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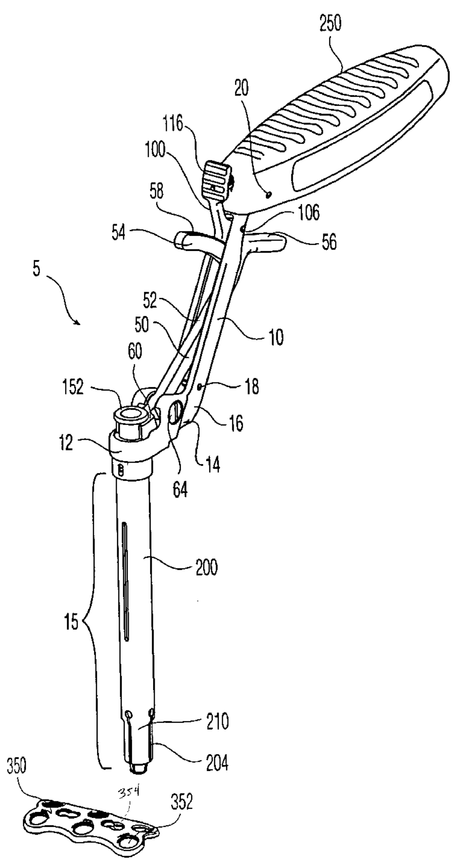
(54) Title: QUICK-RELEASE DRILL GUIDE ASSEMBLY FOR BONE PLATE



(57) Abstract: The present invention relates to a surgical drill-guide assembly (5) that can be releasably attached to a part of a bone-fixation system, for example, a plate (350). The surgical drill-guide assembly of the present invention is used for example, to guide a drill (400), screw, bone fastener, or other instrument or fastener into bone.

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QUICK-RELEASE DRILL GUIDE ASSEMBLY FOR BONE PLATE

FIELD OF THE INVENTION

[0001] The present invention relates to a surgical drill-guide assembly that can be releasably attached to a part of a bone-fixation system, for example, a bone plate. The surgical drill-guide assembly of the present invention is used for example, to guide a drill-bit, screw, bone fastener, or other instrument or fastener into bone or other tissue.

BACKGROUND OF THE INVENTION

[0002] The use of surgical fixation plates for a variety of orthopedic applications is widely accepted. The plates are used by surgeons or users to stabilize, mend, or align a patient's bone as well as alter compression of patient's bones. Plates are typically fastened to the bones with a plurality of fasteners such as screws that are installed through holes in the plate. Proper orientation and alignment of fasteners and secure surgical fixation of the plates can mitigate some of the potential future complications after implantation.

[0003] Bone plates used, for example, in spinal applications must be installed with special care, as the plates may be used for long-term, intervertebral fixation, bone-fragment fixation, and/or anterior decompression in the cervical region of the spine. The margin for error in spinal surgery is quite small, particularly because of the sensitivity of the spinal cord and the risk inherent with invasive procedures around the spinal cord. In particular, the dimensions of vertebral bone available for setting fasteners are fairly limiting.

[0004] Each fixation screw should properly align with its associated plate hole so that each screw is seated correctly with the plate and enters the bone at an appropriate angle. Any misalignment of the screw within the plate hole risks tissue damage and spinal cord injury. In addition, improperly seated screws may result in an unstable or insecure connection of the plate to the bony material, thus potentially defeating the usefulness of the plate. Locking plates, in particular, demand precise fastener alignment.

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[0004A] The discussion of documents, acts, materials, devices, articles and the like is included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

[0004B] Throughout the description and claims of this specification, the word "comprise" and variations of the word, such as "comprising" and "comprises", is not intended to exclude other additives, components, integers or steps.

SUMMARY OF THE INVENTION

[0004C] According to a first aspect of the invention there is provided a drill-guide assembly, comprising:

an alignment drill-barrel configured to receive and guide a drill-bit, the alignment drill-barrel having a proximal end and a distal end;

a bushing configured to slidably receive the alignment drill-barrel, the bushing having a radially expandable forward-end and a proximal end, the forward-end configured to be insertable within a fastener hole in a bone plate;

a release knob having serrations; and

a movable ratchet gear mechanism having a first leg, a second leg and a tail,

the first leg of the ratchet-gear mechanism connected to the alignment drill-barrel,

the second leg of the ratchet-gear mechanism having pawls configured and adapted to engage the serrations to hold the alignment drill-barrel in position,

the tail of the ratchet gear mechanism operable by a user to selectively move the ratchet-gear mechanism,

wherein, movement of the ratchet-gear mechanism slides the alignment drill-barrel relative to the bushing to radially expand the forward end to releasably lock the bushing to the plate.

[0004D] According to a second aspect of the invention there is provided a drill-guide assembly, comprising:

an alignment barrel having a proximal end and a distal end;

a bushing configured to slidably receive the alignment barrel, the bushing having a radially expandable forward-end and a proximal end, the forward-end configured to be insertable within a hole or recess in a bone plate;

a release knob having serrations; and

a movable ratchet gear mechanism having a first leg, a second leg and a tail,

the first leg of the ratchet-gear mechanism connected to the alignment barrel,

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the second leg of the ratchet-gear mechanism having pawls configured and adapted to engage the serrations to hold the alignment barrel in position,

the tail of the ratchet gear mechanism operable by a user to selectively move the ratchet-gear mechanism,

wherein, movement of the ratchet-gear mechanism slides the alignment barrel relative to the bushing to radially expand the forward end to releasably lock the bushing to the plate, and a first drill guide coupled to the bushing, wherein the first drill guide is configured to receive and guide a drill-bit.

[0005] The present invention relates to a drill-guide assembly, which in one embodiment comprises an alignment drill-barrel, a bushing, a dual-arm support, a ratchet-gear mechanism, a handle member, and a release knob.

[0006] The alignment drill-barrel has a proximal end and a forward-end also called the distal end. The proximal end of the alignment drill-barrel preferably has two ridges, and the distal end is generally tapered. The alignment drill-barrel is configured to receive and guide a drill-bit, bone tap, screw, bone fastener or other instrument into bone or other tissue. The alignment drill-barrel preferably allows for the passage of fixation pins or bone screws, drills, taps, or awls through it in a predetermined trajectory.

[0007] The bushing preferably has a radially expandable forward-end and a proximal end, wherein the forward-end is configured to engage a fastener hole in a bone-plate. The radially expandable forward end of the bushing preferably has a plurality of finger portions. The radially expandable forward end also preferably has a shoulder, neck, and an outwardly projecting rim disposed forward of the neck. The bushing is configured to slidably receive the alignment drill-barrel. Sliding the alignment drill-barrel toward the forward end of the bushing preferably expands the forward end of the bushing to secure the drill-guide assembly in a bone-plate.

[0008] The dual-arm support in one embodiment is generally "L-shaped" with the two ends of the "L" forming an obtuse angle. The dual-arm support preferably has a space provided in its center region. In one embodiment, the end portion, which is generally horizontally disposed, comprises a pivot-hole for inserting a pivot screw. At one end, the dual-arm support is immovably or fixedly connected to the proximal end of the bushing, while at its other end, the dual-arm support is immovably connected to the front end of the handle member.

[0009] The handle member in an exemplary embodiment has a front end and a back end. It is generally oval shaped with broad grooves on top to provide better grip for the surgeon or user using the drill-guide assembly. The handle may be hollow or solid depending upon design choice.

[0010] The ratchet-gear mechanism in one embodiment is generally "Y-shaped" and is housed within the space of the dual-arm support. At one end, the first leg of the ratchet-gear mechanism is pivotably connected to the dual-arm support at a pivot-point. That end of the first leg further extends beyond the pivot point forming a C-shaped vice-grip. The C-shaped vice-grip attaches to the alignment drill-barrel. The C-shaped vice-grip grasps the alignment drill-barrel in between the two ridges at the proximal end. In a preferred embodiment, the plane of the C-shaped vice-grip is generally perpendicular to the axial direction of the alignment drill-barrel, and the bushing. The second leg of the Y-shaped ratchet-gear mechanism comprises pawls on the outer side which permit incremental swiveling of the ratchet-gear mechanism in a plane perpendicular to the plane of C-shaped vice-grip. The tail-end of the Y-shaped ratchet-gear mechanism acts as a trigger and generally moves in a rotational motion relative to the pivot point in a direction toward or away from the handle member. Movement of the ratchet-gear mechanism, and particularly the C-shaped vice grip, slides the alignment drill-barrel relative to the bushing.

[0011] The release knob in an exemplary embodiment has a curved longitudinal member with a base. The base has serrations on one side of its circumferential border and a hole on the other side. The release knob is pivoted through the hole in the base about a dowel pin that is attached to the dual-arm support.

[0012] When the tail of the Y-shaped ratchet-gear mechanism is pressed by a finger of a user in a rotary motion in a direction toward the handle member, the distal end of the alignment drill-barrel is urged into the bushing which in turn, expands the forward-end of the bushing, thus locking the bushing within a hole or recess of the bone-plate. The bushing is configured and dimensioned to expand within a bone-plate hole or recess such that it is releasably locked to the bone-plate.

[0013] When the Y-shaped ratchet-gear mechanism engages the release knob, the pawls on the outer surface of the second leg of the Y-shaped ratchet-gear mechanism engage the serrations on the release knob to lock the drill-guide to the bone-plate. The alignment drill-barrel preferably self-aligns with the axis of the fastener hole in the plate.

[0014] When the release knob is further pressed, the pawls are disengaged from the serrations, and the Y-shaped ratchet-gear mechanism returns to an unactuated position, preferably by action of a biasing member such as a spring. The Y-shaped ratchet-gear mechanism, in turn, through its C-shaped vice-grip moves the alignment drill-barrel in a longitudinal direction along its axis, away from the fingers. As a result, the bushing assumes a retracted position thereby disengaging the hole or recess.

[0015] Another embodiment of a drill-guide assembly is described, comprising an alignment barrel having a proximal end and a distal end; a bushing configured to slidably receive the alignment barrel, the bushing having a radially expandable forward-end and a proximal end, the forward-end configured to be insertable within a hole or recess in a bone plate; a release knob having serrations; and a movable ratchet gear mechanism having a first leg, a second leg and a tail, the first leg of the ratchet-gear mechanism connected to the alignment barrel, the second leg of the ratchet-gear mechanism having pawls configured and adapted to engage the serrations to hold the alignment barrel in position, the tail of the ratchet gear mechanism operable by a user to selectively move the ratchet-gear mechanism, wherein, movement of the ratchet-gear mechanism slides the alignment barrel relative to the bushing to radially expand the forward end to releasably lock the bushing to the plate, and a first drill guide coupled to the bushing, wherein the first drill guide is configured to receive and guide a drill-bit.

[0016] The first drill guide may be coupled to the bushing by a first connecting element. The first connecting element may have at least two bores for respectively receiving at least a portion a bushing therethrough and at least a portion of a drill guide therethrough. The first drill guide may also be further coupled to the bushing by a second connecting element, and the second connecting element may have at least two bores for respectively receiving at least a portion of a bushing therethrough and at least a portion of a drill guide therethrough.

[0017] At least two bores of the first connecting element may be separated by a first distance, and the at least two bores of the second connecting element may be separated by a second distance, wherein the first distance may be greater than the second distance, and wherein the second connecting element may be closer to the distal end of the forward end of the bushing than the first connecting element. Alternatively, the first connecting element may be closer to the distal end of the forward end of the bushing than the second connecting element.

[0018] The first connecting element may further comprise a fin bore configured to receive at least a portion of fin therethrough, wherein at least a portion of the fin in configured to engage at least a portion of a hole or recess when the bushing engages a bone-plate.

[0019] The drill-guide assembly may further comprise a second guide coupled to the bushing, wherein the second drill guide is configured to receive and guide a drill-bit. The second drill guide may be coupled to the first drill guide. The first and second drill guide may be coupled to the bushing by a first connecting element. The first connecting element may have at least three bores for respectively receiving at least a portion of the first drill guide therethrough, at least a portion of the second drill guide therethrough, and a least a portion of the bushing therethrough.

[0020] The first connecting element may further include a fin bore configured to receive at least a portion of fin therethrough, wherein at least a portion of the fin in configured to engage at least a portion of a hole or recess when the bushing engages a bone-plate.

[0021] The first drill guide and second drill guide may further be coupled to the bushing by a second connecting element.

[0022] The second connecting element may also have at least three bores for respectively receiving at least a portion of the first drill guide therethrough, at least a portion of the second drill guide therethrough, and a least a portion of the bushing therethrough.

[0023] The bores of the first connecting element receiving first and second drill guides are separated by a first distance, and the bores of the second connecting element receiving first and second drill guides are separated by a second distance, wherein the first distance is greater than the second distance, and wherein the second connecting element may be closer to the distal end of the forward end of the bushing than the first connecting element. Alternatively, the first connecting element may be closer to the distal end of the forward end of the bushing than the second connecting element.

[0024] The first drill guide may have a longitudinal axis, and when the bushing is locked to a bone-plate, the longitudinal axis of the first drill guide may generally be aligned with a first bone-fastener hole of the bone-plate. The drill-guide assembly may further comprise a second drill guide configured to receive and guide a drill-bit and coupled to the bushing, the second drill guide having a longitudinal axis, and when the bushing is locked to a bone-plate, the longitudinal axis of the second drill guide may be generally aligned with a second bone-fastener hole of the bone-plate. The recess of the bone-plate includes at least one shaped area and a slot.

[0025] An alternative method for drilling holes in bone is also described, comprising the steps of: (a) providing a drill-guide assembly, comprising an alignment barrel having a proximal end and a distal end; a bushing configured to slidably receive the alignment barrel, the bushing having a radially expandable forward-end and a proximal end, the forward-end configured to be insertable within a hole or recess in a bone plate; a release knob having serrations; and a movable ratchet gear mechanism having a first leg, a second leg and a tail, the first leg of the ratchet-gear mechanism connected to the alignment barrel, the second leg of the ratchet-gear mechanism having pawls configured and adapted to engage the serrations to hold the alignment barrel in position, the tail of the ratchet gear mechanism operable by a user to selectively move the ratchet-gear mechanism, wherein, movement of the ratchet-gear mechanism slides the alignment barrel relative to the bushing to radially expand the forward end to releasably lock the bushing to the plate, and at least a first guide coupled to the bushing, wherein the first drill guide is configured to receive and guide a drill-bit; (b) inserting the bushing into a recess of a bone plate; (c) aligning at least the first drill guide with a first bone fastener hole in the bone-plate; (d) expanding the bushing in the recess; (e) locking the bushing to the plate; (f) inserting a drill-bit into the first drill guide; and (g) drilling a first hole.

[0026] At least a portion of the forward end of the bushing may be configured to fit in at least a portion of the recess. The bushing may be locked to the plate by locking the alignment barrel and bushing in fixed relation to each other. The drill guide assembly may further comprise a second drill guide coupled to the bushing, wherein the second drill guide is configured to receive and guide a drill-bit.

[0027] The method may further comprise the steps of inserting a drill-bit guide into the second drill guide, and drilling a second hole.

[0028] A kit for use with drilling bones is also described, comprising: (a) a drill-guide assembly, comprising an alignment barrel having a proximal end and a distal end; a bushing configured to slidably receive the alignment barrel, the bushing having a radially expandable forward-end and a proximal end, the forward-end configured to be insertable within a hole or recess in a bone plate; a release knob having serrations; and a movable ratchet gear mechanism having a first leg, a second leg and a tail, the first leg of the ratchet-gear mechanism connected to the alignment barrel, the second leg of the ratchet-gear mechanism having pawls configured and adapted to engage the serrations to hold the alignment barrel in position, the tail of the ratchet gear mechanism operable by a user to selectively move the ratchet-gear mechanism, wherein, movement of the ratchet-gear mechanism slides the alignment barrel relative to the bushing to radially expand the forward end to releasably lock the bushing to the plate; (b) at least first and second drill guides able to be coupled to the bushing; and (c) at least first and second connecting elements for coupling at least one drill guide to the bushing.

[0029] At least the first and second drill guides may have different lengths, and at least the first and second drill guides may have different diameters. At least the first and second connecting elements may each have a bore for receiving at least one drill guide therethrough and a bore for receiving a bushing therethrough, wherein the bores of the first connecting element have a first arrangement, and the bores of the second connecting element have a second arrangement, and wherein the first arrangement may be substantially different than the second arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Preferred features of the present invention are disclosed in the accompanying drawings, wherein similar reference characters denote similar elements throughout the several views. While the presentation is desired and its features presented according to certain illustrated embodiments it is to be understood that the invention is not so limited to the particular embodiments shown and described, wherein:

[0031] FIG. 1 is a perspective view of a first embodiment of a drill-guide assembly;

[0032] FIG. 2 is a cross-sectional view of an embodiment of an alignment drill-barrel that may be used with the assembly of FIG. 1;

[0033] FIG. 3 is a partial cross-sectional view of another embodiment of an alignment drill-barrel that may be used with the assembly of FIG. 1;

[0034] FIG. 4 is a cross-sectional view of an embodiment of the bushing;

[0035] FIG. 5 is a side view of the dual-arm support attached to the bushing and handle member;

[0036] FIG. 6 is a perspective view of the Y-shaped ratchet-gear mechanism;

[0037] FIG. 6A is a side view of the Y-shaped ratchet-gear mechanism;

[0038] FIG. 6B is a perspective view of the drill-guide assembly showing the ratchet-gear mechanism connected to the dual-arm support;

[0039] FIG. 7 is a side view of the release knob;

[0040] FIG. 7A is a perspective view of the ratchet-gear mechanism engaging the release knob;

[0041] FIG. 8 is a side view of the handle member of the drill-guide assembly;

[0042] FIG. 9 is a side view of the bushing with fingers in retracted position;

[0043] FIG. 10 is a side view of the bushing with fingers in expanded position; and

[0044] FIG. 11 is a perspective view of the drill-guide assembly of FIG. 1 engaged to a bone-plate.

[0045] FIG. 12A is a perspective view of another embodiment of a drill-guide assembly with drill guides;

[0046] FIG. 12B is another perspective view of the assembly of FIG. 12A;

[0047] FIG. 12C is a partial top view of an exemplary bone plate that can be used with the assemblies of FIGS. 1 and 12A;

[0048] FIG. 13A is a top view of a proximal connecting element for use with the assembly of FIG. 12A; and

[0049] FIG. 13B is a top view of a distal connecting element for use with the assembly of FIG. 12A.

DETAILED DESCRIPTION OF THE INVENTION

[0050] Referring to FIG. 1, there is shown an exemplary surgical drill-guide assembly 5, which is adapted for use with a cervical spine-locking bone plate having a plurality of fastener holes. While the surgical drill-guide assembly is described in conjunction with a cervical locking plate it will be appreciated that the reference to a cervical locking plate is only exemplary, and that the surgical drill-guide assembly can be used with a variety of bone plates, including a locking and a nonlocking bone-plate as well as for example, bone plates for long bones, maxillofacial applications, etc.

[0051] This embodiment of a drill-guide assembly 5 can be secured or locked into a fastener hole in a bone plate. A related embodiment of a drill-guide assembly 500 that can be secured or locked into a drill recess 354 is shown *infra* in FIGS. 12A-13B. Locking or securing may facilitate precision in the surgical procedure, for example, drilling or fastening screws or other similar fasteners. Moreover, the drill-guide can be quickly detached and released from the bone-plate improving the speed of surgical procedures involving drilling or similar procedures.

[0052] Drill-guide assembly 5 may include an alignment assembly 15, a release knob 100, a handle member 250, a ratchet-gear mechanism 50, and a dual-arm support 10.

[0053] The alignment assembly 15 may comprise an alignment drill-barrel 150 and a bushing 200. A surgeon or a user can releasably attach the alignment assembly 15 in the fastener hole 352 of a bone-plate 350. Other attachment options are discussed *infra*, particularly in relation to FIGS. 12A-13B. A drill-bit or other such instrument can be inserted into and through the alignment assembly 15.

[0054] Referring to FIG. 2, an embodiment of the alignment drill-barrel 150 is shown. The alignment drill-barrel 150 may have a through bore 185 from its proximal end 174 to its distal end 172. A drill-bit or other instrument may be inserted through the bore 185. In the embodiment of FIG. 2, the drill-barrel comprises a first hollow cylindrical section 156 with an annular diameter of x_{12}, a second hollow cylindrical section 158 with an inside annular diameter of x_{18}, and a third hollow cylindrical section 160 with an inside annular diameter of x_{24}, wherein x_{24} is smaller than x_{18}, and x_{18} is smaller than x_{12}. The outside surface of the alignment drill-barrel 150 comprises a shoulder 162 and a shoulder 164 wherein the outside diameter of the first section 166 is x_{14} which is greater than the outside diameter x_{20} of the second section 168. x_{14} has an exemplary diameter of 3 mm to 10 mm, preferably about 8 mm. The third section 170 is a conical section that tapers from an outside diameter x_{22} at shoulder 164 to a diameter x_{26} at the distal end 172. The proximal end 174 of the alignment drill-barrel 150 preferably has first circular ridge 152 and second circular ridge 154. The first and the second circular ridges 152 and 154 respectively, have an outside diameter x_{16}.

[0055] In this embodiment, the first circular ridge 152 is flush with the proximal end 174 of the alignment drill-barrel 150. The conical section 170 tapers from an outside diameter x_{22} at the transition 164 to an outside diameter x_{26} at end 172. Preferably, inner diameter x_{24} is constant along the length of conical section 170 of alignment drill-barrel 150 as defined along center line 180.

[0056] Referring to FIG. 3, an alignment drill-barrel 150 according to another embodiment is shown. In FIG. 3, alignment drill-barrel 150 is hollow with a cylindrical section 182 and a tapered, conical section 184 to facilitate movement of alignment drill-barrel 150 within bushing 200. Cylindrical section 182 has outside diameter x_5, while conical section 184 tapers from an outside diameter x_5 at the transition 186 to an outside diameter x_6 at the distal end 188. Preferably, inner diameter x_7 may be constant along the length of alignment drill-barrel 150 as defined along center line 190.

[0057] Referring to FIG. 4, a bushing is shown. Bushing 200 may coaxially receive alignment drill-barrel 150 about a central line 240. Bushing 200 may be substantially symmetrical about line 240. The forward end 222 of bushing 200 may preferably be comprised of longitudinally extending fingers 210. Individual fingers 210 may be separated by slits 204 extending longitudinally between adjacent fingers 210. Slits 204 as shown, for example, in FIG. 4, may include a circular portion 206 that serves to minimize stress concentration when fingers 210 are flexed. Fingers 210 may be resiliently biased inwardly and naturally assume an inward disposition when in a relaxed state. At a front portion of the expandable forward end 202 of bushing 200, the fingers 210 may form a radially expandable circumferential neck 208. At the back end of and adjacent to neck 208 may preferably be a shoulder 212.

[0058] Neck 208 may span a length that is slightly longer than the thickness of the fastener hole wall from the bone-side surface to the top surface of a bone-plate. Thus, neck 208 can be inserted into the bone-plate fastener hole 352 and the fingers 210 expanded to secure the bushing 200 to the plate. More particularly, movement of alignment drill-barrel 150 within bushing 200 may expand fingers 210 to secure the bushing 200 to the bone plate. In this manner, the drill-guide assembly can be secured to the plate, restricting relative movement. In a preferred embodiment, fingers 210 forming a radially expandable rim 214 may be provided at the front end of and adjacent to neck 208.

[0059] In another embodiment, the distal end 222 of the bushing 200 may not contain the rim 214, the neck 208 or the shoulder 212, but instead has a tapered end with the inner and the outer diameter of the tapered end decreasing from point 220 shown in FIG. 4. In such an embodiment, the taper is such that it may fit freely through a fastener hole in a bone plate.

[0060] In alternate embodiments, no rim may be used. The several portions of bushing 200, i.e., the neck 208, the shoulder 212, and the rim 214, may preferably be a single piece of material of unitary construction.

[0061] In other alternate embodiments, fingers 210 need not include a shoulder, neck, and/or a rim. Instead, for example, a small pin may be used to secure the bushing to the plate. In an alternatively preferred embodiment, the inward bias of fingers 210 is selected to produce the desired friction with the bone-plate 350 so that the fingers 210 fit snugly within the bone-plate fastener hole 352 (or drill recess 354, as discussed *infra* in relation to FIGS. 12A-13B), preferably allowing operation of handle member 250 with only one hand. Alternative resiliency for fingers 210 may be varied to suit the purpose of the design.

[0062] In a preferred embodiment bushing 200 has one or more longitudinal slots on its side 224 in axial direction 240 just above the circular portion 206. These slots provide better cleaning during autoclave or other disinfection and/or cleaning procedures.

[0063] Referring to FIG. 4, bushing 200 has a circumferential ridge 218 with an outer diameter x_3, and a region 216 has an outer diameter x_4. x_4 has an exemplary dimension of 4 mm to 20 mm, preferably about 8 mm.

[0064] As shown in FIG. 5, in one embodiment, dual-arm support 10 connects the handle member 250 to the alignment assembly 15. More specifically, in the exemplary embodiments of FIGS. 1 and 2, the dual-arm support 10 is fixedly connected at its end to the proximal end 174 of the alignment assembly 15. Dual-arm support 10 preferably is generally "L-shaped" with first part 14 connected to bushing 200. More specifically, end 12 of dual-arm support 10 is attached to ridge 218 at the proximal end 242 of the bushing 200.

[0065] The dual-arm support 10 is preferably fixed with the bushing 200 by welding. In an alternative embodiment, friction fitting, press fitting, and such can be used. Outer diameter x_3 of ridge 218 is about the same size as inner diameter x_1 of the clamp 12 of the dual-arm support 10. Bushing 200 may also be fixed to dual-arm support 10 by releasable fastener means. First part 14 is generally perpendicular to the axial direction of the alignment assembly 15 or the bushing 200. The second part 16 of the dual-arm support 10 preferably forms an obtuse angle θ_{d1} with the first part 14 of the dual-arm support 10. θ_{d1} may range from about 90° to about 180º, and more preferably from about 105º to about 135º. Dual-arm support 10 and handle member 250 are fixedly connected by a dowel pin 20 at the front end of the handle member 250, so that they are immovable with respect to each other. In the preferred embodiment, handle member 250 is located remotely from the drilling site, thereby increasing visibility near the locking bone plate 350.

[0066] As shown in FIG. 5, the second part 16 of the dual-arm support 10 may be attached to the first part 14 by a dowel pin 18, or the dual-arm support 10 may be an integral, monolithic construction. The second part 16 of the dual-arm support 10 also forms an obtuse angle θ_{d2} with the handle member 250. θ_{d2} may range from about 90° to about 180º, and more preferably from about 105º to about 135º. The handle member 250 and the dual-arm support 10 generally form an "S" shape or a zigzag shape, and in a preferred embodiment, the longitudinal axis 24 of the first part 14 and the longitudinal axis 26 of the second part 16 lie in the same plane. The longitudinal axis 280 of the handle member 250 also preferably lies in the same plane as the longitudinal axis 24 of the first part 14 and the longitudinal axis 26 of the second part 16 of the dual-arm support 10. Preferably the longitudinal axis 24 of the first-part 14 of the dual-arm support 10 is generally parallel with the longitudinal axis 280 of the handle member 250.

[0067] Referring to FIG. 6, there is shown an exemplary embodiment of the ratchet-gear mechanism 50. The ratchet-gear mechanism 50 allows the user to manipulate the locking and release of the drill-guide assembly 5 with the bone-plate 350 by engagement and disengagement, respectively, of the pawls 58 with the serrations 102. The ratchet-gear mechanism 50, in a preferred embodiment is generally "Y-shaped" with a first leg 52, a second leg 54, and a tail 56.

[0068] The first leg 52 of the ratchet-gear mechanism comprises a generally C-shaped vice-grip 60 at its end, and a pivot hole 62 for insertion of a pivot screw 64. The C-shaped vice-grip 60 grips the alignment drill-barrel 150 in between the first ridge 152 and second ridge 154 (see also FIG. 2) located at the end 174 of the drill-barrel 150. As shown in FIG. 6A, in a preferred embodiment, the plane of the C-shaped vice-grip 60 that forms an anterior portion of the first leg 52 of the Y-shaped ratchet-gear mechanism 50 makes an acute angle θ_d with the longitudinal axis 64 of the first leg 52 of the Y-shaped ratchet-gear mechanism 50. At the point of inflexion between the longitudinal first leg 52 and the C-shaped vice grip 60, pivot screw 64 and hole 62 are located. This pivot mechanism 62 helps the movement of the alignment drill-barrel 150. In a preferred embodiment, the acute angle is from about 25° to about 45°. In a further preferred embodiment the acute angle θ_d is such that when the ratchet-gear mechanism 50 is completely disengaged from the serrations 102 of the release knob 100, the alignment drill-barrel 150 can be removed from the bushing 200 in a longitudinal direction away from the fingers 210 by moving the ratchet-gear mechanism 50 in a direction away from the handle member 250, about the pivot screw 64. θ_d may be 0º to 90º, with an exemplary dimension of 60º.

[0069] The second leg 54 of the Y-shaped ratchet-gear mechanism 50 comprises horizontal pawls 58 which engage serrations 102 at the end of the release knob 100. The tail 56 of the Y-shaped ratchet-gear mechanism 50 acts as a trigger for a user to apply a force to actuate movement of the alignment drill-barrel 150.

[0070] Referring to FIG. 7, the release knob 100 is pivoted about a dowel pin 106 which is inserted through the dowel pin hole 104 in the release knob 100, and the release knob hole 142 in the second part 16 of the dual-arm support 10. With pivotal support from the dowel pin 106, the serrations 102 on the surface of the release knob 100 can engage with the pawls 58 on the second leg 54 of the Y-shaped ratchet-gear mechanism, when the tail 56 (trigger) of the Y-shaped ratchet-mechanism is pressed or moved in a direction toward the handle member 250. In a preferred embodiment, the release knob 100 has a rubber sleeve 106 or a sleeve made from a material which provides a firm traction when the surgeon or the user presses the release knob 100. Alternatively, or additionally the surface of the release knob may have surface texturing to increase the traction when a surgeon or a user manipulates the release knob 100.

[0071] Referring to FIG. 8, handle member 250 is shown. Handle member 250 is generally oval shaped with broad grooves 252 on top to provide better grip to the surgeon or user when using the drill-guide assembly 5. At the front end 254 of the handle member 250, there are two cavities, the first cavity 256 and the second cavity 258. The first cavity 256 has an axis along line 260 and the second cavity 258 has an axis along line 270. The first cavity 256 houses compression spring 272 and the second cavity 258 houses the dual-arm support 10, or more specifically the second part 16 of the dual-arm support 10. The second part 16 of the dual-arm support 10 is fixed to the handle member 250 by a dowel pin 20. The dowel pin 20, in a preferred embodiment, is generally perpendicular to the axis 280 of the handle member 250. Exemplary dimensions of the handle are 100 to 150 mm long with a width at the widest point of 15 mm to 40 mm.

[0072] When a surgeon or a user presses the trigger 56, toward handle member 250, the ratchet-gear mechanism 50 swivels. Due to the movement of the Y-shaped ratchet-gear mechanism 50 in the direction of the handle member 250, the alignment drill-barrel 150 moves the bushing 200 in the downward direction toward the bone-plate 350. Due to the conical shape 170 of the alignment drill-barrel 150 (FIG. 2), the fingers 210 on the bushing 200 expand in an outward direction as the front end 172 of alignment drill-barrel 150 approaches the front edge 214 of bushing 200. When the outward diameter of the fingers 210 matches that of the fastener hole 352, the drill-guide assembly 5 locks to the bone-plate 350. A surgical drill-bit 400 or any other appropriate bit, screw, tap, awl, or such device, can be inserted through the alignment drill-barrel 150.

[0073] Alignment drill-barrel 150 may be configured and dimensioned to be slidably received within bushing 200. The alignment drill-barrel 150 and bushing 200 may cooperate to permit drill-guide assembly 5 to lock to a bone plate 350. The conical section 184 of the alignment drill-barrel 150 may cooperate with fingers 210 of bushing 200 to expand fingers 210 when the alignment drill-barrel 150 is moved into a locked position. The conical section 184 of alignment drill-barrel 150 may push outwardly against the inner surface of the bushing 200 as alignment drill-barrel 150 is moved forward to expand the forward end 214 of the bushing 200. In this embodiment, the conical section mates with and pushes against the inner surface of the bushing 200 forward of circular portion 206 of slits 204 in fingers 210, to push the fingers 210 radially outward (*see* FIG. 4).

[0074] Alignment drill-barrel 150 may be aligned within bushing 200, such that center line 240 or 190 may be collinear with line 180. When bushing 200 is placed in a fastener hole of a bone plate, and ratchet-gear mechanism 50 is actuated such that the almost fully actuated position is reached (i.e. when trigger 56 is substantially parallel to handle member 250), end 172 of alignment drill-barrel 150 may be substantially coplanar with rim 214 of bushing 200. It should be noted that alignment drill-barrel 150 may be coaxially received in bushing 200 which may also be the path of surgical drill-bit 400 inserted in cannula 182 of the alignment drill-barrel 150.

[0075] Generally, a surgeon or user should continue to depress the trigger 56 and handle member 250 toward each other to maintain an actuated position of Y-shaped ratchet-gear mechanism. Depending on the size of the fastener hole 352 (or drill recess 354, *see* FIGS. 12A-13B) and the firmness of the locking desired, the pawls 58 located on the second leg 54 of the Y-shaped ratchet-gear mechanism 50 may engage with the serrations 102 on the release knob 100 holding the ratchet-gear mechanism 50 in place. The release knob 100 preferably may be held firm in its position by the compression force of the spring mechanism 272, which may be located at the front end 254 inside the cavity 256 of the handle member 250. With the ratchet-gear mechanism 50 provided in this drill-guide assembly 5, the serrations 102 on the release knob 100 can be used to releasably lock Y-shaped ratchet-gear mechanism 50 at the desired level of actuation. This may obviate the need for a surgeon or user to continue to depress the trigger 56 relative to handle member 250 after desired actuation has occurred. The pawls 58 on the second leg 54 of the Y-shaped ratchet-gear mechanism 50 may engage the serrations 102 on the release knob 100 when the trigger 56 is pressed sufficiently. The release knob 100 may be held in a fixed position as a result of the compression force exerted by the compressed spring 272.

[0076] When the release knob 100 is pressed in the direction of the front end 254 of the handle member 250, the spring member 272 may be compressed, the pawls 58 may be disengaged from the serrations 102, and the Y-shaped ratchet-gear mechanism 50 may become unactuated. When the Y-shaped ratchet-gear mechanism 50 is unactuated, the force that is keeping the alignment drill-barrel 150 in a position toward fingers 210 may be released. As a result, the alignment drill-barrel 100 may no longer be pushing the fingers 210 on the bushing 200 in an outward direction toward the bone-plate 350. The alignment drill-barrel 150 can be then moved in a longitudinal direction away from the fingers 210 on the bushing 200. As a result, the bushing 200 may assume a retracted position as demonstrated in FIG. 9. Once the fingers 210 retract, the drill-assembly 5 may unlock from the fastener hole 352 or drill recess 354 of the bone-plate 350 and the user or surgeon can withdraw it.

[0077] When the release knob 100 is pressed to further compress the spring, the pawls 58 may disengage from serrations 102, thereby de-actuating the Y-shaped ratchet-gear mechanism 50, which in turn, through the pivot action at the pivot screw 64 may result in the movement of the alignment drill-barrel 150 in a direction away from the bone-plate 350.

[0078] Advantageously, a surgeon or user can operate drill-guide 5 with only one hand, due to the ergonomic positioning of trigger 56 and handle member 250. With the embodiment illustrated in FIG. 1, a user can attach the drill-guide by using a finger, such as an index finger, to engage and manipulate the tail 56 of the ratchet-gear mechanism 50, and while a second different finger, such as a thumb, to engage and manipulate the release knob 100.

[0079] When the alignment drill-barrel 150 is in the unlocked position as shown in FIG. 9, the conical section 184 allows fingers 210 to return to a relaxed, contracted position. This allows bushing 200 to be inserted and retracted from plate fastener hole. The inner surface of the bushing 200 forward of steps 220 in bushing 200 is preferably tapered at an angle θ_B to line 240 that is about 1 degree more than taper angle θ_T of conical sections 184, and preferably angle θ_B is about 4 degrees. A desirable amount of movement of alignment drill-barrel 150 within bushing 200 is thus provided to bias fingers 210 of bushing 200 from a contracted position to an expanded position. Alternative taper angles of conical section 184 and inner surface of bushing 200 may be chosen according to varying design criteria. In addition, a preferred, short movement of trigger 56 (ratchet-gear mechanism 50) is required to expand and contract fingers 210 of bushing 200.

[0080] Before and during bone plate implantation, the surgeon or user may insert the expandable distal end 222 of bushing 200 in particular neck 208 and rim 214, into fastener hole 352 or drill recess 354 in a bone plate 350. By pressing trigger 56 of the Y-shaped ratchet-gear mechanism 50 relative to the handle member 250, the surgeon or user may grasp and manipulate the plate 350 without an additional plate holder if so desired. Friction between the forward conical section 184 of the alignment drill-barrel 150 and the inner surface of fingers 210 especially at neck 208 and rim 214 may retain the expandable distal end 222 of bushing 200 in an expanded, locked position. Thus, when bushing 200 is in the expanded, locked position in a fastener hole of a plate placed in position for implantation, movement of the plate during the drilling operation can be minimized.

[0081] Drill-barrel 150 may preferably be sized so that once the bone plate 350 is properly positioned over the implantation site and bushing 206 is locked to the plate, the insertion point of a surgical drill-bit 400 at the proximal end of drill-barrel 150, is located at a distance beyond the patient's body such that a spinning surgical drill-bit 400 will not laterally reach or harm surrounding tissues that the surgeon or user does not intend to drill.

[0082] Preferably, the surgical drill-bits used with surgical drill-guide assembly 5 are configured and dimensioned to drill holes of about 12, 14, or 16 mm in depth. Suitable drill-bits typically have integral stops so that when the drill-bits are used with alignment drill-barrel of an established length, the holes produced by the drill-bit will not be deeper than the intended depth using a given bit. The stops may be positioned to abut the upper surfaces at the proximal end of drill-barrel 150, when a drill-bit has been inserted in the barrel to a particular depth.

[0083] Another embodiment of a drill-guide assembly 500 is shown in FIGS. 12A-13B. As with drill-guide assembly 5 (see FIG. 1, *supra*), assembly 500 may include an alignment assembly 515, release knob 600, handle member 650, ratchet-gear mechanism 550, bushing 450 with fingers 570 and slits 572, and a dual-arm support 610, the components of which may exhibit some or all of the characteristics of the corresponding components described above in relation to assembly 5.

[0084] Drill-guide assembly 500 may also include first and second drill guides 502, 504 for use with surgical drill (e.g., 400). Drill guides 502, 504 may be connected to bushing

450 by proximal and distal connecting elements 510, 512, which are discussed in more detail below in relation to FIGS. 13A-13B. Drill guides 502, 504 may also have proximal ends 506, 508 and distal ends 516, 518, with a bores 507, 509 extending therebetween. The bores 507, 509 should be sized to receive at least a portion of a surgical drill, and should preferably align with a bone fastener hole 352 during use. Drill guides 502, 504 may have a length L_1, L_2 (*see* Figs. 12A-B) from about 150 mm to about 350 mm, and more preferably, a length of about 260 mm. Generally, drill guides 502, 504 have a greater length than bushing 450. Drill guide lengths L_1, L_2 may or may not be approximately equal.

[0085] Bores 507, 509 may have a variable diameter B_1, B_2 along the length L_1, L_2 of drill guides 502, 504. Bore diameter B_1, B_2 may have a diameter of about 5 mm to about 15 mm at proximal ends 506, 508 and/or distal ends 516, 518.

[0086] Drill-guide assembly 500 may be used with the plate shown in FIG. 12C. Plate 350 may have a plurality of fastener holes 352 and at least one drill recess 354 in body 351. Recess 354 may have shaped areas 356a, 356b with midpoint 358a, 358b, with a distance MPD between midpoints. Recess 354 may also have a slot area 360 extending between shaped areas 356a, 356b.

[0087] Alternatively, recess 354 may at least partially comprise a polygonal shape, such as a hexagon, rectangle, or square. The recess 354 may also take the shape of a plurality of polygonal shapes, for example, two overlapping hexagons may comprise the shape of the recess 354 to form a combination-polygonal recess. These embodiments may be particularly useful in bone-plates with a reduced area in which to place a recess 354 for purposes of aligning assembly 500.

[0088] In use, the fingers 570 of bushing 450 of assembly 500 may be inserted into drill recess 354, instead of fastener hole 352. The engagement and/or locking of the bushing 450 within a drill recess 354 may take some or all of the characteristics of the engagement and/or locking of bushing 200 with a fastener hole 352, as described above. Generally, it may be preferable for the bushing 450 to engage the drill recess 354 at shaped area 356a, 356b. The placement and locking of bushing 450 at shaped area 356a may align drill guides 502, 504 with fastener holes 352a, 352b, respectively. Similarly, the placement and locking of bushing 450 at shaped area 356b may align drill guides 502, 504 with fastener holes 352c, 352d, respectively.

[0089] Assembly 500 may also have a fin 514 to assist the insertion, locking, and/or alignment of the assembly in a drill recess 354. Fin 514 may generally be an elongated component, with at least a portion of the fin 514 secured in the distal connecting element 512 at fin bore 536 (*see* FIG 13B). In use, when the bushing engages a shaped area 356a, 356b, the fin concurrently engages slot 360. The fin 514 may or may not touch the sides of the slot 360 when the bushing 450 is fully inserted into a shaped area 356a, 356b.

[0090] FIG. 13A is a top view of a proximal connecting element 510, and FIG. 13B is a top view of a distal connecting element 512. Proximal connecting element 510 may have a bushing bore 530a, and first and second drill guide bores 532a, 534a. First and second drill guide bores 532a, 534a may have respective midpoints 537a, 539a, wherein a distance D_1 extends between midpoints 537a, 539a. Distal connecting element 512 similarly may have a bushing bore 530b, and first and second drill guide bores 532b, 534b with respective midpoints 537b, 539b. Midpoints 537b, 539b may have a distance D_2 between them. Distal connecting element 512 may also have a fin bore 536 located near the bushing bore 530b. Fin bore 536 may receive at least a portion of a fin 514, as discussed above.

[0091] Bushing bores 530a, 530b may receive at least a portion of a bushing 450. Likewise, first and second drill guide bores 532a, 534a, 532b, 534b may receive at least a portion of a first and second drill guide 502, 504, respectively. Generally, the proximal connecting element 510 may be situated near the proximal ends 506, 508 of first and second drill guide 502, 504, and the distal connecting element 512 may be situated near the distal ends 516, 518 of the first and second drill guides 502, 504. While the embodiment in FIGS. 12A-12B show two connecting elements, 502, 504, it contemplated that only one connecting element could be used, or that more than two connecting elements could be utilized with a single assembly 500.

[0092] The placement of the bores in the connecting elements 510, 512 may determine the angles and arrangements of which the bushing 450 and first and second drill guides 502, 504 are situated in relation to one another. For instance, the embodiment shown in FIGS 12A-13B utilizes proximal connecting element 510 with distance D_1 larger than the distance D_2 of the distal connecting element 512. The result of this arrangement is, as bushing 450 and first and second drill guides 502, 504 are generally linear, that the bushing and drill guides are generally convergent from the proximal end of the assembly to the distal end of the assembly 500. However, it is contemplated that D_1 and D_2 could be substantially equal, thereby creating an arrangement where the bushing and drill guides would be substantially parallel. Moreover, D_2 may be greater than D_1, thereby creating a divergent relationship between the bushing and/or drill guides from the proximal to the distal end of the assembly 500. Generally, both D_1 and D_2 may be from about 5 mm to about 35 mm. The sizes of the bores of each connecting element 510, 512 may generally fit a desired engagement portion of a bushing and/or drill guide.

[0093] Those skilled in the art will recognize that bushing 200, 450 may be configured and dimensioned to fit bone plate fastener holes and/or drill recesses with shapes other than circular. For example, bushing 200, 450 may be adapted to fit elliptical, hexagonal, star-shaped, or square fastener holes and/or drill recesses.

[0094] Preferably, the components of surgical drill-guide assembly 5 are metallic, passivated, and electropolished. Most preferably, the components are formed of stainless steel, except for the springs which are formed of spring steel, although other materials may be used. Preferably, at least the handle member is forged, while the other components may be machined, and the surgical drill-guide assembly preferably has a matte finish so that the surfaces of the components do not reflect operating room light in such a manner as to distract the surgeon or user. Some components may be subjected to heat treatments so that the surfaces are work hardened. The surfaces are preferably burr-free. Preferably, the surface finish allows individual components to move with respect to each other in a smooth and non-binding fashion through each component's entire range of motion. Additionally, all pins and fasteners are preferably flush with the surfaces into which they are fixed.

[0095] The present invention also involves several methods of drilling holes. In one embodiment, a surgeon or user may insert the bushing of a surgical drill-guide assembly into a fastener hole of a bone-plate and may depress the ratchet-gear mechanism to slide the alignment drill-barrel forward, expanding the bushing preferably by the conical portions of the alignment drill-barrel radially spreading the fingers in the bushing. The surgeon or user may then lock the bushing to the plate by locking the alignment drill-barrel and the bushing in fixed relation to each other, which thereby may relieve the surgeon or user of the need to squeeze the ratchet-gear mechanism toward the handle (*see* FIG. 11). The surgeon or user may align the surgical drill-bit along the drilling axis defined through the center of the bore in the alignment drill-barrel and inserts the drill-bit in the barrel. The surgeon or user then may drill a first hole coaxial with the central axis of a first fastener hole in the plate. The drill-bit may be stopped at a predetermined distance to provide a hole of predetermined depth. The drill-bit may be removed from the alignment drill-barrel. The bushing may thereafter be unlocked from the plate by pressing the release knob, which may release the bushing from the fastener hole so that the user can then freely and unfetteredly remove the drill-guide assembly from the plate.

[0096] In another embodiment of use, a surgeon or user may insert the bushing of a surgical drill-guide assembly into a shaped area drill recess of a bone-plate and may depress the ratchet-gear mechanism to slide the alignment drill-barrel forward, expanding the bushing preferably by the conical portions of the alignment drill-barrel radially spreading the fingers in the bushing. The fin of the assembly may concurrently engage the slot of the recess. The surgeon or user may then lock the bushing to the plate by locking the alignment drill-barrel and the bushing in fixed relation to each other, which thereby may relieve the surgeon or user of the need to squeeze the ratchet-gear mechanism toward the handle (*see*

FIG. 11). The surgeon or user may align the surgical drill-bit along the drilling axis defined through the centers of the bores of the first and/or second drill guides and may insert the drill-bit into the bores as desired.

[0097] While the invention has been shown and described herein with reference to particular embodiments, it is to be understood that the various additions, substitutions, or modifications of form, structure, arrangement, proportions, materials, and components and otherwise, used in the practice of the invention and which are particularly adapted to specific environments and operative requirements, may be made to the described embodiments without departing from the spirit and scope of the present invention. For example, the surgical drill-guide assembly may have alignment drill-barrel that can be angulated in the cephalad/caudal or sagittal planes, thereby permitting a range of angles to be chosen for the holes to be drilled and further permitting a range of spacings of plate holes to be accommodated. Moreover, alignment drill-barrel that is removeably attachable to the base may be provided so that a surgeon or user may select alignment drill-barrel with holes that precisely accommodate a desired drill-bit size. In addition, the drill-guide assembly handle may include a grip that generally follows the contours of fingers that hold the grip. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and not limited to the foregoing description.

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The claims defining the invention are as follows:

1. A drill-guide assembly, comprising:

an alignment drill-barrel configured to receive and guide a drill-bit, the alignment drill-barrel having a proximal end and a distal end;

a bushing configured to slidably receive the alignment drill-barrel, the bushing having a radially expandable forward-end and a proximal end, the forward-end configured to be insertable within a fastener hole in a bone plate;

a release knob having serrations; and

a movable ratchet gear mechanism having a first leg, a second leg and a tail,

the first leg of the ratchet-gear mechanism connected to the alignment drill-barrel,

the second leg of the ratchet-gear mechanism having pawls configured and adapted to engage the serrations to hold the alignment drill-barrel in position,

the tail of the ratchet gear mechanism operable by a user to selectively move the ratchet-gear mechanism,

wherein, movement of the ratchet-gear mechanism slides the alignment drill-barrel relative to the bushing to radially expand the forward end to releasably lock the bushing to the plate.

2. The drill-guide assembly of claim 1, wherein the ratchet-gear mechanism is pivotably mounted.

3. The drill-guide assembly of claim 1, wherein the release knob is pivotably mounted.

4. The drill-guide assembly of claim 1, wherein the ratchet-gear mechanism swivels incrementally.

5. The drill-guide assembly of claim 1, wherein the alignment drill-barrel comprises a through bore from the distal end to the proximal end.

6. The drill-guide assembly of claim 1, wherein the alignment drill barrel further comprises a first hollow cylindrical section, a second hollow cylindrical section and a third hollow cylindrical section wherein the annular diameter of the third cylindrical section is at least equal to the annular diameter of the second cylindrical section, and wherein the annular diameter of the second cylindrical section is at least equal to the annular diameter of the first cylindrical section.

7. The drill-guide assembly of claim 6, wherein the annular diameter of the third cylindrical section is constant along the center line of the cylindrical section.

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8. The drill-guide assembly of claim 1, wherein the alignment drill-barrel further comprises two ridges at the proximal end.

9. The drill-guide assembly of claim 8, wherein the outside surface of the alignment drill barrel has a shoulder at the distal end.

10. The drill-guide assembly of claim 8, wherein the outside diameter of the third cylindrical section tapers to form a conical shape.

11. The drill-guide assembly of claim 1, wherein the bushing further comprises radially expandable fingers.

12. The drill-guide assembly of claim 11, wherein the fingers form a radially expandable circumferential neck and assume an inward unexpanded disposition in relaxed state.

13. The drill-guide assembly of claim 12, wherein the bushing further comprises a shoulder adjacent to the radially expandable circumferential neck.

14. The drill-guide assembly of claim 11, wherein the distal end of the bushing comprises a tapered end with the inner and the outer diameter of the tapered end decreasing in direction of the tip.

15. The drill-guide assembly of claim 11, wherein the bushing is made from a single piece of material of unitary construction.

16. The drill-guide assembly of claim 11, wherein the bushing further comprises a pin for securing the drill-guide assembly to a bone-plate.

17. The drill-guide assembly of claim 11, wherein the bushing comprises at least one vertical slot above a circular portion on the bushing.

18. The drill-guide assembly of claim 1, further comprising:

a handle member for grasping by a user; and

a dual-arm support having first and second parts, the first part of the dual-arm support fixedly connected to the proximal end of the bushing and the second part of the dual-arm support fixedly connected to the handle member;

wherein the release knob is moveably connected to the handle member; and

wherein the first leg of the ratchet-gear mechanism is also pivotably connected to the dual-arm support.

19. The drill-guide assembly of claim 18, wherein the dual-arm support is L-shaped.

20. The drill-guide assembly of claim 18, wherein the dual-arm support is fixed to the bushing by a method of fixing selected from the group consisting of welding, friction fitting, and press fitting.

21. The drill-guide assembly of claim 18, wherein the first part of the dual-arm support and the axial direction of the alignment assembly form an angle in the range of from about 75 degree to about 120 degree.

22. The drill-guide assembly of claim 18, wherein the second part of the dual-arm support and the first part of the dual-arm support form an angle in the range of from about 90 degree to about 150 degree.

23. The drill-guide assembly of claim 18, wherein the handle member has a front end and a back end, and wherein the dual-arm support and the handle member are fixedly connected at the front end of the handle member.

24. The drill-guide assembly of claim 18, wherein the dual-arm support is an integral, monolithic construction.

25. The drill-guide assembly of claim 18, wherein the second part of the dual-arm support and the handle member form an angle in the range from about 90 degree to about 150 degree.

26. The drill-guide assembly of claim 18, wherein the longitudinal axis of the handle member lies in the same plane as the longitudinal axis of the first part of the dual-arm support, and the longitudinal axis of the second part of the dual-arm support.

27. The drill-guide assembly of claim 18, wherein the longitudinal axis of the handle member is parallel to the longitudinal axis of the first part of the dual-arm support.

28. The drill-guide assembly of claim 18, wherein the dual-arm support is immovably connected to the bushing at the proximal end of the bushing and the dual-arm support is immovably connected to the handle member.

29. The drill-guide assembly of claim 18, wherein the dual support has an open space and the ratchet gear mechanism is disposed in the open space and pivotally mounted therein.

30. The drill-guide assembly of claim 18, wherein the ratchet gear mechanism is Y-shaped.

31. The drill-guide assembly of claim 30, wherein, the first leg of the ratchet-gear mechanism further extends beyond the pivot point forming a C-shaped vice-grip; wherein the C-shaped vice-grip grasps the alignment drill-barrel between two ridges on the alignment drill-barrel.

32. The drill-guide assembly of claim 31, wherein the plane of the C-shaped vice-grip makes an acute angle with the longitudinal axis of the first leg of the Y-shaped ratchet-gear mechanism.

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33. The drill-guide assembly of claim 31, wherein the acute angle is in a range of from about 25 degree to about 45 degree.

34. The drill-guide assembly of claim 18, wherein the handle member is fixed to the dual-arm support with a pin that is perpendicular to the axis of the handle member.

35. The drill-guide assembly of claim 18, wherein said expandable forward-end of said bushing is circular shaped, and freely insertable and removable from said bone plate fastener holes in a contracted position, and engaging the bone-plate when in an expanded position.

36. The drill-guide assembly of claim 18, wherein said radially expandable forward-end comprises a plurality of finger portions.

37. The drill-guide assembly of claim 36, wherein: said radially expandable forward-end of the bushing comprises a shoulder, a neck, and an outwardly projecting rim disposed forward of said neck; wherein said neck and rim together span a length that is slightly longer than the thickness of the bone plate fastener hole wall and the rim abuts the bone-side surface of said plate.

38. The drill-guide assembly of claim 37, wherein the handle member comprises a first cavity and a second cavity at the front end, wherein the first cavity houses a compression spring, and the second cavity houses the second part of the dual-arm support.

39. A drill-guide assembly, comprising:

an alignment barrel having a proximal end and a distal end;

a bushing configured to slidably receive the alignment barrel, the bushing having a radially expandable forward-end and a proximal end, the forward-end configured to be insertable within a hole or recess in a bone plate;

a release knob having serrations; and

a movable ratchet gear mechanism having a first leg, a second leg and a tail,

the first leg of the ratchet-gear mechanism connected to the alignment barrel,

the second leg of the ratchet-gear mechanism having pawls configured and adapted to engage the serrations to hold the alignment barrel in position,

the tail of the ratchet gear mechanism operable by a user to selectively move the ratchet-gear mechanism,

wherein, movement of the ratchet-gear mechanism slides the alignment barrel relative to the bushing to radially expand the forward end to releasably lock the bushing to the plate, and a first drill guide coupled to the bushing, wherein the first drill guide is configured to receive and guide a drill-bit.

40. The drill-guide assembly of claim 39, wherein the first drill guide is coupled to the bushing by a first connecting element.

41. The drill-guide assembly of claim 40, wherein the first connecting element has at least two bores for respectively receiving at least a portion a bushing therethrough and at least a portion of a drill guide therethrough.

42. The drill-guide assembly of claim 41, wherein the first drill guide is further coupled to the bushing by a second connecting element.

43. The drill-guide assembly of claim 42, wherein the second connecting element has at least two bores for respectively receiving at least a portion of a bushing therethrough and at least a portion of a drill guide therethrough.

44. The drill-guide assembly of claim 43, wherein the at least two bores of the first connecting element are separated by a first distance, and the at least two bores of the second connecting element are separated by a second distance, wherein the first distance is greater than the second distance, and wherein the second connecting element is closer to the distal end of the forward end of the bushing than the first connecting element.

45. The drill-guide assembly of claim 43, wherein the at least two bores of the first connecting element are separated by a first distance, and the at least two bores of the second connecting element are separated by a second distance, wherein the first distance is greater than the second distance, and wherein the first connecting element is closer to the distal end of the forward end of the bushing than the second connecting element.

46. The drill-guide assembly of claim 41, wherein the first connecting element further comprises a fin bore configured to receive at least a portion of fin therethrough, wherein at least a portion of the fin in configured to engage at least a portion of a hole or recess when the bushing engages a bone-plate.

47. The drill-guide assembly of claim 39, further comprising a second guide coupled to the bushing, wherein the second drill guide is configured to receive and guide a drill-bit.

48. The drill-guide assembly of claim 47, wherein the second drill guide is coupled to the first drill guide.

49. The drill-guide assembly of claim 48, wherein the first and second drill guide are coupled to the bushing by a first connecting element.

50. The drill-guide assembly of claim 49, wherein the first connecting element has at least three bores for respectively receiving at least a portion of the first drill guide therethrough, at least a portion of the second drill guide therethrough, and a least a portion of the bushing therethrough.

51. The drill-guide assembly of claim 50, wherein the first connecting element further comprises a fin bore configured to receive at least a portion of fin therethrough, wherein at least a portion of the fin in configured to engage at least a portion of a hole or recess when the bushing engages a bone-plate.

52. The drill-guide assembly of claim 50, wherein the first drill guide and second drill guide are further coupled to the bushing by a second connecting element.

53. The drill-guide assembly of claim 52, wherein the second connecting element has at least three bores for respectively receiving at least a portion of the first drill guide therethrough, at least a portion of the second drill guide therethrough, and a least a portion of the bushing therethrough.

54. The drill-guide assembly of claim 53, wherein the bores of the first connecting element receiving first and second drill guides are separated by a first distance, and the bores of the second connecting element receiving first and second drill guides are separated by a second distance, wherein the first distance is greater than the second distance, and wherein the second connecting element is closer to the distal end of the forward end of the bushing than the first connecting element.

55. The drill-guide assembly of claim 53, wherein the bores of the first connecting element receiving first and second drill guides are separated by a first distance, and the bores of the second connecting element receiving first and second drill guides are separated by a second distance, wherein the first distance is greater than the second distance, and wherein the first connecting element is closer to the distal end of the forward end of the bushing than the second connecting element.

56. The drill-guide assembly of claim 39, the first drill guide having a longitudinal axis, and wherein when the bushing is locked to a bone-plate, the longitudinal axis of the first drill guide is generally aligned with a first bone-fastener hole of the bone-plate.

57. The drill-guide assembly of claim 56, further comprising a second drill guide configured to receive and guide a drill-bit and coupled to the bushing, the second drill guide having a longitudinal axis, and wherein when the bushing is locked to a bone-plate, the longitudinal axis of the second drill guide is generally aligned with a second bone-fastener hole of the bone-plate.

58. The drill-guide assembly of claim 39, wherein the recess of the bone-plate includes at least one shaped area and a slot.

59. A drill-guide assembly substantially as hereinbefore described with reference to the accompanying drawings.

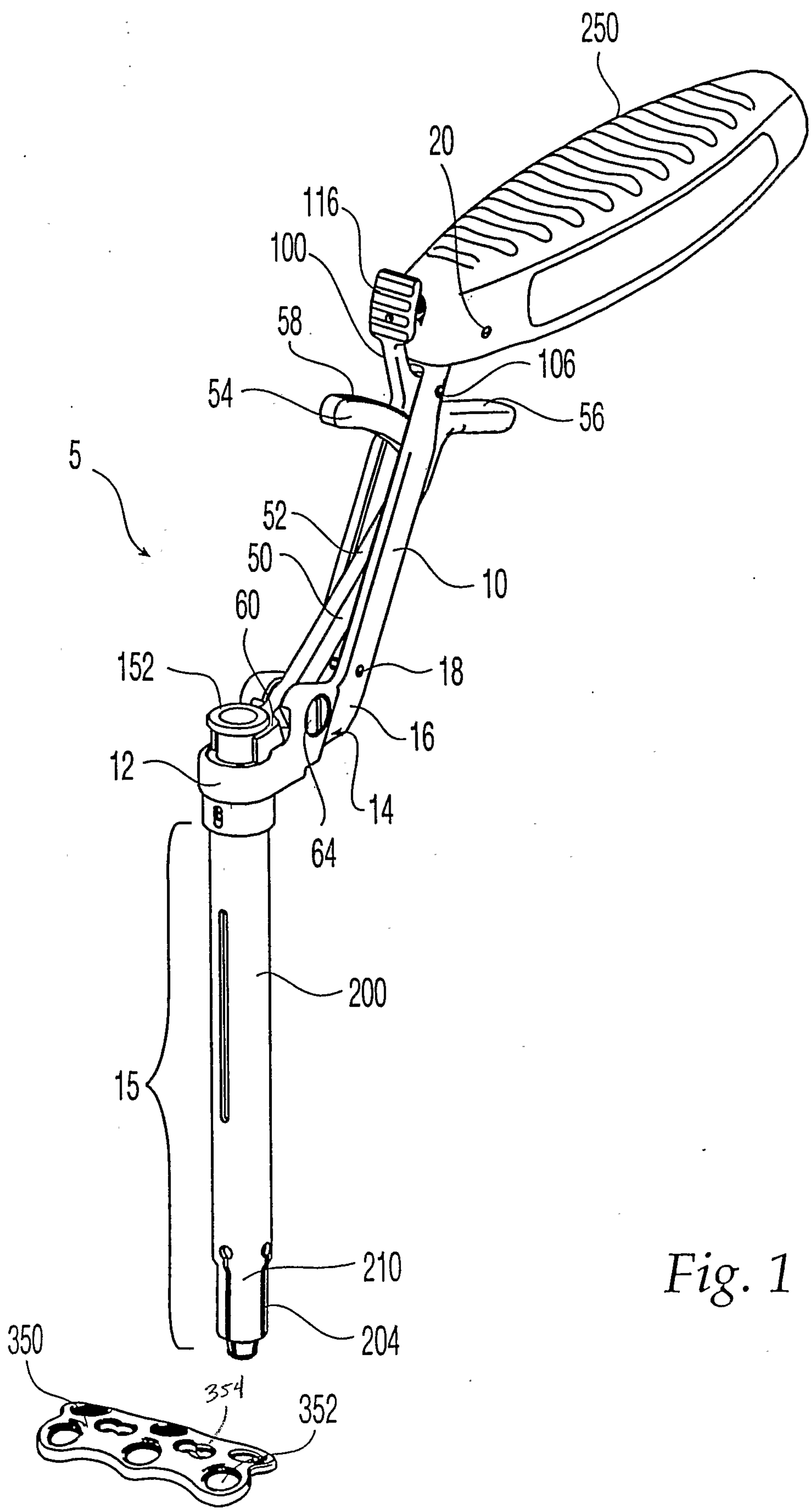
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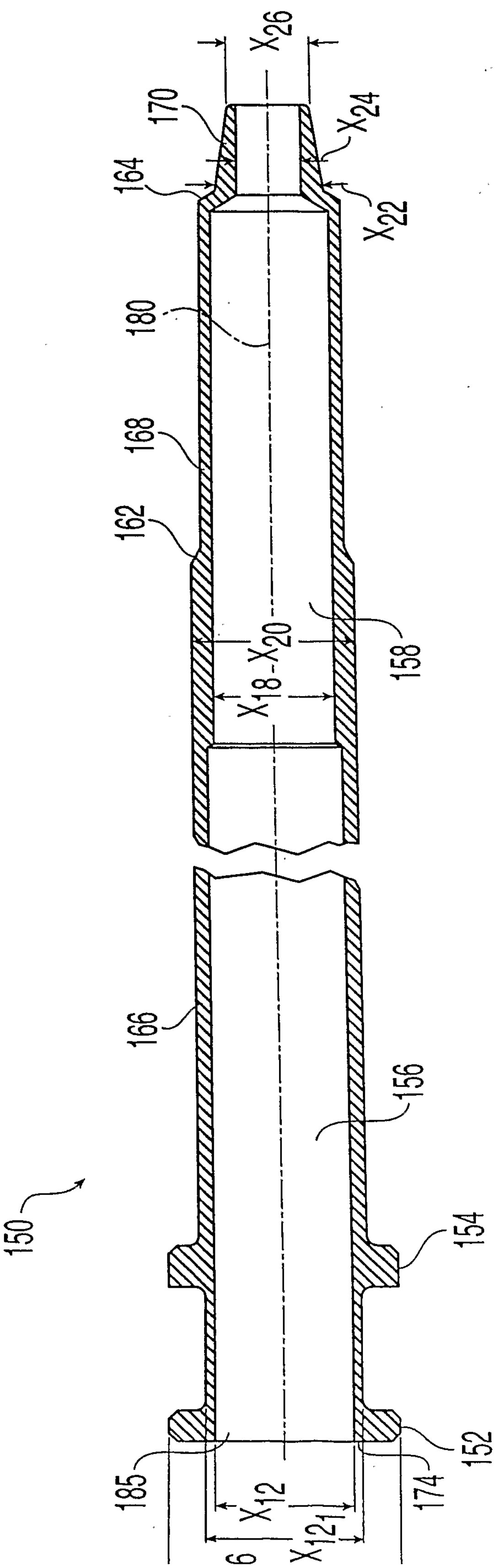
Fig. 1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X18-X20
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185
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X12
X121
6

Fig. 2

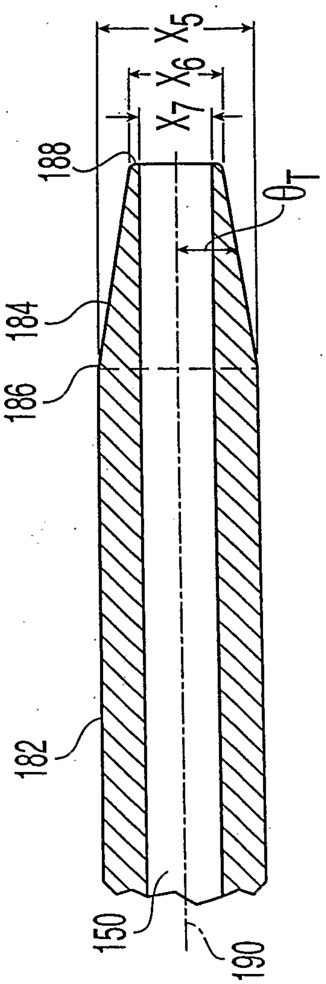
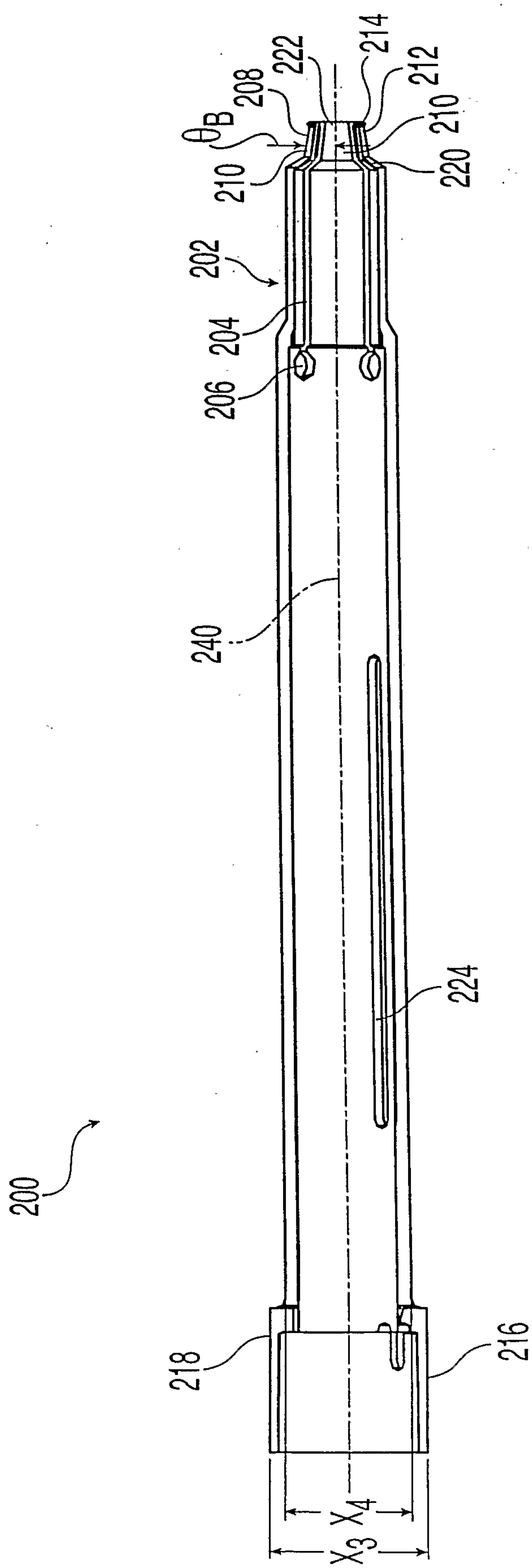


Fig. 3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218
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X_4
X_3

Fig. 4

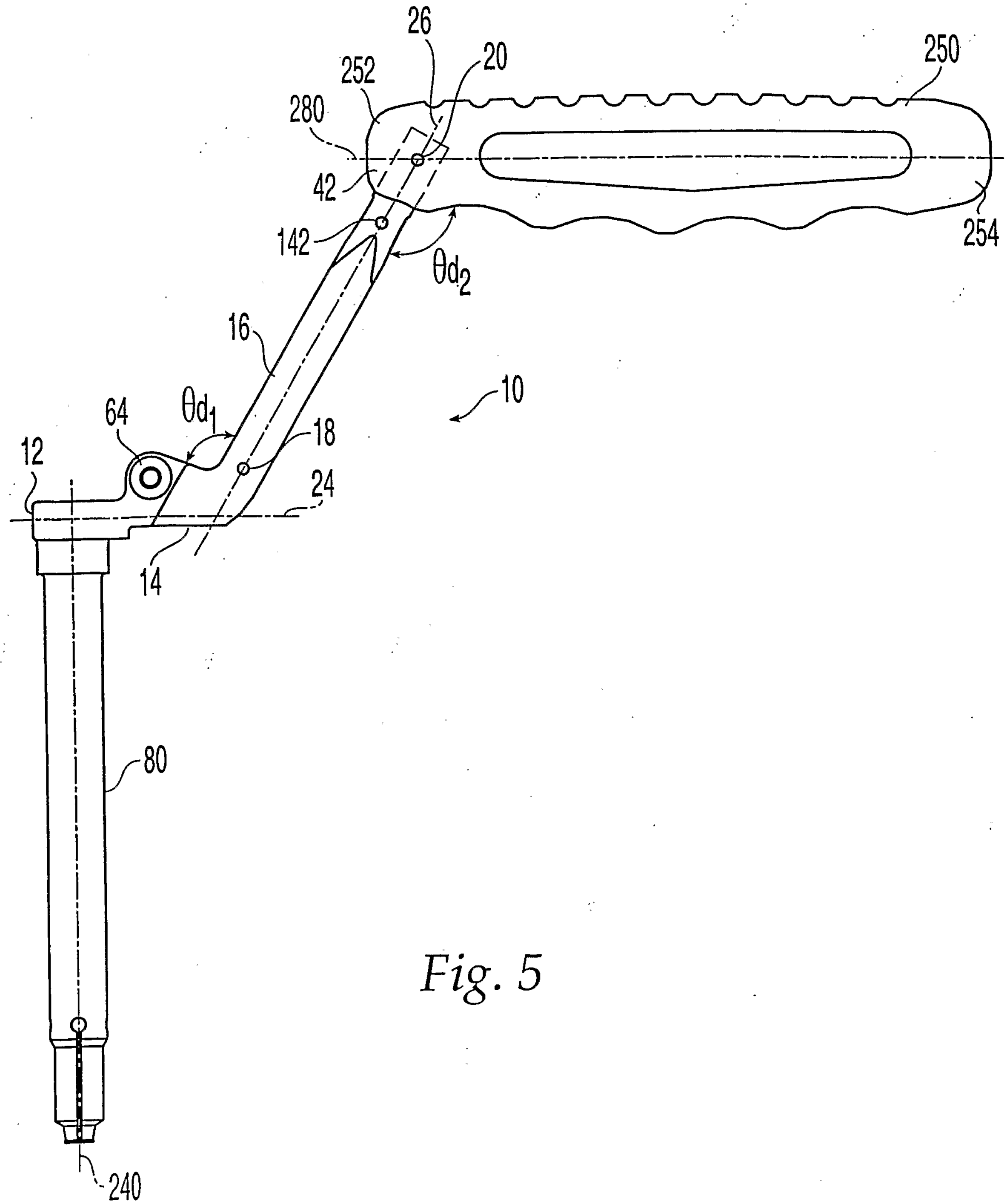

Fig. 5

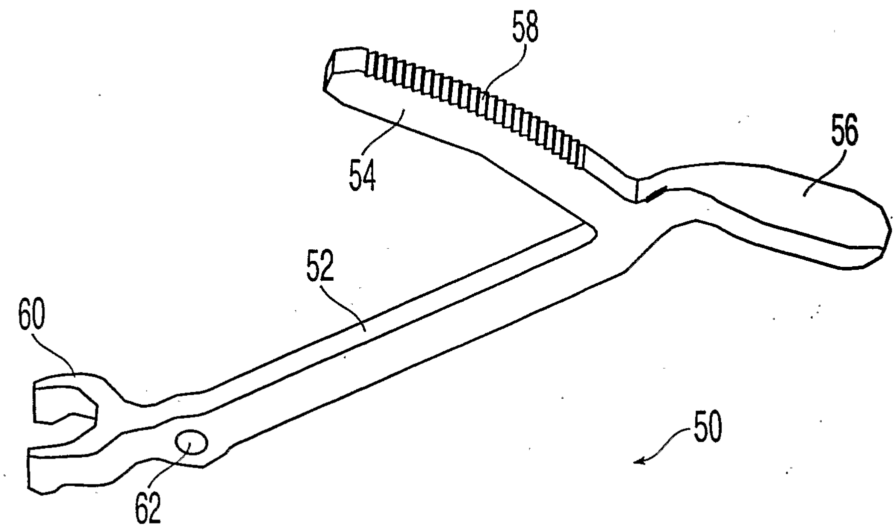

Fig. 6

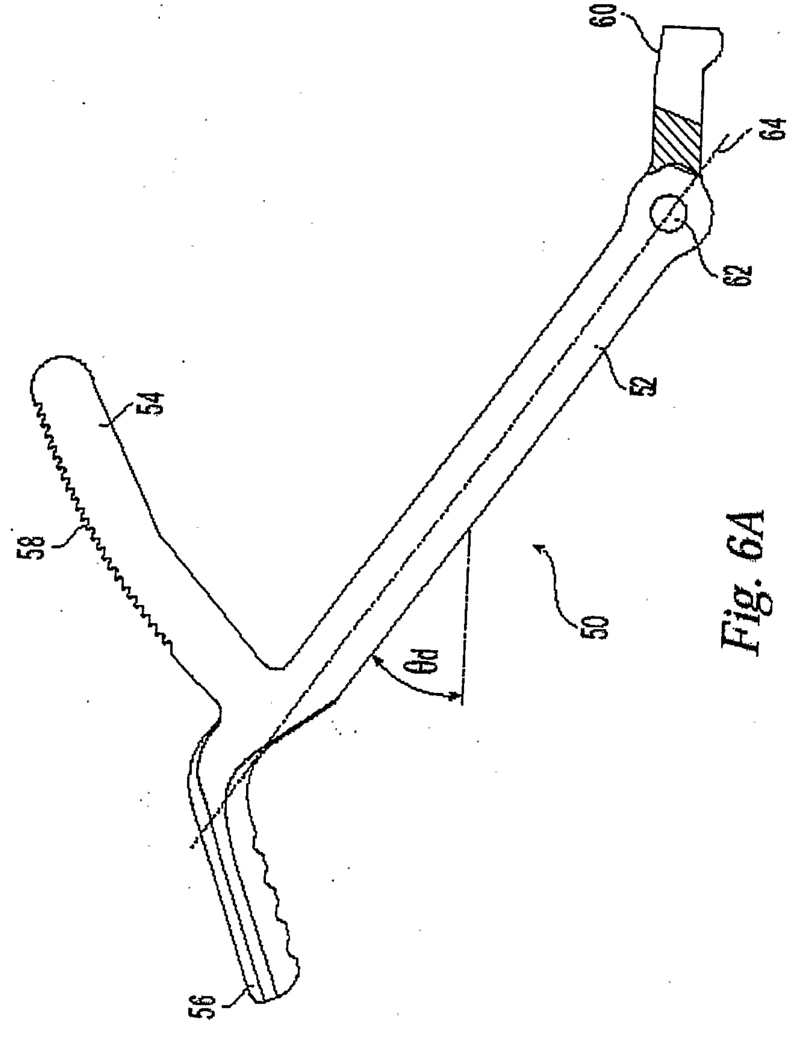

Fig. 6A

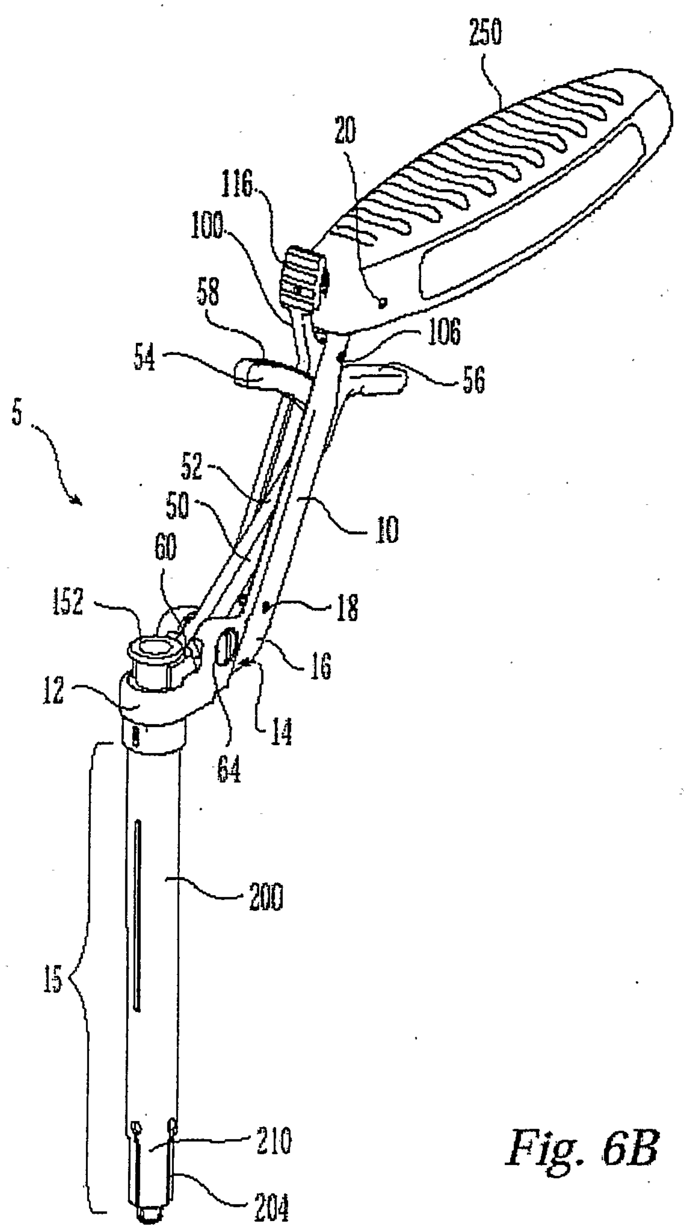
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Fig. 6B

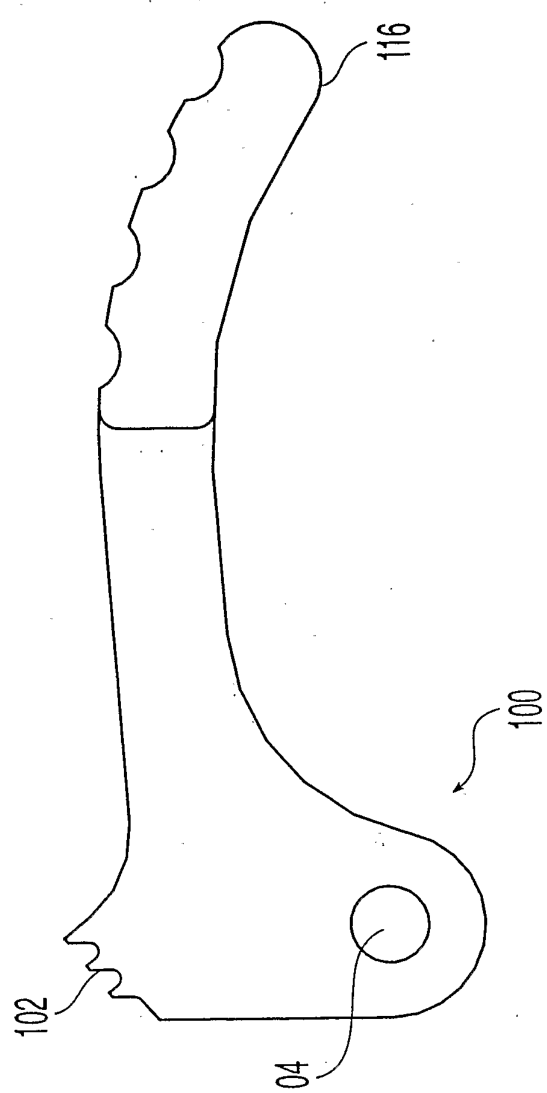


Fig. 7

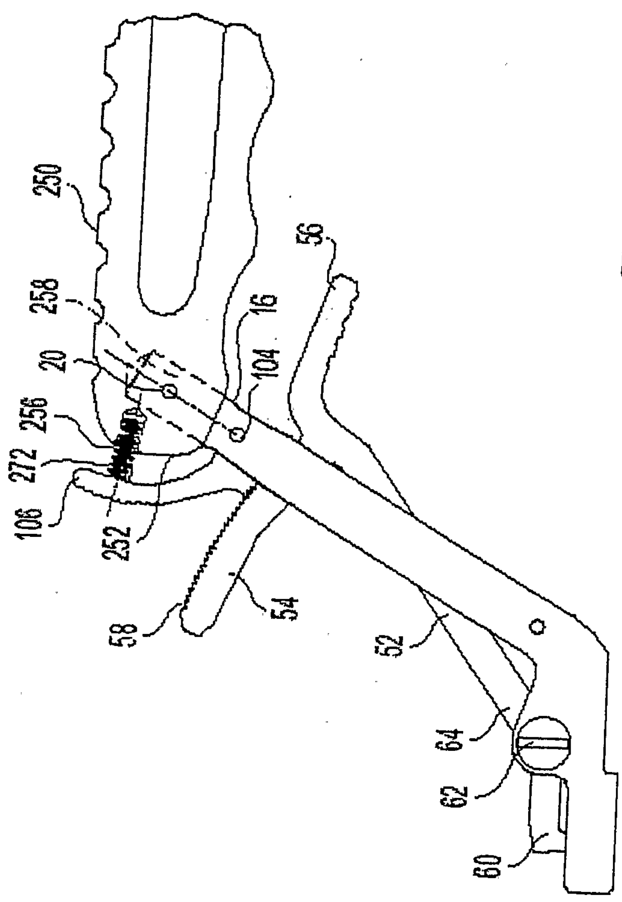


Fig. 7A

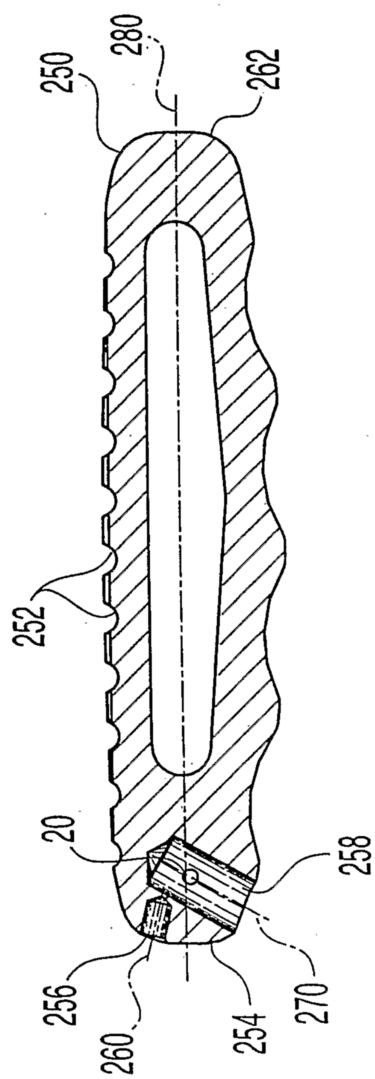


Fig. 8

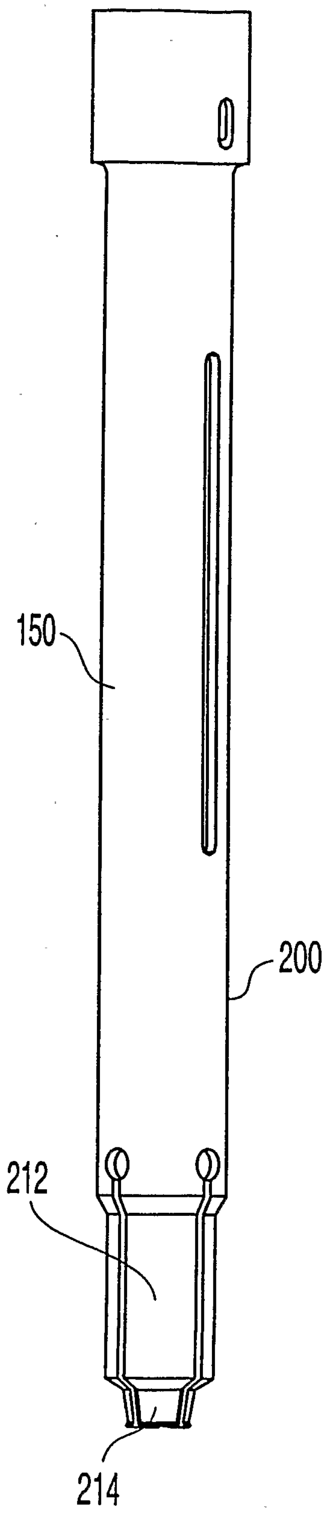


Fig. 9

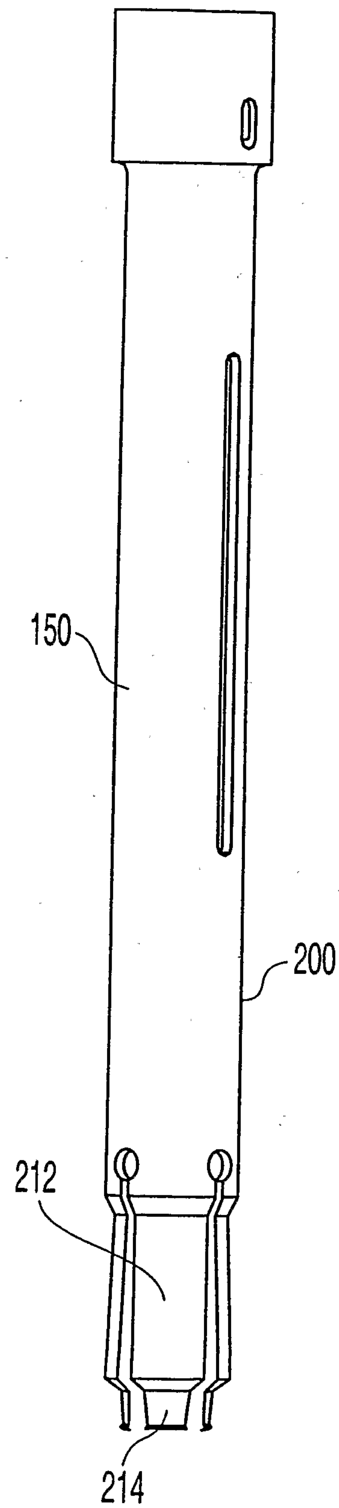


Fig. 10

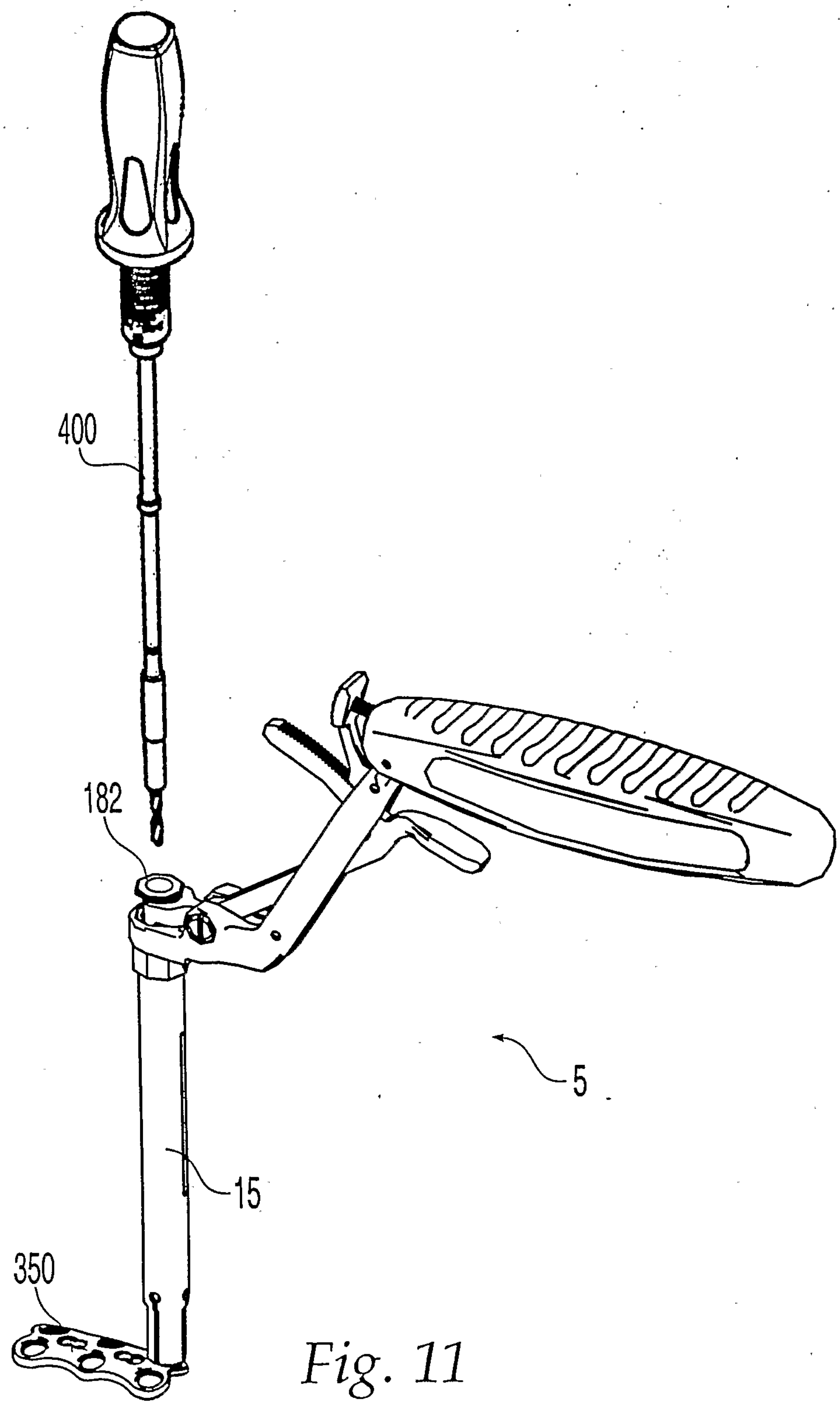
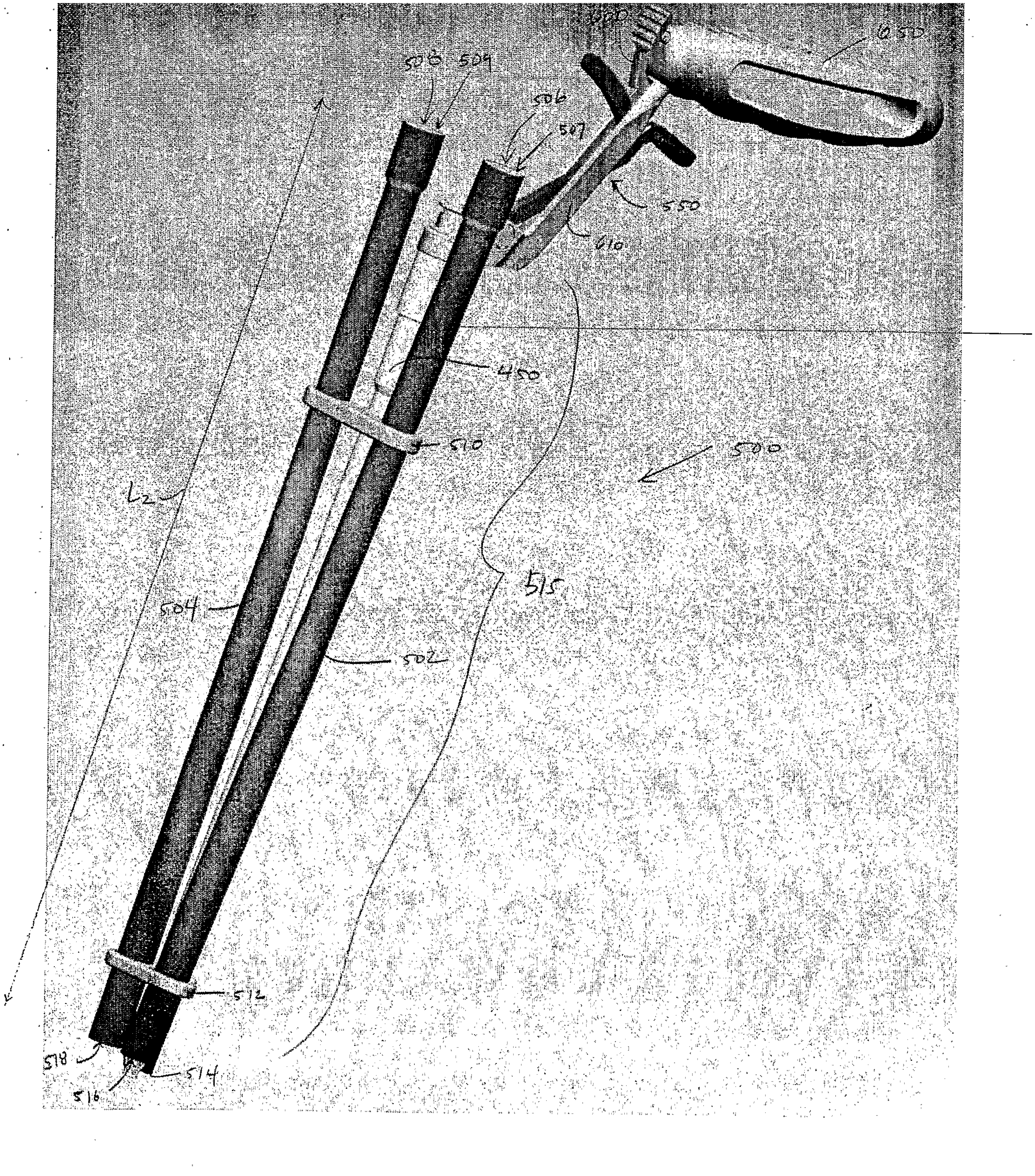


Fig. 11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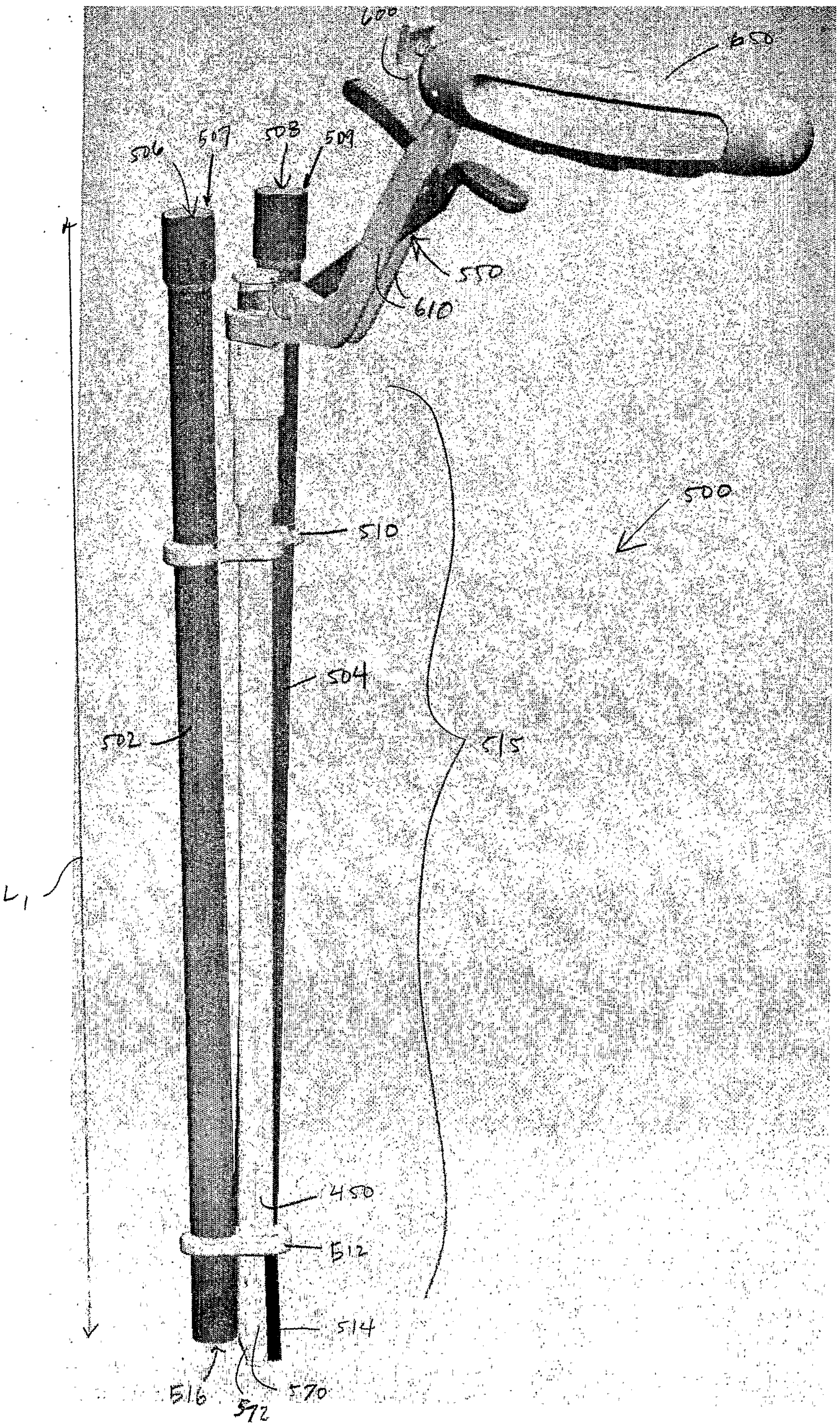
610
650
L2

FIG 12A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570

FIG. 12B

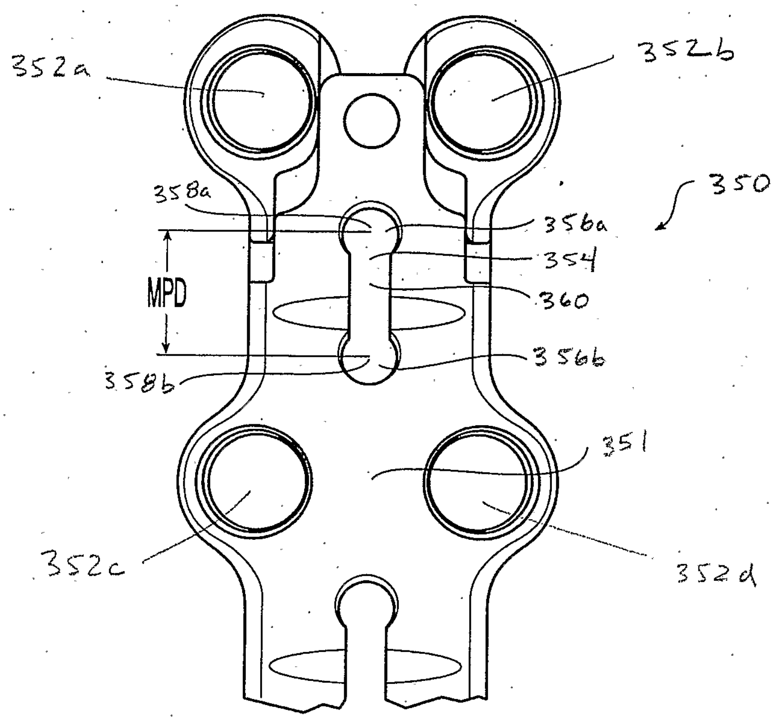

Fig. 12C

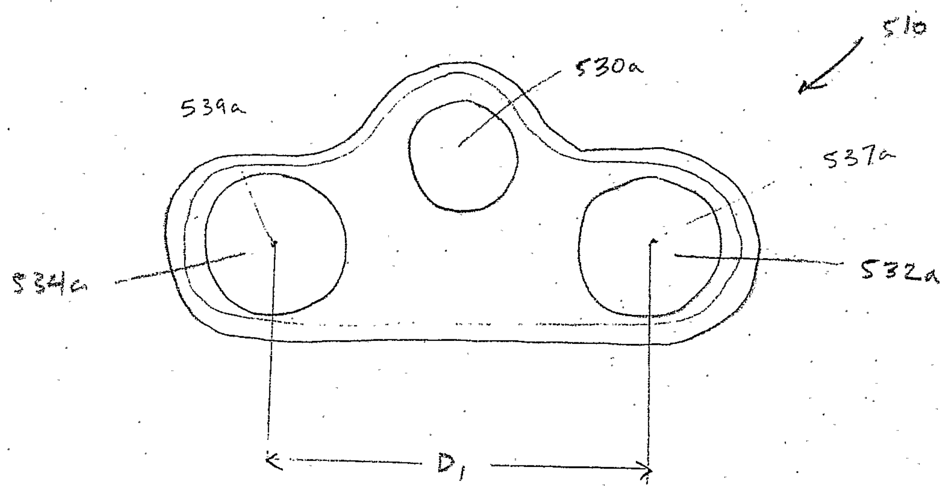

FIG. 13A

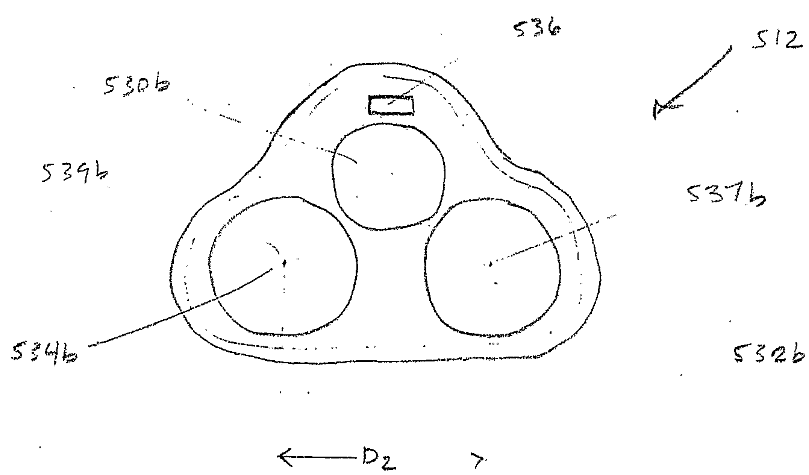

FIG. 13B