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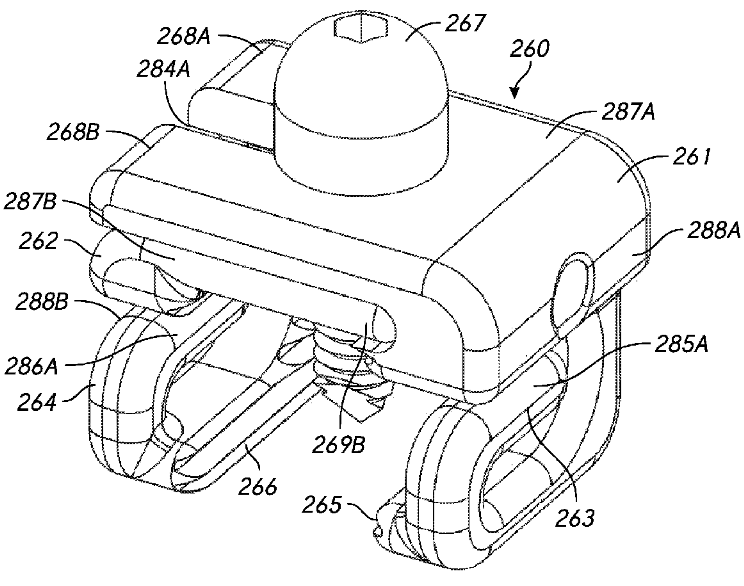

FIG. 20A

(57) Abstract: Methods, systems and apparatuses are provided for torsionally stabilizing a spinal motion segment. One or more implants are placed between two vertebrae to provide torsional stabilization. In particular, one or more implants may be fixed between a superior vertebral body, such as at the spinous process, and an inferior vertebral body. The implants may be connected to the superior vertebral body using a fixation device such as a turnbuckle, an outrigger, a thimble, an endobutton, a suture plug or combinations thereof. The implant may also be connected to the inferior vertebral body using various types of hardware, including staples, screws and anchors. The implant may be kept in tension to provide torsional stabilization and may be comprised of one or more sutures.

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METHODS, SYSTEMS AND APPARATUSES FOR TORSIONAL STABILIZATION

BACKGROUND OF THE INVENTION

[0001] The present application claims priority to U.S. Provisional Patent Application Ser. No. 62/278,308, entitled "METHODS, SYSTEMS AND APPARATUSES FOR TORSIONAL STABILIZATION," filed January 13, 2016, the entire disclosure of which is hereby expressly incorporated by reference in its entirety.

Field of the Invention

[0002] The present application relates to methods, systems and apparatuses to torsionally stabilize a spinal motion segment.

Description of the Related Art

[0003] In many patients, an early finding associated with back pain is a weakening or disruption of the annulus. Patients in this state may then be treated with either micro- or open discectomy to remove any fragments associated with pain. Typically, these patients do well in the short term, but eventually have degeneration leading to axial (back or neck) pain, sometimes also in the presence of radicular pain, radicular weakness or a loss of sensation radicularly.

[0004] In patients with low back pain generally, including those without disruption of the annulus, there is known to be excessive axial rotation, as recently shown by Haughton et al., Measuring the Axial Rotation of Lumbar Vertebrae in Vivo with MR, Am J Neuroradiol 23: 1110-1116, August 2002. Also, scoliosis patients are known to have changes in the multifidus, which is a significant contributor to spinal stabilization and is a significant generator of axial rotation. In both the population of patients with low back pain, and in scoliosis patients, there may be benefit to a device that increases the stability of the segment(s).

[0005] Mechanically, the annulus is a significant structure. In the lumbar spine, the annulus is reported to be on the order of 10mm thick in the anterior half of the body, but perhaps less than 5mm posteriorly. As such, it can represent 40 to 60% of the overall area of the endplate. It is known to resist compression, tension, flexion/extension, lateral bending and axial rotation.

[0006] With weakening or disruption of the annulus, mechanical changes in the annulus' behavior are expected. It is of value to consider the mechanical impact of annular defects in the different loading directions.

[0007] The compression and tension behavior of the annulus is determined by the material properties of the annulus and the annulus' cross-sectional area. The size of the annular defect is a relatively small percentage of the overall annulus. For example, a 10mm diameter defect in an annulus only represents 8% of the overall annular area. As such, an annular defect has a modest impact on the area, and therefore, the compressive and tensile load carrying capacity of the motion segment.

[0008] In flexion/extension or lateral bending motions, the structural behavior of the motion segment is related to the moment of inertia of the annulus. Like tension/compression, the annulus is a significant contributor, and the effect of a defect has a relatively modest impact. Calculations show that an annular defect reduces the moment of inertia of the annulus by only 10%.

[0009] In torsion, the structural behavior of the motion segment is related to the polar moment of inertia of the annulus. Using an approximation of a hollow circular cylinder for the annulus, the impact of a hole in the annulus reduces the polar moment of inertia on the order of 90%, and greatly influences the torsional stiffness of the spine. It is therefore desirable to provide systems, methods and apparatuses that may effectively help stiffen motion segment(s) torsionally.

SUMMARY OF THE INVENTION

[0010] The present application relates to methods, systems and apparatuses for providing torsional stabilization of a spinal motion segment. More specifically, these methods, systems and apparatuses are related to stabilizing the spine torsionally by placing an implant between adjacent vertebral bodies. In some embodiments, one or more implants are oriented in a plane generally aligned with the disc space, so as to stiffen a motion segment torsionally. The stabilizing implant may comprise a single entity or two or more pieces.

[0011] Methods described permit the surgeon to install hardware at two, or preferably three locations, generally aligned with the disc space, and to pass one or more implants between the locations, so as to treat a single spinal level. A single spinal level is defined as a disc space, the vertebral body above the disc space and the vertebral body below the disc space. Preferred fixation on the superior vertebral body is to the spinous process and is the sole point of fixation on the superior vertebral body. Preferred fixation on the inferior vertebral body is bilateral, though fixation could be unilateral.

[0012] Systems for providing torsional stabilization to a spine are provided. In one embodiment, a system comprises at least one implant configured to extend between a superior vertebral body and an inferior vertebral body oriented in a plane generally aligned with the disc space to provide torsional stiffness to the spine. A first fixation device is configured to fix the one or more implants to the inferior vertebral body. A second fixation device is configured to fix the one or more implants to the spinous process of the superior vertebral body.

[0013] In another embodiment, a system for providing torsional stabilization to a spine comprises one or more implants configured to extend between a spinous process of a superior vertebral body and an inferior vertebral body, a fixation device configured to anchor to a posterior surface of the spinous process, the fixation device comprising one or more implant attachment portions configured to receive the one or more implants, and one or more inferior vertebral body anchors, each inferior vertebral body anchor configured to secure one of the one or more implants to the inferior vertebral body such that the implant is in tension between the spinous process and the inferior vertebral body.

[0014] In another embodiment, a system for providing torsional stabilization to a spine comprises a plurality of implants, each implant configured to extend between a spinous process of a superior vertebral body and an inferior vertebral body, a fixation device configured to anchor to the spinous process, the fixation device comprising a pair of anchoring wings, the pair of anchoring wings configured to contact opposite side surfaces of the spinous process, and one or more implant attachment portions, and a plurality of inferior vertebral body anchors, each inferior vertebral body anchor configured to secure one of the plurality of implants to the inferior vertebral body such that the implant is in tension between the spinous process and the inferior vertebral body.

[0015] Methods for providing torsional stabilization to a spine are provided. In one embodiment, a method for providing torsional stabilization to a spine comprises extending an implant in tension between a first vertebral body and a second vertebral body, the implant being attached to a fixation device engaged to the spinous process of the second vertebral body and extending laterally outwardly to attach to a location on the first vertebral body.

[0016] Fixation devices for providing torsional stabilization to a spine and methods of using the same are provided. In one embodiment, a fixation device is configured to anchor to a posterior surface of the spinous process and may comprise one or more implant attachment portions configured to receive one or more implants.

[0017] In another embodiment, a fixation device is configured to anchor to the spinous process and comprises a pair of anchoring wings, the pair of anchoring wings configured to contact opposite side surfaces of the spinous process, and one or more implant attachment portions. Each anchoring wing can include an implant attachment portion.

[0018] Various other systems, methods and apparatuses are contemplated and discussed below. While the systems, methods and apparatuses are described with respect to torsional stabilization of the spine, many of the novel embodiments herein can be used for the stabilization of other areas of the body, and may be used for other applications, including non-spinal applications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. 1 shows a sagittal (side) view of the lumbar spine.

[0020] FIG. 2 shows a top view of a lumbar vertebral body.

[0021] FIG. 3 shows a sagittal (side) view of the cervical spine.

[0022] FIG. 4 shows a top view of a cervical vertebral body.

[0023] FIG. 5 shows an implant having a rounded cross-section according to one embodiment.

[0024] FIG. 6 shows an implant having a rectangular cross-section according to one embodiment.

[0025] FIG. 7A shows a tubular implant according to one embodiment.

[0026] FIG. 7B shows the effect of a compliant tubular implant when passing around a piece of bone.

[0027] FIG. 8 shows a filled tubular implant according to one embodiment.

[0028] FIG. 9A shows a staple which can function as an anchor according to one embodiment.

[0029] FIG. 9B shows a staple assembled to an implant according to one embodiment.

[0030] FIG. 10 shows a front view of an anchor including a bone anchoring portion and an implant receiving portion according to one embodiment.

[0031] FIG. 11 shows an exploded front view of an anchor including a bone anchoring component and an implant attachment post according to one embodiment.

[0032] FIG. 12A shows a front view of an offset anchor according to one embodiment.

[0033] FIG. 12B shows a side view of the offset anchor of FIG. 12A.

[0034] FIG. 13 shows a suture anchor according to one embodiment.

[0035] FIG. 14A shows a side view of an endobutton according to one embodiment.

[0036] FIG. 14B shows a front view of an alternative embodiment of an endobutton according to one embodiment.

[0037] FIG. 15A shows a bottom perspective view of a fixation device according to one embodiment.

[0038] FIG. 15B shows a bottom exploded view of the fixation device of FIG. 15A.

[0039] FIG. 15C shows a top exploded view of the fixation device of FIG. 15A.

[0040] FIG. 15D shows a top assembled view of the fixation device of FIG. 15A.

[0041] FIG. 15E shows a right side view of the fixation device of FIG. 15A.

[0042] FIG. 16 shows a posterior (rear) view of a lumbar vertebral spine.

[0043] FIG. 17A shows a posterior (rear) view of a lumbar vertebral spine with the fixation device of FIG. 15A, sutures, and anchors.

[0044] FIG. 17B shows a sagittal (side) view of the implantation system of FIG. 17A.

[0045] FIG. 18A shows a first bottom perspective view of a fixation device according to one embodiment.

[0046] FIG. 18B shows a second bottom perspective view of the fixation device of FIG. 18A.

[0047] FIG. 18C shows a top exploded view of the fixation device of FIG. 18A.

[0048] FIG. 18D shows a bottom exploded view of the fixation device of FIG. 18A.

[0049] FIG. 18E shows a top assembled view of the fixation device of FIG. 18A.

[0050] FIG. 18F shows a left side view of the fixation device of FIG. 18A.

[0051] FIG. 18G shows a right side view of the fixation device of FIG. 18A.

[0052] FIG. 19A shows a top perspective view of a lumbar vertebral spine with the fixation device of FIG. 18A, sutures, and anchors.

[0053] FIG. 19B shows a sagittal (side) view of the implantation system of FIG. 19A.

[0054] FIG. 19C shows a posterior (rear) view of the implantation system of FIG. 19A.

[0055] FIG. 20A shows a bottom perspective view of a fixation device according to one embodiment.

[0056] FIG. 20B shows a top perspective view of the fixation device of FIG. 20A.

[0057] FIG. 20C shows a bottom exploded view of the fixation device of FIG. 20A.

[0058] FIG. 20D shows a bottom view of the fixation device of FIG. 20A.

[0059] FIG. 20E shows a top view of the fixation device of FIG. 20A.

[0060] FIG. 20F shows a left side view of the fixation device of FIG. 20A.

[0061] FIG. 20G shows a right side view of the fixation device of FIG. 20A.

[0062] FIG. 20H shows a top perspective view of the fixation device of FIG. 20A.

[0063] FIG. 20I shows a top view of the fixation device of FIG. 20A.

[0064] FIG. 20J shows a right side perspective view an anchoring wing of the fixation device of FIG. 20A.

[0065] FIG. 20K shows a left side perspective view an anchoring wing of the fixation device of FIG. 20A.

[0066] FIG. 20L shows a front view of a shank of an anchor of the fixation device of FIG. 20A.

[0067] FIG. 20M shows a perspective view of a cap of an anchor of the fixation device of FIG. 20A.

[0068] FIG. 21A shows a posterior (rear) view of a lumbar vertebral spine with a fixation device, sutures, and anchors applied.

[0069] FIG. 21B shows a sagittal (side) perspective view of the implantation system shown in FIG. 21A.

[0070] FIG. 21C shows a sagittal (side) view of the implantation system shown in FIG. 21A.

[0071] FIG. 21D shows a top view of the implantation system shown in FIG. 21A.

[0072] FIG. 22A shows a top perspective view of a lumbar vertical spine with a fixation device, showing the fixation device in an exploded configuration.

[0073] FIG. 22B shows a sagittal (side) perspective view of the implantation system of FIG. 22A.

[0074] FIG. 22C shows a sagittal (side) perspective view of the implantation system of FIG. 22A, with the fixation device, a suture, and an anchor applied.

[0075] FIG. 22D shows a sagittal (side) perspective view of the implantation system as shown in FIG. 22C having an alternative embodiment of the fixation device.

[0076] FIG. 22E shows a sagittal (side) perspective view of the implantation system as shown in FIG. 22D having an alternative embodiment of the fixation device.

[0077] FIG. 23A shows a side view of a lumbar vertical spine with a fixation device.

[0078] FIG. 23B shows a sagittal (side) perspective view of the implantation system of FIG. 23A with the fixation device secured to the spinous process.

[0079] FIG. 23C shows a sagittal (side) perspective view of the implantation system of FIG. 23A, with the fixation device, a suture, and an anchor applied.

[0080] FIG. 23D shows a side view of the implantation system of FIG. 23A with the fixation device, a suture, and an anchor applied.

[0081] FIG. 23E shows a sagittal (side) perspective view of the implantation system of FIG. 23A with an installation tool with the fixation device secured to the spinous process.

[0082] FIG. 24A shows a bottom perspective view of a top anchoring wing of a fixation device.

[0083] FIG. 24B show a top perspective view of a bottom anchoring wing of a fixation device.

[0084] FIG. 24C shows a sagittal (side) perspective view of a lumbar vertical spine with a fixation device having the components of FIGs. 24A,B, a suture, and an anchor showing the fixation device partially secured to the spinous process during installation.

[0085] FIG. 24D shows a sagittal (side) perspective view of the implantation system of FIG. 24C secured to the spinous process.

[0086] FIG. 25A shows a right sagittal (side) perspective view of a lumbar vertical spine with a fixation device, a suture, and an anchor applied.

[0087] FIG. 25B shows a left sagittal (side) perspective view of the implantation system of FIG. 25A.

[0088] FIG. 25C shows a top view of the implantation system of FIG. 25A showing the fixation device partially secured to the spinous process during installation.

[0089] FIG. 25D shows a top view of the implantation system of FIG. 25C.

[0090] FIG. 26A shows a sagittal (side) perspective view of a lumbar vertical spine and a fixation device with an installation tool disengaged from the spine.

[0091] FIG. 26B shows a top perspective view of the implantation system of FIG. 26A.

[0092] FIG. 26C shows a top perspective view of the implantation system of FIG. 26A having arrows illustrating manipulation of the fixation device to attach the fixation device to the spinous process.

[0093] FIG. 26D shows a top perspective view of the implantation system of FIG. 26A having arrows illustrating manipulation of the fixation device to secure the fixation device to the spinous process.

[0094] FIG. 26E shows a sagittal (side) perspective view of the implantation system of FIG. 26A showing removal of the installation tool from the fixation device.

[0095] FIG. 26F shows a sagittal (side) perspective view of the implantation system of FIG. 26A with the fixation device, the anchor, and a suture applied.

[0096] FIG. 26G shows a posterior (rear) perspective view of the implantation system of FIG. 26A with the fixation device, the anchor, and a suture applied.

[0097] FIG. 26H shows a top view of the implantation system of FIG. 26A with the fixation device, the anchor, and a suture applied.

[0098] FIG. 27A shows a top view of a fixation device.

[0099] FIG. 27B shows a rear view of the fixation device of FIG 27A.

[0100] FIG. 27C shows a top view of a lumbar vertebral spine with the fixation device of FIG 27A, sutures, and anchors applied.

[0101] FIG. 27D shows a sagittal (side) perspective view of a lumbar vertebral spine with the fixation device of FIG 27A, sutures, and anchors applied.

[0102] FIG. 27E shows a posterior (rear) view of a lumbar vertebral spine with the fixation device of FIG 27A, sutures, and anchors applied.

[0103] FIG. 27F shows a partial view of the fixation device of FIG. 27A showing a first step in a process of securing the fixation device.

[0104] FIG. 27G shows a partial view of the fixation device of FIG. 27A showing a second step in a process of securing the fixation device.

[0105] FIG. 27H shows a partial view of the fixation device of FIG. 27A showing a third step in a process of securing the fixation device.

[0106] FIG. 27I shows a partial view of the fixation device of FIG. 27A showing a first step in a process of securing the fixation device.

[0107] FIG. 27J shows a perspective view of a tool for use with the fixation device of FIG 27A.

[0108] FIG. 27K shows a perspective view of an anchor of the fixation system of FIG. 27C.

[0109] FIG. 28A shows a top view of an alternative embodiment of the fixation device of FIG. 27A.

[0110] FIG. 28B shows a posterior (rear) view of the fixation device of FIG. 28A.

[0111] FIG. 28C shows a top perspective view of the fixation device of FIG. 28A.

[0112] FIG. 29A shows a top perspective view of a fixation device.

[0113] FIG. 29B shows a top view of the fixation device of FIG. 29A.

[0114] FIG. 29C shows a posterior (rear) view of the fixation device of FIG. 29A.

[0115] FIG. 29D shows a front view of a portion of the fixation device of FIG. 29A.

[0116] FIG. 29E shows a top perspective cross-sectional view of a portion of the fixation device of FIG. 29A.

[0117] FIG. 29F shows a top cross-sectional view of a portion of the fixation device of FIG. 29A.

[0118] FIG. 29G shows a top view of the fixation device of FIG. 29A and a tool for use with the fixation device.

[0119] FIG 29H shows a perspective view of the tool of FIG. 29G.

[0120] FIG. 29I shows a top cross-sectional view of the fixation device of FIG. 29A and the tool of FIG. 29G showing the fixation device in a locked state.

[0121] FIG. 29J shows a top cross-sectional view of the fixation device of FIG. 29A and the tool of FIG. 29G showing insertion of the tool to unlock the fixation device.

[0122] FIG. 29K shows a perspective view of interior components of the fixation device of FIG. 29A and the tool of FIG. 29G.

[0123] FIG. 29L shows a posterior (rear) view of interior components of the fixation device of FIG. 29A and the tool of FIG. 29G in several positions.

[0124] FIG. 29M shows a top view of the fixation device of FIG. 29A in several positions.

[0125] FIG. 29N depicts a top view of a lumbar vertebral spine with the fixation device of FIG. 29A, sutures, and anchors applied.

[0126] FIG. 29O depicts a posterior (rear) view of a lumbar vertebral spine with the fixation device of FIG. 29A, sutures, and anchors applied.

[0127] FIG. 29P shows a side view of an anchor for use in the implantation system depicted in FIG. 29N.

[0128] FIG. 29Q shows a top view of an anchor for use in the implantation system depicted in FIG. 29N.

[0129] FIG. 29R shows a partial cross-sectional view showing internal features of an anchor for use in the implantation system depicted in FIG. 29N.

[0130] FIG. 29S shows a top perspective view of an anchor for use in the implantation system depicted in FIG. 29N.

[0131] FIG. 30A shows a top view of an alternative embodiment of the fixation device of FIG. 29A.

[0132] FIG. 30B shows a posterior (rear) view of an alternative embodiment of the fixation device of FIG. 29A.

[0133] FIG. 30C shows a top perspective view of an alternative embodiment of the fixation device of FIG. 29A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0134] Methods, systems and apparatuses are provided in certain embodiments of the present application to selectively stabilize the spine torsionally by placing one or more implants between adjacent vertebral bodies generally aligned with the disc space, so as to stiffen a motion segment torsionally One procedure of the present application permits the surgeon to install hardware at two or preferably three locations aligned generally with the disc space as fixation devices, and to pass one or more implants between the locations, so as to treat a single spinal level.

[0135] FIG. 1 shows a sagittal view of the lumbar spine. The present application involves treatment of one or more spinal levels to provide torsional stability. A single spinal level is composed of a disc 11 targeted for treatment, a superior vertebral body 12, and an inferior vertebral body 13.

[0136] To provide torsional stabilization without significantly impacting the flexion/extension or lateral bending motion of spinal segments (which may be referred to as "selective" torsional stabilization), the locations to fix the implants preferably lie generally in a plane perpendicular to the torsional axis of rotation 14 of the disc 11. The torsional axis of rotation 14 is aligned with the long axis of the spine. Any plane generally perpendicular to the torsional axis of rotation 14 is defined as being aligned with the disc space. One generally preferred plane 15 shown in FIG. 1 passes through the spinous process 16 of the superior vertebral body 12, and the mamillary process 17 of the inferior vertebral body 13. An alternative plane 18 passes through the pedicle 19 of the inferior vertebral body 13 but does not pass through any part of the superior vertebral body 12. To provide selective torsional stabilization in the alternative plane 18, a fixation device, such as an anchor, may be attached to the spinous process 16 of the superior vertebral body 12 and one or more implants may be fixed inferior to the spinous process 16.

[0137] FIG. 2 shows a top view of a lumbar vertebral body 21. In this view, it is possible to identify the spinous process 22, the mamillary processes 23 and 24 and the pedicles 25 and 26. It can be seen in this view that an implant passing generally between the mamillary processes 23 and 24 to the spinous process would pass adjacent to the facets 27 and 28.

[0138] FIG. 3 shows a sagittal view of the cervical spine. As shown, a single spinal level is composed of the disc targeted for treatment 31, the superior vertebral body 32, and the inferior vertebral body 33.

[0139] In the cervical spine, the torsional axis of rotation 34 of the disc 31 is shown. The torsional axis 34 is aligned with the long axis of the spine. Any plane generally perpendicular to the torsional axis of rotation is defined as being aligned with the disc space. One generally preferred plane 35 passes through the spinous process 36 of the superior vertebral body 32 and the lateral aspect 37 of the superior articular process of the inferior vertebral body 33.

[0140] It is recognized that due to anatomical and surgical variation, it is unlikely that all points of fixation will lie precisely within a plane perpendicular to the torsional axis 14 and 34 of the targeted disc 11 and 31. However, trigonometry shows that any plane within

+/-17.5 degrees of perpendicularity with the torsional axis of rotation 14 and 34 will result in no more than 30% off axis contribution. Accordingly, preferred planes for fixing one or more implants are those within 17.5 degrees of perpendicularity.

[0141] FIG. 4 shows a top view of a cervical vertebral body 41. In this view, it is possible to identify the spinous process 42, the superior articular processes 43 and 44, and the lateral aspects 45 and 46 of the superior articular processes 43 and 44.

[0142] Methods described permit the surgeon to install hardware at two, preferably three locations, generally aligned with the disc space, and to pass one or more implants between the locations to treat a single spinal level. Hardware may be installed on a first vertebral body, a second vertebral body or both in order to assist in fixation of an implant between vertebral bodies. A first vertebral body may be a superior vertebral body while a second vertebral body may be an inferior vertebral body, or vice versa.

[0143] In a preferred embodiment, hardware is fixed on a superior vertebral body at the spinous process and is the sole point of fixation on the superior vertebral body. Fixation on an inferior vertebral body may be bilateral, such as at two locations extending laterally outwardly on opposite sides of the spinous process. For example, in one embodiment, two implants may be fixed to the spinous process of a superior vertebral body and may extend laterally outward such that one implant is fixed to a first pedicle of an inferior vertebral body and the other implant is fixed to a second pedicle of the inferior vertebral body. In another embodiment, two implants fixed to the spinous process of a superior vertebral body may extend laterally outward such that one implant is fixed to a first mamillary process of an inferior vertebral body and the other implant is fixed to a second mamillary process of the inferior vertebral body. In some embodiments, a single implant can be fixed to the spinous process of a superior vertebral body and locations, e.g., the first and second pedicles or first and second mamillary processes, of the inferior vertebral body. In some embodiments, fixation could be unilateral using a sufficiently stiff implant.

[0144] The location for fixation on the inferior vertebral body is dependent on the level of the spine being operated on. In the lumbar spine, the preferred location for fixation is in the region from the pedicle superiorly and medially onto the mamillary process, bilaterally. At the L5-S 1 spinal level, the preferred location for fixation is to the sacrum, generally aligned with the disc space. In the cervical spine, the preferred location for fixation to the inferior vertebral body is the lateral aspect of the superior articular process.

[0145] Various implants are provided which may provide torsional stabilization to the spine. These implants may be configured to extend in tension between a superior vertebral body and an inferior vertebral body in a plane generally aligned with the disc space to provide torsional stabilization. The implants may be fixed to one or more locations of the superior vertebral body and the inferior vertebral body. As used herein, the term “fix” means direct fixation of an implant to a vertebral body (such as by tying the implant around the vertebral body) or indirect fixation of an implant to a vertebral body by using fixing a fixation device such as a staple, anchor, endobutton or outrigger.

[0146] As illustrated below, the implants may be of various shapes and sizes. While some of the implants may be comprised of relatively stiff materials including metals such as titanium and stainless steel and non-metals such as carbon fiber, in a preferred embodiment, the implant is comprised of a material that allows for sufficient strength and flexibility. In some embodiments, the stabilizing implant is flexible and can be fashioned of a variety of biocompatible materials including polymeric surgical fabrics using resorbable and/or non-resorbable polymers in the form of weaves, braids, knits and embroidery. In some embodiments, the stabilizing implant comprises a solid polymer including resorbable and non-resorbable polymers, autograft soft tissue, allograft soft tissue, allograft or autograft bone, metal fabrics, metal meshes or solid metal components in addition to titanium and metal, as well as biocompatible composites. Having a flexible implant allows the implant to be used advantageously with a variety of hardware at specific locations of the spine. Having a flexible implant also allows for ease in fixing the implant using the preferred methods of the present application, which may allow the implant to be grabbed, pulled and placed in tension in between locations. A flexible implant also permits laying the implant over the posterior part of the facet so as to take a non-linear path between points of fixation. A flexible implant also allows for passing the implant from one location to another, as will be described later in this specification. As an implant may contact bone between its anchor points and will lie within muscle, it may also be advantageous to have the implant coated with a biocompatible hydrophilic material or with a biocompatible hydrogel so that friction may be reduced between the implant and the biological material that it contacts. Besides flexibility, an implant's stiffness may be considered when providing torsional stabilization using one or more implants. The stiffness of an implant can be varied by using different types of materials and/or by adjusting the geometry of the implant to provide a variety of stiffening effects.

[0147] Implants of various geometries are now provided. FIG. 5 shows one embodiment of an implant 51 having a generally rounded cross-section. FIG. 6 shows one embodiment of an implant 61 having a generally rectangular cross-section. FIG. 7A shows one embodiment of an implant 71 having a tubular cross-section.

[0148] In a preferred embodiment, the implants are comprised of a flexible, compliant material that allows the implant to be shaped with ease in and around spinal segments. FIG. 7B shows the effect of using the compliant tube implant 71 of FIG. 7A when passing the implant around a piece of bone 72. As shown, the cross section at both ends 73 and 74 are generally tubular while in the central portion 75 of the implant 71, the thickness of the implant is reduced. This reduction in thickness corresponds to a collapse of the tube in this region which may be beneficial in applications where the implant comes in contact with the bone. Allowing the implant 71 to be flexible and work around the bone 72 reduces wear and tear to the bone. In addition, in some embodiments, deformation of the implant 71 at its central portion 75 can result in increased strength of the implant by deformation strengthening at the central region of the implant.

[0149] FIG. 8 shows a filled tubular implant 81 according to one embodiment. In this embodiment, the implant is again tubular in cross section 82, but the tube is also filled with material 83. Filler material 83 can act as a cushion for various loads on the implant. Examples of filler material in the tubular implant 81 include elastic materials such as rubber, viscoelastic materials and advanced polymers, metal monofilament, animal derived materials (allograft, autograft) and combinations of the above. The benefits of this structure are that the inner material 83 may be used as the load carrying element, while the tube 82 is designed to better integrate with the adjacent material. For example, the inner material could be a polymer or metal monofilament and the external tube could be highly porous. The monofilament provides the strength to torsionally stabilize the spinal level, whereas the highly porous external tube permits integration of the implant with adjacent soft tissue.

[0150] The stabilizing implant may be fixed to the bone using a variety of available means, including screws, staples, anchors (including soft tissue anchors) and other types of hardware. The hardware can be fashioned of a variety of biocompatible materials, including resorbable and non-resorbable polymers, metals, as well as assemblies of polymers and metals. Besides or in addition to using hardware, an implant may be fixed to bone using a surgical adhesive.

[0151] FIG. 9A shows a staple 91 which can be used as an anchor in the present application. FIG. 9B shows an anchor 91 assembled to an implant 92. The implant 92 corresponds to the implant 61 of FIG. 6 having a generally rectangular cross-sectional area. Methods and means of assembling an implant to an anchor are described later.

[0152] FIG. 10 shows an embodiment of an anchor 101 comprised of a threaded bone anchoring portion 102 and an implant receiving portion 103. The hole 104 in the implant receiving portion 103 can be configured to match, but be a slightly oversized version of the cross section of the implant.

[0153] FIG. 11 shows an exploded view of an embodiment of an anchor comprised of a bone anchoring component 112 and an implant attachment post 113. The bone anchoring component is threaded externally to attach to the bone, and the thread could be self-tapping to minimize the number of instruments required to insert the device. The bone anchoring component 112 also features an internal threaded hole 114 to receive the threaded portion 115 of the implant attachment post 113. The implant attachment post 113 also has a cap 116 which can have a feature (not shown) to permit tightening of the implant attachment post 113 to the bone anchoring component 112.

[0154] FIG. 12A shows a front view of an offset anchor 121. The anchor has two holes 122, 123. The first hole 122 is intended to receive a screw (not shown) that can be used to fix the anchor to the bone. The second hole 123 is intended to receive an implant.

[0155] FIG. 12B shows a side view of the offset anchor 121 shown in FIG. 12A. As seen in the side view, the anchor permits attachment at one location (using hole 122) while fixing the implant at a second location by using hole 123. Fixation of the implant at hole 123 could be accomplished by a variety of means and methods, which will be described later. Using an offset anchor, such as shown in FIGS. 12A and 12B, advantageously allows for fixation of the implant at a suitable bone site, such as the pedicle, while still permitting the implant to be generally aligned with the disc space. Using an offset anchor advantageously permits fixation of implants to locations further away from the disc space, such as to sites which may have greater volumes of bone or locations that are easier to access.

[0156] As described above, various stabilizing implants (such as those shown in FIGS. 5 through 8) may be placed in the spine, often in a generally transverse manner, to provide torsional stabilization to a spinal motion segment. According to one embodiment, the stabilizing implant may be comprised of wires or cables made of a metal, a metal alloy (such as nitinol), a mono or multifilament polymeric material, or combinations thereof. In a preferred embodiment, the stabilizing implant is comprised of one or more sutures placed in tension between multiple locations along the spine to limit axial torsion in one or more directions. The amount of tension in one or more sutures may vary between 5 and 200 N, more preferably between 10 and 150 N. In some embodiments, the sutures may be used on their own as a stabilizing implant, while in other embodiments, the sutures are used as a stabilizing implant in addition to other implants.

[0157] Stabilizing implants may be fixed to various locations of the spine by using one or more anchoring devices. These anchoring devices may include the anchors shown in FIGS. 9 through 12, including one or more staples, threaded bone anchors, offset anchors, as well as various other anchors and combinations thereof. In some embodiments, one or more suturing anchors (as shown in FIG. 13) may also be used.

[0158] FIG. 13 illustrates a suture anchor 511 according to one embodiment that includes a threaded anchoring portion 515, a suture eye 521, and a receiving hole 530. The suture anchor 511 may serve to anchor an end point of one or more sutures 575 that enter through the receiving hole 530. The suture anchor 511 may be comprised of various materials, including but not limited to stainless steel, titanium, titanium alloy, nitinol, composites (such as combinations of TCP/PLGA), polymeric materials such as PEEK, polyglycolic or polylactic acid polymers, and combinations thereof.

[0159] The suture eye 521 may be of varying configurations and geometries, and may be used to hold one or more pieces of suture 575. In one embodiment, one or more pieces of suture may be looped through the eye 521. Additionally, the eye 521 may also hold a knot of one or more sutures 575. In another embodiment, the suture anchor 511 may be a knotless system such that there is no need to loop a suture around an eye portion of a suture anchor. One preferred embodiment of a suture and anchor combination uses a single suture that is attached to the anchor in the midst of the suture, resulting in two ends of a single suture for use as the stabilizing implant. This may be achieved by passing the suture through an eye 521 in the anchor, or by knotting the suture to itself after passing through an eye 521. This preferred embodiment in that it enables use with an endobutton (shown in FIG. 14) to tension the stabilizing implant by tying one end of the suture to the other.

[0160] One embodiment of the present application may use one or more suturing anchors 511 (as shown in FIG. 13) to torsionally stabilize a spinal motion segment by placing in tension one or more sutures 575 between an inferior vertebrae and a superior vertebrae. The stabilizing implant may include sutures 575 that are preloaded and fixed to one or more anchors 521. In another embodiment, one or more suturing anchors 511 may be used in conjunction with an endobutton to tension one or more sutures between adjacent vertebrae to resist axial torsion.

[0161] In embodiments that are comprised of one or more sutures, the sutures may be absorbable and made, for example, of a biodegradable polymeric fiber. Alternatively, the sutures may be non-biodegradable and made of a material such as polypropylene, polyester or polyethylene. One of skill in the art will appreciate that various sutures may be used as a stabilizing implant and the choice of materials is not limited to those materials mentioned above. Furthermore, the stabilizing implant may use one or more sutures that may be braided or unbraided. In one embodiment, a suture used as a stabilizing implant is constructed of a monofilament polymer chain having a braided jacket.

[0162] As shown in FIG. 13, the anchoring portion 515 of the suture anchor 511 may be externally threaded to facilitate insertion of the suture anchor into the bone. In one embodiment, the suture anchor 511 may be inserted into a pre-drilled hole of a bone. In another embodiment, the suture anchor 511 may be self-tapping by using the threaded anchoring portion 515. Regardless of the type of anchor used, one or more instruments may be used to facilitate placement of the anchor in a desired location of the bone.

[0163] FIG. 14A illustrate one embodiment of an endobutton 621 having holes 635. In an embodiment utilizing sutures as the stabilizing implant, one or more sutures connected to suturing anchors may be threaded through holes 635 of the endobutton. The endobutton 621 may then be advanced into contact with a spinous process of a vertebrae. The sutures may then be knotted to each other or the endobutton 621, resulting in tension in the sutures to limit axial torsion. In one embodiment, the endobutton 621 and sutures may be used to attach various types of soft tissue to the spinous process, including allograft, autograft, or xenograft tissue. FIG. 14B illustrates an embodiment of an endobutton 622, showing an alternative endobutton design.

[0164] Various devices and hardware are now described which may be used to fix one or more implants to the superior vertebrae, and more specifically, the spinous process of the superior vertebrae. In some embodiments, devices may fix to, extend around, clamp about, or otherwise engage one or more lateral surfaces of the spinous process including, e.g., the embodiments shown in FIGs. 15A-E and 17A-B, 18A-G and 19A-C, 20A-K and 21A-D, 24A-D, 25A-D, 26A-H, 27A-I, 28A-C, 29A-G and 29I-O, and 30A-C. In some embodiments, devices may fix to or otherwise engage a posterior surface of the spinous process including, e.g., the embodiments shown in FIGs. 20A-K and 21A-D, 22A-E, 23A-E, 24A-D, and 25A-D. In some embodiments, devices may fix to, extend around, clamp about, or otherwise engage a superior and/or inferior surface of the spinous process including, e.g., the embodiments shown in FIGs. 24A-D. In some embodiments, the hardware used for fixation to the spinous process may also be used to fix one or more implants to the inferior vertebral body. The hardware can be attached to the spinous process of the superior vertebrae by engaging the spinous process and/or by engaging a hole through the spinous process. Using hardware described below advantageously provides a stable mechanism for securing the implants at or near the spinous process. In addition, using hardware of different geometries provides the additional benefit of allowing for attachment of one or more implants either at the spinous process or near the spinous process (e.g., below or along the side of the spinous process), thus providing the flexibility for fixing an implant at various locations to optimize torsional stability from subject to subject. The use of hardware also permits distributing force applied to the spinous process over a sufficiently large area so as to avoid local failure of the cancellous bone that constitutes the spinous process. Also, hardware can be manufactured out of a resorbable material so that the device has a temporary function – providing torsional stability until the resorbable material decays to the point where the mechanical function of the device is lost.

[0165] FIGS. 15A, 15B, 15C, 15D, and 15E show a bottom perspective, bottom exploded, top exploded, top assembled, and right side view, respectively, of a fixation device 201. The fixation device 201 includes a central body 210, and a right anchoring wing 202 and a left anchoring wing 203 extending from the body 210. The right anchoring wing 202 can include an anchoring component 204 having spiked extremities on an inner surface of the anchoring wing 202 for attaching to e.g., lateral sides of the spinous process. In the illustrated embodiment, the right anchoring wing 202 includes two spiked extremities, although more or fewer are also possible. As shown, the right anchoring wing 202 can also or alternatively include a ridged or otherwise textured surface 205 on the inner surface of the right anchoring wing 202. For example, the ridged surface 205 can have a plurality of ridge members extending from the anchoring wing 202 in the same direction or generally in the same direction as the spiked extremities of the anchoring component 204. The ridged surface 205 can contact the surface of the spinous process to increase the resistance to relative motion of the fixation device 201 with respect to the spinous process. The left anchoring wing 203 can include an anchoring component 206 similar to anchoring component 204 and/or a ridged or otherwise textured surface 207 similar to ridged surface 205. In the illustrated embodiment, the inner surfaces of the right anchoring wing 202 and left anchoring wing 203 are oriented to face each other and are configured to contact the lateral sides of the spinous process.

[0166] Fixation device 201 further includes an implant attachment mechanism oriented at a lower portion of the central body 210. In the illustrated embodiment, the attachment mechanism includes a recessed receiving portion 208 and a protuberant knob-shaped portion 209 oriented below the receiving portion 208. The knob-shaped portion 209 is shaped so that the outer edges of the portion 209 extend beyond the greatest circumference of the receiving portion 208. In other words, the knob-shaped portion 209 has a greater circumference and/or diameter than the receiving portion 208. The receiving portion 208 is shaped to receive one or more implants, such as a suture, that can wrap around the edge of the receiving portion 208. The knob-shaped portion 209 is shaped to maintain the implant(s) in the receiving portion 208, for example, by restricting movement of an implant engaged with the receiving portion 208 in a direction perpendicular to a circular cross-section of the receiving portion 208. The outer edges of the central body 210 also extend beyond the greatest circumference of the receiving portion 208, restricting movement of an implant above the receiving portion 208. In other words, the central body 210 has a greater circumference and/or diameter than the receiving portion 208. As depicted in FIG. 15E, in the illustrated embodiment, the circumference of receiving portion 208 is smallest at a cross-section defined by plane 224. The circumference of receiving portion 208 at cross-sections parallel to plane 224 gradually increases between plane 224 and the central body 210 and between plane 224 and the knob-shaped portion 209.

[0167] As depicted in the exploded views of FIGs. 15B and 15C, the central body 210 is structurally coupled or integrally formed with the right anchoring wing 202. An at least partially ring-shaped member 214 extends from and is coupled or integrally formed with the left anchoring wing 203. However, in other embodiments, the central body 210 can be coupled to or integrally formed with the left anchoring wing 203, and an at least partially ring-shaped member 214 can extend from and be coupled to or integrally formed with the right anchoring wing 202. The ring-shaped member 214 can couple to the central body 210, either removably or permanently. In the illustrated embodiment, the central body 210 further includes a locking mechanism having a plurality of teeth 211 extending out from an outer surface of a cylindrical section 212 of the central body 210. The teeth 211 are configured to engage a plurality of teeth 213 extending from an interior surface of the ringed shaped member 214. The ringed shaped member 214 is shaped to fit around the cylindrical section 212 of the central body 210 and to secure the anchoring wing 203 to the central body 210 through the engagement of the teeth 211 with the teeth 213, as depicted in FIG. 15D. The teeth 211 and teeth 213 can be engaged at different positions so that the distance between the wings 202 and 203 can be altered so that the surfaces 205 and 207 engage the spinous process. The teeth 211 and teeth 213 can form a ratchet mechanism. In some embodiments, the teeth 211 and teeth 213 allow the wings 202, 203 to be adjusted in one direction relative to each other, e.g., toward each other, but resist movement of the wings 202, 203 in the opposite direction relative to each other, e.g., away from each other.

[0168] FIG. 16 shows a posterior (rear) view of a lumbar vertebral spine. As shown, a single spinal level is composed of the disc targeted for treatment 131, a superior vertebral body 132, and an inferior vertebral body 133. In this view, it is possible to visualize the spinous process 134 of the superior vertebral body 132, as well as the mamillary processes 135 and 136 of the inferior vertebral body 133.

[0169] FIG. 17A shows a posterior (rear) view of a lumbar vertebral spine with the fixation device 201, sutures, and anchors applied. The fixation device 201 is affixed at the spinous process 134 of the superior vertebral body 132. Sutures 215 and 216 wrap around receiving portion 208 of the fixation device 201. Suture 215 is affixed at a pedicle 217 of the right side of the inferior vertebral body 133 by an anchor 219, placing suture 215 in tension between the spinous process 134 and pedicle 217 in a plane generally aligned with the disc space. Suture 216 is affixed at a pedicle 218 of the left side of the inferior vertebral body 133 by an anchor 220, placing the suture 216 in tension between the spinous process 134 and the pedicle 218 in a plane generally aligned with the disc space. In alternative embodiments, sutures 215 and 216 may be affixed to the inferior vertebral body 133 at other locations including the mammillary processes. Alternative embodiments may include only a single suture affixed to receiving portion 208 and one of the anchors 218 or 219.

[0170] FIG. 17B shows a sagittal (side) view of the implantation system shown in FIG. 17A. As in FIG. 17A, the fixation device 201 is affixed at the spinous process 134 of the superior vertebral body 132. FIG. 17B also shows suture 215 wrapped around receiving portion 208 of the fixation device 201 and affixed at pedicle 217 of the right side of the inferior vertebral body 133 by anchor 219.

[0171] FIGS. 18A, 18B, 18C, 18D, 18E, 18F, and 18G show a first bottom perspective, second bottom perspective, top exploded, bottom exploded, top assembled, left side, and right side view, respectively, of a fixation device 230. The fixation device 230 includes a right anchoring wing 231 and a left anchoring wing 232. In the illustrated embodiment, the right 231 and left 232 anchoring wings have a generally curved or arcuate shape. The inner surface of the right anchoring wing 231 can include an anchoring component 233 having spiked extremities positioned proximate to a first end of the right anchoring wing 231 for attaching to e.g., lateral sides of the spinous process. In the illustrated embodiment, the right anchoring wing 231 includes two spiked extremities, although more or fewer are also possible. The inner surface of the right anchoring wing 231 can also or alternatively include a corrugated or otherwise textured surface 243 which can contact the surface of the spinous process to increase the resistance to relative motion of the fixation device 230 with respect to the spinous process. The right anchoring wing 231 also includes an implant receiving component 235, which can be positioned proximate to the first end of the right anchoring wing 231 and proximate to the anchoring component 233 as shown. In the illustrated embodiment, the implant receiving component includes a hook 245A, the end of which is curved upwards towards the top of the fixation device 230, and an opening 245B for inserting a suture and securing the suture over and/or around the hook 245A. The inner surface of the left anchoring wing 232 can include an anchoring component 234 having spiked extremities positioned proximate to a first end of the left anchoring wing 232 for attaching to the spinous process. In the illustrated embodiment, the left anchoring wing 232 includes two spiked extremities, although more or fewer are also possible. The inner surface of the left anchoring wing 232 can also or alternatively include a corrugated or otherwise textured surface 244 which can contact the surface of the spinous process to increase the resistance to relative motion of the fixation device 230 with respect to the spinous process. The left anchoring wing 232 also includes an implant receiving component 236, which can be positioned proximate to the first end of the left anchoring wing 232 and proximate to the anchoring component 234 as shown. In the illustrated embodiment, the implant receiving component includes a hook 246A, the end of which is curved upwards towards the top of the fixation device 230, and an opening 246B for inserting a suture and securing the suture over and/or around the hook. In the illustrated embodiment, the inner surfaces of the right anchoring wing 231 and left anchoring wing 232 are oriented to face each other and are configured to contact the lateral sides of the spinous process.

[0172] As depicted in the exploded views of FIGs. 18C and 18D, the fixation device 231 includes an attachment mechanism for attaching the right anchoring wing 231 to the left anchoring wing 232. In the illustrated embodiment, the attachment mechanism includes a protruding member 238 and a receiving member, which has an opening or recess, 237. The protruding member 238 is positioned proximate to a second end of the left anchoring wing 232 opposite the first end and protrudes from a bottom surface of the left anchoring wing 232. The receiving member, such as an opening or recess, 237 is positioned in a top surface of the right anchoring wing 231 proximate to a second end of the right anchoring wing 231 opposite the first end. However, in other embodiments, the protruding member 238 can extend from the right anchoring wing 231 and the left anchoring wing 232 can include the receiving member 237. The attachment mechanism is configured so that the protruding member 238 fits within the receiving member 237. The protruding member 238 can be rotated within the receiving member 237, allowing for adjustment of the distance between the anchoring components 233 and 234 to adapt to the size of the spinous process. The protruding member 238 can also be locked in place within the receiving member 237 to prevent movement and dislodgment after the fixation device 231 is attached to the spinous process.

[0173] Figure 19A depicts a top perspective view of a lumbar vertebral spine with the fixation device 230, sutures, and anchors applied. The fixation device 230 is affixed to the spinous process 134 of the superior vertebral body 132. Suture 239 is secured at the implant receiving component 235 of the fixation device 230. For example, the suture 239 can be wrapped or looped around the hook 245A as shown. Suture 239 is also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by an anchor 241, placing suture 239 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. Suture 240 is secured at the implant receiving component 236 of the fixation device 230, for example, wrapped or looped around the hook 246A. Suture 240 is also affixed at the pedicle 218 of the left side of the inferior vertebral body 133 by an anchor 242, placing the suture 240 in tension between the spinous process 134 and the pedicle 218 in a plane generally aligned with the disc space.

[0174] FIG. 19B shows a sagittal (side) view of the implantation system shown in Fig. 19A. As in FIG. 19A, the fixation device 230 is affixed at the spinous process 134 of the superior vertebral body 132. FIG. 19B also shows the suture 239 affixed to the right anchoring wing 231 of the fixation device 230 and affixed at pedicle 217 of the right side of the inferior vertebral body 133 by anchor 241.

[0175] FIG. 19C shows a posterior (rear) view of the implantation system shown in FIG. 19A. As in FIG. 19A, the fixation device 230 is affixed at the spinous process 134 of the superior vertebral body 132. FIG. 19C also shows the suture 239 affixed to the right anchoring wing 231 of the fixation device 230 and affixed at pedicle 217 of the right side of the inferior vertebral body 133 by anchor 241. FIG. 19C further shows the suture 240 affixed to the left anchoring wing 232 of the fixation device 230 and affixed at pedicle 218 of the right side of the inferior vertebral body 133 by anchor 242. Alternative embodiments may include only a single suture affixed to one of the anchoring wings 231 or 232 and one of the anchors 241 or 242.

[0176] FIGs. 20A, 20B, 20C, 20D, 20E, 20F, and 20G show a bottom perspective, top perspective, bottom exploded, bottom, top, left side, and right side view, respectively, of fixation device 260. The fixation device 260 includes a first anchoring wing 261, which in the illustrated embodiment is a right anchoring wing 261, a second anchoring wing 262, which in the illustrated embodiment is a left anchoring wing 262, and a spinous process anchor 267. One of skill in the art would appreciate that the differing features described for each of the right anchoring wing 261 and left anchoring wing 262 need not be limited to right and left orientations, respectively. In other embodiments, the first anchoring wing 261 is a left anchoring wing including at least some of the features described herein with respect to right anchoring wing 261 and the second anchoring wing 262 is a right anchoring wing including at least some of the features described herein with respect to left anchoring wing 262. In the illustrated embodiment, each anchoring wing is generally L-shaped, having a posterior portion, labeled 287A and 287B on the right anchoring wing 261 and left anchoring wing 262, respectively, and a lateral portion, labeled 288A and 288B on the right anchoring wing 261 and left anchoring wing 262, respectively positioned generally perpendicular to the posterior portions 287A,B. The posterior portions 287A,B of each anchoring wing include coupling arms for engaging the other anchoring wing and/or the spinous process anchor 267. The lateral portions 288A,B of each anchoring wing are configured to extend along and engage a lateral surface of the spinous process, and include an implant receiving component. The right anchoring wing 261 includes an implant receiving component 263, which, in the illustrated embodiment, includes a hook 285A, the end of which is curved upwards towards the top of the fixation device 260, and an opening 285B for inserting a suture and securing the suture over and/or around the hook. The right anchoring wing 261 further includes a corrugated or otherwise textured inner surface 265 which can contact the lateral surface of the spinous process to increase the resistance to relative motion of the fixation device 260 with respect to the spinous process. The left anchoring wing 262 also includes an implant receiving component 264 including a hook 286A, the end of which is curved upwards towards the top of the fixation device 260, and an opening 286B for inserting a suture and securing the suture over and/or around the hook. The left anchoring wing 262 further includes a corrugated section 266 which can contact the surface of the spinous process to increase the resistance to relative motion of the fixation device 260 with respect to the spinous process.

[0177] As depicted in FIG. 20C, the right anchoring wing 261 includes a pair of coupling arms 268A,B separated by a channel 284A, and the left anchoring wing 262 includes a pair of coupling arms 269A,B separated by a channel 284B. Each of the channels 284A,B and coupling arms 268A,B and 269A, B has a proximal end and a distal end, the proximal end oriented closest to the lateral portions 288A,B of each anchoring wing. The channels 284A and 284B are configured to receive the anchor 267 and allow for the anchor 267 to fit between each pair of coupling arms when the coupling arms are engaged, couple to, or contact each other and/or the anchor 267. As shown, the right anchoring wing can further include a receiving portion 279, e.g., a recess or channel configured to receive the distal ends of the coupling arms 269A,B of the left anchoring wing 262 when the right anchoring wing 261 and left anchoring wing 262 are coupled together at their closest position as described herein. FIGs. 20J and 20K show a right side perspective view of right anchoring wing 261 and a left side perspective view of the left anchoring wing 262, respectively.

[0178] The spinous process anchor 267 includes a cap 270 and a shank 274. FIGs. 20L and 20M show a front view of shank 274 and a perspective view of the cap 270, respectively. As shown in, for example, Figures 20C and 20M, the cap 270 includes a socket 271, and an internal thread (not shown). As shown in, for example, Figures 20C and 20L, the shank 274 includes a socket 272, a first threaded portion 273, a smooth shaft 275, a disc 276, a second threaded portion 277, and a distal tip 278. The socket 272 is configured to receive a tool for applying a rotational force to the shank 274. The shank is configured so that upon application of a rotational force, the distal tip 278 can drive into the bone of the spinous process and the second threaded portion 277 can anchor the shank to the spinous process. The first threaded portion 273 is configured to engage the internal thread of the cap 271 to couple the cap 271 to the shank 274. The socket 271 of the cap 270 is configured to receive a tool for applying a rotational force to the cap 270. A rotational force may be applied to fasten the internal thread of the cap 270 to the thread 273 of the shank 274. After the cap 270 is coupled to the shank 274, a rotational force may be applied through the socket 271 and/or socket 272 to drive the anchor 267 into the spinous process. In some embodiments, the anchor 267 can be configured to be received in a posterior surface of the spinous process.

[0179] As depicted in FIGs. 20D, 20E, 20H, and 20I, the distal ends of the coupling arms 269A,B are oriented posterior to the coupling arms 269A,B when attached to the spinous process. The cap 270 is positioned behind coupling arms 268 A,B and the disc 276 is positioned in front of coupling arms 269A,B, such that the coupling arms 268A,B and 269A,B engage the smooth shaft 275 of the anchor 267. In other words, the channels 284A and 284B receive the smooth shaft 275, and the arms 269A,B and 268A,B are positioned between the cap 270 and the disc 276. The outer diameters of the cap 271 and the disc 276 are greater than the width of the channels between each pair of coupling arms 268A,B and 269A,B. The cap 270 can be fastened to secure coupling arms 268A,B and 269A,B in place between the cap 270 and the disc 276 to prevent motion of the anchoring wings 261 and 262 when the fixation device 260 is secured to the spinous process.

[0180] The channels 284A and 284B allow for adjustment of the distance between the anchoring wings 261 and 262 and/or the distance between each anchoring wing and the anchor 267 to adapt to the size of the spinous process. FIGs. 20A-B and 20D-G depict an embodiment in which coupling arms 268A,B and 269A,B are positioned so that the anchor 267 is located at the proximal end of each channel 284A and 284B between coupling arms 268A,B and coupling arms 269A,B. Thus, FIGs. 20A-B and 20D-G show the configuration of fixation device 260 with the anchoring wings 261, 262 closest together or having the least distance between corrugated section 265 and 266. In this configuration, the coupling arms 269A,B are configured to fit within the receiving portion 279 of the right anchoring wing 261 as shown. FIGs. 20H and 20I show a top perspective and a top view respectively of the fixation device 260 in a configuration in which the anchor is positioned closer to the distal end of each pair of coupling arms along the channel between each pair of coupling arms 268A,B and 269A,B.

[0181] FIG. 21A shows a posterior (rear) view of a lumbar vertebral spine with a fixation device 260, sutures, and anchors applied. The fixation device 260 is affixed to the spinous process 134 of the superior vertebral body 132. The anchor 267 is affixed to the posterior surface of the spinous process 134. Suture 280 is secured to the fixation device 260 at the implant receiving component 263 (not shown), and also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by an anchor 282, placing suture 280 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. Suture 281 is secured to the fixation device 260 at the implant receiving component 264 (not shown), and also affixed at the pedicle 218 of the left side of the inferior vertebral body 133 by an anchor 283, placing the suture 281 in tension between the spinous process 134 and the pedicle 218 in a plane generally aligned with the disc space. Alternative embodiments may include only a single suture affixed to one of the implant receiving components 263 or 264 and one of the anchors 282 or 283.

[0182] FIG. 21B shows a sagittal (side) perspective view of the implantation system shown in FIG. 21A. As in FIG. 21A, the fixation device 260 is affixed at the spinous process 134 of the superior vertebral body 132. FIG. 21B also shows the suture 281 affixed to the implant receiving component 264 of the left anchoring wing 262 and affixed at the pedicle 218 of the left side of the inferior vertebral body 133 by anchor 283.

[0183] FIG. 21C shows a sagittal (side) view of the implantation system shown in FIG. 21A. As in FIG. 21A, the fixation device 260 is affixed at the spinous process 134 of the superior vertebral body 132. FIG. 21C also shows the suture 281 affixed to the implant receiving component 264 of the left anchoring wing 262 and affixed at the pedicle 218 of the left side of the inferior vertebral body 133 by anchor 283.

[0184] FIG. 21D shows a top view of the implantation system shown in FIG. 21A. As in FIG. 21A, the fixation device 260 is affixed at the spinous process 134 of the superior vertebral body 132. FIG 21D also shows the suture 280 affixed to the fixation device 260 and affixed to the pedicle 217 to the right side of the inferior vertebral body. FIG 21D further shows the suture 281 affixed to the fixation device 260 and affixed to the pedicle 218 to the left side of the inferior vertebral body.

[0185] FIG. 22A shows a top perspective view of a lumbar vertical spine with a fixation device 300, showing the fixation device 300 in an exploded configuration. The fixation device 300 includes a central section 301, a right wing 302, a left wing 303 and a spinous process anchor 304. The right wing 302 and left wing 303 are structurally coupled or integrally formed with the central piece 301. The right wing 302 and left wing 303 are configured to extend from the central section 301 and angle outwardly and towards a more anterior section of the spinous process 134 when affixed thereto. The central piece 301 can include a spiked extremity 305 for affixing to the posterior surface of the spinous process extending from an upper section of the central piece 301 and a spiked extremity 306 for affixing to the posterior surface of the spinous process extending from a lower section of the central piece 301. Although Figure 22A shows 2 spiked extremities 305 and 306, more or fewer are also possible. The right wing 302 and left wing 303 can each include a hole 308 and a hole 309, respectively, for securing a suture thereto. The central piece can include a hole 307 for receiving the anchor 304. The anchor 304 includes a cap 310, a threaded portion 311 and a distal tip 312. Upon application of rotational force to the anchor 304, the distal tip 312 can drive into the bone of the spinous process 134 and the threaded portion 311 can anchor the anchor 304 to the posterior surface of the spinous process 134. The cap 310 has a greater circumference or diameter than the hole 307, allowing for the securement of the fixation device 300 to the spinous process 134.

[0186] FIG. 22B shows a sagittal (side) perspective view of the implantation system of FIG. 22A. As in FIG. 22A, the fixation device 300 is shown in an exploded configuration. As depicted in FIG. 22B, the anchor 304 further includes a socket 313 configured to receive a tool for applying a rotational force to the anchor 304. FIG. 22B further shows a hole 140 that has been drilled, cut, or otherwise formed in the spinous process to facilitate receipt and securement of the anchor 304. In some embodiments, the anchor 304 can be self-tapping and a hole 140 need not be formed prior to insertion of the anchor 304 into the spinous process.

[0187] FIG. 22C shows a sagittal (side) perspective view of the implantation system of FIG. 22A, with the fixation device 300, a suture 314, and an anchor 315 applied. The fixation device 300 is secured to the spinous process 134 of the superior vertebral body 132 by the spiked extremities 305 and 306 and the anchor 304. The suture 314 is secured to the fixation device 300 at the hole 308, and also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by the anchor 315 placing suture 314 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. Although not shown, in some embodiments, a second suture may be secured to the fixation device at the hole 309 (not shown) of the left wing 303, and also affixed to the pedicle 218 of the left side of the inferior vertebral body 133 by an anchor, placing the suture in tension between the spinous process 134 and pedicle 218 in a plane generally aligned with the disc space.

[0188] FIG. 22D shows a sagittal (side) perspective view of the implantation system as shown in FIG. 22C having an alternative embodiment 300A of the fixation device 300. In the illustrated embodiment, the fixation device 300A has two spiked extremities 305A and 305B extending from the upper section of the central piece 301 in contrast to the spiked extremity 305 depicted in FIGs. 22A-C. Although not shown, the fixation device 300A of FIG. 22D may also have two spiked extremities extending from the lower portion of the central piece 301. More or fewer spiked extremities are also contemplated.

[0189] FIG. 22E shows a sagittal (side) perspective view of the implantation system as shown in FIG. 22D having an alternative embodiment 300B, of the fixation device 300. As in embodiment 300A depicted in FIG. 22D, the fixation device 300B has two spiked extremities 305A and 305B extending from the upper section of the central piece 301. In the illustrated embodiment, fixation device 300B includes a right wing 302A and left wing 303A that extend straight outward from the central section 301, perpendicular to an axis running along the length of the anchor 304 from the cap 310 to the distal tip 312.

[0190] FIG. 23A shows a side view of a lumbar vertical spine with a fixation device 320. The fixation device 320 can include a posterior disc 321, an anterior disc 322, and an implant receiving portion 323 positioned between the posterior disc 321 and anterior disc 322. The receiving portion 323 can be a cylindrical groove positioned between the posterior disc 321 and anterior disc 322. The receiving portion 323 is shaped to receive one or more implants, such as a suture, that can wrap around the edge or an outer perimeter of the receiving portion 323. The posterior disc 321 and anterior disc 322 each have a greater circumference and/or diameter than the receiving portion 323 in order to restrict movement of implants secured to the implant receiving portion. Extending from an anterior surface (i.e., a surface facing away from the receiving portion 323 and posterior disc 321) of the anterior disc 322 is a plurality of spiked extremities 324 located around the periphery of the anterior disc 322 for affixing the fixation device 320 to the posterior surface of the spinous process 134. FIG. 23A shows 6 spiked extremities, but more or fewer are also possible. The fixation device 320 further includes a spinous process anchor 325 extending from the anterior surface of the anterior disc 322 for affixing the fixation device 320 to the posterior surface of the spinous process 134. The anchor 325 can be structurally coupled or integrally formed with the fixation device 320. In some embodiments, the anchor 325 is a separate component from the fixation device 320, and the fixation device 320 further includes a locking mechanism for securing the anchor 325 to the fixation device 320. The anchor 325 includes a threaded portion 326 and a distal tip 327. Upon application of rotational force, the distal tip 327 can drive into the bone of the spinous process 134 and the threaded portion 326 can anchor the anchor 325 to the spinous process 134.

[0191] FIG. 23B shows a sagittal (side) perspective view of the implantation system of FIG. 23A with the fixation device 320 secured to the spinous process 314. As shown in FIG. 23B, the fixation device 320 further includes a socket 328 configured to receive a tool for applying a rotational force to the anchor 325. The socket 328 can extend through the posterior disc 321, receiving portion 323, and anterior disc 322 such that a tool inserted into the socket 328 can engage the anchor 325. In some embodiments, the anchor

325 can be rotated relative to or independent of the anterior disc 322, receiving portion 323, and/or posterior disc 321 such that the anchor 325 can be rotated into the bone without rotation of the remainder of the fixation device 320. Because the anchor 325 is coupled to the remainder of the fixation device 320, as the anchor 325 is rotated into the bone, the anterior disc 322 can be drawn toward the bone and the spiked extremities 324, if present, can be drawn into engagement with the bone.

[0192] FIG. 23C shows a sagittal (side) perspective view of the implantation system of FIG. 23A, with the fixation device 320, a suture 329, and an anchor 330 applied. The fixation device 330 is secured to the spinous process 134 of the superior vertebral body 132 by the spiked extremities 324 and the anchor 325. The suture 329 is wrapped around the receiving portion 323 of the fixation device 300, and is also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by the anchor 330, placing suture 329 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. Although not shown, in some embodiments, a second suture may be wrapped around the receiving portion 323, and also affixed to the pedicle 218 of the left side of the inferior vertebral body 133 by an anchor, placing the suture in tension between the spinous process 134 and pedicle 218 in a plane generally aligned with the disc space. FIG. 23D shows a side view of the implantation system of FIG. 23A with the fixation device 320, a suture 329, and an anchor 330 applied.

[0193] FIG. 23E shows a sagittal (side) perspective view of the implantation system of FIG. 23A with the fixation device 320 secured to the spinous process 134. FIG. 23E further shows a tool 331 inserted into the socket 328. The tool can be rotated to cause the rotation of the anchor 325.

[0194] FIG. 24A and 24B show a bottom perspective view of a top anchoring wing 341 and a top perspective view of a bottom anchoring wing 342, respectively, of a fixation device 340. As shown in the assembled views of FIGs. 24C-24D, in use the top anchoring wing 341 and bottom anchoring wing 342 are coupled together and extend over or clamp about superior and inferior surfaces, respectively, of the spinous process 134. As shown in FIG. 24A, a first end of the top anchoring wing 341, includes a connecting member 347, which can include a hole 481 configured to receive a fastener for securing the anchoring wing 341 to the anchoring wing 342. Extending upward from the connecting member 347, i.e., towards the superior surface of the spinous process when the top anchoring wing 341 and bottom anchoring wing 342 are secured to the spinous process 134, is a first portion 482 having a surface 343 configured to engage the posterior surface of the spinous process. The first portion 482 further includes a hole 346 configured to receive an spinous process anchor. In the illustrated embodiment, the hole 346 is positioned proximate a first end of the first portion 482 proximate the connecting member 347. In some embodiments, the hole 346 can be positioned perpendicular to the hole 381. Extending from a second end of the first portion 482 opposite the connecting member 347 is a curved anchoring component 344 that extends above the top surface of the spinous process 134 in use. The anchoring component 344 may be positioned at an angle, such as for example, greater than about 65 degrees to less than 115, relative to the first portion 482. The anchoring component 344 can also be wider than the first portion 482 and curved so that it can wrap around the lateral surfaces of the spinous process 134 in use. As shown, the anchoring component 344 can have one or more spiked extremities 345 for attaching to the top surface of the spinous process. In the illustrated embodiment depicted in FIG. 24A, the anchoring component 344 has 3 spiked extremities 345, but more or fewer are also possible.

[0195] As depicted in FIG. 24B, the anchoring wing 342 includes connecting members 353 and 354 having holes 483 and 484 configured to receive a fastener for securing the anchoring wing 342 to the anchoring wing 341. To assemble the fixation device 340, the connecting member 347 of anchoring wing 341 can be positioned between the connecting members 353 and 354 of anchoring wing 342 such that the holes of each connecting member are aligned, and a fastener (e.g., fastener 359 shown in FIGs. 24C-24D) can be inserted through the holes of each connecting member to secure the anchoring wing 342 to the anchoring wing 341. The anchoring wing 342 can further include a hole 355 in a section 496 of the anchoring wing 342 configured to be positioned posterior to the hole 346 of the anchoring wing 341 when the anchoring wings 341, 342 are assembled. In the illustrated embodiment, the hole 355 is configured to align with hole 346 of anchoring wing 341 such that a spinous process anchor (e.g., spinous process anchor 357 shown in FIGs. 24C-24D) can be inserted through both holes 346, 355 and into the spinous process. In the illustrated embodiment, the hole 355 is positioned at a first end of the bottom anchoring wing 342, which is a top end of the bottom anchoring wing 342 in use, and the connecting members 353, 354 are positioned proximate, e.g., adjacent to in the illustrated embodiment, the section including the hole 355. Extending downwardly from the connecting members 353 and 354 is a first portion 485 having a surface 348 configured to at least partially contact or engage the posterior surface of the spinous process. Extending outwardly and anteriorly from lateral sides of the first portion 485 are implant receiving members 351 and 352, having holes 486 and 487, respectively, for receiving an implant. Extending from an end of the first portion 485 opposite the connecting members 353 and 354 is an anchoring component 349 that extends below the bottom of the spinous process in use. The anchoring component 349 may be positioned at an angle, such as for example, greater than about 65 degrees to less than 115, relative to the first portion 485. The anchoring component 349 can also be wider than the first portion 485 and curved so that it can wrap around the lateral surfaces of the spinous process 134. As shown, the anchoring component can have spiked extremities 350 for attaching to the bottom surface of the spinous process. In the illustrated embodiment depicted in FIG. 24B, the anchoring component 349 has 3 spiked extremities 350, but more or fewer are also possible.

[0196] FIG. 24C shows a sagittal (side) perspective view of a lumbar vertical spine with a fixation device 340, a suture 356, a spinous process anchor 357, and an anchor 358. As depicted in FIG. 23C, the implantation system is partially assembled. The anchoring wing 341 is shown secured to the anchoring wing 342 by a fastener 359. The anchoring wing 341 is also shown engaging the posterior and top surfaces of the spinous process 134 of the superior vertebral body 132. The anchoring wing 342 is shown withdrawn from the spinous process 134 and unattached to the suture 356. The fastener 359 extends laterally when inserted through hole 481 of connecting member 347 and holes 483 and 484 of connecting members 353 and 354, allowing the anchoring wing 341 and the anchoring wing 342 to pivot relative to each other to allow the fixation device 340 to attach to the spinous process. For example, the anchoring wing 342 can pivot from the position shown in FIG. 24C to the position shown in FIG. 24D, in which the anchoring wing 342 is secured to the inferior surface of the spinous process.. The anchoring wings 341 and 342 may also pivot to allow for attachment to spinous processes of different sizes. The spinous process anchor 357 is shown partially inserted into holes 346 and 355 of the fixation device 340. Suture 356 is affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by the anchor 358.

[0197] FIG. 24D shows a sagittal (side) perspective view of a lumbar vertical spine with the fixation device 340, suture 356, spinous process anchor 357, and anchor 358 applied. The fixation device 340 is secured to the spinous process 134 of the superior vertebral body 132 by the spiked extremities 345 and 350 and the anchor 357. The suture 356 is secured to the implant receiving member 352 of the fixation device 340, and is also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by the anchor 358, placing suture 356 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. Although not shown, in some embodiments, a second suture may be secured to implant receiving member 351, and also affixed to the pedicle 218 of the left side of the inferior vertebral body 133 by an anchor, placing the suture in tension between the spinous process 134 and pedicle 218 in a plane generally aligned with the disc space.

[0198] FIG. 25A shows a right sagittal (side) perspective view of a lumbar vertical spine with a fixation device 360, a suture 361, and an anchor 363 applied. The fixation device 360 includes a right anchoring wing 364 and a left anchoring wing 365. The right anchoring wing 364 includes a body portion, an upper connecting member 368, and a lower connecting member 371. When in use, the body portion of the right anchoring wing 364 contacts the lateral surface of the spinous process 134, and the upper connecting member 368 and lower connecting member 371 are positioned posterior to the spinous process 134. In some embodiments, the upper and lower connecting members 368, 371 can be integrally formed with or coupled to the body portion. The left anchoring wing 365 includes a body portion, an upper connecting member 369, and a lower connecting member 370. When in use, the body portion of the left anchoring wing 365 contacts the lateral surface of the spinous process 134, and the upper connecting member 368 and lower connecting member 370 are positioned posterior to the spinous process 134. The right anchoring wing 364 is secured to the left anchoring wing by a fastener 366, e.g., a pin, extending through the upper connecting member 368 and the upper connecting member 369 of the right anchoring wing 364 and left anchoring wing 365, respectively, and by a fastener 367 extending through the lower connecting member 371 and the lower connecting member 370 of the right anchoring wing 364 and the left anchoring wing 365, respectively. In the illustrated embodiment, the upper and lower connecting members 369, 370 of the left anchoring wing 365 are positioned between the upper and lower connecting members 368, 371 of the right anchoring wing 364. However, in other embodiments, the upper and lower connecting members 368, 371 of the right anchoring wing 364 can be positioned between the upper and lower connecting members 369, 370 of the left anchoring wing, the upper connecting member 368 of the right anchoring wing 364 could be positioned on top of the upper connecting member 369 of the left anchoring wing 365 and the lower connecting member 371 of the right anchoring wing 364 could be positioned on top of the lower connecting member 370 of the left anchoring wing 365, or the upper connecting member 369 of the left anchoring wing 365 could be positioned on top of the upper connecting member 368 of the right anchoring wing 364 and the lower connecting member 370 of the left anchoring wing 364 could be positioned on top of the lower connecting member 371 of the right anchoring wing 365. In use, a spinous process anchor 362 extends through an opening 490 formed between the right anchoring wing 364 and the left anchoring wing 365 when secured together and into the spinous process 134 to secure the fixation device 360 to the spinous process 134 of the superior vertebral body 132. The fixation device 360 can also be secured to the lateral surfaces of the spinous process by spiked extremities (not shown) extending from inner surfaces of the right anchoring wing 364 and left anchoring wing 365.

[0199] The fixation device 260 further includes an implant receiving member 372 positioned on the right side of the right anchoring wing 364. In the illustrated embodiment, the implant receiving member 372 extends downward from the lower connecting member 371 of the right anchoring wing 364. However, in other embodiments having different arrangements of connecting members, the implant receiving member 372 may extend from the lower connecting member 370 of the left anchoring wing 364 or other portions of the fixation device 260. The implant receiving member 372 can include a hole 495 that receives the suture 361 in use. The suture 361 is secured to the implant receiving member 372, and is also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by the anchor 363, placing suture 361 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. In alternative embodiments, the fixation device 360 may further include an implant receiving member on the left side of the fixation device 360 for receiving a second suture. The second suture can be affixed to the pedicle 218 of the left side of the inferior vertebral body 133 by an anchor, placing the suture in tension between the spinous process 134 and pedicle 218 in a plane generally aligned with the disc space. FIG. 25B shows a left sagittal (side) perspective view of the implantation system of FIG. 25A

[0200] FIG. 25C shows a top view of the implantation system of FIG. 25A, showing the left anchoring wing 365 and the anchor 362 disengaged from the spinous process. The fasteners 366 and 367 allow the right anchoring wing 364 and the left anchoring wing 365 to pivot relative to each other, allowing the fixation device 360 to be coupled to the spinous process and to attach to spinous processes of varying sizes. The left anchoring wing 365 can include a spiked extremity 374 for attaching to the spinous process 134. Although only 1 spiked extremity is shown, more are also possible. The right anchoring wing 364 can include a spiked extremity 373 for attaching to the spinous process. Although only 1 spiked extremity is shown, more are also possible. FIG. 25D shows a top view of the implantation system of FIG. 25C, showing the left anchoring wing 365 and anchor 362 affixed to the spinous process. In some embodiments, the anchor 362 can also be configured to secure the right anchoring wing 364 and left anchoring wing 365 in place when affixed to the spinous process. For example, the anchor 362 can include a conical wedge section having a narrower portion extending into the opening 490 and a wider end extending beyond the outer boundaries of the opening 490 so as to secure the anchoring wings in place.

[0201] FIG. 26A and 26B show a sagittal (side) perspective view and a top perspective view, respectively, of a lumbar vertical spine and a fixation device 380 disengaged from the spine. FIG. 26A further shows an anchor 387 affixed to the pedicle 217 of the right side of the inferior vertebral body 133. The fixation device 380 includes a right anchoring wing 381, a left anchoring wing 382, and a central body 383. The right anchoring wing 381 and left anchoring wing 382 are structurally coupled or integrally formed with the central body 383 and extend anteriorly and inwardly therefrom. The right anchoring wing 381 and left anchoring wing 382 include teeth 384 and teeth 385, respectively, for attaching to the spinous process 134. The right anchoring wing can further include tool receiving components 386 and 387 configured to receive a tool 390. Tool 390 includes rods 392A and 392B that can be inserted into receiving components 386 and 387, respectively. The rods 392A and 392B are integrally formed with a handle 393. In other embodiments, the rods 392A and 392B can be separate from but coupled to the handle 393. The left anchoring wing 382 can include tool receiving components 388 and 389 configured to receive a tool 391. Tool 391 includes rods 394A and 394B that can be inserted into receiving components 388 and 389, respectively. The rods 394A and 394B are integrally formed with a handle 395. In other embodiments, the rods 394A and 394B can be separate from but coupled to the handle 395. Extending from the bottom of the central body 383 is an implant receiving member 396 having a hole for receiving one or more implants.

[0202] FIG. 26C shows a top perspective view of the implantation system of FIG. 26A showing arrows representing movement of the tools 390 and 391 prior to securing the fixation device 380 to the spinous process 134. The arrows depicted in FIG. 26 show a direction in which a force can be applied to the tools 390 and 391 to cause the wings 381 and 382 to spread outward from the center of the fixation device 380. The fixation device 380 can be made of a materially that is sufficiently flexible to allow for the wings 381 and 382 to spread outward and also sufficiently resilient so that the wings 381 and 382 return to their initial configuration when the force is no longer acting upon them. Prior to the spreading of the wings 390 and 391, the distance between the teeth 384 and 385 is sufficiently small so that the teeth cannot fit over the lateral edges of the spinous process 134. Upon application of the force to the tools 390 and 391, the wings 381 and 382 can spread wide enough so that the teeth 384 and 385 can fit over the lateral edges of the spinous process 134.

[0203] FIG. 26D shows a top perspective view of the implantation system of FIG. 26A showing arrows representing movement of the tools 390 and 391 after the fixation device 380 is placed over the spinous process 134. In some embodiments, the fixation device 380 is sufficiently resilient such that the teeth 384 and 385 attach to the spinous process 134 following removal of the outward force to the wings 381 and 382 as depicted in FIG. 26C. In other embodiments, a force, as represented by the arrows in FIG. 26D, can be applied to the tools 390 and 391 to cause the teeth 384 and 385 to attach to or be further secured to the spinous process 134.

[0204] FIG. 26E shows a sagittal (side) perspective view of the implantation system of FIG. 26A showing arrows representing the removal of tools 390 and 391 from the fixation device 380. After the fixation device 380 is attached to the spinous process 134, a force can be applied to the tools 390 and 391 in the direction of the arrows shown in FIG. 26E to remove the tools 390 and 391 from the implantation device 380.

[0205] FIGs. 26F, 26G, and 26H show a sagittal (side) perspective view, a posterior (rear) perspective view, and a top view, respectively, of the implantation system of FIG. 26A with the fixation device 380, anchor 397, and a suture 398 applied. The fixation device 380 is secured to the spinous process 134 of the superior vertebral body 132 by the teeth 384 and 385. The suture 398 is secured to the implant receiving member 396 of the fixation device 380, and is also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by the anchor 397, placing suture 398 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. Although not shown, in some embodiments, a second suture may be secured to implant receiving member 396, and also affixed to the pedicle 218 of the left side of the inferior vertebral body 133 by an anchor, placing the suture in tension between the spinous process 134 and pedicle 218 in a plane generally aligned with the disc space.

[0206] FIGs. 27A and 27B show a top view and a rear view, respectively, of a fixation device 400. The fixation device 400 includes a central body 401. Extending anteriorly from the central body 401 are anchor receiving members 402 and 403, the anchor receiving members 402 and 403 having holes 497 and 498, respectively, for receiving a spinous process anchor. The anchor receiving members 402, 403 can be integrally formed with the central body 401. In the illustrated embodiment, the central body 401 and anchor receiving members 402, 403 are generally U-shaped. Anchor receiving members 402 and 403 are configured to receive spinous process anchors 410 and 411, respectively. The anchors 410 and 411 further include distal tips 418 and 425, respectively, which can drive into the bone of the lateral surface of the spinous process. Extending laterally from the central body 401 are implant receiving members 404 and 405. The implant receiving member 404 includes a hole 406 for securing an implant. The fixation device 400 includes an anchor lock 408 extending through the implant receiving member 404 and configured for adjusting and/or securing the anchor 410 in position. The implant receiving member 405 includes a hole 407 for securing an implant. The fixation device 400 includes an anchor lock 409 extending through implant receiving member 405 and configured for adjusting and/or securing the anchor 411 in position. In some embodiments, the width between the anterior surface and the posterior surface of central body 401, when viewing a front view of the fixation device 400, can be about 2 mm. The distance between the lateral inner surfaces of anchor receiving members 402 and 403 can be about 10 mm. The distance between the distal tip 418 and the anterior surface of receiving member 402, if viewing a front view of the fixation device 400, can be about 3.3 mm. The distance between the distal tip 418 and the anterior surface of the central body 401, if viewing a front view of the fixation device 400, can be about 8.7 mm. Measurements are similar for the components associated with anchor receiving member 403. The distance between the lateral outer surfaces of implant receiving members 404 and 405 can be about 26 mm. The distance between the superior and inferior surfaces of each implant receiving member 404, 405 can be about 10 mm. The distance between the center of hole 406 and the center of hole 407 can be about 19 mm.

[0207] FIGs. 27C, 27D, and 27E show a top view, a sagittal (side) perspective view, and a posterior (rear) view of a lumbar vertebral spine with the fixation device 400, sutures, and anchors applied. The fixation device 400 is affixed at the spinous process 134 of the superior vertebral body 132. Suture 426 is secured to hole 406 of implant receiving member 404 of the fixation device 400, and is also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by the anchor 428, placing suture 426 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. Suture 427 is secured to hole 407 of implant receiving member 405 of the fixation device 400, and also affixed to the pedicle 218 of the left side of the inferior vertebral body 133 by anchor 429, placing the suture in tension between the spinous process 134 and pedicle 218 in a plane generally aligned with the disc space. Alternative embodiments may include only a single suture affixed to one of the implant receiving members 404 or 405 and one of the anchors 428 or 429.

[0208] The anchor lock 408 includes a spring 412 wrapped around a shaft 413, a locking ring 414, a gear 415, and a socket 416. The spring 412 is disposed on a posterior side of the implant receiving member 404, and the gear 415 is positioned on an anterior side of the implant receiving member 404. The gear 415 engages a toothed rod 417 of the anchor 410. The socket 416 is configured to receive a tool for rotation of the anchor lock 408. Rotation of the anchor lock 408, and thus the gear 415, can cause translational movement of the anchor 410 such that the anchor 410 can be advanced towards or away from a lateral surface of the spinous process in use. Similarly, the anchor lock 409 includes a spring 419 wrapped around a shaft 420, a locking ring 421, a gear 422, and a socket 423. The gear 422 engages a toothed rod 424 of the anchor 411. Rotation of the anchor lock 409, and thus the gear 422, can cause translational movement of the anchor 411 such that the anchor 410 can be advanced towards or away from a lateral surface of the spinous process in use.

[0209] FIGs. 27F, 27G, 27H, and 27I show a partial view of the fixation device 400 showing the anchor lock 408 and anchor 410 at different stages of an anchor adjusting and locking process. FIG. 27F shows the anchor lock 408 in a locked position as well as cut-away views of several components of the anchor lock 408. As depicted in FIG. 27F, the implant receiving component 404 includes a hole 430 through which the anchor lock 408 extends. In the interior of the hole 430 is a locking mechanism 431 having teeth 432, the teeth 432 oriented as shown when viewing a front view of the device 400, i.e., viewed from the anterior when facing posterior. The teeth 432 are configured to engage teeth 433 of the locking ring 414. When the teeth 432 and teeth 433 are engaged, as depicted in FIG. 27F, rotation of the anchor lock 408 is prevented. FIG. 27F further shows a tool 434 that can engage the socket 416 of the anchor lock 408. As shown in FIG. 27I, in the illustrated embodiment, the tool 434 includes a hexagonal tip 437, and the socket 416 has a corresponding hexagonal shape, as shown in FIG. 27B, to receive the hexagonal tip 437 of the tool 434. In other embodiments, the tip 437 and socket 416 can have other corresponding shapes. The tool 434 can be used to apply a force to the anchor lock 408 in the direction shown by the arrow 435A in order to disengage the teeth 433 from the teeth 432. The circumference/diameter of the spring 412 is greater than that of the hole 430. When the anchor lock 408 is translated in the direction shown by the arrow 435A, the spring 412 is compressed.

[0210] FIG. 27G shows the anchor lock 408 in an unlocked position after a force has been applied in the direction of the arrow 435A. As depicted in FIG. 27G, the locking ring has moved out of the hole 430. Consequently, rotation of the locking anchor 408 is no longer prevented by the locking mechanism 431.

[0211] FIG. 27H shows the anchor lock 408 in an unlocked position after a rotational force has been applied to the tool 434. As depicted by arrows 435B and 435C, a rotational force on tool 434 (indicated by arrow 435B) causes rotation of the gear 415, which in turn causes the translational movement of the anchor 410 (indicated by arrow 435C).

[0212] FIG. 27I shows the anchor 410 in a locked position after the tool 434 has been removed from the socket 416. After removal of the tool 434, the spring 412 is released, causing the anchor lock 408 to move in the direction shown by the arrow 435D. This causes the locking ring 414 to re-engage with the locking mechanism 431, preventing the rotation of gear 415 and securing anchor 410 in place. The anchor lock 409 can function in the same manner in order to lock the anchor 411 in place.

[0213] FIG. 27J shows a perspective view of the tool 434. The hexagonal tip 437 is configured for use with the sockets 416 and 423 of anchor locks 408 and 409, respectively. The tool 434 can also be configured for use with anchors 428 and 429. FIG. 27K depicts a perspective view of an example embodiment of an anchor 428 for attaching to a pedicle. The anchor includes a threaded portion 438, a socket 439 for receiving a tool such as tool 434, a hole 318 for receiving an implant, and a distal tip (not shown) for driving into the bone of the pedicle.

[0214] FIGs. 28A, 28B, and 28C show a top view, a posterior (rear) view, and a top perspective view, respectively, of an alternative embodiment 400A, of the fixation device 400 as depicted in FIGs. 27A-I. The fixation device 400A includes central body 401, anchor receiving member 403, anchor 411, implant receiving member 405, and anchor lock 409 for securing the anchor 411 in position. In the alternative embodiment of fixation device 400, shown as fixation device 400A, the anchor receiving member 402 and the implant receiving member 404 are replaced with an anchoring member 402A and an implant receiving member 404A. The anchoring member 402A has a spiked extremity 410A extending from an inner surface for anchoring to the lateral surface of the spinous process. The implant receiving member 404A includes a hole 406A for securing an implant. Compared to fixation device 400, fixation device 400A lacks the spinous process anchor 410 and anchor lock 408. The fixation device 400A includes the stationary spiked extremity 410A instead of the adjustable spinous process anchor 410. In use, the spiked extremity 410A can be secured to the spinous process, and the spinous process anchor 411 can be adjusted to engage the other lateral side of the spinous process and adapt to different sized spinous processes. In other embodiments, an alternative embodiment of the fixation device 400 can include the spinous process anchor 410 and anchor lock 408 but lack the spinous process anchor 411 and anchor lock 409 and instead include a stationary spiked extremity extending from an inner surface of the anchoring member 403.

[0215] FIGs. 29A and 29B show at top perspective and a top view of a fixation device 440. The fixation device includes an at least partially hollow central body 441. As shown, the central body 441 can be curved. The central body 441 includes an opening 452 in a posterior wall. The central body 441 further includes implant receiving members 442 and 443, which, in the illustrated embodiment, are positioned to either side of the opening 452. The central body 441 also at least partially houses anchoring members 444 and 445. Each anchoring member includes a curved shaft that can slide into and out from the central body 441. The anchoring member 444 further includes a distal tip 446and a toothed section 448. As shown, the distal tip 446 is located at a first end of the anchoring member 444 positioned away from the central body 441. The toothed section 448 is located proximate an opposite second end of the anchoring member 444 and disposed within the central body 441. The anchoring member 445 further includes a distal tip 447 and a toothed section 449. As shown, the distal tip 447 is located at a first end of the anchoring member 445 positioned away from the central body 441. The toothed section 449 is located proximate an opposite second end of the anchoring member 445 and disposed within the central body 441. The anchoring member 444 is positioned inside an upper portion of the central body 441 above the anchoring member 445, which is positioned inside a lower portion of the central body 441.

In other embodiments, the anchoring members 444, 445 can be reversed such that the anchoring member 445 is positioned above the anchoring member 444. A locking mechanism 451 is removably positioned between the toothed sections 448 and 449 to lock the anchoring members 444 and 445 in place relative to each other. FIG. 29B shows a dotted line 450 representing the arcuate path followed by anchoring members 444 and 445 as the anchoring members extend out of the central body 441.

[0216] FIG. 29C shows a posterior (rear) view of the fixation device 440 showing the anchoring members 444, 445 removed. FIG. 29C shows the locking mechanism 451, including an at least somewhat flexible or resilient arm 453 and a tongue 454. FIG. 29D shows a front view of a portion of the anterior surface of the central body 441 with anchoring members 444 and 445 removed. FIG. 29D also shows the locking mechanism 451. The locking mechanism 451 is positioned along or within the anterior wall of the central body 441. The arm 453 can be integrally formed with or coupled to the central body 441. FIGs. 29E and 29F show a top perspective cross-sectional view and a top cross-section view, respectively, of a portion of the fixation device 440. As shown in FIGs. 29D-F, the anterior wall of the central body 441 includes a gap 456 that extends along the arm 453 and the tongue 454 and a gap 457 between the anterior wall of the central body 441 and the arm 453. The gaps 456 and 457 allow the arm 453 to move relative to the central body 441. As shown in FIGs. 29A and 29I, the arm 453 and tongue 454 are biased such that the tongue 454 is positioned between teeth of the toothed section 448 and teeth of the toothed section 449. The tongue 454 therefore inhibits the anchoring members 444, 445 from moving relative to the central body 441.

[0217] FIG. 29G shows a top view of a fixation device 440 and a tool 458 for adjusting the anchoring members 444 and 445. The tool 458 includes a shaft 460 and a cross-head tip 459. FIG 29H shows a perspective view of the tool 458. FIG. 29I shows a top cross-sectional view of the fixation device 440 showing the locking mechanism 451 and the tool 458 before the tool 458 is applied to the fixation device 440. FIG. 29J shows a top cross-sectional view of the fixation device 440 showing the tip 459 inserted into the opening 452 and between the toothed sections 449 and 448. When fully inserted, the tip 459 depresses the tongue 454 allowing for movement of the anchoring members 444 and 445.

FIG. 29K shows a perspective view of the anchoring members 444 and 445 after insertion of the tool 458. As depicted in FIG. 29K, the shaft of the tool 458 can be rotated to cause the relative movement of the anchoring members 444 and 445 into and out of the central body 441. FIG. 29L shows a posterior (rear) view of the anchoring members 444 and 445 with the tip 459 inserted at a start position, a middle position, and an end position, showing the rotation of the tip 459 at each position. For illustrative purposes, the shaft 460 is not shown. FIG. 29M shows a top view of the fixation device 440 at the start position, middle position, and end position as depicted in FIG. 29L. FIG. 29M shows the movement of the anchoring members 444 and 445 as the tool 458 is rotated.

[0218] In the illustrated start position, the anchoring members 444 and 445 are withdrawn into the central body 441 to their greatest extent such that a relatively shorter segment of each anchoring member 444, 445 extends from the central body 441. As the tool 458 is rotated, the tip 459 causes toothed portion 449 to move in one direction (to the right in FIG. 29L and clockwise if viewed from a top-down perspective) and the toothed portion 448 to move in the opposite direction (to the left in FIG. 29L and counterclockwise if viewed from a top-down perspective). As shown in the middle figure of FIG. 29M, this causes the anchoring members 444, 445, to extend to a greater extent from the central body 441. A gap between the distal tip 446 of the anchoring member 444 and the distal tip 447 of the anchoring member 445 is therefore smaller in the middle position than in the starting position. If the tool 458 is rotated further, the toothed portions 448, 449 and anchoring members 444, 445 reach the end position, in which the anchoring members 444, 445 are extended from the central body to the greatest extent and the gap between the distal tips 446, 447 is smaller than in the middle position. In use, the fixation device 440 can be initially set at the start position or at a position in which the gap between the distal tips 446, 447 is larger than a width of the patient's spinous process. Once inserted into the patient and positioned about the spinous process such that the central body is posterior to, and in some cases adjacent and/or in contact with, the posterior surface of the spinous process, the tool 458 can be rotated to cause the anchoring members 444, 445 to extend from the central body 441 until the distal tips 446, 447 engage the lateral surfaces of the spinous process. In some embodiments, the tool 458 is coupled to the fixation device 440 prior to insertion of the fixation device 440 into the body. In some such embodiments, the tool 458 can also serve as a delivery tool to deliver the fixation device 440 to the spinous process. In other embodiments, the fixation device 440 can be inserted into the body and the tool 458 can be coupled to the fixation device 440 inside the body.

[0219] FIGs. 29N and 29O depict a top view and a posterior (rear) view of a lumbar vertebral spine with the fixation device 440, sutures, and anchors applied. The fixation device 440 is affixed at the spinous process 134 of the superior vertebral body 132. Suture 461 is secured to implant receiving member 442 of the fixation device 440, and is also affixed at the pedicle 217 of the right side of the inferior vertebral body 133 by the anchor 463, placing suture 461 in tension between the spinous process 134 and the pedicle 217 in a plane generally aligned with the disc space. Suture 462 is secured to implant receiving member 443 of the fixation device 400, and also affixed to the pedicle 218 of the left side of the inferior vertebral body 133 by anchor 464, placing the suture in tension between the spinous process 134 and pedicle 218 in a plane generally aligned with the disc space. Alternative embodiments may include only a single suture affixed to one of the implant receiving members 442 or 443 and one of the anchors 463 or 464.

[0220] FIGs. 29P, 29Q, 29R and 29S show a side view, a top view, a partial cross-sectional view showing internal features, and a top perspective view of an example embodiment of an anchor 463 that can be used to secure an implant to the pedicle. The anchor 463 includes a threaded portion 465, a distal tip 466 for driving through the bone of the pedicle, and a head 468. The head 468 includes a hole 467 for receiving an implant, a socket 469 for receiving a tool such as tool 458, and, optionally, a lip 470 for guiding the tool to the center of the socket 469.

[0221] FIGs. 30A, 30B, and 30C show a top view, a posterior (rear) view, and a top perspective view, respectively, of an alternative embodiment 440A, of the fixation device 440 as depicted in FIGs. 29A-O. The fixation device 440A includes central body 441, implant receiving members 442 and 443, and anchoring member 445 at least partially housed inside of the central body 441. In the alternative embodiment of fixation device 440, shown as fixation device 440A, the anchoring member 444 is replaced with an anchoring member 444A. Unlike anchoring member 444, which can rotatably slide into and out of the housing of central body 441, anchoring member 444A is a curved extension of central body 441 having spiked extremities 446A at an anterior end. As depicted in FIG. 30C, the fixation device 440A includes two spiked extremities, but more or less are also possible. In use, the anchoring member 444A can be secured to the lateral surface of the spinous process via the spiked extremities 446A, and the anchoring member 445 can be adjusted using the tool 458 to extend the anchoring member 445 from the central body 441 until the distal tip 447 engages the opposite lateral surface of the spinous process.

[0222] Fixation to locations on the inferior vertebral body, such as at the mamillary processes or the pedicles, can be accomplished by using a variety of hardware, including the staple shown in FIG. 9A and the bone anchors shown in FIGS. 10 and 11. Additionally, there are a variety of metal and polymeric screws, some made of either resorbable and/or non-resorbable polymers, that can be used to anchor an implant to the inferior vertebral body. In some embodiments, the anchor comprises a suture anchor capable of being fixed into the inferior vertebral body. Additionally, other mechanical means of fixation include screws and nails to fix the implant to the inferior vertebral body. In these cases, the mechanical means would pass through the implant and into the selected boney location.

[0223] Alternatively, a surgical adhesive could be used to fix the implant directly to the bone and eliminate some or all hardware. In this case, the implant would be put in proximity to the desired bone location, the adhesive applied to either the implant or the bone location and the implant held against the bone until the adhesive set, using whatever technique the adhesive producer suggests for setting the adhesive.

[0224] While this invention has been particularly shown and described with reference to embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention. For all of the embodiments described above, the steps of the methods need not be performed sequentially.

[0225] Language of degree used herein, such as the terms “approximately,” “about,” “generally,” and “substantially” as used herein represent a value, amount, or characteristic close to the stated value, amount, or characteristic that still performs a desired function or achieves a desired result. For example, the terms “approximately”, “about”, “generally,” and “substantially” may refer to an amount that is within less than 10% of, within less than 5% of, within less than 1% of, within less than 0.1% of, and within less than 0.01% of the stated amount. As another example, in certain embodiments, the terms “generally parallel” and “substantially parallel” refer to a value, amount, or characteristic that departs from exactly parallel by less than or equal to 15 degrees, 10 degrees, 5 degrees, 3 degrees, 1 degree, 0.1 degree, or otherwise.

[0226] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. Thus, it is intended that the present invention cover modifications and variations of this invention.

WHAT IS CLAIMED IS:

1. A system for providing torsional stabilization to a spine comprising:

one or more implants configured to extend between a spinous process of a superior vertebral body and an inferior vertebral body;

a fixation device configured to anchor to a posterior surface of the spinous process, the fixation device comprising one or more implant attachment portions configured to receive the one or more implants; and

one or more inferior vertebral body anchors, each inferior vertebral body anchor configured to secure one of the one or more implants to the inferior vertebral body such that the implant is in tension between the spinous process and the inferior vertebral body.

2. The system of Claim 1, further comprising a spinous process anchor configured to affix the fixation device to the spinous process, wherein the fixation device comprises an opening configured to receive the spinous process anchor.

3. The system of Claim 1, wherein the fixation device comprises one or more protrusions configured to anchor to the posterior surface of the spinous process.

4. The system of Claim 1, wherein the fixation device comprises one or more wings.

5. The system of Claim 4, wherein at least one of the one or more wings comprises at least one of the one or more implant attachment portions.

6. The system of Claim 4, wherein at least one of the one or more wings is configured to contact a surface of the spinous process.

7. The system of Claim 4, wherein at least one of the one or more wings comprises a textured surface configured to contact a surface of the spinous process.

8. The system of Claim 4, wherein at least one of the one or more wings comprises a protrusion configured to anchor to a surface of the spinous process.

9. The system of Claim 4, wherein the fixation device comprises a top wing configured to contact a superior surface of the spinous process and a bottom wing configured to contact an inferior surface of the spinous process.

10. The system of Claim 4, wherein the fixation device comprises a pair of wings configured to engage opposite sides of the spinous process.

11. The system of Claim 2, wherein the fixation device comprises at least two wings, wherein the at least two wings are connected to one another by the spinous process anchor.

12. The system of Claim 1, wherein the one or more implant attachment portions comprise one or more of a hole, a groove, and a hook.

13. The system of Claim 1, wherein the one or more implants are selected from the group consisting of polymeric fabrics, soft tissue grafts, wires, cables, sutures, and combinations thereof.

14. The system of Claim 1, wherein the one or more inferior vertebral body anchors are selected from the group consisting of screws, staples, soft tissue anchors, suture anchors, and combinations thereof.

15. The system of Claim 1, wherein each of the one or more inferior vertebral body anchors is configured to secure one of the one or more implants to a pedicle of the inferior vertebral body such that the implant is in tension between the spinous process and the pedicle.

16. The system of any one of Claims 1-15, wherein the fixation device comprises an adjustment mechanism configured to facilitate adjustment of the fixation device between a plurality of different orientations.

17. The system of Claim 4, wherein the fixation device comprises an adjustment mechanism configured to facilitate adjustment of the fixation device between a plurality of different orientations and at least two wings, wherein the adjustment mechanism is configured to alter a distance between the at least two wings.

18. A system for providing torsional stabilization to a spine comprising:

a plurality of implants, each implant configured to extend between a spinous process of a superior vertebral body and an inferior vertebral body;

a fixation device configured to anchor to the spinous process, the fixation device comprising a pair of anchoring wings, the pair of anchoring wings configured to contact opposite side surfaces of the spinous process, and one or more implant attachment portions; and

a plurality of inferior vertebral body anchors, each inferior vertebral body anchor configured to secure one of the plurality of implants to the inferior vertebral body such that the implant is in tension between the spinous process and the inferior vertebral body.

19. The system of Claim 18, wherein at least one of the anchoring wings comprises an implant attachment portion.

20. The system of Claim 19, wherein each anchoring wing comprises an implant attachment portion.

21. The system of Claim 18, further comprising a spinous process anchor configured to affix the fixation device to the spinous process, wherein the fixation device comprises an opening configured to receive the spinous process anchor.

22. The system of Claim 18, wherein at least one of the pair of anchoring wings comprises a textured surface configured to contact a surface of the spinous process.

23. The system of Claim 18, wherein at least one of the pair of anchoring wings comprises a protrusion configured to anchor to a surface of the spinous process.

24. The system of Claim 21, wherein the pair of anchoring wings are connected to one another by the spinous process anchor.

25. The system of Claim 18, wherein the pair of anchoring wings comprise complementary connection members configured to allow connection of the pair of anchoring wings to one another at a plurality of different positions.

26. The system of Claim 18, wherein each implant attachment portion comprises one or more of a hole, a groove, and a hook.

27. The system of Claim 18, wherein the one or more implants are selected from the group consisting of polymeric fabrics, soft tissue grafts, wires, cables, sutures, and combinations thereof.

28. The system of Claim 18, wherein the one or more inferior vertebral body anchors are selected from the group consisting of screws, staples, soft tissue anchors, suture anchors, and combinations thereof.

29. The system of Claim 18, wherein each of the one or more inferior vertebral body anchors is configured to secure one of the one or more implants to a pedicle of the inferior vertebral body such that the implant is in tension between the spinous process and the pedicle.

30. The system of any one of Claims 18-29, wherein the fixation device comprises an adjustment mechanism configured to facilitate adjustment of the fixation device between a plurality of different orientations.

31. The system of Claim 30, wherein the adjustment mechanism is configured to alter a distance between the pair of anchoring wings.

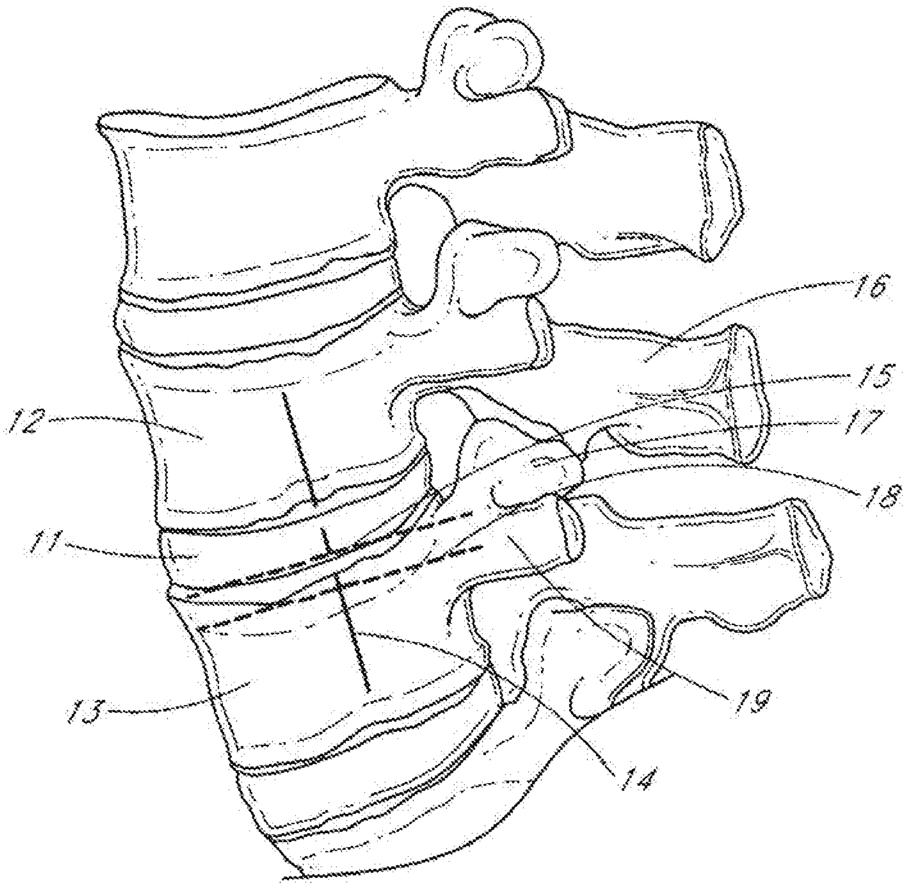


FIG. 1

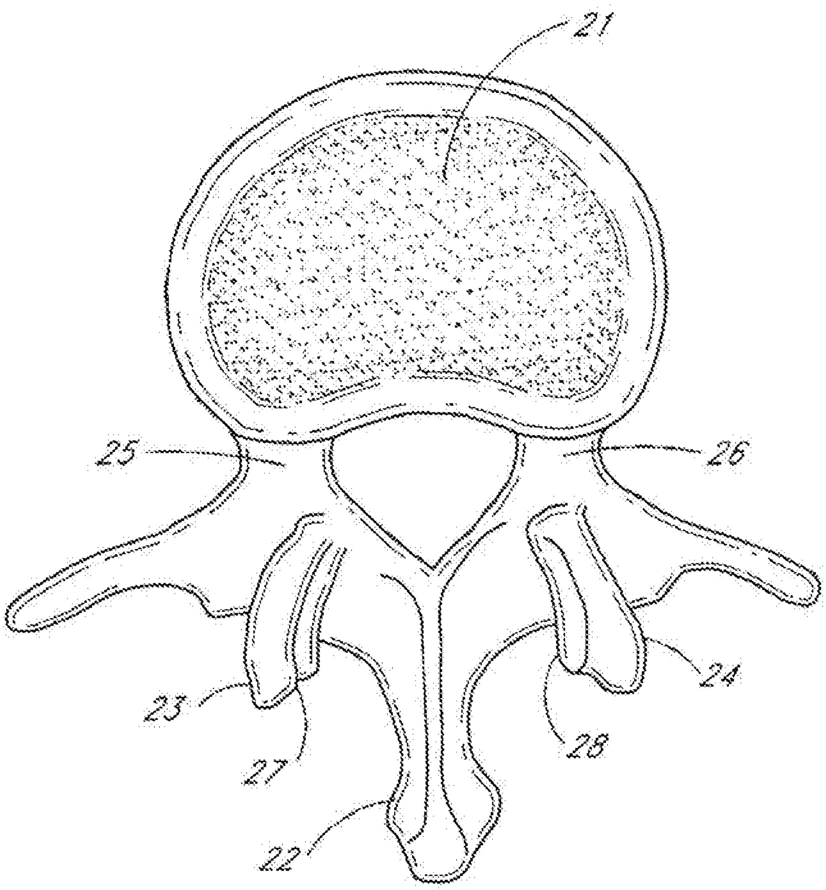


FIG. 2

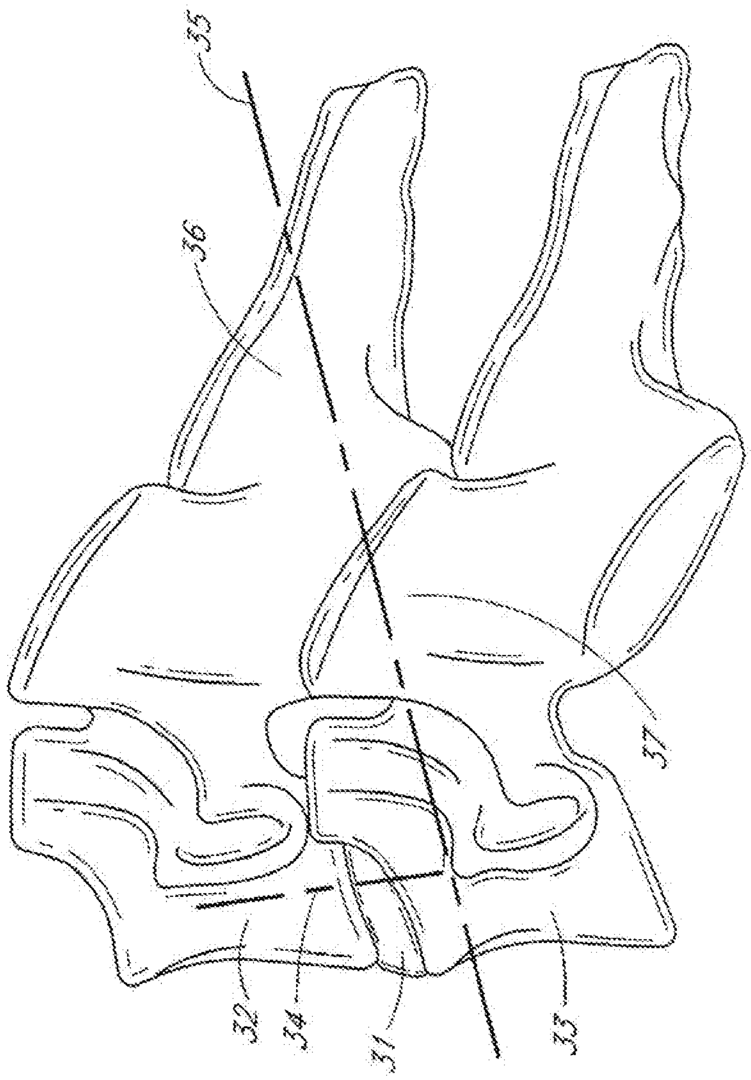


FIG. 3

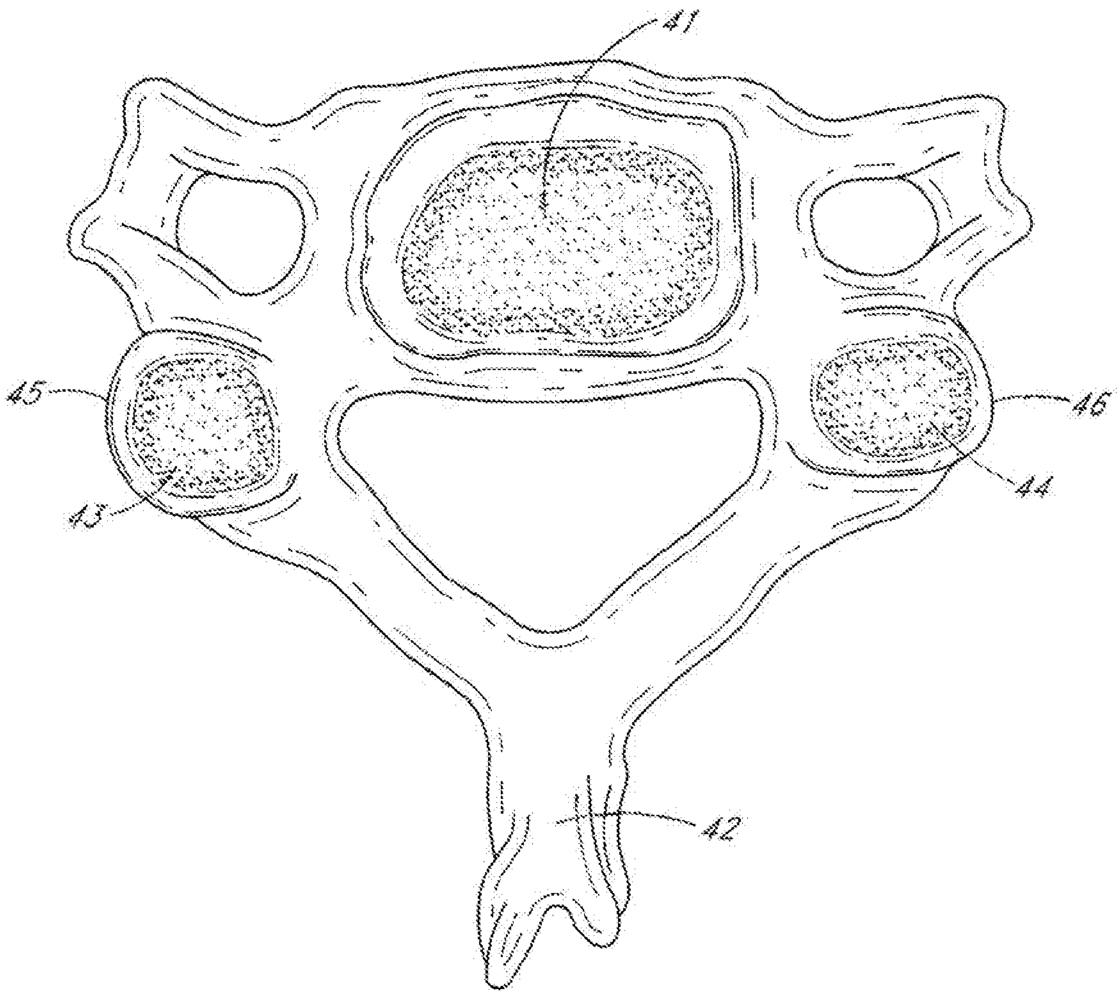


FIG. 4

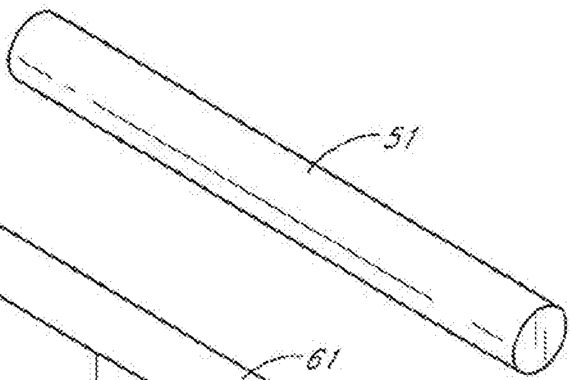


FIG. 5

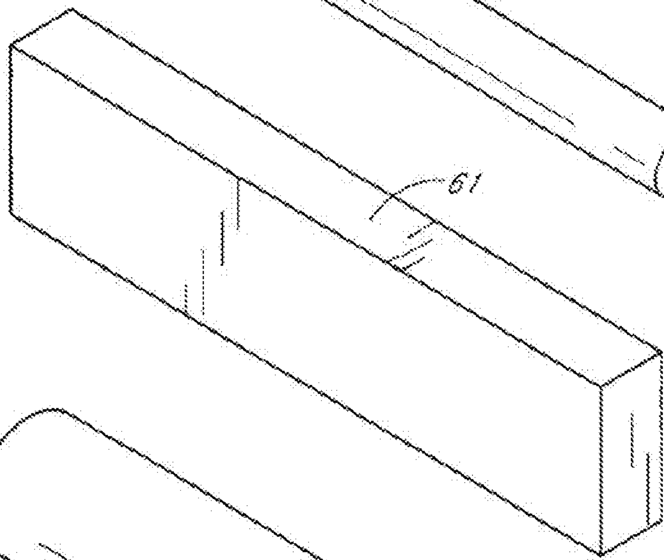


FIG. 6

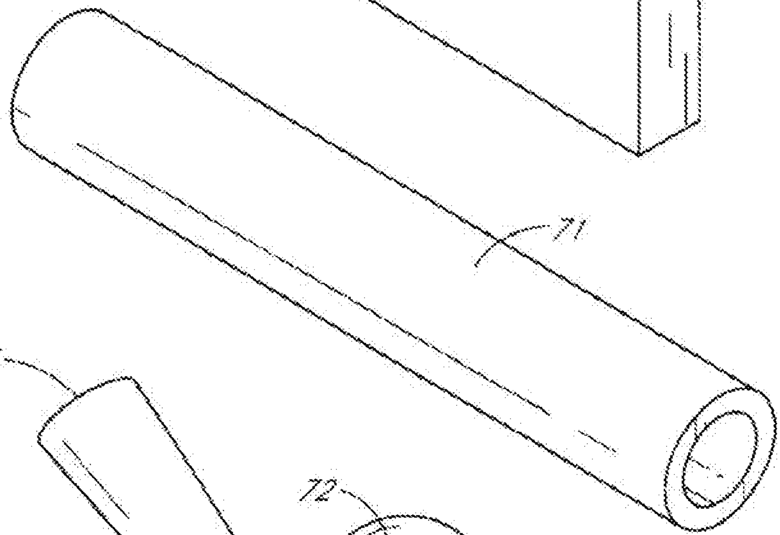


FIG. 7A

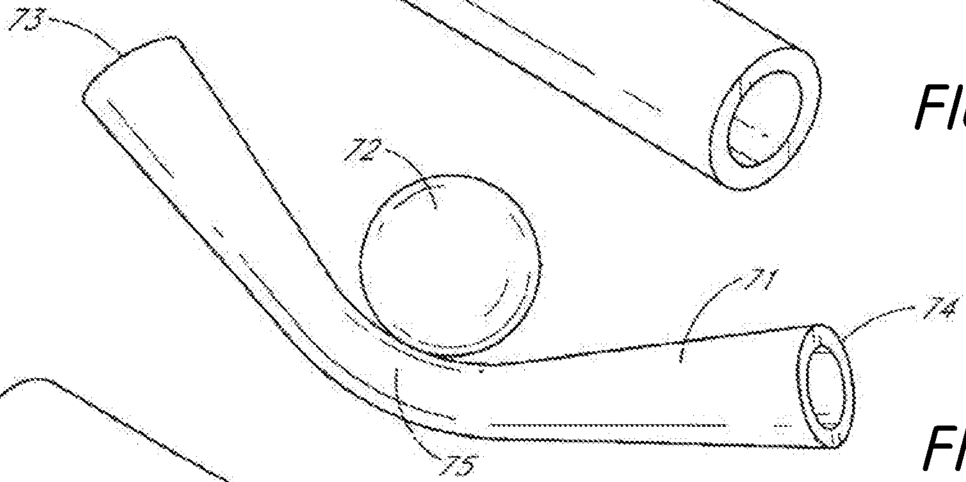


FIG. 7B

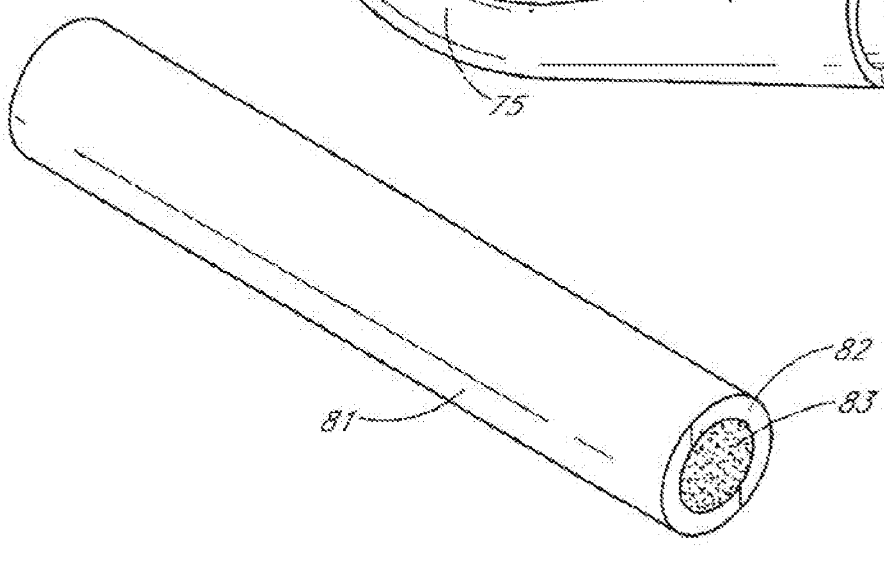


FIG. 8

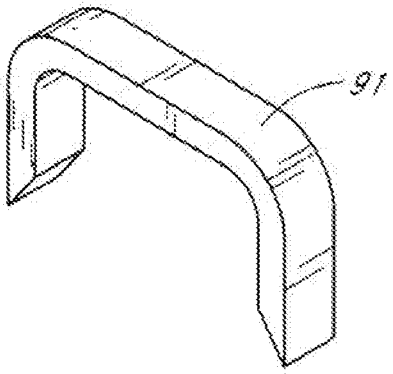


FIG. 9A

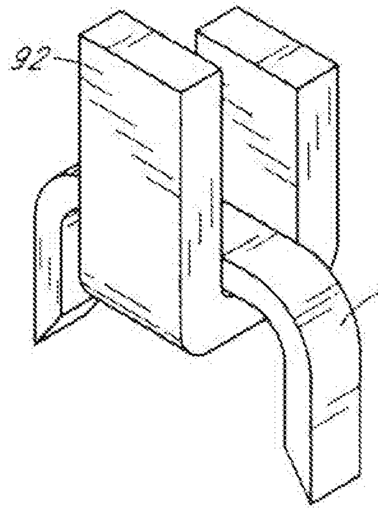


FIG. 9B

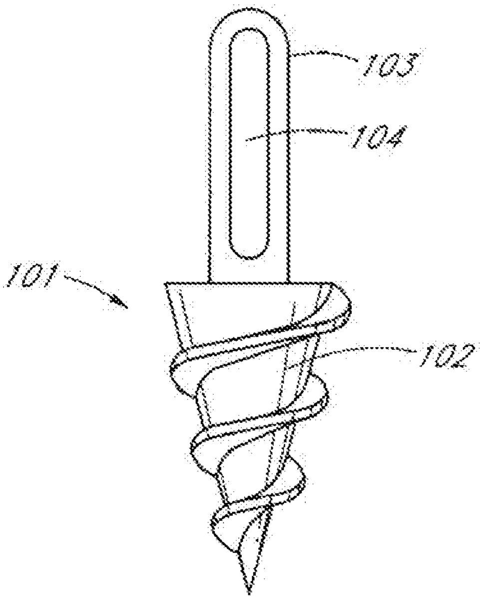


FIG. 10

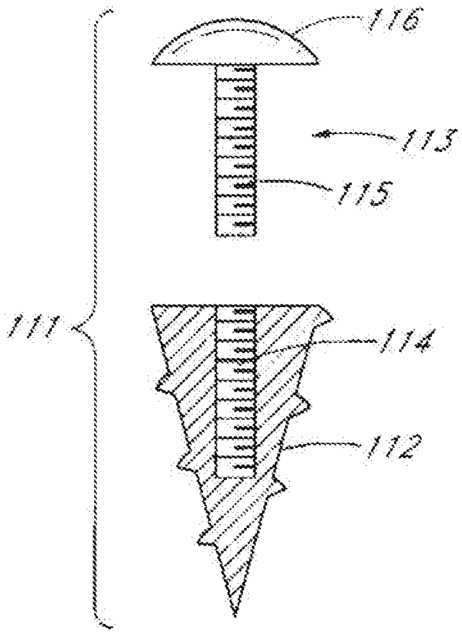


FIG. 11

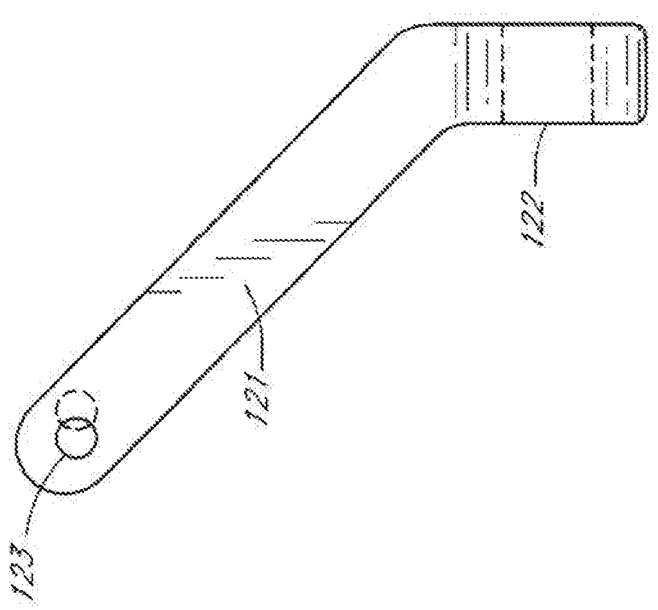


FIG. 12B

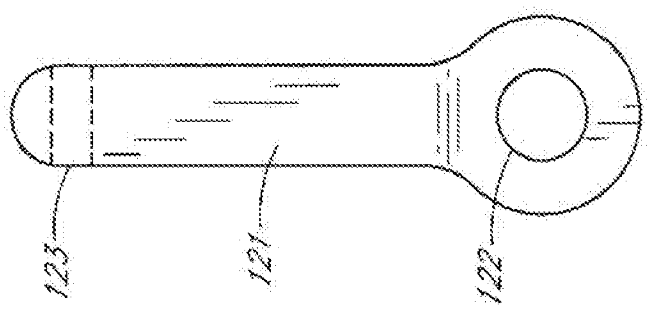


FIG. 12A

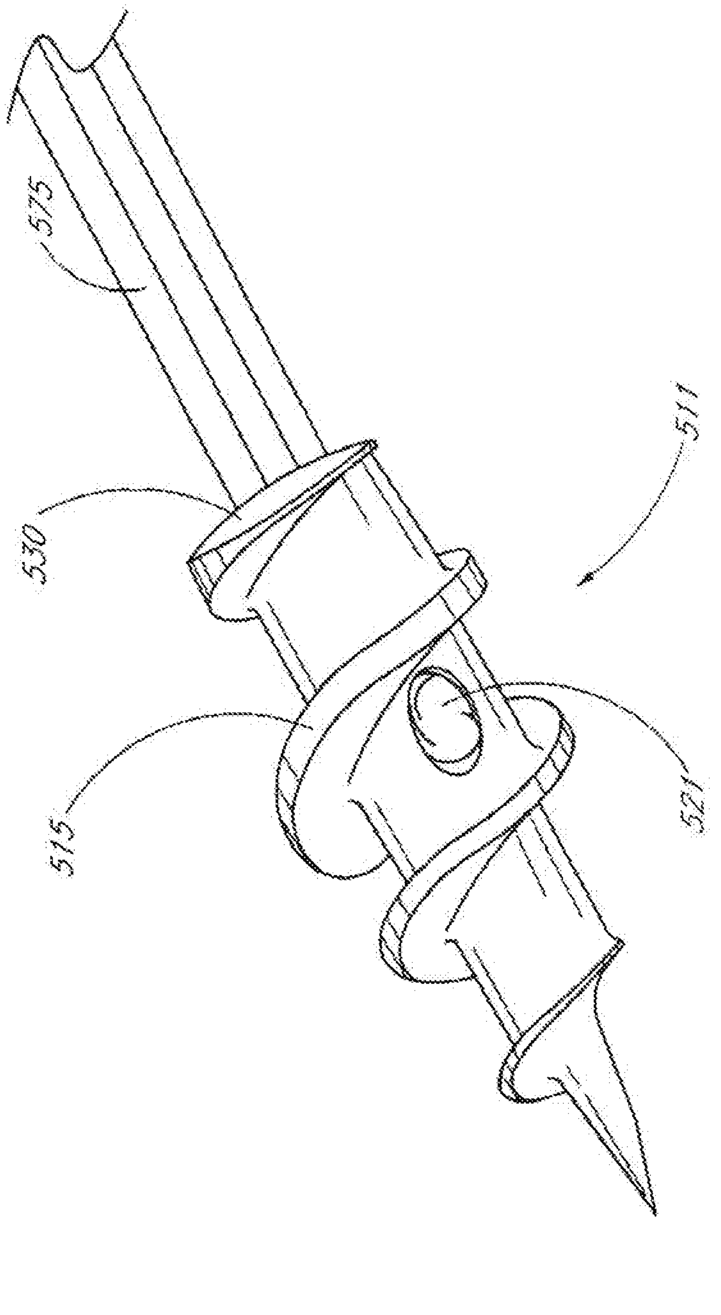


FIG. 13

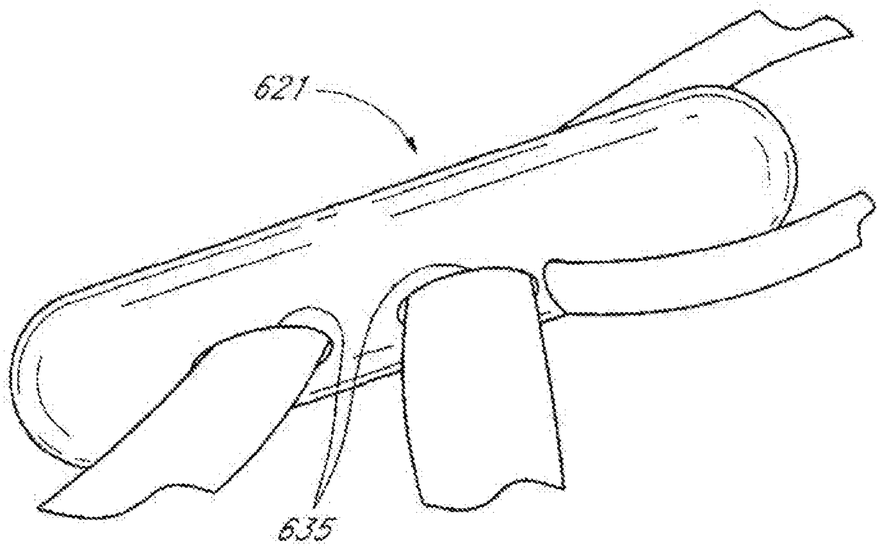


FIG. 14A

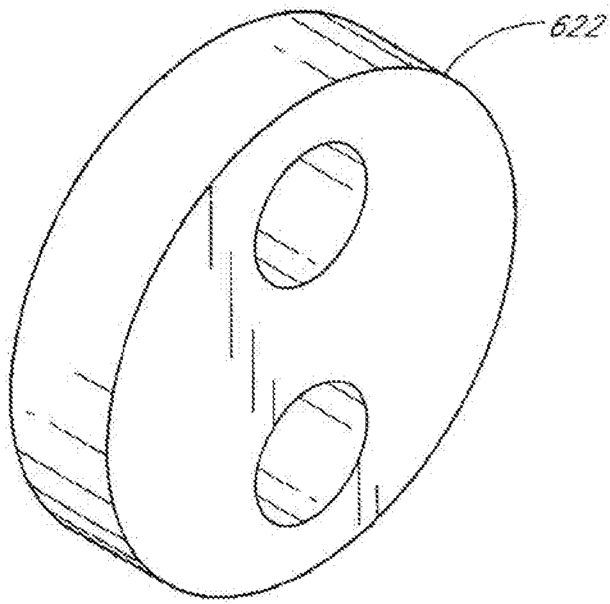


FIG. 14B

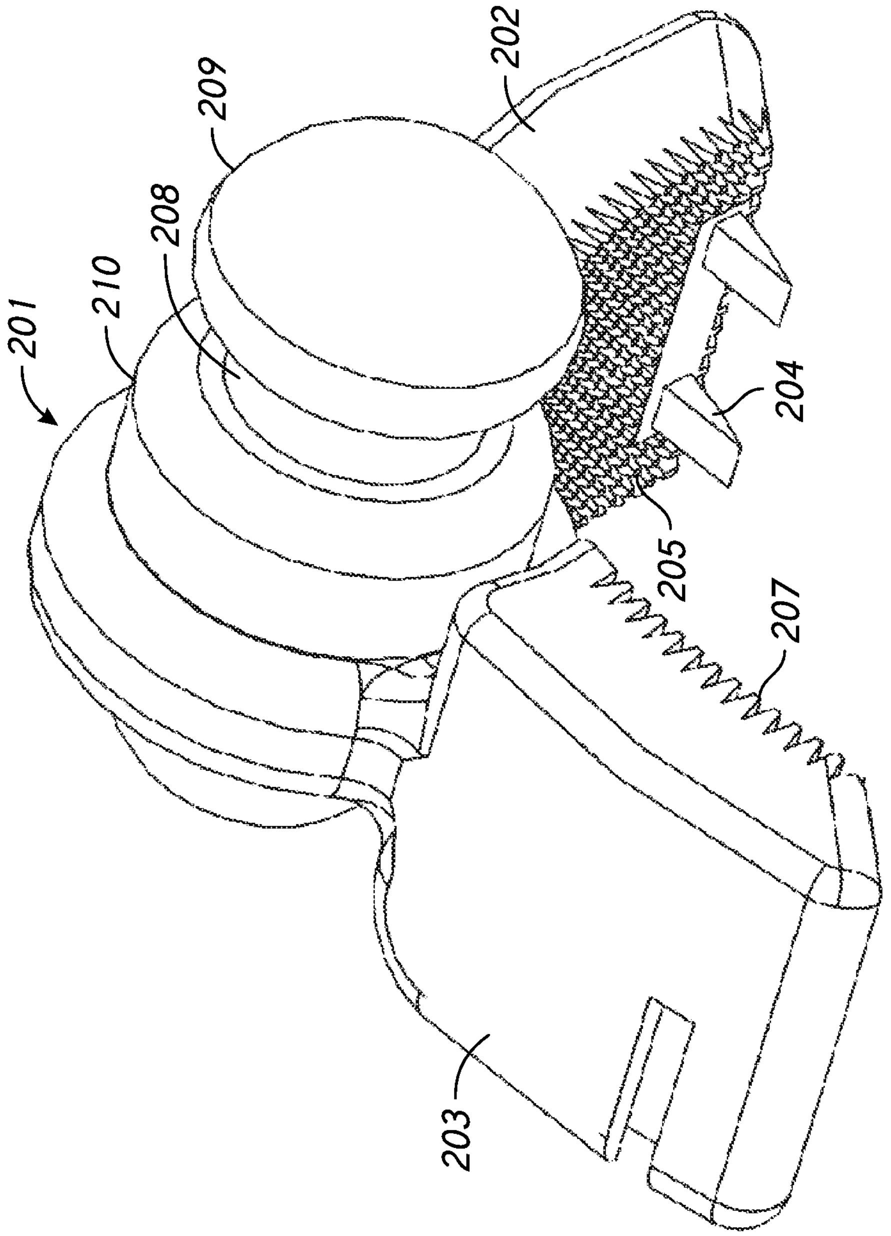


FIG. 15A

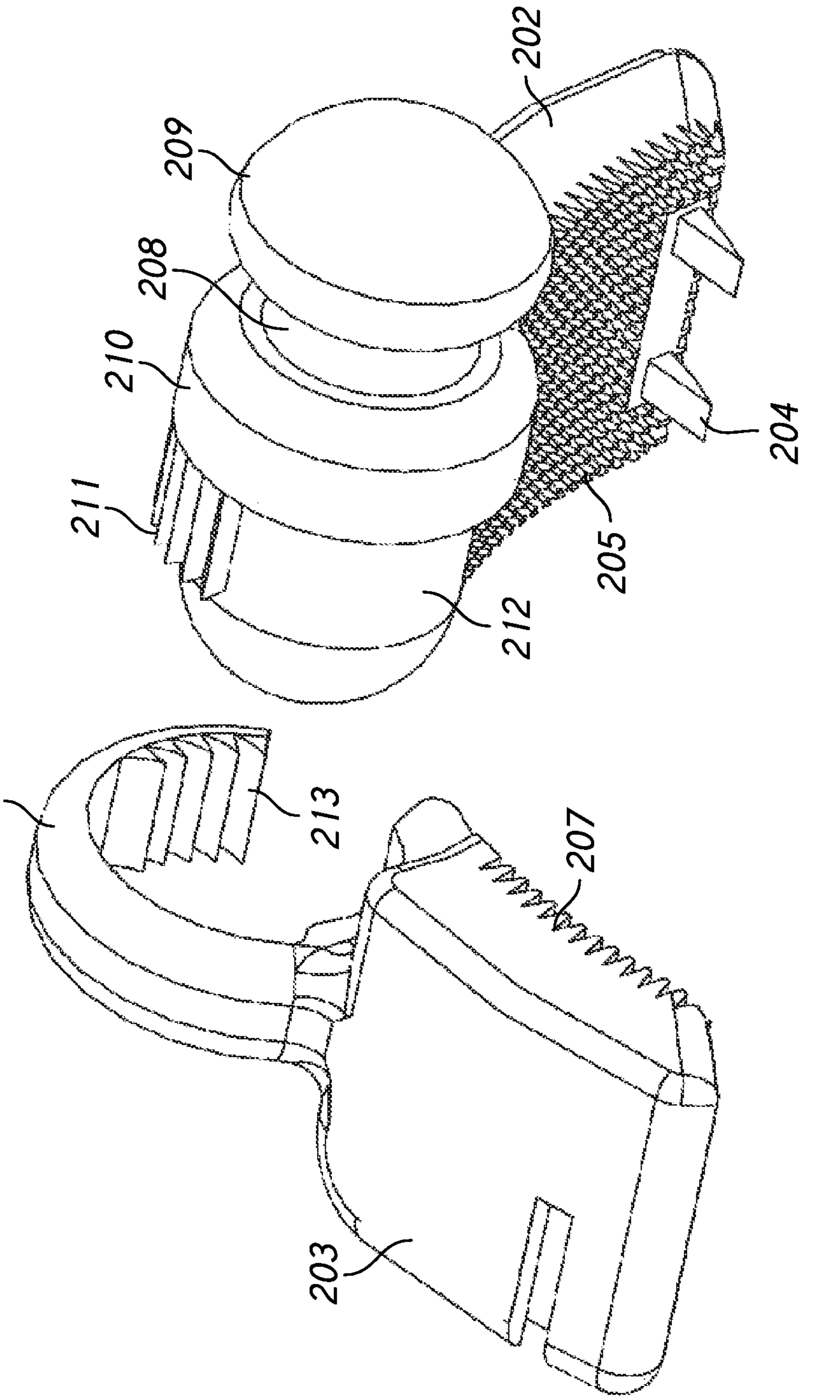


FIG. 15B

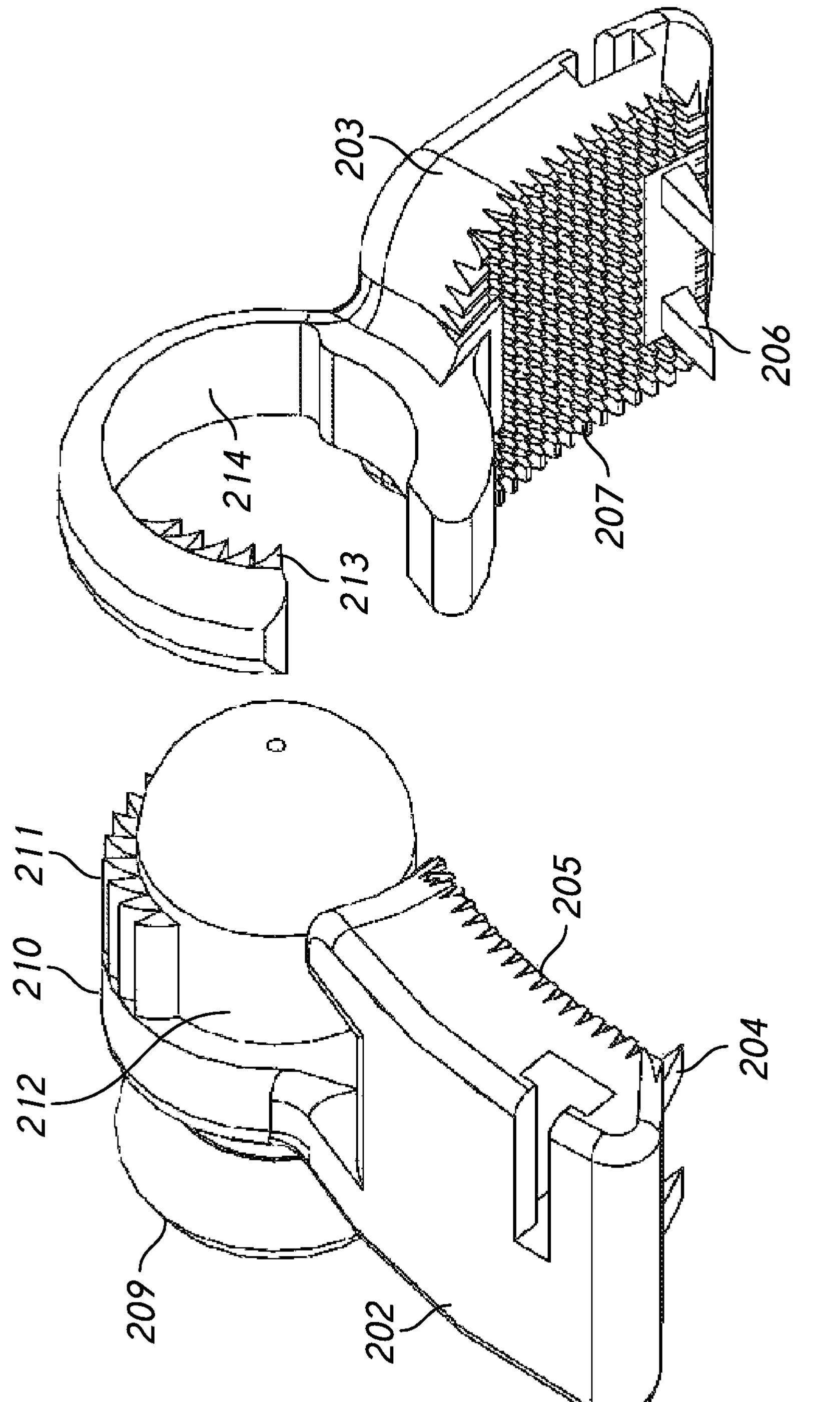


FIG. 15C

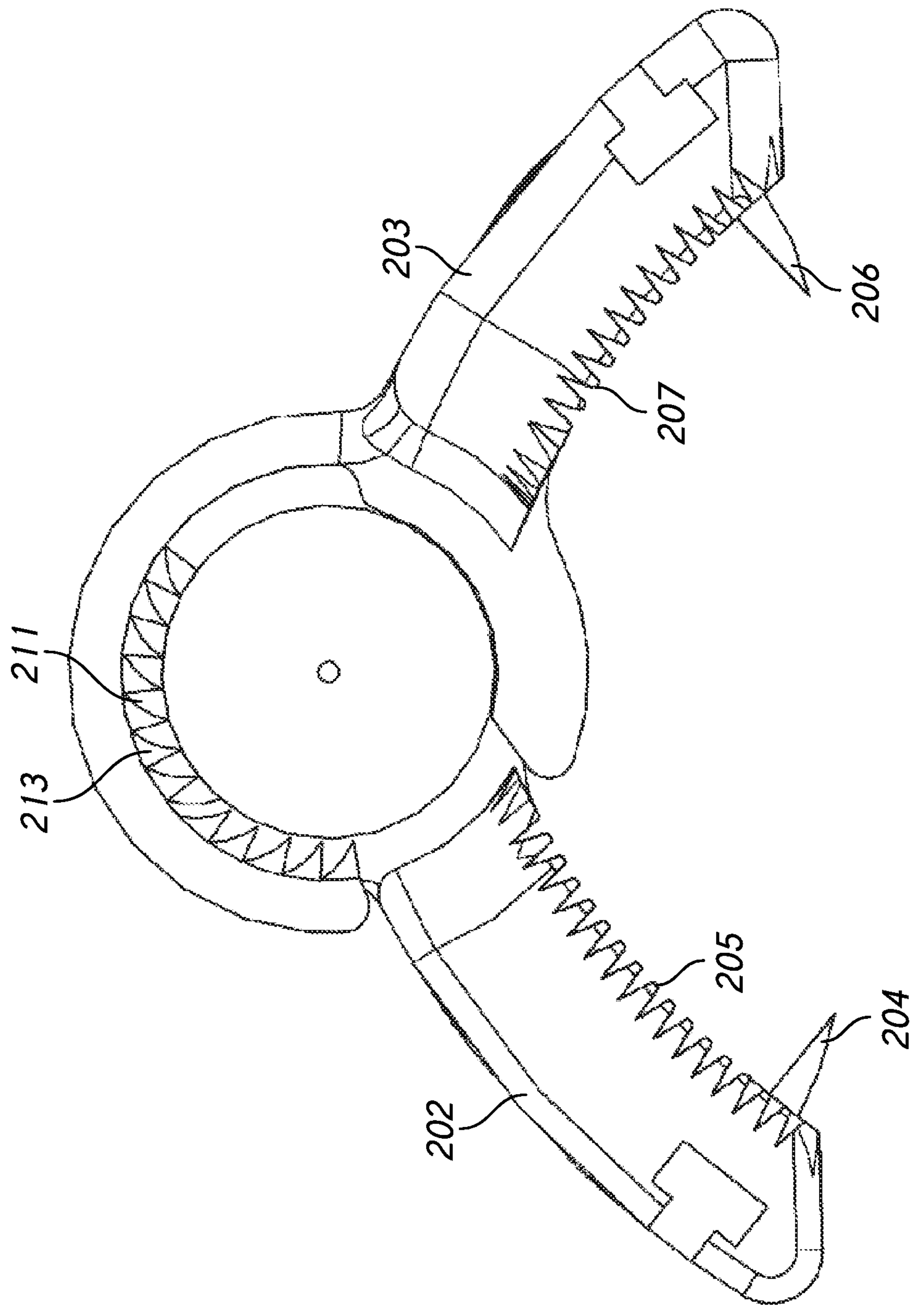


FIG. 15D

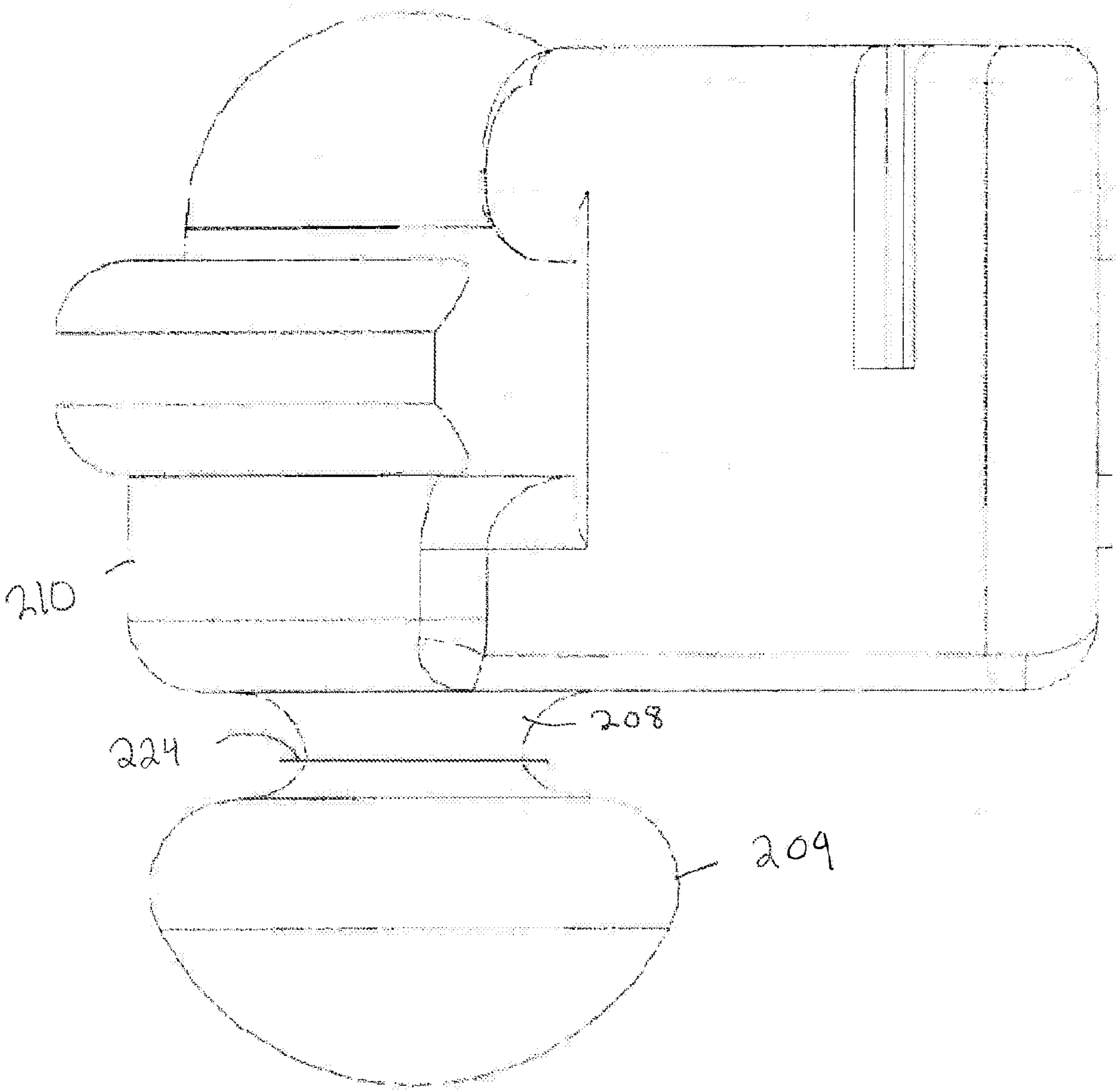


FIG 15E

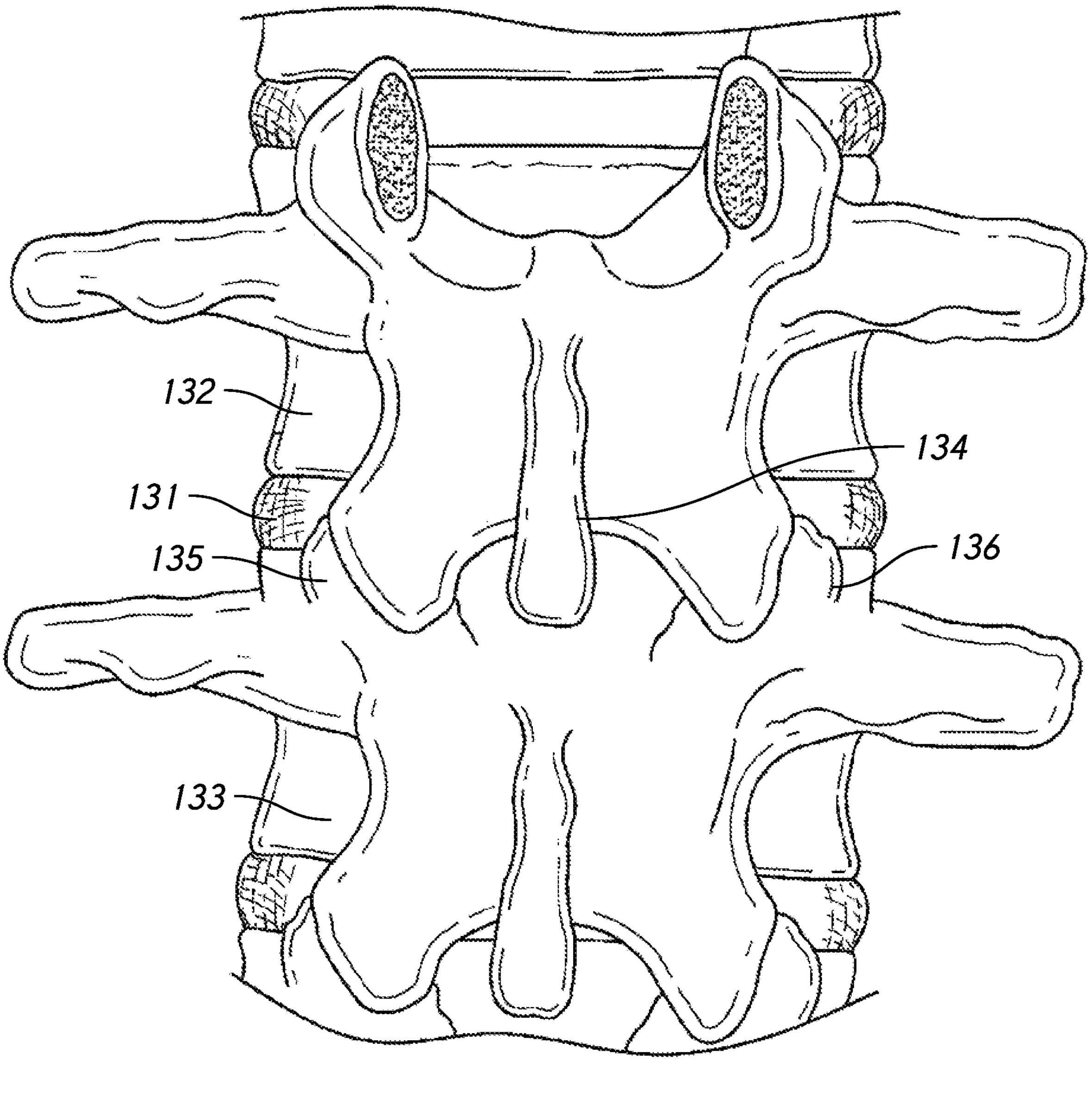


FIG. 16

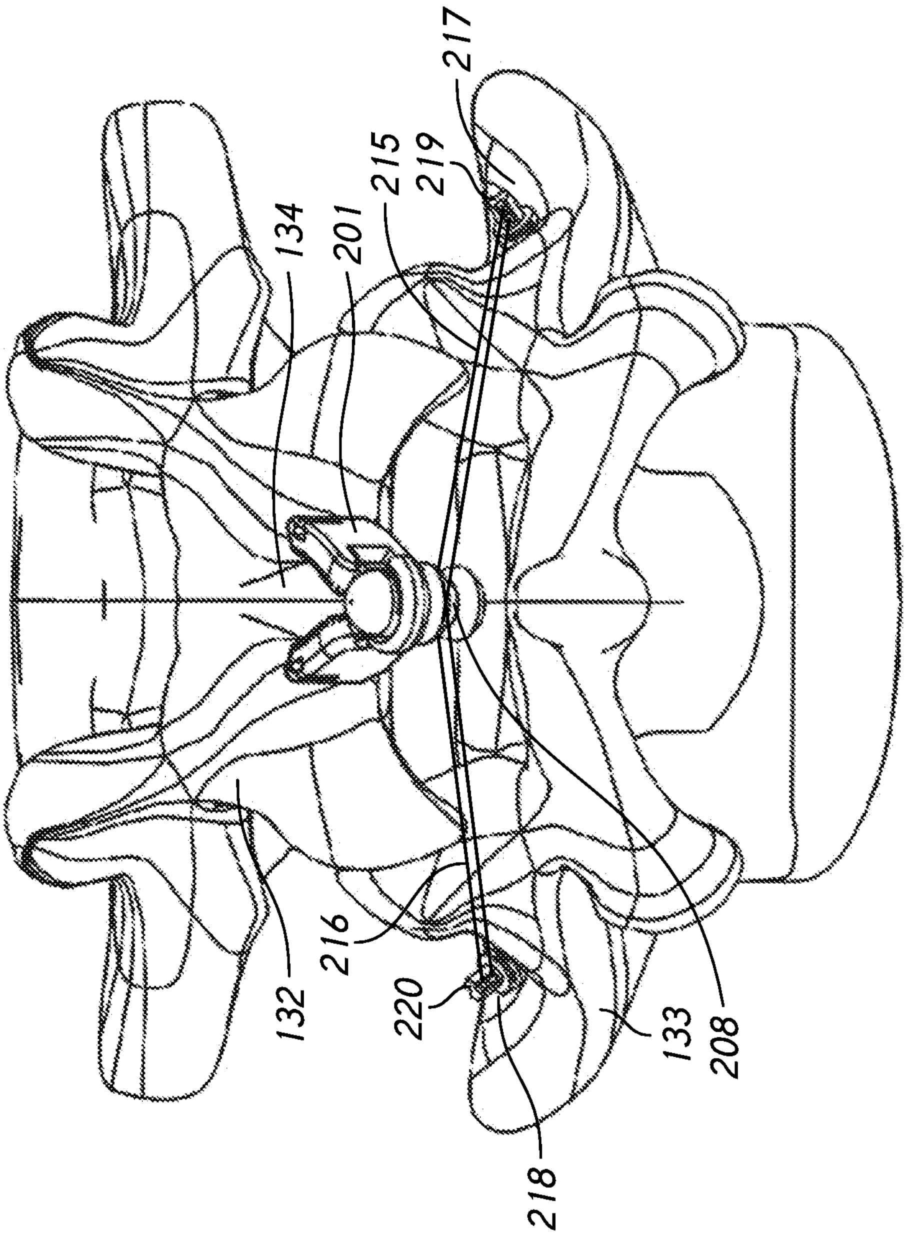


FIG. 17A

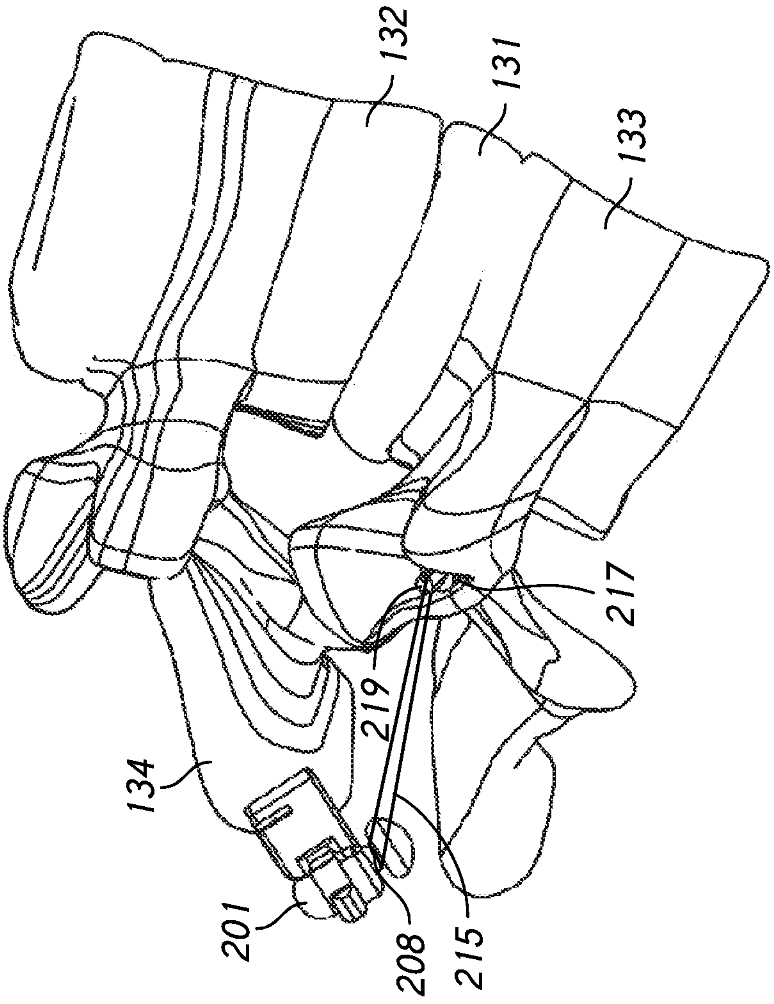


FIG. 17B

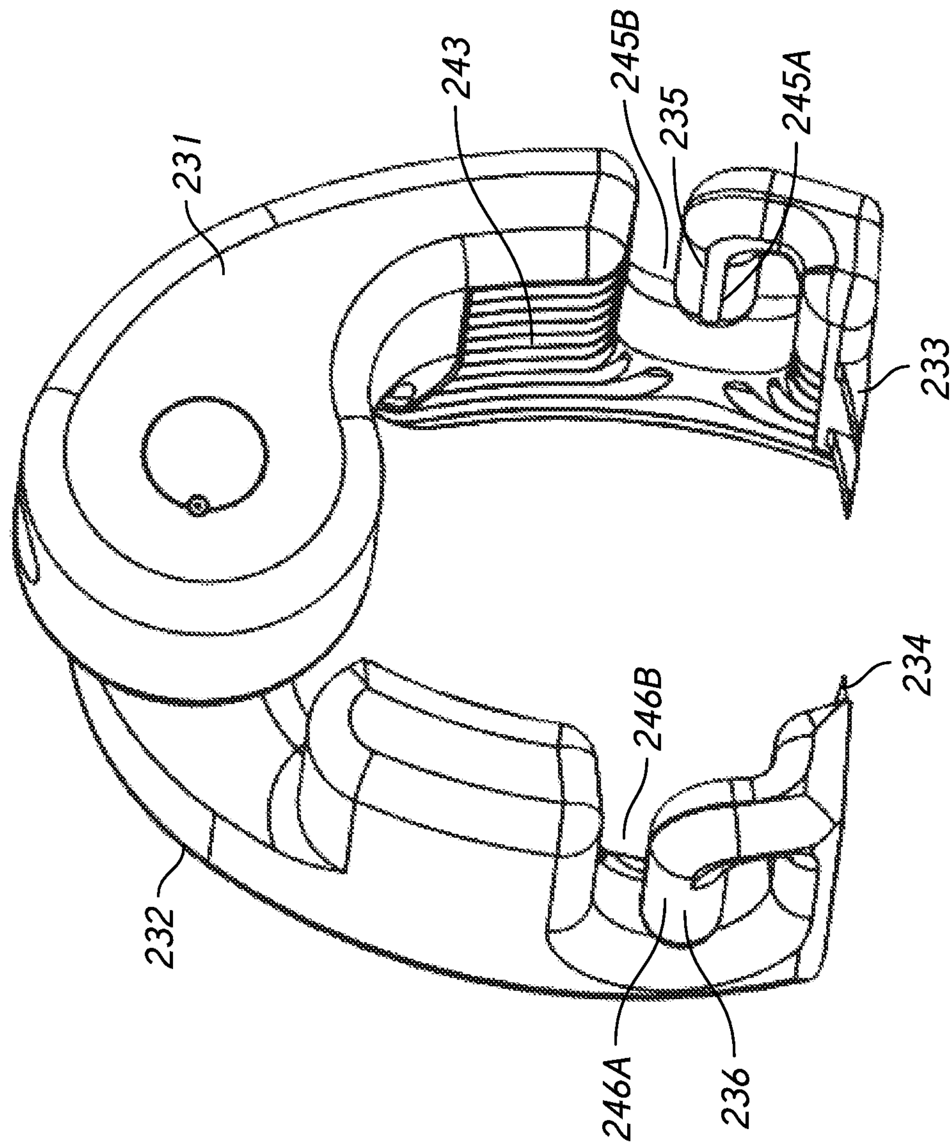


FIG. 18A

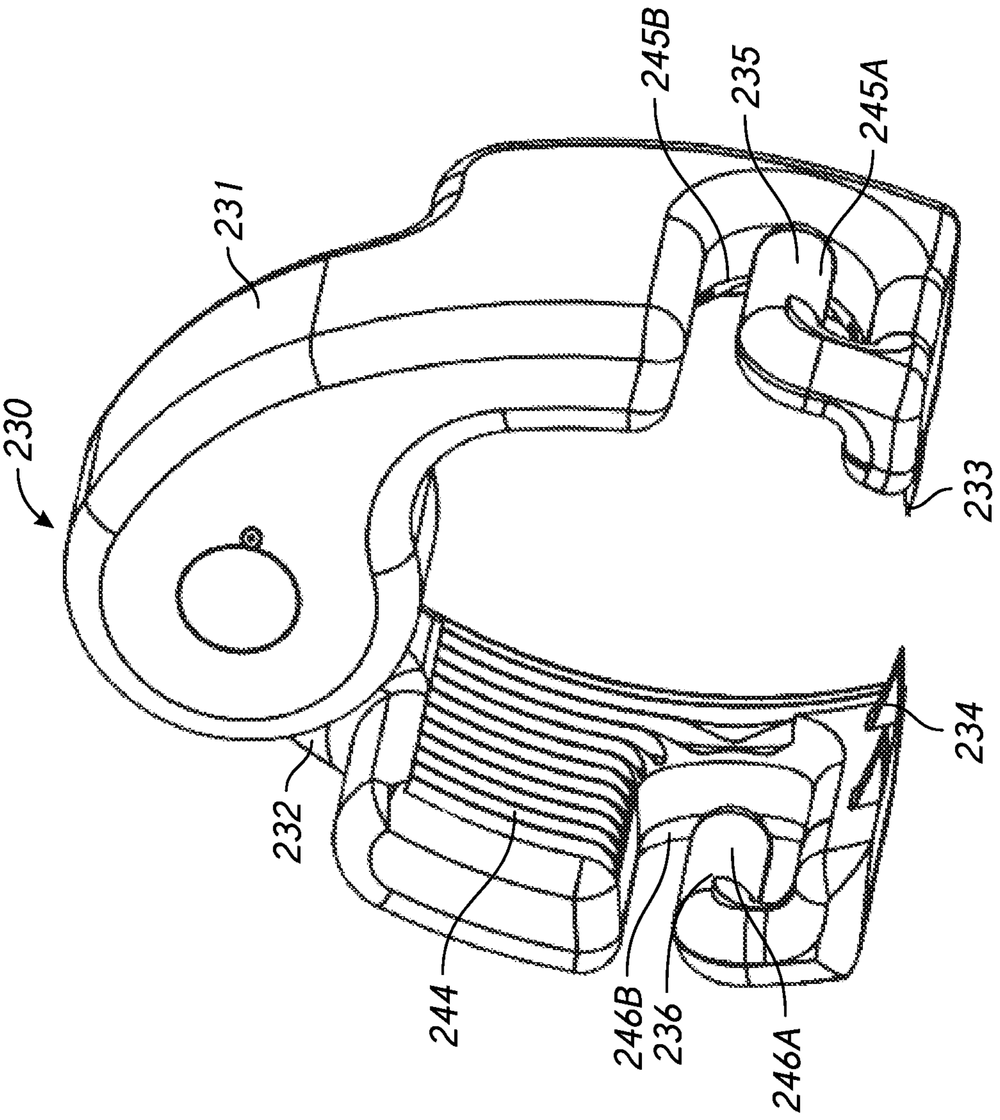


FIG. 18B

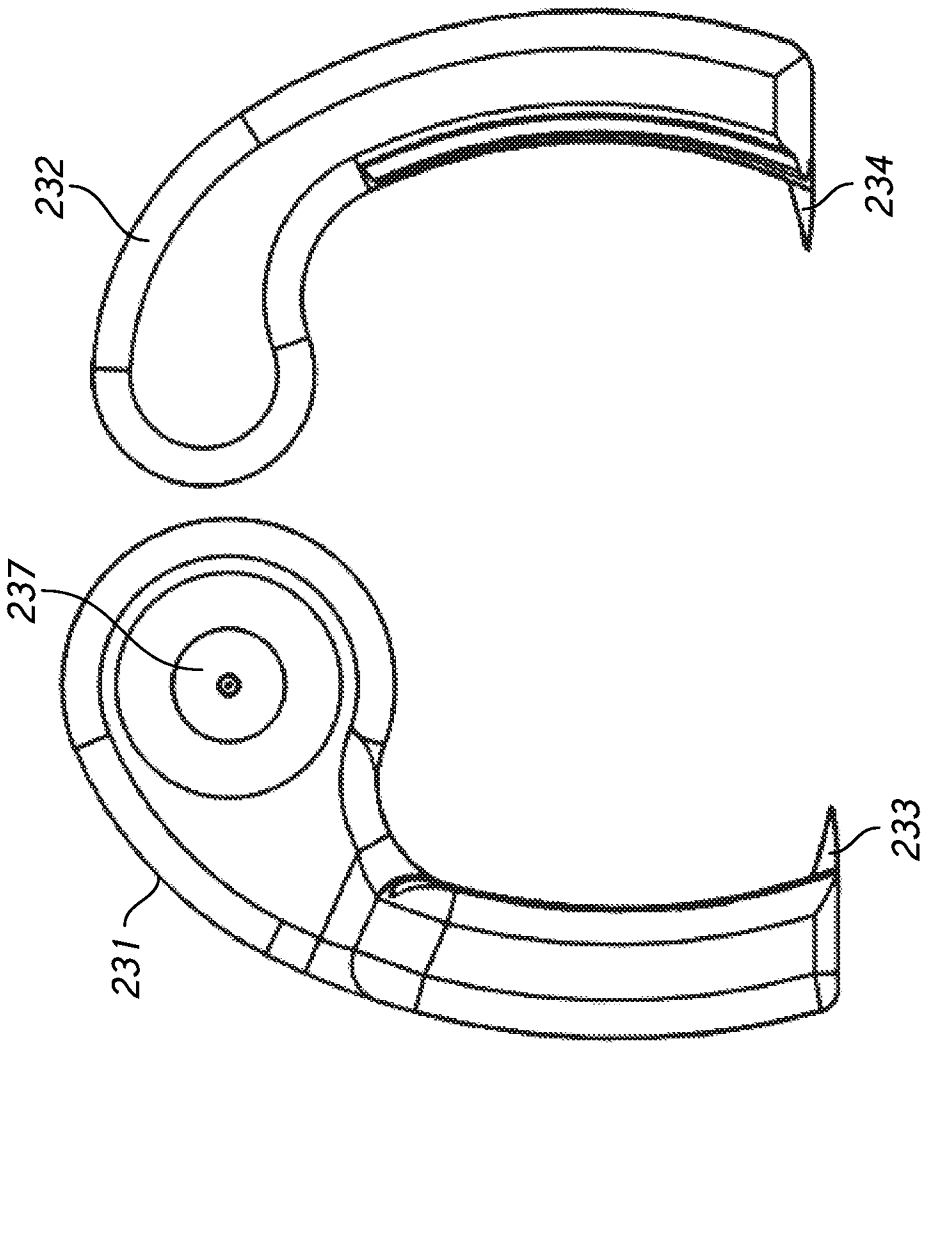


FIG. 18C

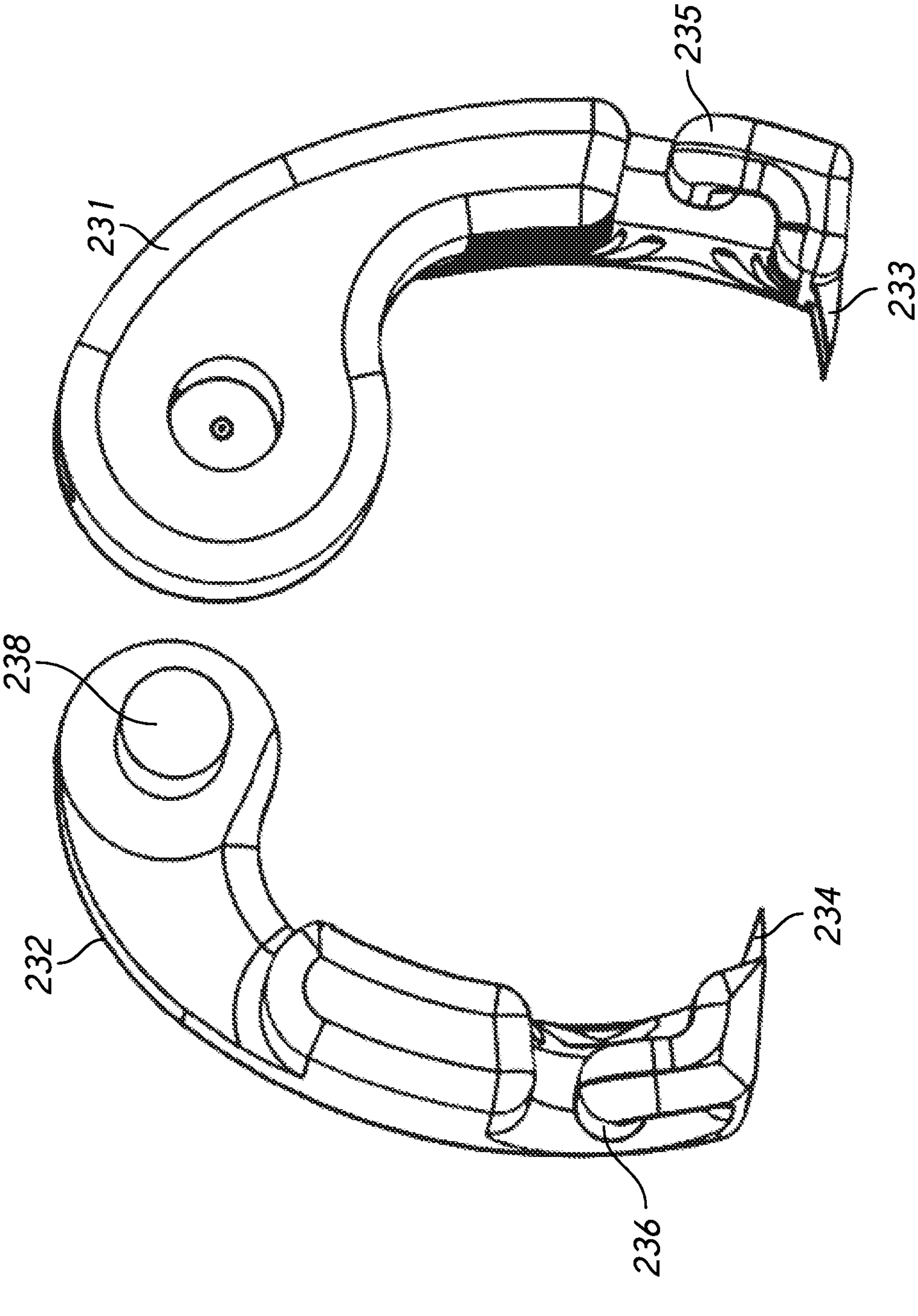


FIG. 18D

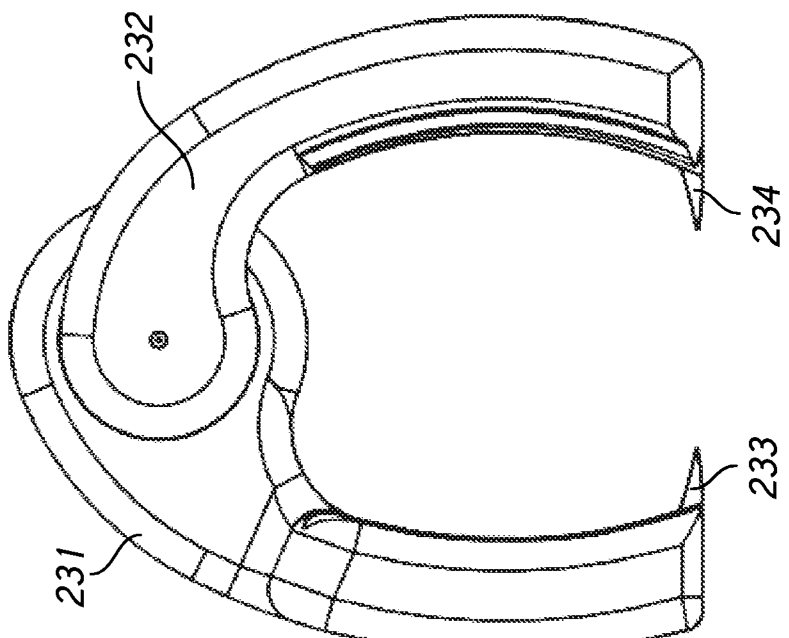


FIG. 18E

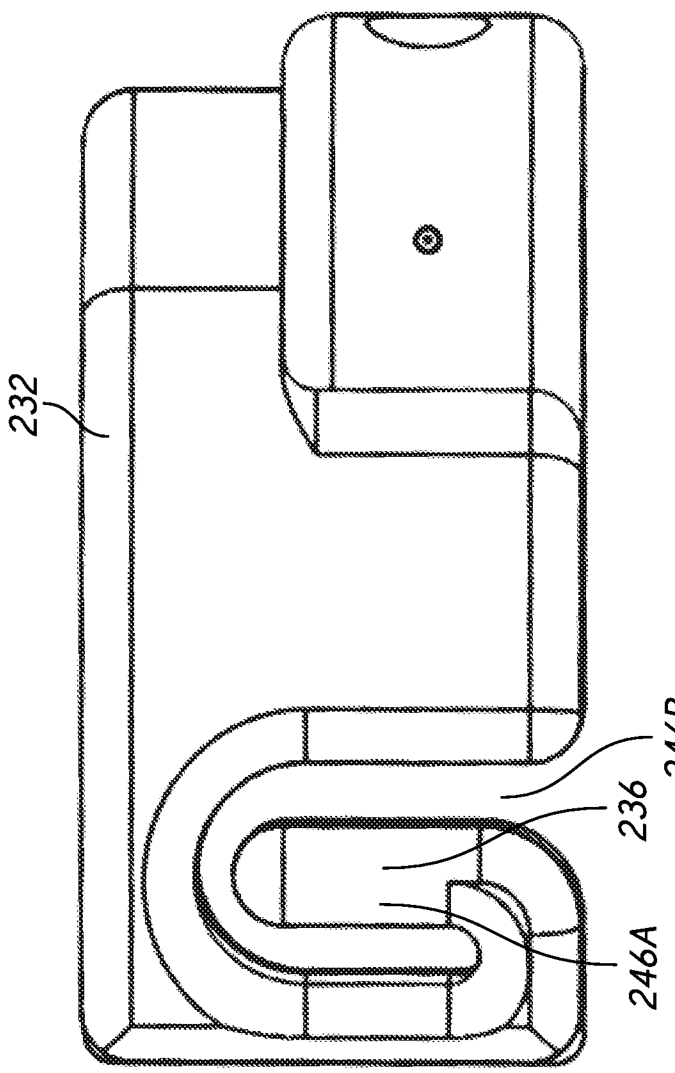


FIG. 18F

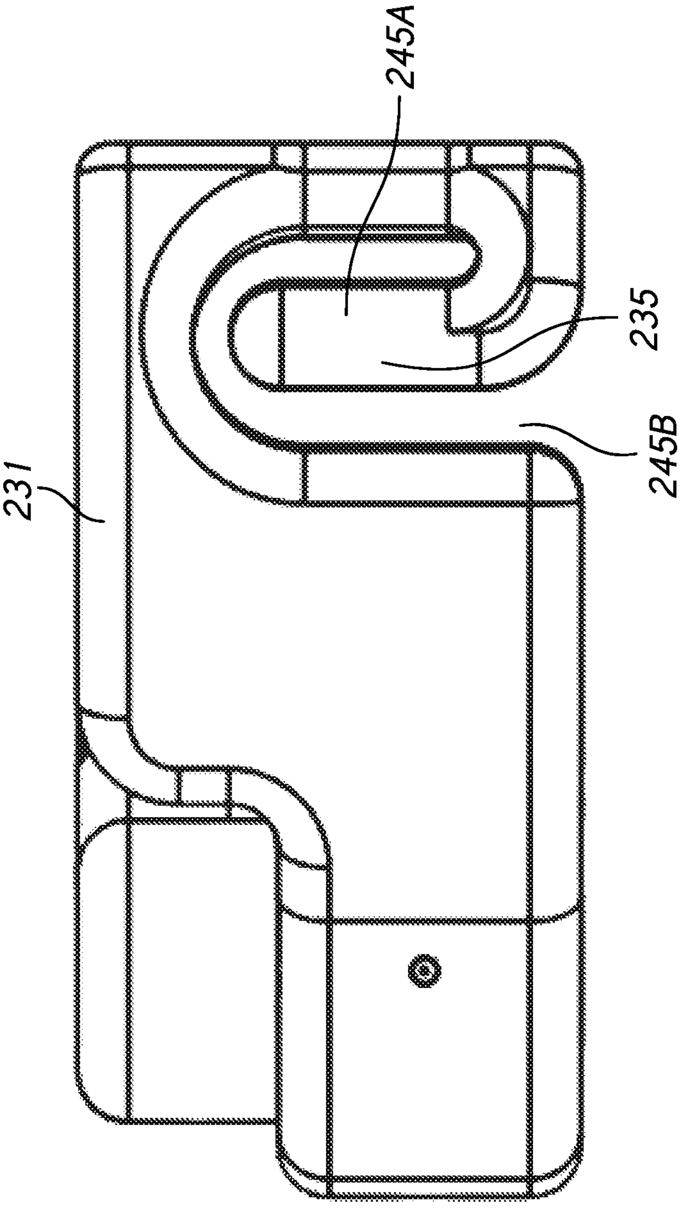


FIG. 18G

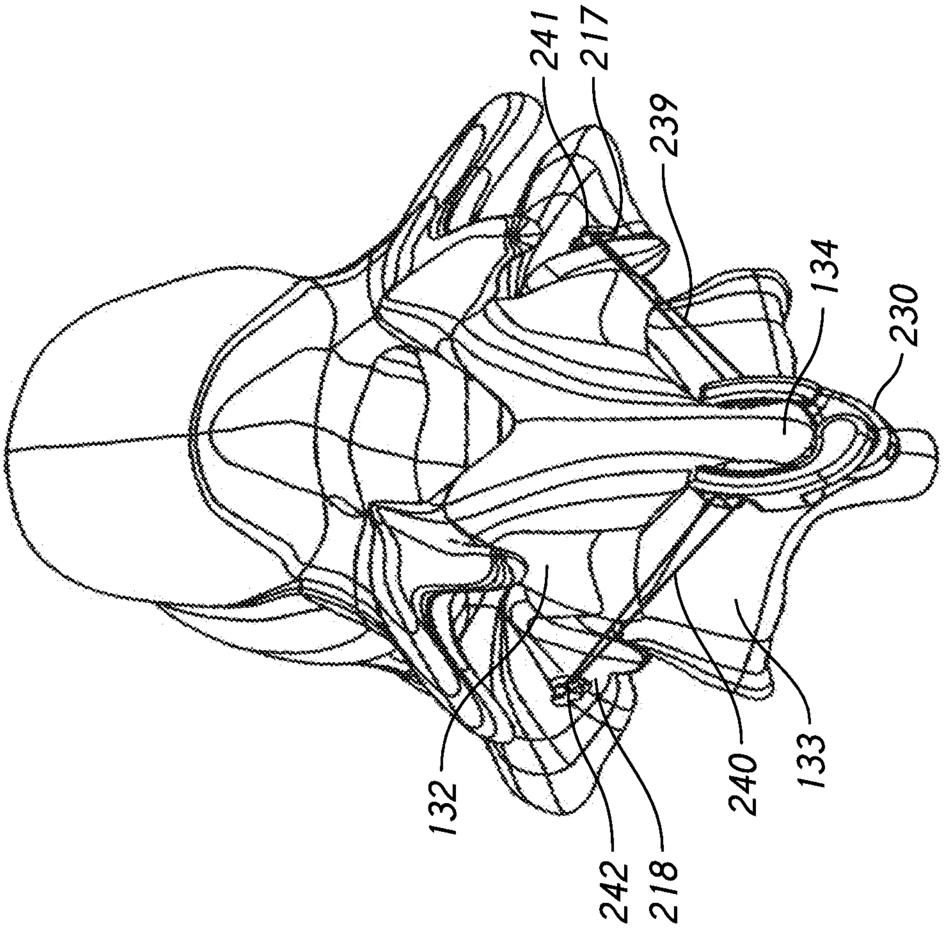


FIG. 19A

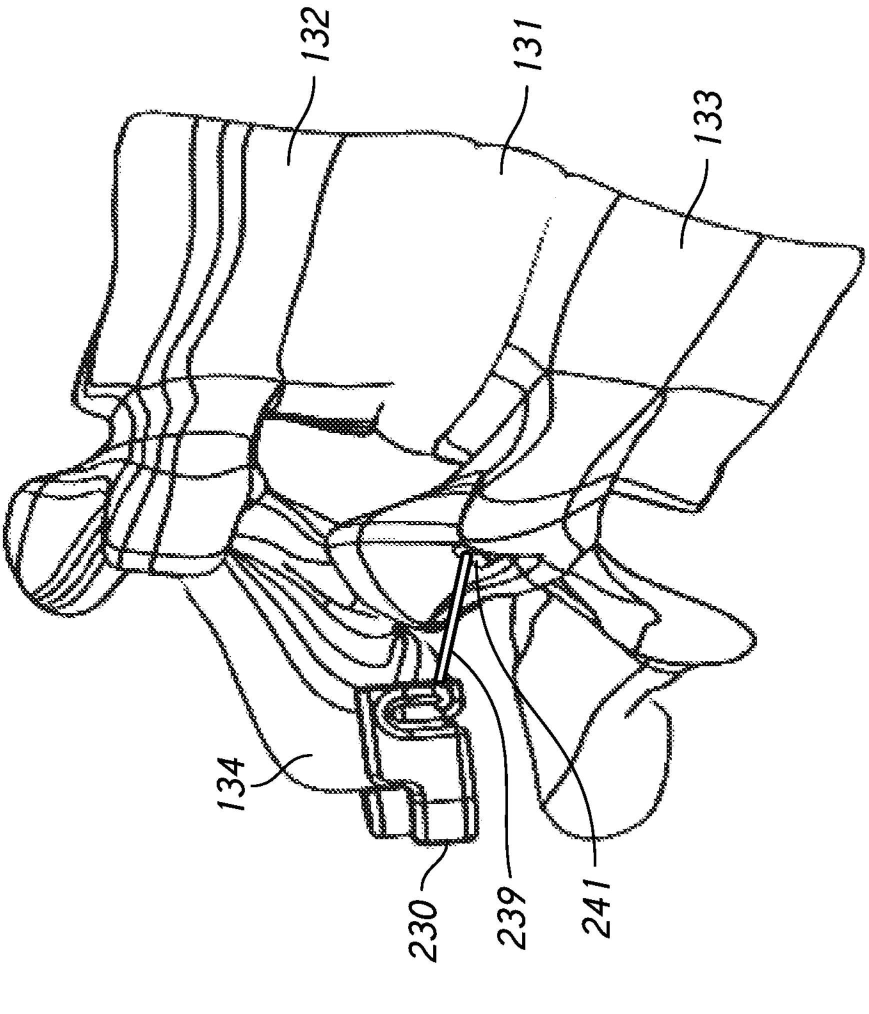


FIG. 19B

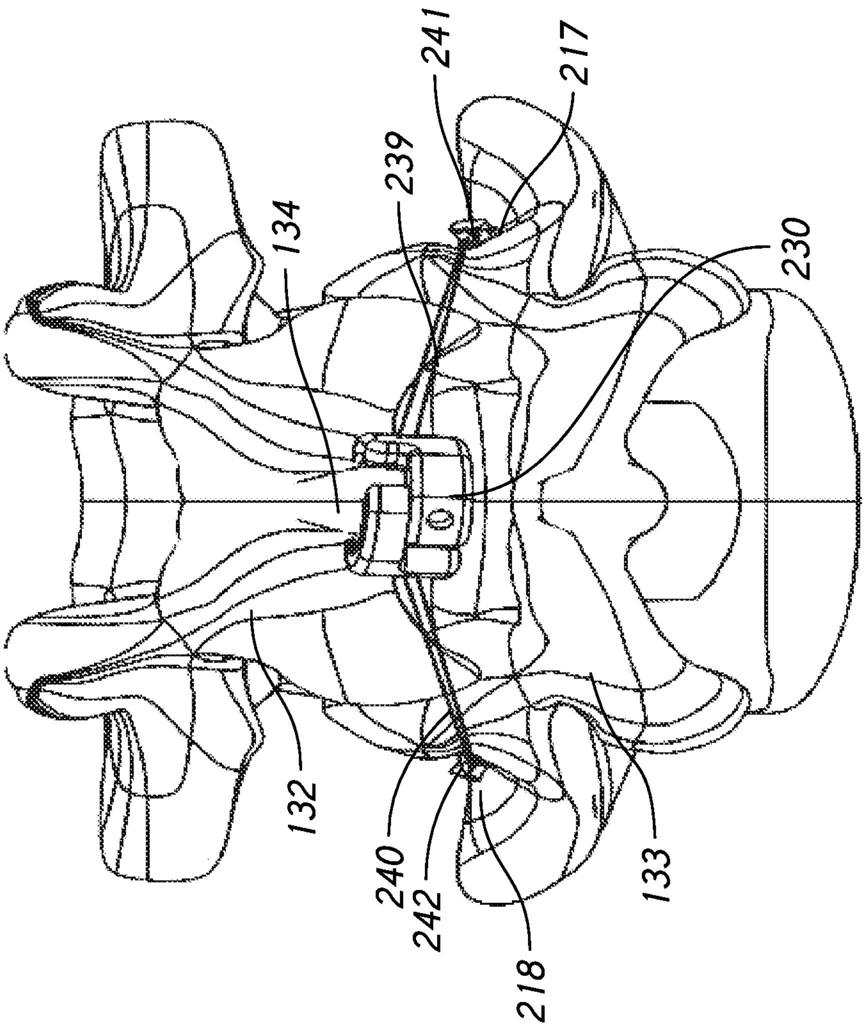
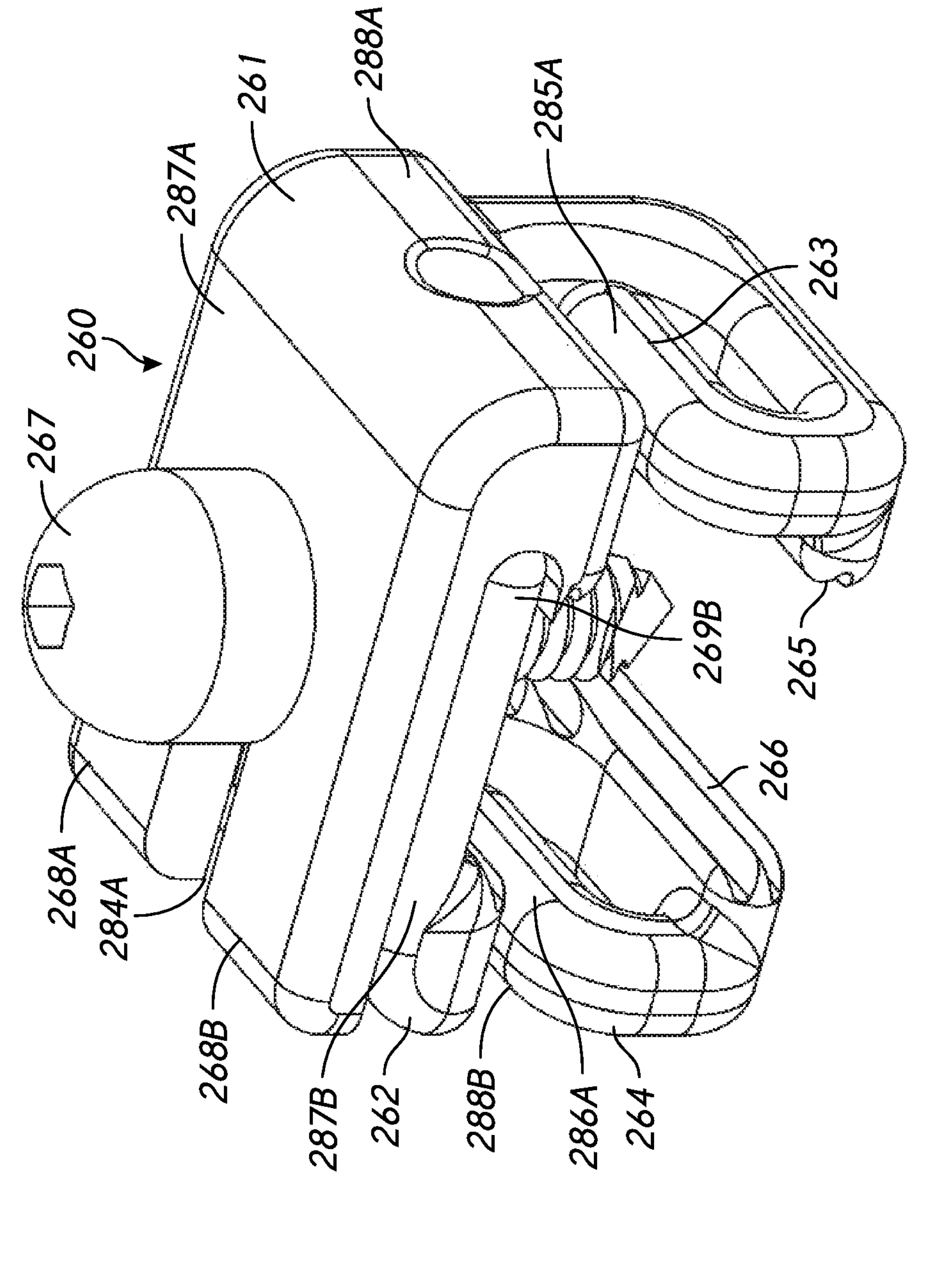


FIG. 19C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267
287A
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269B
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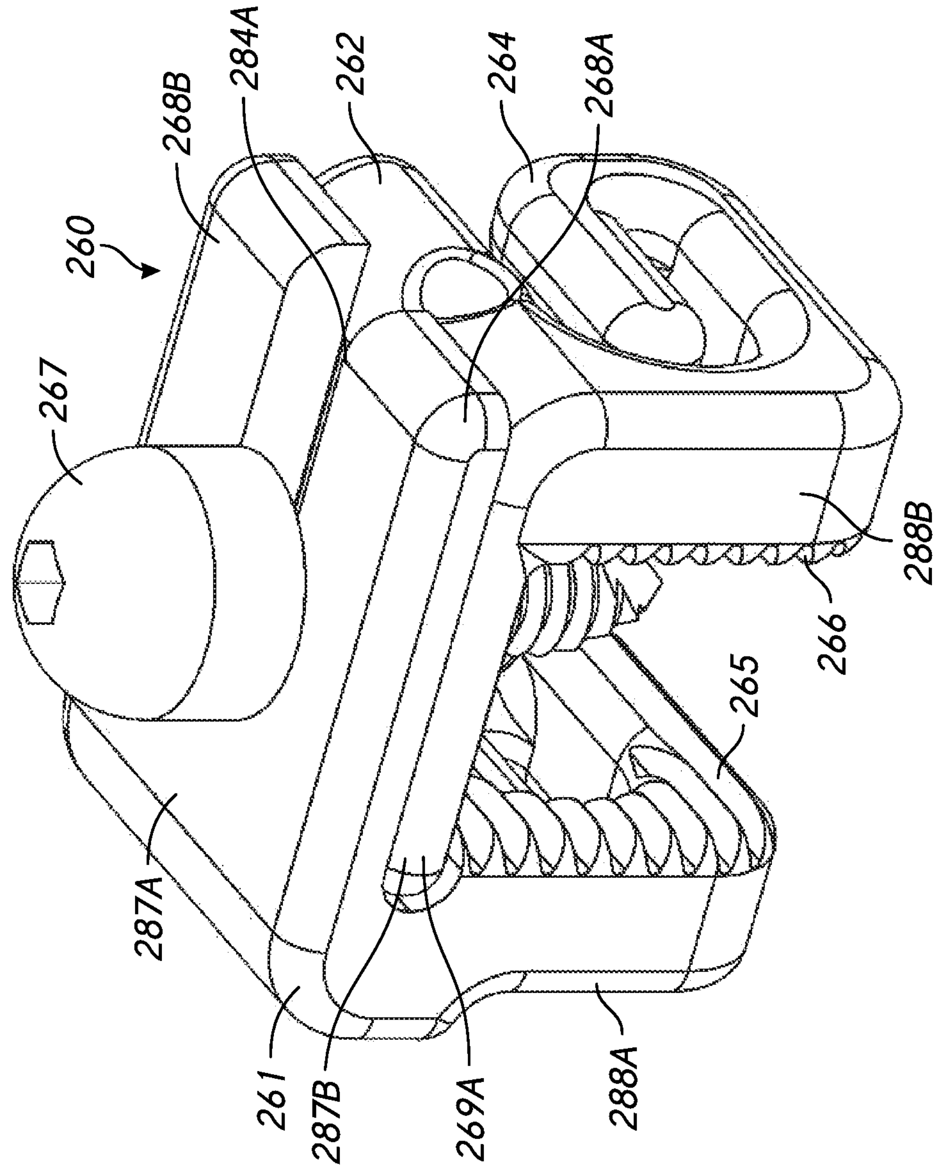
268A
284A
268B
287B
262
288B
286A
264

FIG. 20A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288B
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265
287A
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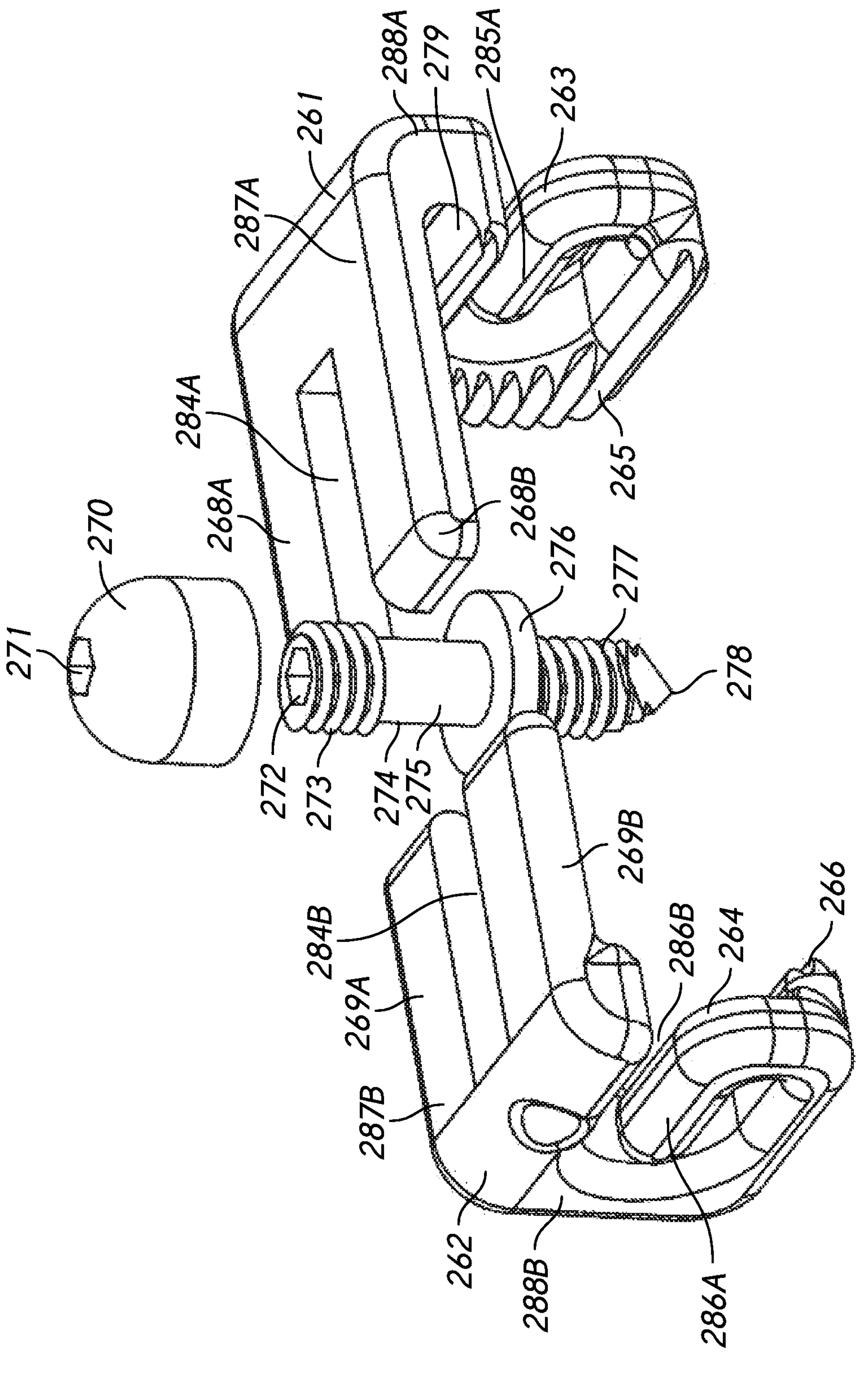
287B
269A
288A

FIG. 20B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284B
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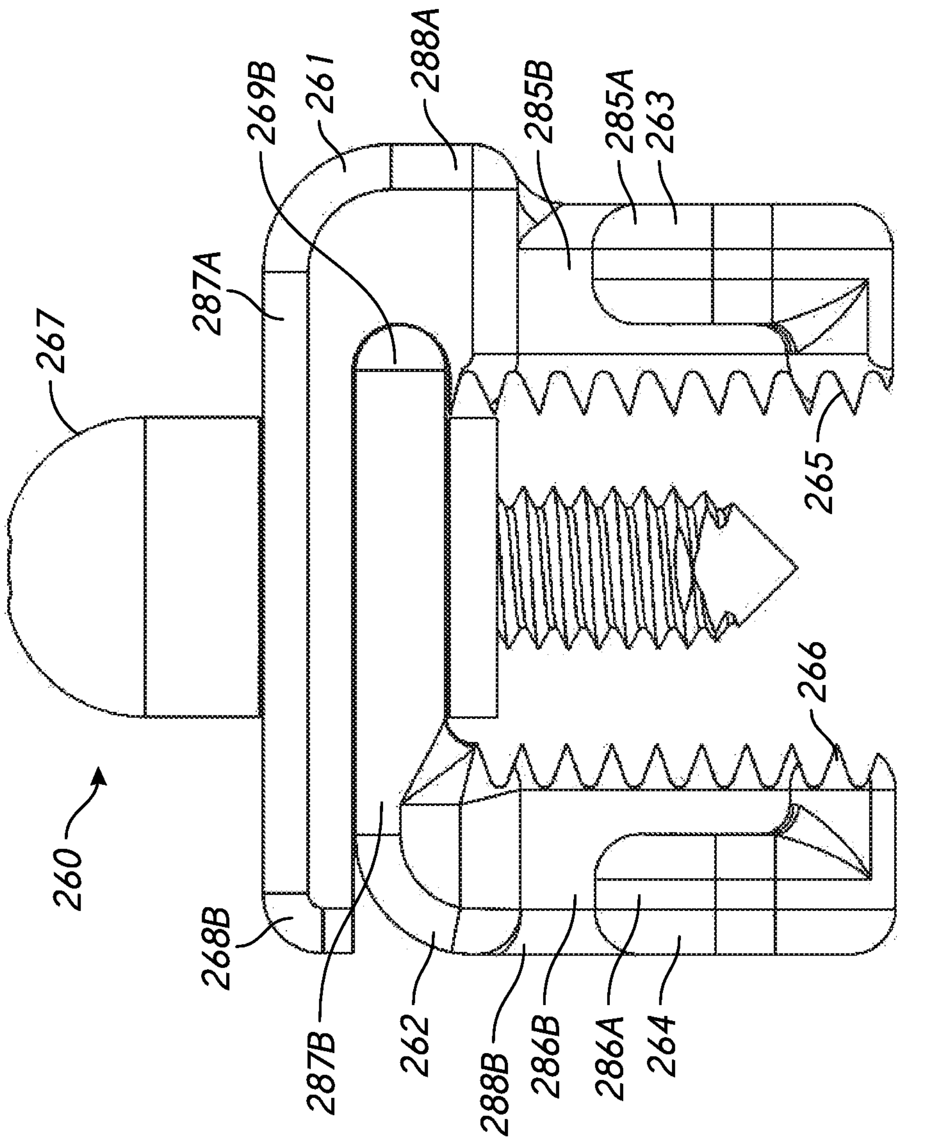
286B
264
269A
287B
262
288B
286A

FIG. 20C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288B
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286A
264

FIG. 20D

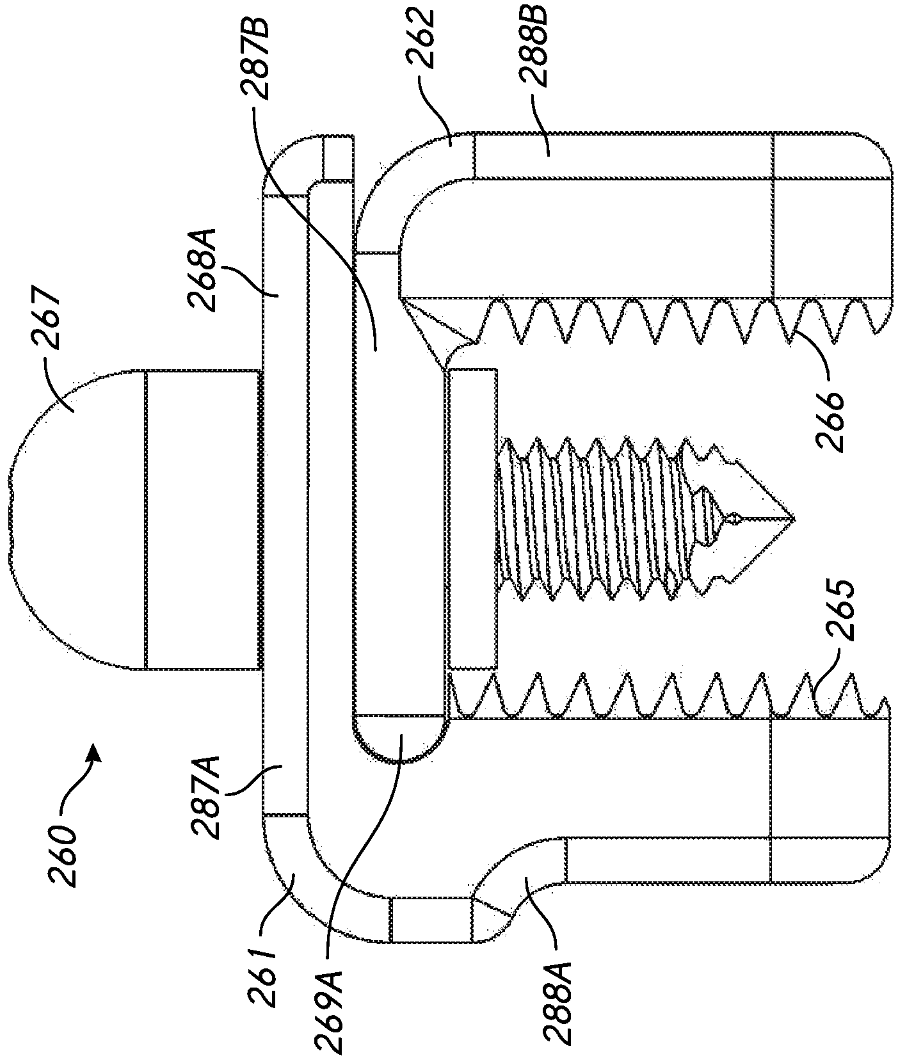


FIG. 20E

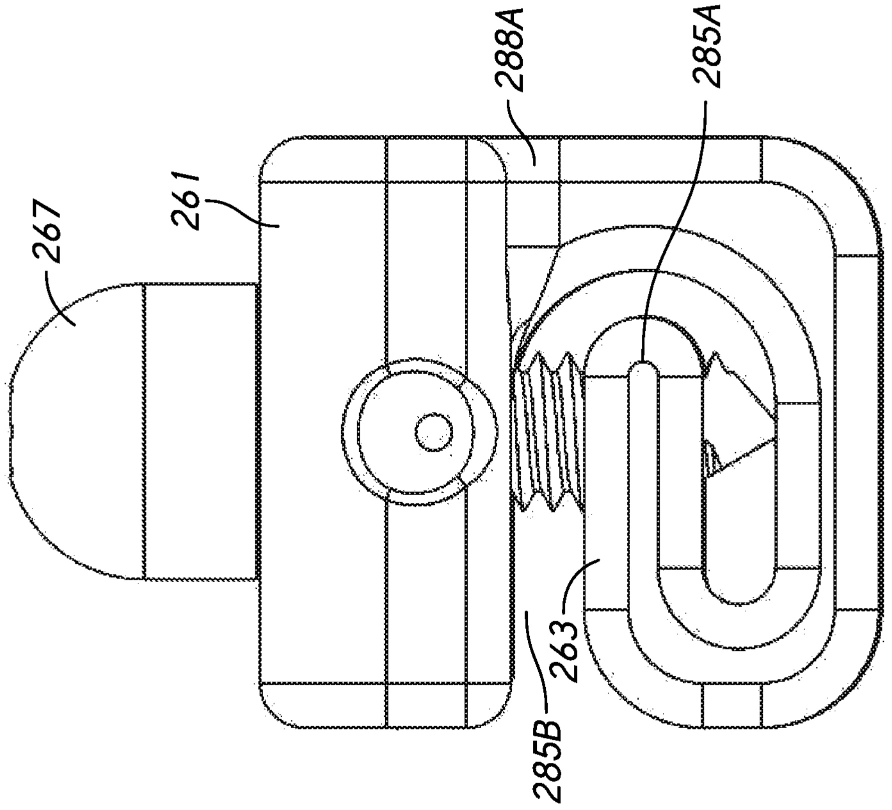


FIG. 20G

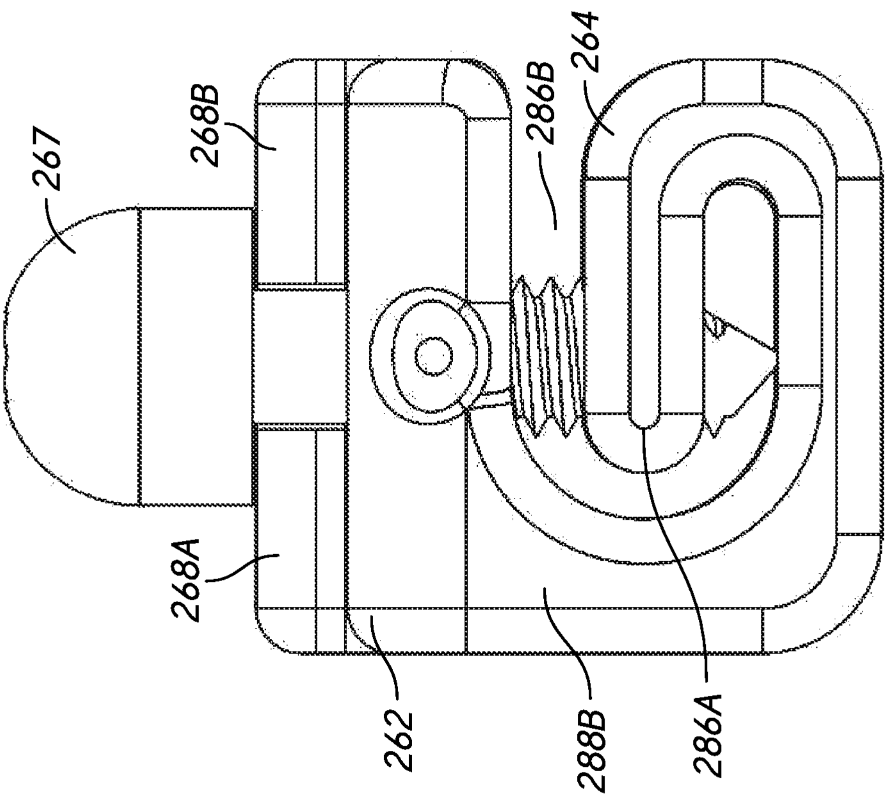
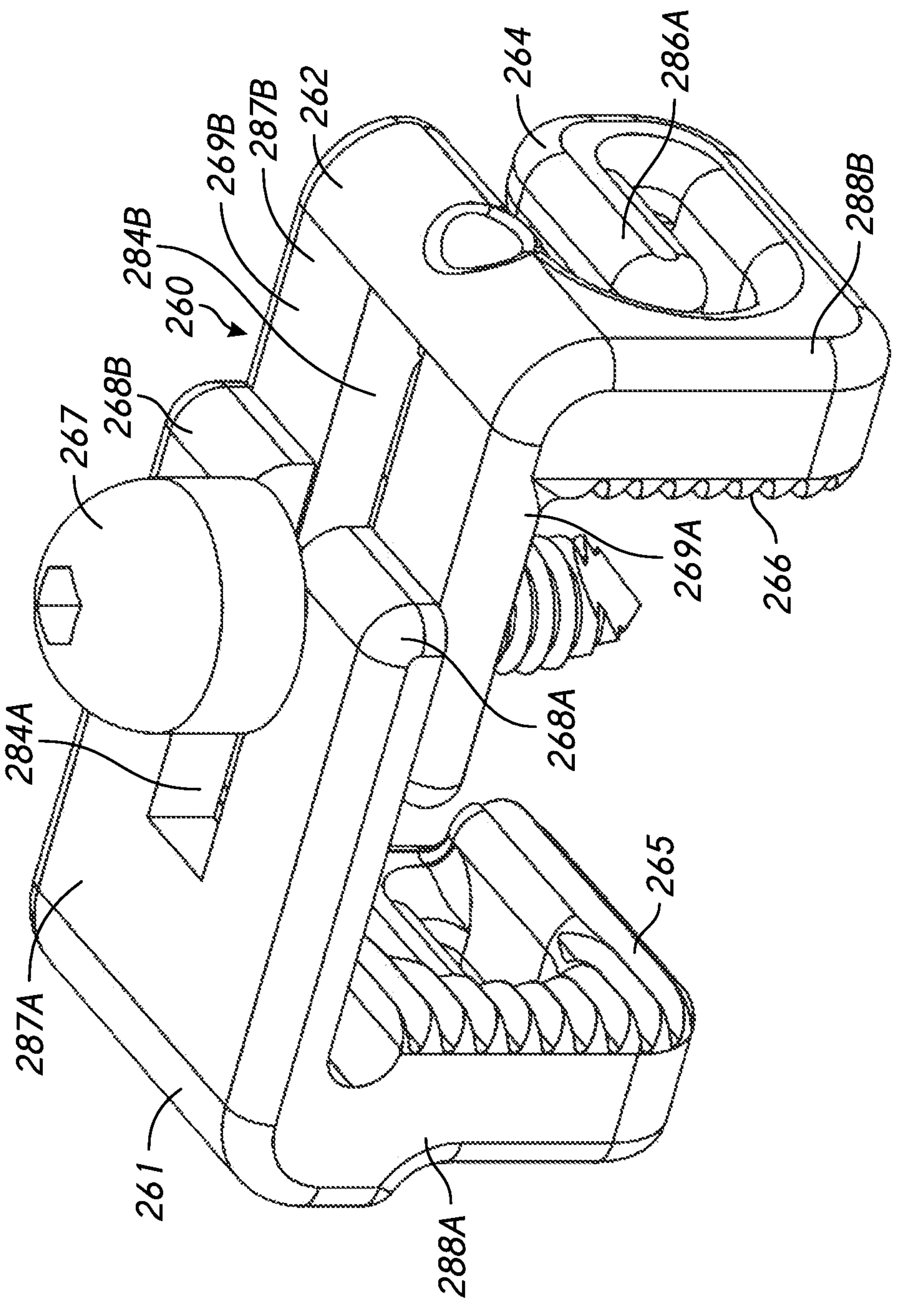


FIG. 20F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268B
269A
269B
284A
284B
286A
287A
287B
288A
288B

FIG. 20H

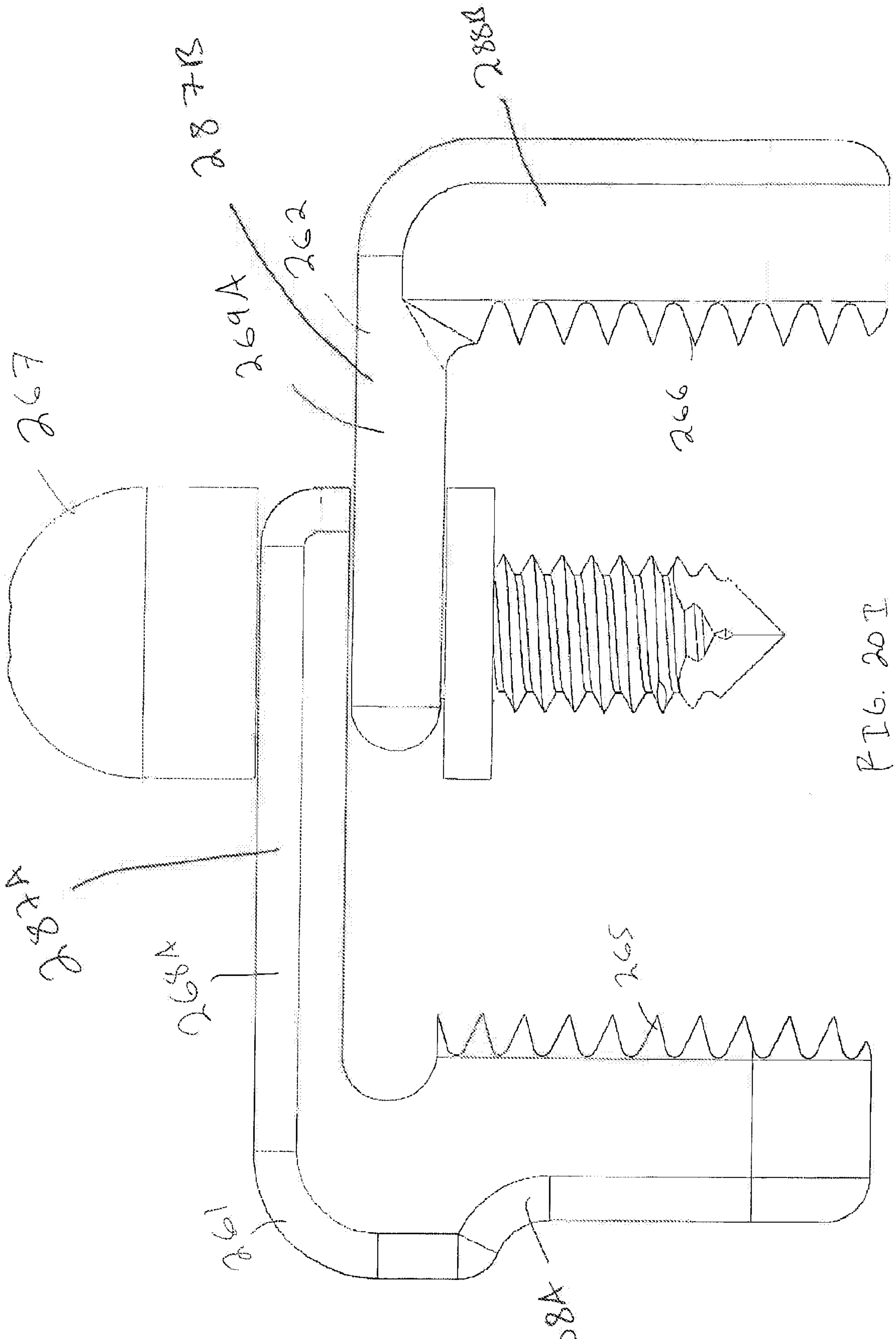


FIG. 20I

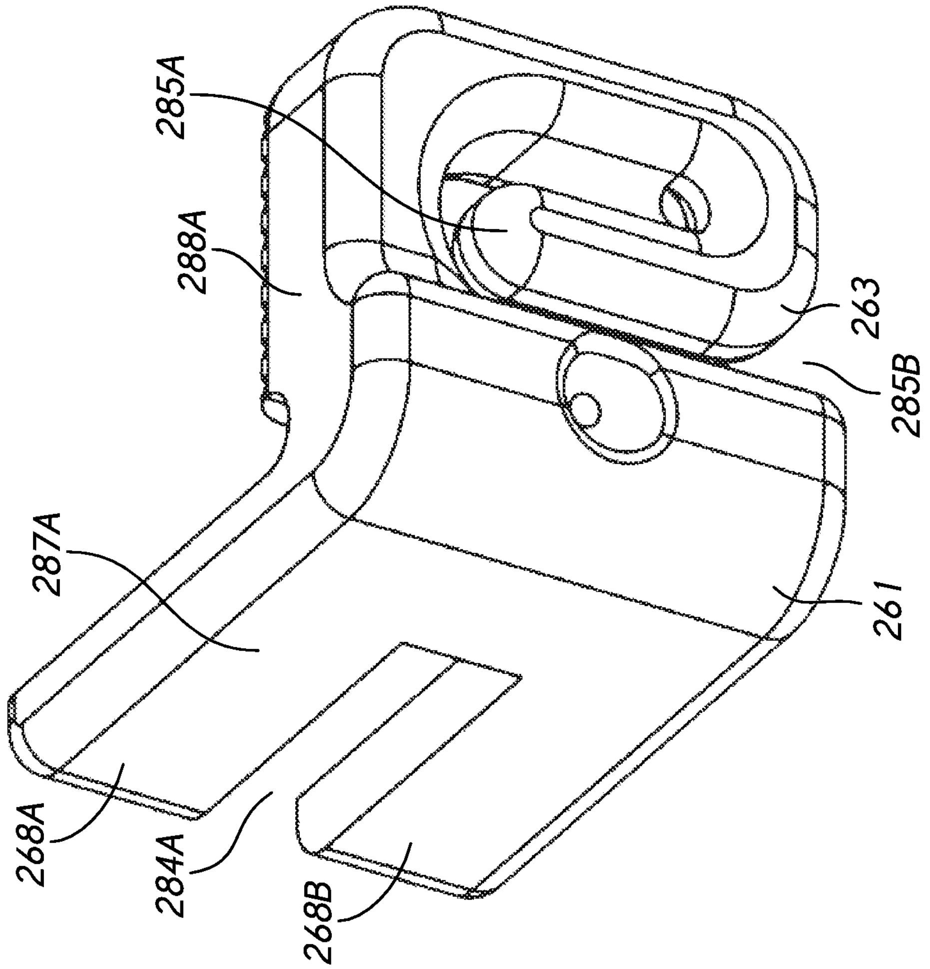


FIG. 20J

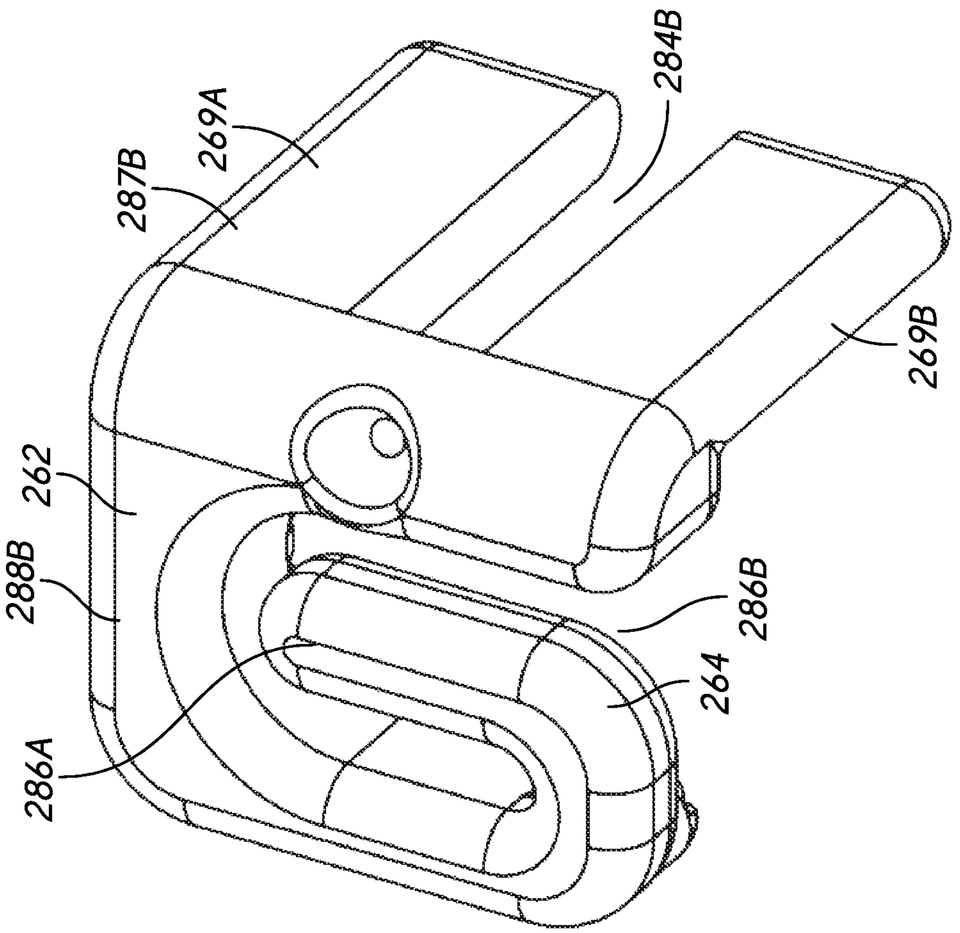


FIG. 20K

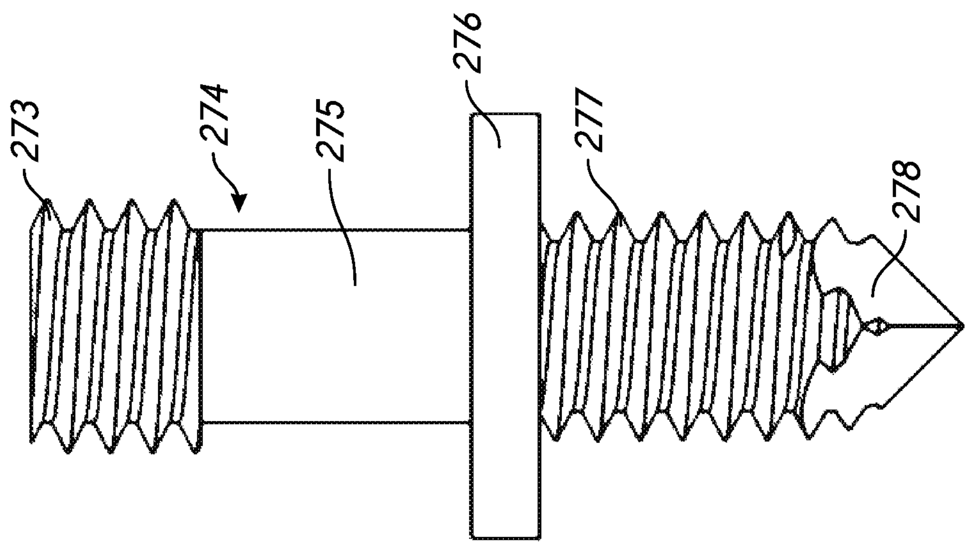


FIG. 20L

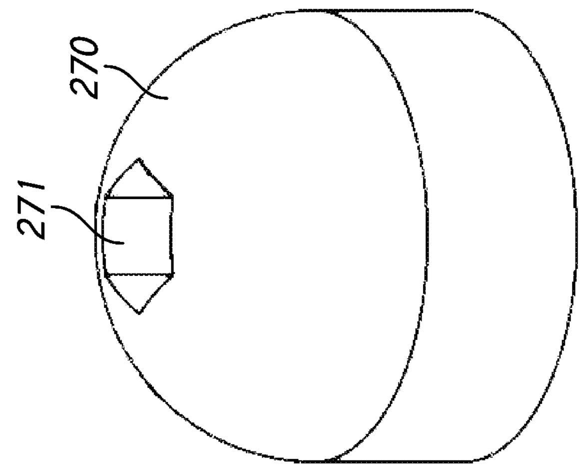


FIG. 20M

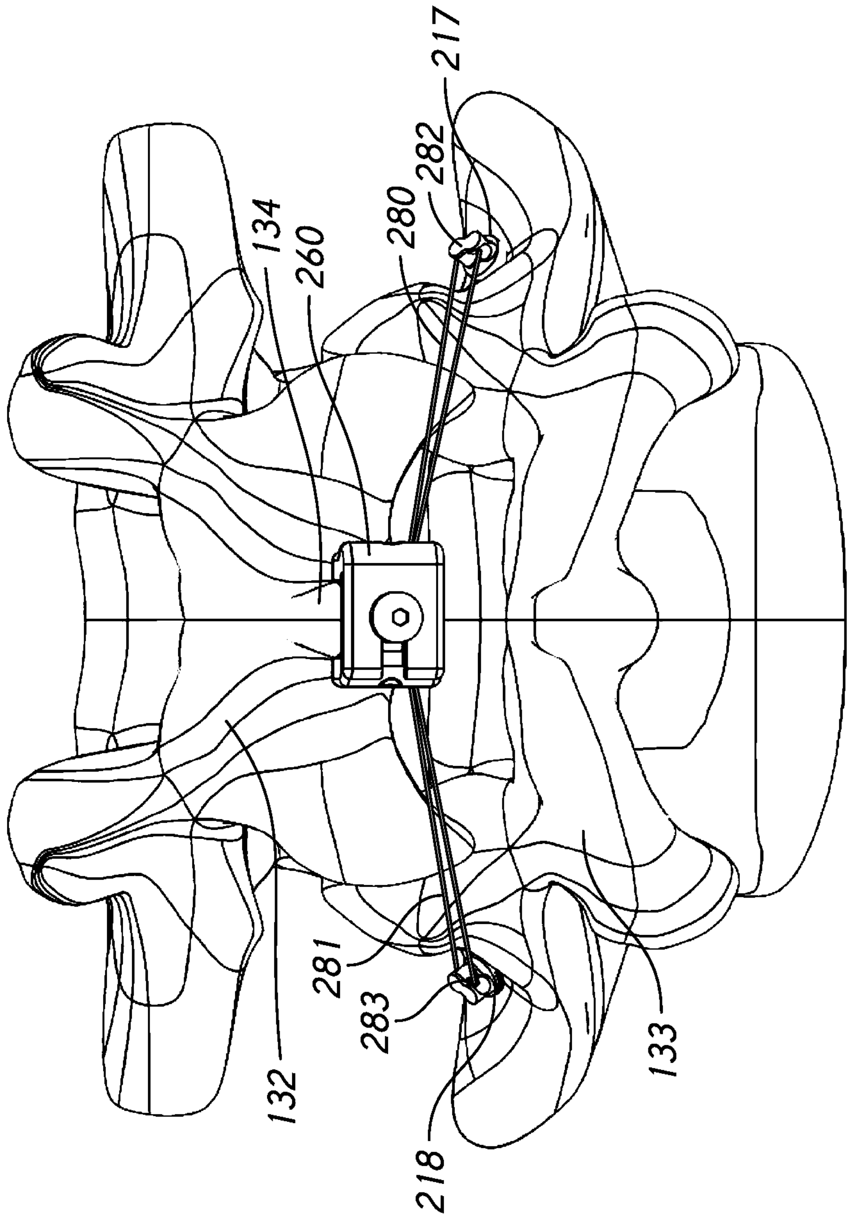


FIG. 21A

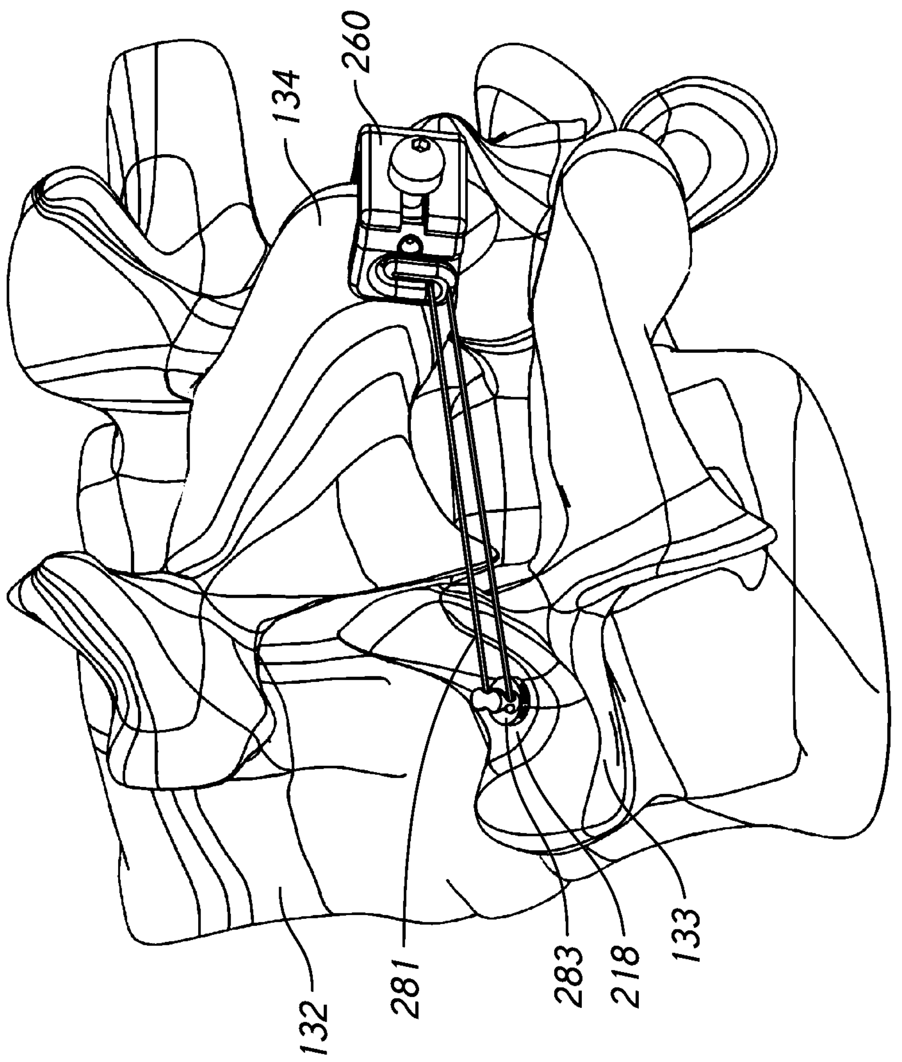


FIG. 21B

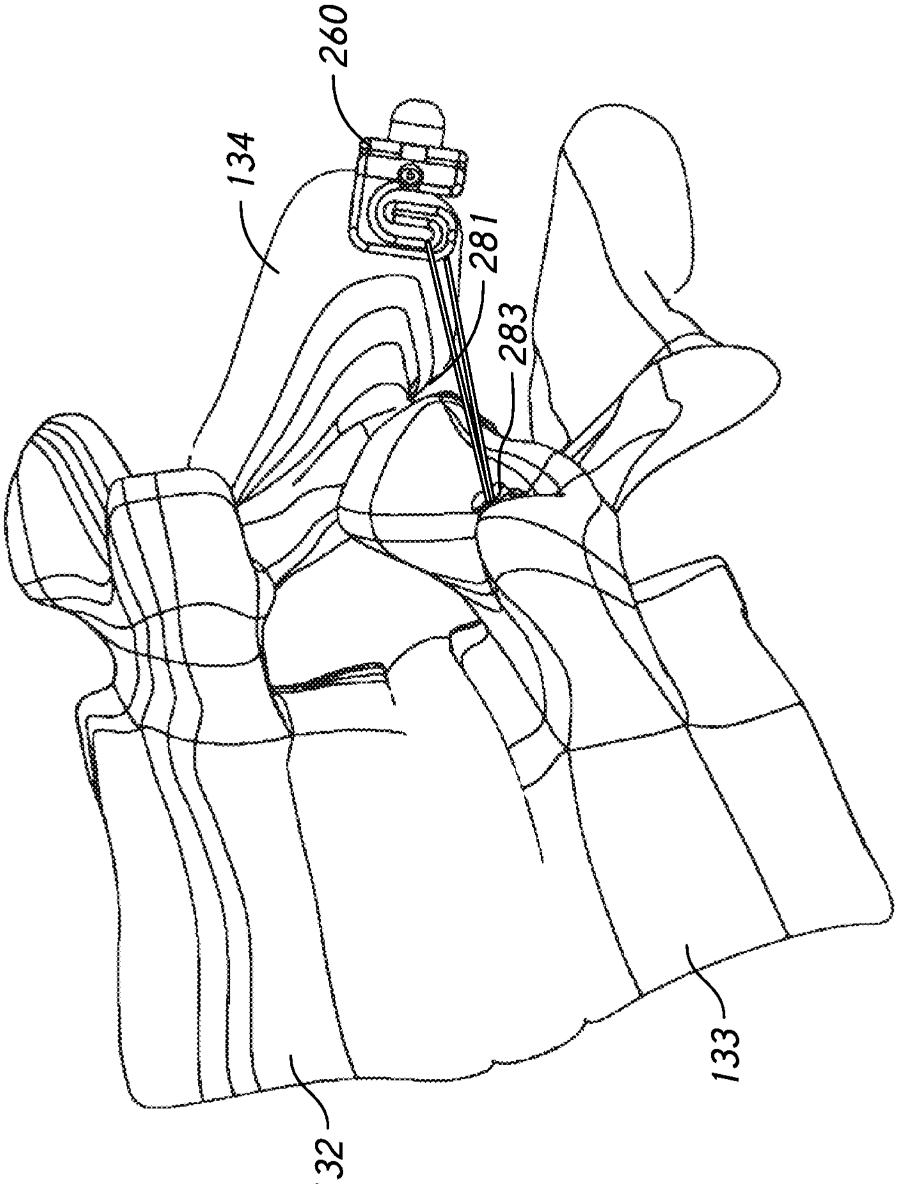


FIG. 21C

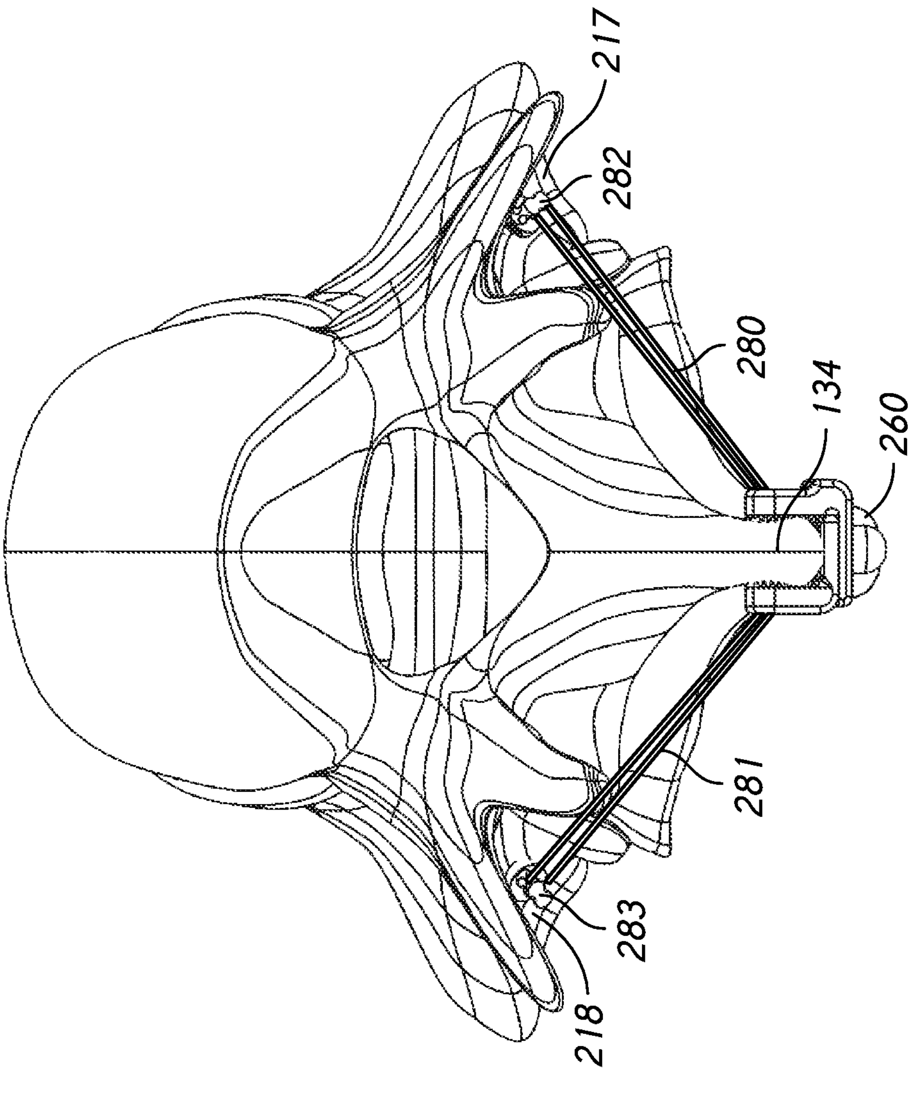


FIG. 21D

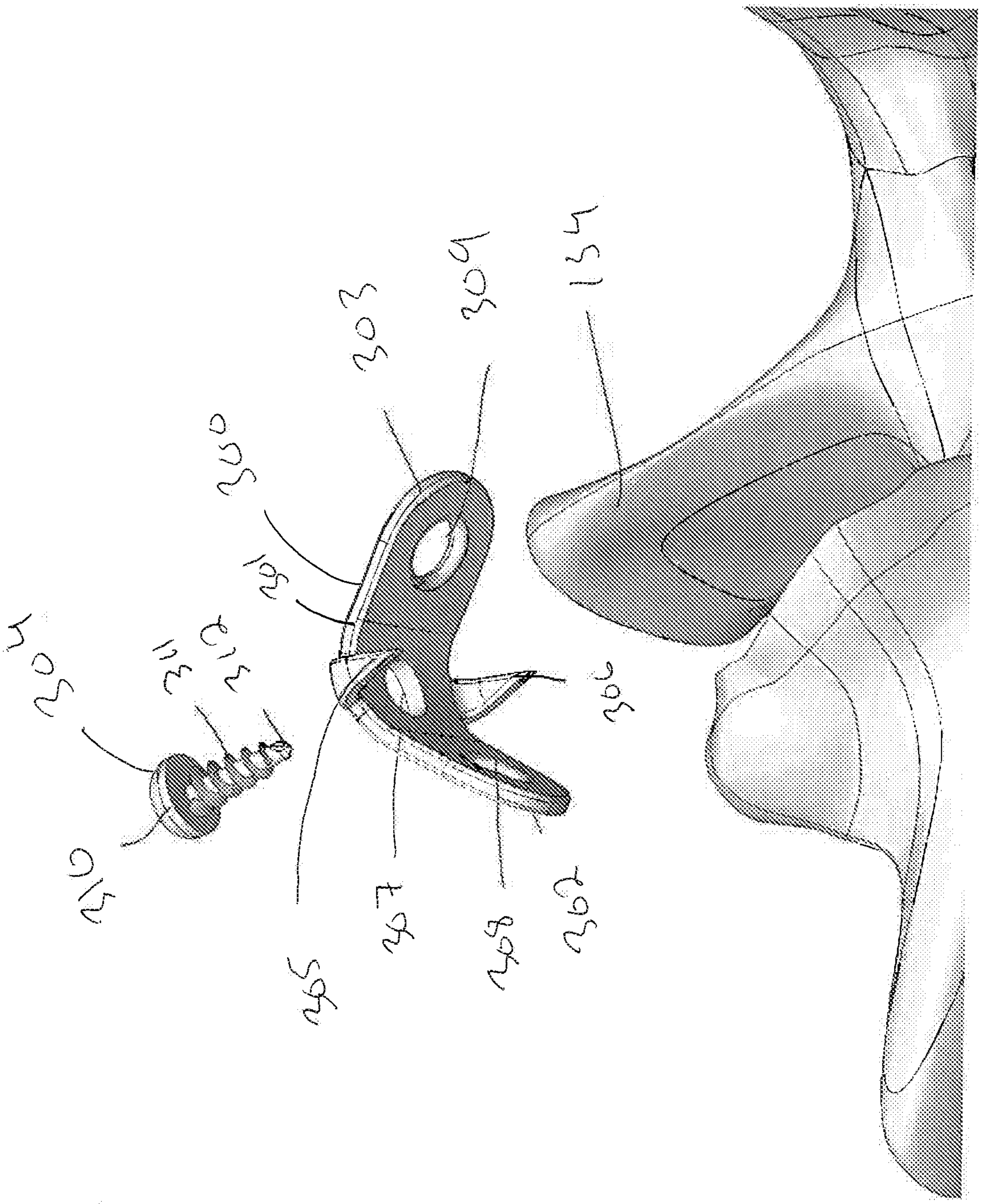


FIG. 22A

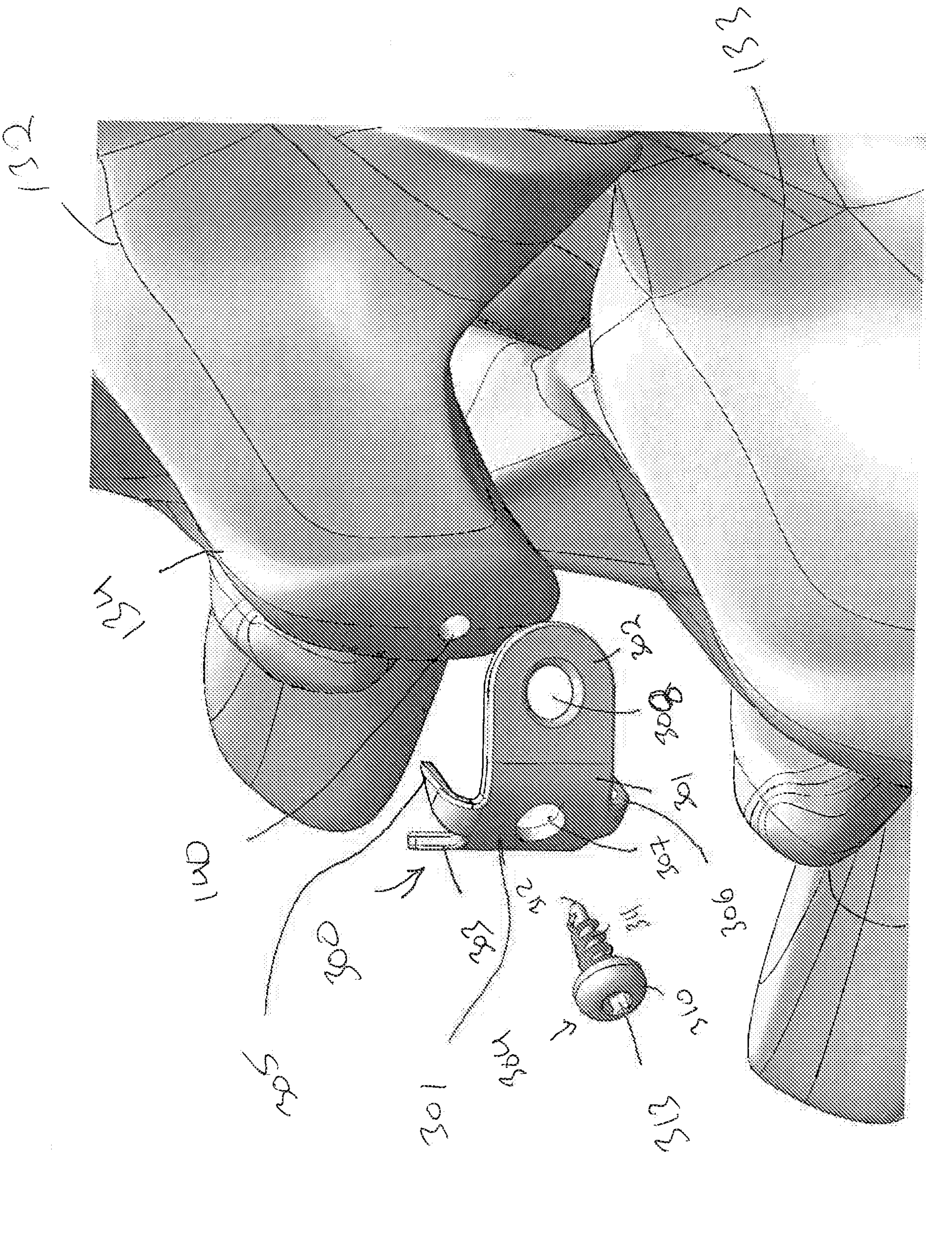


FIG. 22B

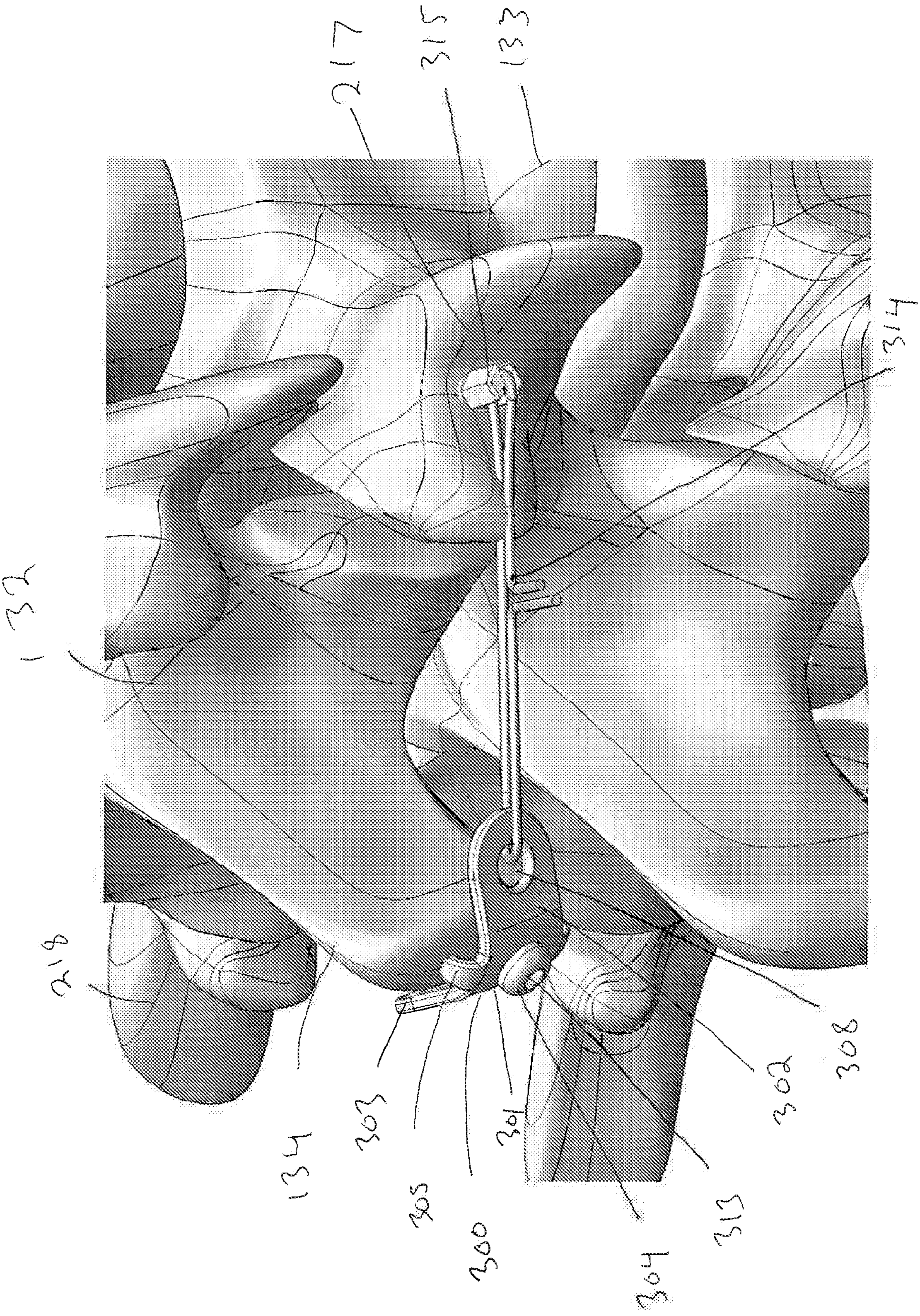


FIG. 22C

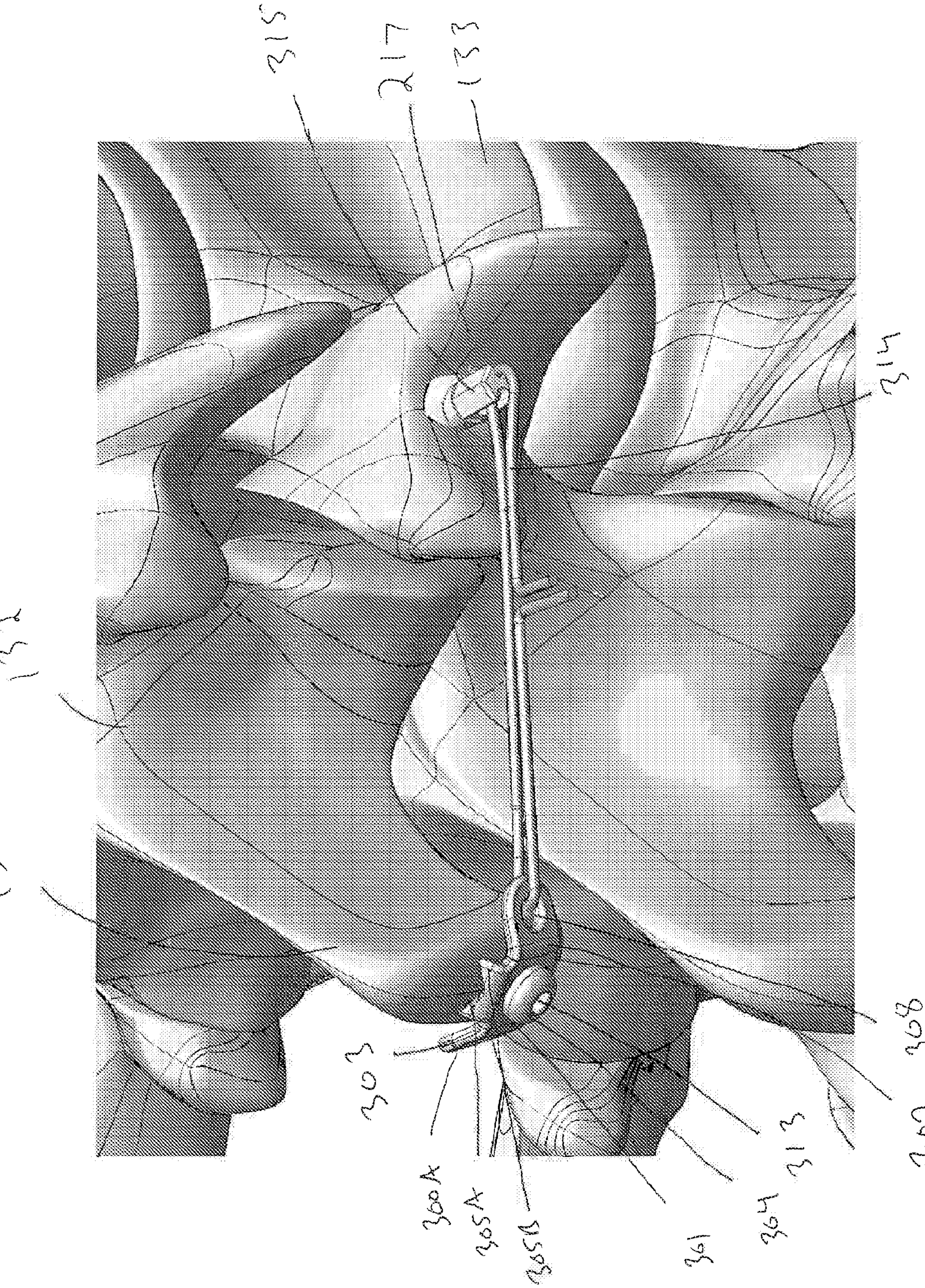


FIG. 22O

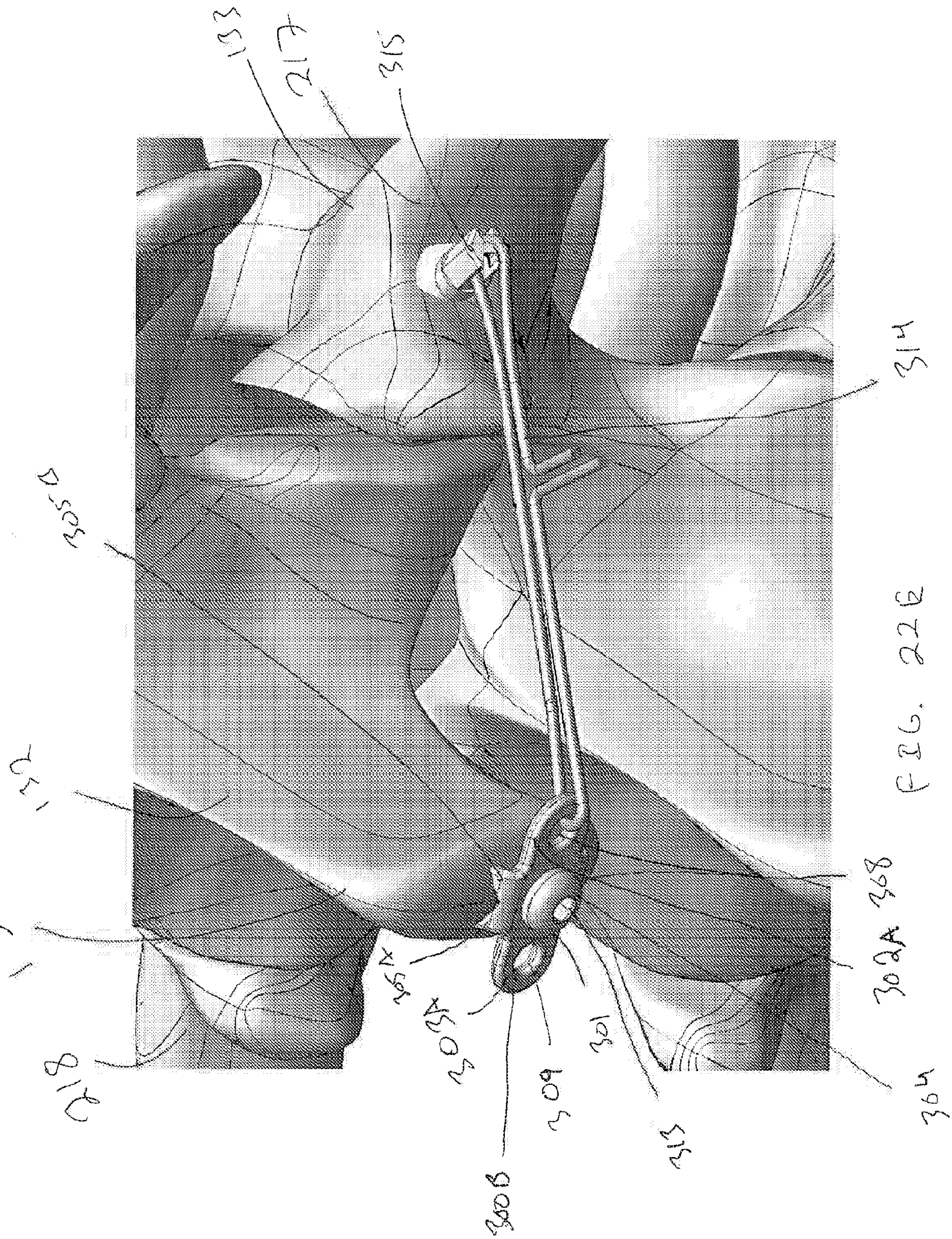


FIG. 22E

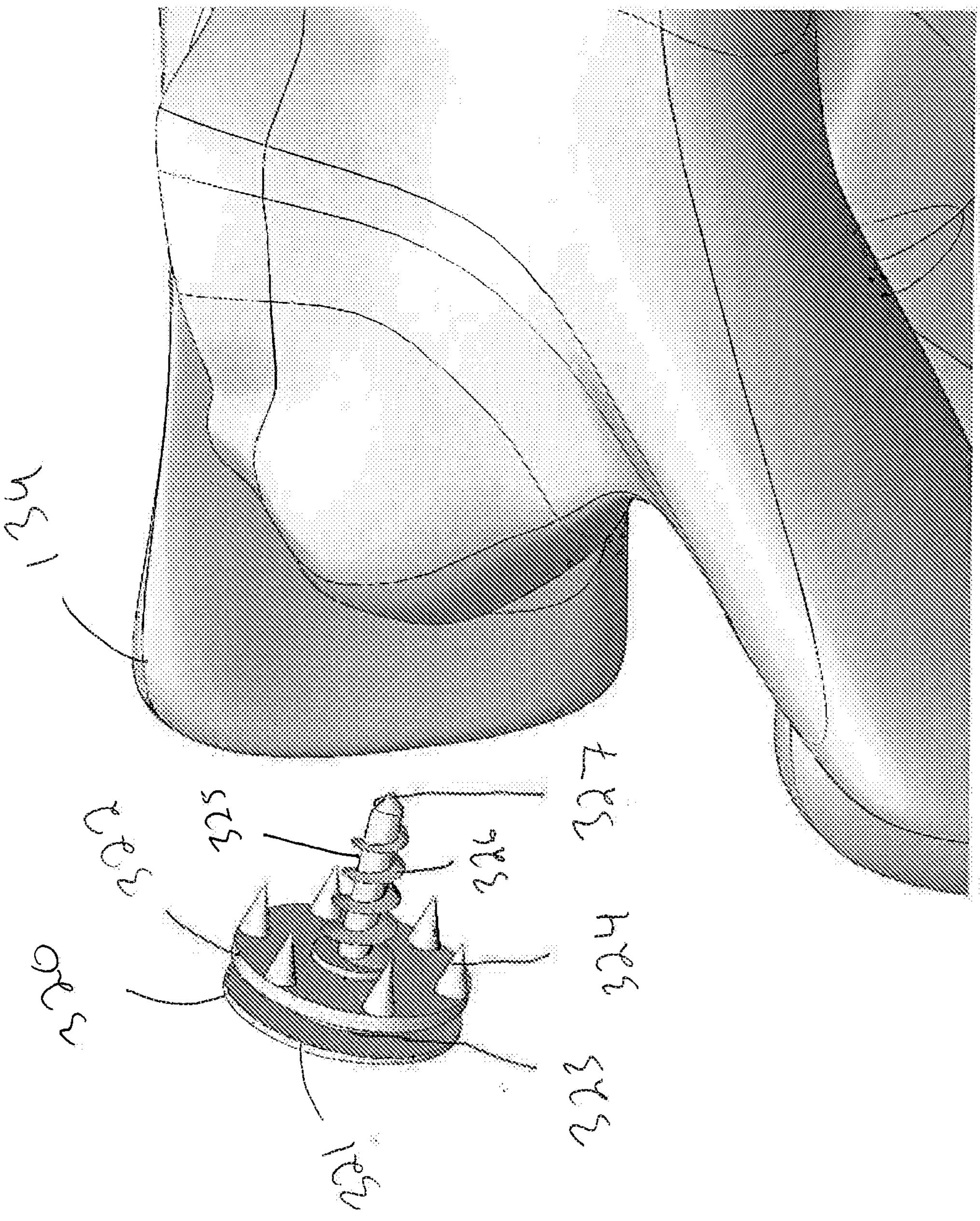


FIG. 23A

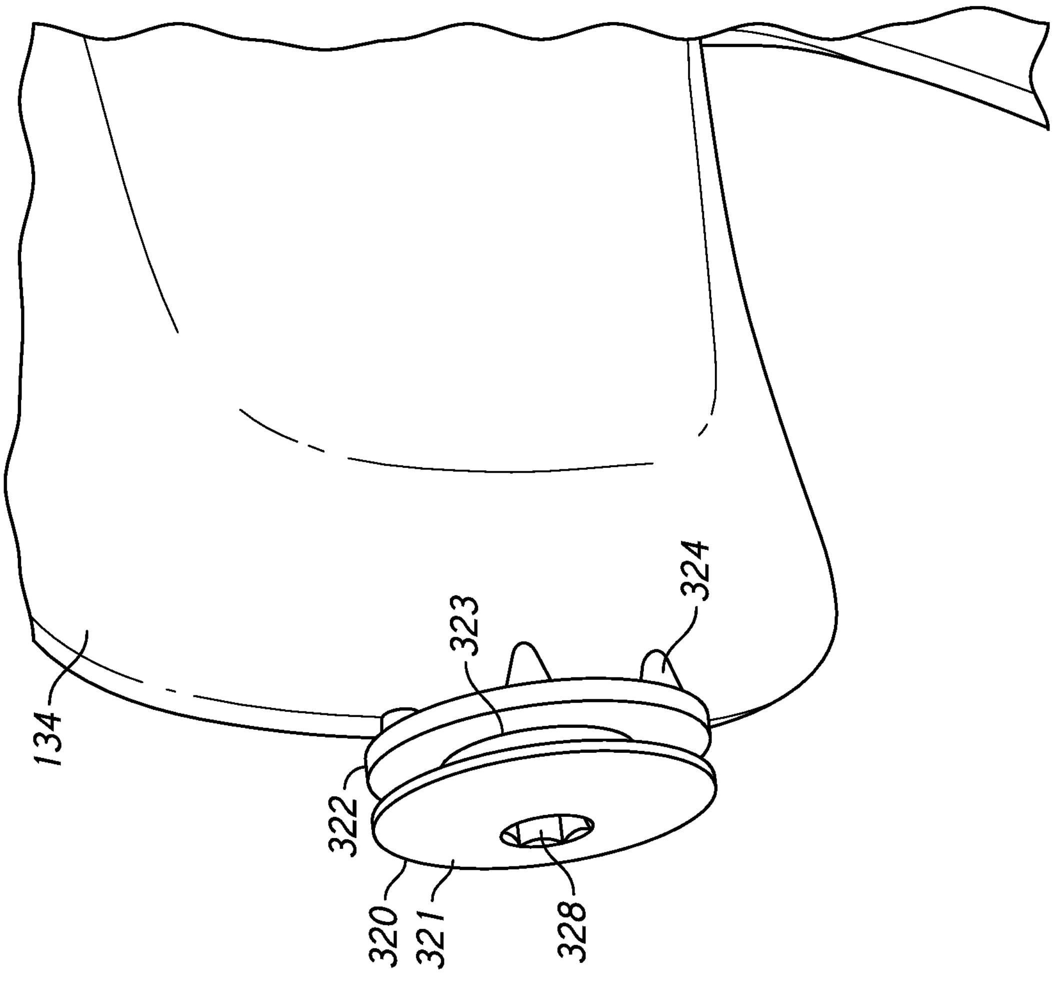


FIG. 23B

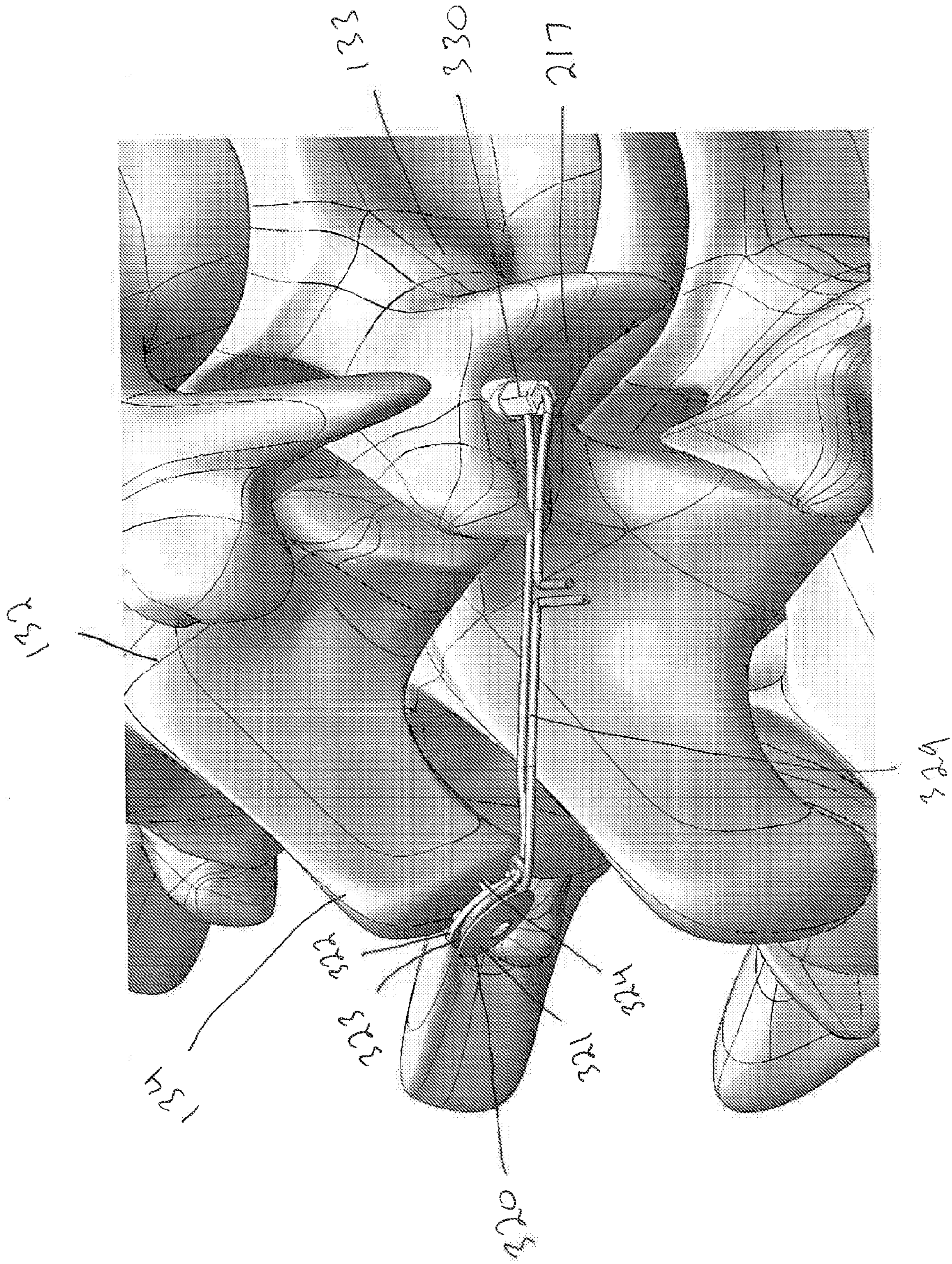
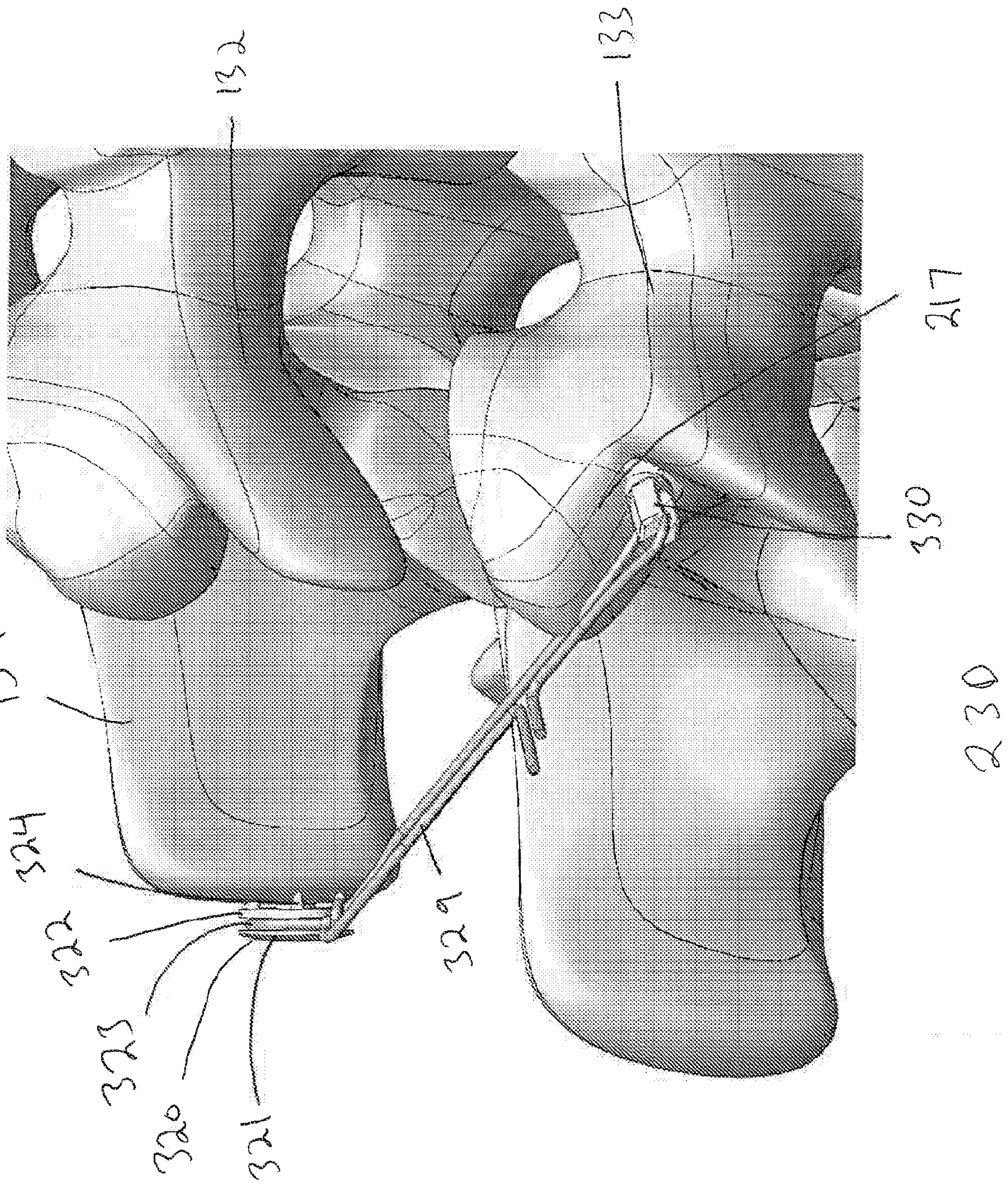


FIG. 23C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133
217
330
230
134
324
322
323
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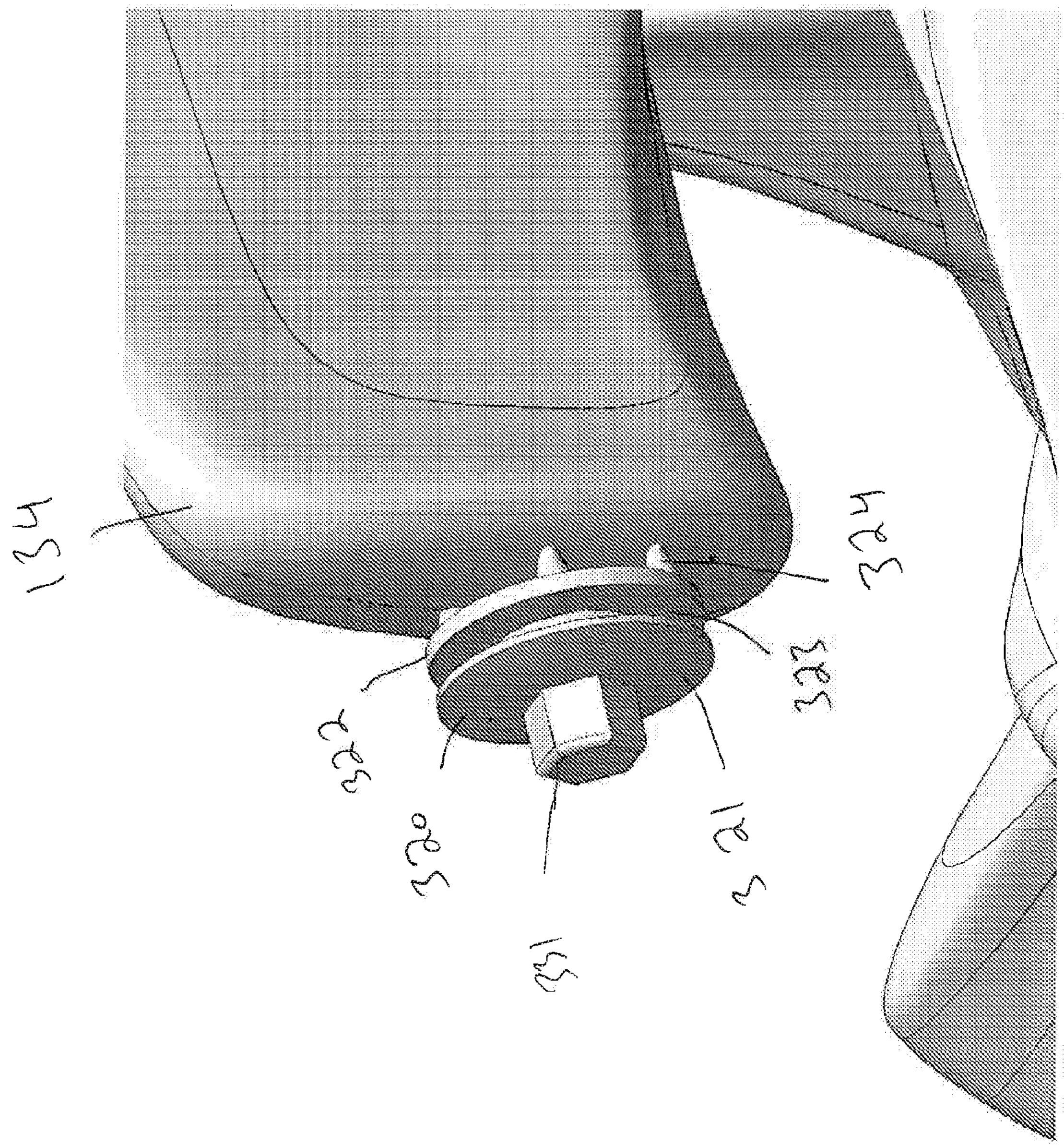
321
329



23E

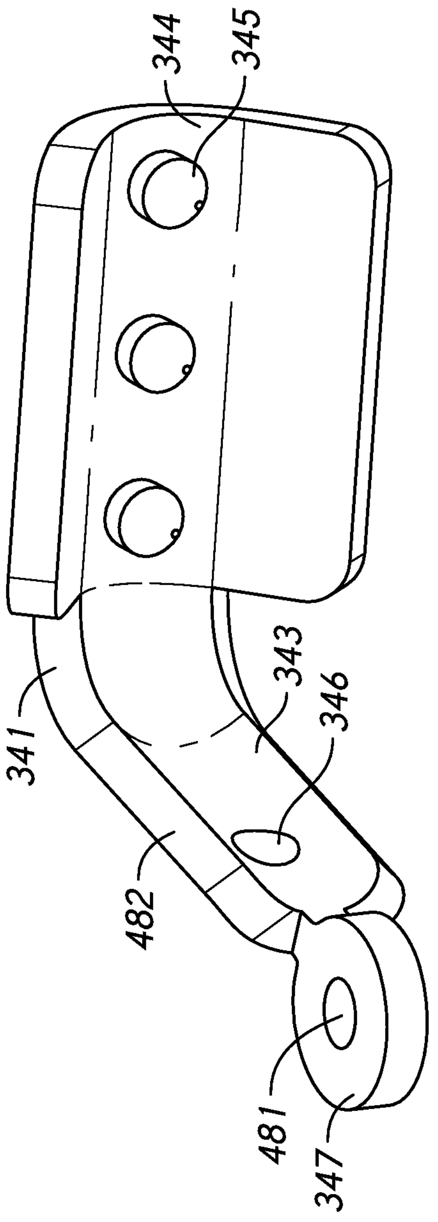


FIG. 24A

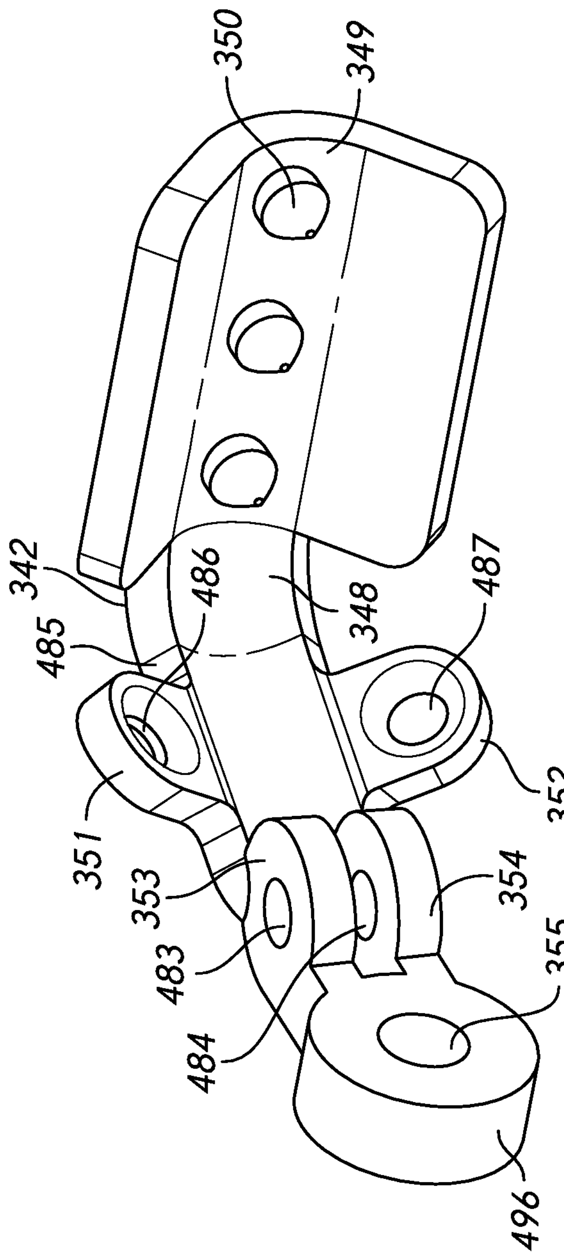


FIG. 24B

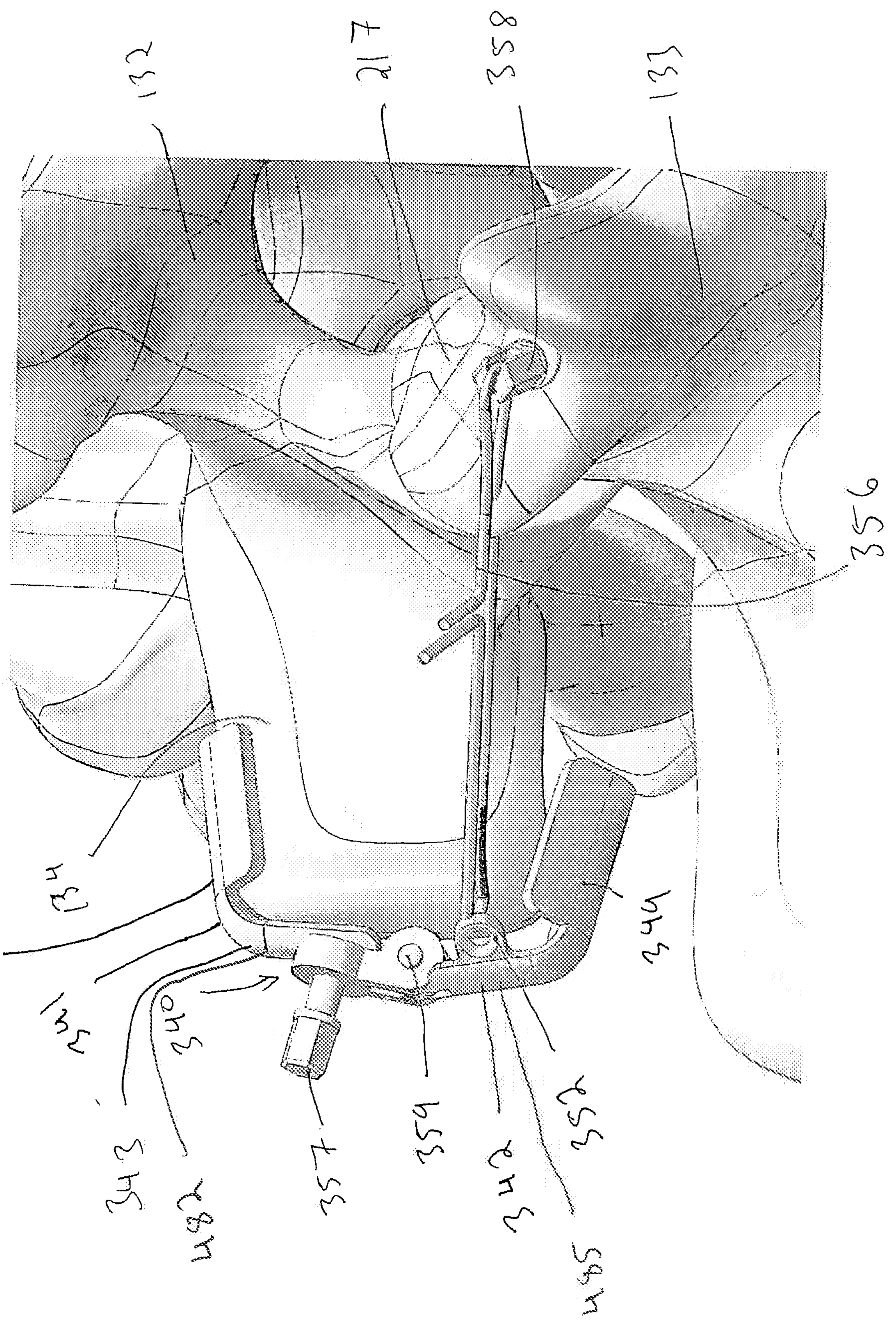


FIG 24C

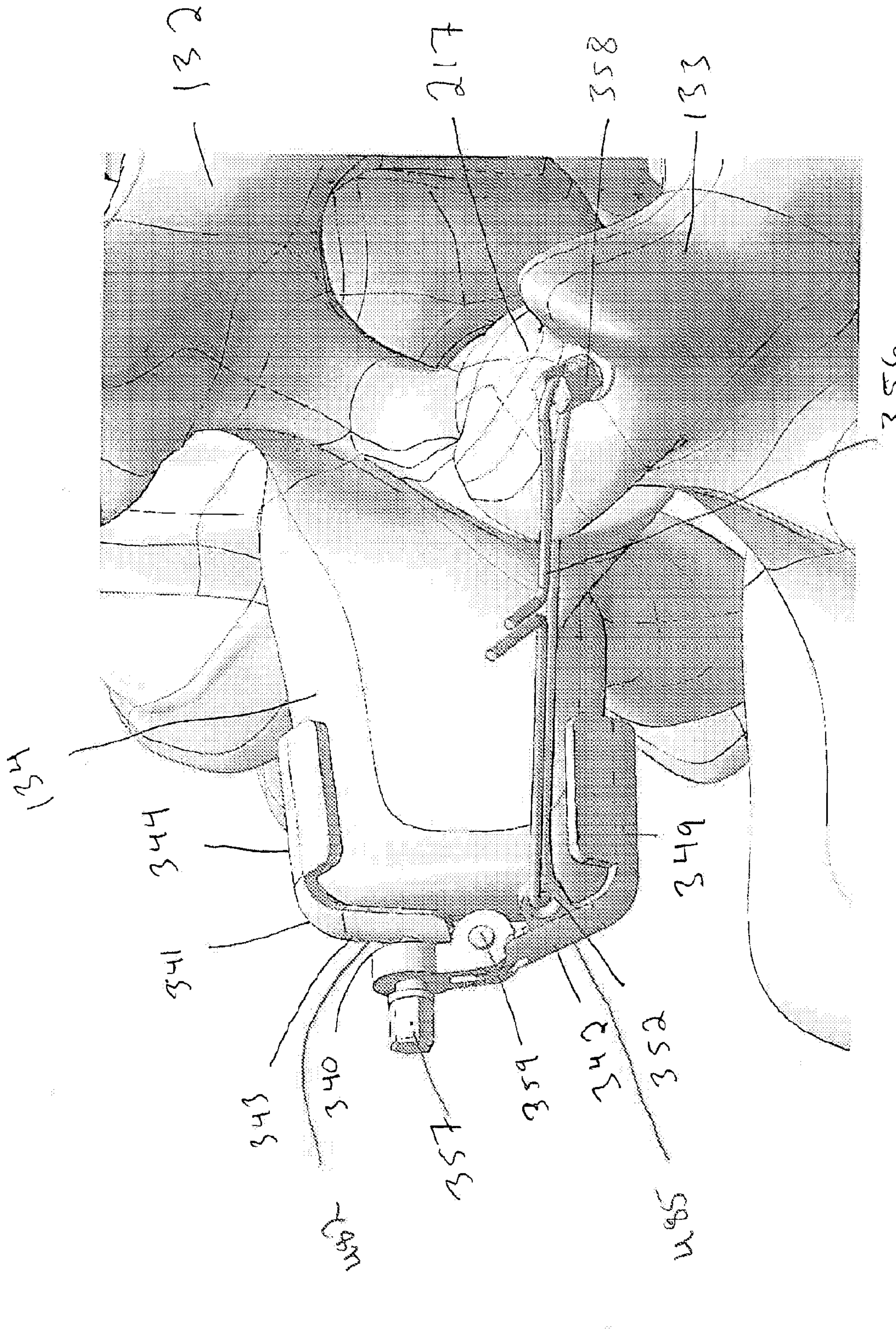


FIG 24D

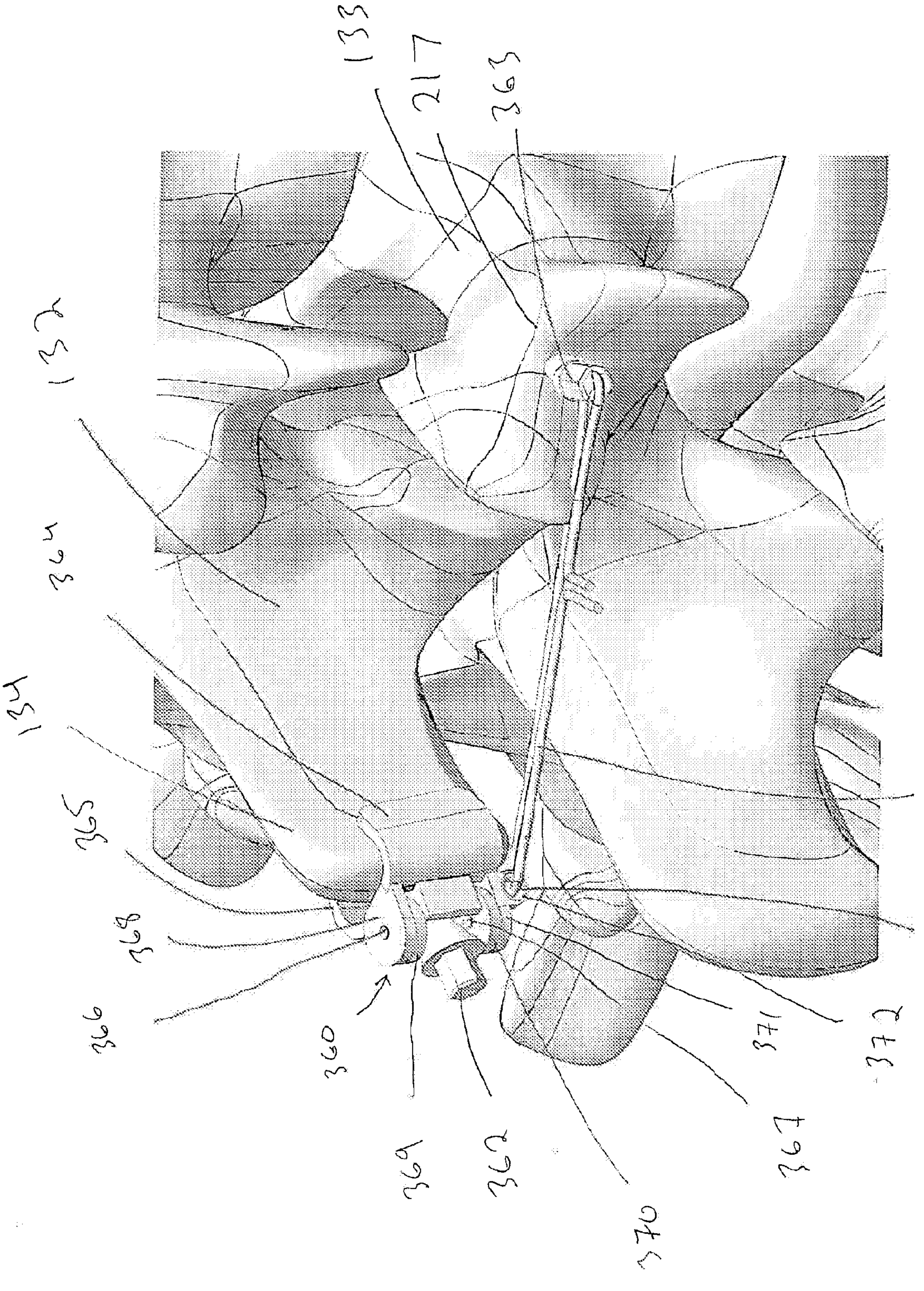

133
217
363
132
131
364
134
365
368
366
360
369
362
370
367
372
371
495
361

FIG 25A

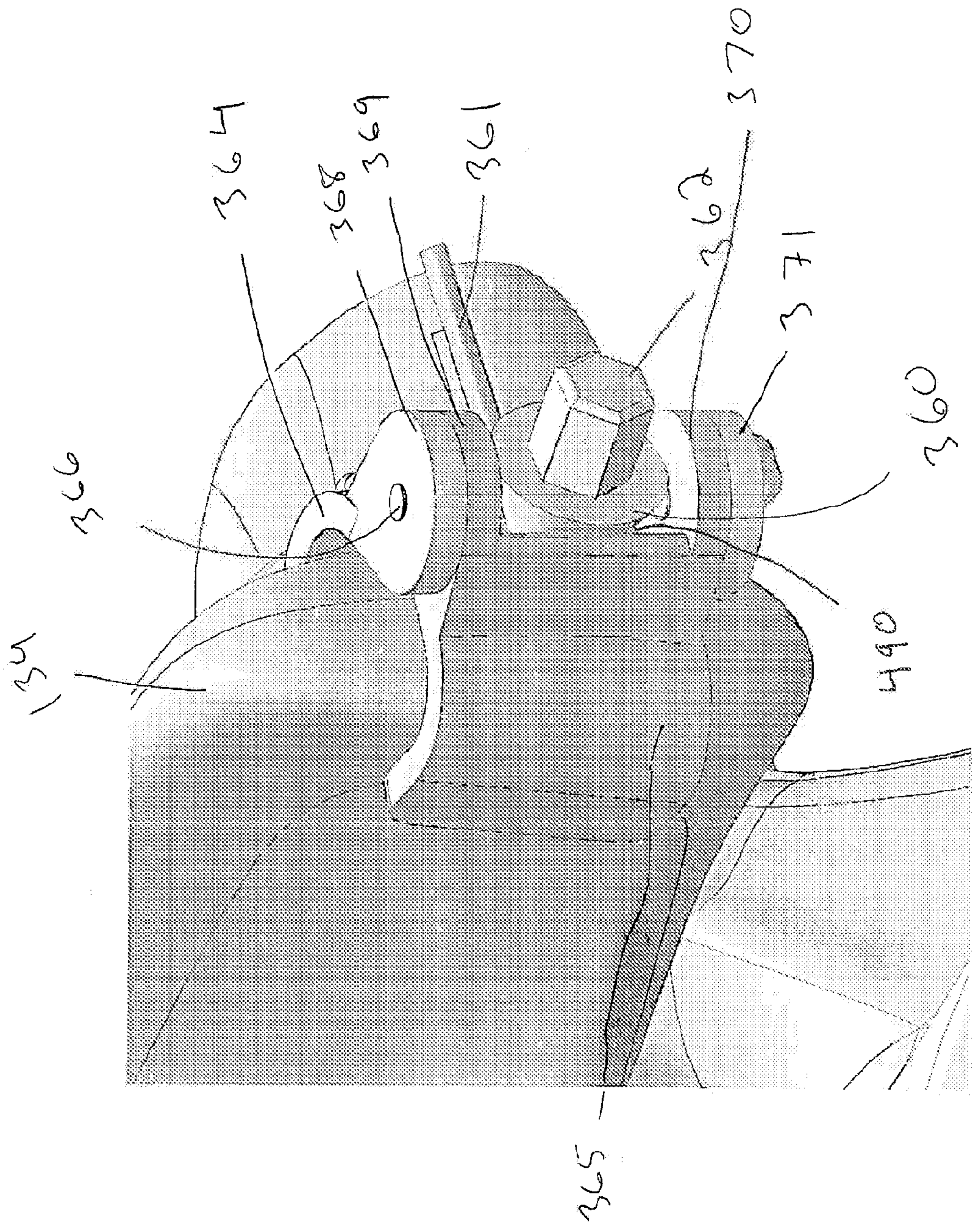


FIG. 25B

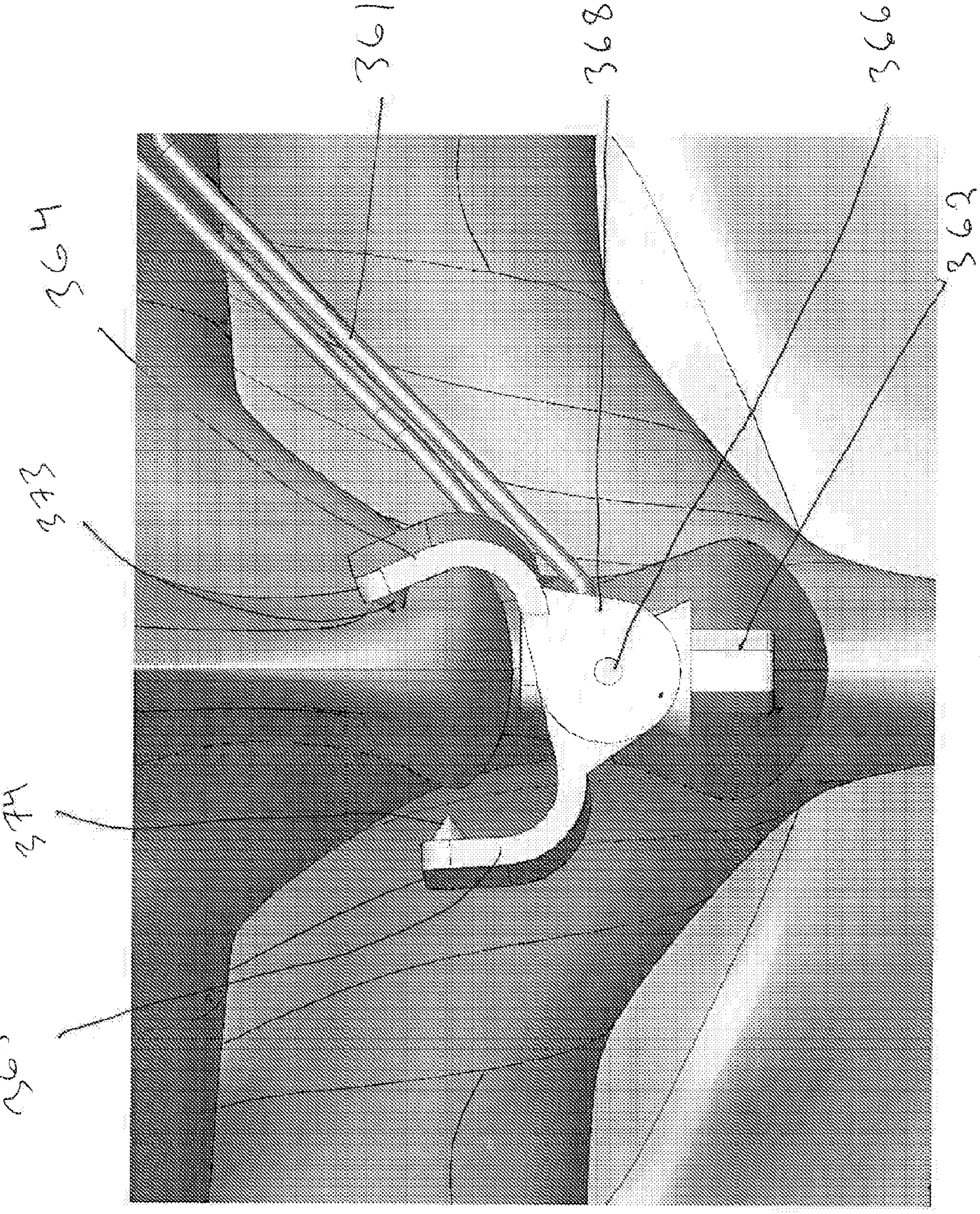


FIG. 25C

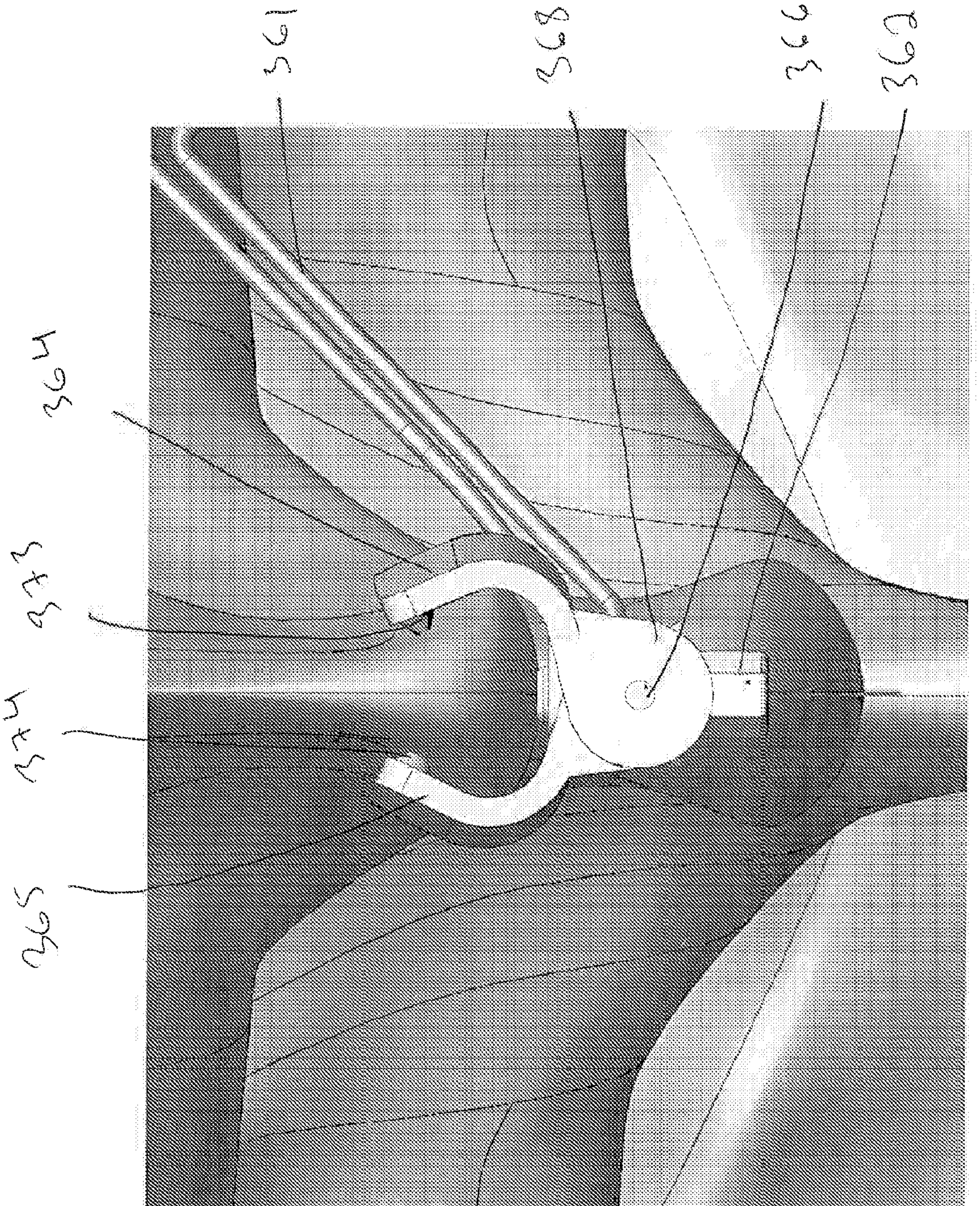


FIG. 38B

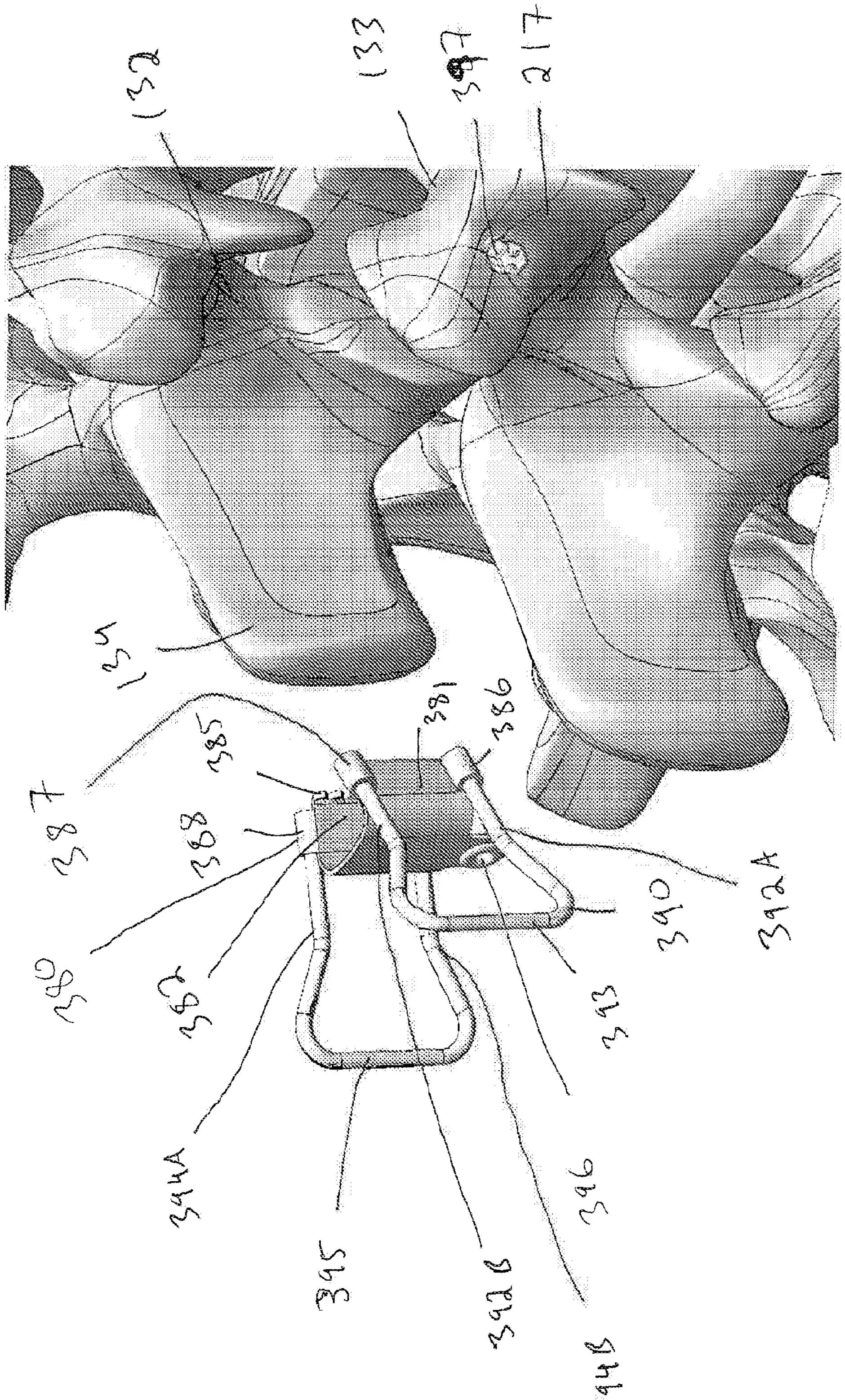

132
133
397
217
134
387
385
381
386
388
380
382
392A
390
393
394A
395
392B
396
394B

FIG. 26A

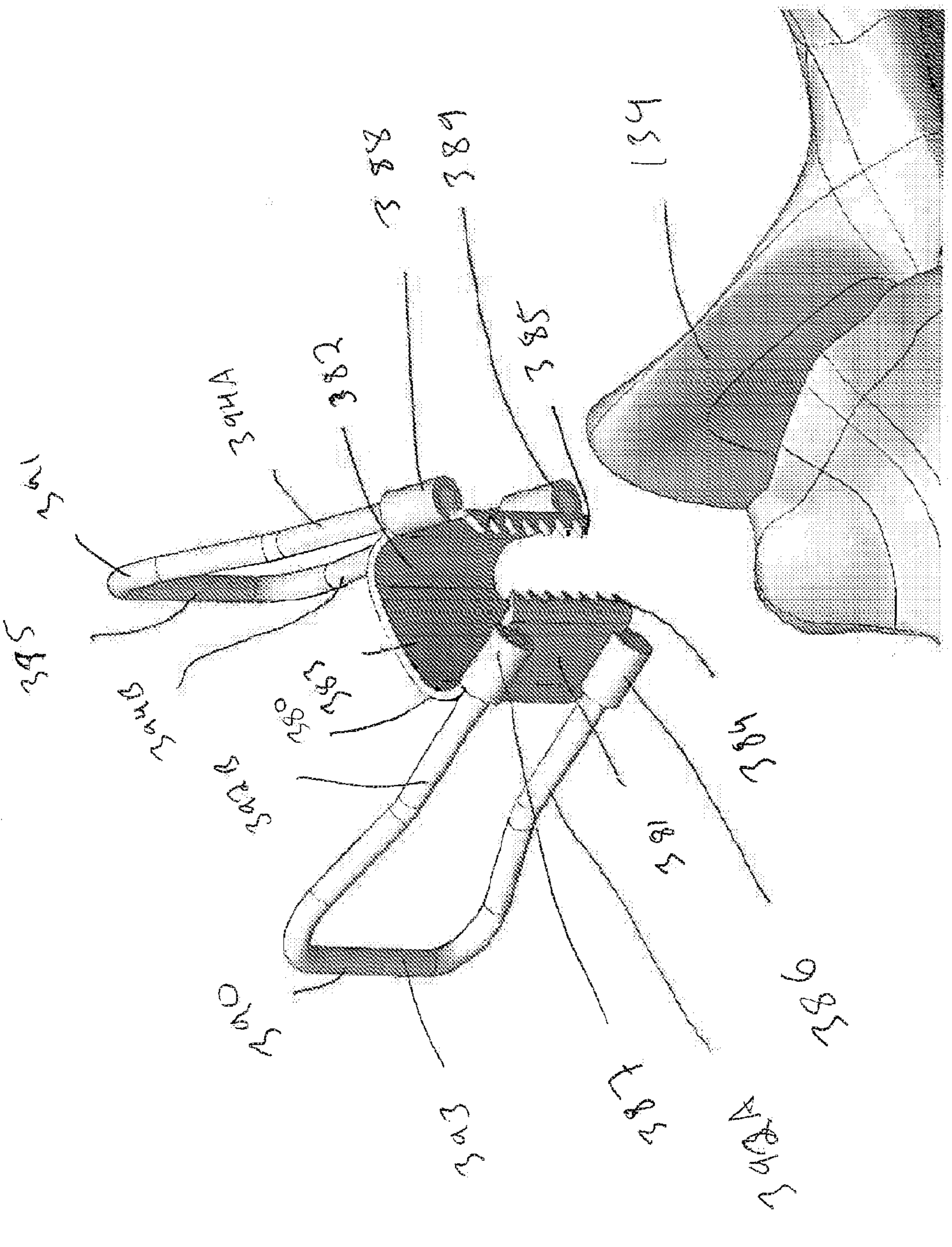


FIG 26B

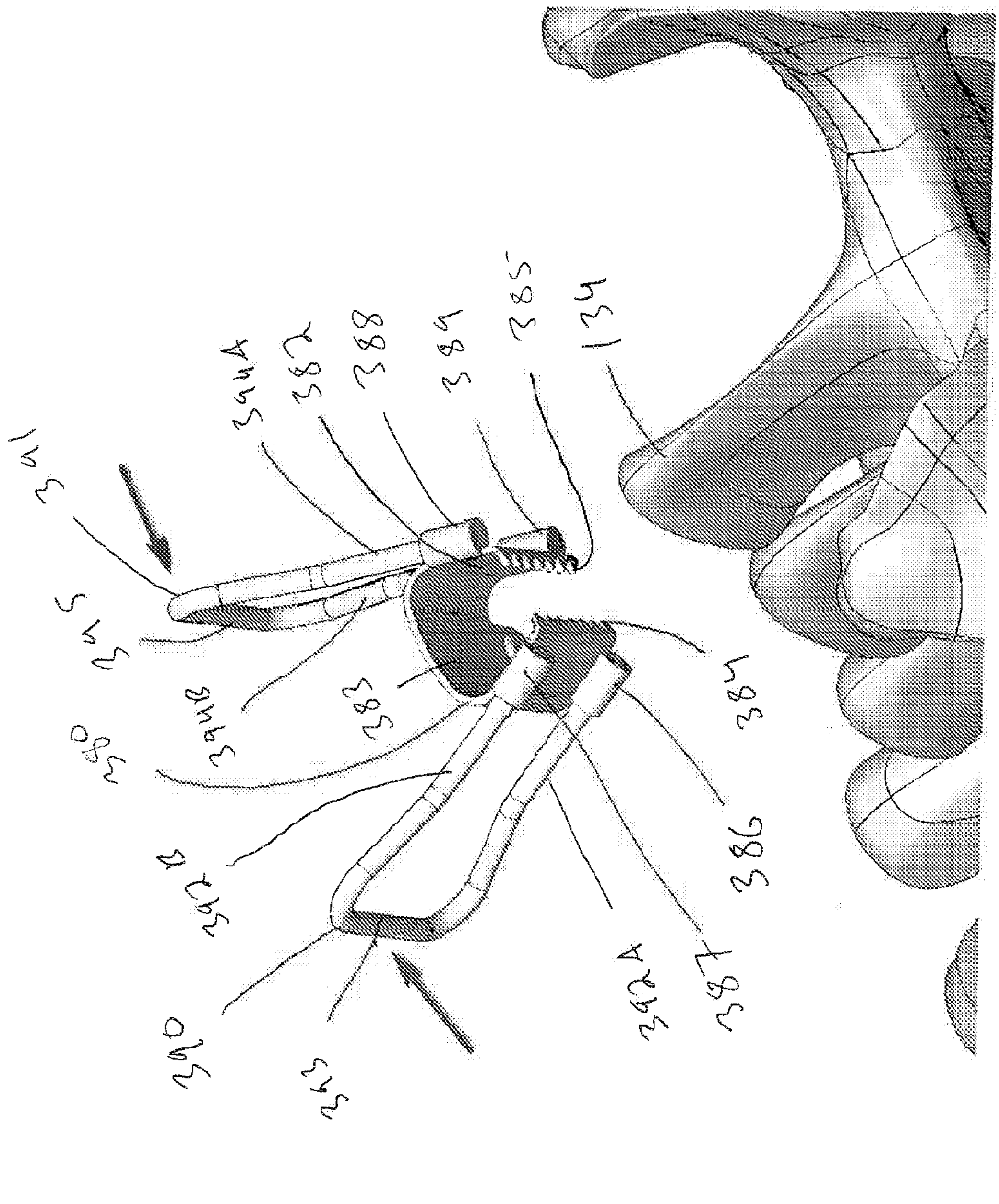

391
394A
382
388
389
385
134
395
394B
383
384
380
392B
386
392A
387
390
393

FIG 26C

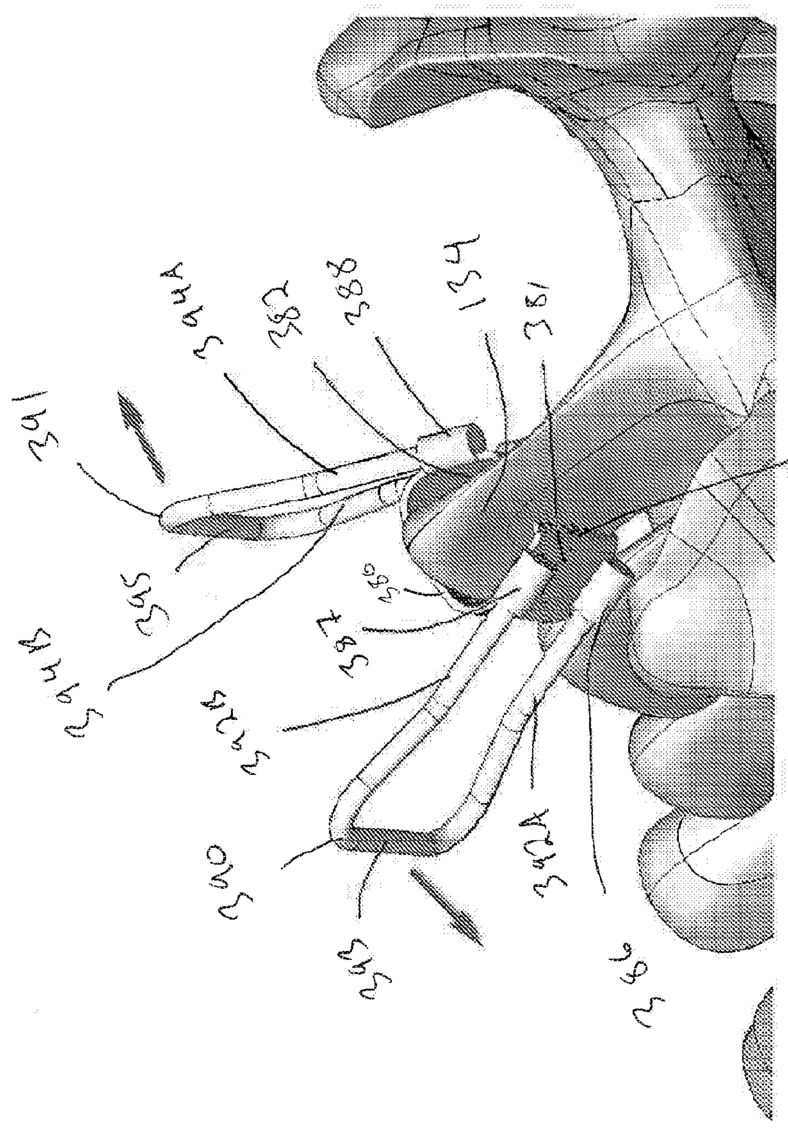

391
394A
382
388
134
381
384
395
394B
380
387
392B
390
393
392A
386

FIG 26D

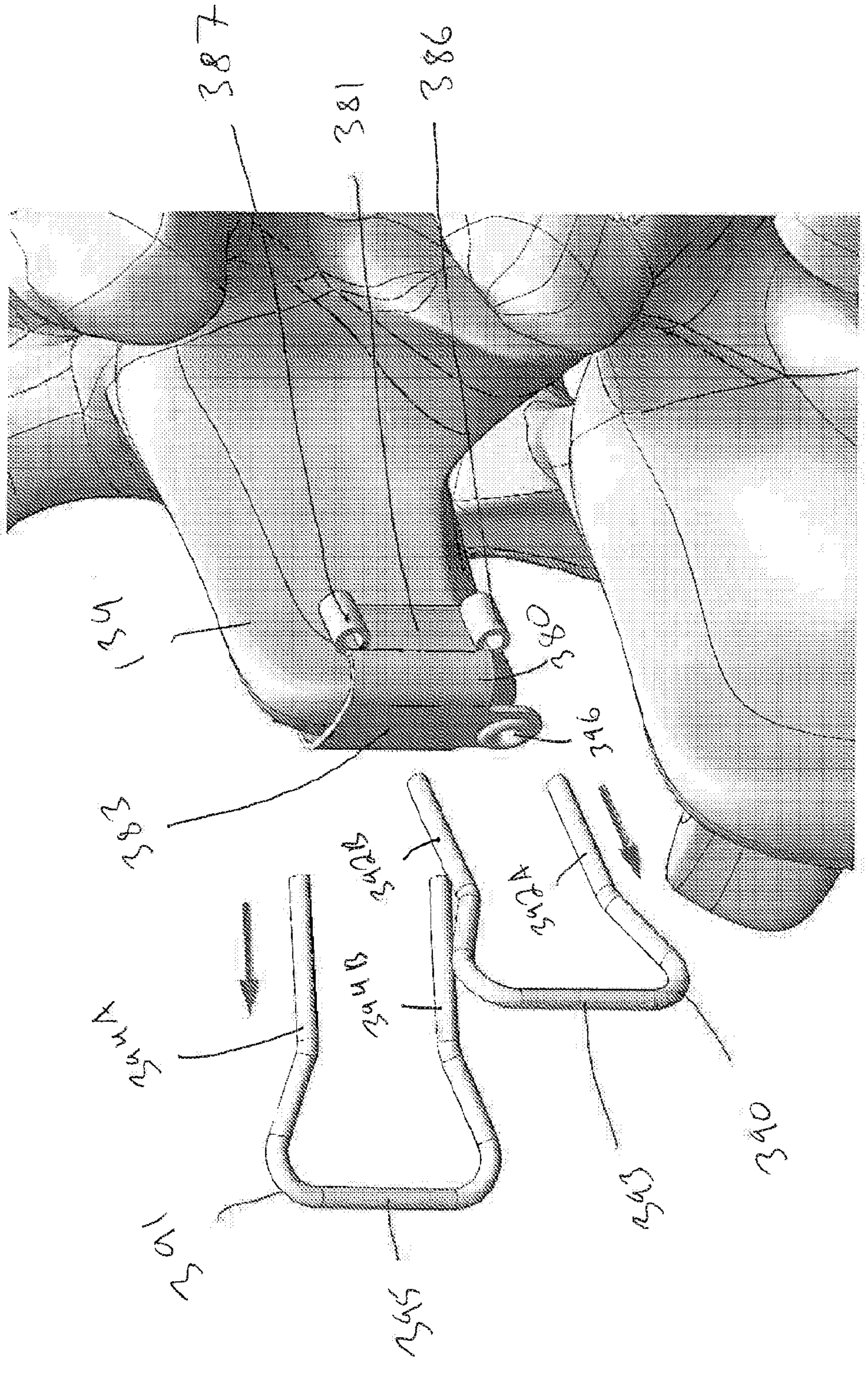


FIG 96E

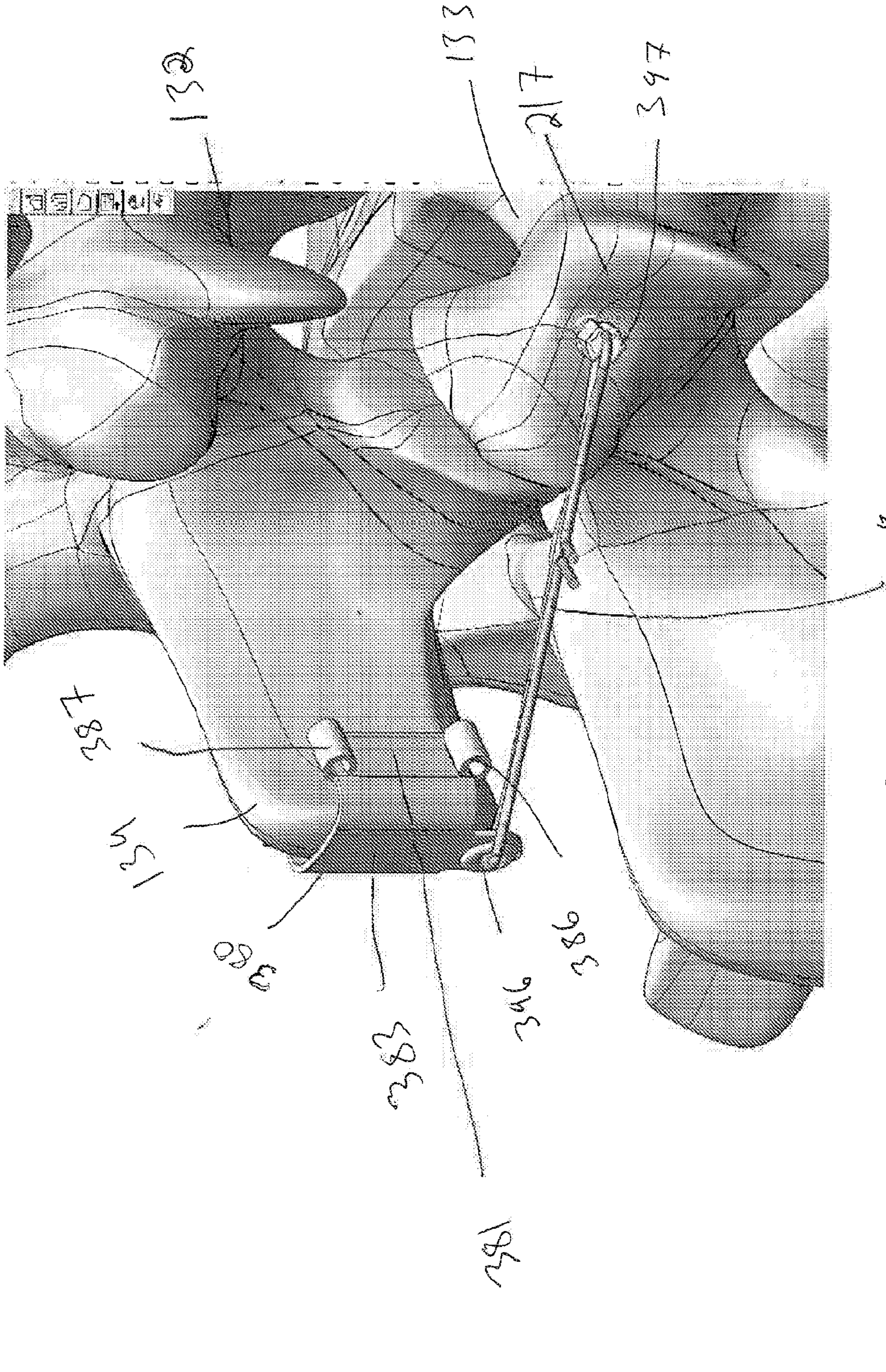


FIG. 26F

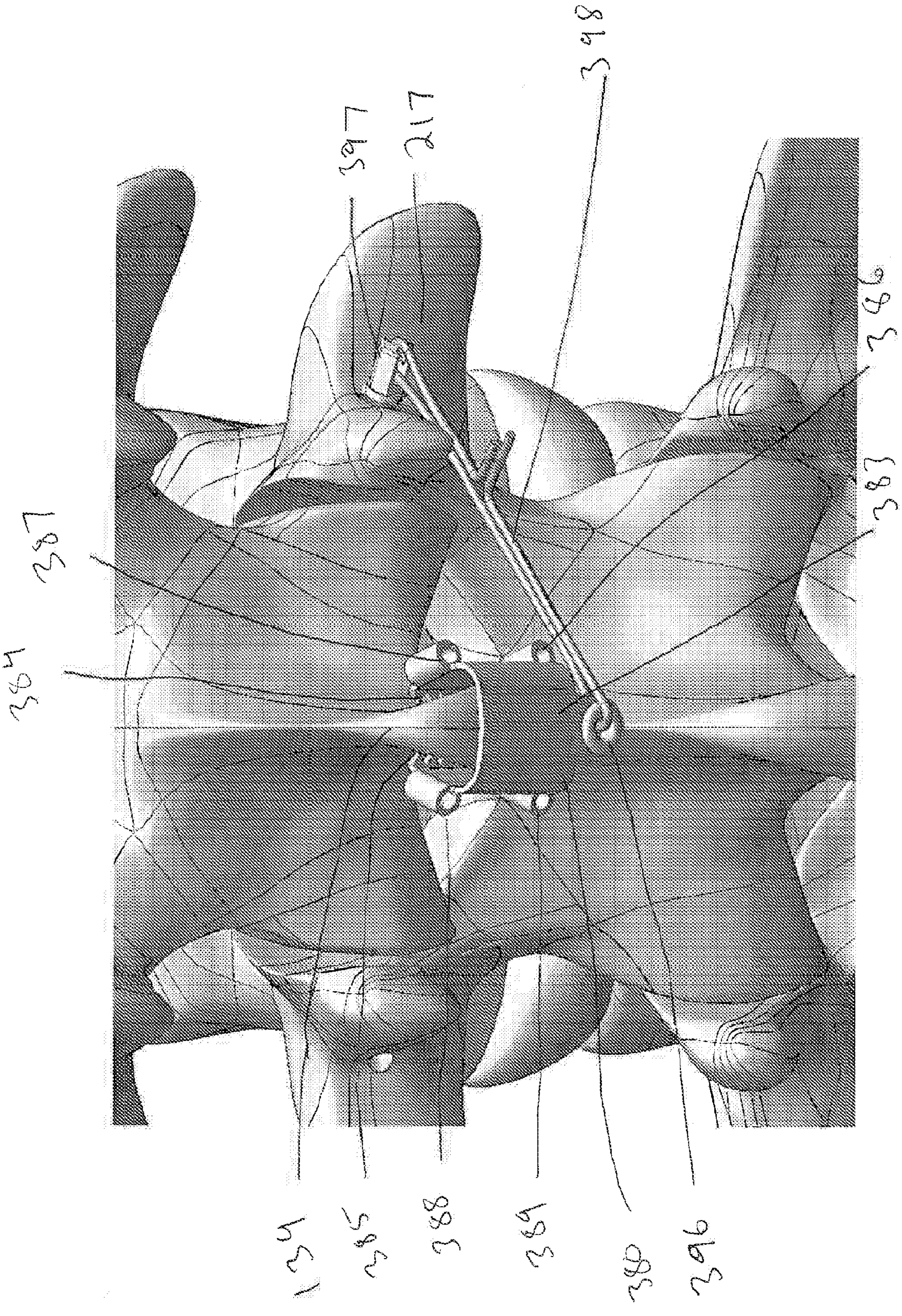


FIG. 26G

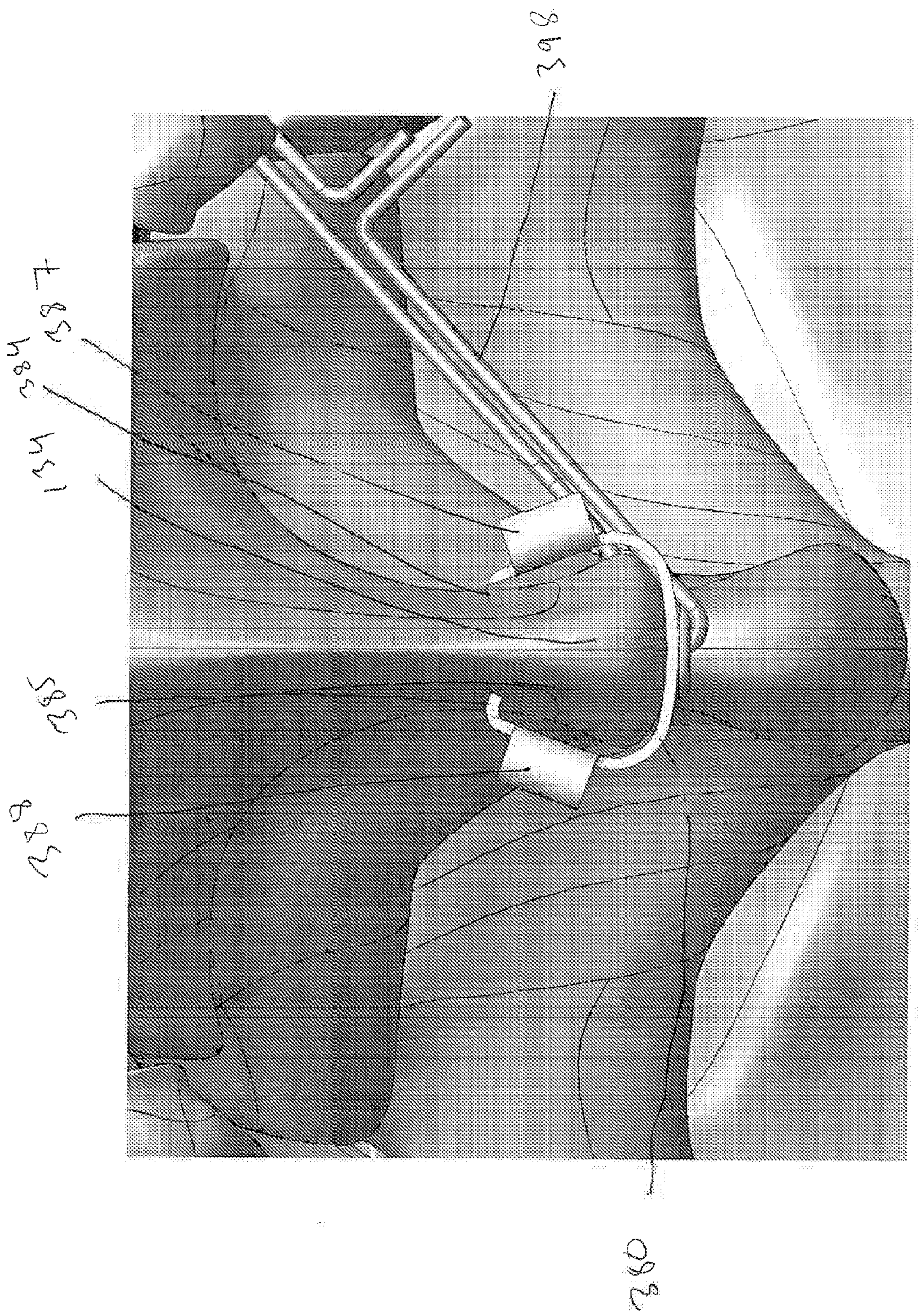
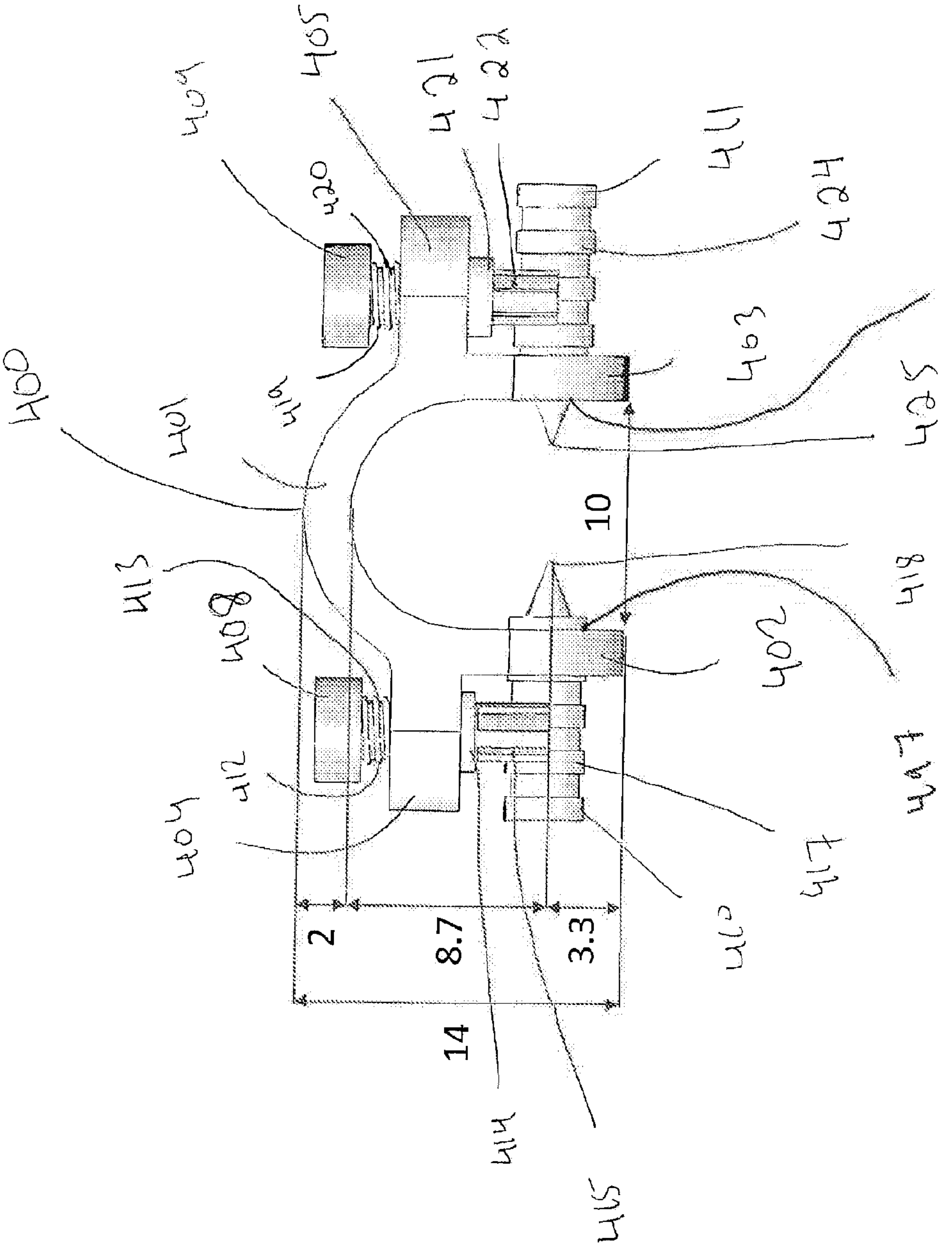


FIG. 26H


400
401
402
403
404
405
408
411
412
413
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418
420
421
422
424
425
427
428
2
8.7
3.3
14
10

FIG. 27A

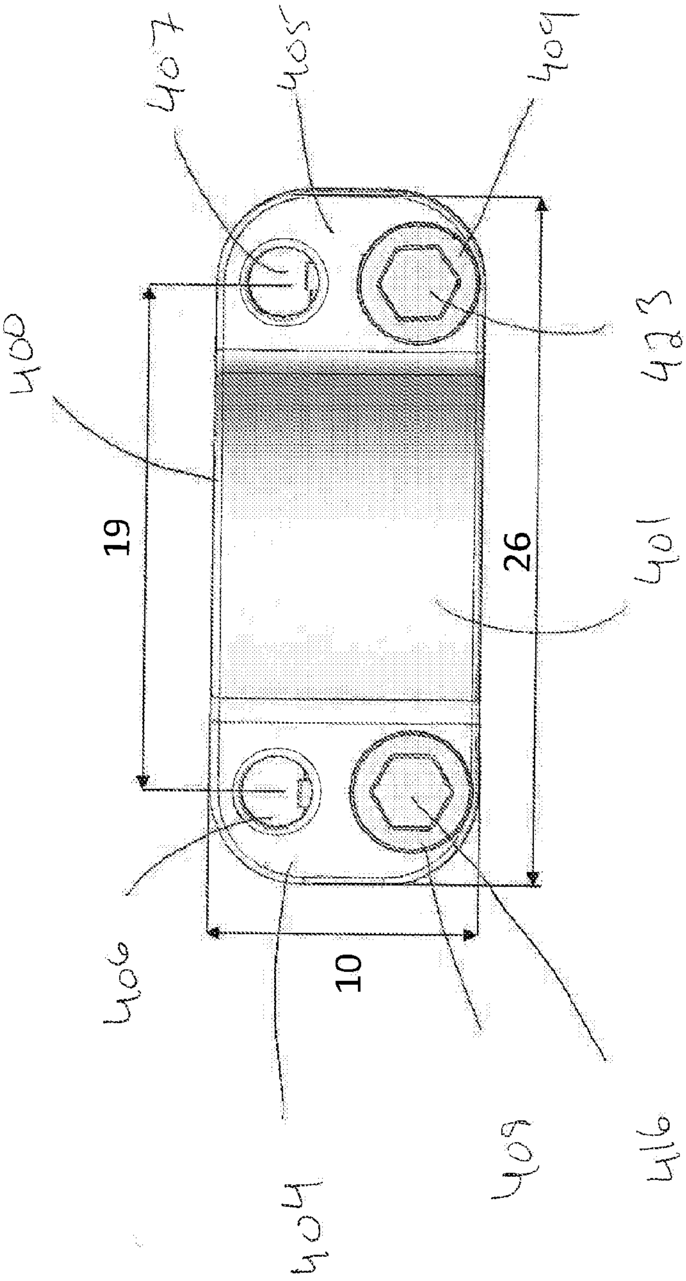


FIG. 27B

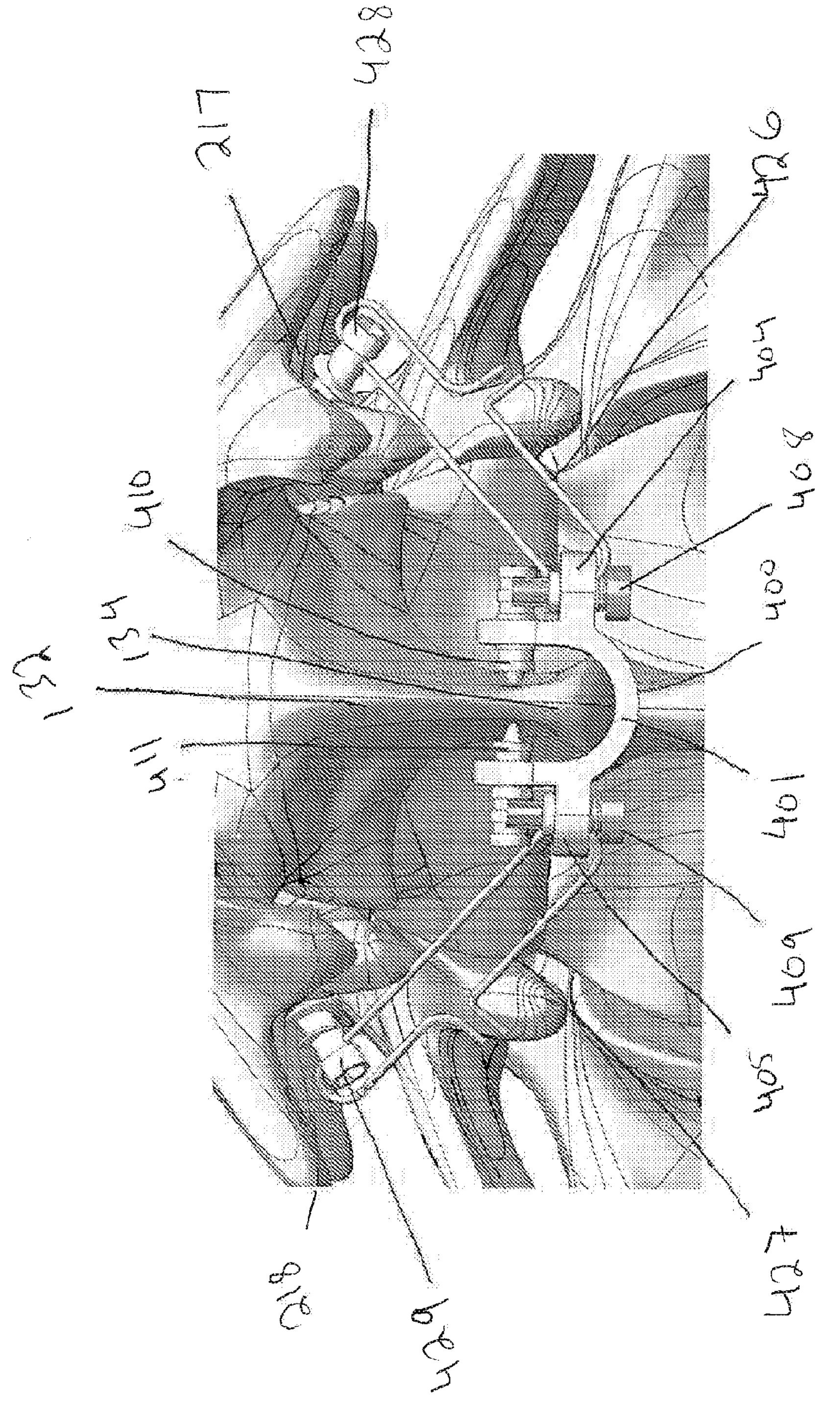


FIG 29C

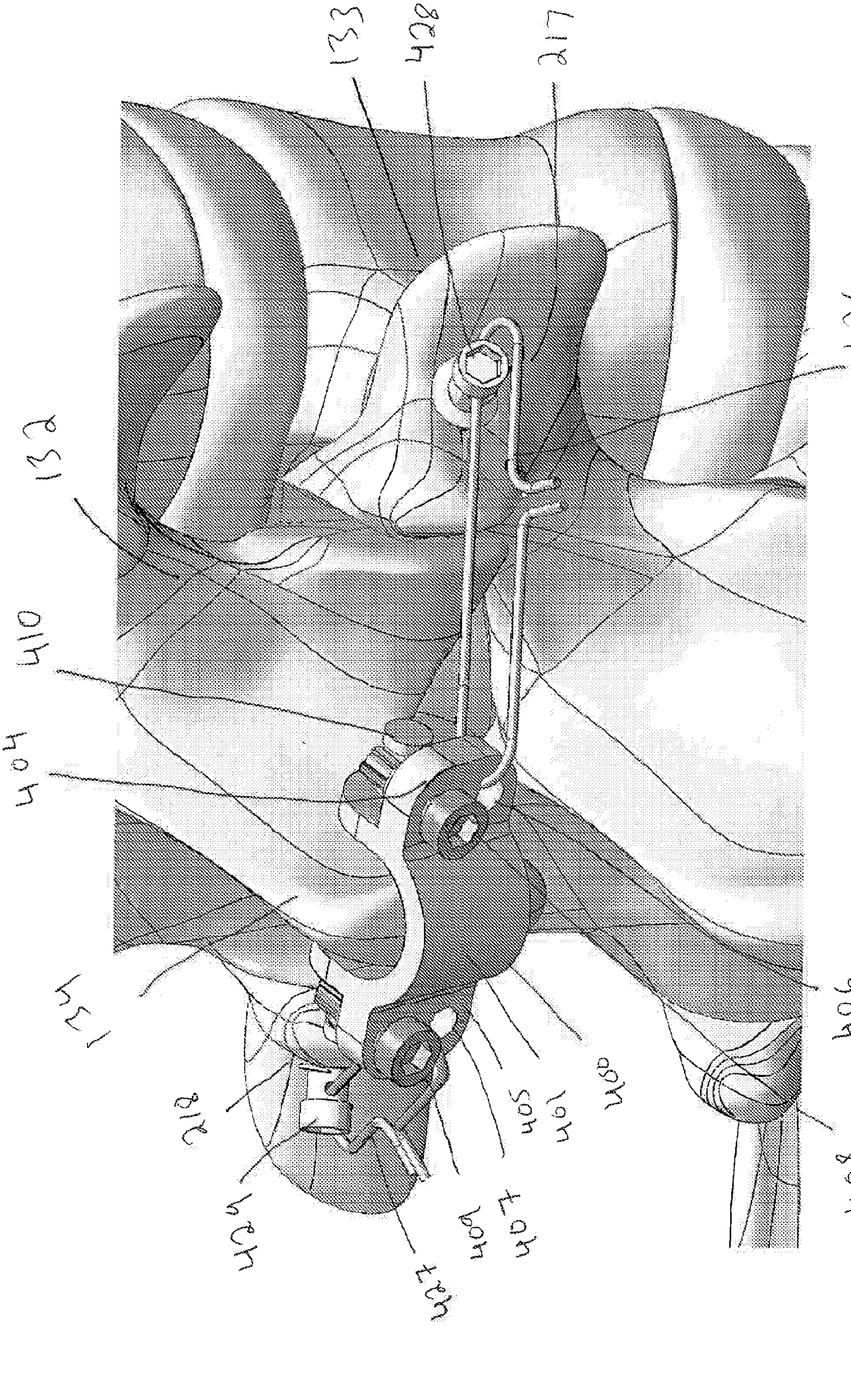

133
428
217
426
132
410
404
134
218
424
427
409
407
405
401
400
406
408

FIG. 270

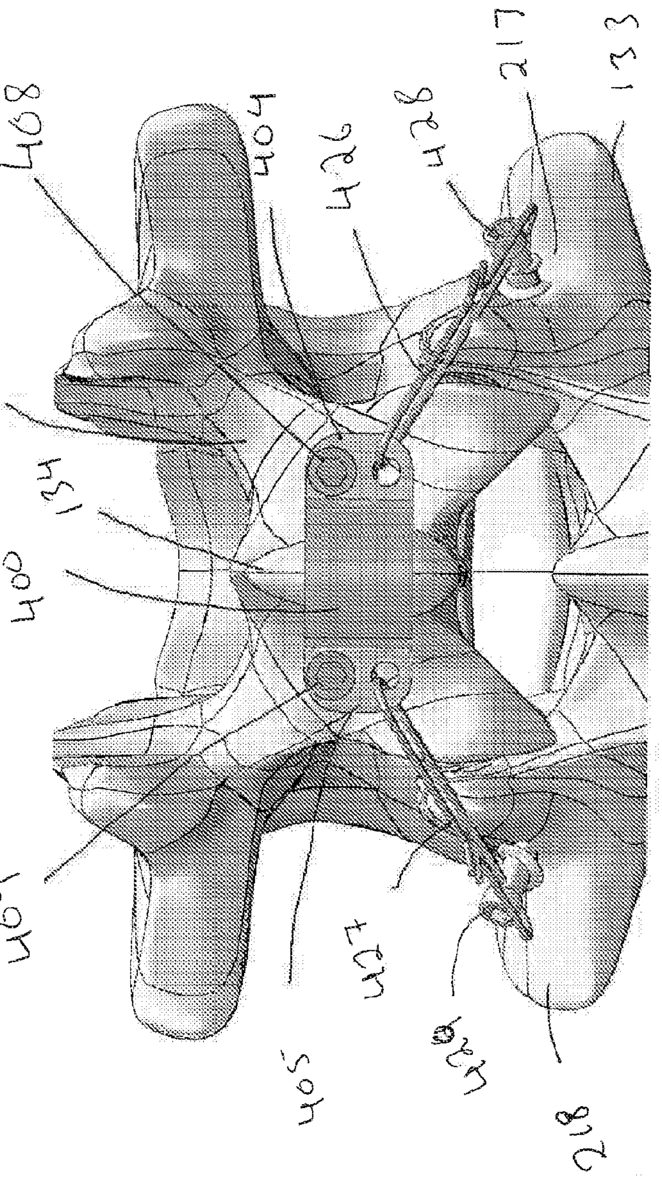


FIG. 27E

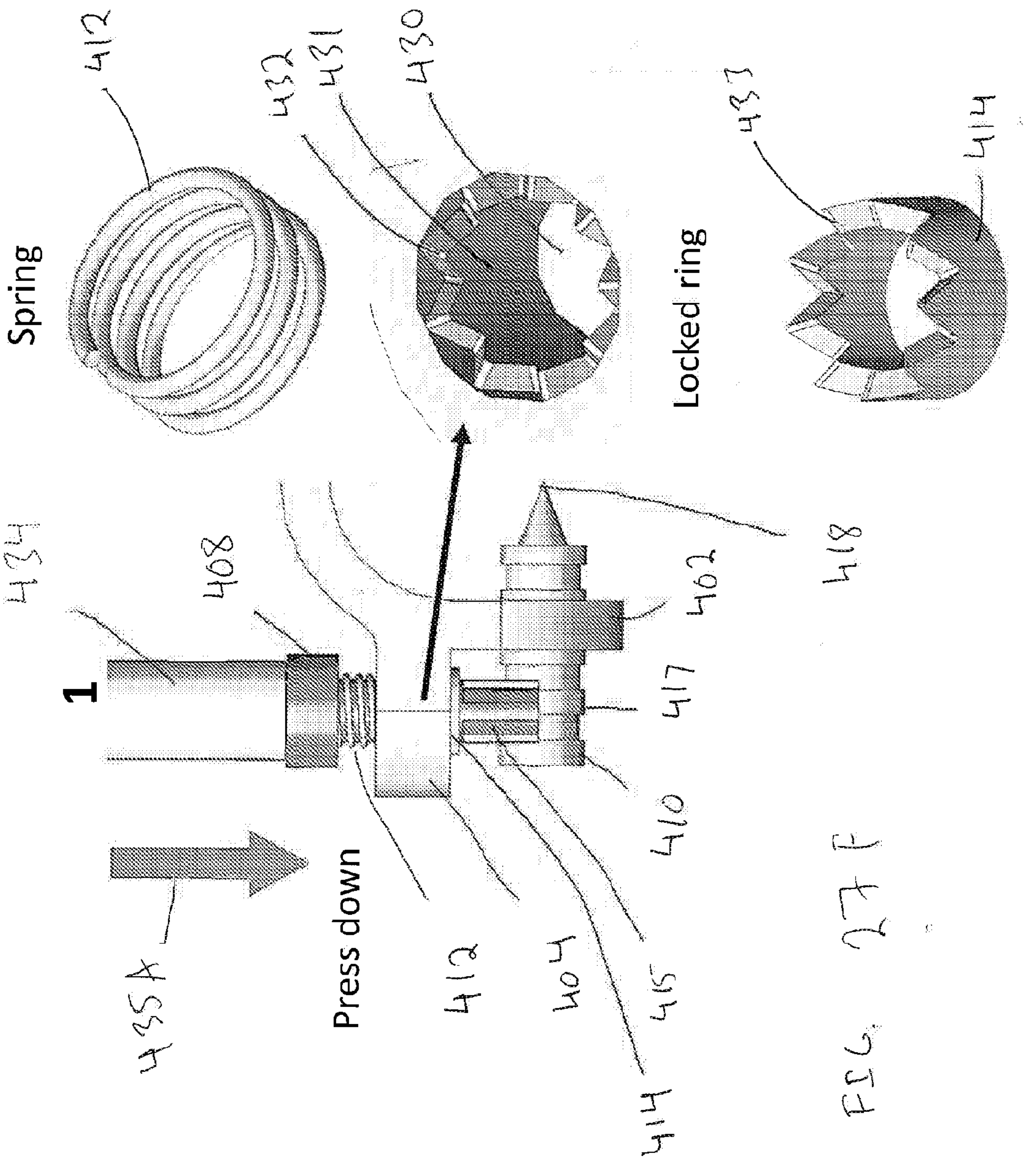

Spring
412
432
431
430
Locked ring
433
414
1
434
408
418
402
417
410
435A
Press down
412
404
415
414

FIG. 27F

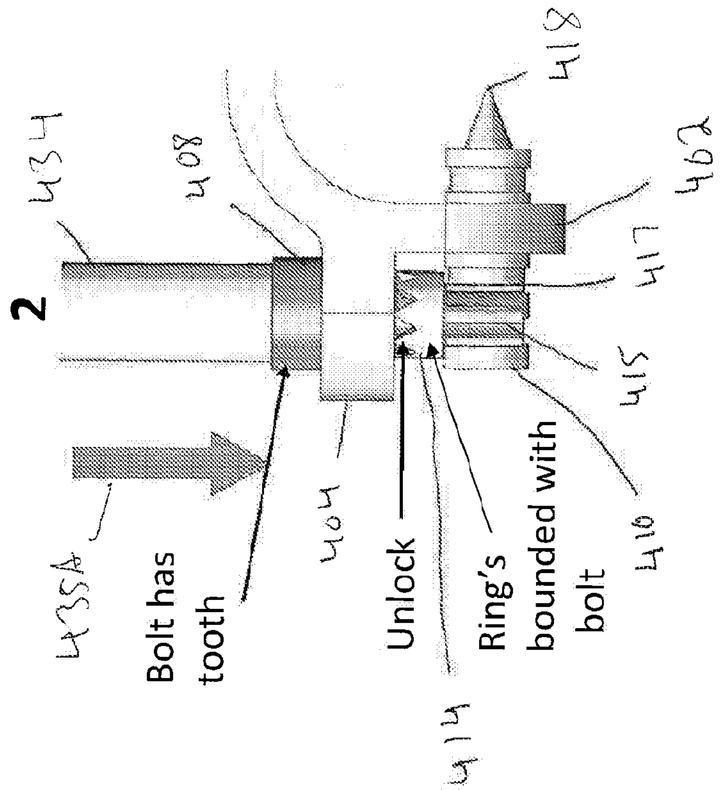

2
434
408
418
462
417
415
410
435A
Bolt has tooth
404
Unlock
414
Ring's bounded with bolt

FIG. 27G

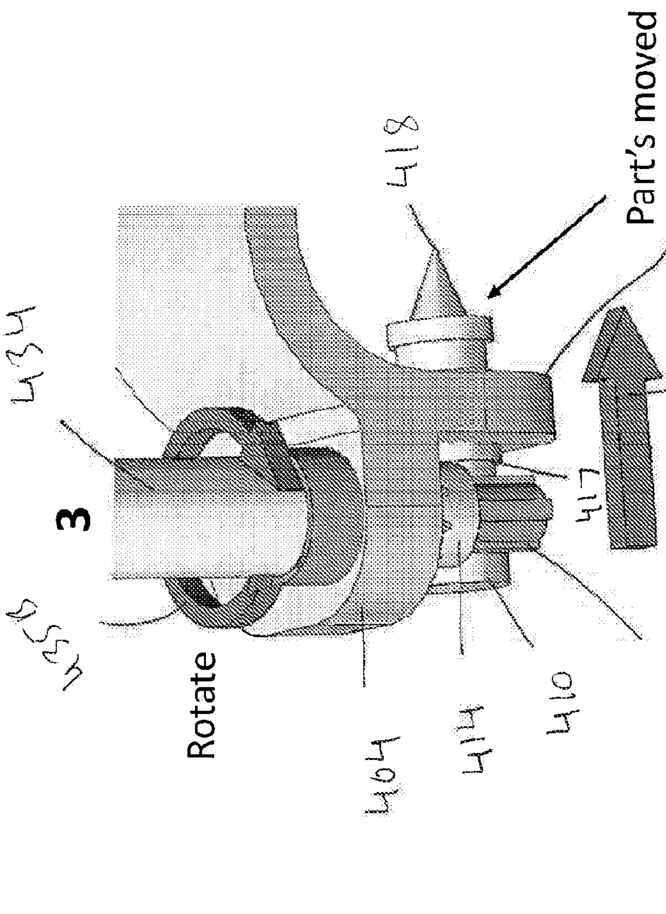


FIG. 27H

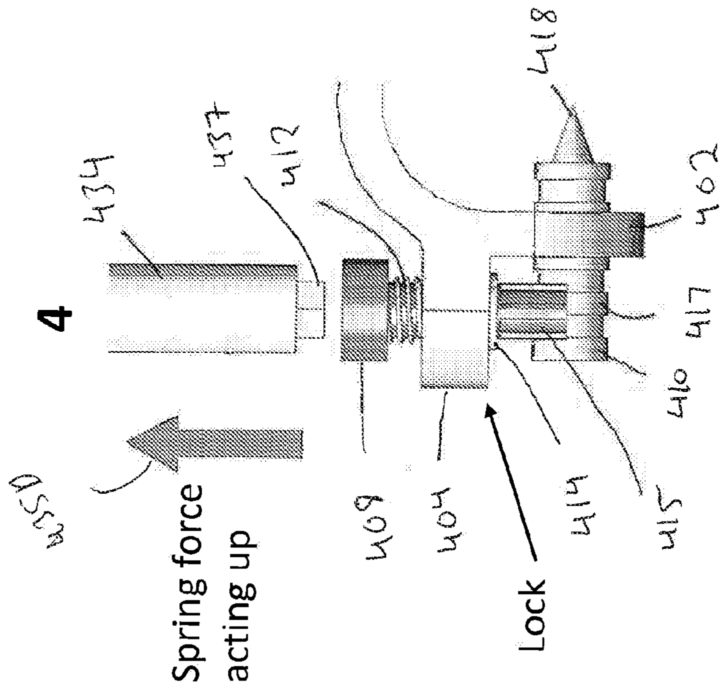


FIG. 27I

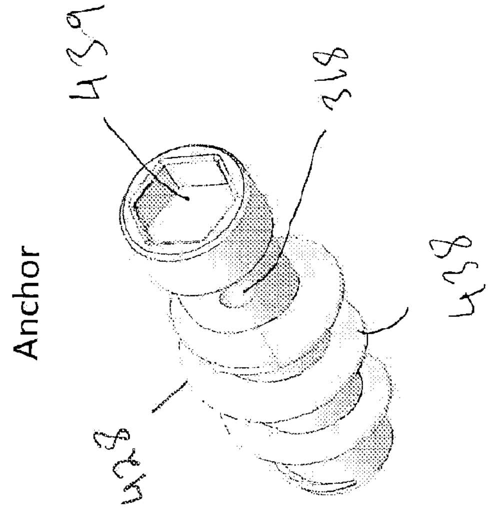


FIG. 27K

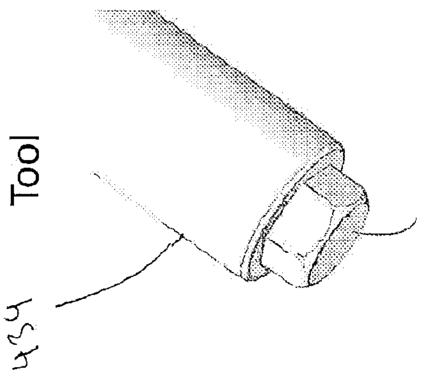


FIG. 27J

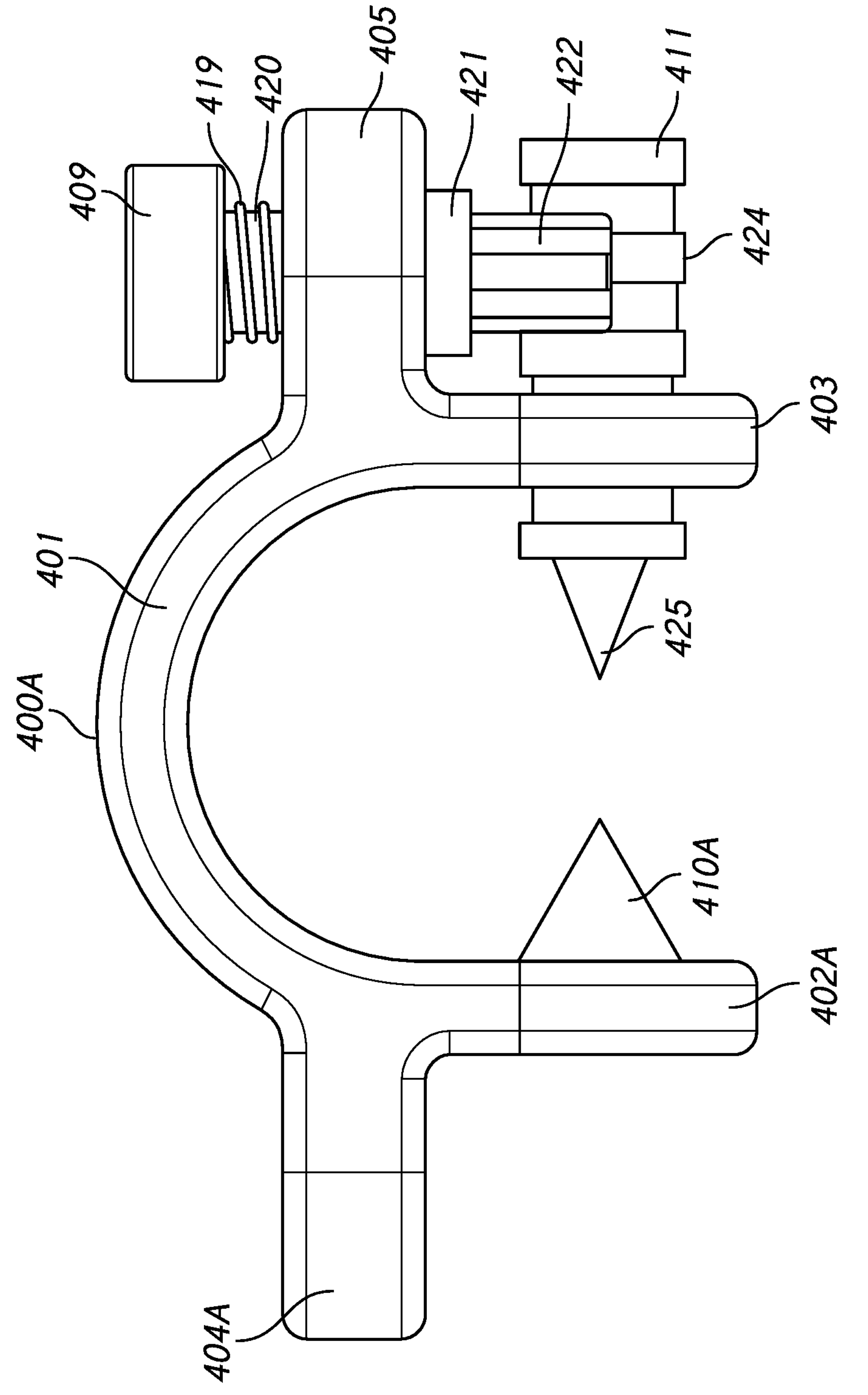


FIG. 28A

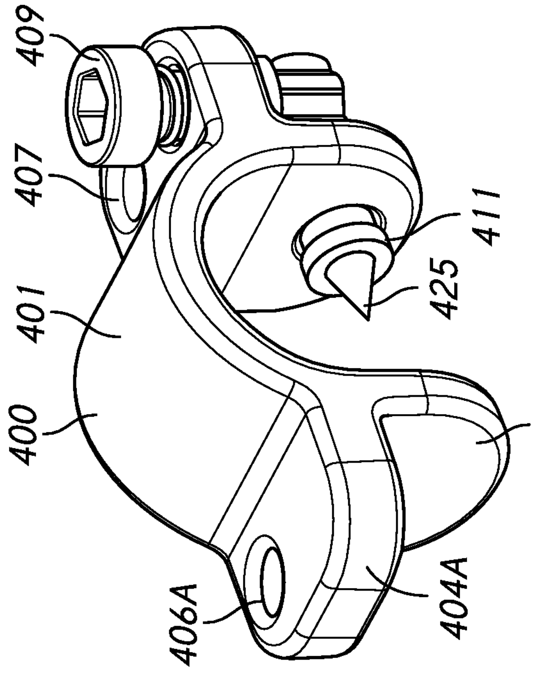


FIG. 28C

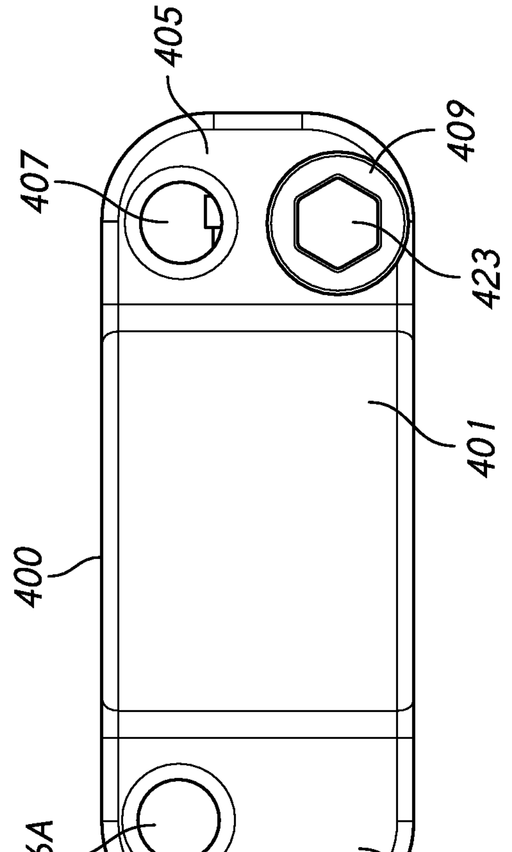


FIG. 28B

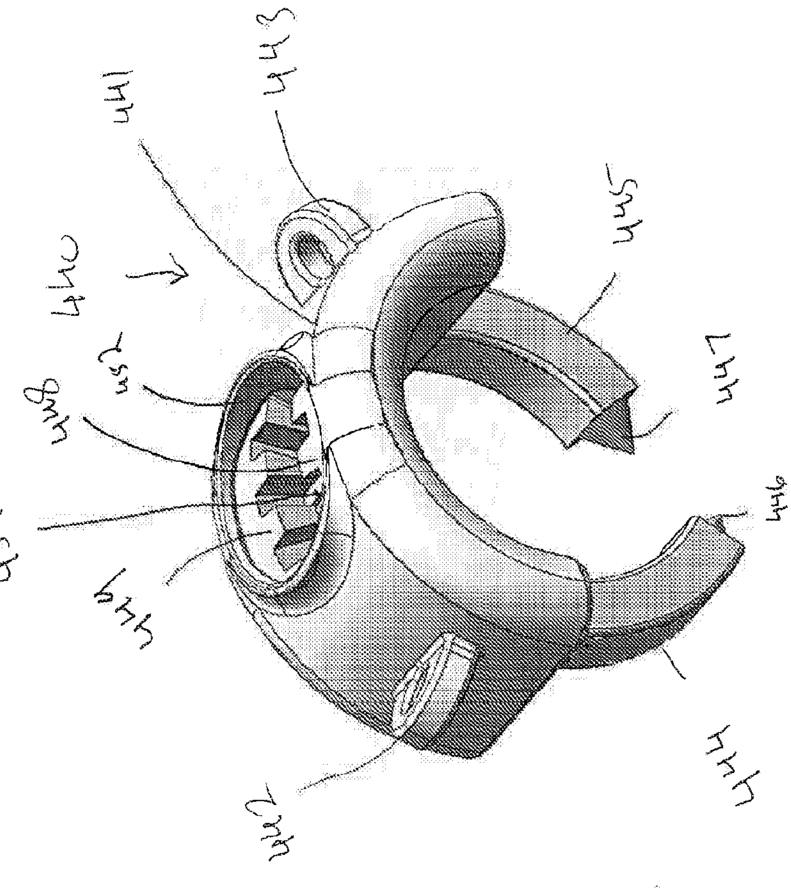


FIG. 94A

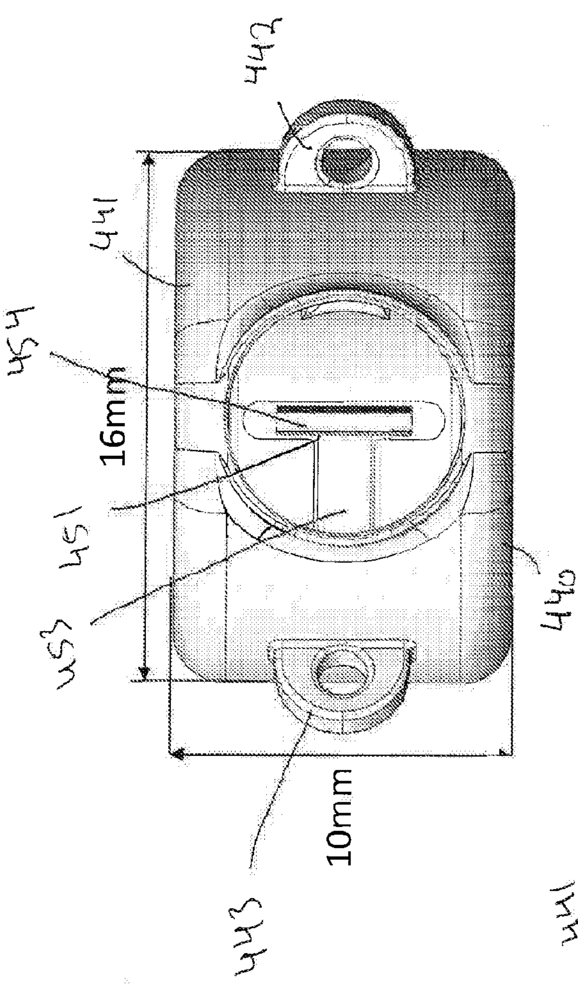


FIG. 29C

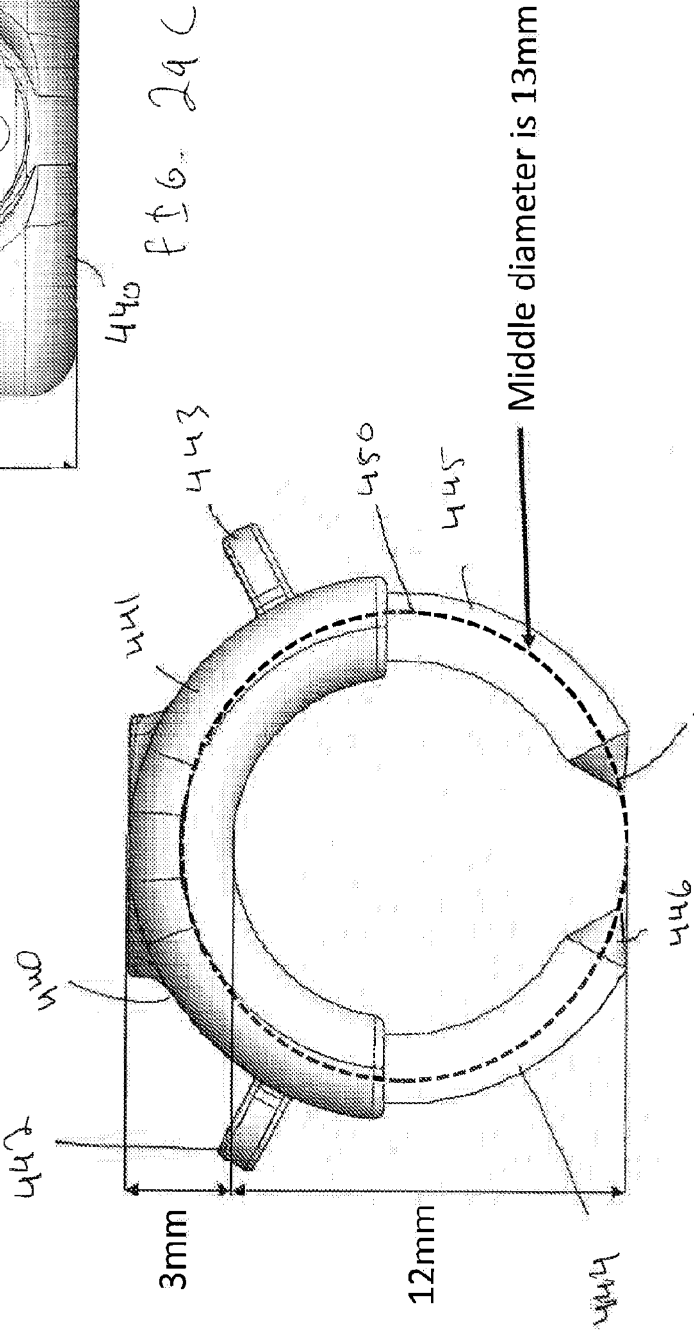


FIG. 29B

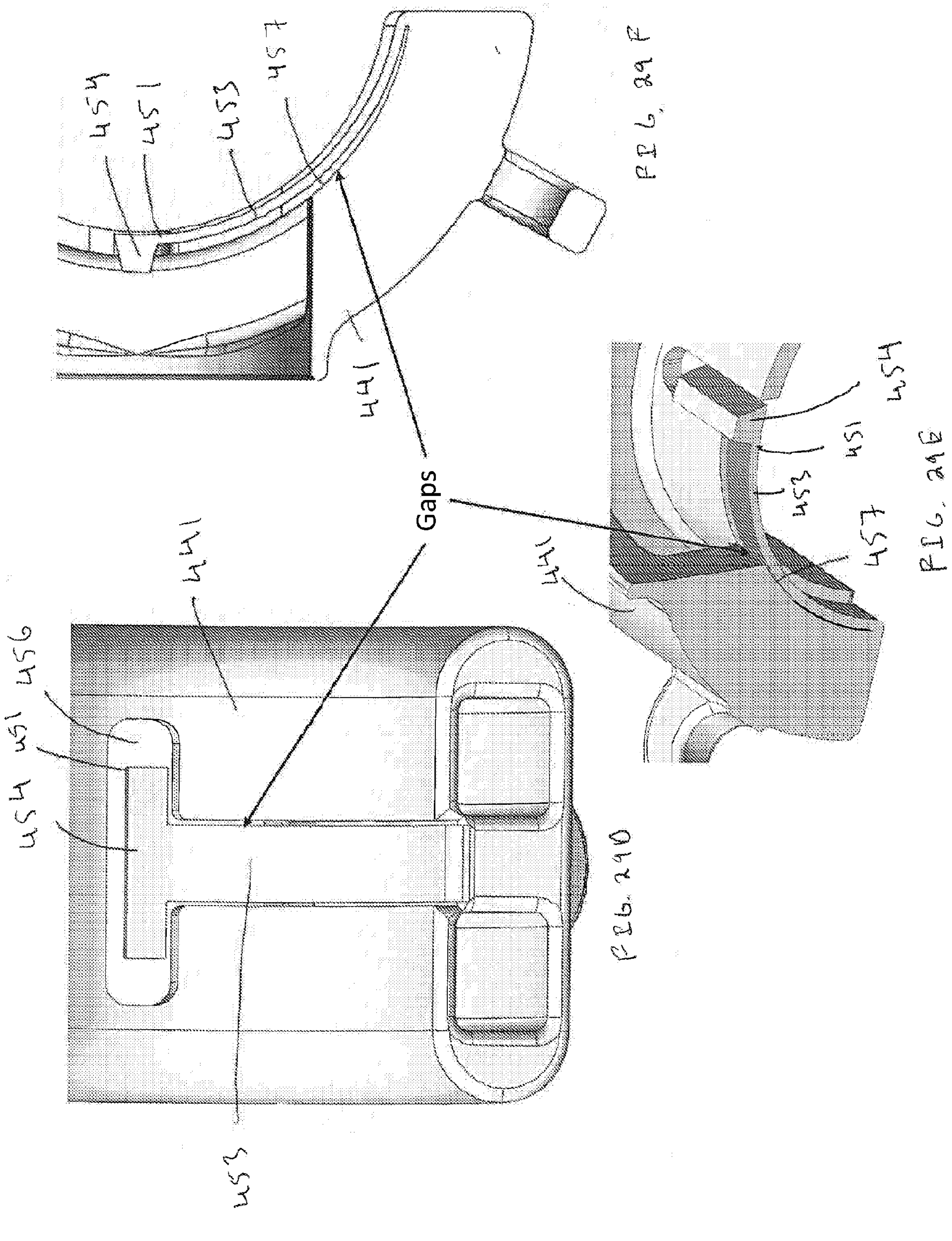


FIG. 29F

FIG. 29E

FIG. 29D

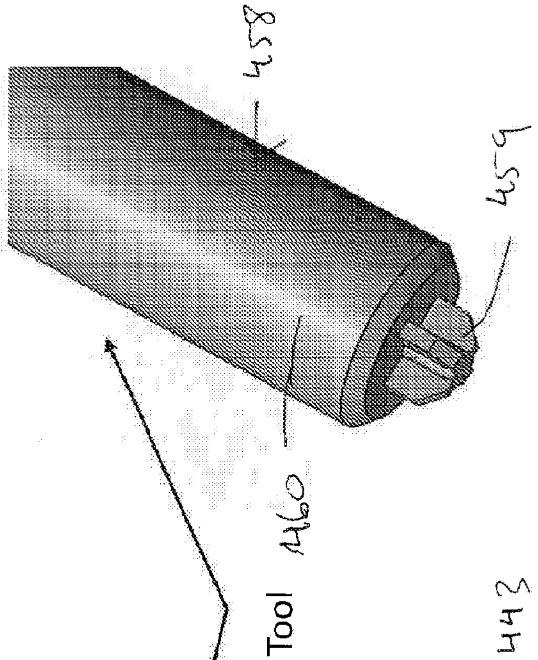


FIG 29A

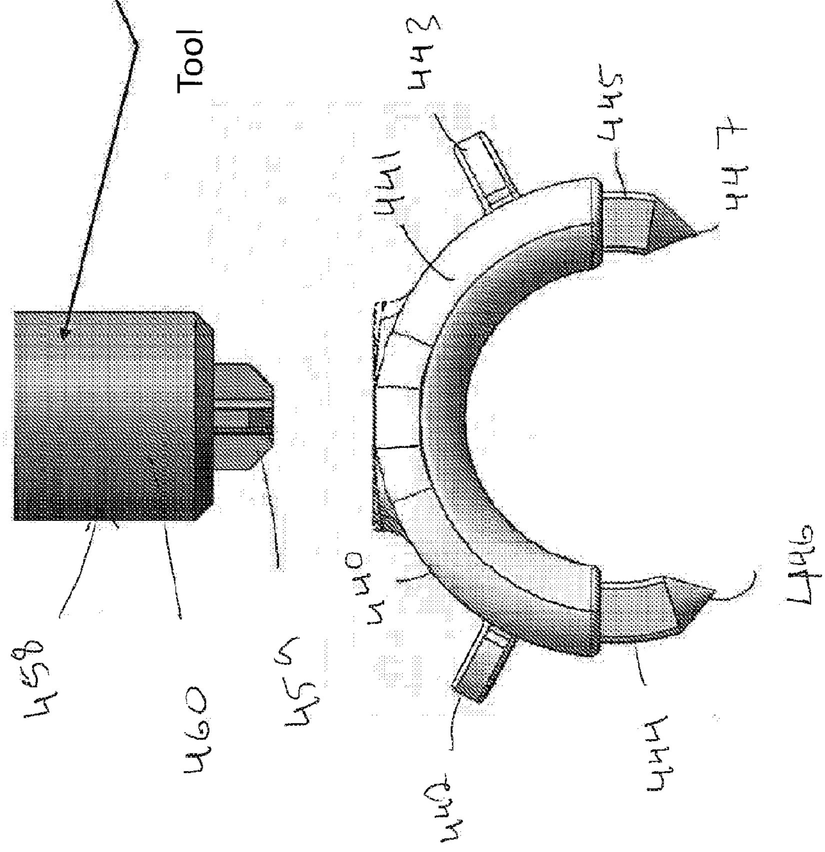


FIG 29B

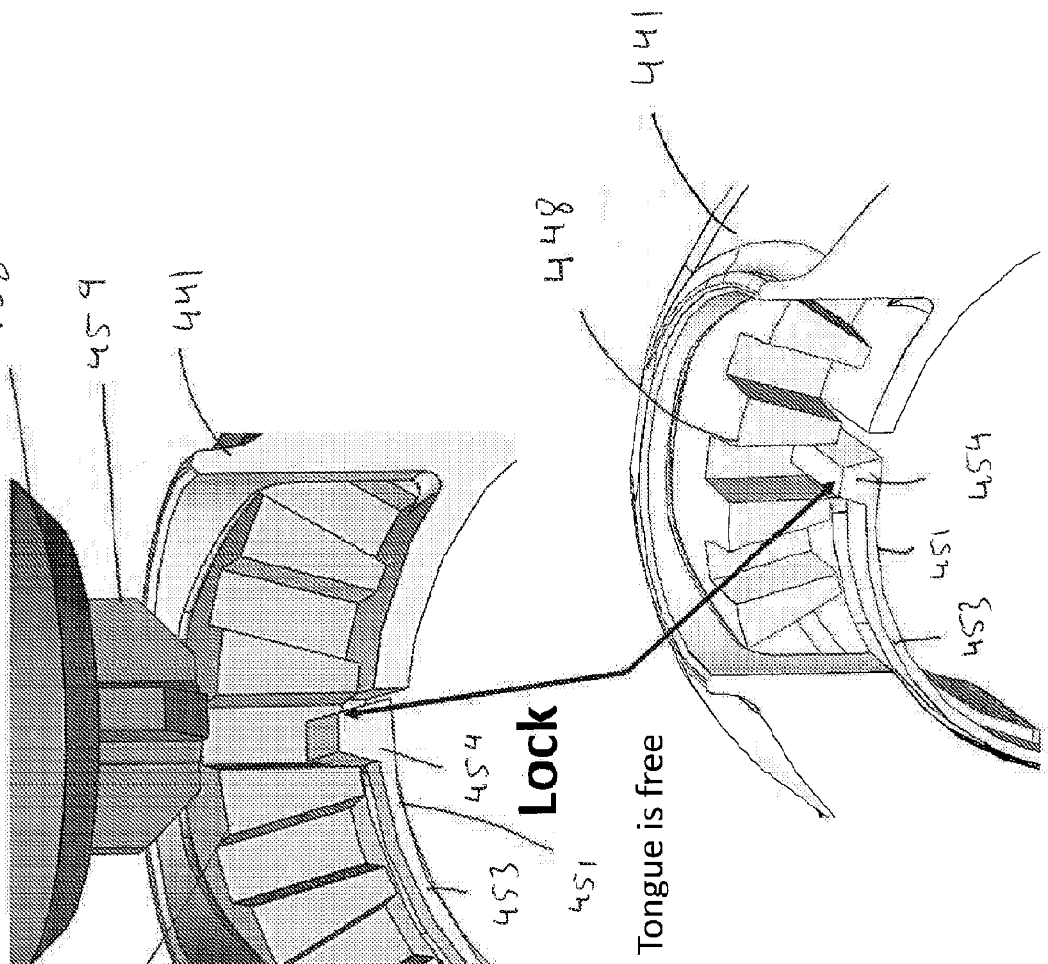

458
459
441
448
454
Lock
451
453
Tongue is free
448
441
454
451
453

FIG. 29I

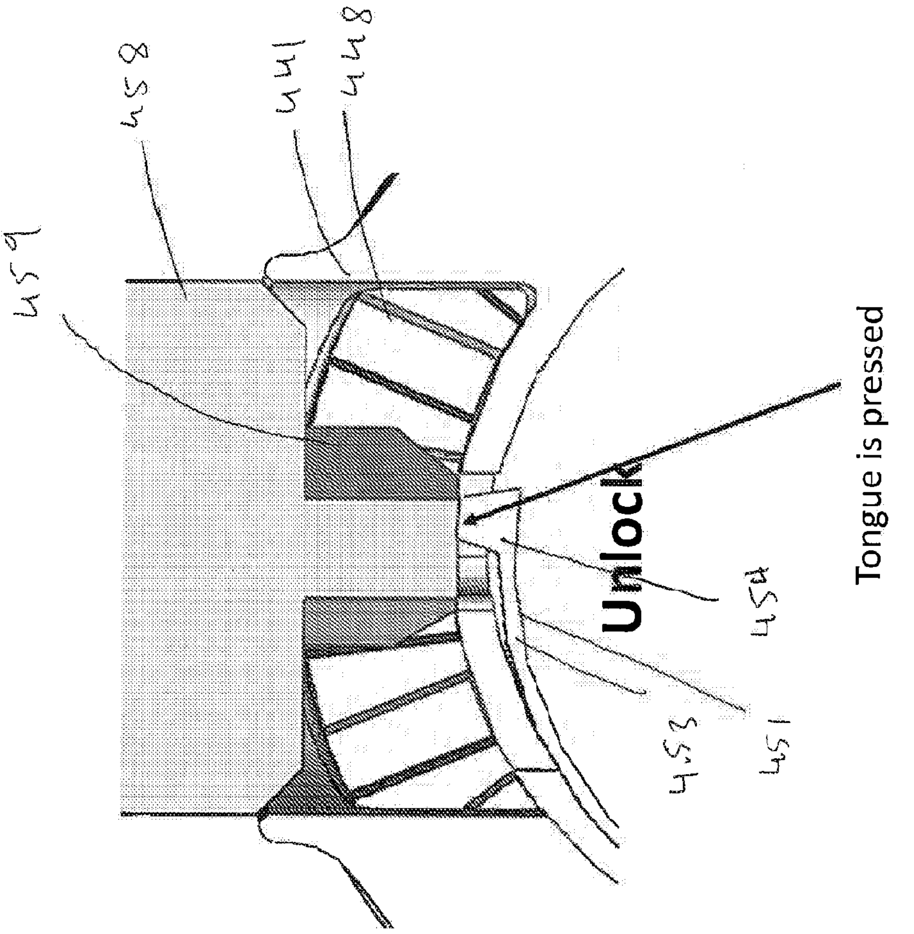
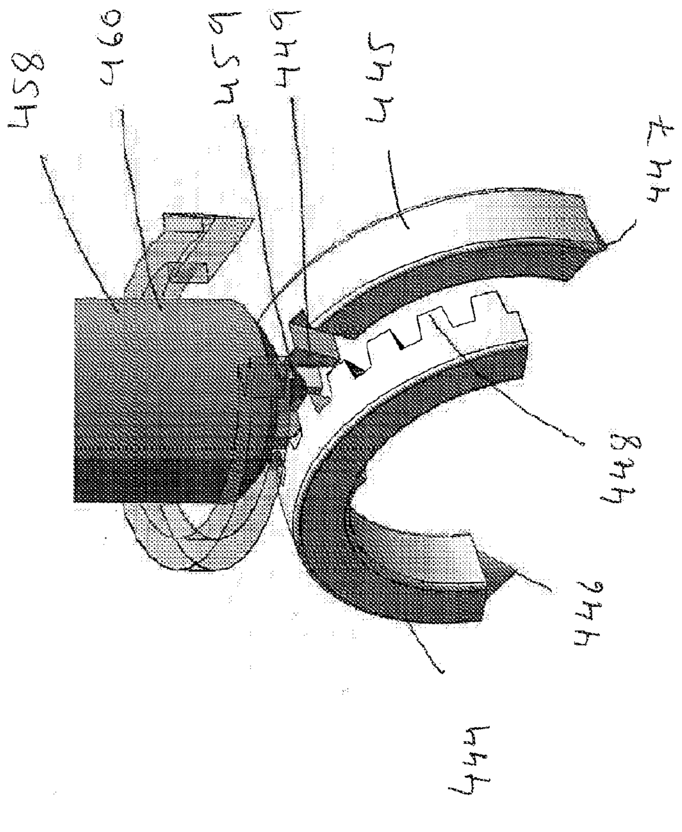


FIG. 99J



29K

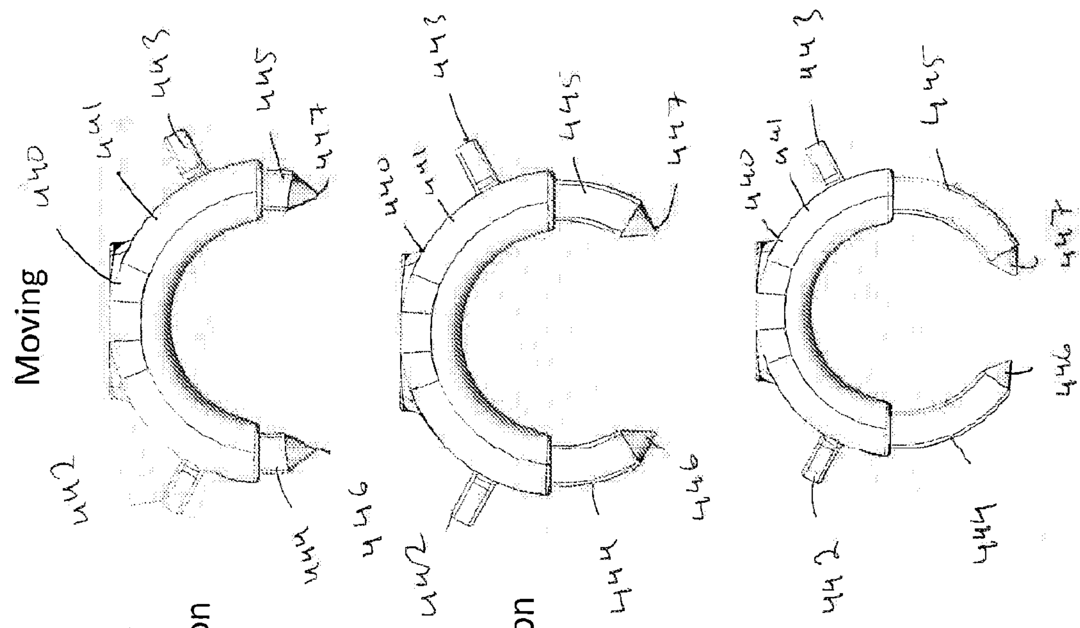


FIG. 29K

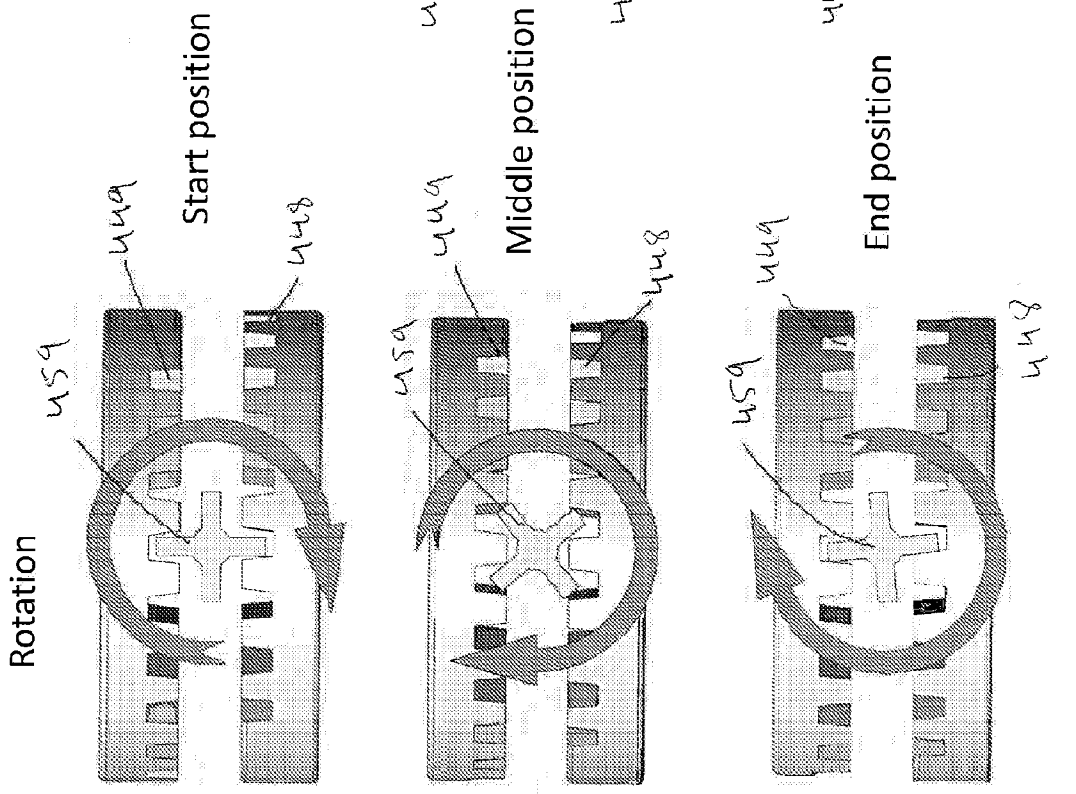


FIG. 29L

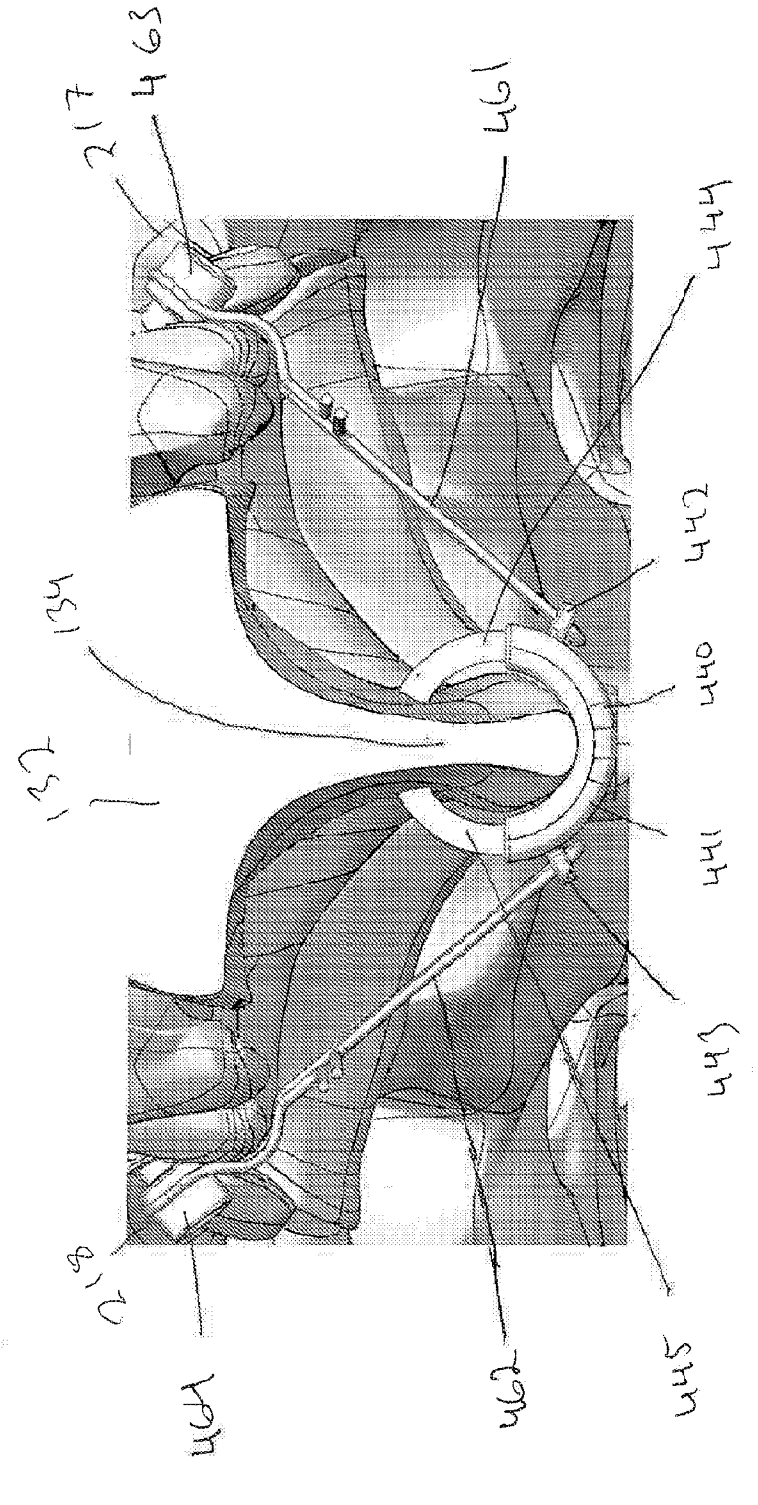


FIG 29N

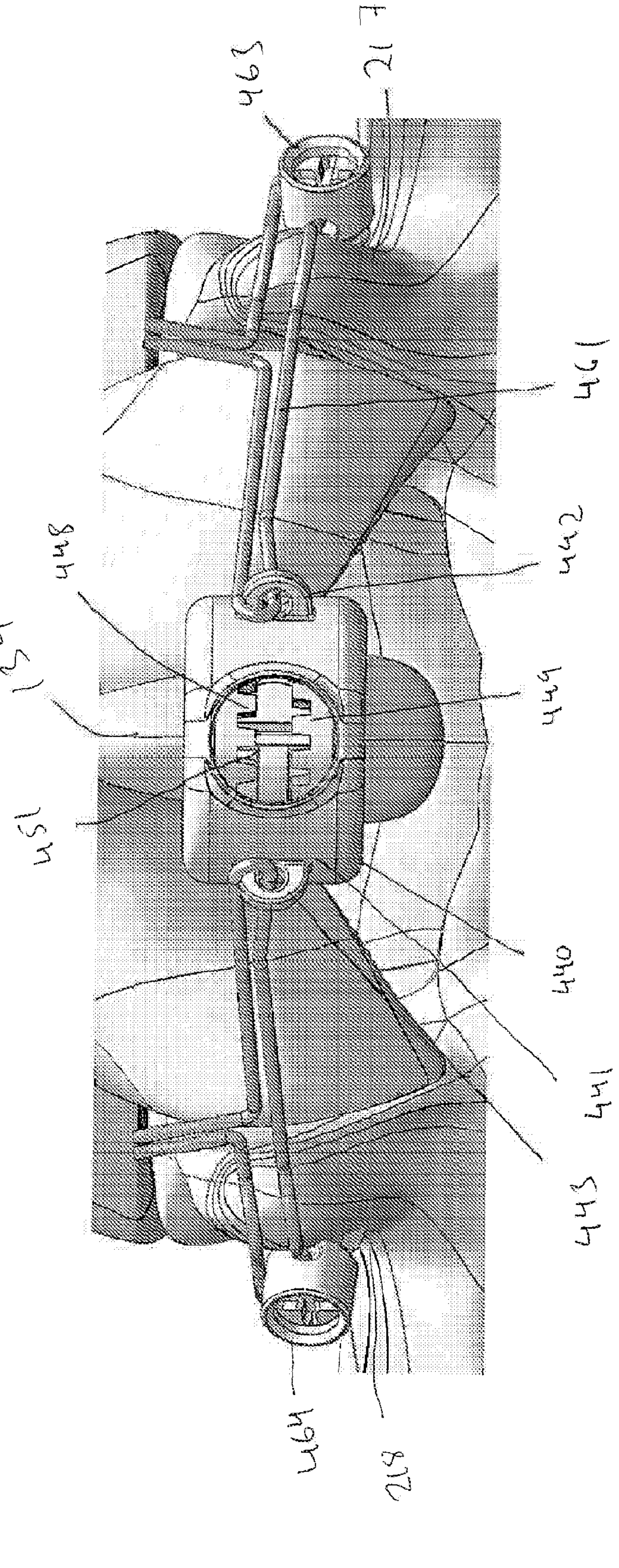


FIG. 29O

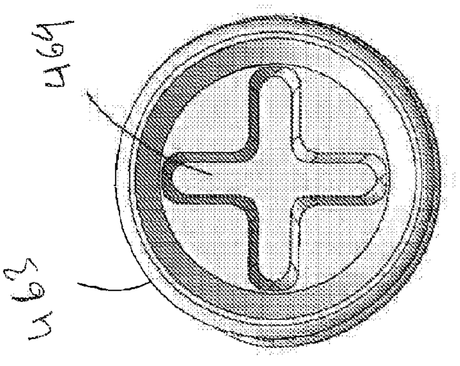


FIG 29Q

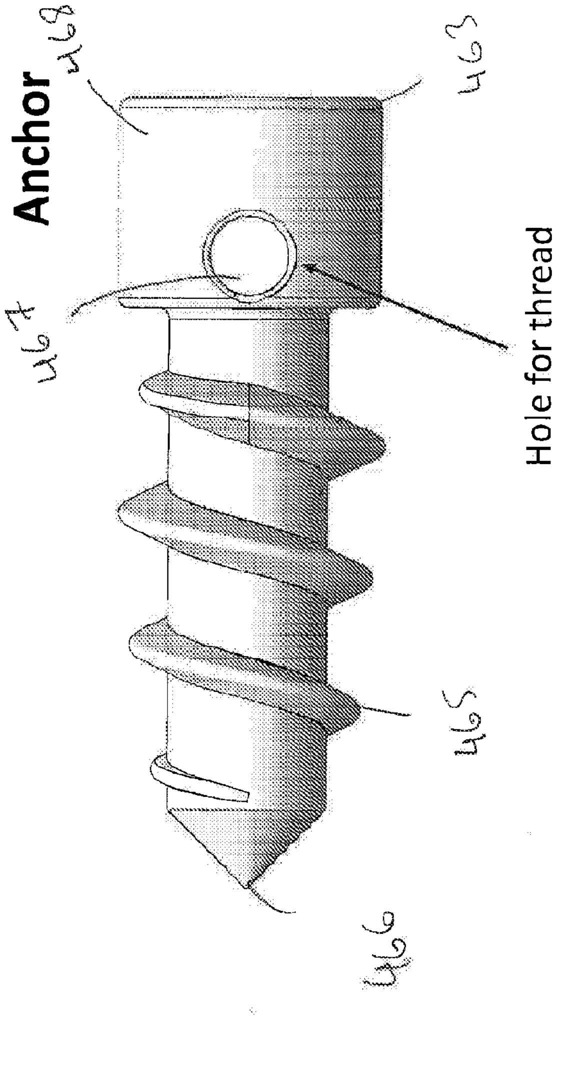


FIG. 29P

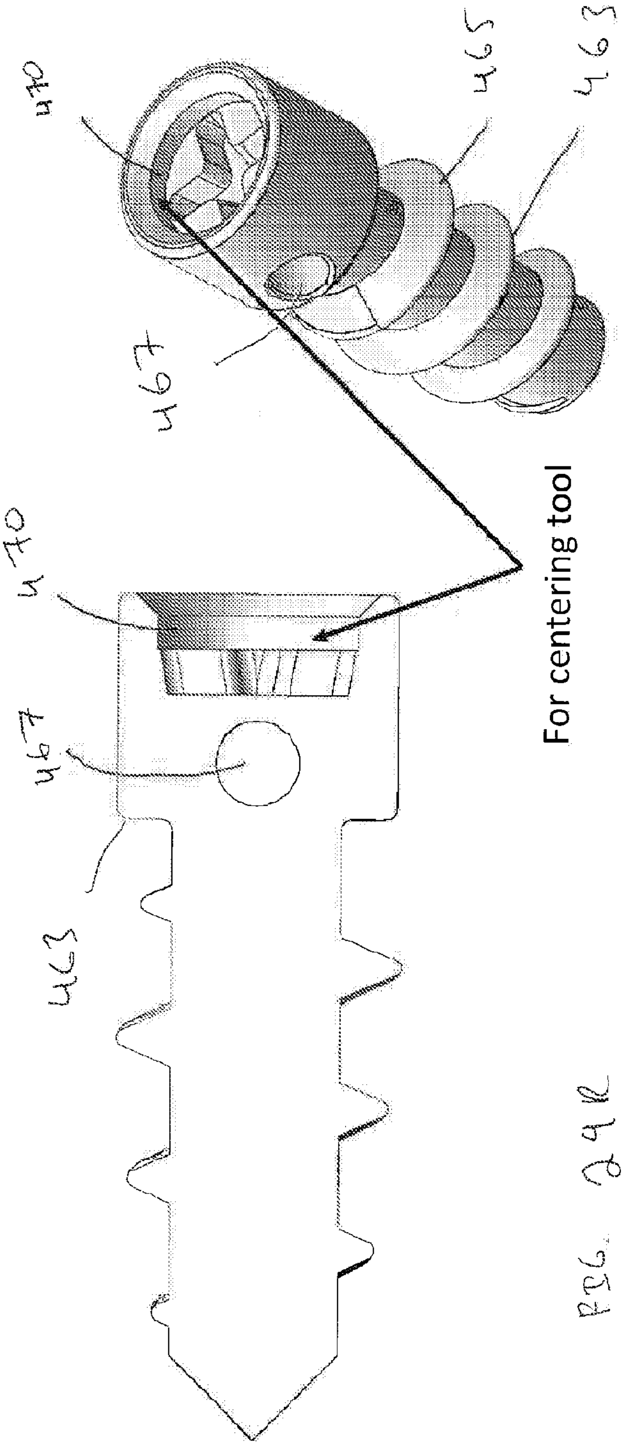


FIG. 29S

FIG. 29R

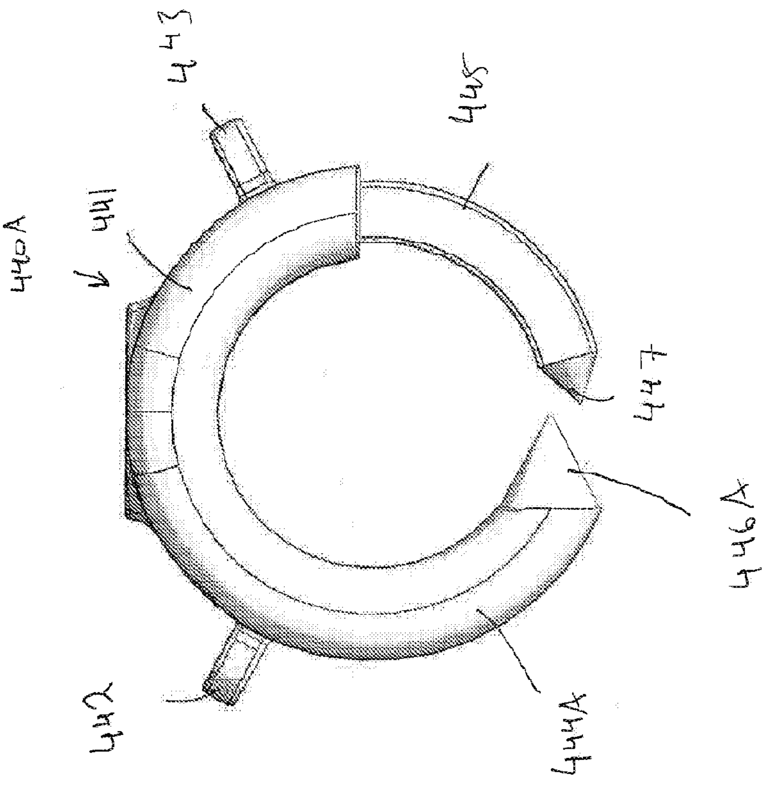


FIG 30A

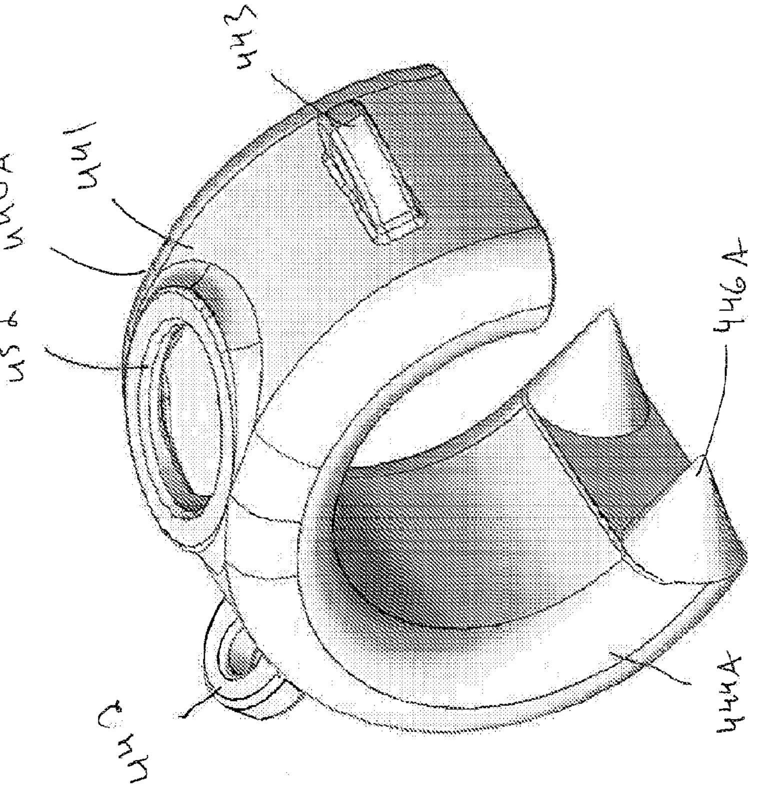


FIG. 30C

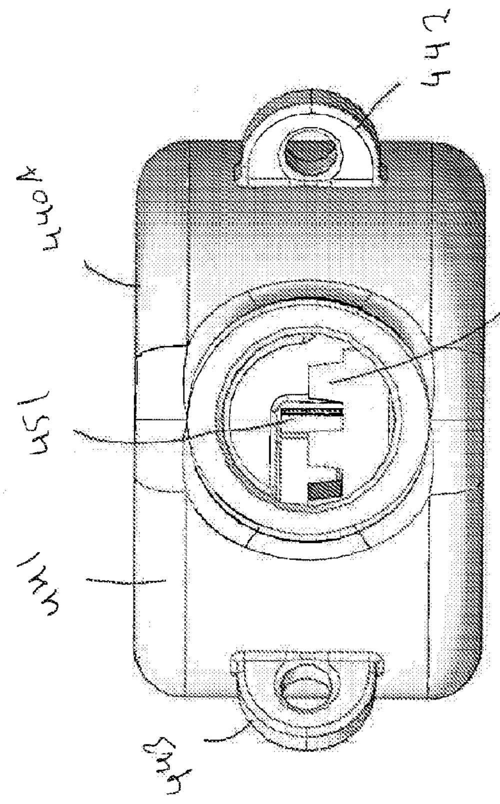


FIG. 30B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 17/13244

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61B 17/70 (2017.01)
CPC - A61B 117/7062, A61B 17/7064, A61B 17/7067, A61B 17/7068
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)
CPC: A61B 117/7062, A61B 17/7064, A61B 17/7067, A61B 17/7068
IPC(8): A61B 17/70 (2017.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 606/86A, 246, 248, 249, 250 (keyword limited; terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase; Google Patents; Google
Search Terms Used: spinous, process*, interspinous, wing%, tether*, sutur*, cable%, wire%, string%, inferior, superior, top, bottom, upper, lower, fixation, tension

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/0036246 A1 (CARL et al) 16 February 2006 (16.02.2006) fig 4A, 4B, 4C, para [0076], [0078]	1-2, 4-6, 10-12, 14-15, 16/(1-2, 4-6, 10-12, 14-15), 18-21, 25-26, 28-29, (30-31)/(18-21, 25-26, 28-29)
Y		3, 7-8, 16/(3, 7-8), 22-23, (30-31)/(22-23)
A		9
X	US 2009/0105761 A1 (ROBIE) 23 April 2009 (23.04.2000) fig 15A, 15C, 16, para [0129]-[0130], [0148], [0151]	1, 4, 13, 16/(1, 4; 13), 17-18, 21, 24, 27 (30-31)/(18, 21, 24, 27)
A		9
Y	US 2013/0041408 A1 (DINVILLE et al) 14 February 2013 (14.02.2013) fig 4A, 6A, para [0148], [0157]	3, 7-8, 16/(3, 7-8), 22-23, (30-31)/(22-23)
A		9
A	US 2007/0055373 A1 (HUDGINS et al) 08 March 2007 (08.03.2007) entire document	1-31
A	US 2008/0319487 A1 (FIELDING et al) 25 December 2008 (25.12.2008) entire document	1-31
A	US 2007/0233077 A1 (KHALILI) 04 October 2007 (04.10.2007) entire document	1-31

☐ Further documents are listed in the continuation of Box C. ☐

* 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	Date of mailing of the international search report
05 March 2017	03 APR 2017
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