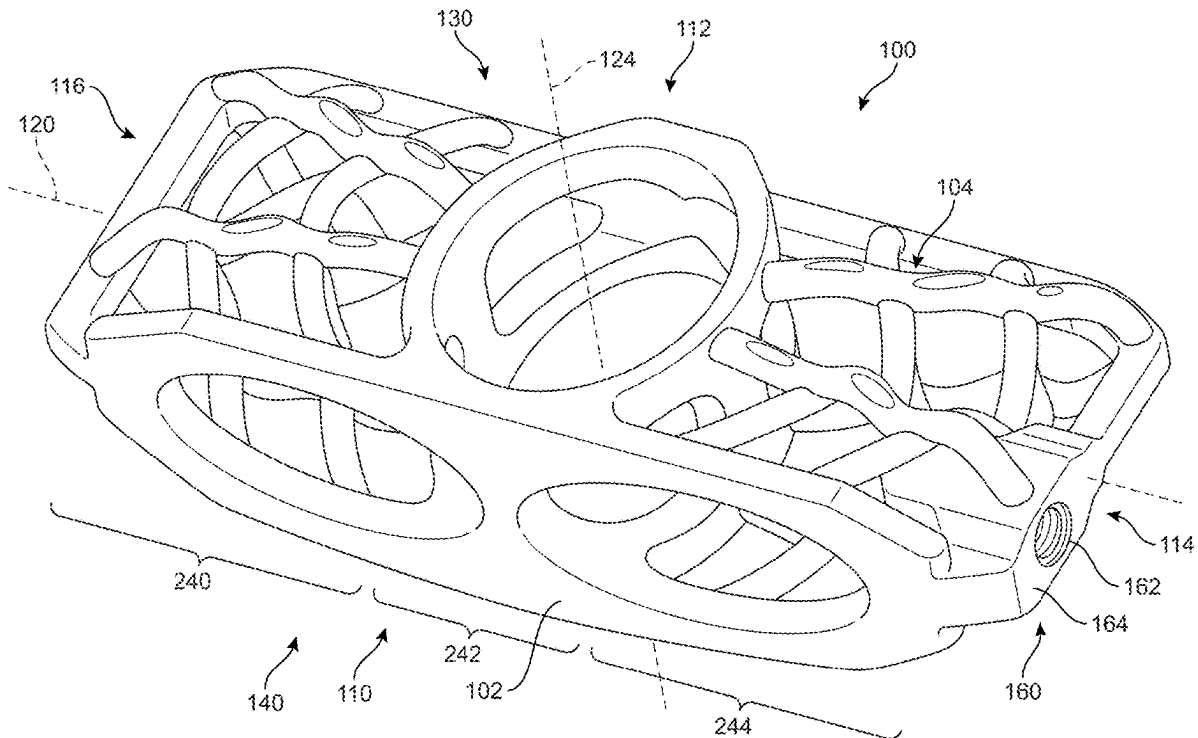


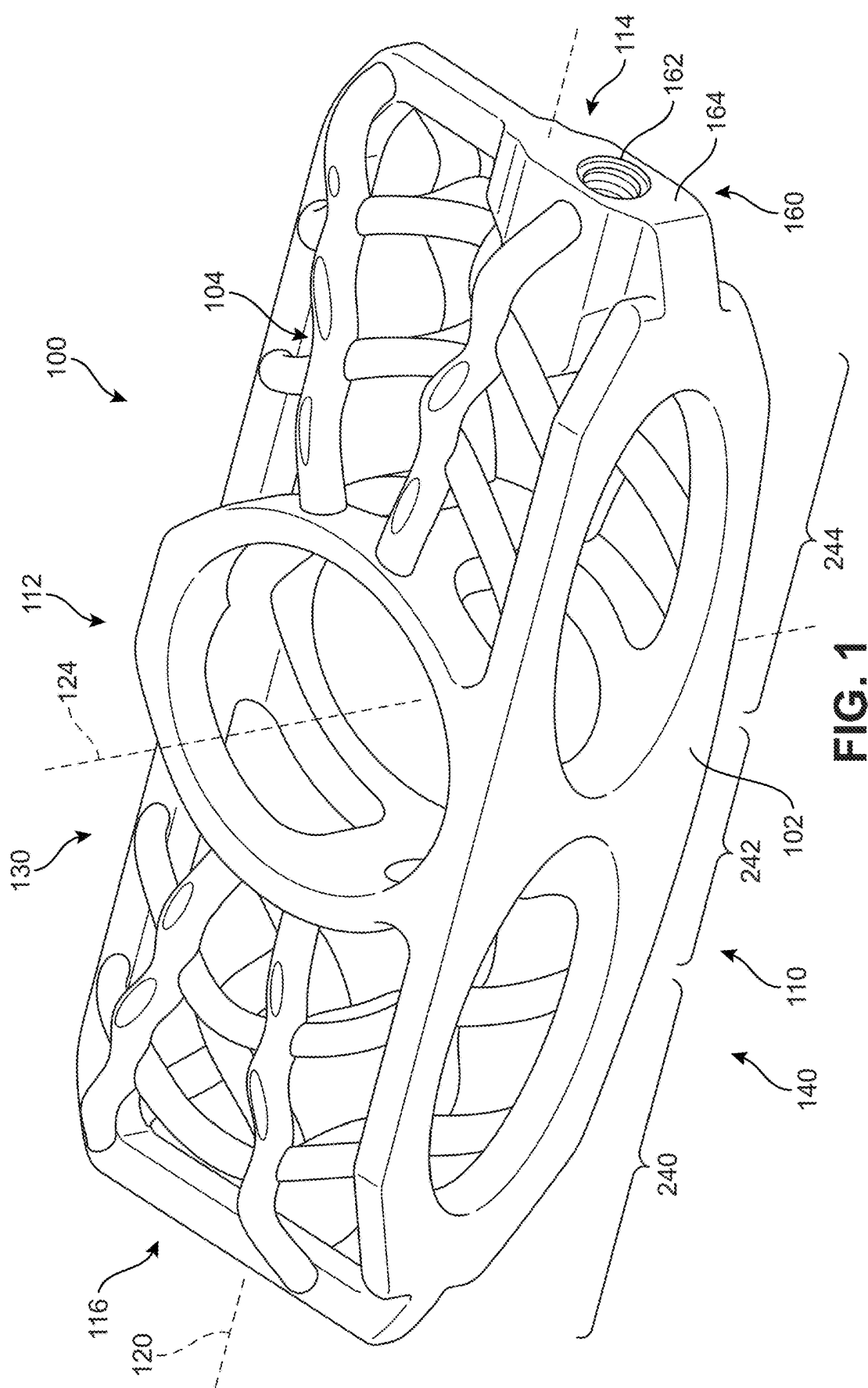


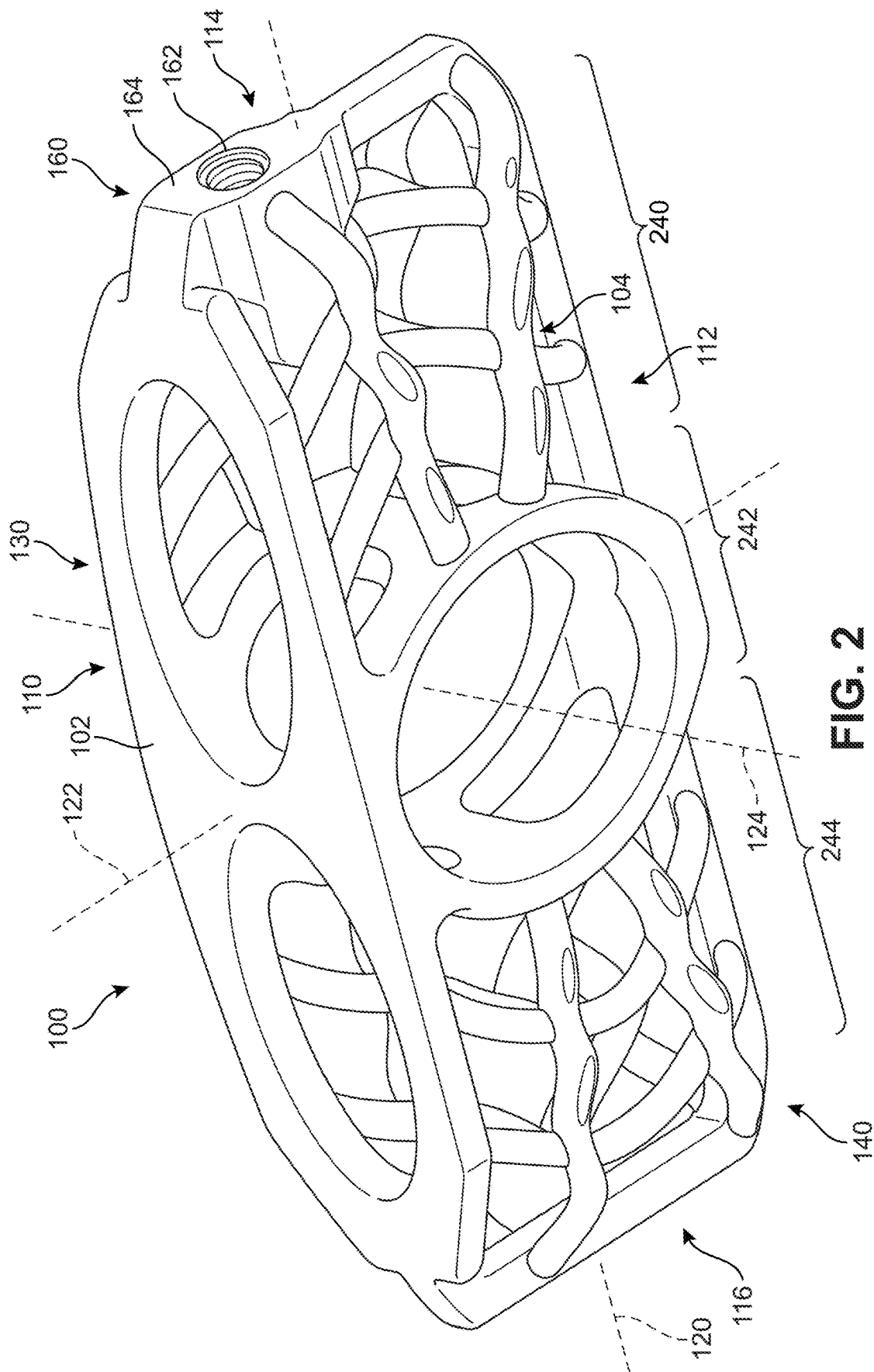
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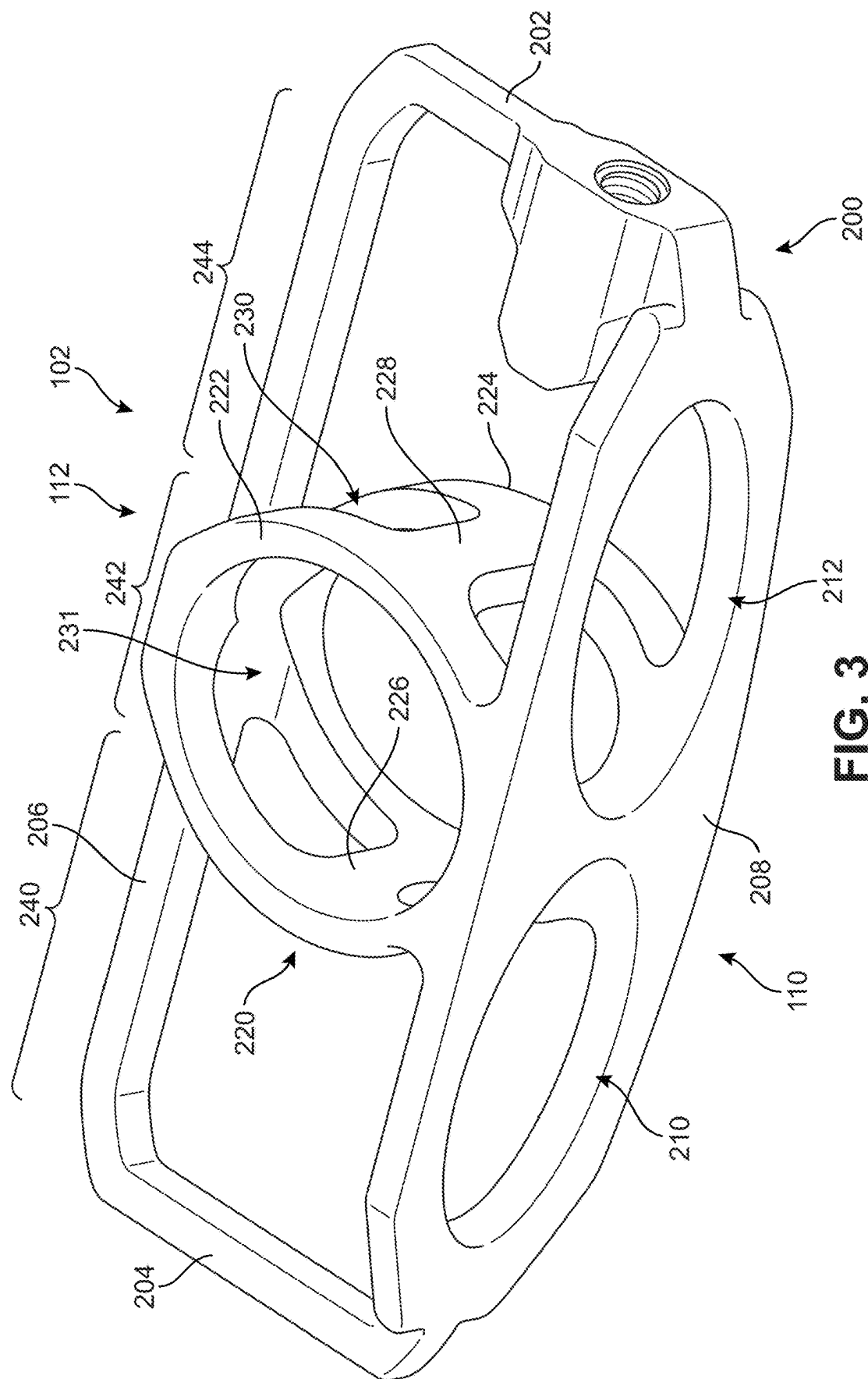
(19) **United States**(12) **Patent Application Publication**  
**Bishop et al.**(10) **Pub. No.: US 2025/0248825 A1**(43) **Pub. Date: Aug. 7, 2025**(54) **IMPLANT WITH STRUCTURAL MEMBERS  
ARRANGED AROUND A RING****Publication Classification**(71) Applicant: **Institute for Musculoskeletal Science  
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**Joseph M. Nyahay**, Eagleville, PA  
(US)(51) **Int. Cl.**  
*A61F 2/44* (2006.01)  
*A61F 2/30* (2006.01)  
*A61F 2/46* (2006.01)  
(52) **U.S. Cl.**  
CPC ..... *A61F 2/447* (2013.01); *A61F 2/4455*  
(2013.01); *A61F 2002/302* (2013.01); *A61F*  
*2002/30235* (2013.01); *A61F 2002/30289*  
(2013.01); *A61F 2002/30593* (2013.01); *A61F*  
*2002/30784* (2013.01); *A61F 2002/3093*  
(2013.01); *A61F 2002/4495* (2013.01); *A61F*  
*2002/4629* (2013.01)(21) Appl. No.: **19/190,918**(22) Filed: **Apr. 28, 2025****Related U.S. Application Data**(63) Continuation of application No. 18/429,100, filed on  
Jan. 31, 2024, now Pat. No. 12,303,400, which is a  
continuation of application No. 17/566,146, filed on  
Dec. 30, 2021, now Pat. No. 11,938,039, which is a  
continuation of application No. 16/725,790, filed on  
Dec. 23, 2019, now Pat. No. 11,213,405.(57) **ABSTRACT**

An implant may include a body including a ring, the ring further defining an opening, and the body defining a transverse plane dividing the implant into a superior half and an inferior half. The ring may also define a circumferential direction. The implant may further include a first outer member extending outward in a direction away from the ring, wherein the first outer member defines one or more arches, and wherein the ring further defines a central channel extending through the implant.









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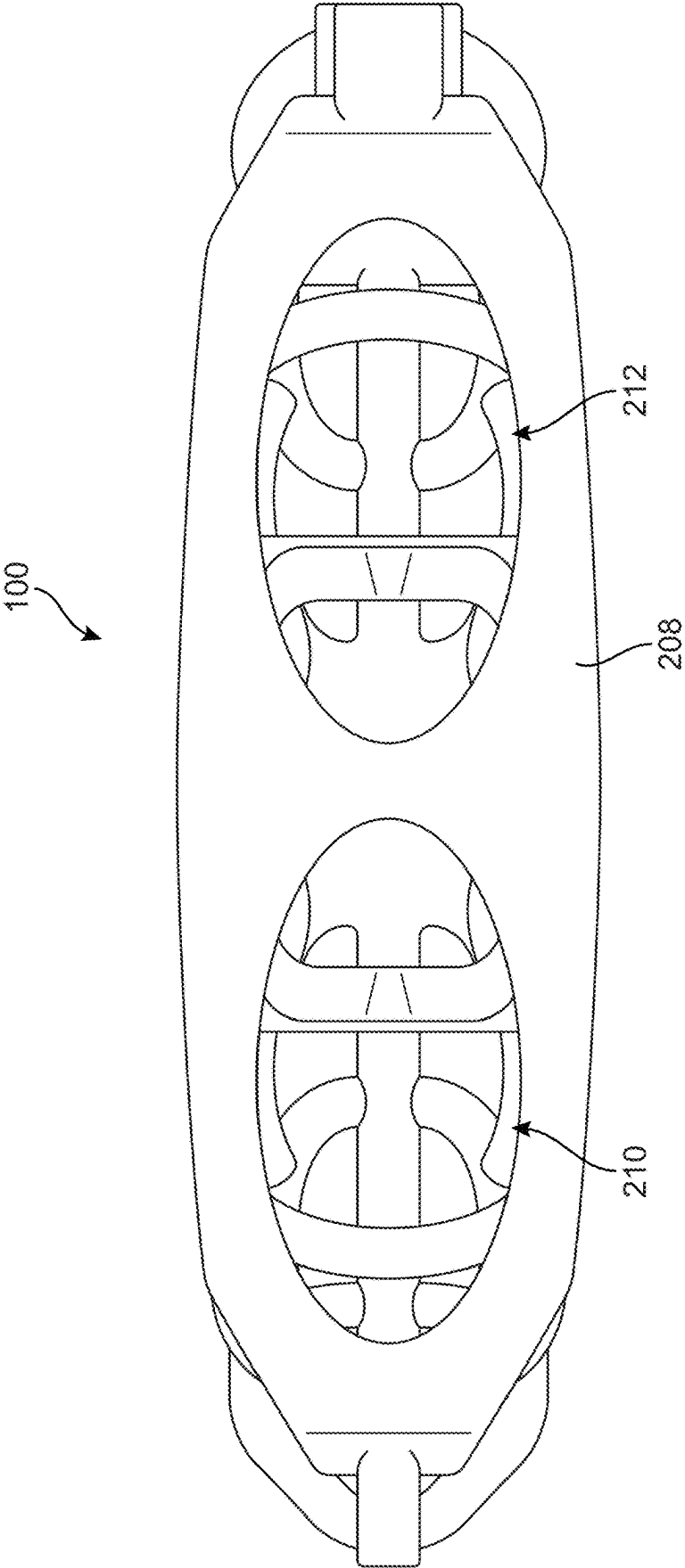
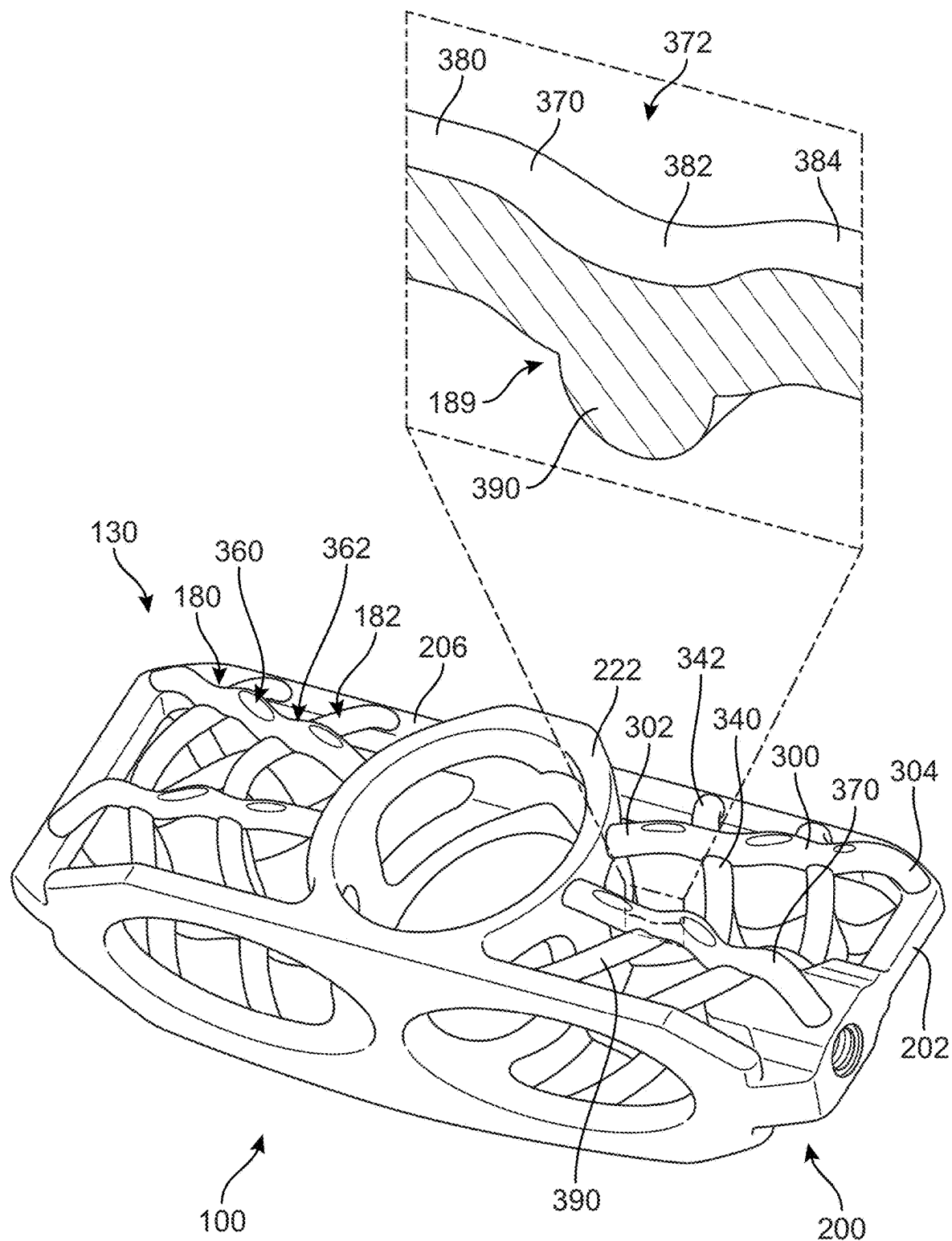
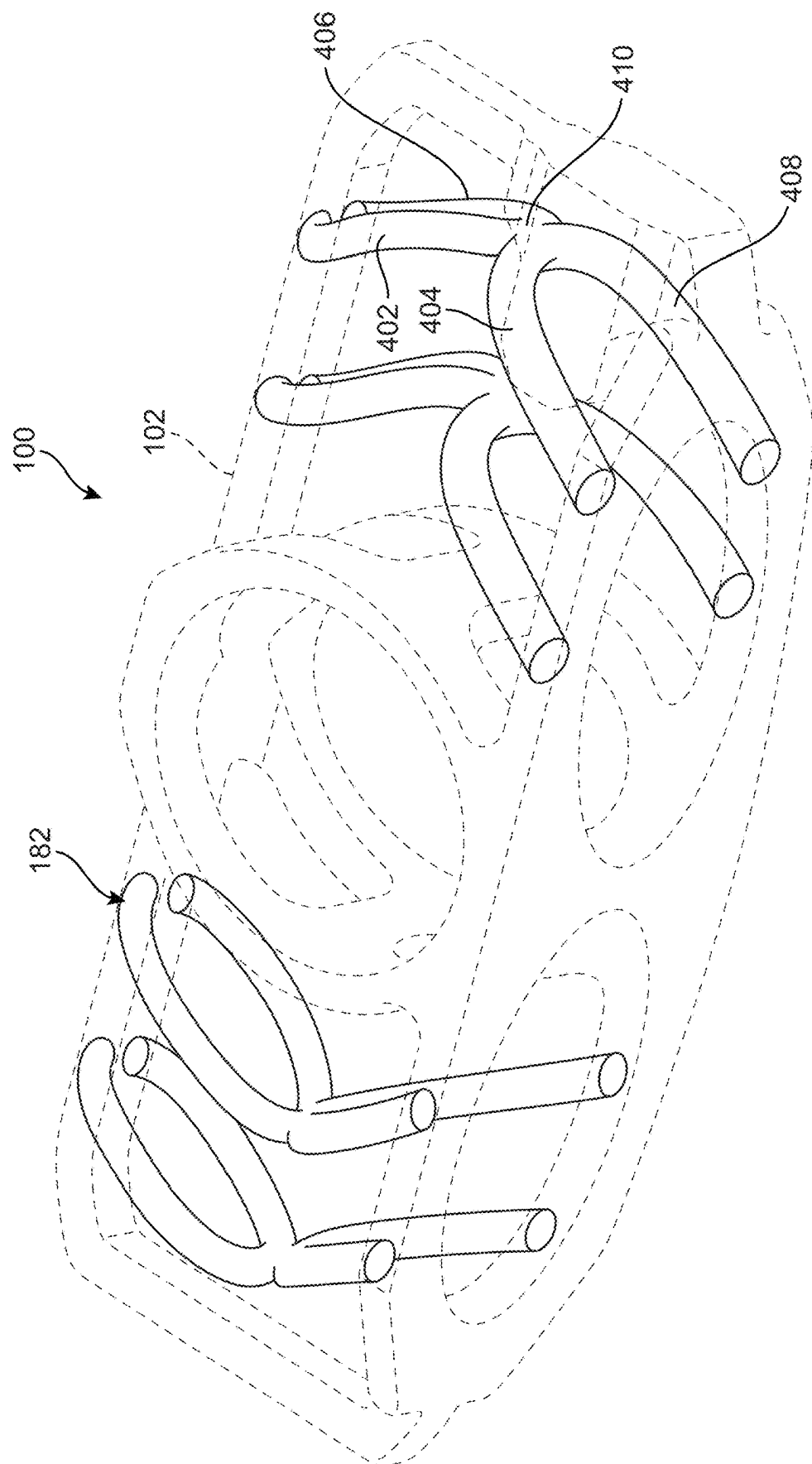


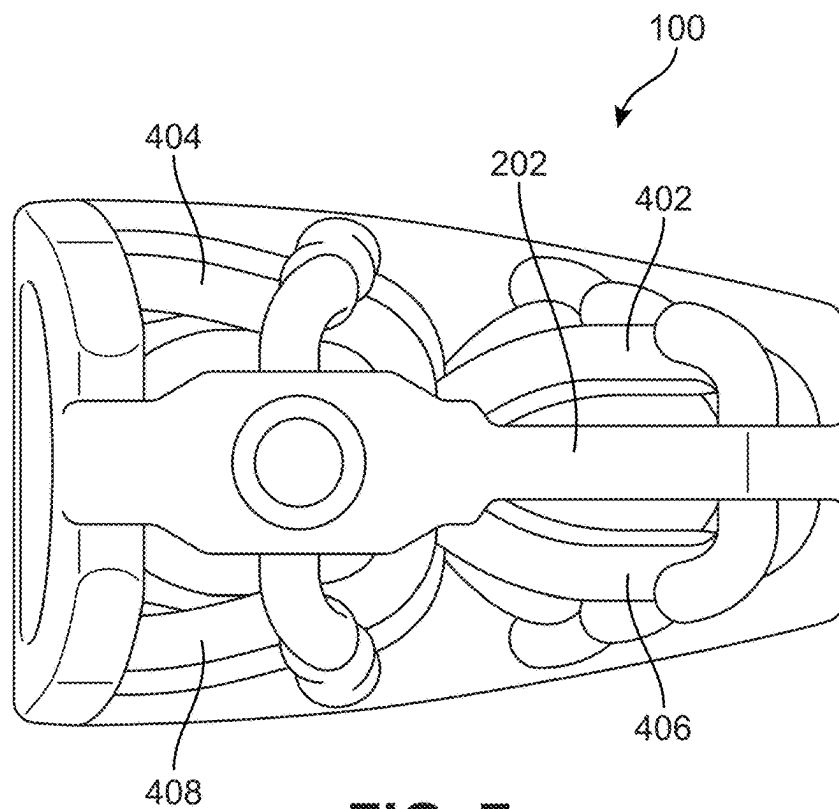
FIG. 4



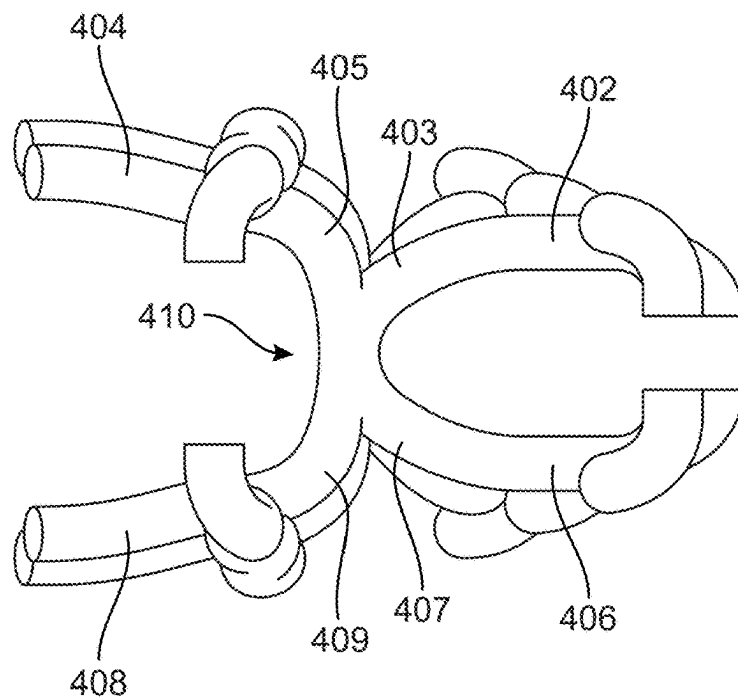
**FIG. 5**



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**FIG. 7**



**FIG. 8**



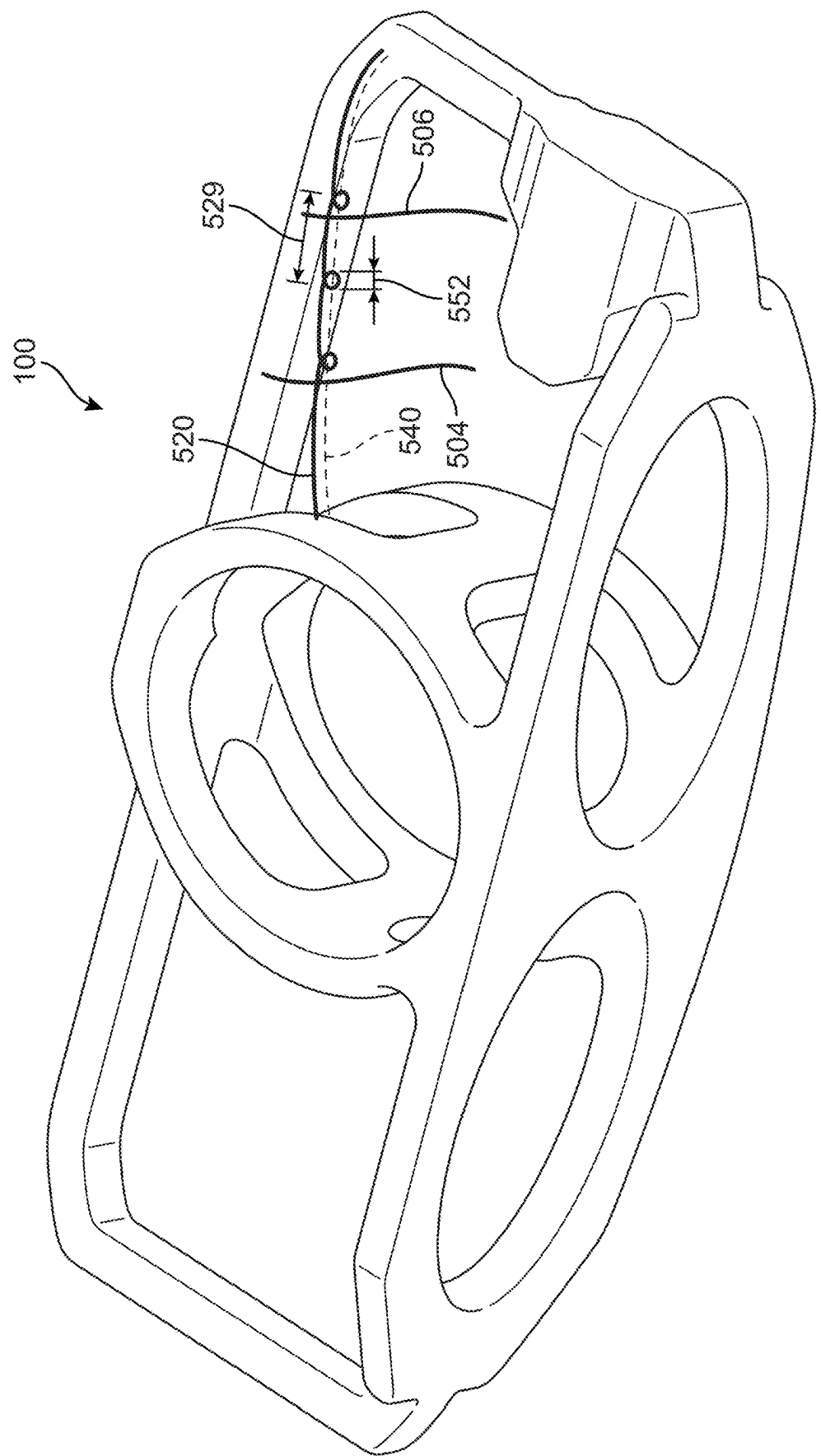


FIG. 9

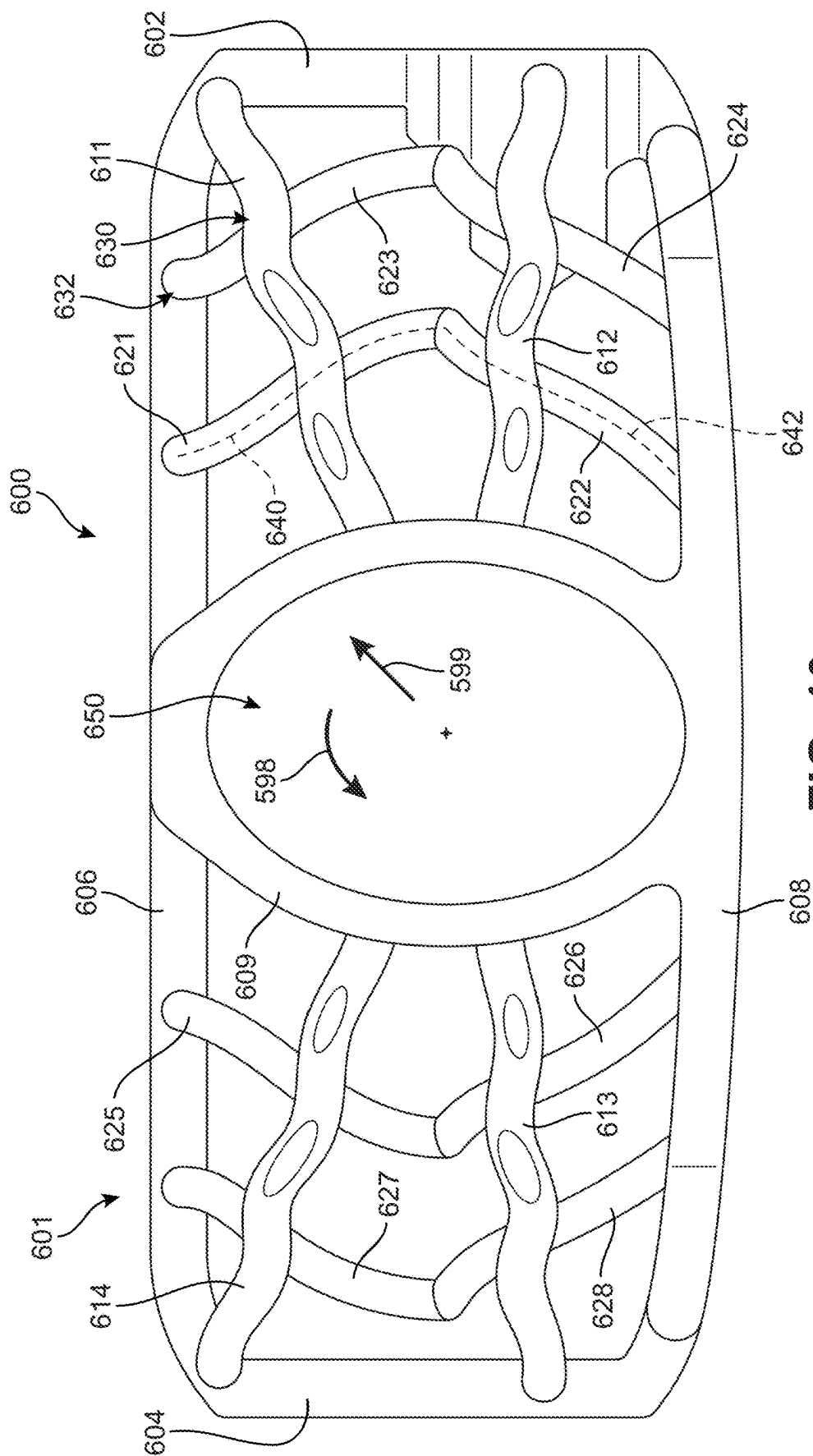


FIG. 10

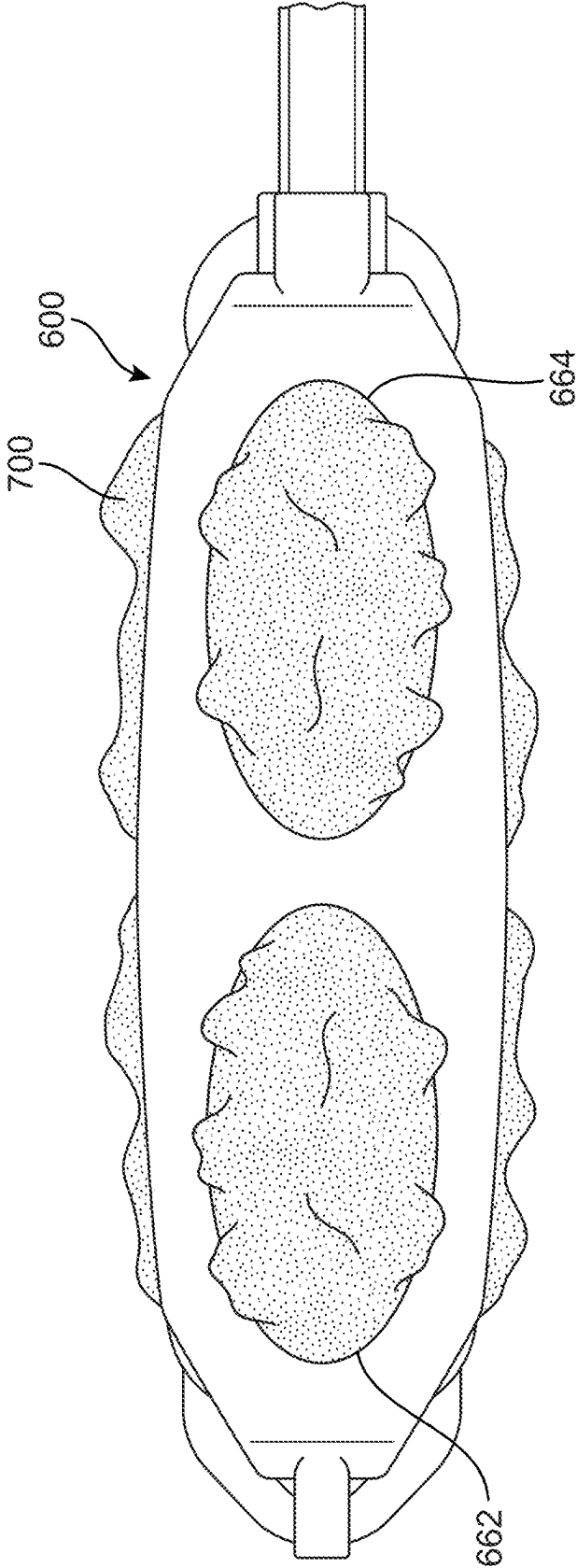
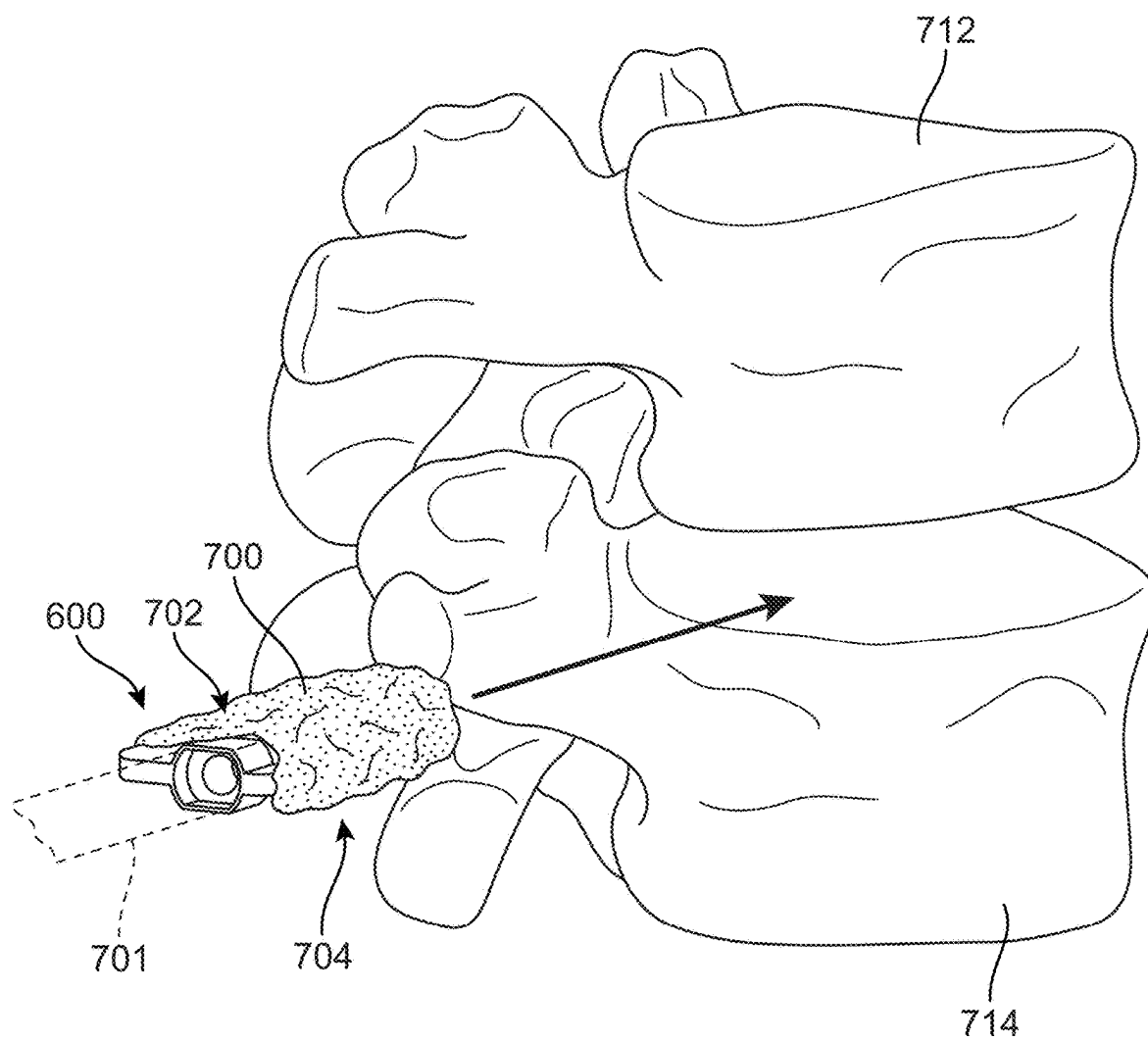
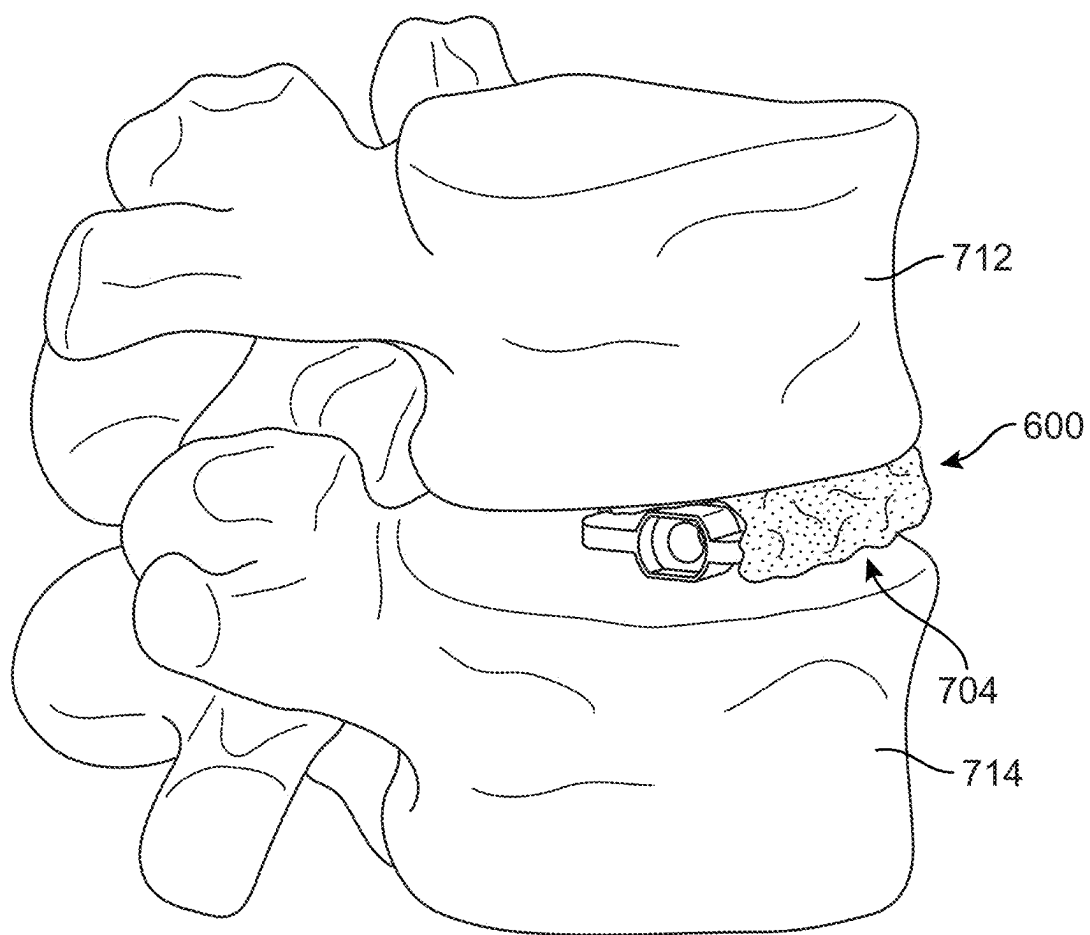


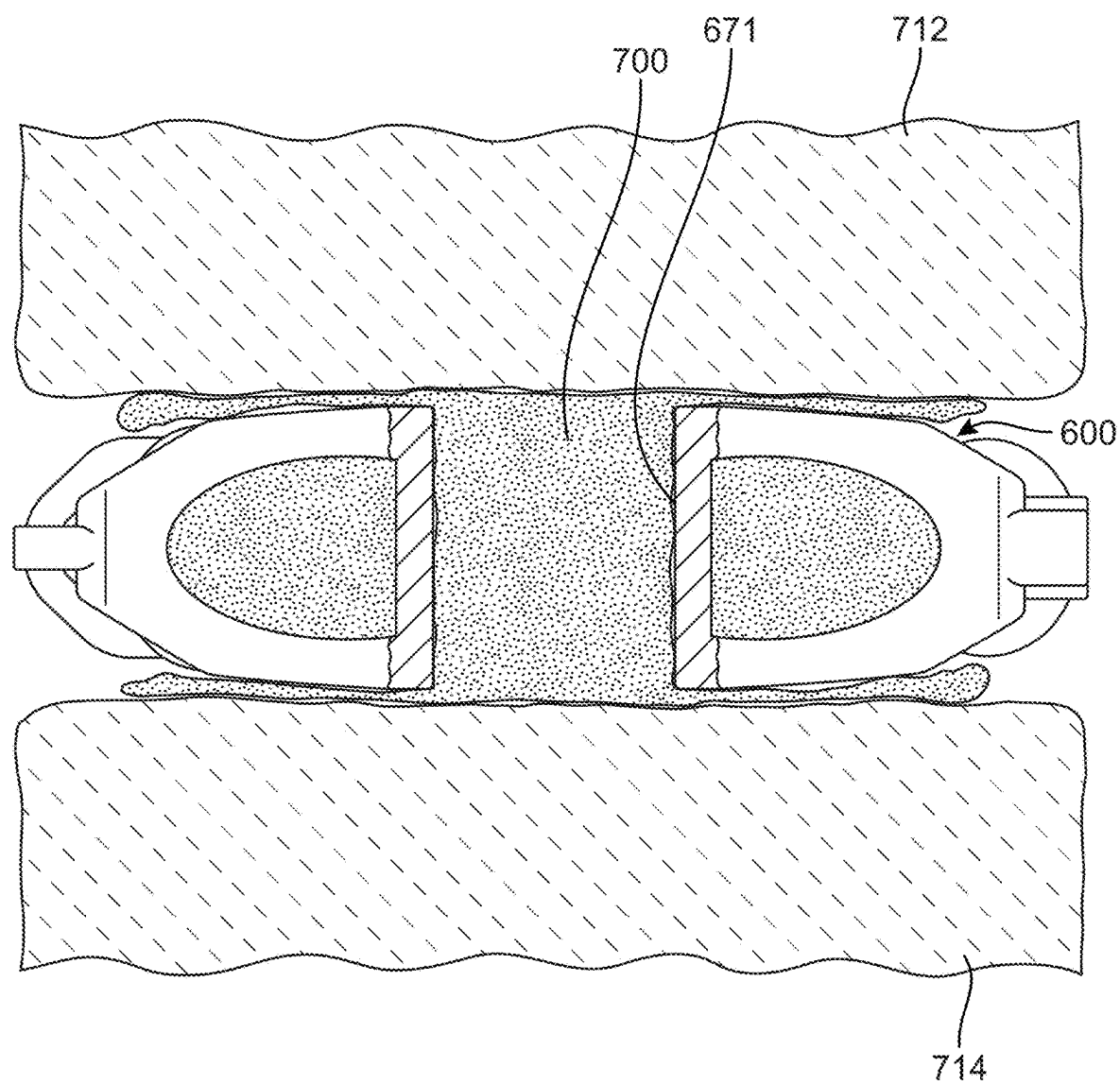
FIG. 11



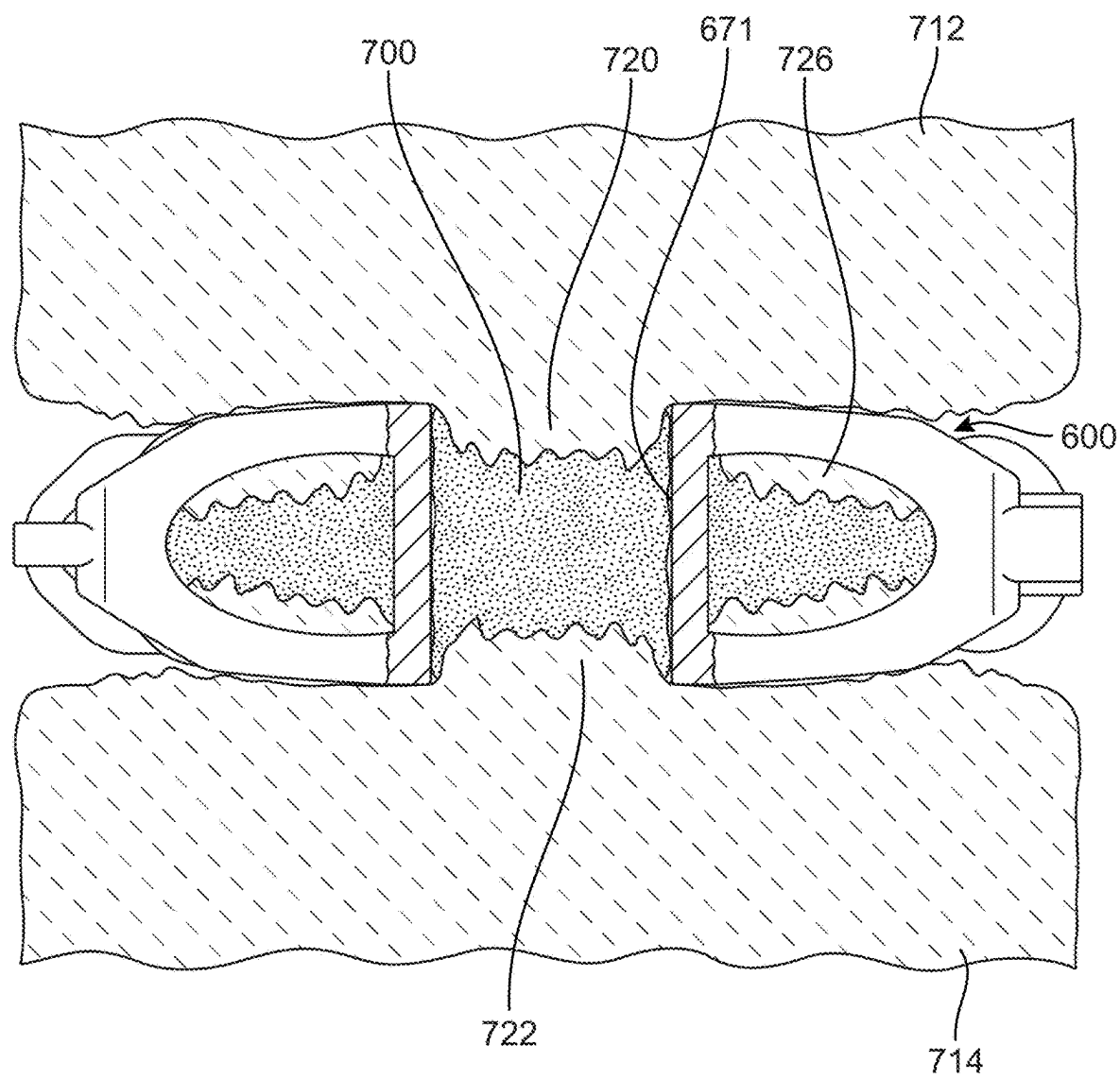
**FIG. 12**



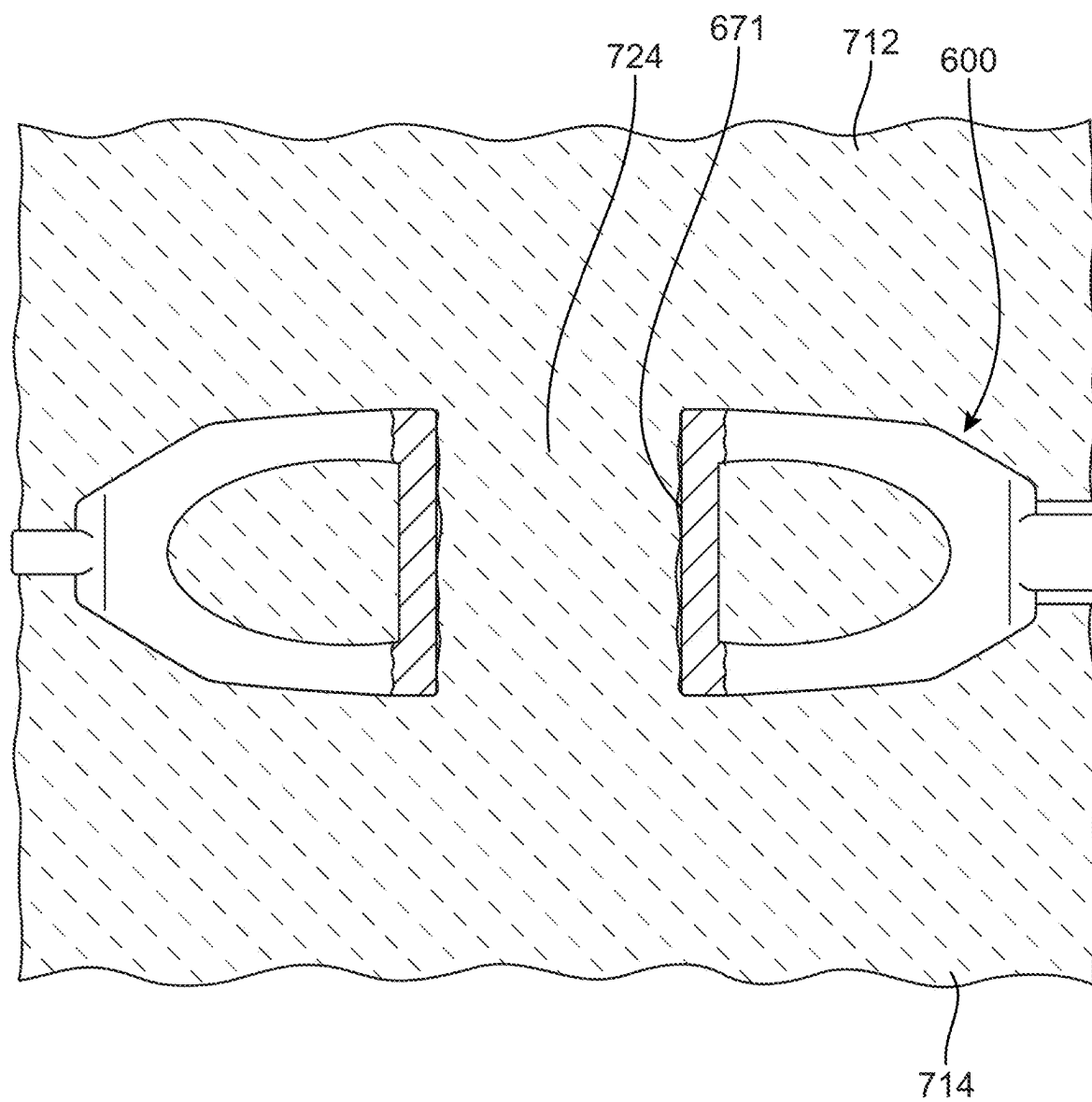
**FIG. 13**



**FIG. 14**



**FIG. 15**



**FIG. 16**



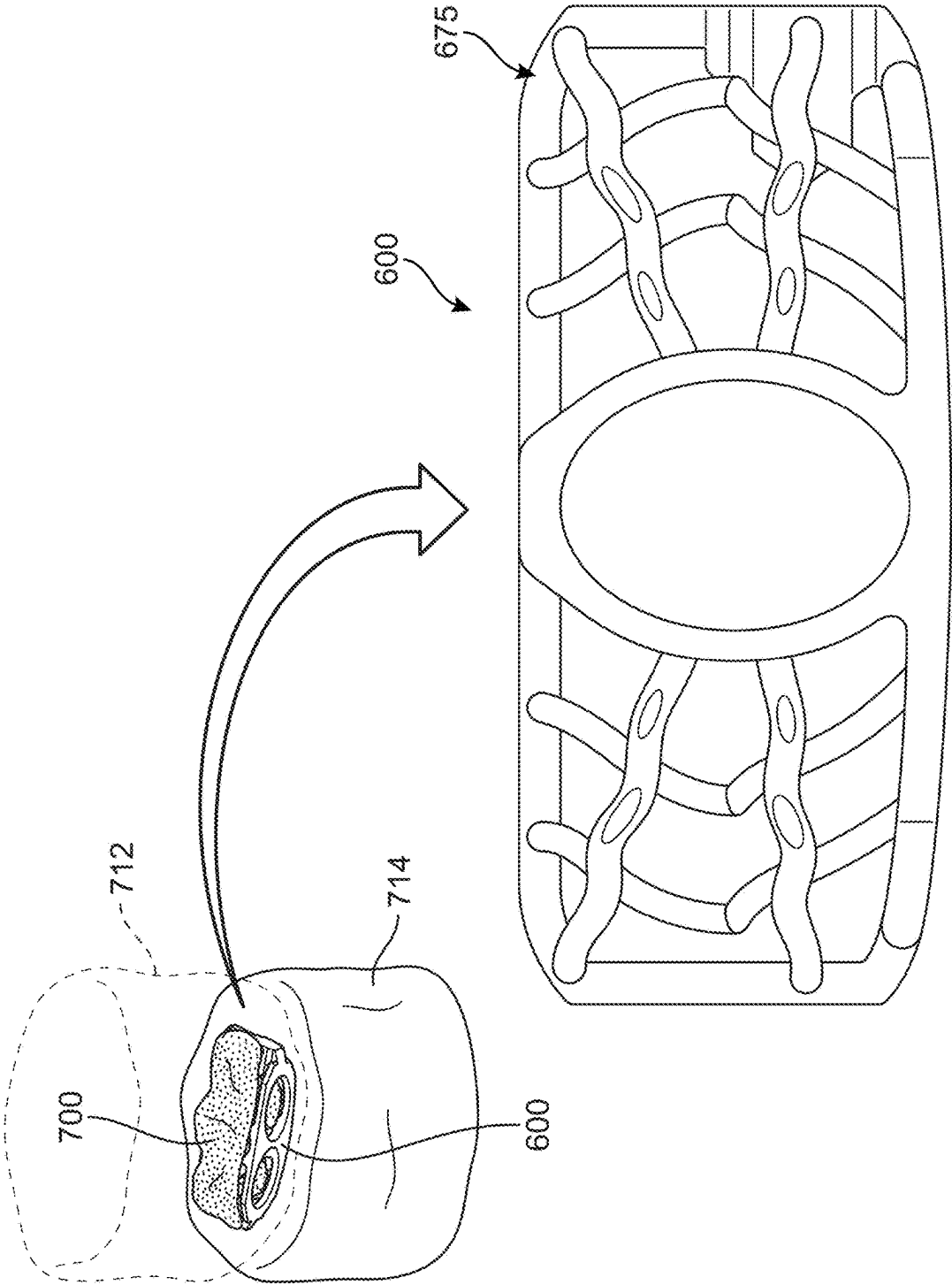


FIG. 17

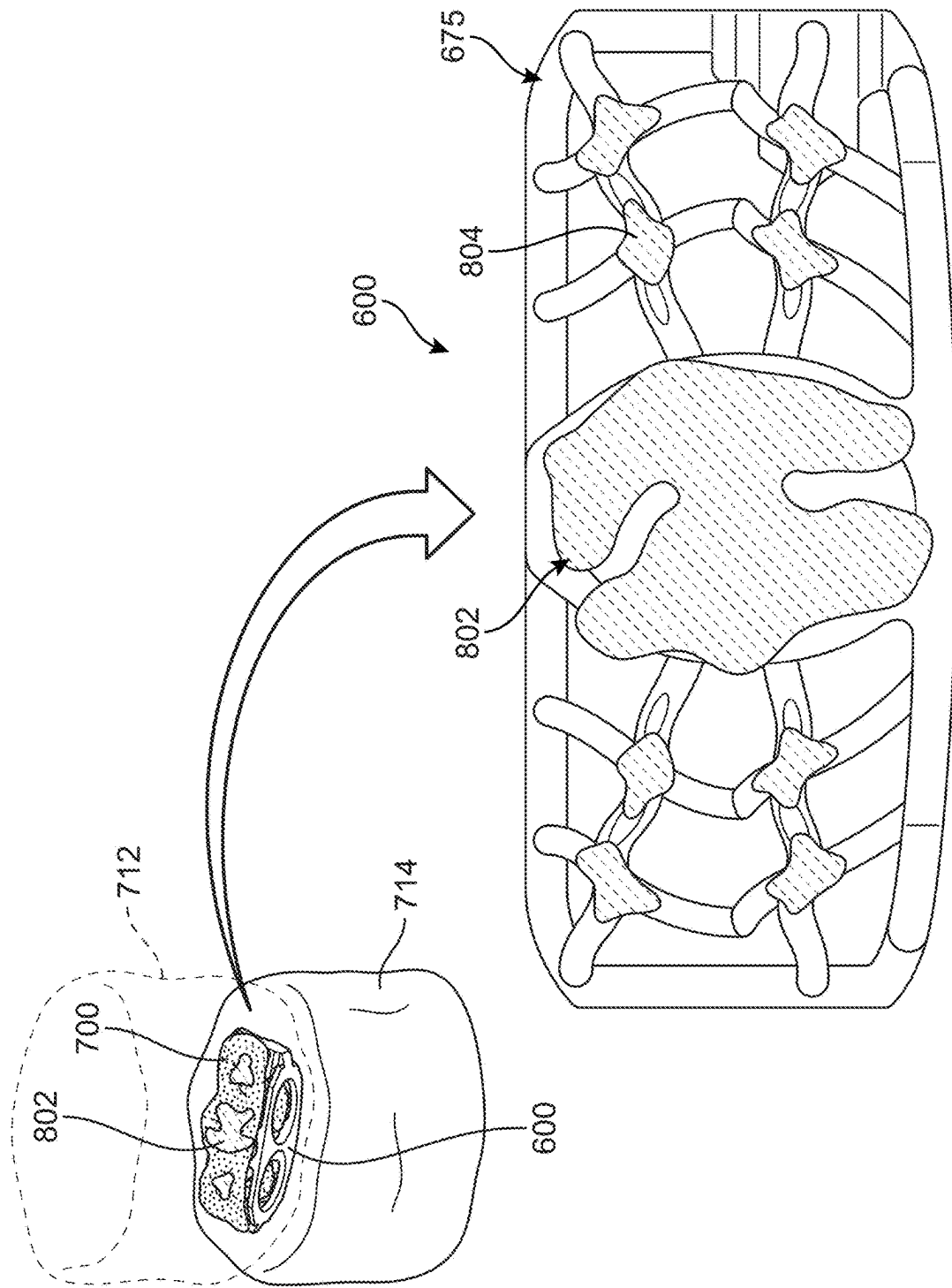


FIG. 18

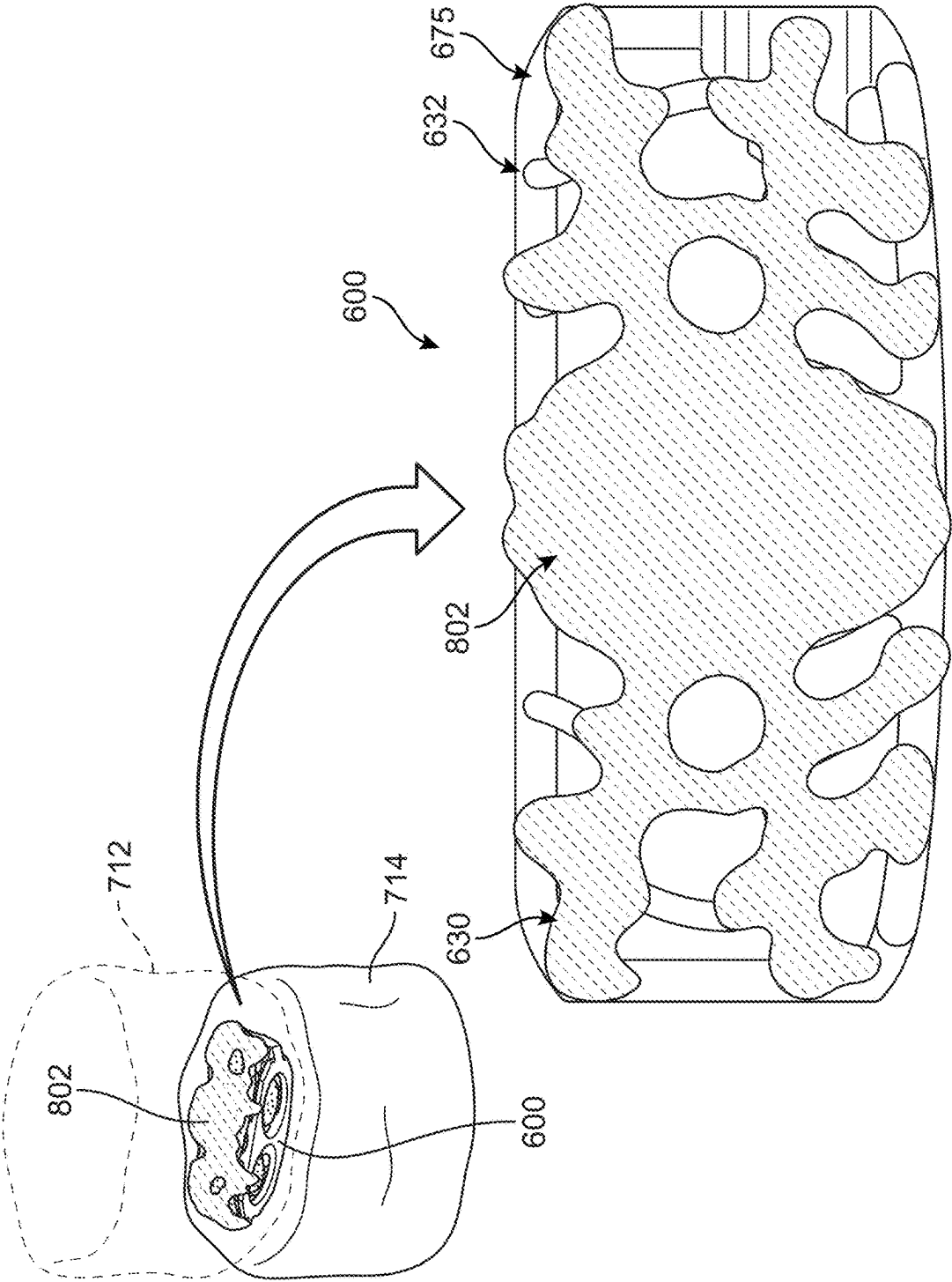
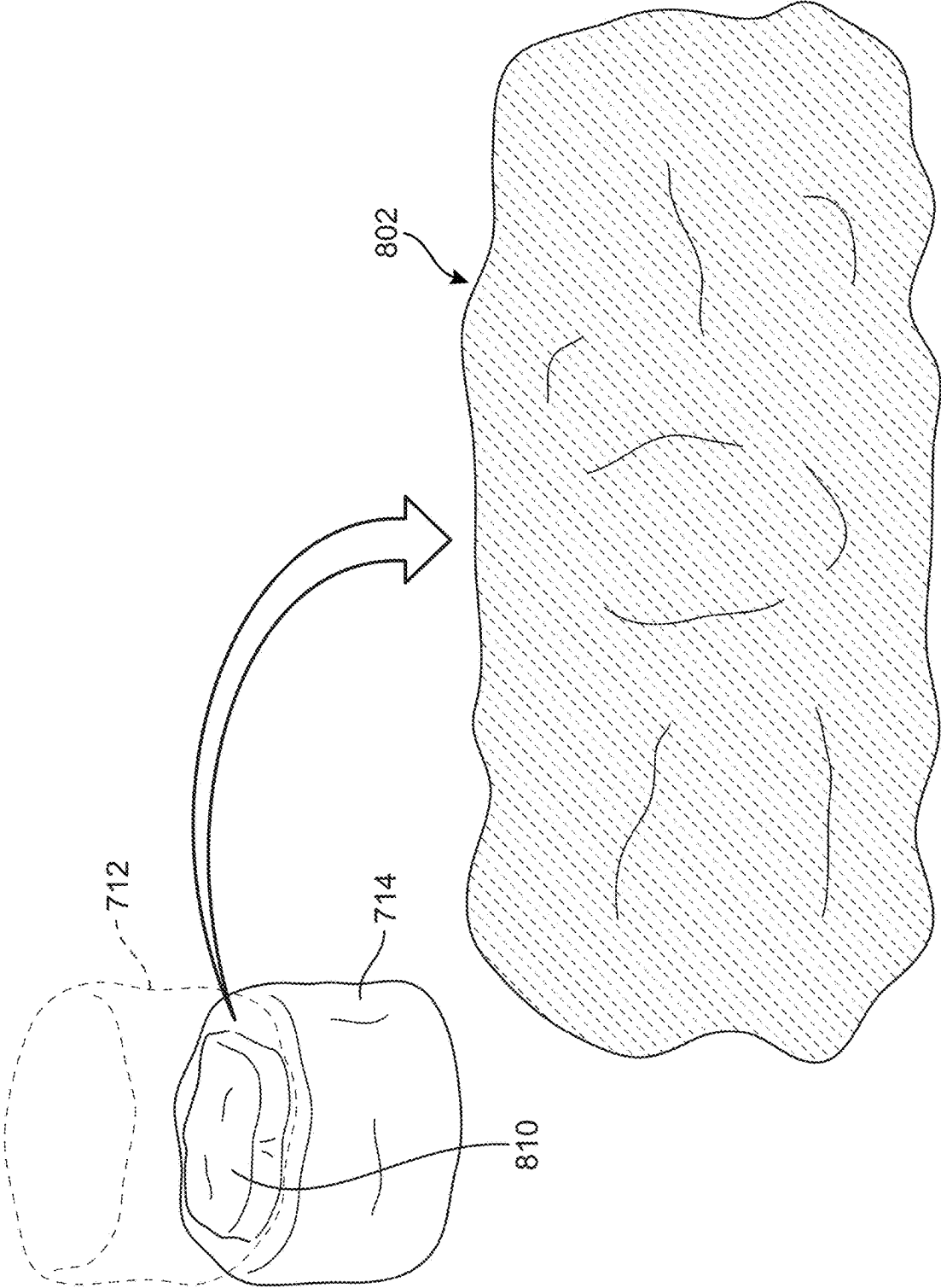


FIG. 19



**FIG. 20**

## IMPLANT WITH STRUCTURAL MEMBERS ARRANGED AROUND A RING

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of Bishop et al., U.S. patent application Ser. No. 18/429,100, filed Jan. 31, 2024, and entitled “Implant with Structural Members Arranged Around a Ring,” which is a continuation of Bishop et al., U.S. patent application Ser. No. 17/566,146, filed Dec. 30, 2021, and entitled “Implant with Structural Members Arranged Around a Ring,” which is a continuation of Bishop et al., U.S. patent application Ser. No. 16/725,790, filed Dec. 23, 2019, and entitled “Implant with Structural Members Arranged Around a Ring,” now U.S. Pat. No. 11,213,405, issued Jan. 4, 2022, which is a continuation of Bishop et al., U.S. patent application Ser. No. 15/457,470, filed Mar. 13, 2017, and entitled “Implant with Structural Members Arranged Around a Ring,” now U.S. Pat. No. 10,512,549, issued Dec. 24, 2019. The entire disclosure of each application listed above is incorporated herein by reference.

### BACKGROUND

[0002] The embodiments are generally directed to implants for supporting bone growth in a patient.

[0003] A variety of different implants are used in the body. Implants used in the body to stabilize an area and promote bone ingrowth provide both stability (i.e. minimal deformation under pressure over time) and space for bone ingrowth.

[0004] Spinal fusion, also known as spondylosynthesis or spondylosyndesis, is a surgical treatment method used for the treatment of various morbidities such as degenerative disc disease, spondylolisthesis (slippage of a vertebra), spinal stenosis, scoliosis, fracture, infection or tumor. The aim of the spinal fusion procedure is to reduce instability and thus pain.

[0005] In preparation for the spinal fusion, most of the intervertebral disc is removed. An implant, the spinal fusion cage, may be placed between the vertebra to maintain spine alignment and disc height. The fusion, i.e. bone bridge, occurs between the endplates of the vertebrae.

### SUMMARY

[0006] In one aspect, an implant includes a body including a ring with an opening. The body defines a transverse plane dividing the implant into a superior half and an inferior half. The ring defines a radial direction and a circumferential direction. The implant includes a bone contacting member attached to the ring, where the bone contacting member extends radially from the ring. The implant also includes a support member attached to the bone contacting member at an attachment region, where the support member extends in the circumferential direction.

[0007] In another aspect, an implant includes a body. The body defines a transverse plane dividing the implant into a superior half and an inferior half. The implant includes a first bone contacting member attached to the body and disposed within the superior half of the implant. The implant also includes a first support member attached to the first bone contacting member, the first support member being disposed within the superior half of the implant. The implant also includes a second bone contacting member attached to the body and disposed within the inferior half of the implant.

The implant also includes a second support member attached to the second bone contacting member, the second support member being disposed within the inferior half of the implant. An end of the first support member is attached to an end of the second support member.

[0008] In another aspect, an implant includes a body and a plurality of bone contacting members extending from a central region of the body to a periphery of the body. Each of the bone contacting members in the plurality of bone contacting members extend radially away from the central region of the body.

[0009] Other systems, methods, features and advantages of the embodiments will be, or will become, apparent to one of ordinary skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description and this summary, be within the scope of the embodiments, and be protected by the following claims.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The embodiments can be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, with emphasis instead being placed upon illustrating the principles of the embodiments. Moreover, in the figures, like reference numerals designate corresponding parts throughout the different views.

[0011] FIG. 1 is a schematic isometric superior view of an embodiment of an implant;

[0012] FIG. 2 is a schematic isometric inferior view of the implant of FIG. 1;

[0013] FIG. 3 is a schematic isometric view of a body of the implant of FIG. 1 shown in isolation;

[0014] FIG. 4 is a schematic side view of the implant of FIG. 1;

[0015] FIG. 5 is a schematic isometric view of the implant of FIG. 1, including an enlarged cut-away view of a structural member;

[0016] FIG. 6 is a schematic isometric view of a plurality of support members arranged within the body of the implant of FIG. 1;

[0017] FIG. 7 is a schematic lateral side view of the implant of FIG. 1;

[0018] FIG. 8 is a schematic lateral side view of the implant of FIG. 1, in which the body has been removed for purposes of clarity;

[0019] FIG. 9 is a schematic isometric view of the implant of FIG. 1, in which member curves of several structural members are illustrated;

[0020] FIG. 10 is a schematic superior view of an embodiment of an implant;

[0021] FIG. 11 is a schematic depicting an implant attached to an implant tool, and where the implant is covered with a bone growth promoting material, according to an embodiment;

[0022] FIG. 12 is a schematic isometric view of an implant being positioned for insertion between two vertebrae, according to an embodiment;

[0023] FIG. 13 is a schematic isometric view of the implant of FIG. 12 inserted between the two vertebrae;

[0024] FIG. 14 is a schematic side view of the implant of FIG. 13 including a partial cut-away view of a central cavity;

[0025] FIG. 15 is a schematic side view of the implant of FIG. 13 indicating areas of new bone growth;

[0026] FIG. 16 is a schematic side view of the implant of FIG. 13 indicating areas of new bone growth;

[0027] FIG. 17 is a schematic isometric view of the implant of FIG. 13 including an enlarged view of the superior side of the implant;

[0028] FIG. 18 is a schematic isometric view of the implant of FIG. 13 indicating areas of new bone growth on the superior side of the implant;

[0029] FIG. 19 is a schematic isometric view of the implant of FIG. 13 indicating areas of new bone growth on the superior side of the implant; and

[0030] FIG. 20 is a schematic isometric view of new bone growth covering the implant of FIG. 13.

#### DETAILED DESCRIPTION

[0031] The embodiments described herein are directed to an implant for use in a spine. The embodiments include implants with a body and one or more structural members. In addition to the various provisions discussed below, any embodiments may make use of any of the body/support structures, frames, plates, coils or other structures disclosed in Morris et al., U.S. Pat. No. 9,918,849, issued on Mar. 20, 2018, and titled “Coiled Implants and Systems and Methods of Use Thereof,” which is hereby incorporated by reference in its entirety. For purposes of convenience, the Morris application will be referred to throughout the application as “The Coiled Implant Application”. Also, any embodiments may make use of any of the body/support structures, elements, frames, plates or other structures disclosed in McShane III et al., U.S. Publication Number 2019/0000642, published on Jan. 3, 2019, and titled “Implant with Arched Bone Contacting Elements,” which is hereby incorporated by reference in its entirety. Also, any embodiments may make use of any of the body/support structures, elements, frames, plates or other structures disclosed in McShane III et al., U.S. Publication Number 2018/0110626, published on Apr. 26, 2018, and titled “Implant with Protected Fusion Zones,” which is hereby incorporated by reference in its entirety and referred to as “The Protective Fusion Zones application”.

[0032] FIGS. 1 and 2 illustrate isometric views of an embodiment of an implant 100, which may be alternatively referred to as a device. Specifically, FIG. 1 is an isometric view of a top or superior side of implant 100, while FIG. 2 is an isometric view of a bottom or inferior side of implant 100. Implant 100 may also be referred to as a cage or fusion device. In some embodiments, implant 100 is configured to be implanted within a portion of the human body. In some embodiments, implant 100 may be configured for implantation into the spine. In some embodiments, implant 100 may be a spinal fusion implant, or spinal fusion device, that is inserted between adjacent vertebrae to provide support and/or facilitate fusion between the vertebrae.

[0033] In some embodiments, implant 100 may include a body 102. Body 102 may generally provide a frame or skeleton for implant 100. In some embodiments, implant 100 may also include a plurality of structural members 104. Plurality of structural members 104 may be fixedly attached to, and/or continuously formed (or “integrally formed”) with, body 102. As used herein, the term “fixedly attached” shall refer to two components joined in a manner such that

the components may not be readily separated (for example, without destroying one or both components).

[0034] As used herein, each structural member comprises a distinctive member or element that spans a portion of an implant. Structural members may overlap or intersect, similar to elements in a lattice or other 3D mesh structure. Some embodiments may use structural members in which the length of the member is greater than its width and its thickness. In embodiments where a structural member has an approximately circular cross-sectional shape, the structural member has a length greater than its diameter. In the embodiments seen in FIGS. 1-2, each structural member is seen to have an approximately rounded or circular cross-sectional shape (i.e., the member has the geometry of a solid tube). However, in other embodiments, a structural member could have any other cross-sectional shape, including, but not limited to, various polygonal cross-sectional shapes, as well as any other regular and/or irregular cross-sectional shapes. In some cases, for example, the cross-sectional size and/or shape of a structural member could vary along its length (e.g., the diameter could change along its length).

[0035] For purposes of clarity, reference is made to various directional adjectives throughout the detailed description and in the claims. As used herein, the term “anterior” refers to a side or portion of an implant that is intended to be oriented towards the front of the human body when the implant has been placed in the body. Likewise, the term “posterior” refers to a side or portion of an implant that is intended to be oriented towards the back of the human body following implantation. In addition, the term “superior” refers to a side or portion of an implant that is intended to be oriented towards a top (e.g., the head) of the body while “inferior” refers to a side or portion of an implant that is intended to be oriented towards a bottom of the body. Reference is also made herein to “lateral” sides or portions of an implant, which are sides, or portions, facing along a lateral direction of the body (which correspond with the left or right sides of a patient).

[0036] In FIGS. 1-2, implant 100 is understood to be configured with an anterior side 110 and a posterior side 112. Implant 100 may also include a first lateral side 114 and a second lateral side 116 that extend between the posterior side 112 and the anterior side 110 on opposing sides of implant 100. Furthermore, implant 100 may also include a superior side 130 and an inferior side 140.

[0037] Reference is also made to directions or axes that are relative to the implant itself, rather than to its intended orientation with regards to the body. For example, the term “distal” refers to a part that is located further from a center of an implant, while the term “proximal” refers to a part that is located closer to the center of the implant. As used herein, the “center of the implant” could be the center of mass and/or a central plane and/or another centrally located reference surface.

[0038] An implant may also be associated with various axes. Referring to FIG. 1, implant 100 may be associated with a longitudinal axis 120 that extends along the longest dimension of implant 100 between first lateral side 114 and second lateral side 116. Additionally, implant 100 may be associated with a posterior-anterior axis 122 (also referred to as a “widthwise axis”) that extends along the widthwise dimension of implant 100, between posterior side 112 and anterior side 110. Moreover, implant 100 may be associated with a vertical axis 124 that extends along the thickness

dimension of implant **100** and which is generally perpendicular to both longitudinal axis **120** and posterior-anterior axis **122**.

[0039] An implant may also be associated with various reference planes or surfaces. As used herein, the term “median plane” refers to a vertical plane which passes from the anterior side to the posterior side of the implant, dividing the implant into right and left halves, or lateral halves. As used herein, the term “transverse plane” refers to a horizontal plane located in the center of the implant that divides the implant into superior and inferior halves. As used herein, the term “coronal plane” refers to a vertical plane located in the center of the implant that divides the implant into anterior and posterior halves. In some embodiments, the implant is symmetric about two planes, such as the median and the transverse plane.

[0040] FIG. 3 illustrates a schematic isometric view of body **102** in isolation, with plurality of structural members **104** removed for purposes of clarity. In some embodiments, a body could include distinct frame portions that are oriented in different directions. In the embodiment shown in FIG. 3, body **102** includes a peripheral frame portion **200**, also referred to as simply “peripheral portion **200**”. In some embodiments, peripheral portion **200** has a longest dimension aligned with longitudinal axis **120** and a widthwise dimension (e.g., the second longest dimension) aligned with posterior-anterior axis **122** of implant **100** (see FIGS. 1 and 2). Peripheral frame portion **200** comprises a first lateral frame portion **202**, a second lateral frame portion **204** and a posterior frame portion **206**, which primarily lie in the transverse plane.

[0041] In some embodiments, one or more sides of an implant (including lateral sides and/or anterior/posterior sides) could include a vertically oriented peripheral frame portion. In the embodiment of FIG. 3, body **102** is seen to include a vertically oriented peripheral frame portion **208** disposed at anterior side **110**, which may also be referred to as an “anterior wall” of implant **100**. In contrast, posterior side **112** lacks any frame portion or wall that extends vertically beyond the thickness of peripheral portion **200** in the embodiments of FIGS. 3-4. The presence of vertically oriented peripheral frame portion **208** may improve support and strength against vertical loads applied along the anterior side of the spine.

[0042] Although the present embodiment uses a vertically oriented frame or wall on the anterior side of implant **100**, in other embodiments, a vertically oriented frame or wall could be located on the posterior side of implant **100** and/or on a lateral side of implant **100**. In still other embodiments, the implant may lack any vertical walls along its perimeter (i.e., along the posterior, anterior or lateral sides).

[0043] Embodiments may include one or more rings. In some embodiments, an implant could include two or more rings that are connected in a ring assembly. As seen in FIG. 3, body **102** includes a ring assembly **220**. Ring assembly **220** is further comprised of a superior ring **222** and an inferior ring **224**. Additionally, ring assembly **220** includes a first support **226** and a second support **228** which extend through an interior region (and intersect the transverse plane) of implant **100** and join superior ring **222** and inferior ring **224**.

[0044] As seen in FIG. 3, ring assembly **220** may be arranged to form a hollow cylinder, which includes openings **230**. This geometry may provide a tubular space (central

cavity **231**) through which bone growth from opposing vertebrae can extend through and fuse at the center of the implant, thereby forming a strong cylindrical column of bone growth. Furthermore, the presence of openings **230** may allow new bone growth to extend from the column and fuse with bone growth occurring in adjacent regions of the interior of implant **100**. Optionally, in other embodiments, a ring assembly may comprise continuous cylindrical walls with no openings.

[0045] In different embodiments, the location of a ring assembly could vary. For purposes of characterizing possible locations of a ring assembly, an implant may be divided into a first lateral side region, a second lateral side region and a central region disposed between the first lateral side region and the second lateral side region. In the exemplary embodiment of FIG. 3, implant **100** includes a first lateral side region **240**, a central region **242** and a second lateral side region **244**. In the exemplary embodiment, therefore, ring assembly **220** is disposed in central region **242** and approximately equally spaced away from opposing lateral ends. Of course, in other embodiments, ring assembly **220** could be disposed in first lateral side region **240** or second lateral side region **244**.

[0046] It may be appreciated that in other embodiments a ring assembly could be disposed centrally with respect to a posterior/anterior direction. Though, in the present embodiment, ring assembly **220** extends the full distance between the posterior and anterior edges of implant **100**.

[0047] In different embodiments, the shape of a ring could vary. In the exemplary embodiment, superior ring **222** and inferior ring **224** each have an oval-like shape. However, in other embodiments, a ring could have any other shape including, but not limited to, a rounded shape, a circular shape, a triangular shape, a square shape, a polygonal shape, a regular shape, an irregular shape, etc.

[0048] A ring assembly, including a superior ring and an inferior ring, could be attached to other portions of the implant in various ways. In some embodiments, a ring assembly may be attached directly to a peripheral frame portion of a body. In other embodiments, a ring assembly could be attached to the body by way of one or more structural members. In the exemplary embodiment, ring assembly **220** is attached directly to both peripheral frame portion **206** and vertically oriented peripheral frame portion **208**, while also being attached to a plurality of structural members (see FIGS. 1-2).

[0049] FIG. 4 is a side view of an embodiment of implant **100**. In some embodiments, vertically oriented peripheral frame portion **208** could include openings. In other embodiments, vertically oriented peripheral frame portion **208** may not include openings. In some embodiments, openings in a frame portion could provide an access point for inserting bone graft material or BGPM into an interior of an implant. The number, size and/or shape of openings in vertically oriented peripheral frame portion **208** could vary. In some cases, three or more openings could be used. In other cases, two openings could be used. In still other cases, a single opening could be used. Exemplary shapes for openings that could be used include, but are not limited to, rounded openings, rectangular openings, polygonal openings, regular openings and/or irregular openings. In the embodiment of FIGS. 3-4, vertically oriented peripheral frame portion **208** includes two large oval-shaped windows that may facilitate insertion of bone graft material (or BGPM) into an interior

of the implant. Specifically, vertically oriented peripheral frame portion **208** includes first window **210** and second window **212**.

**[0050]** Some embodiments can include provisions that facilitate implantation, including insertion and/or fixation of the implant. Some embodiments can include a fastener receiving portion. For example, as best seen in FIGS. 1-2, implant **100** includes a fastener receiving portion **160**. Fastener receiving portion **160** includes a threaded opening **162** and a reinforced collar **164** to support threaded opening **162**. In some embodiments, threaded opening **162** may be configured to receive a tool with a corresponding threaded tip to facilitate implantation of implant **100**. In some embodiments, threaded opening **162** may be used with a screw to help attach implant **100** to a bone or another fixation device. In other embodiments, any other features for receiving fasteners and/or implantation tools could be incorporated into implant **100**.

**[0051]** In some embodiments, an implant can be configured with one or more symmetries. In some cases, an implant may have a mirrored symmetry about one or more reference planes.

**[0052]** Referring to FIGS. 1 and 2, implant **100** may include at least one mirror symmetry. For purposes of reference, implant **100** may be split into a superior half and an inferior half. Here, the “superior half” of implant **100** includes the portions of body **102** and plurality of structural members **104** disposed above the transverse plane. Likewise, the “inferior half” of implant **100** includes the portions of body **102** and plurality of structural members **104** disposed below the transverse.

**[0053]** With respect to the transverse plane (which coincides generally with the plane defined by first lateral frame portion **202**, second lateral frame portion **204** and posterior frame portion **206**), it may be seen that the superior half of implant **100** mirrors the inferior half of implant **100**, at least approximately. This includes not only the geometry of the body but also the shape, size and orientations of each structural member.

**[0054]** Moreover, with respect to the median plane (which approximately divides implant **100** into two lateral halves), it may be seen that two lateral halves mirror one another approximately. This includes not only the geometry of the body but also the shape, size and orientations of each structural member.

**[0055]** An implant may include two or more kinds of structural members (or structural elements). In some embodiments, an implant can include one or more bone contacting structural members, or simply “bone contacting members”. Bone contacting members may generally be fully exposed on the outer surfaces of an implant, including along the superior and inferior sides of the implant. Thus, bone contacting members may be alternatively referred to as “outer members”.

**[0056]** In some embodiments, an implant can include one or more structural members that provide support to one or more bone contacting members. Such supporting structural members may be referred to as “support members”. In some embodiments, at least some portions of each support member may be hidden or covered by a bone contacting member or another element of the implant. Thus, support members may also be characterized as “inner members” as they are generally disposed inwardly of the bone contacting members.

**[0057]** FIG. 5 illustrates a schematic isometric view of implant **100**, according to an embodiment. As seen in FIG. 5, implant **100** may include a plurality of bone contacting members **180** as well as a plurality of support members **182**. As best shown in FIGS. 1-2, plurality of structural members **104** are arranged in four distinct quadrants on implant **100**: a first quadrant associated with superior side **130** and first lateral side region **240**; a second quadrant associated with superior side **130** and a second lateral side region **244**; a third quadrant associated with inferior side **140** and first lateral side region **240**; and a fourth quadrant associated with inferior side **140** and second lateral side region **244**.

**[0058]** The following discussion discusses exemplary structural members in some, but not all, of the quadrants of implant **100**. However, it may be appreciated that similar properties and principles of the specific structural members discussed here may apply to structural members in any of the remaining quadrants.

**[0059]** In some embodiments, one or more structural members could be closed loops without ends. In other embodiments, at least some structural member comprises two ends. In some cases, structural members with two ends could include one or more ends that are attached to another structural member. In other cases, structural members with two ends could be arranged so that both ends are attached to a portion of a body of an implant. In the exemplary embodiment depicted in FIG. 5, each structural member includes two ends, with each end being attached to some portion of body **102**, or attached to another structural member, of implant **100**.

**[0060]** In some embodiments, an implant may include at least one bone contacting member with one end attached to a frame portion and another end attached to a central ring. For example, as seen in FIG. 5, a bone contacting member **300** includes a first end **302** attached to superior ring **222** and a second end **304** attached to first lateral frame **202**.

**[0061]** In different embodiments, support members could be attached to different portions of an implant. In some embodiments, one or more ends of a support member could be attached to a peripheral frame portion of a body. In other embodiments, one or more ends could be attached to another support member. In still other embodiments, one or more portions of a support member could be attached to a bone contacting member. In one embodiment, each support member may be attached to a peripheral frame portion of the body, at least one bone contacting member, and at least one other support member.

**[0062]** In the exemplary embodiment of FIG. 5, each support member includes one end that is attached to a peripheral frame portion. For example, support member **340** includes a first end **342** that is attached to posterior frame portion **206**. Likewise, the remaining support members of plurality of support members **182** each have an end attached to either peripheral frame portion **206** or vertically oriented peripheral frame portion **208**.

**[0063]** Embodiments may include provisions to minimize the number of bars or other supports needed. Some embodiments may include provisions that eliminate the need for any internal supports extending between peripheral frame portion **200** (shown in FIG. 5) and ring assembly **220**, thereby increasing the interior volume available to receive new bone growth. In some embodiments, support members from opposing superior and inferior sides of an implant may



attach directly to one another, thereby eliminating the need for additional longitudinally running structures to receive the support members.

**[0064]** FIG. 6 is a schematic isometric view of plurality of support members 182 with body 102 shown in phantom for purposes of clarity. FIG. 7 illustrates a schematic lateral end view of implant 100, while FIG. 8 illustrates a similar view with body 102 removed for purposes of illustration. As seen in FIGS. 6-8, each support member includes an end that is joined to three other support members at an area adjacent the transverse plane. As an example, first superior support member 402, second superior support member 404, first inferior support member 406 and second inferior support member 408 are all joined at an attachment region 410 that is located approximately in the transverse plane of implant 100. Specifically, as best seen in FIG. 8, an end 403 of first superior support member 402, an end 405 of second superior support member 404, an end 407 of first inferior support member 406 and an end 409 of second inferior support member 408 are all joined together. Using this arrangement, the support members provide reinforcement and support in both the posterior-anterior directions and vertical directions of implant 100 without requiring additional support elements (e.g., longitudinally running beams, bars or plates) that would serve as attachment points for the support members in the center of the implant.

**[0065]** In some embodiments, bone contacting members may be disposed distal to support members, with bone contacting members generally disposed further outwards along the superior and inferior sides of an implant. Thus, bone contacting members may generally be disposed closer to the vertebral end plates following implantation into the spine. Moreover, at regions where a bone contacting member is attached to a support member, the attached portion of the bone contacting member may be disposed distal to the attached portion of the inner member. As one example, FIG. 5 illustrates a schematic isometric view of implant 100 including an enlarged cross-sectional view of an attachment region 189 between bone contacting member 370 and support member 390. Here, bone contacting member 370 is seen to extend up and over support member 390. Moreover, bone contacting member 370 is seen to be located distally to support member 390. Here, distally is intended to mean disposed further from the transverse plane of implant 100.

**[0066]** Embodiments can include provisions for protecting bone growth along and adjacent to bone contacting members of an implant. In some embodiments, a bone contacting member can be configured with a geometry that helps to protect new bone growth in selected regions or “protected fusion zones”. In some embodiments, a bone contacting member can have a spiral, helical or twisted geometry that provide a series of such protected fusion zones for enhanced bone growth.

**[0067]** Some bone contacting members may have a generalized helical geometry. As used herein, a “generalized helical geometry” or “spiraling geometry” refers to a geometry where a part (portion, member, etc.) winds, turns, twists, rotates or is otherwise curved around a fixed path. In some cases, the fixed path could be straight. In other cases, the fixed path can be curved. In the present embodiments, for example, the fixed path is generally a combination of straight segments and curved segments.

**[0068]** Curves having a generalized helical geometry (also referred to as generalized helical curves) may be character-

ized by “coils”, “turns” or “windings” about a fixed path. Exemplary parameters that may characterize the specific geometry of a generalized helical curve can include coil diameter (including both a major and minor diameter) and the pitch (i.e., spacing between adjacent coils). In some cases, the “amplitude” of a coil or loop may also be used to describe the diameter or widthwise dimension of the coil or loop. Each of these parameters could be constant or could vary over the length of a generalized helical curve.

**[0069]** Generalized helical curves need not be circular or even round. In some embodiments, for example, a generalized helical curve could have linearly segmented shape (or locally polygonal shape) such that each “coil” or “turn” is comprised of straight line segments rather than arcs or other curved segments. Generalized helical curves may also include combinations of curved and straight segments. Examples of generalized helical curves are shown and described in The Protected Fusion Zones Application.

**[0070]** For purposes of characterizing the geometry of one or more structural members, each structural member can be understood to have a “central member curve”. The central member curve of each structural member may be defined as a curve that extends along the length of the structural member such that each point along the curve is centrally positioned within the structural member.

**[0071]** In embodiments where a structural member winds or loops around a fixed path with an amplitude or diameter that is much greater than the cross-sectional diameter of the structural member itself, the structural member may be wound into visible distinct coils. Such coils are discussed in thorough detail in the Coiled Implant Application. In other embodiments, however, a structural member could be wound around a fixed path with an amplitude or diameter that is less than the cross-sectional diameter of the structural member itself. In such a case the resulting geometry of a structural member may appear to be twisted, but the geometry may lack the distinct coils seen in the Coiled Implant Application. However, it may be appreciated that while the outermost surface of such a structural member may not exhibit distinct coils, the central member curve of the structural member does have such coils or turns and moreover has a clear generalized helical geometry.

**[0072]** FIG. 9 is a schematic isometric view of implant 100 where the structural members have been removed for purposes of clarity. To depict the geometry of the structural members, the central member curve of several structural members is shown. Specifically, central member curve 520 is shown, which corresponds to the geometry of bone contacting member 300. Additionally, central member curve 504 and central member curve 506 are shown, which correspond with the geometry of support members providing support to bone contacting member 300.

**[0073]** As previously discussed, bone contacting member 300 (FIG. 5) exhibits a twisted geometry indicative of a spiral or helix. However, since the winding occurs with an amplitude much smaller than the thickness of bone contacting member 300, the geometry of the part may be difficult to discern. The generalized helical geometry of bone contacting member 300 becomes much clearer when the geometry of its central member curve 520 (which is clearly seen in FIG. 9) is considered as it winds around a fixed path 540 (also shown in FIG. 9).

**[0074]** In different embodiments, the winding diameter of a helical structural member could vary. In the exemplary

embodiment, a winding diameter **552** of the coils or turns in central member curve **520** are smaller than the diameter of bone contacting member **300**. In other embodiments, the cross-sectional diameter of a bone contacting member could be less than a corresponding winding diameter of the coils or turns of its central member curve. In such an embodiment, the bone contacting member would be configured in a series of distinct coils.

**[0075]** A bone contacting member may not have a generalized helical geometry through its entire length. Instead, its central member curve may be configured with a winding segment where the central member curve completes several full turns (three in FIG. **9**) around a fixed path. Away from the winding segment, its central member curve may not include any turns, twists, etc.

**[0076]** Although the present embodiment includes at least one bone contacting member with a winding segment that makes one or more full turns around a fixed path, other embodiments could be configured with central member curves that only make partial turns around a fixed path.

**[0077]** While the description here has focused on the geometry of a single bone contacting member **300**, it may be appreciated that some or all of the remaining bone contacting members in plurality of structural members **104** may have a similar generalized helical geometry. It may be further appreciated that two different bone contacting members could have slightly different geometries, with distinct bone contacting member curves that include variations in the number of windings, shape of the windings, etc.

**[0078]** In some embodiments, an implant can include bone contacting members that are locally helical over small distances compared to the length, width or height of the implant. For example, implant **100** may be characterized as having bone contacting members that are locally helical or locally spiraling, rather than globally helical. In particular, each bone contacting member of implant **100** is bounded within a single quadrant of implant **100** and does not cross the transverse plane or the median plane of implant **100**. Thus, a full turn of the bone contacting members is accomplished over distances that are much smaller than half the length, width or height of the implant. This allows multiple windings within each quadrant of the implant and also results in the pitch between windings being smaller than the length, width or height of the implant. For example, in FIG. **9**, central member curve **520** has a pitch **529** between adjacent windings or turns that is less than one third of the length of bone contacting member **300**. Pitch **529** is also less than one tenth of the length of implant **100**. This relatively small pitch size allows for a greater number of proximal surface regions along each bone contacting member, thereby increasing the number of available protected fusion zones of the inferior and superior surfaces of implant **100**.

**[0079]** In some embodiments, the helix-like geometry of bone contacting members provides distinct regions exposed on the superior and inferior sides of an implant. For example, referring to FIG. **5**, each bone contacting member includes one or more distal regions **360** that may be seen as “peaks” in the bone contacting member along the superior side **130** of implant **100**. In at least some embodiments, these distal regions **360** may be flattened or “smoothed” to provide a flat or smooth distal-most surface on superior side **130** (and inferior side **140**), thereby facilitating contact with adjacent vertebrae. In other embodiments, a distal surface region may be curved. In some cases, the distal surface region could

have a curvature that matches the curvature of the adjacent surface regions of the bone contacting member. In other cases, the distal surface region could have a different curvature (e.g., more convex) than adjacent surface regions of the bone contacting member.

**[0080]** Bone contacting members may also include proximal regions **362** that are configured as “valleys” in the bone contacting member along the superior side **130** of implant **100**. Whereas the distal regions **360** may come into contact with the vertebrae during and following implantation of implant **100**, proximal regions **362** may be recessed or spaced apart from direct contact with the vertebrae, at least before new bone growth has developed.

**[0081]** As a particular example, FIG. **5** includes an enlarged cross-sectional view of a portion of a bone contacting member **370** and underlying support member **390**. Specifically, an outwardly facing surface portion **372** of bone contacting member **370** is visible. As used herein, the “outwardly facing surface portion” of a bone contacting member is the portion of the surface of the bone contacting member facing towards a vertebra during implantation, or facing away from an interior of the implant. Outwardly facing surface portion **372** includes a first distal surface region **380**, a proximal surface region **382** and a second distal surface region **384**. As discussed in further detail below, this local geometry provides a series of protected fusion zones adjacent each proximal surface region, where new bone growth can be protected during early bone fusion.

**[0082]** While bone contacting members may have generalized helical geometries, the geometries of the support members may be selected to enhance strength and support. In some embodiments, support members could have a generally tube-like (solid) shape and may extend in simple curves from one portion of a body to another. In some cases, the central member curve of a support member may be smoothly curved without any local twists, windings or coils.

**[0083]** Thus, it may be appreciated, that in some embodiments, support members may generally be shorter and their geometry may be more arch-like to improve strength and provide increased support for the bone contacting members. In contrast, the bone contacting members may generally have a longer length and may be less arch-like in shape relative to the support members, as the bone contacting members need to extend across as much of the superior/inferior sides of an implant as possible to provide contact with the vertebrae.

**[0084]** While some embodiments include bone contacting members with generalized helical geometries and support members with arch-like geometries, in other embodiments any structural member could be configured with any type of geometry. For example, in another embodiment, one or more support members could have a generalized helical geometry that create protected fusion zones along the support members. In still another embodiment, one or more bone contacting members could have an arch-like geometry.

**[0085]** In different embodiments, the attachment between a support member and a bone contacting member could occur at various locations. In some embodiments, a support member could be attached near a distal surface region along the outer surface of a bone contacting member. In other embodiments, a support member could be attached near a proximal surface region along the outer surface of a bone contacting member.

[0086] In some embodiments, each support member is configured to attach to a corresponding bone contacting member at a location adjacent (or underlying) a proximal surface region of the bone contacting member. For example, as shown in FIG. 5, an attachment region 189 of support member 390 is attached to bone contacting member 300 at a location corresponding to proximal surface region 382 of bone contacting member 300. Likewise, every other support member of implant 100 attaches to one or more bone contacting members only at locations corresponding to proximal surface regions.

[0087] This configuration provides for protected fusion zones that encompass the space immediately adjacent the proximal regions. The protected fusion zones are locations along the superior/inferior surfaces of an implant where new bone growth can be partially protected from forces applied to the bone contacting members by adjacent support members or directly from a vertebra.

[0088] By configuring one or more bone contacting members with at least one helical portion, the bone contacting member may provide one or more protected fusion zones on the superior and inferior sides of an implant. These protected fusion zones encompass the space immediately adjacent the proximal regions of the bone contacting members. The recessed spaces provided by the proximal regions allow for pockets of new bone growth adjacent initial fusion that may occur at the distal regions. Moreover, because the support members are attached near the proximal surface regions, and not at the distal surface regions, forces applied to the bone contacting members by either the support members or by a vertebra can be directed away from the protected fusion zones, thereby minimizing the disturbance of new bone growth.

[0089] FIG. 10 is a schematic top down view of an implant 600, according to an embodiment. Referring to FIG. 10, implant 600 includes body 601 comprising peripheral frame portion 602, peripheral frame portion 604, peripheral frame portion 606 and peripheral frame portion 608. Additionally, body 601 comprises ring 609 defining a central opening 650.

[0090] For purposes of reference, central opening 650 (and ring 609) define a radial direction 599 and a circumferential direction 598. Here, radial direction 599 extends outwardly from a center of central opening 650, while circumferential direction 598 is an angular direction that is perpendicular with radial direction 599.

[0091] In different embodiments, the orientation of bone contacting members and/or support members could vary. In some embodiments, bone contacting members may be oriented radially away from a center of an implant. In some embodiments, support members may be oriented in a circumferential (or angular) direction that rotates about a center of an implant. In other embodiments, however, bone contacting members could be oriented in a circumferential direction while support members could be oriented in a radial direction. In still other embodiments, one or more structural elements could be oriented in directions orthogonal to the length and/or width of an implant, rather than in radial and/or circumferential directions.

[0092] Implant 600 also includes plurality of bone contacting members 630 and plurality of support members 632. As seen in FIG. 10, plurality of bone contacting members 630, which includes first bone contacting member 611, second bone contacting member 612, third bone contacting member 613 and fourth bone contacting member 614 may

each extend in radial direction 599 (i.e., outwardly from central opening 650 and ring 609). For example, first bone contacting member 611 extends radially from ring 609 to peripheral frame portion 602. Second bone contacting member 612 also extends radially from ring 609 to peripheral frame portion 602, though second bone contacting element 612 has a different angular (or circumferential) position along circumferential direction 598. Also, third bone contacting member 613 extends radially from ring 609 to peripheral frame portion 604. Fourth bone contacting member 614 also extends radially from ring 609 to peripheral frame portion 604, though fourth bone contacting element 614 has a different angular (or circumferential) position along circumferential direction 598.

[0093] As seen in FIG. 10, plurality of support members 632 is further comprised of first support member 621, second support member 622, third support member 623, fourth support member 624, fifth support member 625, sixth support member 626, seventh support member 627 and eighth support member 628. Each of these support members may be oriented approximately in the circumferential direction 598. For example, first support member 621 extends from peripheral frame portion 606 to its attachment with second support member 622 along a path 640 that is approximately parallel with the circumferential direction 598. Likewise, second support member 622 extends from its attachment to first support member 621 to peripheral frame portion 608 along a path 642 that is also approximately parallel with circumferential direction 598. Moreover, it is clear from FIG. 10 that first support member 621 is approximately perpendicular with (radially oriented) first bone contacting member 611 and that second support member 622 is approximately perpendicular with (radially oriented) second bone contacting member 612. Similarly, each remaining support member in plurality of support members 632 is oriented approximately parallel with circumferential direction 598 and is also approximately perpendicular to a bone contacting member to which it attaches.

[0094] The embodiment of FIG. 10 may be characterized as having structural members arranged in a web-like or spider web-like pattern. Moreover, it may be appreciated that while only one side of implant 600 is shown, an opposing side may likewise include a central ring and structural members oriented in a similar web-like pattern.

[0095] This web-like pattern provides radially oriented structural members (bone contacting members) that may help improve strength in multiple directions simultaneously (i.e., the longitudinal and lateral directions). This may also help direct new bone growth from the center of the device (which includes a large central cavity for bone growth) towards the corners and periphery of the device. Moreover, the circumferential orientation of some structural members (support members) in this web-like pattern also improves the strength of the device in multiple directions simultaneously and in directions orthogonal to the radially oriented structural members.

[0096] The arrangement of structural members with the body may also be designed to achieve a desired total open volume. As used herein a total volume is the combined volume of any openings between structural members, any openings in the body, or between structural members and the body. This open configuration may facilitate bone growth in and through the implant. A portion, or substantially all of, the open spaces is optionally filled with a bone graft or bone

growth promoting material prior to or after insertion of the implant to facilitate bone growth.

**[0097]** The total volume of the open spaces (also referred to simply as the open space volume) within any particular implant is dependent on the overall dimension of the implant as well as the size and dimension of individual components within the implant including structural members, frame portions, etc. The open space volume may range from about 20% to 80% of the volume of the implant. In some embodiments, implant **100** may have an open space volume that is between 25% and 80% of the implant's total volume. In still further embodiments, implant **100** may have an open space volume that is between 40% and 75% of the total implant volume.

**[0098]** FIGS. **11-13** illustrate various schematic views of a process of implanting an implant **600**. Referring first to FIGS. **11-13**, the implantation process may begin with the application of a bone growth promoting material, also referred to as a BGPM, to the implant. As used herein, a "bone growth promoting material" is any material that helps bone growth. Bone growth promoting materials may include provisions that are freeze dried onto a surface or adhered to the metal through the use of linker molecules or a binder. Examples of bone growth promoting materials are any materials including bone morphogenetic proteins (BMP s), such as BMP-1, BMP-2, BMP-4, BMP-6, and BMP-7. These are hormones that convert stem cells into bone forming cells. Further examples include recombinant human BMPs (rhBMP s), such as rhBMP-2, rhBMP-4, and rhBMP-7. Still further examples include platelet derived growth factor (PDGF), fibroblast growth factor (FGF), collagen, BMP mimetic peptides, as well as RGD peptides. Generally, combinations of these chemicals may also be used. These chemicals can be applied using a sponge, matrix or gel.

**[0099]** Some bone growth promoting materials may also be applied to an implantable prosthesis through the use of a plasma spray or electrochemical techniques. Examples of these materials include, but are not limited to, hydroxyapatite, beta tri-calcium phosphate, calcium sulfate, calcium carbonate, as well as other chemicals.

**[0100]** A bone growth promoting material can include, or may be used in combination with, a bone graft or a bone graft substitute. A variety of materials may serve as bone grafts or bone graft substitutes, including autografts (harvested from the iliac crest of the patient's body), allografts, demineralized bone matrix, and various synthetic materials.

**[0101]** Some embodiments may use autograft. Autograft provides the spinal fusion with calcium collagen scaffolding for the new bone to grow on (osteoconduction). Additionally, autograft contains bone-growing cells, mesenchymal stem cells and osteoblast that regenerate bone. Lastly, autograft contains bone-growing proteins, including bone morphogenetic proteins (BMP s), to foster new bone growth in the patient.

**[0102]** Bone graft substitutes may comprise synthetic materials including calcium phosphates or hydroxyapatites, stem cell containing products which combine stem cells with one of the other classes of bone graft substitutes, and growth factor containing matrices such as INFUSE® (rhBMP-2-containing bone graft) from Medtronic, Inc.

**[0103]** It should be understood that the provisions listed here are not meant to be an exhaustive list of possible bone growth promoting materials, bone grafts or bone graft substitutes.

**[0104]** In some embodiments, BGPM may be applied to one or more outer surfaces of an implant. In other embodiments, BGPM may be applied to internal volumes within an implant. In still other embodiments, BGPM may be applied to both external surfaces and internally within an implant. As seen in FIGS. **11-13**, a BGPM **700** has been placed inside an interior of implant **600** and also applied on superior and inferior surfaces of implant **600**. Moreover, as shown in FIG. **11**, BGPM **700** has been inserted through (and extends through) a first window **662** and a second window **664** of implant **600**.

**[0105]** FIGS. **12** and **13** show schematic views of the implant pre-implantation (FIG. **12**) and post-implantation (FIG. **13**). Once implanted, implant **600** may be disposed between, and in direct contact with, adjacent vertebra. Specifically, a superior side **702** of implant **600** is disposed against first vertebra **712**. Likewise, an inferior side **704** of implant **600** is disposed against second vertebra **714**.

**[0106]** In different embodiments, implantation methods could vary. In some embodiments, implant **600** may be secured to an implantation tool **701** (partially seen in FIGS. **11-12**) that is used to drive implant **600** into the spine. Implantation tool **701** could be any rod, ram, pole or other device that can be hammered, rammed, or otherwise driven to position implant **600** between adjacent vertebrae. As previously mentioned, in some cases, an implantation tool could be attached to implant **600** at a fastener receiving portion (i.e., a threaded opening for receiving a threaded shaft from a tool).

**[0107]** FIGS. **14-20** depict a schematic sequence of bone growth throughout implant **600**, including through central cavity **671** (FIGS. **14-16**), as well as along the superior and inferior sides of implant **600** (FIGS. **17-20**).

**[0108]** FIGS. **14-16** depict a partial cross-sectional view of implant **600** just after implantation between vertebra **712** and vertebra **714**. Here, BGPM **700** fills an interior of implant **600** and also coats the superior and inferior surfaces in contact with the vertebrae.

**[0109]** Initial bone fusion and growth may occur where the vertebrae are in contact with BGPM **700**. With time, new bone growth begins to extend along the inferior and superior surfaces of implant **600** as well as into central cavity **671**, as seen in FIG. **15**. For example, in FIG. **15**, new bone growth region **720** extends from vertebra **712** into central cavity **671** while new bone growth region **722** extends from vertebra **714** into central cavity **671**. New bone growth regions **726** may also extend into the interior spaces of implant **600** that are adjacent to central cavity **671**.

**[0110]** Eventually, as seen in FIG. **16**, a solid column of new bone growth **724** may form throughout central cavity **671**. This new bone growth in central cavity **671**, along with new bone growth associated with other regions of the interior and exterior of implant **600**, helps to fuse vertebra **712** and vertebra **714**.

**[0111]** FIGS. **17-20** depict a schematic sequence of bone growth along a superior surface **675** of implant **600**. This new bone growth may occur prior to, simultaneously with, or after bone has grown through the interior of implant **600** as described above. While only the superior side is shown in FIGS. **17-20**, it may be appreciated that similar bone growth patterns may occur on the inferior side of the implant simultaneously.

**[0112]** FIG. **17** depicts an isometric view of implant **600** inserted between vertebra **712** and vertebra **714** as well as an

enlarged view of superior surface **675**. It may be appreciated that, BGPM **700** is not visible in the enlarged view in FIG. **17**. This is done for clarity so that new bone growth can be clearly seen as it forms along the surface of structural members of implant **600**.

[0113] In FIG. **18**, new bone growth occurs in multiple locations on superior surface **675**. Specifically, new bone growth region **802** occurs within central cavity **671**, as described above and depicted in FIGS. **14-16**. In addition, new bone growth regions **804** may first form at the protected fusion zones discussed earlier. As disclosed in The Protected Fusion Zone Application, new bone growth regions **804** occurring in protected fusion zones may be protected from local forces between bone contacting members and the vertebrae. This helps minimize the disturbance to new bone growth regions **804** in the protected fusion zones.

[0114] As shown in FIG. **19**, eventually, new bone growth may extend from the protective fusion zones to the entire length of plurality of bone contacting members **630**. In some embodiments, new bone growth may continue to grow along the surfaces of plurality of support members **632** as well.

[0115] It may be appreciated that new bone growth similarly occurs on the inferior surface of implant **600**, as well as extending around the lateral, posterior and anterior sides.

[0116] Finally, as seen in FIG. **20**, new bone growth region **802** may cover the exterior, and fill the interior, of an implant. At this point, there may be a new bone fusion portion **810** that extends between vertebra **712** and vertebra **714** that fuses the vertebrae together.

[0117] In some other embodiments, increased volume for bone graft material and eventually new bone growth may be created by removing one or more structures that are disposed within an internal region of an implant. For example, in another embodiment, the structures connecting superior and inferior rings (e.g., first support **226** and second support **228** shown in FIG. **3**) could be removed. Still other modifications could be made to incorporate any of the structures and/or arrangements as disclosed in U.S. Pat. No. 10,213,317, issued on Feb. 26, 2019, and titled "Implant with Supported Helical Members," which is hereby incorporated by reference in its entirety.

[0118] Embodiments can include provisions for texturing one or more surfaces of an implant. Such texturing can increase or otherwise promote bone growth and/or fusion to surfaces of the implant. In some embodiments, bone contacting members may be textured while support members may not be textured. This helps initial bone growth to be directed along the bone contacting members and especially into the protected fusion zones, rather than growing initially across support members. In other embodiments, however, support members could include surface texturing. In still further embodiments, one or more surfaces of a body could include surface texturing.

[0119] In some embodiments, the surface structure of one or more regions of an implant may be roughened or provided with irregularities. Generally, this roughened structure may be accomplished through the use of acid etching, bead or grit blasting, sputter coating with titanium, sintering beads of titanium or cobalt chrome onto the implant surface, as well as other methods. In some embodiments, the roughness can be created by 3D printing a raised pattern on the surface of one or more regions of an implant. In some embodiments, the resulting roughened surface may have pores of varying sizes. In some embodiments, pore sizes could range between

approximately 0.2 mm and 0.8 mm. In one embodiment, pore sizes could be approximately 0.5 mm. In other embodiments, surface roughness comprising pore sizes less than 0.2 mm and/or greater than 0.8 mm are possible.

[0120] The embodiments can make use of the surface texturing parts, features, processes or methods as disclosed in The Protected Fusion Zone Application.

[0121] The implants for use in the spine have overall dimensions suitable for insertion in the spine, typically between two vertebral bodies. The shape of the implant and dimensions depends on the site into which it is inserted. Exemplary heights for implants such as implant **100** and implant **600** include, but are not limited to, 5 mm to 30 mm. Other embodiments could have incremental heights of any value in the range between the aforementioned range, most often between 8 mm and 16 mm. Still other embodiments could have a height greater than 16 mm. Still other embodiments could have a height less than 8 mm. Additionally, the horizontal footprint of the implant could vary. Exemplary footprint sizes for any embodiments of the implant include, but are not limited to, 15-20 mm in the anterior-posterior direction and 40-60 mm in the lateral-lateral direction. Still other embodiments could be configured with any other footprint sizes.

[0122] The dimensions of one or more structural members could vary. In some embodiments, a structural member could have a cross-sectional diameter in a range between 0.2 and 3 mm. For structural members with polygonal cross sections, the dimensions characterizing the polygon (e.g., first and second diameters for an ellipse) could vary. As an example, a structural member with an elliptic cross section could have a cross section with a first diameter in a range between 0.2 mm and 3 mm and a second diameter in range between 0.2 mm and 3 mm. In other embodiments, a structural member could have any other cross-sectional diameter. Moreover, in some cases a bone contacting member and a support member could have similar cross-sectional diameters while in other cases a bone contacting member and a support member could have different cross-sectional diameters.

[0123] Embodiments can also be provided with various flat/parallel (0-degree), lordotic, and hyper-lordotic angles. In some embodiments, the implant can be configured with an approximately 8-degree angle between the superior and inferior surfaces. In other embodiments, the implant can be configured with an approximately 15-degree angle between the superior and inferior surfaces. In still other embodiments, the implant can be configured with an approximately 20-degree angle between the superior and inferior surfaces. Still other angles are possibly including any angles in the range between 0 and 30 degrees. Still other embodiments can provide a lordotic angle of less than 8 degrees. Still other embodiments can provide a hyper-lordotic angle of more than 20 degrees. In at least some embodiments, the lordotic angle of the implant is accomplished via the geometry of the central keel portion and the side frame portion (posterior or anterior).

[0124] The various components of an implant may be fabricated from biocompatible materials suitable for implantation in a human body, including but not limited to, metals (e.g. titanium or other metals), synthetic polymers, ceramics, and/or their combinations, depending on the particular application and/or preference of a medical practitioner.

[0125] Generally, the implant can be formed from any suitable biocompatible, non-degradable material with sufficient strength. Typical materials include, but are not limited to, titanium, biocompatible titanium alloys (e.g. YTitanium Aluminides,  $Ti_6-Al_4-V$  ELI (ASTM F 136 and F 3001), or  $Ti_6-Al_4-V$  (ASTM F 2989, F 1108 and ASTM F 1472)) and inert, biocompatible polymers, such as polyether ether ketone (PEEK) (e.g. PEEK-OPTIMA®, Invibio Inc and Zeniva Solvay Inc.). Optionally, the implant contains a radiopaque marker to facilitate visualization during imaging.

[0126] In different embodiments, processes for making an implant can vary. In some embodiments, the entire implant may be manufactured and assembled via readditional/CNC machining, injection-molding, casting, insert-molding, co-extrusion, pultrusion, transfer molding, overmolding, compression molding, 3-Dimensional (3-D) printing (including Direct Metal Laser Sintering and Electron Beam Melting), dip-coating, spray-coating, powder-coating, porous-coating, milling from a solid stock material and their combinations. Moreover, the embodiments can make use of any of the features, parts, assemblies, processes and/or methods disclosed in the “The Coiled Implant Application”.

[0127] While various embodiments have been described, the description is intended to be exemplary, rather than limiting, and it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible that are within the scope of the embodiments. Although many possible combinations of features are shown in the accompanying figures and discussed in this detailed description, many other combinations of the disclosed features are possible. Any feature of any embodiment may be used in combination with or substituted for any other feature or element in any other embodiment unless specifically restricted. Therefore, it will be understood that any of the features shown and/or discussed in the present disclosure may be implemented together in any suitable combination. Accordingly, the embodiments are not to be restricted except in light of the attached claims and their equivalents. Also, various modifications and changes may be made within the scope of the attached claims.

What is claimed is:

1. An implant, comprising:
  - a body including a ring, the ring further defining an opening;
  - the body defining a transverse plane dividing the implant into a superior half and an inferior half;
  - a first outer member extending outward in a direction away from the ring;
  - wherein the first outer member defines one or more arches;
  - wherein the opening of the ring further defines a central channel extending through the implant; and
  - wherein the one or more arches of the first outer member extend in a superior or inferior direction.
2. The implant according to claim 1, wherein the central channel extends from a superior side of the implant to an inferior side of the implant.
3. The implant according to claim 1, wherein the body includes a peripheral frame portion that defines an outer periphery of the implant.
4. The implant according to claim 3, wherein the first outer member extends from the ring to the peripheral frame portion.

5. The implant according to claim 1, further including a support attached to the first outer member at an attachment region, wherein the support extends in a circumferential direction defined by the ring.

6. The implant according to claim 5, wherein, at the attachment region, the support is disposed closer to the transverse plane than the first outer member is to the transverse plane.

7. An implant, comprising:

- a body including a ring, the ring further defining an opening;
- the body defining a transverse plane dividing the implant into a first half and a second half;
- a first outer member extending outward in a direction away from the ring and in substantial alignment with the transverse plane;
- wherein the first outer member defines one or more arches;
- wherein the opening of the ring further defines a central channel extending through the implant in a direction substantially perpendicular to the transverse plane; and
- wherein the one or more arches of the first outer member extend in a direction away from the transverse plane.

8. The implant according to claim 7, wherein the central channel extends from a first side of the implant to a second side of the implant.

9. The implant according to claim 7, wherein the body includes a peripheral frame portion that defines an outer periphery of the implant.

10. The implant according to claim 9, wherein the first outer member extends from the ring to the peripheral frame portion.

11. The implant according to claim 7, further including a support attached to the first outer member at an attachment region, wherein the support extends in a circumferential direction defined by the ring.

12. The implant according to claim 11, wherein, at the attachment region, the support is disposed closer to the transverse plane than the first outer member is to the transverse plane.

13. An implant, comprising:

- a body;
- the body defining a transverse plane dividing the implant into a first half and a second half;
- a first outer member disposed within the first half of the implant;
- a first support attached to the first outer member, the first support being disposed within the first half of the implant;
- a second outer member disposed within the second half of the implant;
- a second support attached to the second outer member, the second support being disposed within the second half of the implant;
- wherein the first outer member and the second outer member each form one or more arches;
- wherein the one or more arches of the first outer member extend in a first direction away from the transverse plane;
- wherein the implant includes a ring disposed in a central region of the implant, wherein the first outer member and the second outer member extend away from the ring in substantial alignment with the transverse plane;

wherein the opening of the ring defines a central channel extending through the implant.

14. The implant according to claim 13, wherein the central channel extends from a first side of the implant to a second side of the implant.

15. The implant according to claim 13, wherein the body includes a peripheral frame portion that defines an outer periphery of the implant.

16. The implant according to claim 15, wherein the first outer member extends from the ring to the peripheral frame portion.

17. The implant according to claim 13, wherein the first support is attached to the first outer member at a first attachment region, wherein the first support extends in a circumferential direction defined by the ring.

18. The implant according to claim 17, wherein, at the first attachment region, the first support is disposed closer to the transverse plane than the first outer member is to the transverse plane.

19. The implant according to claim 18, wherein the second support is attached to the second outer member at a second attachment region, wherein the second support extends in the circumferential direction.

20. The implant according to claim 19, wherein, at the second attachment region, the second support is disposed closer to the transverse plane than the second outer member is to the transverse plane.

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