



(12) **United States Patent**
Michelson

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(54) **METHOD FOR INSERTING FRUSTO-CONICAL INTERBODY SPINAL FUSION IMPLANTS**

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(21) Appl. No.: **08/480,904**

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Related U.S. Application Data

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(51) **Int. Cl.⁷** **A61B 17/56**
(52) **U.S. Cl.** **606/61; 623/17**
(58) **Field of Search** **606/61, 72-78; 623/16, 17, 18**

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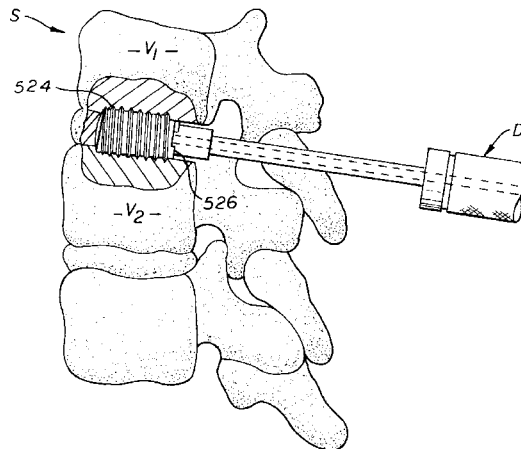
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(57) **ABSTRACT**

The present invention is directed to a method of inserting a variety of interbody spinal fusion implants having at least a partially frusto-conical configuration and the instrumentation and methods by which the implants.

92 Claims, 16 Drawing Sheets



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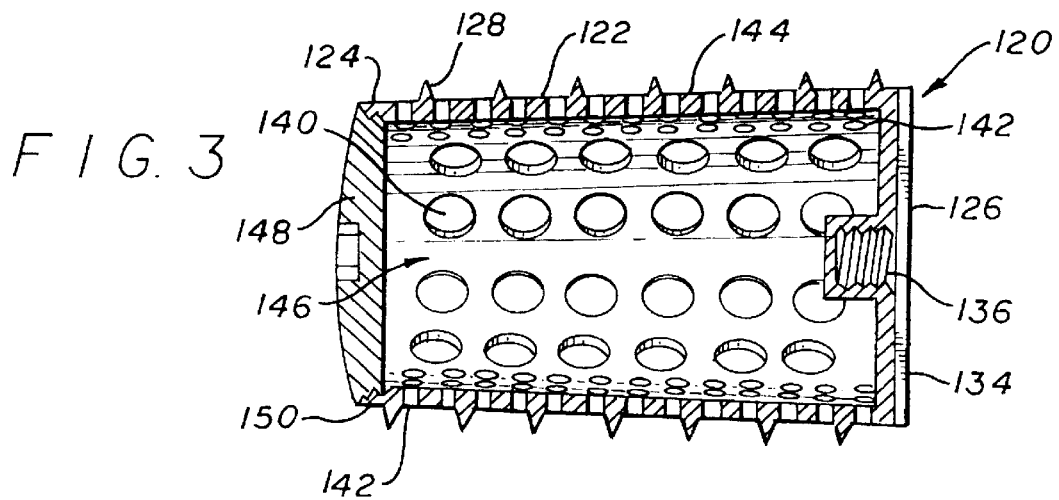
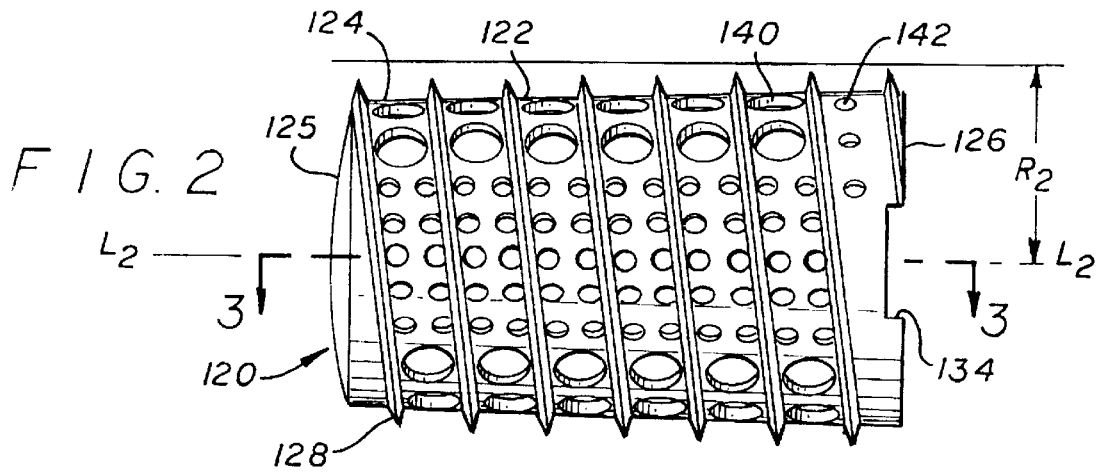
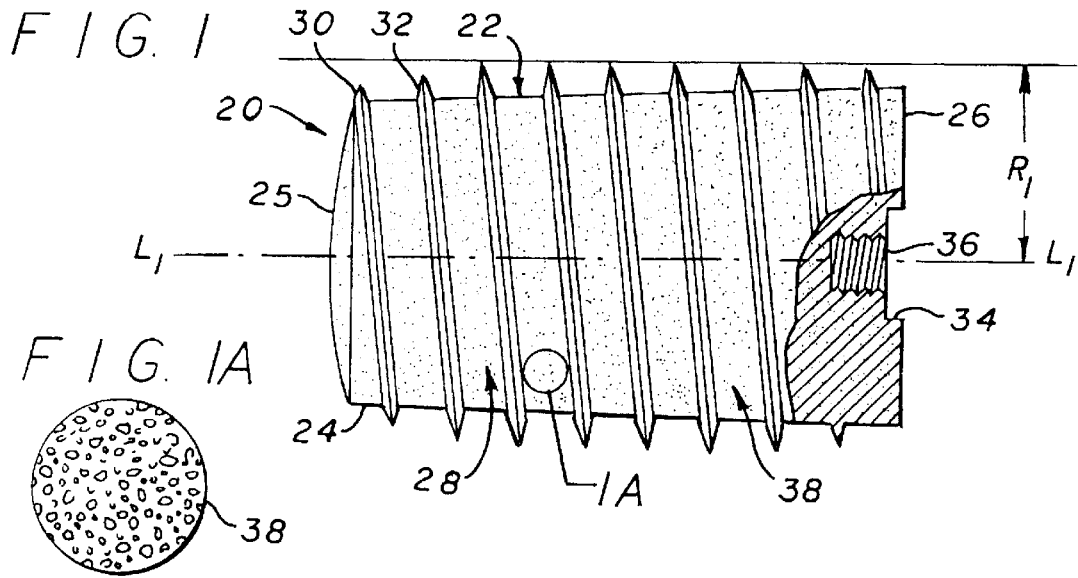
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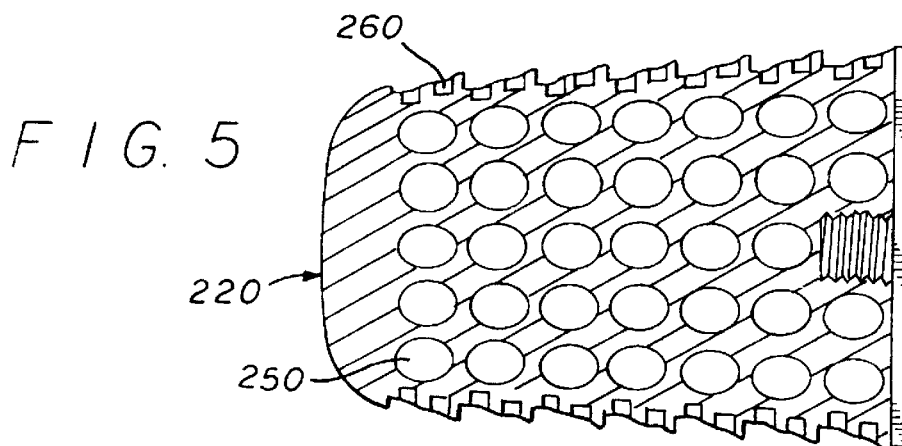
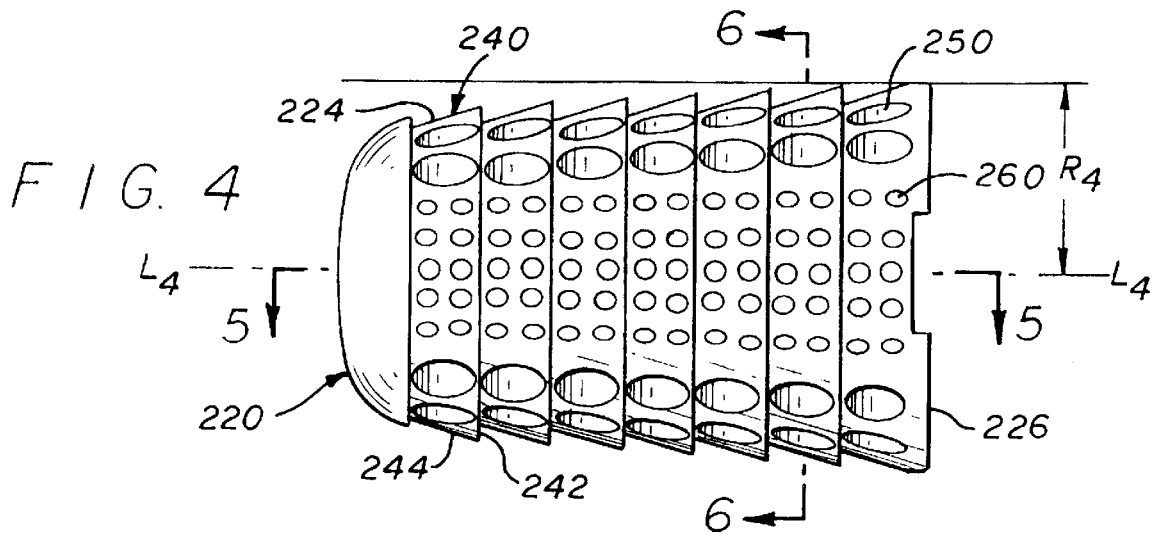
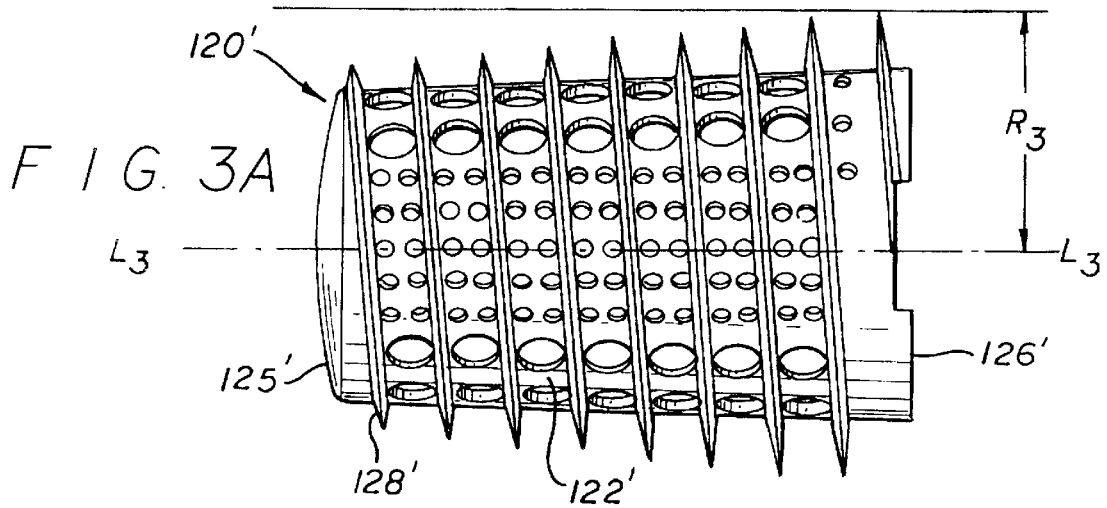


FIG. 6

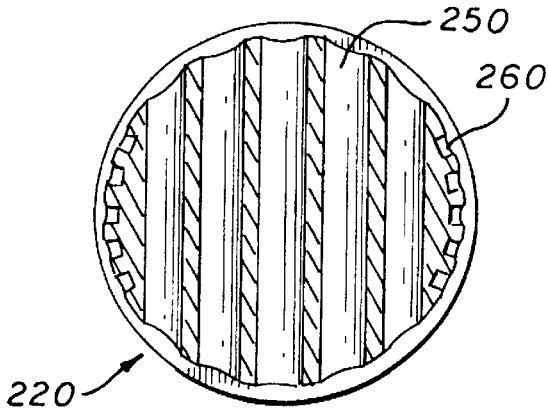


FIG. 6A

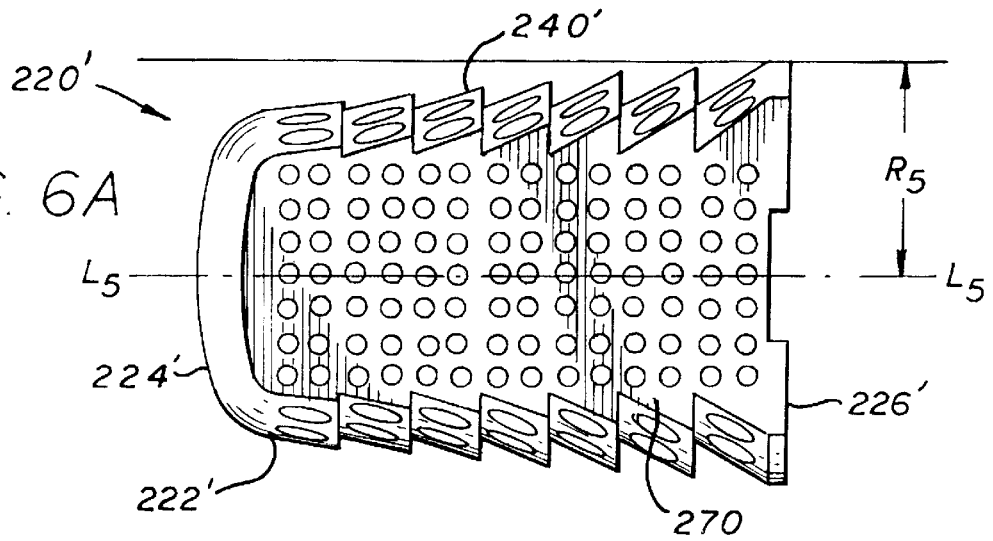
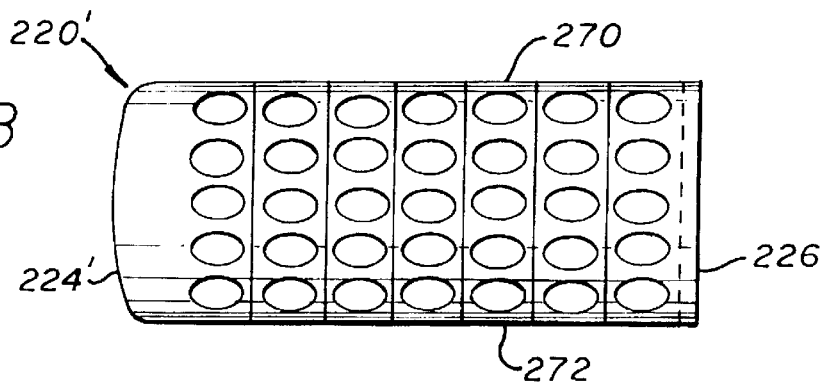
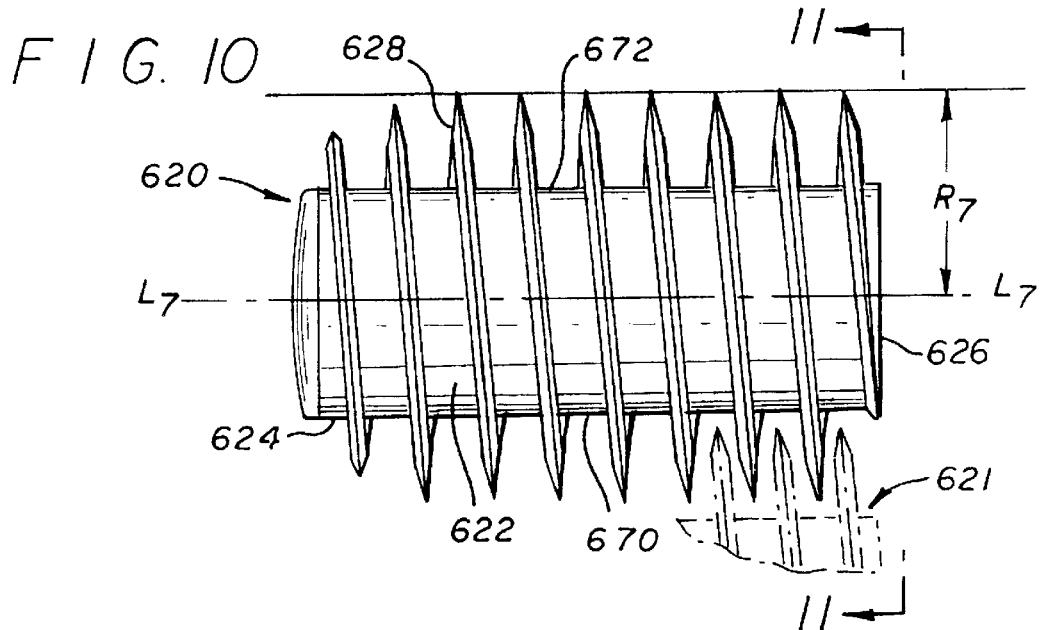
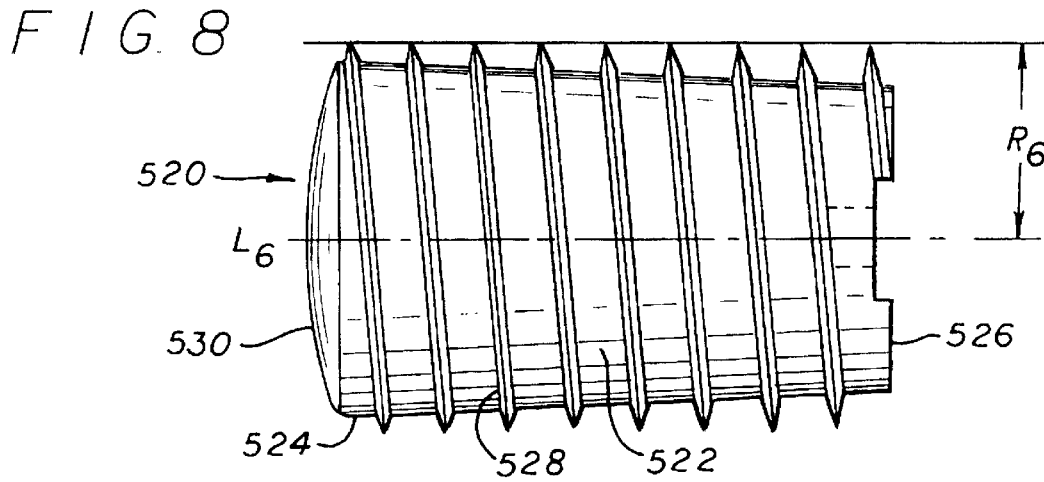
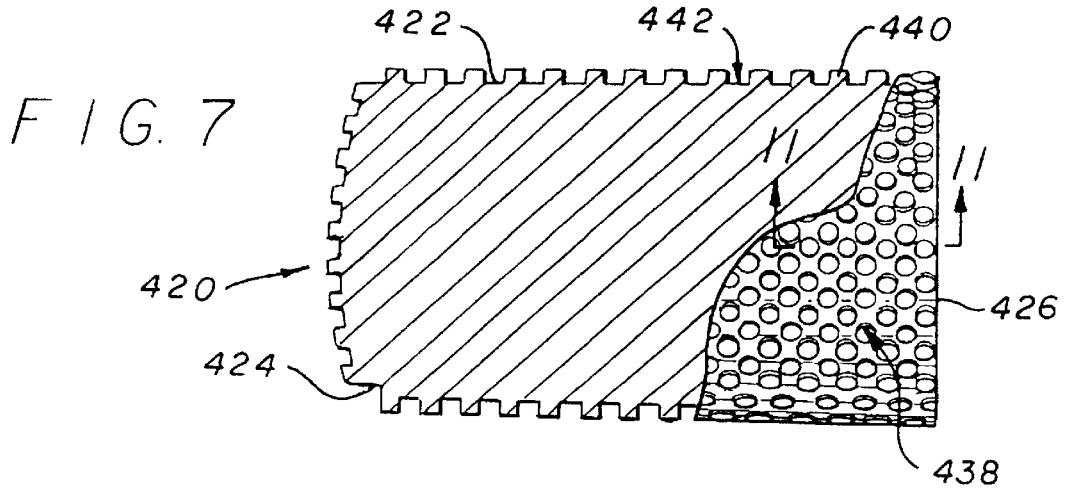


FIG. 6B





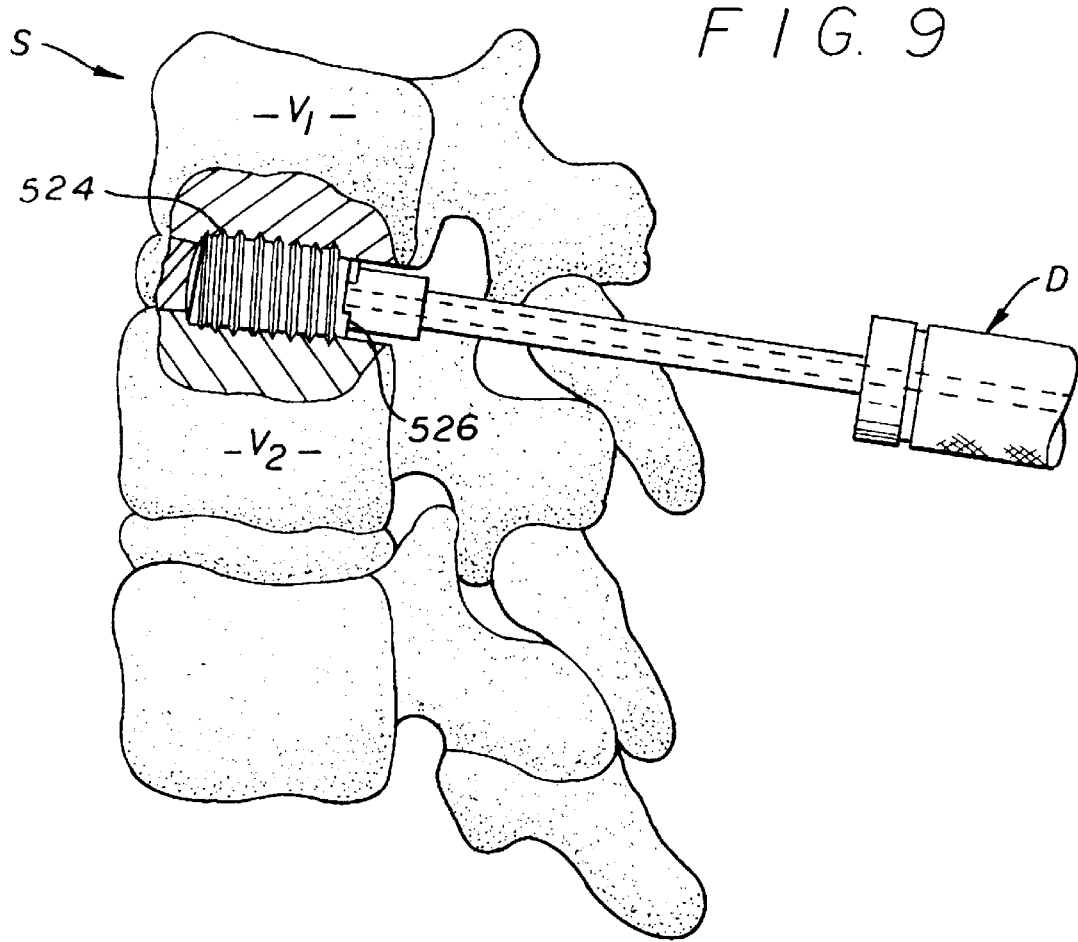


FIG. II

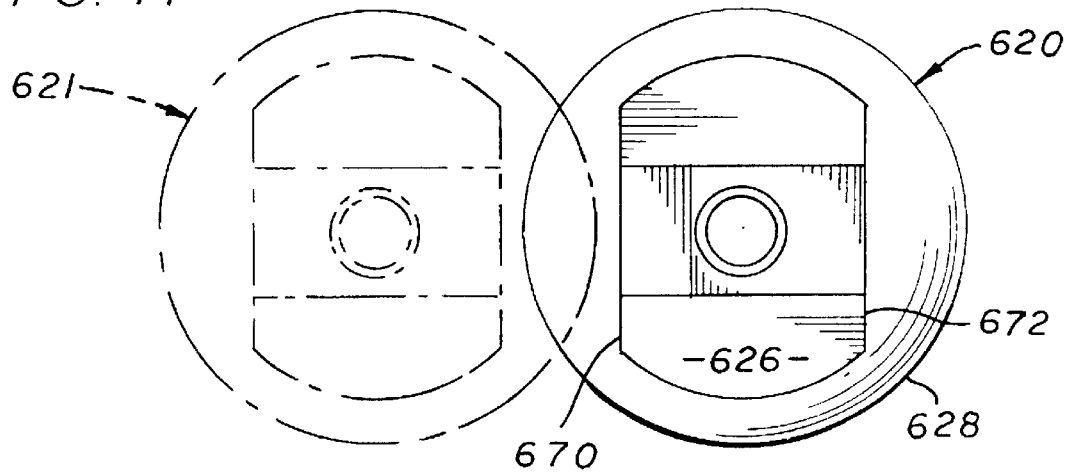


FIG. 12

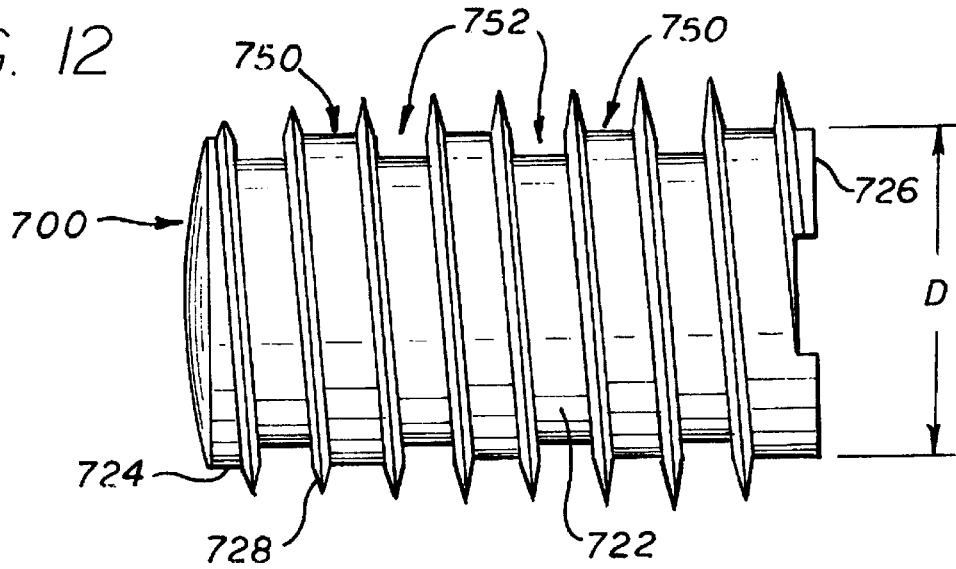


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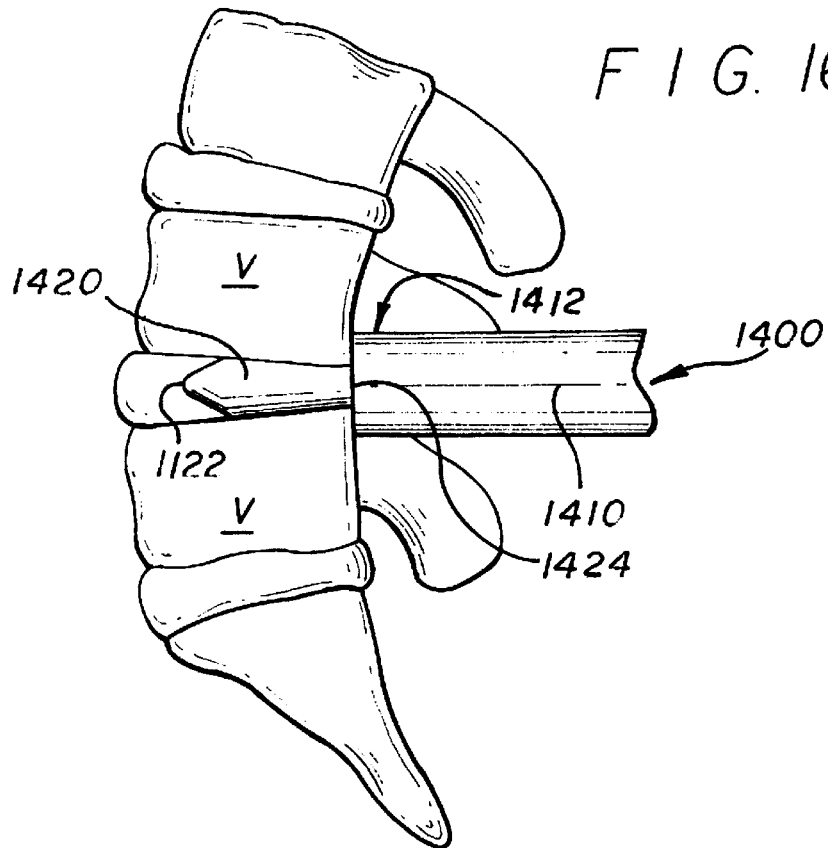


FIG. 13

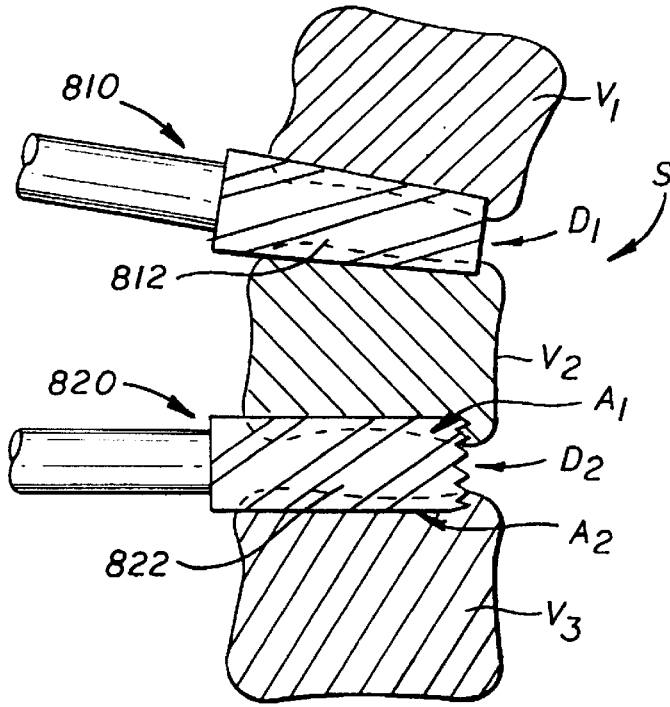


FIG. 14

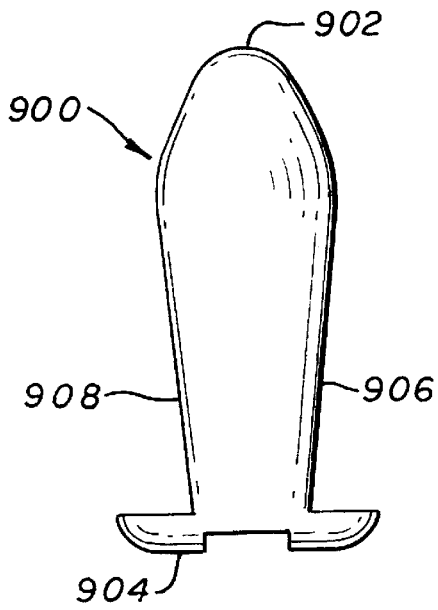
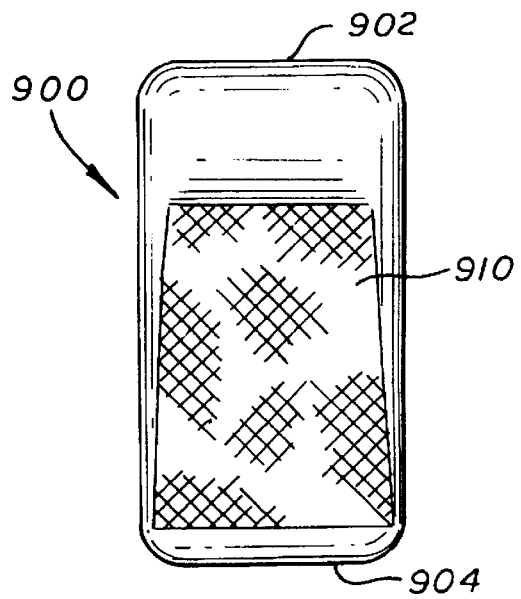


FIG. 15



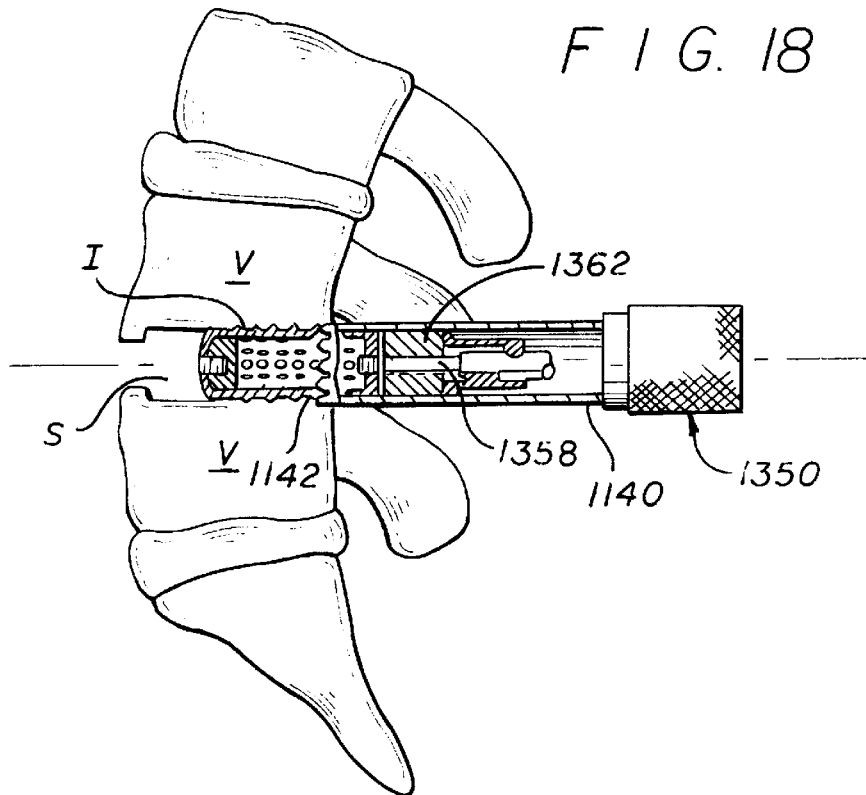
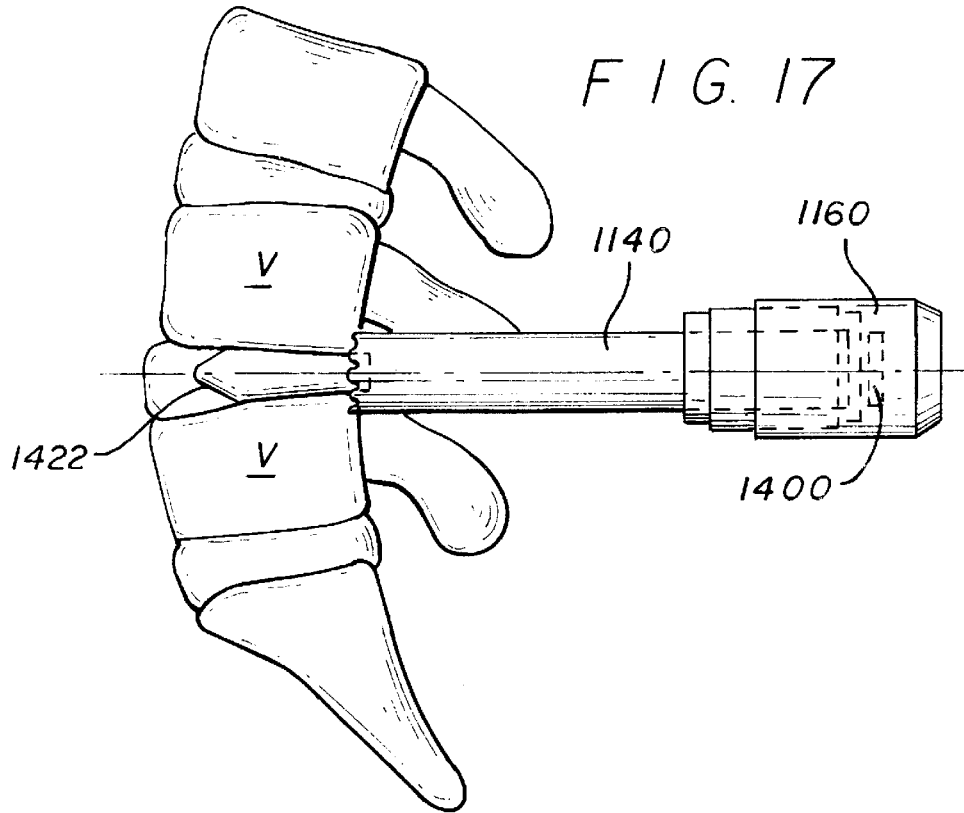


FIG. 19

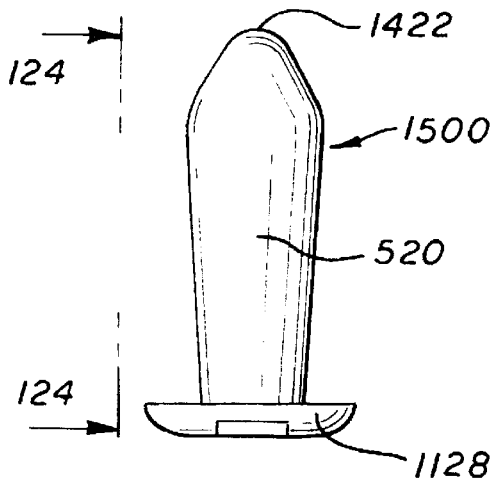
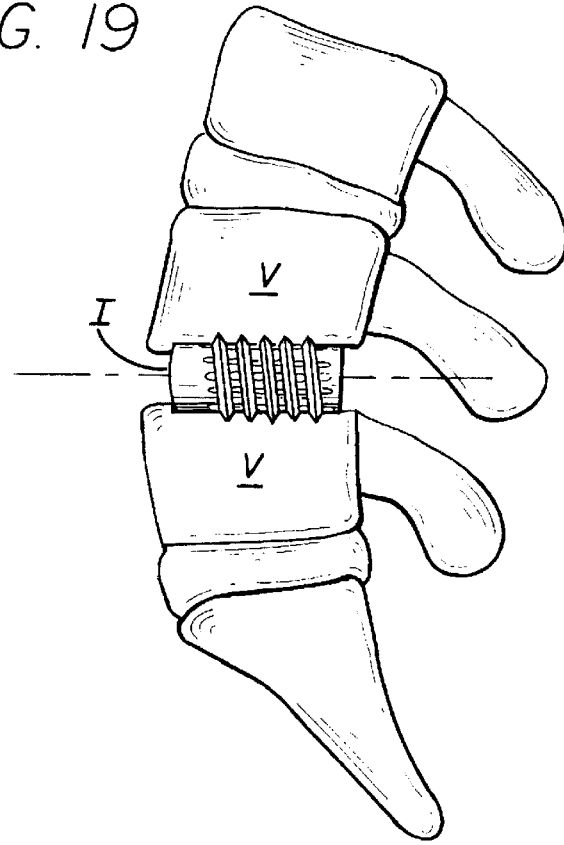


FIG. 20

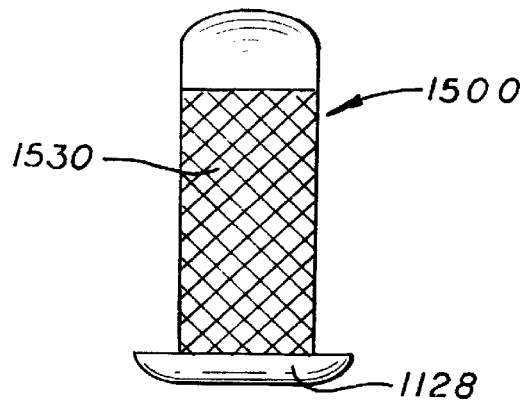


FIG. 21

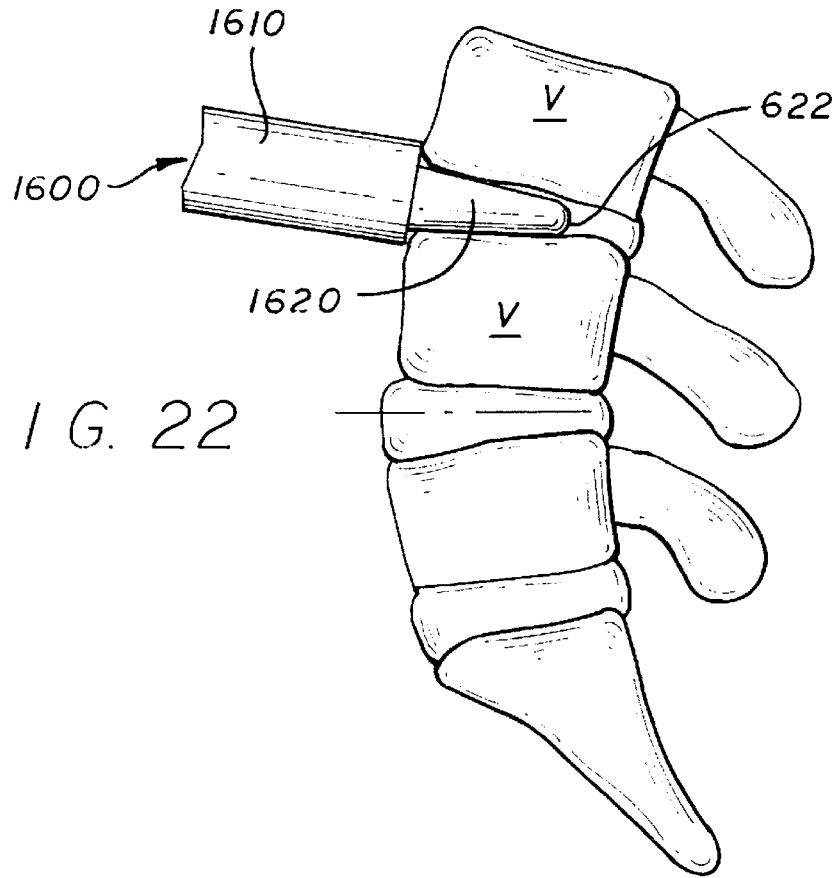


FIG. 23

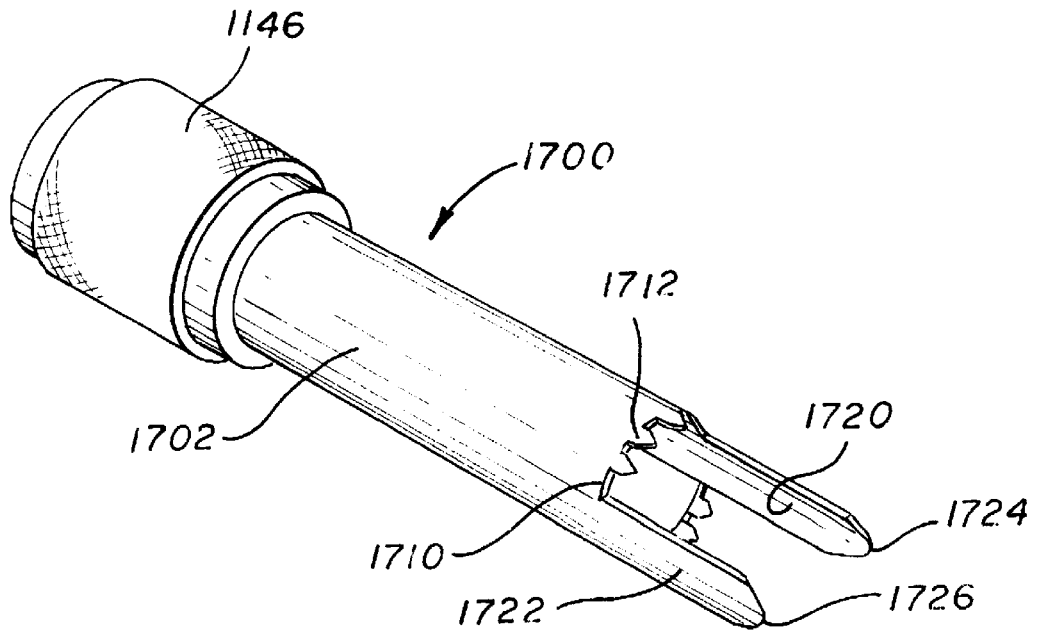


FIG. 24

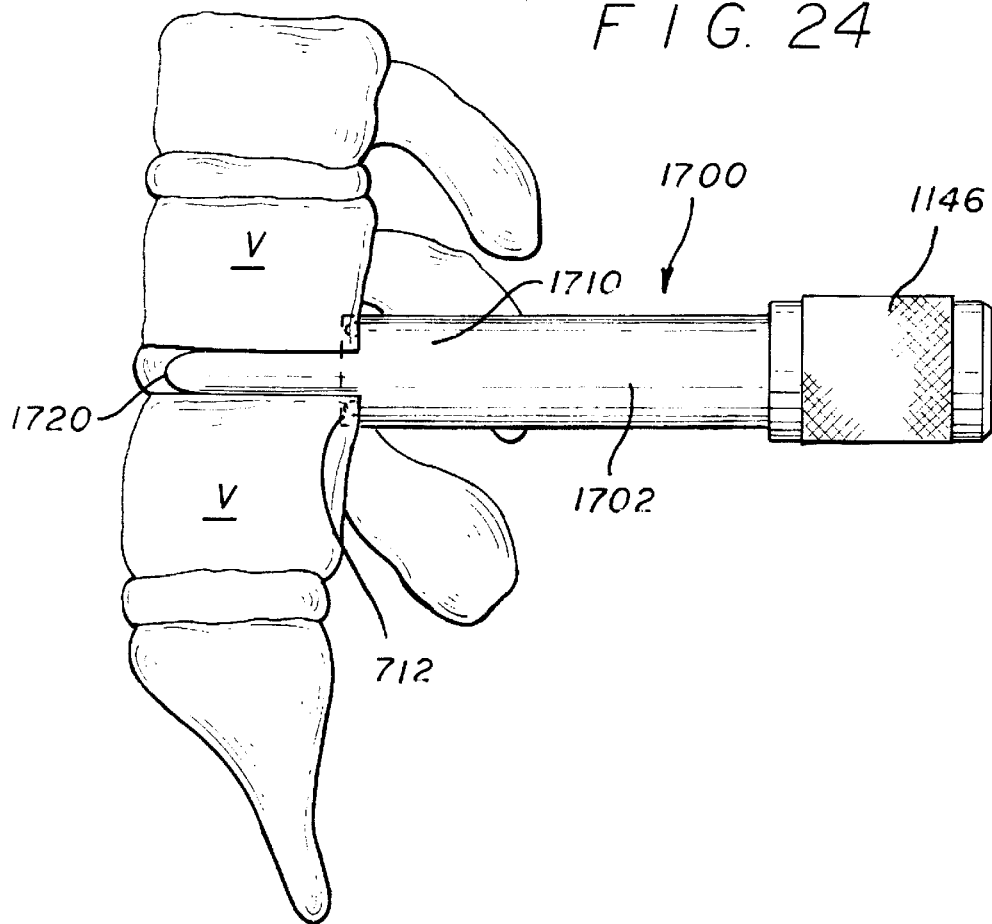
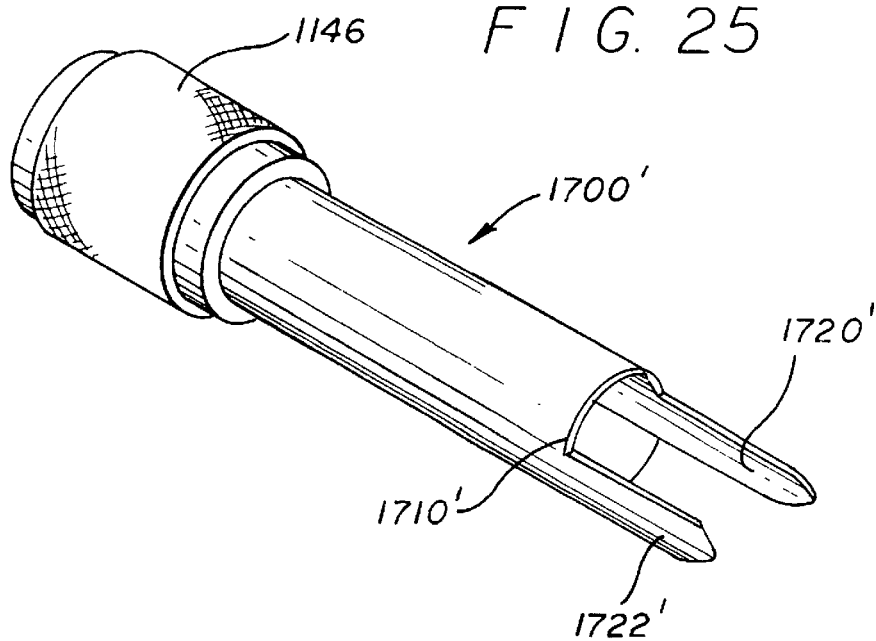


FIG. 25



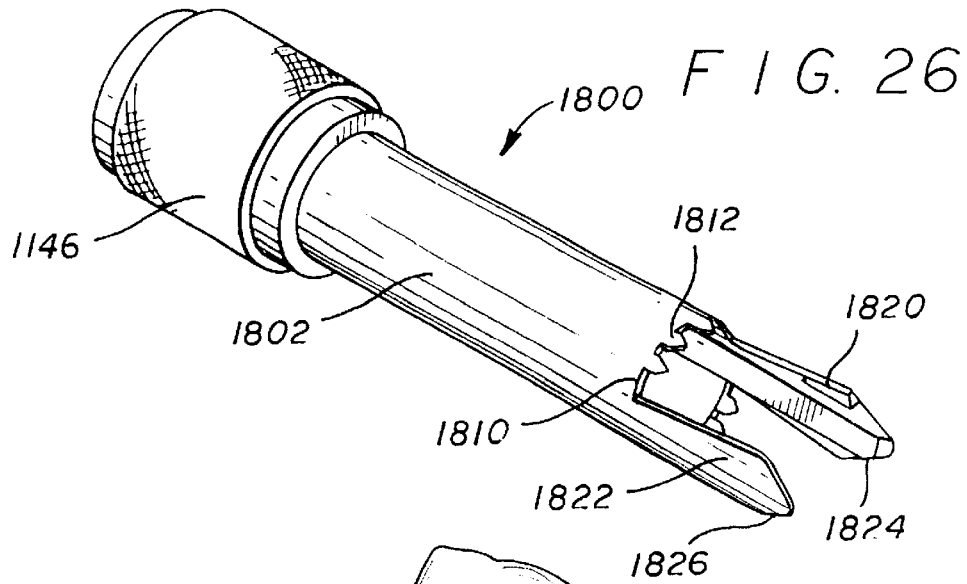
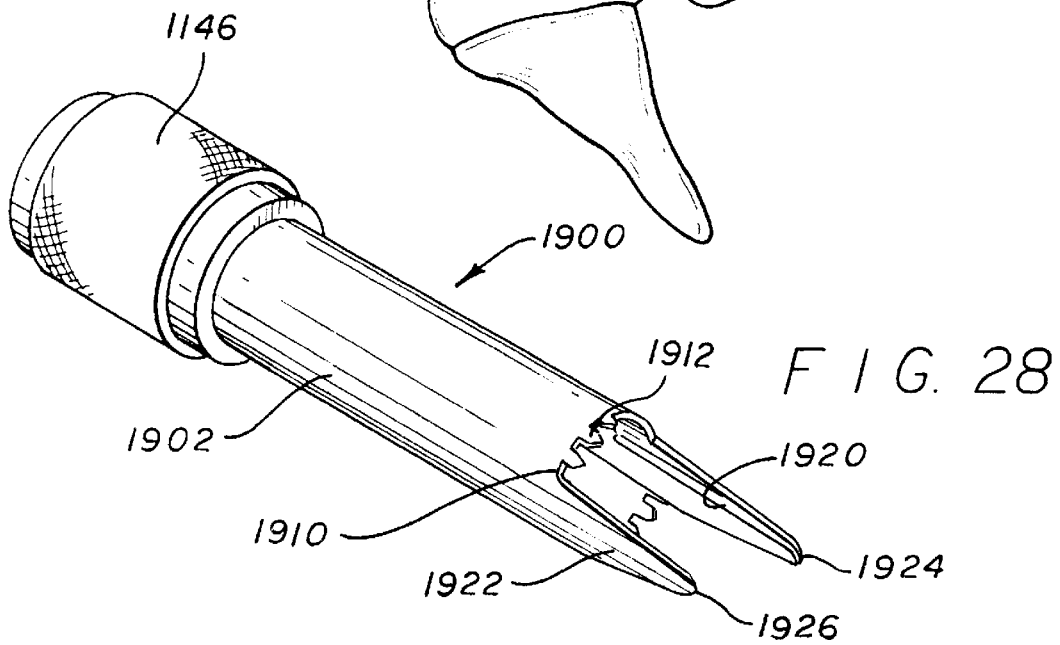
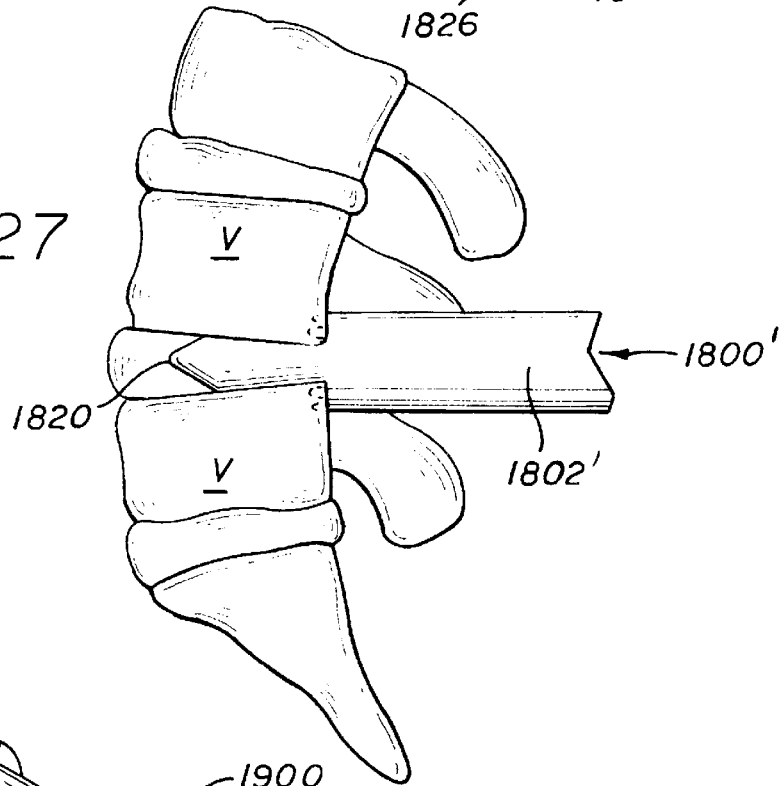


FIG. 27



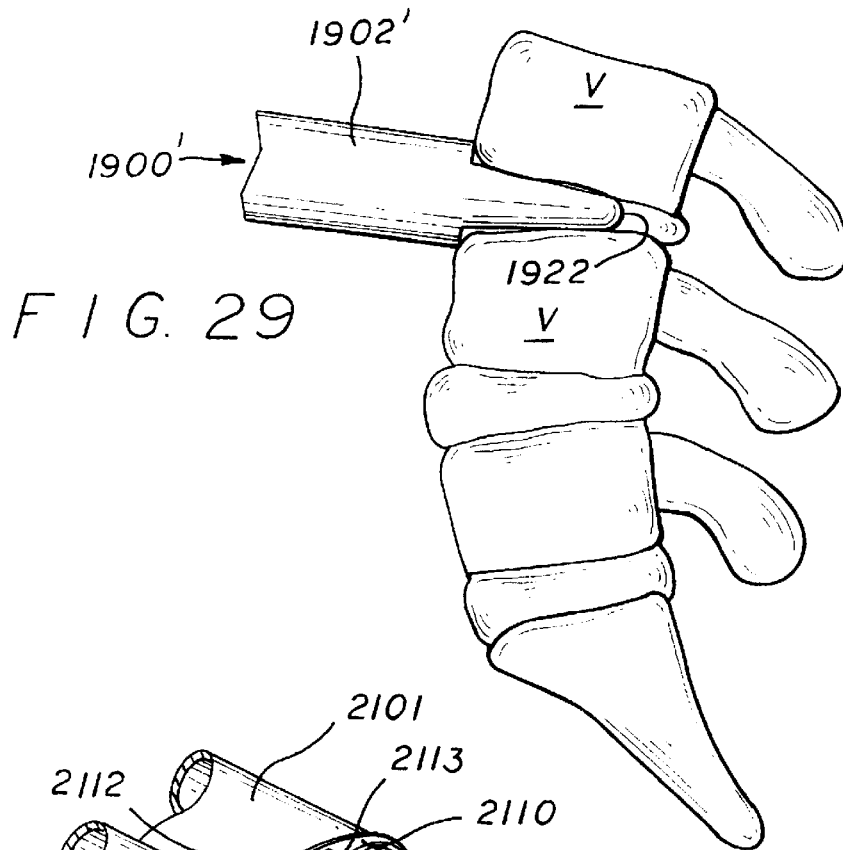


FIG. 29

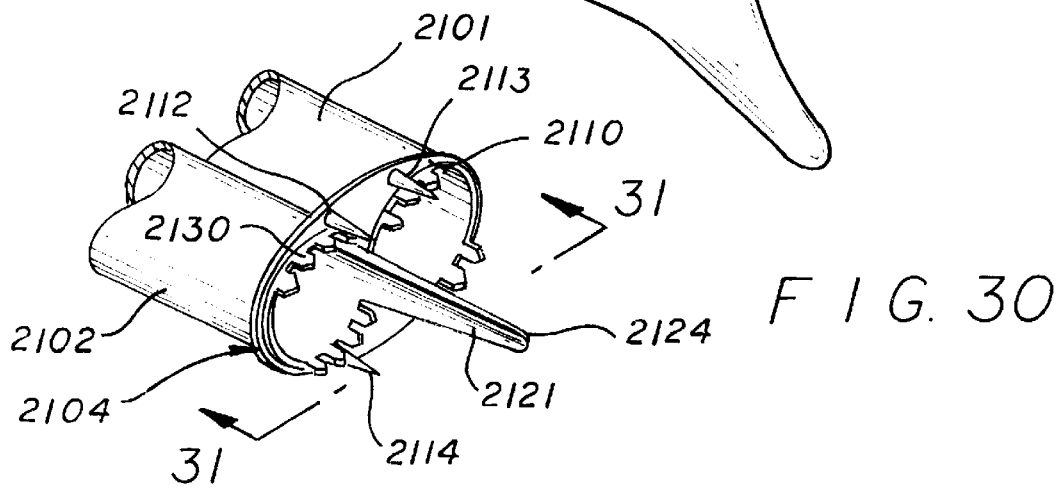


FIG. 30

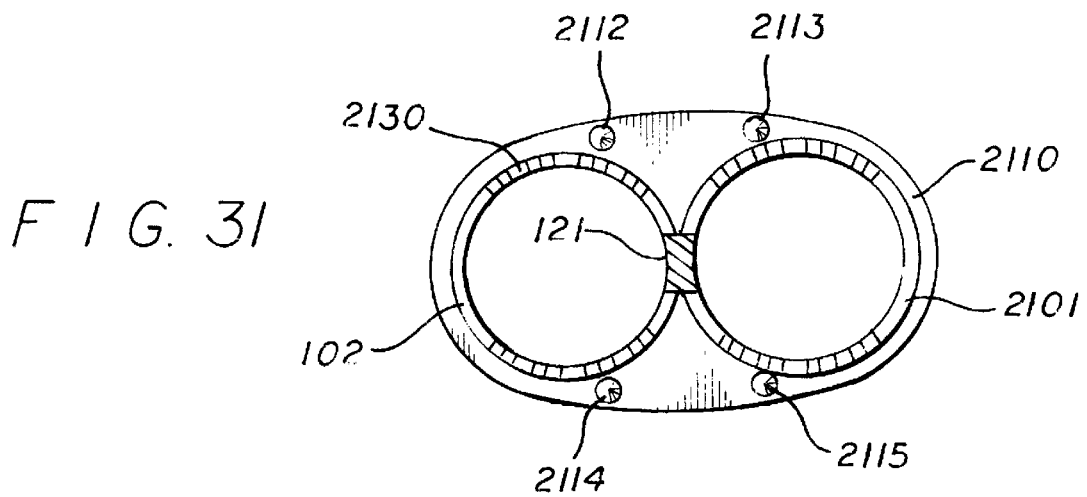
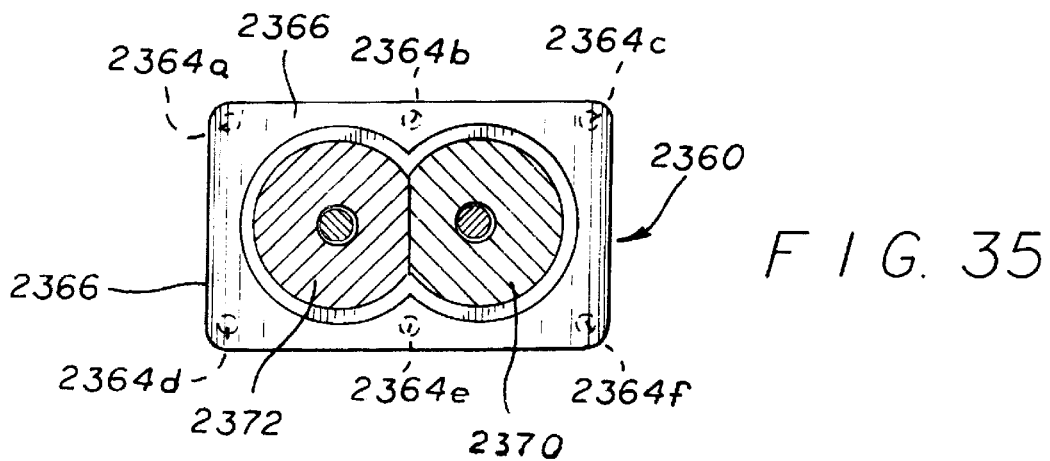
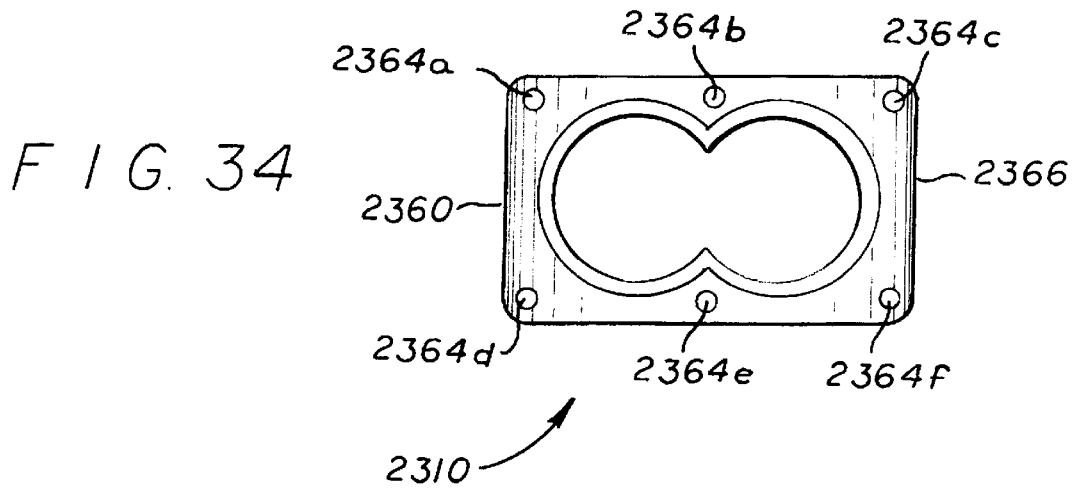
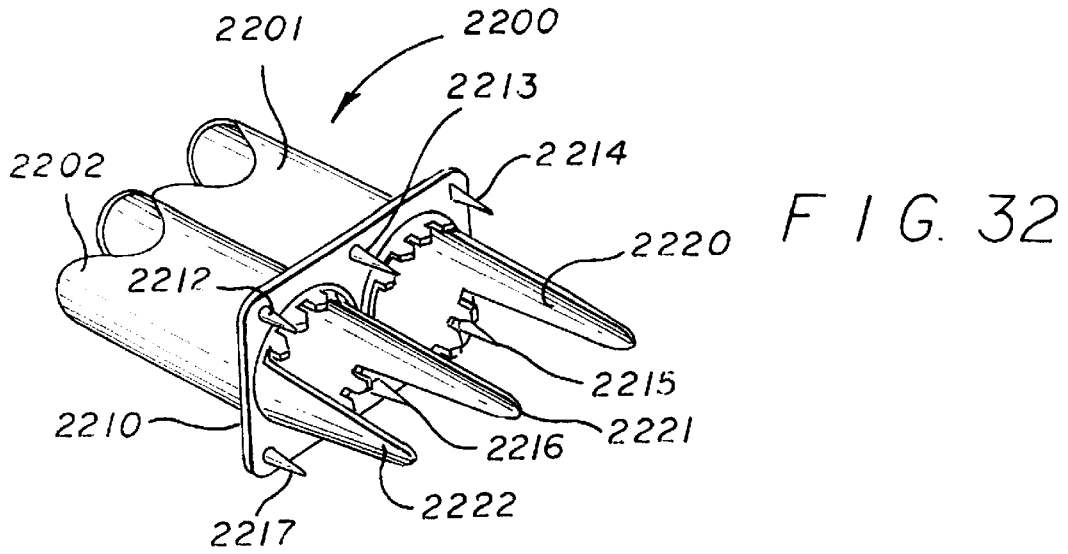


FIG. 31



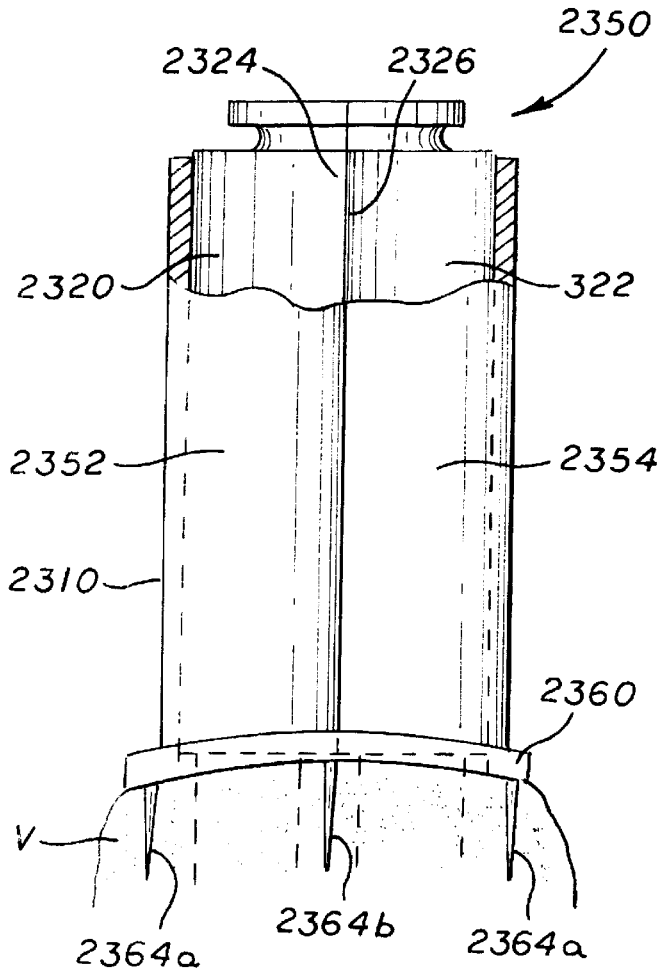


FIG. 33

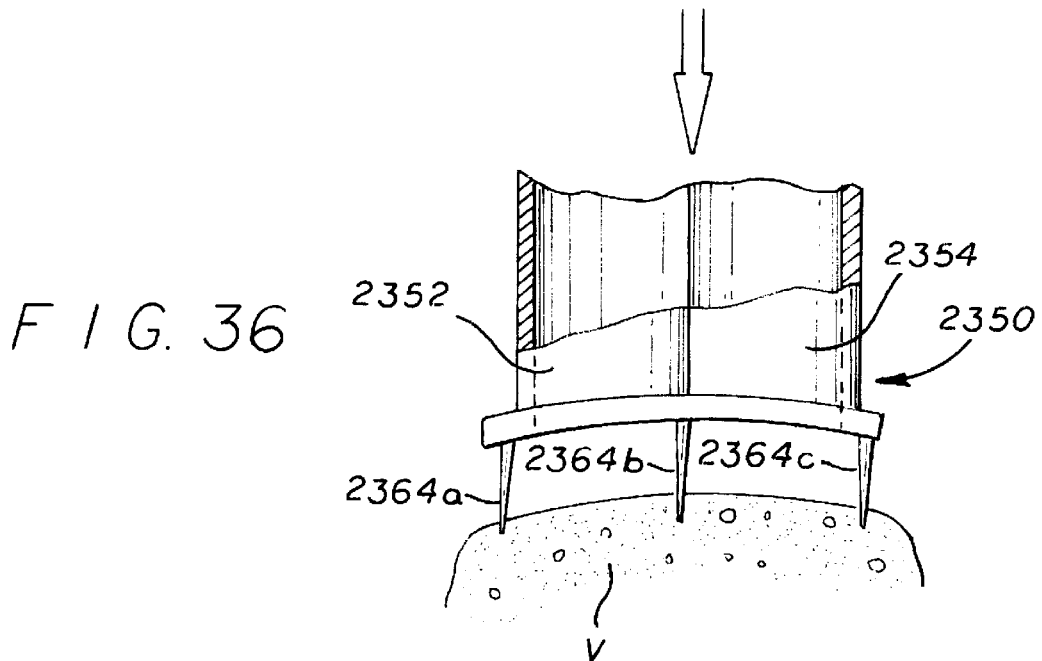
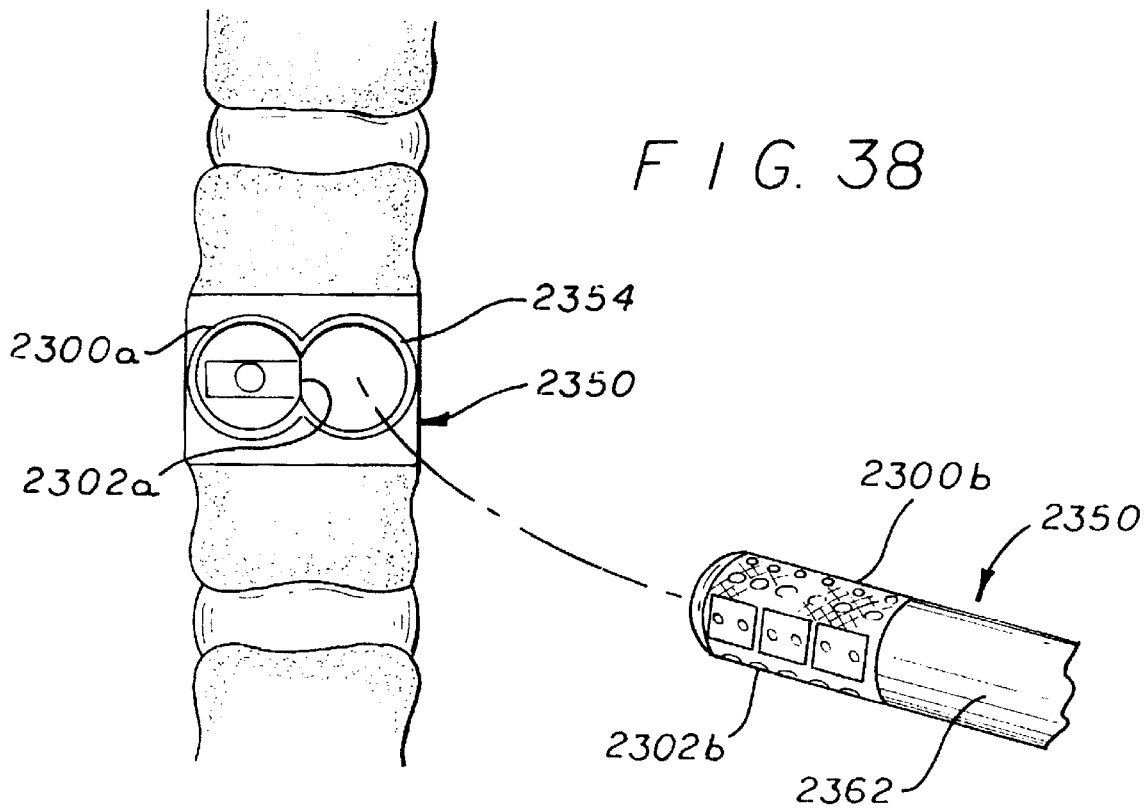
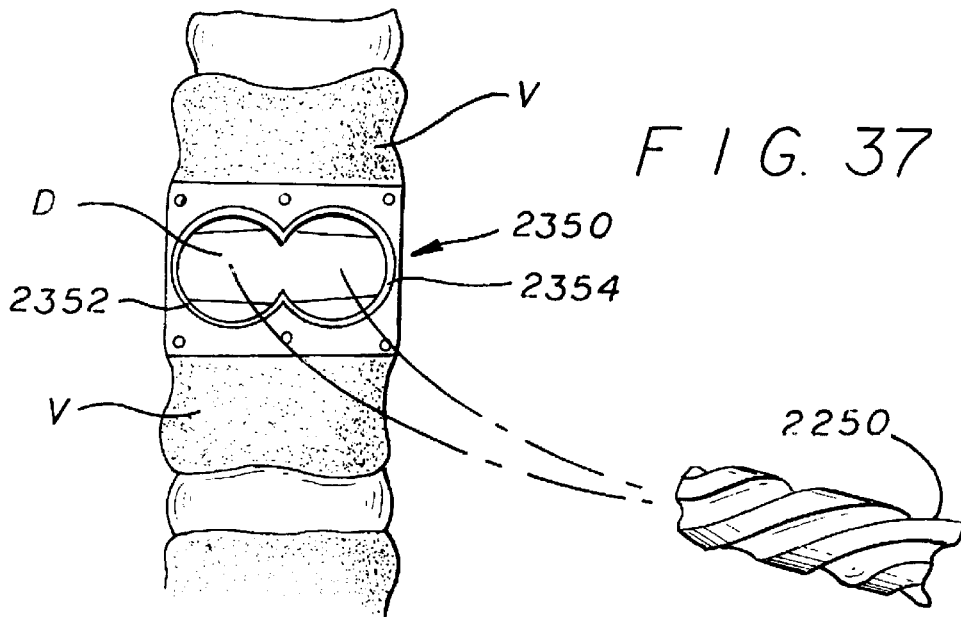


FIG. 36



METHOD FOR INSERTING FRUSTO- CONICAL INTERBODY SPINAL FUSION IMPLANTS

RELATED APPLICATIONS

This application is a continuation in part of U.S. application Ser. No. 08/396,414 filed on Feb. 27, 1995 which is a continuation-in-part of U.S. application Ser. No. 08/074,781 filed on Jun. 10, 1993, now U.S. Pat. No. 5,484,437, which is a continuation in part of U.S. application Ser. No. 07/968,240 filed on Oct. 29, 1992, now U.S. Pat. No. 5,741,253 which is a continuation of U.S. application Ser. No. 07/698,674 filed on May 10, 1991, now abandoned which is a divisional of application Ser. No. 07/205,935 filed on Jun. 13, 1988, now U.S. Pat. No. 5,015,247 all of which are incorporated herein by reference.

This application is also a continuation-in-part of U.S. application Ser. No. 08/390,131 entitled Interbody Spinal Fusion Implants filed on Feb. 17, 1995, now U.S. Pat. No. 5,593,409. This application is also a continuation in part of design patent application Ser. No. 29/023,623 entitled Spinal Distractor filed on May 27, 1994, now U.S. Pat. No. Des. 377,093.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a method for inserting interbody spinal fusion implants, and in particular to a method for inserting spinal fusion implants configured to restore and maintain two adjacent vertebrae of the spine in anatomical lordosis.

2. Description of the Related Art

Interbody spinal fusion refers to the method of achieving bony bridging between adjacent vertebrae through the disc space, the space between adjacent vertebrae normally occupied by a spinal disc. Numerous implants to facilitate such a fusion have been described by Cloward, Brantigan, and others, and are known to those skilled in the art. Generally, cylindrical implants offer the advantage of conforming to an easily prepared recipient bore spanning the disc space and penetrating into each of the adjacent vertebrae. Such a bore may be created by use of a drill. It is an anatomical fact that both the cervical spine and the lumbar spine are normally lordotic, that is convex forward. Such alignment is important to the proper functioning of the spine. Commonly, those conditions which require treatment by spinal fusion are associated with a loss of lordosis.

Michelson, in U.S. patent application Ser. No. 08/396,414, entitled APPARATUS AND METHOD OF INSERTING SPINAL IMPLANTS, teaches a method for restoring the anatomical lordosis of the spine while performing the interbody fusion procedure. While this has been a significant advance over prior methods, it has nevertheless been associated with a sometimes less than desirable consequence, that being the uneven removal of bone from each of the adjacent vertebrae relative to the vertebral endplates adjacent the disc space.

Therefore, there exists a need for spinal fusion implants and instrumentation that permits for the uniform depth of bone removal from each of the adjacent vertebrae while restoring anatomical lordosis.

SUMMARY OF THE INVENTION

The present invention is directed to a method for inserting a variety of interbody spinal fusion implants having at least

a partially frusto-conical configuration to achieve a desired anatomical lordosis of the spine. In the preferred embodiment of the method of the present invention, the spinal fusion implants being inserted have an outer locus in which at least some of the points of the implant comprise a partially or fully frusto-conical shape substantially along the portion of the implant in contact with the adjacent vertebrae of the spine and have an insertion end and a trailing end. The spinal fusion implants may be further modified so that while the upper and lower surfaces are portions of a frusto-cone, or a cylinder at least one side portion may be truncated to form a planar surface that is parallel to the central longitudinal axis of the implant to form straight walls. These implants may have a more tapered aspect at the insertion end of the implant to facilitate insertion. The spinal fusion implants of the present invention may be relatively solid and/or porous and/or hollow, and may have surface roughenings to promote bone ingrowth and stability.

In the preferred method of the present invention, the diseased disc between two vertebrae is at least partially removed. The two vertebrae adjacent the diseased disc are then optimally distracted and placed in the desired amount of lordosis by any of a number of well known means including, but not limited to, those means that distract the vertebral bodies by engaging screws placed into the anterior aspect of the vertebral bodies, and disc space distractors that are placed from the anterior aspect of the spine into the disc space and are then used to urge the vertebral endplates away from each other and into lordosis. When the correct amount of distraction and lordosis have been achieved at the affected disc level, then a frusto-conical space is created from anterior to posterior between the adjacent vertebrae. The frusto-conical space that is created is greater in diameter than the disc space height, such that some bone is removed from each of the adjacent vertebrae. The created space is generally frusto-conical in shape, being greatest in diameter anteriorly and tapering to a lesser diameter posteriorly.

In an alternative method of implant insertion, the use of at least partially frusto-conical interbody spinal fusion implants allows for the creation of lordosis by the implant itself where none is present to begin with. The disc space which in the preferred circumstance would be fully distracted but need not be, but lacking lordosis, could have a bore drilled across that space such that equal arcs of bone are removed from each of the adjacent vertebrae using a drill or bone milling device capable of producing a cylindrical bore. The vertebrae, whether distracted from each other or not, are essentially lacking the full restoration of lordosis. The use of the substantially cylindrical bone drill provides for the removal of a generally uniform thickness of bone from each of the adjacent vertebrae from anterior to posterior. The insertion of a frusto-conical implant, having a larger diameter at its trailing edge than at its leading edge, then forces the anterior aspects of the adjacent vertebrae apart more so than the posterior aspects where the diameter is lesser. This utilizes the implant to produce the desired lordosis.

To further assist incorporation into the spinal fusion bone mass, the spinal fusion implants of the present invention may have wells extending into the material of the implant from the surface for the purpose of holding fusion promoting materials and to provide for areas of bone ingrowth fixation. These wells, or holes, may pass either into or through the implant and may or may not intersect. The spinal fusion implants of the present invention may have at least one chamber which may be in communication through at least one opening to the surface of the implant. Said chamber may have at least one access opening for loading the chamber

with fusion promoting substances. The access opening may be capable of being closed with a cap or similar means. Still further, a variety of surface irregularities may be employed to increase implant stability and implant surface area, and/or for the purpose of advancing the spinal fusion implant into the fusion site such as a thread. The exterior of the spinal fusion implant of the present invention may have wholly or in part, a rough finish, knurling, forward facing ratchetings, threads or other surface irregularities sufficient to achieve the purpose described.

The spinal fusion implants of the present invention offer significant advantages over the prior art implants:

1. Because the spinal fusion implants of the present invention are at least partially frusto-conical in shape, those that taper from the leading edge to the trailing edge they are easy to introduce and easy to fully insert into the spinal segment to be fused. In the preferred embodiment, where the leading edge of the implant is larger than the trailing edge, the implant utilizes a tapered forward portion and an increasing thread height relative to the body from the leading edge to the trailing edge to facilitate insertion.
2. The shape of the implants of the present invention is consistent with the shape of the disc, which the implants at least in part replace, wherein the front of the disc is normally taller than the back of the disc, which allows for normal lordosis. The implants of the present invention are similarly taller anteriorly than they are posteriorly.
3. The spinal fusion implants of the present invention allow for a minimal and uniform removal of bone from the vertebrae adjacent the disc space while still providing for an interbody fusion in lordosis when properly inserted.
4. The spinal fusion implants of the present invention conform to a geometric shape, which shape is readily producible at the site of fusion, to receive said spinal fusion implants.

The spinal fusion implants of the present invention can be made of any material appropriate for human implantation and having the mechanical properties sufficient to be utilized for the intended purpose of spinal fusion, including various metals such as cobalt chrome, stainless steel or titanium including its alloys, various plastics including those which are bio-absorbable, and various ceramics or combination sufficient for the intended purpose. Further, the spinal fusion implants of the present invention may be made of a solid material, a mesh-like material, a porous material and may comprise, wholly or in part, materials capable of directly participating in the spinal fusion process, or be loaded with, composed of, treated or coated with chemical substances such as bone, morphogenic proteins, hydroxyapatite in any of its forms, and osteogenic proteins, to make them bioactive for the purpose of stimulating spinal fusion. The implants of the present invention may be wholly or in part bioabsorbable.

OBJECTS OF THE PRESENT INVENTION

It is an object of the present invention to provide a method for inserting frusto-conical spinal fusion implants into the spine;

It is yet another object of the present invention to provide a method for inserting frusto-conical spinal fusion implants that are capable of maintaining anatomic alignment and lordosis of two adjacent vertebrae during the spinal fusion process;

It is yet another object of the present invention to provide a method for inserting frusto-conical spinal fusion implants that is capable of providing stability between adjacent vertebrae when inserted;

It is further another object of the present invention to provide a method of inserting frusto-conical spinal fusion implants that includes spacing apart and supporting adjacent vertebrae;

It is still further another object of the present invention to provide a method for inserting frusto-conical spinal fusion implants that is consistent in use with the preservation of a uniform thickness of the subchondral vertebral bone;

It is another object of the present invention to provide a method for inserting frusto-conical spinal fusion implants having a shape which conforms to an easily produced complementary bore at the fusion site; and

It is a further object of the present invention to provide a method for inserting a frusto-conical spinal fusion implant which may be placed side by side adjacent to a second identical implant across the same disc space, such that the combined width of the two implants is less than sum of the individual heights of each implant.

These and other objects of the present invention will become apparent from a review of the accompanying drawings and the detailed description of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a frusto-conical spinal fusion implant having a body that is frusto-conical with an external thread having a substantially uniform radius.

FIG. 1A is an enlarged fragmentary view along line 1A of FIG. 1 illustrating the surface configuration of the implant of FIG. 1.

FIG. 2 is a side elevational view of an alternative embodiment of the spinal fusion implant having a frusto-conical body with openings through the wall of the body.

FIG. 3A is an alternative embodiment of the spinal fusion implant having a frusto-conical body with an external thread radius and thread height that are not constant.

FIG. 3 is a cross sectional view along line 3—3 of the implant of FIG. 3A.

FIG. 4 is a side elevational view of an alternative embodiment of the spinal fusion implant having a frusto-conical body and a surface configuration comprising ratchetings for engaging bone, with wells and channels for bone ingrowth.

FIG. 5 is a cross sectional view along line 5—5 of the implant of FIG. 4 illustrating the channels and wells of the implant.

FIG. 6 is a cross sectional view along line 6—6 of the implant of FIG. 4 illustrating the channels and wells of the implant.

FIG. 6A is a side elevational view of an alternative embodiment of the spinal fusion implant having truncated sides forming a planar surface parallel to the longitudinal axis of the implant and ratchetings having a radius and height that are not constant.

FIG. 6B is a top plan view of the spinal fusion implant shown in FIG. 6A.

FIG. 7 is a side elevational view in partial cut-away of an alternative embodiment of the spinal fusion implant having a body that is frusto-conical and a surface configuration comprising a plurality of spaced apart posts.

FIG. 8 is a side elevational view of an alternative embodiment of the spinal fusion implant of FIG. 1.

FIG. 9 is a side elevational view and partial cut-away of a segment of the spinal column in lordosis showing the spinal fusion implant of FIG. 8 being implanted with a driving instrument from the posterior approach to the spinal column.

FIG. 10 is a side elevational view of an alternative embodiment of the spinal fusion implant having a frusto-conical body and truncated sides.

FIG. 11 is an end view along line 11—11 of the spinal fusion implant of FIG. 14 shown placed beside a second identical implant shown in hidden line.

FIG. 12 is a side elevational view of an alternative embodiment of the spinal fusion implant having a body with an irregular configuration.

FIG. 13 is a side elevational view of a segment of the spinal column partially in lordosis showing a first drill and a second drill used in the method of the present invention.

FIG. 14 is a side elevational view of the spinal distractor instrument of the present invention.

FIG. 15 is a top plan view of the spinal distractor instrument of FIG. 14.

FIG. 16 is a side elevational view of a Posterior Long Lordotic Distractor inserted from the posterior aspect of the spine between adjacent vertebrae to restore and maintain lordosis of the spine.

FIG. 17 is a side elevational view of the Posterior Long Lordotic Distractor shown partially in hidden line with the Outer Sleeve and Cap, inserted between adjacent vertebrae to restore and maintain lordosis of the spine with the Outer Sleeve engaging the vertebrae and properly seated over the Posterior Long Lordotic Distractor.

FIG. 18 is a side elevational view partially in cross section of a spinal implant being inserted through an Outer Sleeve between two adjacent vertebrae of the spine in which lordosis has been restored and maintained and in which a portion of bone has been removed from each vertebrae for receiving the spinal fusion implant.

FIG. 19 is a side elevational view of a spinal implant inserted between two adjacent vertebrae of the spine in which lordosis has been restored.

FIG. 20 is a side elevational view of a Posterior Short Lordotic Distractor of the present invention.

FIG. 21 is a top plan view along lines 21—21 of FIG. 20 of the Posterior Short Lordotic Distractor of the present invention.

FIG. 22 is a side elevational view of an Anterior Long Lordotic Distractor of the present invention shown inserted between two adjacent vertebrae from the anterior aspect of the spine to restore and maintain lordosis.

FIG. 23 is a perspective side view of the Extended Outer Sleeve of the present invention having extended members for insertion within the disc space and engaging means for engaging adjacent vertebrae of the spine.

FIG. 24 is a side elevational view of the Extended Outer Sleeve of FIG. 23 shown inserted between adjacent vertebrae of the spine.

FIG. 25 is an alternative embodiment of the Extended Outer Sleeve of FIG. 23 shown without an engaging means for engaging adjacent vertebrae.

FIG. 26 is a perspective side view of a Posterior Lordotic Extended Outer Sleeve of the present invention having uneven extended members for restoring and maintaining lordosis of the spine and engagement means for engaging the vertebrae.

FIG. 27 is a side elevational view of a portion of the Posterior Lordotic Extended Outer Sleeve of FIG. 26 inserted between adjacent vertebrae from the posterior aspect of the spine to restore and maintain lordosis.

FIG. 28 is a perspective side view of an Anterior Lordotic Extended Outer Sleeve of the present invention having extended members for restoring and maintaining lordosis of the spine from the anterior aspect of the spine.

FIG. 29 is a side elevational side view of an alternative embodiment of the Anterior Lordotic Extended Outer Sleeve of FIG. 28 absent the engagement means for engaging the vertebrae, inserted between adjacent vertebrae from the anterior aspect of the spine.

FIG. 30 is a perspective side view of a Dual Extended Outer Sleeve having an uneven extended portion which decreases in height in the direction of insertion.

FIG. 31 is bottom plan view of the foot plate of the Dual Extended Outer Sleeve of FIG. 30.

FIG. 32 is a perspective side view of a Dual Extended Outer Sleeve having uneven extended portions which decrease in height in the direction insertion.

FIG. 33 is an elevational front view of the apparatus of the present invention for use in installing interbody spinal implants having one or more flat sides, shown placed over two Long Distractors with the prongs inserted into the vertebrae.

FIG. 34 is a bottom plan view of the foot plate of the apparatus of the present invention for use in installing the interbody spinal implants having one or more flat sides.

FIG. 35 is a cross sectional view along line 35—35 of FIG. 33 illustrating the apparatus used for inserting interbody spinal implants having one or more flat sides.

FIG. 36 is a partial fragmentary view of the apparatus of the present invention for use in installing interbody spinal implants having one or more flat sides, shown with the prongs being partially inserted into the vertebrae.

FIG. 37 illustrates a step of the method of drilling a hole into a vertebrae with the apparatus of the present invention for use in installing interbody spinal implants having one or more flat sides, shown engaged to two adjacent vertebrae of a spinal column.

FIG. 38 illustrates a step of the method of the present invention for inserting a second interbody spinal implant having one or more flat sides into the interspace between two adjacent vertebrae with one implant shown already installed in place.

DETAILED DESCRIPTION OF THE DRAWINGS

The first part of the Detailed Description Of The Drawings is directed to the description of the structure of the frusto-conical implants inserted by the method of the present invention. The second part of the description of the drawings is directed to the method of the present invention. Frusto-Conical Implants

Referring to FIG. 1, a side elevational view of the spinal fusion implant for insertion with the method of the present invention generally referred to by numeral 20 is shown. The implant 20 has a body 22 that is frusto-conical in shape such that the body 22 has a diameter (root diameter) that is generally frusto-conical. The body 22 has an insertion end 24 and a trailing end 26. The insertion end 24 may include a tapered portion 25 to facilitate insertion of the spinal implant 20. In the preferred embodiment, when the implant 20 is inserted from the anterior aspect of the spine, the body 22 of the implant 20 has a maximum diameter at a point

nearest to the trailing end **26** and a minimum diameter at a point nearest to the insertion end **24**.

The implant **20** has an external thread **28** having a substantially uniform radius R_1 measured from the central longitudinal axis L_1 of the implant **20**. The outer locus of the external thread **28** (major diameter) has an overall configuration that is substantially parallel to the longitudinal axis L_1 . While the major diameter of the implant **20** is substantially uniform, the external thread **28** may be modified at the leading edge by having initially a reduced thread radius to facilitate insertion of the implant **20** and may also be modified to make the external thread **28** self-tapping. In the preferred embodiment, the external thread **28** has a first thread **30** of a lesser radius than the radius R_1 of the remainder of the external thread **28** to facilitate insertion of the implant **20**. The second thread **32** has a greater radius than the first thread **30**, but is still shorter than the radius R_1 of the remainder of the external thread **28** which is thereafter of constant radius.

The body **22** is frusto-conical substantially along the portion of the body **22** in contact with the adjacent vertebrae of the spine which allows for the creating and maintaining of the adjacent vertebrae of the spine in the appropriate angular relationship to each other in order to preserve and/or restore the normal anatomic lordosis of the spine. The substantially uniform radius R_1 of the external thread **28** of the implant **20** allows for the engaging of the bone of the adjacent vertebrae in a position that counters the forces which tend to urge the implant **20** from between the adjacent vertebrae in the direction opposite to which the implant **20** was implanted. The greater thread height measured from the body **22** near the leading end **24** of the implant **20** provides greater purchase into the vertebral bone and again enhances the stability of the implant **20**. Further, the configuration of the external thread **28** increases the surface area of the implant **20** in contact with the vertebrae to promote bone ingrowth.

The implant **20** has a recessed slot **34** at its trailing end **26** for receiving and engaging insertion instrumentation for inserting the implant **20**. The recessed slot **34** has a threaded opening **36** for threadably attaching the implant **20** to instrumentation used for inserting the implant **20**.

Referring to FIG. 1A, the implant **20** has an outer surface **38** that is porous to present an irregular surface to the bone to promote bone ingrowth. The outer surface **38** is also able to hold fusion promoting materials and provides for an increased surface area to engage the bone in the fusion process and to provide further stability. It is appreciated that the outer surface **38**, and/or the entire implant **20**, may comprise any other porous material or roughened surface sufficient to hold fusion promoting substances and/or allow for bone ingrowth and/or engage the bone during the fusion process. The implant **20** may be further coated with bioactive fusion promoting substances including, but not limited to, hydroxyapatite compounds, osteogenic proteins and bone morphogenic proteins. The implant **20** is shown as being solid, however it is appreciated that it can be made to be substantially hollow or hollow in part.

In the preferred embodiment, for use in the lumbar spine, the implant **20** has an overall length in the range of approximately 24 mm to 32 mm with 26 mm being the preferred length. The body **22** of the implant **20** has a root diameter at the insertion end **24** in the range of 8–20 mm, with 14–16 mm being the preferred root diameter at the insertion end, and a root diameter at the trailing end **26** in the range of 10–24 mm, with 16–18 mm being the preferred diameter at the trailing end **26**, when said implants are used in pairs.

When used singly in the lumbar spine, the preferred diameters would be larger.

In the preferred embodiment, the implant **20** has a thread radius R_1 in the range of 6 mm to 12 mm, with 9–10 mm being the preferred radius R_1 . For use in the cervical spine, the implant **20** has an overall length in the range of approximately 10–22 mm, with 12–14 mm being the preferred length. The body **22** of the implant **20** has a root diameter at the insertion end **24** in the range of 8–22 mm, with 16–18 mm being the preferred root diameter at the insertion end when used singly, and 8–10 mm when used in pairs. The body **22** of the implant **20** has a root diameter at the trailing end **26** in the range of 10–24 mm, with 18–20 mm being the preferred root diameter at the trailing end **26** when used singly, and 10–12 mm when used in pairs; a thread radius R_1 in the range of approximately 4–12 mm, with 9–10 mm being the preferred radius R_1 when inserted singularly and 5–7 mm when inserted side by side in pairs.

Referring to FIG. 3, a cross sectional view along line 3—3 of the implant **120** is shown. The implant **120** has an outer wall **144** surrounding an internal chamber **146**. The large and small openings **140** and **142** may pass through the outer wall **144** to communicate with the internal chamber **146**. The internal chamber **146** may be filled with bone material or any natural or artificial bone growth material or fusion promoting material such that bone growth occurs from the vertebrae through the openings **140** and **142** to the material within internal chamber **146**. While the openings **140** and **142** have been shown in the drawings as being circular, it is appreciated that the openings **140** and **142** may have any shape, size configuration or distribution, suitable for use in a spinal fusion implant without departing from the scope of the present invention.

The implant **120** has a cap **148** with a thread **150** that threadably attaches to the insertion end **124** of the spinal fusion implant **120**. The cap **148** is removable to provide access to the internal chamber **146**, such that the internal chamber **146** can be filled and hold any natural or artificial osteoconductive, osteoinductive, osteogenic, or other fusion enhancing material. Some examples of such materials are bone harvested from the patient, or bone growth inducing material such as, but not limited to, hydroxyapatite, hydroxyapatite tricalcium phosphate; or bone morphogenic protein. The cap **148** and/or the spinal fusion implant **120** may be made of any material appropriate for human implantation including metals such as cobalt chrome, stainless steel, titanium, plastics, ceramics, composites and/or may be made of, and/or filled, and/or coated with a bone ingrowth inducing material such as, but not limited to, hydroxyapatite or hydroxyapatite tricalcium phosphate or any other osteoconductive, osteoinductive, osteogenic, or other fusion enhancing material. The cap **148** and the implant **120** may be partially or wholly bioabsorbable.

Referring to FIG. 3A, an alternative embodiment of implant **120** is shown and generally referred to by the numeral **120'**. The implant **120'** has a body **122'** similar to body **122** of implant **120** and has an external thread **128'** having a radius R_3 measured from the central longitudinal axis L_3 of the implant **120'**. The thread radius R_3 is not constant throughout the length of the implant **120'** and the external thread **128'** has a thread height that is also not constant with respect to the body **122'** of the implant **120'**. In the preferred embodiment, the implant **120'** has an external thread **128'** with a radius R_3 that increases in size from the insertion end **124'** to the trailing end **126'** of the implant **120'**.

Referring to FIG. 4, an alternative embodiment of the spinal fusion implant of the present invention is shown and

generally referred to by the numeral **220**. The implant **220** has a frusto-conical body **222** and an outer locus that is generally frusto-conical substantially along the portion of the implant **220** that is in contact with the adjacent vertebrae of the spine. The implant **220** has a surface configuration of forward facing ratchetings **240** suitable for engaging the bone of the adjacent vertebrae. Each of the plurality of ratchetings **240** has a bone engaging edge **242** and ramped portion **244**. The ratchetings **240** have a radius R_4 measured from the central longitudinal axis L_4 of the implant **220** that increases from the insertion end **224** to the trailing end **226**. The height of the ratchetings **240** measured from the body **222** is constant throughout the length of implant **220**.

The orientation of the ratchetings **240** makes the insertion of the implant **220** easier than its removal, as the ramped portions **244** act as an inclined plane on the way in, while the bone engaging edges **242** resist motion in the opposite directions. These forward facing ratchetings **240** tend to urge the implant **220** forward until the unremoved bone of the vertebrae blocks further motion resulting in a very stable spine and implant construct.

In the preferred embodiment, the bone engaging edges **242** of the ratchetings **240** have a height at a highest point measured from the body **222** (root diameter) of the implant **220** in the range of 0.25–2.0 mm, with the preferred height being 0.4 mm for use in the cervical spine and 1.25 mm for use in the lumbar spine.

Referring to FIGS. **5** and **6**, cross sectional views of implant **220** are shown. The implant **220** has channels **250** passing through the implant **220** and wells **260** formed in the surface of the implant **220**. The wells **260** may or may not communicate with the channels **250**. In the preferred embodiment of implant **220**, the channels **250** have a diameter in the range of 0.1 mm to 6 mm, with 2–3 mm being the preferred diameter. The wells **260** have a diameter in the range of 0.1 mm to 6 mm, with 1–3 mm being the preferred diameter range. It is appreciated that although the channels **250** and wells **260** are shown having a generally rounded configuration, it is within the scope of the present invention that the channels **250** and wells **260** may have any size, shape, configuration, and distribution suitable for the intended purpose.

Referring to FIGS. **6A** and **6B**, an alternative embodiment of the implant **220** is shown and generally referred to by the numeral **220'**. The implant **220'** is similar in configuration to implant **220** and has ratchetings **240'** having a radius R_5 measured from the longitudinal central axis L_5 that increases in size from the insertion end **224'** to the trailing end **226'**. The ratchetings **240'** each have a height measured from the body **222'** that is not constant throughout the length of the implant **220'**. In the preferred embodiment, the ratchet radius R_5 and the ratchet height increase in size from the insertion end **224'** to the trailing end **226'**.

As shown in FIG. **6B**, the implant **220'** has truncated sides **270** and **272** forming two planar surfaces which are diametrically opposite and are parallel to the longitudinal axis L_4 . In this manner, two implants **2201** may be placed side by side with one of the sides **270** or **272** of each implant touching, such that the area of contact with the bone of the adjacent vertebrae and the ratchetings **240'** is maximized. Alternatively, the implant **220'** may have one truncated side.

Referring to FIG. **7**, a side elevational view in partial cut-away of an alternative embodiment of the implant of the present invention is shown and generally referred to by the numeral **420**. The implant **420** has a body **422** that is frusto-conical in shape substantially along the portion of the implant **420** that is in contact with the adjacent vertebrae of

the spine and has an insertion end **424** and a trailing end **426**. The implant **420** has an outer surface **438** that is capable of receiving and holding bone, or other materials capable of participating in the fusion process and/or capable of promoting bone ingrowth. In the preferred embodiment, the surface **438** comprises a plurality of posts **440** that are spaced apart to provide a plurality of interstices **442** which are partial wells with incomplete walls capable of holding and retaining milled bone material or any artificial bone ingrowth promoting material. The implant **420** may be prepared for implantation by grouting or otherwise coating the surface **438** with the appropriate fusion promoting substances.

Referring to FIG. **8**, a side elevational view of an alternative embodiment of the spinal fusion implant of the present invention generally referred to by numeral **520** is shown. The implant **520** has a body **522** having a root diameter that is frusto-conical in the reverse direction as that of implant **20** shown in FIG. **1**, in order to preserve and/or restore lordosis in a segment of spinal column when inserted from the posterior aspect of the spine. The body **522** has an insertion end **524** and a trailing end **526**. In the preferred embodiment, the body **522** of the implant **520** has a minimum diameter at a point nearest to the trailing end **526** and a maximum diameter at a point nearest to the insertion end **524**. The insertion end **524** may have an anterior nose cone portion **530** presenting a tapered end to facilitate insertion.

The implant **520** has an external thread **528** having a substantially uniform radius R_6 measured from the central longitudinal axis L_6 of the implant **520**, such that the external diameter of the external thread **528** (major diameter) has an overall configuration that is substantially parallel to the longitudinal axis L_6 . It is appreciated that the thread **528** can have a major diameter that varies with respect to the longitudinal axis L_6 , such that the major diameter may increase from the insertion end **524** to the trailing end **526** or the reverse. The external thread **528** has a thread height measured from the body **522** that increases from the insertion end **524** to the trailing end **526**.

Referring to FIG. **9**, a segment of the spinal column **S** is shown with the vertebrae V_1 and V_2 in lordosis and an implant **520** shown being inserted from the posterior aspect of the spinal column **S** with an instrument driver **D**. The implant **520** is inserted with the larger diameter insertion end **524** first in order to initially distract apart the vertebrae V_1 and V_2 which then angle toward each other posteriorly as the implant **520** is fully inserted. It is appreciated that the insertion of implant **520** does not require the adjacent vertebrae V_1 and V_2 to be placed in lordosis prior to insertion, as the full insertion of the implant **520** itself is capable of creating the desired lordotic angular relationship of the two vertebrae V_1 and V_2 .

In the preferred embodiment of implant **520**, for use in said lumbar spine, the implant **520** has an overall length in the range of approximately 24 mm to 30 mm, with 26 mm being the preferred length. The body **522** of the implant **520** has a root diameter at the insertion end **524** in the range of 12–22 mm, with 16 mm being the preferred root diameter at the insertion end, and a root diameter at the trailing end **526** in the range of 10–20 mm, with 14 mm being the preferred diameter at the trailing end **526**. In the preferred embodiment, the implant **520** has a thread radius R_6 in the range of 6 mm to 12 mm, with 8 mm being the preferred radius R_6 .

Referring to FIG. **10**, an alternative embodiment of the spinal fusion implant of the present invention generally referred to by the numeral **620** and a partial fragmentary

view of a second identical implant, generally referred to by the numeral **621** are shown. The implant **620** has a body **622** that is partially frusto-conical in shape similar to body **22** of implant **20** shown in FIG. 1, and has an insertion end **624** and a trailing end **626**. The body **622** of the implant **620** has truncated sides **670** and **672** forming planar surfaces that are parallel to the longitudinal axis L_7 . In this manner, two implants **620** and **621** may be placed side by side, with one of the sides **670** or **672** of each implant with little space between them, such that the area of contact with the bone of the adjacent vertebrae is maximized. It is appreciated that the body **622** may also be cylindrical in shape and have truncated sides **670** and **672**.

The implant **620** has an external thread **628** having a radius R_6 measured from the central longitudinal axis L_7 that may be constant, such that the major diameter or outer locus of the external thread **628** has an overall configuration that is substantially cylindrical. It is appreciated that the external thread **628** may have a thread radius R_7 that is variable with respect to the longitudinal axis L_7 such that the major diameter or outer locus of the external thread **628** has an overall configuration that is substantially frusto-conical.

Referring to FIG. 11, an end view of the implant **620** placed beside implant **621** is shown. The implant **620** has a thread radius that is substantially constant and has a thread height measured from the body **622** that is greater at the sides **670** and **672**. In this manner, two implants **620** and **621** can be placed beside each other with the external thread **628** of each implant interdigitated allowing for closer adjacent placement of the two implants as a result of the substantial overlap of the external thread **628** at the side **670** or **672** of the implants.

Referring to FIG. 12, an alternative embodiment of the implant of the present invention is shown and generally referred to by the numeral **700**. The implant **700** is similar in configuration to implant **20** shown in FIG. 1, except that the body **722** has an irregular configuration. The configuration of the body **722** has a root diameter D which is variable in size throughout the length of the implant **700** and, as shown in this embodiment, comprises larger diameter portions **750** and smaller diameter portions **752**. It is appreciated that each of the large diameter portions **750** may be of the same or different diameter and each of the smaller diameter portions **752** may be of the same or different diameter.

The outer surface of the body **722** of implant **720** may be filled with fusion promoting substances such that the smaller diameter portions **752** may hold such fusion promoting substances. If so filled, the composite of the implant **700** and the fusion promoting material could still produce an even external surface of the body **722** if so desired.

The Method Of The Present Invention

The embodiments of the frusto-conical implants of the present invention described above may be implanted with the method of the present invention described below.

In the preferred method of the present invention, the diseased disc between two vertebrae is at least partially removed from the anterior aspect of the spine. The two vertebrae adjacent the diseased disc are then optimally distracted and placed in the desired amount of lordosis by any of a number of well known means including, but not limited to, those means that distract the vertebral bodies by engaging screws placed into the anterior aspect of the vertebral bodies, and disc space distractors that are placed from the anterior aspect of the spine into the disc space and are then used to urge the vertebral endplates away from each other and into lordosis. When the correct amount of distract-

tion and lordosis have been achieved at the affected disc level, then a frusto-conical space is created from anterior to posterior between the adjacent vertebrae. The frusto-conical space that is created is greater in diameter than the disc space height, such that some bone is removed from each of the adjacent vertebrae. The created space is generally frusto-conical in shape, being greatest in diameter anteriorly and tapering to a lesser diameter posteriorly.

It should be noted that where the spine is of sufficient width, it may be possible to prepare two such frusto-conical spaces side-by-side at the same disc level, allowing for the use of two implants instead of one. In either event, once the frusto-conical space is prepared and all debris removed, the implant is then inserted into the prepared space across the disc space, penetrating into each of the adjacent vertebrae, from anterior to posterior.

In the preferred embodiment, the diseased disc is first removed by conventional discectomy. The depth of the disc space is then determined by direct measurement. An interspace distractor such as that described by Michelson in U.S. patent application Ser. No. 08/396,414 entitled Apparatus and Method of Inserting Spinal Implants, incorporated herein by reference, is then inserted into the disc space. A series of such distractors are available and are sequentially inserted until the optimal amount of distraction across the disc space is achieved. The interspace distractors utilized for this purpose are wedged so as to induce physiological lordosis. An outer sleeve is then fitted over the barrel portion of the interspace distractor and firmly seated in engagement with the spine. As previously described in U.S. patent application Ser. No. 08/396,414, said outer sleeve may itself have extended portions capable of either maintaining or of obtaining and maintaining distraction. Said outer sleeve may also have vertebrae engaging prongs to further stabilize the outer sleeve to the spine and to more rigidly control motion at the adjacent vertebrae. As described in U.S. patent application Ser. No. 08/396,414, the use of the extended outer sleeve with distractor portions actually makes it possible to achieve the optimal distraction and lordosis without the use of the described interspace distractor. However, if the interspace distractor is used, then the outer sleeve is fully engaged to the spine, the distractor is removed, and in the preferred method by use of a slap-hammer, engaging the most proximal aspect of the distractor.

Referring to FIG. 13, a segment of the spinal column S is shown with vertebrae V_1 and V_2 shown in lordosis adjacent to disc space D_1 and vertebrae V_2 and V_3 shown not in lordosis, but relatively parallel to each other adjacent disc space D_2 . A first drill **810** making an opening **812** across the disc space D_1 , and into adjacent vertebrae V_1 and V_2 , and a second drill **820** making an opening **822** across the disc space D_2 and into adjacent vertebrae V_2 and V_3 are shown in FIG. 13. In the preferred embodiment, the interbody spinal fusion implant itself is threaded and frusto-conical in shape and therefore, the remaining portion of the procedure will be described in regard to that particular embodiment of the present invention, by way of example. With the disc space fully distracted and in anatomical lordosis and with the outer sleeve firmly engaged to the spine, it is then desirable to prepare the spine for receipt of the interbody fusion implant. It is preferable to prepare a space across the disc space and penetrating into the adjacent vertebrae which space corresponds roughly to the root dimensions of the implant to be implanted. For this purpose, a stopped-out bone cutting instrument is inserted through the outer sleeve, the shape of the cutting portion of the first drill **510** generally corresponding to the frusto-conical shape of the root diam-

eter of the implant being inserted. This instrument may take the form of a frusto-conical drill or a mill and may be used to cut the bone by rotation, said rotation being achieved either through a manual handle or with power. Having prepared the space, the surgeon has two options. One is to remove the outer sleeve and then, because the implant is itself frusto-conical, screw the implant in using an implant driver capable of locking to the implant. The other is to leave the outer sleeve in place during the insertion of the implant.

If per the above, the surgeon wishes to remove the outer sleeve, the insertion of the implant itself causes a reproduction of the previous distraction which is easily achieved as the implant itself is frusto-conical in shape and the space created by the removal of the bone to either side of the disc space essentially corresponds to the root diameter of the implant such that as the implant is inserted, the threads are embedded into the vertebrae adjacent the disc space. Once the implant is fully inserted, the insertion apparatus is disconnected from the implant. If the cervical disc space is sufficiently wide from side-to-side, the procedure is performed in the same manner except that either a double-barrelled outer sleeve may be used or the previously described procedure essentially performed twice at the same disc level, such that a pair of implants may be inserted side-by-side.

In the alternative, if the surgeon wishes to leave the outer sleeve in place during the insertion of the implant and if the implant, as per this example has both a minor and a major diameter such as with a threaded implant, then the bone removing portion of the drilling means needs to generally correspond to the root diameter of the implant while the inside diameter of the outer sleeve needs to be great enough to allow the passage of the major diameter of the implant. It is desirable to stabilize the bone removal instrument and to assure that it removes equal portions of bone from each of the adjacent vertebrae. This may be achieved by a reduction sleeve which fits between the bone removal means and the inner wall of the outer sleeve and which essentially corresponds to the difference between the minor and major diameters of the implant, or some portion of the drill shaft proximal to the cutting end may have a diameter which corresponds to the major diameter of the implant even while the distal bone removing portion corresponds to the root diameter of the implant. In either way, the bone removal instrument is both stabilized and centered within the outer sleeve.

The approach to the lumbar spine may either be retroperitoneal, or transperitoneal. The procedure may be performed under direct vision, or laproscopically with the use of an endoscope. Generally it is preferable to utilize two implants which are inserted in an anterior to posterior direction, one to either side of the midline. The implants may be inserted using either a single-barrelled or double-barrelled outer sleeve, and by the methods previously described in the pending U.S. patent application Ser. No. 08/396,414 from which the present methods differ only in the shape of the drill end or bone milling device which is essentially conical. As also previously described, in copending application Ser. No. 08/396,414, the methods can be utilized for the insertion of non-threaded implants in which case said implants are linearly advanced rather than threaded in. And finally, as previously described in co-pending application Ser. No. 08/390,131, the implants themselves may have truncations on the sides to form a planar surface parallel to the longitudinal axis of the implant, such that it is possible to fit two such implants more closely together by narrowing the width of each while preserving their height.

As taught in copending application Ser. No. 08/396,414, a tap may be used after the drilling step and prior to the insertion of the implants.

Referring again to FIG. 13, in an alternative method of implant insertion, the use of at least partially frusto-conical interbody spinal fusion implants allows for the creation of lordosis by the implant itself where none is present to begin with as with the angular relationship of V_2 and V_3 shown in FIG. 13. As per this example, the disc space D_2 which in the preferred circumstance would be fully distracted but need not be, but lacking lordosis, could have a bore drilled across that space such that equal arcs of bone A_1 and A_2 are removed from each of the adjacent vertebrae V_2 and V_3 using a drill **820** or bone milling device capable of producing a cylindrical bore. Where one such boring is performed, it would generally be in the center line and directed from anterior to posterior. This might be appropriate for use in the cervical spine. More commonly and as generally would be the rule in the lumbar spine, a pair of bores would be so created from anterior to posterior, one to each side of the midline. The essential feature here is that the vertebrae V_2 and V_3 , whether distracted from each other or not, are essentially lacking the full restoration of lordosis. The use of the substantially cylindrical bone drill **820** provides for the removal of a generally uniform thickness of bone from each of the adjacent vertebrae from anterior to posterior. The insertion of a frusto-conical implant, having a larger diameter at its trailing edge than at its leading edge, then forces the anterior aspects of the adjacent vertebrae apart more so than the posterior aspects where the diameter is lesser. This utilizes the implant to produce the desired lordosis.

The method for the insertion of the spinal fusion implants of the present invention from the posterior aspect of the spine is described in detail in co-pending patent application Ser. No. 08/396,414 and is incorporated herein by reference. Further, in the method of inserting the implants of the present invention from the posterior aspect of the spine, it is possible to place the adjacent vertebrae in lordosis prior to the bone removal step.

Referring to FIGS. 14 and 15, spinal distractor **900** is shown which is used for distracting the adjacent vertebrae in lordosis prior to the bone removal step. The spinal distractor **900** has a tapered insertion end **902** to facilitate insertion, an instrument engaging end **904**, and top and bottom surfaces **906** and **908**. The top and bottom surfaces **906** and **908** are in an angular relationship to each other and are furthest apart at a point near the insertion end **902** to produce the desired lordosis when inserted in the disc space between two adjacent vertebrae. The top and bottom surfaces **906** and **908** have surface roughenings **910** for engaging the bone of the adjacent vertebrae and stabilizing the spinal distractor **900** when inserted.

When the human spine is viewed from the side, it consists of a balanced series of curves, as opposed to the vertebrae being stacked one upon another in a straight line when viewed from the side. In both the cervical and lumbar regions of the spine, the vertebrae relate to each other so as to form curves where the apex of said curves is displaced forward within the body, and those segments of the spine are said to be in lordosis. In contradistinction, in the thoracic portion of the spine, the vertebrae relate to each other so as to form a curve where the apex of said curve is displaced posteriorly and is said to be in kyphosis. The methods and instrumentation of the present invention have as one of its purposes to provide for the permanent stabilization of contiguous vertebrae by fusion, there is then a need for a means to preserve said lordosis/kyphosis if present, or to restore

said lordosis/kyphosis if already lost, prior to the completion of the fusion procedure.

The following embodiments of the present invention, either individually or in combination, provide for both the stabilization and fusion to be performed with the related vertebrae in the correct anatomic lordosis or kyphosis. Where it is possible to approach the spine from various angles each of the devices, then has different forms appropriate to that specific approach.

Referring to FIG. 16, an alternative embodiment of the instrumentation of the present invention comprising a Posterior Long Lordotic Distractor **1400** capable of restoring and maintaining lordosis of adjacent vertebrae V from the posterior approach of the spine is shown. The Posterior Long Lordotic Distractor **1400** is inserted from the posterior aspect of the spine and comprises a barrel portion **1410** terminating at its distal end **1412** in a disc penetrating portion **1420** which is shown interposed within the disc space between two adjacent vertebrae V. The disc penetrating portion **1420** terminates distally into a leading bullet-shaped front end **1422** which facilitates the insertion of the disc penetrating portion **1420** between the adjacent vertebrae V. The disc penetrating portion **1420** is configured to have an uneven diameter such that it has a lesser diameter, and thus a lesser height within the disc space proximate the distal end **1412** of the barrel portion **1410** and has a greater diameter, and thus greater height within the disc space, in the direction of the front end **1422**. This configuration of the disc penetrating portion **1420** serves to not only restore the intervertebral disc space height upon insertion of the disc penetrating portion **1420** of the Posterior Long Lordotic Distractor **1400**, but also serves to restore and maintain the normal lordosis between the adjacent vertebrae V. The leading bullet-shaped front end **1422** is of particular importance in regard to the Posterior Long Lordotic Distractor **1400** where the largest diameter portion of the disc penetrating portion **1420** would otherwise be entering the disc space first.

The widest diameter of the disc penetrating portion **1420** is less than the diameter of the barrel portion **1410**, such that a circumferential shoulder **1424** is formed at the distal end **1412** of the barrel portion **1410** which prevents over penetration into the disc space of the Posterior Long Lordotic Distractor **1400**. It can readily be appreciated that such a configuration of the disc penetrating portion **1420** renders the Posterior Long Distractor **1400** quite stable within the disc space and resistant to backing out as the compressive forces of the spine upon the disc penetrating portion **1420** tend to urge it forward, while simultaneously the circumferential shoulder **1424** makes such further motion impossible, thus making the Posterior Long Distractor **1400** exceedingly stable.

Referring to FIG. 17, in preparation for the bone removal step, the Posterior Long Lordotic Distractor **1400** is shown with the disc penetrating portion **1420** in place between the adjacent vertebrae V to restore and maintain lordosis of the spine. An Outer Sleeve **1140** described in reference to FIG. 5 of U.S. Pat. No. 5,484,437, is properly seated over the Posterior Long Lordotic Distractor **1400** using a mallet and the Driver Cap **160**. While the bone removal step may be performed by either the drilling method described in reference to FIGS. 11A and 11C or the "Trephine Method" described in reference to FIG. 11B of U.S. Pat. No. 5,484,437, the "Trephine Method" is preferred in this situation as it leaves the Posterior Long Lordotic Distractor **1400** undisturbed until sufficient space has been created by the removal of bone at least as great as the thickness of the wall of the

trephine **1270** itself to allow for the unobstructed removal of the Posterior Long Lordotic Distractor **1400**.

If the "Trephine Method" described above in reference to FIG. 11B of U.S. Pat. No. 5,484,437 is used with the Posterior Long Lordotic Distractor **1400** the Outer Sleeve **1140** would first be fitted with an Inner Sleeve **1242** such as that shown in FIG. 11B, prior to both being placed simultaneously down over the barrel portion **1410** of the Posterior Long Lordotic Distractor **1400**. Once the Outer Sleeve **1140** is concentrically seated relative to the barrel portion **1410**, the Inner Sleeve **1242** alone would be removed, and the trephine **1270** would then be placed over the Posterior Long Lordotic Distractor **1400** and within the confines of the Outer Sleeve **1140** and into the adjacent vertebrae V across the disc space to the appropriate depth. The use of an Inner Sleeve is not required as the trephine **1270** is both centered and aligned by the Posterior Long Lordotic Distractor **1400**.

In addition to cutting the two hemi-cylinders of bone, one for each vertebrae V, the saw-like sharp cutting teeth **1271** of the trephine **1270** shown in FIG. 11B removes a path of bone equal to the distance of the splaying out of each of the cutting teeth **1271** relative to its neighbor and which distance cannot be less than the wall thickness of the trephine **1270** itself. Thus, once the trephine **1270** is removed, left behind is a semi-cylindrical space outlining each of the arcs of bone cut from the adjacent vertebrae V such that the two spaces combined provide for sufficient space such that it is then possible to extract the Posterior Long Lordotic Distractor **1400** without disturbing the vertebrae V themselves as the vertebrae V are held in position by the Outer Sleeve **1140** which engages both of the vertebrae V.

Referring to FIGS. 18 and 19, since the vertebrae V are placed into lordosis prior to the bone removal step, the space S created by the bone removal is cut at an angle relative to the vertebrae V in the shape of a cylinder, and which corresponds to the shape of the cylindrical implant I. In this manner, the cylindrical implant I with parallel walls may be inserted between adjacent vertebrae V which have been stabilized for fusion in angular relationship to each other so as to preserve the normal curvature of the spine.

Referring to FIGS. 20 and 21, an elevational side view and a top plan view, respectively, of a Posterior Short Lordotic Distractor **1500** for posterior use generally referred to by the numeral **1500** is shown. The Posterior Short Lordotic Distractor **1500** is similar to the Short Distractor **1120** described in reference to the Convertible Distractor and comprises a disc penetrating portion **1520** identical to that of the Posterior Long Lordotic Distractor **1400** and an increased diameter head **128** as described in reference to FIGS. 3-3F of U.S. Pat. No. 5,484,437. As discussed above for the Posterior Long Distractor **1400**, the configuration of the disc penetrating portion **1520** renders the Posterior Short Lordotic Distractor **1500** quite stable. This is an especially important feature for the Posterior Short Lordotic Distractor **1500** because it is left under the delicate dural sac and nerves while work is being performed on the contralateral side of the spine. If the Posterior Short Lordotic Distractor **1500** were other than stable, injury to these structures might result. To further prevent unwanted backing out of the Posterior Short Lordotic Distractor **1500**, the bone engaging surface **1530** may be knurled or otherwise roughened, or have forward facing ratchetings.

Referring to FIG. 22, an Anterior Long Lordotic Distractor **1600** for use anteriorly within the spine is shown. It can be seen that the configuration of the disc penetrating portion **620** is the reverse of the disc penetrating portion **1420** of the Posterior Long Lordotic Distractor **1400** in that the disc

penetrating portion **1620** is of greatest diameter and height proximate the barrel portion **1610** and that the diameter and height are diminished more distally in the direction towards the front end **1622** along the disc penetrating portion **1620**. The Anterior Long Lordotic Distractor **1600** serves to restore and maintain lordosis of the spine by distraction of the adjacent vertebrae V. As described above for the Posterior Short Lordotic distractor **1500**, it is appreciated that an Anterior Short Lordotic Distractor (not shown) having a disc penetrating portion **1520** may be similarly devised.

It can be seen that all of the lordotic distractors, both the anterior and the posterior embodiments, have specialized leading bullet-shaped or nosecone-shaped portions so as to facilitate the insertion of the disc penetrating portions within the disc space. This is of particular importance in regard to the Posterior Lordotic Distractors where the largest diameter portion of the disc penetrating portion **1420** would otherwise be entering the disc space first.

Referring to FIGS. **23** and **25**, an alternative embodiment of the present invention for maintaining distraction during the surgical procedure involves a more specialized form of the previously described Outer Sleeve **1140** and is shown and identified as the Extended Outer Sleeve **1700**. The Extended Outer Sleeve **1700** comprises a hollow tubular member **1702** having a distal end **1710** which has been extended such that a pair of extended portions **1720** and **1722**, which are essentially a continuation of the hollow tubular member **1702** itself (with or without reinforcement), are opposed 180 degrees from each other, tapered at their leading edges **1724** and **1726** for ease of introduction, and of such height as to restore the height of the intervertebral disc space. Located at the distal end **1710** may be a plurality of teeth **1712**, similar to those previously described above, or other engagement means for engaging the bone of the adjacent vertebrae V. It is appreciated that the distal end **1710** may have no teeth **1712**.

The Extended Outer Sleeve **1700** is entirely a new invention such as has never existed in the art or science of surgery, the Extended Outer Sleeve **1700** offers numerous advantages over all previously described drilling sleeves and the Outer Sleeve **1140** herein previously described. The Extended Outer Sleeve **1700** by dint of its extended portions **1720** and **1722** which are inserted between the adjacent vertebrae does itself act as an intervertebral distractor and is therefore essentially a combination outer sleeve and distractor. The Extended Outer Sleeve **1700** is exceedingly stable as the extended portions **1720** and **1722** are trapped within the disc space and further held there by the considerable compressive loads within the spine.

Referring to FIG. **25**, because of the stability thus provided, a further derivative advantage is that the teeth **1772** on the distal end **1710** of the Extended Outer Sleeve **1700** may either be eliminated as shown in FIG. **26**, or in the preferred embodiment be made of a lesser size. Further, it should be noted that teeth **1712** when present would be confined to the area directly in line with the vertebrae V and the extended portions **1720** and **1722** would ensure the proper rotatory alignment.

A further advantage, to be discussed in more detail subsequently, is that the extended portions **1720** and **1722** confine the surgery to the area within and between the extended portions **1720** and **1722** and protect all other tissues external to the extended portions **1720** and **1722**.

Having now described the novel concept of the Extended Outer Sleeve **1700**, attention may now be directed to further variations of the Extended Outer Sleeve **1700** capable of not only restoring and maintaining the appropriate intervertebral

disc space height, but additionally being able to restore and maintain anatomic lordosis or kyphosis, as desired, throughout the surgical procedure.

Referring to FIG. **26**, a Posterior Lordotic Extended Outer Sleeve **1800** for use from the posterior approach of the spine is shown. The Posterior Lordotic Extended Outer Sleeve **1800** comprises a hollow tubular member **1802** having a distal end **1810** which has been extended such that a pair of extended portions **1820** and **1822**, which are essentially a continuation of the tubular member **1802**, are opposed 1180 degrees from each other. The extended portions **1820** and **1822** differ from the extended portions **1720** and **1722** in that the extended portions **1820** and **1822** are configured to restore and maintain lordosis of the spine similar to the disc penetrating portion **1420** of the Posterior Long Lordotic Distractor **1400**, the features of which are herein incorporated by reference.

The extended portions **1820** and **1822** each have a height that is lesser at a point proximate the distal end **1810** of the tubular member **1802** that increases in the direction away from the tubular member **1802**. The extended portions **1820** and **1822** are tapered at their leading edges **1824** and **1826**, respectively to facilitate insertion into the disc space.

Between the extended portions **1820** and **1822**, may be a plurality of teeth **1812** for engaging the bone of the vertebrae V when the Extended Outer Sleeve **1800** is inserted within the disc space between the adjacent vertebrae V.

Referring to FIG. **27**, a Posterior Lordotic Extended Outer Sleeve **800** in place within the intervertebral disc space is shown.

Referring to FIG. **28**, an Anterior Extended Outer Sleeve **900** for use from the anterior approach of the spine is shown. The Anterior Lordotic Extended Outer Sleeve **900** comprises a hollow tubular member **1902** having a distal end **1910** which has been extended such that a pair of extended portions **1920** and **1922** which are essentially a continuation of the tubular member **1902** and are opposed 1180 degrees from each other. The extended portions **1920** and **1922** differ from the extended portions **1820** and **1822** in that the extended portions **1920** and **1922** are configured to restore and maintain lordosis of the spine from the anterior approach similar to the disc penetrating portion **1620** of the Anterior Long Lordotic Distractor **1600**, the features of which are herein incorporated by reference.

The extended portions **1920** and **1922** each have a height that is greater at a point proximate to the distal end **1910** of the tubular member **1902** that decreases in the direction away from the tubular member **1902**. The extended portions **1920** and **1922** are tapered at their leading edges **1924** and **1926**, respectively to facilitate insertion into the disc space.

While the Lordotic Extended Outer Sleeve for use anteriorly is shown in the singular form and in use in the lumbar spine, it is understood that it may take a double barreled form and in either form, be used throughout the spine.

Referring to FIGS. **29** and **30**, a Lumbar Dual Extended Outer Sleeve is shown and generally referred to by the numeral **2100**. The Dual Extended Outer Sleeve **2100** comprises two hollow tubular members **2101** and **2102**. The two hollow tubular members **2101** and **2102** have a distal end **2104** which has been extended to form an extended portion **2121** which is essentially a continuation of the hollow tubular members **2101** and **2102** joined together. The extended portion **2121** is similar in shape and function to the extended portions **2920** and **2922** described above in reference to FIG. **31**. The extended portion **2121** has a height that is greater at a point proximate the distal end **2104** and decreases in the direction away from the hollow tubular

members **2101** and **2102**, in order to maintain the normal curvature of the spine by correcting the angular relationships of the vertebrae V. The extended portion **2121**, is tapered at its leading edge **2124** to facilitate insertion of the extended portion **2121** into the disc space between two adjacent vertebrae V. Located at the distal end of the tubular members **2101** and **2102** are sharpened teeth **2130** for engaging the vertebrae V.

Each of the hollow tubular members **2101** and **2102** are displaced from each other ideally the sum of the difference between the minor and major diameters of two threaded spinal implants I combined, but not less than that difference for one implant I, as it is possible to have the threads of one implant I nest interposed to the threads of the other implant I such that they both occupy a common area between them. Typically, the walls of each hollow tubular members **2101** and **2102** have a combined thickness at the point which the walls of the hollow tubular members **2101** and **2102** are in contact with each other which is approximately 2.0 mm. This is achieved by machining away part of each hollow tubular member **2101** and **2102** to reduce the wall thickness of each hollow tubular member **1101** and **1102** prior to joining them together. In this manner, the two hollow tubular members **2101** and **2102** may be placed closer together so that two spinal implants I may be placed closer together when inserted within the disc space between adjacent vertebrae W. The hollow tubular member **2101** and **2102** can be overlapped or displaced from each other so as to control the distance between implants when the Dual Extended Outer Sleeve is utilized and two implants implanted.

The hollow tubular members **2101** and **2102** may be bridged in part or wholly throughout their length, but are typically fixed by a foot plate **2110**, similar in function, but not in configuration, to Foot Plate **344** described above in reference to FIGS. 7C and 7D.

Referring specifically to FIG. 31, the foot plate **2110** has an oval configuration that contours and hugs the vertebrae and has a plurality of prongs **2112–2115** extending from the bottom of the foot plate **2110** is shown. The prongs **2112–2115** are sufficiently long to engage the bone of adjacent vertebrae V, but limited in length so as not to over penetrate beyond the vertebrae once inserted.

Referring to FIG. 32, a second Dual Extended Outer Sleeve **2200**, is shown. The Dual Extended Outer Sleeve **1200** is similar to the Dual Extended Outer Sleeve **2100**, except that it has additional extended portions **2220** and **2222** which have a height that is greater near the distal end **2204** of the hollow tubular members **2201** and **2202** and decreases in the direction away from the hollow tubular members **2201** and **2202**. The extended portions **2220–2222** are similar in shape and function to the extended portions **2920** and **2922** described above in reference to FIG. 31. Moreover, as the foot plate **2210** is rectangular and larger than foot plate **2110**, additional prong **2216** and **2217** may be added.

Further, it should be appreciated that the lordotic distractor for use posteriorly when referring to their use in the lumbar spine, would be used anteriorly if applied to the thoracic spine, either in the single or double-barrel form. This is because the thoracic spine is normally curved into kyphosis which is the reverse of lordosis. That is, in approaching the thoracic spine anteriorly, it would be desirable to distract the back of the disc space more than the front, and that would require an Extended Outer Sleeve which would resemble that seen in FIG. 28; though when used in this new context, it would more correctly be referred to as an Anterior Thoracic Kyphotic Extended Outer Sleeve. As

with the Posterior Lordotic Outer Sleeve, the Posterior and Anterior Long Lordotic Posterior Short Lordotic Distractor and Anterior Short Lordotic Distractors, though referred to previously as lordotic when placed into the lumbar spine from the posterior approach, would now more correctly, when placed in the thoracic spine from the anterior approach be called Kyphotic Thoracic Distractors.

It can readily be appreciated that the described Extended Outer Sleeves may be used with the Short and Long Distractors having a disc penetrating portion of uniform diameter or in combination with the lordotic and kyphotic distractors of complimentary configuration.

Referring to FIGS. 33–38, shown is the apparatus **2350** for use in installing an improved interbody spinal fusion implant **2300** having one or more flat sides as disclosed in co-pending application filed on Feb. 17, 1995, entitled IMPROVED INTERBODY SPINAL FUSION IMPLANTS which is incorporated herein by reference. The apparatus **2350** comprises a Dual Outer Sleeve **2310** having a pair of overlapping, hollow cylindrical tubes **2352** and **2354** identical in size and each having an internal diameter slightly larger than the outer diameter of the spinal fusion implant. The cylindrical tubes **2352**, **2354** are in communication with each other along their length and are displaced from each other ideally a distance that is slightly greater than the sum of the diameters of two spinal fusion implants **2300** placed side-by-side with the flat sides of each spinal fusion implant touching. The cylindrical tubes **2352** and **2354** are joined longitudinally such that they are partially overlapping. The hollow cylindrical tubes **2352** and **2354** are mounted on a foot plate **2362** similar to the foot plate described in FIG. 32. There are a series of prongs **2364a–2364f** projecting from the bottom **2366** of the foot plate **2360** which are used to engage the Dual Outer Sleeve **2310** to the base of the adjacent vertebrae V.

Referring specifically to FIG. 34, the apparatus **2350** is introduced over two Long Distractors **2320** and **2322** placed side-by-side and protruding anteriorly from the vertebrae V. The Long Distractors **2320** and **2322** are similar to the Long Distractor **100** described in U.S. Pat. No. 5,484,437 except that they have a flat side **2324** and **2326**, respectively.

Referring to FIGS. 34 and 35, in one embodiment, the foot plate **2360** is essentially rectangular, but without sharp corners. It is appreciated by those skilled in the art, that other shapes can be utilized.

As shown in FIGS. 33 and 36, the foot plate **1360** is contoured so as to approximate the external curvature of the vertebrae V anteriorly. Extending forward from foot plate **1360** are the multiple sharp prongs **2364a–2364f** which are sufficiently long to permit fixation of the foot plate **2360** to the vertebrae V. The prongs **2364a–2364f** are limited in length so as to not penetrate the vertebrae V too far posteriorly and number from 2 to 10, but preferably 6.

Referring to FIG. 36, as the Dual Outer Sleeve **2350** is driven forward, the prongs **2364a–2364f** extending from foot plate **2360** are embedded into the opposed vertebrae V until their forward motion is inhibited by the foot plate **2360** becoming congruent to and being stopped by, the anterior aspect of the vertebrae V.

As shown in FIG. 33, once the apparatus **2350** has been fully seated, the vertebrae V adjacent the interspace D to be fused are rigidly held via foot plate **2360** and the prongs **2364a–2364f**. Thus, it is possible to remove either one, or if desired, both of the long distractors **2320** and **2322**. The dual outer sleeve has been described above for inserting two implants each having at least one flat side, may have extended portions for intradiscal insertion which are capable

of producing distraction as well as kyphosis or lordosis as previously described with such extensions extending in line with the lateral walls of the cylindrical tubes.

Referring to FIG. 37, once the Dual Outer Sleeve 2350 has been fully seated, one of the Long Distractors 2320 and 2322 is removed and the surgeon may drill the interspace D utilizing drill 250 using each of the hollow cylinders 2352, 2354 to guide the drill 250 in order to create overlapping holes in which the spinal fusion implants 2300a and 2300b may be inserted. It is also appreciated by those skilled in the art, that a hollow inner sleeve (not shown) may be inserted into the hollow cylinders 2352, 2354 through which the drilling is performed or the Long Distractors may be left in place and a hollow trephine that fits over each of the Long Distractors 2320 and 2322 may be used to drill the interspace D. It is readily appreciated that the tubular members can be of a variety of shapes and sizes. Further, the removal of disc and bone may be accomplished by the use of a burr, or a chisel of appropriate shape for that purpose and with or without the use of a drill. The implants would then have shapes appropriate for use in the spaces so formed.

Referring to FIG. 38, once the interspace D has been drilled, an implant Driver 350 described above is used to insert the spinal fusion implants 2300 and 2300b preferably by linear advancement. The implant driver instrument 350 may be used to either insert or to remove the spinal fusion implants 2300a and 2300b.

Once affixed to the implant Driver 350, the spinal fusion implant 2300a is then introduced through one of the hollow cylindrical tubes 2352, 2354 and driven into the interspace D by the application of an impaction force transmitted through the implant driver instrument 350. Once the spinal fusion implant 2300a is inserted into the interspace D, the surface roughenings of the outer surface of the spinal fusion implant 2300a engage the bone of the vertebrae V and the implant Driver 350 is detached from the spinal fusion implant 2300a. The implant driver instrument 350 is then withdrawn from the Dual Outer Sleeve 2350 and the spinal fusion implant 2300a is fully installed and inset in the interspace D as shown in FIG. 38.

Once a first spinal fusion implant 2300a is inserted into the interspace D, a second spinal fusion implant 2300b is driven into the interspace D so that the flat side 2302a or 2302b of each spinal fusion implant 2300a and 2300b are adjacent to each other and are touching. In this manner, two spinal fusion implants 2300a and 2300b are implanted within the interspace D and engage the bone of the adjacent vertebrae V without exceeding the width of the spinal column. It is appreciated that there are other ways that two spinal implants can have complimentary shapes and that they can be inserted by linear advancement through a single (both at once) or dual outer sleeve having intradiscal extended members for stabilization, distraction, and/or to effect lordosis or kyphosis.

While the present invention has been described in detail with regards to the preferred embodiments, it is appreciated that other variations of the present invention may be devised which do not depart from the inventive concept of the present invention. In particular, it is appreciated that the various teachings described in regards to the specific embodiments herein may be combined in a variety of ways such that the features are not limited to the specific embodiments described above.

Each of the features disclosed in the various embodiments and their functional equivalents may be combined in any combination sufficient to achieve the purposes of the present invention as described herein.

What is claimed is:

1. A method for inserting at least one frusto-conical spinal fusion implant made of a material appropriate for human implantation, said implant having bone engaging means for engaging the adjacent vertebrae in a segment of the spinal column, comprising the steps of:

distracting said adjacent vertebrae and placing said adjacent vertebrae in an angular relationship;

forming a frusto-conical bore from the anterior or posterior aspect of the spinal column across the distracted disc space between said adjacent vertebrae and into the adjacent vertebrae, said bore being at least in part greater in diameter than the distracted disc space such that some bone is removed from each of the adjacent vertebrae; and

inserting a frusto-conical spinal fusion implant into said bore.

2. The method of claim 1 in which said bore is greatest in diameter anteriorly and tapering to a lesser diameter posteriorly.

3. The method of claim 1 in which said bore is substantially cylindrical.

4. The method of claim 1 in which said step of forming includes the steps of using a drill having a substantially frusto-conical shaped bone removing portion.

5. The method of claim 1 further comprising the step of inserting a second spinal fusion implant across the disc space so as to engage each of the adjacent vertebrae, said second implant being side by side and adjacent to said first implant.

6. The method of claim 5 further comprising the steps of forming a second bore across the disc space partially overlapping said first bore, the combined width of said first and second bores being less than the sum of the individual diameters of said first and second bores; and inserting said second implant.

7. The method of claim 1 in which the step of forming said bore includes the substep of removing a portion of bone parallel to the vertebral endplates of the adjacent vertebrae.

8. The method of claim 1, wherein the distracting step includes the step of inserting a spinal distractor into the disc space between the adjacent vertebrae to induce angulation to the adjacent vertebrae.

9. The method of claim 8, further comprising the step of positioning a sleeve over said spinal distractor and into contact with the adjacent vertebrae.

10. The method of claim 9, further comprising the step of removing said spinal distractor prior to the step of forming.

11. The method of claim 9, wherein the positioning step includes the step of positioning a sleeve having an extension for insertion into the disc space and for bearing against end plates of the adjacent vertebrae.

12. The method of claim 11, wherein the positioning step includes the sub-step of inducing angulation to the adjacent vertebrae.

13. The method of claim 12, wherein the inducing angulation step includes the step of restoring lordosis to the adjacent vertebrae.

14. The method of claim 12, wherein the inducing angulation step includes the step of restoring kyphosis to the adjacent vertebrae.

15. The method of claim 9, wherein the forming step includes the sub-step of drilling the bore.

16. The method of claim 15, wherein the forming step further comprises the sub-step of placing a drill having a diameter greater than the disc space through said sleeve prior to the sub-step of drilling.

17. The method of claim 9, wherein the step of inserting includes the sub-step of inserting said implant through said sleeve and into the bore.

18. The method of claim 9, further comprising the step of placing an inner sleeve within said sleeve prior to the step of forming the bore.

19. The method of claim 18, further comprising the step of removing said inner sleeve prior to the step of inserting said implant.

20. The method of claim 1, wherein the forming step includes the sub-step of milling the bore.

21. The method of claim 1, further comprising the step of loading said implant with fusion promoting material prior to the step of inserting.

22. The method of claim 1, further comprising the step of loading said implant with osteogenic material prior to the step of inserting.

23. The method of claim 1, further comprising the step of coating said implant with bone morphogenic proteins prior to the step of inserting.

24. The method of claim 1, wherein the step of inserting includes inserting an implant containing a fusion promoting substance.

25. The method of claim 1, wherein the step of inserting includes inserting an implant comprising a fusion promoting substance.

26. The method of claim 1, wherein the step of inserting includes inserting an implant comprising a bone ingrowth surface.

27. A method for inserting at least one frusto-conical spinal fusion implant made of a material appropriate for human implantation, said implant having bone engaging means for engaging the adjacent vertebrae in a segment of the spinal column, comprising the steps of:

distracting the adjacent vertebrae;

forming a bore from the anterior or posterior aspect of the spinal column across the disc space and into the adjacent vertebrae, said bore being at least in part greater in diameter than the disc space between the distracted vertebrae such that some bone is removed from each of the adjacent vertebrae; and

inserting a frusto-conical spinal fusion implant into said bore.

28. The method of claim 27 in which said bore is generally cylindrical in shape.

29. The method of claim 22 in which said step of forming the step of includes using a drill having a substantially cylindrical shaped bone removing portion.

30. The method of claim 22 further comprising the step of inserting a second spinal fusion implant across the disc space so as to engage each of the adjacent vertebrae, said second implant being side by side and adjacent to said first implant.

31. The method of claim 30 further comprising the steps of forming a second bore across the disc space partially overlapping said first bore, the combined width of said first and second bores being less than the sum of the individual diameters of said first and second bores; and inserting said second spinal fusion implant into said second bore.

32. The method of claim 27 in which the step of forming said bore includes the substep of removing a portion of bone parallel to the endplates of the adjacent vertebrae.

33. The method of claim 27, wherein the distracting step includes the step of inserting a spinal distractor into the disc space between the adjacent vertebrae to induce angulation to the adjacent vertebrae.

34. The method of claim 33, further comprising the step of positioning a sleeve over said spinal distractor and into contact with the adjacent vertebrae.

35. The method of claim 34, further comprising the step of removing said spinal distractor prior to the step of forming.

36. The method of claim 41, wherein the positioning step includes the step of positioning a sleeve having an extension for insertion into the disc space and for bearing against end plates of the adjacent vertebrae.

37. The method of claim 34, wherein the positioning step includes the sub-step of inducing angulation to the adjacent vertebrae.

38. The method of claim 37, wherein the inducing angulation step includes the step of restoring lordosis to the adjacent vertebrae.

39. The method of claim 37, wherein the inducing angulation step includes the step of restoring kyphosis to the adjacent vertebrae.

40. The method of claim 34, wherein the forming step includes the sub-step of drilling the bore.

41. The method of claim 40, wherein the forming step further comprises the sub-step of placing a drill having a diameter greater than the disc space through said sleeve prior to the sub-step of drilling.

42. The method of claim 41, further comprising the step of placing an inner sleeve within said sleeve prior to the step of forming the bore.

43. The method of claim 42, further comprising the step of removing said inner sleeve prior to the step of inserting said implant.

44. The method of claim 34, wherein the step of inserting includes the sub-step of inserting said implant through said sleeve and into the bore.

45. The method of claim 27, wherein the forming step includes the sub-step of milling the bore.

46. The method of claim 22, further comprising the step of loading said implant with fusion promoting material prior to the step of inserting.

47. The method of claim 27, further comprising the step of loading said implant with osteogenic material prior to the step of inserting.

48. The method of claim 27, further comprising the step of coating said implant with bone morphogenic proteins prior to the step of inserting.

49. The method of claim 27, wherein the step of inserting includes inserting an implant containing a fusion promoting substance.

50. The method of claim 27, wherein the step of inserting includes inserting an implant comprising a fusion promoting substance.

51. The method of claim 27, wherein the step of inserting includes inserting an implant comprising a bone ingrowth surface.

52. A method for inserting a spinal implant across a disc space between adjacent vertebrae of a human spine, comprising the steps of:

distracting said adjacent vertebrae to induce angulation to the adjacent vertebrae;

forming a bore from the anterior or posterior aspect of the spinal column across the distracted disc space between said adjacent vertebrae and into the adjacent vertebrae, said bore having opposed arcuate portions in an angular relationship to one another along at least a portion of each of the adjacent vertebrae; and

inserting into said bore said spinal implant having opposed arcuate portions in an angular relationship to one another along the length of said implant and oriented toward the adjacent vertebrae.

53. The method of claim 52, wherein the distracting step includes the step of inserting a spinal distractor into the disc

space between the adjacent vertebrae to induce angulation to the adjacent vertebrae.

54. The method of claim **53**, further comprising the step of positioning a sleeve over said spinal distractor and into contact with the adjacent vertebrae.

55. The method of claim **52**, further comprising the step of removing said spinal distractor prior to the step of forming.

56. The method of claim **54**, wherein the positioning step includes the step of positioning a sleeve having an extension for insertion into the disc space and for bearing against end plates of the adjacent vertebrae.

57. The method of claim **56**, wherein the positioning step includes the sub-step of inducing angulation to the adjacent vertebrae.

58. The method of claim **57**, wherein the inducing angulation step includes the step of restoring lordosis to the adjacent vertebrae.

59. The method of claim **57**, wherein the inducing angulation step includes the step of restoring kyphosis.

60. The method of claim **54**, wherein the forming step includes the sub-step of drilling the bore.

61. The method of claim **60**, wherein the forming step further comprises the sub-step of placing a drill having a diameter greater than the disc space through said sleeve prior to the sub-step of drilling.

62. The method of claim **54**, wherein the step of inserting includes the sub-step of inserting said implant through said sleeve and into the bore.

63. The method of claim **54**, further comprising the step of placing an inner sleeve within said sleeve prior to the step of forming the bore.

64. The method of claim **63**, further comprising the step of removing said inner sleeve prior to the step of inserting said implant.

65. The method of claim **52**, wherein the forming step includes the sub-step of milling the bore.

66. The method of claim **52**, further comprising the step of loading said implant with fusion promoting material prior to the step of inserting.

67. The method of claim **54**, further comprising the step of loading said implant with osteogenic material prior to the step of inserting.

68. The method of claim **52**, further comprising the step of coating said implant with bone morphogenic proteins prior to the step of inserting.

69. The method of claim **52**, wherein the step of inserting includes inserting an implant containing a fusion promoting substance.

70. The method of claim **52**, wherein the step of inserting includes inserting an implant comprising a fusion promoting substance.

71. The method of claim **52**, wherein the step of inserting includes inserting an implant comprising a bone ingrowth surface.

72. A method for inserting a spinal implant across a disc space between adjacent vertebrae of a human spine, comprising the steps of:

forming a bore from the anterior or posterior aspect of the spinal column across the disc space and into the adjacent vertebrae, said bore being at least in part greater in diameter than the distracted disc space such that some bone is removed from each of the adjacent vertebrae; and

inserting into said bore said spinal implant having opposed arcuate portions oriented toward the adjacent

vertebrae, said arcuate portions being in a diverging relationship to one another along the length of said implant sufficient to induce angulation of the vertebrae.

73. The method of claim **72**, further comprising the step of distracting the adjacent vertebrae prior to the forming step.

74. The method of claim **73**, wherein the distracting step includes the step of inserting a spinal distractor into the disc space between the adjacent vertebrae to induce angulation to the adjacent vertebrae.

75. The method of claim **74**, further comprising the step of positioning a sleeve over said spinal distractor and into contact with the adjacent vertebrae.

76. The method of claim **75**, further comprising the step of removing said spinal distractor prior to the step of forming.

77. The method of claim **75**, wherein the positioning step includes the step of positioning a sleeve having an extension for insertion into the disc space and for bearing against end plates of the adjacent vertebrae.

78. The method of claim **77**, wherein the positioning step includes the sub-step of inducing angulation to the adjacent vertebrae.

79. The method of claim **78**, wherein the inducing angulation step includes the step of restoring lordosis to the adjacent vertebrae.

80. The method of claim **78**, wherein the inducing angulation step includes the step of restoring kyphosis.

81. The method of claim **75**, wherein the forming step includes the sub-step of drilling the bore.

82. The method of claim **81**, wherein the forming step further comprises the sub-step of placing a drill having a diameter greater than the disc space through said sleeve prior to the sub-step of drilling.

83. The method of claim **75**, wherein the step of inserting includes the sub-step of inserting said implant through said sleeve and into the bore.

84. The method of claim **75**, further comprising the step of placing an inner sleeve within said sleeve prior to the step of forming the bore.

85. The method of claim **84**, further comprising the step of removing said inner sleeve prior to the step of inserting said implant.

86. The method of claim **72**, wherein the forming step includes the sub-step of milling the bore.

87. The method of claim **72**, further comprising the step of loading said implant with fusion promoting material prior to the step of inserting.

88. The method of claim **72**, further comprising the step of loading said implant with osteogenic material prior to the step of inserting.

89. The method of claim **72**, further comprising the step of coating said implant with bone morphogenic proteins prior to the step of inserting.

90. The method of claim **72**, wherein the step of inserting includes inserting an implant containing a fusion promoting substance.

91. The method of claim **72**, wherein the step of inserting includes inserting an implant comprising a fusion promoting substance.

92. The method of claim **72**, wherein the step of inserting includes inserting an implant comprising a bone ingrowth surface.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,210,412 B1
DATED : April 3, 2001
INVENTOR(S) : Gary Karlin Michelson

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 22, claim 14,

Line 3, change "asdjacent" to -- adjacent --;

Column 23, claim 29,

Line 1, change "22" to -- 27 --, and change "said" to -- the --;

Line 2, delete "the step of";

Column 23, claim 30,

Line 1, change "22" to -- 27 --;

Column 24, claim 36,

Line 1, change "41" to -- 34 --;

Column 24, claim 46,

Line 1, change "22" to -- 27 --;

Column 25, claim 55,

Line 1, change "52" to -- 54 --; and

Column 25, claim 67,

Line 1, change "54" to -- 52 --.

Signed and Sealed this

Sixteenth Day of October, 2001

Attest:

Nicholas P. Godici

Attesting Officer

NICHOLAS P. GODICI
Acting Director of the United States Patent and Trademark Office