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Suddaby

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(54) **STAND-ALONE EXPANDABLE INTERBODY SPINAL FUSION DEVICE WITH LOCKING MECHANISM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 209 days.

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(57) **ABSTRACT**

(52) **U.S. Cl.**

CPC *A61F 2/447* (2013.01); *A61F 2002/30471* (2013.01); *A61F 2002/30484* (2013.01); *A61F 2002/30494* (2013.01); *A61F 2002/30512* (2013.01); *A61F 2002/30522* (2013.01); *A61F 2002/30525* (2013.01); *A61F 2002/30538* (2013.01); *A61F 2002/30551* (2013.01); *A61F 2002/30579* (2013.01); *A61F 2002/30622* (2013.01); *A61F 2002/4475* (2013.01)

A stand-alone expandable interbody spinal fusion device, including a superior component, an inferior component, an expansion mechanism operatively arranged to displace the superior component in a first direction relative to the inferior component about a first hinge, and a locking mechanism. The locking mechanism including a plate operatively arranged to pivot about a second hinge, the plate further including a first through-bore and a first plurality of teeth, a pawl operatively arranged to pivot about a third hinge, the pawl further including a second through-bore, and a post operatively arranged to pass through the second and third through-bores such that after the superior component is displaced in the first direction, the locking mechanism prevents displacement of the superior component in a second direction, opposite the first direction.

(58) **Field of Classification Search**

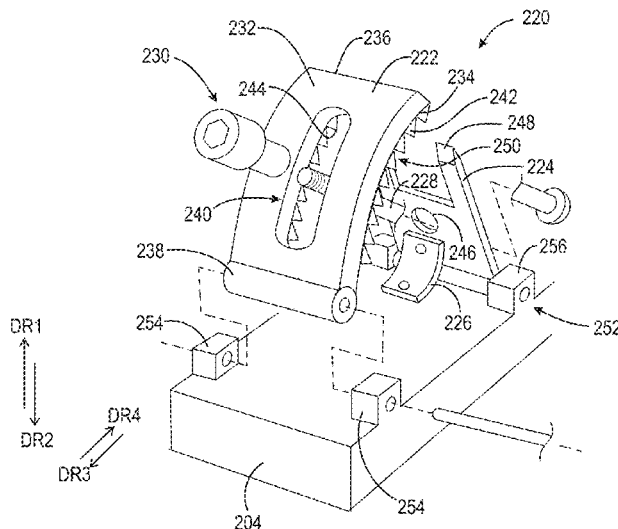
None
See application file for complete search history.

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12 Claims, 25 Drawing Sheets



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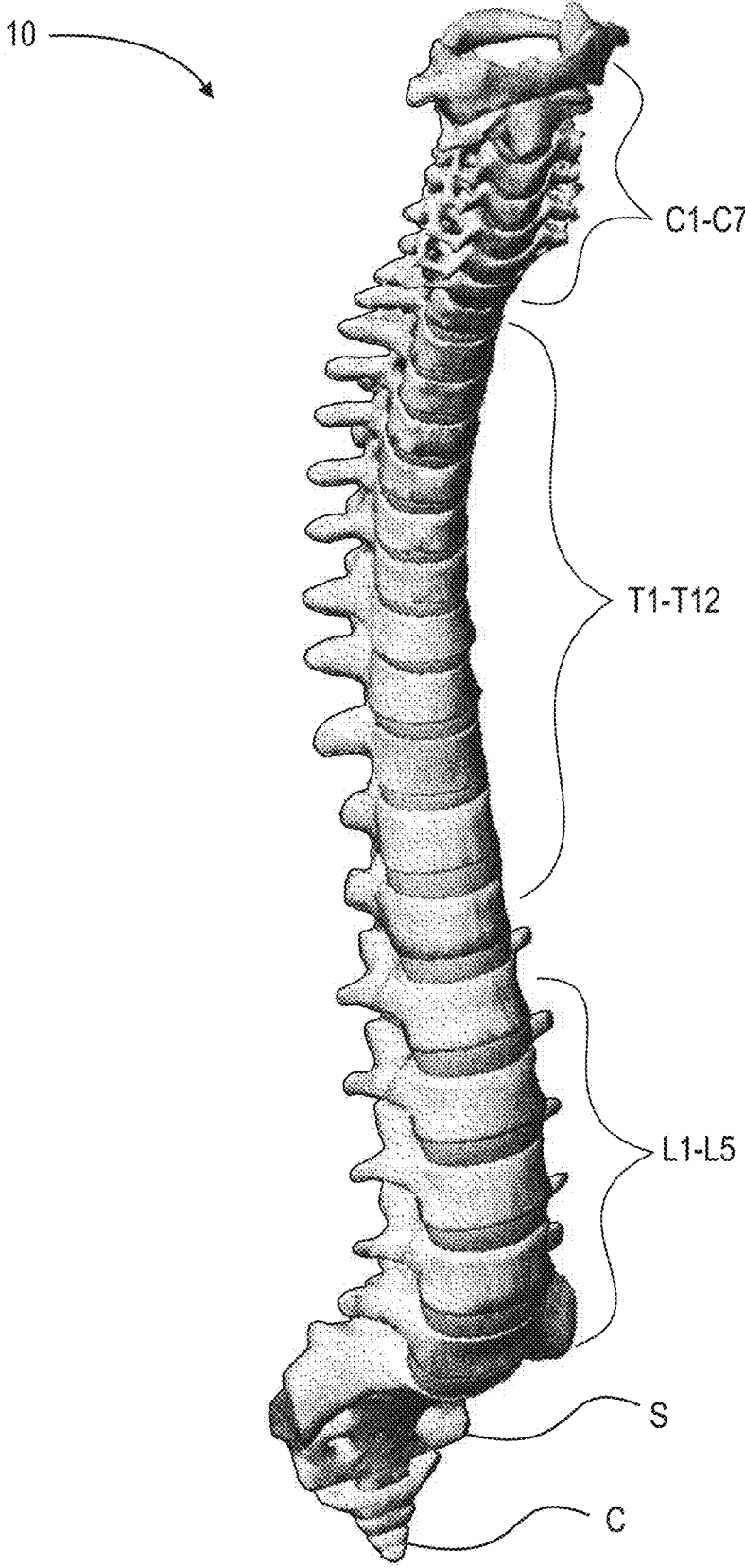


Fig. 1

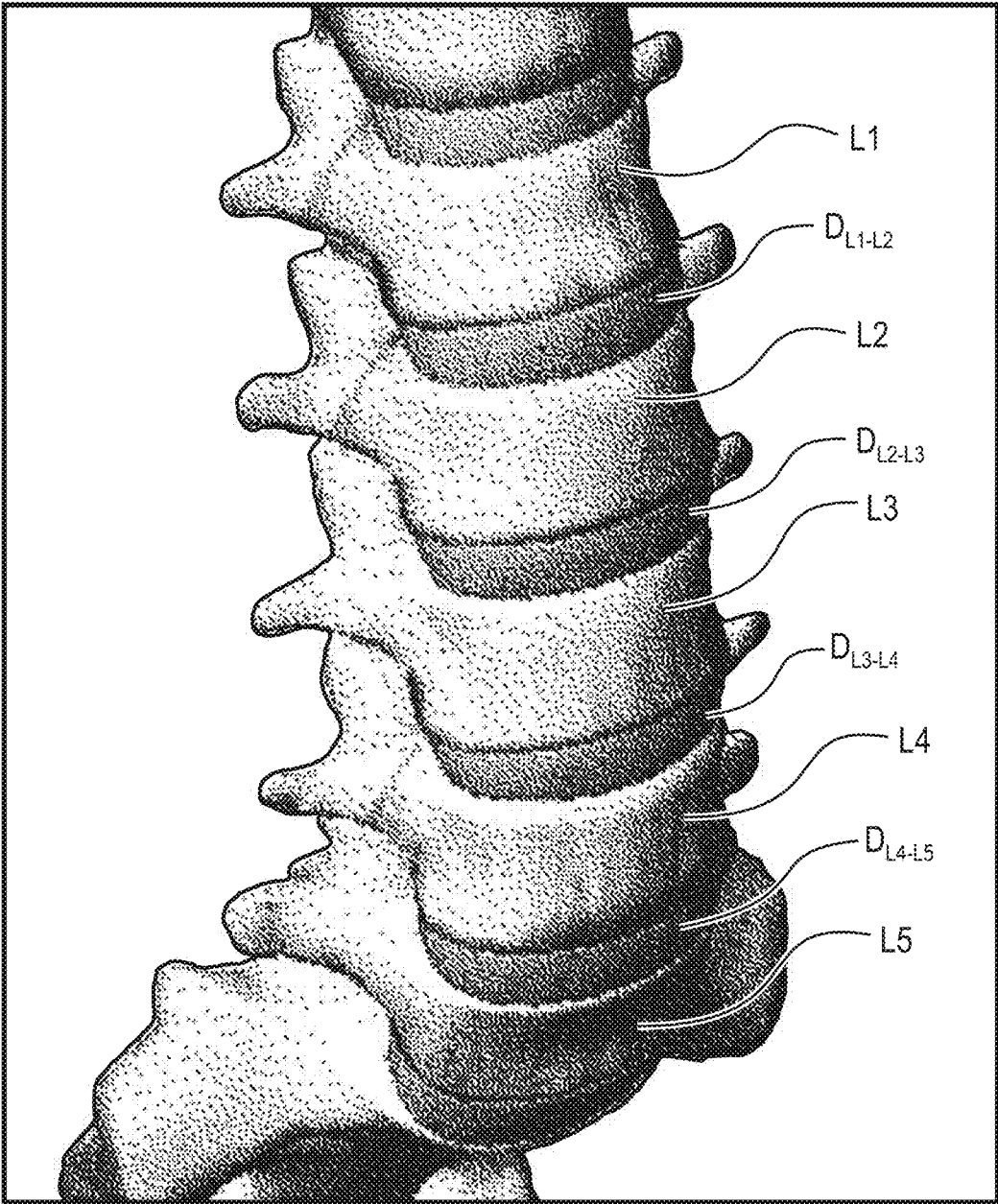


Fig. 2

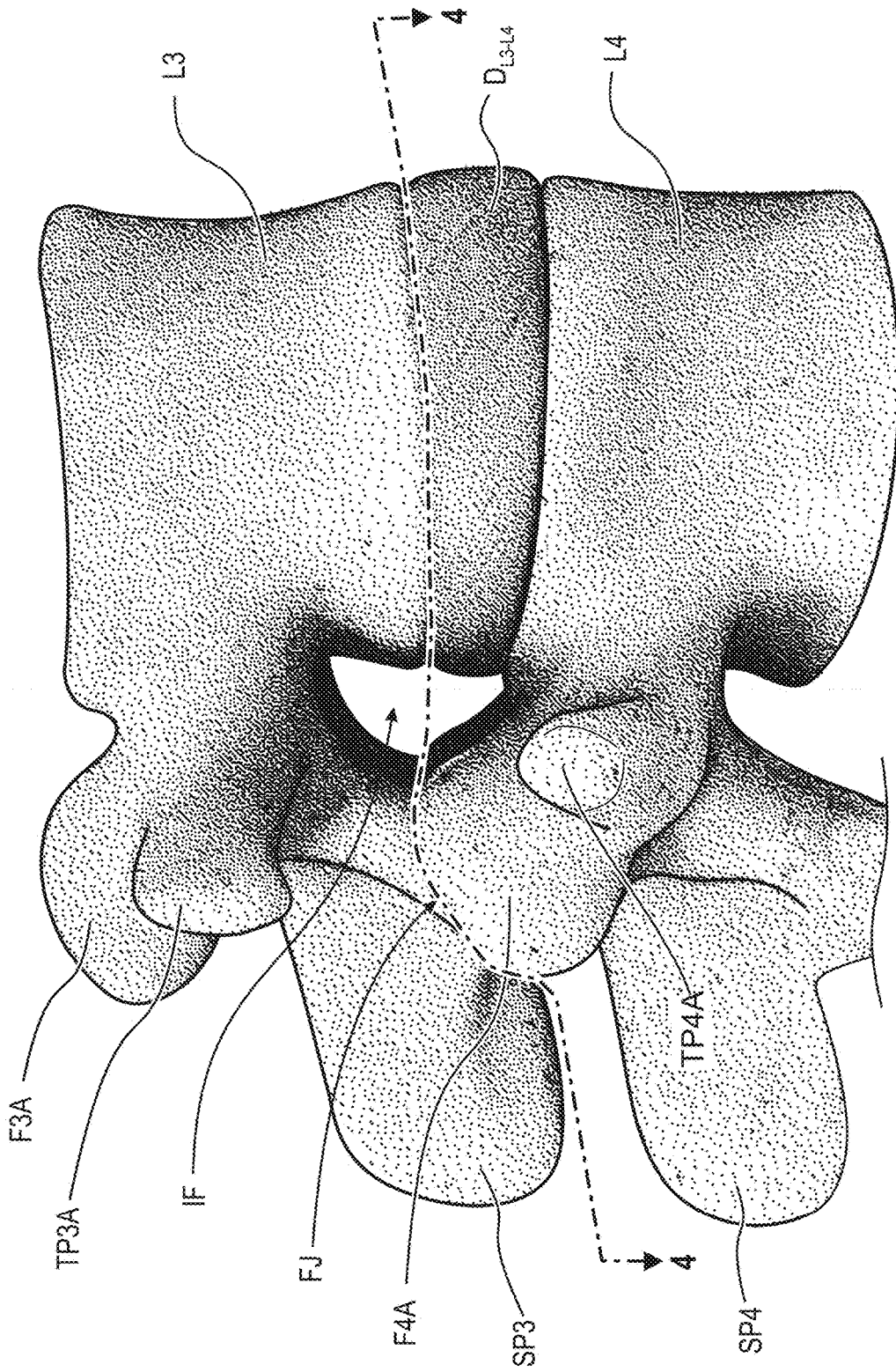


Fig. 3

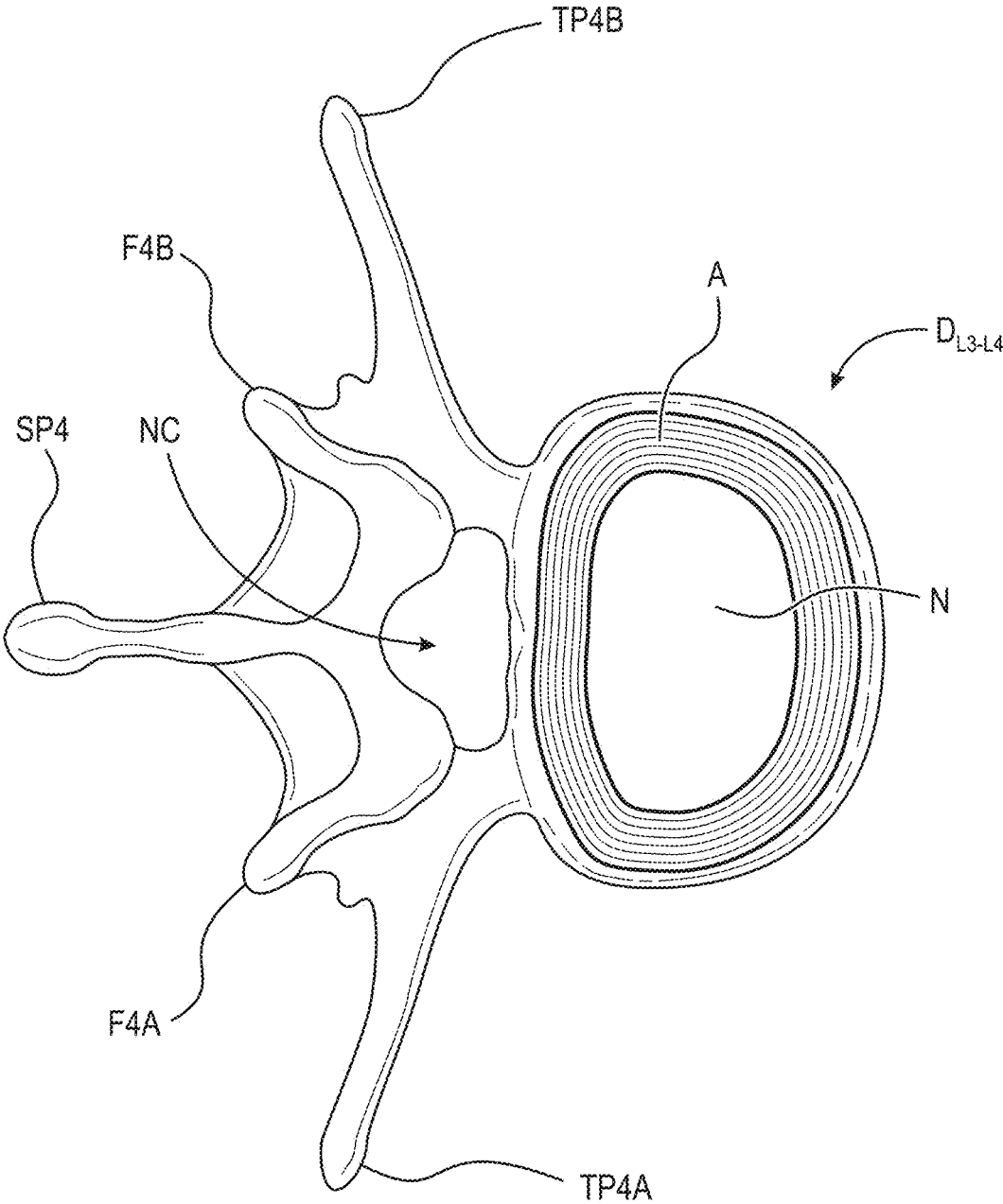


Fig. 4

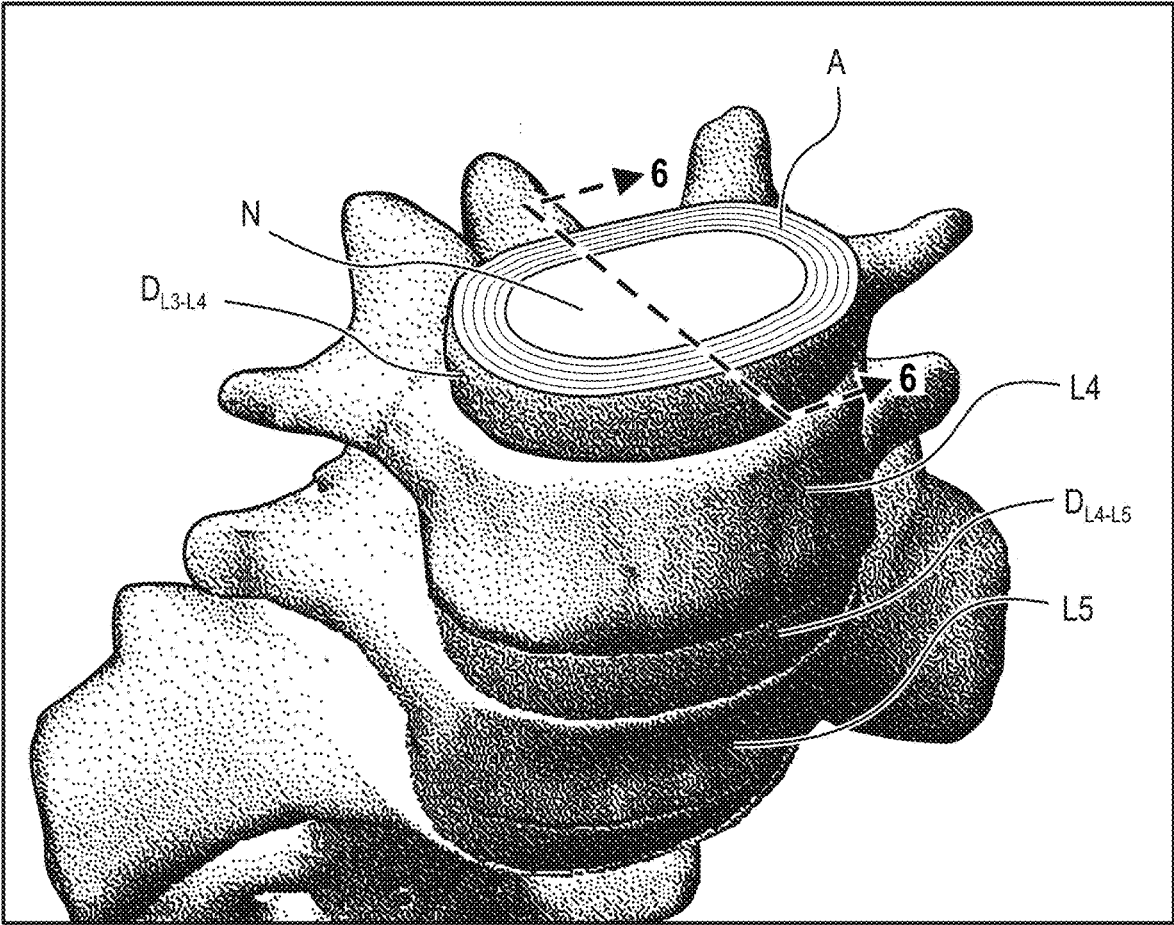


Fig. 5

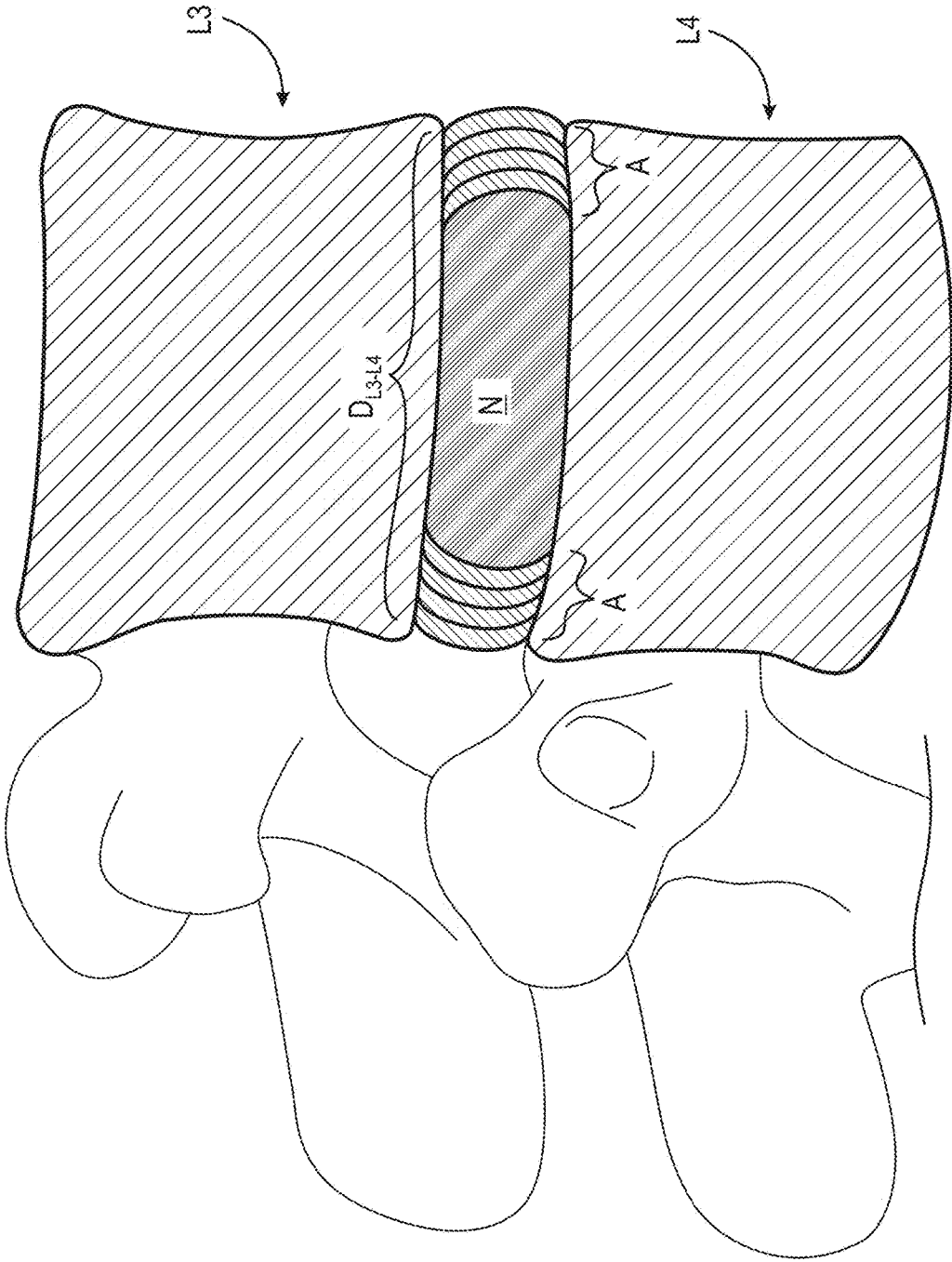


Fig. 6

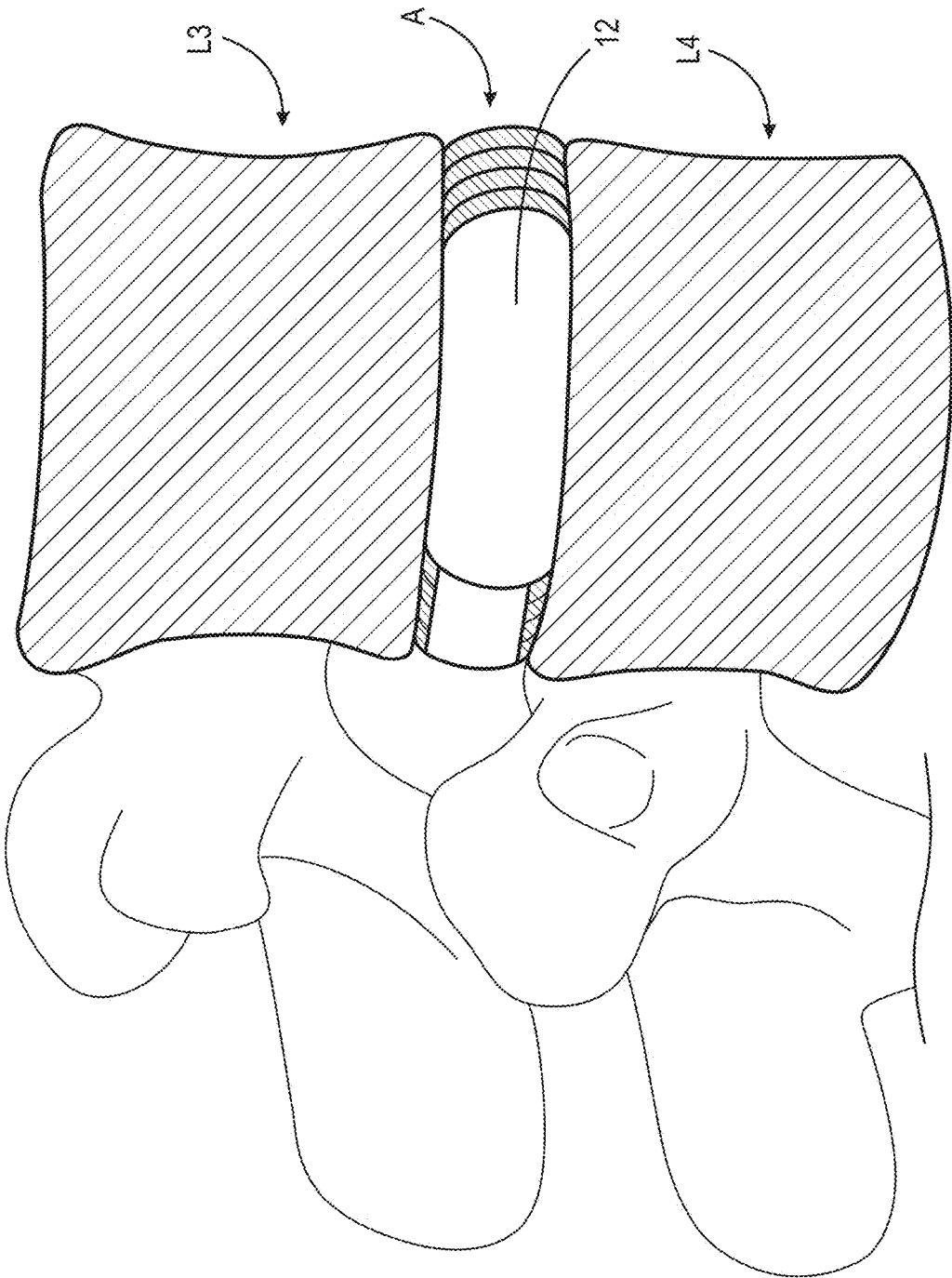


Fig. 7

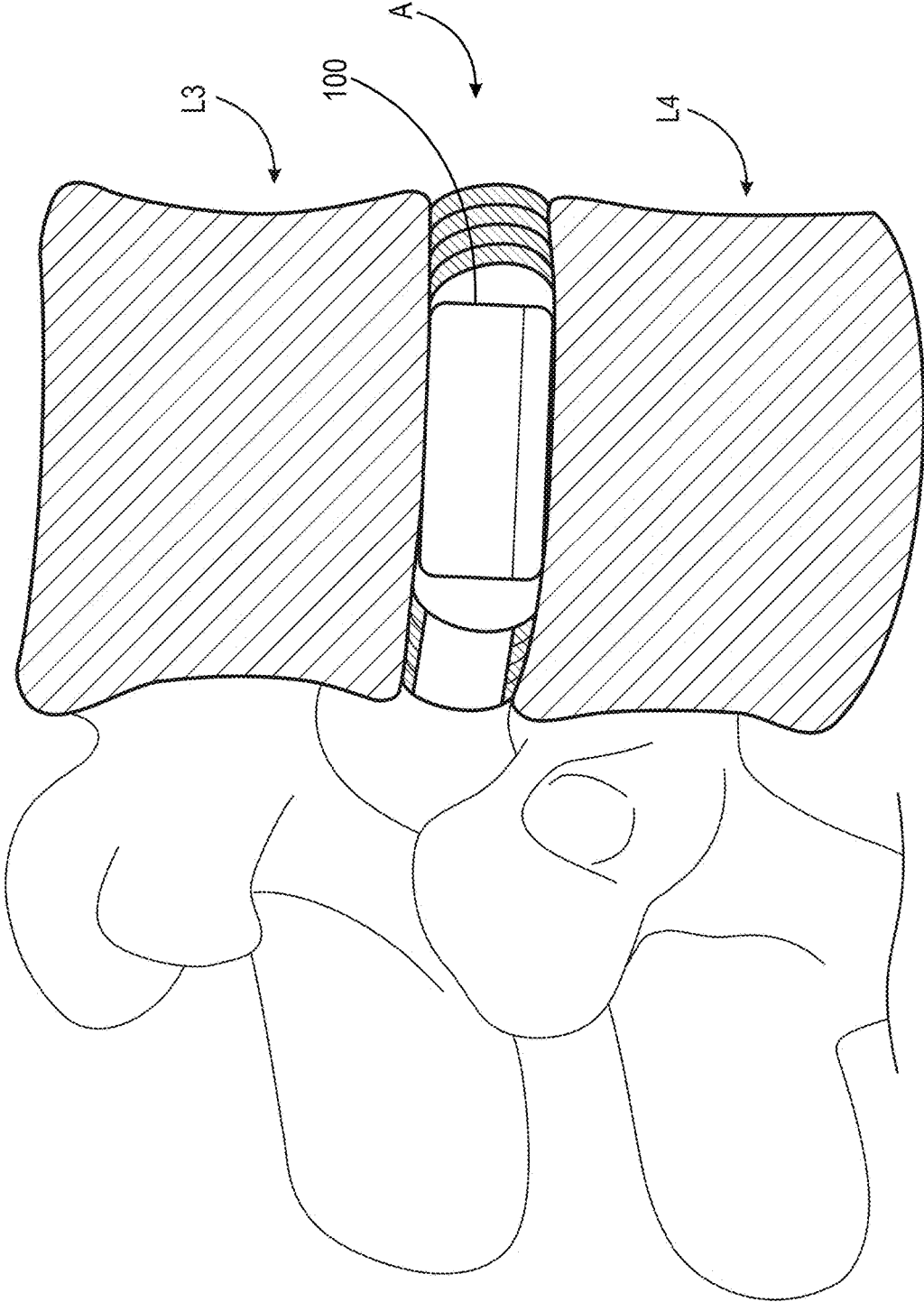


Fig. 8

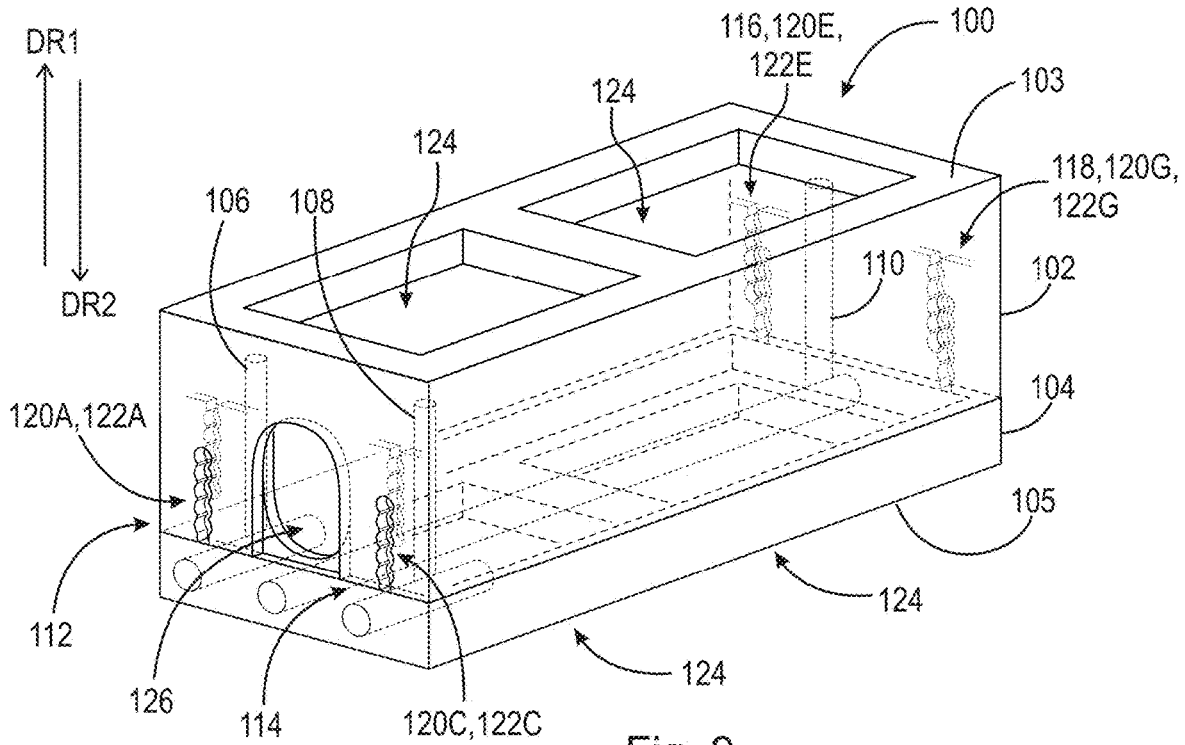


Fig. 9

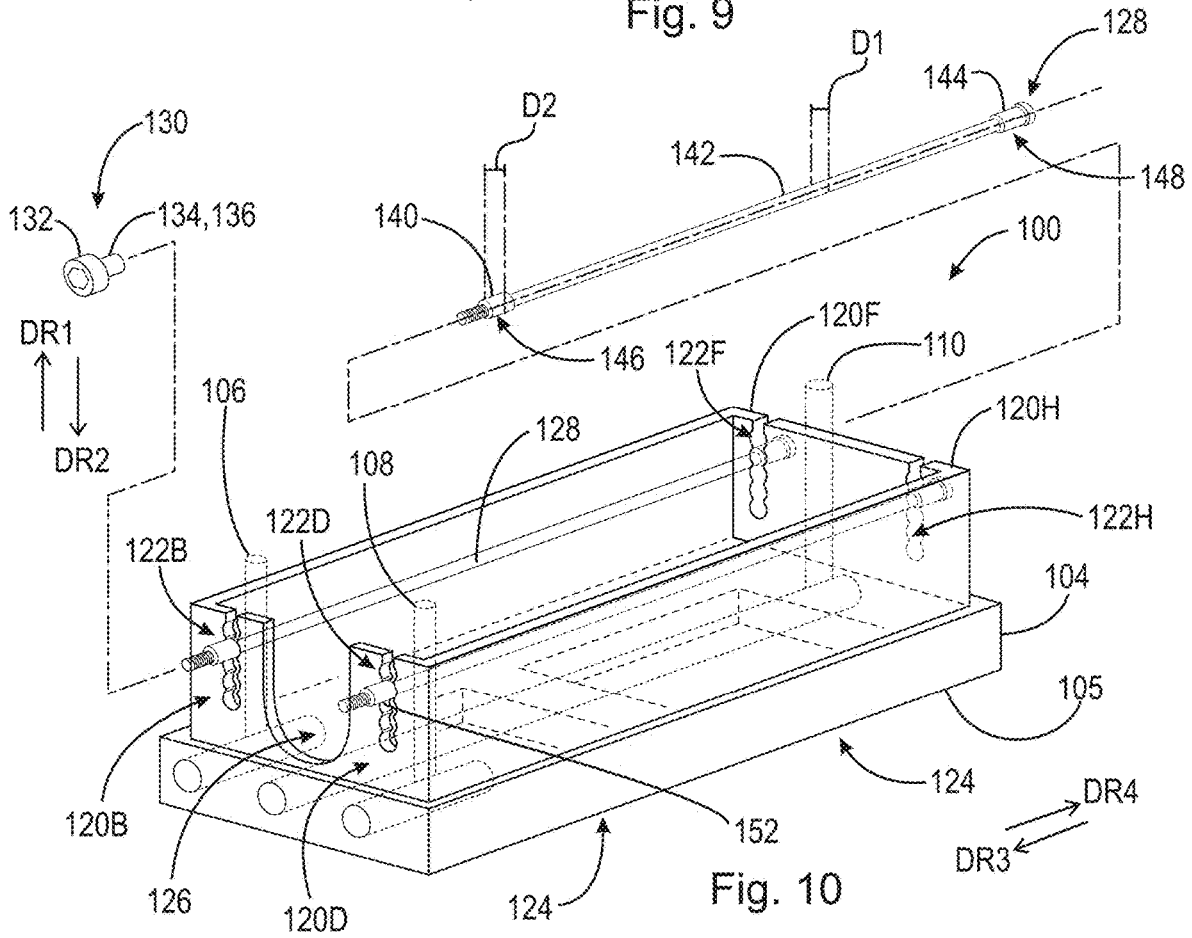


Fig. 10

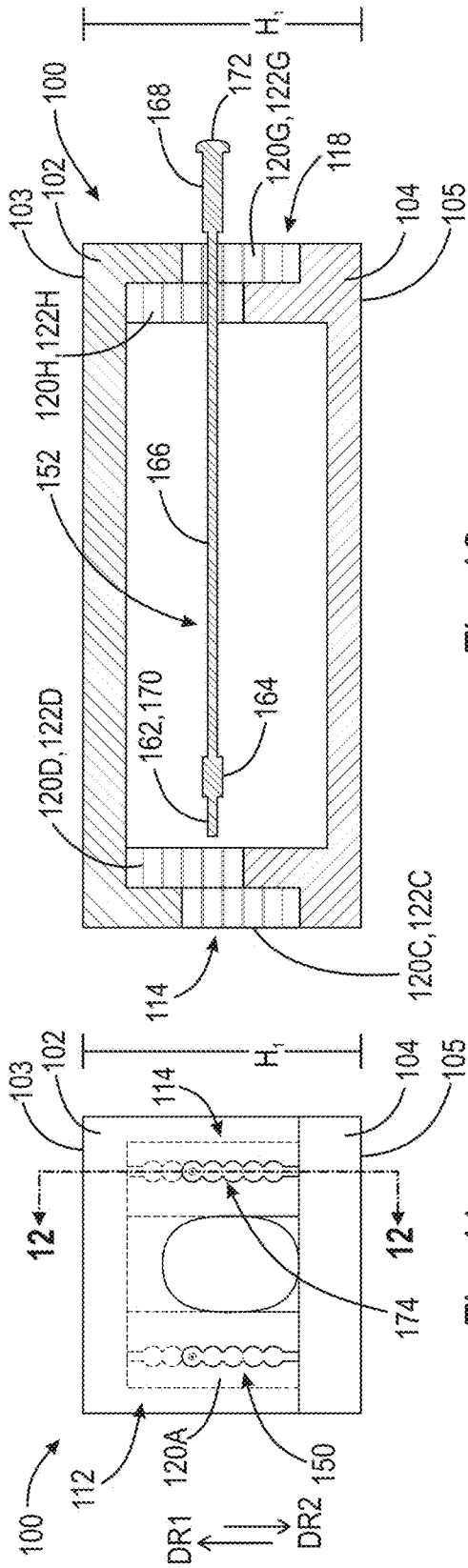


Fig. 12

Fig. 11

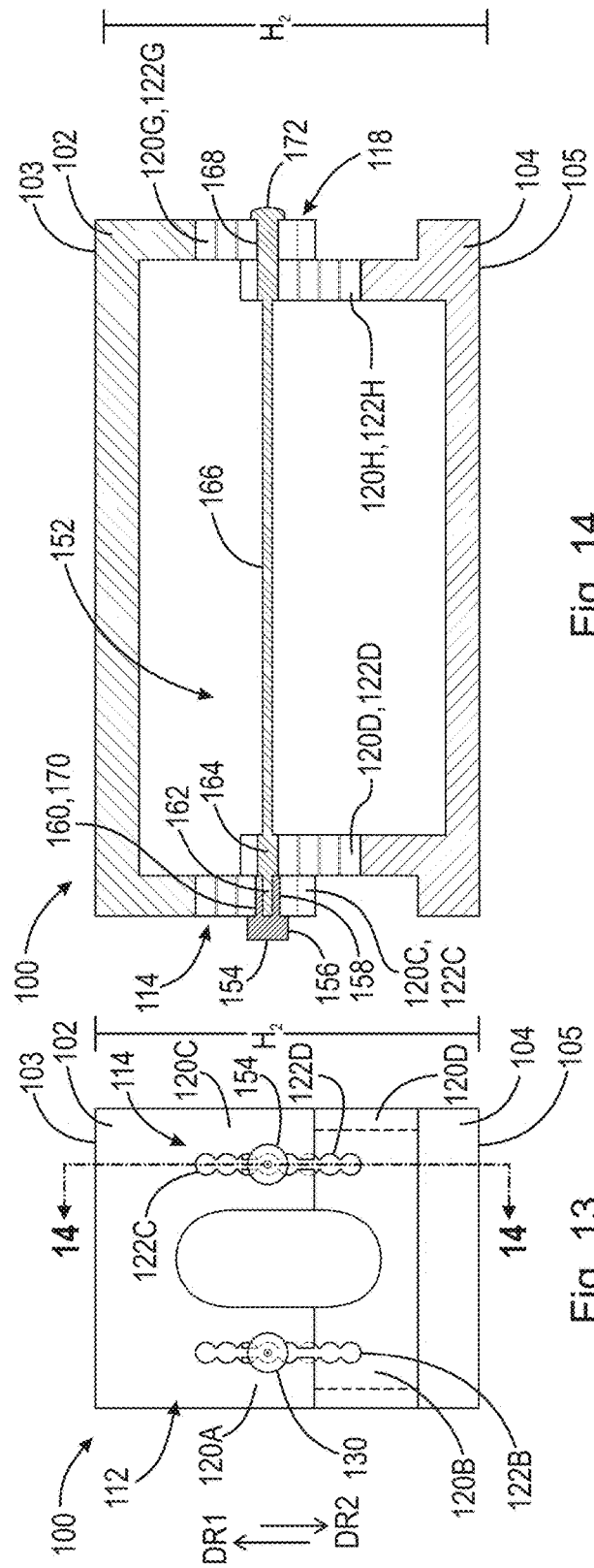


Fig. 14

Fig. 13

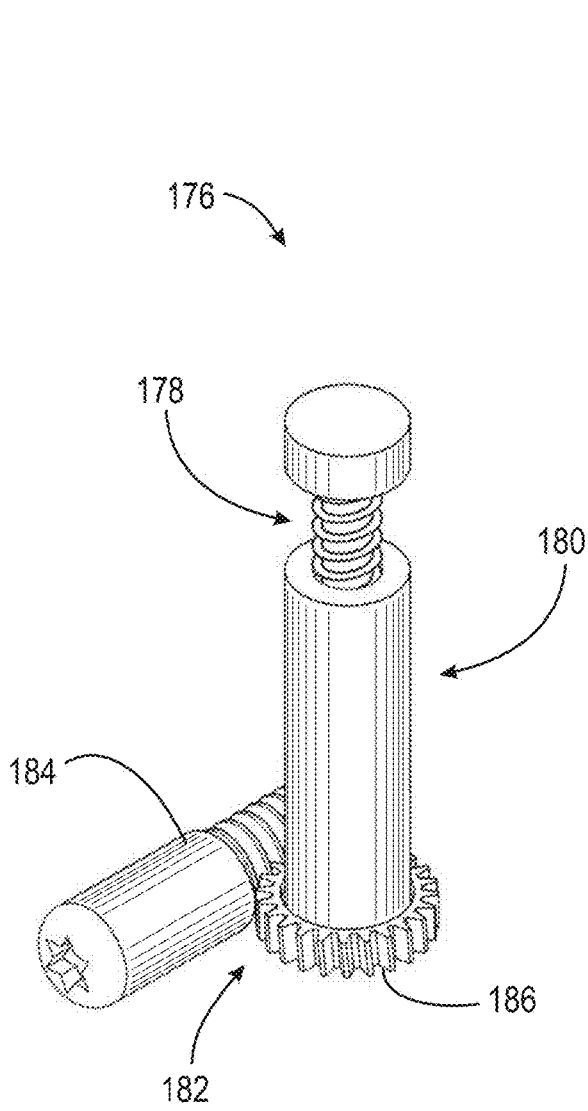


Fig. 15

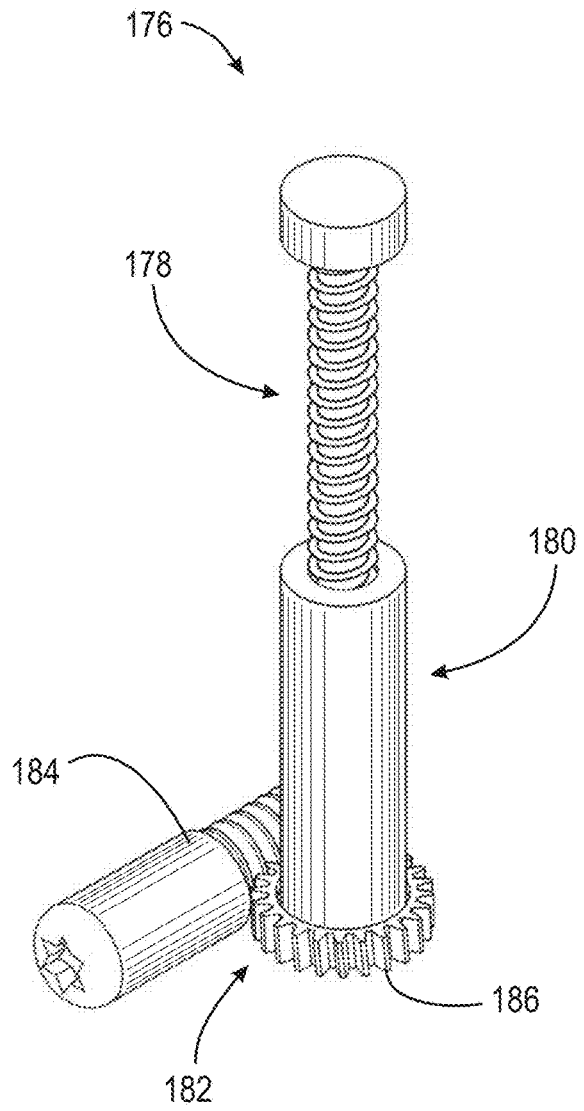


Fig. 16

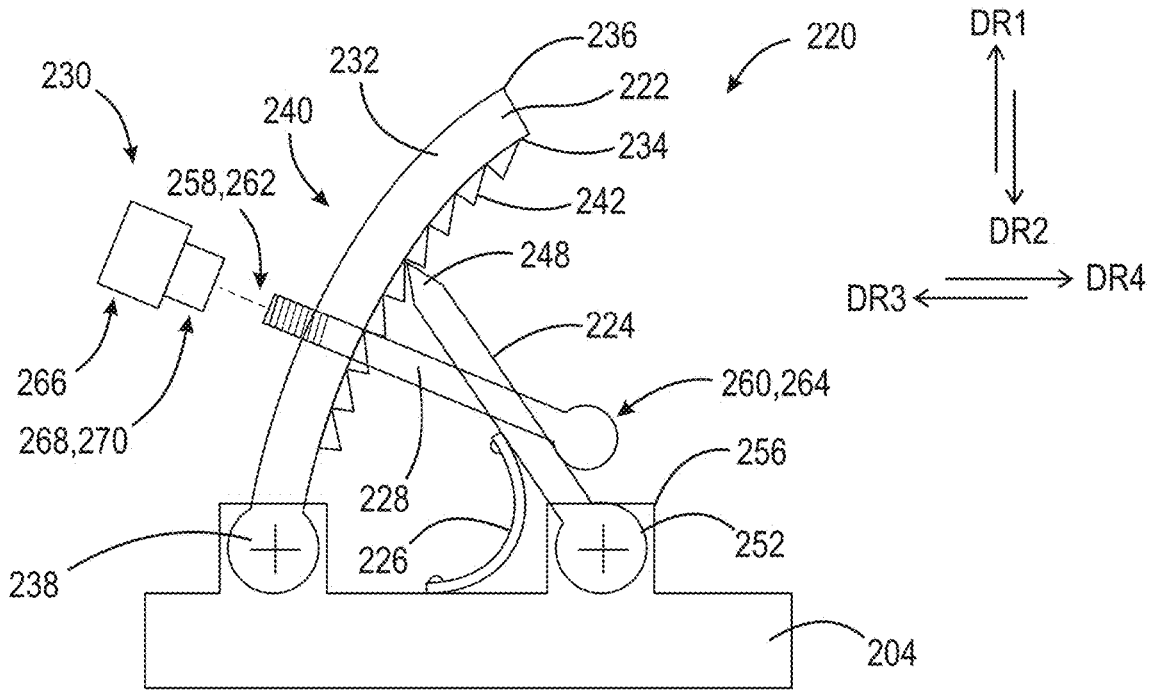


Fig. 17

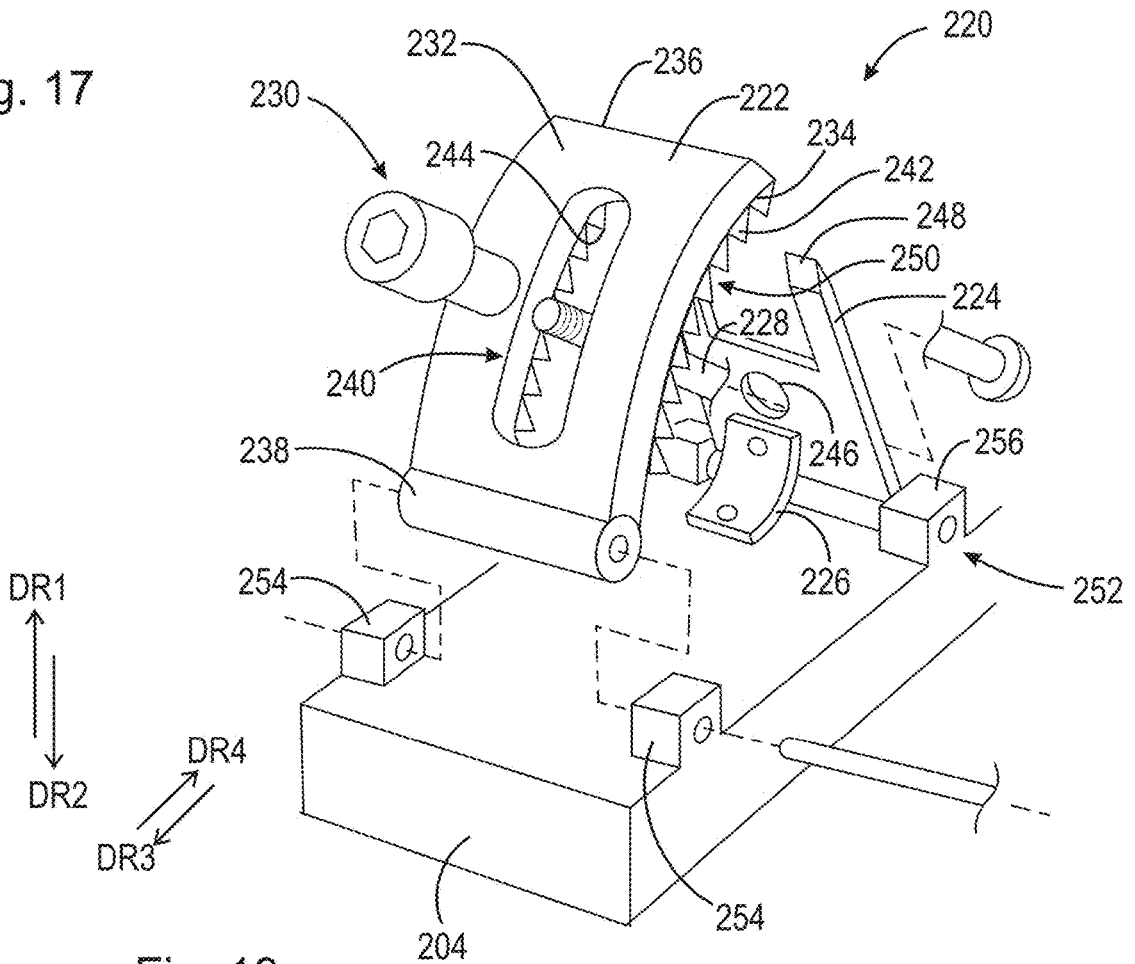
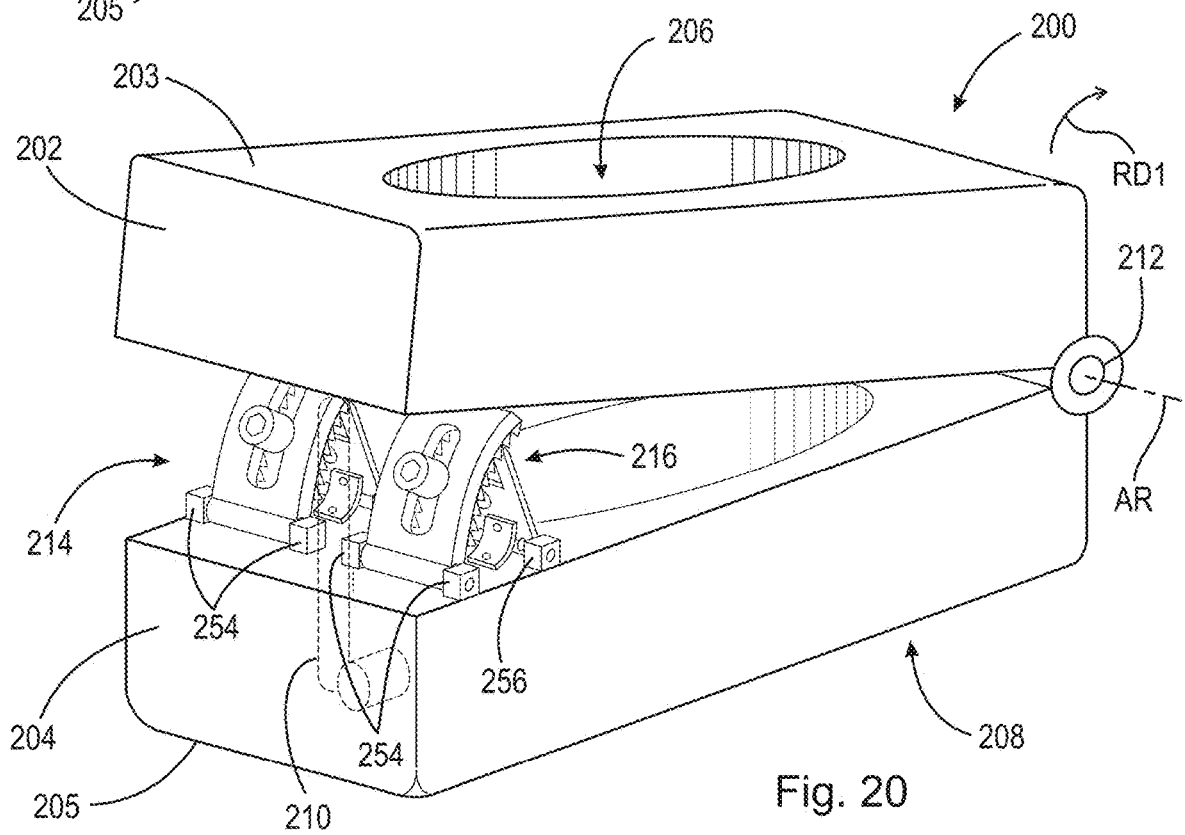
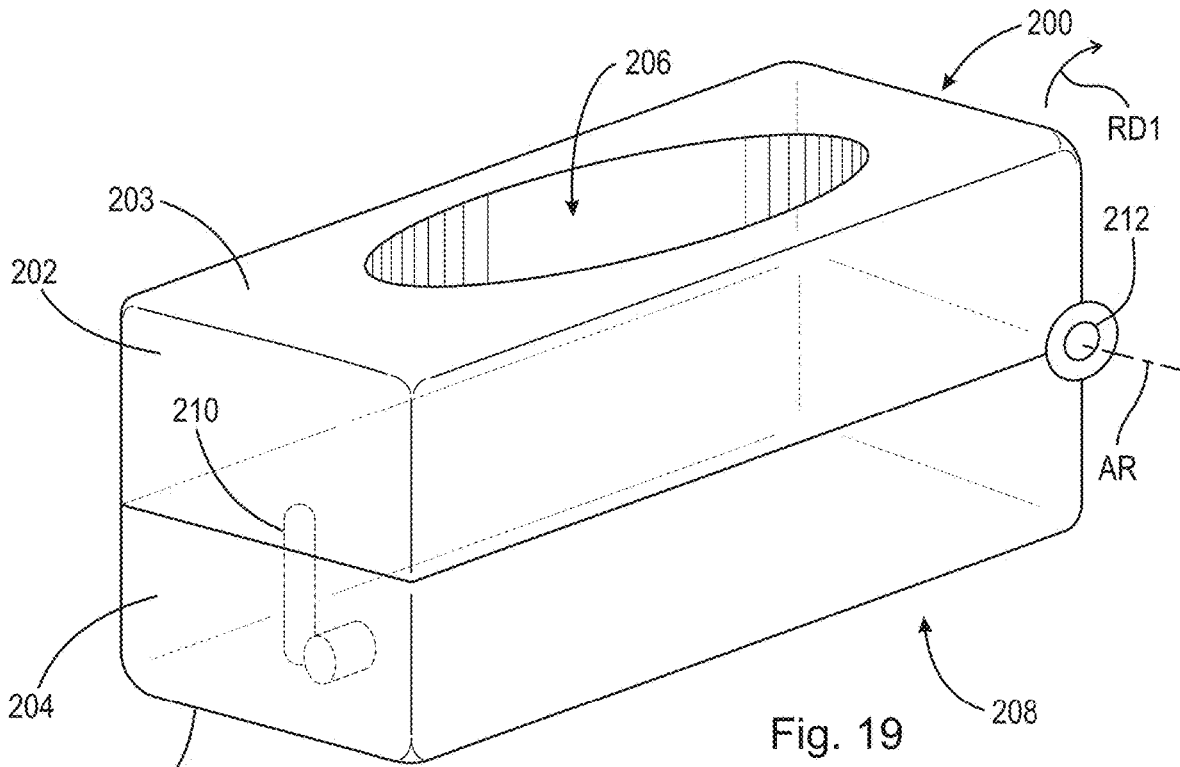
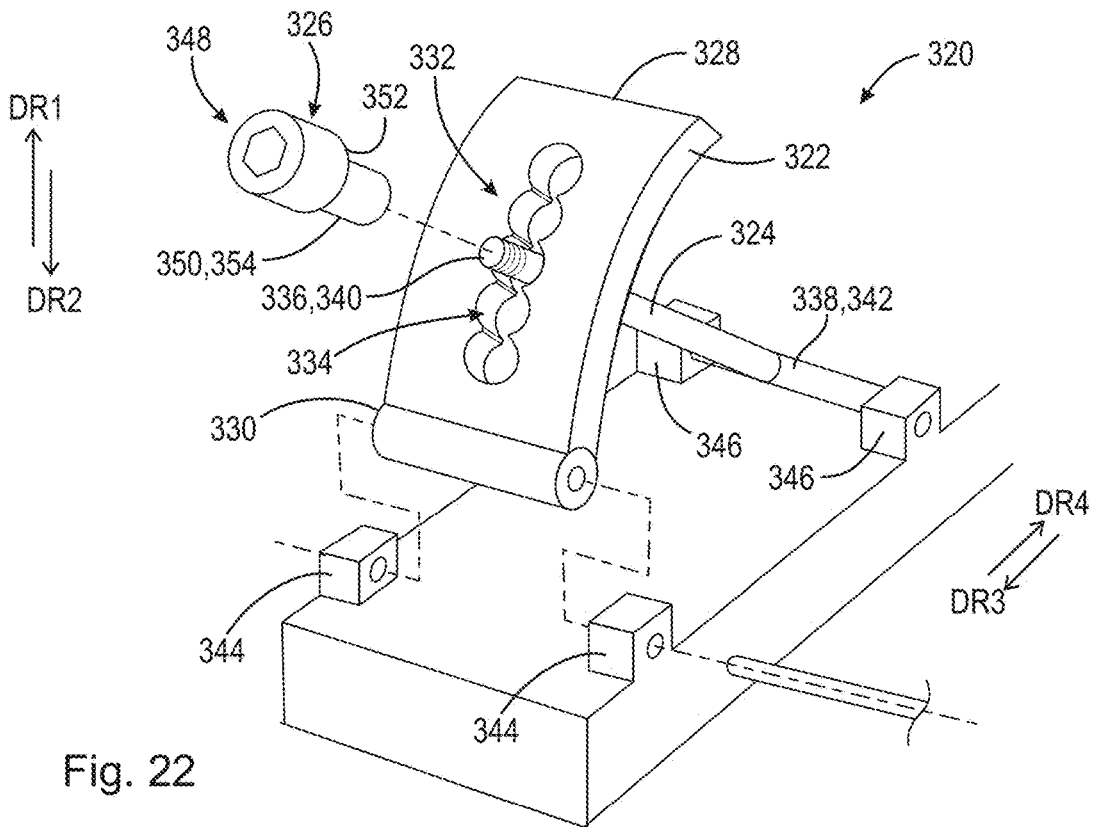
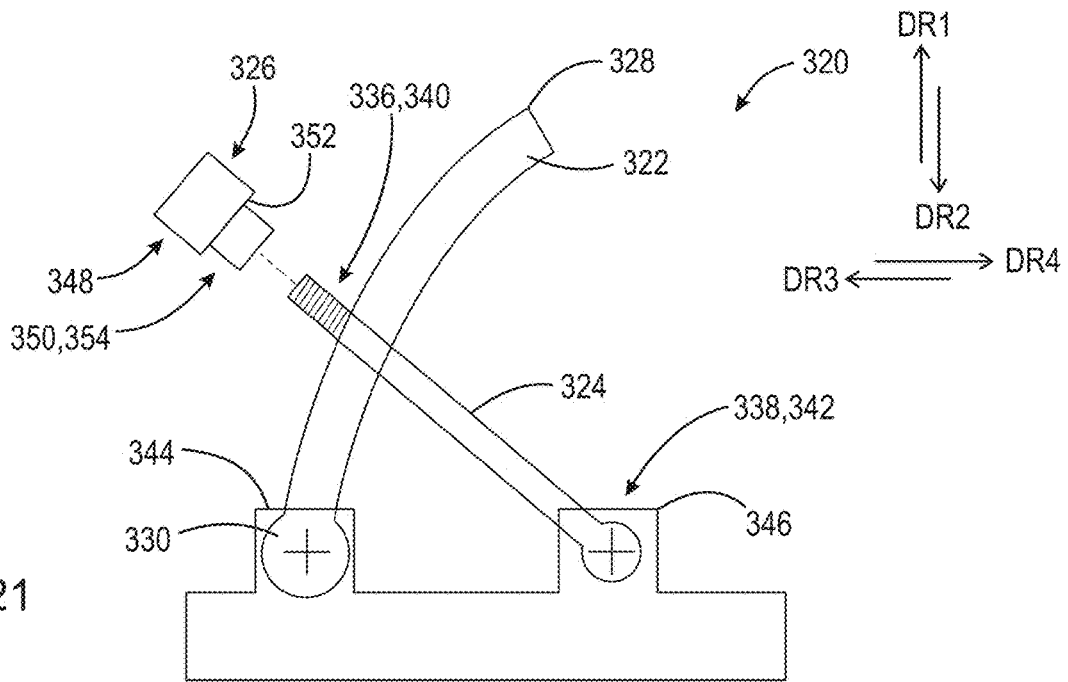
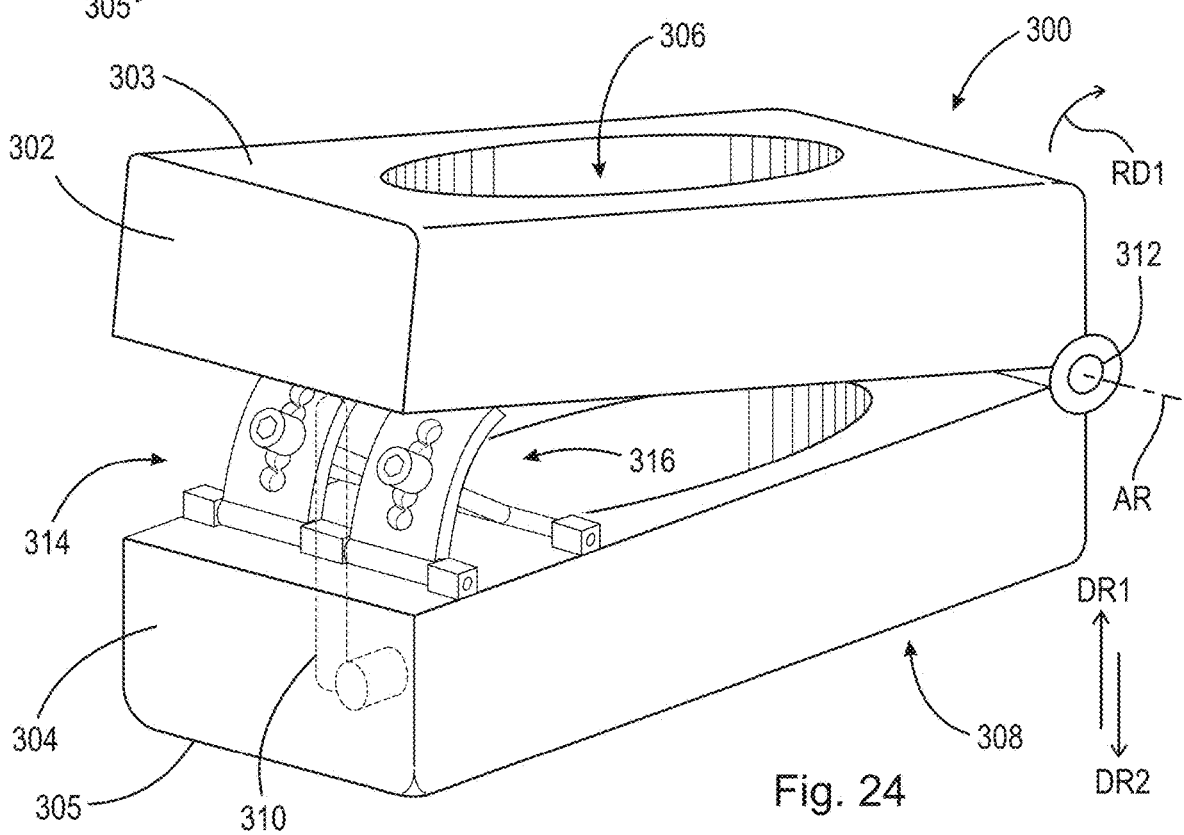
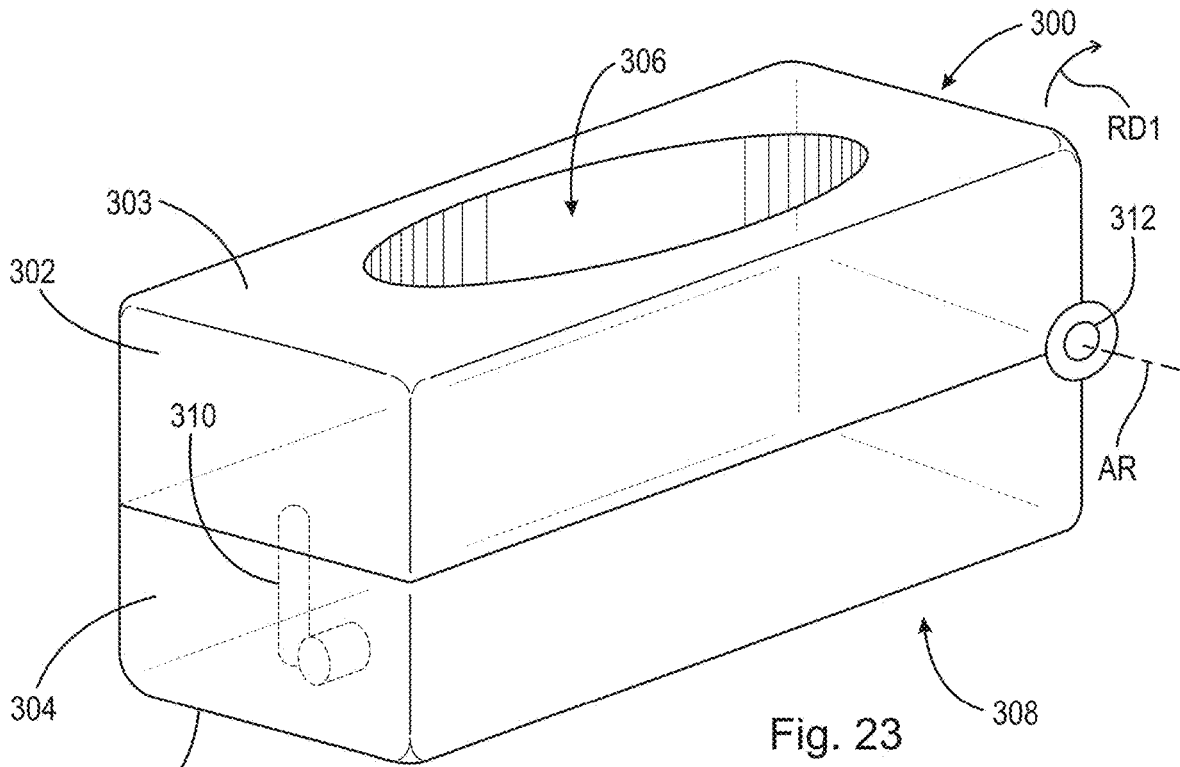


Fig. 18







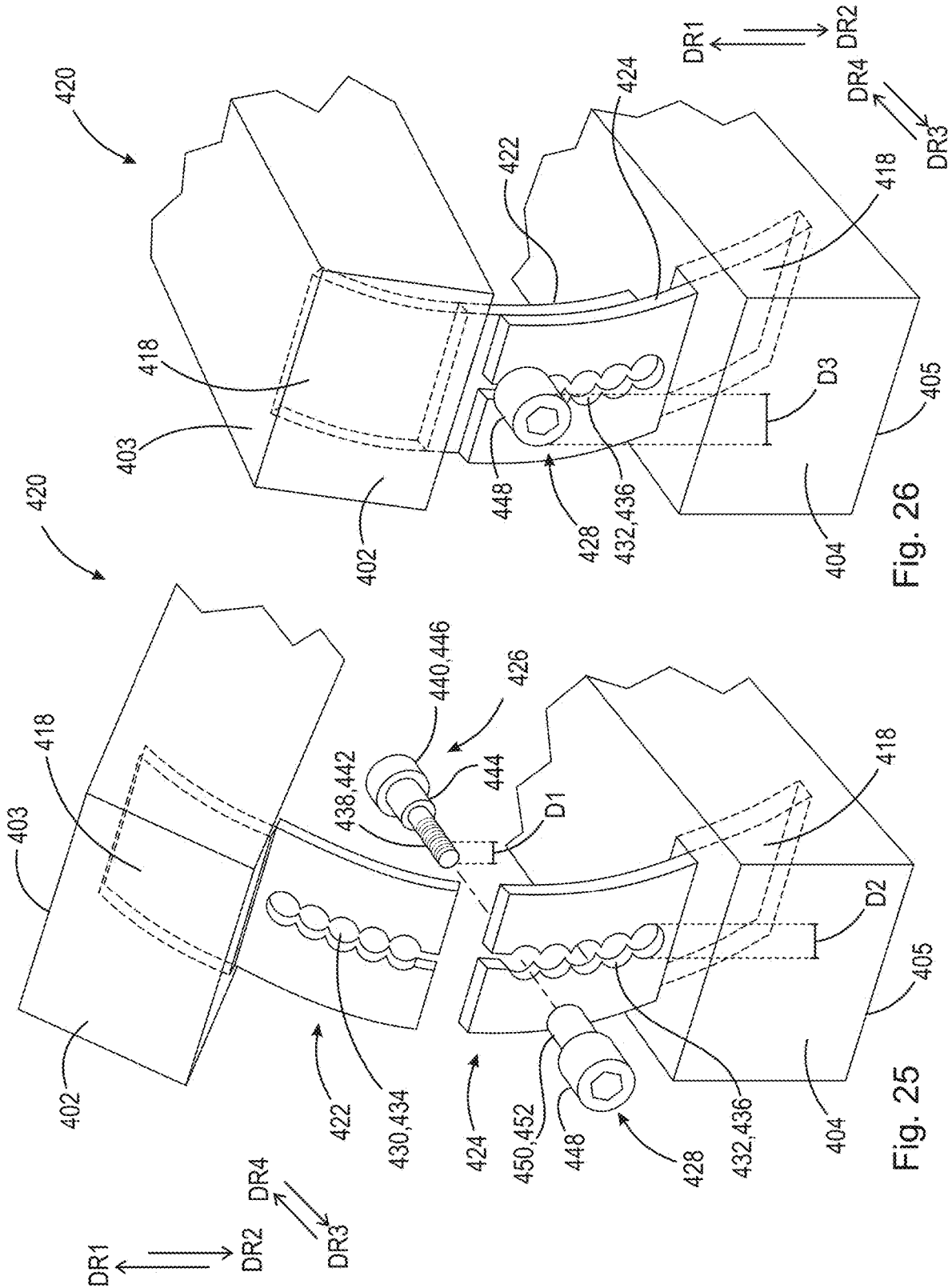
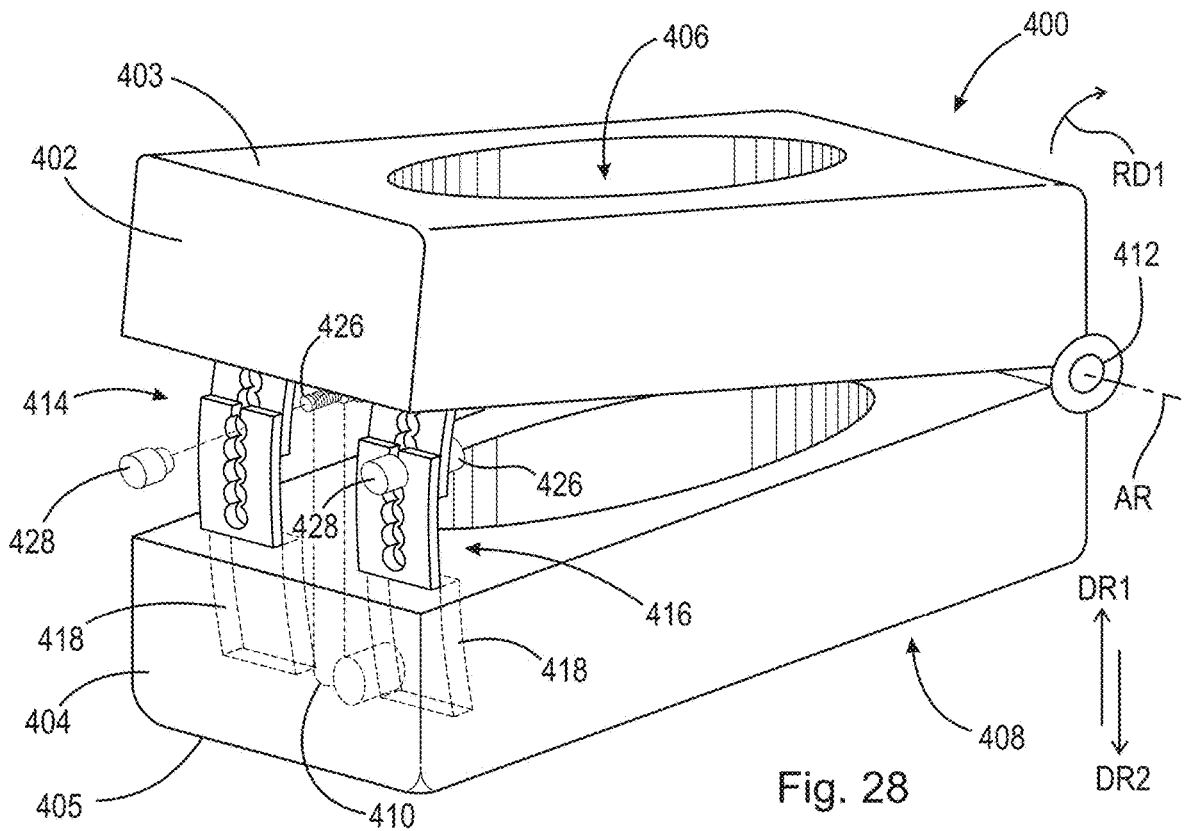
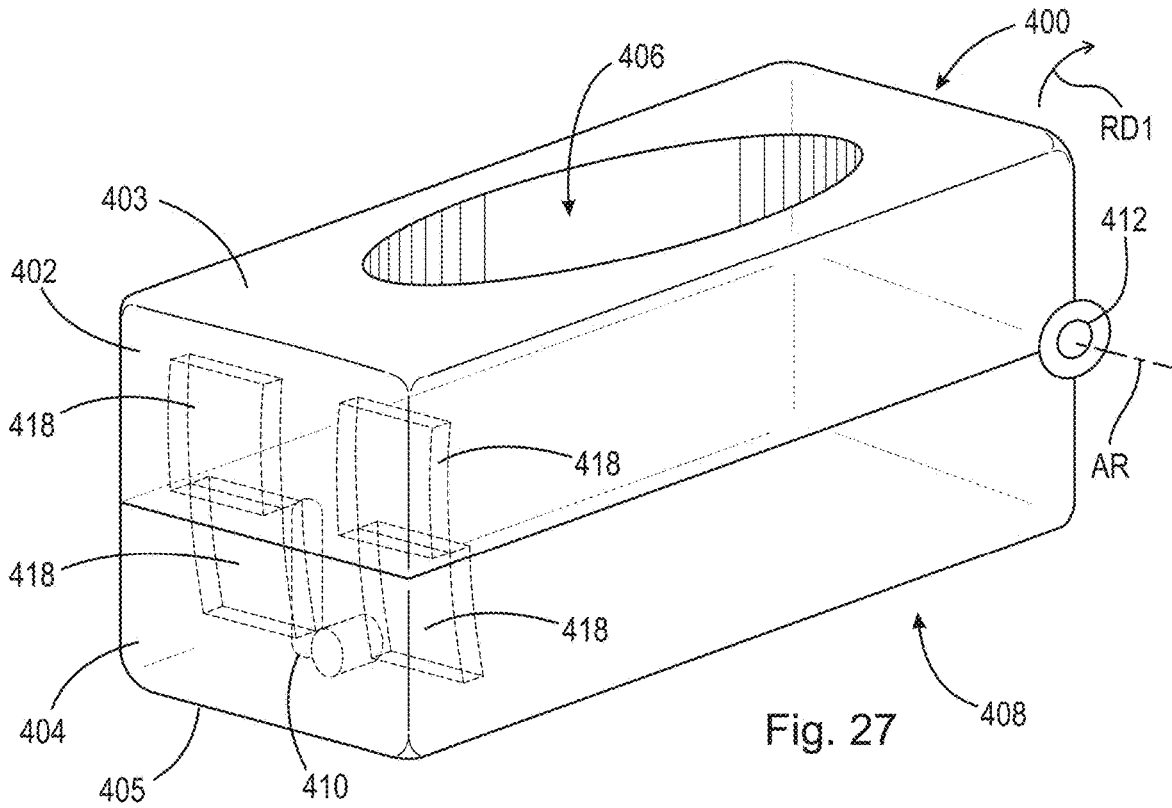


Fig. 26

Fig. 25



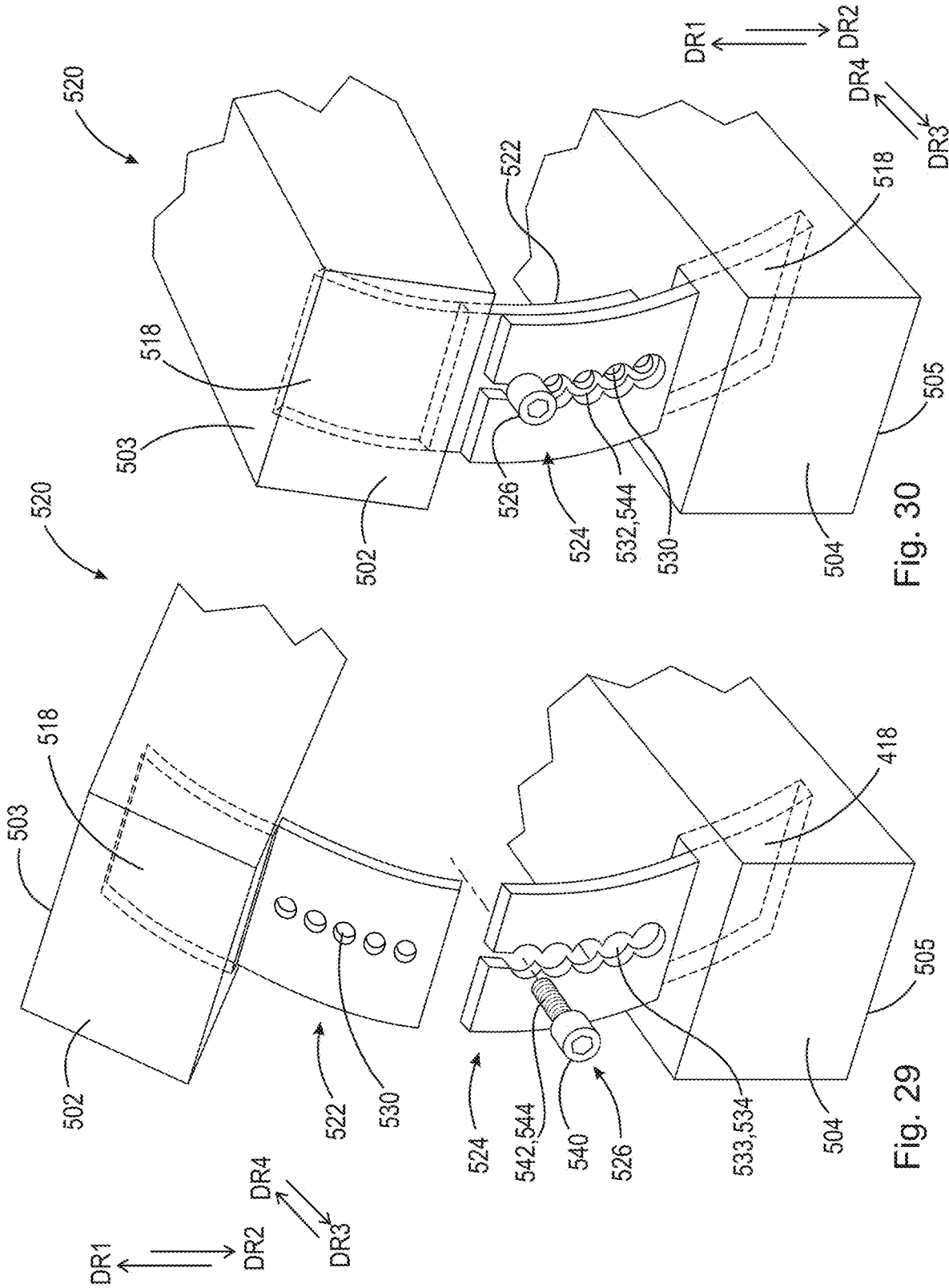
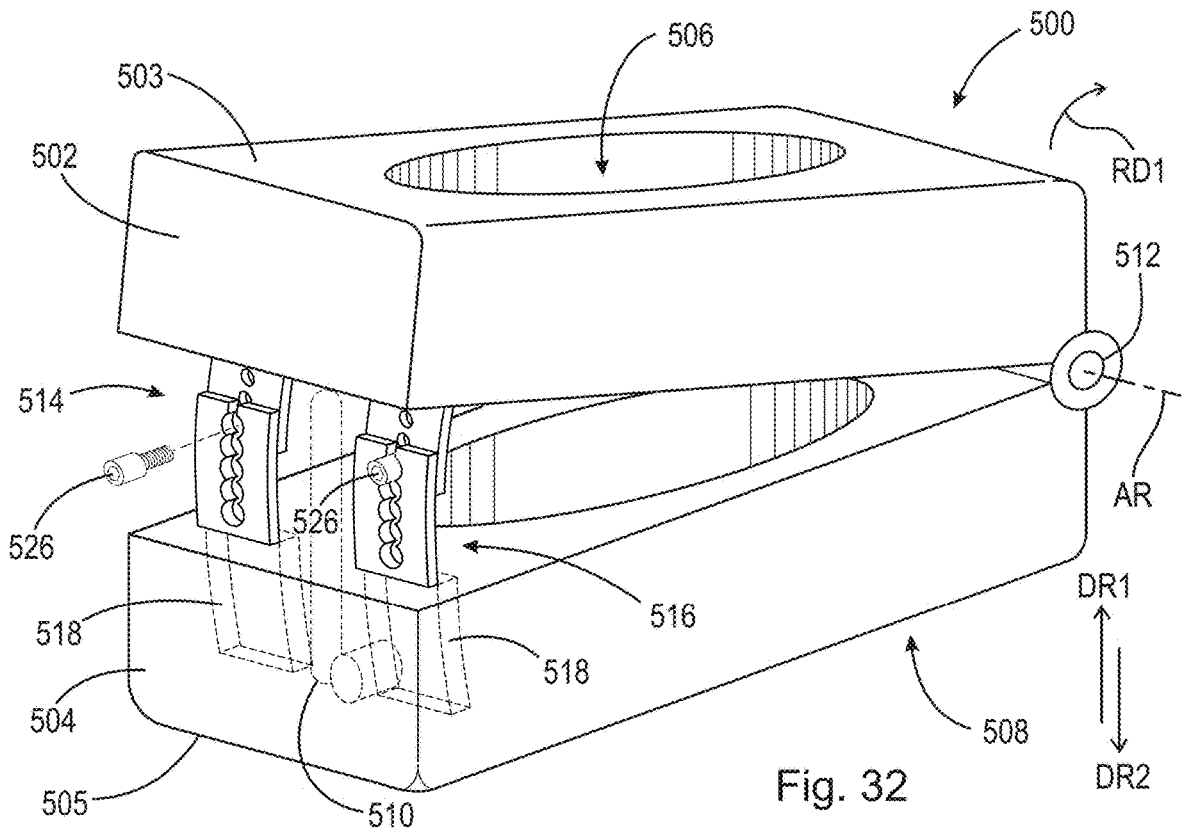
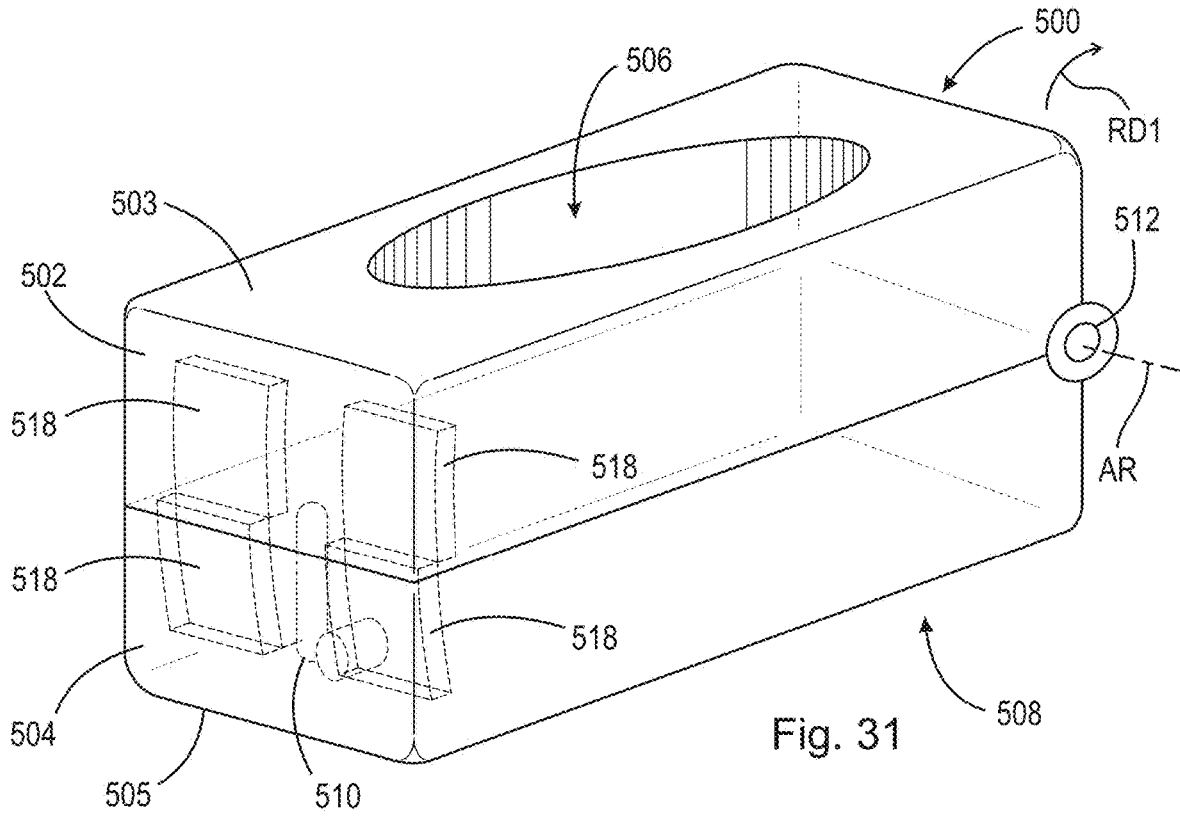


Fig. 30

Fig. 29



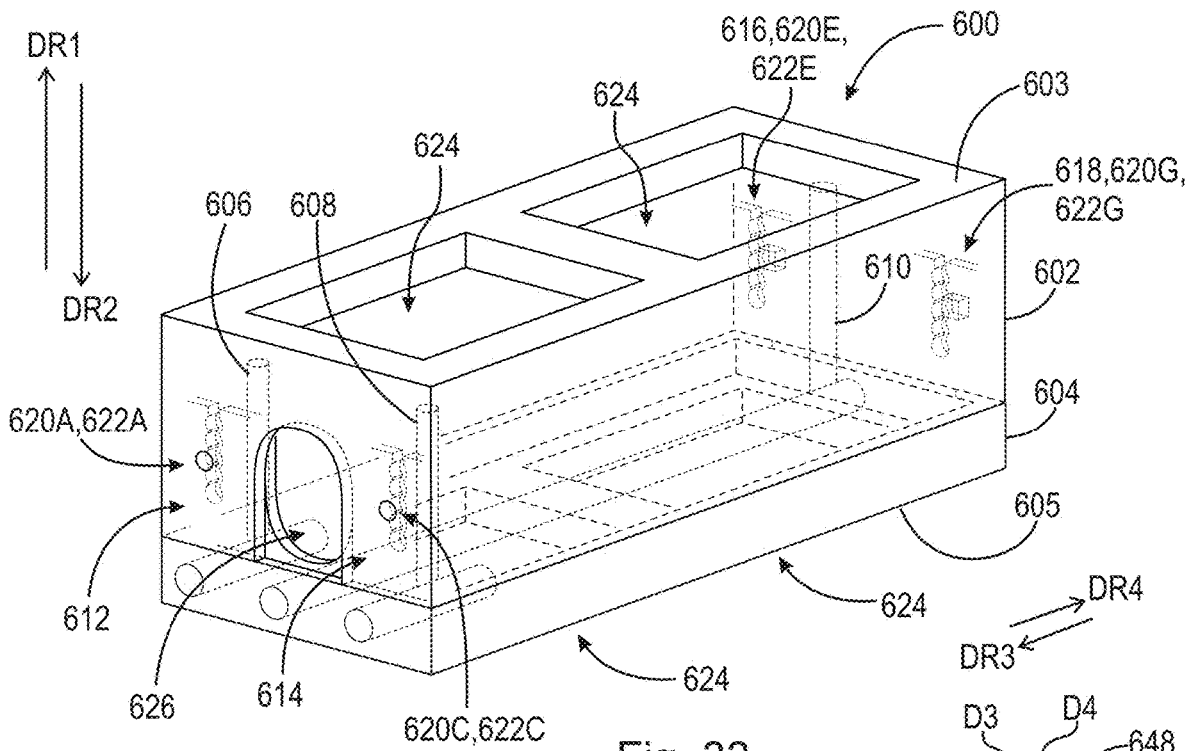


Fig. 33

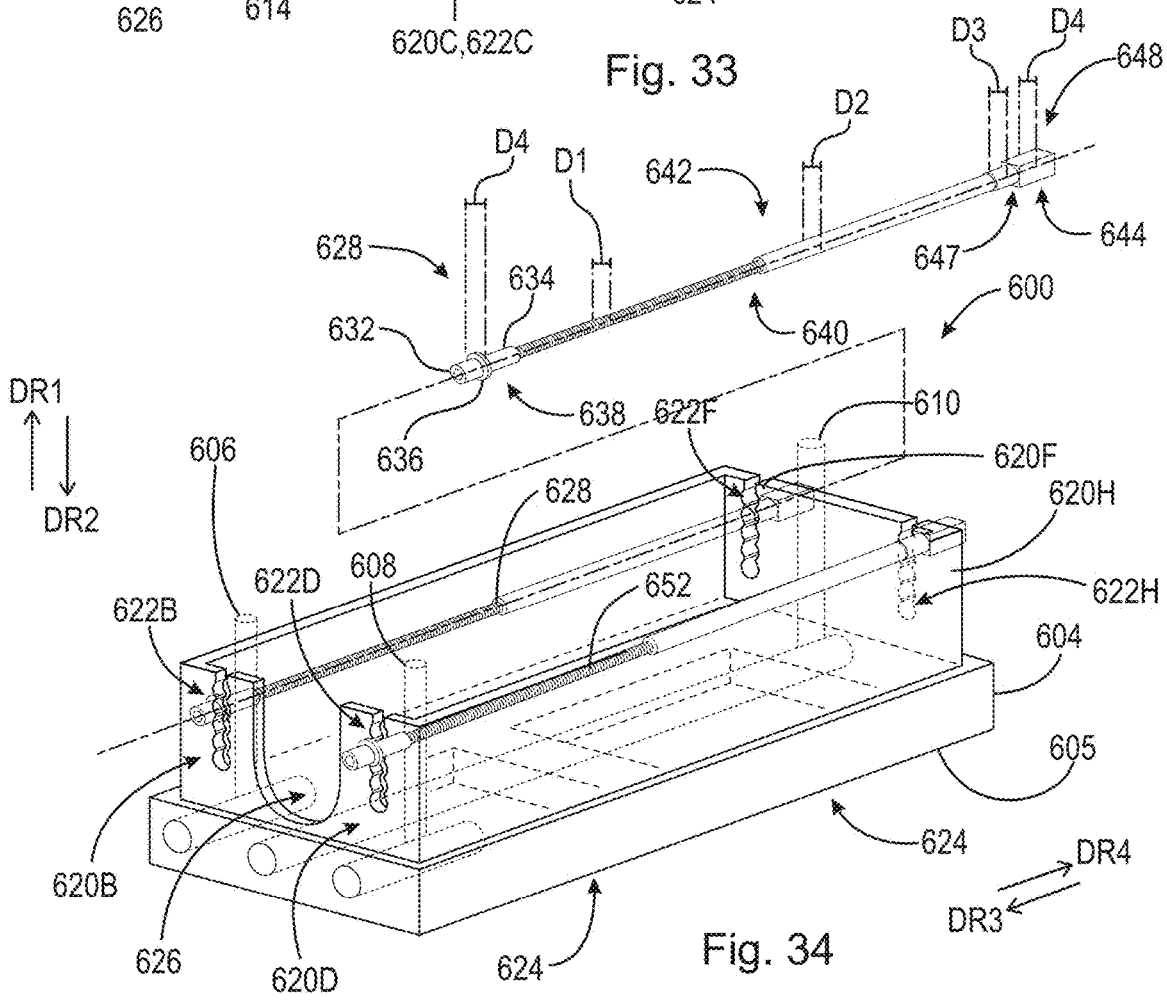


Fig. 34

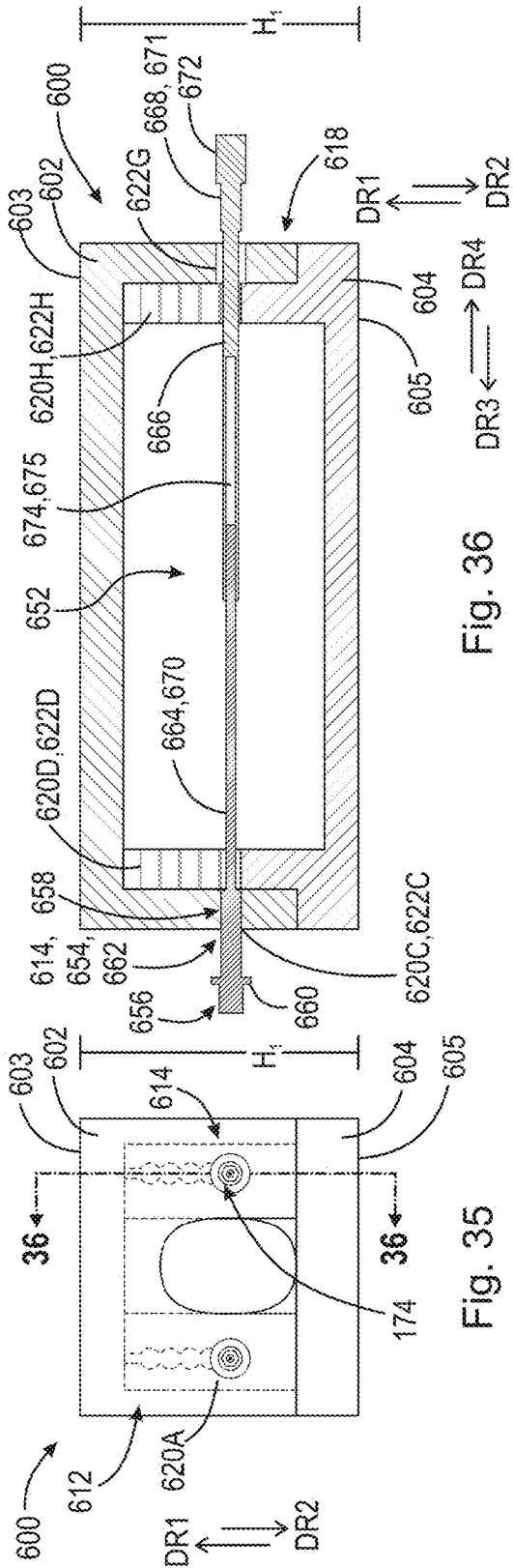


Fig. 35

Fig. 36

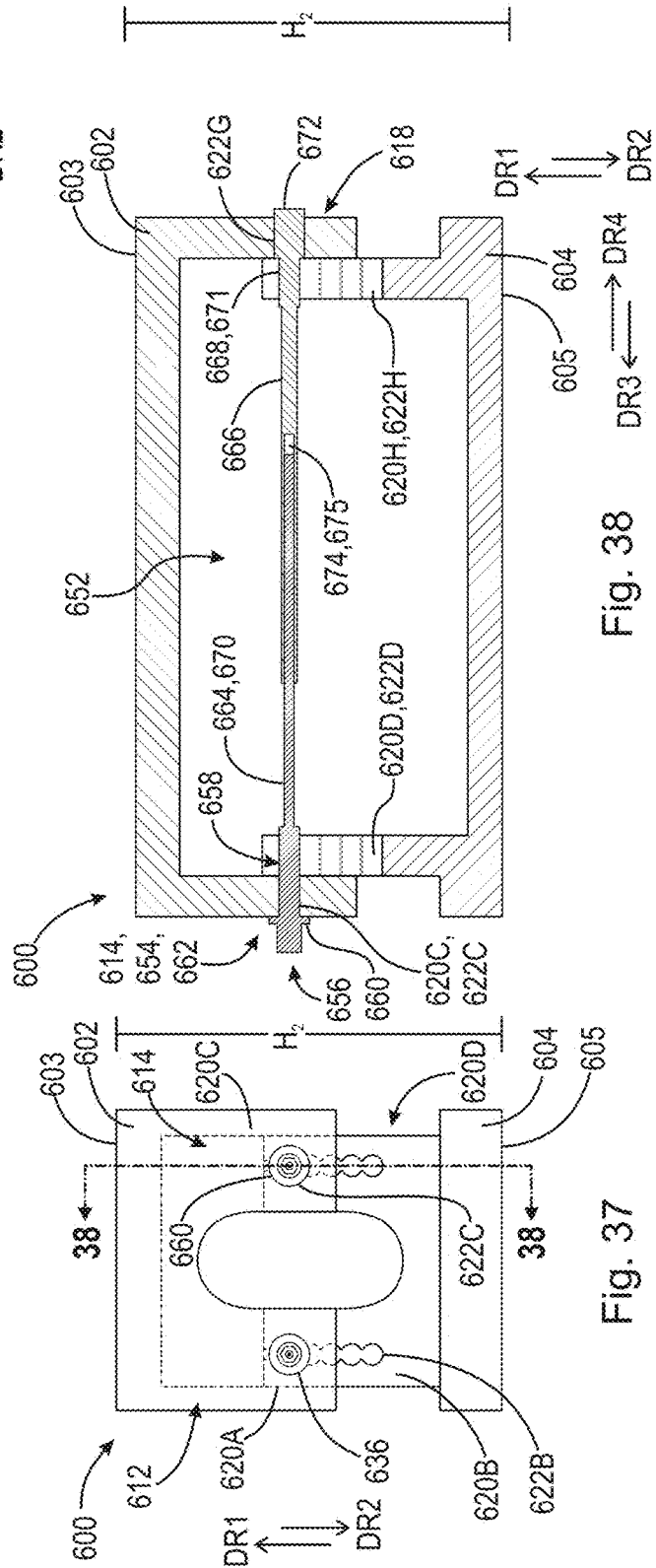


Fig. 37

Fig. 38

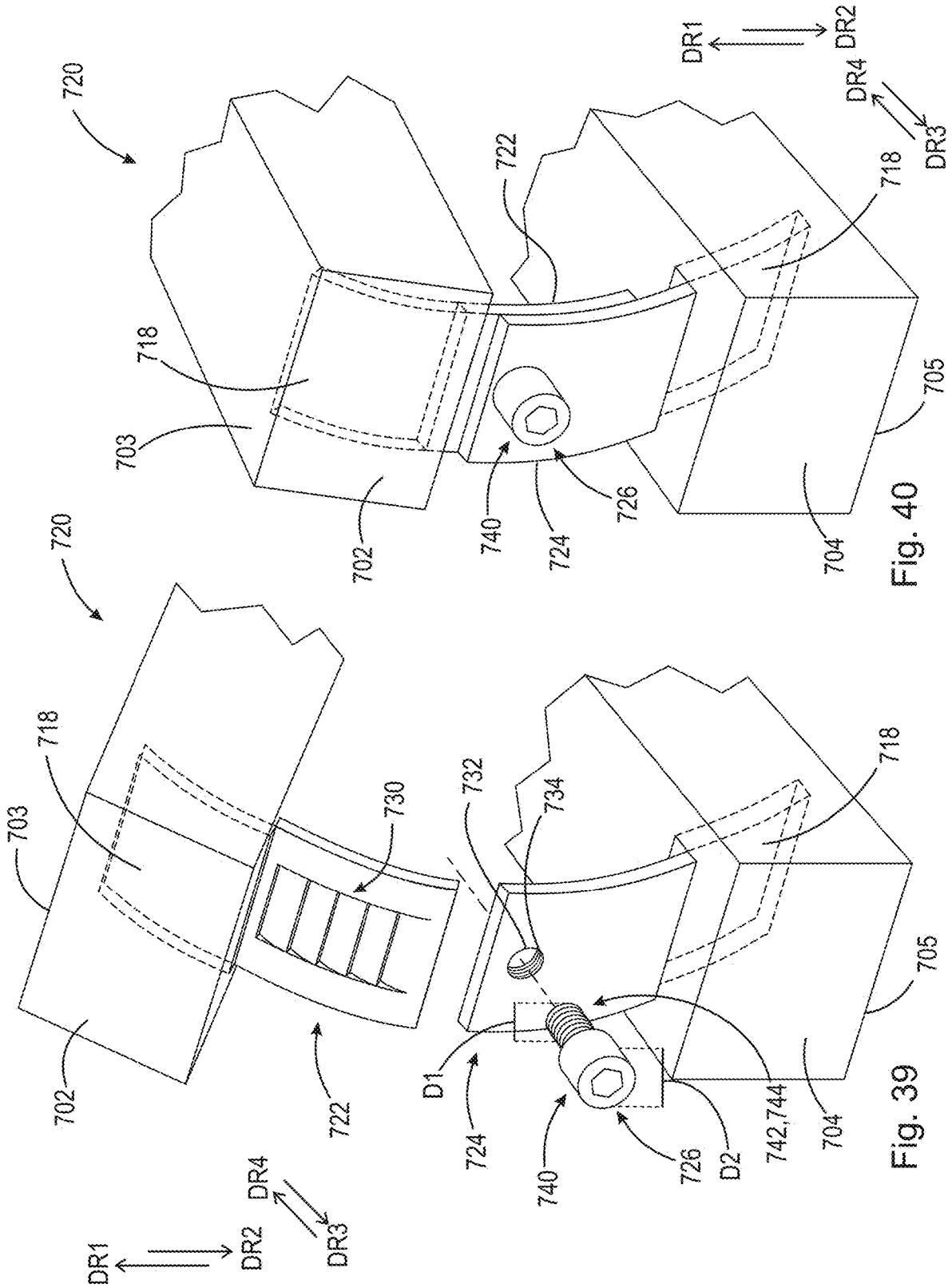
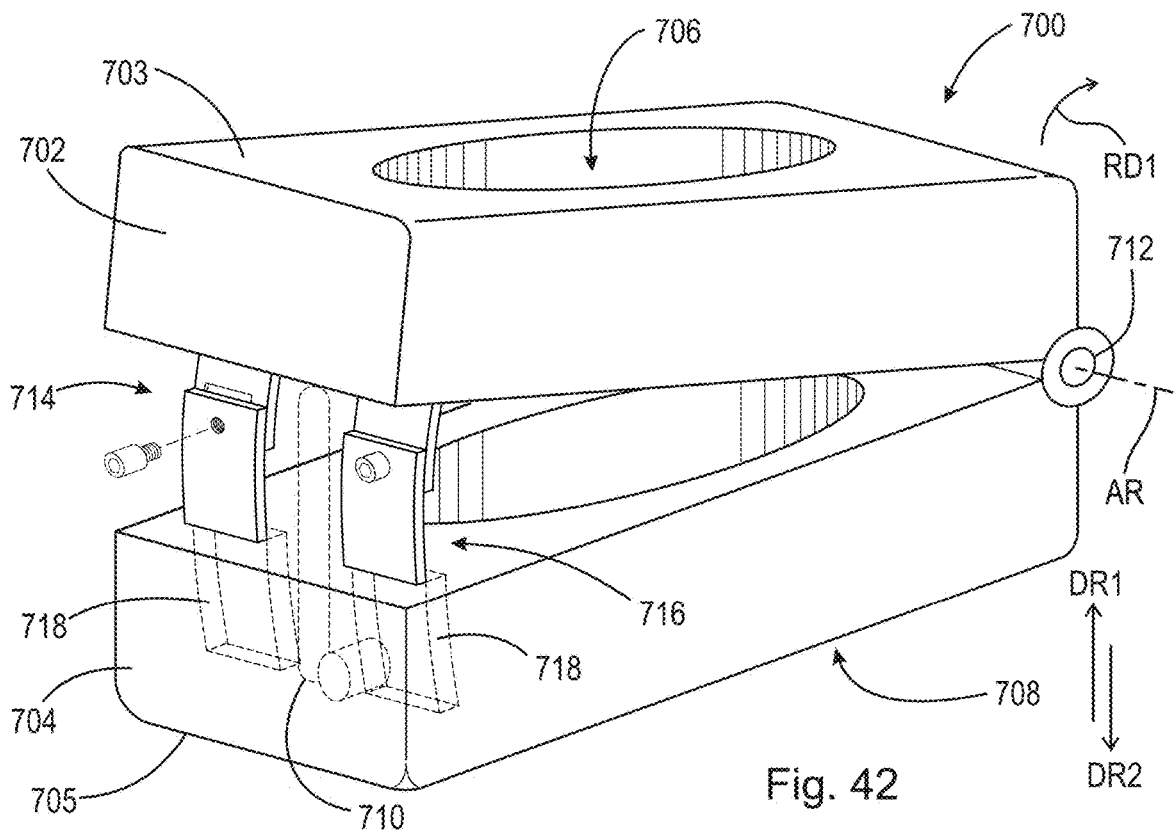
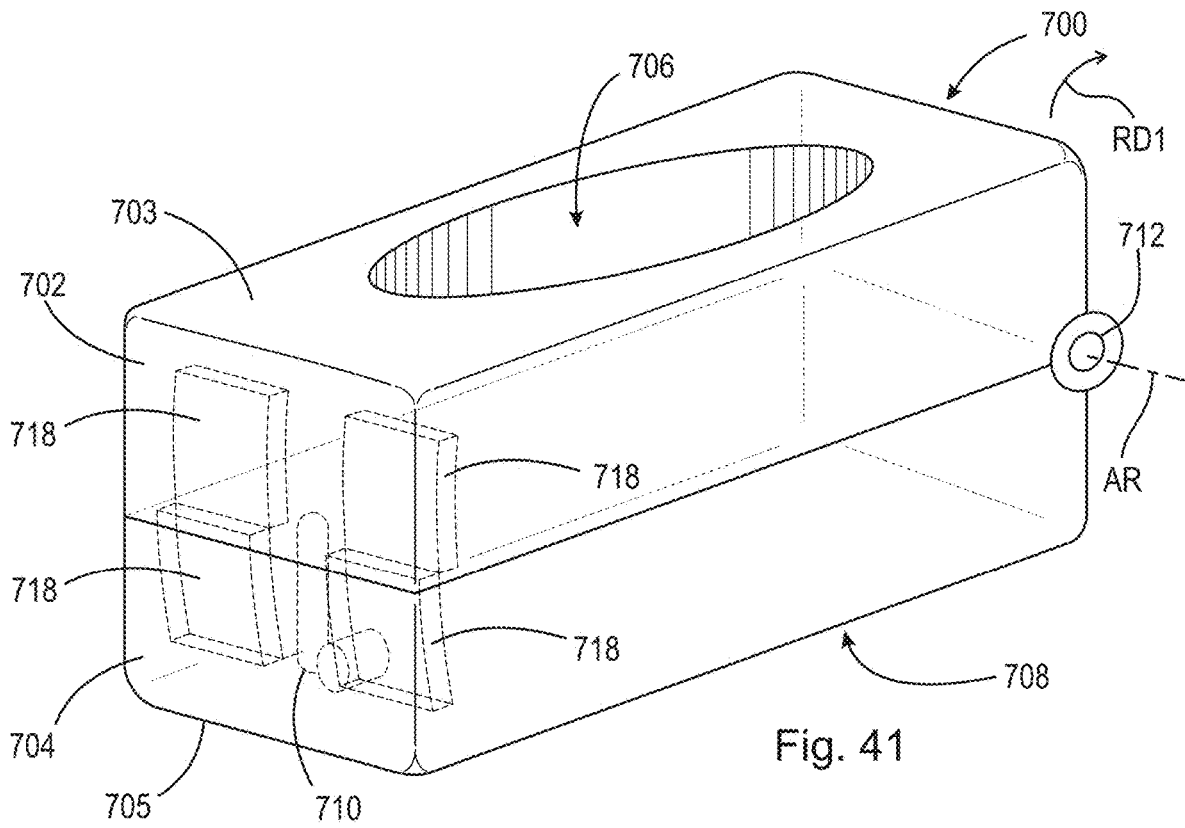


Fig. 40

Fig. 39



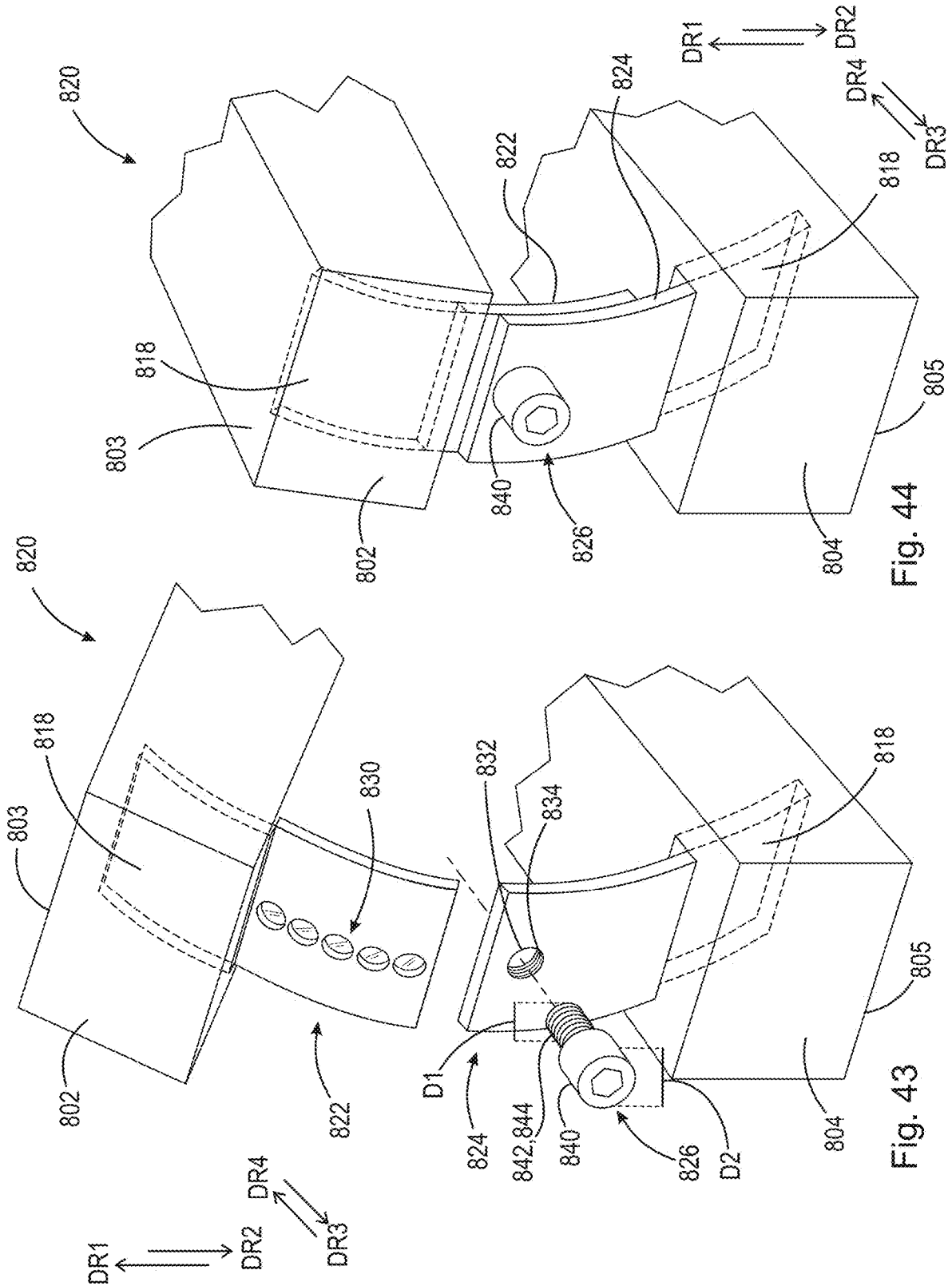
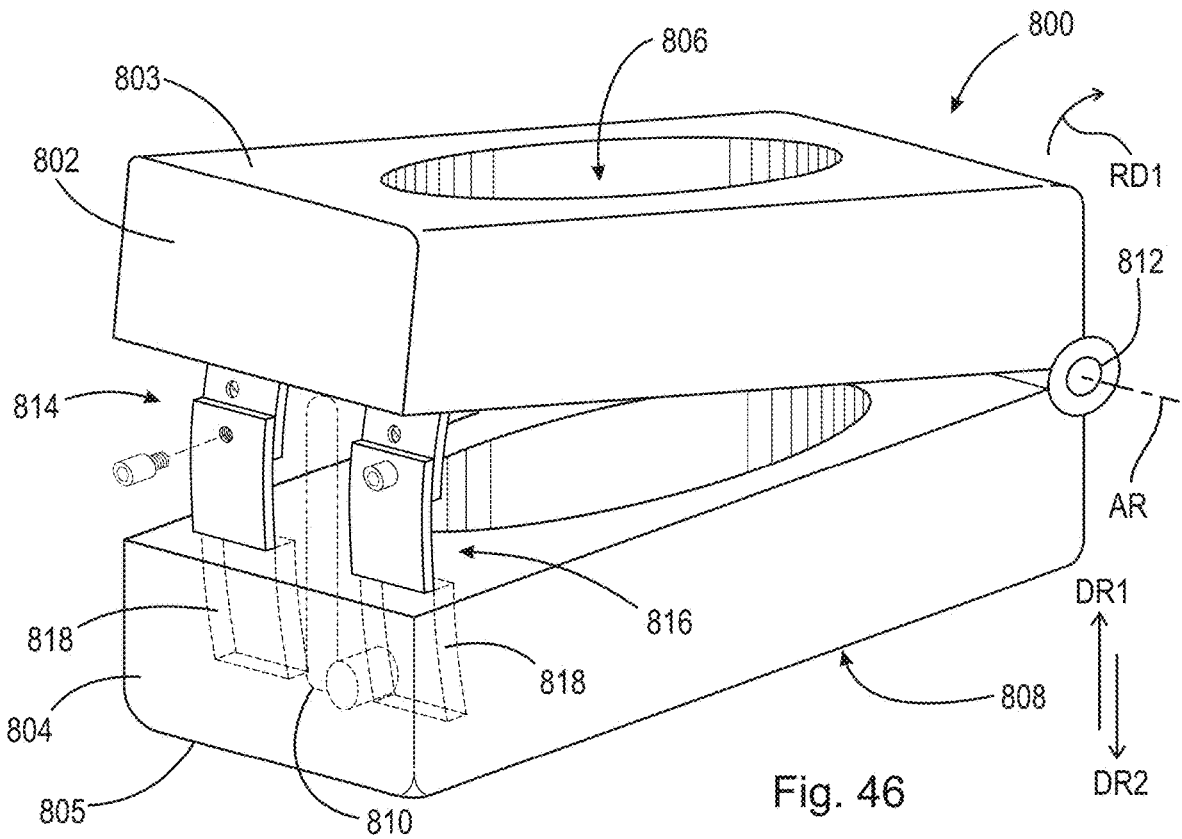
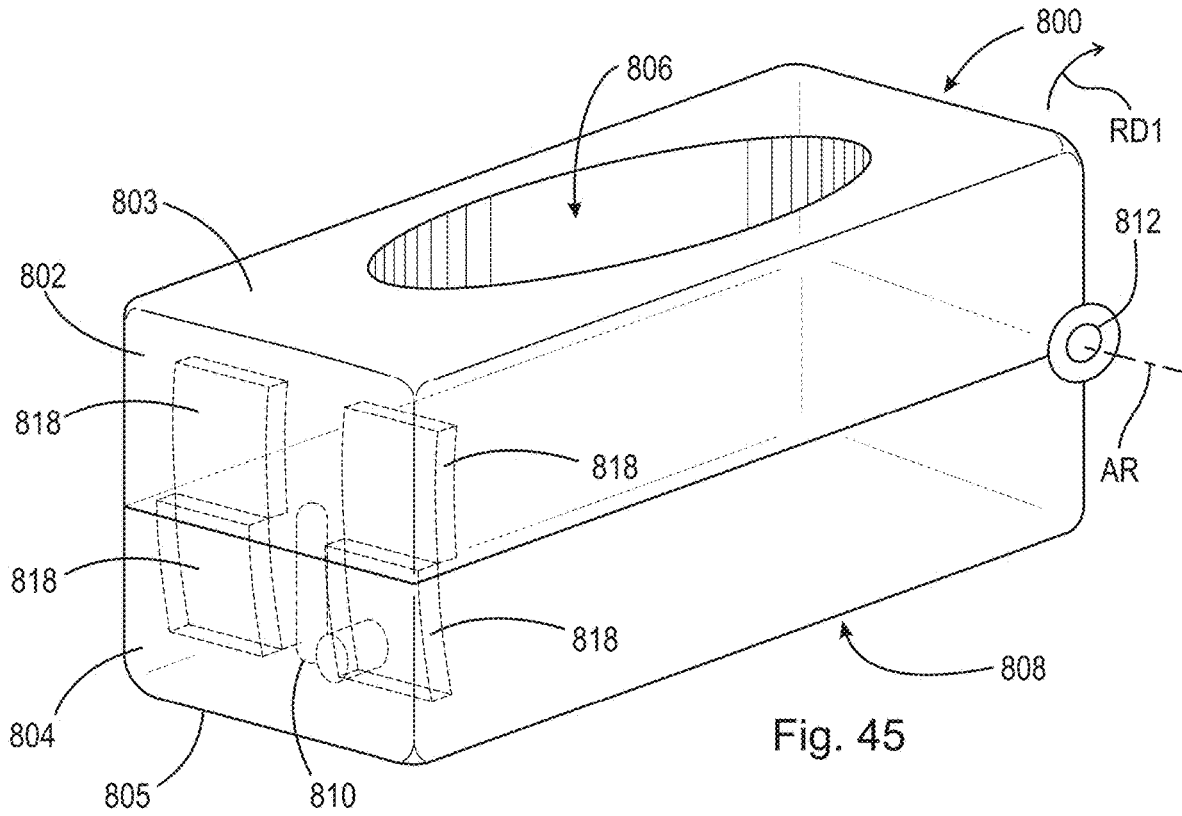


Fig. 44

Fig. 43



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STAND-ALONE EXPANDABLE INTERBODY SPINAL FUSION DEVICE WITH LOCKING MECHANISM

FIELD

The disclosure relates to spinal surgery, more particularly to intervertebral prosthesis, and, even more specifically, to a stand-alone expandable interbody spinal fusion device with a locking mechanism.

BACKGROUND

The spinal column, or backbone, is one of the most important parts of the body. It provides the main support, allowing us to stand upright, bend, and twist. As shown in FIG. 1, thirty three (33) individual bones interlock with each other to form the spinal column. The vertebrae are numbered and divided into regions. The cervical vertebrae (C1-C7) form the neck, support the head and neck, and allow nodding and shaking of the head. The thoracic vertebrae (T1-T12) join with the ribs to form the rib cage. The five lumbar vertebrae (L1-L5) carry most of the weight of the upper body and provide a stable center of gravity when a person moves. Five vertebrae of the sacrum S and four of the coccyx C are fused. This comprises the back wall of the pelvis. Intervertebral discs are located between each of the mobile vertebra. Intervertebral discs comprise a thick outer layer with a crisscrossing fibrous structure annulus A that surrounds a soft gel-like center, the nucleus N. Discs function like shock-absorbing springs. The annulus pulls the vertebral bodies together against the elastic resistance of the gel-filled nucleus. When we bend, the nucleus acts like a ball bearing, allowing the vertebral bodies to roll over the incompressible gel. Each disc works in concert with two facet joints, forming a spinal motion segment. The biomechanical function of each pair of facet joints is to guide and limit the movement of the spinal motion segment. The surfaces of the joint are coated with cartilage that helps each joint move smoothly. Directly behind the discs, the ring-like vertebral bodies create a vertical tunnel called the spinal canal, or neuro canal. The spinal cord and spinal nerves pass through the spinal canal, which protects them from injury. The spinal cord is the major column of nerve tissue that is connected to the brain and serves as an information superhighway between the brain and the body. The nerves in the spinal cord branch off to form pairs of nerve roots that travel through the small openings between the vertebrae and the intervertebral foramen.

The repetitive forces which act on these intervertebral discs during repetitive day-to-day activities of bending, lifting and twisting cause them to break down or degenerate over time. Overt trauma, or covert trauma occurring in the course of repetitive activities disproportionately affect the more highly mobile areas of the spine. Disruption of a disc's internal architecture leads to bulging, herniation or protrusion of pieces of the disc and eventual disc space collapse. Resulting mechanical and chemical irritation of surrounding neural elements cause pain, attended by varying degrees of disability. In addition, loss of disc space height relaxes tension on the longitudinal ligaments, thereby contributing to varying degrees of spinal instability such as spinal curvature.

Neural irritation and instability resulting from severe disc damage has been treated by removing the damaged disc and fusing adjacent vertebral elements. Removal of the disc relieves the mechanical and chemical irritation of neural

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elements, while osseous union solves the problem of instability. For example, in one surgical procedure, known as a discectomy (or diskectomy) with interbody fusion, the surgeon removes the nucleus of the disk and replaces it with an implant. As shown in FIG. 2, it may be necessary, for example, for the surgeon to remove the nucleus of the disc between the L3 and L4 vertebrae. Disc D_{L3-L4} is shown in an enlarged view in FIG. 3. This figure also shows various anatomical structures of the spine, including facets F3A and F4A, facet joint FJ, spinous processes SP3 and SP4, transverse processes TP3A and TP4A, and intervertebral foramen IF. FIG. 4 is a top view of the section of the spinal column shown in FIG. 3, with the L3 vertebra removed to expose annulus A and nucleus N of disc D_{L3-L4} . Neural canal NC is also shown. FIG. 5 is an anterior perspective view of the section of the spinal column shown in FIG. 4. FIG. 6 is a partial cross-sectional view of the section of the spinal column shown in FIG. 5, but with vertebra L3 in place atop disc D_{L3-L4} .

While cancellous bone appears ideal to provide the biologic components necessary for osseous union to occur, it does not initially have the strength to resist the tremendous forces that may occur in the intervertebral disc space, nor does it have the capacity to adequately stabilize the spine until long term bony union occurs. For these reasons, many spinal surgeons have found that interbody fusion using bone alone has an unacceptably high rate of bone graft migration or even expulsion or nonunion due to structural failure of the bone or residual degrees of motion that retard or prohibit bony union.

Intervertebral prosthesis in various forms have therefore been used to provide immediate stability and to protect and preserve an environment that fosters growth of grafted bone such that a structurally significant bony fusion can occur.

After insertion, and shortly after the conclusion of the surgical process, these interbody devices experience the full weight of the patient's upper body, originally experienced by the disc prior to replacement. This weight may be sufficient to cause expandable intervertebral implants such as the implants disclosed in U.S. patent application Ser. No. 15/416,270 filed Jan. 26, 2017, which application is herein incorporated by reference in its entirety, to collapse from its expanded state to its unexpanded height negatively affecting the quality of bone fusion.

Thus, there is a long-felt need for a stand-alone expandable interbody spinal fusion device with a locking mechanism operatively arranged to prevent collapse of an interbody device after insertion.

SUMMARY

According to aspects illustrated herein, there is provided a stand-alone expandable interbody spinal fusion device including a superior component, an inferior component, an expansion mechanism operatively arranged to displace the superior component in a first direction relative to the inferior component about a first hinge, and, a locking mechanism comprising. The locking mechanism including a plate operatively arranged to pivot about a second hinge, the plate further comprising a first through-bore and a first plurality of teeth, a pawl operatively arranged to pivot about a third hinge, the pawl further comprising a second through-bore, and a post operatively arranged to pass through the second and third through-bores such that after the superior component is displaced in the first direction, the locking mechanism prevents displacement of the superior component in a second direction, opposite the first direction.

According to aspects illustrated herein, there is provided a stand-alone expandable interbody spinal fusion device including a superior component, an inferior component, an expansion mechanism operatively arranged to displace the superior component in a first direction relative to the inferior component about a hinge, and a locking mechanism. The locking mechanism including a first plate fixedly secured to the superior component, the first plate further comprising a first through-bore, a second plate fixedly secured to the inferior component, the second plate further comprising a second through-bore, a post having a first end and a second end such that after the superior component is displaced in the first direction, the locking mechanism prevents displacement of the superior component in a second direction, opposite the first direction.

According to aspects illustrated herein, there is provided a stand-alone expandable interbody spinal fusion device including a superior component, an inferior component, an expansion mechanism operatively arranged to displace the superior component in a first direction relative to the inferior component, and a locking mechanism. The locking mechanism including a first plate fixedly secured to the superior component, the first plate further comprising a first through-bore, a second plate fixedly secured to the inferior component, the second plate further comprising a second through-bore, a third plate fixedly secured to the superior component, the third plate further comprising a third through-bore, a fourth plate fixedly secured to the inferior component, the fourth plate further comprising a fourth through-bore, and a post arranged to engage with the first through-bore, the second through-bore, the third through-bore, and the fourth through-bore, such that after the superior component is displaced in the first direction, the locking mechanism prevents displacement of the superior component in a second direction, opposite the first direction.

These and other objects, features, and advantages of the present disclosure will become readily apparent upon a review of the following detailed description of the disclosure, in view of the drawings and appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which:

FIG. 1 is an anterior perspective view of spinal column 10;

FIG. 2 is an anterior perspective view of the lumbar section of spinal column 10;

FIG. 3 is a lateral perspective view of L3, L4 vertebrae and disc D_{L3-L4} and related spinal anatomy;

FIG. 4 is a top view of a section of the spinal column, taken generally along line 4-4 in FIG. 3;

FIG. 5 is an enlarged anterior perspective view of the spinal column shown in FIG. 2, except with vertebra L3 and all other structure above L3 removed;

FIG. 6 is a partial cross-sectional view of the L4 vertebra and D_{L3-L4} disc shown in FIG. 5, including L3 in cross-section;

FIG. 7 is a partial cross-sectional view of the L4 vertebra and D_{L3-L4} disc shown in FIG. 5, showing the removal of the disc nucleus post-discectomy including L3 in cross-section;

FIG. 8 illustrates the introduction of the stand-alone expandable interbody spinal fusion device into the disc space in an unexpanded state;

FIG. 9 is a perspective view of a first embodiment of a stand-alone expandable interbody spinal fusion device, in an unexpanded state;

FIG. 10 is a partially-exploded perspective view of a stand-alone expandable interbody spinal fusion device with a first embodiment of a locking mechanism, in an expanded state;

FIG. 11 is a front view of a stand-alone expandable interbody spinal fusion device with a first embodiment of a locking mechanism, in an unexpanded state;

FIG. 12 is a cross-sectional view of a stand-alone expandable interbody spinal fusion device with a first embodiment of a locking mechanism, in an unexpanded state, taken generally along line 12-12 in FIG. 11;

FIG. 13 is a front view of a stand-alone expandable interbody spinal fusion device with a first embodiment of a locking mechanism, in an expanded state;

FIG. 14 is a cross-sectional view of a stand-alone expandable interbody spinal fusion device with a first embodiment of a locking mechanism, in an expanded state, taken generally along line 14-14 in FIG. 13;

FIG. 15 is a perspective view of an expansion mechanism in an unexpanded state;

FIG. 16 is a perspective view an expansion mechanism in an expanded state;

FIG. 17 is a side view of a second embodiment of a locking mechanism;

FIG. 18 is a front perspective partially exploded view of a second embodiment of a locking mechanism;

FIG. 19 is a front perspective view of a stand-alone expandable interbody spinal fusion device with a second embodiment of a locking mechanism, in an unexpanded state;

FIG. 20 is a front perspective view of a stand-alone expandable interbody spinal fusion device with a second embodiment of a locking mechanism, in an expanded state;

FIG. 21 is a side view of a third embodiment of a locking mechanism;

FIG. 22 is a front perspective partially exploded view of a third embodiment of a locking mechanism;

FIG. 23 is a front perspective view of a stand-alone expandable interbody spinal fusion device with a third embodiment of a locking mechanism, in an unexpanded state;

FIG. 24 is a front perspective view of a stand-alone expandable interbody spinal fusion device with a third embodiment of a locking mechanism, in an expanded state;

FIG. 25 is a front perspective partial view of a fourth locking mechanism in an unlocked state;

FIG. 26 is a front perspective partial view of a fourth locking mechanism in a locked state;

FIG. 27 is a front partially-exploded perspective view of a stand-alone expandable interbody spinal fusion device with a fourth embodiment of a locking mechanism in an unexpanded state;

FIG. 28 is a front perspective view of a stand-alone expandable interbody spinal fusion device with a fourth embodiment of a locking mechanism in an expanded state;

FIG. 29 is a front perspective partial view of a fifth locking mechanism in an unlocked state;

FIG. 30 is a front perspective partial view of a fifth locking mechanism in a locked state;

FIG. 31 is a front partially-exploded perspective view of a stand-alone expandable interbody spinal fusion device with a fifth embodiment of a locking mechanism in an unexpanded state;

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FIG. 32 is a front partially-exploded perspective view of a stand-alone expandable interbody spinal fusion device with a fifth embodiment of a locking mechanism in an expanded state;

FIG. 33 is a perspective view of a sixth embodiment of a stand-alone expandable interbody spinal fusion device, in an unexpanded state;

FIG. 34 is a partially-exploded perspective view of a stand-alone expandable interbody spinal fusion device with a sixth embodiment of a locking mechanism, in an expanded state;

FIG. 35 is a front view of a stand-alone expandable interbody spinal fusion device with a sixth embodiment of a locking mechanism, in an unexpanded state;

FIG. 36 is a cross-sectional view of a stand-alone expandable interbody spinal fusion device with a sixth embodiment of a locking mechanism, in an unexpanded state, taken generally along line 36-36 in FIG. 35;

FIG. 37 is a front view of a stand-alone expandable interbody spinal fusion device with a sixth embodiment of a locking mechanism, in an expanded state;

FIG. 38 is a cross-sectional view of a stand-alone expandable interbody spinal fusion device with a sixth embodiment of a locking mechanism, in an expanded state, taken generally along line 38-38 in FIG. 37;

FIG. 39 is a front perspective partial view of a seventh embodiment of a locking mechanism in an unlocked state;

FIG. 40 is a front perspective partial view of a seventh embodiment of a locking mechanism in a locked state;

FIG. 41 is a front partially-exploded perspective view of a stand-alone expandable interbody spinal fusion device with a seventh embodiment of a locking mechanism in an unexpanded state;

FIG. 42 is a front perspective view of a stand-alone expandable interbody spinal fusion device with a seventh embodiment of a locking mechanism in an expanded state;

FIG. 43 is a front perspective partial view of an eighth embodiment of a locking mechanism in an unlocked state;

FIG. 44 is a front perspective partial view of an eighth embodiment of a locking mechanism in a locked state;

FIG. 45 is a front partially-exploded perspective view of a stand-alone expandable interbody spinal fusion device with an eighth embodiment of a locking mechanism in an unexpanded state;

FIG. 46 is a front perspective view of a stand-alone expandable interbody spinal fusion device with an eighth embodiment of a locking mechanism in an expanded state.

DETAILED DESCRIPTION OF EMBODIMENTS

At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements. It is to be understood that the claims are not limited to the disclosed aspects.

Furthermore, it is understood that this disclosure is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the claims.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure pertains. It should be understood that any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the example embodiments. The assembly of the present disclo-

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sure could be driven by hydraulics, electronics, and/or pneumatics. It should be appreciated that the term “substantially” is synonymous with terms such as “nearly,” “very nearly,” “about,” “approximately,” “around,” “bordering on,” “close to,” “essentially,” “in the neighborhood of,” “in the vicinity of,” etc., and such terms may be used interchangeably as appearing in the specification and claims. It should be appreciated that the term “proximate” is synonymous with terms such as “nearby,” “close,” “adjacent,” “neighboring,” “immediate,” “adjoining,” etc., and such terms may be used interchangeably as appearing in the specification and claims. The term “approximately” is intended to mean values within ten percent of the specified value.

The term “Superior Component” as used in the present disclosure is intended to mean the component of the body of the implant located in the highest position relative to the other components in first direction DR1.

The term “Inferior Component” as used in the present disclosure is intended to mean the component of the body of the implant located in the lowest position relative to the other components in first direction DR1.

The term “gear shaft” as used in the present disclosure is intended to mean any gear currently understood in the art that has been elongated such that it is substantially cylindrical in shape.

The term “pawl” as used in the present disclosure is intended to mean a plate or bar having one end arranged to engage the teeth of a ratchet and place pressure on the ratchet in a first direction such that the ratchet can only be disengaged from the teeth by motion in a second direction, opposite the first direction.

Adverting now to the Figures, and as described previously, FIGS. 1-6 depict various parts and sections of spinal anatomy. FIG. 7 illustrates a partial cross-sectional view of the L3 and L4 vertebra with disc D_{L3-L4} removed (post discectomy) and able to receive stand-alone expandable interbody spinal fusion device 100.

FIG. 8 illustrates a partial cross-sectional view of the L3 and L4 vertebra with stand-alone expandable interbody spinal fusion device 100 in place within disc space 12 in an unexpanded state.

FIG. 9 is a perspective view of stand-alone expandable interbody spinal fusion device 100, in an unexpanded state. Device 100 comprises superior component 102, inferior component 104, and expansion mechanisms 106, 108, and 110 (described infra) arranged to displace superior component 102 in a first direction DR1 relative to inferior component 104, giving device 100 an expanded height H_2 greater than unexpanded height H_1 (shown in FIGS. 11 and 13). Device 100 also comprises locking mechanisms 112, 114, 116, and 118 arranged between superior component 102 and inferior component 104 (locking mechanisms 116 and 118 are shown in FIG. 10).

Locking mechanism 112 comprises plates 120A (shown in FIG. 9) and 120B (shown in FIG. 10). Locking mechanism 114 comprises plates 120C (shown in FIG. 9) and 120D (shown in FIG. 10). Locking mechanism 116 comprises plates 120E (shown in FIG. 9) and 120F (shown in FIG. 10). Locking mechanism 118 comprises plates 120G (shown in FIG. 9) and 120H (shown in FIG. 10). Each of plates 120A-120H further include a plurality of through-bores, i.e., plurality of through-bores 122A-122H, respectively. It should be appreciated that, although plates 120A-120H are shown as integral within superior component 102 and inferior component 104, plates 120A-120H could also

be discrete plates, fixedly secured to superior component **102** and inferior component **104**.

Superior component **102** and inferior component **104** further comprise at least one first aperture **124** arranged to allow fusion between bone fusing material and the adjacent vertebra and a second aperture **126** located on the front face of device **100** and arranged to allow the introduction of bone fusing material into device **100**. Second aperture **126** is illustrated as an arched slot as a non-limiting example, however, it should be appreciated that second aperture **126** could be an aperture of any suitable shape, e.g., triangular, circular, rectangular, elliptical, etc., that would allow for the introduction of bone fusing material into device **100**. Superior component **102** has a first surface **103** and inferior component **104** has a first surface **105**.

FIG. **10** is a perspective view of stand-alone expandable interbody spinal fusion device **100**, in an expanded state. It should be appreciated that FIG. **10** is a partial view, i.e., superior component **102** has been removed for clarity. During surgery and after device **100** is implanted in disc space **12**, a surgeon can apply torque to expansion mechanisms **106**, **108**, and **110** via any device that imparts rotational force upon expansion mechanisms **106**, **108**, and **110** (e.g., a screw driver or impact driver). Expansion mechanisms **106**, **108** and **110** are preferably the embodiment illustrated in FIGS. **15** and **16**, described infra. Furthermore, it should be appreciated that although expansion mechanisms **106**, **108**, and **110** are depicted within inferior component **104** in FIGS. **9-14**, expansion mechanisms **106**, **108**, and **110** could be arranged within superior component **102**. This rotational force causes expansion mechanisms **106**, **108**, and **110**, to displace superior component **102** in direction DR1 relative to inferior component **104** giving device **100** an expanded height H_2 , greater than H_1 (shown in FIGS. **11** and **13**). It should be appreciated that expansion mechanisms **106**, **108**, and **110**, can be expanded to any height between unexpanded height H_1 and expanded height H_2 . Device **100** further comprises post **128** and fastener **130**. Post **128** and fastener **130** are provided to secure locking mechanisms **112** and **116** in position once device **100** is expanded to its final height. Fastener **130** has a first end **132** and a second end **134**. First end **132** is operatively arranged to engage with any device known in the art that can impart rotational motion onto fastener **130**, e.g., a drill. Second end **134** includes female threading **136**. Post **128** further includes four sections, i.e., section **138**, section **140**, section **142**, and section **144**. Section **138** comprises male threading **146** operatively arranged to engage with female threading **136**. Section **144** comprises stopping element **148**. It should be appreciated that, although stopping element **148** is depicted as a flanged member, other variations of stopping elements can be used, e.g., a spherical stopping element. Sections **138** and **142** have diameter $D1$ and sections **140** and **144** have diameter $D2$, where $D2$ is greater than $D1$. Prior to locking, sections **138** and **142** having diameter $D1$ are loosely seated in longitudinal space **150** (shown in FIG. **11**) arranged between each through-bore in the plurality of through-bores **122A**, **122B**, **122E**, and **122F**. After device **100** has been inserted into disc space **12** and expanded to an appropriate height, a surgeon can apply torque to first end **132** of fastener **130**, pulling post **128** in direction DR3 into the locked position. In the locked position, sections **140** and **144** are completely seated in one of the through-bores of plurality of through-bores **122A**, **122B**, **122E**, and **122F**, which correspond to the chosen device height. In this locked position, device **100** is prevented from collapsing in direction DR2.

Device **100** further comprises post **152** and fastener **154** (shown in FIG. **14**). Post **152** and fastener **154** are provided to secure locking mechanisms **114** and **118** in position once device **100** is expanded to its final height. Fastener **154** has a first end **156** and a second end **158**. First end **156** includes a recess operatively arranged to engage with any device known in the art that can impart rotational motion onto fastener **154**, e.g., a drill. Second end **158** includes female threading **160**. Post **152** includes four sections, i.e., section **162**, section **164**, section **166**, and section **168**. Section **162** comprises male threading **170** operatively arranged to engage with female threading **160** of fastener **154**. Section **168** comprises stopping element **172**. It should be appreciated that, although stopping element **172** is depicted as a flanged member, other variations of stopping elements can be used, e.g., a spherical stopping element. Sections **162** and **166** have diameter $D1$ and sections **164** and **168** have diameter $D2$ where $D2$ is greater than $D1$. Prior to locking, sections **162** and **166**, having diameter $D1$, are loosely seated in longitudinal space **174** (shown in FIG. **11**) arranged between each through-bore in the plurality of through-bores **122C**, **122D**, **122G**, and **122H**. After device **100** has been inserted into disc space **12** and expanded to an appropriate height, a surgeon can apply torque to first end **156** of fastener **154**, pulling post **152** in direction DR3 into the locked position. In the locked position, sections **164** and **168** are seated in one of the through-bores of plurality of through-bores **122C**, **122D**, **122G**, and **122H**, which corresponds to the chosen device height. In this locked position, device **100** is prevented from collapsing in direction DR2.

FIG. **11** is a front view of stand-alone expandable interbody spinal fusion device **100**, in an unexpanded state having an unexpanded height H_1 . FIG. **12** is a cross-sectional view of stand-alone expandable interbody spinal fusion device **100**, in an unexpanded state having an unexpanded height H_1 . FIG. **13** is a front view stand-alone expandable interbody spinal fusion device **100**, in an expanded state having an expanded height H_2 , greater than H_1 . FIG. **14** is a cross-sectional view of stand-alone expandable interbody spinal fusion device **100** in an expanded state having an expanded height H_2 , greater than H_1 . It should be appreciated that in FIGS. **12** and **14**, expansion mechanisms **106**, **108** and **110** have been removed for clarity. It should also be appreciated that, although pluralities of through-bores **122A-122H** are illustrated with a longitudinal space between each through-bore of each plurality of through-bores, it is also contemplated that plurality of through-bores **122A-122H** could include multiple discrete through-bores, separate and distinct from each other with no longitudinal space between them.

FIG. **15** is a perspective view of expansion mechanism **176** in an unexpanded state. Expansion mechanism **176** comprises threaded rod **178**, threaded sleeve **180**, and worm drive **182** having worm **184** and gear **186**. A portion of threaded rod **178** can be embedded within superior component **102** such that it is rotationally fixed; however, it should be appreciated that the frictional engagement between the top surface of threaded rod **178** and the inner surface of superior component **102** may be sufficient to prevent threaded rod **178** from freely rotating. During surgery and after device **100** is implanted in disc space **12**, a surgeon can apply torque to worm drive **182** via any device that imparts rotational force upon worm **184** (e.g., a screw driver or impact driver). Torque is transferred 90 degrees through worm drive **182**, via worm **184** and gear **186**. Rotation of gear **186** causes threaded sleeve **180** to rotate. As threaded sleeve **180** rotates, threaded rod **178** remains rotationally

locked due to the portion embedded within superior component 102, or frictional contact with the inner surface of superior component 102. As threaded sleeve 180 rotates, the threads of the rotationally locked threaded rod 178 ride upward along the threads within threaded sleeve 180, displacing threaded rod 178, and subsequently superior component 102, in direction DR1. Threaded rod 178 includes a stopping feature to prevent threaded rod 178 from being ejected from threaded sleeve 180. For example, the lower portion of threaded rod 178 could be threadless (not shown in the figures), and therefore prevent threaded rod 178 from being ejected from threaded sleeve 180. When threaded rod 178 reaches its maximum expansion, the unthreaded portion of threaded rod 178 remains within threaded sleeve 180, preventing threaded rod 178 from being pushed out of threaded sleeve 180. Alternatively, the stopping feature could be a flange on the recessed portion of threaded rod 178 arranged to engage with a retention shoulder (not shown in the figures) within threaded sleeve 180 in a fully expanded state. It should be appreciated that worm drive 182 could be arranged to transfer torque in other arrangements, i.e., 180 degrees, 270 degrees, or any desirable angle required by the arrangement of worm 184 and gear 186. It should further be appreciated that although a gear 186 is depicted in the figures as a spur gear, other suitable gears may be selected, i.e., a bevel gear, a hypoid gear, a spiral gear, or a face gear. FIG. 16 is a perspective view of an expansion mechanism 176 in an expanded state.

FIG. 17 is a side view of locking mechanism 220. Locking mechanism 220 comprises plate 222, pawl 224, biasing element 226, post 228, and fastener 230. Plate 222 includes first surface 232, second surface 234, corner 236, hinge 238, and through-bore 240 operatively arranged to receive post 228 and fastener 230. When in the locked position, corner 236 abuts superior component 102 to stop superior component 102 from being displaced in direction DR2. Second surface 234 comprises first plurality of teeth 242 and second plurality of teeth 244. Pawl 224 includes through-bore 246, first pawl head 248, second pawl head 250, and hinge 252. Through-bore 246 is operatively arranged to accept post 228. First and second pawl heads 248 and 250 taper to a point and are operatively arranged to engage with first and second plurality of teeth 242 and 244, respectively, on second surface 234 of plate 222. Prior to locking, plate 222 and pawl 224 are freely pivotable about hinges 238 and 252, respectively. Hinges 238 and 252 are pivotably secured to first protrusion 254 and second protrusion 256 of inferior component 204 (discussed infra), respectively. It should be appreciated that although hinges 238 and 252 are illustrated as pivotably secured to first protrusion 254 and second protrusion 256, respectively, hinges 238 and 252 could also be placed in a recess within inferior component 204. Biasing element 226 is fixedly secured between inferior component 204 and pawl 224 and provides spring bias to pawl 224 in direction DR1 and/or DR4. It should be appreciated that, although biasing element 226 is depicted in FIGS. 17-20 as a flat spring, other biasing elements known in the art can be used to bias pawl 224 in direction DR1. Post 228 includes first end 258 and second end 260. First end 258 includes male threading 262, and second end 260 includes a stopping element 264. It should be appreciated that, although stopping element 264 is depicted as a spherical member, other variations of stopping elements can be used, e.g., a flanged stopping element. Fastener 230 includes first end 266 and second end 268. First end 266 is operatively arranged to engage with any device known in the art that can impart rotational motion onto fastener 230, e.g., a drill. Second end

268 includes female threading 270 operatively arranged to engage with male threading 262 of post 228.

After device 200 has been inserted into disc space 12 and expanded to an appropriate height, a surgeon can apply torque to first end 266 of fastener 230, pulling post 228 in direction DR3. As post 228 is pulled in direction DR3, stopping element 264 of post 228 forces pawl 224 in direction DR3 against biasing element 226 about hinge 252. When sufficient force is applied, first and second pawl heads 248 and 250, respectively, engage with first and second plurality of teeth 242 and 244 locking the plate 222 in place and preventing the collapse of device 200 (shown in FIGS. 19 and 20) in direction DR2.

FIG. 19 is a front perspective view of device 200 having two locking mechanisms 214 and 216 in an unexpanded state. It should be appreciated that in an example embodiment locking mechanisms 214 and 216 are embodied as locking mechanism 220 discussed supra. Device 200 comprises superior component 202, inferior component 204, and expansion mechanism 210 arranged to displace superior component 202 in first direction DR1 relative to inferior component 204. Superior component 202 and inferior component 204 further comprise at least one first aperture 206 and at least one second aperture 208, respectively, which are arranged to allow fusion between bone fusing material and the adjacent vertebra. Superior component 202 has a first surface 203 and inferior component 204 has a first surface 205. Device 200 further comprises hinge 212 fixedly secured to superior component 202 and inferior component 204 and arranged to rotatably displace the superior component about axis of rotation AR. Expansion mechanism 210 is preferably expansion mechanism 176 described supra. Although FIGS. 19 and 20 depict expansion mechanism 210 fixedly secured within inferior component 204, it should be appreciated that expansion mechanism 210 could also be fixedly secured within superior component 202.

FIG. 20 is a front perspective view of device 200 having locking mechanisms 214 and 216 in an expanded state. After superior component 202 is displaced about axis of rotation AR, locking mechanisms 214 and 216 are engaged and locked as discussed supra. Once locked, superior component 202 is prevented from moving in direction DR2.

FIG. 21 is a side view of locking mechanism 320. Locking mechanism 320 comprises plate 322, post 324, and fastener 326. Plate 322 includes corner 328, hinge 330, and plurality of through-bores 332 operatively arranged to receive post 324 and fastener 326. When in the locked position, corner 328 abuts superior component 102 to stop superior component 102 from being displaced in direction DR2. Post 324 includes first end 336 and second end 338. First end 336 includes male threading 340, and second end 338 includes hinge 342. Plurality of through-bores 332 (illustrated in FIG. 22) further includes longitudinal space 334 arranged to receive first end 336 of post 324. Before locking, plate 322 and post 324 are freely pivotable about hinges 330 and 342, respectively, and first end 336 of post 324 moves freely within longitudinal space 334 (shown in FIG. 22) of plurality of through-bores 332. Hinges 330 and 342 are pivotably secured to first protrusion 344 and second protrusion 346, respectively, of inferior component 302 (discussed infra). It should be appreciated that although hinges 330 and 342 are illustrated as pivotably secured to first protrusion 344 and second protrusion 346, respectively, hinges 330 and 342 could also be placed in a recess within inferior component 304. Fastener 326 includes first end 348, second end 350, and flange 352. First end 348 is operatively arranged to engage with any device known in the art that can impart

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rotational motion onto fastener 326, e.g., a drill. Second end 350 includes female threading 354 operatively arranged to engage with male threading 340 of post 324. Flange 352 has diameter D1, and is operatively arranged abut against the surface of plate 322 when second end 350 is seated within one of plurality of through-bores 332 of plate 322.

After device 300 (shown in FIGS. 23 and 24) has been inserted into disc space 12 and expanded to an appropriate height, a surgeon can apply torque to first end 348 of fastener 326, pulling fastener 326 in direction DR4. As fastener 326 is pulled in direction DR4, flange 352 also moves in direction DR4 until flange 352 abuts the surface of plate 322 while second end 350 of fastener 326 is seated within one of plurality of through-bores 332 of plate 322 locking plate 322 in place and preventing the collapse of device 300 (shown in FIGS. 23 and 24) in direction DR2.

FIG. 23 is a front perspective view of device 300 with locking mechanisms 314 and 316, in an unexpanded state. It should be appreciated that in an example embodiment, locking mechanisms 314 and 316 are embodied as locking mechanism 320 discussed supra. Device 300 comprises superior component 302, inferior component 304, and expansion mechanism 310 arranged to displace superior component 302 in a first direction DR1 relative to inferior component 304. Superior component 302 and inferior component 304 further comprise at least one first aperture 306 and at least one second aperture 308, respectively, which arranged to allow fusion between bone fusing material and the adjacent vertebra. Superior component 302 has a first surface 303 and inferior component 304 has a first surface 305. Device 300 further comprises hinge 312 fixedly secured to superior component 302 and inferior component 304 and arranged to rotatably displace the superior component about axis of rotation AR. Although, FIGS. 23 and 24 depict expansion mechanism 310 fixedly secured within inferior component 304, it should be appreciated that expansion mechanism 310 could also be fixedly secured within superior component 302.

FIG. 24 is a front perspective view device 300 with locking mechanisms 314 and 316, in an expanded state. After superior component 302 is displaced about axis of rotation AR, locking mechanisms 314 and 316 are engaged and locked as discussed supra. Once locked, superior component 302 is prevented from moving in direction DR2.

FIG. 25 is a partial front perspective view of a locking mechanism 420 in an unlocked state. Locking mechanism 420 comprises plates 422 and 424, post 426, and fastener 428. Plates 422 and 424 are fixedly secured to superior component 402 and inferior component 404 (discussed infra), respectively. Plates 422 and 424 include first plurality of through-bores 430 and second plurality of through-bores 432, respectively. First plurality of through-bores 430 and second plurality of through-bores 432, which have diameter D2, less than diameter D3, and greater than diameter D1. First plurality of through-bores 430 and second plurality of through-bores 432 are operatively arranged to receive post 426 and fastener 428. First plurality of through-bores 430 includes longitudinal space 434, and second plurality of through-bores 432 includes longitudinal space 436. Post 426 includes a first end 438 and a second end 440. First end 438 has diameter D1 and includes male threading 442, and second end 440 includes shoulder 444 and stopping element 446. Shoulder 444 has diameter D2 and is operatively arranged to engage with first plurality of through-bores 430. Fastener 428 includes first end 448 and second end 450. First end 448 has diameter D3 (shown in FIG. 26) and is operatively arranged to engage with any device known in the

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art that can impart rotational motion onto fastener 428, e.g., a drill. Second end 450 has diameter D2 and includes female threading 452 operatively arranged to engage with male threading 442 of post 426.

Before locking, post 426 is freely moveable within longitudinal spaces 434 and 436. During surgery, and after device 400 (discussed infra) has been expanded to its final height, a surgeon imparts rotational motion to fastener 428. Female threading 452 of fastener 428 engages with male threading 442 of post 426 pulling post 426 in direction DR3. Post 426 is pulled in direction DR3 until shoulder 444 engages one of the through-bores of first plurality of through-bores 430 and second end 450 of fastener 428 engages one of the through-bores of the second plurality of through-bores 432. When both second end 450 of fastener 428 and shoulder 444 of post 426 are engaged with the respective through-bores, device 400 is locked and is prevented from collapsing in direction DR2. It should be appreciated that, although not depicted in the figures, it is possible for shoulder 444 or second end 450 of fastener 428 to engage with both the first plurality of through-bores 430 and second plurality of through-bores 432 simultaneously. FIG. 26 is a partial front perspective view of a locking mechanism 420 in a locked state. When device 400 is in the fully collapsed state plates 422 and 424 nest within recesses 418.

FIG. 27 is a front perspective view of device 400 with locking mechanisms 414 and 416, in an unexpanded state. Device 400 comprises superior component 402, inferior component 404, and expansion mechanism 410 arranged to displace superior component 402 in a first direction DR1 relative to inferior component 404. Superior component 402 and inferior component 404 further comprise at least one first aperture 406 and at least one second aperture 408, which are arranged to allow fusion between bone fusing material and the adjacent vertebra. Superior component 402 has a first surface 403 and inferior component 404 has a first surface 405. Device 400 further comprises hinge 412 fixedly secured to superior component 402 and inferior component 404 and arranged to rotatably displace the superior component about axis of rotation AR. Locking mechanisms 414 and 416 are preferably locking mechanism 420 described supra. Expansion mechanism 410 is preferably expansion mechanism 176 described supra. It should be noted that since plates 422 and 424 are fixedly secured to superior and inferior components 102 and 104, respectively, recesses 418 are provided within which plates 422 and 424 can nest while device 400 is in a collapsed state. It should further be appreciated that plates 422 and 424 can be hingedly secured to superior component 402 and inferior component 404, respectively. FIG. 28 is a front perspective view of device 400 with locking mechanisms 414 and 416 in an expanded state.

FIG. 29 is a partial front perspective view of a locking mechanism 520 in an unlocked state. Locking mechanism 520 comprises plates 522 and 524, and fastener 426. Plates 522 and 524 are fixedly secured to superior component 502 and inferior component 504 (discussed infra), respectively. Plate 522 includes first plurality of through-bores 530 and plate 524 includes second plurality of through-bores 532. Each through-bore of first plurality of through-bores 530 has diameter D2. Each through-bore of the second plurality of through-bores 532 has diameter D1 larger than D2. First plurality of through-bores 530 and second plurality of through-bores 532 are operatively arranged to fastener 526. Second plurality of through-bores 532 further includes longitudinal space 534. Fastener 526 includes first end 540 and

second end 542. First end 540 has diameter D2 and is operatively arranged to engage with any device known in the art that can impart rotational motion onto fastener 526, e.g., a drill. Second end 542 has diameter D1 and includes male threading 544 operatively arranged to engage with any of the through-bores of first plurality of through-bores 530.

Before locking, fastener 526 is freely moveable within longitudinal space 534. During surgery, and after device 500 (discussed infra) has been expanded to its final height, a surgeon imparts rotational motion to fastener 526. Male threading 544 of fastener 526 engages any of the through-bores of first plurality of through-bores 530 which pulls fastener 526 in direction DR4. When first end 540 of fastener 526 is engaged with second plurality of through-bores 532 and second end 542 is engaged with first plurality of through-bores 530, device 500 is locked and is prevented from collapsing in direction DR2. FIG. 30 is a partial front perspective view of a locking mechanism 520 in a locked state. When device 500 is in the fully collapsed state plates 522 and 524 nest within recesses 518.

FIG. 31 is a front perspective view of device 500 with locking mechanisms 514 and 516, in an unexpanded state. Device 500 comprises superior component 502, inferior component 504, and expansion mechanism 510 arranged to displace superior component 502 in a first direction DR1 relative to inferior component 504. Superior component 502 and inferior component 504 further comprise at least one first aperture 506 and at least one second aperture 508, which are arranged to allow fusion between bone fusing material and the adjacent vertebra. Superior component 502 has a first surface 503 and inferior component 504 has a first surface 505. Device 500 further comprises hinge 512 fixedly secured to superior component 502 and inferior component 504 and arranged to rotatably displace the superior component about axis of rotation AR. Locking mechanisms 514 and 516 are preferably locking mechanism 520 described supra. Expansion mechanism 510 is preferably expansion mechanism 176 described supra. It should be noted that since plates 522 and 524 are fixedly secured to superior and inferior components 502 and 504, respectively, recesses 518 are provided within which plates 522 and 524 can nest while device 500 is in a collapsed state. It should further be appreciated that plates 522 and 524 can be hingedly secured to superior component 502 and inferior component 504, respectively. FIG. 32 is a front perspective view of device 500 with locking mechanisms 514 and 516 in an expanded state.

FIG. 33 is a perspective view of stand-alone expandable interbody spinal fusion device 600, in an unexpanded state. Device 600 comprises superior component 602, inferior component 604, and expansion mechanisms 606, 608, and 610 (described infra) arranged to displace superior component 602 in a first direction DR1 relative to inferior component 604, giving device 600 an expanded height H_2 greater than unexpanded height H_1 (shown in FIGS. 37 and 38). Device 600 also comprises locking mechanisms 612, 614, 616, and 618 arranged between superior component 602 and inferior component 604.

Locking mechanism 612 comprises plate 620A (shown in FIG. 33) and 620B (shown in FIG. 34). Locking mechanism 614 comprises plates 620C (shown in FIG. 33) and 620D (shown in FIG. 34). Locking mechanism 616 comprises plates 620E (shown in FIG. 33) and 620F (shown in FIG. 34). Locking mechanism 618 comprises plates 620G (shown in FIG. 33) and 620H (shown in FIG. 34). Plates 620A and 620C further include through-bores 622A and 622C, respectively. Plates 620E and 620G further comprise square

through-bores 622E and 622G, respectively. Plates 620B, 620D, 620F, and 620H further comprise a plurality of through-bores, i.e., plurality of through-bores 622B, 622D, 622F, and 622H, respectively. It should be appreciated that, although plates 620A-620H are shown as integral within superior component 602 and inferior component 604, plates 620A-620H could also be discrete plates, fixedly secured to superior component 602 and inferior component 604.

Superior component 602 and inferior component 604 further comprise at least one first aperture 624 arranged to allow fusion between bone fusing material and the adjacent vertebra and a second aperture 626 located on the front face of device 600 and arranged to allow the introduction of bone fusing material into device 600. Second aperture 626 is illustrated as an arched slot as a non-limiting example, however, it should be appreciated that second aperture 626 could be an aperture of any suitable shape, e.g., triangular, circular, rectangular, elliptical, etc., that would allow for the introduction of bone fusing material into device 600. Superior component 602 has a first surface 603 and inferior component 604 has a first surface 605.

FIG. 34 is a perspective view of stand-alone expandable interbody spinal fusion device 600, in an expanded state. It should be appreciated that FIG. 34 is a partial view, i.e., superior component 602 has been removed for clarity. During surgery and after device 600 is implanted in disc space 12, a surgeon can apply torque to expansion mechanisms 606, 608, and 610 via any device that imparts rotational force upon expansion mechanisms 606, 608, and 610 (e.g., a screw driver or impact driver). Expansion mechanisms 606, 608 and 610 are preferably the embodiment illustrated in FIGS. 15 and 16, described supra. Furthermore, it should be appreciated that although expansion mechanisms 606, 608, and 610 are depicted within inferior component 604 in FIGS. 33-38, expansion mechanisms 606, 608, and 610 could be arranged within superior component 602. The rotational force causes expansion mechanisms 606, 608, and 610, to displace superior component 602 in direction DR1 relative to inferior component 604 giving device 600 an expanded height H_2 , greater than H_1 (shown in FIGS. 37 and 38). It should be appreciated that expansion mechanisms 606, 608, and 610, can be expanded to any height between unexpanded height H_1 and expanded height H_2 . Device 600 further comprises post 628. Post 628 is provided to secure locking mechanisms 612 and 616 in position once device 600 is expanded to its final height. Post 628 comprises first section 638, second section 640, third section 642, and fourth section 644. First section 638 has a first end 632, a second end 634, and a flange 636. First end 632 is operatively arranged to engage with any device known in the art that can impart rotational motion onto first section 638, e.g., a drill. Second end 634 is arranged non-rotatably secure to second section 640. Second section 640 includes external helical male threading 646. Third section 642 includes a substantially hollow shaft with cavity 650. Cavity 650 includes internal helical female threading 651 operatively arranged to engage with male threading 646. Fourth section 644 includes cylindrical portion 647 non-rotatably secured to third section 642; and, stopping element 648 which is embodied as a substantially rectangular member operatively arranged to abut the surface of plate 620F and prevent movement of post 628 in direction DR3. Second section 640 has a diameter D1. Third section 642 has diameter D2 larger than D1. Cylindrical portion 647 of fourth section 644 has diameter D3 larger than D2, and stopping element 648 has diameter D4 larger than D3. Flange 636 has diameter D4 larger than D3.

Prior to locking, first end 632 of first section 638 is slidingly engaged with through-bore 622A (shown in FIG. 33); second section 640 is loosely seated in the longitudinal space formed between each through-bore of plurality of through-bores 622B of plate 620B; third section 642 is loosely seated in the longitudinal space formed between each through-bore of plurality of through-bores 622F of plate 620F; and cylindrical portion 647 of fourth section 644 is slidingly engaged with square through-bore 622E of plate 620E.

After device 600 has been inserted into disc space 12 and expanded to an appropriate height, a surgeon can apply torque to first end 632 of first section 638. The torque is then transferred to second section 640 having male threading 646. Second section 640 engages with female threading 651 in cavity 650 of third section 642, pulling post 628 in direction DR3 into the locked position. In the locked position, flange 636 abuts the surface of plate 620A preventing further displacement in direction DR4; second end 634 of first section 638 is completely seated in one of the through-bores of plurality of through-bores 622B which corresponds to the chosen device height. In this locked position, device 600 is prevented from collapsing in direction DR2. Additionally, in the locked position, cylindrical portion 647 of fourth section 644 is completely seated in one of the through-bores of plurality of through-bores 622F of plate 620F; and, stopping element 648 abuts the outer surface of plate 620F preventing further displacement of third section 642 and fourth section 644 in direction DR3.

Device 600 further comprises post 652 (shown in FIGS. 34, 36, and 38). Post 652 is provided to secure locking mechanisms 614 and 618 in position once device 600 is expanded to its final height. Post 652 further comprises first section 662, second section 644, third section 666, and fourth section 668. First section 662 includes first end 656, second end 658, and flange 660. First end 656 includes a recess operatively arranged to engage with any device known in the art that can impart rotational motion onto first section 662, e.g., a drill. Second end 658 is non-rotatably secured to second section 664. Second section 664 includes external helical male threading 670. Third section 666 includes a substantially hollow shaft with cavity 674. Cavity 674 includes internal helical female threading 675 operatively arranged to engage with male threading 670. Fourth section 668 includes cylindrical portion 671 non-rotatably secured to third section 666; and, stopping element 672 which is embodied as a substantially rectangular member operatively arranged to abut the surface of plate 620H and prevent movement of post 652 in direction DR3. Second section 664 has a diameter D1. Third section 666 has diameter D2 larger than D1. Cylindrical portion 671 of fourth section 668 has diameter D3 larger than D2, and stopping element 672 has diameter D4 larger than D3. Flange 660 has diameter D4 larger than D3.

After device 600 has been inserted into disc space 12 and expanded to an appropriate height, a surgeon can apply torque to first end 656 of first section 662. The torque is then transferred to second section 664 having male threading 670. Second section 664 engages with female threading 675 in cavity 674 of third section 666, pulling post 652 in direction DR3 into the locked position. In the locked position, flange 660 abuts the surface of plate 620C preventing further displacement in direction DR4; second end 658 of first section 662 is completely seated in one of the through-bores of plurality of through-bores 622D which corresponds to the chosen device height. In this locked position, device 600 is prevented from collapsing in direction DR2. Addi-

tionally, in the locked position, cylindrical portion 671 of fourth section 668 is completely seated in one of the through-bores of plurality of through-bores 622H of plate 620H; and, stopping element 672 abuts the outer surface of plate 620F preventing further displacement of third section 642 and fourth section 644 in direction DR3.

FIG. 39 is a partial front perspective view of a locking mechanism 720 in an unlocked state. Locking mechanism 720 comprises plates 722 and 724, and fastener 726. Plates 722 and 724 are fixedly secured to superior component 702 and inferior component 704 (discussed infra), respectively. Plate 722 includes plurality of catches 730 and plate 724 includes through-bore 732. Through-bore 732 has female threading 734. Plurality of catches 730 is illustrated as a plurality of tapered depressions having a taper back section and a flat ridge similar to a ratchet mechanism which are arranged to prevent motion in one direction while allowing motion in a second direction. Fastener 726 includes first end 740 and second end 742. Second end 742 has diameter D1 and includes male threading 744 operatively arranged to engage with female threading 734 of through-bore 732. First end 740 of fastener 726 has diameter D2 larger than D1. First end 740 is operatively arranged to engage with any device known in the art that can impart rotational motion onto fastener 726, e.g., a drill. Each catch of plurality of catches 730 has a width greater than or equal to diameter D2.

Before locking, fastener 726 is loosely engaged with female threading 734 of through-bore 732. During surgery, and after device 700 (discussed infra) has been expanded to its final height, a surgeon imparts rotational motion to fastener 726. Male threading 744 of fastener 726 further engages with female threading 734 of through-bore 732 which pulls fastener 726 in direction DR4. When second end 742 of fastener 726 is engaged with one of the catches of plurality of catches 730, device 700 is locked and is prevented from collapsing in direction DR2. FIG. 40 is a partial front perspective view of a locking mechanism 720 in a locked state. When device 700 is in the fully collapsed state plates 722 and 724 nest within recesses 718.

FIG. 41 is a front perspective view of device 700 with locking mechanisms 714 and 716, in an unexpanded state. Device 700 comprises superior component 702, inferior component 704, and expansion mechanism 710 arranged to displace superior component 702 in a first direction DR1 relative to inferior component 704. Superior component 702 and inferior component 704 further comprise at least one first aperture 706 and at least one second aperture 708, which are arranged to allow fusion between bone fusing material and the adjacent vertebra. Superior component 702 has a first surface 703 and inferior component 704 has a first surface 705. Device 700 further comprises hinge 712 fixedly secured to superior component 702 and inferior component 704 and arranged to rotatably displace the superior component about axis of rotation AR. Locking mechanisms 714 and 716 are preferably locking mechanism 720 described supra. Expansion mechanism 710 is preferably expansion mechanism 176 described supra. It should be noted that since plates 722 and 724 are fixedly secured to superior and inferior components 702 and 704, respectively, recesses 718 are provided within which plates 722 and 724 can nest while device 700 is in a collapsed state. It should further be appreciated that plates 722 and 724 can be hingedly secured to superior component 702 and inferior component 704, respectively. FIG. 42 is a front perspective view of device 700 with locking mechanisms 714 and 716 in an expanded state.

FIG. 43 is a partial front perspective view of a locking mechanism 820 in an unlocked state. Locking mechanism 820 comprises plates 822 and 824, and fastener 826. Plates 822 and 824 are fixedly secured to superior component 802 and inferior component 804 (discussed infra), respectively. Plate 822 includes plurality of catches 830 and plate 824 includes through-bore 832. Through-bore 832 has female threading 834. Plurality of catches 830 are illustrated as a series of cylindrical partial-through-bores. Fastener 826 includes first end 840 and second end 842. Second end 842 has diameter D1 and includes male threading 844 operatively arranged to engage with female threading 834 of through-bore 832. First end 840 of fastener 826 has diameter D2 larger than D1. First end 840 is operatively arranged to engage with any device known in the art that can impart rotational motion onto fastener 826, e.g., a drill. Each catch of plurality of catches 830 has a width greater than or equal to diameter D2.

Before locking, fastener 826 is loosely engaged with female threading 834 of through-bore 832. During surgery, and after device 800 (discussed infra) has been expanded to its final height, a surgeon imparts rotational motion to fastener 826. Male threading 844 of fastener 826 further engages with female threading 834 of through-bore 832 which pulls fastener 826 in direction DR4. When second end 842 of fastener 826 is engaged with one of the catches of plurality of catches 830, device 800 is locked and is prevented from collapsing in direction DR2. FIG. 44 is a partial front perspective view of a locking mechanism 820 in a locked state. When device 800 is in the fully collapsed state plates 822 and 824 nest within recesses 818.

FIG. 45 is a front perspective view of device 800 with locking mechanisms 814 and 816, in an unexpanded state. Device 800 comprises superior component 802, inferior component 804, and expansion mechanism 810 arranged to displace superior component 802 in a first direction DR1 relative to inferior component 804. Superior component 802 and inferior component 804 further comprise at least one first aperture 806 and at least one second aperture 808, which are arranged to allow fusion between bone fusing material and the adjacent vertebra. Superior component 802 has a first surface 803 and inferior component 804 has a first surface 805. Device 800 further comprises hinge 812 fixedly secured to superior component 802 and inferior component 804 and arranged to rotatably displace the superior component about axis of rotation AR. Locking mechanisms 814 and 816 are preferably locking mechanism 820 described supra. Expansion mechanism 810 is preferably expansion mechanism 176 described supra. It should be noted that since plates 822 and 824 are fixedly secured to superior and inferior components 802 and 804, respectively, recesses 818 are provided within which plates 822 and 824 can nest while device 800 is in a collapsed state. It should further be appreciated that plates 822 and 824 can be hingedly secured to superior component 802 and inferior component 804, respectively. FIG. 46 is a front perspective view of device 800 with locking mechanisms 814 and 816 in an expanded state.

It will be appreciated that various aspects of the disclosure above and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

REFERENCE NUMERALS

- 10 Spinal column
- C1-C7 Cervical vertebrae
- 5 T1-T9 Thoracic vertebrae
- L1-L5 Lumbar vertebrae
- S Sacrum
- C Coccyx
- D1 First diameter
- 10 D2 Second diameter
- D3 Third diameter
- D4 Fourth diameter
- DR1 Direction
- DR2 Direction
- 15 DR3 Direction
- DR4 Direction
- D_{L1-L2} Disc
- D_{L2-L3} Disc
- D_{L3-L4} Disc
- 20 D_{L4-L5} Disc
- F Facet
- FJ Facet joint
- H₁ Collapsed height
- H₂ Expanded height
- 25 SP Spinous process
- TP Transverse process
- IF Intervertebral foramen
- A Annulus
- AR Axis of rotation
- 30 N Nucleus
- NC Neural canal
- H₁ Unexpanded height
- H₂ Expanded height
- RIM Rotational direction 1
- RD2 Rotational direction 2
- 21 Disc space
- 100 Device
- 102 Superior component
- 103 First surface
- 40 104 Inferior component
- 105 Second surface
- 106 Expansion mechanism
- 108 Expansion mechanism
- 110 Expansion mechanism
- 45 112 Locking mechanism
- 114 Locking mechanism
- 116 Locking mechanism
- 118 Locking mechanism
- 120A Plate
- 50 120B Plate
- 120C Plate
- 120D Plate
- 120E Plate
- 120F Plate
- 55 120G Plate
- 120H Plate
- 122A Through-bores
- 122B Through-bores
- 122C Through-bores
- 60 122D Through-bores
- 122E Through-bores
- 122F Through-bores
- 122G Through-bores
- 122H Through-bores
- 65 124 First aperture
- 126 Second aperture
- 128 Post

130 Fastener
 132 First end
 134 Second end
 136 Female threading
 138 First section
 140 Second section
 142 Third section
 144 Fourth section
 146 Male threading
 148 Stopping element
 150 Longitudinal space
 152 Post
 154 Fastener
 156 First end
 158 Second end
 160 Female threading
 162 First section
 164 Second section
 166 Third section
 168 Fourth section
 170 Male threading
 172 Stopping element
 174 Longitudinal space
 176 Expansion mechanism
 178 Threaded rod
 180 Threaded sleeve
 182 Worm drive
 184 Worm
 186 Gear
 220 Locking mechanism
 222 Plate
 224 Pawl
 226 Biasing element
 228 Post
 230 Fastener
 232 First surface
 234 Second surface
 236 Corner
 238 Hinge
 240 Through-bore
 242 First plurality of teeth
 244 Second plurality of teeth
 246 Through-bore
 248 First pawl head
 250 Second pawl head
 252 Hinge
 254 First protrusion
 256 Second protrusion
 258 First end
 260 Second end
 262 Male threading
 264 Stopping element
 266 First end
 268 Second end
 270 Female threading
 200 Second embodiment
 202 Superior component
 203 First surface
 204 Inferior component
 205 Second surface
 206 First aperture
 208 Second Aperture
 210 Expansion mechanism
 212 Hinge
 214 Locking Mechanism
 216 Locking Mechanism
 320 Locking mechanism

322 Plate
 324 Post
 326 Fastener
 328 Corner
 5 330 Hinge
 332 Plurality of through-bores
 334 Longitudinal space
 336 First end
 338 Second end
 10 340 Male threading
 342 Hinge
 344 First protrusion
 346 Second protrusion
 348 First end
 15 350 Second end
 352 Flange
 354 Female threading
 300 Device
 302 Superior component
 20 303 First surface
 304 Inferior component
 305 Second surface
 306 First aperture
 308 Second aperture
 25 310 Expansion mechanism
 312 Hinge
 314 Locking Mechanism
 316 Locking Mechanism
 420 Locking mechanism
 30 422 Plate
 424 Plate
 426 Post
 428 Fastener
 430 Plurality of through-bores
 35 432 Plurality of through-bores
 434 Longitudinal space
 436 Longitudinal space
 438 First end
 440 Second end
 40 442 Male threading
 444 Shoulder
 446 Stopping element
 448 First end
 450 Second end
 45 452 Female threading
 400 Device
 402 Superior component
 403 First surface
 404 Inferior component
 50 405 Second surface
 406 First aperture
 408 Second aperture
 410 Expansion mechanism
 412 Hinge
 55 414 Locking mechanism
 416 Locking mechanism
 418 Recess
 520 Locking mechanism
 522 Plate
 60 524 Plate
 526 Fastener
 530 Plurality of through-bores
 532 Plurality of through-bores
 534 Longitudinal space
 65 540 First end
 542 Second end
 544 Male threading

500 device
 502 Superior component
 503 First surface
 504 Inferior component
 505 Second surface
 506 First aperture
 508 Second aperture
 510 Expansion mechanism
 512 Hinge
 514 Locking mechanism
 516 Locking mechanism
 518 Recess
 600 Device
 602 Superior component
 603 First surface
 604 Inferior component
 605 Second surface
 606 Expansion mechanism
 608 Expansion mechanism
 610 Expansion mechanism
 612 Locking mechanism
 614 Locking mechanism
 616 Locking mechanism
 618 Locking mechanism
 620A Plate
 620B Plate
 620C Plate
 620D Plate
 620E Plate
 620F Plate
 620G Plate
 620H Plate
 622A Through-bore
 622B Through-bores
 622C Through-bore
 622D Through-bores
 622E Square through-bore
 622F Through-bores
 622G Square through-bore
 622H Through-bores
 624 First aperture
 626 Second aperture
 628 Post
 630 Fastener
 632 First end
 634 Second end
 636 Flange
 638 First section
 640 Second section
 642 Third section
 644 Fourth section
 646 Male threading
 647 Cylindrical portion
 648 Stopping element
 650 Cavity
 651 Female threading
 652 Post
 654 Fastener
 656 First end
 658 Second end
 660 Flange
 662 First section
 664 Second section
 666 Third section
 668 Fourth section
 670 Male threading
 671 Cylindrical portion

672 Stopping element
 674 Cavity
 675 Female threading
 720 Locking mechanism
 5 722 Plate
 724 Plate
 726 Fastener
 730 Plurality of catches
 732 Through-bore
 10 734 Female threading
 740 First end
 742 Second end
 744 Male threading
 700 Device
 15 702 Superior component
 703 First surface
 704 Inferior component
 705 Second surface
 706 First aperture
 20 708 Second aperture
 710 Expansion mechanism
 712 Hinge
 714 Locking mechanism
 716 Locking mechanism
 25 718 Recess
 820 Locking mechanism
 822 Plate
 824 Plate
 826 Fastener
 30 830 Plurality of catches
 832 Through-bore
 834 Female threading
 840 First end
 842 Second end
 35 844 Male threading
 800 Device
 802 Superior component
 803 First surface
 804 Inferior component
 40 805 Second surface
 806 First aperture
 808 Second aperture
 810 Expansion mechanism
 812 Hinge
 45 814 Locking mechanism
 816 Locking mechanism
 818 Recess

What is claimed is:

- 50 1. A stand-alone expandable interbody spinal fusion device, comprising:
 a superior component;
 an inferior component;
 an expansion mechanism operatively arranged to displace
 55 the superior component in a first direction relative to the inferior component about a first hinge; and,
 a locking mechanism comprising:
 a plate operatively arranged to pivot about a second
 hinge, the plate further comprising a first aperture
 60 and a first plurality of teeth;
 a pawl operatively arranged to pivot about a third hinge, the pawl further comprising a second aperture; and,
 a post operatively arranged to pass through the first and
 65 second apertures,
 wherein after the superior component is displaced in the first direction, the locking mechanism prevents dis-

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placement of the superior component in a second direction, opposite the first direction.

2. The stand-alone expandable interbody spinal fusion device as recited in claim 1, further comprising a biasing element operatively arranged between the pawl and the inferior component.

3. The stand-alone expandable interbody spinal fusion device as recited in claim 1, wherein the second hinge is operatively arranged on a first protrusion of the inferior component, and the third hinge is operatively arranged on a second protrusion of the inferior component.

4. The stand-alone expandable interbody spinal fusion device recited in claim 1, wherein the plate further comprises a second plurality of teeth.

5. The stand-alone expandable interbody spinal fusion device recited in claim 4, wherein the plate has a first surface and a second surface, where the first plurality of teeth and the second plurality of teeth are operatively arranged on the second surface of the plate.

6. The stand-alone expandable interbody spinal fusion device recited in claim 5, wherein the pawl further comprises a first pawl head, operatively arranged to engage with the first plurality of teeth.

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7. The stand-alone expandable interbody spinal fusion device recited in claim 6, wherein the pawl further comprises a second pawl head, operatively arranged to engage with the second plurality of teeth.

8. The stand-alone expandable interbody spinal fusion device recited in claim 1, wherein the post further comprises a first end and a second end, the first end having a first threading operatively arranged to receive a fastener and the second end having a stopping element.

9. The stand-alone expandable interbody spinal fusion device recited in claim 1, wherein the biasing element is a flat spring.

10. The stand-alone expandable interbody spinal fusion device recited in claim 1, wherein the third hinge is arranged between the first hinge and the second hinge.

11. The stand-alone expandable interbody spinal fusion device recited in claim 1, wherein the pawl is arranged between the first hinge and the plate.

12. The stand-alone expandable interbody spinal fusion device recited in claim 1, wherein the first plurality of teeth are directed toward the first hinge.

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