotation between the tissue protection sleeve **1180** and a trocar **1245** or other instrument that passes through the sleeve **1180**.

[0224] Turning now to FIGS. **53** and **54**, in one embodiment, the distance from the center of each hole on the plate **300** to the bottom of each recess **1114** in the aiming guide **1102** may be constant. In other words, as best seen in FIG. **53**, distances between aiming guide **1102** and the plate **300** (e.g., distances b**1**, b**2**, and b**3**) may all be equal distances. As best seen in FIG. **54**, this results in a unique depth (e.g., depth d**1**, d**2**, d**3**, d**4**) of each recess cut **1114** in order to match the curvature of the lateral distal femur plate **300**. For example, the depths may decrease as follows d**1**>d**2**>d**3**>d**4**.

The depths may also increase or vary between adjacent holes **1110**. This enables a fixed-length soft tissue sleeve **1180** to closely align with the plate **300** in any hole **1110**.

[0225] Turning now to FIGS. **55**A-**55**B, a kickstand sleeve **1400** is shown according to one embodiment. The kickstand sleeve **1400** may be used in any of the oblique kickstand holes **1124** in the aiming guide **1102**. The kickstand tissue protection sleeve **1400** may include a tubular shaft **1402** defining a central through bore or cannulation **1404** and a handle **1406** extends radially from the proximal end of the shaft **1402**. The handle **1406** may facilitate greater control and rotation of the kickstand tissue protection sleeve **1400** as it is inserted at an angle relative to the bone plate **300**. As best seen in FIG. **55**B, the proximal portion of the central cannulation **1404** of the kickstand sleeve **1400** may include a clearance diameter **1408** to accommodate a trocar **1245**, drill sleeve **1200**, or the like. The clearance diameter **1408** may be enlarged in diameter relative to the remainder of the cannulation **1404**.

[0226] The oblique kickstand screw holes **1124** in the distal femur plate **300** allow for engagement of the strong bone on the medial condyle of the femur and promote stabilization of the construct through triangular, off-axis fixation. Providing a way to target the nominal axis of the kickstand holes **1124** through the guide **1102** allow an easier MIS approach to placing locking or non-locking screws in these oblique holes.

[0227] Turning now to FIGS. **56**-**61**, a soft tissue trocar instrument **1245** is shown according to one embodiment. The trocar **1245** is configured to be received through the soft tissue and kickstand sleeves **1180**, **1400**. The trocar **1245** may be used to keep cannulations clear of tissue when inserting a cannulated instrument. As shown in FIG. **56**, the trocar **1245** may include a body or shaft **1410** with a tip **1412** at its distal end and an enlarged grip base **1422** at its proximal end. The tip **1412** may include a sharp cone tip or spade tip, for example. Between the shaft **1410** and grip base **1422**, the trocar **1245** may include a deformable retention tab **1414** to retain the trocar **1245** in the soft tissue sleeve **1180**, **1400**, an external hexagon **1416** for rotational control, a stepped shoulder **1418** to accommodate different tissue sleeve lengths, and/or a retention groove **1420** on the end of the enlarged base **1422** to engage with a removeable handle **1424**. The deformable retention tab **1414** may be formed by one or more slits or relief cuts. The external hexagon **1416** may include any polygonal shaped configured to correspond with the opening **1376** in the tissue protection sleeve **1180**. The enlarged grip base **1422** may include a cylindrical drum with concave faces configured to be easily gripped by a user. The retention groove **1420** may include a continuous or interrupted circumferential groove in the grip base **1422** near the proximal end of the trocar **1245**.

[0228] With emphasis on FIG. **57**, the trocar **1245** is receivable through the kickstand sleeve **1400**. The shaft **1410** is positionable through the central cannulation **1404** of the sleeve **1400**. The shoulder **1418** is receivable in the clearance diameter **1408** and the grip base **1422** bottoms out against the face **1407** of the handle **1406**. The kickstand sleeve **1400** is longer than the soft tissue sleeve **1180**, because the kickstand sleeve **1400** has to reach the plate **300** on an oblique angle. The clearance diameter **1408** in the kickstand sleeve **1400** allows the trocar **1245** to reach this further distance.

[0229] With emphasis on FIGS. **58** and **59**, the trocar **1245** is receivable through the tissue protection sleeve **1180**. The shaft **1410** is positionable through the central cannulation **1184** of the sleeve **1180**. As best seen in FIG. **58**, the shoulder **1418** of the trocar **1245** bottoms out when the shoulder **1418** contacts the proximal face **1181** of the head member **1384** of the sleeve **1180**. The trocar **1245** stops at the stepped shoulder **1418** so that the cone tip **1412** is aligned at the end of the soft tissue sleeve **1180**. When the trocar **1245** is inserted into the soft tissue sleeve **1180**, the retention tab **1414** provides friction between the two components to keep them provisionally assembled. As best seen in FIG. **59**, the hexagonal features **1376**, **1416** or other interlocking configuration of the trocar **1245** and soft tissue sleeve **1180** may intermesh. The interlocking allows for the trocar **1245** and sleeve **1180** to lock in rotation to each other.

[0230] With emphasis on FIGS. **60** and **61**, the removable handle **1424** can be connected to the trocar **1245** to aide with insertion. The handle **1424** may include a handle grip **1426** and an attachment ring **1428**. The handle grip **1426** may include an ergonomic handle configured to be held by a user to maneuver the trocar **1245**. The attachment ring **1428** may include a ring or collar with one or more drainage holes **1430** spaced around the periphery. The ring **1428** is configured to surround the base **1422** of the trocar **1245**. The trocar handle **1424** interconnects and retains the trocar **1245** when inserted. As best seen in FIG. **61**, a toroidal spring **1432** may be held captive in the handle **1424** to retain the handle **1424** to the trocar **1245**. The spring **1432** compresses into a groove **1434** in the interior of the ring **1428** and retention groove **1420** in the base **1422**, thereby keeping the components provisionally connected.

[0231] Turning now to FIG. **62**, an example of the aiming guide system **1300** is shown for making the first connection through the aiming arm **1102** into the plate **300** at the furthest hole **1110** possible, which may be known as lock the box. The dotted lines in FIG. **62** represent the box that is formed by making this connection. The first connection may be via the attachment post **1140** at the distal end **1105** of the aiming guide arm **1102**. The final connection made in this scenario may be between the drill sleeve **1200** and the plate **300** at the most proximal hole **1110** possible for the plate **300**. The second connection in the box being at the proximal end **1103** of the aiming arm **1102**. The lock the box step may help to improve the rigidity of the construct and ensure that future intermediary holes **1110** have enhanced targeting accuracy.

[0232] Turning now to FIG. **63**A-**63**B, embodiments of connections between the drill sleeve **1200** and plate **300** are shown. The interface between the drill sleeve **1200** and openings **328** in the plate **300** may include a threaded connection. In one embodiment shown in FIG. **63**A, the tip **1440** of the drill sleeve **1200** may have conical thread geometry **1442** identical to that of a polyaxial locking bone screw. The conical thread **1442** may be wider at the top and narrower toward the distal end. In this manner, the tip **1440** of the drill guide **1200** engages into the polyaxial geometry **1444** in the plate **300** in an identical manner as a screw. In an alternate embodiment shown in FIG. **63**B, each plate hole **328** has separate halo threads **1446**. The halo threads **1446** may include cylindrical machine threads positioned completely above the polyaxial geometry **1444**. In this embodiment, the drill sleeve **1200** does not interlock with the polyaxial geometry **1444**. Instead, the upper halo threads

1446 interface and the remainder of the tip **1440** of the drill sleeve **1200** rests within the polyaxial geometry **1444** of the hole **328**.

[0233] With emphasis on FIGS. **64-66**, steps of properly positioning the tissue protection sleeve **1180** into the aiming arm **1102** are depicted. FIGS. **64**A-**64**B show the tissue protection sleeve **1180** and trocar **1245** not properly seated in the hole **1110** of the aiming arm **1102**. As is evident, the tab **1382** on the sleeve **1180** is not aligned with the slot **1380** in the recess **1114** of the aiming hole **1110**. A push and twist motion in the direction of the arrow may be provided by the user to fully seat the sleeve **1180** in the opening **1110**. FIGS. **65**A-**65**B show the tissue protection sleeve **1180** and trocar **1245** fully engaged and properly seated in the aiming arm **1102**. The tab **1382** on the sleeve **1180** is fully seated in the slot **1380** of the aiming hole **1110**. FIG. **66** shows the tissue protection sleeve **1180** fully and properly seated in the aiming arm **1102**.

[0234] The combination of trocar handle **1424** and hexagonal interfaces **1376**, **1416** on the trocar **1245** and soft tissue sleeves **1180** provide a streamlined procedure to insert tissue sleeves **1180** into the aiming arm **1102**. These three components retain within each other and are easily manipulated as a group. Once an incision is made, inserting the soft tissue sleeve **1180** can be done with the push-and-twist motion to quickly find the proper sleeve orientation. The trocar **1245** can then be retracted leaving the soft tissue sleeve **1180** behind and properly engaged in the aiming arm **1102**.

[0235] The aiming guide assembly allows passage of useful instrumentation for creating portals through soft tissue. These portals allow the passage of other implants and instrumentation that support a minimally invasive procedure. The aiming guide allows for improved lateral imaging and visualization of the fracture. Fracture lines are clearly visible in the metaphyscal region of the femur. Clear access to the distal holes in the head of the plate is maintained. The aiming guide also has fewer components and fewer total assembly steps, allowing for simpler operation and a more streamlined procedure.

[0236] One skilled in the art will appreciate that the embodiments discussed above are non-limiting. While bone plates may be described as suitable for a particular approach (e.g., medial or lateral), one skilled in the art will appreciate that the bone plates can be used for multiple approaches. In addition, while bone plates are described as having particular holes (e.g., locking or non-locking), one skilled in the art will appreciate that any of the bone plates can include locking, non-locking or a combination of locking and non-locking holes. In addition to the bone plates, screws and instruments described above, one skilled in the art will appreciate that these described features can be used with a number of trauma treatment instruments and implants, including external fixators, ring fixators, rods, and other plates and screws. It will also be appreciated that one or more features of one embodiment may be partially or fully incorporated into one or more other embodiments described herein.

What is claimed is:

1. An aiming guide system configured for connection to a bone plate defining a plurality of screw holes, the aiming guide system comprising:

an aiming arm having a rigid body extending from a proximal end to a distal end, a plurality of aiming holes defined through the rigid body and a cylindrical opening defined at a distal end of the rigid body;

a connection assembly including:

a cylindrical boss configured to engage the cylindrical opening;

an attachment post extending from the cylindrical boss and configured to be coupled to the bone plate such that the aiming arm is fixed in position relative to the bone plate with each aiming hole aligned with a respective one of the screw holes; and

a threaded shaft having a shaft body extending between first and second ends, each end including a plurality of threads, the threaded shaft extending through a cannulation of the attachment post with the threads of the first end of the shaft body configured to threadably engage an attachment screw hole in the bone plate;

a polyaxial nut assembly configured to be coupled to and create tension in the threaded shaft to self-center on the threaded shaft and match any angulation of the aiming arm.

2. The aiming guide system of claim **1**, wherein the polyaxial nut assembly includes:

a base;

a spherical nut having a ball and a handle;

a shaft extending between the ball and the handle, wherein the ball is received in the base, thereby providing self-centering and angular flexibility of the polyaxial nut assembly.

3. The aiming guide system of claim **1**, wherein the polyaxial nut assembly includes a spherical nut configured to threadably receive the second end of the shaft body of the threaded shaft.

4. The aiming guide system of claim **3**, wherein the spherical nut is configured to threadably receive either the first or second end of the shaft body of the threaded shaft.

5. The aiming guide system of claim **3**, wherein the polyaxial nut assembly includes:

a base having a spherical inner surface configured to receive the spherical nut to provide self-centering of the polyaxial nut assembly.

6. The aiming guide system of claim **5**, wherein the base includes a polymer washer having a spherical inner surface configured to contact the spherical nut.

7. The aiming guide system of claim **5**, wherein the base includes a spring configured to provide bias for the spherical nut.

8. The aiming guide system of claim **5**, wherein the base includes:

a polymer washer having a spherical inner surface configured to contact the spherical nut; and

a spring disposed below the polymer washer, the polymer washer and the spring together providing frictional resistance for the spherical nut.

9. The aiming guide system of claim **8**, wherein the spring includes a wave spring.

10. The aiming guide system of claim **1**, further comprising a tissue protection sleeve configured to be positioned through one of the plurality of aiming holes such that the tissue protection sleeve defines a through bore from the aiming arm to a respective one of the screw holes in the bone plate, wherein the tissue protection sleeve includes an outer tab configured to be received in one of the slots in the aiming hole, thereby keying the tissue sleeve to the aiming arm.

11. An aiming guide system comprising:

a bone plate having a distal portion and a shaft extending from the distal portion, the bone plate defining a plurality of first screw holes along the shaft, a plurality of second screw holes at the distal portion, and an attachment screw hole proximate the distal portion;

an aiming arm having a rigid body extending from a proximal end to a distal end, a plurality of aiming holes defined through the rigid body and a cylindrical opening defined at a distal end of the rigid body;

a connection assembly including:

a cylindrical boss configured to engage the cylindrical opening;

an attachment post extending from the cylindrical boss and configured to be coupled to the bone plate such that the aiming arm is fixed in position relative to the bone plate with each aiming hole aligned with a respective one of the screw holes; and

a threaded shaft having a shaft body extending between first and second ends, each end including a plurality of threads, the threaded shaft extending through a cannulation of the attachment post with the threads of the first end of the shaft body configured to threadably engage an attachment screw hole in the bone plate;

a polyaxial nut assembly configured to be coupled to and create tension in the threaded shaft to self-center on the threaded shaft and match any angulation of the aiming arm.

12. The aiming guide system of claim **11**, wherein the polyaxial nut assembly includes:

a base;

a spherical nut having a ball and a handle;

a shaft extending between the ball and the handle, wherein the ball is received in the base, thereby providing self-centering and angular flexibility of the polyaxial nut assembly.

13. The aiming guide system of claim **11**, wherein the polyaxial nut assembly includes a spherical nut configured to threadably receive the second end of the shaft body of the threaded shaft.

14. The aiming guide system of claim **13**, wherein the spherical nut is configured to threadably receive either the first or second end of the shaft body of the threaded shaft.

15. The aiming guide system of claim **13**, wherein the polyaxial nut assembly includes:

a base having a spherical inner surface configured to receive the spherical nut to provide self-centering of the polyaxial nut assembly.

16. The aiming guide system of claim **15**, wherein the base includes a polymer washer having a spherical inner surface configured to contact the spherical nut.

17. The aiming guide system of claim **15**, wherein the base includes a spring configured to provide bias for the spherical nut.

18. The aiming guide system of claim **15**, wherein the base includes:

a polymer washer having a spherical inner surface configured to contact the spherical nut; and

a spring disposed below the polymer washer, the polymer washer and the spring together providing frictional resistance for the spherical nut.

19. The aiming guide system of claim **18**, wherein the spring includes a wave spring.

20. The aiming guide system of claim **11**, further comprising a tissue protection sleeve configured to be positioned through one of the plurality of aiming holes such that the tissue protection sleeve defines a through bore from the aiming arm to a respective one of the screw holes in the bone plate, wherein the tissue protection sleeve includes an outer tab configured to be received in one of the slots in the aiming hole, thereby keying the tissue sleeve to the aiming arm.

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