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(54) **METHOD FOR USING A GUARD FOR CREATING A SOCKET POSTERIORLY IN THE LUMBAR SPINE**

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See application file for complete search history.

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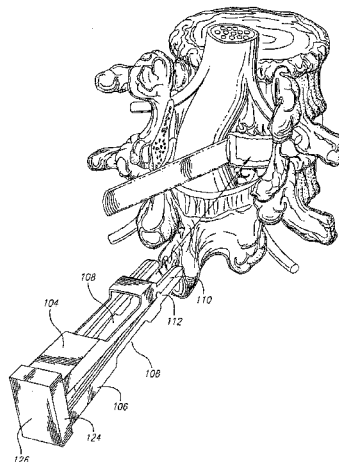
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(57) **ABSTRACT**

A method for guiding a bone removal device to form a socket in the human spine and for inserting a cortical bone implant into the socket. The method includes placing a guard against the posterior aspect of the spine, the guard having a passage therethrough, inserting the bone removal device into the passage, removing a portion of a facet joint with the bone removal device to create the socket having a maximum height, and inserting the cortical bone implant into the socket. The cortical bone implant has a leading end, a trailing end, a mid-longitudinal axis through the ends, and a height transverse to the mid-longitudinal axis, the height of the cortical bone implant being greater than the maximum height of the socket.

21 Claims, 25 Drawing Sheets



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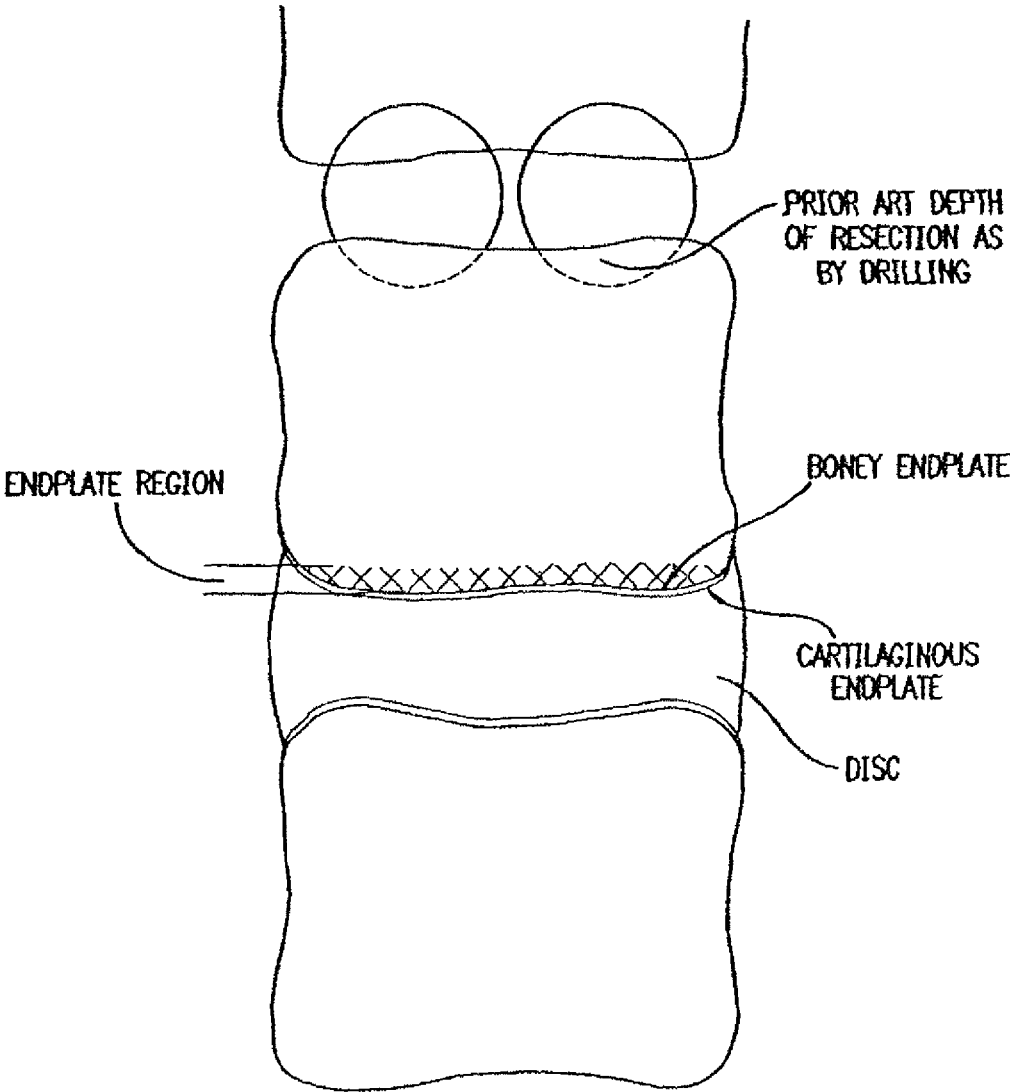
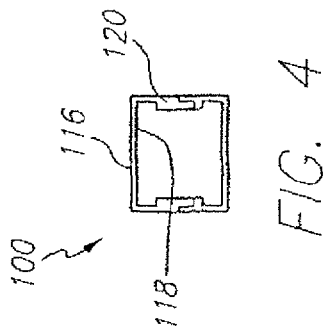
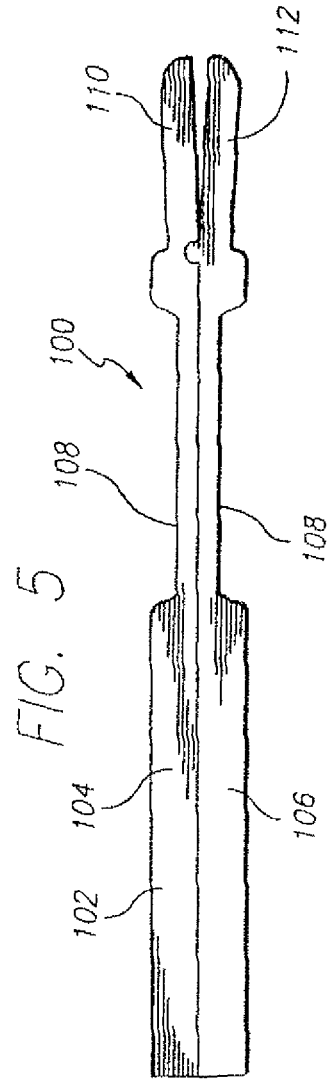
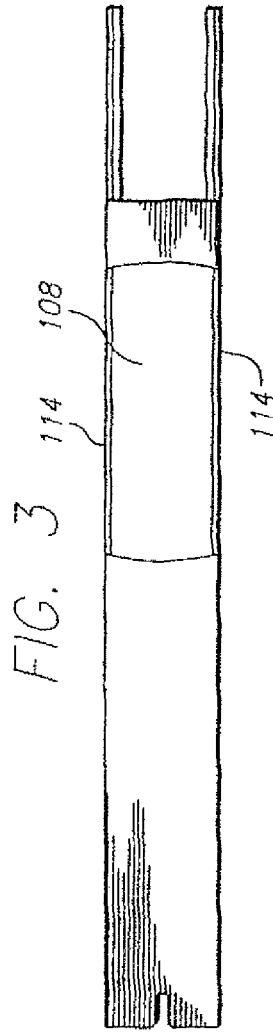
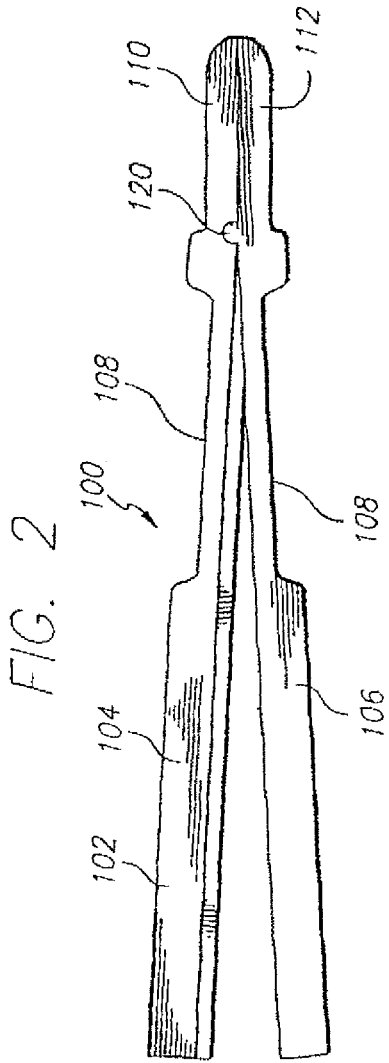


FIG. 1



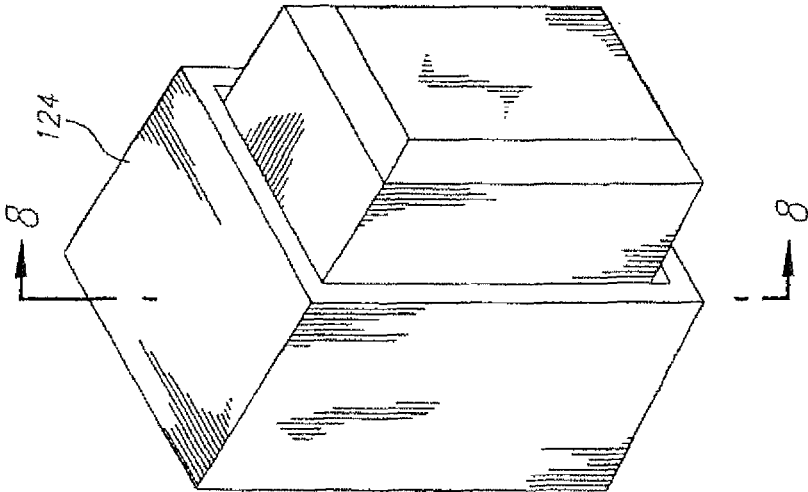


FIG. 7

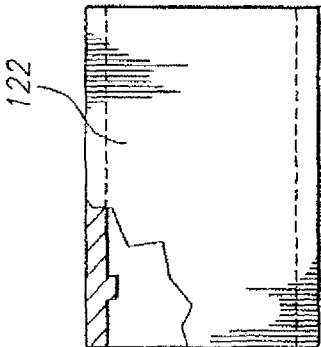


FIG. 6

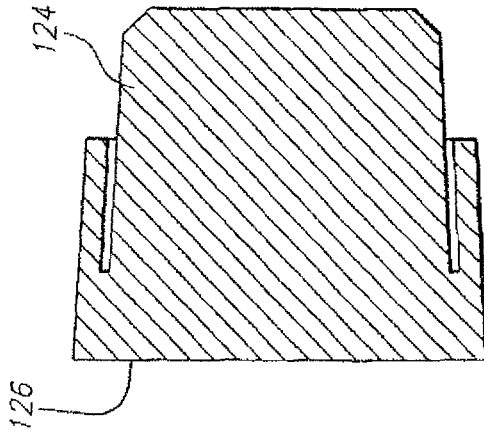
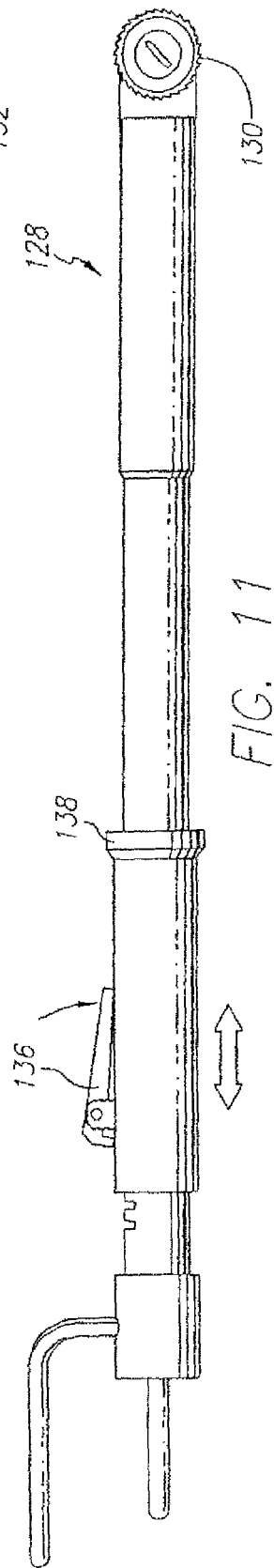
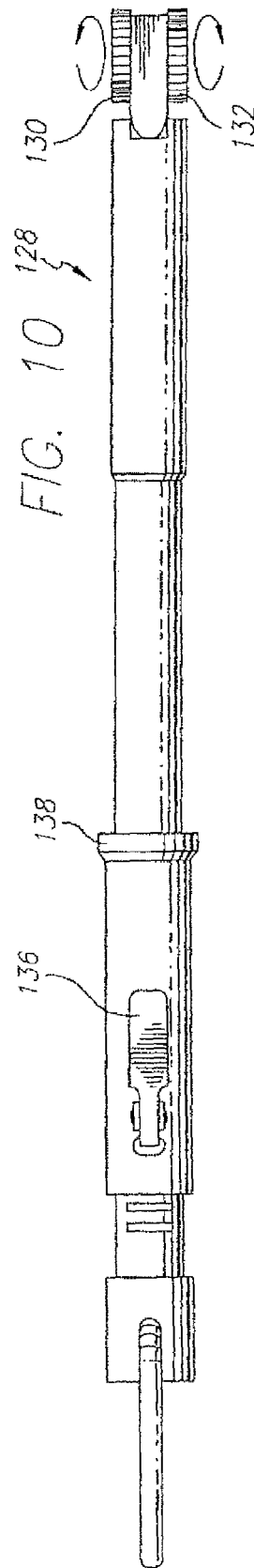
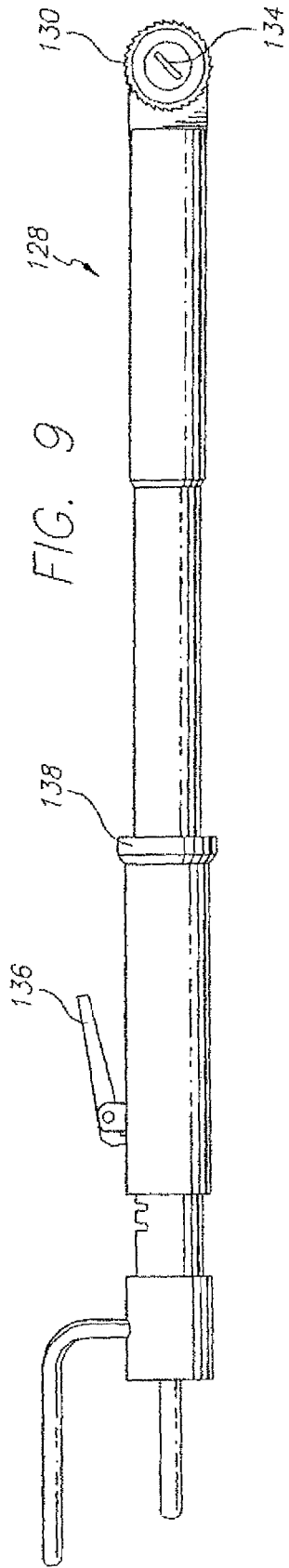


FIG. 8



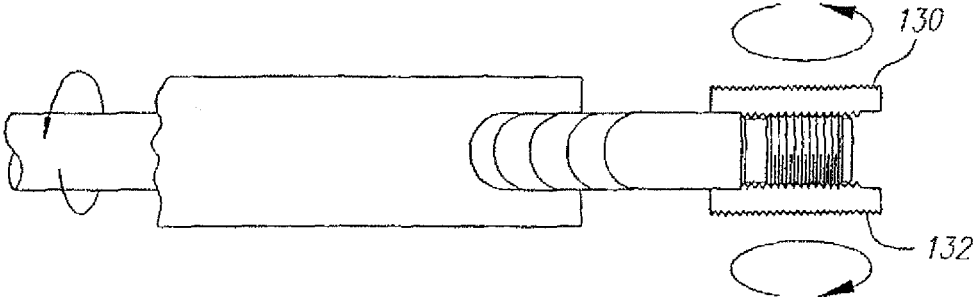


FIG. 12

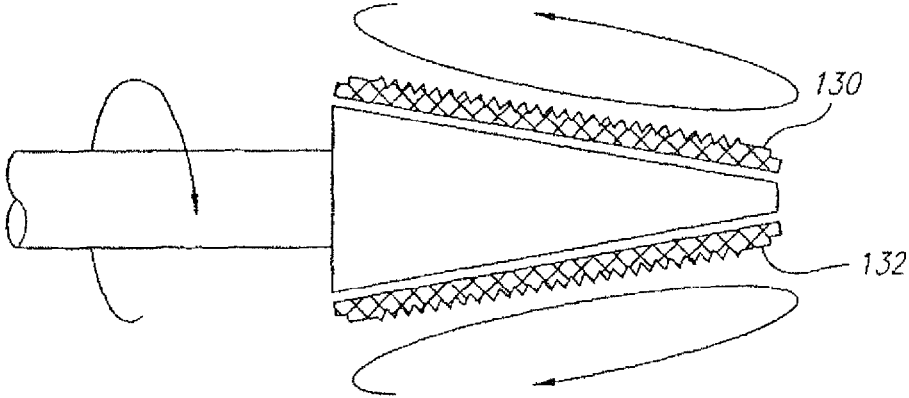


FIG. 13

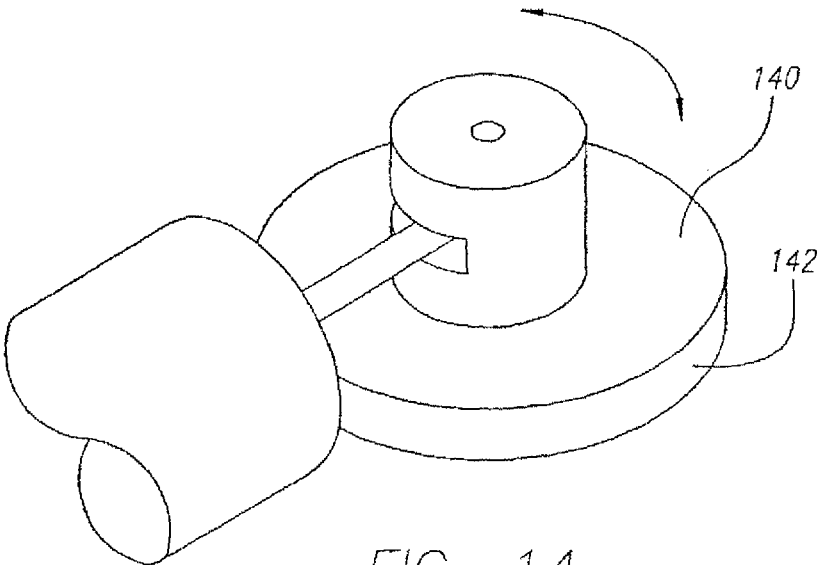


FIG. 14

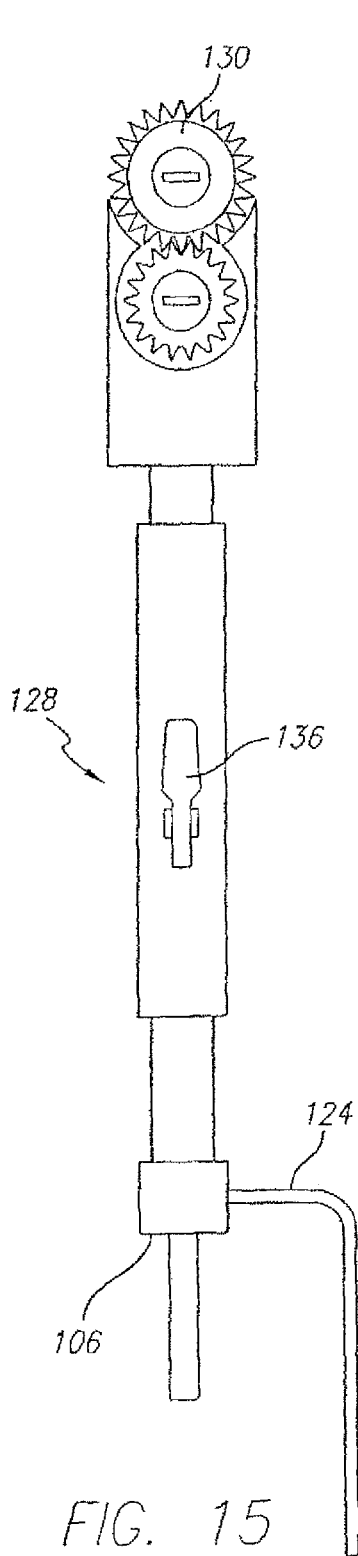


FIG. 15

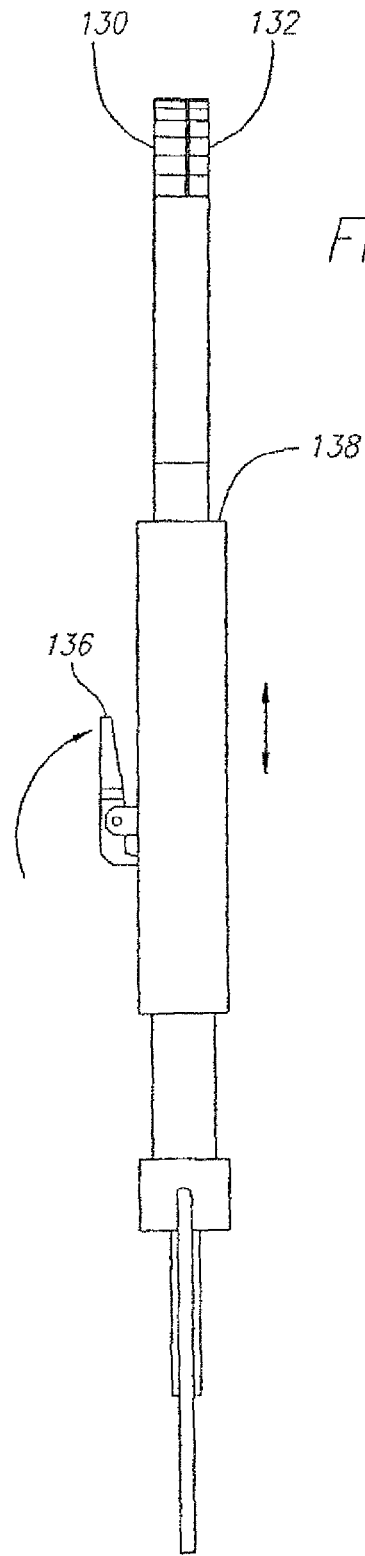
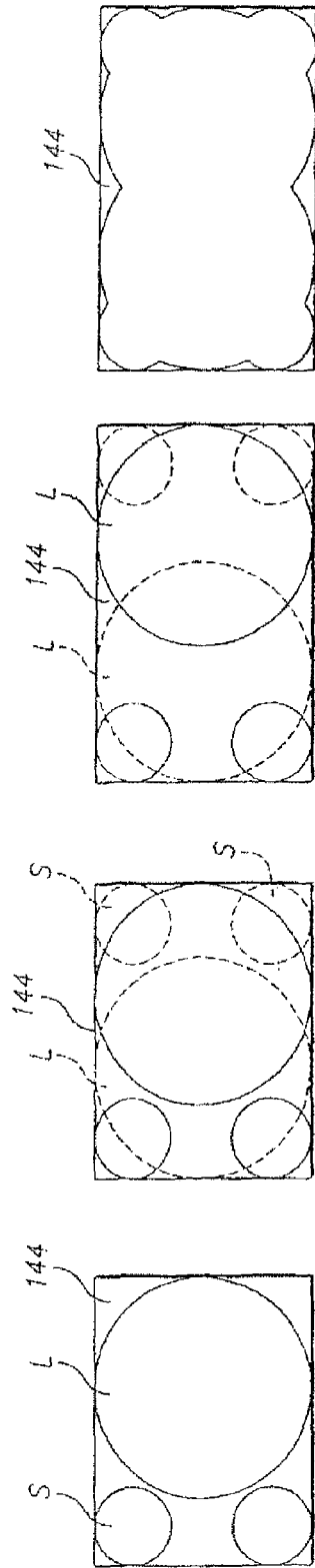


FIG. 16



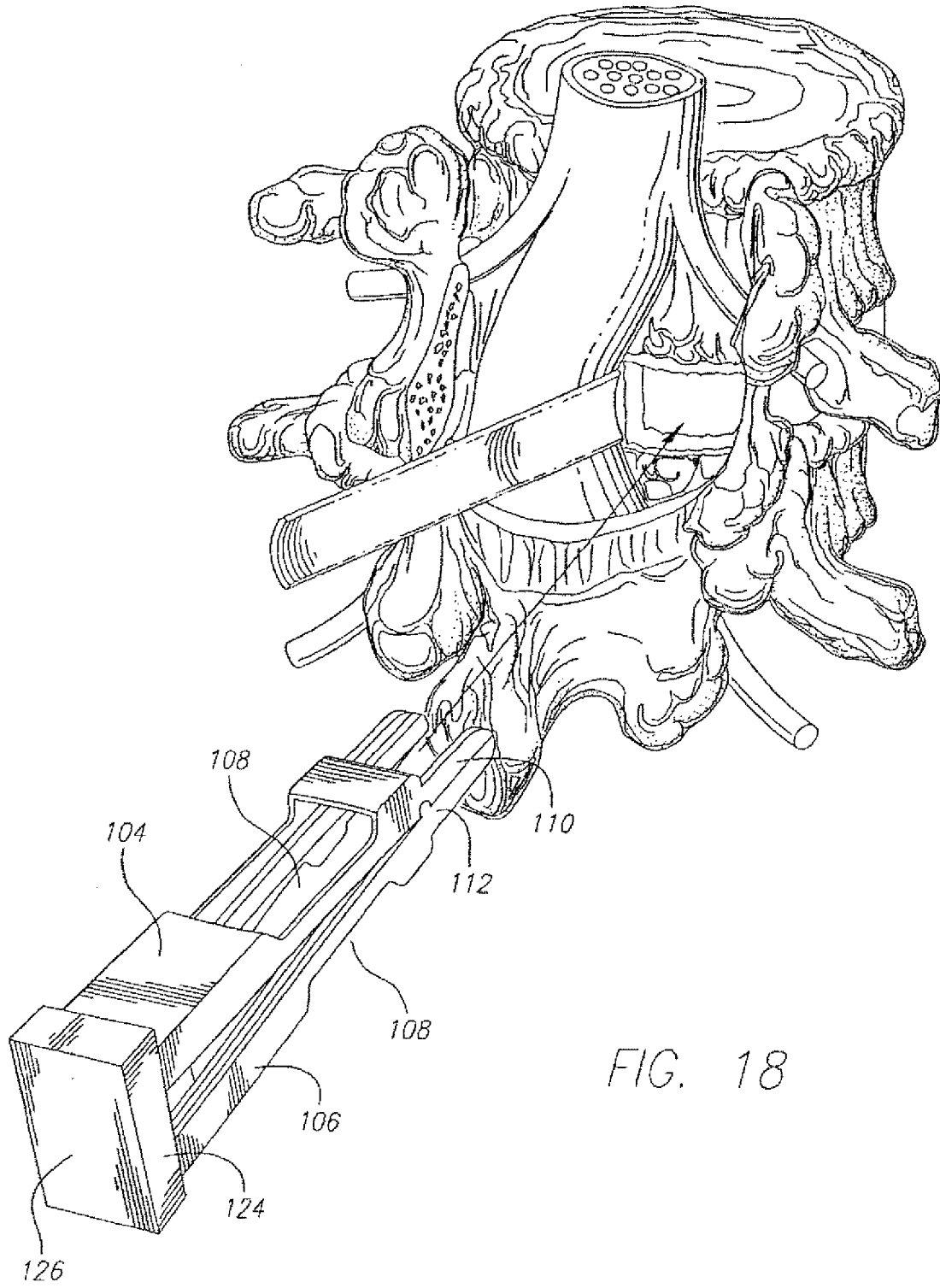
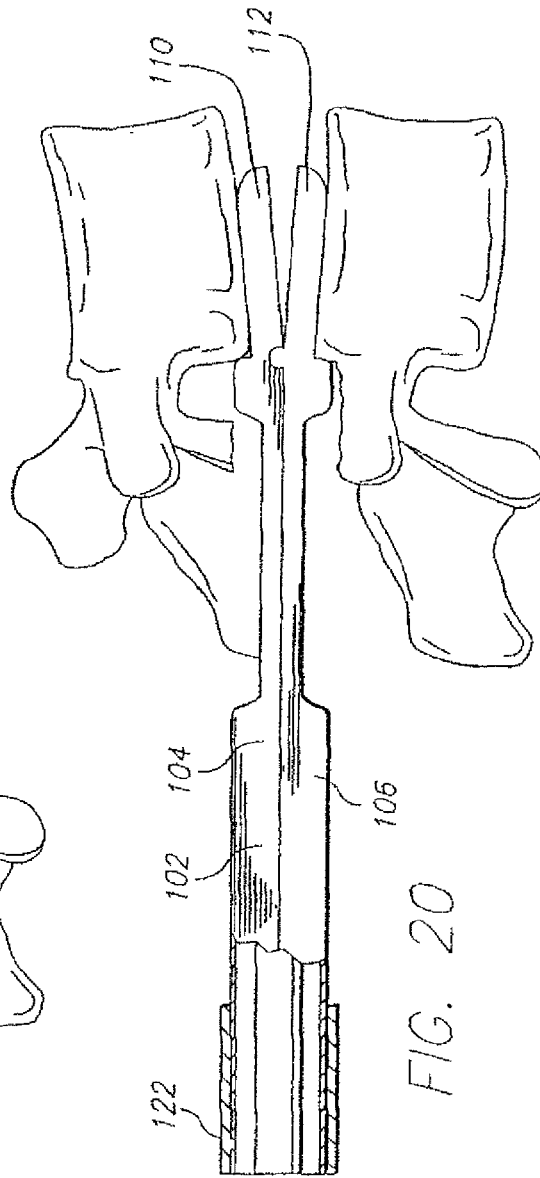
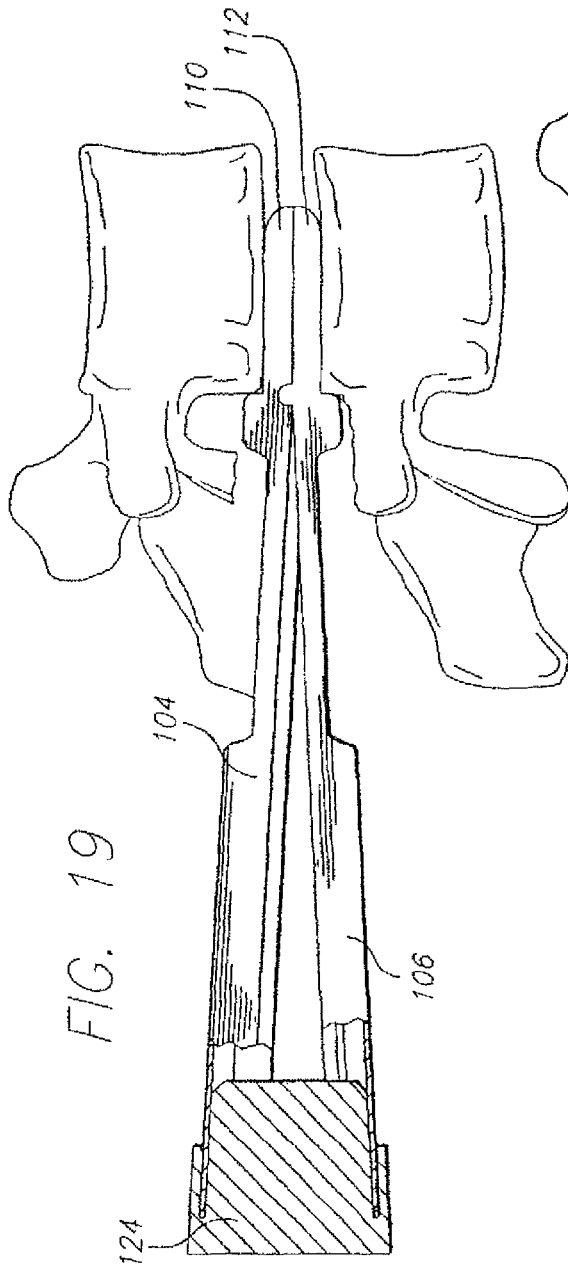


FIG. 18



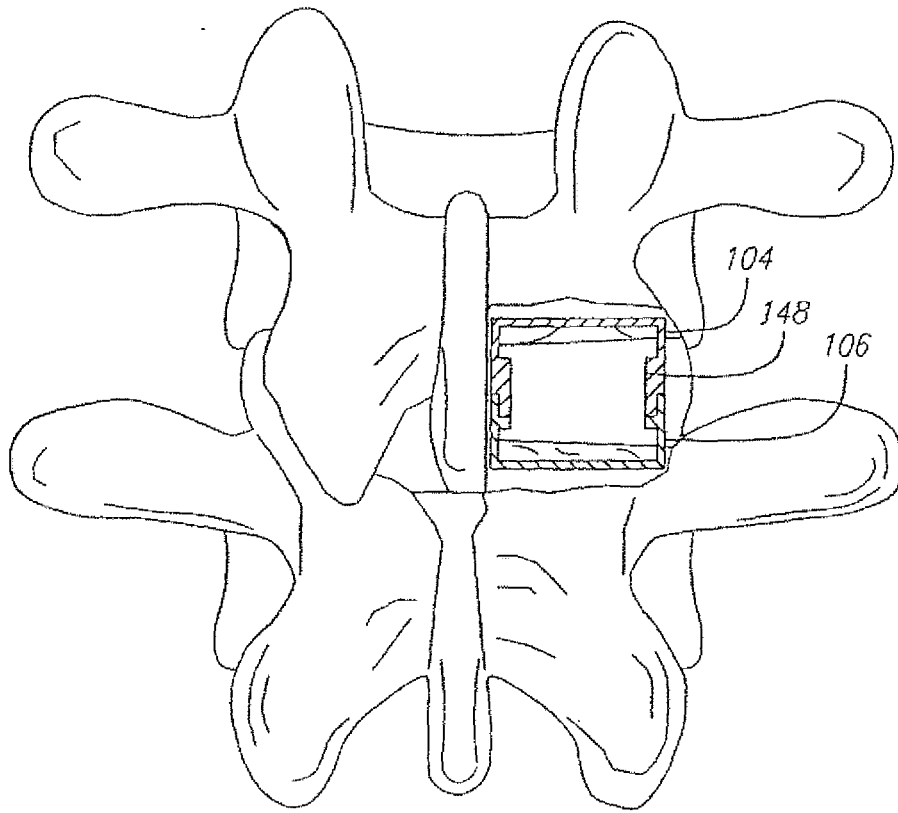


FIG. 21

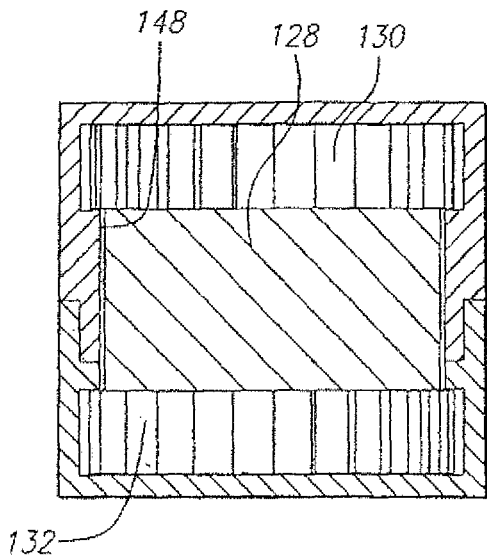


FIG. 23A

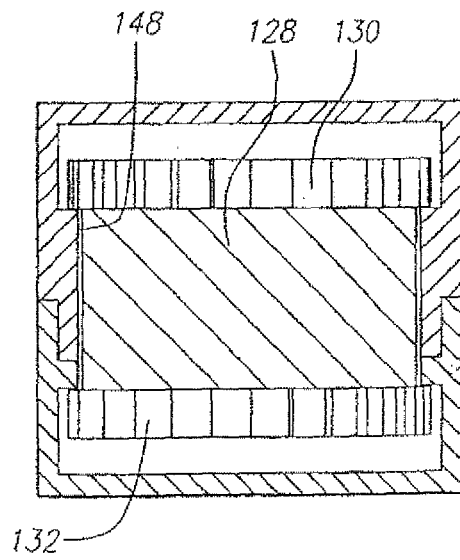


FIG. 23B

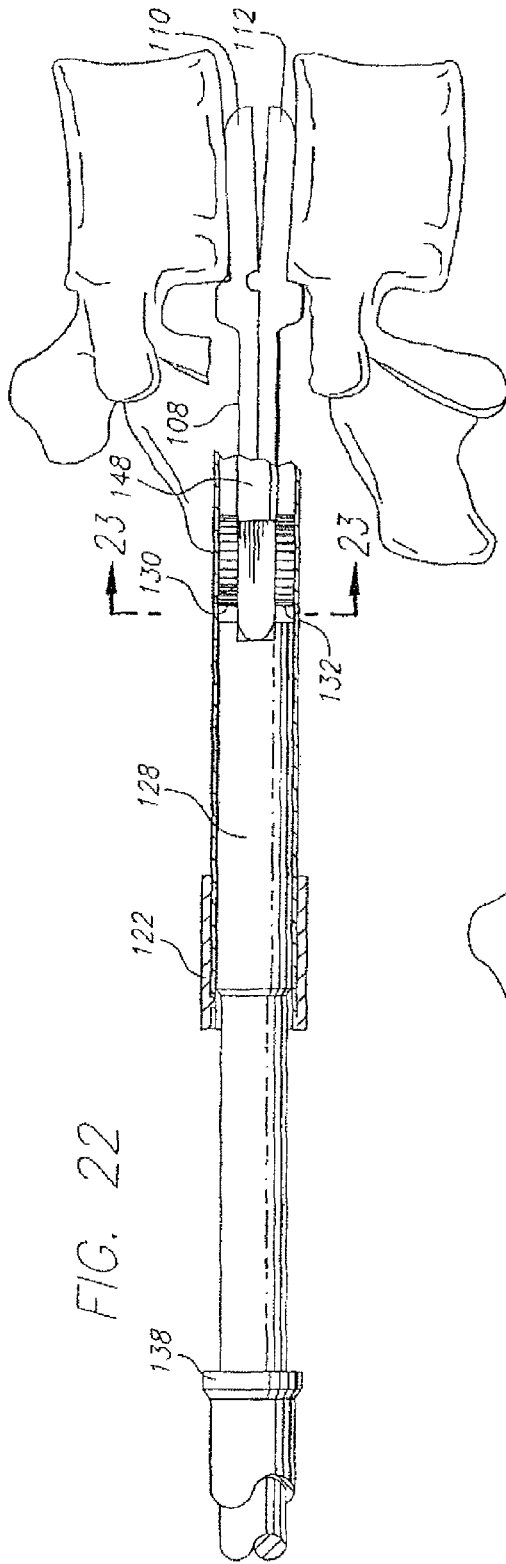


FIG. 22

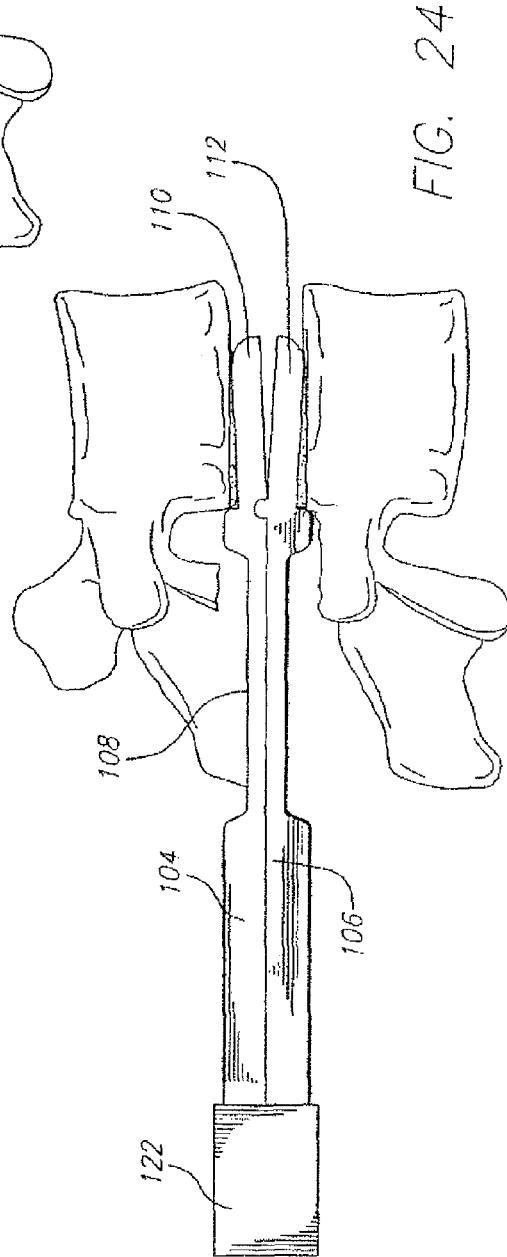
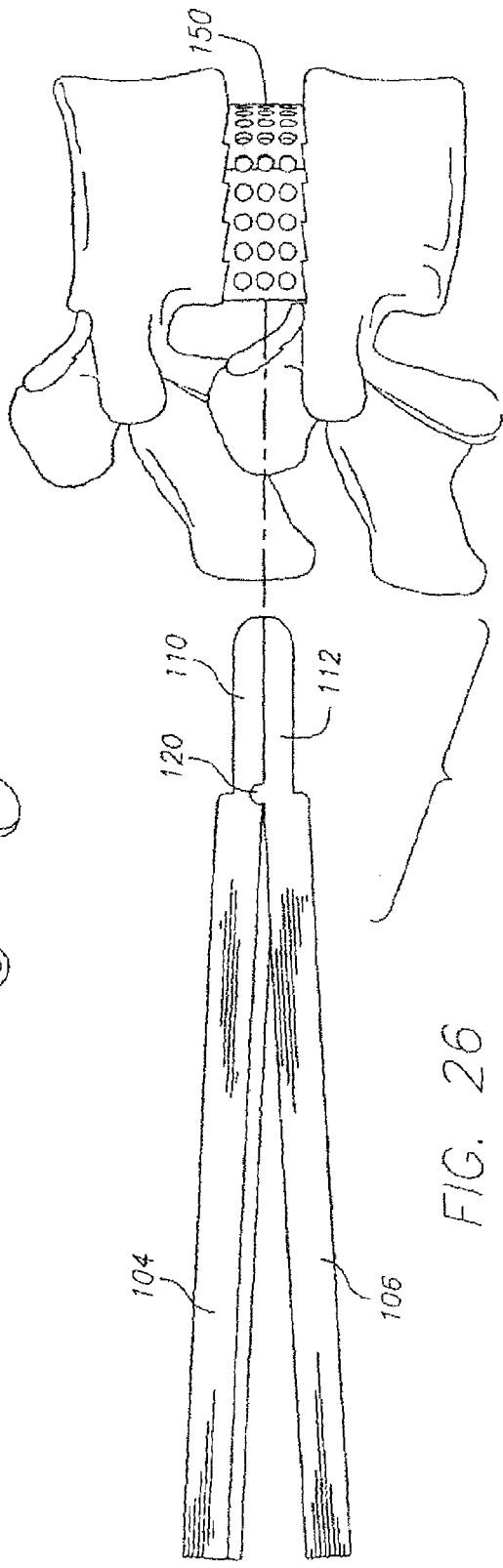
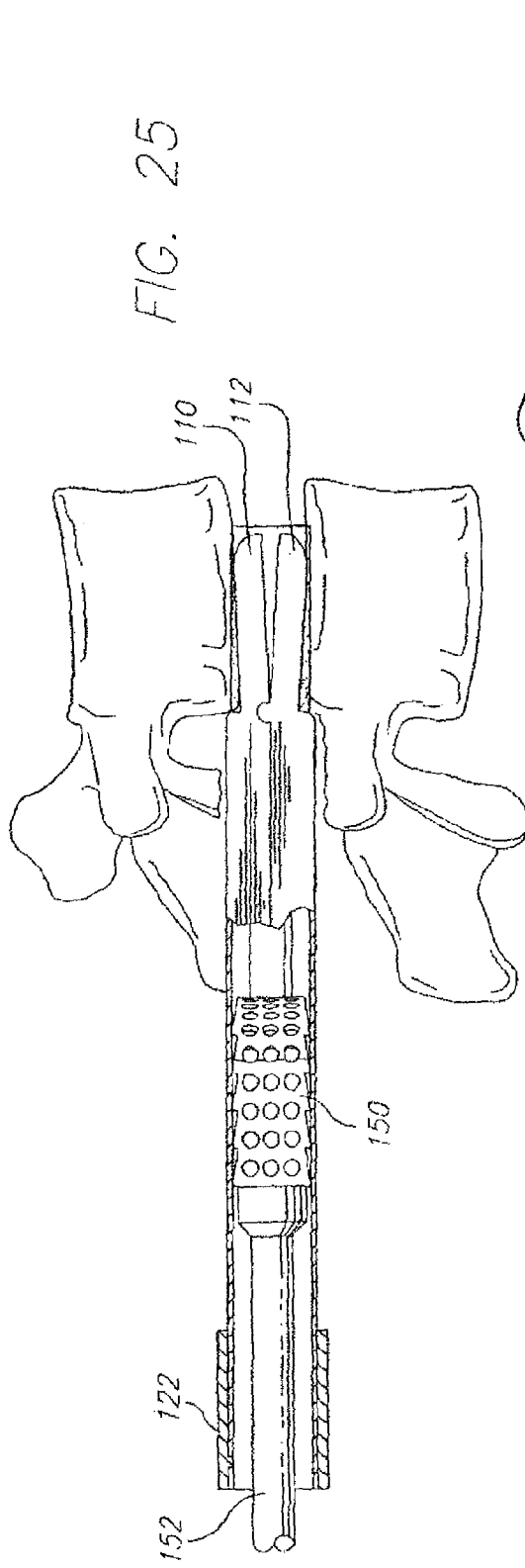


FIG. 24



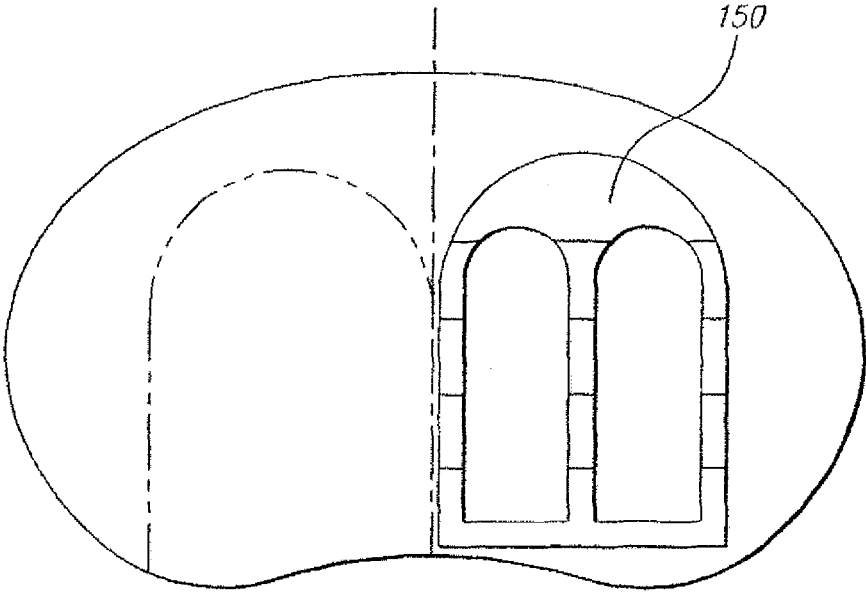
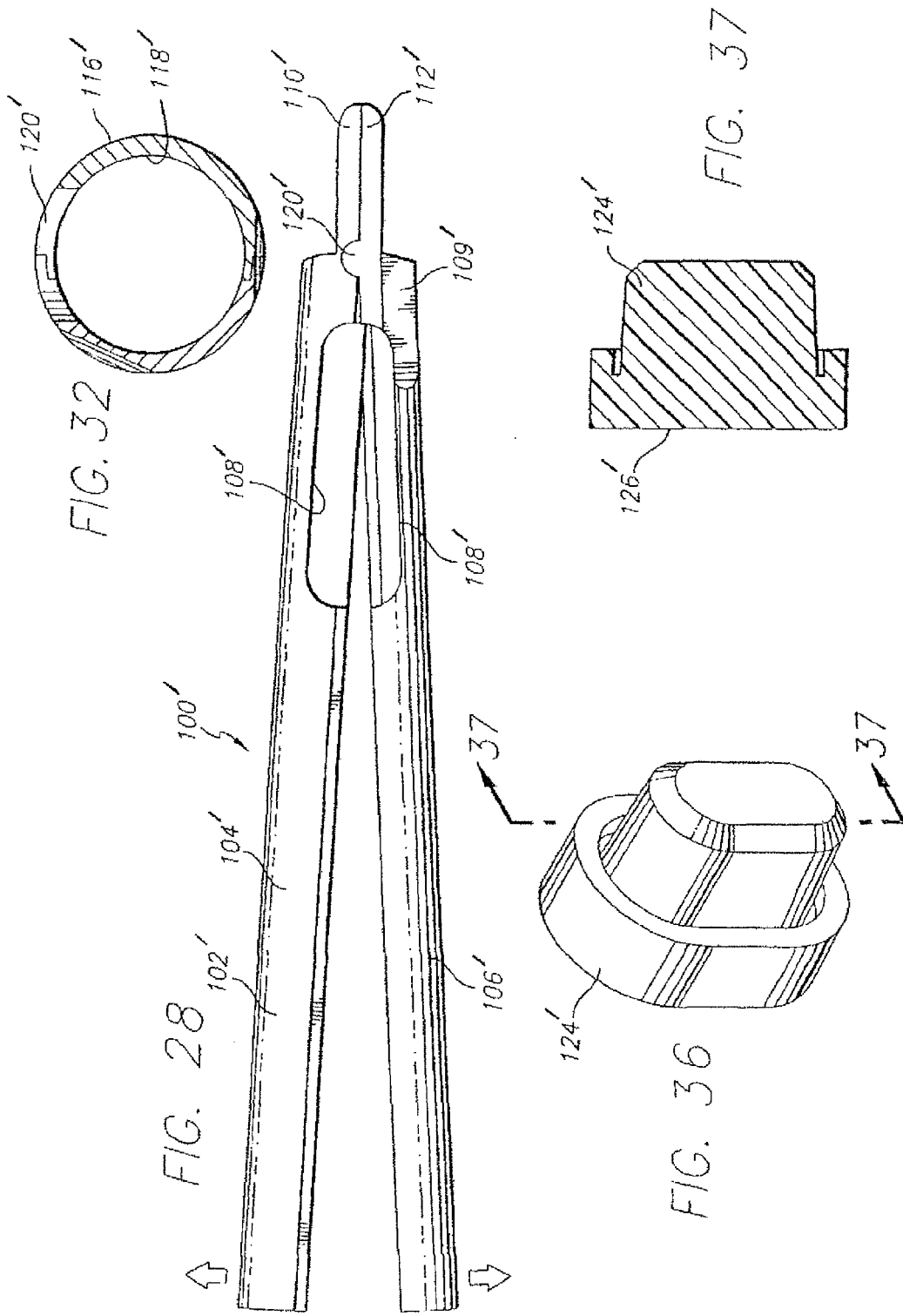


FIG. 27



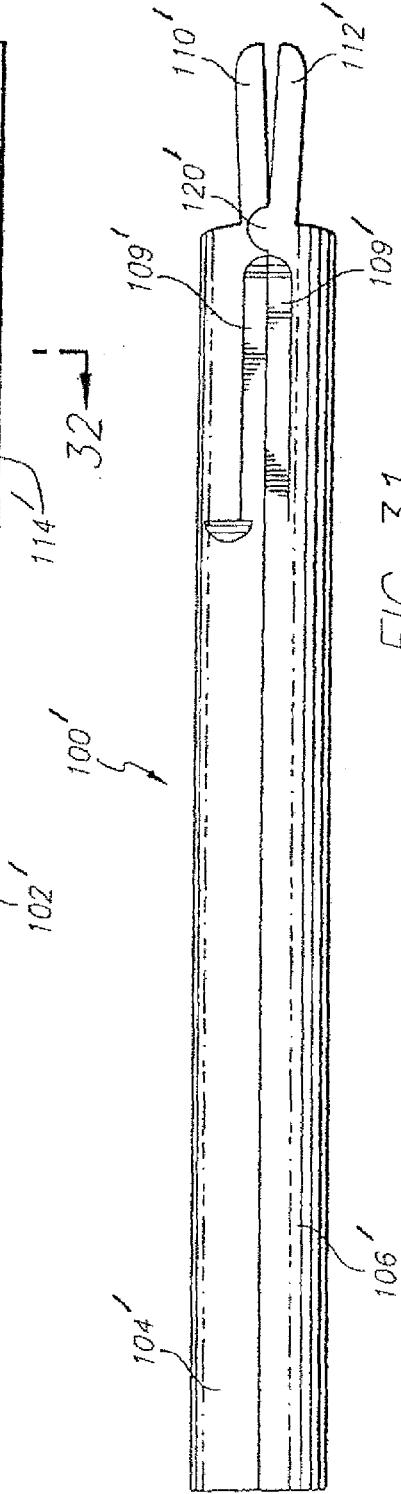
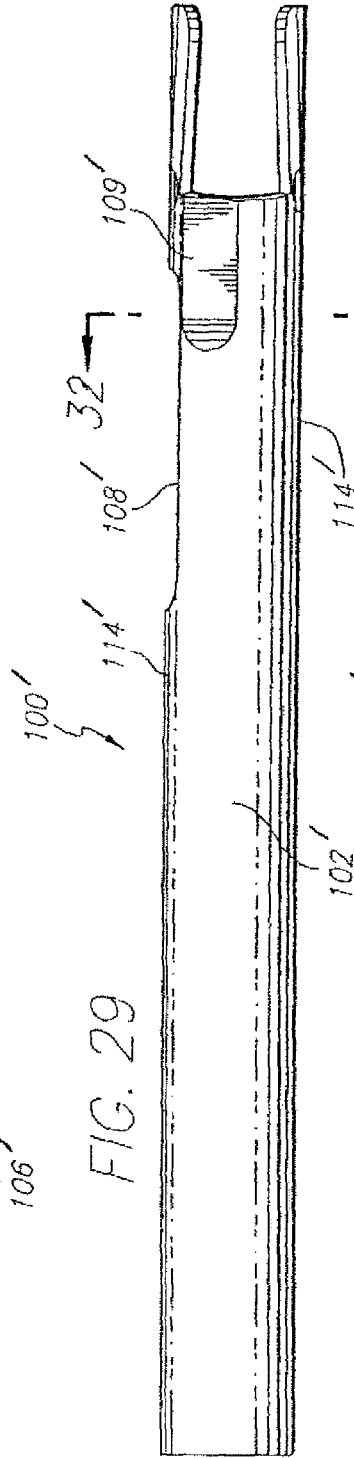
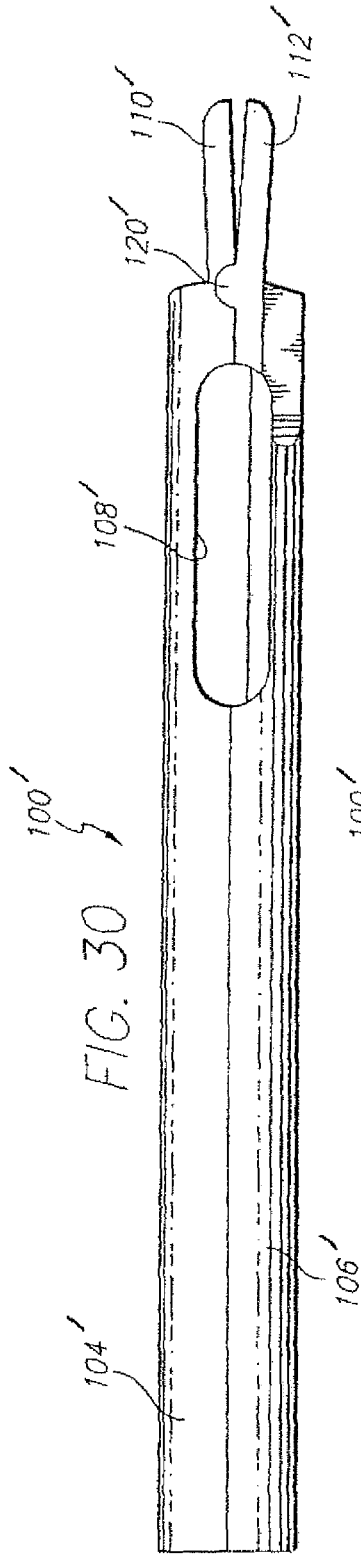


FIG. 31

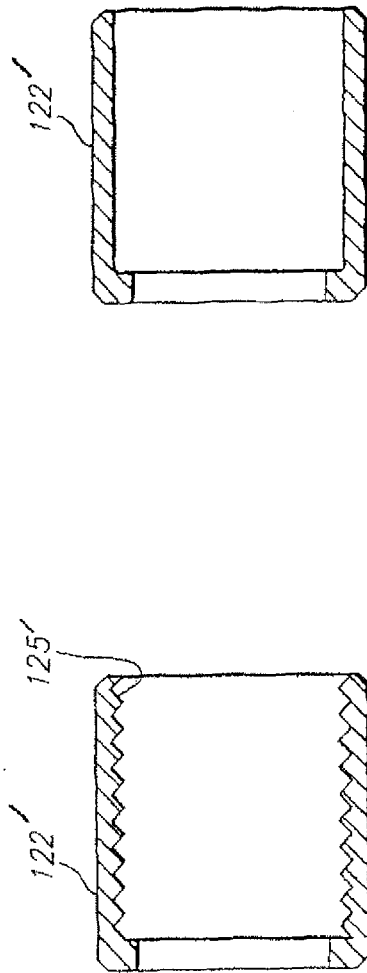
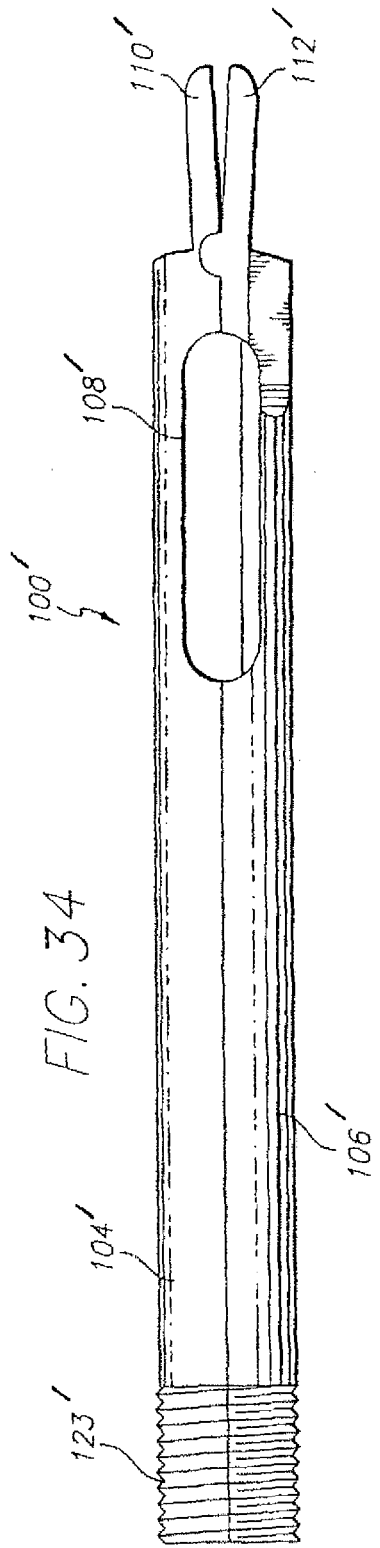
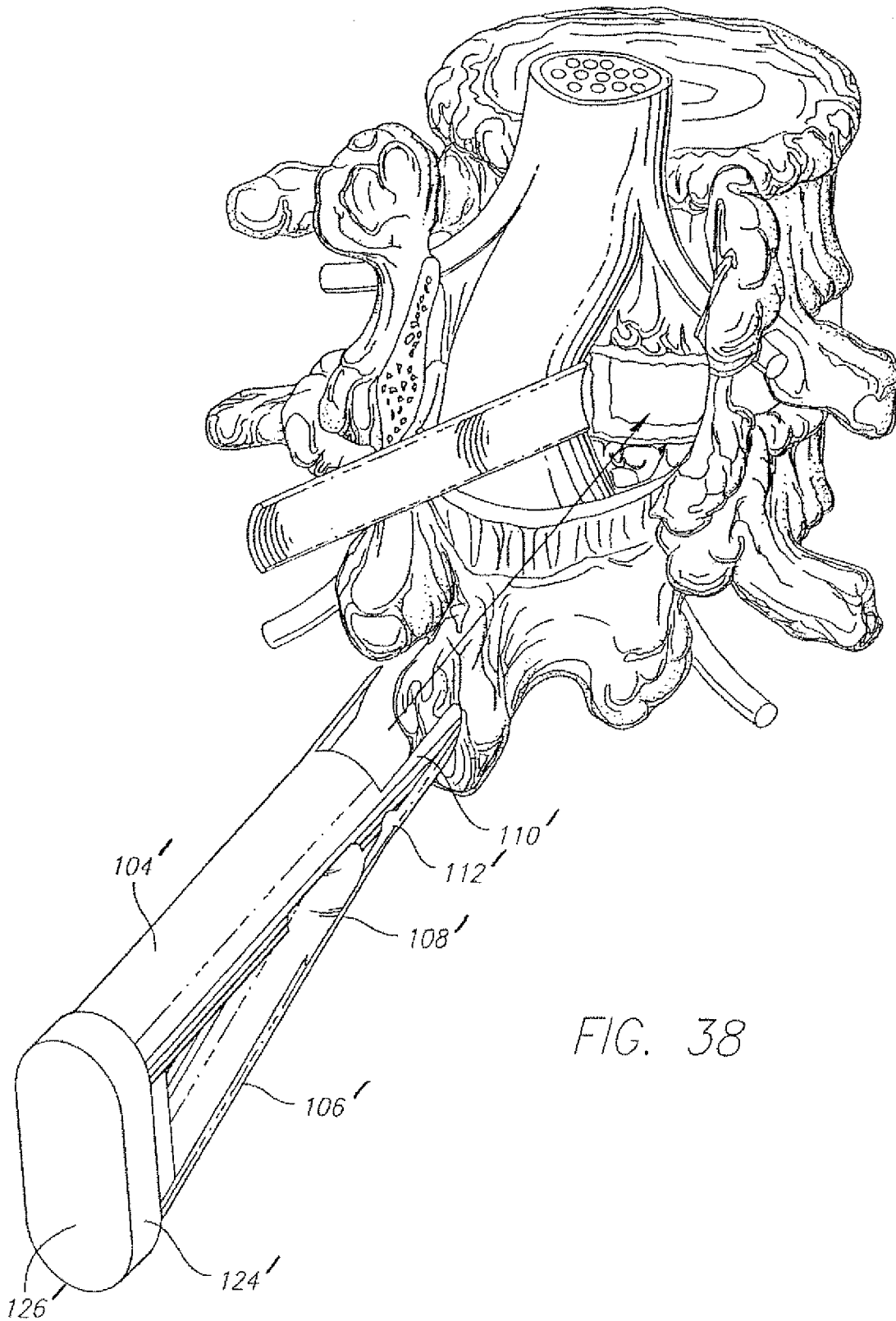


FIG. 33

FIG. 35



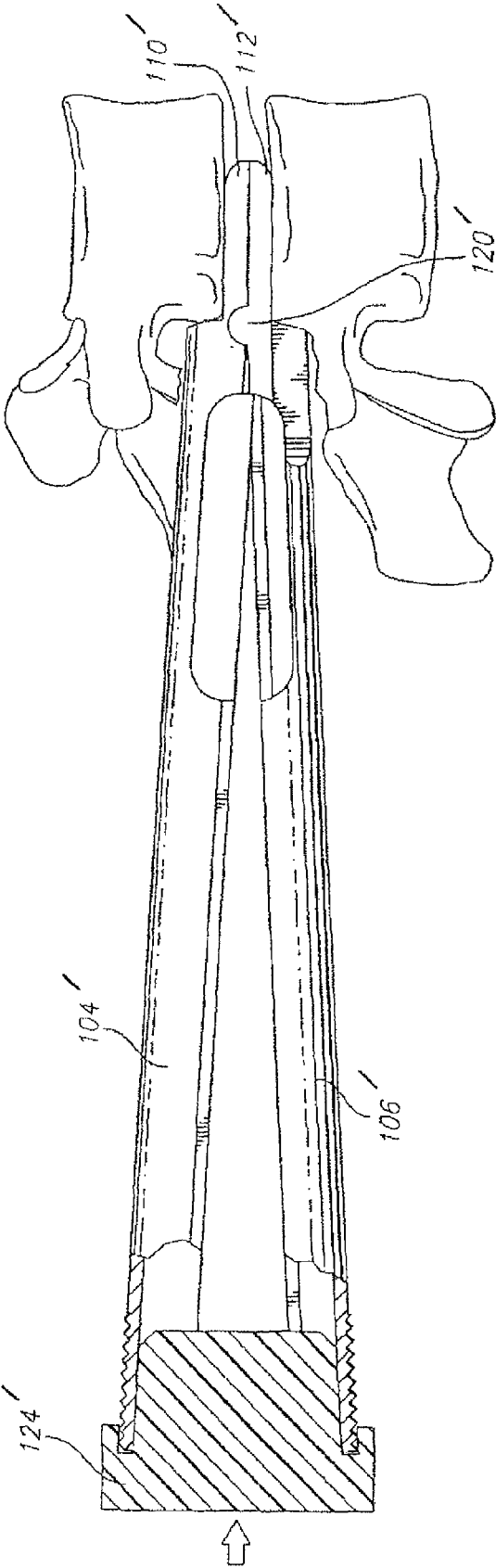
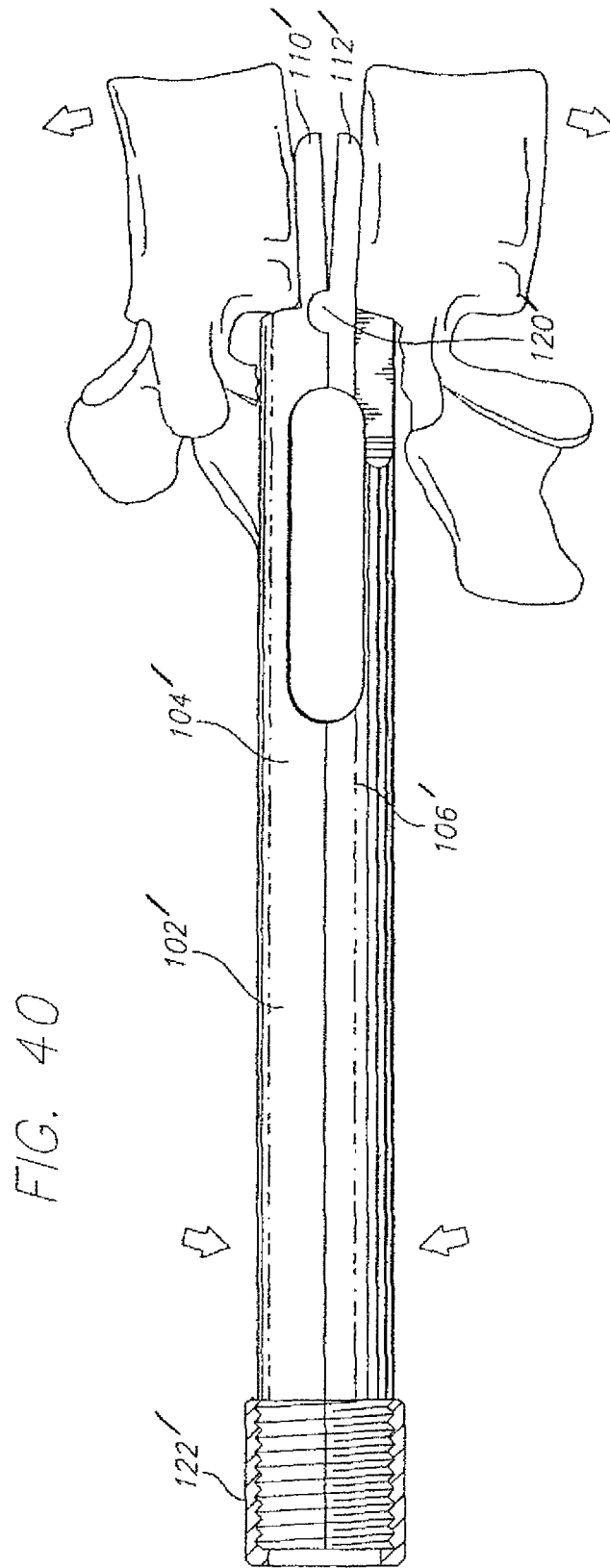


FIG. 39



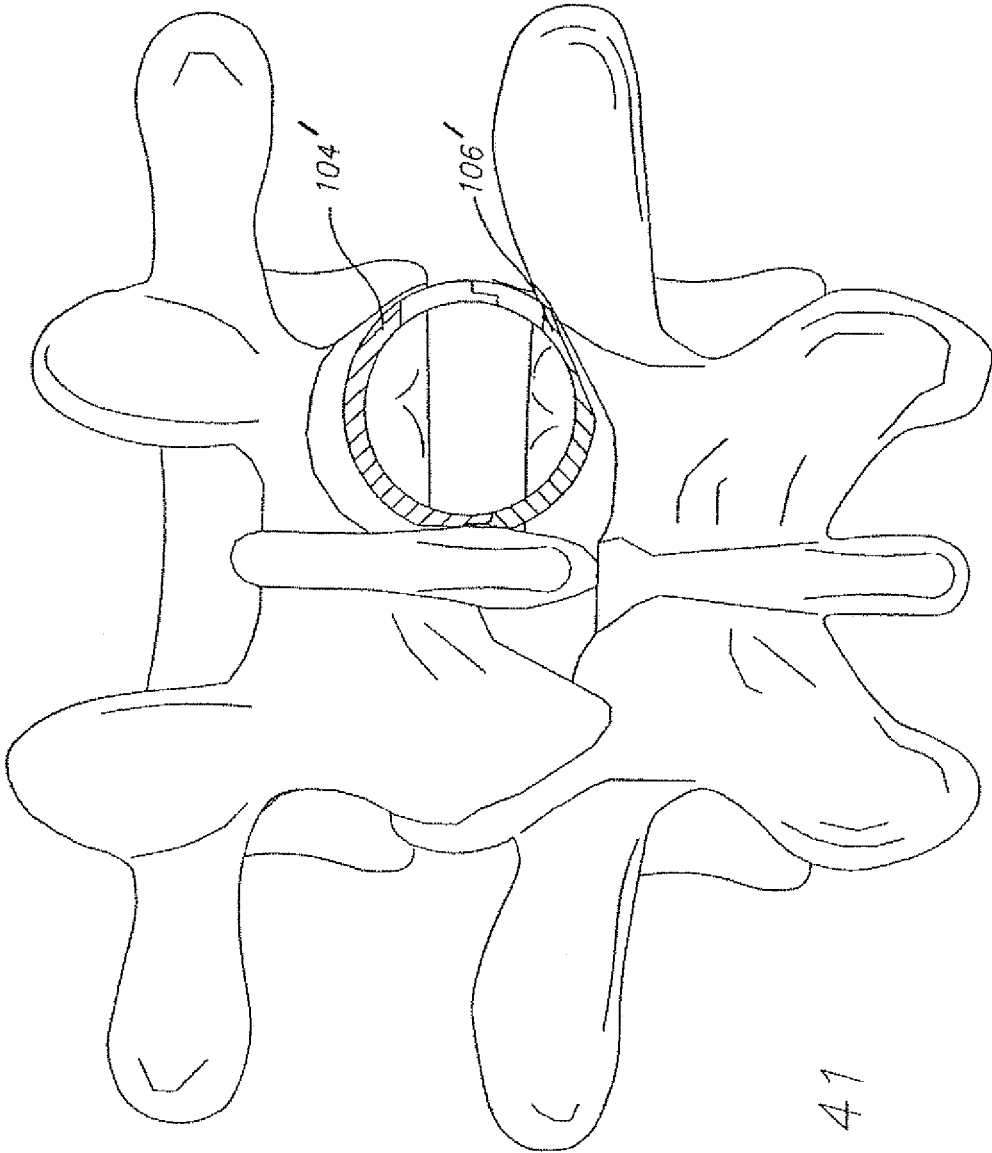


FIG. 41

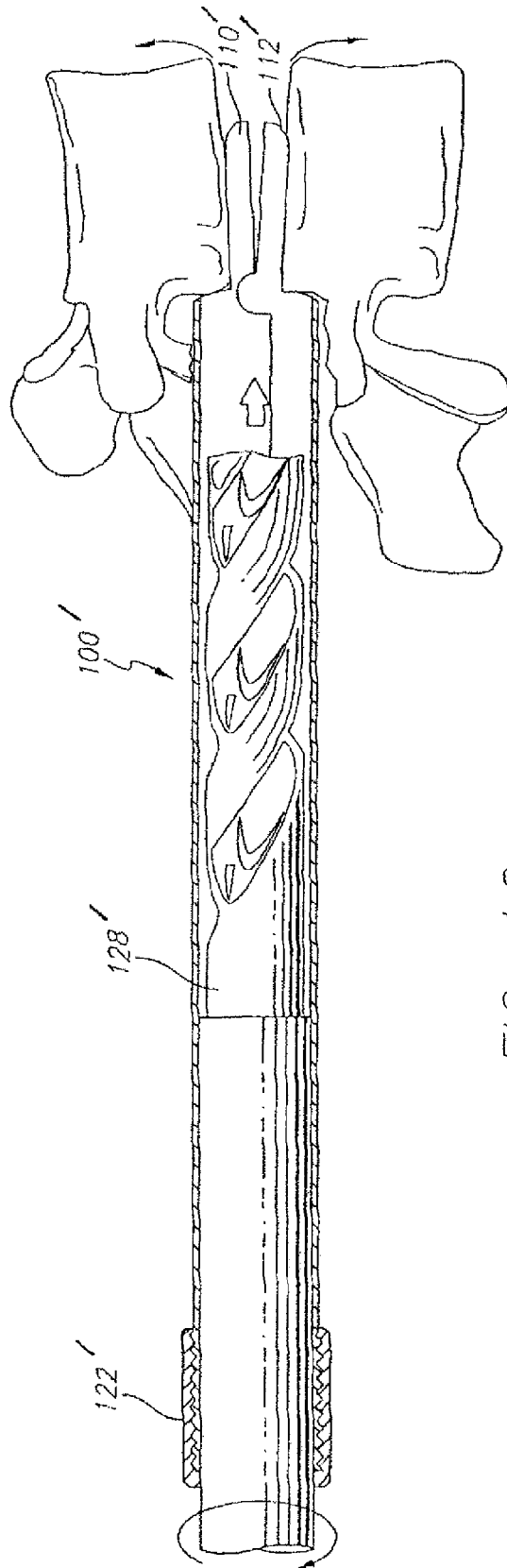
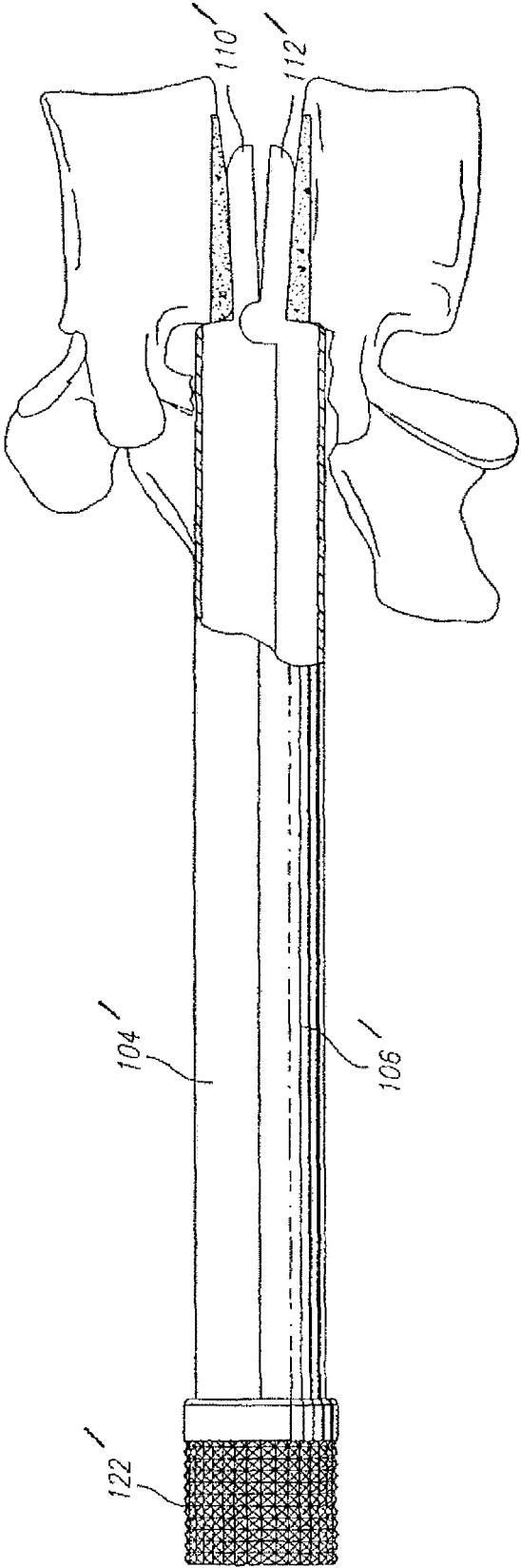


FIG. 42

FIG. 43



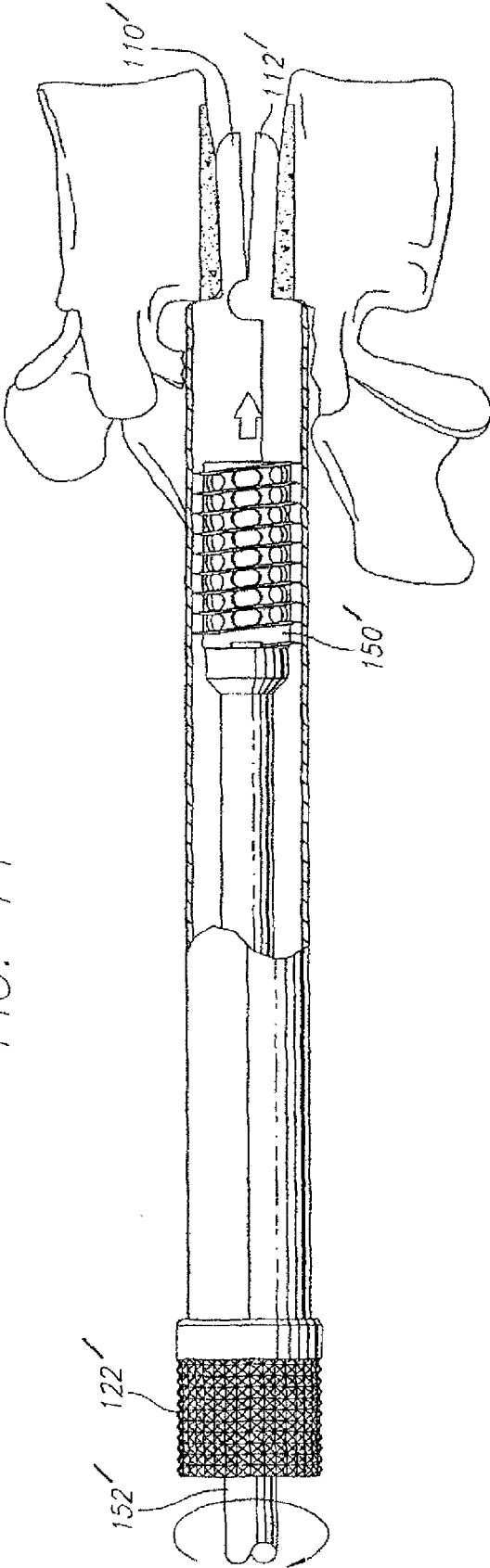


FIG. 44

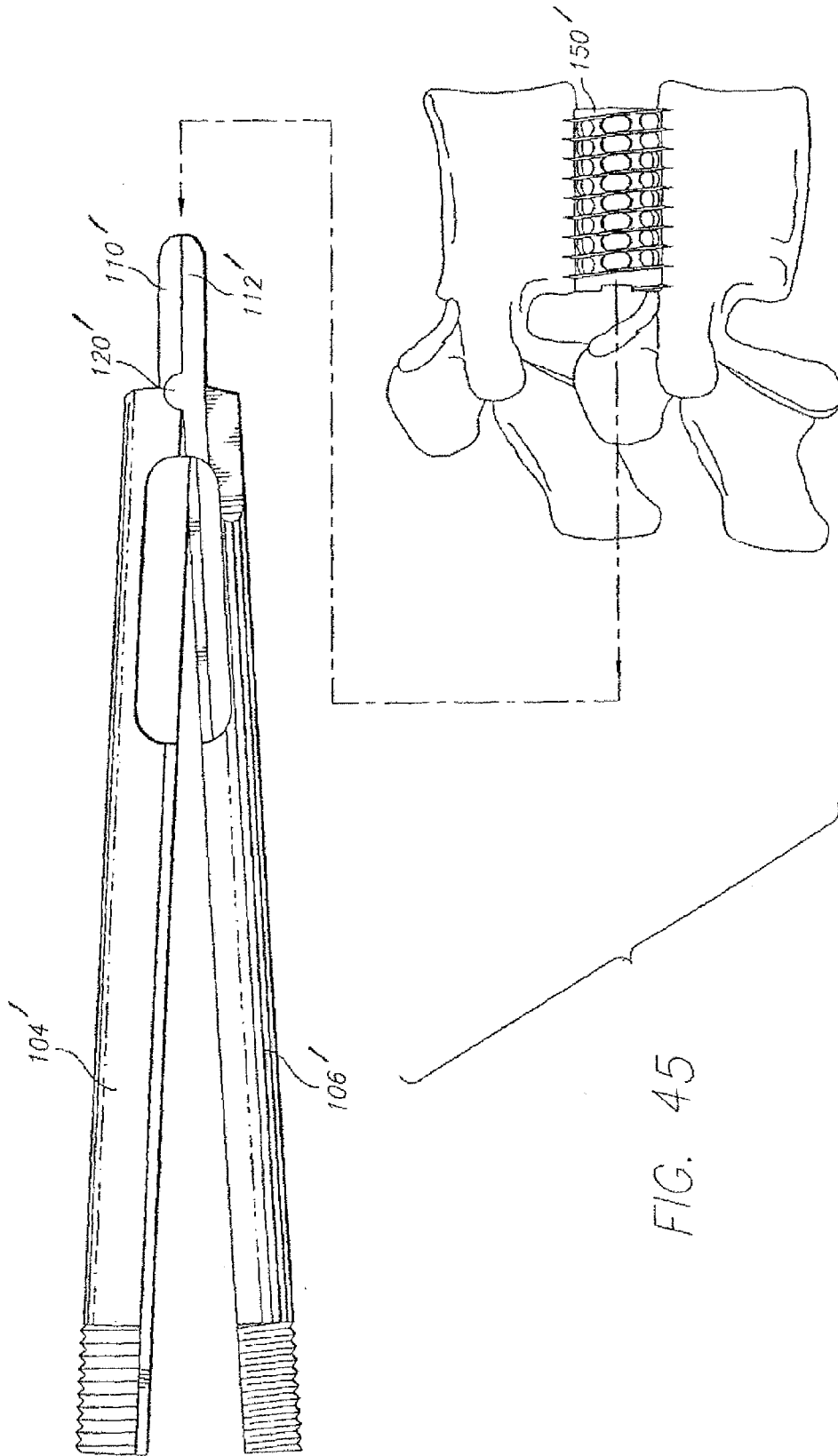


FIG. 45

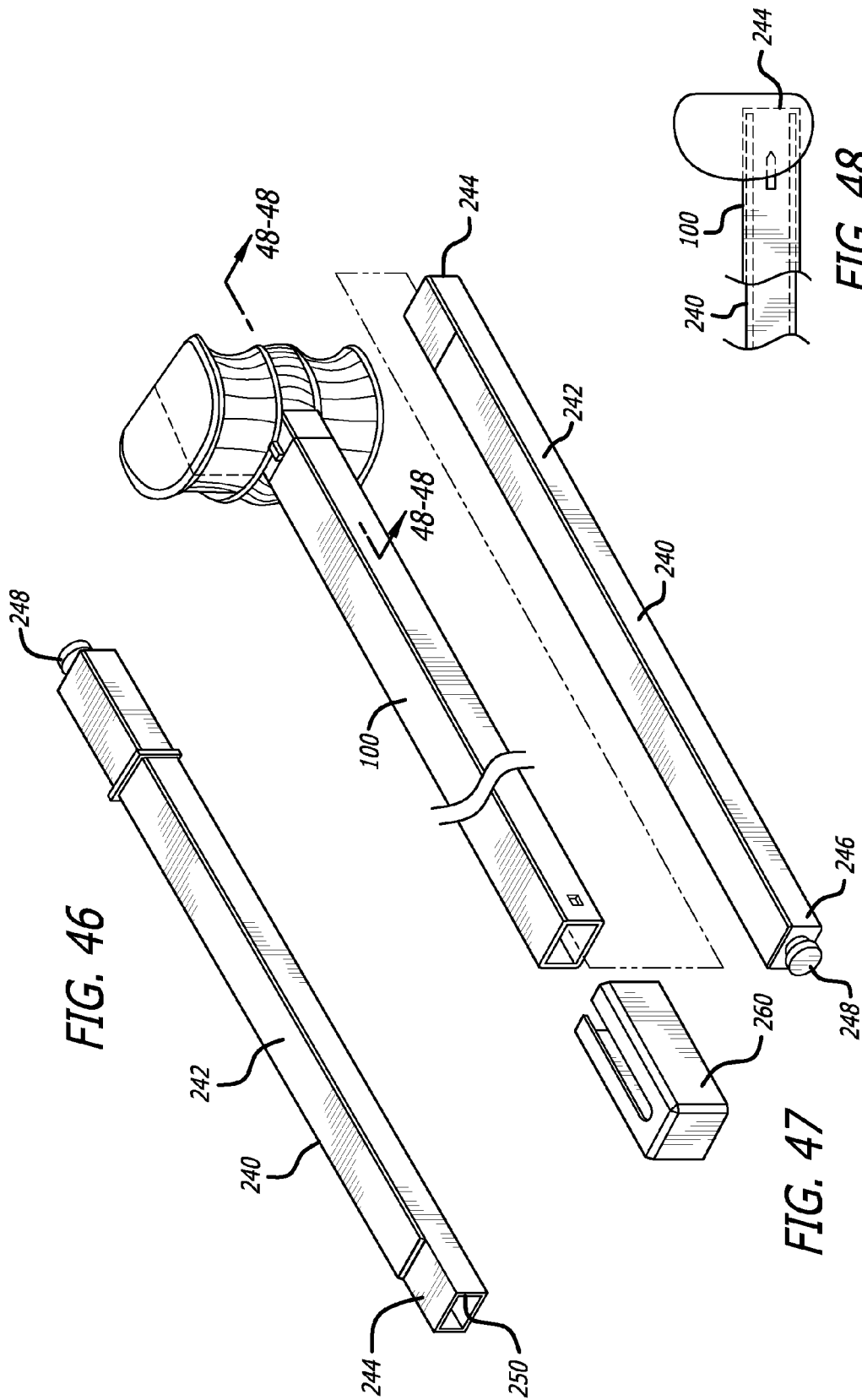


FIG. 46

FIG. 47

FIG. 48

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**METHOD FOR USING A GUARD FOR
CREATING A SOCKET POSTERIORLY IN
THE LUMBAR SPINE**

RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 13/155,289, filed Jun. 7, 2011 (now U.S. Pat. No. 8,764,755); which is a continuation of U.S. application Ser. No. 11/799,406, filed May 1, 2007 (now U.S. Pat. No. 7,955,360); which is a continuation of U.S. application Ser. No. 10/125,847, filed Apr. 19, 2002 (now U.S. Pat. No. 7,211,085); which is a national stage application claiming priority to PCT Application No. PCT/US02/06021, filed Mar. 1, 2002; which claims the benefit of U.S. Provisional Application No. 60/272,381, filed Mar. 1, 2001, and U.S. Provisional Application No. 60/272,382, filed Mar. 1, 2001; the disclosures of which are all incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a device for implantation into a disc space between adjacent vertebral bodies in the human spine, and a device and method for working on those portions of the vertebral bodies adjacent that disc space to remove bone material and thereby access vascular bone, and preferably a device and method for protecting the neurologically structures such as nerve roots and dural sac proximate the implantation site while providing protected access to form an implantation space and then access the implantation space formed between the adjacent vertebral bodies for insertion of an implant therein. The device and associated method are used to position (space apart and align) the vertebral bodies, guide the formation of a surface into or through each of the vertebral body surfaces that are adjacent the intervertebral disc space, and may further be utilized to guide an interbody spinal implant into the implantation space.

In one embodiment, the device and associated method are used to make an implantation space to insert an implant of a height having a known correspondence to the height of the space created. In another embodiment, the device and associated method are used to make an implantation space of known and specific dimensions (e.g., width; depth; and height) and with certain preferred embodiments, permit passage through the device of an implant having a height greater than the height of the implantation space formed through the device.

BACKGROUND OF THE INVENTION

Human vertebral bodies are comprised of a dense, hard outer shell and a relatively less dense inner mass. The hard outer shell is very densely compacted cancellous bone, resembling cortical bone at all but high magnification, and is generally referred to as the cortex. The inner mass is a softer cancellous bone. As shown in FIG. 1, the outer shell of cortex bone (the bony endplate) that is adjacent the disc and the bone immediately beneath that bone (both are subchondral, that is, beneath the cartilage layer or cartilaginous endplate that separates the bone from the disc), are defined for the specific purposes of this specification to comprise the "end plate region" to avoid any confusion that might otherwise arise from any inconsistency in the use of any of these terms. While it is understood that these terms may have other meanings more ordinary or special, and that those of ordinary skill in the art might otherwise differ as to the correct meanings of these

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terms, it is exactly for the purpose of removing any ambiguity that these terms are being so precisely defined specifically for this specification.

The spinal disc that resides between adjacent vertebral bodies maintains the spacing between those vertebral bodies and, in a healthy spine, allows for relative motion between the vertebrae. At the time of surgery, for example in the instance of interbody fusion, that is, where fusion is intended to occur between adjacent vertebral bodies of a patient's spine, the surgeon typically prepares an opening at the site of the intended fusion by removing a substantial amount of the nucleus disc material that exists between the adjacent vertebral bodies to be fused. Because the outermost layers of bone of the vertebral end plate are relatively inert to new bone growth, the surgeon will typically work on the end plate to remove at least the outermost cell layers of bone to gain access to the blood-rich, vascular bone tissue within the vertebral body. In this manner, the vertebrae are prepared in a way that encourages new bone growth consistent with fusion.

Devices for assisting a surgeon in accessing the disc space and adjacent vertebral bodies are known. Drill guides and boxed chisels have been used to form an implantation space between the adjacent vertebral bodies for insertion of a spinal implant therein. Applicant invented a guard and instrument system particularly well suited for use in the lumbar spine and of unequalled advantage for use posteriorly therein through which both the implantation space can be formed and a spinal implant can be inserted into the implantation space, as disclosed in U.S. Pat. No. 5,015,247, filed Jun. 13, 1988, which is hereby incorporated by reference.

Applicant also invented a guard having disc penetrating extension(s), which extensions have utility for stabilizing the guard, stabilizing the adjacent vertebrae relative to each other, urging the vertebrae apart if desired, and aligning the vertebrae to each other if desired to form the implantation space through the guard and insert the spinal implant through the guard into the implantation space, as disclosed in U.S. Pat. No. 6,080,155 filed Feb. 27, 1995, incorporated herein by reference. The disc penetrating extensions can have either parallel or angled upper and lower surfaces in contact with the adjacent vertebral bodies to place the adjacent vertebral bodies parallel to one another or at an angle to one another. The disclosed disc penetrating extensions are rigid.

To obtain a particular orientation between the adjacent vertebral bodies a surgeon selects a guard having a predetermined orientation between the upper and lower surfaces of the disc penetrating extensions. In the case of disc penetrating extensions that have upper and lower surfaces diverging from one another as would be useful for posterior lumbar interbody fusion (PLIF), so as to be higher at the insertion or distal end than at the trailing or proximal end of the extensions, a tapered leading end is used to facilitate insertion of the disc penetrating extensions into the disc space. Such a configuration allows for lordosis of the lumbar segment of a spine to be operated upon from a posterior approach. For extensions that have diverging upper and lower surfaces, additional force is required to drive the guard and extensions into place. Then, after an implant is inserted, it may be difficult to remove a distractor element such as a guard having disc penetrating extensions having a maximum height greater than the height of the disc space posterior height.

Present methods of forming the implantation space between adjacent vertebral bodies generally include the use of one or more of the following: hand held biting and grasping instruments known as rongeurs; drills and drill guides; rotating burrs driven by a motor; and osteotomes and chisels. Applicant has taught various novel instruments to mill out the

recipient fusion site across the height of the disc space including various cutting/milling frames and various novel cutters as disclosed in applicant's U.S. Pat. No. 6,159,214, incorporated herein by reference. The surgeon must work upon the adjacent end plates of the adjacent vertebrae to access the vascular, cancellous bone that is best suited for participating in the fusion and causing active bone growth, and also to attempt to obtain an appropriately shaped surface in the vertebral bodies to receive the implant. Because the end plates of the adjacent vertebrae are not flat, but rather have a complex biological as opposed to geometrical curved shape, it is necessary to conform the vertebrae to the shape of the implant to be received therebetween.

Suitable devices for forming a disc space disclosed by applicant in U.S. Pat. No. 6,083,228, and U.S. patent application Ser. No. 09/663,311, filed Sep. 15, 2000, both of which are hereby incorporated by reference. Both of these disclosures describe various abrading elements and cutting wheels used to form the implantation space. U.S. patent application Ser. No. 09/663,311 discloses the use of a guard or frame having disc penetrating extensions that could be either parallel or angled to properly orient the vertebral bodies relative to one another prior to forming the implantation space.

There is a need for a guard for use in posterior lumbar surgery to create an interbody implantation space while providing for spinal lordosis and while being easily and safely inserted and as easily and safely removed.

SUMMARY OF THE INVENTION

In accordance with the purposes of the present invention, as embodied and broadly described herein, a guard of this invention is provided for use in spinal surgery across a disc space between two adjacent vertebral bodies of a human spine. The guard includes a body having a leading end and an opposite trailing end. The body has a first portion and a second portion proximate the leading end that are in pivotal relationship to one another between an open position and a closed position. The first and second portions each have opposed interior portions that define an opening for providing protected access to the disc space and the adjacent vertebral bodies. The opposed interior portions are adapted to guide a bone removal device therethrough that is sized to form an implantation space across the disc space and at least in part into the adjacent vertebral bodies. The guard also includes at least one disc space penetrating extension extending from the leading end of the body that is adapted for insertion at least in part into the disc space. The extension has a first portion extending from the first portion of the body that has a contact surface adapted to bear against one of the adjacent endplates of the adjacent vertebral bodies. The extension also has a second portion extending from the second portion of the body that has a contact surface adapted to bear against the other of the adjacent endplates of the adjacent vertebral bodies. The contact surfaces of the first and second portions of the extension are in pivotal relationship to one another from an insertion position to a deployed position to move the adjacent vertebral bodies apart upon movement of the first and second portions of the body from the open position to the closed position.

The body of the guard may have a generally rectangular, square, circular, oval, or elliptical cross section along at least a portion of the length of the body. The leading end of the body may be adapted to conform at least in part to the exterior surfaces of the adjacent vertebral bodies by having the leading end cut back to permit the contact surfaces to have an intimate fit with the vertebral bodies when the guard is in the deployed position. The body may include at least one window

adapted to permit the surgeon to observe the surgery through the window and/or permit portions of bone extending through the window to be removed by the bone removal device passing through the body of the guard.

The guard may include a second disc penetrating extension diametrically opposite to a first disc penetrating extension. Each disc penetrating extension may have a tapered leading end and have contact surfaces that are parallel to each other over a substantial portion of the length of each extension when in the insertion position. The first and second portions of each disc penetrating extension may be adapted to touch one another when in the insertion position.

The first and second portions of the body may be hinged to one another to rotatably articulate relative to one another about an axis of rotation that is fixed relative to the mid-longitudinal axis of the guard when moved from the open position to the closed position. The body may have an interior surface having a cooperating surface for guiding a corresponding cooperating surface on the bone removal device.

The guard may include an impaction cap adapted to cooperatively engage the trailing end of the body when the body is in the open position. The guard may include a lock in the form of a collar adapted to cooperatively engage the body of the guard when the body is in the closed position to hold the body in the closed position.

The guard may form part of a combined spinal surgery set that includes a bone removal device, an implant driver, and a spinal implant, or any combination thereof. The bone removal device may have a working end having at least two cutters selected to create a predetermined surface contour into each of the adjacent vertebral bodies as the working end is moved. The implant may be sized and shaped to at least in part match the space formed in the spine by the bone removal device and may be adapted to be combined or treated with a natural or artificial bone growth promoting material or substance.

In accordance with the purposes of another embodiment of the present invention, as embodied and broadly described herein, a guard of this invention is provided for use in spinal surgery across a disc space between two adjacent vertebral bodies of the human spine. The guard includes a body having an opening for providing protected access to the disc space and the adjacent vertebral bodies. The opening has opposed interior portions that are adapted to guide therethrough a bone removal device sized to form an implantation space across the disc space and at least in part into the adjacent vertebral bodies. The guard also includes at least one disc space penetrating extension extending from the body that is adapted for insertion at least in part into the disc space. The disc penetrating extension has a first portion having a contact surface adapted to bear against one of the adjacent endplates of the adjacent vertebral bodies and a second portion having a contact surface adapted to bear against the other of the adjacent endplates of the adjacent vertebral bodies. The contact surfaces of the first and second portions are adapted to rotatably articulate relative to one another between an insertion position and a deployed position to move the adjacent vertebral bodies apart.

In accordance with the purposes of a further embodiment of the present invention, as embodied and broadly described herein, a method of this invention is provided for inserting a spinal implant at least in part within and across the generally restored height of a disc space between two adjacent vertebral bodies of a human spine. The method includes the steps of positioning into the disc space between the adjacent vertebral bodies a guard having a body and an extension for insertion at least in part into the disc space and for bearing against end plates of the adjacent vertebral bodies to restore the spacing of

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the disc space between the adjacent vertebrae, the guard having a first portion oriented toward one of the adjacent vertebral bodies and a second portion oriented toward another of the adjacent vertebral bodies, the first and second portions being rotatably articulating relative to one another such that when the body moves from an open position to a closed position the extension moves from an insertion position to a deployed position to move the adjacent vertebral bodies apart; rotatably articulating the guard to move the body from the open position to the closed position and the extension from the insertion position to the deployed position to move the adjacent vertebral bodies apart; and forming, through the guard, an opening across height of the disc space and into at least a portion of the endplates of the adjacent vertebral bodies.

The method may include the further steps of performing the spinal implant surgery from a position posterior to the transverse processes of the vertebrae adjacent the disc space; performing the procedure on both sides of the spinal midline of the spine; securing the body of the guard in the closed position; and inserting two implants into the spine.

The positioning step may include the further steps of positioning a guard having multiple extensions for insertion into the disc space; placing the body of the guard in the open position; driving the extension into the disc space; and inducing angulation to the adjacent vertebral bodies relative to one another,

The rotatably articulating step may include the further steps of orienting the adjacent vertebral bodies in a predetermined relationship relative to each other; and inducing lordosis to the adjacent vertebral bodies.

The forming step may include the further steps of inserting the bone removal device through the guard to a desired depth; forming the implantation space with the bone removal device; and forming opposed receiving surfaces in the end plates of the vertebral bodies corresponding at least in part in size, shape, and contour to an implant to be implanted. The forming step may include any one of milling, drilling, reaming, abrading, chiseling, and trephining the implantation space.

The method may include the further steps of inserting the implant into the implantation space through the guard, or inserting the implant into the implantation space after removing the guard from the disc space. The inserting step may include the further steps of inserting the implant using an implant inserter; and removing the implant inserter after using the implant inserter to insert the implant into the implantation space. The inserting step may also include inserting a spinal implant that is a spinal fusion implant that has upper and lower surfaces for placement between and in contact with the adjacent vertebral bodies, each of the upper and lower surfaces having at least one opening adapted to permit for the growth of bone from adjacent vertebral body to adjacent vertebral body through the implant. The inserting step may include inserting a spinal implant having a hollow between the upper and lower surfaces; inserting a spinal implant that is expandable; and inserting a spinal implant having surface projections configured to resist expulsion of the implant from the implantation space. The inserting step may include inserting any one of an inert spacer, an artificial disc, or a bone graft.

The inserting step may further include the steps of compressively loading the implant with fusion promoting substances selected from one of bone, bone derived products, demineralized bone matrix, ossifying proteins, bone morphogenetic protein, hydroxyapatite, and genes coding for the production of bone; and retaining the fusion promoting sub-

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stance within the implant after the loading step. The step of retaining the fusion promoting substance may include attaching a cap to the implant.

The inserting step may also include the steps of treating the implant with a fusion promoting substance; inserting an implant in combination with a chemical substance adapted to inhibit scar formation; inserting an implant in combination with an antimicrobial material; inserting an implant including a fusion promoting substance or having a bone ingrowth surface; inserting an implant being at least in part of one of bone and bone growth promoting material; and inserting an implant in combination with at least one of a fusion promoting substance, bone, bone growth promoting material, bone derived products, demineralized bone matrix, ossifying proteins, bone morphogenetic protein, hydroxyapatite, and genes coding for the production of bone.

The method may further include the steps of collapsing the extensions and removing the guard from the disc space.

The accompanying drawings, which are incorporated in and constitute a part of this specification, are by way of example only and not limitation, and illustrate several embodiments of the invention, which together with the description, serve to explain the principles of the invention. The scope of the invention is limited only by the scope of the claims as from the present teachings other embodiments of the present invention shall be apparent to those skilled in the art.

OBJECTS OF THE PRESENT INVENTION

The present invention has a number of embodiments, at least some of which have as an object of at least one embodiment of the present invention to provide a device and method for quickly, safely, effectively, and accurately spacing apart and positioning a pair of adjacent vertebral bodies to receive an implant, which is anything designed to be left in the body for an extended length of time, working upon the properly positioned vertebral body end plate regions adjacent a disc space so as to remove bone to produce a receiving surface corresponding to an implant having upper and lower surfaces to be implanted between the adjacent vertebrae.

It is a further object of at least one embodiment of the present invention to provide a device and method that permits the insertion of disc penetrating extensions of a guard into the disc space posteriorly in a first position that facilitates insertion and removal of the disc penetrating extensions into and from the disc space and then permits the disc penetrating extensions to be moved into a second position that orients the adjacent vertebral bodies in a preferred lordotic relationship relative to the device and each other.

It is a further object of the present invention, in at least certain embodiments, to provide a device capable of working upon both of the vertebral body end plate regions adjacent a disc space to produce opposed receiving surfaces in the adjacent end plates corresponding at least in part in size, shape, and contour to an implant to be implanted with the exception of the height of the implant, which may be greater than the distance between the opposed receiving surfaces that may be distracted or otherwise moved apart by insertion of the implant, and in so doing to define the shape to the implantation space.

It is a further object of the present invention to provide a device that works with linear insertion, i.e., insertion along a single axis, and without removing the device during the process of disc space preparation and, if so desired with certain embodiments of the present invention, implant placement.

These and other objectives of the present invention will occur to those of ordinary skill in the art based on the description of the preferred embodiments of the present invention described below. However, not all embodiments of the inventive features of the present invention need achieve all the objectives identified above, and the invention in its broadest aspects is not limited to the preferred embodiments described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings together with the description, serve to explain the objects, advantages, and principles of the invention. In the drawings:

FIG. 1 is a front elevation view of two disc levels of the lumbar spine showing the prior art depth of resection resulting from drilling through the bony end plate region of adjacent vertebral bodies and showing the endplate region on a vertebral body;

FIG. 2 is a side view of one preferred embodiment of a guard of the present invention with the disc penetrating extensions closed into a first or insertion position;

FIG. 3 is a top and bottom view of the guard shown in FIG. 2;

FIG. 4 is a proximal or trailing end view of the guard shown in FIG. 2;

FIG. 5 is a side view of the guard of FIG. 2 with the disc penetrating extensions opened into a second or deployed position;

FIG. 6 is side view with a partial cross-section of a lock collar for use with the guard of FIG. 2;

FIG. 7 is a perspective view of an impaction cap for use with the guard of FIG. 2;

FIG. 8 is a cross-sectional view of the impaction cap of FIG. 7 taken along line 8-8 of FIG. 7;

FIG. 9 is a top view of a cutting device configured to pass through the guard shown in FIG. 2;

FIG. 10 is a side view of the cutting device of FIG. 9;

FIG. 11 is a top view of the cutting device of FIG. 9 showing a spring-biased lever that may be used to adjust the position of a stop member;

FIG. 12 is a side view of a double-wheel cutting device having opposed abrading or cutting elements;

FIG. 13 is a side view of a double-wheel cutting device having abrading or cutting surfaces inclined relative to one another to form a space between the adjacent vertebral bodies that approximate the lordotic curvature of a human spine at the location that will receive the implant;

FIG. 14 is a detailed view illustrating a single-wheel cutting device;

FIG. 15 is a top plan view of a spinal interspace shaper bone removal device;

FIG. 16 is a side elevation view of the bone removal device of FIG. 15;

FIG. 17A is a diagrammatic illustration of a hole pattern formed with a drill guide and large and small drills;

FIG. 17B is a diagrammatic illustration of the hole pattern formed after the drill guide is flipped 180 degrees and additional holes are drilled with the large and small drill bits;

FIG. 17C is a diagrammatic illustration of the space created with the drill guide of FIG. 17B, but where the space to be prepared is wider than in FIG. 17B;

FIG. 17D is the configuration of the space created with the drill guide instrument and the holes drilled as shown in FIG. 17C;

FIG. 17E is a diagrammatic illustration of a hole drilled with a central bore drill guide into the space of FIG. 17D;

FIG. 17F is the configuration of the space created with the drill guide instrument and central bore drill guide instrument of FIG. 17E;

FIG. 18 is a rear perspective view of a lumbar segment of a spine with the dural sac retracted to the left showing a partial discectomy and the guard with disc penetrating extensions of FIG. 2 approaching the disc space between the adjacent vertebral bodies with the disc penetrating extensions in the first or insertion position;

FIG. 19 is a side view of the guard of FIG. 2 inserted fully within the spine with the disc penetrating extensions parallel to one another in the insertion position with the impaction cap of FIG. 7 and a portion of the trailing end of the guard in partial cross-section;

FIG. 20 is a side view of the guard of FIG. 2 in the deployed position with the disc penetrating extensions shown in the deployed position to induce lordosis to the vertebral bodies with the lock collar of FIG. 6 shown in partial cross-section coupled to the trailing end of the guard to maintain the guard in a closed position;

FIG. 21 shows a trailing end view of the guard of FIG. 2 in the deployed position between adjacent vertebral bodies with portions of the end plates of the adjacent vertebral bodies visible through the interior of the guard;

FIG. 22 shows a cross-sectional side view of the guard of FIG. 2 in the deployed position with the disc penetrating extensions in the deployed position to induce angulation to the adjacent vertebral bodies and a side view of the cutting device being inserted along tracks on the inside of the guard with the lock collar of FIG. 6 installed;

FIG. 23A is a cross-sectional view of the cutting device and guard along line 23-23 of FIG. 22 with the cutting device height approximating the height of the passage through the guard;

FIG. 23B is a cross-sectional view of an alternative embodiment of the cutting device and guard along line 23-23 of FIG. 22 with the cutting device height less than the height of the passage through the guard so as to permit passage through the guard of an implant having a height greater than the height of the insertion space formed through the guard;

FIG. 24 is a side view of the guard inserted into the adjacent vertebral bodies with the guard in the inserted position with the lock collar on the trailing end thereof and the disc penetrating extensions in the deployed position showing the portions of the vertebral end plates removed by the cutting device;

FIG. 25 is a partial cross-sectional side view of the guard of FIG. 2 showing a spinal fusion implant and inserter passing through the guard to insert an implant into the disc space between the adjacent vertebral bodies;

FIG. 26 shows a side view of the spinal segment with the implant of FIG. 25 inserted in the disc space and the guard with the disc penetrating extensions returned to the insertion position to facilitate the removal of the guard;

FIG. 27 is a top plan view of the lower vertebral body of the spinal segment of FIG. 26 with the spinal fusion implant inserted in the socket formed in the vertebral end plate region by the cutting device and a dashed line illustrating the location of a second socket to be formed in the vertebral body for placement of a second spinal fusion implant when the process is repeated;

FIG. 28 is a side view of another preferred embodiment of a guard of the present invention with the disc penetrating extensions closed into a first or insertion position;

FIG. 29 is a bottom view of the guard shown in FIG. 28;

FIG. 30 is a side view of the guard of FIG. 28 with the disc penetrating extensions opened into a second or deployed position;

FIG. 31 is an opposite side view of the guard of FIG. 28 with the disc penetrating extensions opened into a deployed position;

FIG. 32 is a cross-sectional view of the guard shown in FIG. 29 taken along line 32-32 of FIG. 29;

FIG. 33 is side cross-sectional view of a lock collar for use with the guard of FIGS. 30 and 31;

FIG. 34 is a side view of another preferred embodiment of a guard with the disc penetrating extensions opened into a deployed position;

FIG. 35 is a side cross-sectional view of a lock collar for use with the guard of FIG. 34;

FIG. 36 is a perspective view of an impaction cap for use with the guard of FIG. 28 or FIG. 34;

FIG. 37 is a cross-sectional view of the impaction cap of FIG. 36 taken along line 37-37 of FIG. 36;

FIG. 38 is a rear perspective view of a lumbar segment of a spine with the dural sac retracted to the left showing a partial discectomy and the guard with disc penetrating extensions of FIG. 34 approaching the disc space between the adjacent vertebral bodies with the disc penetrating extensions in the insertion position;

FIG. 39 is a side view of the guard of FIG. 34 inserted fully within the spine with the disc penetrating extensions parallel to one another in the insertion position with the impaction cap of FIG. 36 and a portion of the trailing end of the guard in partial cross-section;

FIG. 40 is a side view of the guard of FIG. 34 in the deployed position with the disc penetrating extensions shown in the deployed position to induce lordosis to the vertebral bodies with the lock collar of FIG. 35 shown in partial cross-section coupled to the trailing end of the guard to maintain the guard in a closed position;

FIG. 41 shows a trailing end view of the guard of FIG. 34 in the deployed position between adjacent vertebral bodies with portions of the end plates of the adjacent vertebral bodies visible through the interior of the guard;

FIG. 42 shows a cross-sectional side view of the guard of FIG. 34 in the deployed position with the disc penetrating extensions in a deployed position to induce angulation to the adjacent vertebral bodies and a side view of a drill being inserted through the trailing end of the guard with the lock collar of FIG. 35 installed;

FIG. 43 is a partial cross-sectional side view of the guard of FIG. 34 inserted into the adjacent vertebral bodies with the locking cap of FIG. 35 on the trailing end thereof and the disc penetrating extensions in the deployed position showing the portions of the vertebral end plates removed by a bone removal device;

FIG. 44 is a partial cross-sectional side view of the guard of FIG. 34 and locking collar of FIG. 35 coupled thereto showing a spinal fusion implant and inserter passing through the guard to insert the implant into the disc space between the adjacent vertebral bodies;

FIG. 45 shows an exploded side view of the spinal segment with the implant of FIG. 44 inserted in the disc space and the guard with the disc penetrating extensions returned to the insertion position to facilitate the removal of the guard from between the adjacent vertebral bodies;

FIG. 46 is a leading end side perspective view of a bone compactor of the present invention;

FIG. 47 is an exploded trailing end side perspective view of the compactor of FIG. 46 for insertion within the guard shown engaging the spine and inserted in the disc space between two

adjacent vertebral bodies with an impaction cap for advancing the compactor into the disc space; and

FIG. 48 is a cross-sectional view along lines 48—48 of FIG. 47 illustrating the compactor placed within the guard inserted into the disc space on one side of the vertebral midline.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENT

Reference is now made in detail to the present preferred embodiments of the invention, as illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used throughout the drawings to refer to the same or like parts. For example, reference numbers without a prime are used in relation to a guard having a rectangular cross-section such as described with reference to FIGS. 2-27. Reference numbers with a prime are used in relation to a guard having a circular cross-section or opposed upper and lower arcuate portions such as described with reference to FIGS. 28-45.

FIGS. 2-5 are generally directed to an embodiment of a guard having a rectangular cross-section for use in spinal surgery for forming an implantation space between adjacent vertebral bodies of the lumbar spine from a posterior approach. As shown in FIG. 2, a guard 100 has a body 102 with a first portion 104 and a second portion 106. Guard 100 also has disc penetrating extensions 110, 112. In particular, first disc penetrating extension 110 extends from first portion 104 of body 102 and second disc penetrating extension 112 extends from second portion 106 of body 102.

In preferred embodiments, but not requisite, various windows 108 in guard body 102 allow the surgeon to remove portions of a facet, pedicle, or spinous process in the same procedure as the bone removal of the vertebral bodies for creating an insertion space therebetween. It is within the scope of the present invention to use a variety of window shapes in addition to the shape depicted to accommodate projecting bone structures. Window 108 also may be used in observing the procedure at various stages of the operation and if so desired for passing instruments therethrough. Rather than or in addition to a window 108, the guard may have one or more indentations of the wall of the body 102 to make room for a facet, pedicle, or spinous process. As best seen in top view FIG. 3, disc-penetrating extensions 110, 112 are preferably at least in part coextensive with the sides 114 of body 102.

FIG. 2 shows guard 100 with body 102 with disc penetrating extensions 110, 112 in a first or closed position, for insertion into the disc space between adjacent lumbar vertebral bodies to be operated upon. Whereas FIG. 5 shows guard 100 with body 102 closed and disc penetrating extensions 110, 112 in a second or expanded or deployed position. FIG. 4 shows a proximal end view of guard 100 with exterior surface 116, interior surface 118, and hinges 120.

FIG. 6 is a side view with a partial cross-section of a lock collar 122 for use with guard 100. Lock collar 122 is used when body 102 of guard 100 is in the closed position to lock guard 100 into that position.

A perspective view of an impaction cap 124 for use with guard 100 is shown in FIG. 7. FIG. 8 is a cross-sectional view of impaction cap 124. Impaction cap 124 is fit over the proximal or trailing end of guard 100 with body 102 in the open position and disc penetrating extensions 110, 112 in the closed, first, or insertion position. While it may be possible to insert the extensions of the guard into the disc space by holding the body of guard 100, impaction cap 124 provides a

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contact surface **126** upon which force can be applied, such as with a mallet, to drive disc penetrating extensions **110**, **112** of guard **100** into the disc space between adjacent vertebral bodies.

A variety of bone removal devices are useable with the guard of the present invention. For example, FIGS. 9-11 show a cutting device **128** configured to pass through guard **100** for cutting the vertebral end plates of the adjacent vertebral bodies to form an implantation space for receipt of a spinal implant. Cutting device **128** includes an upper cutter **130** and a lower cutter **132**, as disclosed in WO 99/63891. FIGS. 9 and 11 are each a top view of cutting device **128** and FIG. 10 is a side view. In this embodiment, upper and lower cutters **130**, **132** are two disc-shaped members that mount on the distal end of the cutting device **128** by a recessed screw **134** and screw shaft (not shown). In the embodiment of the present invention shown in FIGS. 9-11, the upper and lower cutters **130**, **132** and their associated cutting surfaces may be rotated in opposite directions so as to counteract and balance any torque applied to cutting device **128** as the cutters remove the requisite material through the vertebral end plate regions. Counter-rotating motion of cutters **130**, **132** is illustrated by the arrows in FIG. 10. Cutters **130**, **132** are preferably configured with sharpened leading edges about the periphery to facilitate cutting during linear advancement of cutting device **128**. FIG. 11 is a top view of cutting device **128** showing a spring-biased lever **136** that may be used to adjust the position of a stop member **138** to limit the depth of insertion of cutting device **128** within guard **100** and thus into the spine. Cutting device **128** may also be adapted to include cutters or abrading elements which have a pair of opposed, outwardly facing abrading surfaces or cutters **130**, **132** which lie in planes that may be parallel to each other, as shown in the embodiment of FIG. 12, or, alternatively, convergent to each other, as shown in FIG. 13.

FIG. 14 shows a single wheel embodiment of cutting device **128**. In FIG. 14, cutting device **128** includes a single wheel **140** having a single abrading surface **142** that works on one vertebral surface at a time within the disc space.

FIGS. 15 and 16 show an improved spinal interspace shaper bone removal device **128** from the top plan view and side elevation view, respectively. Device **128** includes drive members positioned adjacent cutting members, instead of between cutting members, to permit the overall height of device **128** to be less than was previously possible with cutting member having a drive member therebetween because cutting members can be placed closer together, as described in applicant's U.S. application Ser. No. 09/972,560, filed Oct. 6, 2001, incorporated herein by reference.

FIGS. 17A-F show another embodiment of a bone removal device useable with the guard of the present invention. In this embodiment, a drill guide **144** is used in combination with large drills and small drills as disclosed in U.S. Pat. No. 6,224,607, the disclosure of which is hereby incorporated by reference. As shown in FIG. 17A, the holes created with the large drills (L) and small drills (S) form a pattern as indicated in the dotted lines. After the first three holes have been drilled, guide **144** is removed from within guard **100**, rotated 180 degrees and then reinserted into guard **100**. Guide **144** is now oriented such that a large bore is positioned over the area in which the small holes were drilled and small bores are positioned over the area in which the large bore was drilled. The drilling procedure with large drills and small drills is repeated to create a pattern of holes as indicated by the dotted lines in FIG. 17B. As a result of this drilling procedure, a substantial

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portion of bone is removed from the end plates of the adjacent vertebrae creating a space approximating the configuration of a rectangle.

FIGS. 17E and 17F show the use of a large central bore (c) guide **146**. Guide **146** has a large bore that is centrally placed, such that when a large drill is passed through central bore guide **146**, the portion of bone remaining in the central portion of the space being created can be removed. As shown in FIG. 17C, the use of central bore guide **146** may be of particular value in removing remaining bone where guide **144** has a hole pattern that when reversed provides for a lesser amount of overlap of bores formed through the large bore. FIG. 17D shows the space created with the drilling procedure through FIG. 17C. The hole created with central bore guide **146** is shown in dotted line in FIG. 17E. As shown in FIG. 17F, the space created with the drilling procedure disclosed above results in a substantial portion of bone being removed from the end plate of adjacent vertebrae creating a space that more closely approximates the configuration of a rectangle.

FIGS. 18-27 show the progression of various steps of a preferred method for using guard **100** and other associated equipment disclosed herein.

FIG. 18 is a perspective view of a segment of a spine viewed from a posterior aspect with the dural sac retracted to the left showing that a partial distectomy has already been performed. Guard **100** with disc penetrating extensions **110**, **112** are shown approaching the disc space between the adjacent vertebral bodies with disc penetrating extensions **110**, **112** in the first or insertion position. Impaction cap **124** is positioned on the proximal or trailing end of guard **100** to maintain it in the open position such that the disc penetrating extensions are closed into the insertion position. In this position, guard **100** is ready to be placed or driven into the disc space between the adjacent vertebral bodies.

In FIG. 19, the extensions of guard **100** are fully inserted into the spine with the disc penetrating extensions parallel to one another in the first or insertion position. Impaction cap **124** is shown holding the guard in the open position and the disc penetrating extension in the first or insertion position. While the disc penetrating extensions of the first position are shown with a parallel orientation to one another, it is anticipated that the disc penetrating extensions may also be at an angle to one another in the first or closed position.

In FIG. 20, body **102** of guard **100** is shown in a closed position with the disc penetrating extensions shown in the second, open or inserted position to induce lordosis to the vertebral bodies. After closing the body of guard **100**, the proximal or trailing end has lock collar **122** placed around it to maintain the body of guard **100** in the closed position.

FIG. 21 shows a proximal end view of guard **100** with the body in the closed and inserted position between adjacent vertebral bodies with portions of the end plates of the adjacent vertebral bodies visible through the interior of guard **100**.

In FIG. 22 the body of guard **100** is in a closed position with disc penetrating extensions **110**, **112** in the second, expanded or inserted position to induce angulation to the adjacent vertebral bodies. At the distal end of guard **100** shown in cross-section is a side view of cutting device **128** being inserted along tracks **148** on interior surface **118** of guard **100**. Guard **100** provides protected access to the disc space and the adjacent vertebral bodies for cutting device **128** via the elongated opening in guard **100**. In one embodiment shown in FIGS. 22, 23A, and 25, an implant **150** is preferably sized and shaped to match the space formed in the spine by cutting device **128**.

In another embodiment shown in FIGS. 23B and 25, the guard opening may be taller than the height of cutting device **128**. Such a taller opening allows the implantation of an

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implant **150** taller than the height of cutting device **128**. Implant **150** is then preferably sized and shaped without much regard to height so that a taller implant **150** may be selected for insertion to the space formed in the spine by cutting device **128**.

Guard **100** may also include one or more tracks **148** to direct cutting device **128** while accessing the disc space and adjacent vertebral bodies via the elongated opening in guard **100**. Such tracks **148** may include any surface designed to direct cutting device **128**. Tracks **148** also serve to keep cutter device **128** from easily rotating or moving side to side within the guard opening. FIGS. **23A** and **23B** show a cross-sectional view of cutter device **128** and guard **100** along line **23--23** of FIG. **22**. In FIG. **24** after cutting device **128** is removed one can observe the portion of the vertebral end plates removed by cutting device **128**.

As best shown in FIG. **25**, an implant **150**, such as an impacted block, interbody fusion device, motion preserving device or other insert and an inserter **152** may be passed through guard **100** to insert implant **150** into the disc space between the adjacent vertebral bodies which guard may be left in place throughout the procedure.

Implant **150** may be made of artificial or naturally occurring materials suitable for implantation in the human spine. Implant **150** may also take a variety of shapes, for example, rectangular or square cross section. Implant **150** can comprise bone including, but not limited to, cortical bone. Implant **150** can also be formed of material other than bone, such as metal including, but not limited to, titanium and its alloys or ASTM material, surgical grade plastics, plastic composites, ceramics, or other materials suitable for use as an interbody implant. The plastics may be bioresorbable. Implant **150** can further be formed of bone growth promoting materials, including but not limited to, bone morphogenetic proteins, hydroxyapatite, and genes coding for the production of bone. Implant **150** can be treated with a bone growth promoting substance, can be a source of osteogenesis, or can be at least in part bioabsorbable. Implant **150** also can be formed of a porous material. Further, implant **150** may be used in combination with chemical substances and/or compounds applied at the trailing end of the implant to inhibit scar formation, and a cap may be of benefit in shielding fusion-promoting substances contained in the implant from these scar formation inhibiting chemicals and compounds.

As illustrated in FIG. **26**, after implant **150** is inserted into the implantation space into contact between the adjacent vertebral bodies, body **102** of guard **100** is opened and disc penetrating extensions **110**, **112** are thus placed in the first, closed position to facilitate the removal of guard **100** from the disc space. If not for the ability of the extensions to be retrieved from their lordotic inserted position, there would be no easy way to remove the guard.

FIG. **27** is a top plan view of the lower vertebral body of the spinal segment and spinal fusion implant **150** inserted in the implantation space or socket formed in the vertebral end plate by cutting device **128**. A dashed line illustrates the location of a second implantation space or socket to be formed in the vertebral body for placement of a second spinal fusion implant when the process is repeated.

In summary, a preferred method of the present invention includes: performing from a posterior approach in the lumbar spine at least a partial laminectomy sufficient for access to the disc space; performing at least a partial discectomy, which more preferably provides sufficient space to receive the guard disc penetrating extensions to a depth which may be generally similar to the depth of implant **150** to be received; retracting and protecting the dural sac; inserting guard **100** with exten-

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sions **110,112** into the disc space; inducing lordosis to the adjacent vertebral bodies; securing body **102** of guard **100** in the closed position; and inserting cutting device **128** through guard **100** to a desired depth. The depth of insertion may be monitored by x-ray. At this point debris may be removed by irrigation suction from within and/or about guard **100**. Extensions **110**, **112** are then collapsed and guard **100** is then removed. Any additional debris may be removed after removal of guard **100**, again by irrigation suction. Implant **150** may be inserted through guard **100** prior to its removal from the disc space, or may be inserted after guard **100** is removed while retractors are utilized as needed to protect the proximate neural structures.

Guard **100** preferably is used for posterior lumbar interbody implantation procedures. Guard **100** includes a height, a width, and a distance between its front and rear portion. The height of body **102** is preferably between 8-25 mm and the opening height is preferably 8-20 mm. The width of the opening of body **102** is preferably 10-25 mm. Disc penetrating extensions **110**, **112** may have any shape or configuration suitable for the intended purpose disclosed herein including extensions with parallel or angled upper and lower surfaces. Preferably, disc penetrating extensions **110**, **112** have a combined height when closed of 6-18 mm and a length of 12-32 mm. For posterior lumbar interbody fusion, cutting device **128** is preferably 8-20 mm in height and 10-25 mm in width. These dimensions could be greater or less and still be useful for their stated purpose while still being within the inventive scope of the present invention.

FIGS. **28-31** are directed to another embodiment of a guard in accordance with the present invention and generally referred to by the reference number **100'**. Guard **100'** has a circular cross-section or has at least opposed upper and lower arcuate portions. Guard **100'** is adapted for use in spinal surgery for forming an implantation space between adjacent vertebral bodies of the lumbar spine from a posterior approach. The structure and use of guard **100'** is similar to that described above in relation to guard **100** as illustrated in FIGS. **2-27**, hereby incorporated by reference, except as otherwise noted below.

FIGS. **28-32** show a guard **100'** similar to guard **100** except that it preferably has a circular cross-section or least opposed upper and lower arcuate portions. Guard **100'** is preferably adapted to guide a bone removal device therethrough to form an implantation space having opposed arcuate surfaces into the endplates of the opposed arcuate surfaces. Such an implantation space is preferably adapted to receive an implant having at least one arcuate portion such as by way of example only implant **150'**, illustrated in FIGS. **44** and **45** and described in more detail below.

FIG. **28** shows guard **100'** having a body **102'** with a first portion **104'** and a second portion **106'**. Guard **100'** also has disc penetrating extensions **110'**, **112'**. In particular, first disc penetrating extension **110'** extends from first portion **104'** of body **102'** and second disc penetrating extension **112'** extends from second portion **106'** of body **102'**.

FIGS. **28**, **29**, **31**, and **34** show that guard **100'** may have one or more indentations **109'** of the wall of body **102'** to make room for a facet, pedicle, or spinous process of vertebrae adjacent to the disc space into which guard **100'** is to be inserted. Indentation **109'**, shown in FIG. **29**, allows guard **100'** to clear the pedicle of the lower vertebra. Indentation **109'**, shown in FIG. **31**, avoids interference with the bulge of the spinous process. Alternatively, indentation **109'** of FIG. **31** could be a window to allow bone to protrude inside of guard **100'** to be cut off during the bone removal step of the surgical procedure.

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FIG. 34 shows a side view of an alternative embodiment of guard 100' including a threaded end 123' cooperatively engaging lock collar 122' of FIG. 35 having matching threads 125'. Threads 125' of collar 122' provide additional protection against accidental dislodgment of the locking collar from guard 100' during a surgical procedure.

As shown in FIGS. 38-45, the use of guard 100' generally parallels the use of guard 100 shown in FIGS. 18-27 except that a bone removal device in the form of a drill 128' is preferably used to prepare an implantation space sized and shaped to receive implant 150'.

FIG. 38 is a perspective view of a segment of a spine viewed from a posterior aspect with the dural sac retracted to the left showing that a partial discectomy has already been performed. Guard 100' with disc penetrating extensions 110', 112' are shown approaching the disc space between the adjacent vertebral bodies with disc penetrating extensions 110', 112' in the first or insertion position. Impaction cap 124' is positioned on the proximal or trailing end of guard 100' to maintain it in the open position such that the disc penetrating extensions are closed into the insertion position. In this position, guard 100' is ready to be placed or driven into the disc space between the adjacent vertebral bodies.

FIGS. 39 and 40 show guard 100' rotationally articulating to permit movement of disc penetrating extensions 110', 112' in response to movement of first portion 104' and second portion 106' of body 102' relative to one another. The rotational articulation preferably occurs about hinge 120', which is preferably formed in first and second portions 104', 106' of body 102'.

In FIG. 42 the body of guard 100' is in a closed position with disc penetrating extensions 110', 112' in the second, expanded or inserted position to induce angulation to the adjacent vertebral bodies. At the distal end of guard 100' shown in cross-section is a side view of drill 128' being inserted through guard 100'. Guard 100' provides protected access to the disc space and the adjacent vertebral bodies for drill 128' via the elongated opening in guard 100'.

As shown in FIGS. 44 and 45, a preferred embodiment of threaded implant 150' has a body sized to match the implantation space formed in the spine by drill 128' and is screwed into the adjacent vertebral bodies. Drill 128' may have a reduced diameter cutting portion relative to the shaft diameter or may be inserted through an inner sleeve that passes into guard 100' to guide drill 128' to form an implantation space smaller than the passage through guard 100'. Thus, the interior opening of guard 100' may be taller than the height of the cutting portion of drill 128'. Such a taller opening allows the implantation of an implant 150' taller than the height of the cutting portion of drill 128'. For example, a taller oval implant or one with truncated sides may be linearly inserted into the implantation space having opposed arcuate cuts into the adjacent vertebral bodies. Implant 150' may be threaded, ratcheted, knurled, or have any other surface projections to facilitate engaging the adjacent vertebral bodies. Implant 150' may also have a variety of shapes, for example, circular or oval in cross section. Implant 150' can comprise, be formed of, and/or be treated with materials and/or substances such as those described above relative to implant 150.

Guard 100' preferably is used for posterior lumbar interbody implantation procedures. Guard 100' includes a height, a width, and a distance between its front and rear portion. The height of body 102' is preferably between 8-25 mm and the opening height is preferably 8-20 mm. Disc penetrating extensions 110', 112' may have any shape or configuration suitable for the intended purpose disclosed herein including extensions with parallel or angled upper and lower surfaces in

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the closed or open position. Preferably, disc penetrating extensions 110', 112' have a combined height when closed of 6-18 mm and a length of 12-32 mm. For posterior lumbar interbody fusion, drill 128' is preferably 8-20 mm in height. These dimensions could be greater or less and still be useful for their intended purpose while still being within the inventive scope of the present invention.

As shown in FIGS. 46-48, a box-shaped bone compactor 240 has a shaft 242 terminating in a compaction end 244. Compaction end 244 of shaft 242 may include beveled, radiused, or thinned edges to ease introduction. Compactor end 244 compresses any remaining bony protuberances. A trailing end 246 of shaft 242 may include an extraction head 248 for coupling to an extraction instrument.

In a preferred embodiment, there is no fixed stop until approximately 32-36 mm, so that a slotted and calibrated impaction cap 260 can be used to predictably and adjustably insert compaction end 244 into the intervertebral space to the desired optimal depth. Alternatively, compactor 240 can have a fixed depth limiting means. As a further alternative, leading edges 250 of compactor 240 can be sharpened so that it functions wholly or in part as a chisel to cut rather than compact the bone. This is considered less desirable, though still workable, than the preferred compaction end 244 by which the density of the bone at the prepared recipient site is actually increased by the compaction process. In use, compactor 240 is inserted into the guard and advanced to compact portions of bone forming the implantation space to increase the density of the bone forming the implantation space.

Although various embodiments of the present invention have been disclosed for purposes of illustration and are for purposes of example only and not limitation, it will be understood by those of ordinary skill in the art that changes, modifications, and substitutions may be incorporated in these embodiments without departing from the spirit of the present invention or the scope of the appended claims.

I claim:

1. A method for inserting a bone implant into a posterior aspect of the human spine, comprising:
 - placing a guard against the posterior aspect of the spine, the guard having a passage therethrough;
 - inserting a bone removal device into the passage of the guard, the bone removal device having a cutting portion;
 - drilling a portion of a facet joint with the bone removal device to create a socket having a maximum height; and
 - inserting a bone implant into the socket created by the bone removal device, the bone implant having a leading end, a trailing end, a mid-longitudinal axis through the ends, and a height transverse to the mid-longitudinal axis, the height of the bone implant being greater than the maximum height of the socket.
2. The method of claim 1, wherein the bone removal device is a drill.
3. The method of claim 1, further comprising applying an impaction force against a trailing end of the guard to stabilize the guard relative to the posterior aspect of the spine.
4. The method of claim 1, further comprising monitoring the depth of insertion of the bone removal device with a radiographic imaging device.
5. The method of claim 1, further comprising irrigating inside and outside the guard.
6. The method of claim 1, wherein the bone implant, inserted through the passage of the guard, has a circular cross section.
7. The method of claim 1, wherein the guard has a rectangular cross section.

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8. The method of claim 1, wherein a portion of the socket is formed in an endplate of a vertebral body with the bone removal device.

9. The method of claim 1, wherein the guard includes two extensions at a leading end thereof for insertion at least in part between two adjacent vertebral bodies.

10. The method of claim 1, wherein the guard includes an upper portion and a lower portion, the upper and lower portions being pivotally attached to one another.

11. A method for inserting a bone implant into a posterior aspect of the human spine, comprising:

placing a guard against the posterior aspect of the spine, the guard having a passage therethrough;

forming a socket through a portion of a facet joint using a bone removal device inserted through the passage of the guard, wherein forming the socket includes compacting portions of bone forming the socket to increase the density of the bone forming the socket, the socket having a maximum height; and

inserting a bone implant having a circular cross section into the socket, the bone implant having a leading end, a trailing end, a mid-longitudinal axis through the ends, and a height transverse to the mid-longitudinal axis, the height of the bone implant being greater than the maximum height of the socket.

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12. The method of claim 11, wherein the bone removal device has a rotatable cutting portion.

13. The method of claim 12, wherein the bone removal device is a drill.

14. The method of claim 12, wherein a portion of the socket is formed in an endplate of a vertebral body with the bone removal device.

15. The method of claim 11, further comprising applying an impaction force against a trailing end of the guard to stabilize the guard relative to the posterior aspect of the spine.

16. The method of claim 11, further comprising monitoring the depth of insertion of the bone removal device with a radiographic imaging device.

17. The method of claim 11, further comprising irrigating inside and outside the guard.

18. The method of claim 11, wherein the bone implant is inserted through the passage of the guard.

19. The method of claim 11, wherein the guard has a rectangular cross section.

20. The method of claim 11, wherein the guard includes two extensions at a leading end thereof for insertion at least in part between two adjacent vertebral bodies.

21. The method of claim 11, wherein the guard includes an upper portion and a lower portion, the upper and lower portions being pivotally attached to one another.

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