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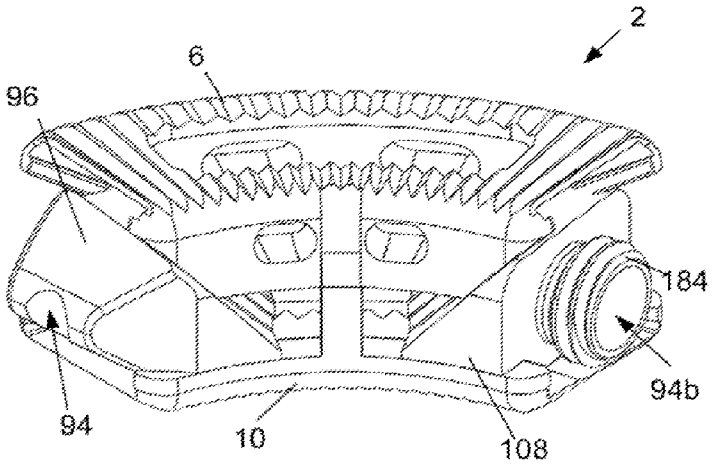

Fig. 49b

(57) **Abstract**: An implantable orthopedic stability device is disclosed. The device can have a contracted and an expanded configuration. A method of using the device between adjacent vertebral body surfaces for support and/or fixation of either or both of the adjacent vertebrae is also disclosed.

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TITLE OF THE INVENTION

FIXATION DEVICE AND METHOD

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BACKGROUND OF THE INVENTION

1. Technical field:

[0001] Devices and methods for fixation of tissue are disclosed. More specifically, the devices and methods can be for inter body vertebral fusion of vertebrae or fusion of other bones to one another.

2. Background of the Art:

[0002] A vertebroplasty device and method that eliminates or reduces the risks and complexity of the existing art is desired. A vertebroplasty device and method that may reduce or eliminate the need to inject a liquid directly into the compression fracture zone is also desired.

[0003] Other ailments of the spine result in degeneration of the spinal disc in the intervertebral space between the vertebral bodies. These include degenerative disc disease and traumatic injuries. In either case, disc degeneration can cause pain and other complications. . Conservative treatment can include non-operative treatment requiring patients to adjust their lifestyles and submit to pain relievers and a level of underlying pain. Operative treatment options include disc removal. This can relieve pain in the short term, but also often increases the risk of long-term problems and can result in motor and sensory deficiencies resulting from the surgery. Disc removal and more generally disc degeneration disease are likely to lead to a need for surgical treatment in subsequent years. The fusion or fixation will minimize or substantially eliminate relative motion between the fixed or fused vertebrae. In surgical treatments, adjacent vertebra can be fixated or fused to each other using devices or bone grafts. These may include, for example, screw and rod systems, interbody spacers (e.g., PEEK spacers or allograft bone grafts) threaded fusion cages and the like.

[0004] Some fixation or fusion devices are attached to the vertebra from the posterior side. The device will protrude and result in additional length (i.e., needed to overlap the vertebrae) and additional hardware to separately attach to each vertebrae. Fusion cages and allografts are contained within the intervertebral space, but must be inserted into the intervertebral space in the same dimensions as desired to occupy the intervertebral space. This requires that an opening sufficient to allow the cage or graft must be created through surrounding tissue to permit the cage or graft to be inserted into the intervertebral space.

[0005] A spinal fixation or fusion device that can be implanted with or without the need for additional hardware is desired. Also desired is a fixation or fusion device that can be deployed in a configuration where overlapping the fixated or fused vertebrae is not required.

[0006] Also desired is an intervertebral device the may be inserted in to the intervertebral space at a first smaller dimension and deployed to a second, larger dimension to occupy the intervertebral space. The ability to insert an intervertebral spacer at a dimension smaller than the deployed dimension would permit less disruption of soft and boney tissue in order to access the intervertebral space.

SUMMARY OF THE INVENTION

[0007] A device that can replace or supplement the screw or rod elements of a typical fusion system is disclosed. The device can be placed in the inter-vertebral space to fuse adjacent vertebrae and/or create a bone mass within the inter-vertebral space in a patient's spine.

[0008] The device can be less invasive than typical existing devices. For example, the device can be in a compacted (i.e., small) configuration when inserted into a patient and transformed into an expanded (i.e., large) configuration when positioned at the target site. For example, the device can be expanded when the device is between the inferior and superior vertebral body surfaces. The device can create less soft tissue (e.g., bone) disruption than a typical fusion system. The device in an expanded configuration can improve anchoring within the joint, structural stability, and create an environment for bone healing and growth leading to fusion between adjacent vertebrae.

[0009] During deployment into tissue (e.g., bone), one, two or more holes can be drilled into the target site to create a deployment hole in which to insert the device. The deployment hole can be round or non-round (e.g., by drilling more than one overlapping or adjacent hole, or crafting a square or rectangular hole), for example to substantially match the transverse cross-section of the device in a contracted configuration.

[0010] The device can be cannulated, for example having a lateral (i.e., transverse or latitudinal) and/or lengthwise (i.e., longitudinal) channel through the device. The device can be deployed over a wire or leader, such as a guidewire. The device can be slid over the guidewire, with the guidewire passing through the longitudinal channel of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is an exploded view of a variation of the expandable support device.

[0012] Figures 2 through 4 illustrate variations of cross-section A-A of Figure 1.

[0013] Figures 5 and 6 illustrate variations of cross-section B-B of Figure 1.

[0014] Figure 7 illustrates the variation of the expandable support device of Figure 1 with the ramps slidably attached to the base.

[0015] Figures 8 and 9 are perspective and side views, respectively, of the variation of the expandable support device of Figure 7 with the top and ramps in pre-assembly positions.

[0016] Figures 10, 11 and 12 are perspective, side and end views, respectively of the variation of the device of Figure 1 in an assembled configuration.

[0017] Figure 13 is a variation of close-up section E-E of Figure 12 in a first configuration.

[0018] Figure 14 is a variation of close-up section E-E of Figure 12 in a second configuration.

[0019] Figures 15 and 16 are a variation close-up section D-D of Figure 11 in first and second configurations, respectively.

[0020] Figures 17, 18, 20 and 21 are perspective, side, end and top views, respectively, of the variation of the device of Figure 1 in a pre-deployment configuration.

[0021] Figures 19 and 22 are side and top views, respectively, of a variation of the device of Figure 1 in a pre-deployment configuration.

[0022] Figure 23 illustrates a method of longitudinally compression and radially expanding the variation of the device of Figure 17, for example after deployment at a target site.

[0023] Figures 24 and 25 are perspective and top views, respectively, of the variation of the device of Figure 1 in a deployed configuration. Figure 22 is illustrated with the top and the base in see-through views for illustrative purposes.

[0024] Figures 26 and 27 illustrate variations of the locking pin.

[0025] Figures 28 and 29 illustrate a variation of a method for using the variation of the locking pin of Figure 26.

[0026] Figures 30 and 31 illustrate a variation of a method for using the variation of the locking pin of Figure 27.

[0027] Figures 32, 33 and 34 are top, side and end views, respectively, of a variation of the device with the locking pin.

[0028] Figures 35 and 36 are side and end views, respectively, of a variation of the device with the locking pin.

[0029] Figures 37 and 38 are side and end views, respectively, of a variation of the device with the locking pin.

[0030] Figures 39a, 39b and 39c are bottom perspective, end and side views, respectively, of a variation of the device in a longitudinally expanded configuration.

[0031] Figures 40a, 40b, and 40c are bottom perspective, end and side views, respectively, of the device of Figures 39a through 39c in a longitudinally compressed and radially expanded configuration.

[0032] Figures 41a through 41d are top, top perspective, side, and bottom perspective views, respectively, of a variation of the device in a longitudinally expanded and radially contracted configuration.

[0033] Figures 42a through 42c are top, side and top perspective views, respectively, of the variation of the device of Figures 41a through 41d with the side ramps not shown for illustrative purposes.

[0034] Figures 43a through 43d are top, top perspective, side, and bottom perspective views, respectively, of the device of Figures 41a through 41d in a longitudinally contracted and radially (e.g., height) expanded configuration.

[0035] Figures 44a through 44c are top, side and top perspective views, respectively, of the variation of the device of Figures 43a through 43d with the side ramps not shown for illustrative purposes.

[0036] Figures 45a and 45b are top and top perspective views, respectively, of a variation of the bottom plate.

[0037] Figures 46a and 46b are bottom and bottom perspective views, respectively, of a variation of the top plate.

[0038] Figures 47a and 47b are top perspective and bottom perspective exploded views, respectively, of the variation of the device of Figures 41a through 41d.

[0039] Figures 48a through 48d are top, top perspective, side, and bottom perspective views, respectively, of a variation of the device in a longitudinally expanded and radially contracted configuration.

[0040] Figures 49a through 49d are top, top perspective, side, and bottom perspective views, respectively, of the device of Figures 48a through 48d in a longitudinally contracted and radially (e.g., height) expanded configuration.

[0041] Figures 50a and 50b are side and top perspective views of the device of Figures 49a through 49d in a longitudinally contracted configuration, with the top plate exploded away from the rest of the device.

[0042] Figures 51a and 51b are top and top perspective views, respectively, of a variation of the bottom plate.

[0043] Figures 52a through 52c are bottom, bottom perspective, and end perspective views, respectively, of a variation of the top plate.

[0044] Figures 53a through 53d are top, top perspective, side, and bottom perspective exploded views, respectively, of the variation of the device of Figures 48a through 48d. Figures 53c and 53d illustrate the device upside down compared to the orientation shown in Figures 53a and 53b.

[0045] Figure 54 illustrates a visualization of a variation of a method for deploying the device into the spine between adjacent vertebrae.

[0046] Figures 55a and 55b illustrate visualizations of variations of the device deployed into the spine between adjacent vertebrae.

[0047] Figures 56a and 56b illustrate variations of methods for inserting one or more devices into one or more target sites.

DETAILED DESCRIPTION

[0048] A device 2 is disclosed that can be inserted into a target site 264 with the device 2 in a compressed or contracted (i.e., small) configuration. Once positioned in the deployment site, the device 2 can be transformed into an expanded (i.e., larger, bigger) configuration. The device 2 can be inserted and expanded in orthopedic target sites 264 for fixation and/or support. For example, the device 2 can be inserted and expanded over a guidewire between adjacent vertebral bodies.

[0049] Figure 1 illustrates that the device 2 can have a first longitudinal end and a second longitudinal end along a longitudinal axis 4. The longitudinal axis 4 can be straight or substantially straight. The device 2 can have a bottom or plate 286 (bottom and base plate are used interchangeably) and a top plate 6. The base 138 or bottom plate 10 and top plate 6 can be or have plates 286, panels, struts 216 (e.g., legs), ports, cells 88, and combinations thereof. The base plate 10 and top plate 6 can be configured to be slidably attachable to the other. For example, the base (or top) plate can have one or more stability bars 102. The top (or base) plate can have one or more stability grooves 128. The stability bars 102 can be configured to be slidably attachable to the stability grooves 128.

[0050] The slidable attachment of the top and base plates can permit the base 138 to move radially (with respect to the longitudinal axis 4) relative to the top and vice versa.

[0051] The top plate 6 can have a high-friction and/or low-friction texture extending radially away from the base 138. For example, the top plate 6 can have one or numerous rows of top teeth 118. The bottom plate 10 can have a high-friction and/or low-friction texture extending radially away from the base plate. For example, the bottom plate 10 can have one or numerous rows of bottom teeth 104. The top teeth 118 and the bottom teeth 104

[0052] The top plate 6 can have one or more side ports 114 and/or top ports. The base plate can have one or more base ports 120 and/or side ports 114. The base ports 120, side ports 114, and/or top ports can be ingrowth channels 28. The ports can be circular,

square, triangular, oval, elongated in the longitudinal direction, elongated in the radial direction, or combinations thereof.

[0053] The top plate 6 can have a top chamfer 156. The base plate can have a base chamfer. The chamfers can be atraumatic edges. The chamfers can extend along the perimeter of the base 138 and/or top.

[0054] The device 2 can have one, two or more wedges, for example a first or distal side ramp 96 on a first longitudinal side (e.g., the distal side) of the base plate and a second or proximal side ramp 108 on a second longitudinal side (e.g., the proximal side) of the base plate. The side ramps 96 and 108 can be configured to be slidably attachable to the base plate 10 and/or the top plate 6. The wedges or ramps 96 and 108 can be separate from each other. The ramps 96 and 108 can move independent of each other. The ramps 96 and 108 can be constrained by the top and bottom plates 6 and 10 to move concurrently and at the same rate in opposite directions. The angled faces of the ramps 96 and 108 can face each other. The "pointed" ends of the ramps 96 and 108 can point toward each other.

[0055] The ramps 96 and 108 and top plate 6 can be brought within proximity of the base plate 10. The ramps 96 and 108 can be slidably attached to the base plate 10. The ramps 96 and 108 can have ramp second tongues and grooves 98. The base plate 10 can have one or more base tongues and grooves 106. The ramp second tongues and grooves 98 can be configured to slidably attach to the base tongues and grooves 106.

[0056] The ramps 96 and 108 can be configured to be slidably attachable to the top plate 6. For example, the ramps 96 and 108 can have ramp first tongues and grooves 100. The top plate 6 can have top tongues and grooves 284. The ramp first tongues and grooves 100 can slidably engage the top tongues and grooves 284.

[0100] The first tongues and grooves can be at a ramp angle 136 with respect to the second tongues and grooves. The ramp angle 136 can be from about 15° to about 75°, more narrowly from about 30° to about 60°, for example about 45°.

[0101] One or more of the ramps 96 and 108 can have a ramp locking plate port 110. The ramp locking plate ports 110 can each be configured to receive a ramp locking plate. The ramps 96 and 108 can each have ramp ports, such as the threaded ramp ports. The

threaded ramp ports can pass through the ramps 96 and 108, for example opening into the ramp locking plate port 110.

[0102] Figure 2 illustrates that each of the top, or base 138 or bottom plates can have a plate thickness 122. The plates 286 can be thinned adjacent to some or all ports. The plate thickness 122 can be substantially constant along the length of the top or base 138. The plate thickness 122 can be non-constant, for example along the length and/or width of the top port or base port 120 and the top teeth 118 or base teeth. Each plate 286 of the first side ramp 96 and the second side ramp 108 can have a substantially constant plate thickness 122 along the height of the plate 286 save for the respective ramp ports.

[0103] Figure 3 illustrates that the top and/or bottom plates can thin as the plate 286 nears the port. For example, the plate 286 can have a maximum plate thickness 126 and a minimum plate thickness 124. The maximum plate thickness 126 and minimum plate thickness 124 can be measured with or without accounting for the change in thickness due to the teeth. The minimum plate thickness 124 can be substantially less than the maximum thickness 126. The minimum plate thickness 124 can be substantially 0. The plate 286 can slope outward (as shown), inward, or a combination of both (e.g., sloping inward and outward concurrently to form the rim of the port at a radius from the longitudinal axis between the radii of the outer and inner surfaces of the plate 286).

[0104] When the device 2 is in a deployed configuration in vivo, the device 2 can be partially or substantially filled with a liquid, gel, or solid (e.g., in small parts or granules) filler 262 material, or combinations thereof, such as bone morphogenic powder or any other material disclosed herein or combinations thereof. The filler 262 material can contact or be in near contact with the surrounding tissue near the edge of the ports, for example where the plate 286 is thinned. The filler 262 can be inserted into the device 2 before, and/or during (i.e., prepacked) , and/or after the device 2 is inserted and/or expanded in the target site.

[0105] As the device 2 is expanded and contracted, the volume of the interior channel of the device (i.e., defined between the top and base plates and the opposing ramps) can remain constant. For example, filler can be inserted into the device 2 before the device is radially expanded. The device 2 can be longitudinally contracted and radially expanded (e.g., expanded in height). The ratio of the volume of filler to the volume of the interior

channel of the device can then remain substantially constant as the device is radially expanded . For example, the decrease in volume of the interior channel of the device caused by the contracting ramps can be substantially equivalent to the increase in volume of the interior channel of the device 2 caused by the radially expanding top and base plates.

[0106] Figure 4 illustrates that the plates 286 of the first side ramp 96 and/or the second side ramp 108 can thin as the plate 286 nears the threaded ramp port(s). The minimum plate thickness 124 can be substantially less than the maximum plate thickness 126. The minimum plate thickness 124 can be substantially 0. The plate 286 can slope outward (as shown), inward, or a combination of both (e.g., sloping inward and outward concurrently to form the rim of the port at a radius from the longitudinal axis between the radii of the outer and inner surfaces of the plate 286).

[0107] Figure 5 illustrates that the stability bars 102 can be configured to slide into the stability groove 128 when the top and base plates intersect. The radially inner surface of the stability bar 102 can be substantially the same or a greater radius from the longitudinal axis of the expandable support device 188 as the radius of the radially outer surface of the top plate 6 adjacent to the side port 114 (i.e., within the stability groove 128). The stability bar 102 can be configured to not directly attach to the top plate 6 when the top is translated into the base plate, or the stability bars 102 can be configured to bias inward against and frictionally hold the top when the top plate 6 is translated into the base plate.

[0108] Figure 6 illustrates that the stability bars 102 can have one or more latches 130 along the length of the stability bar 102, for example at the terminal end of the stability bars 102, as shown. The latch 130 can be configured to attach to the top plate 6. The latch 130 can protrude radially inward. The latch 130 can have a latch top 288 and a latch bottom 134.

[0109] The latch top 288 can be configured to allow the top to pass over the latch 130. For example, the latch top 288 can be rounded and configured to push radially outward and clear of the top plate 6 when the top is pressed down into the latch top 288. The latch bottom 134 can be configured to grasp or otherwise attach to the top when the top is translated to a particular location into the base plate.

[0110] The stability bars 102 can be configured to resiliently bend radially outward and/or inward.

[0111] Figure 7 illustrates that the ramps 96 and 108 can be slidably attached, as shown by arrows, to the base plate 10 before the ramps 96 and 108 are slidably attached to the top plate 6. The ramp second tongues and grooves 98 can be slidably engaged with the base tongues and grooves 106, as shown in Figures 12, 13 and 14.

[0112] Figures 8 and 9 illustrate that the ramps 96 and 108 can be positioned, as shown by arrows, so that one or both ramp first tongues and grooves 100 can be aligned to slidably engage the top tongues and grooves 284 as the top plate 6 is translated toward the base plate, as shown by arrows. The stability bar 102 can be slid into the stability groove 128.

[0113] Figures 10 through 12 illustrate that as the top plate 6 is translated toward the base plate, as shown by arrows, the top plate 6 can slidably engage one or more of the ramps 96 and 108. The first tongues and grooves can slidably engage the top tongues and grooves 284.

[0114] Figure 13 illustrates that there can be a substantial ramp gap 140 between the side ramp and the base plate, for example before the expandable support device 188 is completely deployed. The ramp gap 140 can have a ramp gap height 150. The ramp gap height 150 can vary, for example, from about 0 mm (0 in.) to about 4 mm (0.2 in.). The side ramps can substantially slide along the base plate. For example, the ramp second tongue and groove 98 can slide along the base tongue and groove 106, separated by the ramp gap 140. Most or all of the friction in this configuration can be created by the ramp second tongue in contact with the base tongue 148 and/or side of the base groove 146.

[0115] The wall of the base groove 146 can have an outwardly slanted configuration relative to the height of the wall of the base groove 146 from the bottom of the base plate.

[0116] Figure 14 illustrates that the first side ramp 96 and the base 138 can be pressed into or otherwise translated toward each other. For example, after implantation of the device 2, the surrounding tissue in the in vivo environment can naturally compress the device 2.

[0117] The ramp gap 140 can be substantially closed. The ramp gap height 150 can be substantially about 0. The side ramps can be substantially friction fit along the base

plate. For example, the friction in this configuration can be created along the top surface of substantially the entire base plate including the top of the base tongue 148, and the bottom surface of substantially the entire side ramps.

[0118] As the side ramp is pushed, as shown by arrows, toward the base plate, the ramp second tongues 144 can be pressed between the base grooves 146, for example, frictionally fitting the side ramps into the base plate. The base grooves 146 can be tapered, as shown, to force the ramp second tongues 144 to wedge fit or press fit into the base grooves 146 when the side ramp is pushed towards the base plate.

[0119] The side ramps can have less friction with the base plate in the configuration of the expandable support device 188 of Figure 13 than in the configuration of the expandable support device 188 of Figure 14.

[0120] Figure 15 illustrates that the second side ramp 108 (and/or the first side ramp 96, not shown) can have ramp bottom teeth 152 on the side of the second side ramp 108 (and/or first side ramp 96) facing the base plate. The ramp bottom teeth 152 can extend into the ramp gap 140. Either or both side ramps can have teeth on any and/or all sides of the side ramp, for example the surfaces that contact the base plate and the top plate 6. The top plate 6 can have additional teeth, not shown, along surfaces that contact the side ramps.

[0121] The ramp bottom teeth 152 and/or base interior teeth 154 can be unidirectionally or bidirectionally oriented (i.e., providing additional resistance against movement in one direction, or substantially the same resistance against movement in either direction).

[0122] As the side ramp translates, as shown by arrows, with respect to the base plate, the ramp gap height 150 is substantially non-zero, as shown in Figures 13 and 15. When the ramp gap height 150 is substantially non-zero, the ramp bottom teeth 152 can slide over the base interior teeth 154.

[0123] Figure 16 illustrates that when the side ramp and base plate are pressed together, as shown by arrows, for example when deployed in vivo, the ramp gap height 150 can be minimized, for example approaching about 0 mm (0 in.). The ramp bottom teeth 152 can interlock with the base interior teeth 154. The interlocked ramp bottom teeth 152 and base interior teeth 154 can provide an interference fit or otherwise prevent or minimize the side ramp translating relative to the base plate.

[0124] In place of, or in addition to, the ramp bottom teeth 152 and/or the base top teeth, the respective surfaces can have high friction surfaces, for example a textured (e.g., knurled) surface and/or coated with a high friction material. The respective surfaces can also be smooth, having no teeth or texturing.

[0125] The side ramp can be pulled away from the base plate by reducing the compressive force between the side ramp and the base plate and pulling or pushing the side ramp.

[0126] The side ramp can have a belt and suspenders lock with the base plate.

[0127] Figures 17, 18, and 20 illustrate that the ramps can be pushed outward, as shown by arrows, toward each ramp's respective longitudinal side of the base plate. The ramps 96 and 108 can be pushed outward, for example, by a deployment or other tool. When the ramps 96 and 108 are slid outward, as shown, the top plate 6 and base plate can translate toward each other, as shown by arrow. The top plate 6 and base plate can then have a radially compressed (e.g., only in the "y"-axis or from the top of the page to the bottom of the page of Figures 17, 18, and 20) configuration. The top plate 6 can interference fit against the bottom plate 10 when the expandable support device 188 is fully radially compressed, as shown. The interference fit of the top against the bottom plate, and the slidable attachment of the ramps 96 and 108 to the top and the bottom plate 10 can lock the top plate 6, base plate and ramps 96 and 108 together (e.g., not allowing any to separate). The device 2 can be attached to a deployment tool 80 (e.g., by removably attaching to one or more ramp ports) and/or delivered to a target site 264 in the radially compressed configuration.

[0128] Figures 19 and 22 illustrate that one or more locking pin channels 164 can be defined transversely through the device 2. A locking pin 162 can be inserted through each locking pin channel 164. The locking pin 162 can be inserted through the locking pin channel 164 after the device 2 has been inserted at the target site 264 and expanded. The locking pin channel 164 can be defined by locking pin ports 166 on the stability bars 102 and the side port 114. The locking pin ports 166 can be circular, as shown, oval, or combinations thereof.

[0129] The locking pin 162 can be configured to limit the vertical expansion of the device 2. For example, the locking pin 162 can be configured to substantially prevent the device 2 from disassembling.

[0130] Figure 23 illustrates that the device 2 can be longitudinally compressed, as shown by arrows, resulting in radial and/or vertical expansion, as shown by arrow, for example performed after the device 2 is positioned within a vertebra or between vertebrae. The ramps 96 and 108 can be slidably translated along the longitudinal axis and inward and/or toward the center of the device 2. The expansion 92 of the device 2 can increase the height and provide structure support for a compressed or otherwise damaged vertebra (e.g., when the device 2 is deployed within a vertebra) and/or return adjacent vertebrae to a more natural/physiological configuration (e.g., when the device 2 is deployed between adjacent vertebrae).

[0131] Figure 24 and 25 illustrate the device 2 in a deployed configuration, for example after completion of the longitudinal compression 160 and radial and/or vertical expansion as shown in Figure 23.

[0132] Figure 26 illustrates a variation of the locking pin 162 that can have a pin shaft 170 with a driver slot 172, for example, configured to receive a screw driver or drill bit. The pin shaft 170 can have pin thread 168 configured to releasably or fixedly attach to one or both of the ramp ports. The pin thread 168 can extend along all or part of the length of the pin shaft 170. The pin shaft 170 can be rotatably or fixedly attached to or integral with a locking plate 290. The locking plate 290 can be at the end of the pin shaft 170 with the driver slot 172. The locking plate 290 can be at the same or opposite end of the pin shaft 170 from the thread.

[0133] Figure 27 illustrates that the pin shaft 170 can have no locking plate 290. The pin thread 168 can be at the end of the pin shaft 170 with the driver slot 172. One end of the pin shaft 170, for example opposite the driver slot 172, can be an abutment end 174.

[0134] Figure 28 illustrates that the locking pin 162 can be inserted, as shown by arrow, through the second side ramp 108. Figure 29 illustrates that the pin shaft 170 can be translated and rotated, as shown by arrows, to screw the pin thread 168 into the threaded distal ramp port 94 in the first side ramp 96. The ramp locking plate can fit into the ramp

locking plate port 110. The locking pin 162 can be screwed tightly enough to substantially fix the locking pin 162.

[0135] Figure 30 illustrates that the locking pin 162 can be inserted, as shown by arrow, through the threaded ramp port. The second side ramp 108 and/or the top and/or the bottom plates can have a ramp abutment section 180. The ramp abutment section 180 can be configured to interference fit with and/or fixedly attach to the abutment end 174.

[0136] Figure 31 illustrates that the pin shaft 170 can be translated and rotated, as shown by arrows. The abutment end 174 can interference fit and/or fixedly attach to the ramp abutment section 180.

[0137] A biocompatible adhesive or epoxy can be applied to the pin thread 168, threaded ramp port, abutment end 174, ramp abutment section 180, or combinations thereof.

[0138] Figures 32, 33 and 34 illustrate that one, two or more locking pin channels 164 can be defined longitudinally through the device 2. One, two or more locking pins 162 can be inserted in each locking pin channel 164, for example during or after deployment of the remainder of the device 2. The locking pins 162 can prevent overexpansion and/or overcompression and/or disassembly of the device 2.

[0139] The locking pin channel 164 can have locking pin ports 166 through the top, and/or bottom plates, and/or either or both side ramps.

[0140] Two locking pin channel 164 can be located on opposite sides of the threaded ramp port. The locking pin channels 164 and ports can have a circular cross-section (i.e., be cylindrical), as shown in Figure 34.

[0141] Figures 35 and 36 illustrates that the locking pin 162 can be cylindrical. The locking pin channel 164 and locking pin port 166 can have elongated cross-sections, such as an oval or rectangular or oblong cross-sections. The locking pin 162 can be free to move vertically within a range of motion within the locking pin port 166.

[0142] Figures 37 and 38 illustrate that the locking pin 162 can be a substantially similar shape and size as the locking pin channel 164. The locking pin 162 can be substantially unmovable within the locking pin port 166. The locking pin 162, locking pin channel 164 and locking pin port 166 can all have elongated cross-sections, such as an oval or rectangular or oblong cross-sections.

[0143] One or both of the ramps 96 and 108 can have first fixing teeth 192. The first fixing teeth 192 can be in contact with the top and/or the bottom. The top and/or the bottom (shown as bottom only) plates 286 can have second fixing teeth 190.

[0144] The first fixing teeth 192 can mechanically interact with the second fixing teeth 190 to allow relative translation in a first direction. The first fixing teeth 192 and the second fixing teeth 190 can interact to obstruct (e.g., by interference fitting the first fixing teeth 192 against the second fixing teeth 190) relative translation in a second direction. For example, the fixing teeth can obstruct the side ramps from moving longitudinally away from each other (i.e., and obstruct the top from moving closer to the bottom). Also for example, the fixing teeth can allow relative translation of the side ramps toward each other (i.e., and allow the top to move away from the bottom).

[0145] The second side ramp 108 can have a first end 186. The first end 186 can be configured to dissect tissue. The first end 186 can have a blunt or sharp point.

[0146] The second side ramp 108 can have a tool connector 184, such as an externally and/or internally threaded cylinder extending longitudinally from the second side ramp 108 away from the first side ramp 96. The tool connector 184 can be configured to removably attach to a deployment tool 80.

[0147] The first side ramp 96 and second side ramp 108 can be longitudinally compressed toward each other. For example, an external deployment tool 80 can be attached to the first side ramp 96 and second side ramp 108 and apply a compressive force. The base 138 and top plates 6 can expand away from each other.

[0148] The first fixing teeth 192 can unidirectionally interference fit the second fixing teeth 190. The unidirectional interference fit of the first fixing teeth 192 and the second fixing teeth 190 can substantially impede or prevent the opposite ramps 96 and 108 from moving longitudinally away from each other, for example, therefore impede or preventing compression 196 of the top toward the bottom and vice versa.

[0149] The unidirectional interference fit of the first fixing teeth 192 and the second fixing teeth 190 can allow the opposite ramps 96 and 108 to move longitudinally toward each other, for example, therefore allowing the top to expand away from the bottom and vice versa.

[0150] The expandable support devices 188 can have textured and/or porous surfaces for example, to increase friction against bone surfaces, and/or promote tissue ingrowth. The expandable support devices 188 can be coated with a bone growth factor, such as a calcium base 138.

[0151] Figures 39a through 39c illustrate that the bottom ports can be one or more circular ports, for example six ports. The bottom ports can be aligned in a single row parallel with the longitudinal axis of the device 2.

[0152] The side ports 114 can open against the edge of the top plate 6 on one or more sides (e.g., the bottom sides, as shown) of the side ports 114.

[0153] The top plate 6 can have top plate side teeth 198 on the external lateral sides of the top plate 6. The bottom plate 10 can have bottom plate side teeth 202 on the external lateral sides of the bottom plate. The top plate side teeth 198 and/or the bottom plate side teeth 202 can be oriented from the top to the bottom of the device 2 (i.e., perpendicular to the longitudinal axis of the device 2). The top plate side teeth 198 can be aligned with the bottom plate side teeth 202.

[0154] The external lateral sides of the first side ramp 96 and/or second side ramp 108 can have ramp side teeth 200. The ramp side teeth 200 can be oriented parallel with the longitudinal axis of the device 2. The top plate side teeth 198 and/or the bottom plate side teeth 202 can be oriented perpendicular to the orientation of the ramp side teeth 200.

[0155] Figures 40a through 40c illustrate that the top plate 6 and/or bottom plate 10 can be expanded away from each other in the directions of the orientation of the longitudinal axes of the top plate side teeth 198 and the bottom plate side teeth 202. The first and/or second side ramps 108 can be contracted toward one another in the direction of the orientation of the longitudinal axis of the ramp side teeth 200 of the first and second side ramps 108. The top plate side teeth 198, bottom plate side teeth 202, and ramp side teeth 200 can act as low-friction rails 42 against surrounding tissue when the device 2 is radially expanded at the target site 264.

[0156] The side ports 114 that open to the bottom edge of the top plate 6 can create a single side port 114 that can extend to the bottom plate.

[0157] The plates 286 and wedges 18 can be rigid or exhibit ductile or deformable expansion 92 during deployment. The transverse cross-section of the device 2 can be

non-round. For example, The device 2 can have a square or rectangular transverse cross-section. The device 2 can have a substantially triangular or quadrilateral (e.g., trapezoidal) cross-section. The device 2 can have a round, hexagonal, octagonal, or other transverse cross-sectional configuration.

[0158] Figures 41a through 41d illustrate that the device 2 can be curved, rounded (e.g., a continuous curvature along the entire length) or bent (e.g., at one or more angles at specific, discrete positions along the length). Any or all of the components of the device 2 can be curved, for example the top plate 6, bottom plate 10, a distal ramp 96, the proximal ramp 108, and combinations thereof. During use, the device 2 can be inserted into a target site, for example intervertebrally, rotating and translating the device 2, so the concave aspect of the curvature can be positioned to miss nearby sensitive tissue (e.g., the spinal cord) during placement.

[0159] The longitudinal axis of the device 2 can have a device radius of curvature 300. The device radius of curvature 300 can be from about 0.5 cm (0.2 in.) to about 40 cm (16 in.), more narrowly from about 1 cm (0.4 in.) to about 20 cm (8 in.), yet more narrowly from about 1.9 cm (0.75 in.) to about 7.0 cm (2.75 in.), for example about 3.2 cm (1.25 in.).

[0160] The proximal ramp 108 can have one or more proximal protrusions 304. For example, a single protrusion can extend proximally from the proximal ramp 108 centered with or asymmetric or off-center (as shown) to the longitudinal axis 4. The protrusion 304 can have a proximal ramp hole 302a, for example extending from the top of the protrusion 304 part or all of the way through the protrusion 304.

[0161] A deployment tool can releasably or fixedly attach to the proximal ramp hole 302a and/or protrusion 304. For example, the deployment tool can be rotatably attached to the proximal ramp hole 302a. For example, the deployment tool can have a removable pin that can be inserted into the hole proximal ramp hole 302a. The pin, still fixed to the deployment tool, can then be press fit (e.g., friction fit or interference fit) or rotated inside of the hole 302a, acting as a rotatable hinge. The pin can rotationally stabilize the device 2.

[0162] The pin can act as a stabilization device. The deployment tool can press on one or both sides of the protrusion 304 to rotate the device 2 about the proximal ramp hole 302a.

[0163] The distal ramp 96 can have a distal ramp keyhole 302b. The distal ramp keyhole 302b can extend from the top of the distal ramp 96 part or all the way through the distal ramp 96. The distal ramp keyhole 302b can be cylindrical (as shown), square, triangular, oval, rectangular, or star-shaped in cross section. An attachment key 308 can be inserted into the distal ramp key hole 302b, as shown by arrow in Figure 41b. The inserted attachment key 308 can abut against the larger cylinder 170b and the distal

[0164] The attachment key 308 can have the same cross-section as the distal ramp key hole 302b.

[0165] The locking pin 162 can be straight (as shown) or curved, such as having a substantially equal radius of curvature to the longitudinal axis. The locking pin 162 can have a proximal locking head plate or tool interface proximal section 290a that can extend proximally of the proximal ramp 108 when the device 2 is in a radially contracted and longitudinally expanded configuration. The locking pin 162 can be fixedly or detachably attached to the distal ramp 96.

[0166]

[0167] Figures 42a through 42c illustrate that the locking pin 162 can have an adjustable length. The locking pin 162 can have a smaller cylinder or proximal locking pin shaft 170a with radially outer threads and a larger outer cylinder or distal locking pin shaft 170b with radially inner threads. The smaller cylinder 170a can helically (e.g., threadably, as a screw or bolt) engage the larger cylinder 170b (e.g., as a nut).

[0168] The outside of the smaller cylinder 170a and the inside of the larger cylinder 170b can have a set of slidably engaging longitudinal ribs, slides, rails, guides, or combinations thereof.

[0169] The smaller cylinder 170a can be spring loaded with respect to the larger cylinder 170b. The inside of the locking pin 162 can have hydraulic fluid and an internal seal and/or piston so the locking pin 162 can act as a hydraulic damper or shock absorber.

[0170] The locking pin 162 can have a distal locking head or plate 290b. The distal locking head 290b can have a larger diameter than the diameter of the distal locking pin shaft 170b and distal ramp port 94a. The distal locking head 290b can be releasably attached to or fixed in or distal to the distal ramp port 94a.

[0171] The locking pin 162 can have a proximal locking head or plate 290a. The proximal locking head 290a can have a larger diameter than the diameter of the proximal locking pin shaft 170a and the proximal ramp port 94b. When the locking pin 162 is shortened, the proximal locking pin head170a can abut or interference fit with the proximal ramp 108, pushing the proximal ramp 108 toward the distal ramp 96, longitudinally contracting and radially expanding the device 2.

[0172] The distal locking head 290b can have a key interface 306. The key interface 306 can be a notch, divot, threads, other engagement feature, or combinations thereof. The key interface 306 can slidably receive the attachment key 308, for example after the attachment key 308 is delivered into the distal keyhole 302b. The attachment key 308 can fix the locking pin 162 to the distal ramp 96, for example transferring force from the distal locking plate 290a to the distal ramp, capable of translating the distal ramp 96 proximally and distally with respect to the proximal ramp 108 when the length of the locking pin 162 is expanded and contracted..

[0173] Figures 43a through 43d and 44a through 44c illustrate that the locking pin 162 can be attached to the distal ramp 96. The locking pin 162 can be longitudinally shortened. The distal ramp 96 can be contracted toward the proximal ramp 108, resulting in a longitudinal contraction of the device and a radial (e.g., height) expansion between the top plate 6 and the bottom plate 10. The ramps 96 and 108 can longitudinally contract along a straight or curved path (e.g., correlating with the shape of the grooves in the top plate, ramps and base plate) toward the center of the device 2.

[0174] The top plate 6 can extend in a parallel or non-parallel plane away from the bottom plate10. A compressive force can be exerted between the proximal and distal ramps 108 and 96 along the longitudinal axis 4.

[0175] The attachment key 308 is not shown in Figure 44b and shown in phantom lines in Figure 44c for illustrative purposes.

[0176] Figures 45a and 45b illustrate that the base plate 10 can have proximal base grooves 106a and distal base grooves 106b. The proximal base grooves 106a can be a separate groove than the distal base grooves 106b. The proximal and distal base grooves 106a and 106b can be substantially straight (as shown) or curved.

[0177] The longitudinal axis of the proximal base grooves 106a and the longitudinal axis of the distal base grooves 106b can form a base groove angle 310. The base groove angle 310 can be from about 125° to about 175°, more narrowly from about 140° to about 160°, for example about 154°.

[0178] Figures 46a and 46b illustrate that the top plate 6 can have proximal top grooves 284a and distal top grooves 284b. The proximal top grooves 284a can be separate from the distal top grooves 284b. The top grooves 284a and 284b can be substantially straight (as shown) or curved.

[0179] The longitudinal axis of the proximal top grooves 284a and the longitudinal axis of the distal top grooves 294b can form a top groove angle 312. The top groove angle 312 can be equal to the bottom groove angle 310.

[0180] Figures 47a and 47b illustrate that the components of the device 2 can be slidably and rotatably assembled.

[0181] The outer locking pin shaft 170b can have an outer locking pin shaft channel 314. The inner locking pin shaft 170a can screw, slide, clip or otherwise engage into the outer locking pin shaft channel 314. The inner locking pin shaft 170a can be longitudinally translated within the locking pin shaft channel 314, for example by rotating the inner locking pin shaft 170a with respect to the outer locking pin shaft 170b. The total length of the locking pin 162 can be adjusted.

[0182] Figures 48a through 48d and 49a through 50a illustrate that the device can have a radius of curvature 300. A compressive force can be exerted onto the ramps 96 and 108 along the longitudinal axis 4. For example, the locking pin and/or deployment tool can be flexible and/or have a rigid shape with a radius of curvature that matches the radius of curvature 300 of the device 2.

[0183] The ramps 96 and 108 can longitudinally contract along a curved path, such as along the longitudinal axis 4, toward the center of the device 4. During radial expansion, the top plate 6 can extend in a parallel plane away from the bottom plate 10.

[0184] The distal ramp 96 can have threading on inside of a distal ramp port 94a. The distal ramp port 94a can be aligned with the longitudinal axis 4.

[0185] The proximal ramp 108 can have threading on the radial exterior and/or interior of the tool connector 184. The proximal ramp 108 can have the tool connector 184, for

example extending proximally from the remainder of the device 2. The tool connector 184 can be a cylindral proximal extension from the proximal ramp 108. The threading on the radial outside of the tool connector 184 can, for example, removably attach to a deployment tool.

[0186] Figures 50a and 50b illustrate that the device can be assembled by sliding the iramps 96 and 108 onto the base plate. The ramps 96 and 108 can then be contracted to close to or at their respective inner-most positions on the base plate 10. The top plate 6 can then be delivered, as shown by arrow, onto the ramps 96 and 108. The ramps 96 and 108 can then be slid outward, extending away from the opposite ramp, as shown by arrows, engaging the top plate and pulling the top plate and the bottom plate together.

[0187] Figures 51a and 51b illustrate that the inner base groove 106' and/or outer base groove 106" can be curved along a part or the entire length of the respective base grooves 106. The inner base groove 106' can have an inner base groove radius of curvature 316" from about 1.3 cm (0.5 in.) to about 6.4 cm (2.5 in.) for example about 2.5 cm (1.0 in.). The outer base groove 106" can have an outer base groove radius of curvature 316" from about 2.5 cm (1.0 in.) to about 7.6 cm (3.0 in.), for example about 3.8 cm (1.5 in.).

[0188] Figures 52a through 52c illustrate that the inner proximal and distal top grooves 284a' and 284b' and outer proximal and distal top grooves 284a" and 284b" can be curved along a part or the entire length of the respective grooves.

[0189] The inner top grooves 284a' and 284b' can have inner top groove radii of curvature 318' from about 1.3 cm (0.5 in.) to about 6.4 cm (2.5 in.) for example about 2.5 cm (1.0 in.). The inner top groove radii of curvature 318' can be the same or different for the inner proximal and distal top grooves 284a' and 284b'.

[0190] The outer top grooves 284a" and 284b" can have outer top groove radii of curvature 318" from about 2.5 cm (1.0 in.) to about 7.6 cm (3.0 in.), for example about 3.8 cm (1.5 in.). The outer top groove radii of curvature 318" can be the same or different for the outer proximal and distal top grooves 284a" and 284b".

[0191] Figures 53a through 53d illustrate that that the components of the device 2 can be slidably assembled. A deployment tool and/or fixation rod can be inserted into the device after the component are assembled.

[0192] The device 2 can have one or more radiopaque and/or echogenic markers. For example, the device 2 can have aligned markers on the top plate 6, middle plate 8 and bottom plate. When the device 2 is in a contracted pre-deployment configuration, the markers can be located immediately adjacent to one another, for example appearing as a single marker. When the device 2 is in an expanded configuration, the markers can move apart from each other, indicating to a doctor performing the implantation and deployment procedure using visualization (e.g., x-ray or ultrasound-based) that the device 2 has expanded. Under visualization the markers can also indicate the location and orientation of the device 2.

METHOD OF USING

[0193] The devices can be made from PEEK, any medical grade polymer or metal, or any other material disclosed herein. For example, the side ramps can be made from titanium and/or a titanium alloy and the bottom and/or top plates can be made from PEEK. The device can be coated, for example with bone morphogenic protein (BMP), ceramic, and/or any other material disclosed herein, before, during or after deployment into the target site. The device can be deployed less (e.g., minimally) invasively, over the wire, percutaneously, used with a vertebral body replacement or fusion cage, or combinations thereof. The device can be expandable and un-expandable for removal or repositioning.

[0194] Figure 54 illustrates that the device can be removably attached to a delivery system or deployment tool. The deployment tool can insert the device into the target site. For example the deployment tool can be pushed over a guidewire.

[0195] When the device is positioned as desired (e.g., between adjacent vertebral plates) and expanded and/or locked, the deployment tool can then be releases from the device. The device can be configured to lock itself into place with outward expansion, wedging, or interference force when receiving a release force from the deployment tool or otherwise. For example, the device can have unidirectionally sliding teeth oppositely located on the adjacent surfaces of the wedges and plates.

[0196] A leader or wire, such as a guidewire, can be inserted or otherwise deployed into the target site, for example, the wire can be percutaneously inserted in a minimally invasive procedure. The wire can be inserted into the intervertebral space, for example

between a first vertebral plate and an adjacent, second, vertebral plate. The wire can be anteriorly and/or posteriorly inserted. The wire can be laterally inserted.

[0197] Whether or not the device is inserted over or along the wire, the device can be inserted into the target site (e.g., between adjacent vertebral bodies) from an anterior, lateral, posterior, transforaminal approach, or combinations thereof.

[0198] Figure 54 illustrates the deployment tool inserted to a target site in vivo between a first vertebra and a second vertebra. For example, the device can be placed at the target site after a partial or complete discectomy. When the device is in a contracted configuration, the tool can position the device between a first vertebral body of the first vertebra and a second vertebral body of the second vertebra. The device can be inserted into the target site a direction substantially parallel to the surfaces of the vertebral body end plates. The device can be placed between a first vertebral end plate of the first vertebral body and the adjacent second vertebral end plate of the second vertebral body. In this inter-vertebral location, the top plate of the device can be in contact with or directly adjacent to the first vertebral end plate. The bottom plate of the device can be in contact with or directly adjacent to the second vertebral end plate.

[0199] Figures 55a and 55b illustrate that the deployment tool can radially expand the device between the first vertebral end plate and the second vertebral end plate. The top plate 6 can press against and/or embed into the first vertebral end plate 234. The bottom plate 10 can press against and/or embed into the second vertebral end plate 238. The device 2 can fuse or fix the first vertebra 234 to the second vertebra 238.

[0200] Figures 56a illustrates that one, two or more devices 2, such as a first device 2a and a second device 2b, can be inserted, deployed and/or implanted the target site, such as in a vertebral body 324 or on a vertebral body 324 (e.g., between adjacent vertebral bodies). The devices 2 can be oriented so the longitudinal axes 4 of the devices 2 are substantially parallel with an anterior-posterior axis 320 of the patient.

[0201] The first device 2a can be oriented so the first device longitudinal axis 4a can be substantially parallel with the anterior-posterior axis 320.

[0202] The second device 2b can be oriented so the second device longitudinal axis 4b can be substantially parallel with the anterior-posterior axis 320. The second device 2b

can be positioned in a substantially symmetric location and angular orientation to the first device 2a with respect to the anterior-posterior axis 320.

[0203] The concavity of the radius of curvature 300 of the device can face toward (as shown) or away from the medial direction (i.e., the central anterior-posterior axis 320).

[0204] After placed into position at the target site, the device 2 can be longitudinally contracted and radially expanded. For example, as shown, the second device 2b has been radially expanded, and the first device 4a has been delivered to the target site and not yet radially expanded. Multiple devices 4 can be delivered concurrently or sequentially. Multiple devices 4 can be radially expanded sequentially or concurrently.

[0205] The devices 4 can be inserted with a surgical technique such as an Anterior Lumbar Interbody Fusion (ALIF), shown by arrow 322a, Posterior Lumbar Interbody Fusion (PLIF), shown by arrow 322b, Transforaminal Lumbar Interbody Fusion (TLIF), shown by arrow 322c, a direct linear lateral delivery, as shown by arrow 322d, a curvilinear lateral delivery initially inserted posteriorly, as shown by arrow 322e, or other methods or combinations thereof.

[0206] Operative planning and templating can be performed using MRI and CAT imaging scans to determine what size device fits the patient's anatomy and pathology.

[0207] The disc (i.e., intervertebral) space or other target site can then be prepared. For PLIF procedures, the vertebrae can be accessed through an incision in the patient's back (i.e., posterior to the vertebrae). Depending on the number of vertebral levels to be fused, about a 3-6 inch incision can be made in the patient's back. The spinal muscles can then be retracted (or separated), for example, to allow access to the target vertebral discs. The lamina can then be removed (i.e., a laminectomy), for example, to be able to see and access the nerve roots. The facet joints, which can lie directly over the nerve roots, can be trimmed, for example, to allow more room for the nerve roots. The target disc and surrounding tissue can then be removed and the bone surfaces of adjacent vertebrae can be prepared (e.g., cleaned, abraded, debrided, textured, scored, coated with osteogenic powders or other agents, or combinations thereof).

[0208] The devices 2 can then be inserted into the target site. One or more devices 2 and/or bone graft (e.g., autograft, allograft, xenograft), BMP, or combinations thereof, can be inserted into the target site or disc space, for example, to promote fusion between

the vertebrae. Additional instrumentation (e.g., rods or screws) can also be used at this time to further stabilize the spine.

[0209] TLIF can include delivering the device 2 to the spine in a path more from the side of the spinal canal than a PLIF approach and through a midline incision in the patient's back. TLIF can reduce the amount of surgical muscle dissection and can minimizes nerve manipulation required to access the vertebrae, discs and nerves.

[0210] TLIF can include removing disc material from the spine and inserting the device(s) 2 and bone graft, BMP, screws, rods, or combinations thereof.

[0211] ALIF is performed inserting the from the front (anterior) of the body, usually through a 3-5 inch incision in the lower abdominal area or on the side. This incision may involve cutting through, and later repairing, the muscles in the lower abdomen.

[0212] A mini open ALIF approach can be performed. A mini open ALIF can preserves the muscles and allow access to the front of the spine through an incision. This approach maintains abdominal muscle strength and function and can be used to fuse the L5-S1 disc space., for example

[0213] Once the incision is made and the vertebrae are accessed, and after the abdominal muscles and blood vessels have been retracted, the disc material can be removed. The surgeon can then insert the devices 2 and/or bone graft, rods, screws, BMP, or combinations thereof, for example to stabilize the spine and facilitate fusion.

[0214] The target site for the device(s) 2 can be between sacral, lumbar, thoracic, cervical vertebrae, or combinations thereof. The target site can be between other bones, such as intercostal (between ribs), in the knee, elbow, wrist, ankle, or combinations thereof.

[0215] Figure 56b illustrates that one (as shown) or more devices 2 can be inserted into the target site, such as in a vertebral body or on a vertebral body (e.g., between adjacent vertebral bodies). The longitudinal axis 4 of the device 2 can be oriented substantially perpendicular to the anterior-posterior axis 320 (i.e., parallel to a lateral axis). The concavity of the radius of curvature 300 can face anteriorly or posteriorly.

[0216] The device 2 can be filled with a filled before or after radial expansion. Tissue ingrowth can occur into the top plate through the top ports, bottom plate through the bottom ports, and elsewhere through the device.

[0217] The device 2 can provide fusion between the adjacent vertebrae. The devices 2 can have radiopaque and/or echogenic visualization markers, for example the markers can be along the top plate, bottom plate, and one or more panels of the plates. The deployment tool can also have one or more markers. The devices 2 can be inserted into multiple interbody target sites of the spine to provide fusion between adjacent vertebral bodies. A first device can be inserted into a first interbody site and a second device can be inserted into a second interbody site. The first and second devices can be inserted bilaterally, for example both devices can be inserted between the same first vertebra and second vertebra from opposite lateral sides.

[0218] Any or all elements of the device 2 and/or other devices or apparatuses described herein can be made from, for example, a single or multiple stainless steel alloys, nickel titanium alloys (e.g., Nitinol), cobalt-chrome alloys (e.g., ELGILOY® from Elgin Specialty Metals, Elgin, IL; CONICHROME® from Carpenter Metals Corp., Wyomissing, PA), nickel-cobalt alloys (e.g., MP35N® from Magellan Industrial Trading Company, Inc., Westport, CT), molybdenum alloys (e.g., molybdenum TZM alloy, for example as disclosed in International Pub. No. WO 03/082363 A2, published 9 October 2003, which is herein incorporated by reference in its entirety), tungsten-rhenium alloys, for example, as disclosed in International Pub. No. WO 03/082363, polymers such as polyethylene teraphathalate (PET), polyester (e.g., DACRON® from E. I. Du Pont de Nemours and Company, Wilmington, DE), poly ester amide (PEA), polypropylene, aromatic polyesters, such as liquid crystal polymers (e.g., Vectran, from Kuraray Co., Ltd., Tokyo, Japan), ultra high molecular weight polyethylene (i.e., extended chain, high-modulus or high-performance polyethylene) fiber and/or yarn (e.g., SPECTRA® Fiber and SPECTRA® Guard, from Honeywell International, Inc., Morris Township, NJ, or DYNEEMA® from Royal DSM N.V., Heerlen, the Netherlands), polytetrafluoroethylene (PTFE), expanded PTFE (ePTFE), polyether ketone (PEK), polyether ether ketone (PEEK), poly ether ketone ketone (PEKK) (also poly aryl ether ketone ketone), nylon, polyether-block co-polyamide polymers (e.g., PEBAX® from ATOFINA, Paris, France), aliphatic polyether polyurethanes (e.g., TECOFLEX® from Thermedics Polymer Products, Wilmington, MA), polyvinyl chloride (PVC), polyurethane, thermoplastic, fluorinated ethylene propylene (FEP), absorbable or resorbable polymers such as

polyglycolic acid (PGA), poly-L-glycolic acid (PLGA), polylactic acid (PLA), poly-L-lactic acid (PLLA), polycaprolactone (PCL), polyethyl acrylate (PEA), polydioxanone (PDS), and pseudo-polyamino tyrosine-based acids, extruded collagen, silicone, zinc, echogenic, radioactive, radiopaque materials, a biomaterial (e.g., cadaver tissue, collagen, allograft, autograft, xenograft, bone cement, morselized bone, osteogenic powder, beads of bone) any of the other materials listed herein or combinations thereof. Examples of radiopaque materials are barium sulfate, zinc oxide, titanium, stainless steel, nickel-titanium alloys, tantalum and gold.

[0219] The device 2 can be made from substantially 100% PEEK, substantially 100% titanium or titanium alloy, or combinations thereof.

[0220] Any or all elements of the device 2 and/or other devices or apparatuses described herein, can be, have, and/or be completely or partially coated with agents for cell ingrowth.

[0221] The device 2 and/or elements of the device and/or other devices or apparatuses described herein can be filled, coated, layered and/or otherwise made with and/or from cements, fillers, and/or glues known to one having ordinary skill in the art and/or a therapeutic and/or diagnostic agent. Any of these cements and/or fillers and/or glues can be osteogenic and osteoinductive growth factors.

[0222] Examples of such cements and/or fillers includes bone chips, demineralized bone matrix (DBM), calcium sulfate, coralline hydroxyapatite, biocoral, tricalcium phosphate, calcium phosphate, polymethyl methacrylate (PMMA), biodegradable ceramics, bioactive glasses, hyaluronic acid, lactoferrin, bone morphogenic proteins (BMPs) such as recombinant human bone morphogenetic proteins (rhBMPs), other materials described herein, or combinations thereof.

[0223] The agents within these matrices can include any agent disclosed herein or combinations thereof, including radioactive materials; radiopaque materials; cytogenic agents; cytotoxic agents; cytostatic agents; thrombogenic agents, for example polyurethane, cellulose acetate polymer mixed with bismuth trioxide, and ethylene vinyl alcohol; lubricious, hydrophilic materials; phosphor cholene; anti-inflammatory agents, for example non-steroidal anti-inflammatories (NSAIDs) such as cyclooxygenase-1 (COX-1) inhibitors (e.g., acetylsalicylic acid, for example ASPIRIN® from Bayer AG,

Leverkusen, Germany; ibuprofen, for example ADVIL® from Wyeth, Collegeville, PA; indomethacin; mefenamic acid), COX-2 inhibitors (e.g., VIOXX® from Merck & Co., Inc., Whitehouse Station, NJ; CELEBREX® from Pharmacia Corp., Peapack, NJ; COX-1 inhibitors); immunosuppressive agents, for example Sirolimus (RAPAMUNE®, from Wyeth, Collegeville, PA), or matrix metalloproteinase (MMP) inhibitors (e.g., tetracycline and tetracycline derivatives) that act early within the pathways of an inflammatory response. Examples of other agents are provided in Walton et al, Inhibition of Prostoglandin E_2 Synthesis in Abdominal Aortic Aneurysms, Circulation, July 6, 1999, 48-54; Tambiah et al, Provocation of Experimental Aortic Inflammation Mediators and Chlamydia Pneumoniae, Brit. J. Surgery 88 (7), 935-940; Franklin et al, Uptake of Tetracycline by Aortic Aneurysm Wall and Its Effect on Inflammation and Proteolysis, Brit. J. Surgery 86 (6), 771-775; Xu et al, Sp1 Increases Expression of Cyclooxygenase-2 in Hypoxic Vascular Endothelium, J. Biological Chemistry 275 (32) 24583-24589; and Pyo et al, Targeted Gene Disruption of Matrix Metalloproteinase-9 (Gelatinase B) Suppresses Development of Experimental Abdominal Aortic Aneurysms, J. Clinical Investigation 105 (11), 1641-1649 which are all incorporated by reference in their entireties.

[0224] Any elements described herein as singular can be pluralized (i.e., anything described as "one" can be more than one). Any species element of a genus element can have the characteristics or elements of any other species element of that genus. The above-described configurations, elements or complete assemblies and methods and their elements for carrying out the invention, and variations of aspects of the invention can be combined and modified with each other in any combination.

CLAIMS

We claim:

1. A method of using an orthopedic support device comprising:

positioning the device at a target site, wherein the device has a longitudinal axis, and wherein the longitudinal axis has a radius of curvature less than about 40 cm, and wherein the device comprises a first plate, a second plate opposite to the first plate, a first wedge between the first plate and the second plate at a first end of the device, and a second wedge between the first plate and the second plate at a second end of the device, wherein the first plate has a first extension extending in the direction of the second plate, and wherein the second plate has a first receiver configured to receive the first extension; and

expanding the device at the target site, wherein expanding the target site comprises longitudinally moving the first wedge and the second wedge toward the longitudinal middle of the device, and wherein the first extension slides in the first receiver during the expansion of the device.

2. The method of Claim 1, wherein expanding further comprises restricting longitudinal translation between the first plate and the second plate.

3. The method of Claim 2, wherein the restricting longitudinal translation comprises sliding of the first extension in the first receiver.

4. An implantable orthopedic device having a longitudinal axis comprising:

a first plate having a longitudinal axis having a radius of curvature less than about 40 cm;

a second plate opposite to the first plate;

a first wedge between the first plate and the second plate at a first longitudinal end of the device; and

a second wedge between the first plate and the second plate at a second longitudinal end of the device;

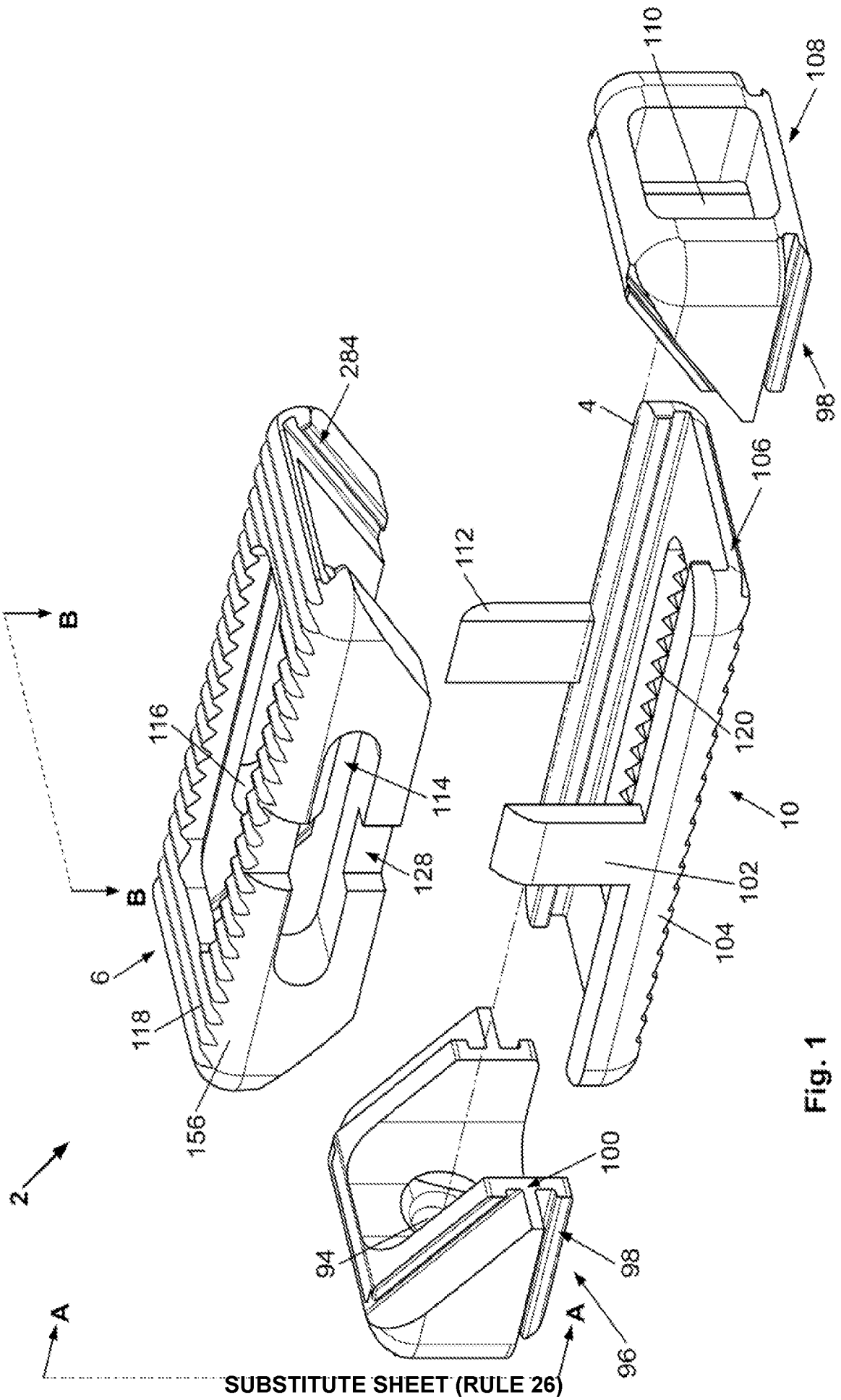
wherein the first plate has a first extension extending in the direction of the second plate, and wherein the second plate has a first receiver configured to slidably receive the first extension; and

wherein the first wedge is longitudinally translatable toward the second wedge, and wherein the first extension slides.

5. The device of Claim 4, wherein the first plate has a first plate face substantially defining a first plane, and wherein the first extension extends away from the first plate face in a direction perpendicular to the first plane.

6. The device of Claim 5, wherein the second plate has a second plate face substantially defining a second plane, and wherein the first receiver is configured to slidably receive the first extension in a slidable direction perpendicular to the second plane.

7. The device of Claim 6, wherein the second plane is parallel with the first plane.


110
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98
106
112
B
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10
B
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6
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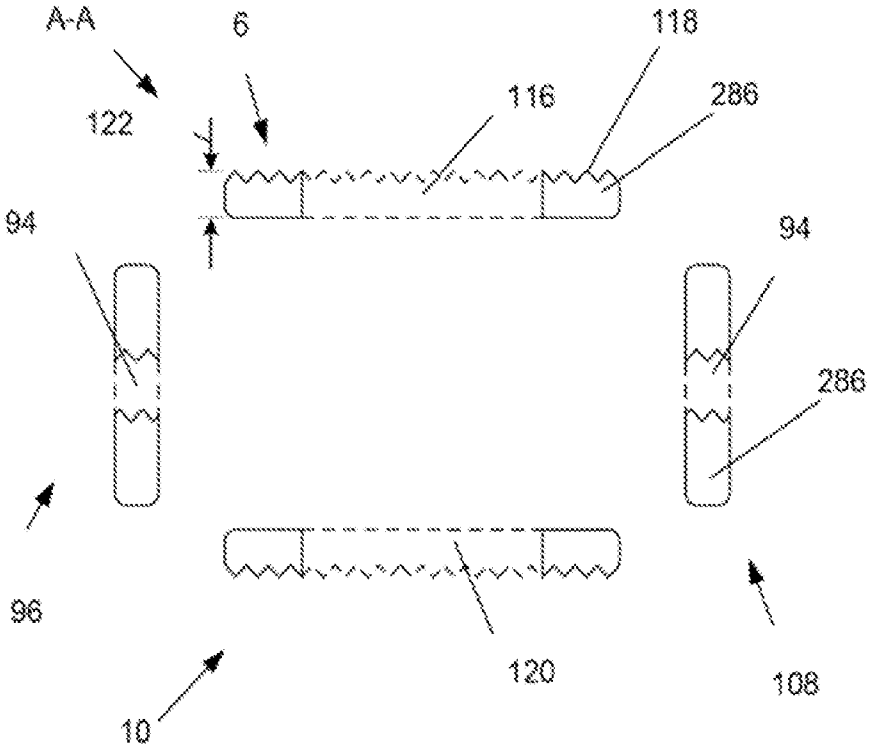
118
156
2
100
94
98
A
A
96

Fig. 1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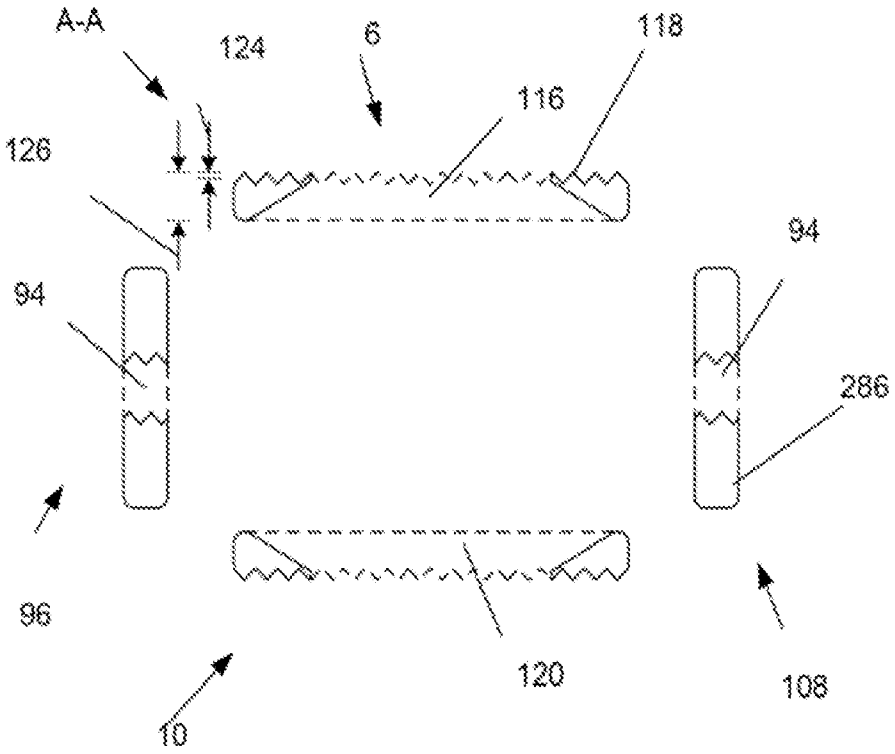
108
10

Fig. 2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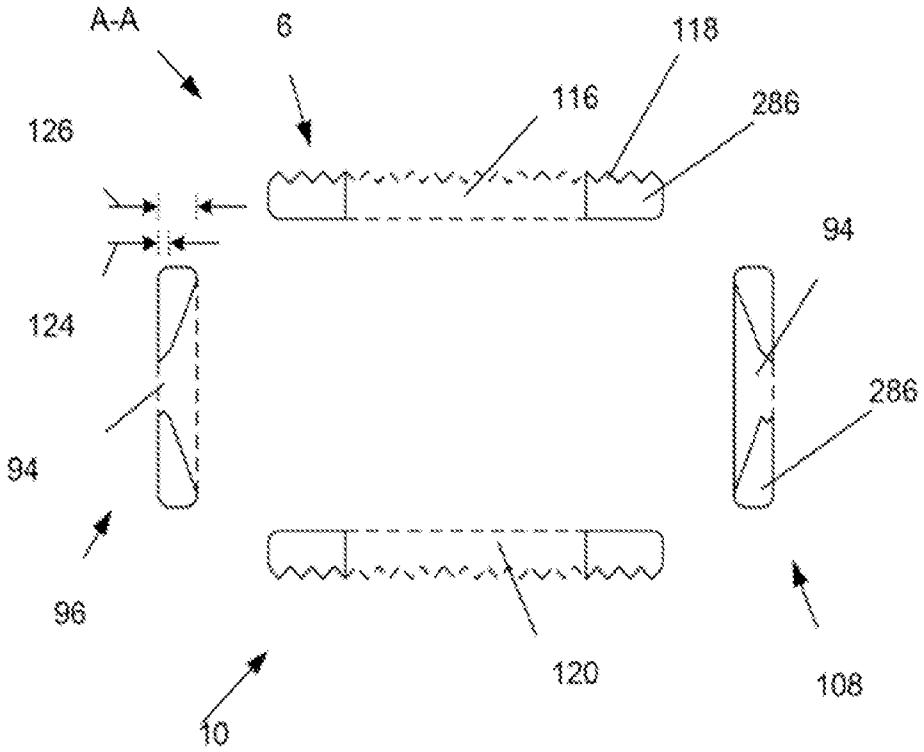
120
108
10

Fig. 3



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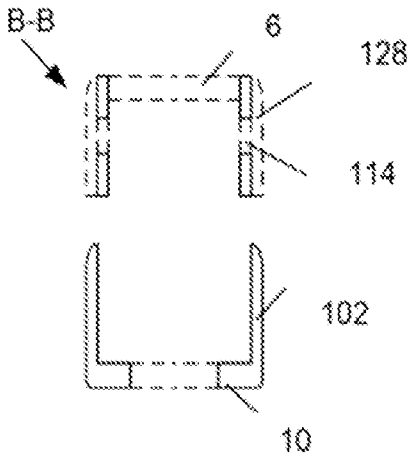

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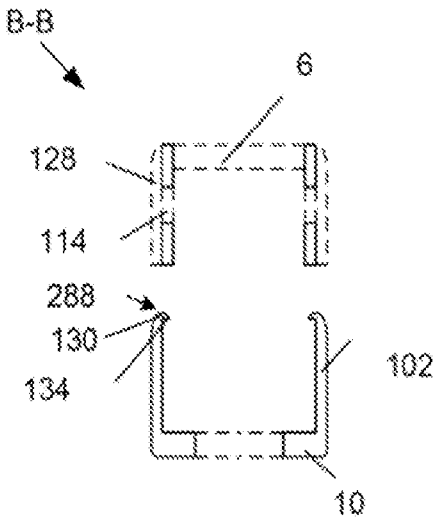


Fig. 6

Fig. 7

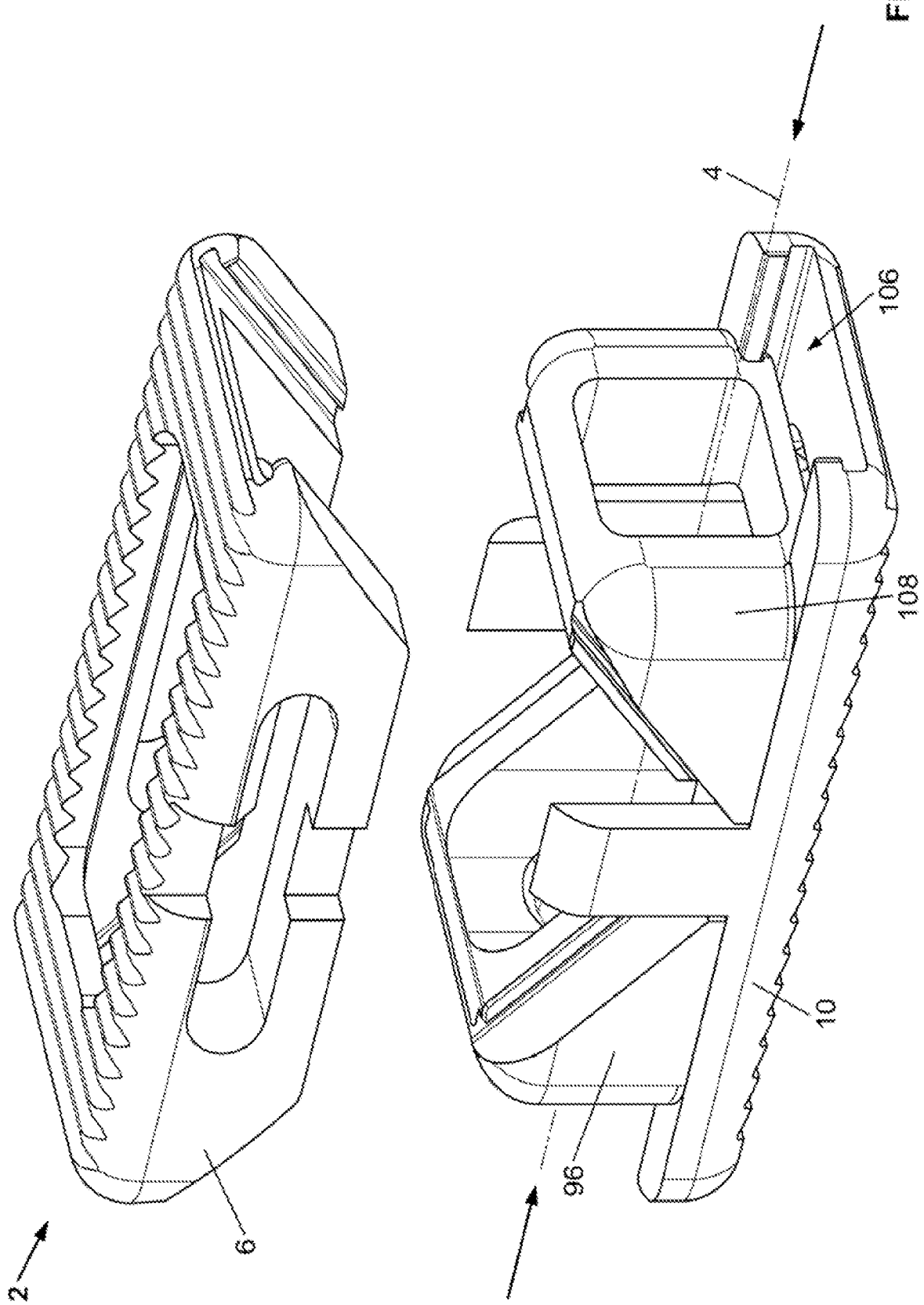
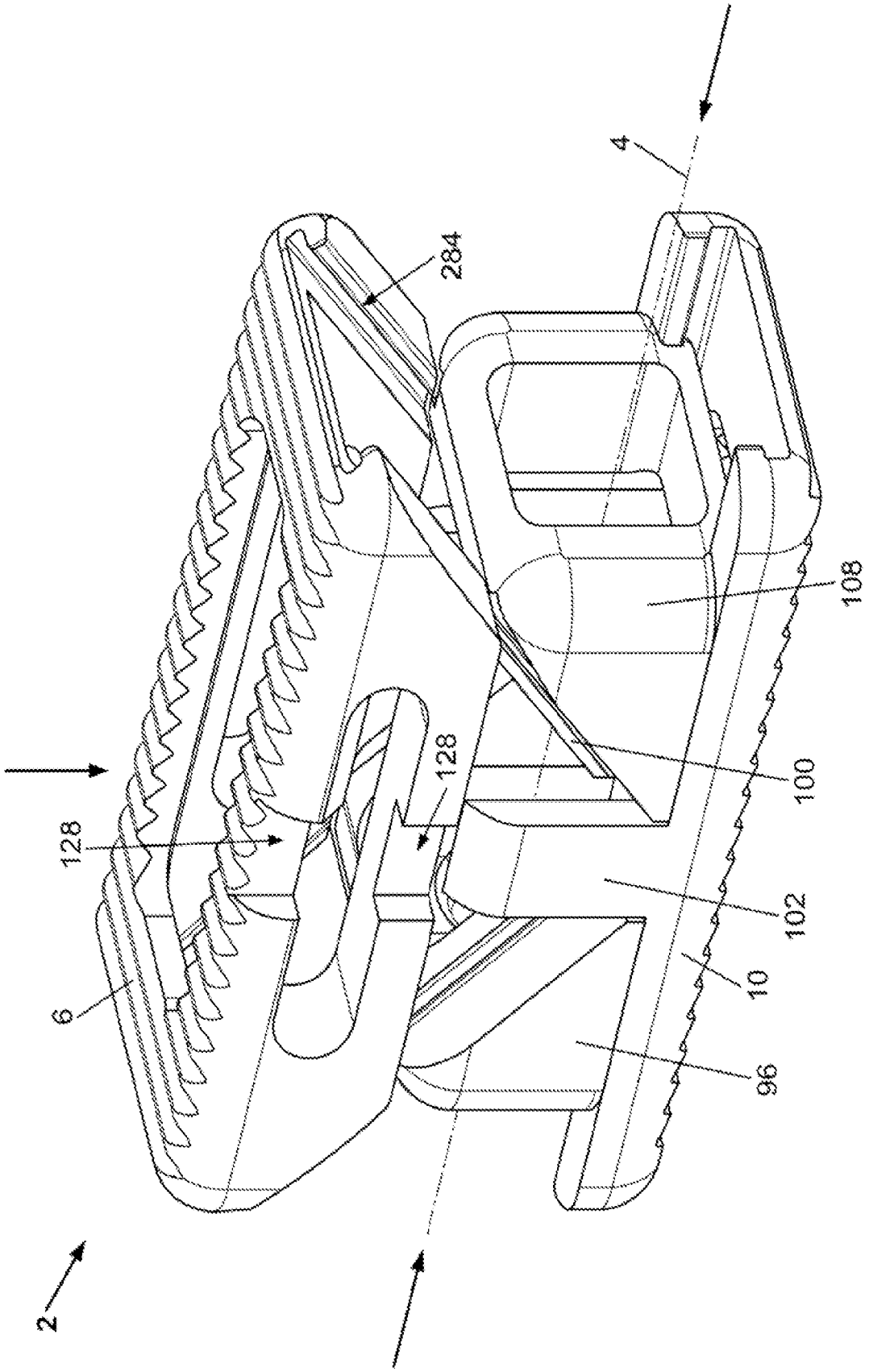


Fig. 8



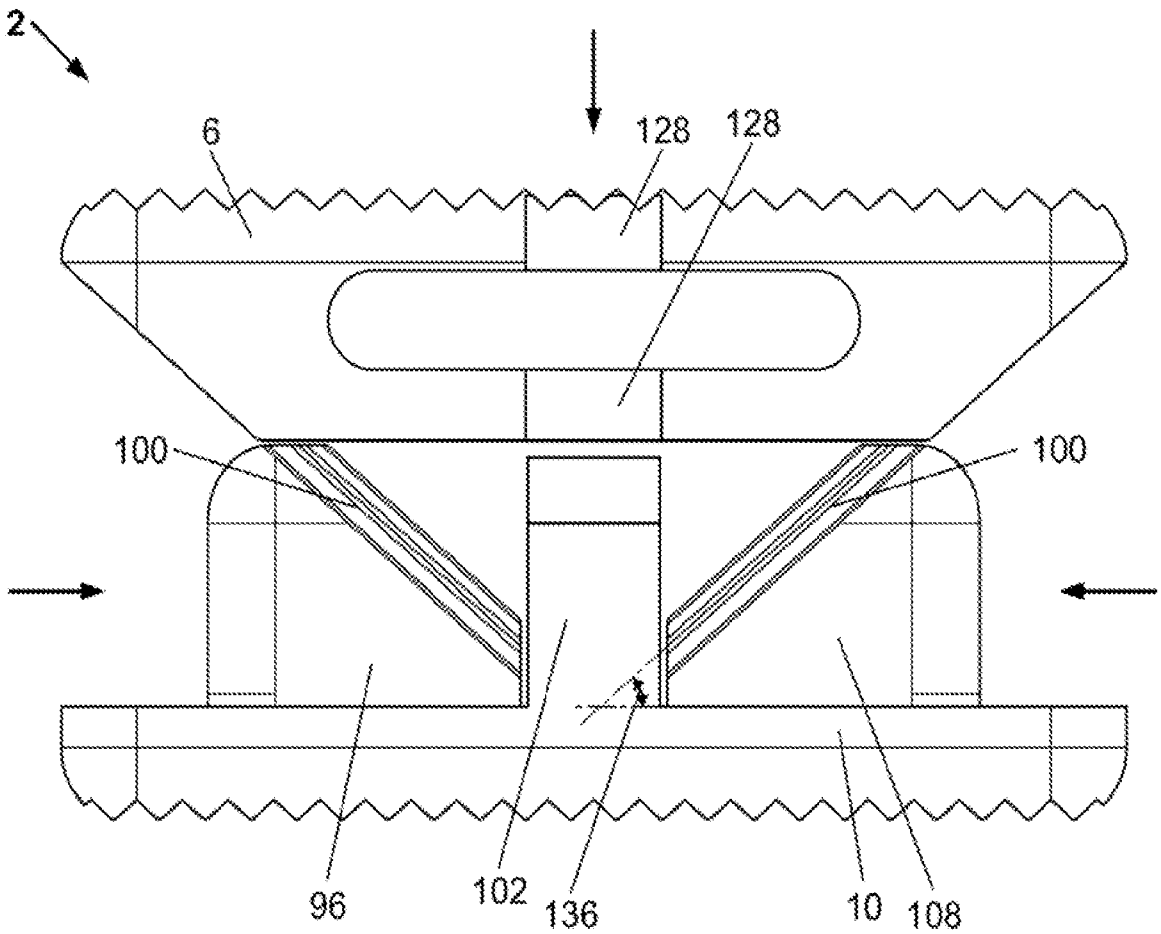


Fig. 9

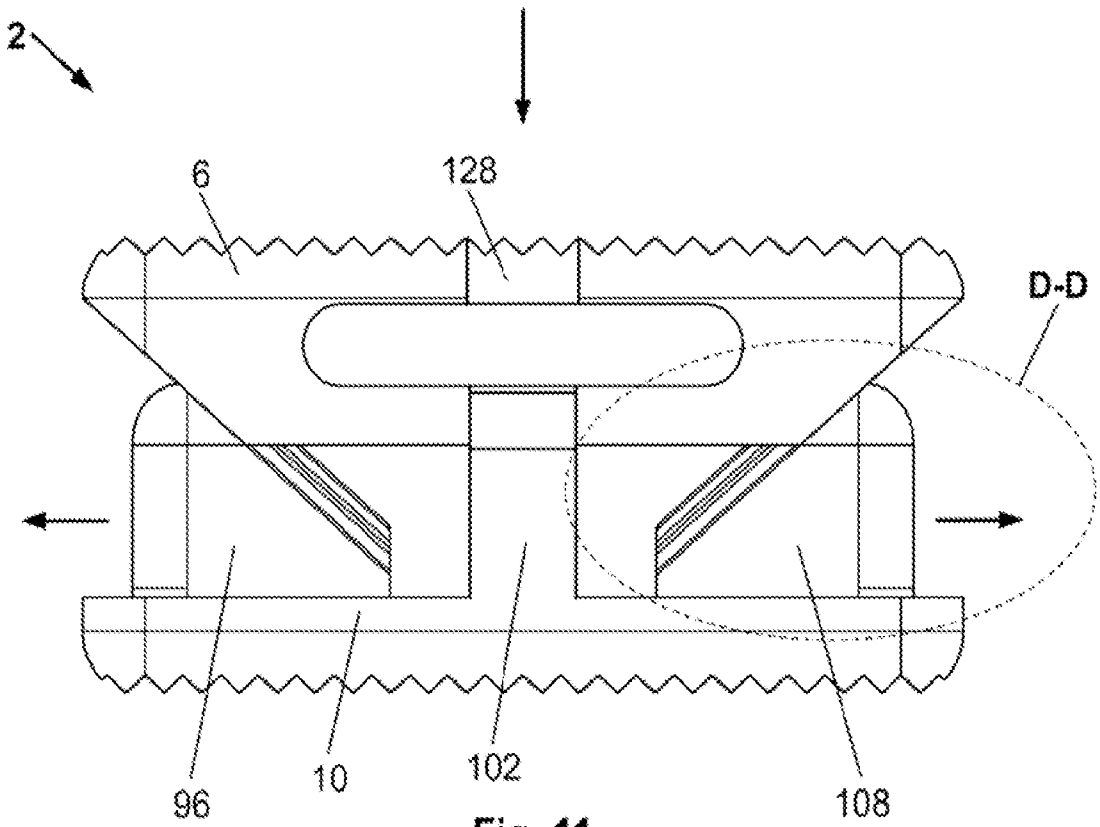
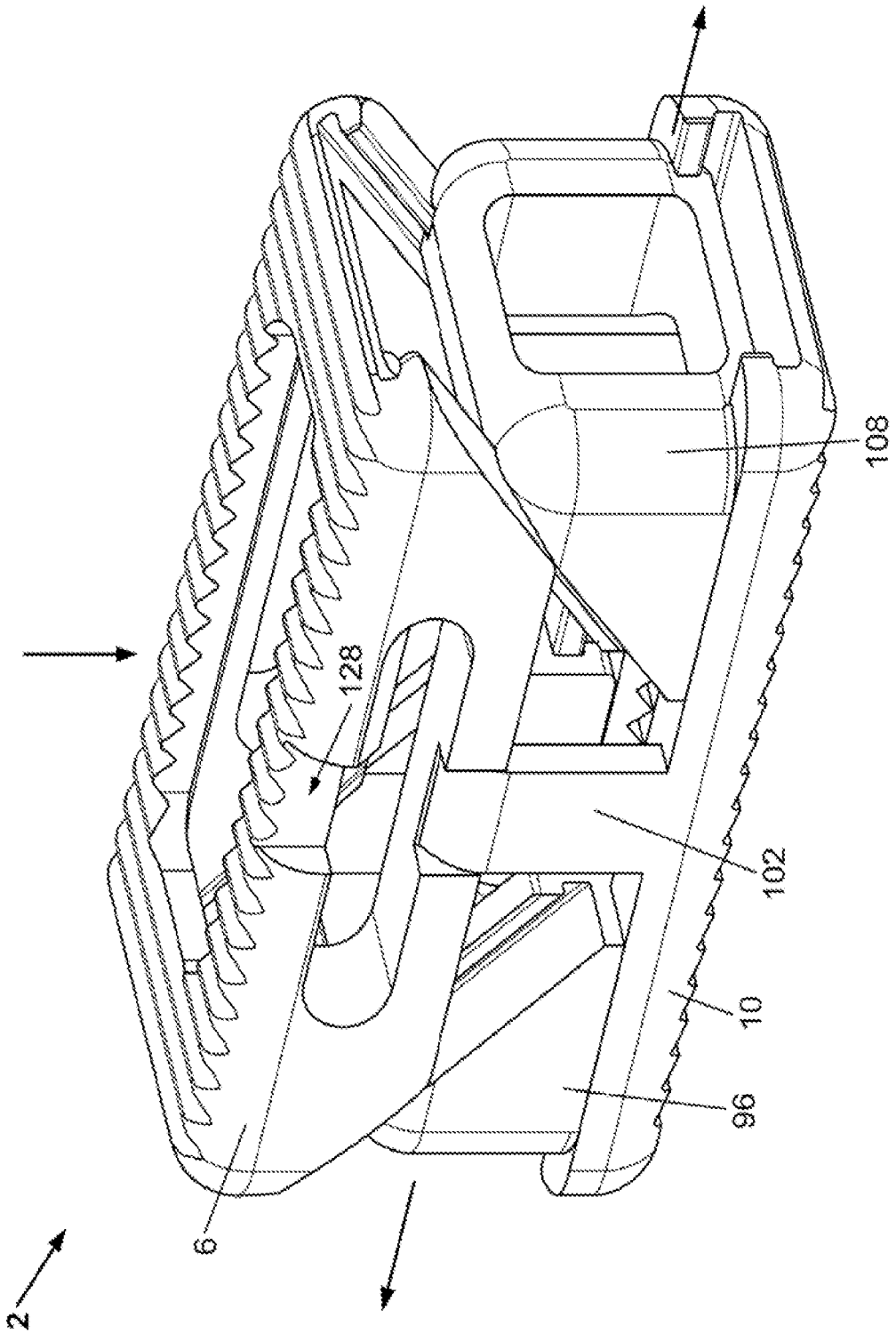


Fig. 11



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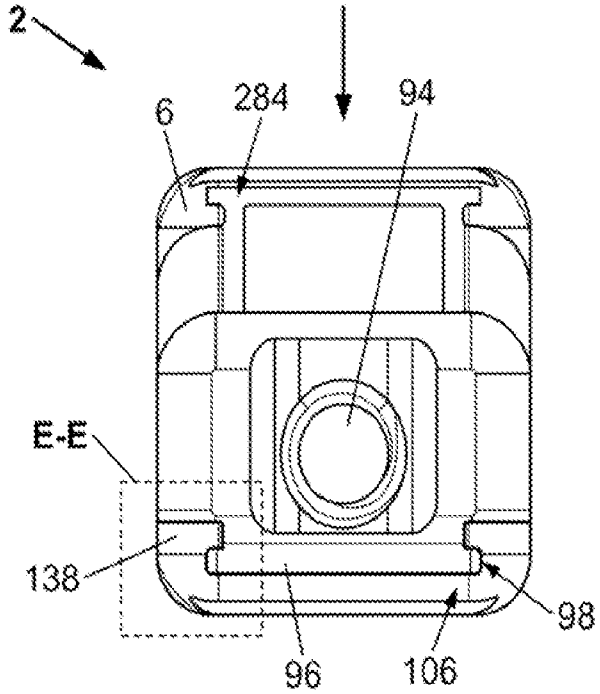

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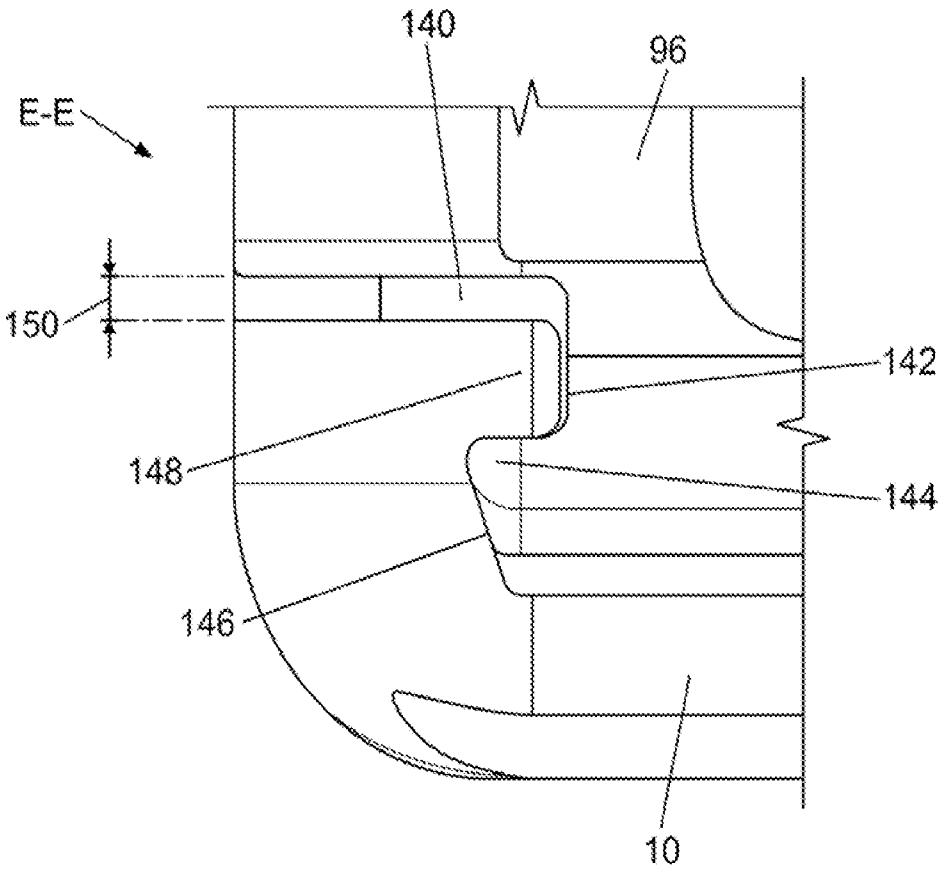

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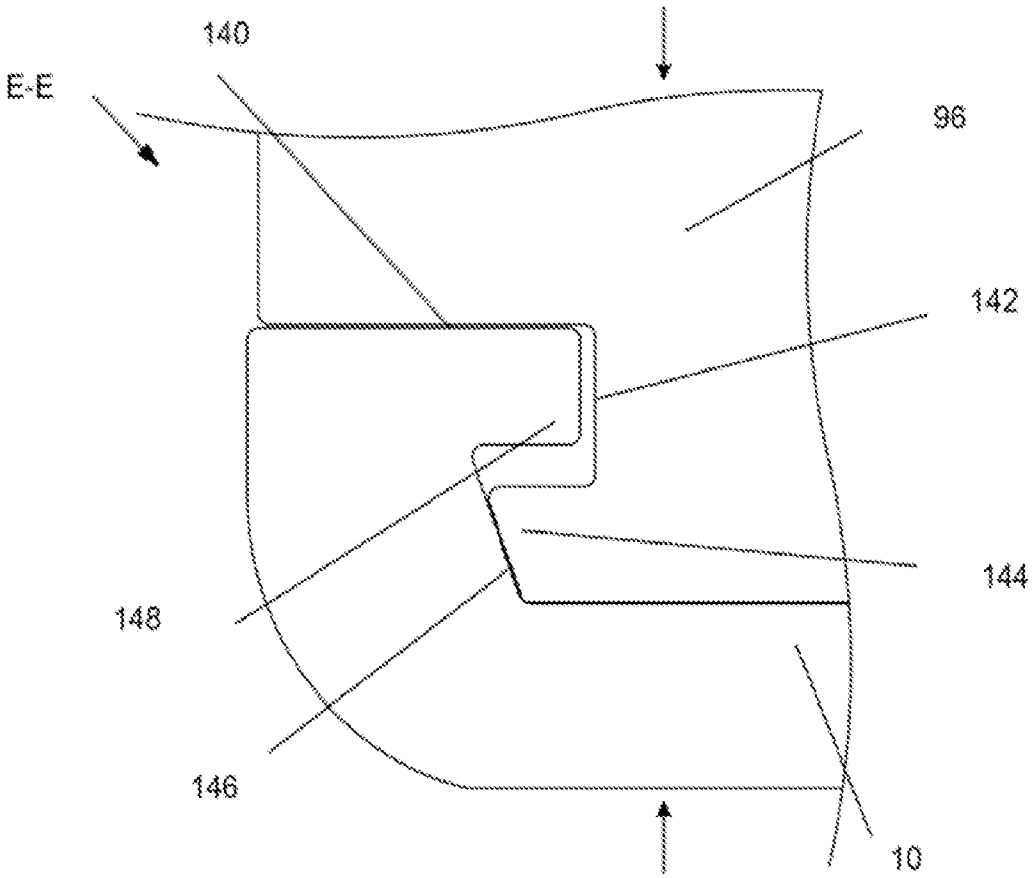

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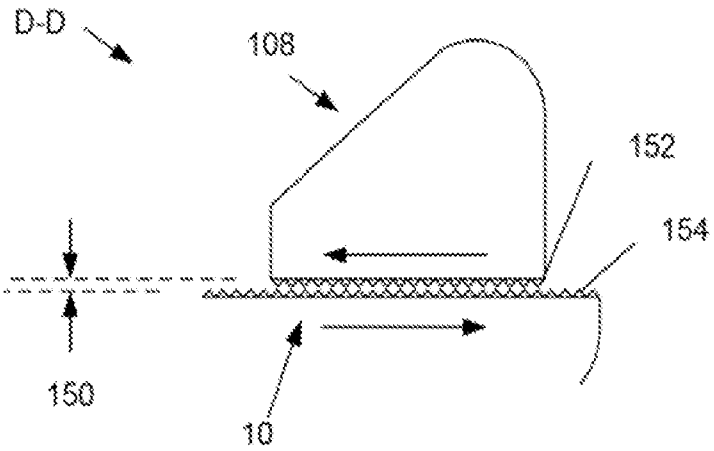

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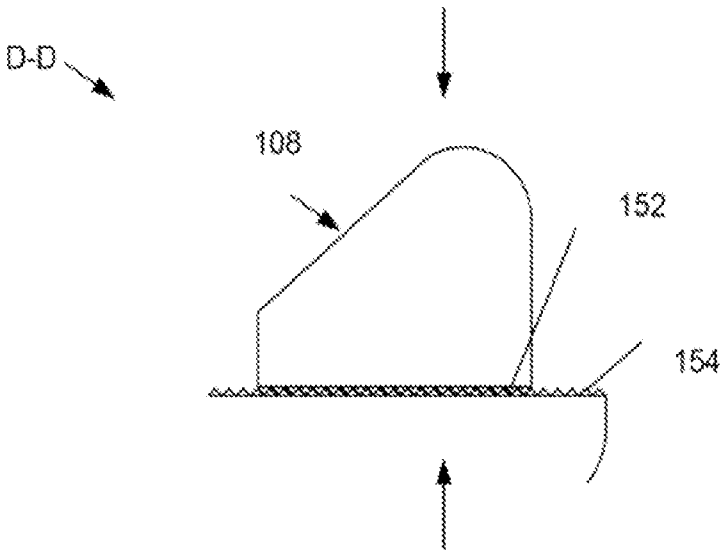

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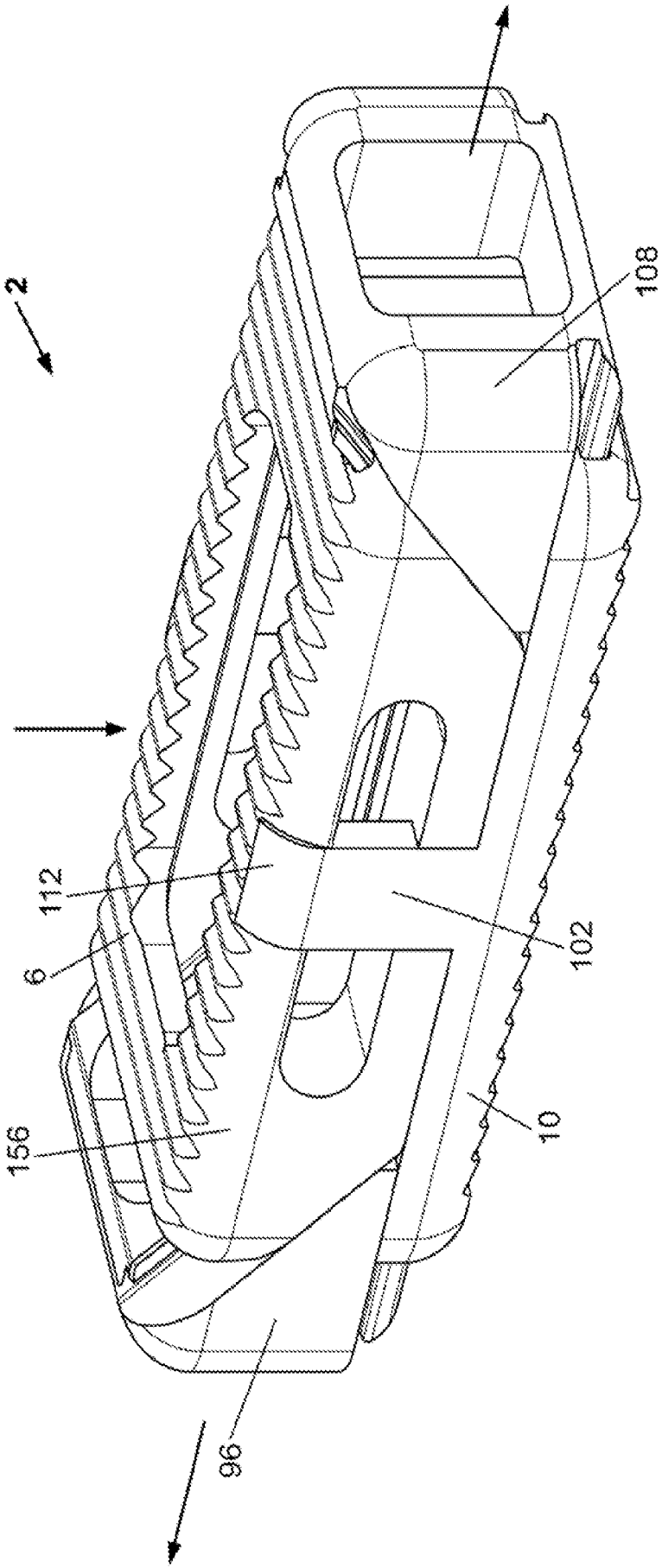

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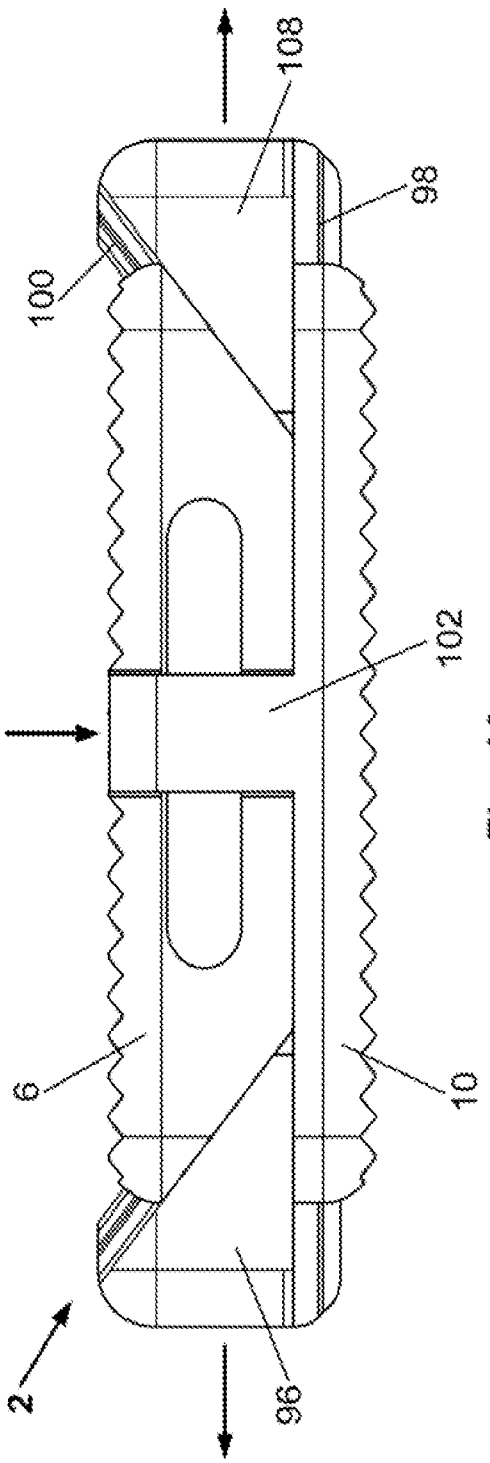

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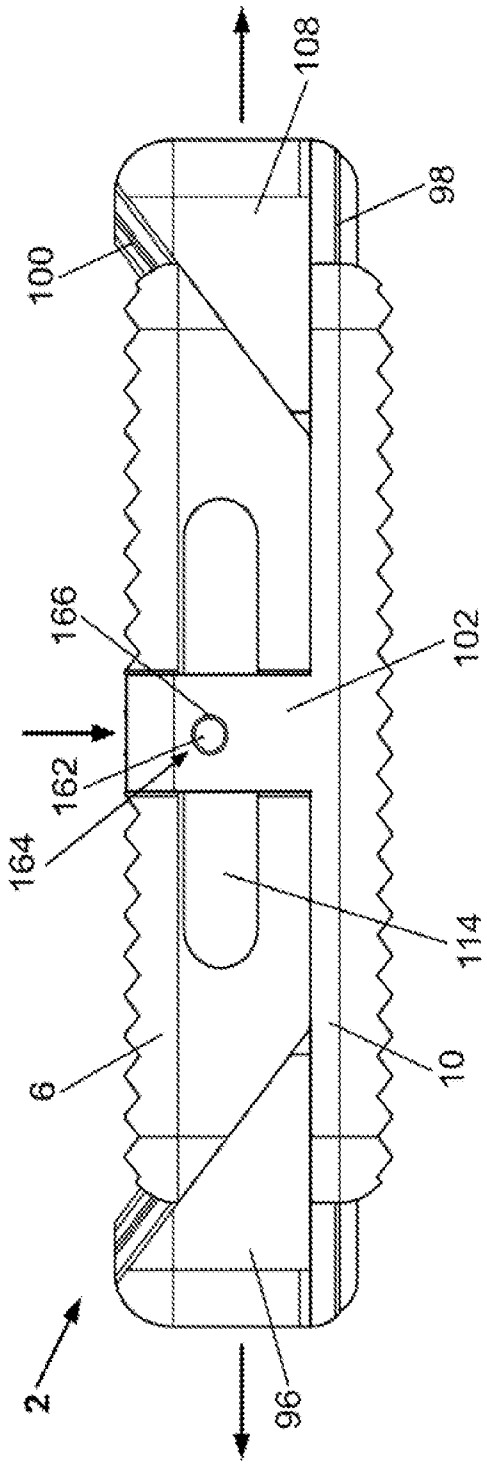

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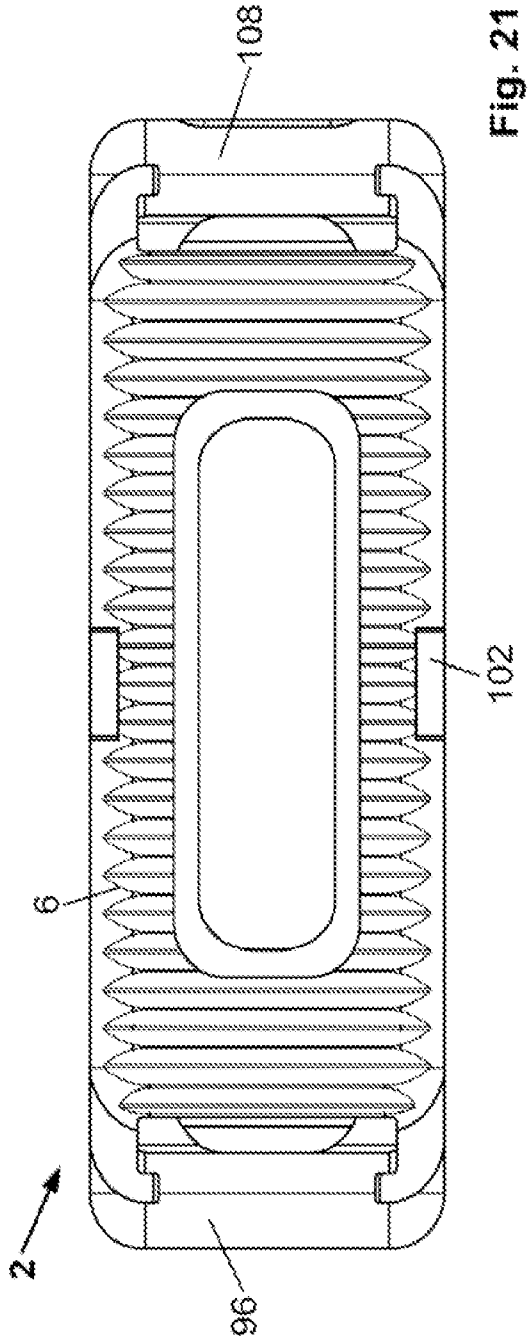

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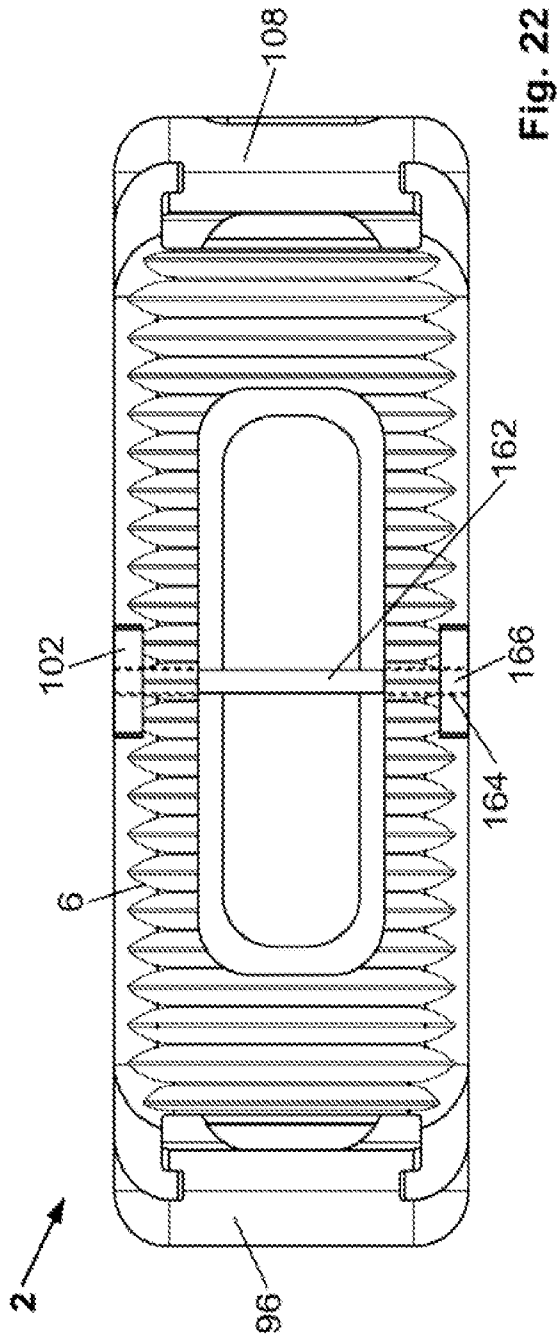

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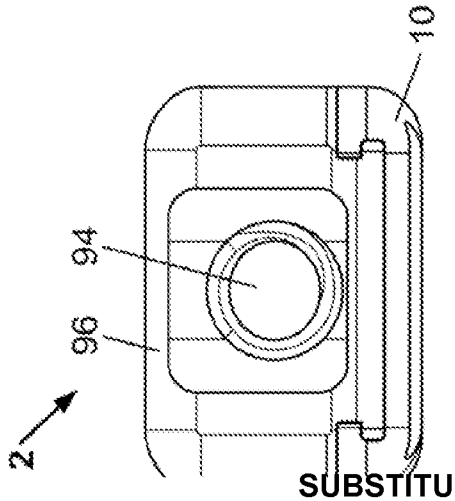

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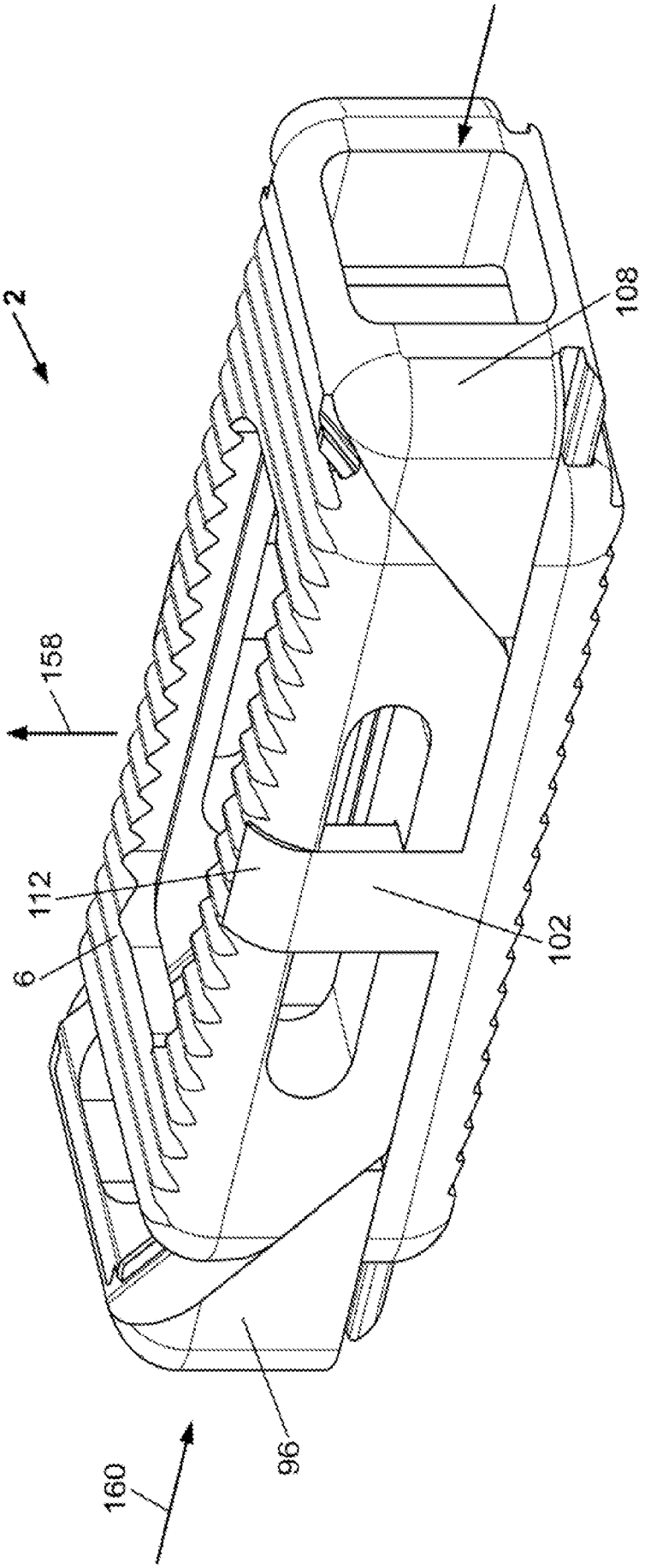

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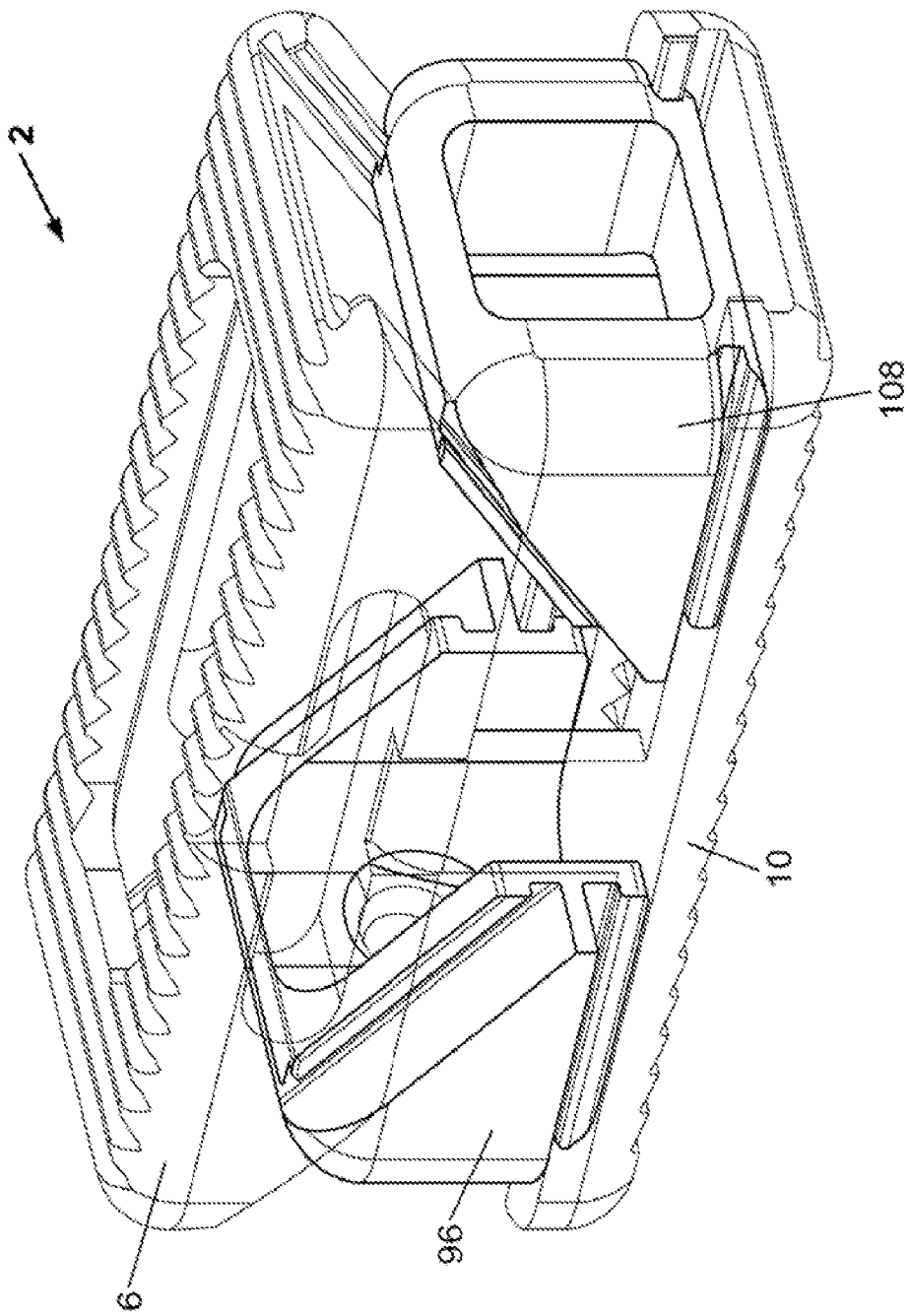
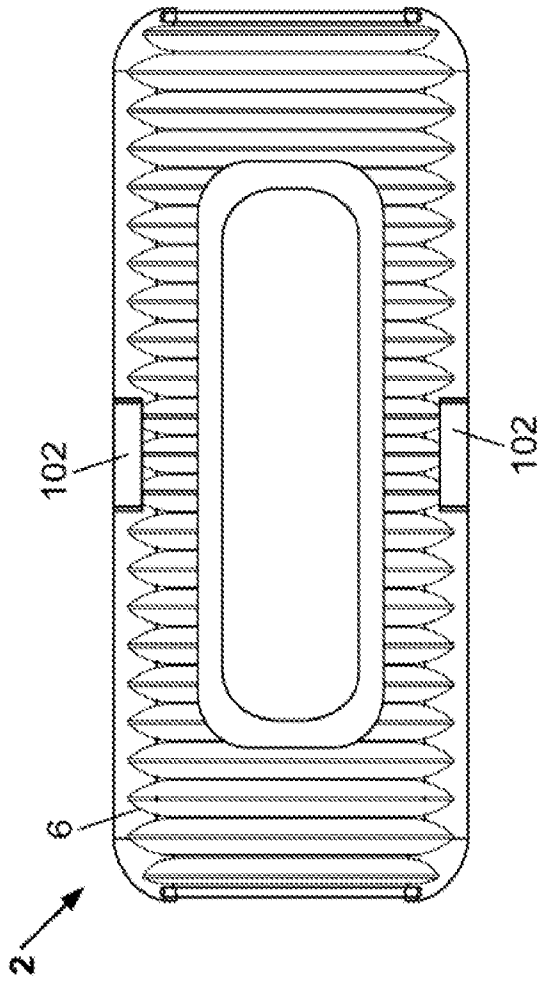
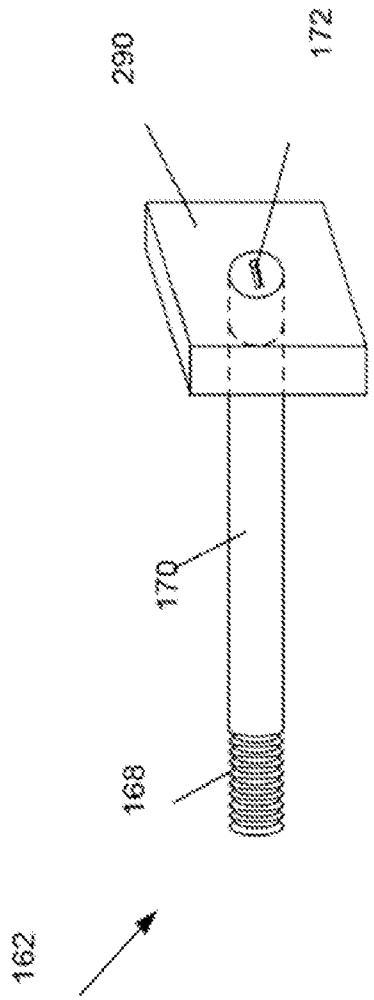


Fig. 24

Fig. 25





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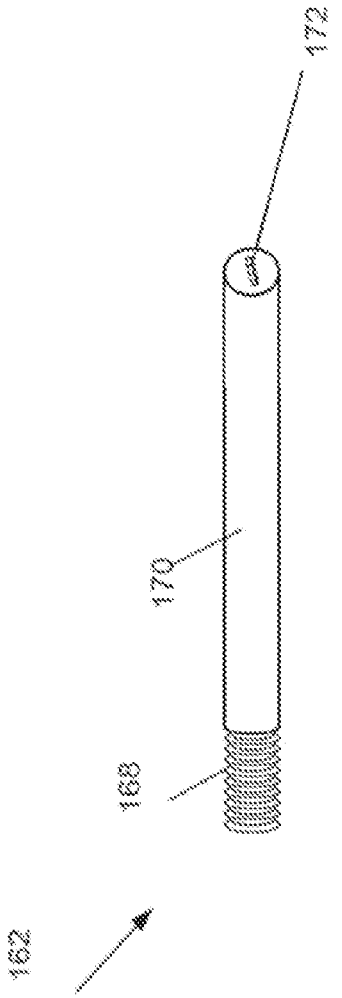

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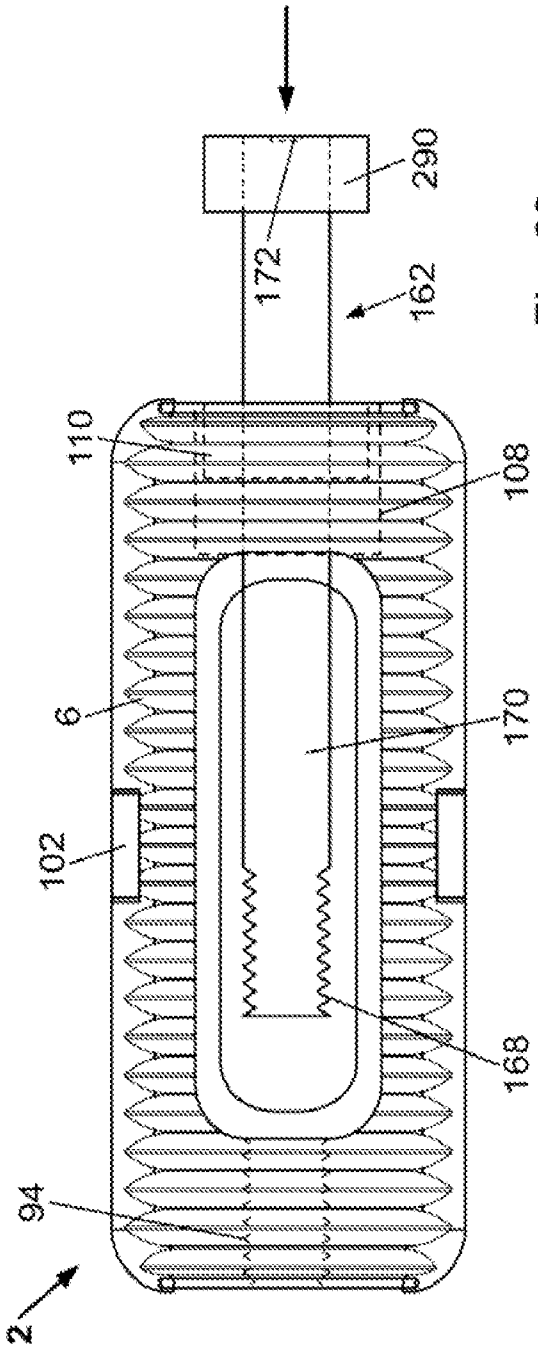

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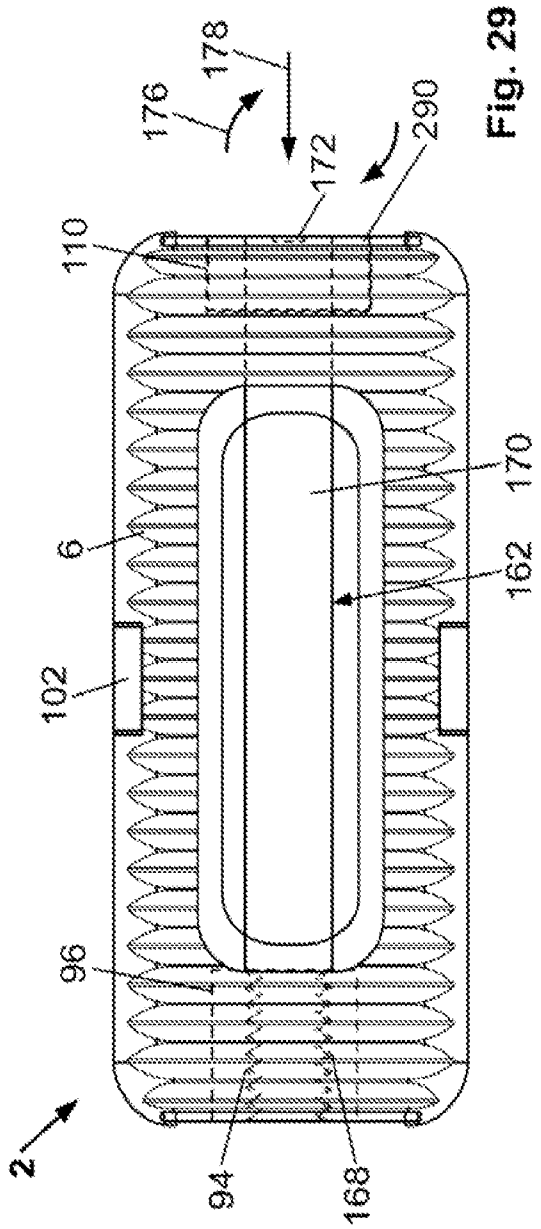
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Fig. 29

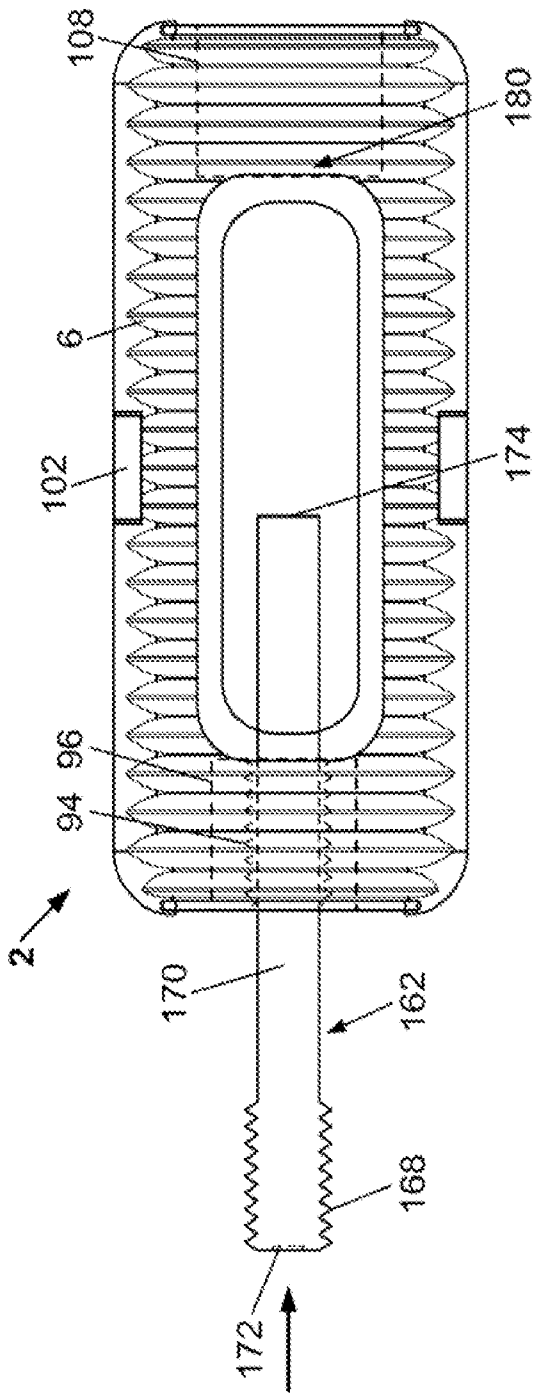
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Fig. 30

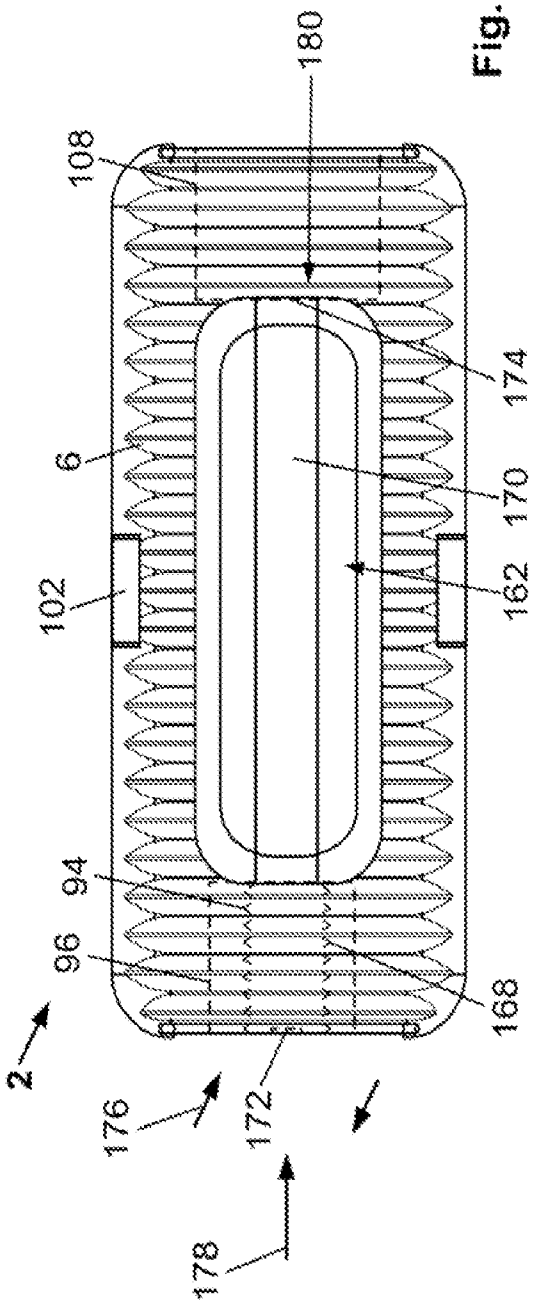
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Fig. 31

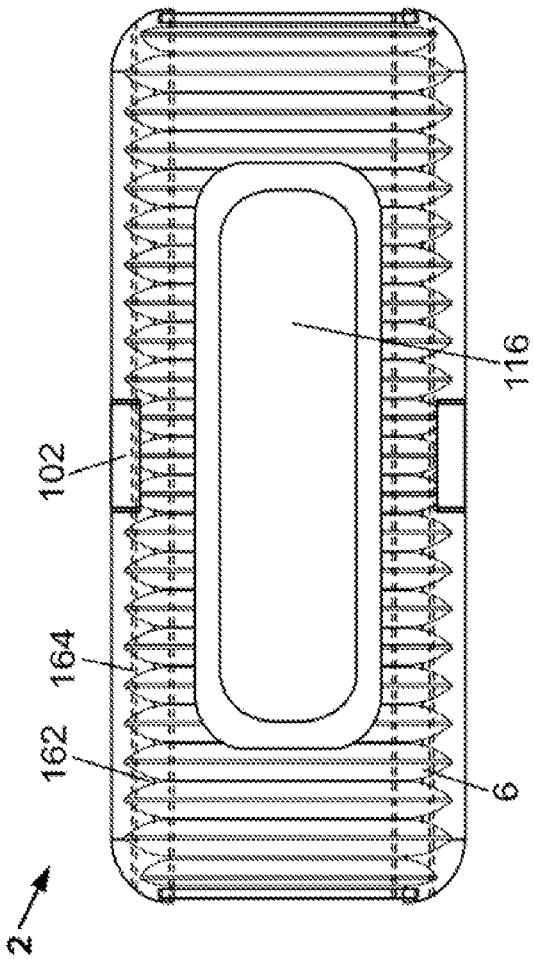
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Fig. 32

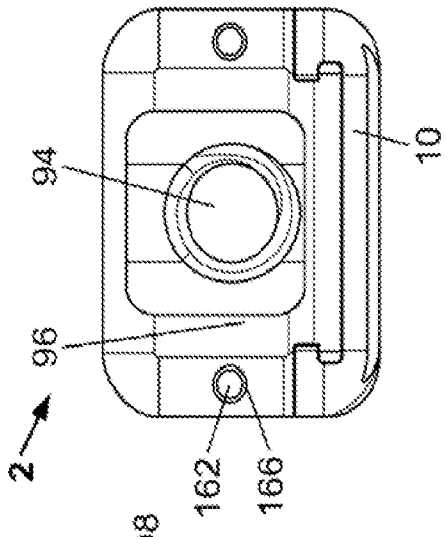

Fig. 34

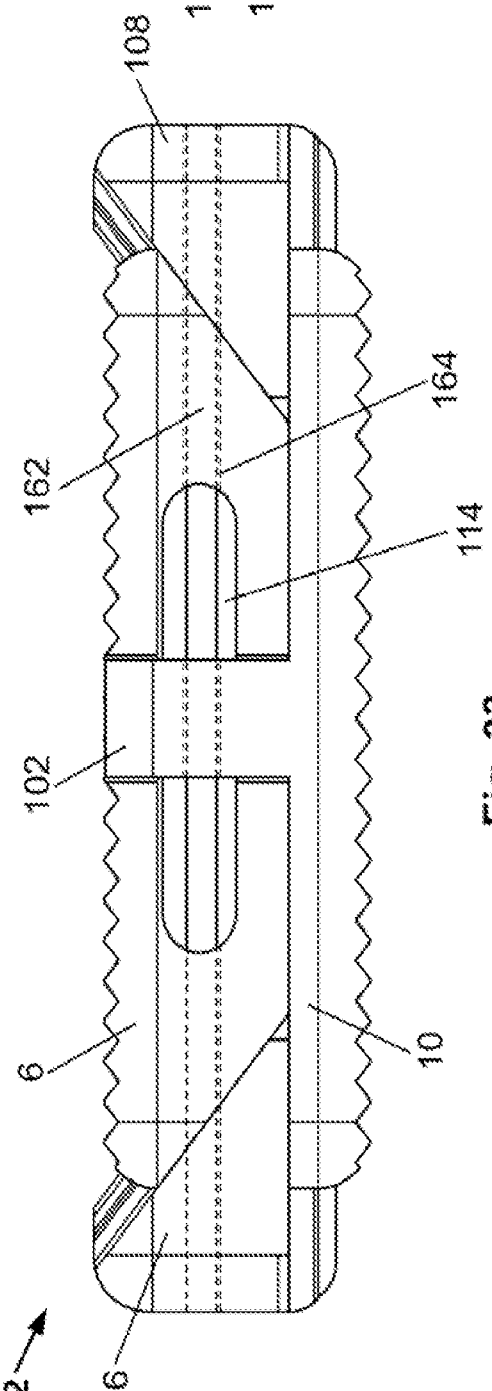

Fig. 33

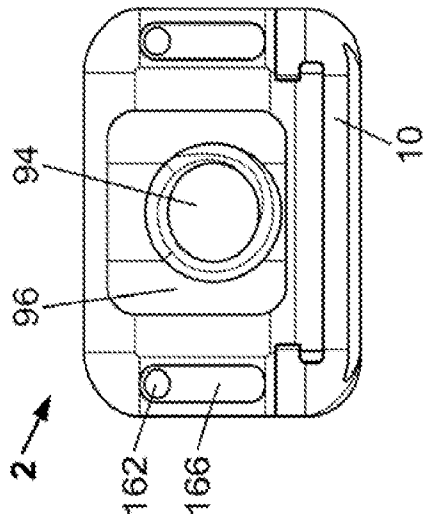

Fig. 36

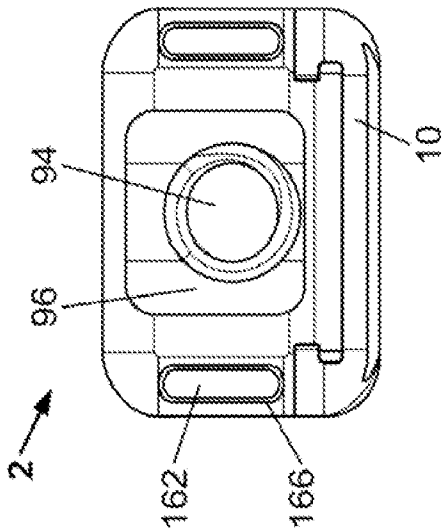

Fig. 38

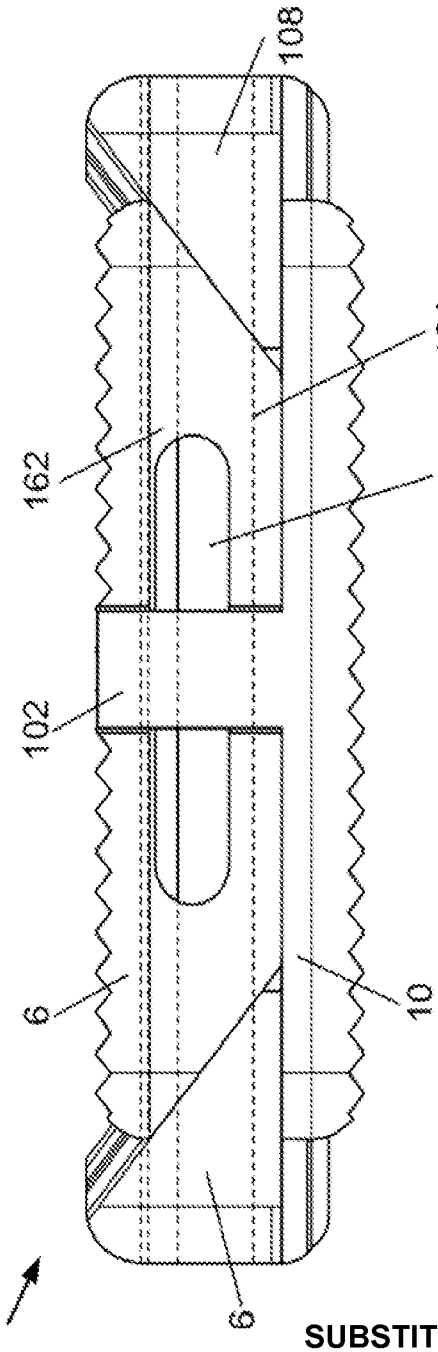

Fig. 35

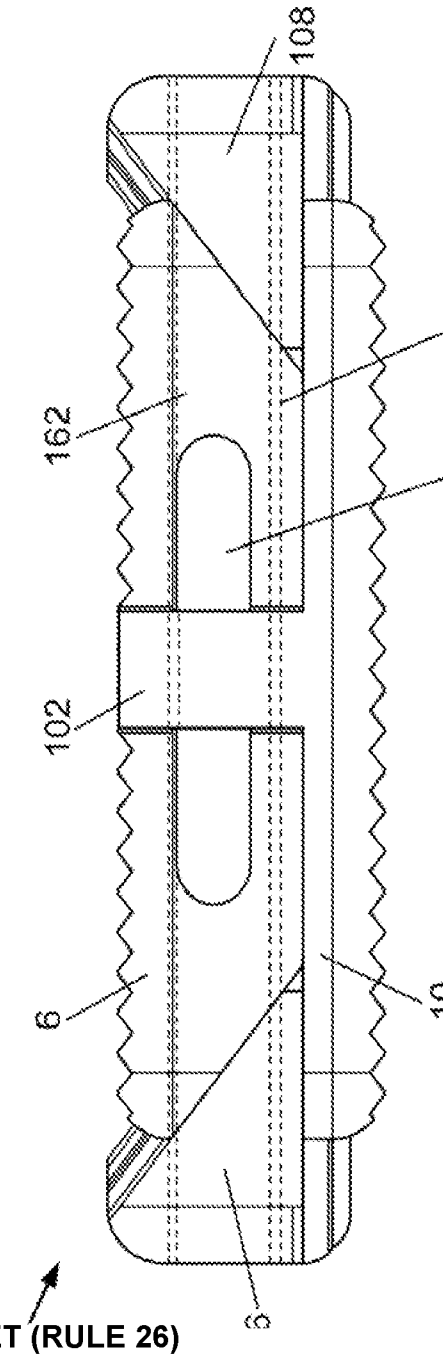

Fig. 37

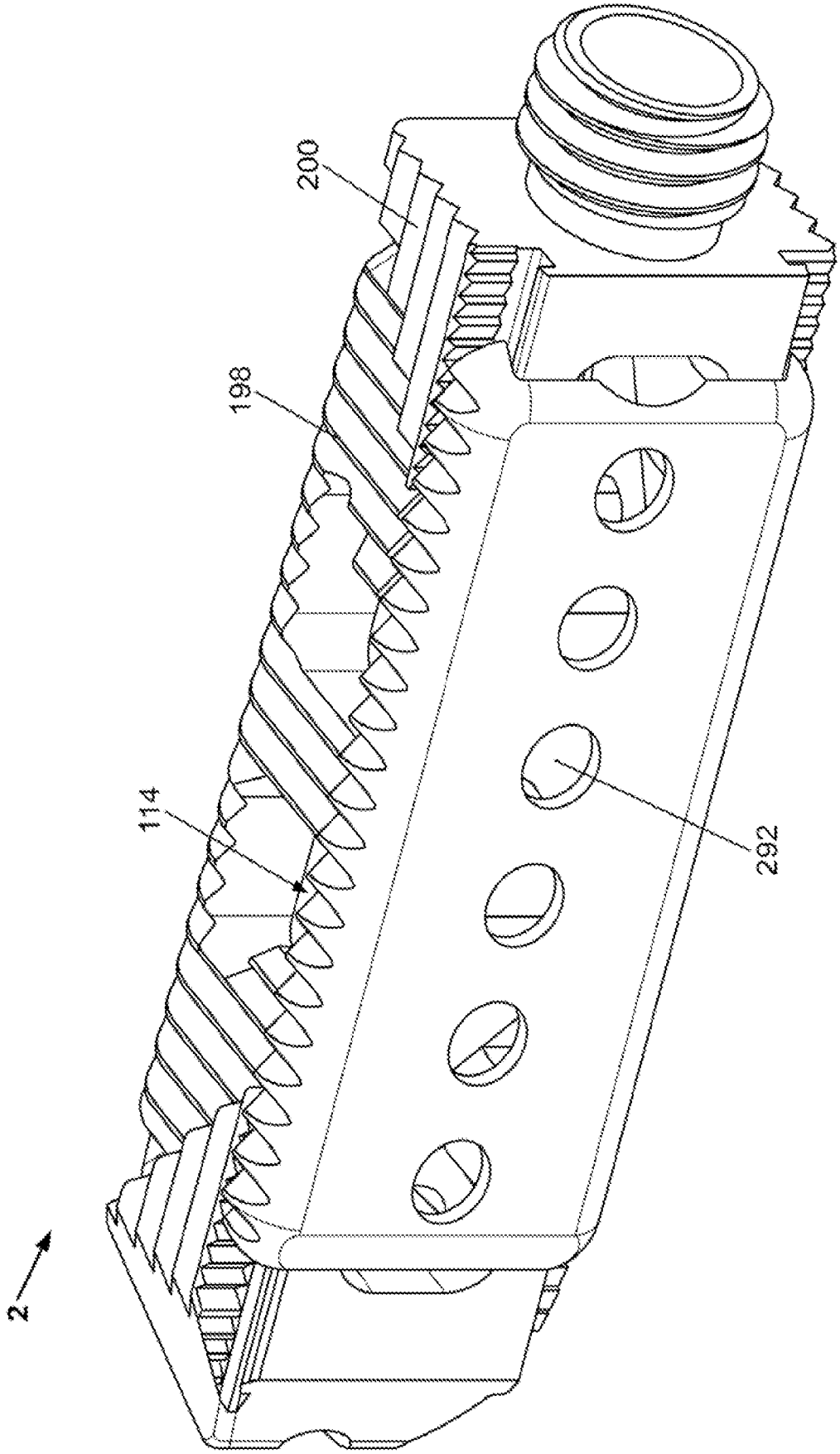

Fig. 39a

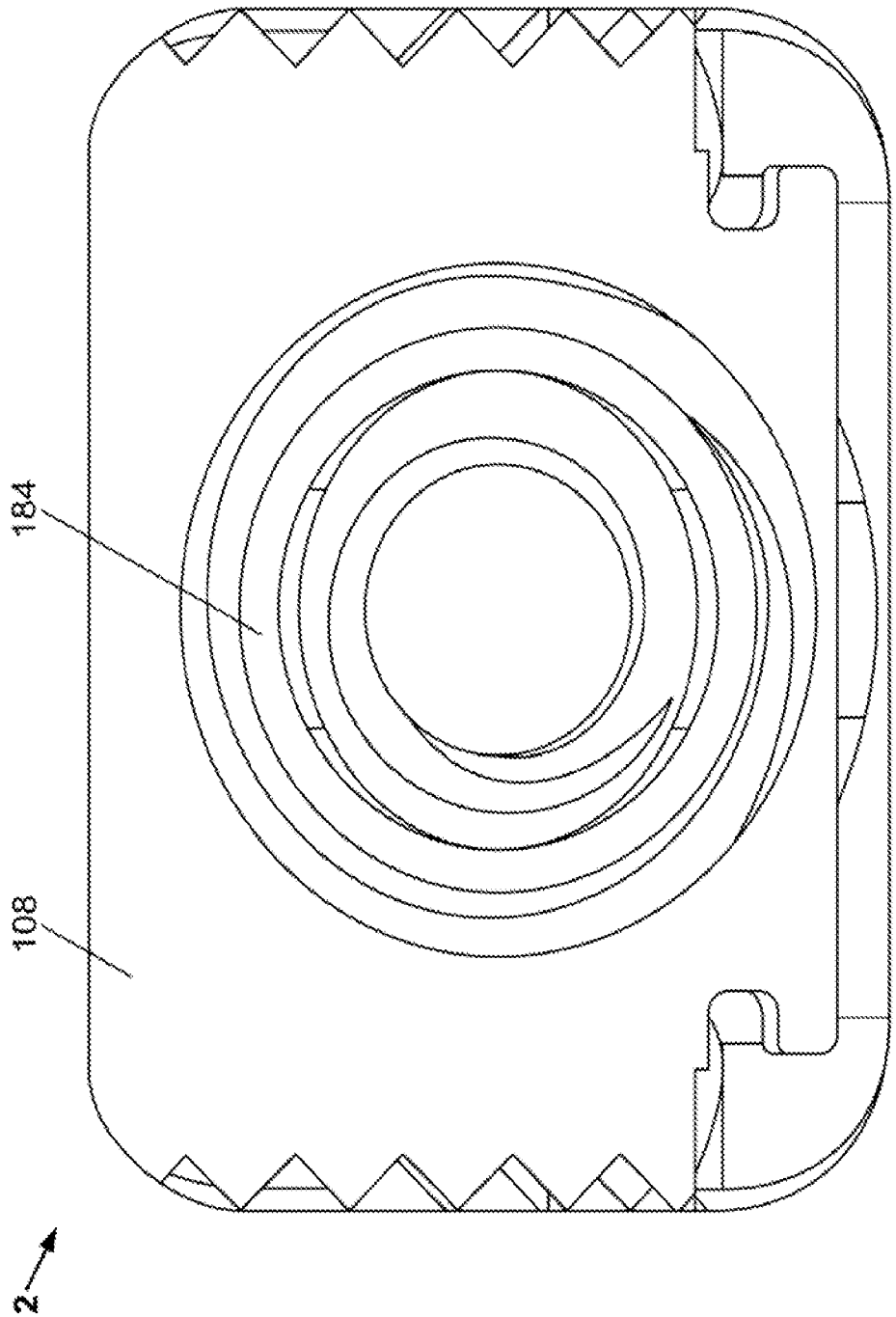

Fig. 39b

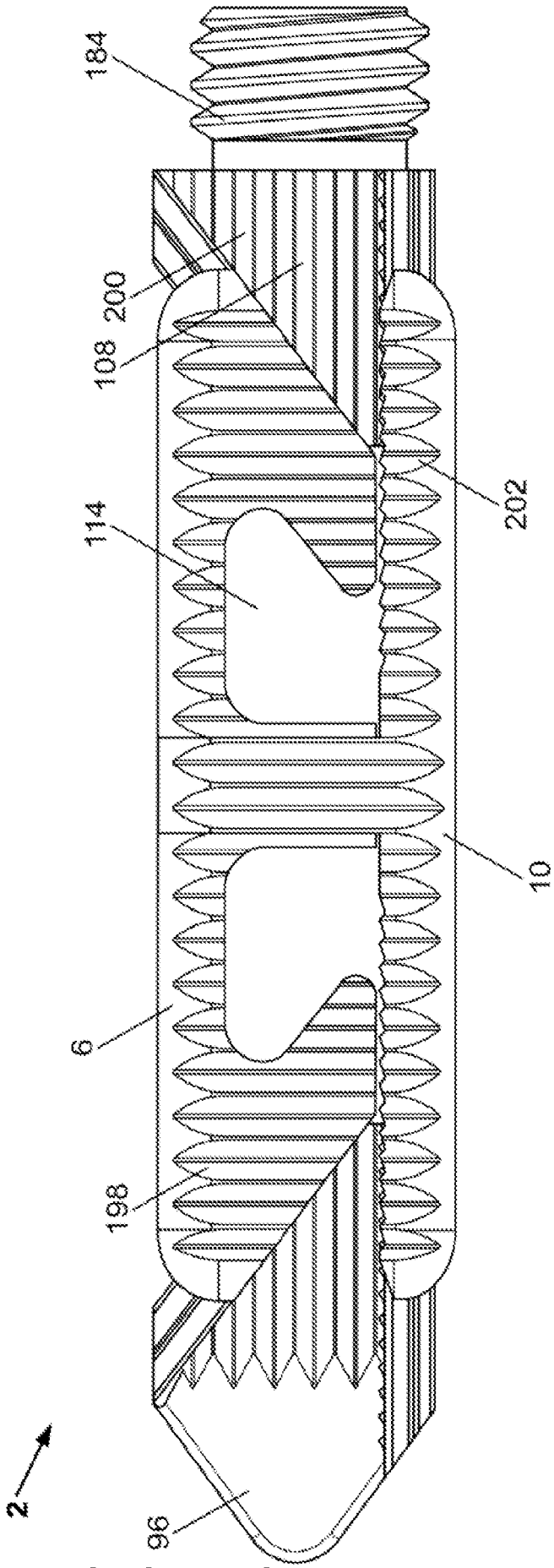

Fig. 39c

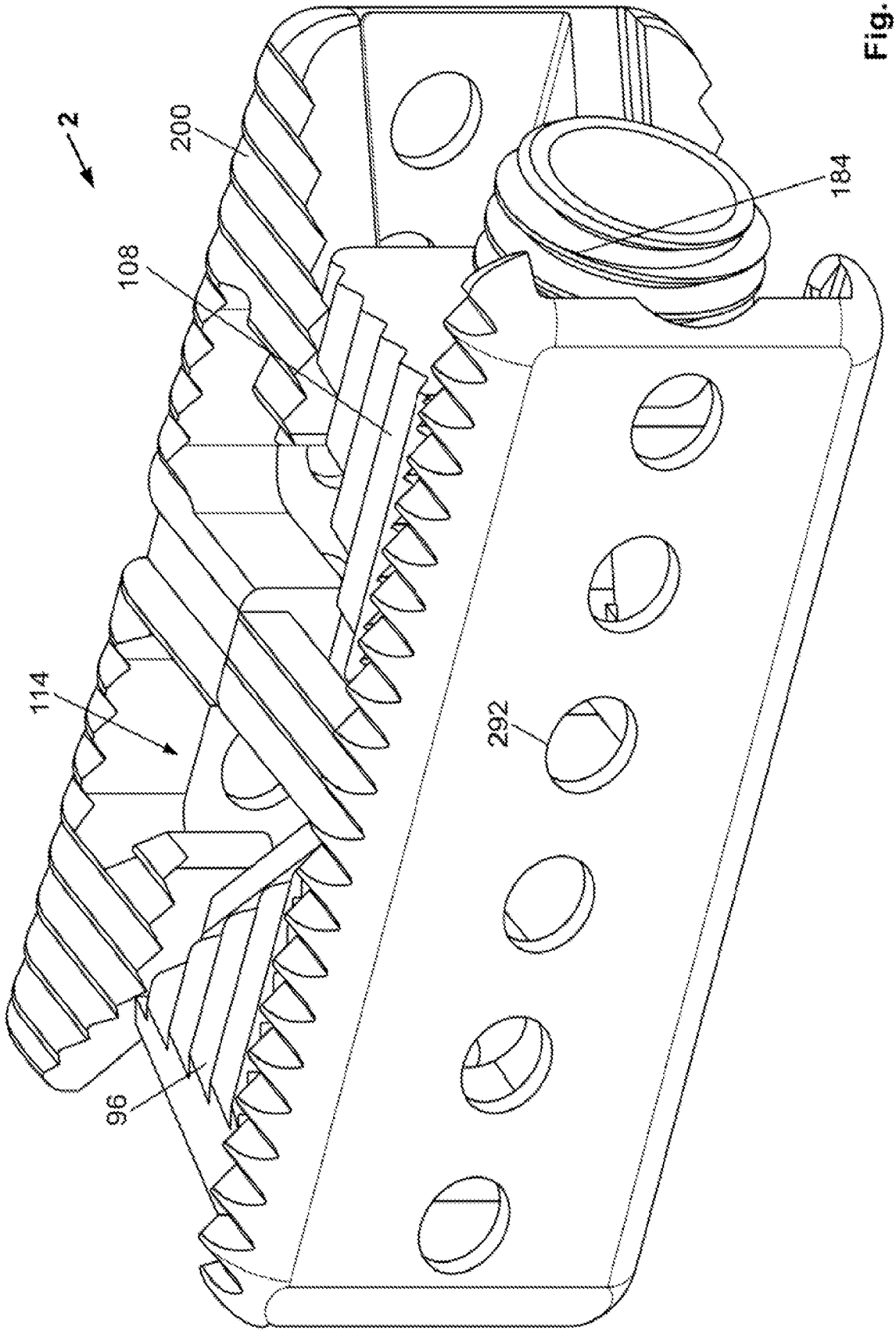

Fig. 40a

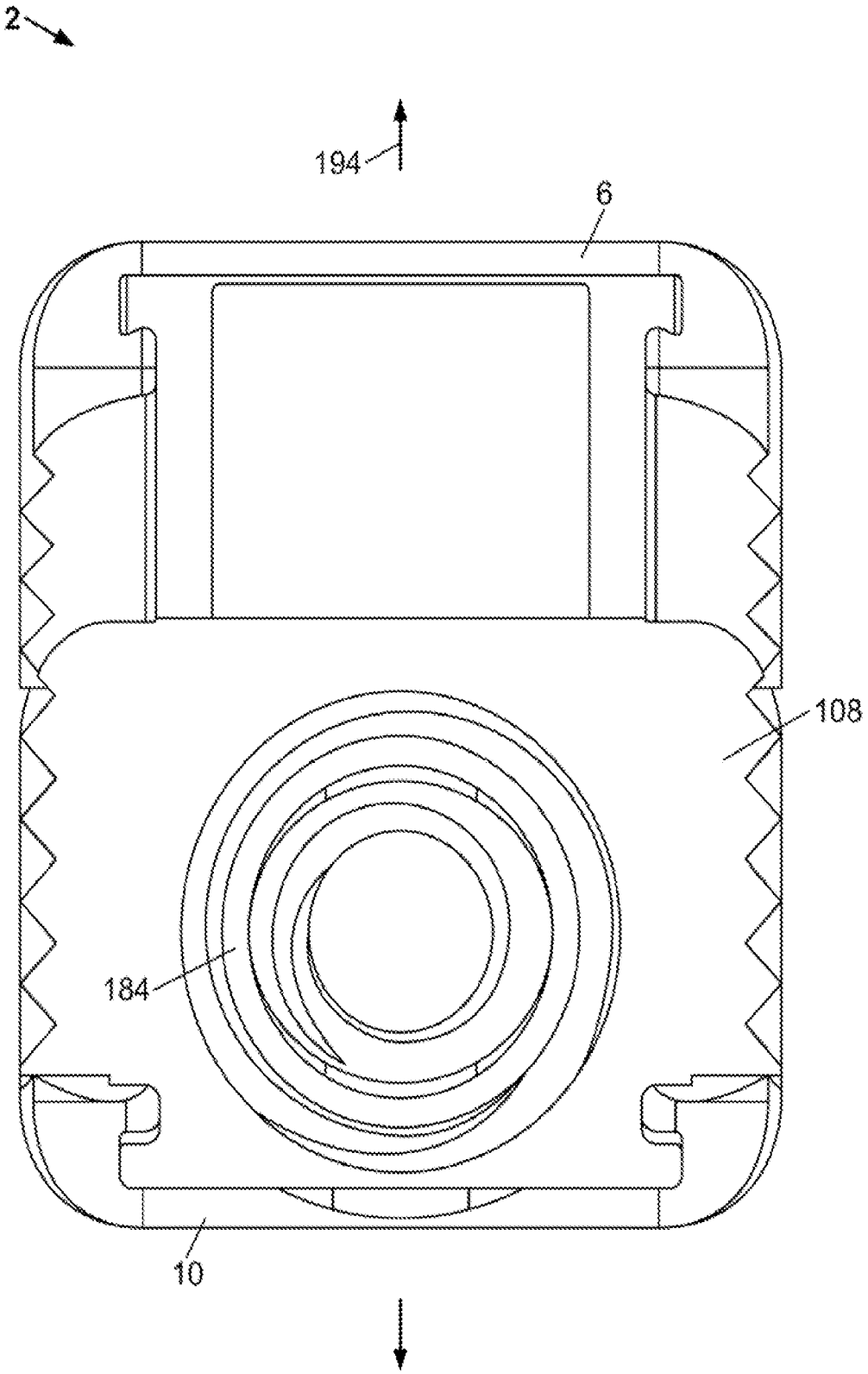

Fig. 40b

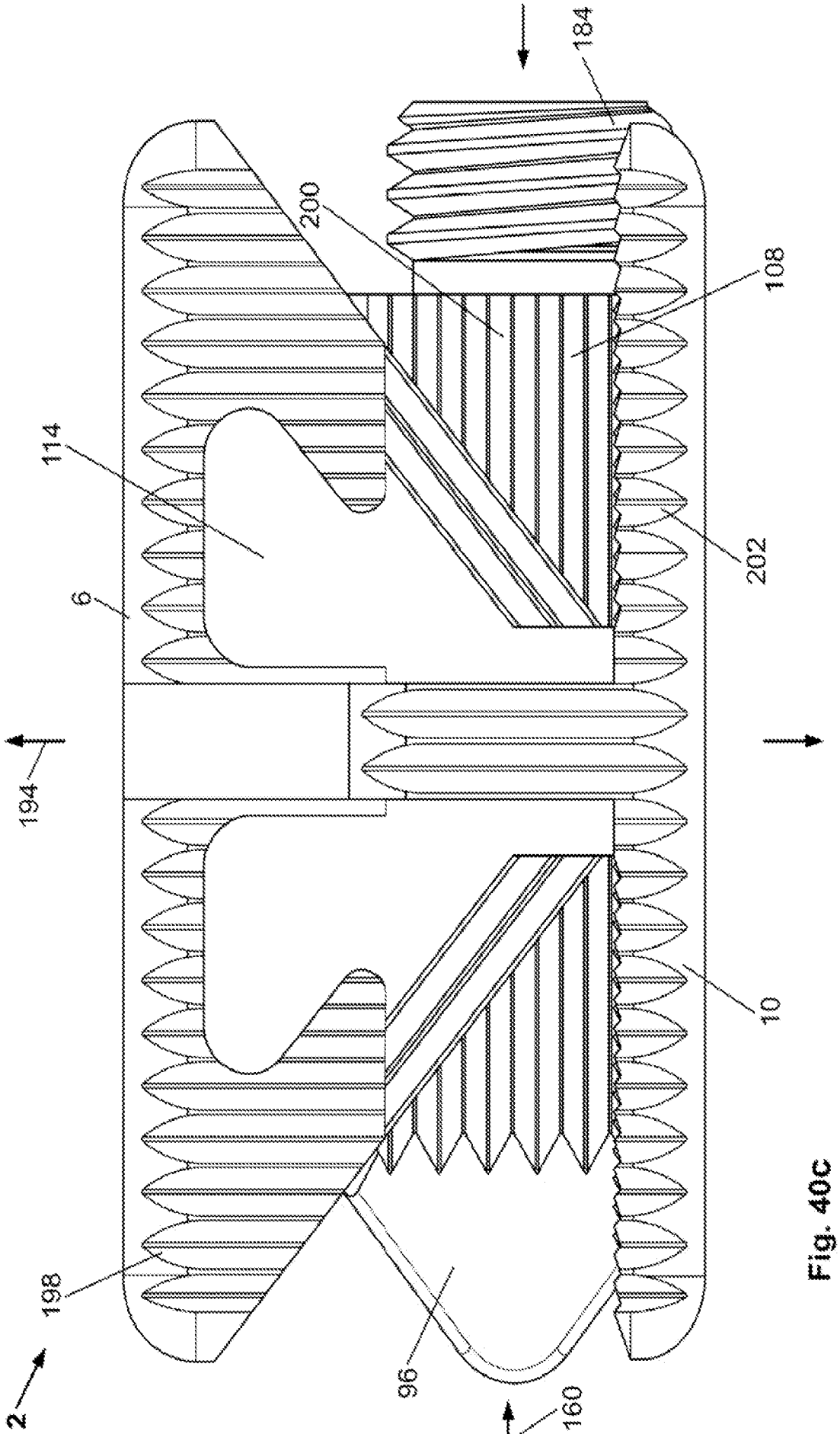

Fig. 40c

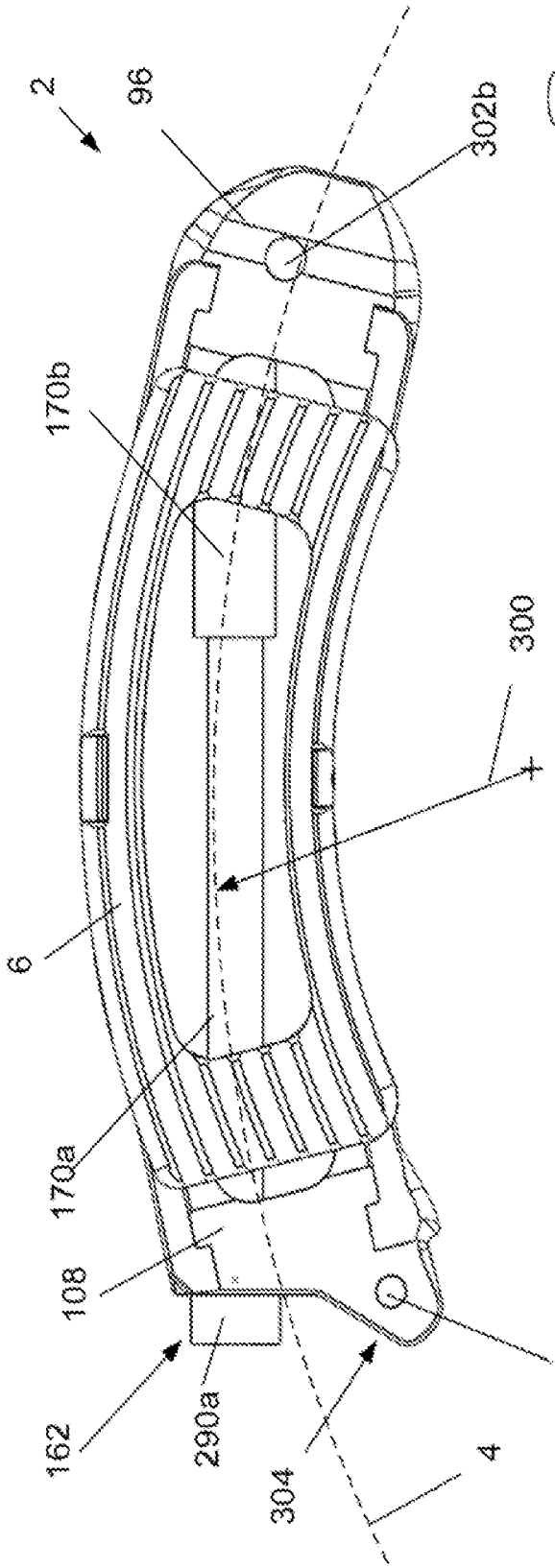

Fig. 41a

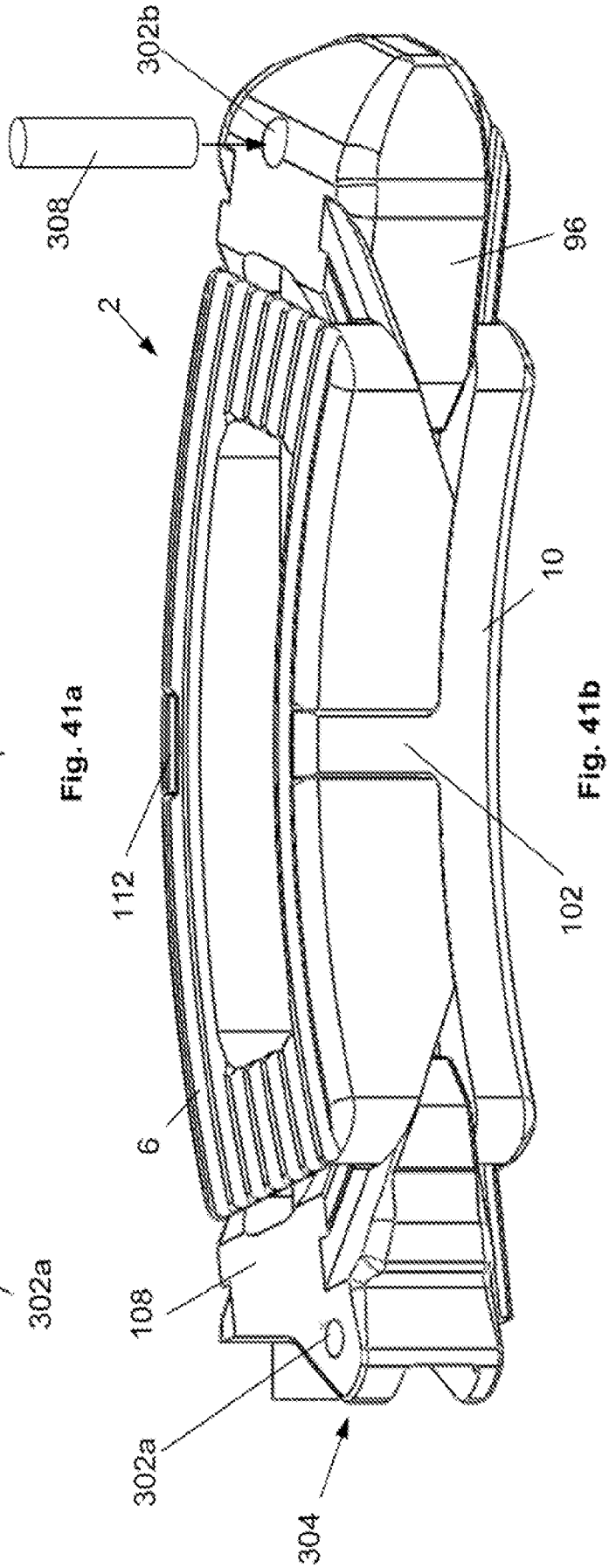

Fig. 41b

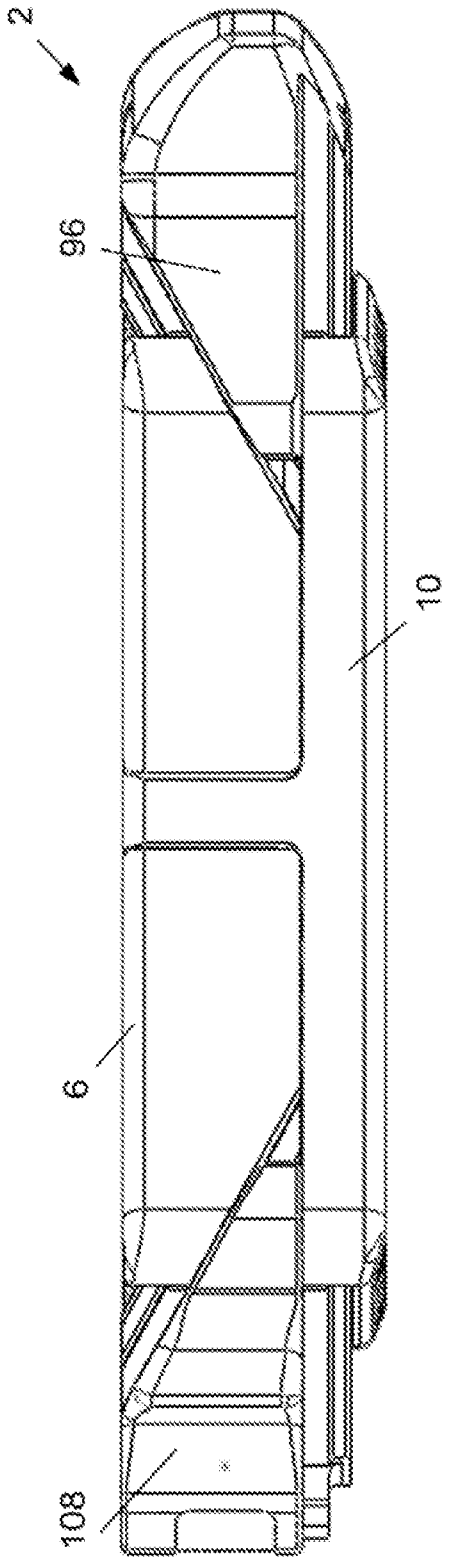

Fig. 41c

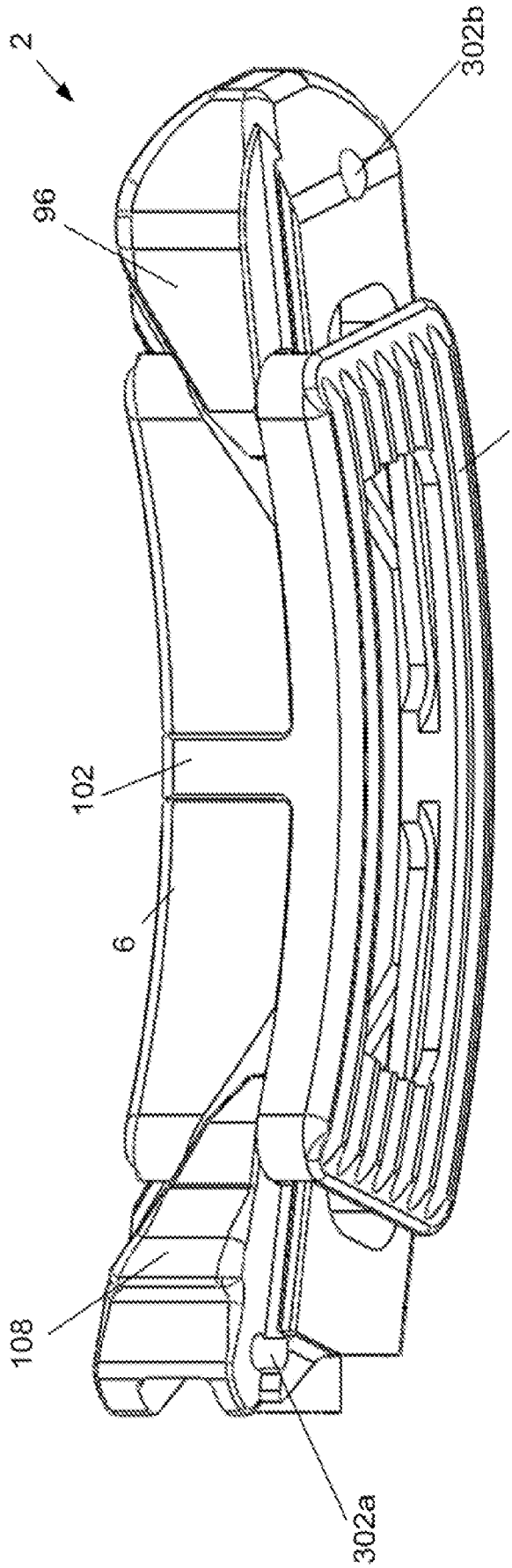

Fig. 41d

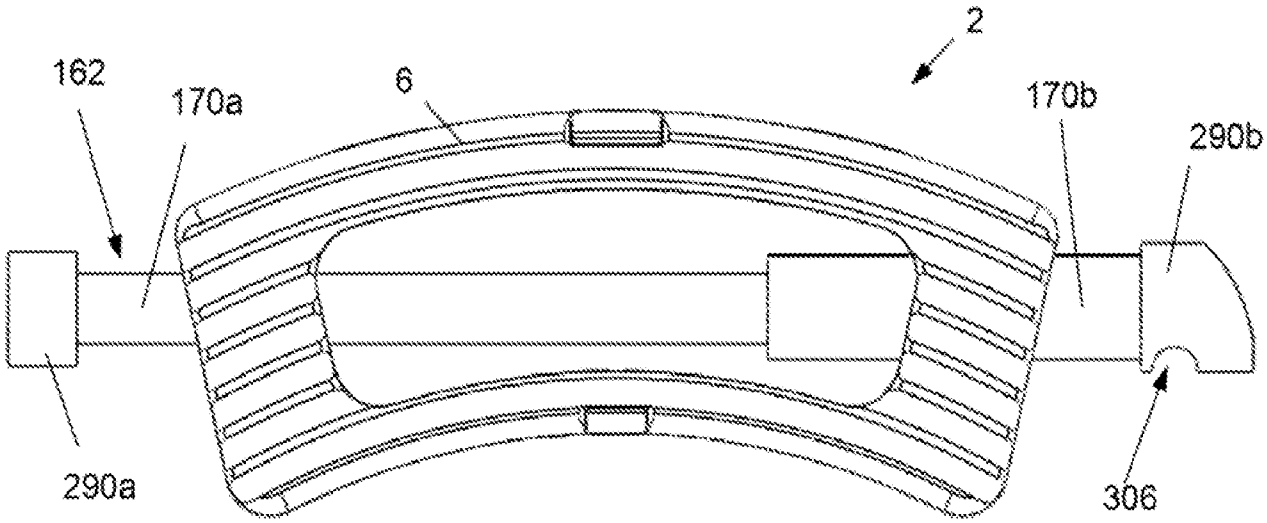

Fig. 42a

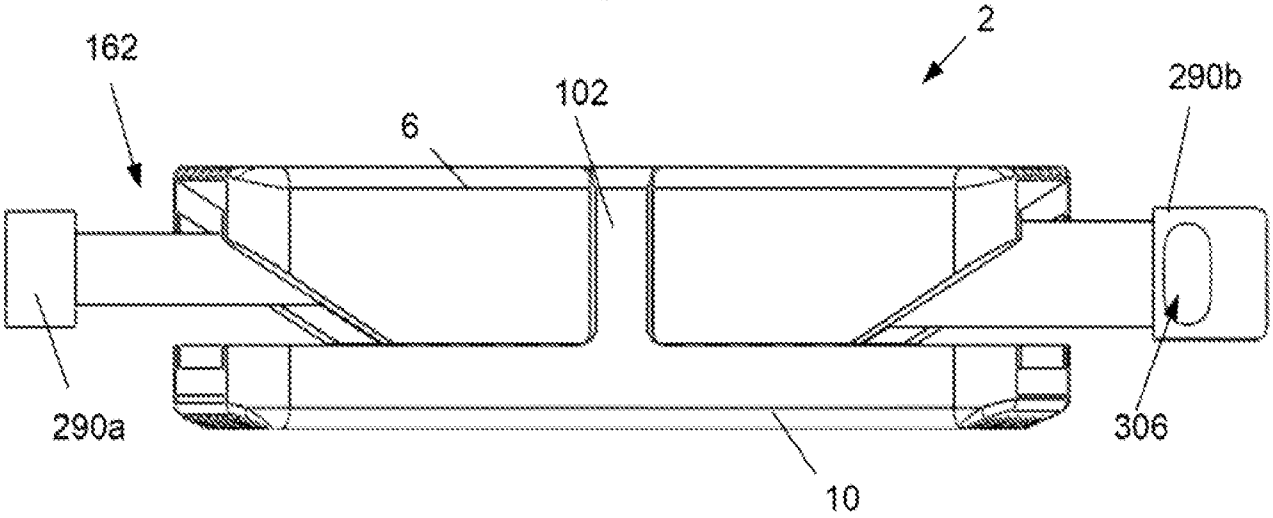

Fig. 42b

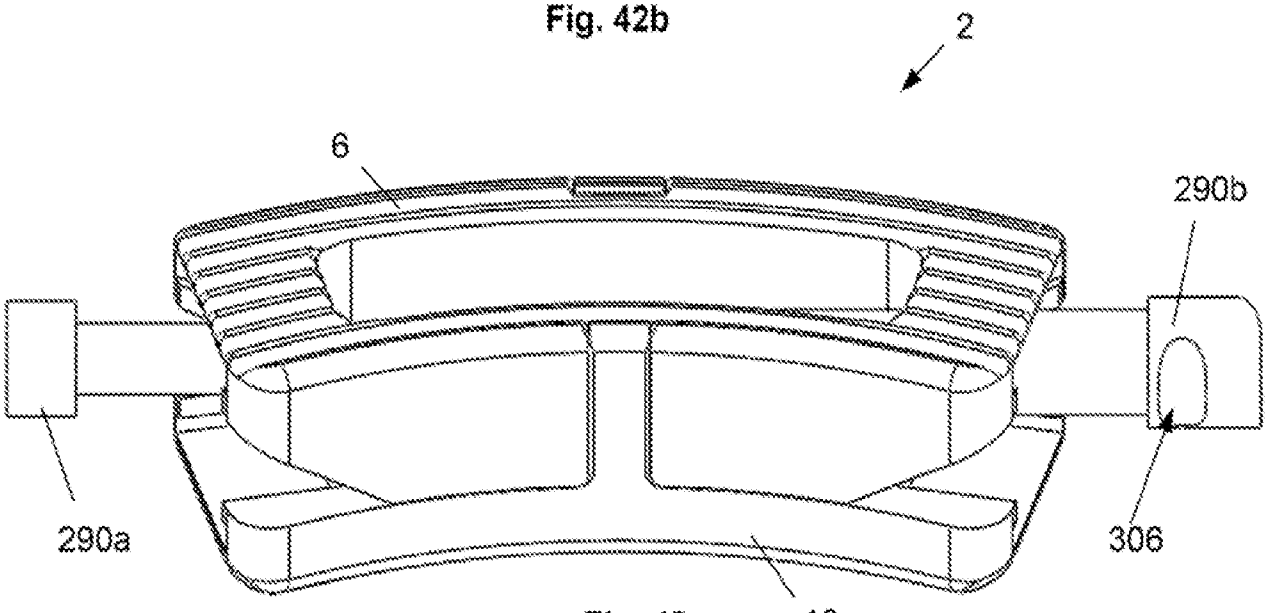

Fig. 42c

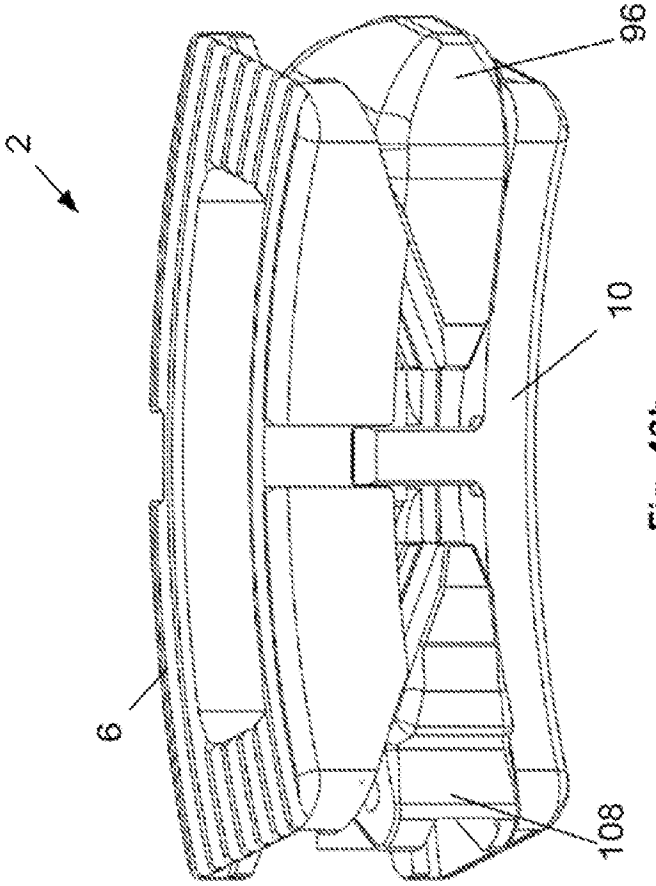

Fig. 43b

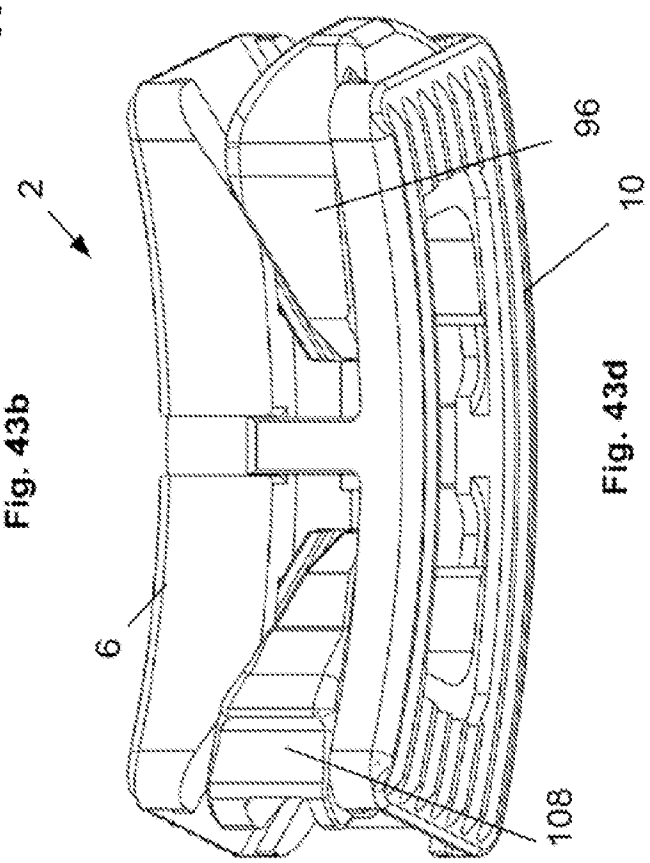

Fig. 43d

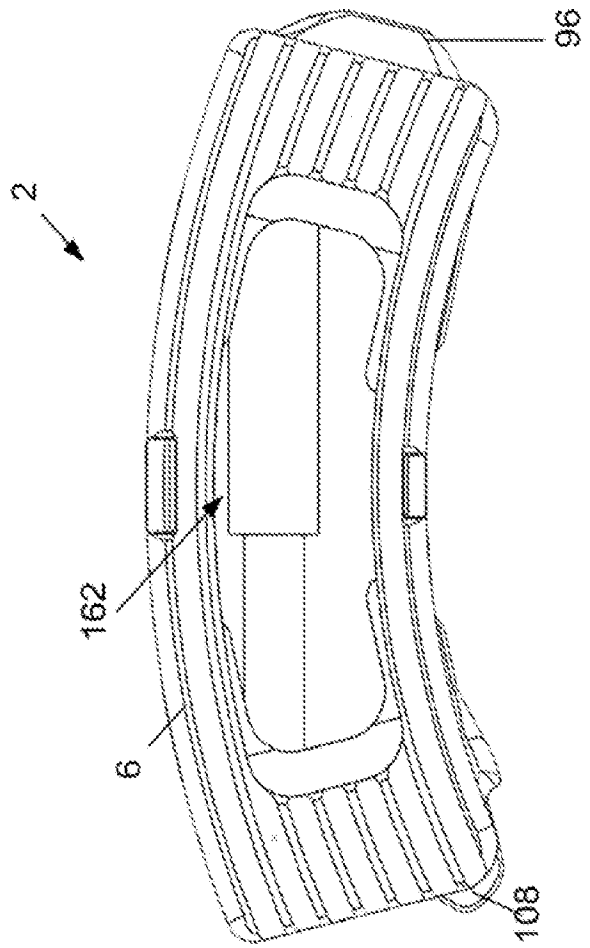

Fig. 43a

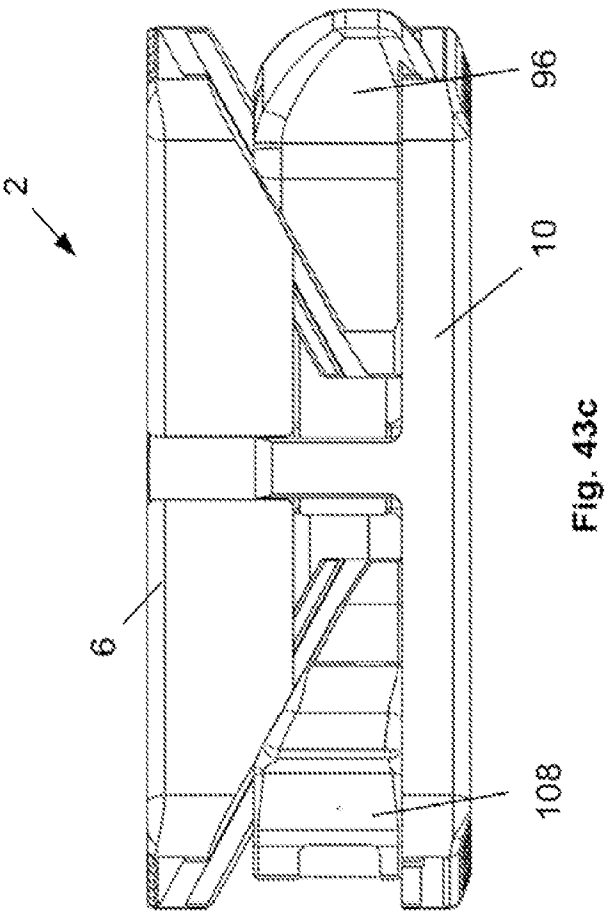

Fig. 43c

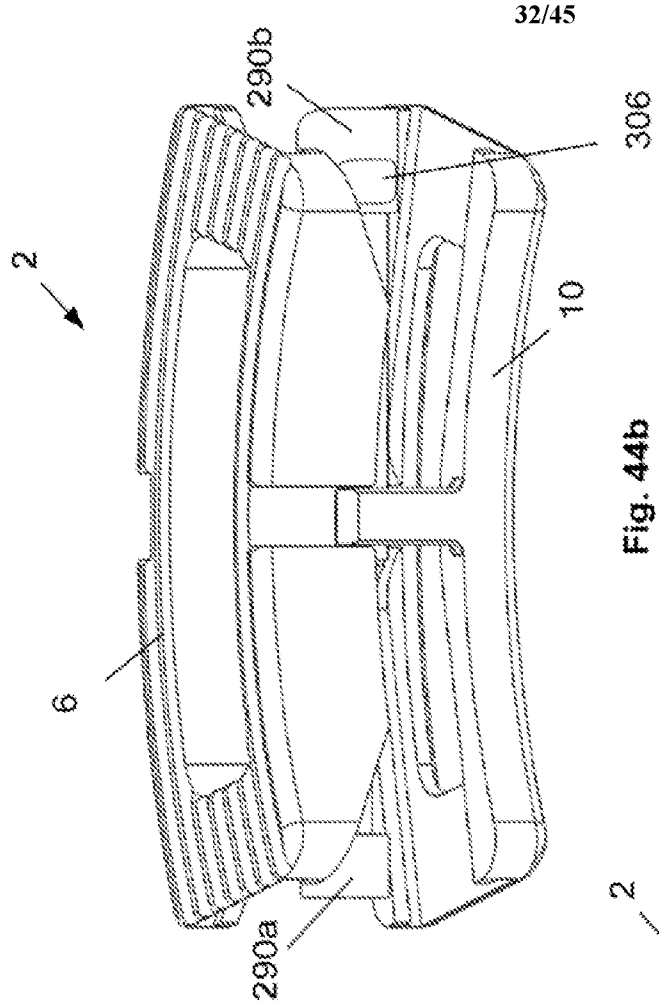

Fig. 44b

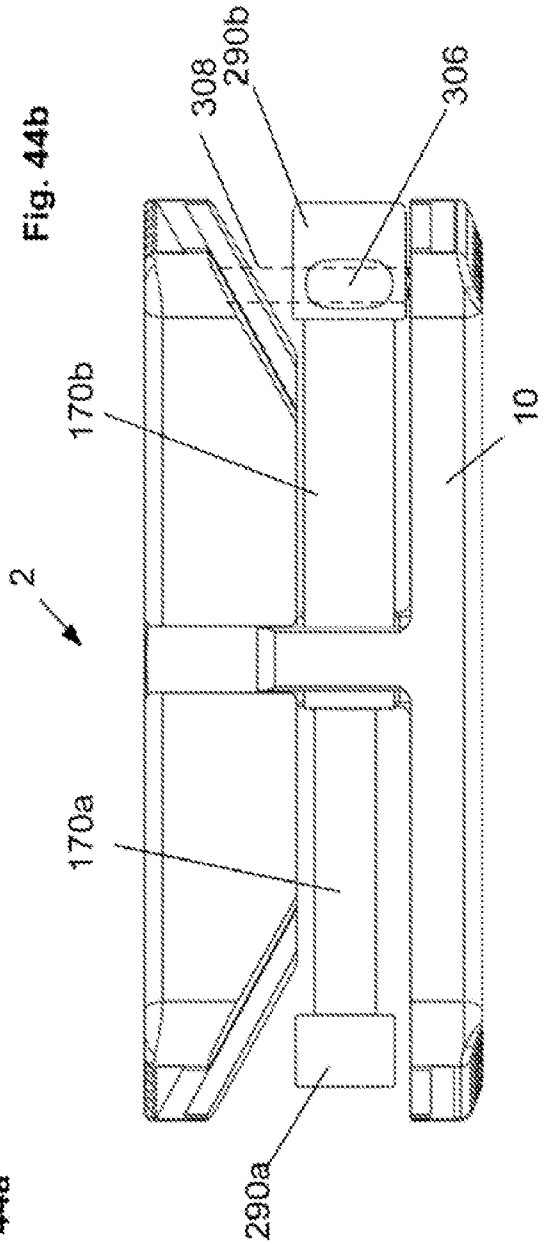

Fig. 44c

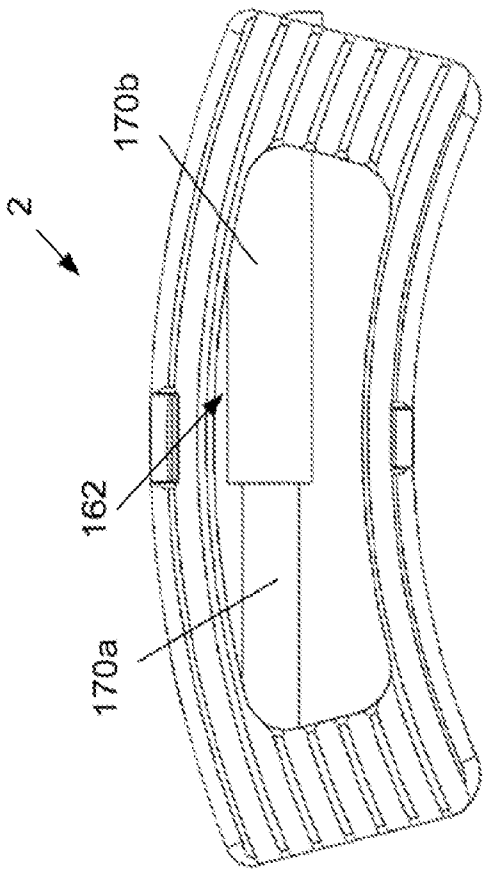

Fig. 44a

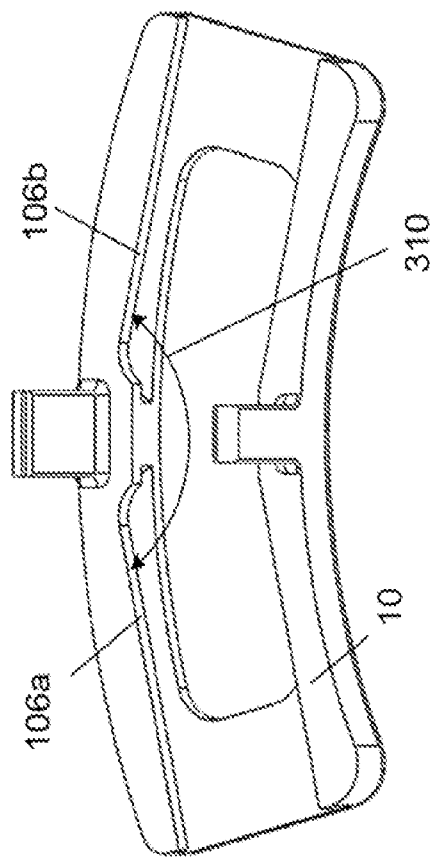

Fig. 45b

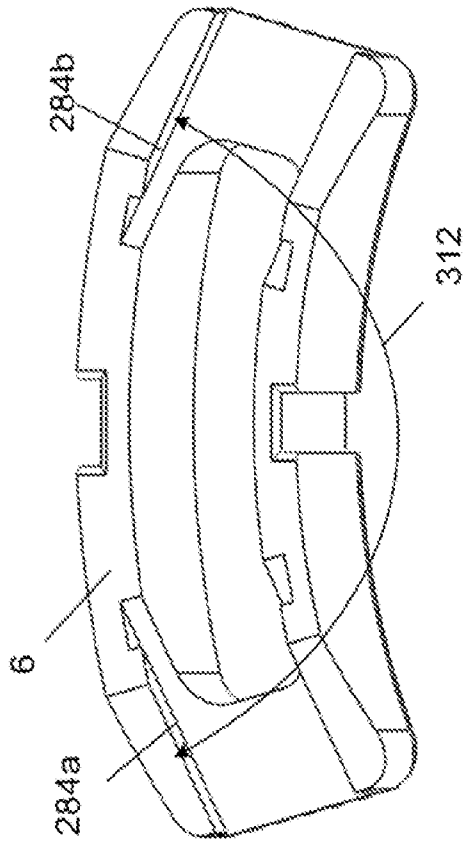

Fig. 46b

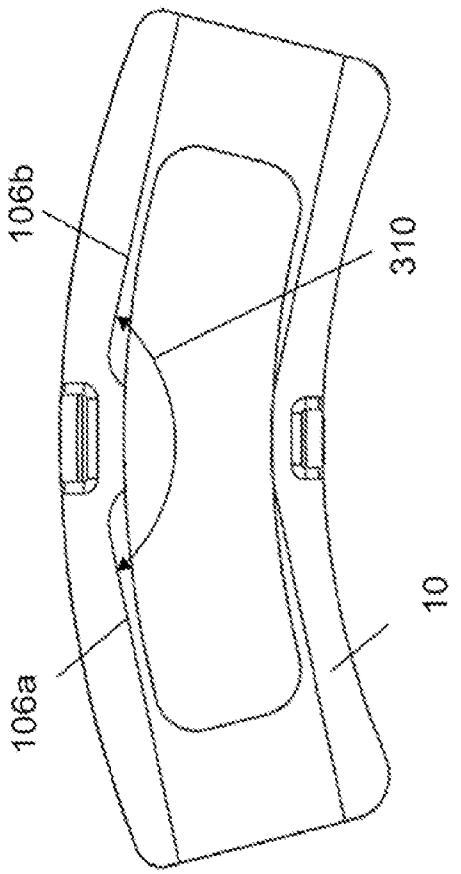

Fig. 45a

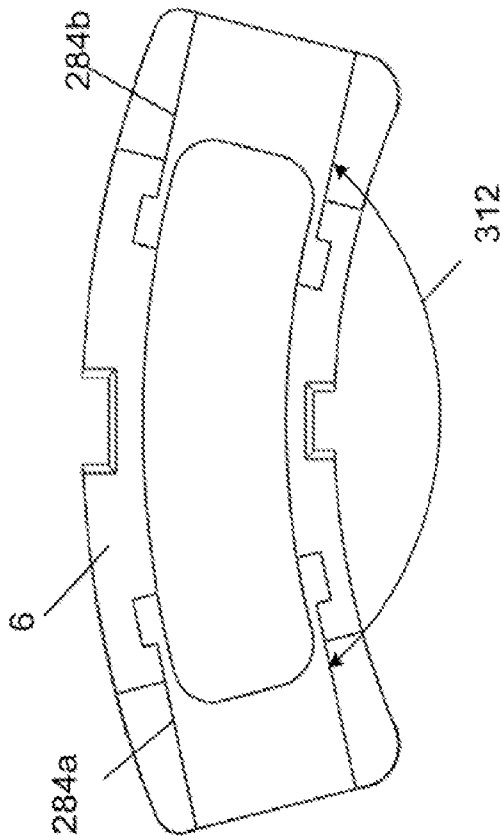

Fig. 46a

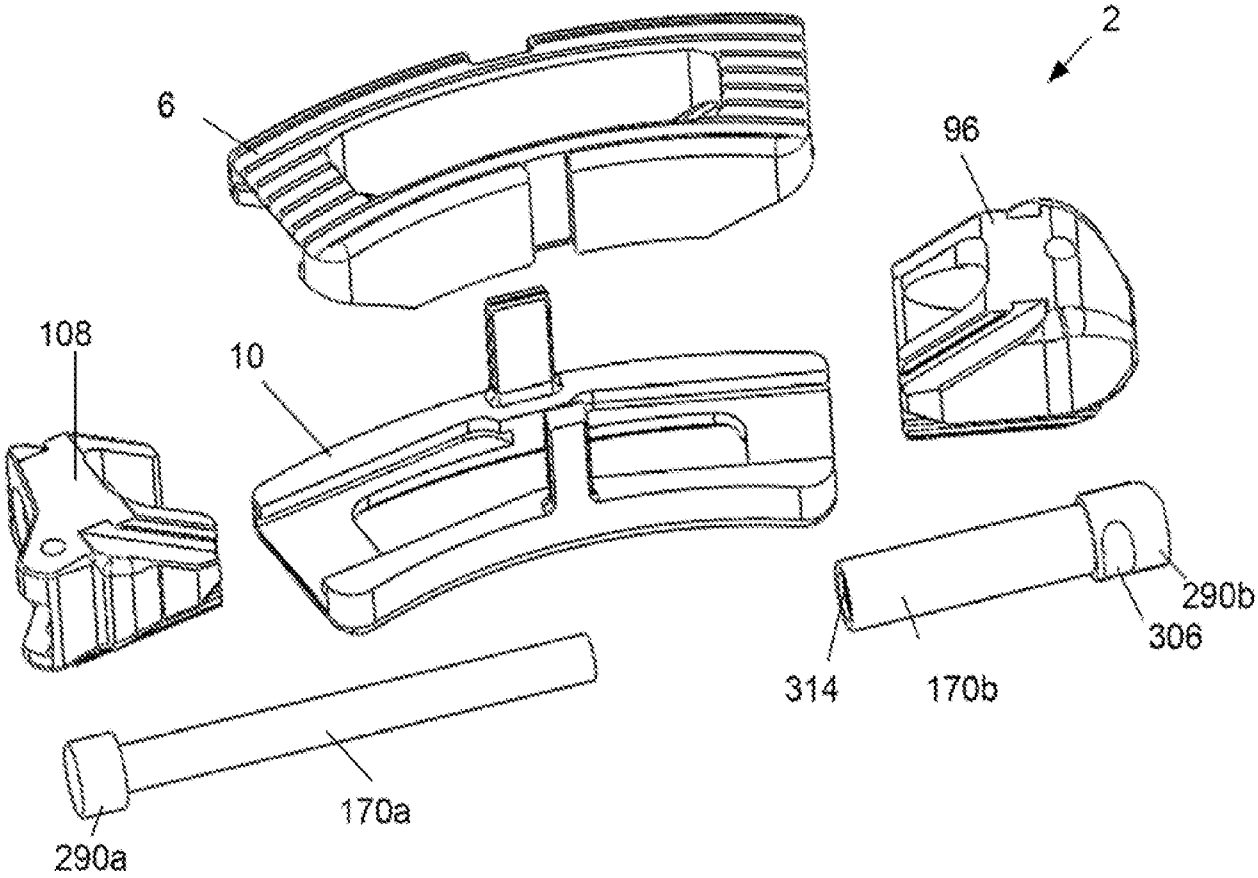

Fig. 47a

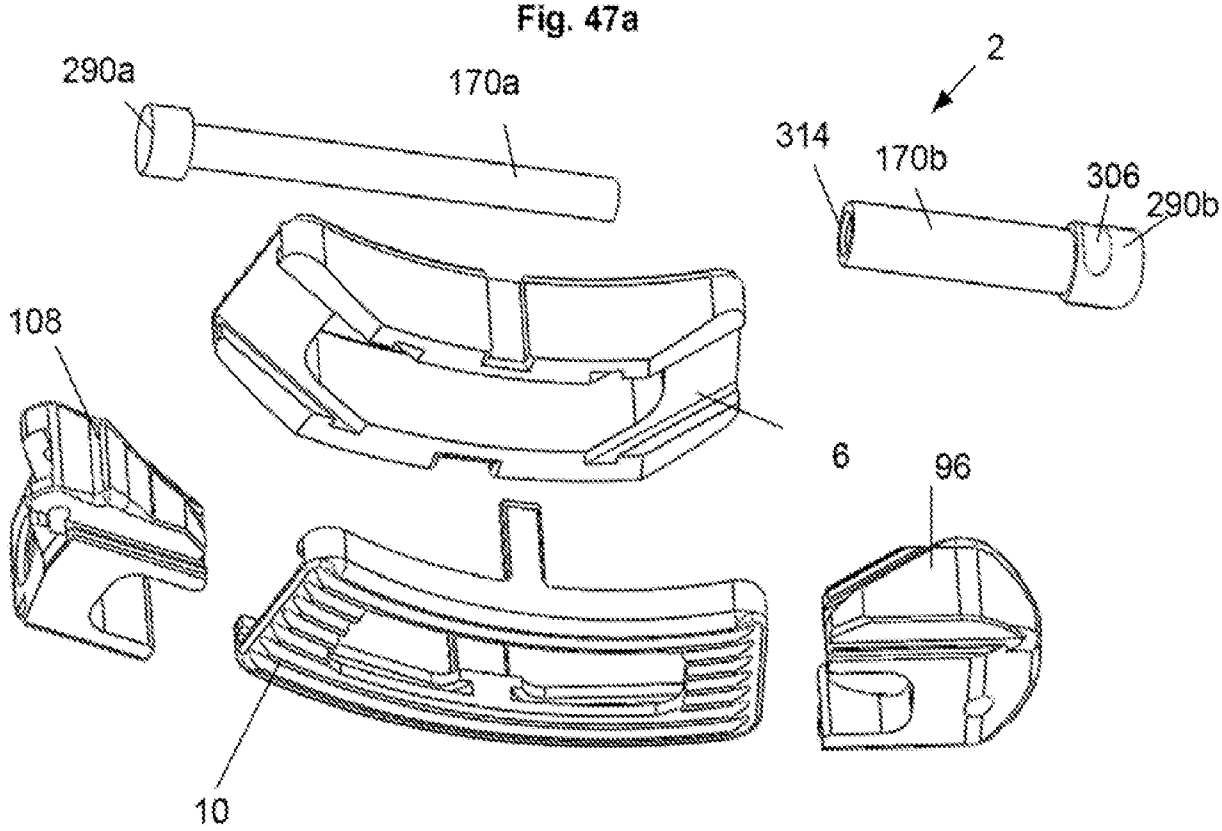

Fig. 47b

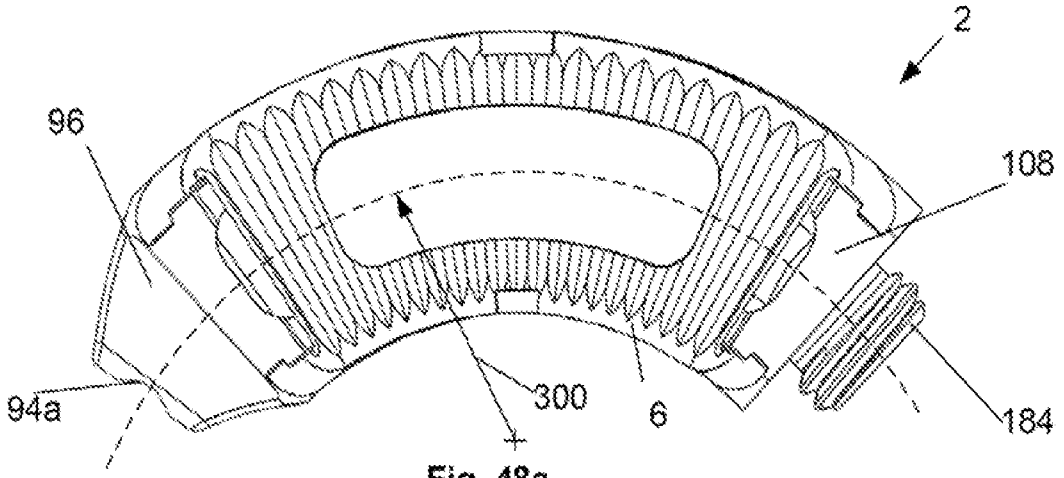

Fig. 48a

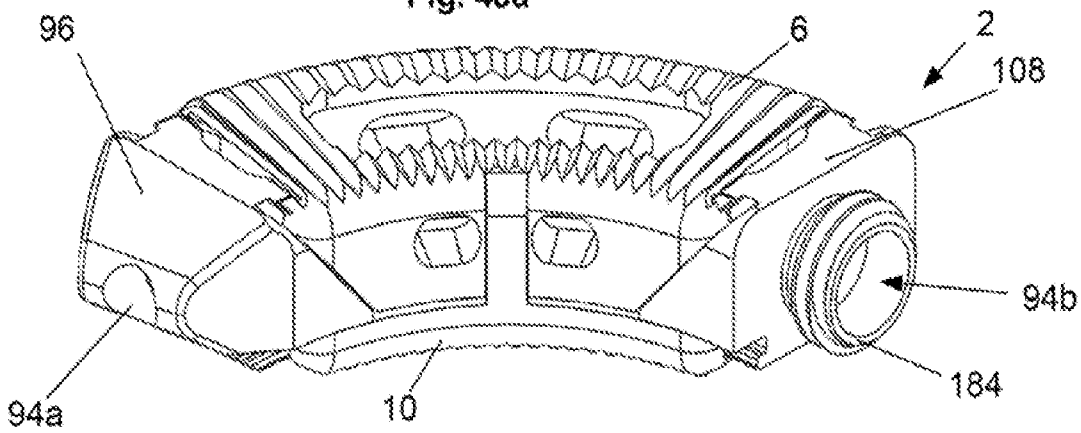

Fig. 48b

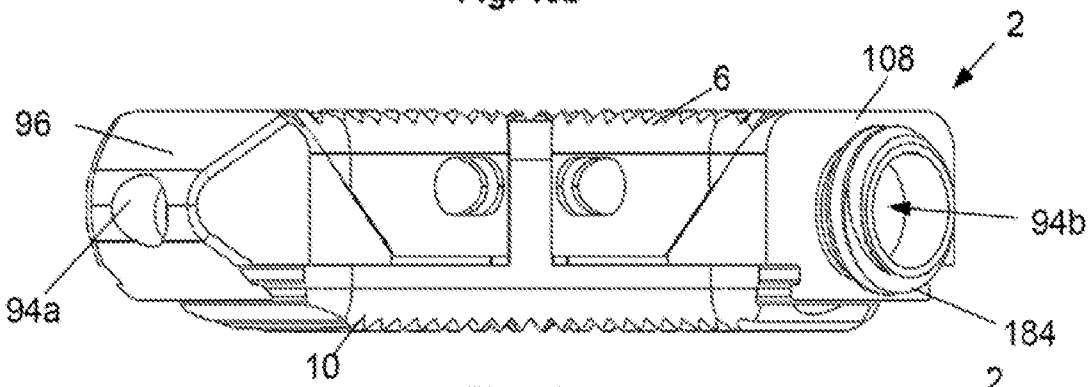

Fig. 48c

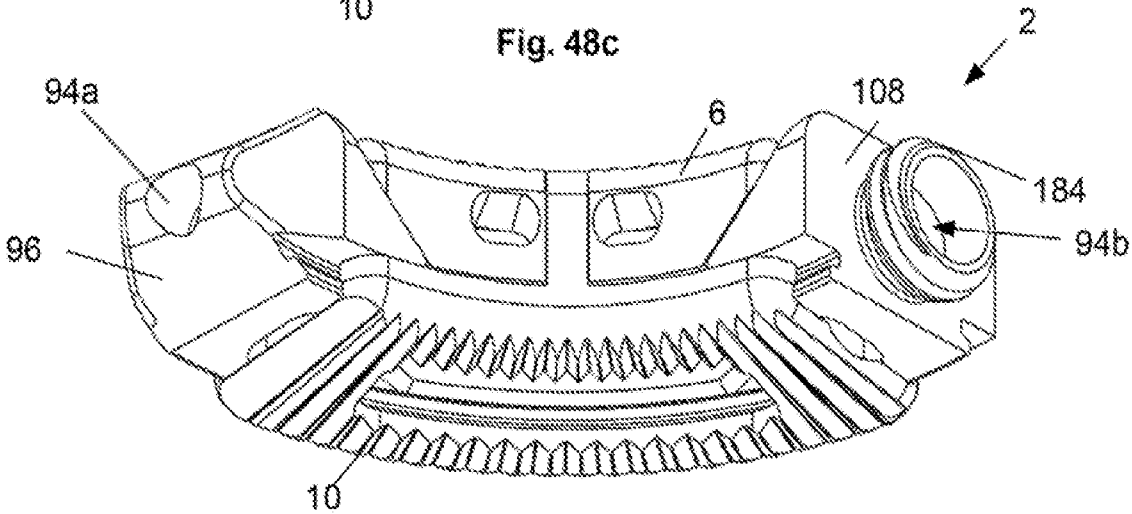

Fig. 48d

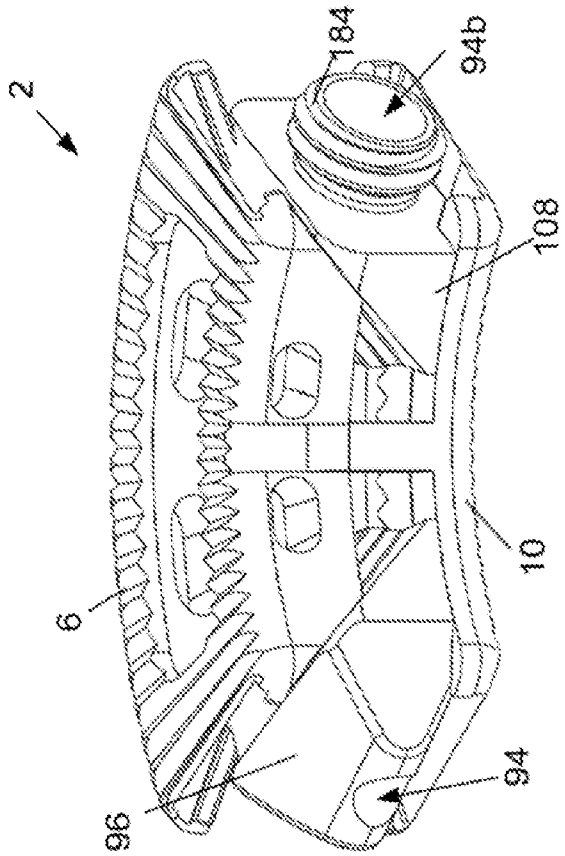

Fig. 49b

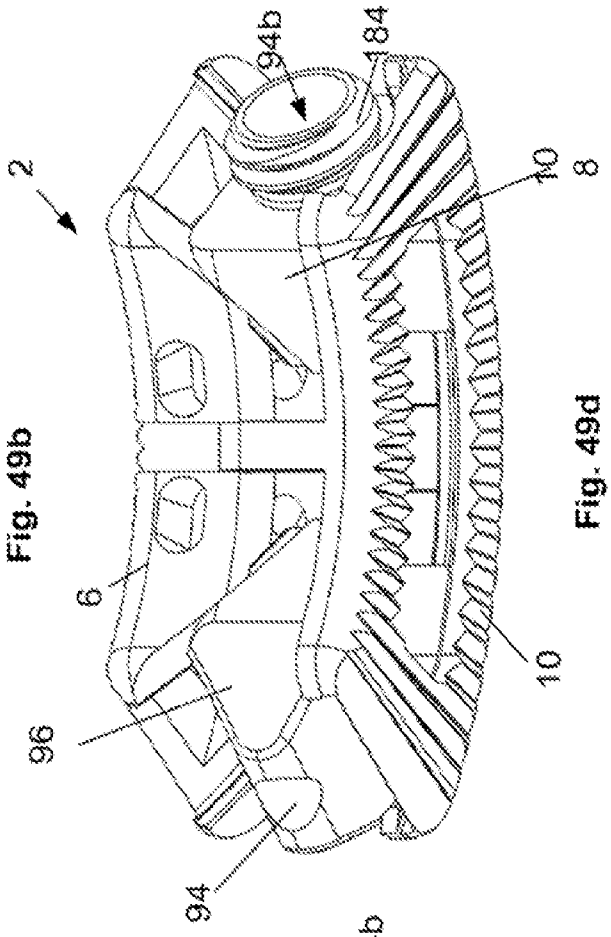

Fig. 49d

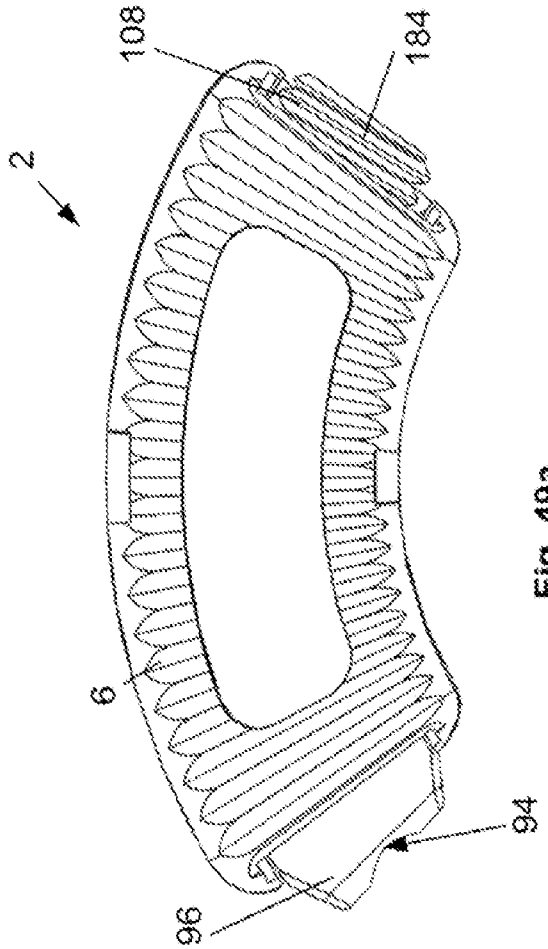

Fig. 49a

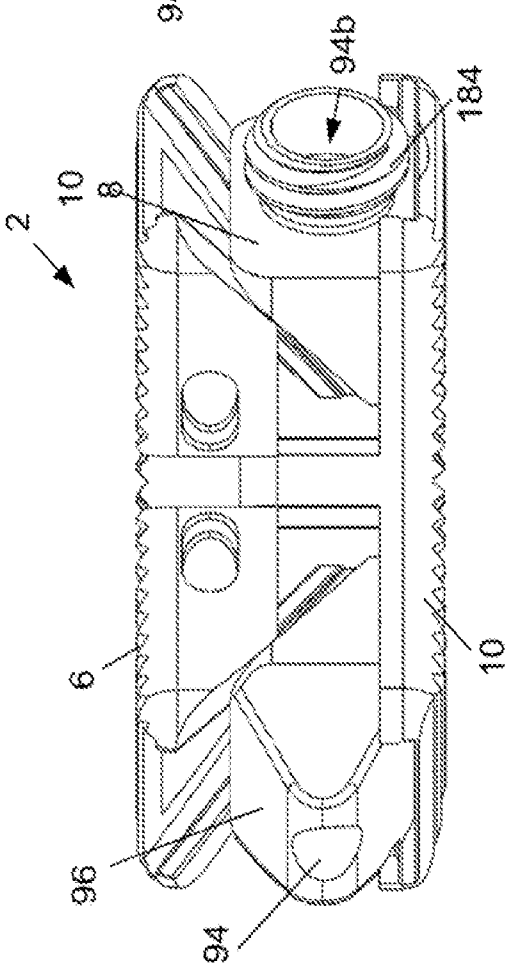

Fig. 49c

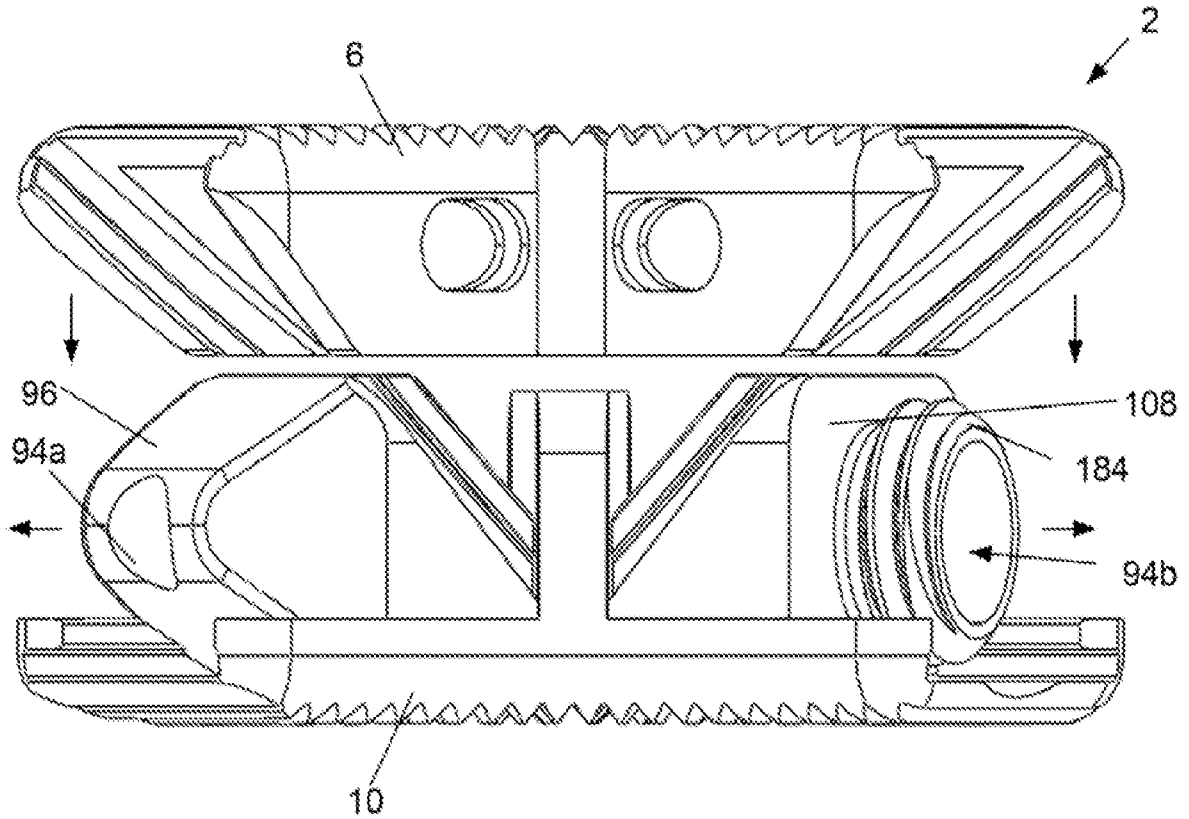

Fig. 50a

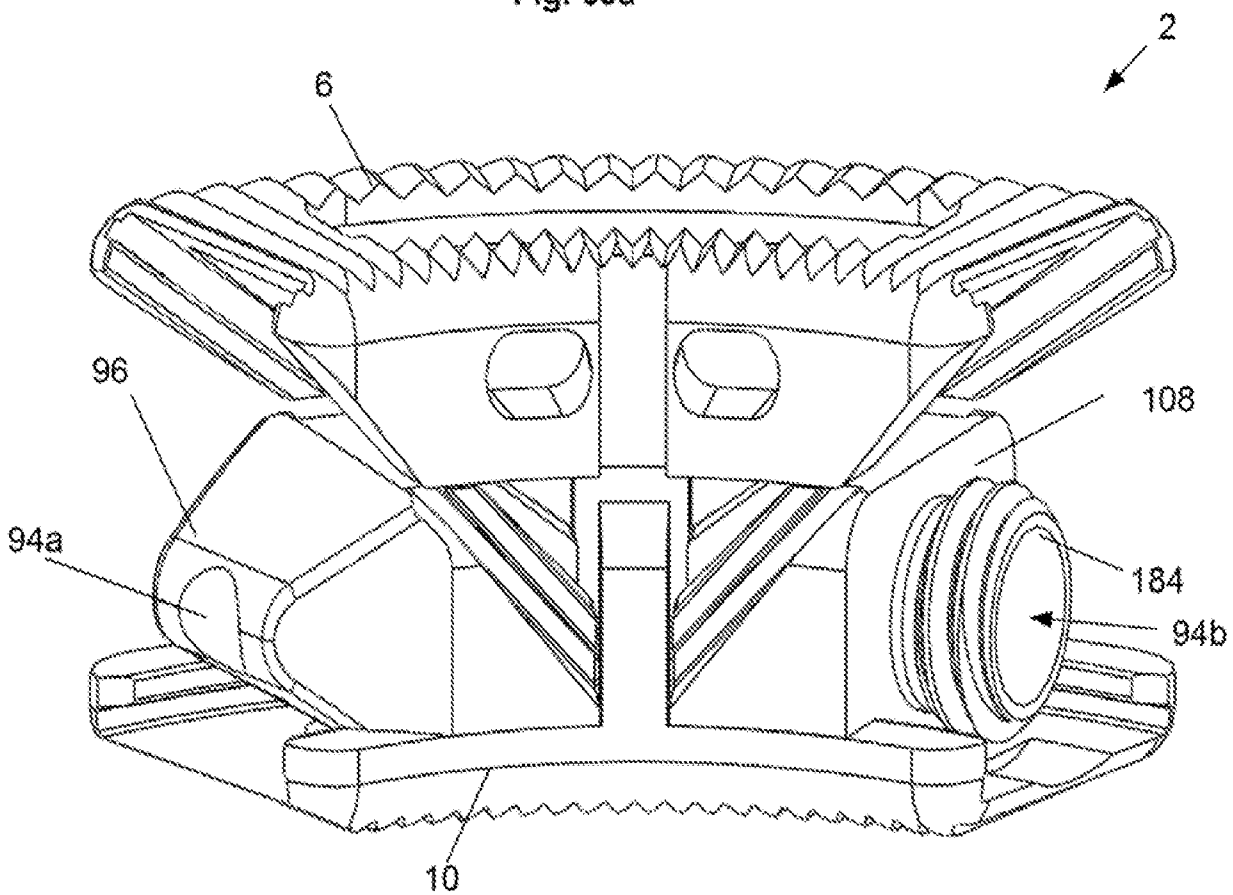

Fig. 50b

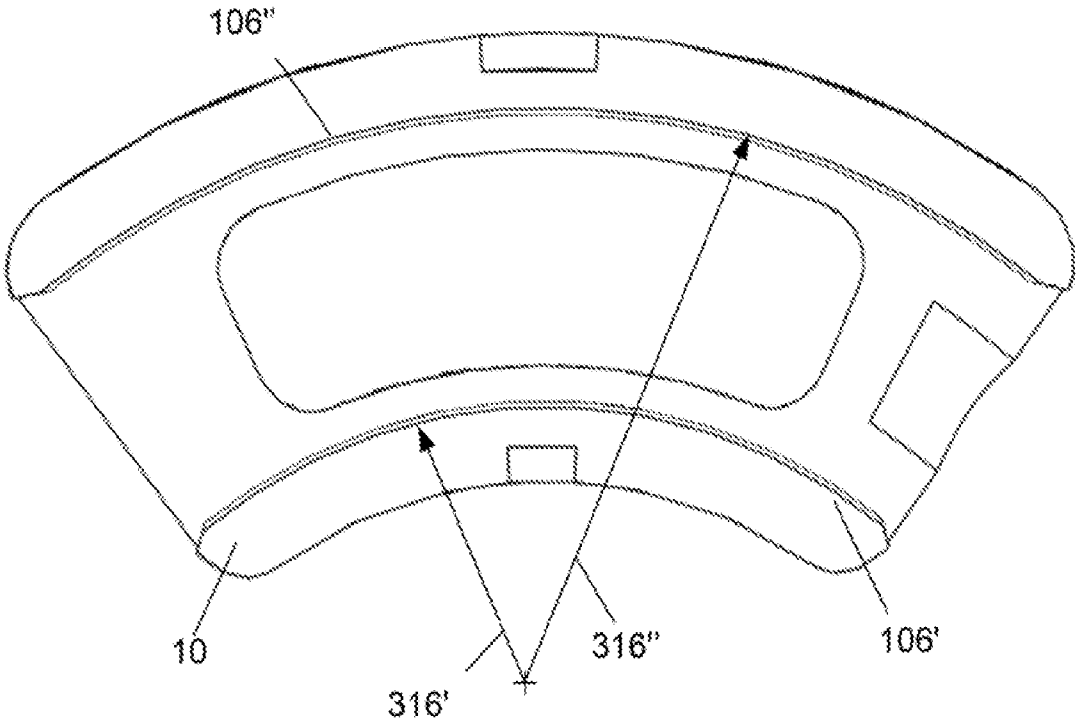

Fig. 51a

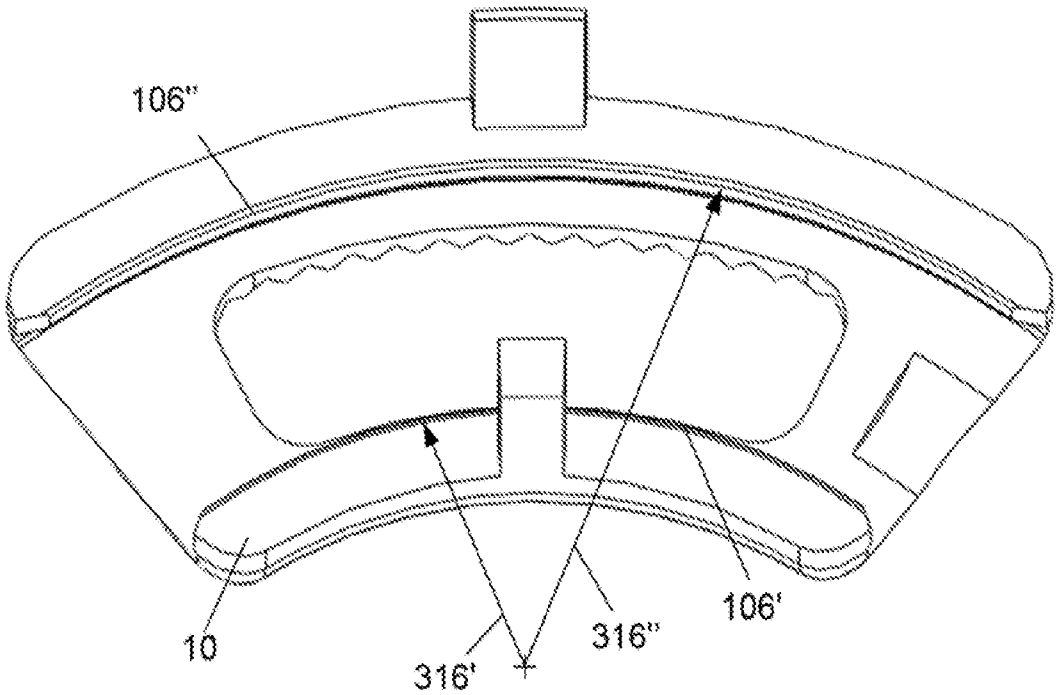

Fig. 51b

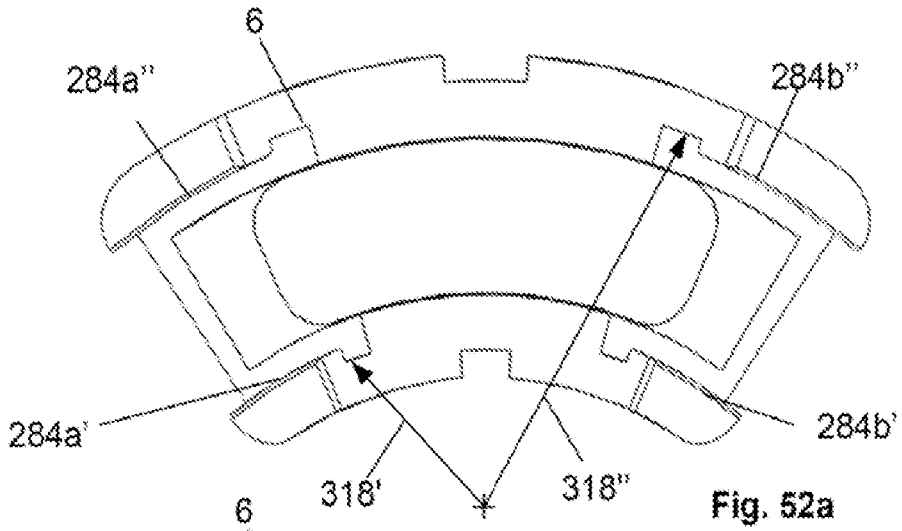

Fig. 52a

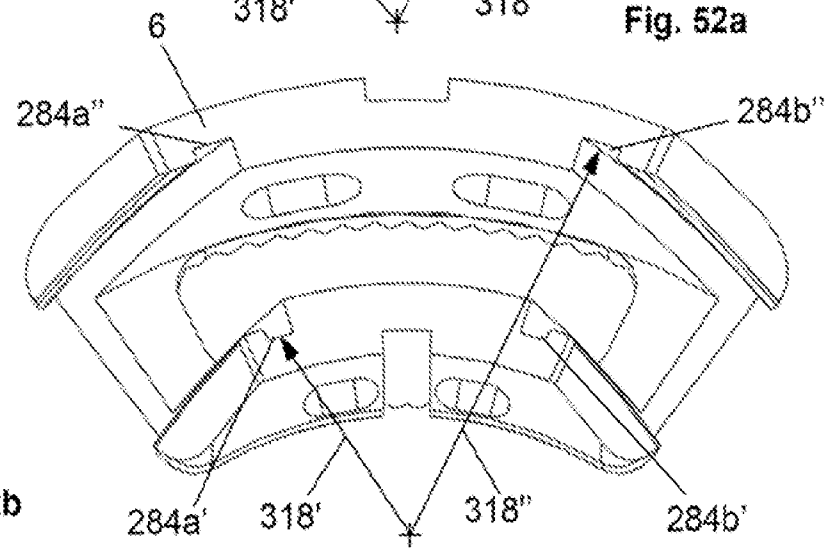

Fig. 52b

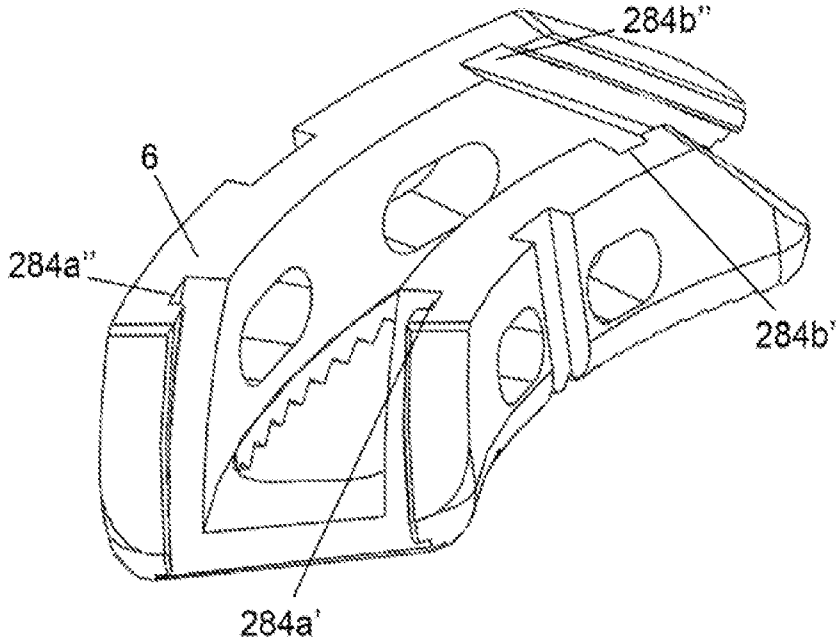

Fig. 52c

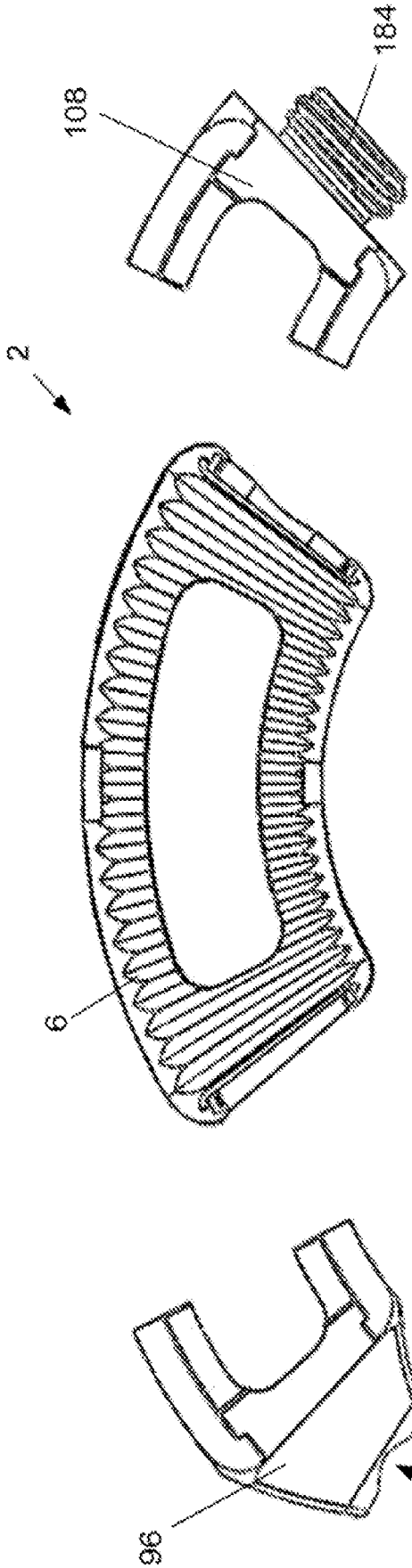

Fig. 53a

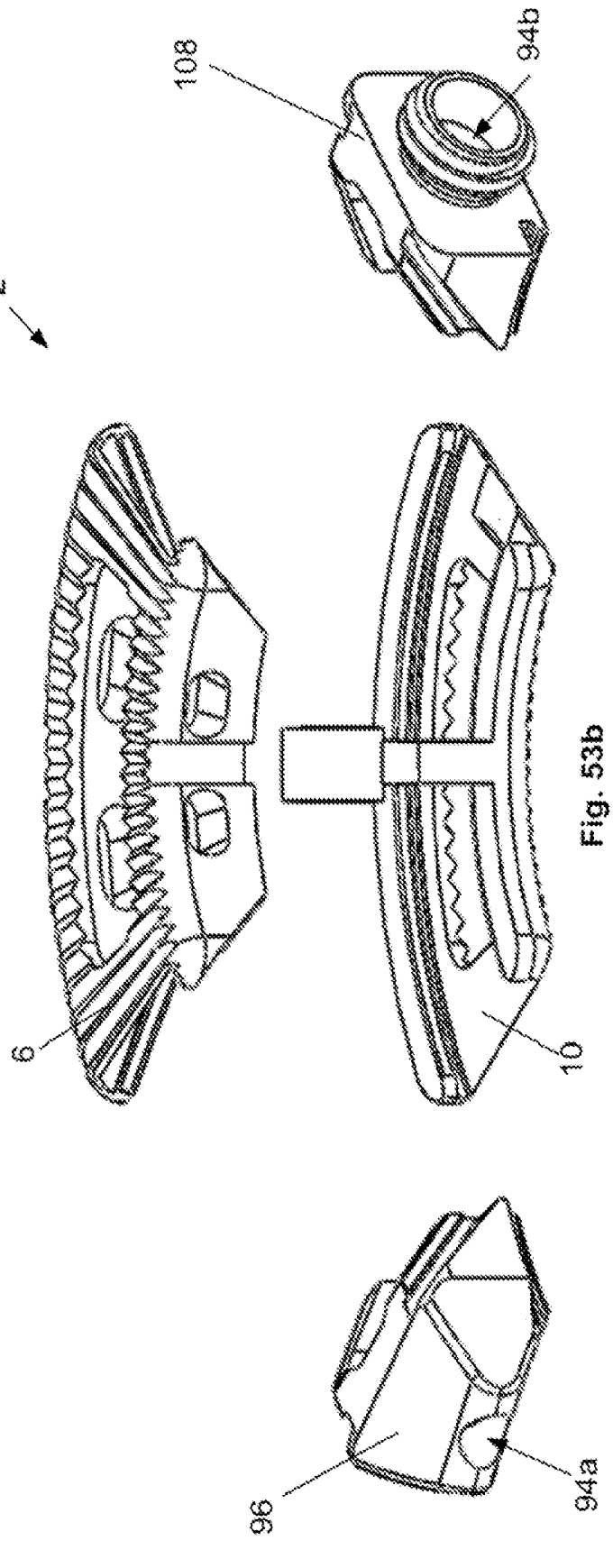

Fig. 53b

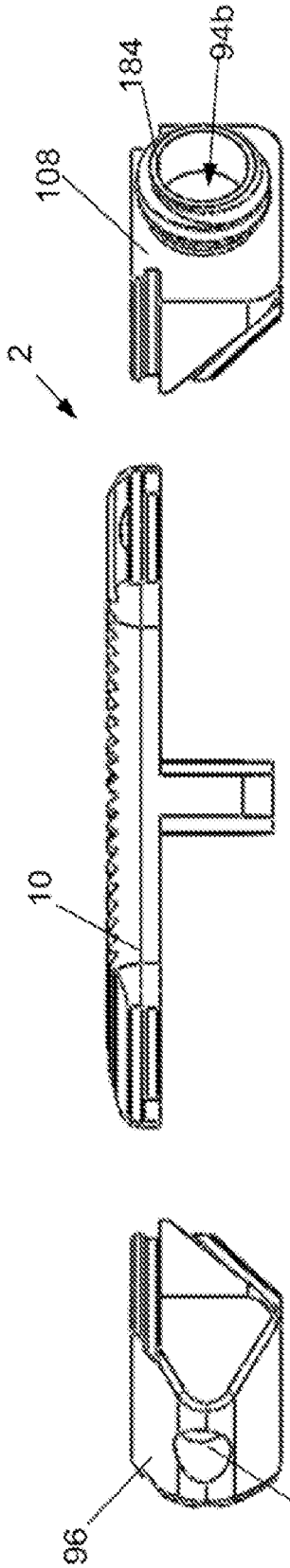

Fig. 53c

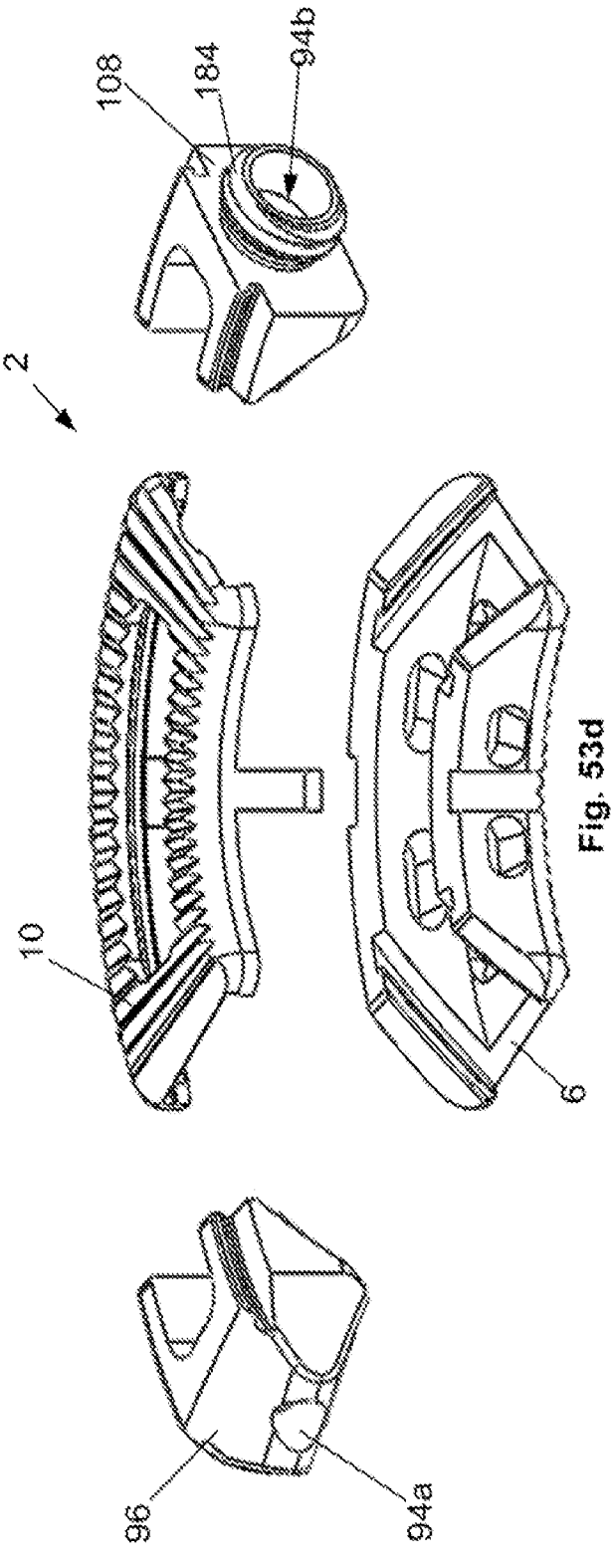

Fig. 53d

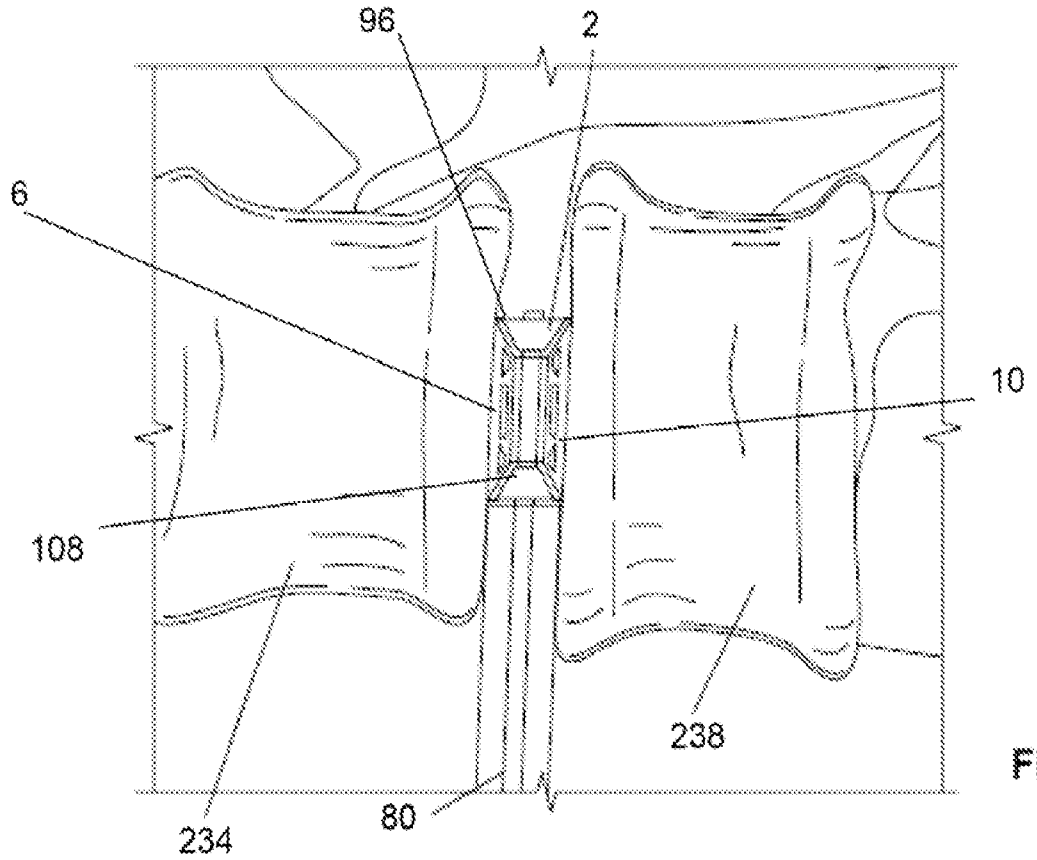

Fig 54

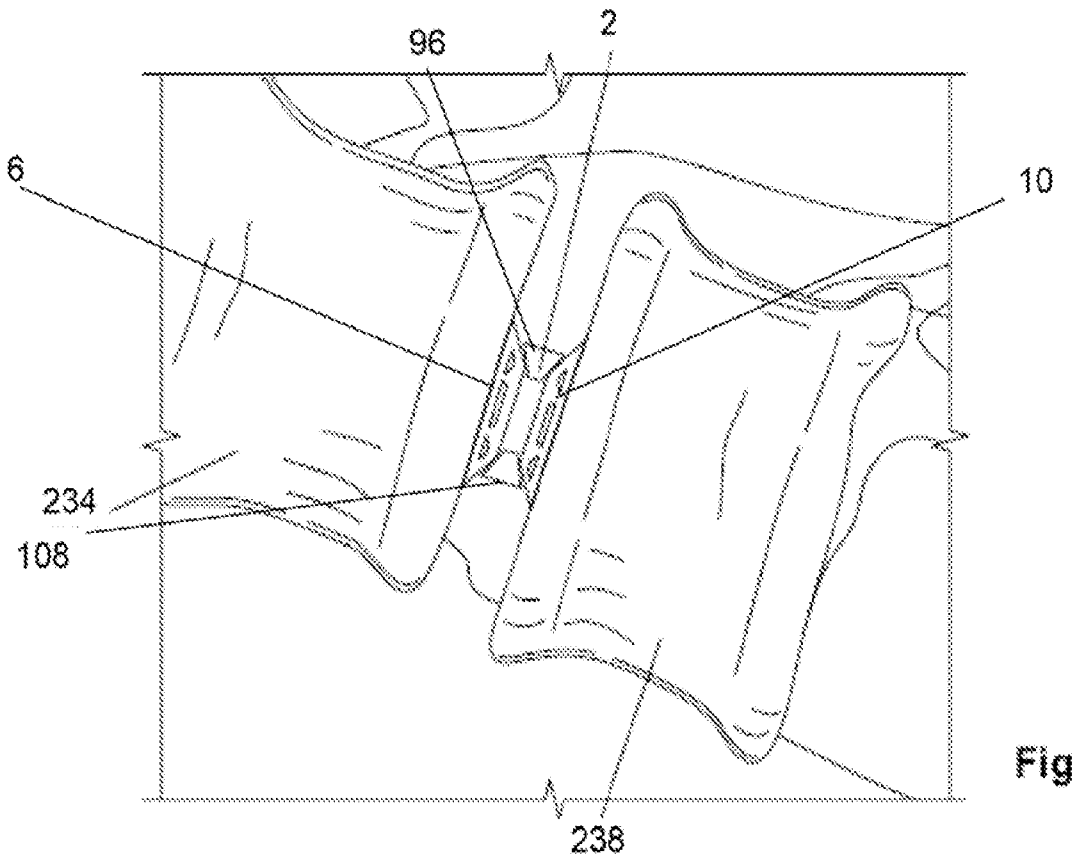

Fig. 55a

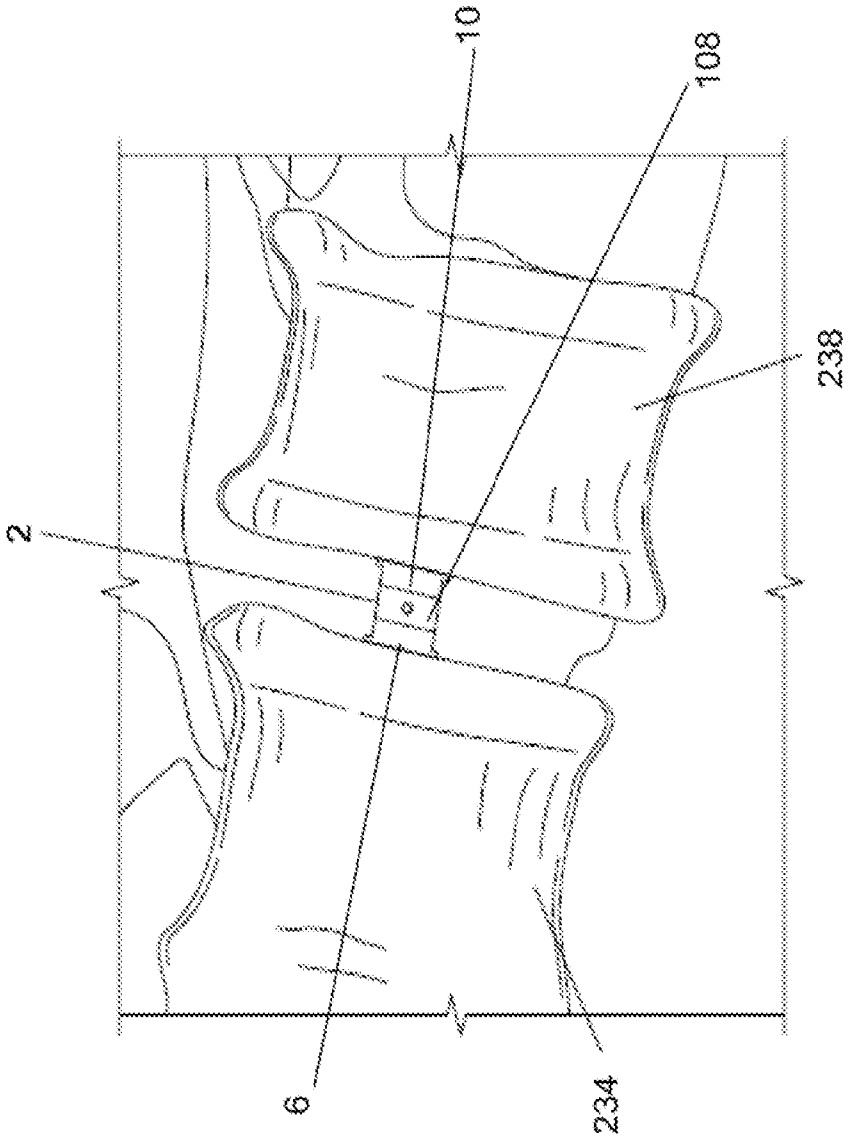

Fig. 55b

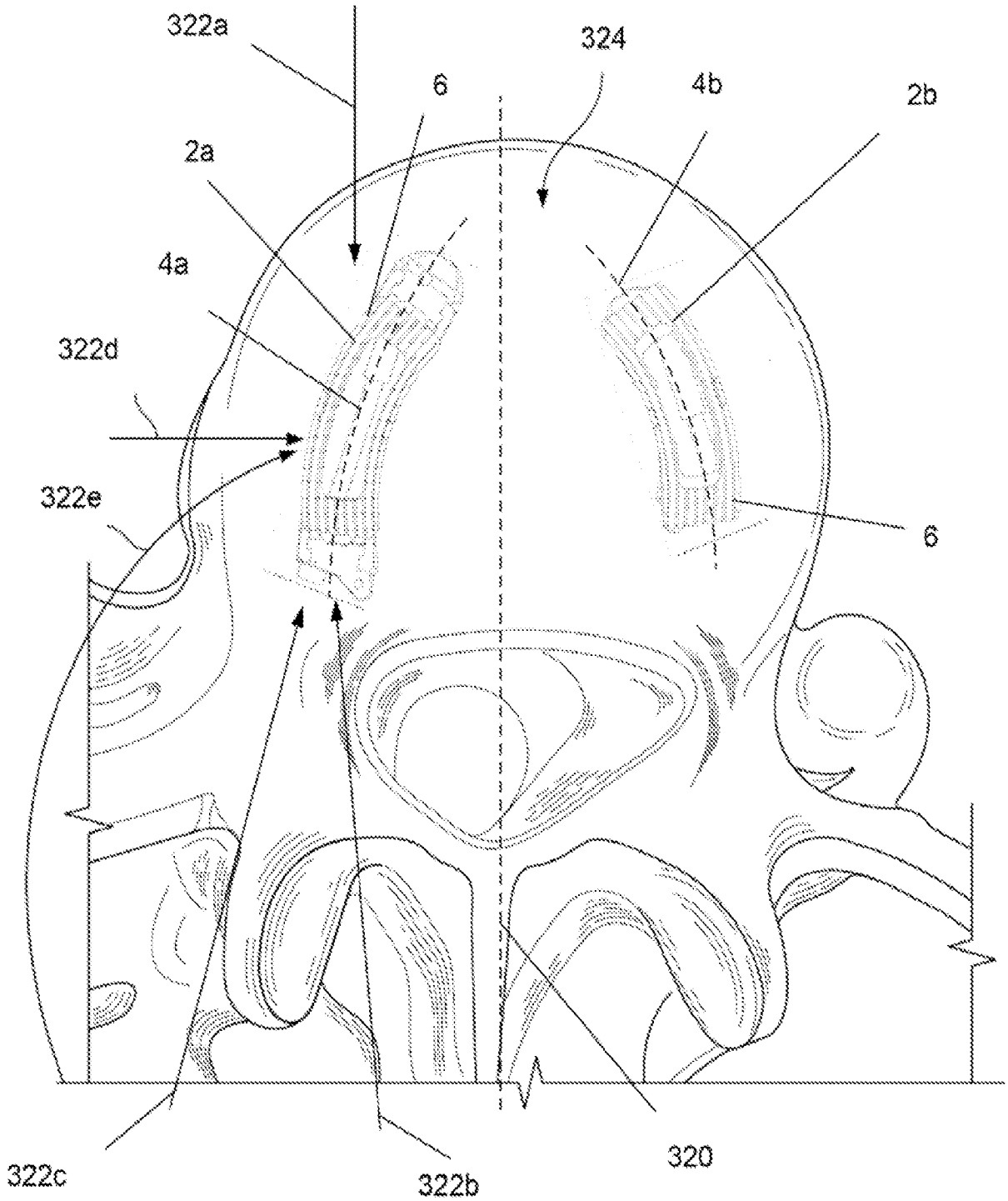

Fig. 56a

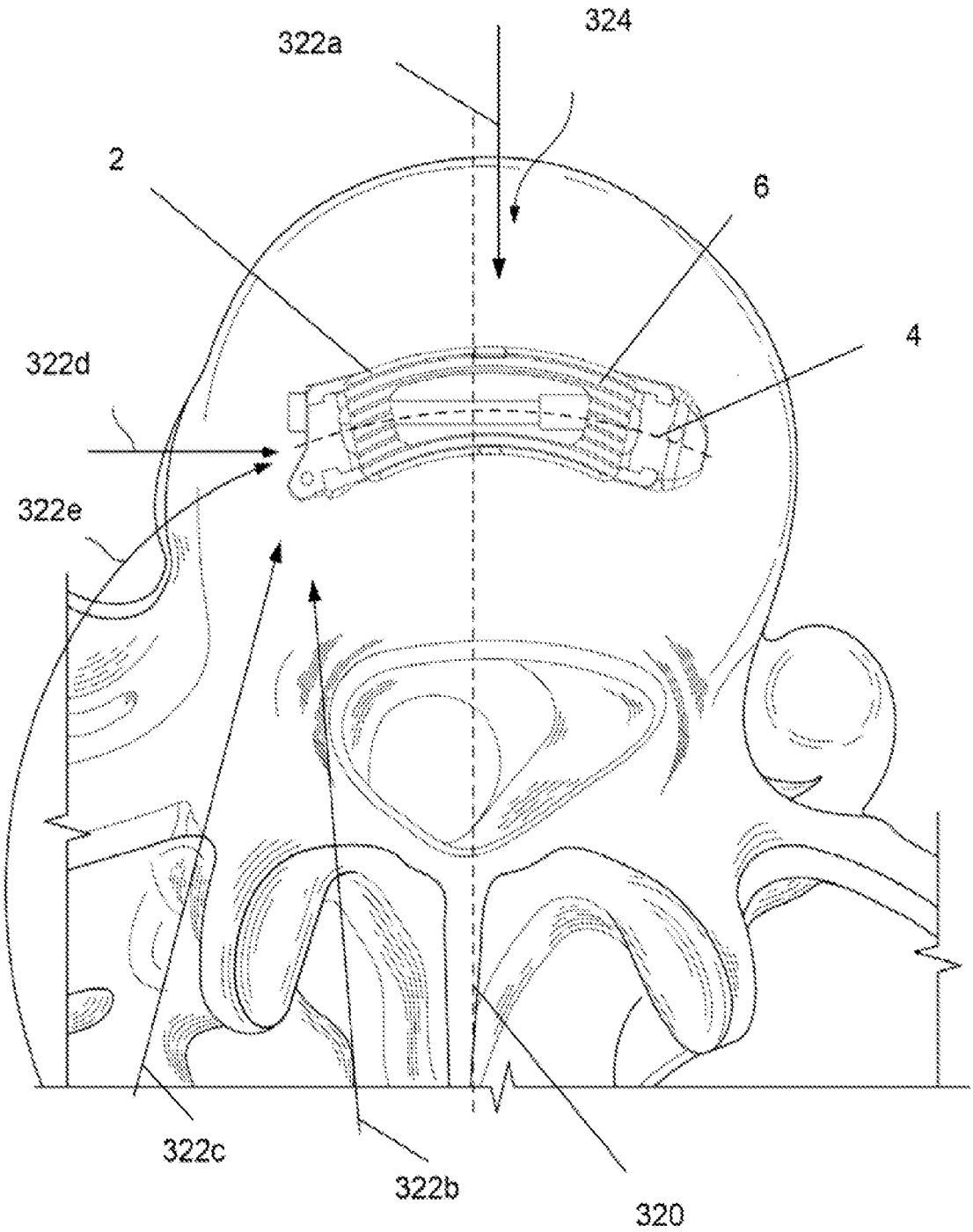

Fig. 56b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/034788

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61B 17/66 (2010.01)
USPC - 606/282
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)
IPC(8) - A61B 17/66 (2010.01)
USPC - 606/105, 282

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010/0016905 A1 (GREENHALGH et al) 21 January 2010 (21.01.2010) entire document	1-7
Y	US 5,895,387 A1 (GUERRERO et al) 20 April 1999 (20.04.1999) entire document	1-7
A	US 2010/0082109 A1 (GREENHALGH et al) 01 April 2010 (01.04.2010) entire document	1-7

☐ 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
30 June 2010	08 JUL 2010
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. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)