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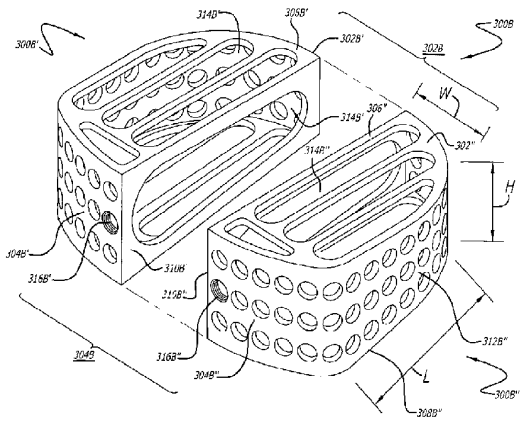

(57) Abstract: An interbody spinal implant adapted for placement across an intervertebral space formed across the height of a disc between two adjacent vertebral bodies. The implant has a leading end that includes at least a portion of an arc of a circle from side to side, and sides that are at least in part straight or a trailing end having a radius of curvature of another circle from side to side. The implant may be made cortical bone, a bone composite, or a material other than bone.

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CONTOURED SPINAL FUSION IMPLANTS

Related applications

This application claims priority to provisional application no. 60/281,187, filed April 3, 2001, and provisional application no. 60/281,112, filed April 2, 2001, both of which are incorporated by reference herein.

Field of the Invention

The present invention relates generally to interbody spinal implants preferably adapted for placement into an implantation space created across the height of a disc space between two adjacent vertebral bodies for the purpose of correcting spinal disease at that interspace. The implants are adapted such that fusion occurs at least in part through the implants. The implant may be made cortical bone, a bone composite, or a material other than bone.

Description of the Related Art

Implants for placement between adjacent vertebral bodies in the spine come in a variety of shapes and sizes and are made of a variety of materials. Such implants for use in human spinal surgery include implants made of bone or selected inert materials, such as titanium, that have a structure designed to promote fusion of the adjacent vertebral bodies by allowing bone to grow through the implant to thereby fuse the adjacent vertebral bodies.

Implants made of bone and utilized in interbody spinal surgery are often formed from a portion of the diaphysis. The diaphysis is the shaft of a major long bone between the epiphyses, the ends of the bone forming the joints.

A diaphyseal ring is formed by making two spaced apart cuts approximately perpendicular to the long axis of the diaphyseal portion of a major long bone with the medullary canal forming an opening through the ring. Such rings are generally harvested from femurs for use in the lumbar spine. Other bones from the arm or leg or other part of the human skeleton may be useful in various regions of the spine.

The cuts are generally spaced apart so as to form a ring of bone having a height corresponding to the restored disc space or slightly greater. Diaphyseal ring bone grafts are placed into the spine within and across the height of the space previously occupied by a spinal disc between adjacent vertebral bodies to

achieve interbody fusion of those vertebral bodies through the disc space. The diaphyseal ring bone graft is incorporated into the bony fusion over time.

Interbody spinal fusion with diaphyseal bone rings, however, has had limited success in the past. While all the causes for failure may not yet be appreciated, it is nevertheless believed that a failure to gain congruity at the interfaces of the bone ring implant to the adjacent vertebral bodies, and a failure to achieve stability of the bone ring implant, may be two of the more significant factors subject to the surgeon's control contributing to such failures.

At the time of surgery, where fusion is intended to occur between adjacent vertebral bodies of a patient's spine; the surgeon typically prepares an opening at the site of the intended fusion by removing some or all of the disc material that exists between the adjacent vertebral bodies to be fused. Because the outermost layers of bone of the vertebral end plate are relatively inert to new bone growth, the surgeon must work on the end plate to remove at least the outermost cell layers of bone to gain access to the blood-rich, vascular bone tissue within the vertebral body. In this manner, the vertebrae are prepared in a way that encourages new bone to grow into or through an implant that is placed between the vertebral bodies.

Present methods of forming this space between adjacent vertebral bodies generally include the use of one or more of the following: hand held biting and grasping instruments known as rongeurs; drills and drill guides; rotating burrs driven by a motor; osteotomes and chisels, and a double wheel cutter or vertebral interspace preparation device. In particular, the double wheel cutter or vertebral interspace preparation device, as disclosed by Michelson in WO 99/63891, incorporated herein by reference, is adapted for linear insertion, i.e., insertion along a single axis, and without the need to substantially move the device from side to side within the disc space along a second axis. In such a preferred embodiment, the device has at its working end an abrading element having a width generally corresponding to the width of the implant to be implanted.

There is a desire to improve congruity at the interfaces of the implant to the adjacent vertebral bodies, and to achieve stability of the implant. Therefore it is advantageous for the contour of the implants to closely match the implantation space formed between and at least in part into the adjacent vertebral bodies to

allow a more uniform load transfer across the implant between the vertebral bodies.

Interbody spinal implants that are entirely or almost entirely made of cortical bone or a bone composite material offer the advantages of that material including an appropriate modulus of elasticity and strength for the prescribed use, the capacity to be bioactive, including being osteoconductive, osteoinductive, osteogenic, and to more generally provide a good substrate for the formation of new bone as fusion occurs. Further, by being bioabsorable the bone material is replaced by the patient's own bone over time, thereby preventing stress shielding and leading to the eventual elimination of any foreign body from the implantation site. As it is desirable to take advantage of one or more of these benefits, there exists a need for an improved interbody spinal fusion implant made of bone, a bone composite material, or a material other than bone having a configuration that provides for an improved congruity of the implant to the vertebral bodies and improved implant stability.

The above discussion of background art is included to explain the context of the present invention. It is not to be taken as an admission that any of the documents or other material referred to was published, known or part of the common general knowledge at the priority date of any one of the claims of this specification.

SUMMARY OF THE INVENTION

In accordance with the purposes of the present invention, as embodied and broadly described herein, there is provided an interbody spinal implant made of cortical bone for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising: a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end; opposed upper and lower portions between said leading and

trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies, said upper and lower portions being non-arcuate along at least a portion of the length of said implant; and opposite sides between said upper portion and said lower portion, and between said leading and trailing ends, said opposite sides defining a width of said implant, at least one of said opposite sides being at least in part straight along at least a portion of the length of said implant, said leading end configured in the shape of approximately one half of a circle from one of said opposite sides to another of said opposite sides, the circle having a diameter generally equal to the width of said implant; said implant being manufactured from a bone ring obtained from a major long bone of a human having a medullary canal, said implant including at least a portion of the medullary canal passing through said upper and lower portions to form at least a portion of a passage adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said passage.

In accordance with the purposes of the present invention, as embodied and broadly described herein, an interbody spinal implant made of cortical bone is provided for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising: a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end; opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies; said implant having a maximum width that is greater than one-half of the width of the adjacent vertebral bodies into which said implant is adapted to be inserted, said leading end configured in the shape of approximately one half of a first circle along the width of said implant, said trailing end having a radius of curvature of a second circle along the width of said implant, the

second circle having a radius greater than the radius of the first circle; and said implant being manufactured from a bone ring obtained from a major long bone of a human having a medullary canal, said implant including at least a portion of the medullary canal passing through said upper and lower portions to form a passage adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said passage. Alternatively, the implants mentioned above may be manufactured from a bone composite material.

In accordance with the purposes of the present invention, as embodied and broadly described herein, there is provided an interbody spinal implant made of a bone composite material for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising: a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end; opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies, said upper and lower portions being non-arcuate along at least a portion of the length of said implant; opposite sides between said upper portion and said lower portion, and between said leading and trailing ends, said opposite sides defining a width of said implant, at least one of said opposite sides being at least in part straight along at least a portion of the length of said

implant, said leading end configured in the shape of approximately one half a circle from one of said opposite sides to another of said opposite sides, the circle having a diameter generally equal to the width of said implant; and said implant being manufactured from a bone composite material, said upper and lower portions of said implant including at least one opening in communication with one another to form at least a portion of a passage adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said passage.

In accordance with the purposes of the present invention, as embodied and broadly described herein, an interbody spinal implant made of a bone composite material for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising: a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end; opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies; said implant having a maximum width that is greater than one-half of the width of the adjacent vertebral bodies into which said implant is adapted to be inserted, said leading end configured in the shape of approximately one half of a first circle along the width of said implant, said trailing end having a radius of curvature of a second circle along the width of said implant, the second circle having a radius greater than the radius of the first circle; and said implant being manufactured from a bone composite material, said upper and lower portions of said implant including at least one opening in communication with one another to form a passage adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through aid passage.

In accordance with the purposes of the present invention, as embodied and broadly described herein, there is provided an artificial interbody spinal implant for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising: a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end; opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies, said upper and lower portions defining a height of said implant, said upper and lower portions being non-arcuate along at least a portion of the length of said implant; and opposite sides between said upper portion and said lower portion, and between said leading and trailing ends, said opposite sides defining a width of said implant, at least one of said opposite sides being at least in part straight along at least a portion of the length of said implant, said leading end configured in the shape of approximately one half of a circle from one of said opposite sides to another one of said opposite sides, the circle having a diameter generally equal to the width of said implant, the width of said implant being greater than the height of said implant; said implant being manufactured from a material other than bone, said upper and lower portions of said implant including at least one opening in communication with one another and adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said implant.

In accordance with the purposes of the present invention, as embodied and broadly described herein, there is provided an artificial interbody spinal implant for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising: a

leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end; opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies; said implant having a maximum width that is greater than one-half of the width of the adjacent vertebral bodies into which said implant is adapted to be inserted, said leading end configured in the shape of approximately one half of a first circle along the width of said implant, said trailing end having a radius of curvature of a second circle along the width of said implant, the second circle having a radius greater than the radius of the first circle; and said implant being manufactured from a material other than bone, said upper and lower portions of said implant including at least one opening in communication with one another and adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said implant.

Additional advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a top plan view of a vertebral body in the lumbar spine with an implantation space formed to receive a spinal implant having a radius of curvature at the leading end that is less than the radius of curvature of the trailing end of the anterior aspect of the vertebral body between the sides of the implantation space.

Fig. 2 is a side elevation view of two adjacent vertebral bodies in the lumbar spine with the implantation space of Fig. 1 formed across the height of the spinal disc and into the adjacent vertebral bodies.

Fig. 3 is a side perspective view of the implantation space of Fig. 1.

Fig. 4 is a top plan view of a vertebral body in the cervical spine with an implantation space formed to receive a spinal implant having a radius of curvature at the leading end that is less than the radius of curvature of the trailing end of the anterior aspect of the vertebral body.

Fig. 5 is a side elevation view of two adjacent vertebral bodies in the cervical spine with the implantation space of Fig. 4 formed across the height of the spinal disc and into the adjacent vertebral bodies.

Fig. 6 is a side perspective view of the implantation space of Fig. 4.

Fig. 7 is a top plan view of a vertebral body in the lumbar spine and a preferred embodiment of an implant in accordance with the present invention installed into the implantation space of Fig.1.

Fig. 8 is a side elevation view of two adjacent vertebral bodies with the implant of Fig. 7 installed into the implantation space of Fig. 1 formed across the height of the spinal disc and into the adjacent vertebral bodies.

Fig. 9 is a top plan view of the implant of Fig. 7.

Fig. 10 is a side elevation view of the implant of Fig. 7.

Fig. 11 is a leading end view of the implant of Fig. 7.

Fig. 12 is a trailing end view of the implant of Fig. 7.

Fig. 13 is a top plan view of a vertebral body in the lumbar spine and another preferred embodiment of an implant in accordance with the present invention installed into the implantation space of Fig.1.

Fig. 14 is a side elevation view of two adjacent vertebral bodies with the implant of Fig. 13 installed into the implantation space of Fig. 1 formed across the height of the spinal disc and into the adjacent vertebral bodies.

Fig. 15 is a top plan view of the implant of Fig. 13.

Fig. 16 is a side elevation view of the implant of Fig. 13.

Fig. 17 is a leading end view of the implant of Fig. 13.

Fig. 18 is a trailing end view of the implant of Fig. 13.

Fig. 19 is a top plan view of another preferred embodiment of an implant in accordance with the present invention for use in the implantation space of Fig. 4.

Fig. 20 is a top plan view of another preferred embodiment of an implant in accordance with the present invention for use in the implantation space of Fig. 4.

Fig. 21 is a rear perspective view of another preferred embodiment of an implant in accordance with another preferred embodiment of the present invention having two members that are preferably mirror images of one another.

Fig. 22 is a top plan view of one of the members of the implant of Fig. 21.

Fig. 23 is an interior side elevation view of one of the members of the implant of Fig. 21.

Fig. 24 is an exterior side elevation view of one of the members of the implant of Fig. 21.

Fig. 25 is a leading end view of one of the members of the implant of Fig. 21.

Fig. 26 is a trailing end view of one of the members of the implant of Fig. 21.

Fig. 27 is a rear perspective view of another preferred embodiment of an implant in accordance with another preferred embodiment of the present invention having two members that are preferably mirror images of one another.

Fig. 28 is a top plan view of one of the members of the implant of Fig. 27.

Fig. 29 is an interior side elevation view of one of the members of the implant of Fig. 27.

Fig. 30 is an exterior side elevation view of one of the members of the implant of Fig. 27.

Fig. 31 is a leading end view of one of the members of the implant of Fig. 27.

Fig. 32 is a trailing end view of one of the members of the implant of Fig. 27.

Fig. 33 is a top plan view of another preferred embodiment of an implant in accordance with the present invention and a second implant that is a mirror image thereof illustrated in dashed line, both implants being shown implanted from an anterior approach to the spine in a vertebral body illustrated in dashed line.

Fig. 34 is a top plan view of another preferred embodiment of an implant in accordance with the present invention and a second implant that is a mirror image thereof illustrated in dashed line, both implants being shown implanted

from an anterior approach to the spine in a vertebral body illustrated in dashed line.

Fig. 35 is a top plan view of another preferred embodiment of an implant in accordance with the present invention and a second implant that is a mirror image thereof illustrated in dashed line, both implants being shown implanted from a posterior approach to the spine in a vertebral body illustrated in dashed line.

Fig. 36 is a top plan view of another preferred embodiment of an implant in accordance with the present invention with bone engaging screws.

Fig. 37 is a side elevation view of the implant of Fig. 36.

Fig. 38 is a leading end view of the implant of Fig. 36.

Fig. 39 is a trailing end view of the implant of Fig. 36 with the bone engaging screws and lock installed.

Fig. 40 is a trailing end view of the implant of Fig. 39 without the bone engaging screws and lock installed.

Fig. 41 is a partial cross sectional side view of a preferred embodiment of a bone screw lock in accordance with the present invention for use with the implant of Fig. 36.

Fig. 42 is a cross sectional side view of another preferred embodiment of a bone screw lock in accordance with the present invention.

Fig. 43 is a top plan view of another preferred embodiment of an implant in accordance with the present invention with bone engaging screws.

Fig. 44 is a side elevation view of the implant of Fig. 43.

Fig. 45 is a leading end view of the implant of Fig. 43.

Fig. 46 is a trailing end view of the implant of Fig. 43 with the bone engaging screws and lock installed.

Fig. 47 is a trailing end view of the implant of Fig. 46 without the bone engaging screws and lock installed.

Fig. 48 is a partial cross sectional side view of a preferred embodiment of a bone screw lock in accordance with the present invention for use with the implant of Fig. 43.

Fig. 49 is a cross sectional side view of another preferred embodiment of a bone screw lock in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The following description is intended to be representative only and not limiting and many variations can be anticipated according to these teachings, which are included within the scope of this inventive teaching. Reference will now be made in detail to the preferred embodiments of this invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Figs. 1-3 show an implantation space 50 formed across the height of the space occupied by a spinal disc D and into vertebral bodies V in the lumbar spine. Implantation space 50 is preferably formed with the apparatus and method disclosed by Michelson in U.S. Patent No. 6,083,228, and WO 99/63891, the disclosures of which are both incorporated herein by reference. The instruments and method are not the subject matter of this application. It is understood that the preparation of the implantation space shown therein are a preferred instrument and method of preparing the implantation spaces and that any method and instrumentation suitable for the purpose may be utilized to prepare the desired implantation space.

Implantation space 50 is preferably formed in the endplate region ER in the subchondral bone of the vertebral body V. Implantation space 50 preferably is formed to have a leading edge 52 with a shape from side to side of approximately one-half of a first circle A. The trailing portion 54 of implantation space 50 preferably includes at least a portion of the anterior aspect of the vertebral body having a radius of curvature of a second circle B from side to side. Preferably the radius of circle A is less than the radius of circle B. Implantation space 50 may further include side edges 56, 58. Side edges 56, 58 preferably include at least a straight portion, may be parallel to one another along lines P and form a curved transition with leading edge 52.

Figs. 4-6 show an implantation space 60 formed across the height of the space occupied by a spinal disc D and into vertebral bodies V in the cervical spine. Implantation space 60 preferably is formed to have a leading edge 62 with a shape from side to side of approximately one half of a first circle A. The trailing portion of implantation space 60 preferably includes at least a portion of the anterior aspect of the vertebral body having a radius of curvature of a second

circle C from side to side. Preferably the radius of circle A is less than the radius of circle C. Implantation space 60, however, preferably does not have straight side edges like implantation space 50 because the anterior to posterior depth of cervical vertebral bodies is less than the anterior to posterior depth of lumbar vertebral bodies. Thus, the radius of circle C is smaller in the cervical spine than the radius of circle B in the lumbar spine.

Figs. 7-12 show an implant 100A in accordance with a preferred embodiment of the present invention. Implant 100A is preferably manufactured from a bone ring obtained from a major long bone of a human. Implant 100A has a leading end 102A for insertion first into the disc space between two adjacent vertebral bodies and a trailing end 104A opposite leading end 102A, and opposite sides 110A, 112A therebetween. Leading end 102A is preferably configured to match the contour of leading edge 52 of implantation space 50 and trailing end 104A is preferably configured to conform to the contour of the anterior aspect of the vertebral body at trailing portion 54 of implantation space 50. Sides 110A, 112A are generally planar and preferably correspond to the configuration of side edges 56, 58 of implantation space 50.

In a preferred embodiment of the present invention, leading end 102A, trailing end 104A, and opposite sides 110A, 112A are machined to have various configurations. Leading end 102A is preferably machined to have a shape of approximately half a first circle from side to side. Where the implantation space is prepared into the vertebral bodies to have a lip or ridge that is at least in part curved, leading end 102A may be adapted to abut at least that portion of the implantation space.

One or both of sides 110A, 112A may also be formed to be at least in part oriented generally parallel to the mid-longitudinal axis of implant 100A and/or to each other. Further, leading end 102A may be tapered to facilitate insertion of implant 100A between the two adjacent vertebral bodies.

Trailing end 104A preferably forms an arc of a second circle from side to side having a radius greater than the radius of the first circle associated with leading end 102A. Preferably, at least a portion of trailing end 104A is adapted to conform to at least a portion of the peripheral contour of the anterior aspect of the vertebral bodies adjacent the disc space into which the implant is adapted to be inserted, though the invention is not so limited.

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Fig. 12 shows that implant 100A preferably has a driver opening 116A at trailing end 104A for cooperatively engaging an instrument for installing implant 100A into the implantation space. Driver opening 116A is preferably configured for threaded engagement with an insertion instrument.

Figs. 8, 10, and 11 show at least a portion of upper and lower surfaces 106A, 108A in an angular relationship to each other from trailing end 104A to leading end 102A for allowing for angulation of the adjacent vertebral bodies relative to each other. Preferably, upper and lower surfaces 106A, 108A are non-arcuate in a direction along the mid-longitudinal axis of implant 100A. Implant 100A preferably has a maximum height that is less than the maximum width of the implant.

As shown in Fig. 9, upper and lower surfaces 106A, 108A preferably have a passage 114A passing therethrough between leading and trailing ends 102A, 104A, respectively, and opposite sides 110A, 112A. Passage 114A is preferably adapted to hold bone growth promoting material to permit for the growth of bone from vertebral body to vertebral body through passage 114A. In addition to passage 114A, upper and lower surfaces 106A, 108A may include at least one opening in communication with one another to permit for the growth of bone from vertebral body to vertebral body through implant 100A, though the invention is not so limited. Upper and lower surfaces 106A, 108A may also be porous and may include a bone ingrowth surface.

As shown in Fig. 9, the implants described herein may include a bone-engaging surface 118A such as knurling for example. Bone engaging surface 118A is configured to engage the bone of the adjacent vertebral bodies to maintain implant 100A within the adjacent vertebral bodies after implantation. Other preferred embodiments of bone-engaging surfaces may include the surfaces of the implant being roughened, ratcheted, splined, or may include at least one protrusion to penetrably engage the bone of the vertebral bodies. By way of example only, the implants of the present invention may include the surface configuration taught by Michelson in U.S. Patent Application No. 09/457,228, entitled "Spinal Implant Surface Configuration," the disclosure of which is incorporated by reference herein.

Implant 100A is preferably, but need not be manufactured from a diaphyseal bone ring. The diaphyseal bone ring is preferably obtained from a

major long bone of the human skeleton. The bone ring is formed by making two spaced apart cuts approximately perpendicular to the long axis of the diaphyseal portion of the major long bone with a portion of the medullary canal forming an opening through the ring. Such rings are generally harvested from femurs for use in the lumbar spine. Other bones from the arm or leg or other part of the human skeleton may be useful in various regions of the spine. The cuts may be made into the long bone generally perpendicular to or at other angles transverse to the long axis of the diaphyseal bone to form the bone ring having upper and lower surfaces. Making the cuts at an angle to each other creates a bone ring with upper and lower surfaces that are angled relative to each other. The angular relationship of the upper and lower surface of the bone ring, when subsequently formed into an implant and implanted into the spine, position the adjacent vertebral bodies in angular relationship to each other to restore the natural curvature of the spine, such as lordosis for example.

The bone may be machined to form an implant having a selected shape suitable for the intended purpose. Examples of tools which may be used to machine the implant include, but are not limited to, burrs, reamers, mills, saws, trephines, chisels, and the like. For example only, the leading end may be shaped to be approximately half a circle from side to side. The sides may be machined to be at least in part straight. The trailing end may be machined to any desired shape suitable for the intended purpose and may preferably be shaped to conform to the anatomical contour of the adjacent vertebral bodies between which the implant is adapted to be inserted. The medullary canal preferably forms a passage adapted to hold bone growth promoting materials and/or substances. Where it is appropriate, it may be desirable to preserve at least a portion of the natural curvature of the perimeter of the bone ring as part of the configuration of the implant shape.

Implant 100A preferably has a length greater than one-half the depth of the vertebral bodies adjacent the disc space into which the implant is adapted to be inserted as measured between the anterior and posterior aspects of the vertebral bodies. Implant 100A also preferably has a maximum width that is greater than one-half the width of the adjacent vertebral bodies into which the implant is adapted to be inserted.

For any of the embodiments of the implants of the present invention made at least in part of bone, instead of being machined from a single bone portion, the implant can be manufactured from a composite bone material which may include at least one of cortical bone fibers, bone filaments, bone particles, or bone dust, and a binding material which may or may not be bioactive and/or bioresorbable such as a plastic, ceramic, for example. By way of example only and not limitation, bioresorbable materials may include polygalactone. Once formed, the composite implant material may be machined or molded, into the desired shape.

Figs. 13-18 show an implant 100B preferably made of a material other than bone in accordance with a preferred embodiment of the present invention. Implant 100B has a leading end 102B for insertion first into the disc space between two adjacent vertebral bodies and a trailing end 104B opposite leading end 102B, and opposite sides 110B, 112B therebetween. Leading end 102B is preferably configured to match the contour of leading edge 52 of implantation space 50 and trailing end 104B is preferably configured to conform to the contour of the anterior aspect of the vertebral body at trailing portion 54 of implantation space 50. Sides 110B, 112B are generally planar and preferably correspond to the configuration of side edges 56, 58 of implantation space 50.

In a preferred embodiment of the present invention, leading end 102B, trailing end 104B, and opposite sides 110B, 112B may have various configurations. Leading end 102B is preferably is in the shape of approximately half a first circle from side to side. Where the implantation space is prepared into the vertebral bodies to have a lip or ridge that is at least in part curved, leading end 102B may be adapted to abut at least that portion of the implantation space.

One or both of sides 110B, 112B may also be formed to be at least in part oriented generally parallel to the mid-longitudinal axis of implant 100B and/or to each other. One or both of sides 110B, 112B may include at least one opening 119B to permit for the growth of bone therethrough and into implant 100B, though the invention is not so limited. Further, leading end 102B may be tapered to facilitate insertion of implant 100B between the two adjacent vertebral bodies.

Trailing end 104B preferably forms an arc of a second circle from side to side having a radius greater than the radius of the first circle associated with leading end 102B. Preferably, at least a portion of trailing end 104B is adapted to conform to at least a portion of the peripheral contour of the anterior aspect of the

vertebral bodies adjacent the disc space into which the implant is adapted to be inserted, though the invention is not so limited.

Fig. 18 shows that implant 100B preferably has a driver opening 116B at trailing end 104B for cooperatively engaging an instrument for installing implant 100 into the implantation space. Driver opening 116B is preferably configured for threaded engagement with an insertion instrument.

Figs. 14, 16, and 17 show at least a portion of upper and lower surfaces 106B, 108B in an angular relationship to each other from trailing end 104B to leading end 102B for allowing for angulation of the adjacent vertebral bodies relative to each other. Preferably, upper and lower surfaces 106B, 108B are non-arcuate in a direction along the mid-longitudinal axis of implant 100B. Implant 100B preferably has a maximum height that is less than the maximum width of the implant.

As shown in Fig. 15, upper and lower surfaces 106B, 108B preferably have at least one opening 114B passing therethrough between leading and trailing ends 102B, 104B, respectively, and opposite sides 110B, 112B. Openings 114 are preferably adapted to hold bone growth promoting material to permit for the growth of bone from vertebral body to vertebral body through openings 114B and through implant 100B. Upper and lower surfaces 106B, 108B may also be porous and may include a bone ingrowth surface.

As shown in Fig. 15, the implants described herein may include a bone-engaging surface 118B such as knurling for example. Bone engaging surface 118B is configured to engage the bone of the adjacent vertebral bodies to maintain implant 100B within the adjacent vertebral bodies after implantation. Other preferred embodiments of bone-engaging surfaces may include the surfaces of the implant being roughened, ratcheted, splined, or may include at least one protrusion to penetrably engage the bone of the vertebral bodies.

The base material used to form the implant of Figs. 13-18 is preferably a material other than bone. In a preferred embodiment, the material of the implant may be formed of an artificial material such as metal including, but not limited to, titanium and its alloys, ASTM material, cobalt chrome, or tantalum, ceramic, various surgical grade plastics, plastic composites, carbon fiber composites, coral, and can include artificial materials which are at least in part bioresorbable.

Implant 100B preferably has a length greater than one-half the depth of the vertebral bodies adjacent the disc space into which the implant is adapted to be inserted as measured between the anterior and posterior aspects of the vertebral bodies. Implant 100B also preferably has a maximum width that is greater than one-half the width of the adjacent vertebral bodies into which the implant is adapted to be inserted.

Fig. 19 shows another preferred embodiment of the present invention of an implant made of bone or a bone composite for use in the cervical spine generally referred to by the numeral 200A. Implant 200A is preferably configured to conform to the shape of implantation space 60 formed in the endplates of adjacent cervical vertebral bodies with instrumentation and methods similar to those used in association with the lumbar spine but modified for use in the cervical spine. Implant 200A may, for example, have a leading end 202A formed to have a shape of approximately one-half a first circle from side to side. Trailing end 204A preferably may be formed as an arc of a second circle from side to side that intersects the curvature of leading end 202A from side to side. The radius of the second circle associated with trailing end 204A is preferably greater that the radius of the first circle associated with leading end 202A.

Fig. 20 shows another preferred embodiment of the present invention of an implant made of a material other than bone for use in the cervical spine generally referred to by the numeral 200B. Implant 200B is preferably configured to conform to the shape of implantation space 60 formed in the endplates of adjacent cervical vertebral bodies. Implant 200B may, for example, have a leading end 202B formed to have a shape of approximately one-half a first circle from side to side. Trailing end 204B preferably may be formed as an arc of a second circle from side to side that intersects the curvature of leading end 202B from side to side. The radius of the second circle associated with trailing end 204B is preferably greater that the radius of the first circle associated with leading end 202B.

Figs. 21-26 show an implant 300A preferably made of bone or a bone composite material in accordance with another preferred embodiment of the present invention adapted for use from the anterior approach to the spine. Fig. 21 shows a rear perspective view of implant 300A. Implant 300A includes at least two members 300A', 300A" that are adapted to be placed side by side with

one another. Member 300A' is preferably, but need not be a mirror image of member 300A". The description of member 300A' is equally applicable to member 300A". Member 300A' has a leading portion 302A' for insertion first into the disc space between two adjacent vertebral bodies and a trailing portion 304A' opposite leading portion 302A'. Member 300A' has a top 306A', a bottom 308A', an interior side 310A', and an exterior facing side 312A' opposite interior facing side 310A'. As used herein, the phrase "interior side" describes the side of the member adapted to be orientated toward the interior side of another member when a pair of members are inserted side by side into the disc space. In a preferred embodiment, interior side 310A' includes at least a portion of the medullary canal of the bone ring.

Leading portions 302A', 302A" of each member 300A', 300A", respectively, form leading end 302A of implant 300A when the members are placed side by side to one another. Leading end 302A of implant 300A is preferably configured in the shape of one-half a first circle from side to side. Trailing end 304A, composed of trailing portions 304A', 304A" when members 300A', 300A" are placed side by side to one another, may, but need not be formed as an arc of a second circle side to side having a radius greater than a radius of the first circle associated with leading end 302A of implant 300A.

Member 300A' is placed side by side with member 300A" so that the portion of the medullary canal of interior side 310A' of each member are adjacent one another to form a passage 314A through implant 300A. Preferably passage 314A is adapted to hold bone growth promoting material to permit for the growth of bone from vertebral body to vertebral body through passage 314A. Member 300A' preferably has a maximum width W that is less than approximately one-half the width of the adjacent vertebral bodies into which the member is adapted to be inserted. Also, the combined width of both members 300A', 300A" is preferably greater than one-half the width of the adjacent vertebral bodies into which the members are adapted to be inserted.

Members 300A', 300A" provide the added advantage in that each member can be inserted through a smaller space than a single larger implant, to achieve the same effect as the larger implant.

Figs. 27-32 show an implant 300B made of a material other than bone in accordance with another preferred embodiment of the present invention adapted

for use from the anterior approach to the spine. Fig. 27 shows a rear perspective view of implant 300B. Implant 300B includes at least two members 300B', 300B" that are adapted to be placed side by side with one another. Member 300B' is preferably, but need not be a mirror image of member 300B". The description of member 300B' is equally applicable to member 300B". Member 300B' has a leading portion 302B' for insertion first into the disc space between two adjacent vertebral bodies and a trailing portion 304B' opposite leading portion 302B'. Member 300B' has a top 306B', a bottom 308B', an interior side 310B', and an exterior facing side 312B' opposite interior facing side 310B'.

Leading portions 302B', 302B" of each member 300B', 300B", respectively, form leading end 302B of implant 300B when the members are placed side by side to one another. Leading end 302B of implant 300B is preferably configured in the shape of one-half a first circle from side to side. Trailing end 304B, composed of trailing portions 304B', 304B" when members 300B', 300B" are placed side by side to one another, may, but need not be formed as an arc of a second circle side to side having a radius greater than a radius of the first circle associated with leading end 302B of implant 300B.

Member 300' is placed side by side with member 300B" so that a portion of interior side 310B' of each member are adjacent one another. Top 306B' and bottom 308B' preferably have at least one opening 314B' passing therethrough between leading and trailing portions 302B', 304B', respectively, and sides 310B', 312B'. Openings 314B' are adapted to hold bone growth promoting material to permit for the growth of bone from vertebral body to vertebral body through openings 314B. Interior side 310B' may also include at least one opening 314B' passing therethrough configured to permit bone growth between and into adjacent members 300B', 300B". Member 300B' preferably has a maximum width W that is less than approximately one-half the width of the adjacent vertebral bodies into which the member is adapted to be inserted. Also, the combined width of both members 300B', 300B" is preferably greater than one-half the width of the adjacent vertebral bodies into which the members are adapted to be inserted.

Members 300B', 300B" provide the added advantage in that each member can be inserted through a smaller space than a single larger implant, to achieve the same effect as the larger implant.

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Fig. 33 shows an implant 400A in accordance with another preferred embodiment of the present invention adapted for use from an anterior approach to the spine. Implant 400A is similar to implant 100A and has a leading end 402A that is shaped as approximately one-half a first circle. Implant 400A is adapted to have a maximum width between sides 410A, 412A that is less than one-half of the width of the adjacent vertebral bodies into which implant 400A is adapted to be inserted. Trailing end 404A forms an arc of a second circle having a radius that is substantially greater than the radius of the first circle associated with leading end 402A. Implants 400A can be made of bone, a bone composite, or a material other than bone.

Fig. 34 shows an implant 500A in accordance with another preferred embodiment of the present invention adapted for use from an anterior approach to the spine. Implant 500A is similar to implant 400A except that both leading end 502A and trailing end 504A are preferably in the shape of a half circle side to side. Implants 500A can be made of bone, a bone composite, or a material other than bone.

Fig. 35 shows an implant 600A in accordance with another preferred embodiment of the present invention adapted for use from a posterior approach to the spine. Implant 600A is similar to implant 400A except that trailing end 604A is preferably at least in part straight from side to side. Implants 600A can be made of bone, a bone composite, or a material other than bone.

Figs. 36-42 show an implant 700A made of bone or a bone composite in accordance with another embodiment of the present invention. Implant 700A is similar to implant 100A and has a leading end 702A in the shape of approximately one-half a first circle A and a trailing end 704A formed as an arc of a second circle C. Implant 700A preferably includes straight portions 711A, 713A along at least a portion of sides 710A, 712A, respectively, that are preferably parallel to each other along lines P. Implant 700A also preferably includes a curved transition from each straight portion 711A, 713A of sides 710A, 712A, respectively, to trailing end 704A to form rounded portions 715A, 717A, respectively. Rounded portion 715A, 717A may be an arc of a third circle E that preferably has a radius less than the radii of circle A associated with leading end 702A and/or circle C associated with trailing end 704A.

In a preferred embodiment, implant 700A may be machined so as to be adapted to receive through bone screw receiving holes 720A at trailing end 704A at least a pair of opposed appropriately sized bone screws 722A preferably, but not necessarily, made of cortical bone. Bone engaging screws 722A may be aligned or offset from each other. At least one screw 722A engages each of the vertebral bodies adjacent a disc space to be fused and into which implant 700A is implanted. A purpose of the bone screws is to rigidly secure the implant within the vertebral segment. A further purpose is to pull each of the adjacent vertebral bodies toward the implant and towards each other. Trailing end 704A of implant 700A preferably includes a recess 724A having bone screw receiving holes 720A therein and an opening 726A configured to cooperatively receive a locking cap 728A adapted to lock at least one bone screw 722A to implant 700A.

As shown in Fig. 41, implant 700A is preferably further machined and adapted to receive a lock 728A, preferably made of cortical bone, at trailing end 704A for securing bone engaging screws 722A therein and preventing the screws from backing out. Locking cap 728A has a top 730A, a stem 732A, and a tool engagement area 734A. In use, locking cap cooperatively engages trailing end 704A of implant 700A at opening 726A to lock at least one bone screw to implant 700A. If desired, locking cap 728A may include a thread on stem 732A to allow locking cap 728A to rotationally engage implant 700A.

Fig. 42 shows another preferred embodiment of a locking cap, generally referred to by the numeral 736A. Locking cap 736A includes a top 738A having a thread 740A at its outer perimeter that is adapted to cooperatively engage a corresponding threaded recess in the implant.

The bone implant, bone screws, and/or locks can be made of a bioresorbable material, including but not limited to cortical bone, plastics and composite plastics. Suitable plastics may include those comprising lactides, galactides, glycolide, capronlactone, trimethylene carbonate, or dioxanone in various polymers, and/or combinations thereof.

Figs. 43-49 show an implant 700B made of a material other than bone in accordance with another embodiment of the present invention. Implant 700B is similar to implant 100B and has a leading end 702B in the shape of approximately one-half a first circle A and a trailing end 704B formed as an arc of a second circle C. Implant 700B preferably includes straight portions 711B, 713B

along at least a portion of sides 710B, 712B, respectively, that are preferably parallel to each other along lines P. Implant 700B also preferably includes a curved transition from each straight portion 711B, 713B of sides 710B, 712B, respectively, to trailing end 704B to form rounded portions 715B, 717B, respectively. Rounded portion 715B, 717B may be an arc of a third circle E that preferably has a radius less than the radii of circle A associated with leading end 702B and/or circle C associated with trailing end 704B.

In a preferred embodiment, implant 700B may be adapted to receive through bone screw receiving holes 720B at trailing end 704B at least a pair of opposed appropriately sized bone screws 722B. Bone engaging screws 722B may be aligned or offset from each other. At least one screw 722B engages each of the vertebral bodies adjacent a disc space to be fused and into which implant 700B is implanted. Trailing end 704B of implant 700B preferably includes a recess 724B having bone screw receiving holes 720B therein and an opening 726B configured to cooperatively receive a locking cap 728B adapted to lock at least one bone screw 722B to implant 700B.

As shown in Fig. 48, implant 700B is preferably adapted to receive a lock 728B at trailing end 704B for securing bone engaging screws 722B therein and preventing the screws from backing out. Locking cap 728B has a top 730B, a stem 732B, and a tool engagement area 734B. In use, locking cap cooperatively engages trailing end 704B of implant 700B at opening 726B to lock at least one bone screw to implant 700B. If desired, locking cap 728B may include a thread on stem 732B to allow locking cap 728B to rotationally engage implant 700B.

Fig. 49 shows another preferred embodiment of a locking cap, generally referred to by the numeral 736B. Locking cap 736B includes a top 738B having a thread 740B at its outer perimeter that is adapted to cooperatively engage a corresponding threaded recess in the implant.

Implant 700B, bone screws 722B, and/or locks 728B, 736B can be made of a bioresorbable material, including but not limited to plastics and composite plastics. Suitable plastics may include those comprising lactides, galactides, glycolide, capronlactone, trimethylene carbonate, or dioxanone in various polymers, and/or combinations thereof.

By way of example only and not limitation, for use in the lumbar spine, the implants of the present invention may have a depth of approximately, 28-36 mm,

a width of approximately, 30-38 mm, and a height (max) of approximately 8-20 mm. The radius of curvature of the leading end may be approximately 15-19 mm and the radius of curvature of the trailing end may be approximately 20-30 mm.

In any of the embodiments of the present invention, the implant may include, be made of, treated, coated, filled, used in combination with, or have an opening, a hollow, or a passage for containing artificial or naturally occurring materials and/or substances suitable for implantation in the human spine. These materials and/or substances include any source of osteogenesis, bone growth promoting materials, bone, bone derived substances or products, demineralized bone matrix, mineralizing proteins, ossifying proteins, bone morphogenetic proteins, hydroxyapatite, genes coding for the production of bone, and bone including, but not limited to, cortical bone. The implant can include at least in part of materials that are bioabsorbable and/or resorbable in the body such as bone and/or bone growth promoting materials. The implant of the present invention can be formed of a porous material or can be formed of a material that intrinsically participates in the growth of bone from one of adjacent vertebral bodies to the other of adjacent vertebral bodies. Where such implants are for posterior implantation, the trailing ends of such implants may be treated with, coated with, or used in combination with chemical substances to inhibit scar tissue formation in the spinal canal. The implant of the present invention may be modified, or used in combination with materials to make it antibacterial, such as, but not limited to, electroplating or plasma spraying with silver ions or other substance. At least a portion of the implant may be treated to promote bone ingrowth between the implant and the adjacent vertebral bodies. The implant of the present invention may be used in combination with a spinal fixation implant such as any object, regardless of material, that can be inserted into any portion of the spine, such as but not limited to interbody spinal implants, structural bone grafts, mesh, cages, spacers, staples, bone screws, plates, rods, tethers of synthetic cords or wires, or other spinal fixation hardware

While the shapes of the various aspects of the implant have been described precisely, the scope of the present invention is not so limited and it is readily anticipated that the contours may be interrupted by minor irregularities such as for example only for the purpose of engaging the bone, encouraging the ingrowth or through growth of bone.

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While specific innovative features were presented in reference to specific examples, they are just examples, and it should be understood that various combinations of these innovative features beyond those specifically shown are taught such that they may now be easily alternatively combined and are hereby anticipated and claimed.

Throughout the description and claims of this specification, the word "comprise" and variations of that word, such as "comprising" and "comprises" are not intended to exclude other additives, steps or integers.

The claims defining the invention are as follows:

1. An interbody spinal implant made of cortical bone for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising:

a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end;

opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies, said upper and lower portions being non-arcuate along at least a portion of the length of said implant; and

opposite sides between said upper portion and said lower portion, and between said leading and trailing ends, said opposite sides defining a width of said implant, at least one of said opposite sides being at least in part straight along at least a portion of the length of said implant, said leading end configured in the shape of approximately one half of a circle from one of said opposite sides to another of said opposite sides, the circle having a diameter generally equal to the width of said implant;

said implant being manufactured from a bone ring obtained from a major long bone of a human having a medullary canal, said implant including at least a portion of the medullary canal passing through said upper and lower portions to form at least a portion of a passage adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said passage.

2. An interbody spinal implant made of cortical bone for insertion at least in part into an implantation space formed across the height of a disc

space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising:

a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end;

opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies;

said implant having a maximum width that is greater than one-half of the width of the adjacent vertebral bodies into which said implant is adapted to be inserted, said leading end configured in the shape of approximately one half of a first circle along the width of said implant, said trailing end having a radius of curvature of a second circle along the width of said implant, the second circle having a radius greater than the radius of the first circle; and

said implant being manufactured from a bone ring obtained from a major long bone of a human having a medullary canal, said implant including at least a portion of the medullary canal passing through said upper and lower portions to form a passage adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said passage.

3. The implant of claim 2, wherein said implant has a perimeter, said passage being within said perimeter of said implant.

4. An interbody spinal implant made of a bone composite material for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising:

a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end;

opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies, said upper and lower portions being non-arcuate along at least a portion of the length of said implant;

opposite sides between said upper portion and said lower portion, and between said leading and trailing ends, said opposite sides defining a width of said implant, at least one of said opposite sides being at least in part straight along at least a portion of the length of said implant, said leading end configured in the shape of approximately one half a circle from one of said opposite sides to another of said opposite sides, the circle having a diameter generally equal to the width of said implant; and

said implant being manufactured from a bone composite material, said upper and lower portions of said implant including at least one opening in communication with one another to form at least a portion of a passage adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said passage.

5. The implant of claim 1 or 4, wherein said passage is between said opposite sides of said implant.

6. The implant of claim 1 or 4, wherein said passage intersects at least one of said opposite sides of said implant.

7. The implant of claim 1 or 4, wherein said passage is between said leading and trailing ends of said implant.

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8. An interbody spinal implant made of a bone composite material for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising:

a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end;

opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies;

said implant having a maximum width that is greater than one-half of the width of the adjacent vertebral bodies into which said implant is adapted to be inserted, said leading end configured in the shape of approximately one half of a first circle along the width of said implant, said trailing end having a radius of curvature of a second circle along the width of said implant, the second circle having a radius greater than the radius of the first circle; and

said implant being manufactured from a bone composite material, said upper and lower portions of said implant including at least one opening in communication with one another to form a passage adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said passage.

9. The implant of claim 4 or 8, wherein said bone composite material includes at least one of cortical bone fibers, bone filaments, bone particles and bone dust.

10. The implant of claim 4 or 8, further comprising a binding material.

11. The implant of claim 10, wherein said binding material is at least one of bioactive and bioresorbable.

12. The implant of claim 8, wherein implant has a perimeter and said passage is at least in part within said perimeter of said implant.

13. The implant of claim 2 or 8, wherein said implant has a perimeter, said passage intersecting at least a portion of said perimeter of said implant.

14. The implant of claim 2 or 8, wherein said passage is between said leading and trailing ends of said implant.

15. The implant of claim 1, 2, 4 or 8, wherein said implant includes at least two members, each member having a leading portion, a trailing portion, a top, a bottom, and at least one side, each member being adapted to be placed side by side with another of said members, said leading portion of said members forming said leading end of said implant when placed side by side.

16. The implant claim 15, wherein each member includes at least a portion of said passage.

17. The implant of claim 1, 2, 4 or 8, wherein said implant comprises at least in part of a bone growth promoting material.

18. The implant of claim 1, 2, 4 or 8, wherein said trailing end is adapted to receive at least one bone screw adapted to engage at least one vertebral body when inserted through said implant.

19. The implant of claim 18, further comprising a lock for locking at least one bone screw to said implant.

20. The implant of claim 19, wherein said lock is made of one of cortical bone and a bioresorbable material.

21. The implant of claim 18, wherein said screw is made of one of cortical bone and a bioresorbable material.

22. An artificial interbody spinal implant for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising:

a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end, said trailing end being adapted to conform from side to side to at least a portion of the peripheral contour of at least one of the anterior and posterior aspects of the vertebral bodies adjacent the disc space into which said implant is inserted;

opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies, said upper and lower portions defining a height of said implant, said upper and lower portions being non-arcuate along at least a portion of the length of said implant; and

opposite sides between said upper portion and said lower portion, and between said leading and trailing ends, said opposite sides defining a width of said implant, at least one of said opposite sides being at least in part straight along at least a portion of the length of said implant, said leading end configured in the shape of approximately one half of a circle from one of said opposite sides to another one of said opposite sides, the circle having a diameter generally equal to the width of said implant, the width of said implant being greater than the height of said implant;

said implant being manufactured from a material other than bone, said upper and lower portions of said implant including at least one opening in communication with one another and adapted to hold

bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said implant.

23. The implant of claim 1, 4 or 22, wherein said implant has a maximum width between said opposite sides that is greater than one-half of the width of the adjacent vertebral bodies into which said implant is adapted to be inserted.

24. The implant of claim 1, 4 or 22, wherein said implant has a maximum width between said opposite sides that is less than one-half of the width of the adjacent vertebral bodies into which said implant is adapted to be inserted.

25. The implant of claim 24, wherein said implant is adapted to be inserted side by side a second of said implant into the disc space between the adjacent vertebral bodies.

26. The implant of claim 1, 2, 4 or 22, wherein at least a portion of said leading end has a reduced height to facilitate insertion of said implant between the two adjacent vertebral bodies.

27. The implant of claim 1, 4 or 22, wherein said trailing end has a radius of curvature of a second circle from side to side.

28. The implant of claim 27, wherein the radius of curvature said trailing end is greater than the radius of curvature of the leading end of said implant.

29. The implant of claim 22, wherein said at least one opening is between said opposite sides of said implant.

30. The implant of claim 22, wherein said at least one opening intersects at least one of said opposite sides.

31. The implant of claim 22, wherein said at least one opening is between said leading and trailing ends of said implant.

32. An artificial interbody spinal implant for insertion at least in part into an implantation space formed across the height of a disc space between adjacent vertebral bodies of a human spine, the vertebral bodies having an anterior aspect and a posterior aspect and a depth therebetween, said implant comprising:

a leading end for insertion first into the disc space and a trailing end opposite said leading end, said implant having a length from said leading end to said trailing end;

opposed upper and lower portions between said leading and trailing ends adapted to be placed at least in part within and across the height of the disc space to contact and support the adjacent vertebral bodies;

said implant having a maximum width that is greater than one-half of the width of the adjacent vertebral bodies into which said implant is adapted to be inserted, said leading end configured in the shape of approximately one half of a first circle along the width of said implant, said trailing end having a radius of curvature of a second circle along the width of said implant, the second circle having a radius greater than the radius of the first circle; and

said implant being manufactured from a material other than bone, said upper and lower portions of said implant including at least one opening in communication with one another and adapted to hold bone growth promoting material for permitting for the growth of bone from vertebral body to vertebral body through said implant.

33. The implant of claim 2, 8 or 32, wherein said leading end and said trailing end of said implant intersect at diametrically opposite points of said implant.

34. The implant of claim 2, 8 or 32, wherein said width of said implant is approximately equal to the diameter of the first circle.

35. The implant of claim 2, 8 or 32, wherein said implant has a height from said upper portion to said lower portion, the height of said implant being less than the maximum width of said implant.

36. The implant of claim 2, 8 or 32, wherein at least a portion of said leading end has a reduced height to facilitate insertion of said implant between the two adjacent vertebral bodies.

37. The implant of claim 1, 2, 4, 8 or 32, wherein said trailing end is adapted to conform from side to side to at least a portion of the peripheral contour of the anterior aspect of the vertebral bodies adjacent a disc space into which said implant is inserted.

38. The implant of claim 32, wherein said implant has a perimeter, said at least one opening being within said perimeter of said implant.

39. The implant of claim 32, wherein said implant has a perimeter, said at least one opening intersecting at least a portion of said perimeter of said implant.

40. The implant of claim 22 or 32, wherein said at least one opening is between said leading and trailing ends of said implant.

41. The implant of claim 2, 8 or 32, further comprising opposite sides between said leading end and said trailing end.

42. The implant of claim 41, wherein at least one of said opposite sides is at least in part straight along at least a portion of the length of said implant.

43. The implant of claim 1, 4, 22 or 41, wherein said implant has a mid-longitudinal axis along the length, at least one of said opposite sides being at least in part oriented generally parallel to the mid-longitudinal axis of said implant.

44. The implant of claim 1, 4, 22 or 41, wherein said opposite sides are at least in part generally parallel one another.

45. The implant of claim 1, 2, 4, 8, 22 or 32, wherein at least a portion of said upper and lower surfaces are in an angular relationship to each other from trailing end to leading end for allowing angulation of the adjacent vertebral bodies relative to each other.

46. The implant of claim 1, 2, 4, 8, 22 or 32, wherein said implant has a maximum length less than and approximating the posterior to anterior depth of the vertebral bodies.

47. The implant of claim 1, 2, 4, 8, 22 or 32, further comprising a bone engaging surface formed on the exterior of at least said upper and lower portions for engaging the adjacent vertebral bodies, said bone engaging surface including at least one of a protrusion, a ratchet, a spike, a spline, surface roughenings, and knurling.

48. The implant of claim 22 or 32, wherein said implant includes at least two members, each member having a leading portion, a trailing portion, a top, a bottom, and at least one side, each member being adapted to be placed side by side with another of said members, said leading portion of said members forming said leading end of said implant when placed side by side.

49. The implant of claim 15 or 48, wherein said implant includes two of said members, each member being a mirror image of the other.

50. The implant of claim 48, wherein each member includes at least a portion of said at least one opening.

51. The implant of claim 1, 2, 4, 8, 22 or 32, in combination with a bone growth promoting material.

52. The implant of claim 51 wherein said bone growth promoting material is selected from one of bone, bone derived products, demineralized bone matrix, mineralizing proteins, ossifying proteins, bone morphogenetic protein, hydroxyapatite, and genes coding for the production of bone.

53. The implant of claim 1, 2, 4, 8, 22 or 32, wherein said implant is treated with a bone growth promoting substance.

54. The implant of claim 1, 2, 4, 8, 22 or 32, wherein said implant is at least in part resorbable.

55. The implant of claim 1, 2, 4, 8, 22 or 32, in combination with a chemical substance adapted to inhibit scar formation.

56. The implant of claim 1, 2, 4, 8, 22 or 32, in combination with an antimicrobial material.

57. The implant of claim 1, 2, 4, 8, 22 or 32, wherein at least a portion of said implant is treated to promote bone ingrowth between said implant and said adjacent vertebral bodies.

58. The implant of claim 1, 2, 4, 8, 22 or 32, in combination with at least one spinal fixation implant.

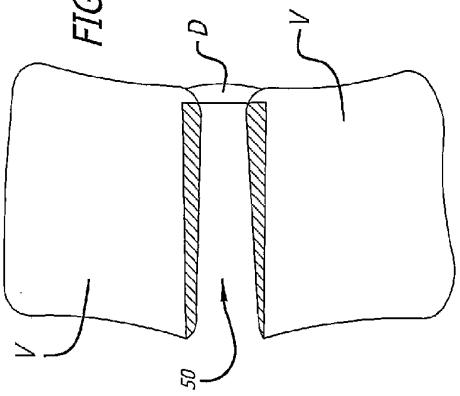
59. The implant of claim 41, further comprising a curved transition between at least one of said opposite sides and said trailing end, said curved transition forming at least part of an arc of a circle.

60. The implant of claim 22 or 32, wherein said trailing end is adapted to receive at least one bone screw adapted to engage at least one vertebral body when inserted through said implant.

61. The implant of claim 60, further comprising a lock for locking at least one bone screw to said implant.

62. An interbody spinal implant, substantially as hereinbefore described with reference to Figures 7 to 12, 13 to 18, 19, 20, 21 to 26, 27 to 32, 33, 34, 35, 36 to 41, 42, 43 to 48 or 49.

Dated: 14 October, 2004
PHILLIPS ORMONDE & FITZPATRICK
Attorneys for:
Gary K Michelson



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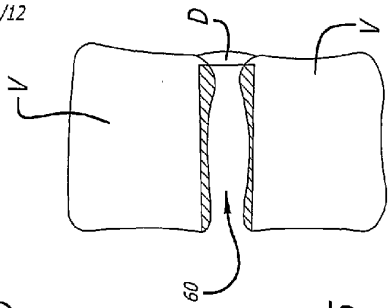

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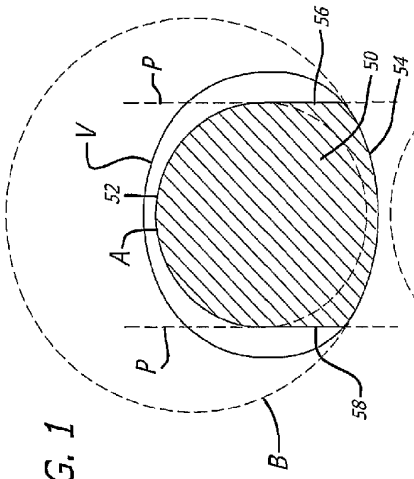
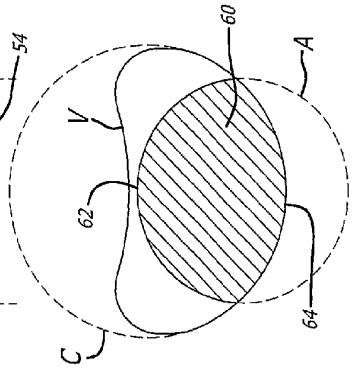


FIG. 1



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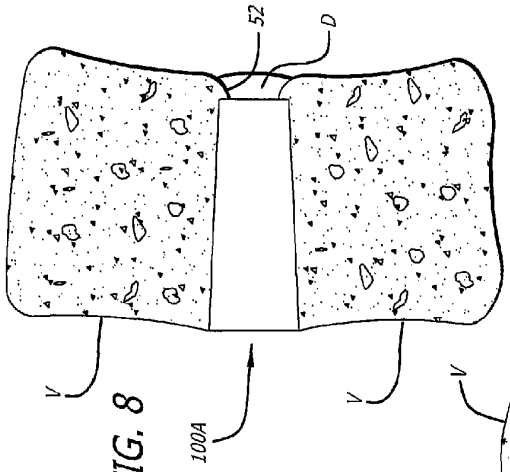

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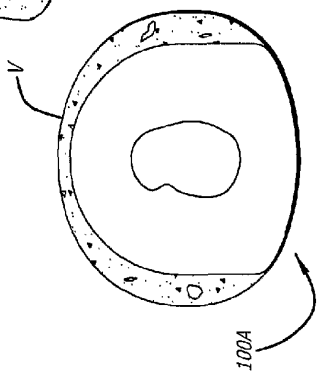


FIG. 7

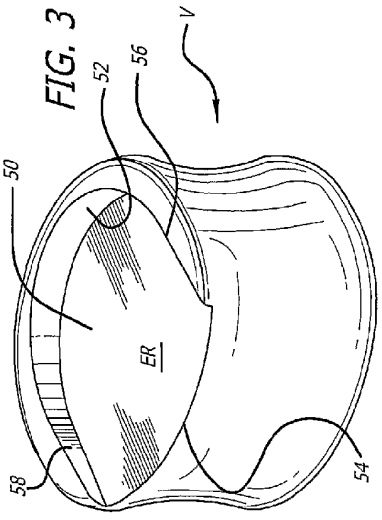
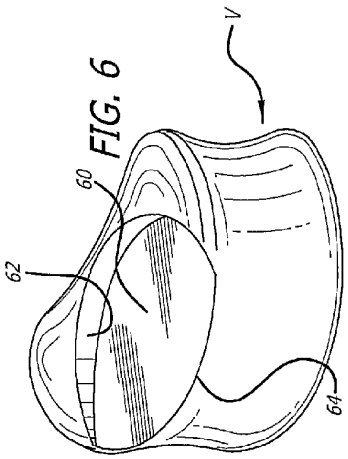


FIG. 3



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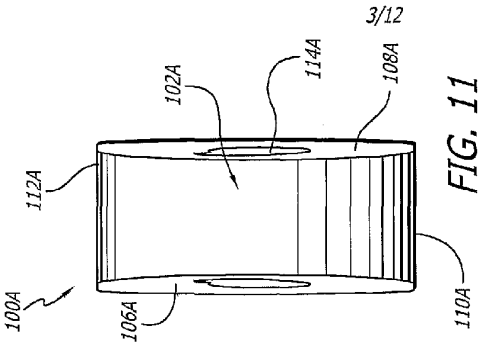

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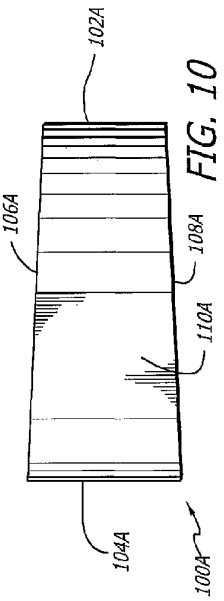

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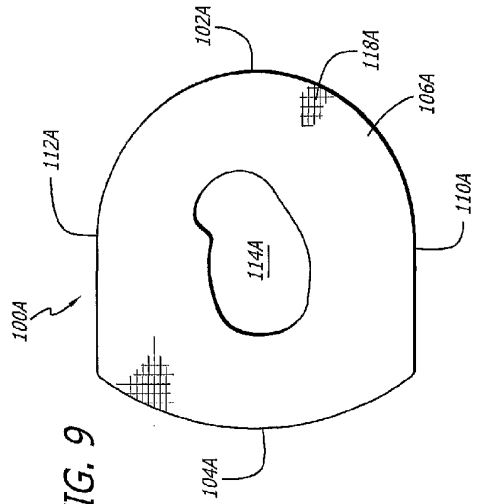

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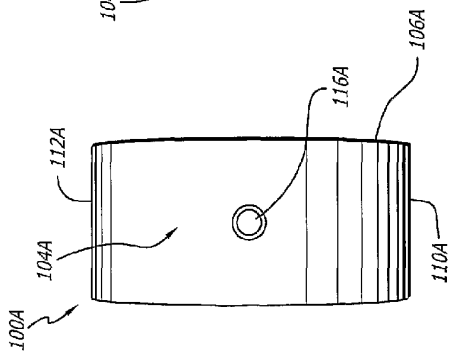

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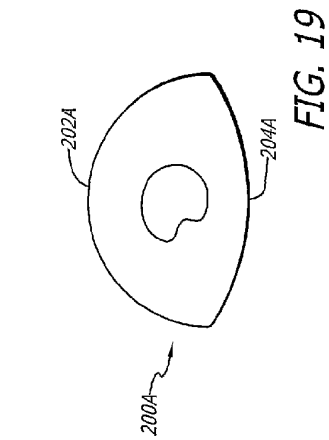

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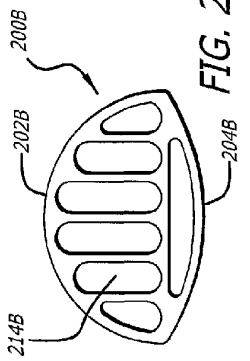
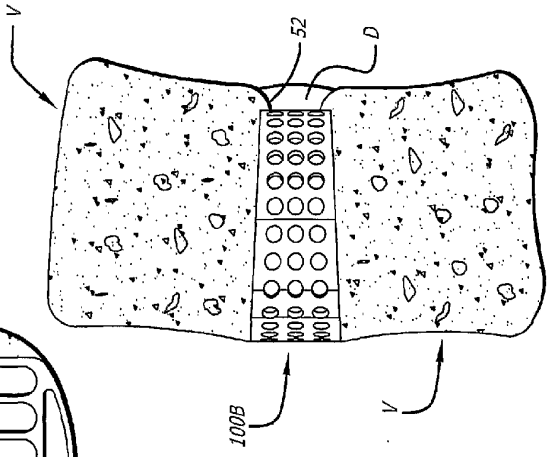


FIG. 20



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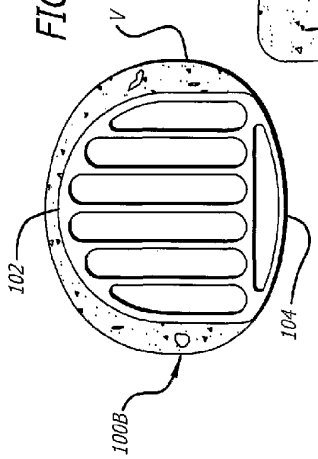

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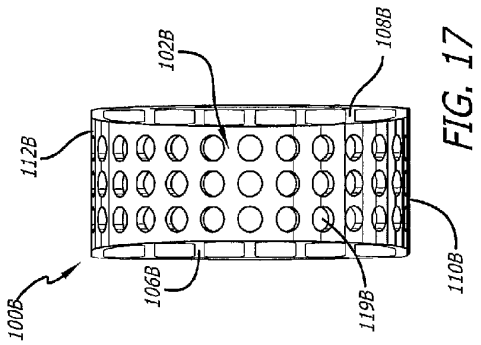

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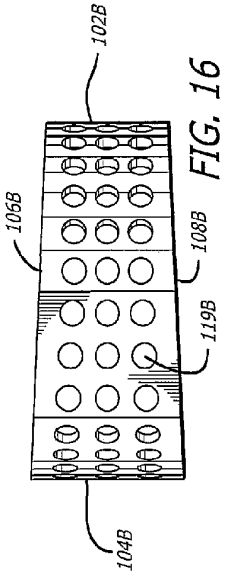

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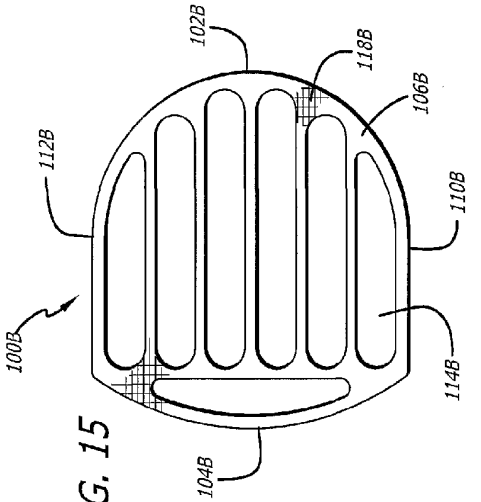

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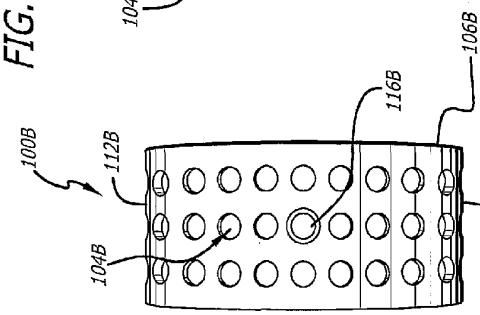

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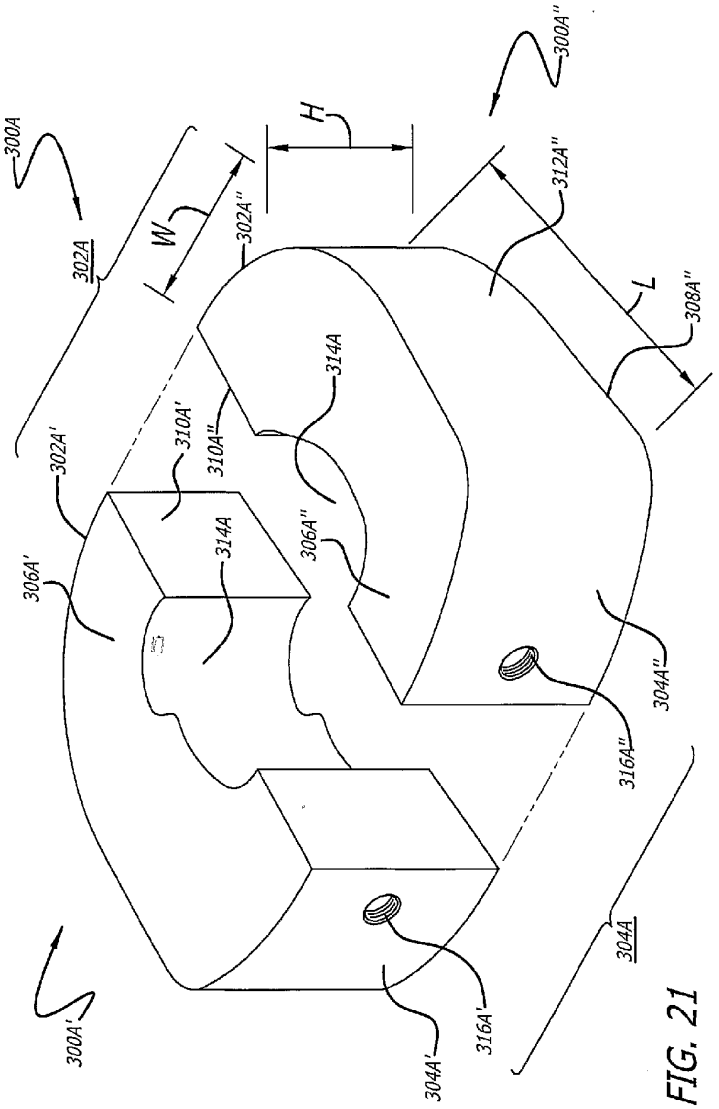
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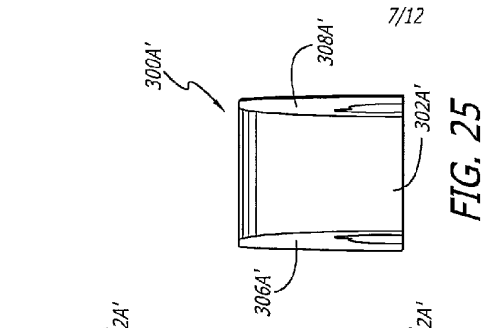
FIG. 21



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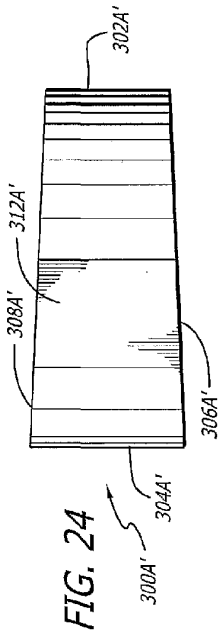

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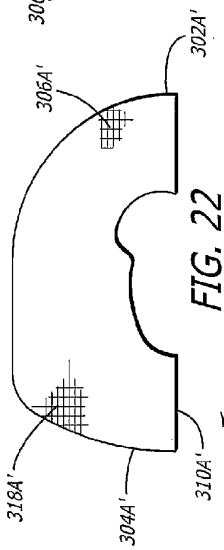

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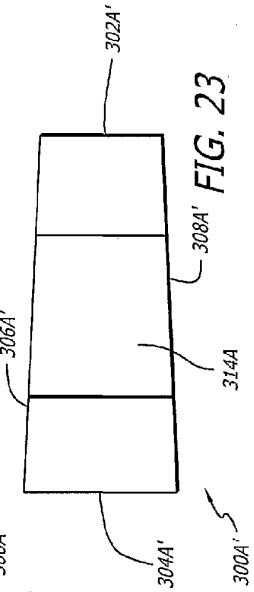
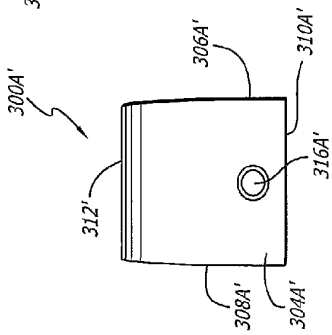


FIG. 23



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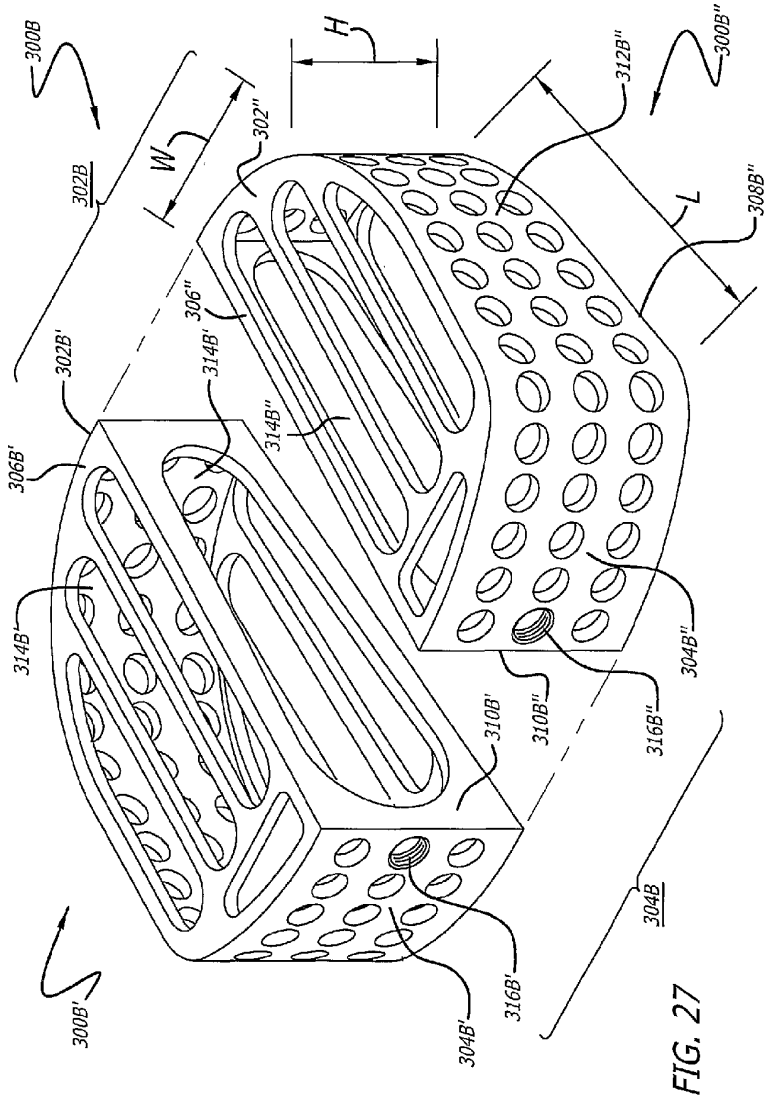
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FIG. 27

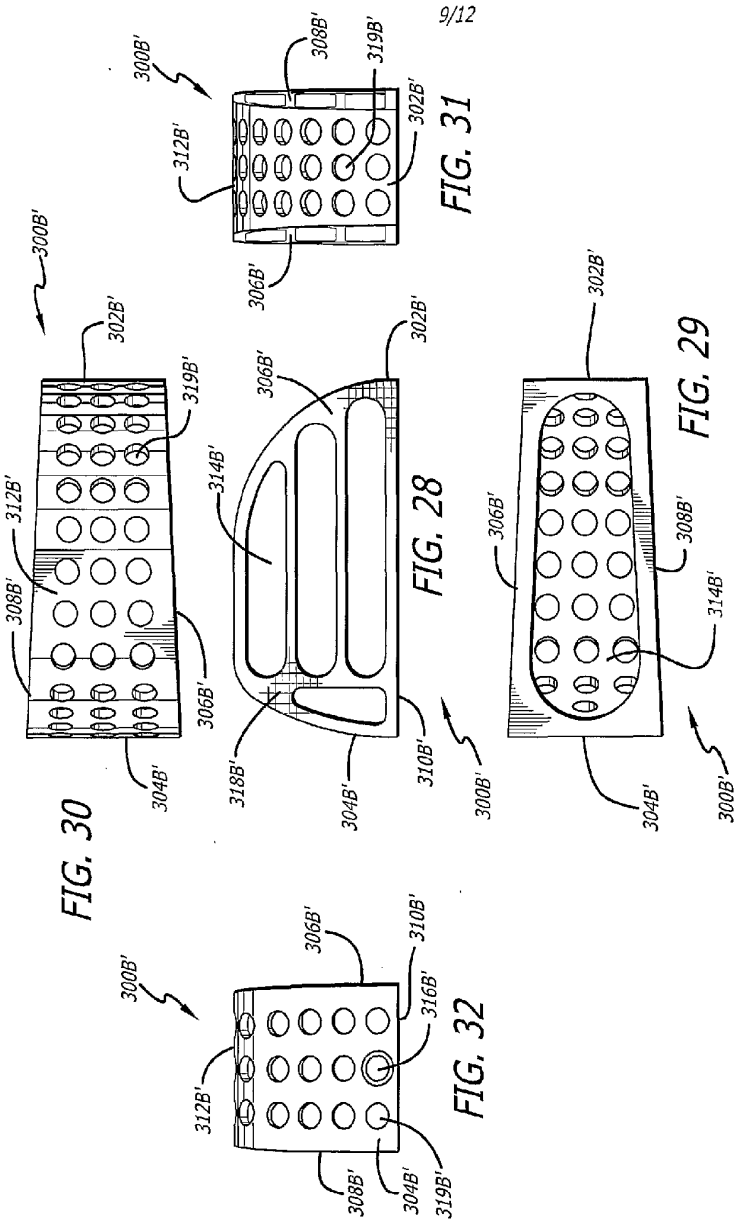


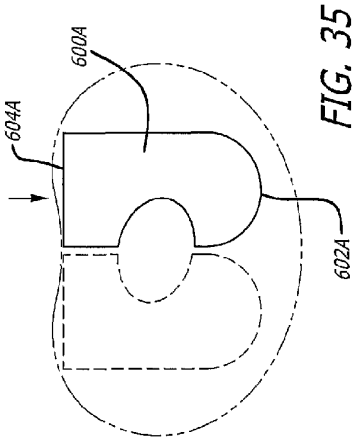
FIG. 30

FIG. 31

FIG. 28

FIG. 29

FIG. 32



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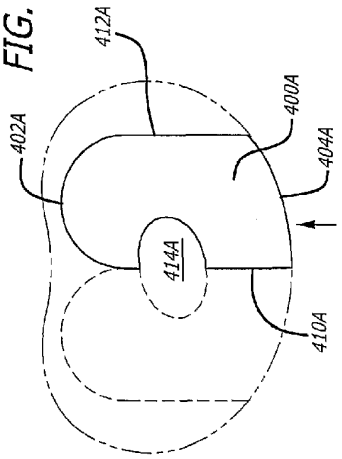

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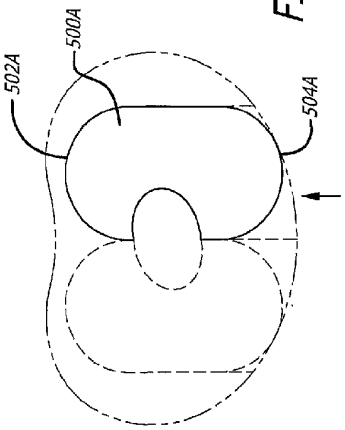

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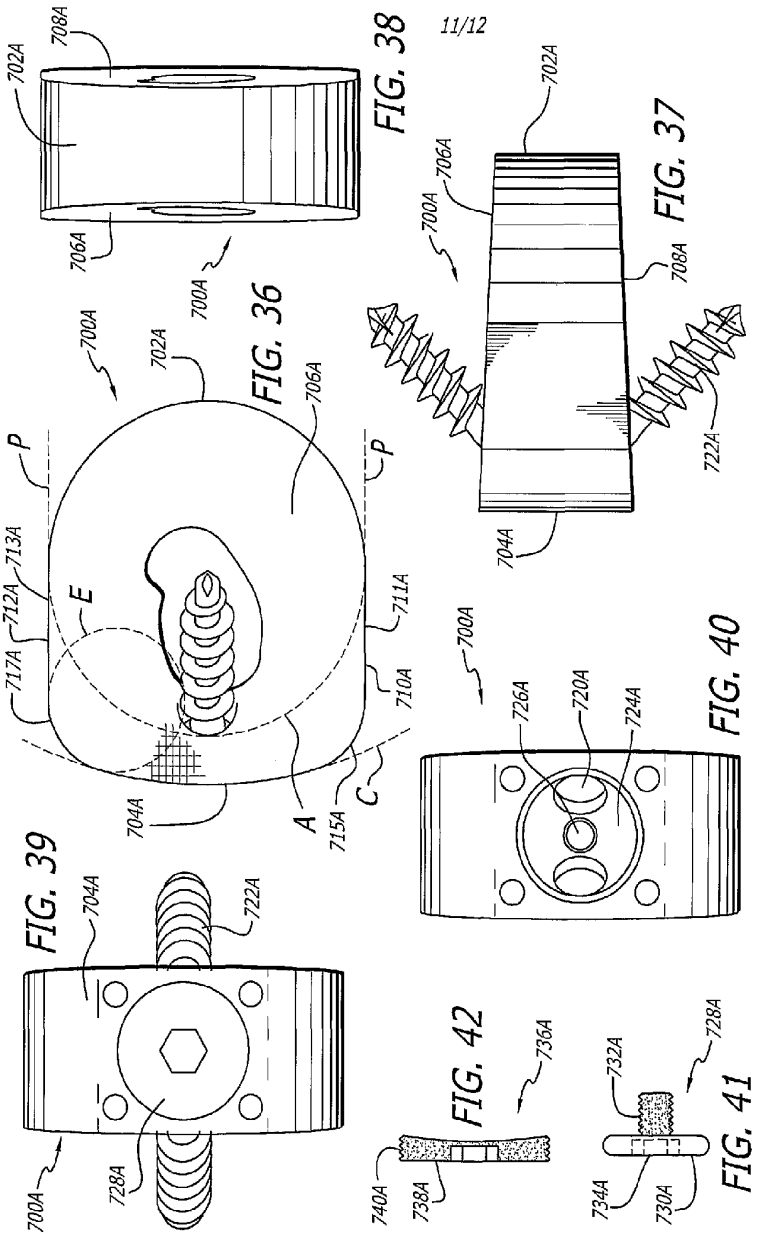
FIG. 36
FIG. 37
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FIG. 41
FIG. 42
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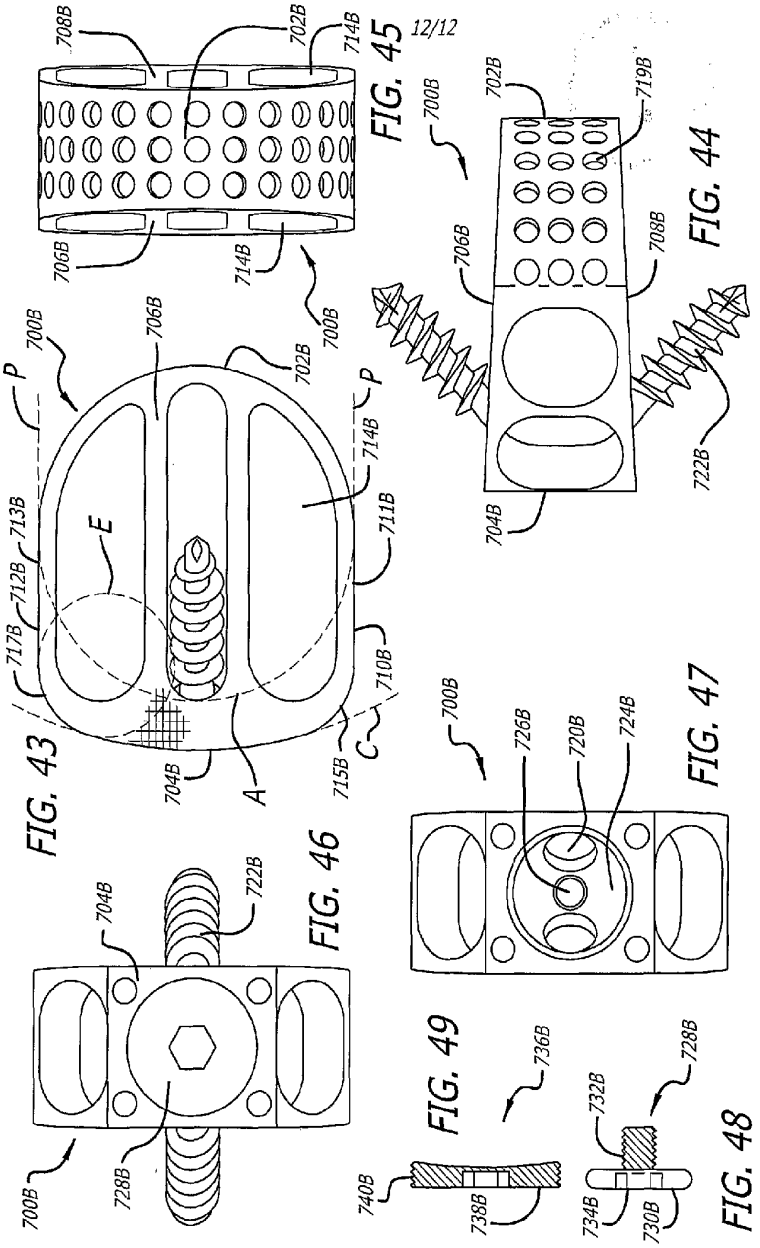
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FIG. 49
FIG. 48