US010898346B1

(12) **United States Patent**
Suddaby

(10) **Patent No.: US 10,898,346 B1**
(45) **Date of Patent: Jan. 26, 2021**

(54) **EXPANDABLE INTERVERTEBRAL FUSION IMPLANT**

(71) Applicant: **Loubert S. Suddaby**, Orchard Park, NY (US)

(72) Inventor: **Loubert S. Suddaby**, Orchard Park, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/516,416**

(22) Filed: **Jul. 19, 2019**

(51) **Int. Cl.**
A61F 2/44 (2006.01)
A61F 2/30 (2006.01)

(52) **U.S. Cl.**
CPC ***A61F 2/447*** (2013.01); *A61F 2002/3055* (2013.01); *A61F 2002/30261* (2013.01); *A61F 2002/30383* (2013.01); *A61F 2002/30405* (2013.01); *A61F 2002/30579* (2013.01); *A61F 2002/30622* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,483,463	A	1/1996	Qin et al.
5,505,732	A	4/1996	Michelson
5,653,761	A	8/1997	Pisharodi
5,653,762	A	8/1997	Pisharodi
5,665,122	A	9/1997	Kambin
5,683,463	A	11/1997	Godefroy et al.
6,126,660	A	10/2000	Dietz
6,159,244	A	12/2000	Suddaby
6,174,334	B1	1/2001	Suddaby
6,325,827	B1	12/2001	Lin
6,332,895	B1	12/2001	Suddaby
7,044,971	B2	5/2006	Suddaby
8,491,659	B2	7/2013	Weiman
8,632,593	B2	1/2014	Suh et al.
8,845,731	B2	9/2014	Weiman
8,845,732	B2	9/2014	Weiman
8,852,279	B2	10/2014	Weiman
9,155,628	B2	10/2015	Glerum et al.
9,833,337	B2	12/2017	Hleihil et al.
9,949,841	B2	4/2018	Glerum et al.
10,010,429	B2	7/2018	Dmuschewski
10,085,849	B2	10/2018	Weiman et al.
10,117,753	B2	11/2018	Suh et al.
10,137,001	B2	11/2018	Weiman
10,143,566	B2	12/2018	Hyder
10,154,912	B2	12/2018	Glerum

(Continued)

FOREIGN PATENT DOCUMENTS

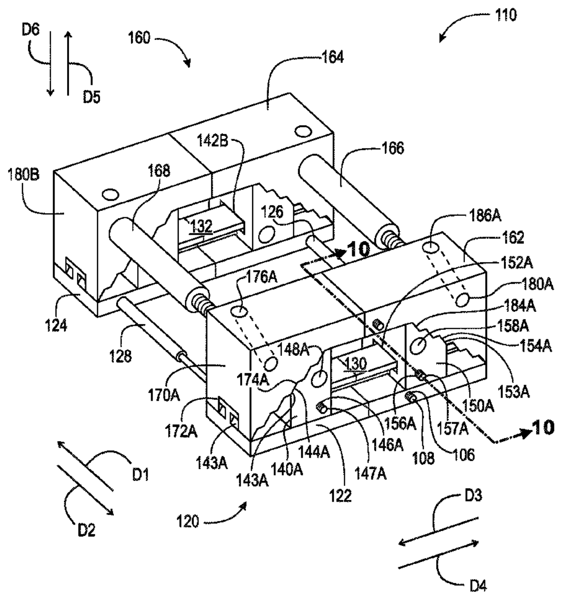
WO	WO2009/064787	5/2009

Primary Examiner — Sameh R Boles
(74) *Attorney, Agent, or Firm* — Simpson & Simpson, PLLC

(57) **ABSTRACT**

An expandable intervertebral fusion implant capable of being expanded in three dimensions, said implant including an inferior component, including a plate, and a first wedge slidably connected to the plate, the first wedge having a first surface, and a superior component including a second wedge, the second wedge having a second surface, wherein the first surface is operatively arranged to engage the second surface to displace the superior component relative to the inferior component. The surfaces of the wedges may be angled and include a plurality of corrugations or steps which engage to allow the implant to expand and collapse.

28 Claims, 14 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0256576	A1	11/2005	Moskowitz et al.	
2008/0140207	A1*	6/2008	Olmos	A61F 2/4657 623/17.16
2009/0222100	A1*	9/2009	Cipoletti	A61F 2/4611 623/17.16
2013/0190876	A1	7/2013	Drochner et al.	
2015/0073552	A1*	3/2015	To	A61F 2/4611 623/17.15
2016/0025629	A1	1/2016	Kettler et al.	
2016/0256291	A1*	9/2016	Miller	A61F 2/4611
2018/0078384	A1	3/2018	Suddaby	
2018/0193164	A1*	7/2018	Shoshtaev	A61F 2/4425
2018/0207002	A1	7/2018	Glerum et al.	
2018/0318101	A1	11/2018	Engstrom	
2019/0029841	A1	1/2019	Suh et al.	
2019/0053912	A1	2/2019	Suddaby	

* cited by examiner

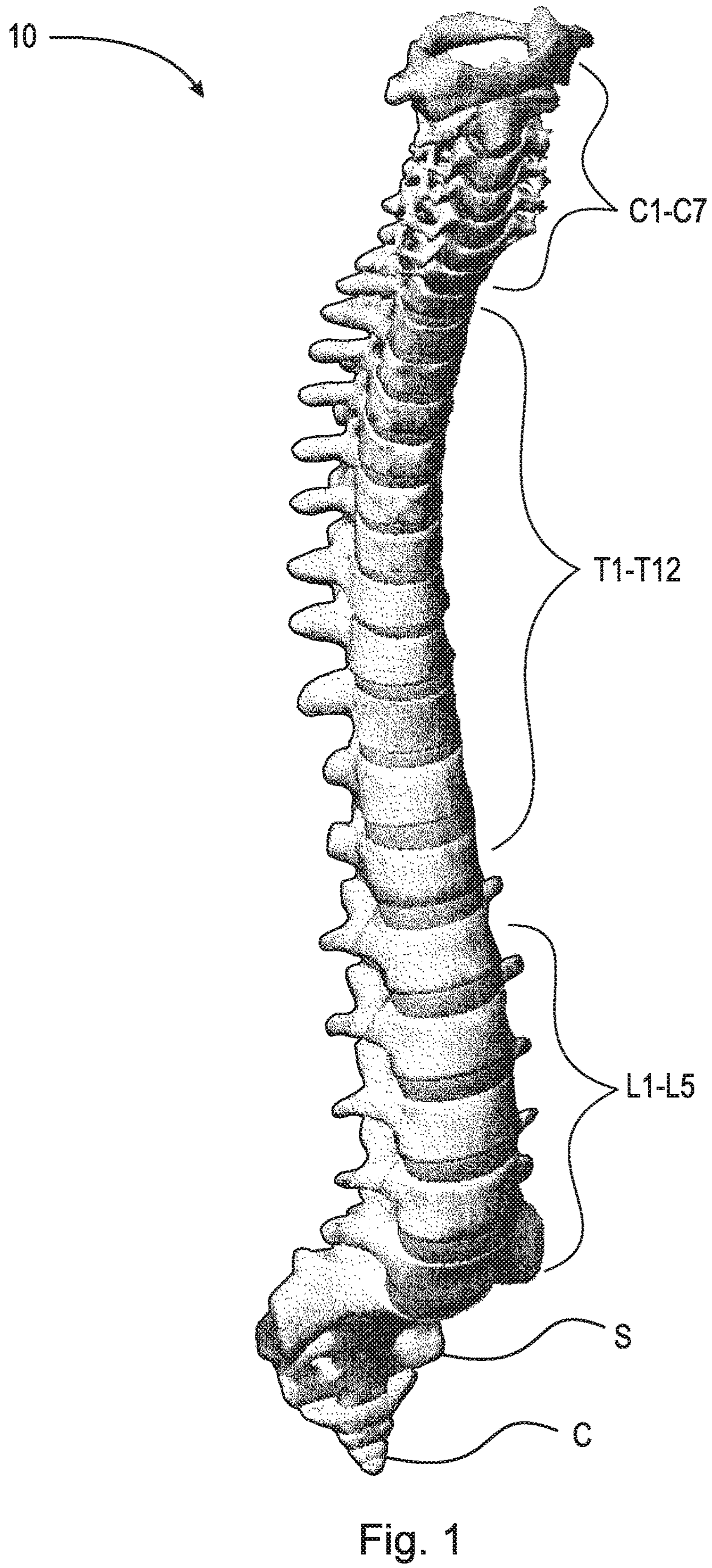


Fig. 1

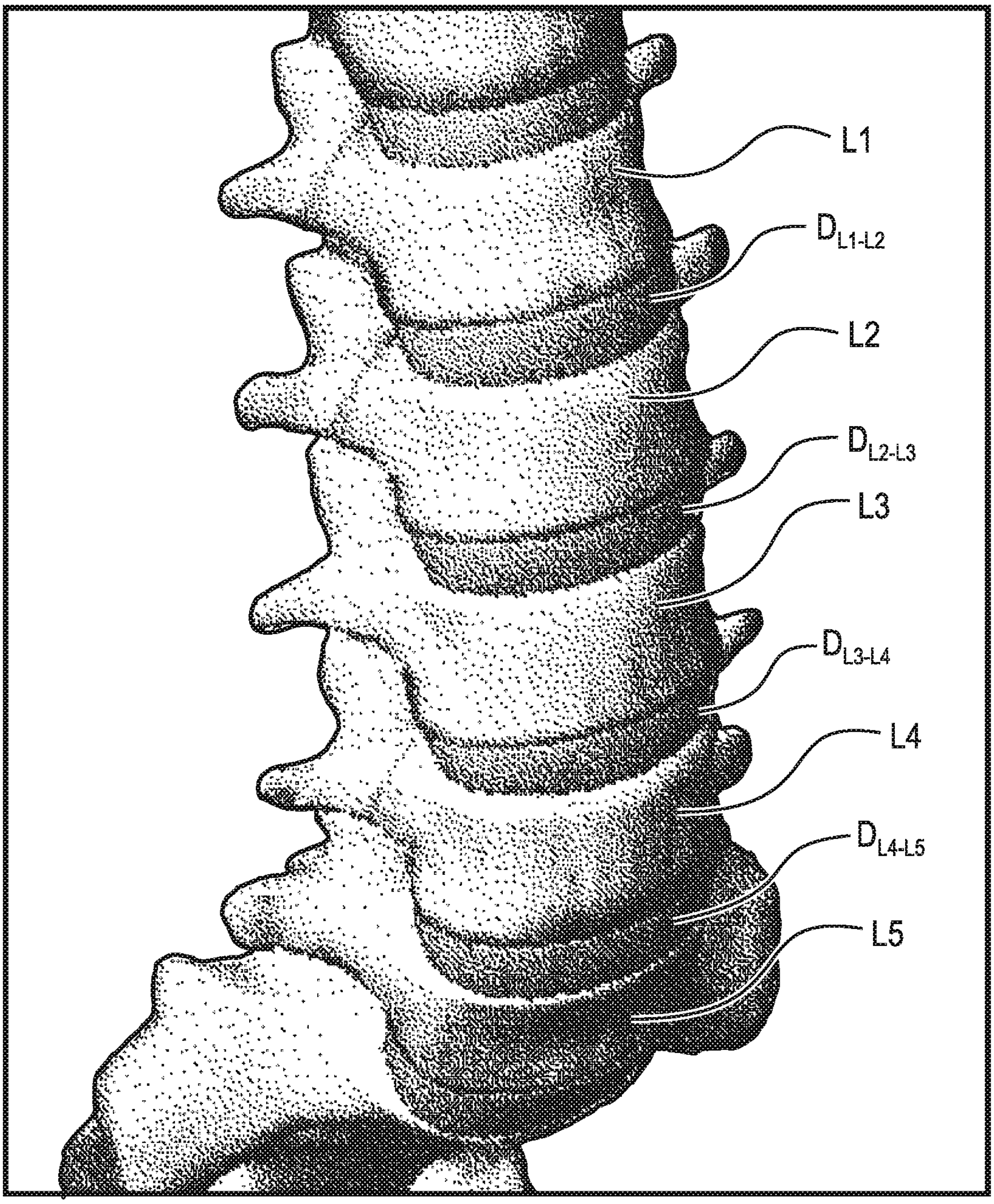


Fig. 2

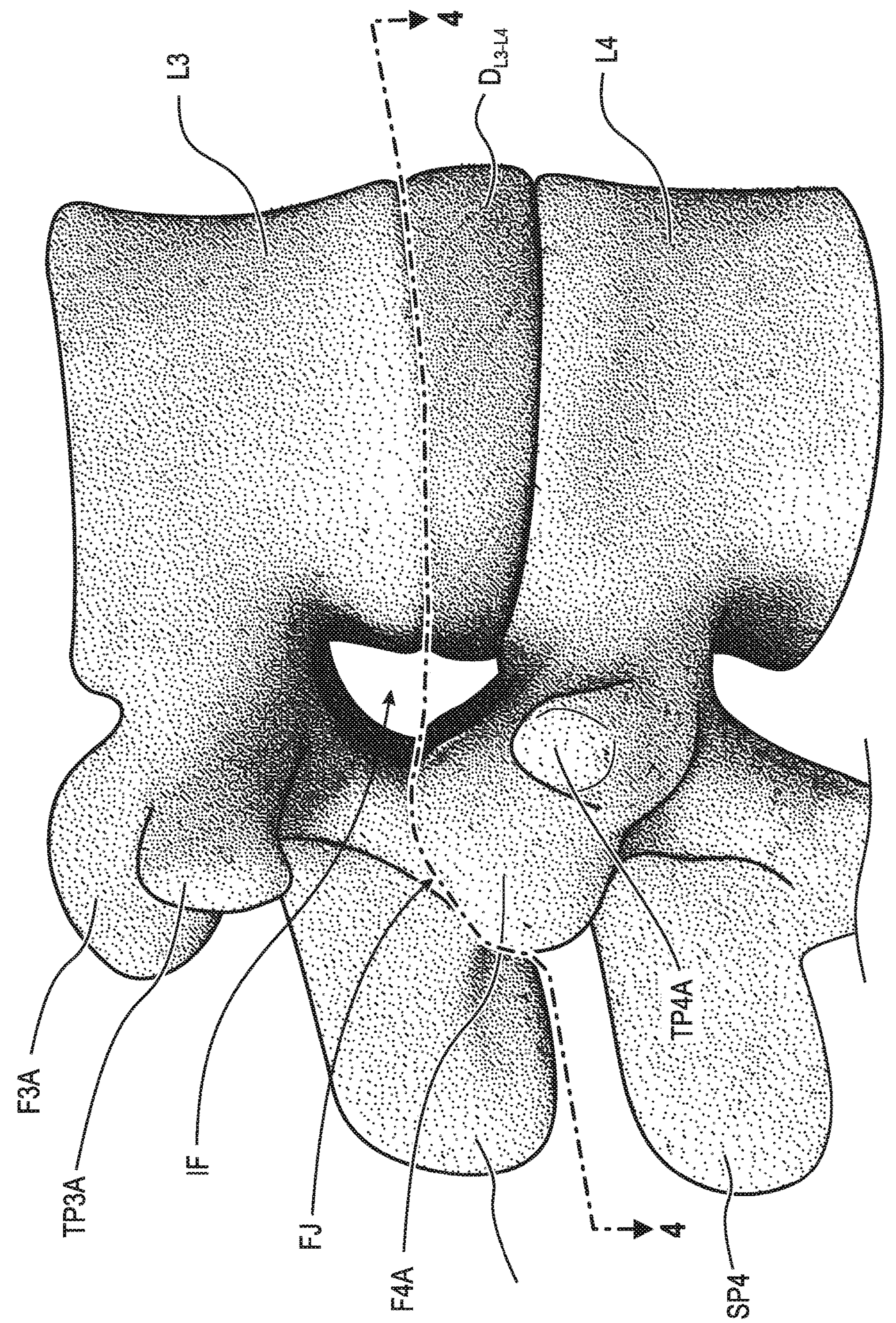


Fig. 3

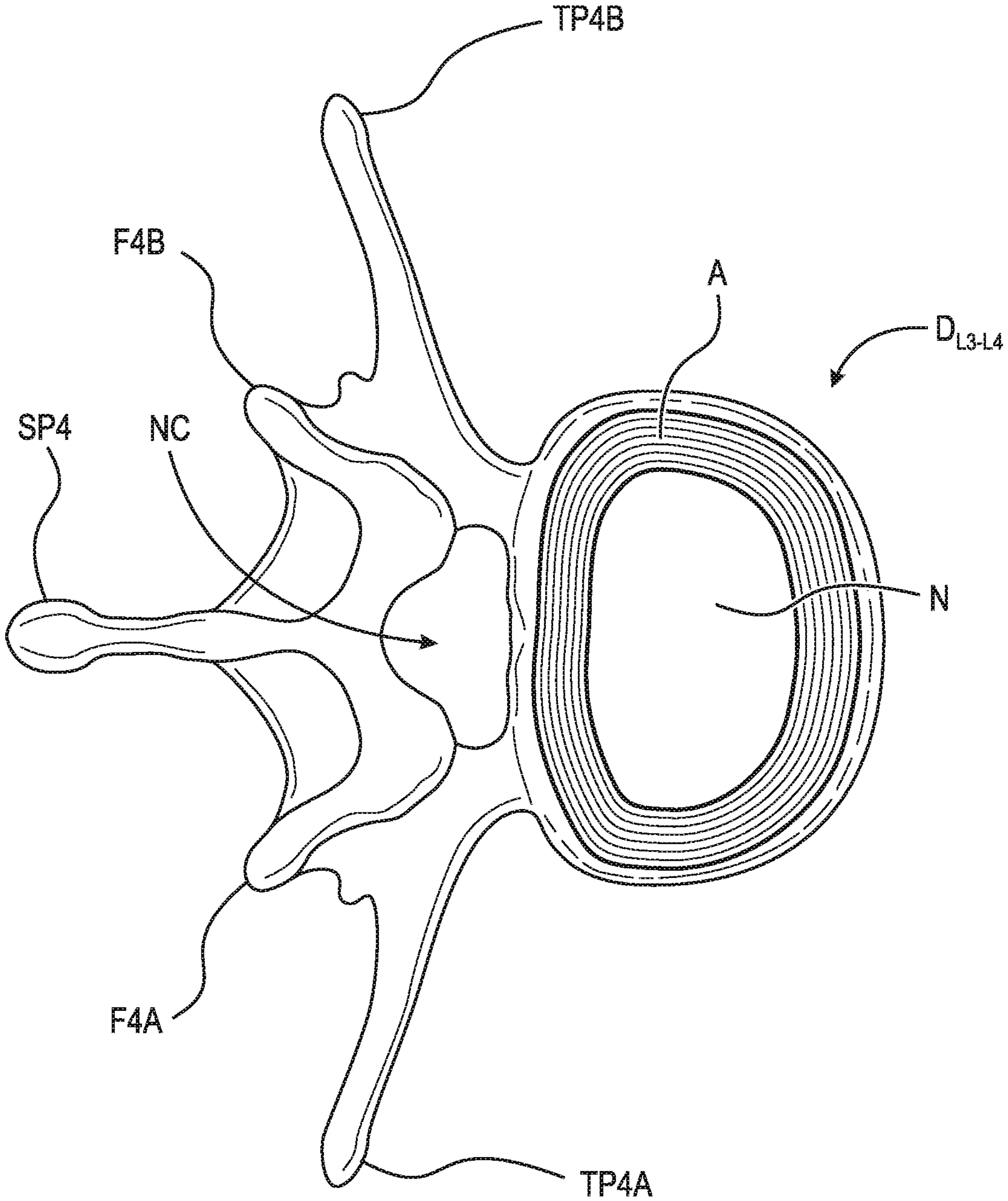


Fig. 4

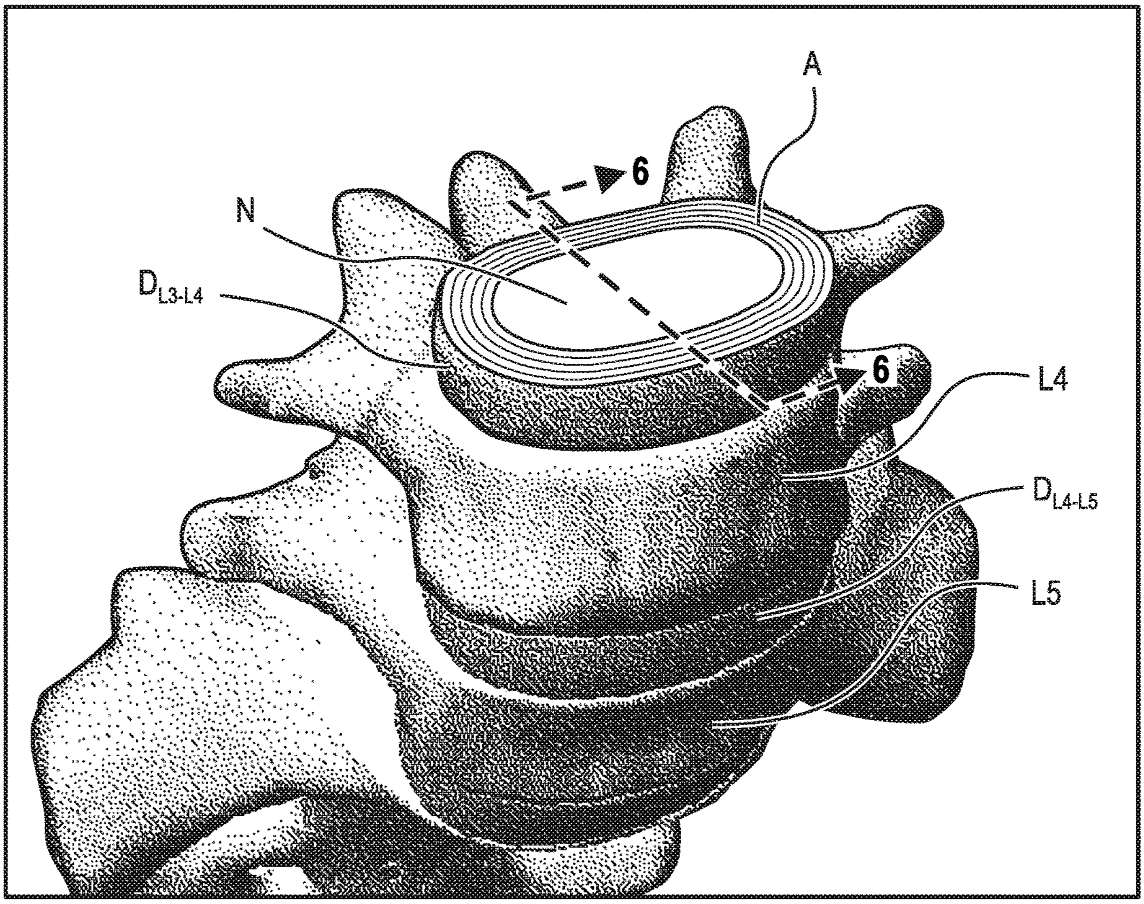


Fig. 5

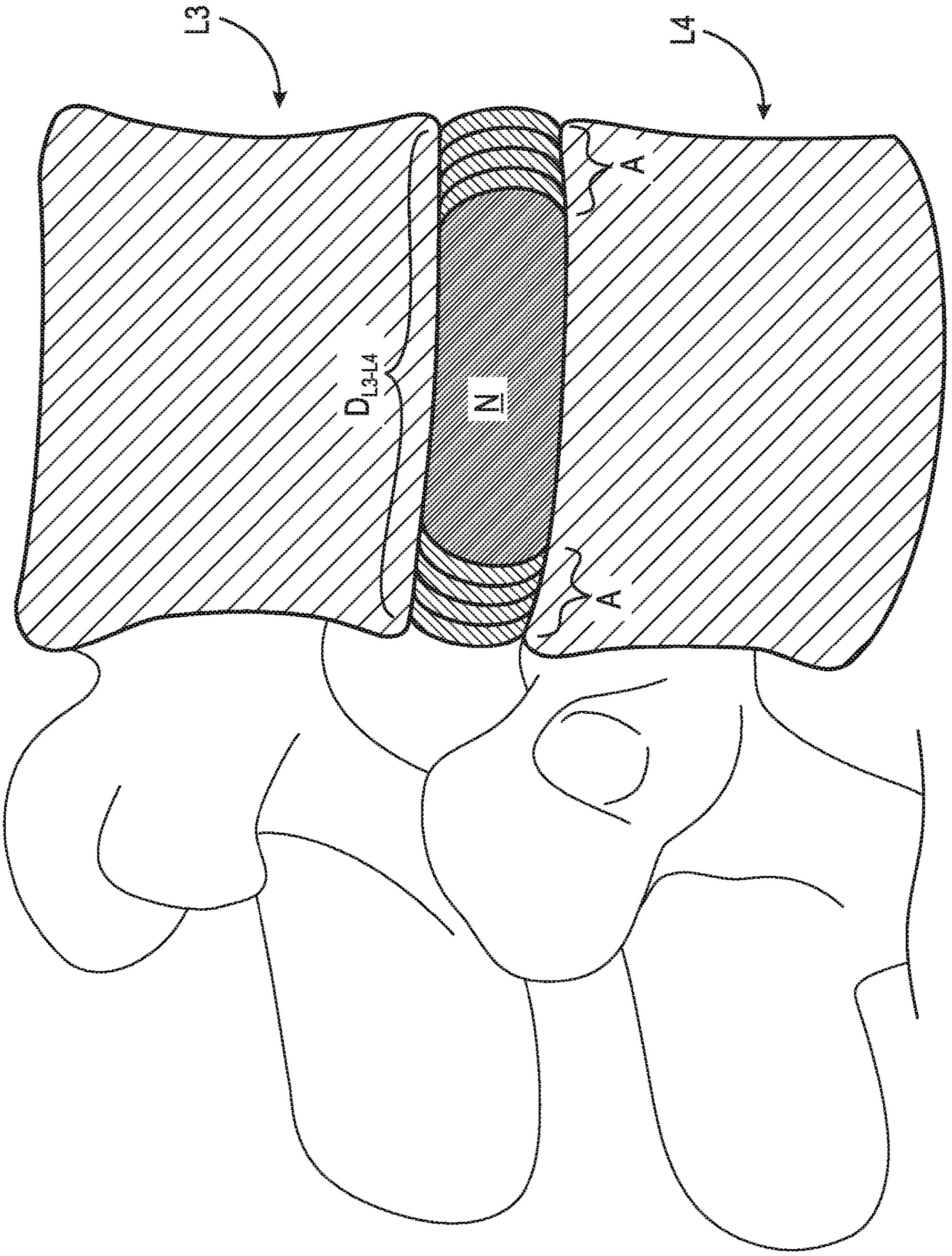


Fig. 6

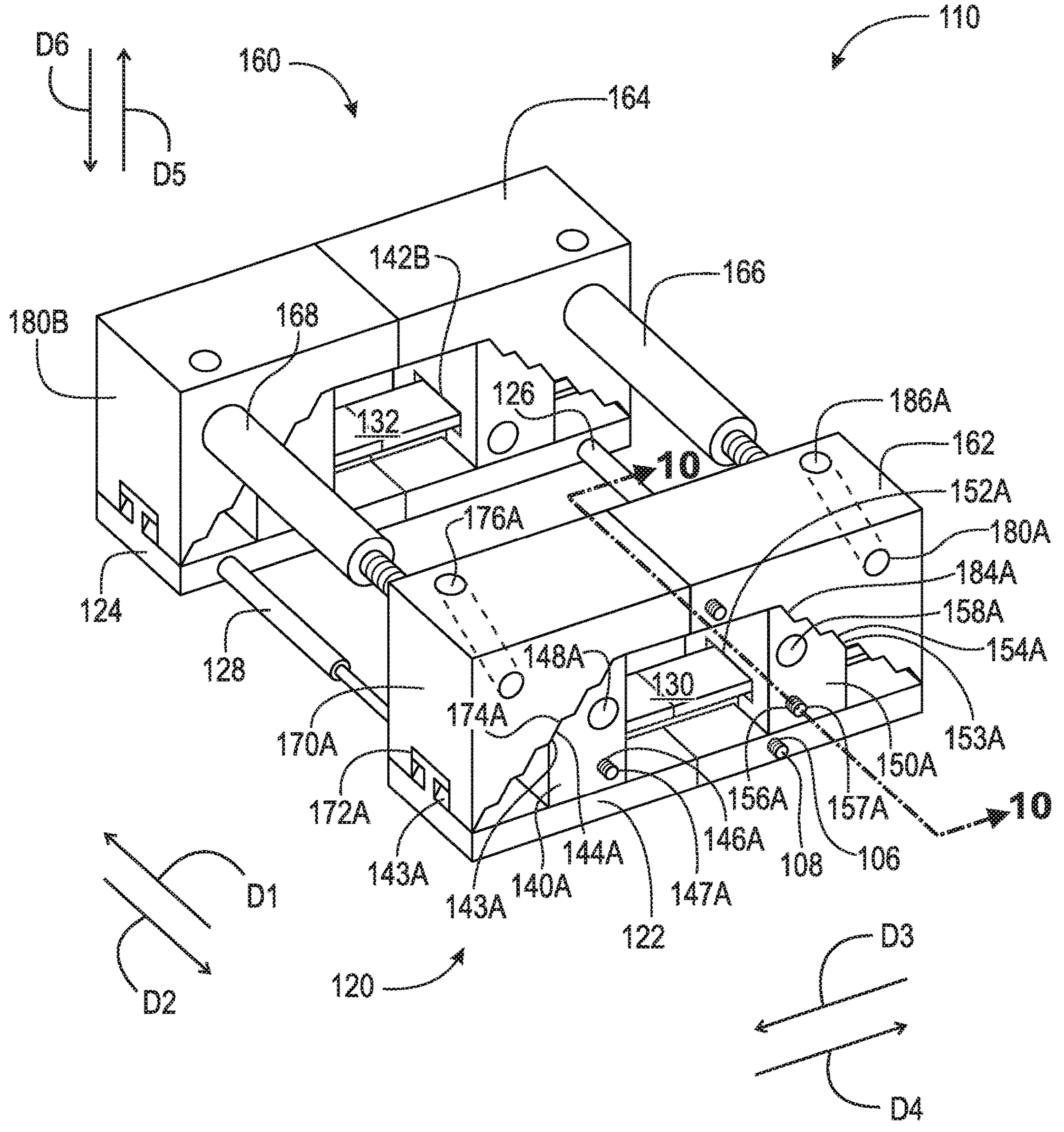

110
160
164
D6
D5
142B
166
180B
168
132
126
10
186A
162
152A
180A
176A
184A
158A
154A
124
148A
130
153A
128
174A
150A
170A
156A
157A
10
172A
143A
144A
146A
108
106
140A
143A
147A
122
D1
D2
120
D3
D4

Fig. 7

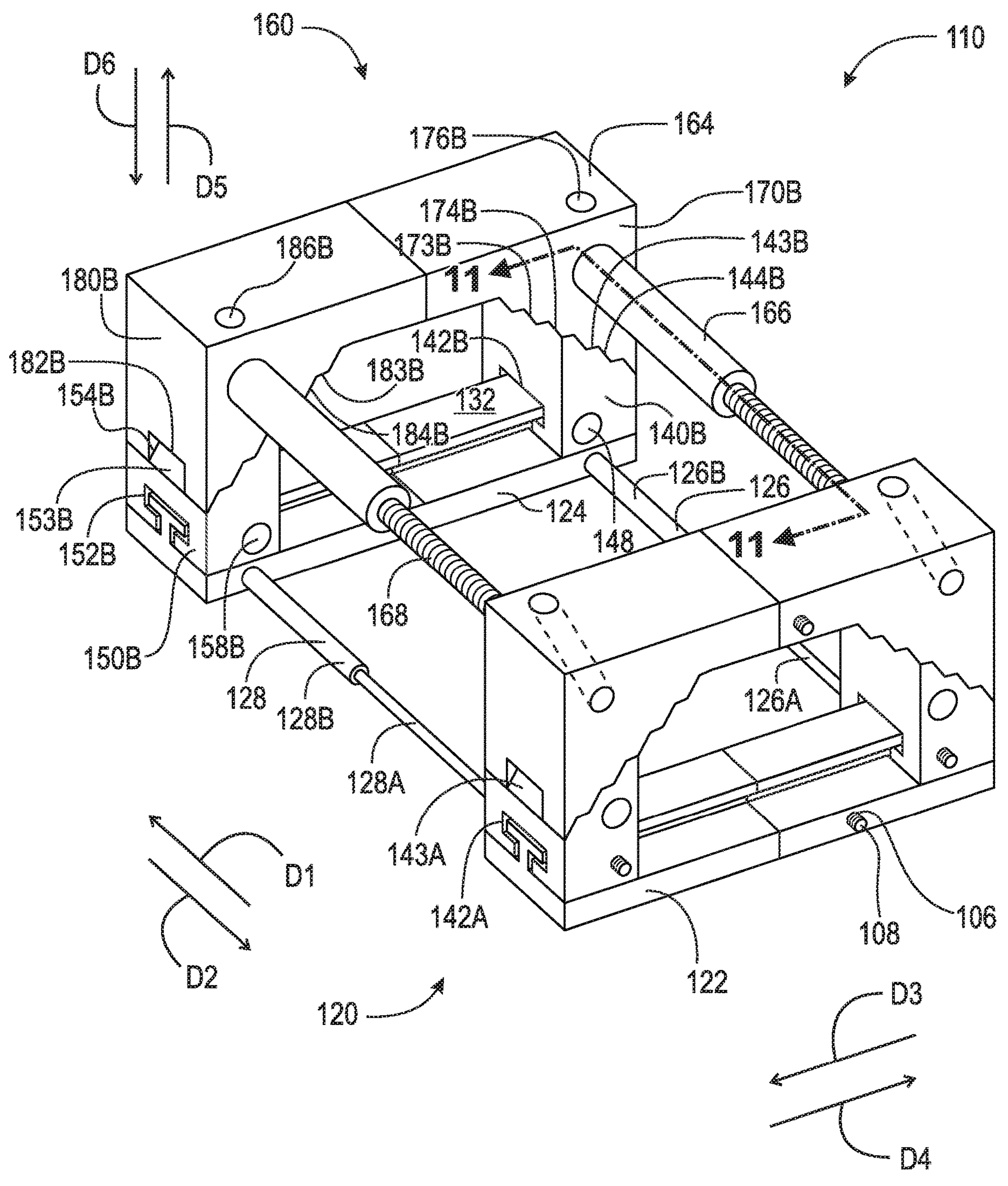

160
110
D6
D5
176B
164
174B
170B
173B
143B
186B
11
144B
180B
166
142B
182B
183B
132
154B
140B
184B
126B
153B
126
124
152B
148
11
168
150B
158B
128
126A
128B
128A
143A
D1
142A
106
108
D2
122
120
D3
D4

Fig. 8

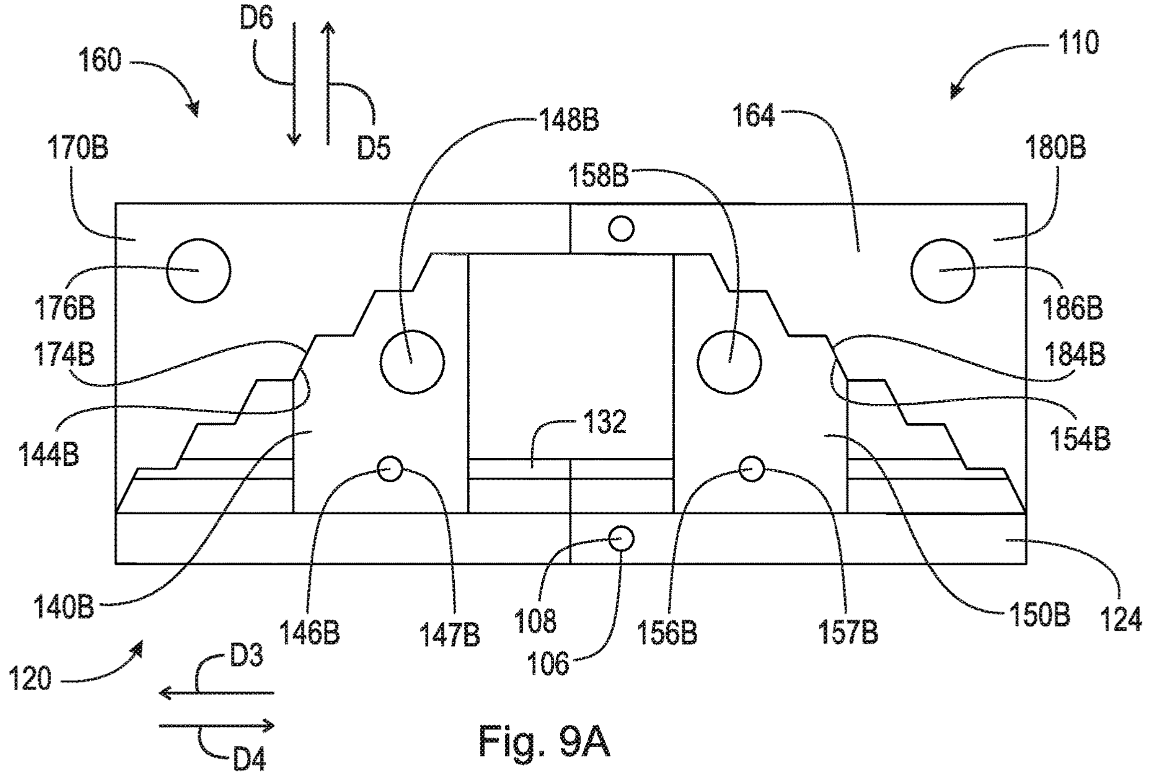

D6
160
110
148B
164
D5
170B
158B
180B
176B
186B
174B
184B
144B
132
154B
140B
146B
147B
108
156B
157B
150B
124
106
120
D3
D4

Fig. 9A

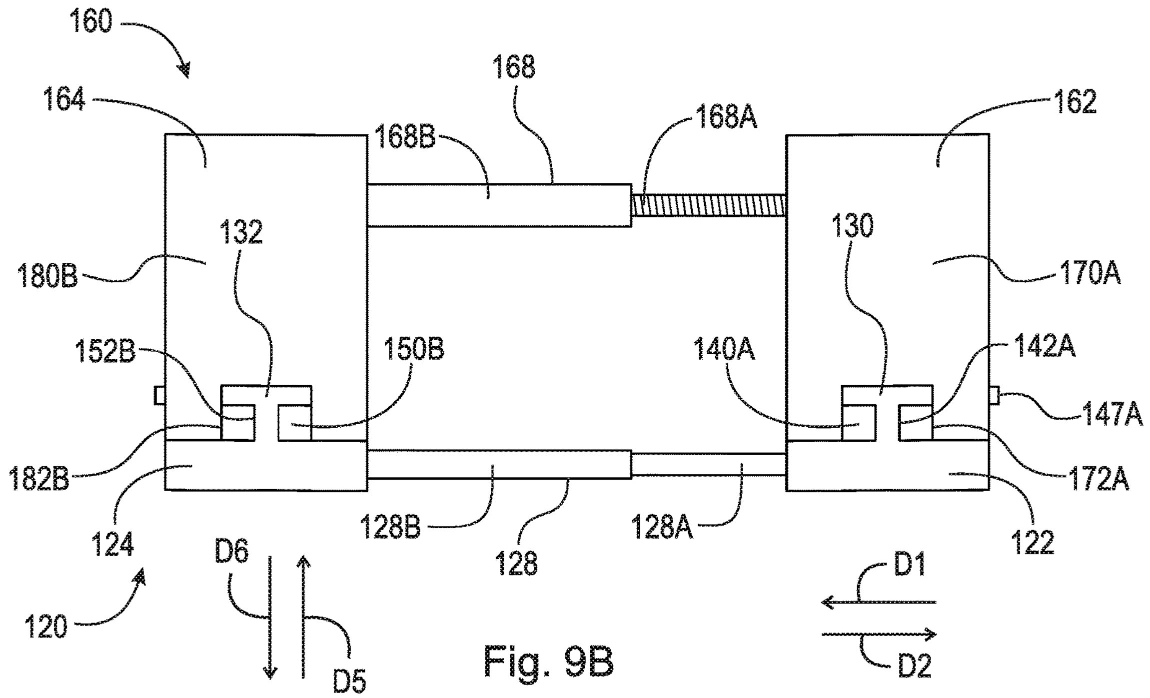

160
164
168
168B
168A
162
132
130
180B
170A
152B
150B
140A
142A
147A
182B
172A
124
128B
128A
122
128
D6
D1
120
D5
D2

Fig. 9B

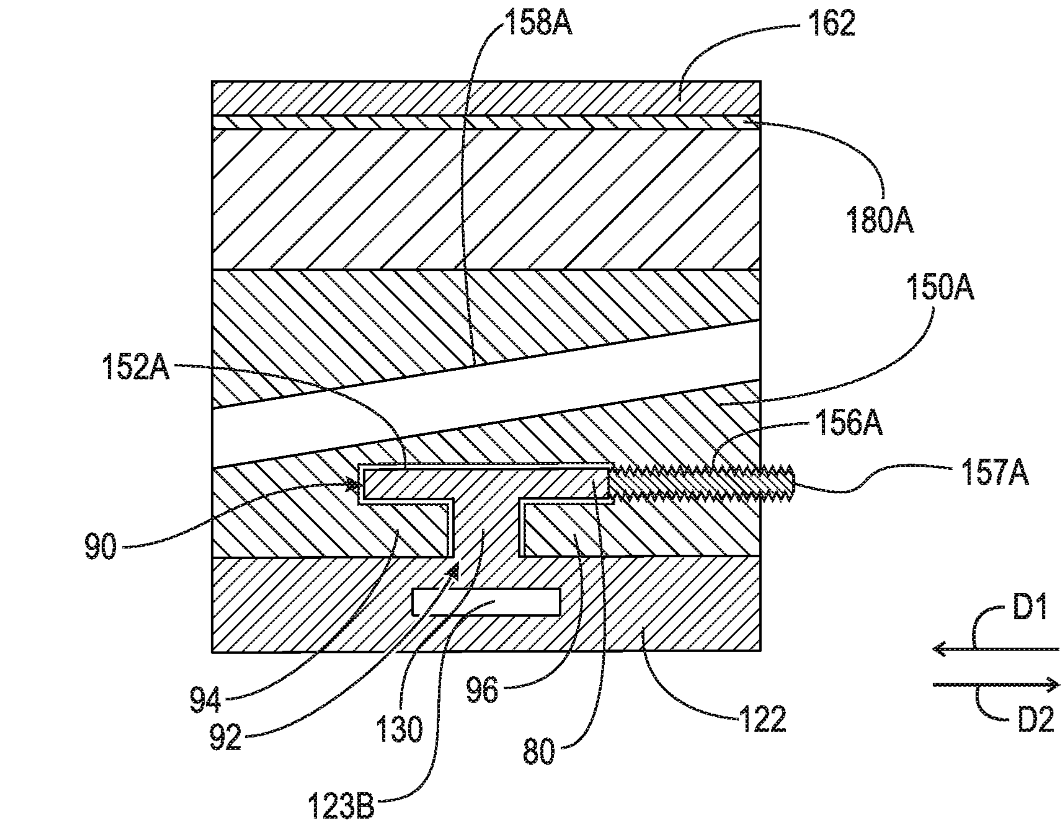

158A
162
180A
150A
152A
156A
157A
90
D1
D2
94
92
130
96
122
80
123B

Fig. 10

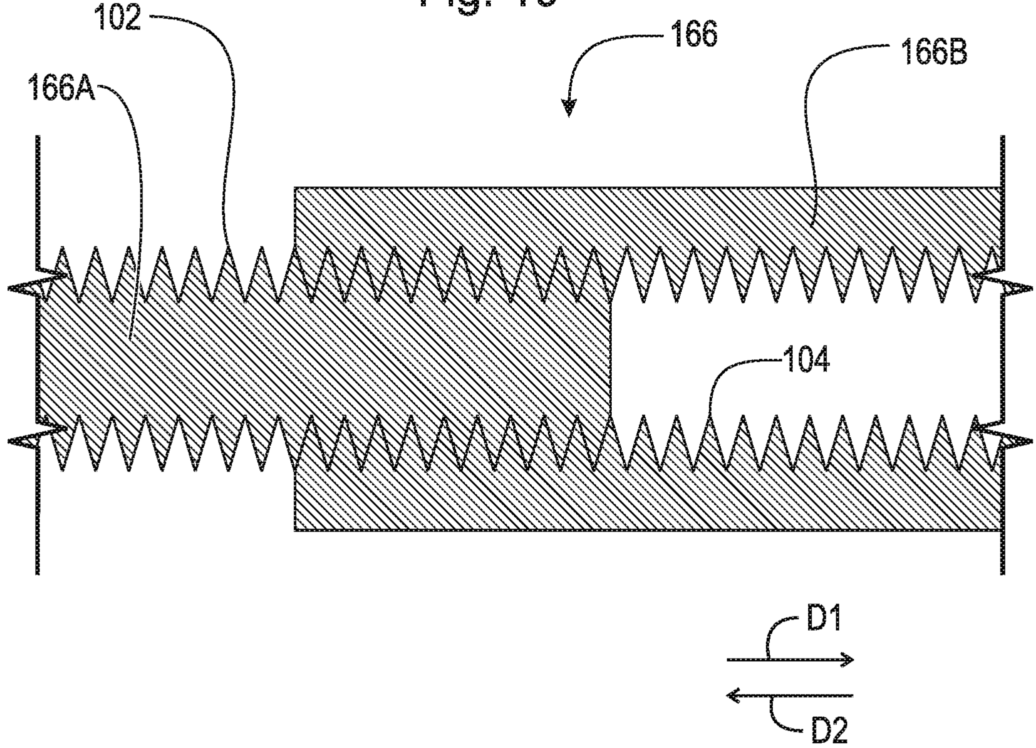

102
166
166B
166A
104
D1
D2

Fig. 11

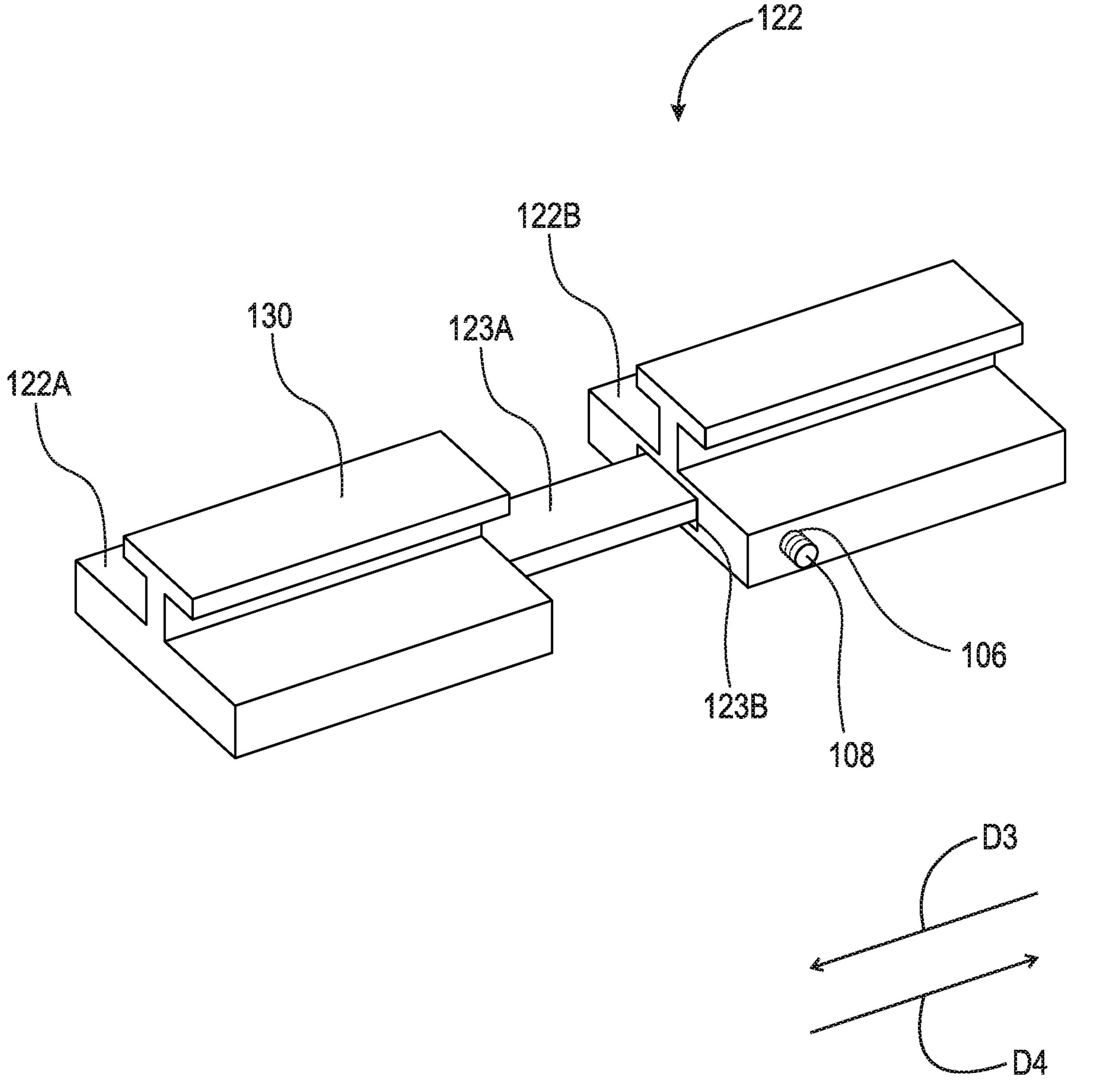


Fig. 12

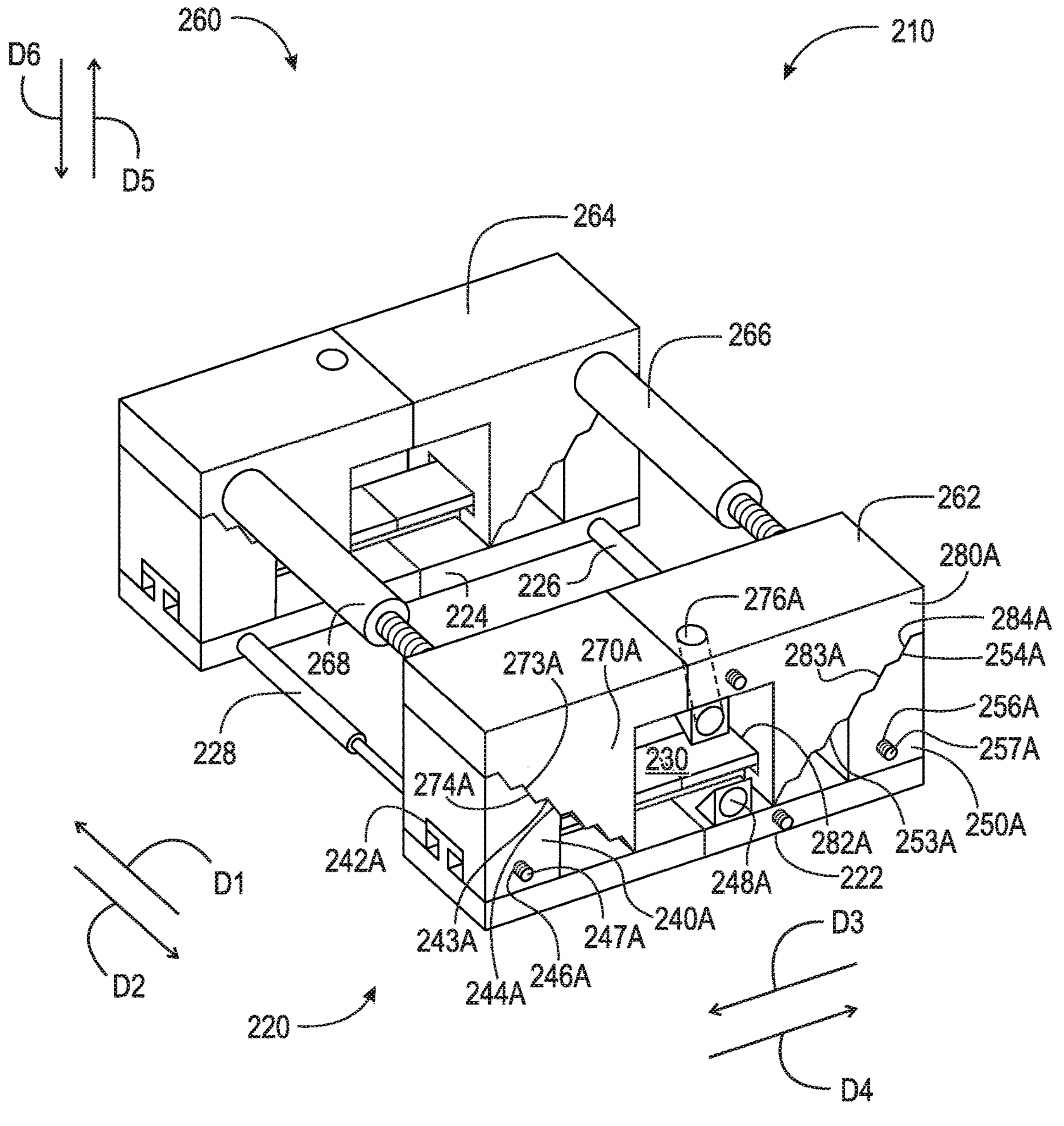

260
210
D6
D5
264
266
262
280A
226
276A
284A
224
254A
268
273A
270A
283A
256A
228
230
257A
274A
250A
282A
253A
242A
248A
222
D1
240A
243A
247A
246A
244A
D3
D2
220
D4

Fig. 13

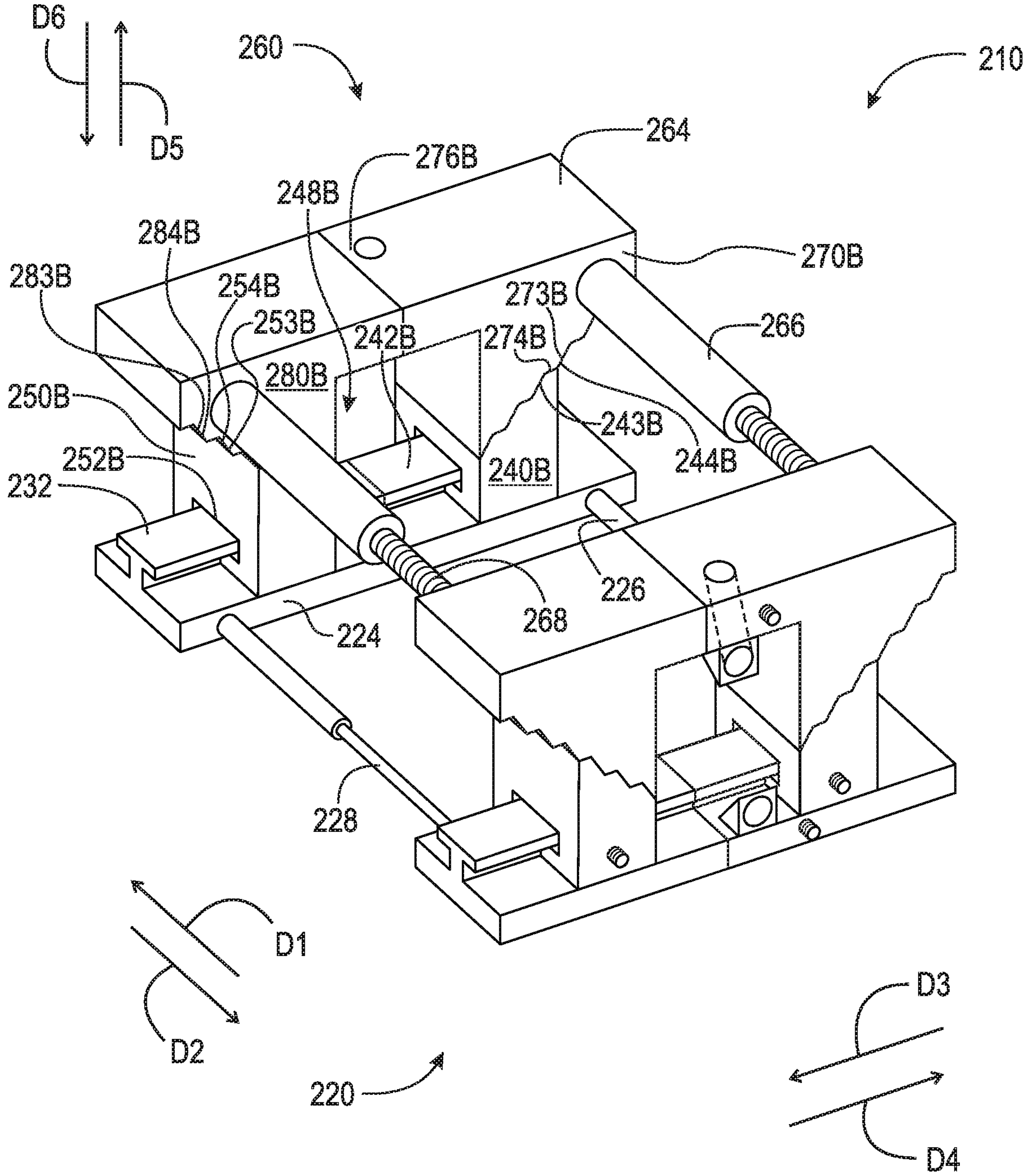

D6
D5
260
210
264
276B
248B
284B
270B
283B
254B
273B
266
253B
242B
274B
280B
250B
243B
244B
252B
240B
232
226
268
224
228
D1
D2
D3
D4
220

Fig. 14

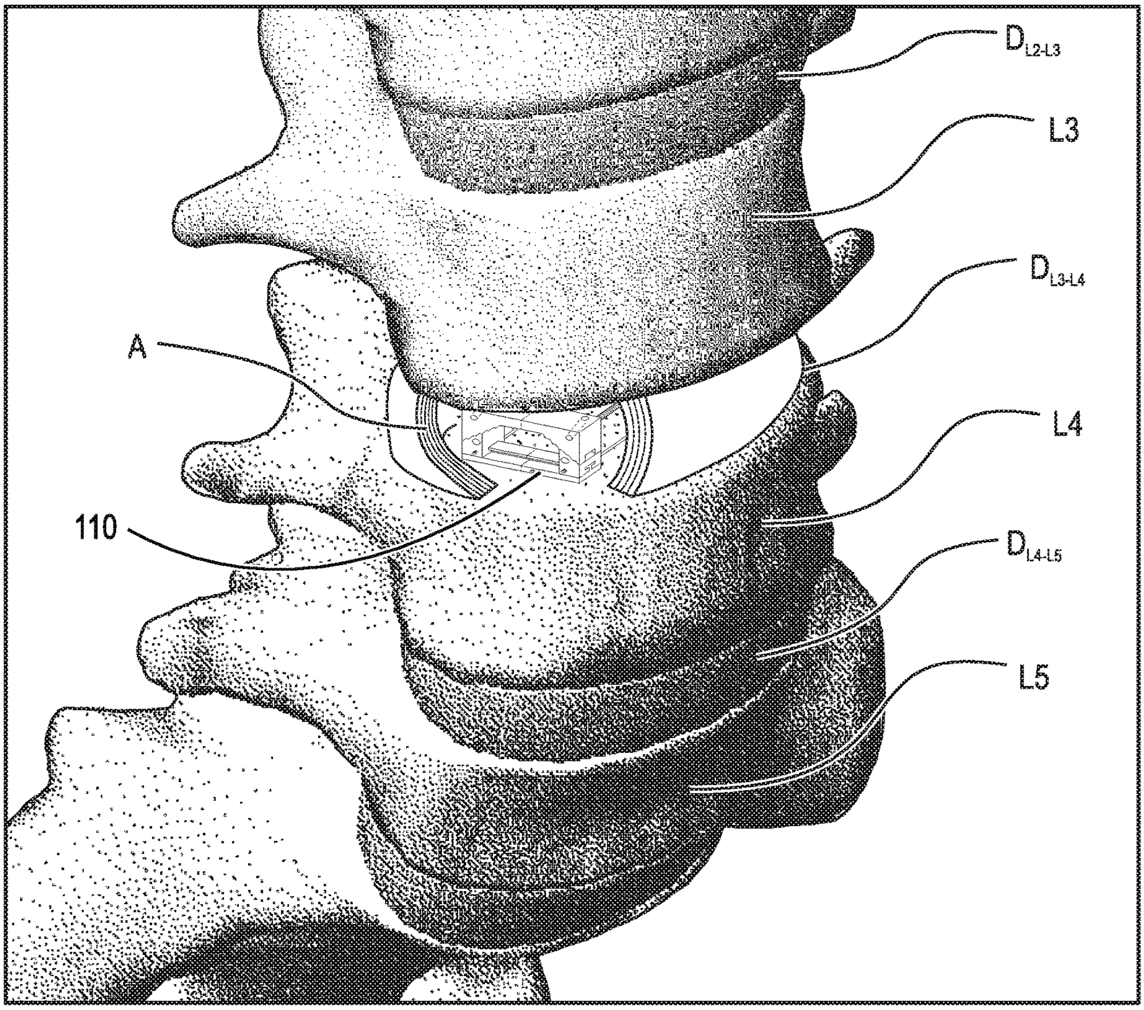


Fig. 15

EXPANDABLE INTERVERTEBRAL FUSION IMPLANT

FIELD

The present disclosure relates to orthopedic surgery, and more particularly to an expandable and deployable intervertebral fusion implant capable of being placed within an intervertebral disc space and expanded in vertical and lateral dimensions.

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 C**1**-C**7** form the neck, support the head and neck, and allow nodding and shaking of the head. The thoracic vertebrae T**1**-T**12** join with the ribs to form the rib cage. The five lumbar vertebrae L**1**-L**5** 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 super-highway 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 foramens.

Various medical conditions require a surgeon to repair, remove and/or replace the aforementioned discs. For example, in one surgical procedure, known as a discectomy (or diskectomy) with interbody fusion, the surgeon removes the nucleus of the disc 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 L**3** and L**4** 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 F**3**A and F**4**A, facet joint FJ, spinous processes SP**3** (not shown) and SP**4**, transverse processes TP**3**A and TP**4**A, and intervertebral foramen IF. FIG. **4** is a top view of the section of the spinal column shown in FIG. **3**, with the L**3** 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**, taken generally along line **6**-**6**, but with vertebra L**3** in place atop disc D_{L3-L4}.

Of all animals possessing a backbone, human beings are the only creatures who remain upright for significant periods of time. From an evolutionary standpoint, this erect posture has conferred a number of strategic benefits, not the least of which is freeing the upper limbs for purposes other than locomotion. From an anthropologic standpoint, it is also evident that this unique evolutionary adaptation is a relatively recent change, and as such has not benefitted from natural selection as much as have backbones held in a horizontal attitude. As a result, the stresses acting upon the human backbone (or "vertebral column"), are unique in many senses, and result in a variety of problems or disease states that are peculiar to the human species.

The human vertebral column is essentially a tower of bones held upright by fibrous bands called ligaments and contractile elements called muscles. There are seven bones in the neck or cervical region, twelve in the chest or thoracic region, five in the lower back or lumbar region, and five in the pelvic or sacral region, which are normally fused together to form the back part of the pelvis. This column of bones is critical for providing structural support for the entire body.

Between the vertebral bones themselves exist soft tissue structures, i.e., discs, composed of fibrous tissue and cartilage that are compressible and act as shock absorbers for sudden downward forces on the upright column. The discs allow the bones to move independently of each other, as well. The repetitive forces which act on these intervertebral discs during repetitive activities of bending, lifting, and twisting cause them to break down or degenerate over time.

Presumably, because of humans' upright posture their intervertebral discs have a high propensity to degenerate. Overt trauma or covert trauma, occurring in the course of repetitive activities, disproportionately affects 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 even chemical irritation of surrounding neural elements (spinal cord and nerves) cause pain, attended by varying degrees of disability. In addition, loss of disc space height relaxes tension on the longitudinal spinal ligaments, thereby contributing to varying degrees of spinal instability.

The time-honored method of addressing the issues of neural irritation and instability resulting from severe disc damage has largely focused on removal of the damaged disc and fusing the adjacent vertebral elements together. Removal of the disc relieves the mechanical and chemical irritation of neural elements, while osseous union (i.e., bone knitting) solves the problem of stability.

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 the grafted bone such that a structurally significant bony fusion can occur.

U.S. Pat. No. 5,505,732 (Michelson), U.S. Pat. No. 5,653,761 (Pisharodi I), U.S. Pat. No. 5,665,122 (Kambin), and U.S. Pat. No. 5,683,463 (Godefroy et al.) disclose different prior art spinal implants. The implant disclosed in U.S. Pat. No. 5,483,463 (Qin et al.) is hollow and tubular, with communicating windows in the top and bottom surfaces. External ribs, which may be serrated, stabilize the implant once it is inserted between the vertebrae. Kambin discloses an intervertebral cage that is expandable by a wedging mechanism. The degree of expansion is rather limited. Michelson and U.S. Pat. No. 5,653,762 (Pisharodi II) disclose shaft-type tools used for installing implants. The prior art devices do not enable one to achieve great ranges of implant height.

Limitations of most present-day intervertebral implants are significant and revolve largely around the marked variation in the disc space height and shape that result from either biologic variability or pathologic change. For example, if a disc space is 20 mm in height, a circular implant bridging this gap requires a minimum diameter of 20 mm just to contact the end plate of the vertebral bone. Generally, end plate disruption must occur to allow a generous bony union, meaning that an additional 2-3 mm must be added on either side resulting in a final implant size of 24-26 mm. During implantation from an anterior approach (i.e., from the front of the body), excessive retraction (or pulling) is often required on the great blood vessels, which greatly enhances the risk of devastating complications such as vascular tears or thrombosis. On the other hand, during a posterior approach, large implant diameters may require excessive traction on neural elements for adequate placement, even if all posterior bony elements are removed. In some instances, an adequate implant size cannot be inserted posteriorly, particularly if there is a significant degree of distraction required to obtain stability by tautening the annular ligamentous band. Compromising on implant size risks suboptimal stability or a loose implant, which has a greater risk of migration within, or expulsion from, the disc space. The alternative of excessively retracting neural elements to facilitate a posterior implant application results in a neuropraxia at best and permanent neural damage at worst.

U.S. Pat. No. 6,174,334 (Suddaby I) and U.S. Pat. No. 6,332,895 (Suddaby II) disclose expandable cages using a ratcheting mechanism in the perimeter to achieve expansion. The aforementioned Suddaby patents do not address issues requiring lateral expansion.

Thus, there is a long-felt need for an expandable and deployable intervertebral fusion implant capable of being placed within an intervertebral disc space and expanded in vertical and lateral dimensions.

SUMMARY

According to aspects illustrated herein, there is provided an expandable intervertebral fusion implant, comprising an inferior component, including a plate, and a first wedge slidably connected to the plate, the first wedge having a first surface, and a superior component including a second wedge, the second wedge having a second surface, wherein the first surface is operatively arranged to engage the second surface to displace the superior component relative to the inferior component.

According to aspects illustrated herein, there is provided an expandable intervertebral fusion implant, comprising an inferior component, including a first plate, a first wedge slidably connected to the first plate, the first wedge having a first surface, a second plate, a second wedge slidably connected to the second plate, the second wedge having a second surface, and at least one first cross-member connecting the first and second plates, and a superior component, including a first component including a third wedge, the third wedge having a third surface, a second component including a fourth wedge, the fourth wedge having a fourth surface, and at least one second cross-member connecting the first and second components, wherein the first and second surfaces are operatively arranged to engage the third and fourth surfaces, respectively, to displace the superior component relative to the inferior component.

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 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 a spinal column;

FIG. **2** is an anterior perspective view of the lumbar section of the spinal column shown in FIG. **1**;

FIG. **3** is a lateral perspective view of two vertebrae, a disc, 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 the top vertebra and all other structure above the top vertebra removed;

FIG. **6** is a partial cross-sectional view of the top and bottom vertebrae and disc, taken generally along line **6-6** in FIG. **5**;

FIG. **7** is a front perspective view of an expandable intervertebral fusion implant, in a fully collapsed state;

FIG. **8** is a front perspective view of the expandable intervertebral fusion implant shown in FIG. **7**, in an expanded state;

FIG. **9**A is a rear elevational view of the expandable intervertebral fusion implant shown in FIG. **7**;

FIG. **9**B is a side elevational view of the expandable intervertebral fusion implant shown in FIG. **7**;

FIG. **10** is a cross-sectional view of a tongue and groove connection taken generally along line **10-10** in FIG. **7**;

FIG. **11** is a cross-sectional view of a cross-member taken generally along line **11-11** in FIG. **8**;

FIG. **12** is a perspective view of a plate in an expanded state;

FIG. **13** is a front perspective view of an expandable intervertebral fusion implant, in a fully collapsed state;

FIG. **14** is a front perspective view of the expandable intervertebral fusion implant shown in FIG. **13**, in an expanded state; and,

FIG. **15** is an anterior perspective view of a spinal column including the expandable intervertebral fusion implant shown in FIG. **7**.

DETAILED DESCRIPTION

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 disclosure could be driven by hydraulics, electronics, pneumatics, and/or springs.

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.

Adverting now to the figures, and as described previously, FIGS. **1-6** depict various parts and sections of spinal anatomy.

FIG. **7** is a front perspective view of expandable intervertebral fusion implant **110**, in a fully collapsed state. FIG. **8** is a front perspective view of expandable intervertebral fusion implant **110**, in an expanded state. FIG. **9**A is a rear elevational view of expandable intervertebral fusion implant **110**. FIG. **9**B is a side elevational view of expandable intervertebral fusion implant **110**. Expandable intervertebral fusion implant **110** generally comprises inferior component **120** and superior component **160**. The following description should be read in view of FIGS. **7-9**B.

Inferior component **120** comprises plate **122**, plate **124**, cross-member **126**, cross-member **128**, wedges **140**A-B, and wedges **150**A-B. In some embodiments, inferior component **120** comprises only plate **122**, wedge **140**A, and wedge **150**A.

Wedges **140**A and **150**A are slidably engaged with plate **122**. In some embodiments, and as shown in the figures, plate **122** comprises rail **130**, and wedges **140**A and **150**A are slidably connected to rail **130**. In some embodiments, plate **122** is expandable, as will be discussed in greater detail below with respect to FIG. **12**.

Wedge **140**A comprises groove **142**A and teeth **144**A arranged on angled surface **143**A. In the embodiment shown in FIGS. **7-12**, wedge **140**A decreases in height in direction D3 (i.e., surface **143**A slopes downward in direction D3). Groove **142**A is operatively arranged to engage rail **130**, as will be discussed in greater detail below with respect to FIG. **10**. Wedge **140**A is arranged to displace relative to plate **122** in direction D3 and direction D**4**. Teeth **144**A are operatively arranged to engage teeth **174**A of wedge **170**A of superior component **160** to expand expandable intervertebral fusion implant **110** and lock it at a set height, as will be discussed in greater detail below. In some embodiments, teeth **144**A are stairs arranged on angled surface **143**A, with each step of the stairs including a tread that is parallel to directions D3 and D4 and a riser that is arranged at an angle relative to directions D3 and D4. The arrangement of teeth **144**A as stairs allows expandable intervertebral fusion implant **110** to expand (i.e., by way of the engagement of the angled risers) and to at least partially lock or maintain at a certain height (i.e., by way of the engagement of the horizontal treads). The arrangement of the teeth **144**A as stairs also allows expandable intervertebral fusion implant **110** to collapse. In some embodiments, teeth **144**A are corrugations (i.e., ridges or grooves) arranged on angled surface **143**A. Wedge **140**A further comprises hole **146**A and locking member **147**A. As shown, locking member **147**A is a set screw which engages threaded hole **146**A in order to fixedly secure wedge **140**A to rail **130**, as will be discussed in greater detail below with respect to FIG. **10**. It should be appreciated that any means suitable for fixedly securing wedge **140**A to plate **122** may be used (e.g., a clamp, crimping the wedge about the rail to fixedly secure it thereto, adhesives, bolts, rivets, welding, soldering, etc.), and that the present disclosure should not be limited to just the use of a set screw. Wedge **140**A may further comprise hole **148**A for securing inferior component **120** to an adjacent vertebra with, for example, a bone screw. Hole **148**A is arranged at an angle relative to plate **122**, for example, generally in direction D**6**, and does not interfere with groove **142**A or rail **130**.

Wedge **150**A comprises groove **152**A and teeth **154**A arranged on angled surface **153**A. In the embodiment shown in FIGS. **7-12**, wedge **150**A decreases in height in direction D**4** (i.e., surface **153**A slopes downward in direction D**4**). Groove **152**A is operatively arranged to engage rail **130**, as will be discussed in greater detail below with respect to FIG. **10**. Wedge **150**A is arranged to displace relative to plate **122** in direction D3 and direction D**4**. Teeth **154**A are operatively arranged to engage teeth **184**A of wedge **180**A of superior component **160** to expand expandable intervertebral fusion implant **110** and lock it at a set height, as will be discussed in greater detail below. In some embodiments, teeth **154**A are stairs arranged on angled surface **153**A, with each step of the stairs including a tread that is parallel to directions D3 and D4 and a riser that is arranged at an angle relative to directions D3 and D4. The arrangement of teeth **154**A as stairs allows expandable intervertebral fusion implant **110** to expand (i.e., by way of the engagement of the angled risers) and to at least partially lock or maintain at a certain height (i.e., by way of the engagement of the horizontal treads). The arrangement of the teeth **154**A as stairs also allows expandable intervertebral fusion implant **110** to collapse. In some embodiments, teeth **154**A are corrugations (i.e., ridges or grooves) arranged on angled surface **153**A. Wedge **150**A further comprises hole **156**A and locking member **157**A. As shown, locking member **157**A is a set screw which engages threaded hole **156**A in order to fixedly secure wedge **150**A to rail **130**, as will be discussed in greater detail below with respect to FIG. **10**. It should be appreciated that any means suitable for fixedly securing wedge **150**A to plate **122** may be used (e.g., a clamp, crimping the wedge about the rail to fixedly secure it thereto, adhesives, bolts, rivets, welding, soldering, etc.), and that the present disclosure should not be limited to just the use of a set screw. Wedge **150**A may further comprise hole **158**A for securing inferior component **120** to an adjacent vertebra with, for example, a bone screw. Hole **158**A is arranged at an angle relative to plate **122**, for example, generally in direction D**6**, and does not interfere with groove **152**A or rail **130**.

Wedges **140**B and **150**B are slidably engaged with plate **124**. In some embodiments, and as shown in the figures, plate **124** comprises rail **132**, and wedges **140**B and **150**B are slidably connected to rail **132**. In some embodiments, plate **124** is expandable, as will be discussed in greater detail below with respect to FIG. **12**.

Wedge **140**B comprises groove **142**B and teeth **144**B arranged on angled surface **143**B. In the embodiment shown in FIGS. **7-12**, wedge **140**B decreases in height in direction D**4** (i.e., surface **143**B slopes downward in direction D**3**). Groove **142**B is operatively arranged to engage rail **132**, as will be discussed in greater detail below with respect to FIG. **10**. Wedge **140**B is arranged to displace relative to plate **124** in direction D**3** and direction D**4**. Teeth **144**B are operatively arranged to engage teeth **174**B of wedge **170**B of superior component **160** to expand expandable intervertebral fusion implant **110** and lock it at a set height, as will be discussed in greater detail below. In some embodiments, teeth **144**B are stairs arranged on angled surface **143**B, with each step of the stairs including a tread that is parallel to directions D**3** and D**4** and a riser that is arranged at an angle relative to directions D**3** and D**4**. The arrangement of teeth **144**B as stairs allows expandable intervertebral fusion implant **110** to expand (i.e., by way of the engagement of the angled risers) and to at least partially lock or maintain at a certain height (i.e., by way of the engagement of the horizontal treads). The arrangement of the teeth **144**B as stairs also allows expandable intervertebral fusion implant **110** to collapse. In some embodiments, teeth **144**B are corrugations (i.e., ridges or grooves) arranged on angled surface **143**B. Wedge **140**B further comprises hole **146**B and locking member **147**B (see FIG. **9**A). As shown, locking member **147**B is a set screw which engages threaded hole **146**B in order to fixedly secure wedge **140**B to rail **132**, as will be discussed in greater detail below with respect to FIG. **10**. It should be appreciated that any means suitable for fixedly securing wedge **140**B to plate **124** may be used (e.g., a clamp, crimping the wedge about the rail to fixedly secure it thereto, adhesives, bolts, rivets, welding, soldering, etc.), and that the present disclosure should not be limited to just the use of a set screw. Wedge **140**B may further comprise hole **148**B for securing inferior component **120** to an adjacent vertebra with, for example, a bone screw. Hole **148**B is arranged at an angle relative to plate **124**, for example, generally in direction D**6**, and does not interfere with groove **142**B or rail **132**.

Wedge **150**B comprises groove **152**B and teeth **154**B arranged on angled surface **153**B. In the embodiment shown in FIGS. **7-12**, wedge **150**B decreases in height in direction D**3** (i.e., surface **153**A slopes downward in direction D**4**). Groove **152**B is operatively arranged to engage rail **132**, as will be discussed in greater detail below with respect to FIG. **10**. Wedge **150**B is arranged to displace relative to plate **124** in direction D**3** and direction D**4**. Teeth **154**B are operatively arranged to engage teeth **184**B of wedge **180**B of superior component **160** to expand expandable intervertebral fusion implant **110** and lock it at a set height, as will be discussed in greater detail below. In some embodiments, teeth **154**B are stairs arranged on angled surface **153**B, with each step of the stairs including a tread that is parallel to directions D**3** and D**4** and a riser that is arranged at an angle relative to directions D**3** and D**4**. The arrangement of teeth **154**B as stairs allows expandable intervertebral fusion implant **110** to expand (i.e., by way of the engagement of the angled risers) and to at least partially lock or maintain at a certain height (i.e., by way of the engagement of the horizontal treads). The arrangement of the teeth **154**B as stairs also allows expandable intervertebral fusion implant **110** to collapse. In some embodiments, teeth **154**B are corrugations (i.e., ridges or grooves) arranged on angled surface **153**B. Wedge **150**B further comprises hole **156**B and locking member **157**B (see FIG. **9**A). As shown, locking member **157**B is a set screw which engages threaded hole **156**B in order to fixedly secure wedge **150**B to rail **132**, as will be discussed in greater detail below with respect to FIG. **10**. It should be appreciated that any means suitable for fixedly securing wedge **150**B to plate **124** may be used (e.g., a clamp, crimping the wedge about the rail to fixedly secure it thereto, adhesives, bolts, rivets, welding, soldering, etc.), and that the present disclosure should not be limited to just the use of a set screw. Wedge **150**B may further comprise hole **158**B for securing inferior component **120** to an adjacent vertebra with, for example, a bone screw. Hole **158**B is arranged at an angle relative to plate **124**, for example, generally in direction D**6**, and does not interfere with groove **152**B or rail **132**.

Cross-members **126** and **128** connect plate **124** to plate **122**. In some embodiments, cross-members **126** and **128** are telescoping cross-members and allow for expandable intervertebral fusion implant **110** to be expanded and collapsed. For example, cross-members may comprise an inner rod displaceable (or slidable) within an outer rod. Plate **124** may be displaced relative to plate **122** in direction D**1** to expand expandable intervertebral fusion implant **110**, specifically inferior component **120**, and direction D**2** to collapse expandable intervertebral fusion implant **110**, specifically inferior component **120**. Cross-members **126** and **128** are fixed to respective ends, or proximate ends, of plates **122** and **124**. It should be appreciated that cross-members **126** and **128** do not have to be fixed at the ends of plates **122** and **124**, but rather can be fixed axially inward from the ends of plates **122** and **124**. In some embodiments, inferior component **120** comprises one cross-member that connects plates **122** and **124**. In some embodiments, inferior component **120** does not comprise any cross-members. In some embodiments, inferior component **120** comprises one or more cross-members connecting plates **122** and **124**, for example, three cross-members. It should be appreciated that although the drawings depict cross-members **126** and **128** having a circular cross-sectional geometry, any geometry suitable for expandably or displaceably connecting plates **122** and **124** may be used, for example, square, rectangular, triangular, ellipsoidal, etc. In some embodiments, cross-members **126** and **128** may be threaded (or locking) telescoping cross-members, similar or equivalent to cross-members **166** and **168** discussed in greater detail below. Additionally, it should be appreciated that in some embodiments, cross-members **126** and **128** are not telescoping and connect plate **124** to plate **122** at a set distance.

Superior component **160** comprises component **162**, component **164**, cross-member **166**, cross-member **168**, wedges **170**A-B, and wedges **180**A-B. In some embodiments, superior component **160** comprises only component **162**, wedge **170**A, and wedge **180**A.

Wedges **170**A and **180**A are connected to component **122**. Wedge **170**A comprises channel **172**A and teeth **174**A arranged on angled surface **173**A. In the embodiment shown in FIGS. **9-12**, wedge **170**A decreases in height in direction D**4** (i.e., surface **173**A slopes downward in direction D**4**). Channel **172**A is operatively arranged to engage rail **130** in a fully collapsed position, as is shown in FIG. **7**. Channel **172**A allows superior component **160** to fully collapse with respect to inferior component **120** (i.e., such that wedges **170**A and **180**A and wedges **170**B and **180**B rest on plates **122** and **124**, respectively). Angled surface **173**A is operatively arranged to engage angled surface **143**A to expand superior component **160** with respect to inferior component **120**. Specifically, as wedge **140**A is displaced in direction D**3** relative to plate **122**, angled surface **143**A engages angled surface **173**A to displace superior component **160** in direction D**5** relative to inferior component **120**. Teeth **174**A are operatively arranged to engage teeth **144**A to lock superior component **160** at a distance relative to inferior component **120**. Specifically, teeth **174**A engage teeth **144**A to allow wedge **140**A to displace in direction D**3** relative to plate **122**, and at the same time, if required, allow wedge **140**A to displace in direction D**4** relative to plate **122**. Such arrangement allows expandable intervertebral fusion implant **110** to expand and collapse in a controlled fashion. In some embodiments, teeth **174**A are stairs arranged on angled surface **173**A, with each step of the stairs including a tread that is parallel to directions D**3** and D**4** and a riser that is arranged at an angle relative to directions D**3** and D**4**. The arrangement of teeth **174**A as stairs allows expandable intervertebral fusion implant **110** to expand (i.e., by way of the engagement of the angled risers) and to at least partially lock or maintain at a certain height (i.e., by way of the engagement of the horizontal treads). The arrangement of the teeth **174**A as stairs also allows expandable intervertebral fusion implant **110** to collapse. In some embodiments, teeth **174**A are corrugations (i.e., ridges or grooves) arranged on angled surface **173**A. Wedge **170**A may further comprise hole **176**A for securing superior component **160** to an adjacent vertebra with, for example, a bone screw. Hole **176**A is arranged at an angle relative to plate **122**, for example, generally in direction D**5**.

Wedge **180**A comprises channel **182**A and teeth **184**A arranged on angled surface **183**A. In the embodiment shown in FIGS. **9-12**, wedge **180**A decreases in height in direction D**3** (i.e., surface **183**A slopes downward in direction D**3**). Channel **182**A is operatively arranged to engage rail **130** in a fully collapsed position, as is shown in FIG. **7**. Channel **182**A allows superior component **160** to fully collapse with respect to inferior component **120** (i.e., such that wedges **170**A and **180**A and wedges **170**B and **180**B rest on plates **122** and **124**, respectively). Angled surface **183**A is operatively arranged to engage angled surface **153**A to expand superior component **160** with respect to inferior component **120**. Specifically, as wedge **150**A is displaced in direction D**4** relative to plate **122**, angled surface **153**A engages angled surface **183**A to displace superior component **160** in direction D**5** relative to inferior component **120**. Teeth **184**A are operatively arranged to engage teeth **154**A to lock superior component **160** at a distance relative to inferior component **120**. Specifically, teeth **184**A engage teeth **154**A to allow wedge **150**A to displace in direction D**4** relative to plate **122**, and at the same time, if required, allow wedge **150**A to displace in direction D**3** relative to plate **122**. Such arrangement allows expandable intervertebral fusion implant **110** to expand and collapse in a controlled fashion. In some embodiments, teeth **184**A are stairs arranged on angled surface **183**A, with each step of the stairs including a tread that is parallel to directions D**3** and D**4** and a riser that is arranged at an angle relative to directions D**3** and D**4**. The arrangement of teeth **184**A as stairs allows expandable intervertebral fusion implant **110** to expand (i.e., by way of the engagement of the angled risers) and to at least partially lock or maintain at a certain height (i.e., by way of the engagement of the horizontal treads). The arrangement of the teeth **184**A as stairs also allows expandable intervertebral fusion implant **110** to collapse. In some embodiments, teeth **184**A are corrugations (i.e., ridges or grooves) arranged on angled surface **183**A. Wedge **180**A may further comprise hole **186**A for securing superior component **160** to an adjacent vertebra with, for example, a bone screw. Hole **186**A is arranged at an angle relative to plate **122**, for example, generally in direction D**5**.

Wedge **170**B comprises channel **172**B and teeth **174**B arranged on angled surface **173**B. In the embodiment shown in FIGS. **7-12**, wedge **170**B decreases in height in direction D**3** (i.e., surface **173**B slopes downward in direction D**3**). Channel **172**B is operatively arranged to engage rail **132** in a fully collapsed position, as is shown in FIG. **7**. Channel **172**B allows superior component **160** to fully collapse with respect to inferior component **120** (i.e., such that wedges **170**A and **180**A and wedges **170**B and **180**B rest on plates **122** and **124**, respectively). Angled surface **173**B is operatively arranged to engage angled surface **143**B to expand superior component **160** with respect to inferior component **120**. Specifically, as wedge **140**B is displaced in direction D**4** relative to plate **124**, angled surface **143**B engages angled surface **173**B to displace superior component **160** in direction D**5** relative to inferior component **120**. Teeth **174**B are operatively arranged to engage teeth **144**B to lock superior component **160** at a distance relative to inferior component **120**. Specifically, teeth **174**B engage teeth **144**B to allow wedge **140**B to displace in direction D**4** relative to plate **122**, and at the same time, if required, allow wedge **140**B to displace in direction D**3** relative to plate **124**. Such arrangement allows expandable intervertebral fusion implant **110** to expand and collapse in a controlled fashion. In some embodiments, teeth **174**B are stairs arranged on angled surface **173**B, with each step of the stairs including a tread that is parallel to directions D**3** and D**4** and a riser that is arranged at an angle relative to directions D**3** and D**4**. The arrangement of teeth **174**B as stairs allows expandable intervertebral fusion implant **110** to expand (i.e., by way of the engagement of the angled risers) and to at least partially lock or maintain at a certain height (i.e., by way of the engagement of the horizontal treads). The arrangement of the teeth **174**B as stairs also allows expandable intervertebral fusion implant **110** to collapse. In some embodiments, teeth **174**B are corrugations (i.e., ridges or grooves) arranged on angled surface **173**B. Wedge **170**B may further comprise hole **176**B for securing superior component **160** to an adjacent vertebra with, for example, a bone screw. Hole **176**B is arranged at an angle relative to plate **124**, for example, generally in direction D**5**.

Wedge **180**B comprises channel **182**B and teeth **184**B arranged on angled surface **183**B. In the embodiment shown in FIGS. **7-12**, wedge **180**B decreases in height in direction D**4** (i.e., surface **183**B slopes downward in direction D**4**). Channel **182**B is operatively arranged to engage rail **132** in a fully collapsed position, as is shown in FIG. **7**. Channel **182**B allows superior component **160** to fully collapse with respect to inferior component **120** (i.e., such that wedges **170**A and **180**A and wedges **170**B and **180**B rest on plates **122** and **124**, respectively). Angled surface **183**B is operatively arranged to engage angled surface **153**B to expand superior component **160** with respect to inferior component **120**. Specifically, as wedge **150**B is displaced in direction D**3** relative to plate **124**, angled surface **153**B engages angled surface **183**B to displace superior component **160** in direction D**5** relative to inferior component **120**. Teeth **184**B are operatively arranged to engage teeth **154**B to lock superior component **160** at a distance relative to inferior component **120**. Specifically, teeth **184**B engage teeth **154**B to allow wedge **150**B to displace in direction D**3** relative to plate **124**, and at the same time, if required, allow wedge **150**B from displacing in direction D**4** relative to plate **124**. Such arrangement allows expandable intervertebral fusion implant **110** to expand and collapse in a controlled fashion. In some embodiments, teeth **184**B are stairs arranged on angled surface **183**B, with each step of the stairs including a tread that is parallel to directions D**3** and D**4** and a riser that is arranged at an angle relative to directions D**3** and D**4**. The arrangement of teeth **184**B as stairs allows expandable intervertebral fusion implant **110** to expand (i.e., by way of the engagement of the angled risers) and to at least partially lock or maintain at a certain height (i.e., by way of the engagement of the horizontal treads). The arrangement of the teeth **184**B as stairs also allows expandable intervertebral fusion implant **110** to collapse. In some embodiments, teeth **184**B are corrugations (i.e., ridges or grooves) arranged on angled surface **183**B. Wedge **180**B may further comprise hole **186**B for securing superior component **160** to an adjacent vertebra with, for example, a bone screw. Hole **186**B is arranged at an angle relative to plate **124**, for example, generally in direction D**5**.

Cross-members **166** and **168** connect component **164** to component **162**. In some embodiments, cross-members **166** and **168** are telescoping cross-members and allow for expandable intervertebral fusion implant **110** to be expanded and collapsed. For example, cross-members may comprise an inner rod displaceable (or slidable) within an outer rod. Component **164** may be displaced relative to component **162** in direction D**1** to expand expandable intervertebral fusion implant **110**, specifically superior component **160**, and direction D**2** to collapse expandable intervertebral fusion implant **110**, specifically superior component **160**. Cross-members **166** and **168** are fixed to respective ends, or proximate ends, of components **162** and **164**. It should be appreciated that cross-members **166** and **168** do not have to be fixed at the ends of components **162** and **164**, but rather can be fixed axially inward from the ends of components **162** and **164**. In some embodiments, superior component **160** comprises one cross-member that connects components **162** and **164**. In some embodiments, superior component **160** does not comprise any cross-members. In some embodiments, superior component **160** comprises one or more cross-members connecting components **162** and **164**, for example, three cross-members. In some embodiments, cross-members **166** and **168** are threadably engaged, as will be discussed in greater detail below with respect to FIG. **11**. It should be appreciated that although the drawings depict cross-members **166** and **168** having a circular cross-sectional geometry, any geometry suitable for expandably or displaceably connecting components **162** and **164** may be used, for example, square, rectangular, triangular, ellipsoidal, etc. Additionally, it should be appreciated that in some embodiments, cross-members **166** and **168** are not telescoping and connect component **164** to component **162** at a set distance.

FIG. **9**B is a side elevational view of expandable intervertebral fusion implant **110** in a fully collapsed state as shown in FIG. **7**. Cross-members **168** and **128**, along with cross-members **126** and **166** (not shown in FIG. **9**B) are telescoping such that expandable intervertebral fusion implant **110** is expandable in the anterior-posterior directions (i.e., directions D**1** and D**2**). Cross-member **168** comprises inner rod **168**A arranged to threadably engage outer rod **168**B. Cross-member **168** may comprise threading operatively arranged to expand and contract expandable intervertebral fusion implant **110**, and lock inner rod **168**A and outer rod **168**B at a set length. The threadable engagement of inner rod **168**A and outer rod **168**B will be discussed in greater detail below. Cross-member **128** comprises inner rod **128**A arranged to slidingly engage outer rod **128**B. Cross-member **128** may further comprise threading or a plurality of pins arranged to lock inner rod **128**A and outer rod **128**B at a set length. Cross-members **126** and **166** are arranged substantially similar to cross-members **128** and **168**. For example, cross-member **126** comprises inner rod **126**A arranged to slidingly engage outer rod **126**B, and may further comprise threading or a plurality of pins arranged to lock inner rod **126**A and outer rod **126**B at a set length. Cross-member **166** comprises inner rod **166**A arranged to slidingly engage outer rod **166**B, and may further comprise threading or a plurality of pins arranged to lock inner rod **166**A and outer rod **166**B at a set length (as is discussed in greater detail with respect to FIG. **11** below).

Also shown in FIG. **9**B are rails **130** and **132** arranged on plates **122** and **124**, respectively. Grooves **142**A and **152**B of wedges **140**A and **150**B engage rails **130** and **132**, respectively, and grooves **152**A and **142**B of wedges **150**A and **140**B engage rails **130** and **132**, respectively (not shown in FIG. **10**B). Furthermore, in the fully collapsed position, channels **172**A and **182**B of wedges **170**A and **180**B engage rails **130** and **132**, respectively, and channels **182**A and **172**B of wedges **180**A and **170**B engage rails **130** and **132**, respectively (not shown).

FIG. **10** is a cross-sectional view of a tongue and groove connection taken generally along line **10-10** in FIG. **7**. Groove **152**A of wedge **150**A generally comprises channel **90**, opening **92**, and sides **94** and **96**. Rail **130** of plate **122** comprises runner **80**. Groove **152**A is arranged to enclose runner **80**, such that wedge **150**A and plate **122** are slidably connected. It should be appreciated that wedge **140**A and wedges **140**B and **150**B are arranged substantially similar to wedge **150**A with respect to engagement with respective rails **130** and **132**. Specifically, groove **142**A of wedge **140**A slidably engages runner **80** of rail **130**. Similarly, grooves **142**B and **152**B of wedges **140**B and **150**B slidably engage the runner of rail **132**.

Also shown in FIG. **10** is locking member or screw **157**A arranged in hole **156**A and engaged with rail **130**. FIG. **10** shows wedge **150**A in a locked position relative to rail **130**. Specifically, screw **157**A has been tightened within hole **156**A (i.e., screw **157**A is displaced in direction D**1**) such that screw **157**A abuts against runner **80**. The frictional force between screw **157**A and runner **80** prevents displacement of wedge **150**A with respect to plate **122**. When screw **157**A is loosened within hole **156**A (i.e., screw **157**A is displaced in direction D**2**) such that screw **157**A no longer abuts against runner **80**, wedge **150**A is again displaceable relative to plate **122**. It should be appreciated that locking member or screw **147**A and locking members or screws **147**B and **157**B are arranged to engage rails **130** and **132**, respectively, in a substantially similar fashion to that of locking member or screw **157** as described above. In some embodiments, plate **122** is expandable and comprises an extension which engages hole **123**B, which will be discussed in greater detail with respect to FIG. **12**.

FIG. **11** is a cross-sectional view of cross-member **166** taken generally along line **11-11** in FIG. **8**. As previously discussed, cross-member **166** comprises inner rod **166**A arranged to displaceably (e.g., threadably) engage outer rod **166**B. In the embodiment shown, inner rod **166**A comprises outer threading **102** and outer rod **166**B comprises inner threading **104**. Outer threading **102** engages inner threading **104** to expand and contract expandable intervertebral fusion implant **110**. For example, as inner rod **166**A is rotated in a first circumferential direction, outer rod **166**B displaces relative to inner rod **166**A in direction D**1**, thereby expanding expandable intervertebral fusion implant **110**. As inner rod **166**A is rotated in a second circumferential direction, outer rod **166**B displaces relative to inner rod **166**A in direction D**2**, thereby contracting or collapsing expandable intervertebral fusion implant **110**. Similarly, as outer rod **166**B is rotated in a first circumferential direction, inner rod **166**A displaces relative to outer rod **166**B in direction D**2**, thereby expanding expandable intervertebral fusion implant **110**. As outer rod **166**B is rotated in a second circumferential direction, inner rod **166**A displaces relative to outer rod **166**B in direction D**1**, thereby contracting or collapsing expandable intervertebral fusion implant **110**. As such, in some embodiments, one of inner rod **166**A and outer rod **166**B is fixedly secured to superior component **160**, and the other is rotatably secured to superior component **160** (i.e., inner rod **166**A must be able to be rotated relative to the outer rod **166**B or vice versa). In some embodiments, at least one of inner rod **166**A and outer rod **166**B is rotatably secured to superior component **160** or inferior component **120**. This similar locking mechanism (i.e., threading) may be used on cross-members **126**, **128**, and **168**. It should be appreciated that telescoping members are known in the art and that any suitable telescoping design may be used. In an example embodiment, one or more cross-members have a locking mechanism. In an example embodiment, no cross-members have a locking mechanism.

FIG. **12** is a perspective view of plate **122**, in an expanded state. It should be appreciated that plate **124**, and plates **222** and **224** (discussed below), may comprise a substantially similar or the same design as plate **122** as described in FIG. **12**. In the embodiment shown, plate **122** comprises section **122**A, section **122**B, and rail **130**. Section **122**B is operatively arranged to displace relative to section **122**B in direction D**4** to expand plate **122**, and in direction D**3** to collapse plate **122**. In some embodiments, section **122**A comprises extension **123**A which slidably engages hole **123**B of section **122**B. One of sections **122**A and **122**B may further comprise a locking mechanism. In the embodiment shown, section **122**B comprises hole **106** and screw **108** (e.g., a set screw), which is operatively arranged to engage extension **123**A to lock section **122**B at a set distance from section **122**A. It should be appreciated that plate **122** may use any known expansion mechanism or means for expansion. It should further be appreciated that plate **122** may use any known locking mechanism to lock section **122**B at a set distance from section **122**A.

In some embodiments, components **162**, **164**, **262**, and **264** comprise a similar design to plate **122**, namely, that each of components **162**, **164**, **262**, and **264** are laterally expandable. For example, each of components **162**, **164**, **262**, and **264** may comprise a first section including an extension and a second section including a hole, the extension is operatively arranged to slidably engage the hole, and the two sections are locked via a set screw (see FIG. **12**).

FIG. **13** is a front perspective view of expandable intervertebral fusion implant **210**, in a fully collapsed state. FIG. **14** is a front perspective view of expandable intervertebral fusion implant **210**, in an expanded state. Expandable intervertebral fusion implant **210** generally comprises inferior component **220** and superior component **260**. The following description should be read in view of FIGS. **13-14**.

Inferior component **220** comprises plate **222**, plate **224**, cross-member **226**, cross-member **228**, wedges **240**A-B, and wedges **250**A-B. In some embodiments, inferior component **220** comprises only plate **222**, wedge **240**A, and wedge **250**A.

Wedges **240**A and **250**A are slidably engaged with plate **222**. In some embodiments, and as shown in the figures, plate **222** comprises rail **230**, and wedges **240**A and **250**A are slidably connected to rail **230**. In some embodiments, plate **222** is expandable, as was discussed above with respect to FIG. **12**.

Wedge **240**A comprises groove **242**A and teeth **244**A arranged on angled surface **243**A. In the embodiment shown in FIGS. **13-14**, wedge **240**A decreases in height in direction D**4** (i.e., surface **243**A slopes downward in direction D**4**). Groove **242**A is operatively arranged to engage rail **230**. Wedge **240**A is arranged to displace relative to plate **222** in direction D**3** and direction D**4**. Teeth **244**A are operatively arranged to engage teeth **274**A of wedge **270**A of superior component **260** to expand expandable intervertebral fusion implant **210** and lock it at a set height, as will be discussed in greater detail below. Wedge **240**A further comprises hole **246**A and locking member **247**A. As shown, locking member **247**A is a set screw which engages threaded hole **246**A in order to fixedly secure wedge **240**A to rail **230**. It should be appreciated that any means suitable for fixedly securing wedge **240**A to plate **222** may be used (e.g., a clamp, crimping the wedge about the rail to fixedly secure it thereto, adhesives, bolts, rivets, welding, soldering, etc.), and that the present disclosure should not be limited to just the use of a set screw.

Wedge **250**A comprises groove **252**A and teeth **254**A arranged on angled surface **253**A. In the embodiment shown in FIGS. **13-14**, wedge **250**A decreases in height in direction D**3** (i.e., surface **253**A slopes downward in direction D**3**). Groove **252**A is operatively arranged to engage rail **230**. Wedge **250**A is arranged to displace relative to plate **222** in direction D**3** and direction D**4**. Teeth **254**A are operatively arranged to engage teeth **284**A of wedge **280**A of superior component **260** to expand expandable intervertebral fusion implant **210** and lock it at a set height, as will be discussed in greater detail below. Wedge **245**A further comprises hole **256**A and locking member **257**A. As shown, locking member **257**A is a set screw which engages threaded hole **256**A in order to fixedly secure wedge **250**A to rail **230**. It should be appreciated that any means suitable for fixedly securing wedge **250**A to plate **222** may be used (e.g., a clamp, crimping the wedge about the rail to fixedly secure it thereto, adhesives, bolts, rivets, welding, soldering, etc.), and that the present disclosure should not be limited to just the use of a set screw. Plate **222** may further comprise hole **248**A for securing inferior component **220** to an adjacent vertebra with, for example, a bone screw. Hole **248**A is arranged at an angle relative to plate **222**, for example, generally in direction D**6**, and does not interfere with rail **230**.

Wedges **240**B and **250**B are slidably engaged with plate **224**. In some embodiments, and as shown in the figures, plate **224** comprises rail **232**, and wedges **240**B and **250**B are slidably connected to rail **232**. In some embodiments, plate **224** is expandable, as was discussed above with respect to FIG. **12**.

Wedge **240**B comprises groove **242**B and teeth **244**B arranged on angled surface **243**B. In the embodiment shown in FIGS. **13-14**, wedge **240**B decreases in height in direction D**3** (i.e., surface **243**B slopes downward in direction D**3**). Groove **242**B is operatively arranged to engage rail **232**. Wedge **240**B is arranged to displace relative to plate **224** in direction D**3** and direction D**4**. Teeth **244**B are operatively arranged to engage teeth **274**B of wedge **270**B of superior component **260** to expand expandable intervertebral fusion implant **210** and lock it at a set height, as will be discussed in greater detail below. Wedge **240**B further comprises hole **246**B and locking member **247**B (not shown). Locking member **247**B is a set screw which engages threaded hole **246**B in order to fixedly secure wedge **240**B to rail **230**. It should be appreciated that any means suitable for fixedly securing wedge **240**B to plate **222** may be used (e.g., a clamp, crimping the wedge about the rail to fixedly secure it thereto, adhesives, bolts, rivets, welding, soldering, etc.), and that the present disclosure should not be limited to just the use of a set screw.

Wedge **250**B comprises groove **252**B and teeth **254**B arranged on angled surface **253**B. In the embodiment shown in FIGS. **13-14**, wedge **250**B decreases in height in direction D**4** (i.e., surface **253**B slopes downward in direction D**4**). Groove **252**B is operatively arranged to engage rail **232**. Wedge **250**B is arranged to displace relative to plate **222** in direction D**3** and direction D**4**. Teeth **254**B are operatively arranged to engage teeth **284**B of wedge **280**B of superior component **260** to expand expandable intervertebral fusion implant **210** and lock it at a set height, as will be discussed in greater detail below. Wedge **245**B further comprises hole **256**B and locking member **257**B (not shown). Locking member **257**B is a set screw which engages threaded hole **256**B in order to fixedly secure wedge **250**B to rail **232**. It should be appreciated that any means suitable for fixedly securing wedge **250**B to plate **222** may be used (e.g., a clamp, crimping the wedge about the rail to fixedly secure it thereto, adhesives, bolts, rivets, welding, soldering, etc.), and that the present disclosure should not be limited to just the use of a set screw. Plate **222** may further comprise hole **248**B for securing inferior component **220** to an adjacent vertebra with, for example, a bone screw. Hole **248**B is arranged at an angle relative to plate **222**, for example, generally in direction D**6**, and does not interfere with rail **232**.

Cross-members **226** and **228** connect plate **224** to plate **222**. In some embodiments, cross-members **226** and **228** are telescoping cross-members and allow for expandable intervertebral fusion implant **210** to be expanded and collapsed. For example, cross-members may comprise an inner rod slidable within an outer rod. Plate **224** may be displaced relative to plate **222** in direction D**1** to expand expandable intervertebral fusion implant **210**, specifically inferior component **220**, and direction D**2** to collapse expandable intervertebral fusion implant **210**, specifically inferior component **220**. Cross-members **226** and **228** are fixed to respective ends, or proximate ends, of plates **222** and **224**. It should be appreciated that cross-members **226** and **228** do not have to be fixed at the ends of plates **222** and **224**, but rather can be fixed axially inward from the ends of plates **222** and **224**. In some embodiments, inferior component **220** comprises one cross-member that connects plates **222** and **224**. In some embodiments, inferior component **220** does not comprise any cross-members. In some embodiments, inferior component **220** comprises one or more cross-members connecting plates **222** and **224**, for example, three cross-members. It should be appreciated that although the drawings depict cross-members **226** and **228** having a circular cross-sectional geometry, any geometry suitable for expandably or displaceably connecting plates **222** and **224** may be used, for example, square, rectangular, triangular, ellipsoidal, etc. In some embodiments, cross-members **226** and **228** may be locking telescoping cross-members, similar or equivalent to cross-members **266** and **268** discussed in greater detail below. Additionally, it should be appreciated that in some embodiments, cross-members **226** and **228** are not telescoping and connect plate **224** to plate **222** at a set distance. Cross-members **226** and **228** may include an inner rod and an outer rod, and may also include threading (or locking pins) as discussed above with respect to FIG. **11**.

Superior component **260** comprises component **262**, component **264**, cross-member **266**, cross-member **268**, wedges **270**A-B, and wedges **280**A-B. In some embodiments, superior component **260** comprises only component **262**, wedge **270**A, and wedge **280**A.

Wedges **270**A and **280**A are connected to component **222**. Wedge **270**A comprises channel **272**A and teeth **274**A arranged on angled surface **273**A. In the embodiment shown in FIGS. **13-14**, wedge **270**A decreases in height in direction D**3** (i.e., surface **273**A slopes downward in direction D**3**). Channel **272**A is operatively arranged to engage rail **230** in a fully collapsed position, as is shown in FIG. **13**. Channel **272**A allows superior component **260** to fully collapse with respect to inferior component **220** (i.e., such that wedges **270**A and **280**A and wedges **270**B and **280**B rest on plates **222** and **224**, respectively). Angled surface **273**A is operatively arranged to engage angled surface **243**A to expand superior component **260** with respect to inferior component **220**. Specifically, as wedge **240**A is displaced in direction D**4** relative to plate **222**, angled surface **243**A engages angled surface **273**A to displace superior component **260** in direction D**5** relative to inferior component **220**. Teeth **274**A are operatively arranged to engage teeth **244**A to lock superior component **260** at a distance relative to inferior component **220**. Specifically, teeth **274**A engage teeth **244**A to allow wedge **240**A to displace in direction D**4** relative to plate **222**, and at the same time, if required, allow wedge **240**A to displace in direction D**3** relative to plate **222**. Such arrangement allows expandable intervertebral fusion implant **210** to expand and collapse in a controlled fashion.

Wedge **280**A comprises channel **282**A and teeth **284**A arranged on angled surface **283**A. In the embodiment shown in FIGS. **13-14**, wedge **280**A decreases in height in direction D**4** (i.e., surface **283**A slopes downward in direction D**4**). Channel **282**A is operatively arranged to engage rail **230** in a fully collapsed position, as is shown in FIG. **13**. Channel **282**A allows superior component **260** to fully collapse with respect to inferior component **220** (i.e., such that wedges **270**A and **280**A and wedges **270**B and **280**B rest on plates **222** and **224**, respectively). Angled surface **283**A is operatively arranged to engage angled surface **253**A to expand superior component **260** with respect to inferior component **220**. Specifically, as wedge **250**A is displaced in direction D**3** relative to plate **222**, angled surface **253**A engages angled surface **283**A to displace superior component **260** in direction D**5** relative to inferior component **220**. Teeth **284**A are operatively arranged to engage teeth **254**A to lock superior component **260** at a distance relative to inferior component **220**. Specifically, teeth **284**A engage teeth **254**A to allow wedge **250**A to displace in direction D**3** relative to plate **222**, and at the same time, if required, allow wedge **250**A to displace in direction D**4** relative to plate **222**. Such arrangement allows expandable intervertebral fusion implant **210** to expand and collapse in a controlled fashion. Component **262** may further comprise hole **276**A for securing superior component **260** to an adjacent vertebra with, for example, a bone screw. Hole **276**A is arranged at an angle relative to plate **222**, for example, generally in direction D**5**.

Wedges **270**B and **280**B are connected to component **224**. Wedge **270**B comprises channel **272**B and teeth **274**B arranged on angled surface **273**B. In the embodiment shown in FIGS. **13-14**, wedge **270**B decreases in height in direction D**4** (i.e., surface **273**B slopes downward in direction D**4**). Channel **272**B is operatively arranged to engage rail **232** in a fully collapsed position, as is shown in FIG. **13**. Channel **272**B allows superior component **260** to fully collapse with respect to inferior component **220** (i.e., such that wedges **270**A and **280**A and wedges **270**B and **280**B rest on plates **222** and **224**, respectively). Angled surface **273**B is operatively arranged to engage angled surface **243**B to expand superior component **260** with respect to inferior component **220**. Specifically, as wedge **240**B is displaced in direction D**3** relative to plate **222**, angled surface **243**B engages angled surface **273**B to displace superior component **260** in direction D**5** relative to inferior component **220**. Teeth **274**B are operatively arranged to engage teeth **244**B to lock superior component **260** at a distance relative to inferior component **220**. Specifically, teeth **274**B engage teeth **244**B to allow wedge **240**B to displace in direction D**3** relative to plate **222**, and at the same time, if required, allow wedge **240**B to displace in direction D**4** relative to plate **222**. Such arrangement allows expandable intervertebral fusion implant **210** to expand and collapse in a controlled fashion.

Wedge **280**B comprises channel **282**B and teeth **284**B arranged on angled surface **283**B. In the embodiment shown in FIGS. **13**-**14**, wedge **280**B decreases in height in direction D**3** (i.e., surface **283**B slopes downward in direction D**3**). Channel **282**B is operatively arranged to engage rail **232** in a fully collapsed position, as is shown in FIG. **13**. Channel **282**B allows superior component **260** to fully collapse with respect to inferior component **220** (i.e., such that wedges **270**A and **280**A and wedges **270**B and **280**B rest on plates **222** and **224**, respectively). Angled surface **283**B is operatively arranged to engage angled surface **253**B to expand superior component **260** with respect to inferior component **220**. Specifically, as wedge **250**B is displaced in direction D**4** relative to plate **224**, angled surface **253**B engages angled surface **283**B to displace superior component **260** in direction D**5** relative to inferior component **220**. Teeth **284**B are operatively arranged to engage teeth **254**B to lock superior component **260** at a distance relative to inferior component **220**. Specifically, teeth **284**B engage teeth **254**B to allow wedge **250**B to displace in direction D**4** relative to plate **222**, and at the same time, if required, allow wedge **250**B to displace in direction D**3** relative to plate **222**. Such arrangement allows expandable intervertebral fusion implant **210** to expand and collapse in a controlled fashion. Component **262** may further comprise hole **276**A for securing superior component **260** to an adjacent vertebra with, for example, a bone screw. Hole **276**A is arranged at an angle relative to plate **222**, for example, generally in direction D**5**.

Cross-members **266** and **268** connect component **264** to component **262**. In some embodiments, cross-members **266** and **268** are telescoping cross-members and allow for expandable intervertebral fusion implant **210** to be expanded and collapsed. For example, cross-members may comprise an inner rod displaceable (or slidable) within an outer rod. Component **264** may be displaced relative to component **262** in direction D**1** to expand expandable intervertebral fusion implant **210**, specifically superior component **260**, and direction D**2** to collapse expandable intervertebral fusion implant **210**, specifically superior component **260**. Cross-members **266** and **268** are fixed to respective ends, or proximate ends, of components **262** and **264**. It should be appreciated that cross-members **266** and **268** do not have to be fixed at the ends of components **262** and **264**, but rather can be fixed axially inward from the ends of components **262** and **264**. In some embodiments, superior component **260** comprises one cross-member that connects components **262** and **264**. In some embodiments, superior component **260** does not comprise any cross-members. In some embodiments, superior component **260** comprises one or more cross-members connecting components **262** and **264**, for example, three cross-members. It should be appreciated that although the drawings depict cross-members **266** and **268** having a circular cross-sectional geometry, any geometry suitable for expandably or displaceably connecting components **262** and **264** may be used, for example, square, rectangular, triangular, ellipsoidal, etc. Additionally, it should be appreciated that in some embodiments, cross-members **266** and **268** are not telescoping and connect component **264** to component **262** at a set distance. In some embodiments, cross-members **266** and **268** may include an inner rod and an outer rod, and may also include locking pins. In some embodiments, cross-members **266** and **268** comprise an inner rod threadably engaged with an outer rod, as discussed above with respect to FIG. **11**.

FIG. **15** is an anterior perspective view of a spinal column including expandable intervertebral fusion implant **110**. Expandable intervertebral implant **110** is inserted into the spinal column between, for example, the L**3** and L**4** vertebrae, or where disc D_{L3-L4} should be. Expandable intervertebral implant **110** is then vertically expanded until the desired height is reached. Expandable intervertebral implant **110** may be expanded in the anterior-posterior directions (i.e., directions D**1** and D**2**) prior to insertion, or after insertion, as previously discussed (i.e., along telescoping cross-members). Expandable intervertebral implant **110** is then filled with fusion material and left in situ.

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
12 Ligament
C**1**-C**7** Cervical vertebrae
T**1**-T**12** Thoracic vertebrae
L**1**-L**5** Lumbar vertebrae
S Sacrum
C Coccyx
D_{L1-L2} Disc
D_{L2-L3} Disc
D_{L3-L4} Disc
D_{L4-L5} Disc
F Facet
FJ Facet joint
SP Spinous process
TP Transverse process
IF Intervertebral foramen
NC Neural canal
A Annulus
N Nucleus
DH Disc space height
80 Runner
90 Channel
92 Opening
94 Side
96 Side
102 Threading
104 Threading
106 Hole
108 Screw
110 Expandable intervertebral fusion implant
120 Inferior component
122 Plate
122A Section

122B Section
123A Extension
123B Hole
124 Plate
126 Cross-member
126A Inner rod
126B Outer rod
128 Cross-member
128A Inner rod
128B Outer rod
130 Rail
132 Rail
140A Wedge
140B Wedge
142A Groove
142B Groove
143A Surface
143B Surface
144A Teeth
144B Teeth
146A Hole
146B Hole
147A Locking member (screw)
147B Locking member (screw)
148A Hole
148B Hole
150A Wedge
150B Wedge
152A Groove
152B Groove
153A Surface
153B Surface
154A Teeth
154B Teeth
156A Hole
156B Hole
157A Locking member (screw)
157B Locking member (screw)
158A Hole
158B Hole
160 Superior component
162 Component
164 Component
166 Cross-member
166A Inner rod
166B Outer rod
168 Cross-member
168A Inner rod
168B Outer rod
170A Wedge
170B Wedge
172A Channel
172B Channel
173A Surface
173B Surface
174A Teeth
174B Teeth
176A Hole
176B Hole
180A Wedge
180B Wedge
182A Channel
182B Channel
183A Surface
183B Surface
184A Teeth
184B Teeth
186A Hole
186B Hole
210 Expandable intervertebral fusion implant
220 Inferior component
222 Plate
224 Plate
226 Cross-member
226A Inner rod (not shown)
226B Outer rod (not shown)
228 Cross-member
228A Inner rod (not shown)
228B Outer rod (not shown)
230 Rail
232 Rail
240A Wedge
240B Wedge
242A Groove
242B Groove
243A Surface
243B Surface
244A Teeth
244B Teeth
246A Hole
246B Hole
247A Screw
247B Screw
248A Hole
248B Hole
250A Wedge
250B Wedge
252A Groove
252B Groove
253A Surface
253B Surface
254A Teeth
254B Teeth
256A Hole
256B Hole
257A Screw
257B Screw
260 Superior component
262 Component
264 Component
266 Cross-member
266A Inner rod (not shown)
266B Outer rod (not shown)
268 Cross-member
268A Inner rod (not shown)
268B Outer rod (not shown)
270A Wedge
270B Wedge
272A Channel
272B Channel
273A Surface
273B Surface
274A Teeth
274B Teeth
276A Hole
276B Hole
280A Wedge
280B Wedge
282A Channel
282B Channel
283A Surface
283B Surface
284A Teeth
284B Teeth

D1 Direction
D2 Direction
D3 Direction
D4 Direction
D5 Direction
D6 Direction

What is claimed is:

1. An expandable intervertebral fusion implant, comprising:
- an inferior component, including:
  - a plate; and,
  - a first wedge slidably connected to the plate, the first wedge including a first surface comprising a first plurality of teeth; and,
- a superior component including a second wedge, the second wedge including a second surface comprising a second plurality of teeth;
- wherein:
  - the first surface is operatively arranged to engage the second surface to displace the superior component relative to the inferior component;
  - the second plurality of teeth are operatively arranged to engage the first plurality of teeth to maintain the expandable intervertebral fusion implant at a height and in a fully expanded position; and,
  - in a fully collapsed position of the expandable intervertebral fusion implant, the first wedge and the second wedge are arranged entirely between the plate and the superior component.

2. The expandable intervertebral fusion implant as recited in claim **1**, wherein the first plurality of teeth include a first plurality of stairs and the second plurality of teeth include a second plurality of stairs.

3. The expandable intervertebral fusion implant as recited in claim **2**, wherein:
- each step in the first plurality of stairs includes a first tread arranged parallel to the plate and a first riser arranged at a first angle relative to the plate; and,
- each step in the second plurality of stairs includes a second tread arranged parallel to the first tread and a second riser arranged at a second angle relative to the plate.

4. The expandable intervertebral fusion implant as recited in claim **3**, wherein the second riser is arranged parallel to the first riser.

5. The expandable intervertebral fusion implant as recited in claim **1**, wherein the first wedge is operatively arranged to be locked to the plate.

6. The expandable intervertebral fusion implant as recited in claim **5**, wherein the first wedge further comprises a screw operatively arranged to lock the first wedge with respect to the plate.

7. The expandable intervertebral fusion implant as recited in claim **1**, wherein the plate comprises a rail, the first wedge being slidably engaged with the rail.

8. The expandable intervertebral fusion implant as recited in claim **1**, wherein:
- the inferior component further comprises a third wedge having a third surface; and,
- the superior component further comprises a fourth wedge having a fourth surface;
- wherein the third surface is operatively arranged to engage the fourth surface to displace the superior component relative to the inferior component.

9. The expandable intervertebral fusion implant as recited in claim **8**, wherein the third wedge is displaceable relative to the first wedge.

10. The expandable intervertebral fusion implant as recited in claim **8**, wherein the fourth wedge is fixedly securable to the second wedge.

11. The expandable intervertebral fusion implant as recited in claim **8**, wherein as the first wedge is displaced in a first direction relative to the plate, the superior component is displaced in a second direction relative to the inferior component.

12. The expandable intervertebral fusion implant as recited in claim **11**, wherein as the third wedge is displaced in a third direction relative to the plate, the third direction being opposite the first direction, the superior component is displaced in the second direction relative to the inferior component.

13. The expandable intervertebral fusion implant as recited in claim **11**, wherein the second direction is perpendicular to the first direction.

14. The expandable intervertebral fusion implant as recited in claim **1**, wherein the plate is expandable.

15. The expandable intervertebral fusion implant as recited in claim **1**, wherein the superior component is expandable.

16. An expandable intervertebral fusion implant, comprising:
- an inferior component, including:
  - a first plate;
  - a first wedge slidably connected to the first plate, the first wedge having a first surface;
  - a second plate;
  - a second wedge slidably connected to the second plate, the second wedge having a second surface; and,
  - at least one first cross-member connecting the first and second plates; and,
- a superior component, including:
  - a first component including a third wedge, the third wedge having a third surface;
  - a second component including a fourth wedge, the fourth wedge having a fourth surface; and,
  - at least one second cross-member connecting the first and second components;
- wherein:
  - the first and second surfaces are operatively arranged to engage the third and fourth surfaces, respectively, to displace the superior component relative to the inferior component; and,
  - in a fully collapsed position of the expandable intervertebral fusion implant, the first wedge and the third wedge are arranged entirely between the first plate and the first component.

17. The expandable intervertebral fusion implant as recited in claim **16**, wherein at least one of the first surface and the second surface comprises a first plurality of teeth and at least one of the third surface and the fourth surface comprises a second plurality of teeth, the second plurality of teeth operatively arranged to engage the first plurality of teeth to maintain the expandable intervertebral fusion implant at a height.

18. The expandable intervertebral fusion implant as recited in claim **16**, wherein at least one of the first wedge and the second wedge is operatively arranged to be locked to the first and/or second plates, respectively.

19. The expandable intervertebral fusion implant as recited in claim **16**, wherein the first plate comprises a first rail, the first wedge being slidably engaged with the first rail.

20. The expandable intervertebral fusion implant as recited in claim **16**, wherein:
- the inferior component further comprises:

a fifth wedge including a fifth surface, the fifth wedge slidably engaged with the first plate; and,

a sixth wedge including a sixth surface, the sixth wedge slidably engaged with the second plate; and,

the superior component further comprises:

a seventh wedge including a seventh surface, the seventh wedge connected to the first component; and,

an eighth wedge including an eighth surface, the eighth wedge connected to the second component;

wherein the fifth and sixth surfaces are operatively arranged to engage the seventh and eighth surfaces, respectively, to displace the superior component relative to the inferior component.

21. The expandable intervertebral fusion implant as recited in claim **20**, wherein the first, second, fifth, and sixth wedges are displaceable relative to each other.

22. The expandable intervertebral fusion implant as recited in claim **20**, wherein the third wedge is fixedly secured to the seventh wedge, and the fourth wedge is fixedly secured to the eighth wedge.

23. The expandable intervertebral fusion implant as recited in claim **20**, wherein as the first wedge is displaced in a first direction relative to the first plate or the fifth wedge is displaced in a second direction, opposite the first direction, relative to the first plate, the superior component is displaced in a third direction relative to the inferior component.

24. The expandable intervertebral fusion implant as recited in claim **23**, wherein as the second wedge is displaced in the first direction relative to the second plate or the sixth wedge is displaced in the second direction relative to the second plate, the superior component is displaced in the third direction.

25. The expandable intervertebral fusion implant as recited in claim **23**, wherein the third direction is perpendicular to the first and second directions.

26. The expandable intervertebral fusion implant as recited in claim **16**, wherein at least one of the first plate and the second plate is expandable.

27. The expandable intervertebral fusion implant as recited in claim **16**, wherein at least one of the first and second cross-members are telescoping.

28. An expandable intervertebral fusion implant, comprising:

an inferior component, including:

a plate; and,

a first wedge slidably connected to the plate, the first wedge having a first surface; and,

a superior component including a second wedge, the second wedge having a second surface;

wherein:

the first wedge is operatively arranged to displace in a first direction from a middle of the plate to an end of the plate and the first surface is operatively arranged to engage the second surface to displace the superior component in a second direction away from the inferior component, the second direction being perpendicular to the first direction; and,

in a fully collapsed position of the expandable intervertebral fusion implant, the first wedge and the second wedge are arranged between the plate and the superior component.

* * * * *