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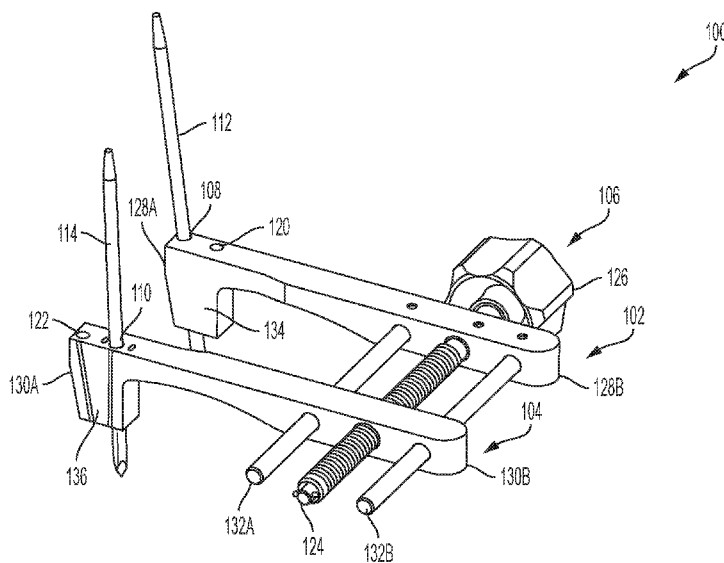


FIG. 4

(57) Abstract: A compressor-distractor device may be used during a surgical procedure, such as a surgical procedure to correct a bunion deformity. In some examples, the compressor-distractor includes first and second engagement arms having first and second pin-receiving holes, respectively. The first and second pin-receiving holes may be angled relative to each other. The compressor-distractor may also include an actuator operatively coupled to the first and second engagement arms. In some example uses, a clinician may pin a first surgical device to a patient's bones use a pair of parallel pins. After removing the surgical device over the parallel pins, the clinician may thread the parallel pins through the angled first and second pin-receiving holes of the compressor-distractor, causing the bones to move relative to each other. Thereafter, the clinician may actuate the actuator on the compressor-distractor to move the bones towards and/or away from each other.



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COMPRESSOR-DISTRACTOR FOR ANGULARLY REALIGNING BONE PORTIONS

RELATED APPLICATIONS

[0001] This application claims the benefit of US Provisional Application No. 62/696,565 filed July 11, 2018, and US Provisional Application No. 62/805,228, filed February 13, 2019. The entire contents of each of these applications are incorporated herein by reference.

TECHNICAL FIELD

[0002] This disclosure relates generally to devices and techniques for repositioning bones and, more particularly, to devices and techniques for repositioning bones in the foot.

BACKGROUND

[0003] Bones within the human body, such as bones in the foot, may be anatomically misaligned. For example, one common type of bone deformity is hallux valgus, which is a progressive foot deformity in which the first metatarsophalangeal joint is affected and is often accompanied by significant functional disability and foot pain. The metatarsophalangeal joint is laterally deviated, resulting in an abduction of the first metatarsal while the phalanges adduct. This often leads to development of soft tissue and a bony prominence on the medial side of the foot, which is called a bunion.

[0004] Surgical intervention may be used to correct a bunion deformity. A variety of different surgical procedures exist to correct bunion deformities and may involve removing the abnormal bony enlargement on the first metatarsal and/or attempting to realign the first metatarsal relative to the adjacent metatarsal. Surgical instruments that can facilitate efficient, accurate, and reproducible clinical results are useful for practitioners performing bone realignment techniques.

SUMMARY

[0005] In general, this disclosure is directed to devices and techniques that can be used during a surgical bone realignment procedure. In some examples, a compressor-distractor device is described that may be used during a surgical procedure, such as a surgical procedure to correct a bunion deformity. The compressor-distractor can include first and second engagement arms that define first and second pin-receiving holes, respectively. The first and second pin-receiving holes may be angled relative to each other. The compressor-distractor

may also include an actuator operatively coupled to the first and second engagement arms. For example, the first and second engagement arms of the compressor-distractor may be movably connected to each other via a threaded rod. Rotation of an actuator knob attached to the threaded rod can cause the first and second engagement arms to move relative to each other.

[0006] The compressor-distractor may be used during a surgical procedure in which one or more other surgical instruments are also used. For example, the compressor-distractor may be used during a procedure in which a bone preparation guide is also deployed for preparing the bones that are to be subsequent distracted and/or compressed together using the compressor-distractor. The bone preparation guide may be pinned to two different bone portions, which may be two different bones separated by a joint or two portions of the same bone (e.g., separated by a fracture or break). In either case, one end of the bone preparation guide may be pinned to one bone portion while another end of the bone preparation guide may be pinned to the other bone portion. The bone preparation guide may be pinned to the two bone portions using a pair of pins that extend parallel to each other through a pair of fixation apertures on the bone preparation guide, optionally along with one or more additional pins that may extend through one or more additional fixation apertures on the bone preparation guide that may be skewed or angled at a non-zero degree angle relative to the parallel pins. In some configurations, the bone preparation guide defines one or more slots through which a bone preparation instrument (e.g., cutting instrument) is inserted to prepare opposed end faces of the two bones.

[0007] After utilizing the bone preparation guide to prepare the two bone portions, the clinician may remove any angled pins (e.g., non-parallel pins) inserted through the bone preparation guide into the bone portions, leaving the parallel-aligned pins (e.g., a pair of parallel pins) in the bone portions. The bone preparation guide can be slide or translated along the parallel-aligned pins until the fixation apertures of the bone preparation guide come off the distal ends of the pins. At this point, the bone preparation guide may be separated from the pins, leaving the pins in the bone portions. The compressor-distractor can then be installed over the pins by threading the parallel-aligned pins through the first and second pin-receiving holes of the compressor-distractor. The first and second pin-receiving holes of the compressor-distractor can be aligned with the distal ends of the two pins and then the compressor-distractor slide or translated down the pins toward the bone portions.

[0008] When the first and second pin-receiving holes of the compressor-distractor are angled relative to each, the process of installing the compressor-distractor on the pins will cause the

pins to move. In particular, the pins may move from being substantially parallel-aligned to each other to a position in which the pins are angled relative to each other at a non-zero degree angle defined by the compressor-distractor in one or more planes, such as two or more planes. As a result, the first and second bone portions in which the pins are inserted may move a distance corresponding to the angular movement of the pins.

[0009] After installing the compressor-distractor on the pins, the clinician may actuate the actuator to move the first and second engagement arms away from each other and, as a result, move the bone portions away from each other. This can provide an enlarged separation gap between the bone portions for cleaning the inter-bone space in anticipation for fixation. For example, the clinician may remove bone chips and/or tissue debris from the inter-bone space between the two bone portions, further cut or prepare an end face of one or both bone portions, or otherwise prepare for fixation. The clinician may also actuate the actuator to move the first and second engagement arms toward each other and, as a result, move the bone portions toward each other. The clinician may move the first and second engagement arms toward each other until the end faces of the bone portions are pressing against each other, resulting in a compressive force being applied to the bone portions. In some example, the clinician then fixates the bone portions by applying one or more fixation members to the bone portions.

[0010] In one example, a compressor-distractor is described that includes a first engagement arm having a first pin-receiving hole for receiving a first pin inserted into a first bone portion and a second engagement arm having a second pin-receiving hole for receiving a second pin inserted into a second bone portion. The compressor-distractor also includes an actuator operatively coupled to the first engagement arm and the second engagement arm. The actuator is configured to move the first and second engagement arms away from each other to move the first bone portion away from the second bone portion and is also configured to move the first and second engagement arms toward each other to move the first bone portion toward the second bone portion. The example specifies that the first pin-receiving hole is angled relative to the second pin-receiving hole at a non-zero degree angle.

[0011] In another example, a method is described that includes positioning a first fixation aperture of a bone preparation guide over a first bone portion and a second fixation aperture of the bone preparation guide over a second bone portion. The example specifies that the first and second fixation apertures are parallel to each other. The example method also involves inserting a first pin through the first fixation aperture into the first bone portion and a second pin through the second fixation aperture into the second bone portion. After sliding

the bone preparation guide off the first pin and the second pin while the leaving the first pin inserted into the first bone portion and the second pin inserted into the second pin, the method involves inserting a compressor-distractor on the first pin and on the second pin. The example specifies that the compressor-distractor is inserted on the first and second pins by at least positioning the first pin through a first pin-receiving hole of a first engagement arm of the compressor-distractor and positioning the second pin through a second pin-receiving hole of a second engagement arm of the compressor-distractor. The compressor-distractor has an actuator operatively coupled to the first engagement arm and the second engagement arm. The example specifies that the first pin-receiving hole is angled relative to the second pin-receiving hole at a non-zero degree angle such that inserting the compressor-distractor on the first pin and on the second pin causes the first bone portion to move relative to the second bone portion.

[0012] The details of one or more examples are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIGS. 1A and 1B are front views of a foot showing a normal first metatarsal position and an example frontal plane rotational misalignment position, respectively.

[0014] FIGS. 2A and 2B are top views of a foot showing a normal first metatarsal position and an example transverse plane misalignment position, respectively.

[0015] FIGS. 3A and 3B are side views of a foot showing a normal first metatarsal position and an example sagittal plane misalignment position, respectively.

[0016] FIG. 4 is a perspective view of an example compressor-distractor according to disclosure.

[0017] FIG. 5 is a frontal plane view of the example compressor-distractor of FIG. 4 showing an example angular offset between pin-receiving holes.

[0018] FIG. 6 is a sagittal plane view of the example compressor-distractor of FIG. 4 showing an example angular offset between pin-receiving holes.

[0019] FIG. 7 is a top plan view of an example bone preparation guide that can be used with a compressor-distractor.

[0020] FIG. 8 is a perspective view of an example bone preparing guide, spacer, and tissue removing instrument check member that can be used with a compressor-distractor.

[0021] FIG. 9 is a side perspective view of a foot depicting a bone preparation instrument inserted into a joint.

[0022] FIG. 10 is a perspective view of a foot depicting a bone positioning guide on the foot prior to an alignment of a first metatarsal.

[0023] FIG. 11 is a perspective view of a foot depicting a bone positioning guide on the foot after an alignment of a first metatarsal.

[0024] FIG. 12 is a perspective view of a foot depicting a bone positioning guide on the foot after an alignment of a first metatarsal and with a spacer inserted into a joint space.

[0025] FIG. 13 is a perspective view of a foot depicting a bone preparation guide positioned on the foot.

[0026] FIG. 14 is a perspective view of a foot depicting a bone preparation guide on the foot with pins inserted through the bone preparation guide.

[0027] FIG. 15 is a perspective view of a foot depicting a removal of a bone preparation guide.

[0028] FIG. 16 is a side perspective view of a foot depicting bone plates across a joint between first and second bones.

[0029] FIGS. 17 and 18 are a front perspective and side view, respectively, of a compressor-distractor showing an alternative configuration of a first engagement arm and a second engagement arm.

[0030] FIG. 19 is perspective illustration of a foot showing an example deployment of a compressor-distractor having a bone contacting portion defining a cutout.

[0031] The details of one or more examples are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

DETAILED DESCRIPTION

[0032] In general, the present disclosure is directed to devices and techniques for correcting a misalignment of one or more bones. The disclosed devices and techniques can be implemented in a surgical procedure in which one bone portion is realigned relative to another bone portion. In some examples, the technique is performed on one or more bones in the foot or hand, where bones are relatively small compared to bones in other parts of the human anatomy. For example, the foregoing description generally refers to example techniques performed on the foot and, more particularly a metatarsal and cuneiform of the foot. However, the disclosed techniques may be performed on other bones, such as the tibia,

fibula, ulna, humerus, femur, or yet other bone, and the disclosure is not limited in this respect unless otherwise specifically indicated. In some applications, however, the disclosed techniques are used to correct a misalignment between a metatarsal (e.g., a first metatarsal) and a second metatarsal and/or a cuneiform (e.g., a medial, or first, cuneiform), such as in a bunion correction surgery.

[0033] FIGS. 1–3 are different views of a foot 200 showing example anatomical misalignments that may occur and be corrected according to the present disclosure. Such misalignment may be caused by a hallux valgus (bunion), natural growth deformity, or other condition causing anatomical misalignment. FIGS. 1A and 1B are front views of foot 200 showing a normal first metatarsal position and an example frontal plane rotational misalignment position, respectively. FIGS. 2A and 2B are top views of foot 200 showing a normal first metatarsal position and an example transverse plane misalignment position, respectively. FIGS. 3A and 3B are side views of foot 200 showing a normal first metatarsal position and an example sagittal plane misalignment position, respectively. While FIGS. 1B, 2B, and 3B show each respective planar misalignment in isolation, in practice, a metatarsal may be misaligned in any two of the three planes or even all three planes. Accordingly, it should be appreciated that the depiction of a single plane misalignment in each of FIGS. 1B, 2B, and 3B is for purposes of illustration and a metatarsal may be misaligned in multiple planes that is desirably corrected.

[0034] With reference to FIGS. 1A and 2A, foot 200 is composed of multiple bones including a first metatarsal 210, a second metatarsal 212, a third metatarsal 214, a fourth metatarsal 216, and a fifth metatarsal 218. The metatarsals are connected distally to phalanges 220 and, more particularly, each to a respective proximal phalanx. The first metatarsal 210 is connected proximally to a medial cuneiform 222, while the second metatarsal 212 is connected proximally to an intermediate cuneiform 224 and the third metatarsal is connected proximally to lateral cuneiform 226. The fourth and fifth metatarsals 216, 218 are connected proximally to the cuboid bone 228. The joint 230 between a metatarsal and respective cuneiform (e.g., first metatarsal 210 and medial cuneiform 222) is referred to as the tarsometatarsal (“TMT”) joint. The joint 232 between a metatarsal and respective proximal phalanx is referred to as a metatarsophalangeal joint. The angle 234 between adjacent metatarsals (e.g., first metatarsal 210 and second metatarsal 212) is referred to as the intermetatarsal angle (“IMA”).

[0035] As noted, FIG. 1A is a frontal plane view of foot 200 showing a typical position for first metatarsal 210. The frontal plane, which is also known as the coronal plane, is generally

considered any vertical plane that divides the body into anterior and posterior sections. On foot 200, the frontal plane is a plane that extends vertically and is perpendicular to an axis extending proximally to distally along the length of the foot. FIG. 1A shows first metatarsal 210 in a typical rotational position in the frontal plane. FIG. 1B shows first metatarsal 210 with a frontal plane rotational deformity characterized by a rotational angle 236 relative to ground, as indicated by line 238.

[0036] FIG. 2A is a top view of foot 200 showing a typical position of first metatarsal 210 in the transverse plane. The transverse plane, which is also known as the horizontal plane, axial plane, or transaxial plane, is considered any plane that divides the body into superior and inferior parts. On foot 200, the transverse plane is a plane that extends horizontally and is perpendicular to an axis extending dorsally to plantarly (top to bottom) across the foot. FIG. 2A shows first metatarsal 210 with a typical IMA 234 in the transverse plane. FIG. 2B shows first metatarsal 210 with a transverse plane rotational deformity characterized by a greater IMA caused by the distal end of first metatarsal 210 being pivoted medially relative to the second metatarsal 212.

[0037] FIG. 3A is a side view of foot 200 showing a typical position of first metatarsal 210 in the sagittal plane. The sagittal plane is a plane parallel to the sagittal suture which divides the body into right and left halves. On foot 200, the sagittal plane is a plane that extends vertically and is perpendicular to an axis extending proximally to distally along the length of the foot. FIG. 3A shows first metatarsal 210 with a typical rotational position in the sagittal plane. FIG. 3B shows first metatarsal 210 with a sagittal plane rotational deformity characterized by a rotational angle 240 relative to ground, as indicated by line 238.

[0038] A compressor-distractor according to the disclosure can be useful during a bone positioning procedure to correct an anatomical misalignment of a bones or bones. In some applications, the compressor-distractor can help establish and/or maintain a realignment between a metatarsal and an adjacent cuneiform. The metatarsal undergoing realignment may be anatomically misaligned in the frontal plane, transverse plane, and/or sagittal plane, as illustrated and discussed with respect to FIGS. 1–3 above. Accordingly, realignment may involve releasing the misaligned metatarsal for realignment and thereafter realigning the metatarsal in one or more planes, two or more planes, or all three planes. After suitably realigning the metatarsal, the metatarsal can be fixated to hold and maintain the realigned positioned.

[0039] While a metatarsal can have a variety of anatomically aligned and misaligned positions, in some examples, the term “anatomically aligned position” means that an angle of

a long axis of first metatarsal 210 relative to the long axis of second metatarsal 212 is about 10 degrees or less (e.g., 9 degrees or less) in the transverse plane and/or sagittal plane. In certain embodiments, anatomical misalignment can be corrected in both the transverse plane and the frontal plane. In the transverse plane, a normal IMA 234 between first metatarsal 210 and second metatarsal 212 is less than about 9 degrees. An IMA 234 of between about 9 degrees and about 13 degrees is considered a mild misalignment of the first metatarsal and the second metatarsal. An IMA 234 of greater than about 16 degrees is considered a severe misalignment of the first metatarsal and the second metatarsal. In some embodiments, methods and/or devices according to the disclosure are utilized to anatomically align first metatarsal 210 by reducing the IMA from over 10 degrees to about 10 degrees or less (e.g., to an IMA of 9 degrees or less, or an IMA of about 1-5 degrees), including to negative angles of about -5 degrees or until interference with the second metatarsal, by positioning the first metatarsal at a different angle with respect to the second metatarsal.

[0040] With respect to the frontal plane, a normal first metatarsal will be positioned such that its crista prominence is generally perpendicular to the ground and/or its sesamoid bones are generally parallel to the ground and positioned under the metatarsal. This position can be defined as a metatarsal rotation of 0 degrees. In a misaligned first metatarsal, the metatarsal may be axially rotated between about 4 degrees to about 30 degrees or more. In some embodiments, methods and/or devices according to the disclosure are utilized to anatomically align the metatarsal by reducing the metatarsal rotation from about 4 degrees or more to less than 4 degrees (e.g., to about 0 to 2 degrees) by rotating the metatarsal with respect to the adjacent cuneiform.

[0041] A compressor-distractor according to the disclosure may be useful to distract a misaligned metatarsal from an adjacent cuneiform to provide access to the end faces of the bones and/or tarsometatarsal joint. The compressor-distractor may also be useful to apply a compressive force to the metatarsal and adjacent cuneiform (e.g., after preparing the end faces of the bones) to press the bones together to facilitate fixation. Additionally or alternatively, the compressor-distractor may impart and/or maintain relative movement between the metatarsal and adjacent cuneiform, such as rotation and/or pivoting of one bone relative to the other bone. For example, an angular offset provided by pin-receiving holes of the compressor-distractor may be effective to move the metatarsal from an anatomically misaligned position to an anatomically aligned position. As the compressor-distractor is translated over pins inserted into the metatarsal and cuneiform, the angular offset of the pin-receiving holes may cause the pins to move from being generally parallel to an angular

alignment dictated by the pin-receiving holes. The resulting movement of the metatarsal relative to cuneiform caused by this movement can help position the metatarsal in an aligned position.

[0042] FIG. 4 is a perspective view of an example compressor-distractor 100 according to disclosure. Compressor-distractor 100 is illustrated as having a first engagement arm 102 and a second engagement arm 104. Compressor-distractor 100 also includes an actuator 106 that is operably coupled to the first engagement arm 102 and the second engagement arm 104. Actuator 106 can be actuated to move the two engagement arms toward each other and away from each other to adjust a separation distance between the two arms. Further, as will be discussed in greater detail, each engagement arm includes at least one pin-receiving hole that is configured to receive a pin inserted into a bone.

[0043] For example, first engagement arm 102 may include a first pin-receiving hole 108 and second engagement arm 104 may include a second pin-receiving hole 110. The first pin-receiving hole 108 can receive a first pin 112, while the second pin-receiving hole 110 can receive a second pin 114. The first pin 112 and second pin 114 can be inserted into different bones or bone portions being worked upon. In the case of a bone realignment procedure, for example, first pin 112 can be inserted into a metatarsal (e.g., first metatarsal 210) and second pin 114 can be inserted into a cuneiform (e.g., medial cuneiform 222). The pin-receiving holes can anchor compressor-distractor 100 to the bones being compressed and/or distracted via the pins inserted through the holes and into the underlying bones. Additionally or alternatively, the pin-receiving holes can be used to impart relative movement between one bone in which first pin 112 is inserted and another bone in which second pin 114 is inserted.

[0044] For example, first pin-receiving hole 108 and second pin-receiving hole 110 may be angled relative to each other at a non-zero degree angle such that, when compressor-distractor 100 is inserted over a substantially parallel set of pins, the angled receiving holes cause the pins to move relative to each other to align with the pin-receiving holes. The direction and extent of movement imposed by the angled pin-receiving holes of compressor-distractor 100 may vary depending on the desired surgical application in which the compressor-distractor is being used. In the case of a misaligned metatarsal, such as a bunion procedure for instance, the pin-receiving holes may be angled to impart a frontal plane rotation and/or a sagittal plane translation. As a result, when compressor-distractor 100 is installed over pins position in the metatarsal and adjacent cuneiform, the angled pin-receiving holes may cause the metatarsal to rotate in the frontal plane relative to the cuneiform and/or translate in the sagittal plane (e.g., downwardly or plantarly) to help correct a misalignment of the metatarsal.

[0045] FIG. 5 is a frontal plane view of compressor-distractor 100 showing an example angular offset between first pin-receiving hole 108 and second pin-receiving hole 110. In this example, the two pin-receiving holes are angled relative to each other in the frontal plane by an angle 116. Angle 116 may be measured between two linear pins (e.g., first pin 112 and second pin 114) inserted through respective receiving holes in the perspective of the frontal plane. While the degree of angular offset between first pin-receiving hole 108 and second pin-receiving hole 110 may vary, in the case of a metatarsal realignment procedure, angle 116 may range from 2° to 20°, such as from 6° to 15°, or from 8° to 12°, or approximately 10°. The two pin-receiving holes may be offset in a direction that causes the metatarsal to rotate laterally as the compressor-distractor 100 is installed over first and second pins 112, 114. For example, when compressor-distractor 100 is positioned on the medial side of the foot, the first pin-receiving hole 108 may be angled to cause first pin 112 to rotate toward the lateral side of the foot relative to second pin 114.

[0046] In addition to or in lieu of providing a frontal plane angulation, compressor-distractor 100 may be configured to impart sagittal plane rotation, when the compressor-distractor 100 is installed over first and second pins 112, 114. For example, when installed over substantially parallel first and second pins 112, 114 positioned in the metatarsal and cuneiform, respectively, the angulation of first and second pin holes 108, 110 may cause the metatarsal to rotate or flex plantarly (e.g., such that the distal end of the metatarsal is rotated plantarly about the TMT joint).

[0047] FIG. 6 is a sagittal plane view of compressor-distractor 100 showing another example angular offset between first pin-receiving hole 108 and second pin-receiving hole 110. In this example, the two pin-receiving holes are angled relative to each other in the sagittal plane by an angle 118. Angle 118 may be measured between two linear pins (e.g., first pin 112 and second pin 114) inserted through respective receiving holes in the perspective of the sagittal plane. While the degree of angular offset between first pin-receiving hole 108 and second pin-receiving hole 110 may vary, in the case of a metatarsal realignment procedure, angle 118 may range from 5° to 12°, such as from 7° to 10°, or from 8 to 9°, or approximately 8.5°. The two pin-receiving holes may be offset in a direction that causes the metatarsal to rotate (e.g., downwardly or plantarly) in the sagittal plane as the compressor-distractor 100 is installed over first and second pins 112, 114.

[0048] In general, features described as pin-receiving holes may be void spaces extending linearly through the body of compressor-distractor 100 and configured (e.g., sized and/or shaped) to pass a pin inserted into a bone therethrough. While the pin-receiving holes may

have any polygonal (e.g., square, rectangle) or arcuate (e.g., curved, elliptical) shape, the pin-receiving holes may typically have a circular cross-sectional shape. In some examples, the pin-receiving holes have a diameter ranging from .1 mm to 10 mm, such as from .5 mm to 4 mm. The pin-receiving holes may have a length (e.g., extending through the thickness of first engagement arm 102 or second engagement arm 104) ranging from 5 mm to 50 mm, such as from 10 mm to 25 mm.

[0049] Compressor-distractor 100 can have any suitable number of pin-receiving holes. In general, providing multiple pin-receiving holes on each side of the compressor-distractor 100 may be useful to provide alternative angulation or movement options for the clinician using the compressor-distractor. For example, compressor-distractor 100 may have a plurality of pin-receiving holes for use with first pin 112 and/or second pin 114. During a surgical procedure, the clinician may select a certain pin-receiving hole from the plurality of pin-receiving holes into which first pin 112 and/or second pin 114 are to be inserted. The clinician may select the pin-receiving hole combination based on the amount and direction of movement the clinician desires the first bone to move relative to the second bone upon installing the compressor-distractor over first and second pins 112, 114. After selecting the desired pin-receiving hole combination, the clinician can direct the distal end of first and second pins 112, 114 into the corresponding selected pin-receiving holes then translate compressor-distractor 100 from the distal end of the pins down towards the proximal end of the pins.

[0050] It should be appreciated that while compressor-distractor 100 may have multiple pin-receiving holes for first pin 112 and/or second pin 114, the disclosure is not limited in this respect. In other configurations, compressor-distractor 100 may only have a single pin-receiving hole into which first pin 112 and/or second pin 114 can be inserted. In still other configurations, compressor-distractor 100 may have one or more pin-receiving hole(s) that rotate and/or slide within one or more slots to provide adjustable angulation, allowing the clinician to adjust the angular alignment of first and/or second pin-receiving holes 108, 110.

[0051] In the example of FIG. 4, compressor-distractor 100 is illustrated as having two pin-receiving holes associated with first pin 112 and two pin-receiving holes associated with second pin 114. In particular, FIG. 4 illustrates first engagement arm 102 as having previously-described first pin-receiving hole 108 and second engagement arm 104 as having previously-described second pin-receiving hole 110. In addition, first engagement arm 102 is illustrated as having a third pin-receiving hole 120, while second engagement arm 104 has a

fourth pin-receiving hole 122. First and second engagement arms 102, 104 may each have fewer pin-receiving holes (e.g., one) or more pin-receiving holes (e.g., three, four, or more).

[0052] In some configurations, the third pin-receiving hole 120 is angled relative to the fourth pin-receiving hole 122 at a non-zero degree angle in a second plane different than a first plane in which first pin-receiving hole 108 is angled relative to second pin-receiving hole 110. For example, first pin-receiving hole 108 may be angled relative to second pin-receiving hole 110 in the frontal plane and/or sagittal plane. Third pin-receiving hole 120 may be parallel to second pin-receiving hole 110 in the frontal plane but angled relative to the second pin-receiving hole in the sagittal plane. Further, fourth pin-receiving hole 122 may be parallel to first pin-receiving hole 108 in the frontal plane but angled relative to the first pin-receiving hole in the sagittal plane. Third and fourth pin-receiving holes 120, 122 can be angled relative to each other and/or first and second pin-receiving holes 108, 110 at any of the angles discussed above. When configured as illustrated in FIG. 4, a clinician desiring both frontal plane and sagittal plane movement can use the first and second pin holes 108, 110. By contrast, when the clinician desires sagittal plane movement but not frontal plane movement, the clinician can use first and fourth pin-receiving hole 108, 122.

[0053] As briefly discussed above, compressor-distractor 100 can open and close to compress and distract the bones to which the compressor-distractor is secured. To facilitate movement, compressor-distractor 100 is illustrated as having an actuator 106. Actuator 106 is configured to control movement of first engagement arm 102 relative to second engagement arm 104. Actuator 106 may be implemented using any feature that provides controllable relative movement between the two engagement arms, such as rotary movement, sliding movement, or other relative translation. In some configurations, actuator 106 is configured to move first and second engagement arms 102, 104 at least 1 mm away from each other, such as a distance ranging from 1 mm to 45 mm, a distance ranging from 1 mm to 5 mm, or a distance ranging from 1 mm to 2.5 mm during distraction. Actuator 106 may be actuated during compression until the faces of the bones to which compressor-distractor 100 is attached are suitably compressed and/or the sidewall faces of first and second engagement arms 102, 104 contact each other.

[0054] In the example of FIG. 4, actuator 106 is illustrated as including a shaft 124 connected to the first engagement arm 102 and the second engagement arm 104. Shaft 124 may be threaded and actuator 106 may further include a knob 126 coupled to the shaft. Rotation of knob 126 in one direction may cause first engagement arm 102 to move closer to second

engagement arm 104, while rotation of the knob in the opposite direction can cause the first engagement arm to move away from the second engagement arm.

[0055] To secure actuator 106 to compressor-distractor 100, the actuator may be fixedly connected to one of the arms. For example, shaft 124 of actuator 106 may be fixedly attached along its length to first engagement arm 102 and rotatable relative to the arm. As a result, when knob 126 is rotated, second engagement arm 104 may move along the length of shaft 124 towards and/or away from first engagement arm 102. This provides relative movement between the two arms while first engagement arm 102 remains in a fixed position relative to actuator 106.

[0056] In FIG. 4, first engagement arm 102 is illustrated as extending from a distal end 128A to a proximal end 128B. Similarly, second engagement arm 104 is illustrated as extending from a distal end 130A to a proximal end 130B. Actuator 106 is positioned adjacent the proximal ends 128B, 130B of the first and second engagement arms 102, 104, respectively, such as the proximal half of the arms in the illustrated configuration. Offsetting actuator 106 from the pin-receiving holes may be useful, for example, to provide clearance for the clinician to manipulate the actuator when compressor-distractor 100 is inserted on pins installed in bones. In the case of a foot surgery, first and second engagement arms 102, 104 may have a length affective to position actuator 106 to be offset medially from the foot being operated on while first pin-receiving hole 108 is engaged with a first pin 112 inserted into a metatarsal and second pin-receiving hole 110 is engaged with a second pin 114 engaged with a cuneiform.

[0057] To help stabilize first engagement arm 102 relative to second engagement arm 104 during movement along shaft 124, compressor-distractor 100 may also include one or more unthreaded shafts extending parallel to the threaded shaft. In FIG. 4, for example, actuator 106 has a first unthreaded shaft 132A and a second unthreaded shaft 132B (collectively referred to as “unthreaded shaft 132”). Unthreaded shaft 132 extends parallel to threaded shaft 124 and helps stabilize second engagement arm 104 as it moves along the threaded shaft towards and away from first engagement arm 102. Threaded shaft 124 is illustrated as extending through a threaded aperture in the sidewall of second engagement arm 104, while unthreaded shaft 132 is illustrated as extending through an unthreaded aperture in the sidewall of the engagement arm.

[0058] First engagement arm 102 and second engagement arm 104 can have a variety of different sizes and shapes. In general, each engagement arm may define a length offsetting the pin-receiving holes from actuator 106. In some examples, distal end 128A of first

engagement arm 102 defines a first pin block 134 and/or distal end 130A of second engagement arm 104 defines a second pin block 136. The pin blocks may be regions of the respective engagement arms defining pin-receiving holes and through which the pin-receiving holes extend. First and second pin blocks 134, 136 may have a thickness greater than a thickness of the remainder of the engagement arms. For example, as shown, pin blocks 134, 136 may extend downwardly (e.g., plantarly) from a remainder of the engagement arms and/or actuator 106.

[0059] In FIG. 4, first engagement arm 102 is illustrated as having a same length as second engagement arm 104. As a result, distal end 128A of the first engagement arm is parallel with the distal end 130A of the second engagement arm. In other configurations, one engagement arm may be longer than the other engagement arm to provide an offset. For example, first engagement arm 102 may be longer than second engagement arm 104, e.g., causing the first engagement arm to extend farther laterally when applied to a foot being operated upon than second engagement arm 104. This configuration may be useful during bunion correction procedures to impart transverse plane movement (e.g., rotation) of the metatarsal relative to the cuneiform to close the IM angle.

[0060] Compressor-distractor 100 may be fabricated from any suitable material or combination of materials, such as metal (e.g., stainless steel) and/or polymeric materials. In some configurations, compressor-distractor 100 is fabricated from a radiolucent material such that it is relatively penetrable by X-rays and other forms of radiation, such as thermoplastics and carbon-fiber materials. Such materials are useful for not obstructing visualization of bones using an imaging device when the bone positioning guide is positioned on bones.

[0061] A compressor-distractor according to the disclosure may be used as part of a surgical procedure in which at least two pins are inserted into different bones or different portions of the same bone. The at least two pins may be inserted in generally parallel alignment and/or the pins may be realigned during the surgical procedure so as to be substantially parallel (e.g., prior to installation of compressor-distractor 100). The two pins may be substantially parallel in that the pins are positioned side-by-side and have substantially the same distance continuously between the two pins in each of the three planes (e.g., the distance varies by less than 10%, such as less than 5% across the lengths of the pins in any given plane, with different continuous distances in different planes). Compressor-distractor 100 can be inserted over the parallel pins by threading the parallel pins into the pin-receiving holes of the device, thereby causing the pins to move from a substantially parallel alignment to an angled alignment dictated by the angulation of the pin-receiving holes. Compressor-distractor 100

may then be used to distract the bone portions into which the pins are inserted (e.g., by actuating actuator 106 to draw the bone portions away from each other) and/or compress the bone portions into which the pins are inserted (e.g., by actuating actuator 106 to move the bone portions towards each other).

[0062] In some examples, compressor-distractor 100 is used as part of a metatarsal realignment procedure in which a metatarsal is realigned relative to an adjacent cuneiform and/or metatarsal in one or more planes, such as two or three planes. Additional details on example bone realignment techniques and devices with which compressor-distractor 100 may be used are described in US Patent 9,622,805, titled “BONE POSITIONING AND PREPARING GUIDE SYSTEMS AND METHODS,” filed on December 28, 2015 and issued April 18, 2017, and US Patent 9,936,994, titled “BONE POSITIONING GUIDE,” filed on July 14, 2016 and issued on April 10, 2018, and US Patent Publication No. 2017/0042599 titled “TARSAL-METATARSAL JOINT PROCEDURE UTILIZING FULCRUM,” filed on August 14, 2016. The entire contents of each of these documents are hereby incorporated by reference.

[0063] The pins over which compressor-distractor 100 is installed may be used to pin and/or guide another medical instrument used during the surgical technique. For example first and second pins 112, 114 may be used to pin a first medical instrument to the bones or bone portions being operated upon. The medical instrument can be removed over the parallel pins, leaving the pins inserted into the bone or bone portions, and compressor-distractor 100 subsequently placed over the pins.

[0064] For example, in the case of a metatarsal realignment procedure, first and second pins 112, 114 may be used to pin a bone preparation guide to a foot being operated upon. The bone preparation guide can be used to prepare an end face of a metatarsal and an adjacent end face of a corresponding cuneiform. The bone preparation guide can be taken off the first and second pins and compressor-distractor 100 installed on the pins. As compressor-distractor 100 is positioned on first and second pins 112, 114, the angularly aligned pin-receiving holes may cause the first metatarsal to move in one or more planes to facilitate realignment. The compressor-distractor 100 can be manipulated to open the joint space between the metatarsal and cuneiform, e.g., to facilitate joint cleanup, and further manipulated to compress the two bones together for fixation.

[0065] FIG. 7 illustrates an example bone preparation guide 150 that may be used as part of a surgical procedure involving compressor-distractor 100. In some examples, bone preparation guide 150 includes a body 154 defining a first guide surface 160 to define a first preparing

plane and a second guide surface 164 to define a second preparing plane. A tissue removing instrument (e.g., a saw, rotary bur, osteotome, etc., not shown) can be aligned with the surfaces to remove tissue (e.g., remove cartilage or bone and/or make cuts to bone). The first and second guide surfaces 160, 164 can be spaced from each other by a distance, (e.g., between about 2 millimeters and about 10 millimeters, such as between about 4 and about 7 millimeters). In the embodiment shown, the first and second guide surfaces are parallel, such that cuts to adjacent bones using the guide surfaces will be generally parallel.

[0066] In some configurations, as shown in FIG. 7, a first facing surface 166 is positioned adjacent the first guide surface 160 and/or a second facing surface 168 is positioned adjacent the second guide surface 164. In such configurations, the distance between the first guide surface and the first facing surface defines a first guide slot, and the distance between the second guide surface and the second facing surface defines a second guide slot. Each slot can be sized to receive a tissue removing instrument to prepare the bone ends. The first and second slots may be parallel or skewed. In the illustrated example, the facing surfaces each contain a gap, such that the surface is not a single, continuous surface. In other embodiments, the facing surfaces can be a single, continuous surface lacking any such gap.

[0067] An opening 170 can be defined by the body 154 between the first and second guide surfaces. The opening can be an area between the guide surfaces useful for allowing a practitioner to have a visual path to bones during bone preparation and/or to receive instruments. In the configuration shown, the opening extends across the body and a distance from a surface 172 opposite of the first facing surface 166 to a surface 174 opposite of the second facing surface 168.

[0068] The illustrated bone preparation guide also includes a first end 176 extending from the body 154 in a first direction and a second end 178 extending from the body in a second direction. The second direction can be different than the first direction (e.g., an opposite direction). As shown, each of the first end and the second end can include at least one fixation aperture 180 configured to receive a fixation pin to secure the bone preparation guide to an underlying bone. For example, first end 176 of bone preparation guide 150 may define a first fixation aperture through which first pin 112 (FIG. 4) is inserted and the second end 178 of bone preparation guide 150 may define a second fixation aperture through which second pin 114 (FIG. 4) is inserted. These two fixation apertures may be parallel aligned, such that first and second pins 112, 114 extend through the holes parallel to each other. The first end 176 and/or the second end 178 of bone preparation guide 150 may also

defined one or more additional fixation apertures that are angled (at a non-zero degree angle) or otherwise skewed relative to the two parallel fixation apertures.

[0069] In use, a clinician may insert the two parallel pins through fixation apertures 180 and may optionally insert one or more angled pins through the one or more angled fixation apertures. This combination of parallel and angled pins may prevent bone preparation guide 150 from being removed from the underlying bones being worked upon. When the clinician has completed using the bone preparation guide, the angled pin or pins may be removed leaving the two parallel pins inserted into the underlying bones. Bone preparation guide 150 can be slid or otherwise moved up and off the parallel pins and compressor-distractor 100 thereafter inserted down over the pins.

[0070] In some examples as shown in FIG. 7, bone preparation guide 150 can also include a first adjustable stabilization member 182 engaged with the first end 176 and/or a second adjustable stabilization member 184 engaged with the second end 178. Each of the members can be threaded and engage a threaded aperture defined by the ends. The elevation of each end can be adjusted with respect to a bone by adjusting the stabilization member. In some embodiments, as shown, the stabilization members are cannulated such that they can receive a fixation pin.

[0071] With reference to FIG. 8, bone preparation guide 150 may include or be used with a spacer 188 that extends downward from the body 154. Spacer 188 may be configured to be placed into a joint (e.g., within the TMT joint). In some embodiments, the spacer 188 is selectively engageable with the body of the bone preparation guide and removable therefrom. The spacer can have a first portion 190 configured to extend into a joint space and a second portion 192 engageable with the body 154. In the embodiment shown, the spacer can be received within opening 170, such that the spacer extends from the body in between the first and second guide surfaces. Such a spacer can be useful for positioning the body at a desired position with respect to a joint and for properly positioning the guide with respect to bones to be cut in more than one plane (e.g., three planes selected from more than one of a frontal plane, a transverse plane, and a sagittal plane). The distance between the spacer and the first guide surface can define a length of tissue removal (e.g., bone or cartilage to be cut) from a first bone, and the distance between the spacer and the second guide surface can define a length of tissue removal (e.g., bone or cartilage to be cut) from a second bone.

[0072] As also shown in FIG. 8, bone preparation guide 150 may include or be used with a tissue removal location check member 194. Tissue removal check member 194 may be engageable with the body 154 and configured to extend to a first bone and a second bone.

The tissue removal location check member can have a first portion 196 configured to extend into contact with first and second bones and a second portion 198 engageable with the body. In the embodiment shown, the tissue removal check member 194 is configured to extend in the body 154 at both the first and second guiding surfaces. The tissue removal location check member 194 may be useful for allowing a practitioner to see where a tissue removing instrument guided by the surfaces will contact the bone to be prepared.

[0073] Bone preparation facilitated by bone preparation guide 150 can be useful, for instance, to facilitate contact between leading edges of adjacent bones, separated by a joint, or different portions of a single bone, separated by a fracture, such as in a bone alignment and/or fusion procedure. A bone may be prepared using one or more bone preparation techniques. In some applications, a bone is prepared by cutting the bone. The bone may be cut transversely to establish a new bone end facing an opposing bone portion. Additionally or alternatively, the bone may be prepared by morselizing an end of the bone. The bone end can be morselized using any suitable tool, such as a rotary bur, osteotome, or drill. The bone end may be morselized by masticating, fenestrating, crushing, pulping, and/or breaking the bone end into smaller bits to facilitate deformable contact with an opposing bone portion.

[0074] During a surgical technique utilizing compressor-distractor 100, a bone may be moved from an anatomically misaligned position to an anatomically aligned position with respect to another bone. Further, both the end of the moved bone and the facing end of an adjacent end may be prepared for fixation. In some applications, the end of at least one of the moved bone and/or the other bone is prepared after moving the bone into the aligned position. In other applications, the end of at least one of the moved bone and/or the other bone is prepared before moving the bone into the aligned position.

[0075] Movement of one bone relative to another bone can be accomplished using one or more instruments and/or techniques. In some examples, bone movement is accomplished using a bone positioning device that applies a force to one bone at a single location, such that the bone both translates and rotates in response to the force. This may be accomplished, for example, using a bone positioning guide that includes a bone engagement member, a tip, a mechanism to urge the bone engagement member and the tip towards each other, and an actuator to actuate the mechanism. Additionally or alternatively, bone movement may be accomplished using compressor-distractor 100 by imparting movement to one bone relative to another bone as the compressor-distractor is positioned on substantially parallel pins, causing the pins to move out of their substantially parallel alignment and resulting in movement of the underlying bones in one plane (e.g., frontal plane, sagittal plane, transverse

plane), two or more planes, or all three planes. As yet a further addition or alternative, a clinician may facilitate movement by physically grasping a bone, either through direct contact with the bone or indirectly (e.g., by inserting a K-wire, grasping with a tenaculum, or the like), and moving his hand to move the bone.

[0076] Regardless of the how movement is accomplished, a surgical technique may or may not utilize a fulcrum. A fulcrum may provide a structure about which rotation and/or pivoting of one bone relative to another bone occurs. The fulcrum can establish and/or maintain space between adjacent bones being moved, preventing lateral translation or base shift of the bones during rotation and/or pivoting. For example, to help avoid the proximal-most base of the first metatarsal 210 from shifting toward the proximal-most base of the second 212, a clinician can insert the fulcrum in the notch between first metatarsal 210 and second metatarsal 212 at the base of the metatarsals (e.g., adjacent respective cuneiform) before moving the first metatarsal. The fulcrum can provide a point about which first metatarsal 210 can rotate and/or pivot while helping minimize or avoid base compression between the first metatarsal and the second metatarsal. In addition, use of the fulcrum may cause first metatarsal 210 and medial cuneiform 222 to be better angled relative to guide slots positioned over the end faces of the bones, providing a better cut angle through the guide slots than without use of the fulcrum. This can help reduce or eliminate unwanted spring-back, or return positioning, of first metatarsal 210 after initial realignment of the metatarsal.

[0077] An example method for performing a bone alignment procedure utilizing a compressor-distractor according to the disclosure will now be described with respect to FIGS. 7–16 depicting a foot 200 having a first metatarsal 210, a medial cuneiform 222, and a second metatarsal 212. Unless otherwise indicated, the example steps described can be carried out in any order and need not be performed in the order described.

[0078] After customary surgical preparation and access, a bone preparation instrument 296 can be inserted into the joint (e.g., first tarsal-metatarsal joint) to release soft tissues and/or excise the plantar flare from the base of the first metatarsal 210, as shown in FIG. 9. Excising the plantar flare may involve cutting plantar flare off the first metatarsal 210 so the face of the first metatarsal is generally planar. This step helps to mobilize the joint to facilitate a deformity correction. In some embodiments, the dorsal-lateral flare of the first metatarsal may also be excised to create space for the deformity correction (e.g., with respect to rotation of the first metatarsal). In certain embodiments, a portion of the metatarsal base facing the medial cuneiform can be removed during this mobilizing step.

[0079] An incision can be made and, if a bone positioning instrument is going to be used, a tip 50 of a bone positioning guide 10 inserted on the lateral side of a metatarsal other than the first metatarsal 210, such as the second metatarsal 212. As shown in FIG. 10, the tip can be positioned proximally at a base of the second metatarsal 212 and a third metatarsal 214 interface. A surface of a bone engagement member 40 can be placed on the proximal portion of the first metatarsal 210. In some embodiments, the bone engagement member engages a medial ridge of the first metatarsal 210. As shown, the body 20 of the positioning guide can be generally perpendicular to the long axis of the second metatarsal 212.

[0080] To help avoid a base shift, a clinician can insert a fulcrum in the notch between first metatarsal 210 and second metatarsal 212 at the base of the metatarsals (e.g., adjacent respective cuneiform) before actuating bone positioning guide 10 or otherwise moving the first metatarsal relative to the medial cuneiform. The fulcrum can provide a point about which first metatarsal 210 can rotate and/or pivot while helping minimize or avoid base compression between the first metatarsal and the second metatarsal.

[0081] In applications utilizing bone positioning guide 10, the actuator on the bone positioning guide can be actuated to reduce the angle (transverse plane angle between the first metatarsal and the second metatarsal) and rotate the first metatarsal about its axis (frontal plane axial rotation). The first metatarsal 210 can be properly positioned with respect to the medial cuneiform 222 by moving the bone engagement member 40 bone positioning guide with respect to the tip 50 of the bone positioning guide. In some embodiments, such movement simultaneously pivots the first metatarsal with respect to the cuneiform and rotates the first metatarsal about its longitudinal axis into an anatomically correct position to correct a transverse plane deformity and a frontal plane deformity. Again, however, other applications utilizing compressor-distractor 100 may be performed without utilizing bone positioning guide 10.

[0082] Independent of whether bone positioning guide 10 is used, an example technique may include positioning joint spacer 188 can be positioned within the joint between the first metatarsal and the medial cuneiform, as illustrated in FIG. 12. Bone preparation guide 150 can be placed over the joint spacer 188 as shown in FIG. 13 and engaged with the joint spacer to set a position and orientation of the bone preparation guide relative to the joint. In other embodiments, bone preparation guide 150 is placed on the bones without using joint spacer 188 to aid with positioning.

[0083] As depicted in FIG. 14, one or more fixation pins can be inserted into apertures of the bone preparation guide 150 to secure the guide to the first metatarsal 210 and the medial

cuneiform 222. The fixation pins inserted into the apertures of bone preparation guide 150 includes a first fixation pin 112 and second fixation pin 114. The first and second fixation pins 112, 114 may be inserted in substantially parallel alignment. The first and second fixation pins 112, 114 may project at least 25 mm above the surface of the bones into which the pins are inserted, such as at least 50 mm, or at least 75 mm. One or more additional pins can be inserted at an angle or in a converging orientation to help prevent movement of the bone preparation guide 150 during a tissue removing step. After insertion of the pins, the spacer 188 (if used) can optionally be removed in embodiments having a selectively engageable spacer.

[0084] In some applications, the end of the first metatarsal 210 facing the medial cuneiform 222 can be prepared with a tissue removing instrument 296 guided by a guide surface of bone preparation guide 150 (e.g., inserted through a slot defined by a first guide surface and a first facing surface). In some embodiments, the first metatarsal 210 end preparation is done after at least partially aligning the bones, e.g., by actuating bone positioning guide 10 before preparing the end of first metatarsal 210. In other embodiments, the first metatarsal 210 end preparation is done before the alignment of the bones, e.g., by preparing the end of the first metatarsal 210 before installing compressor-distractor 100 to cause realignment.

[0085] In addition to preparing the end of first metatarsal 210, the end of the medial cuneiform 222 facing the first metatarsal 210 can be prepared with the tissue removing instrument 296 guided by a guide surface of bone preparation guide 150 (e.g., inserted through a slot defined by a second guide surface and a second facing surface). In some embodiments, the medial cuneiform 222 end preparation is done after the alignment of the bones. In yet other embodiments, the medial cuneiform 222 end preparation is done before the alignment of the bones. In embodiments that include cutting bone or cartilage, the cuneiform cut and the metatarsal cut can be parallel, conforming cuts. In some examples, a saw blade can be inserted through a first slot to cut a portion of the medial cuneiform and the saw blade can be inserted through a second slot to cut a portion of the first metatarsal.

[0086] Any angled/converging pins can be removed and the bone preparation guide 150 can be lifted off the substantially parallel first and second pins 112, 114, as shown in FIG. 15. These substantially parallel pins can receive compressor-distractor 100. For example, the clinician can position compressor-distractor 100 so the bottom side of first pin-receiving hole 108 is positioned over first pin 112 and the bottom side of second pin-receiving hole 110 is positioned over second pin 114. The clinician can then slide compressor-distractor 100 down over the pins toward the underlying bones, e.g., until the bottom side of the compressor-

distractor is adjacent to or in contact with the underlying bones. The clinician may adjust the spacing between first engagement arm 102 and second engagement arm 104 by actuating actuator 106 until the separation distance corresponds to the spacing between first and second pins 112, 114, before installing the compressor-distractor down over the pins. In the process of inserting compressor-distractor 100 on the pins, the angulation between first pin-receiving hole 108 and second pin-receiving hole 110 can cause first and second pins 112, 114 to shift from their substantially parallel alignment to a nonparallel alignment corresponding to the angular position of the pin-receiving holes. As the first and second pins 112, 114 move relative to each other, first metatarsal 210 may move relative to medial cuneiform 222 a direction and distance corresponding to the movement of first pin 112 relative to second pin 114.

[0087] In applications where bone positioning guide 10 is utilized, the bone positioning guide may be removed before or after bone preparation guide 150 is removed and compressor-distractor 100 is installed. In either case, in some examples, a temporary fixation device such as an olive pin, k-wire, or other fixation structure may be used to maintain the position of the underlying bones (e.g., first metatarsal 210 relative to medial cuneiform 222) while bone preparation guide 150 is removed and compressor-distractor 100 is installed.

[0088] With compressor-distractor 100 pinned to underlying bones (e.g., first metatarsal 210 and medial cuneiform 222), actuator 106 may be actuated to distract the underlying bones. For example, the clinician may turn knob 126 to cause second engagement arm 104 to move away from first engagement arm 102, opening or enlarging a gap between the underlying bones. When pin to first metatarsal 210 and medial cuneiform 222, the clinician can actuate actuator 106 to open the TMT joint.

[0089] With the underlying bones distracted, the clinician may clean or otherwise prepare the space between the bones and/or the end face of one or both bones. The clinician may clean the space by removing excess cartilage, bone, and/or other cellular debris that may natively exist or may have been created during the bone preparation step that may inhibit infusion.

[0090] Independent of whether the clinician utilizes compressor-distractor 100 to distract the underlying bones for cleaning, the clinician may actuate actuator 106 to compress the bones together for permanent fixation infusion. The clinician may turn knob 126 to cause second engagement arm 104 to move toward first engagement arm 102, for example until the end faces of the underlying bones contact each other and/or a compressive force is applied through pins 112, 114 to the end faces. With the two end faces pressed together via compressor-distractor 100, the clinician may provisionally or permanently fixate the bones or

bones portions together. For example, one or more bone fixation devices can be applied across the joint and to the two bones to stabilize the joint for fusion, such as two bone plates positioned in different planes. FIG. 16 illustrates an example fixation device arrangement that includes a first bone plate 310 positioned on a dorsal-medial side of the first metatarsal and medial cuneiform and a second bone plate 320 positioned on a medial-plantar side of the first metatarsal and the medial cuneiform. In other embodiments, second bone plate 320 can be a helical bone plate positioned from a medial side of the cuneiform to a plantar side of the first metatarsal across the joint space. The plates can be applied with the insertion of bone screws. Example bone plates that can be used as first bone plate 310 and/or second bone plate 320 are described in US Patent Publication No. US2016/0192970, titled "Bone Plating System and Method" and filed January 7, 2016, which is incorporated herein by reference. Other types in configurations of bone fixation devices can be used, and the disclosure is not limited in this respect.

[0091] As noted above, compressor-distractor 100 can have a variety of different sizes, shapes, and configurations. FIGS. 17 and 18 are a front perspective and side view, respectively, of compressor-distractor 100 showing an alternative configuration of first engagement arm 102 and second engagement arm 104. As shown in this example, first pin block 134 and second pin block 136 do not extend perpendicularly (e.g., at a 90 degree angle) off of a remainder of first engagement arm 102 and second engagement arm 104, respectively. Rather, the proximal ends of first engagement arm 102 and second engagement arm 104 extending away from first pin block 134 and second pin block 136, respectively, extend at a non-zero degree angle 140. Configuring the proximal ends of first engagement arm 102 and second engagement arm 104 to angle away from their respective pin blocks may be useful to help position the arms out of sight of the pin blocks and, correspondingly, surgical sight. This can help remove the proximal ends of first engagement arm 102 and second engagement arm 104, including actuator 106 carried by the proximal portion of the arms, from visually obstructing the site being worked on.

[0092] In the illustrated configuration of FIGS. 17 and 18, the proximal ends of first engagement arm 102 and second engagement arm 104 are illustrated as being angled upwardly, e.g., with respect to gravity and/or the surgical site on which first pin block 134 and second pin block 136 are positioned during use. In various examples, angle 140 may range from 1 degree to 90 degrees, such as from 40 degrees to 80 degrees, or from 50 degrees to 70 degrees. In use, the angulation provided the angled arms can position actuator 106 outwardly (e.g., medially) from the surgical site.

[0093] In addition to or in lieu of configuring compressor-distractor 100 with angled engagement arms, first pin block 134 and second pin block 136 may be contoured to be positioned on bones being worked on. As perhaps best illustrated in FIG. 18, a terminal or bone contacting portion 142 of each pin block may define a contoured end configured to be positioned against a generally circular bone. The contoured face may include a dorsal or top wall surface 144 configured to be positioned on a generally dorsal portion of a bone being worked on and a sidewall surface 146 (e.g., medial sidewall surface) configured to be positioned on a generally side portion of the bone being worked. In the illustrated example, the top wall surface 144 is joined to the sidewall surface 146 through a continuous radius of curvature, although the surfaces may be joined at other angles of curvature or as intersecting wall surface segments without a joining radius of curvature. In either case, top wall surface 144 and sidewall surface 146, in combination, may define a pocket or cavity in which a bone is positioned during use of compressor-distractor 100.

[0094] Configuring one or both pin blocks of compressor distractor 100 with a pocket can be useful to provide a cutout opening on the open side of the pocket. This cutout opening can allow the clinician to visually observe the position of the pin blocks and/or bone during placement of compressor-distractor 100. In addition, the cutout opening can allow for the placement of a bone fixation device, e.g., while compressor-distractor 100 remains attached to the bones being fixated by pins.

[0095] FIG. 19 is perspective illustration of a foot showing an example deployment of compressor-distractor 100 with a bone contacting portion 142 defining a cutout. As shown in this example, bone contacting portion 142 of second pin block 136 is positioned over medial cuneiform 222. Compressor-distractor 100 is lifted dorsally off the bone face while still being pinned to the medial cuneiform 222 and first metatarsal 210. The cutout defined in the bone contacting portion 142 provides a cavity in which a bone plate 310 can be inserted. When used in this way, the bone plate (or other fixation element) can be attached across the joint (e.g., tarsal-metatarsal joint) while compressor-distractor 100 is still pinned to the metatarsal and cuneiform being worked on. When so used, the clinician may or may not provisionally fixate the metatarsal to another bone (e.g., opposed cuneiform) prior to permanently fixating.

[0096] Compressor-distractor devices and techniques have been described. In some examples, a compressor-distractor according to disclosure is included in a disposable, sterile kit that includes associated surgical instrumentation, such as bone positioning guide and/or a preparation guide described herein. Other components that may be included within the sterile

kit include bone fixation devices, bone fixation screws, pins for insertion into pin-receiving holes, and the like.

[0097] Various examples have been described. These and other examples are within the scope of the following claims.

CLAIMS:

1. A compressor-distractor comprising:
 - a first engagement arm having a first pin-receiving hole for receiving a first pin inserted into a first bone portion;
 - a second engagement arm having a second pin-receiving hole for receiving a second pin inserted into a second bone portion; and
 - an actuator operatively coupled to the first engagement arm and the second engagement arm, the actuator being configured to move the first and second engagement arms away from each other to move the first bone portion away from the second bone portion and also being configured to move the first and second engagement arms toward each other to move the first bone portion toward the second bone portion,wherein the first pin-receiving hole is angled relative to the second pin-receiving hole at a non-zero degree angle.
2. The compressor-distractor of claim 1, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in a frontal plane.
3. The compressor-distractor of claim 2, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in the frontal plane at an angle ranging from 2 degrees to 20 degrees.
4. The compressor-distractor of claim 2, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in the frontal plane at an angle ranging from 6 degrees to 15 degrees.
5. The compressor-distractor of any one of the foregoing claims, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in a sagittal plane.
6. The compressor-distractor of claim 5, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in the sagittal plane at an angle ranging from 5 degrees to 12 degrees.

7. The compressor-distractor of claim 5, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in the sagittal plane at an angle ranging from 7 degrees to 10 degrees.
8. The compressor-distractor of any one of the foregoing claims, wherein the first engagement arm further comprises a third pin-receiving hole, the second engagement arm further comprises a fourth pin-receiving hole, the first pin-receiving hole is angled relative to the second pin-receiving hole at a non-zero degree angle in a first plane, and the first pin-receiving hole is angled relative to the fourth pin-receiving hole at a non-zero degree angle in a second plane.
9. The compressor-distractor of claim 8, wherein the first plane is a frontal plane and the second plane is a sagittal plane.
10. The compressor-distractor of either of claims 8 or 9, wherein the first pin-receiving hole is parallel to the fourth pin-receiving hole in the frontal plane, and the second pin-receiving hole is parallel to the third pin-receiving hole in the frontal plane.
11. The compressor-distractor of any one of the foregoing claims, wherein the actuator comprises a shaft connected to the first engagement arm and the second engagement arm.
12. The compressor-distractor of claim 11, wherein the shaft is threaded and the actuator includes a knob coupled to the shaft.
13. The compressor-distractor of either of claims 11 or 12, wherein the actuator further comprises at least one unthreaded shaft extending parallel to the threaded shaft.
14. The compressor-distractor of claim 13, wherein the first engagement arm extends from a distal end to a proximal end, the threaded shaft is fixedly connected to the first engagement arm adjacent the proximal end, and the at least one unthreaded shaft is fixedly connected to the first engagement arm adjacent the proximal end, and

the second engagement arm extends from a distal end to a proximal end and includes at least one unthreaded aperture adjacent the proximal end through which the at least one unthreaded shaft extends and a threaded aperture adjacent the proximal end through which the threaded shaft extends.

15. The compressor-distractor of any one of the foregoing claims, wherein the first engagement arm extends from a distal end to a proximal end, the second engagement arm extends from a distal end to a proximal end, the distal end of the first engagement arm defines a first pin block having a thickness greater than a remainder of the first engagement arm, and

the distal end of the second engagement arm defines a second pin block having a thickness greater than a remainder of the second engagement arm.

16. The compressor-distractor of claim 15, wherein the proximal end of the first engagement arm and the proximal end of the second engagement arm are angled upwardly from the first pin block and the second pin block, respectively, at a non-zero degree angle.

17. The compressor-distractor of claim 16, wherein the non-zero degree angle ranges from 40 degrees to 80 degrees.

18. The compressor-distractor of any one of claims 15–17, wherein first pin block and the second pin block each define a cutout.

19. The compressor-distractor of any one of the foregoing claims, wherein the first pin-receiving hole and the second pin-receiving hole each define a circular opening having a diameter ranging from 0.5 millimeters to 4 millimeters.

20. The compressor-distractor of any one of the foregoing claims, wherein the actuator is configured to move the first engagement arm a distance ranging from 1 millimeter to 2.5 millimeters away from the second engagement arm.

21. A method comprising:

inserting a first pin into a first bone portion and a second pin into a second bone portion such that the first pin is substantially parallel to the second pin;

inserting a compressor-distractor on the first pin and on the second pin by at least positioning the first pin through a first pin-receiving hole of a first engagement arm of the compressor-distractor and positioning the second pin through a second pin-receiving hole of a second engagement arm of the compressor-distractor, the compressor-distractor including an actuator operatively coupled to the first engagement arm and the second engagement arm,

wherein the first pin-receiving hole is angled relative to the second pin-receiving hole at a non-zero degree angle such that inserting the compressor-distractor on the first pin and on the second pin causes the first bone portion to move relative to the second bone portion.

22. The method of claim 21, further comprising

prior inserting the first pin and the second pin, positioning a first fixation aperture of a bone preparation guide over the first bone portion and a second fixation aperture of the bone preparation guide over the second bone portion, the first and second fixation apertures being parallel to each other,

wherein inserting the first pin and the second pin comprises inserting the first pin through the first fixation aperture into the first bone portion and the second pin through the second fixation aperture into the second bone portion.

23. The method of claim 22, further comprising, prior to inserting the compressor-distractor on the first pin and on the second pin, sliding the bone preparation guide off the first pin and the second pin while leaving the first pin inserted into the first bone portion and the second pin inserted into the second bone portion.

24. The method of either of claims 22 or 23, wherein the bone preparation guide includes at least one cutting slot, and further comprising cutting an end of the first bone portion through the at least one cutting slot and cutting an end of the second bone portion through the at least one cutting slot.

25. The method of any one of claim 22–24, wherein the bone preparation guide includes at least one cutting slot, and further comprising, prior to sliding the bone preparation guide off the first pin and the second pin, cutting an end of the first bone portion through the at least one cutting slot and cutting an end of the second bone portion through the at least one cutting slot.

26. The method of any one of claim 21–25, further comprising actuating the actuator on the compressor-distractor to cause the first engagement arm to move away from the second engagement arm and, in turn, cause the first bone portion to move away from the second bone portion.

27. The method of claim 26, further comprising:
while the first engagement arm is moved away from the second engagement arm, cleaning a space between the first bone portion and the second bone portion, and
subsequently actuating the actuator on the compressor-distractor to cause the first engagement arm to move toward the second engagement arm and, in turn, cause the first bone portion to move toward the second bone portion, until the first bone portion is compressing against the second bone portion.

28. The method of claim 27, further comprising fixating the first bone portion to the second bone portion while the first engagement arm is moved toward the second engagement arm and causing the first bone portion to compress against the second bone portion.

29. The method of any one of claim 21–28, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in a frontal plane such that inserting the compressor-distractor on the first pin and on the second pin causes the first bone portion to rotate relative to the second bone portion in the frontal plane.

30. The method of claim 29, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in the frontal plane at an angle ranging from 2 degrees to 20 degrees.

31. The method of claim 29, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in the frontal plane at an angle ranging from 6 degrees to 15 degrees.

32. The method of any one of claim 21–31, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in a sagittal plane such that inserting the compressor-distractor on the first pin and on the second pin causes the first bone portion to rotate plantarily relative to the second bone portion in the sagittal plane.

33. The method of claim 32, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in the sagittal plane at an angle ranging from 5 degrees to 12 degrees.
34. The method of claim 32, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in the sagittal plane at an angle ranging from 7 degrees to 10 degrees.
35. The method of any one of claim 21–34, wherein the first pin-receiving hole is angled relative to the second pin-receiving hole in at least two planes such that inserting the compressor-distractor on the first pin and on the second pin causes the first bone portion to move relative to the second bone portion in at least two planes.
36. The method of claim 35, where the two planes include a frontal plane and a sagittal plane.
37. The method of any one of claim 21–36, wherein the actuator comprises a threaded shaft movably connected to the first engagement arm and the second engagement arm.
38. The method of any one of claim 21–37, wherein the first bone portion is a metatarsal and the second bone portion is a cuneiform.
39. The method of claim 38, wherein the metatarsal is a first metatarsal, and the cuneiform is a medial cuneiform.
40. A compressor-distractor comprising:
a first engagement arm having a first pin-receiving hole for receiving a first pin inserted into a first bone portion, the first engagement arm extending from a distal end to a proximal end, and the distal end of the first engagement arm defining a first pin block having a thickness greater than a remainder of the first engagement arm;
a second engagement arm having a second pin-receiving hole for receiving a second pin inserted into a second bone portion, the second engagement arm extending from a distal

end to a proximal end, and the distal end of the second engagement arm defining a second pin block having a thickness greater than a remainder of the second engagement arm; and

an actuator operatively coupled to the first engagement arm and the second engagement arm, the actuator being configured to move the first and second engagement arms away from each other to move the first bone portion away from the second bone portion and also being configured to move the first and second engagement arms toward each other to move the first bone portion toward the second bone portion,

wherein the proximal end of the first engagement arm and the proximal end of the second engagement arm are angled upwardly from the first pin block and the second pin block, respectively, at a non-zero degree angle.

41. The compressor-distractor of claim 40, wherein the non-zero degree angle ranges from 40 degrees to 80 degrees.

42. The compressor-distractor of either of claims 40 or 41, wherein first pin block and the second pin block each define a cutout.

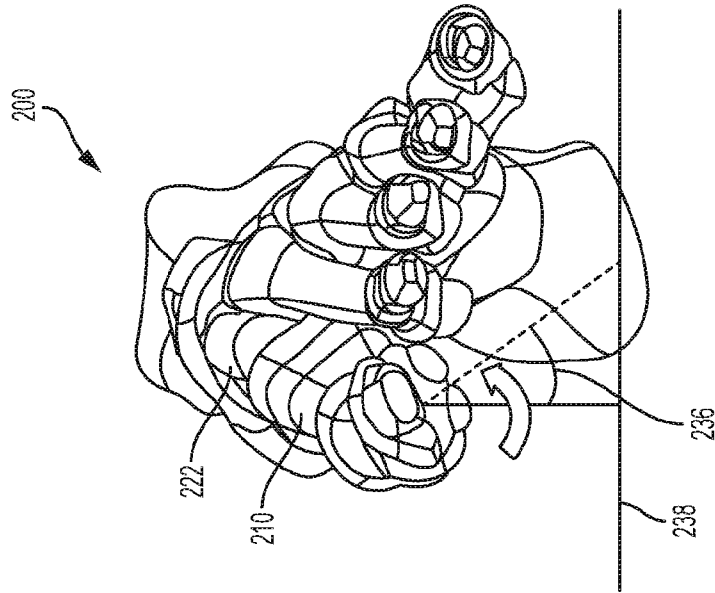


FIG. 1B

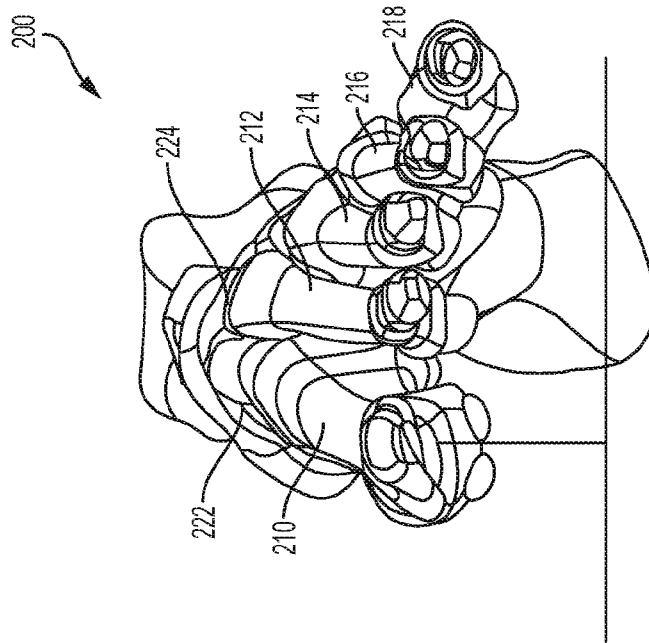


FIG. 1A

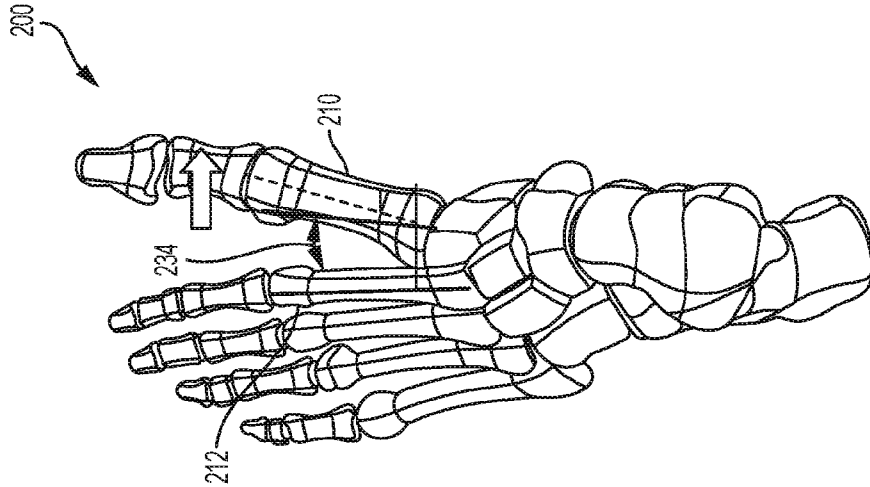


FIG. 2B

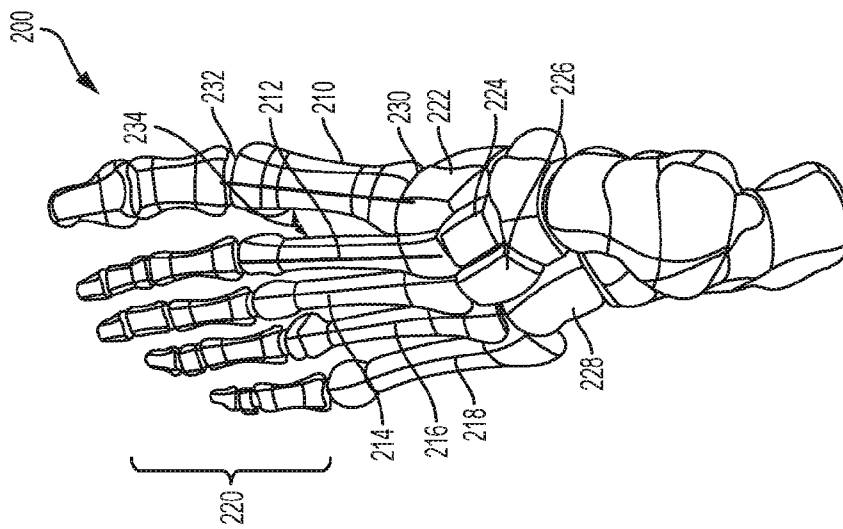


FIG. 2A

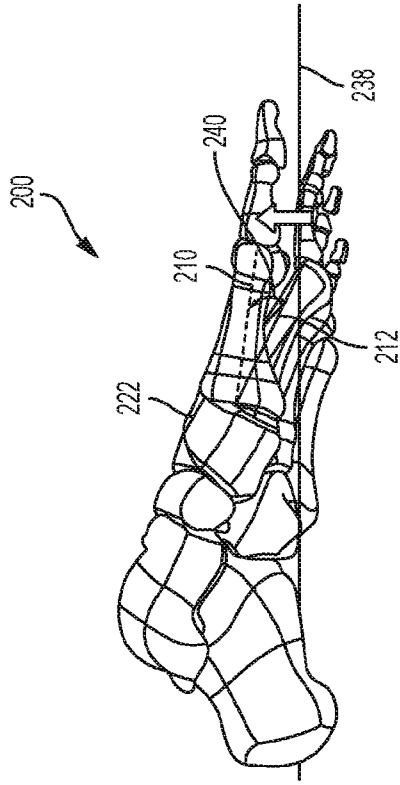


FIG. 3A

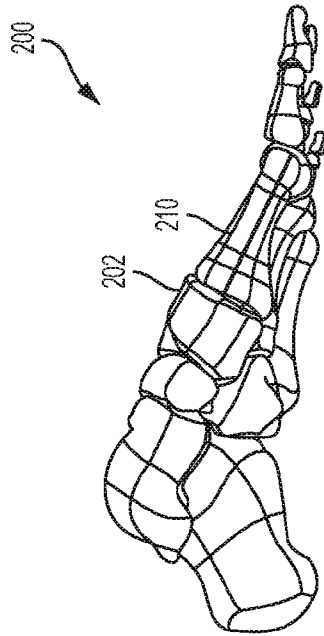


FIG. 3B

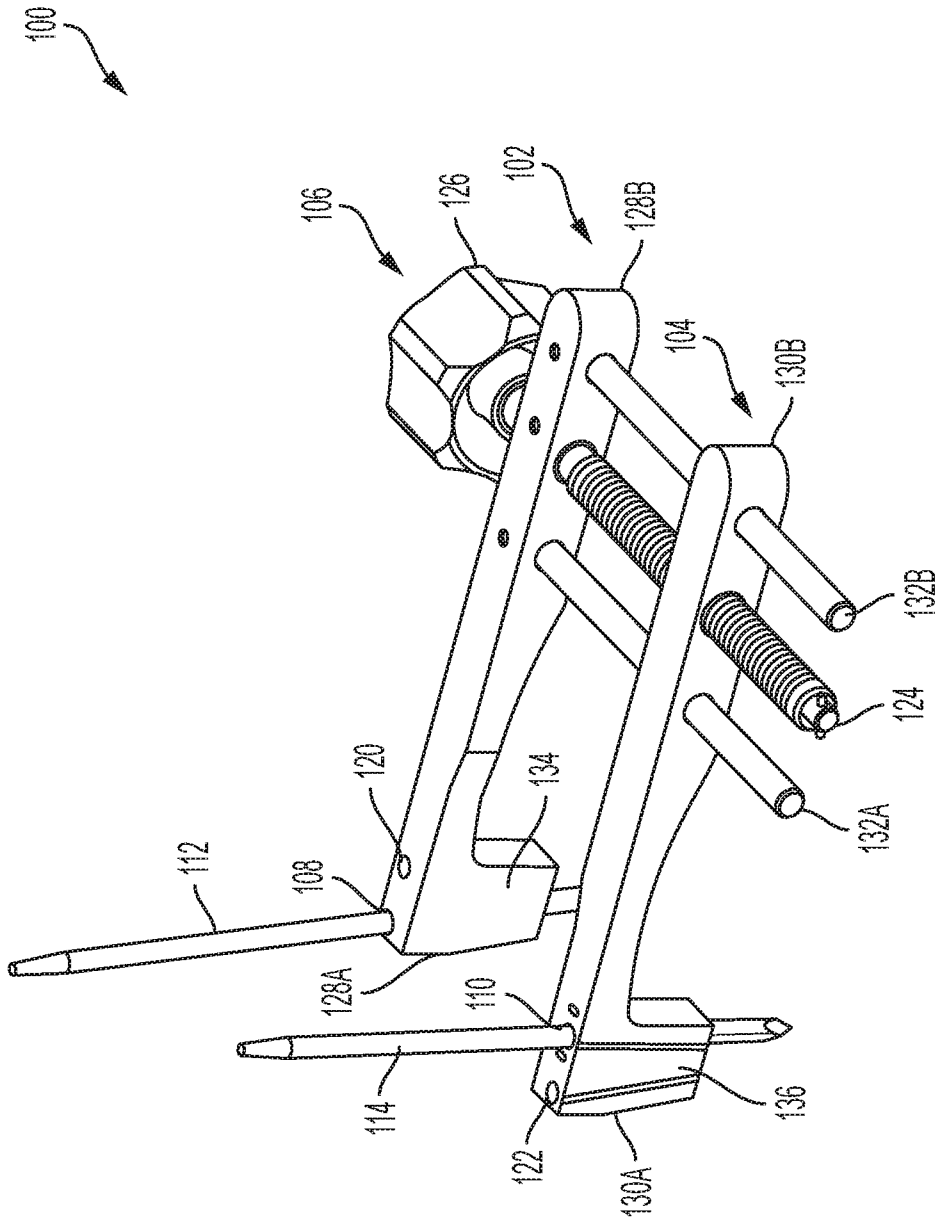


FIG. 4

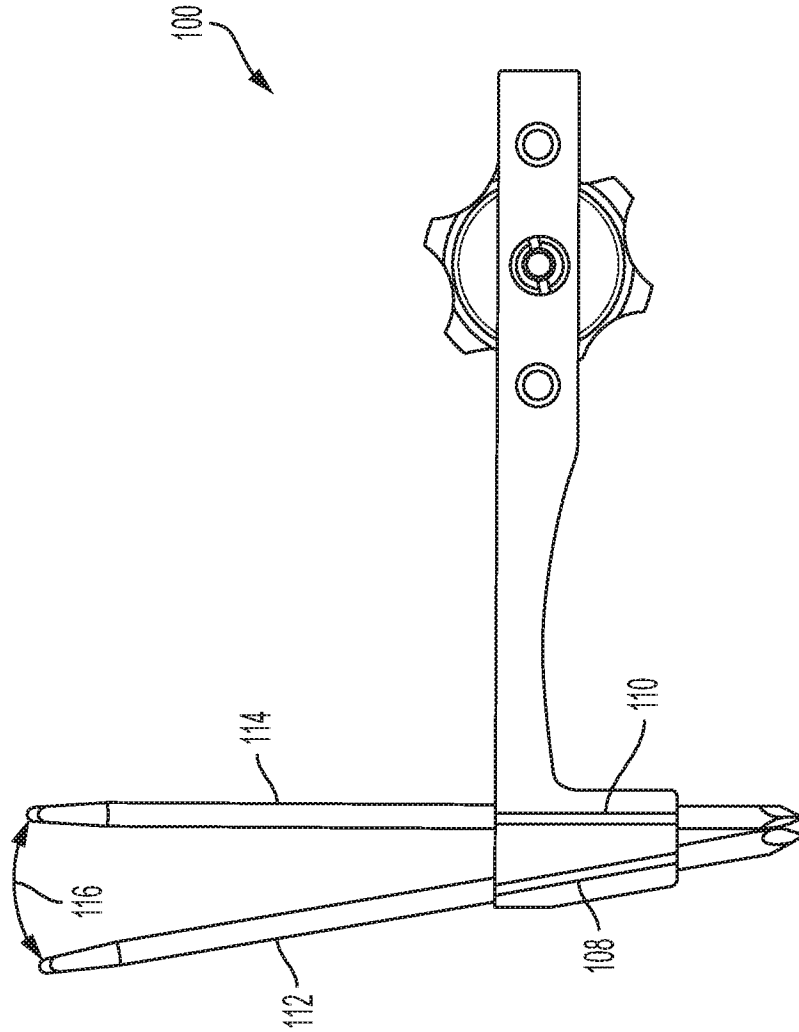


FIG. 5

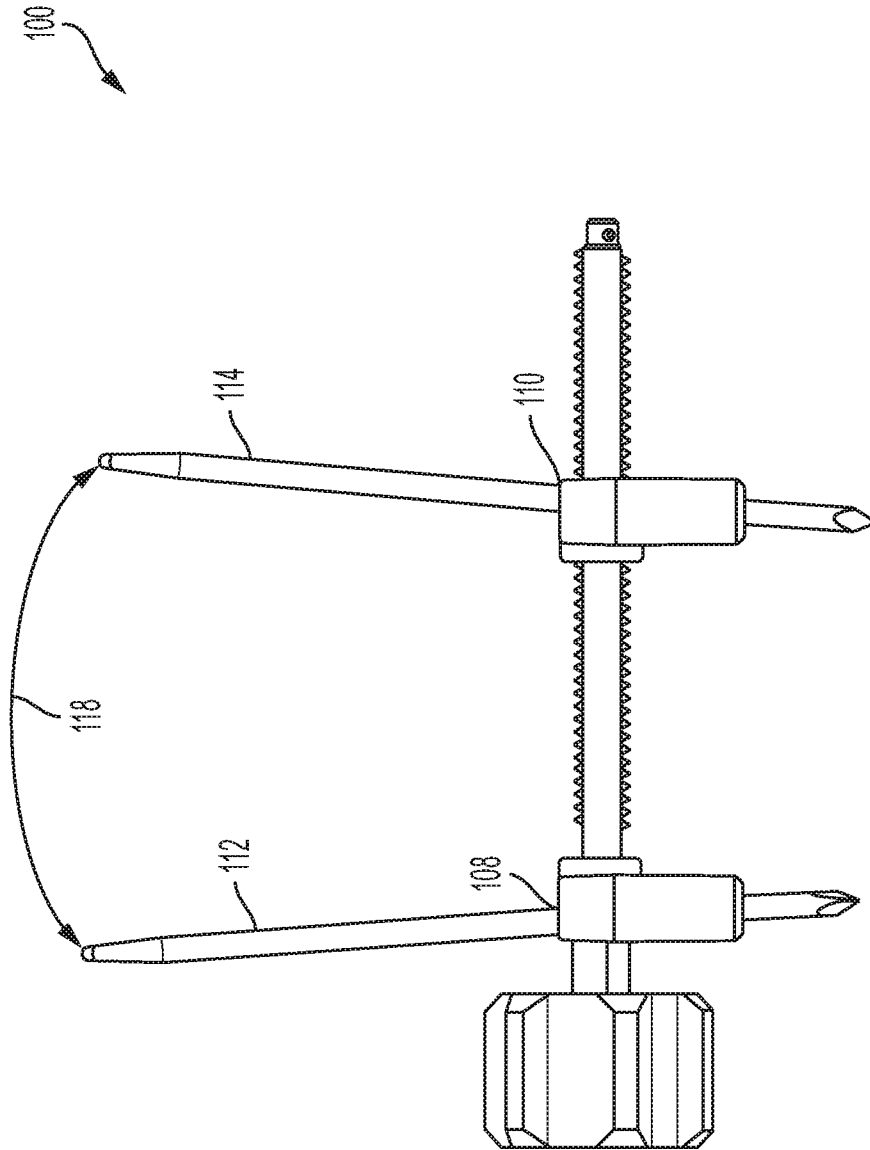


FIG. 6

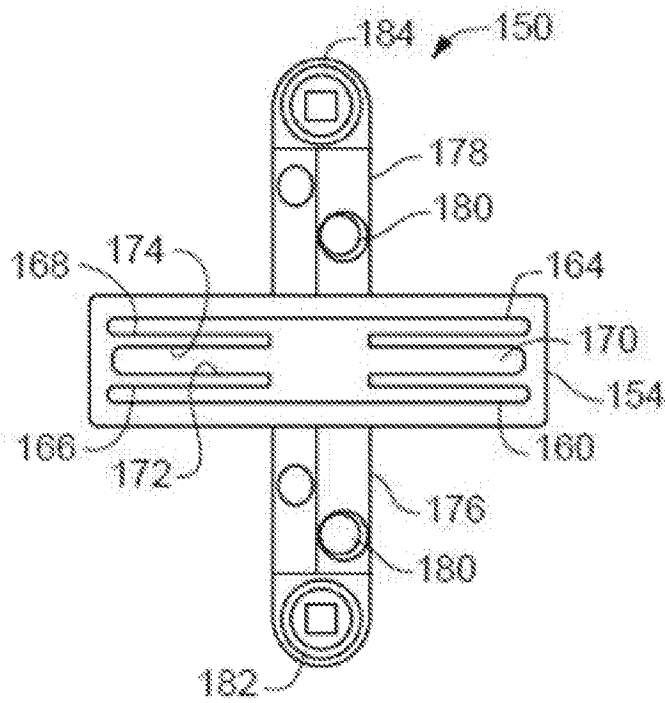
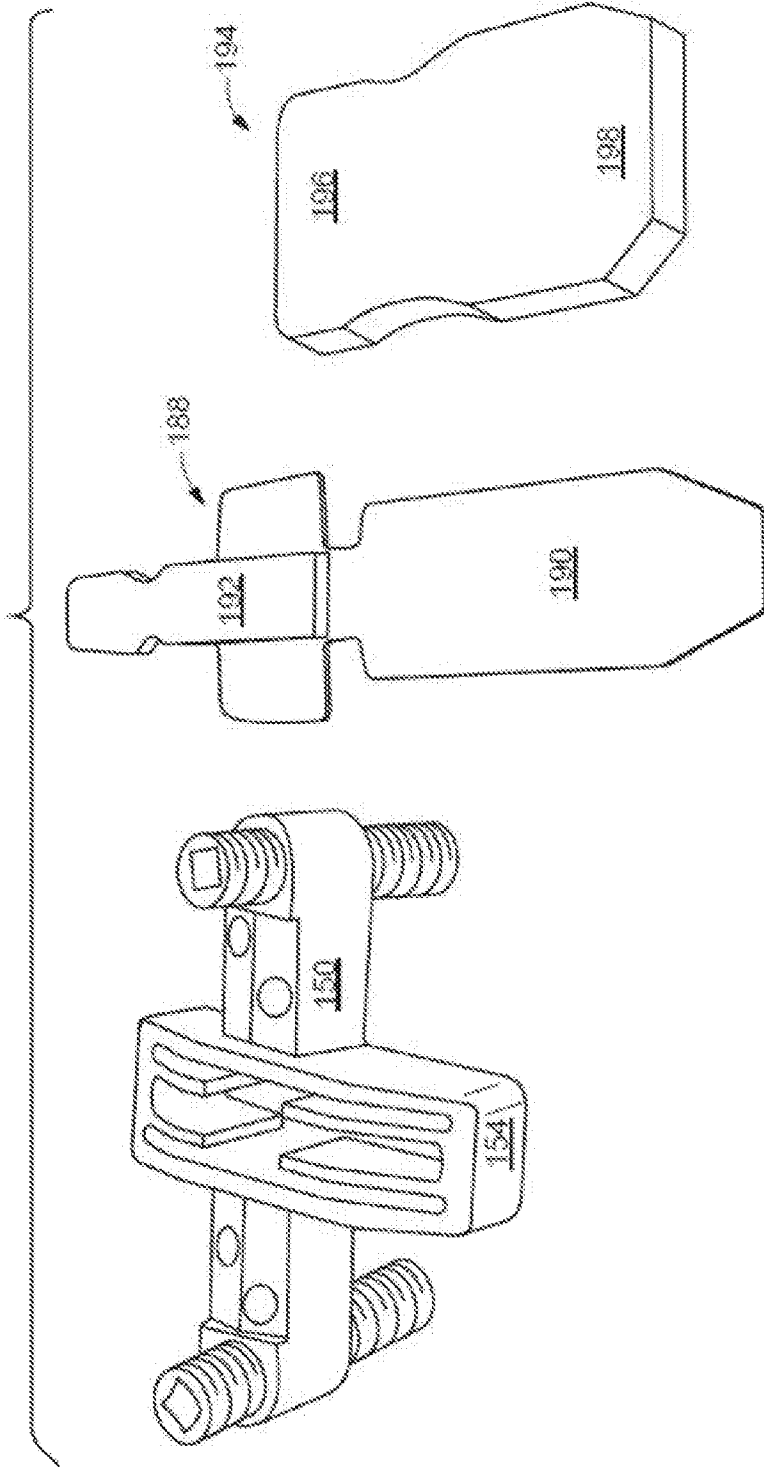


FIG. 7

FIG. 8



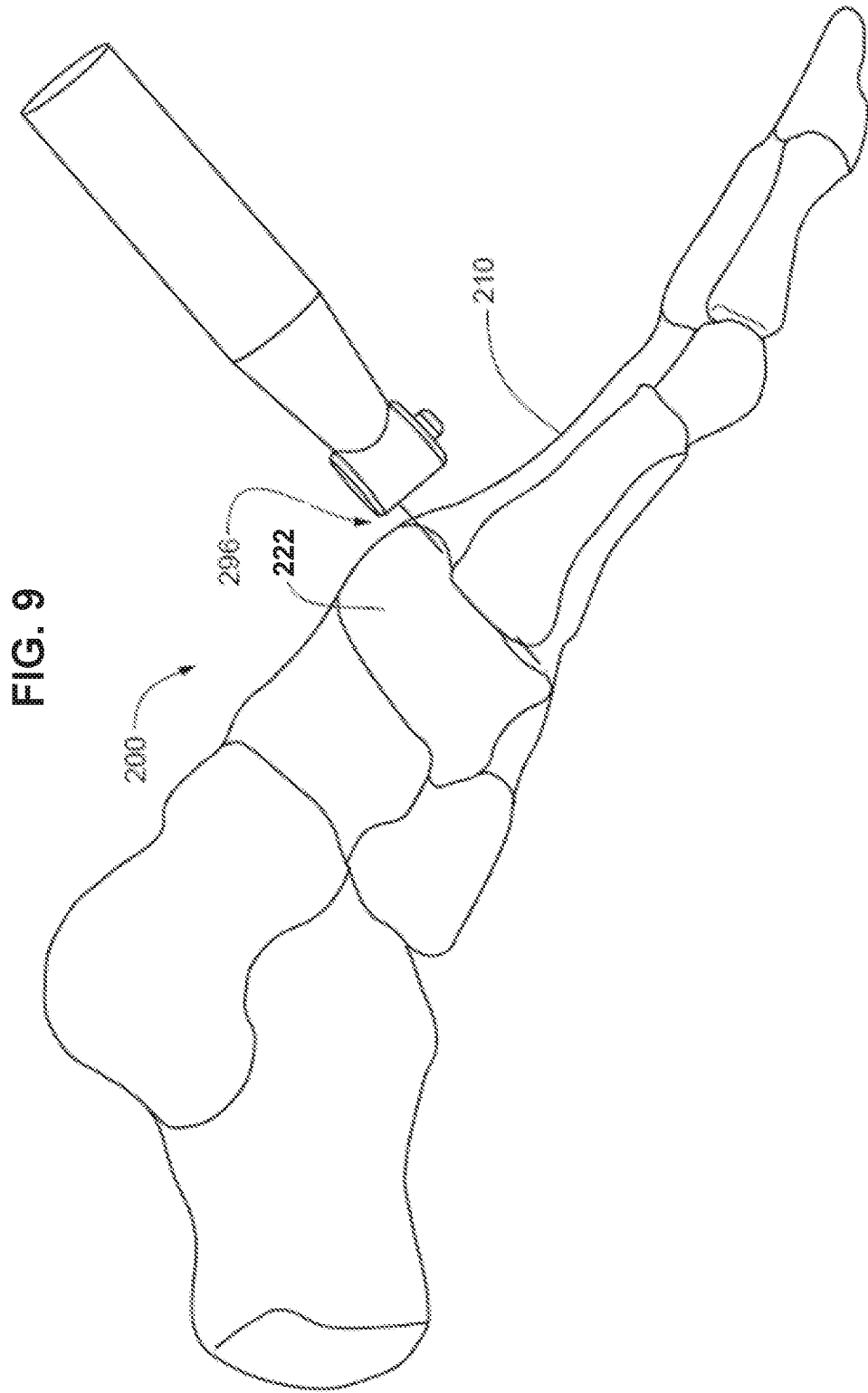
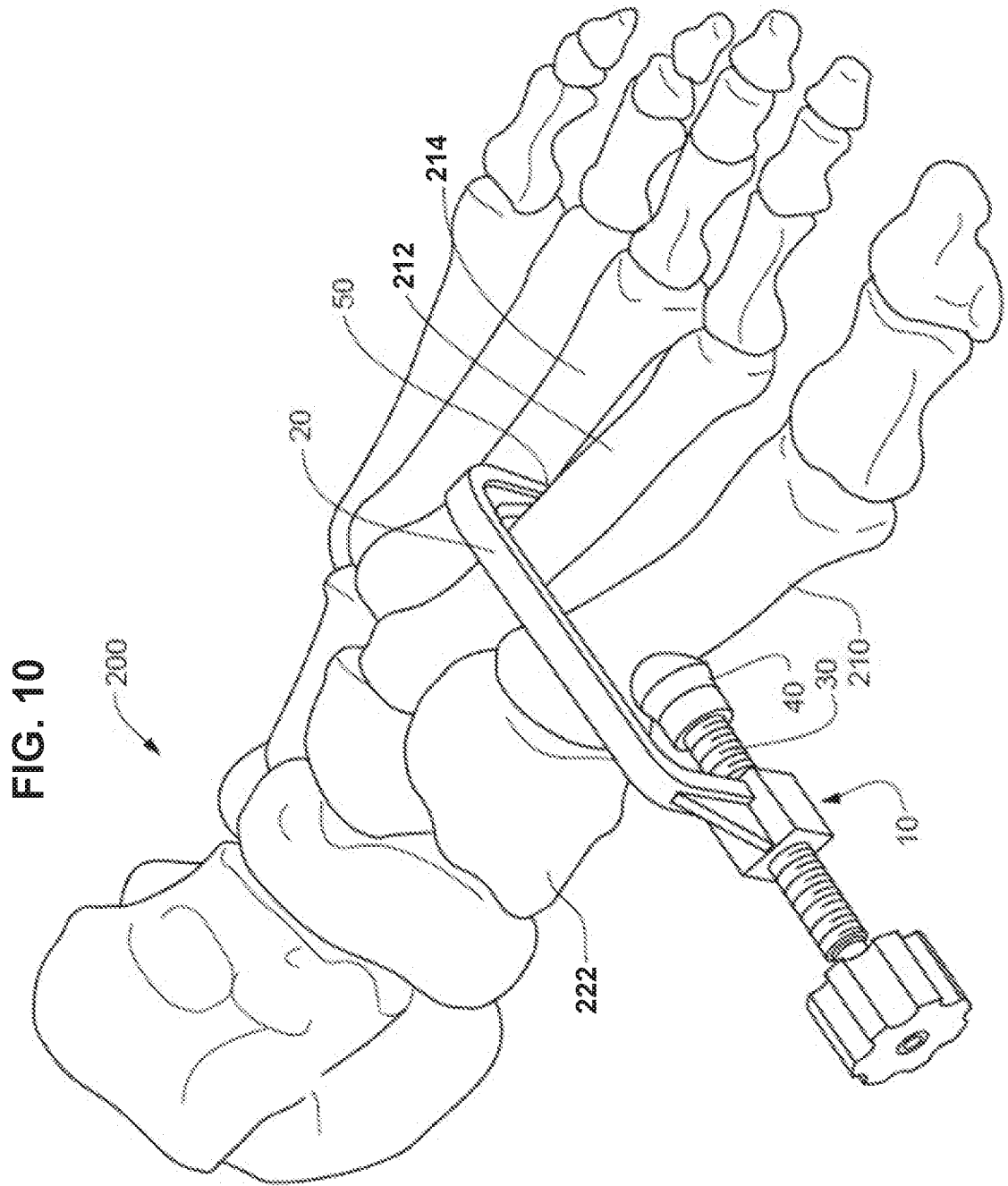
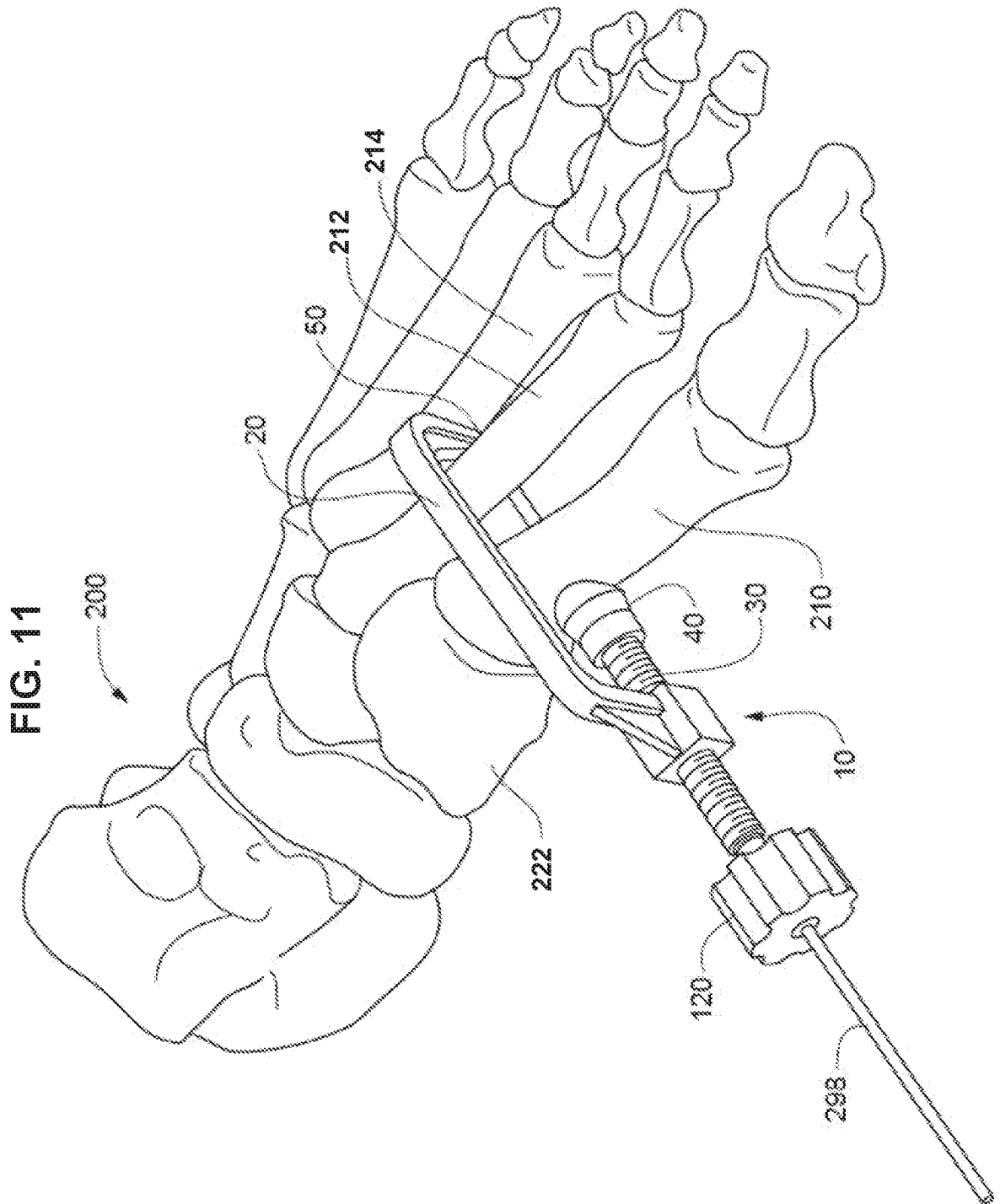
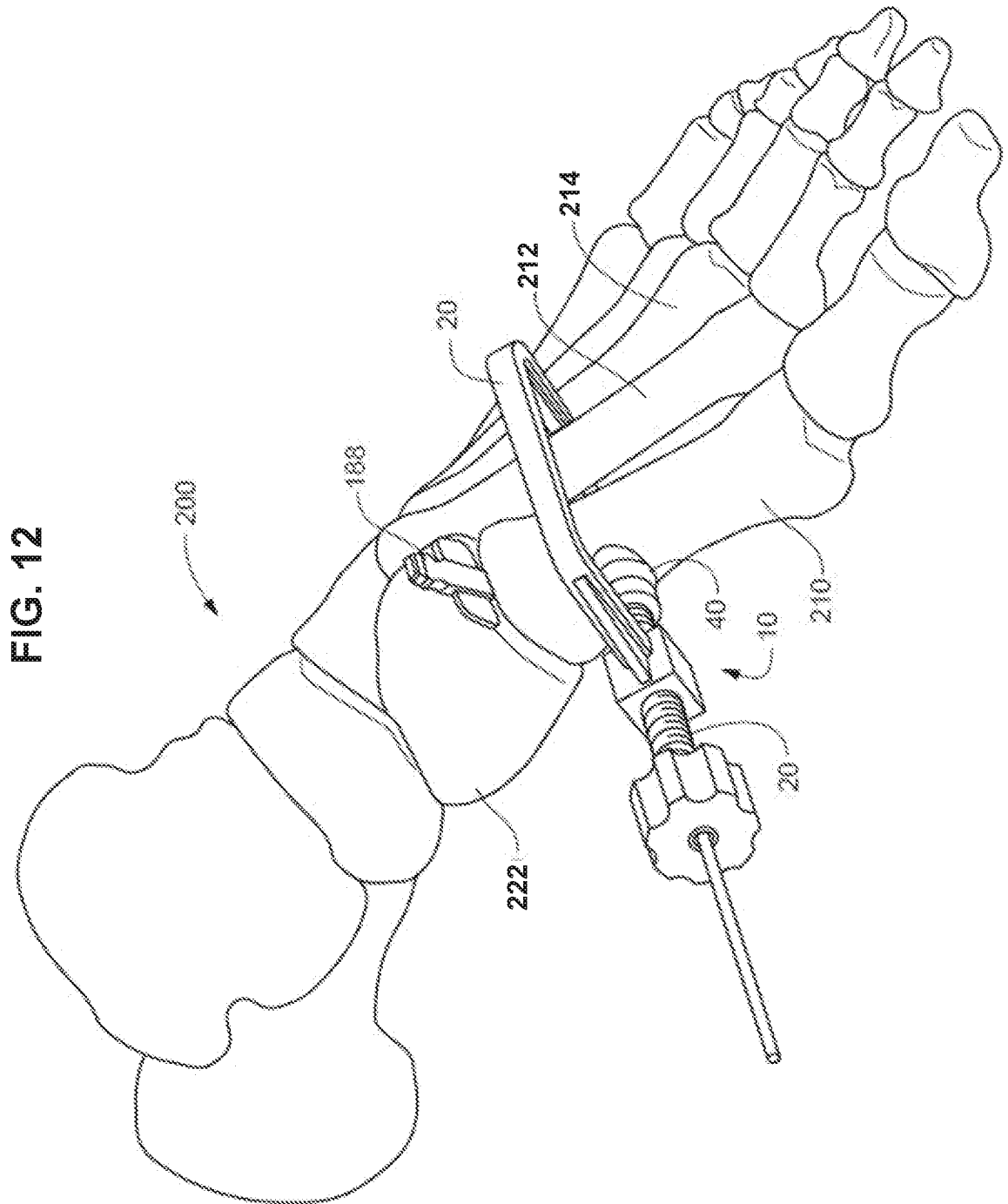
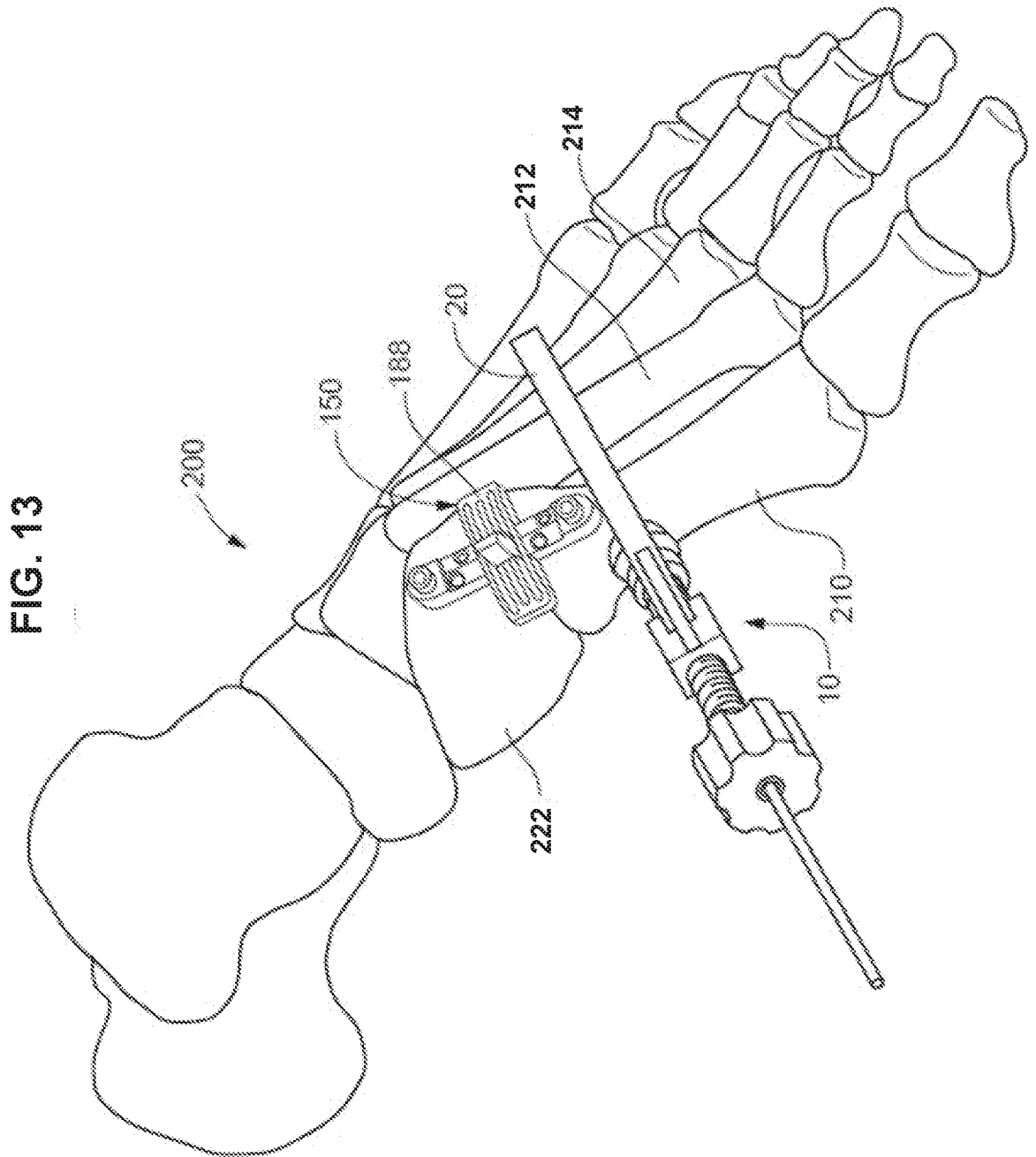


FIG. 9









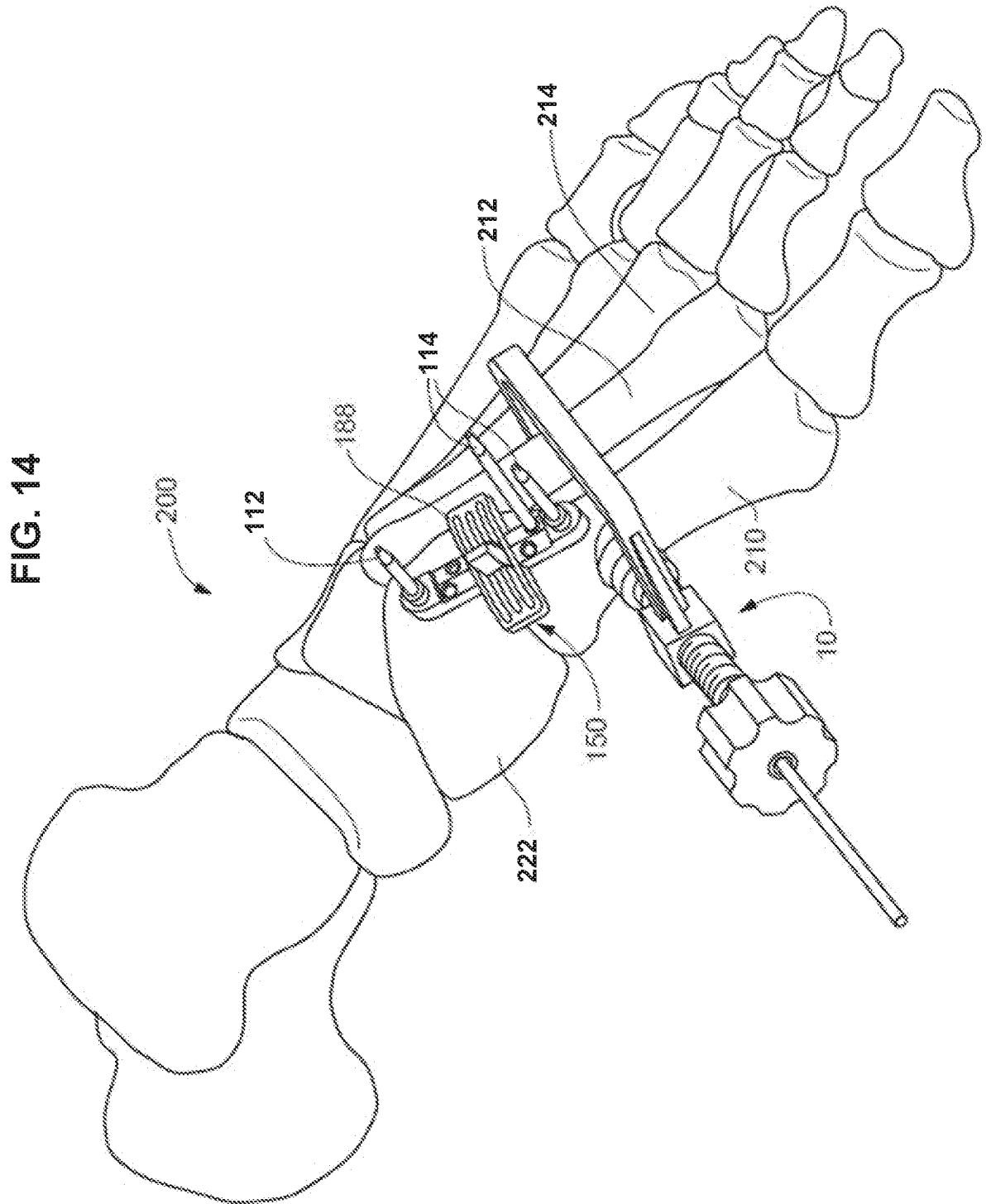
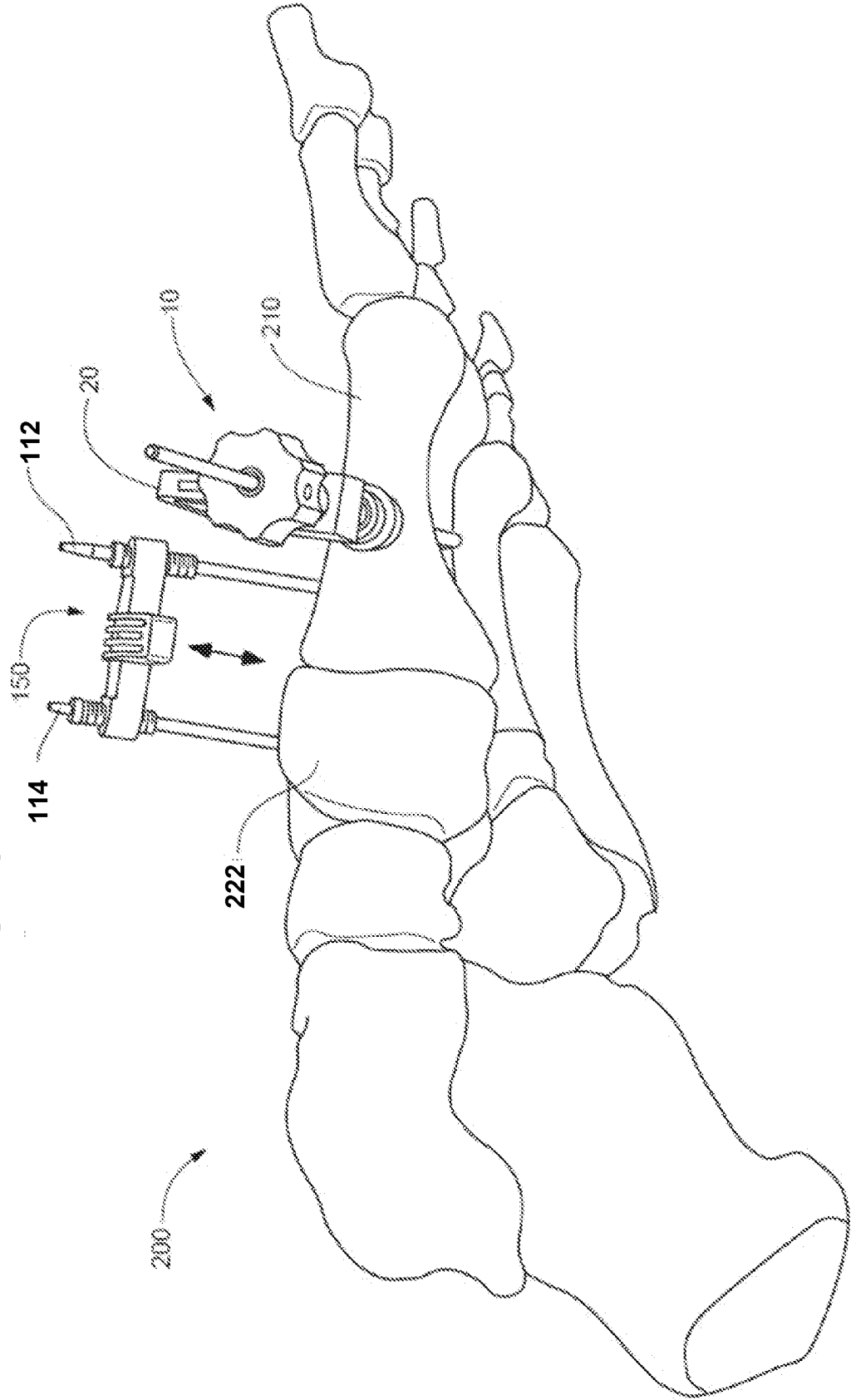
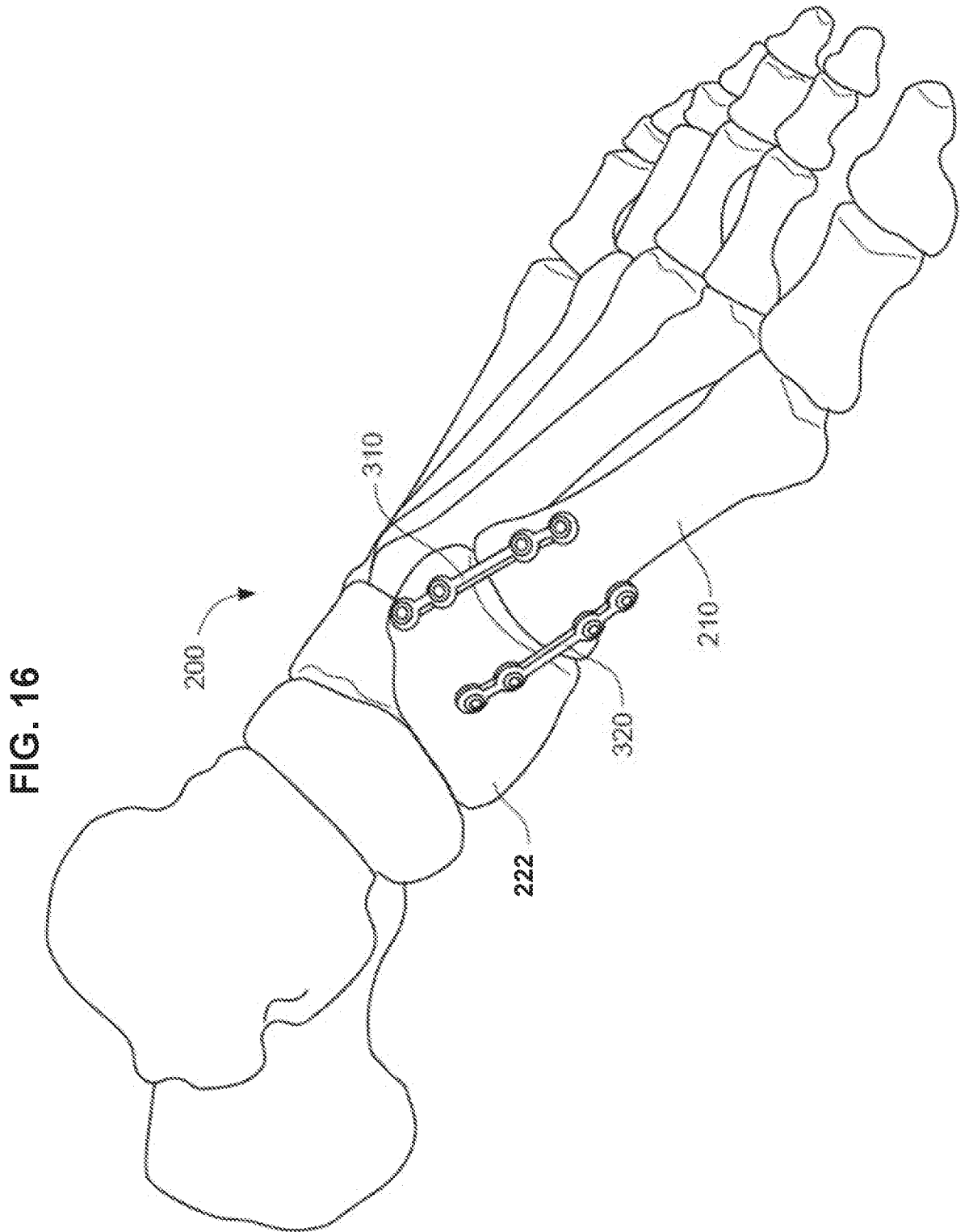


FIG. 15





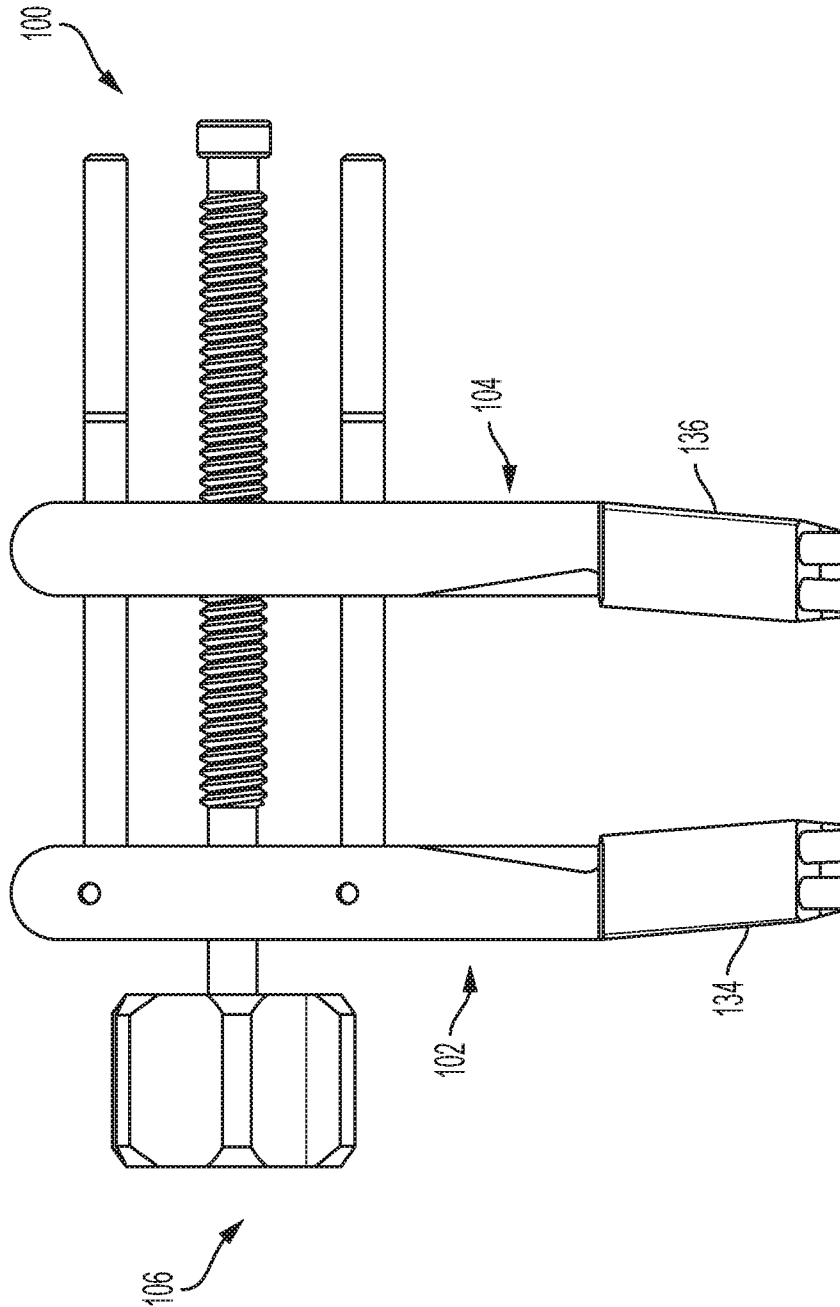


FIG. 17

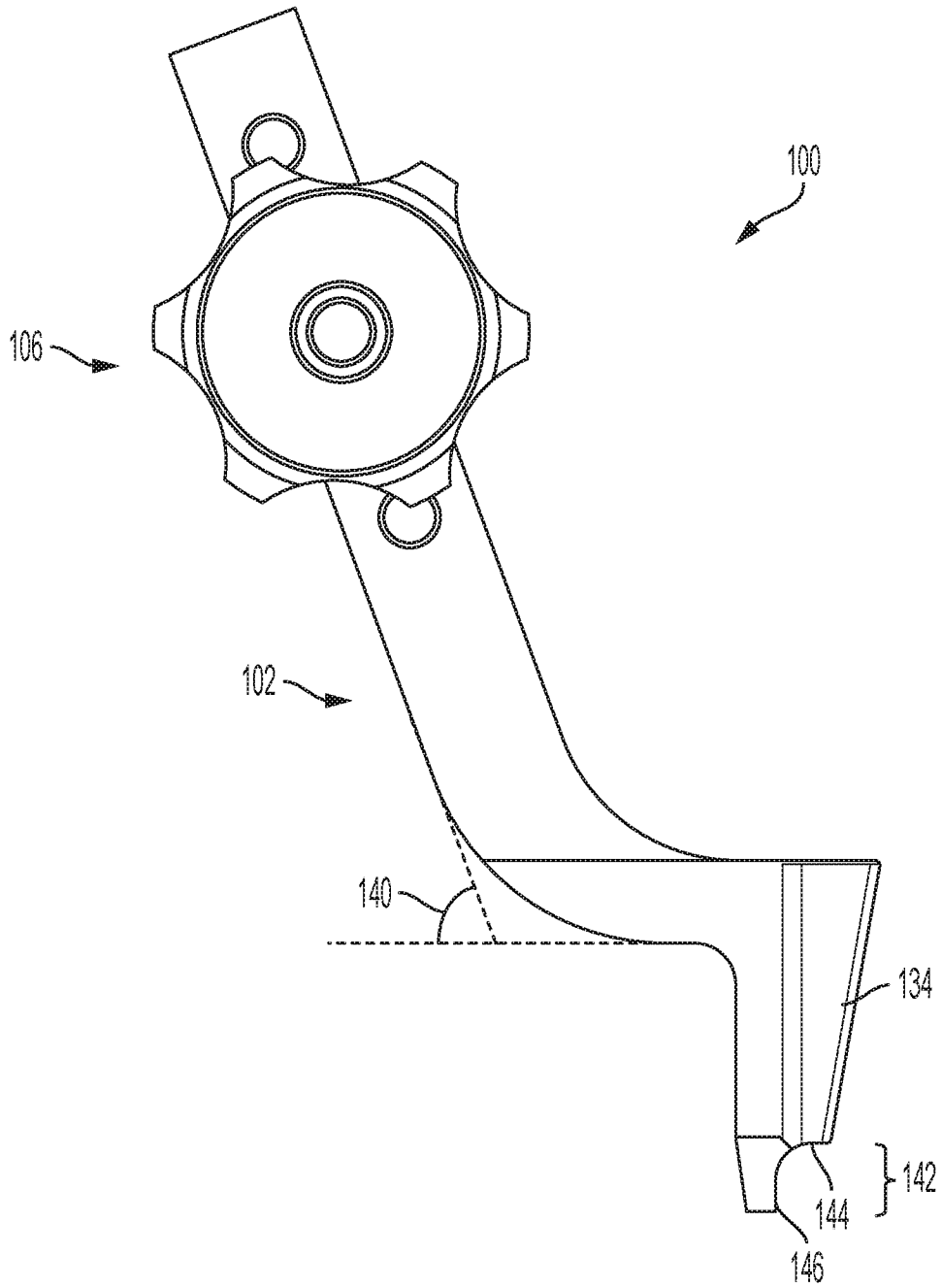


FIG. 18

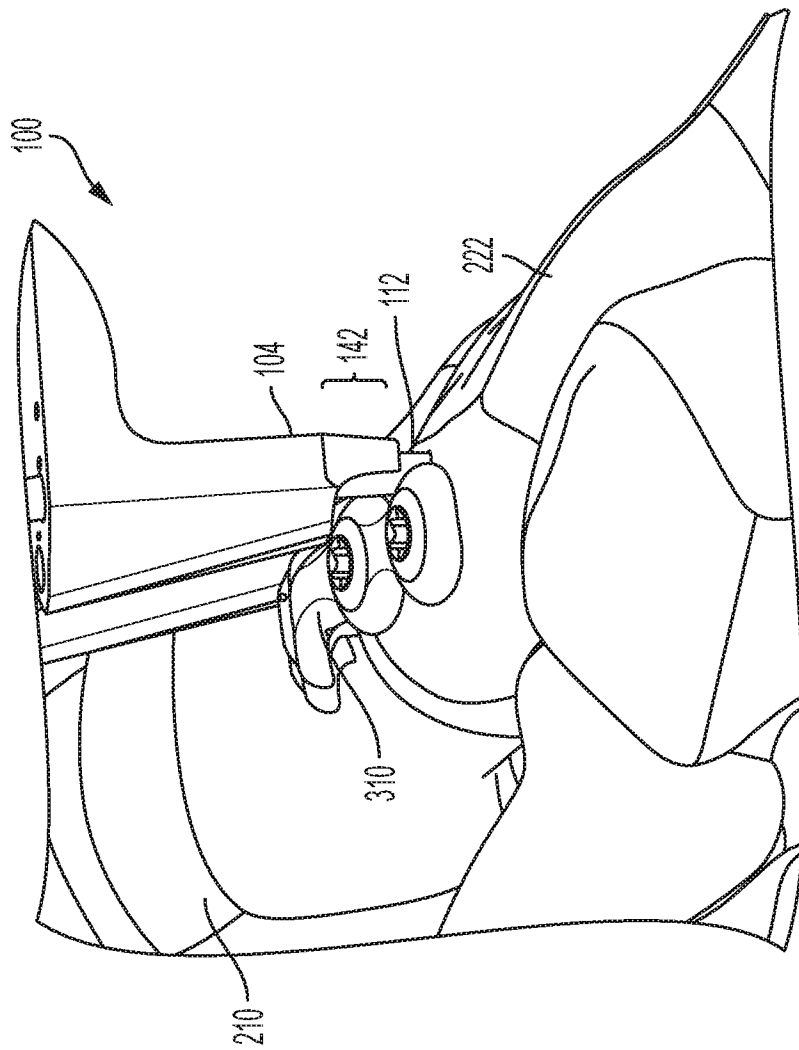


FIG. 19

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/41365

A. CLASSIFICATION OF SUBJECT MATTER
 IPC(8) - A61B 17/66 (2019.01)
 CPC - A61B 17/6458, 17/6466, 17/66, 2017/565

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

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

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	WO 2005/122923 A1 (RULE) 29 December 2005 (29.12.2005) see especially pg 4, ln 22-23, pg 5, ln 1-12, pg 5, ln 21 to pg 6, ln 10, fig 1-2	1-7 ----- 21-24
X	US 2008/0262500 A1 (COLLAZO) 23 October 2008 (23.10.2008) see especially para [0029], [0032], [0034]-[0037], [0039], [0040], [0046], fig 1-3	40-42
Y	US 2017/0014173 A1 (TREACE MEDICAL CONCEPTS INC) 19 January 2017 (19.01.2017) see especially para [0095], [0096], [0098]-[0100], [0103], [0106], fig 20, 21A, 21B, 22, 23	21-24
A	US 2016/0270800 A1 (SANDERS) 22 September 2016 (22.09.2016) see whole document	1-7, 21-24, 40-42
A	US 2014/0228899 A1 (WRIGHT MEDICAL TECHNOLOGY INC) 12 June 2014 (12.06.2014) see whole document	1-7, 21-24, 40-42
A	US 2009/0187189 A1 (MIRZA et al) 23 July 2007 (26.07.2007) see whole document	1-7, 21-24, 40-42
A	US 5,304,177 A (PENNIG) 19 April 1994 (19.04.1994) see whole document	1-7, 21-24, 40-42
A	US 4,187,841 A (KNUTSON) 12 February 1980 (12.02.1980) see whole document	1-7, 21-24, 40-42
A	US 2,432,695 A (SPEAS) 16 December 1947 (16.12.1947) see whole document	1-7, 21-24, 40-42
A	US 2,251,209 A (STADER) 29 July 1941 (29.07.1941) see whole document	1-7, 21-24, 40-42

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

6 September 2019

Date of mailing of the international search report

04 OCT 2019

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
 P.O. Box 1450, Alexandria, Virginia 22313-1450
 Facsimile No. 571-273-8300

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/41365

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.: 8-20, 25-39
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.