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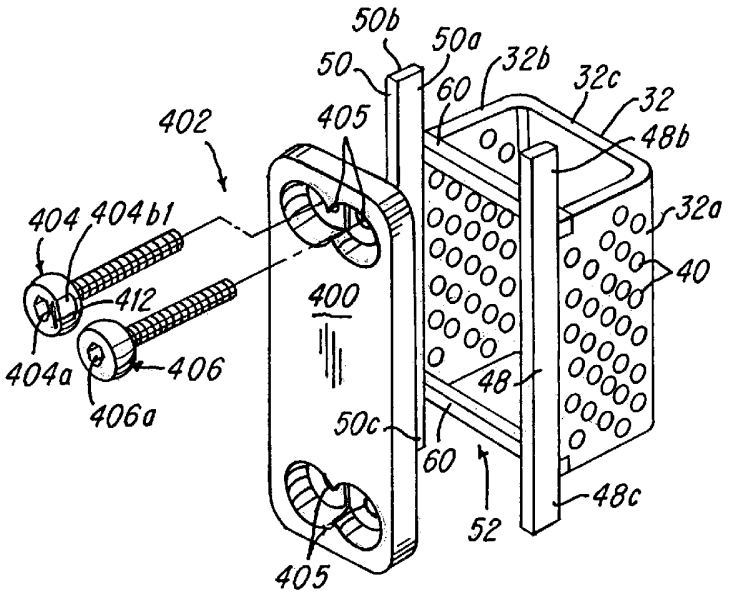

(57) Abstract: This invention relates to a spinal fusion system and method for use as a prosthetic implant. The system and method includes a housing dimensioned to be situated between adjacent spinal bones, such as adjacent vertebrae. The housing cooperates with the spinal bones to define a graft area for receiving graft material, which may be inserted anteriorly into the housing during a surgical operation such as a vertebrectomy or discectomy. A housing may have various features such as migration preventers to prevent the housing from migrating posteriorly towards a spinal column and can be used with a cover that permits the housing to "float" relative thereto. Screws are provided in one embodiment and are dimensioned or configured to lock against each other to retain the screws and, consequently, the cover in place.

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SPINAL FUSION SYSTEM AND METHOD FOR FUSING SPINAL BONES

BACKGROUND OF THE INVENTION

1. Field Of The Invention

This invention relates to a veritable prosthetic system and device and a method for implanting the device and, more particularly, to a spinal fusion system and method for fusing spinal bones.

2. Description of the Related Art

Many types of prosthetic devices have been proposed in the past. For example, U.S. Patent 5,192,327 to Brantagan concerns a surgical prosthetic modular implant used singularly or stacked together to support and fuse together adjacent vertebrae or to totally or partially replace one or more vertebrae in a vertebral column. Other surgical implant devices and methods are shown in U.S. Patents 5,192,327; 5,261,911; 5,713,899; 5,776,196; 6,136,002; 6,159,245; 6,224,602; 6,258,089; 6,261,586; 6,264,655; 6,306,136; 6,328,738 and 6,592,586. Some or all of these devices have improved the success rate and have simplified the surgical techniques in inter-body veritable fusion.

Among some of the problems associated with the prior art devices is that after the device is inserted into a patient during a surgical procedure, there was a possibility of retropulsion of the inter-body device and graft material into the spinal cord or other neurological element.

Another problem with the prior art devices is that grafting material, which was inserted into the devices during the surgical procedure, could not easily be inserted from an anterior direction.

Moreover, in some of the prior art devices, the cover, if any, was typically fastened directly to the device and to spinal bones, which prevented the cover from being capable of moving relative to the device. In addition, in devices that used a cover, the cover did not function to both retain the grafting material in the device and simultaneously fix the spinal bones relative to each other.

Another problem with prior art cage systems is that the screws or fasteners which secured the cover onto the cages sometimes had a tendency to unscrew themselves which is undesirable because the graft material may exit the cage or because the cage itself may move. Another problem is that the screws may withdraw, causing injury to local structures by the screws themselves.

What is needed, therefore, is a system and method, which facilitates overcoming one or more of the aforementioned problems as well as other problems and to provide a device that has unique features that will facilitate reducing the risk associated with neurological surgeries and advance the present state of the art.

SUMMARY OF THE INVENTION

It is, therefore, one object of the invention to provide a spinal fusion system and method which utilizes a housing that can be inserted, but comprises features which, for example, enables the device to float relative to a cover, facilitates retaining any graft material within the device, facilitates fixing a relative relation among or between spinal bones, facilitates providing a cover for covering one or multiple devices, and/or includes locking features that facilitates preventing the screws which secure the cover to the spinal bones from the retracting.

Another object of one embodiment is to provide a plurality of screws that are capable of locking to facilitate preventing the fasteners to become unfastened or unscrewed.

Another object of the invention is to provide fasteners at least one of which has an eccentric to facilitate locking against an adjacent fastener in order to retain the fasteners and the cover in a locked position.

In one aspect, this invention comprises a cage system for use as a prosthetic implant comprising: a housing dimensioned to be situated in a graft area between adjacent vertebrae, the housing comprising at least one wall that defines an opening after the housing is situated between the adjacent vertebrae to permit anterior loading of graft material, and a cover for covering the opening to facilitate preventing anterior migration of the graft material, a locking system for retaining a prosthetic implant cover on a cage, the locking system comprising: a first fastener for securing the prosthetic implant cover to the cage, at least one second fastener that engages the first fastener and secures the cover to the cage and engages the first fastener to retain at least one of the first and second fasteners thereto.

In another aspect, this invention comprises a locking system for retaining a prosthetic implant cover on a cage, said locking system comprising: a first fastener for retaining said prosthetic implant cover on said cage; at least one second fastener that engages said first fastener to retain at least one of said first and second fasteners thereto.

In still another aspect, this invention comprises a locking system for retaining a prosthetic implant cover on a cage, said locking system comprising: at least one pair of adjacent screws situated adjacent each other; said at least one of said at least one pair of adjacent screws comprising a camming head for engaging a head of the other of said at least one pair of adjacent screws to facilitate retaining said screws in a locked position.

In yet another aspect, this invention comprises a medical screw for use in association with a medical implant in a patient; a threaded

portion; and an eccentric head portion coupled to said threaded portion, said eccentric head portion permitting an adjacent screw to be screwed and, thereafter, engaging said adjacent screw when said eccentric head portion is rotated, thereby facilitating preventing medical screw and said adjacent screw from unscrewing.

In still another aspect, this invention comprises spinal fusion system for use as a prosthetic implant comprising a housing dimensioned to be situated between adjacent spinal bones, the housing defining a graft area for receiving a graft or graft-like material for generating a fusion between the adjacent spinal bones, the housing comprising at least one wall that defines an opening after the housing is situated between the adjacent spinal bones to permit post-placement loading of graft material, wherein the spinal fusion system further comprises a cover for covering the opening to facilitate preventing anterior migration of the graft material, wherein the housing further comprises a first wall portion and a second wall portion, the first and second wall portions being integrally formed into the housing and defining a channel area for receiving the cover.

These and other objects and advantages of the invention will be apparent from the following description, the accompanying drawing and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partial side view a human spine illustrating anteriorly discs between various spinal bones;

Fig. 2 is a partial side view of the spinal column shown in Fig. 1 illustrating several of the discs removed, for example, after surgical procedure;

Fig. 3 is a partial side view of the human spine with the housings according to one embodiment of the invention situated therein;

Fig. 4 is a partial side view of the human spinal column illustrating graft material being inserted anteriorly into the housing;

Fig. 5 is a partial exploded side view of the embodiment shown in Fig. 1-4 illustrating a cover and a plurality of screws which will secure the cover to the spinal column;

Fig 6 is a side view similar to Fig. 5 illustrating after the cover has been mounted to the spinal column;

Fig. 7 is a exploded view of the device shown in Fig. 6, illustrating a plurality of housings and a single cover for use with covering the plurality of housings;

Fig. 8 is partial side view illustrating an elongated housing and cover used during a vertebrectomy procedure;

Fig. 9 is a partial side view of the spinal column illustrated in Fig. 8 showing the elongated housing situated between adjacent spinal bones in a single cover to be affixed to those spinal bones;

Fig. 10 is an exploded view of the circle area shown in Fig. 8;

Fig. 11 is a exploded view of the elongated housing illustrated in Figs. 8 and 9 and the cover and screws associated therewith;

Fig. 12 is a partial fragmentary view of the cover and housing after the cover has been situated between a pair of rails associated with the housing;

Fig. 13 illustrates a partial side view of an embodiment showing a plurality of housings of different sizes used with a single cover;

Fig. 14 is a exploded view of the housings and cover illustrated in Fig. 13;

Fig. 15 is a partial anterior side view a human spine illustrating the discs between various spinal bones;

Fig. 16 is a partial anterior view of the spinal column shown in Fig. 1 illustrating several of the discs removed, such as by surgical procedure;

Fig. 17 is a partial anterior view of the human spine with the housings according to one embodiment of the invention situated therein;

Fig. 18 is a partial anterior view of the human spinal column illustrating graft material being inserted anteriorly into the housing;

Fig. 19 is a partial exploded anterior view of the embodiment shown in Fig. 1-4 illustrating a cover and a plurality of screws for securing the cover to the spinal column;

Fig. 20 is a anterior view similar to Fig. 5 illustrating the cover mounted to the spinal column;

Fig. 21 is a fragmentary view illustrating various features of the cover;

Fig. 22 is another fragmentary view of the cover after the screws are mounted and the locking mechanism retains the screws therein;

Fig. 23 is a fragmentary sectional view of the embodiment shown in Fig. 22 illustrating various features of the locking mechanism;

Fig. 24 is a schematic view of a process or method in accordance with an embodiment of the invention;

Fig. 25 illustrations another embodiment of the invention without crossbars or migration preventers;

Fig. 26 is a view of another embodiment of the invention showing the crossbars integrally formed in the housing and without migration preventers;

Fig. 27 is a view illustrating a plurality of migration preventers, without any crossbars;

Fig. 28 is a view illustrating a housing with a plurality of projections which cooperate with the cover to prevent the housing from migrating anteriorly;

Fig. 29 is another view of the housing illustrating a plurality of removable crossbars without any migration preventers;

Fig. 30 illustrates another embodiment of the invention, similar to the devices illustrated earlier relative to Fig. 1-20 showing details of the cross bars and notches for receiving them;

Fig. 31 is a view of a housing having walls having recessed areas for receiving the cover;

Fig. 32 is a view of another embodiment of the invention showing the plurality of fasteners or screws in an unlocked position;

Fig. 33 is a view of the fasteners or screws shown in Fig. 32 in a locked position;

Fig. 34 is a view taken along the line 34 – 34 in Fig. 32;

Fig. 35 is a view taken along the line 35 – 35 in Fig. 33; and

Fig. 36 is an exploded view of the other embodiment of the invention with the locking screws illustrated in Figs. 32 – 35.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to Fig. 1, a partial side view of a patient or person P is shown having a spinal column S and a plurality of spinal bones, such as vertebrae, 10, 12, 14 and 16. Note that a disc, such as discs 18, 20 and 22 in Fig. 1, is located between adjacent pairs of spinal bones (e.g., between bones 10 and 12, 12 and 14, and 14 and 16). During a spinal fusion procedure, such as a discectomy, the discs 18, 20 and 22 may be removed so that adjacent vertebrae may be fused together

Fig. 2 illustrates a fragmentary view of the spinal column S shown in Fig. 1, with the discs 18, 20 and 22 removed. It should also be understood that during another surgical procedure, such as a vertebrectomy, it may be desired to remove part of all of one of the spinal bones 10-16, as illustrated in Fig. 13. In this type of neurological procedure, it may also be desired to fuse adjacent spinal bones together for reasons that are conventionally known. This invention provides means for facilitating and performing such procedures. For ease of illustration, Figs. 15 - 20 provide corresponding anterior views to the side views shown in Figs. 1-6, respectively.

In the embodiment being described, a spinal fusion system 24 is provided for use as a prosthetic implant during a neurological procedure such as the aforementioned vertebrectomy or discectomy. In general, after the discs 18, 20 and 22 (Fig. 1) are removed, as illustrated in Fig. 2, a plurality of receiving areas 26, 28 and 30 (Figs. 2 and 17) are defined by the areas between the surfaces of adjacent spinal bones 10,

12, 14 and 16. As illustrated in Fig. 2, the area 26 is bounded in part by the surface 10a of spinal bone 10 and surface 12a of spinal bone 12. Likewise, area 28 is partially bounded by surface 12b of spinal bone 12 and surface 14a of spinal bone 14, and area 30 is bounded by surface 14b of spinal bone 14 and surface 16a of spinal bone 16.

As illustrated in Figs. 3-7 and 11 and as will be described in more detail later herein, the spinal fusion system 24 comprises a housing 32 dimensioned to be situated or received between adjacent spinal bones, such as bones 10 and 12. A housing 32 is situated in each of the plurality of receiving areas 26, 28 and 30, as illustrated in Figs. 3-4. Each housing 32 cooperates with adjacent spinal bones to define a graft area, such as areas 34, 35 and 36 in the view illustrated in Fig. 17, for receiving graft material 38 (Figs. 4 and 18). As illustrated in Figs. 4 and 18, the graft material 38 is situated in the areas 34, 35 and 36 after placement of the housing 32.

As illustrated in Fig. 11, the housing 32 is generally U-shaped as shown. In the embodiment being described, the housing 32 comprises a well 33 defining multiple sides and comprises a predetermined shape selected to cause the graft material to be formed into a multi-sided fused coupling between adjacent spinal bones, such as bones 10 and 12 in Fig. 3. Although not shown, the housing 32 could define a shape other than rectangular, such as semi-circular, oval or other suitable shape as may be desired. Note that the housing 32 comprises a first wall 32a, a second wall 32b and a third wall 32c joining the first wall 32a and the second wall 32b. One or more of the walls 32a-32c may comprise a plurality of holes or apertures 40 which facilitate the fusing process. The apertures 40 also permit visualization of graft material 30 on x-rays.

As mentioned later herein, the predetermined shape defined by the spinal fusion system 24 may provide a fused multi-sided plug of fusion material 32 having a height H (Figs. 14 and 16) of at least two millimeters, but typically less than approximately 180 millimeters. This height H may vary depending on the vertical size or height H (as viewed in Fig. 16) of the areas 26-30 to be filled. For example, in the area 26

illustrated in Figs. 2, 14 and 16, the height H of the area 26 generally corresponds to a height H1 (Fig. 1) of a disc, such as disc 18. Thus, the fusion material 38 (Fig. 18) would resultantly have a fused height H2 (Fig. 18) that generally corresponds to the height H (Fig. 16) and height H1 (Fig. 1). If, for example, a housing 32 having a longer height is required, such as height H3 in Fig. 14 and height H4 in Fig. 13, such as in the event of a vertebrectomy, then the fusion system 24 and housing 32 will define a height that generally corresponds to the dimension or height H (Fig. 9) to be traversed. Thus, it should be understood that the dimensions of the generally U-shaped housing 32 of the spinal fusion system 24 is selected depending on the size of the area 26-30 to be filled and the environment or application in which the spinal fusion system 24 is used. In general, the width and depth of the housing 32 will be approximately 9 – 20 millimeters and 7 – 20 millimeters, respectively.

As illustrated in Figs. 5-7, 11, 14 and 21-22, the spinal fusion system 24 further comprises a cover 42 comprising a plurality of apertures 44 that receive a plurality of screws 46, respectively, which are screwed directly into the spinal bones 10 and 16, as illustrated, for example, in Figs. 5-6.

As illustrated in Fig. 11, the housing 32 comprises a first rail, channel wall or wall portion 48 and a second rail, channel wall or wall portion 50 which cooperate to define a channel area 52 for receiving the cover 42. It should be understood that when the cover 42 is received in the channel 52, the sides 42a and 42b become associated with the sides 48a and 50a. It should be understood that the cover 42 is not directed permanently secured to the housing 32 after it is received in channel area 52. This feature permits the housing 32 secured to the housing 32 to migrate or float relative to the cover 42 even after the cover 42 is fixed to one or more of the spinal bones 10-16 as illustrated in Figs. 6 and 20. As illustrated in Fig. 23, the edges 42a and 42b of cover 42 and sides 48a and 50a may be beveled and complementary to facilitate locating and mating engagement between the cover 42 and housing 32.

As illustrated in Figs. 3-6 and 16-20, after the graft material 38 is placed in the housing 32 and the graft areas 35-36 (Fig. 17) defined by the housing 32 and adjacent spinal bones, then the cover 42 is situated between the walls or rails 48 and 50, as illustrated in Figs. 6 and 19. The screws 46 may then be used to secure the cover 42 to one or more of the spinal bones 10-16 as illustrated in Figs. 6 and 20. It should be understood that a feature of the invention is that the cover 42 facilitates aligning the housings 32 in a substantially co-lineal or relatively aligned position relative to each other and to the spinal bones 10-16, as illustrated in Figs. 6, 19 and 20. In the setting of multiple level discectomy, the floating cover 42 allows limited, controlled settling of the cages or housings 32 in the vertical plane with respect to the cover 42. As illustrated in Figs. 6, 8, 10 and 20, the cover 42 also provides means for providing a mechanical fixation of the adjacent spinal bones 10-16 relative to each other. Thus, while the housing 32 cooperates with adjacent spinal bones, such as spinal bones 10 and 12, to define a graft receiving area 34, the cover is multi-functional in that it not only covers the opening of any graft areas, such as area 34 (Fig. 17), but it also secures and retains the spinal bones 10-16 in a fixed spatial relationship relative to each other and relative to the housings 32. It should also be understood that the cover 42 may be fixed to one or more of the spinal bones 10-16 as may be desired to accomplish either of the aforementioned functions.

As illustrated in Fig. 11, note that the walls 48 and 50 further define projections 48b, 48c, 50b and 50c as shown. As illustrated in Figs. 3-6 and 17-20, the projections 48b, 48c, 50b and 50c provide a plurality of migration preventers for preventing the housing 32 from migrating posteriorly in the direction of arrow A (Fig. 3) toward the spinal cord S or other neurological elements after the housing 32 is situated between the adjacent spinal bones 10-16 as illustrated. Further, the migration preventers 48b, 48c, 50b and 50c enable a surgeon to locate each housing 32 between adjacent spinal bones, such as spinal bones 10-16 in Fig. 1, and move the housing 32 in the direction of arrow A in

Fig. 3 until the migration preventers 48b, 48c, 50b and 50c engage the surface 10a of spinal bone 10 and migration preventers 48b, 48c, 50b and 50c engage the surface 12a of spinal bone 12. As illustrated in Fig. 3, after the housings 32 are situated between the spinal bones 10-16 as shown, the migration preventers 48b, 48c, 50b and 50c facilitate preventing the wall 32c from being over-inserted by the surgeon or from being over-inserted to a point where it engages the spinal cord S or other neurological elements.

The spinal fusion system 24 further comprises at least one migration stop or crossbar 60 as illustrated in Figs. 11, 12, 29 and 30. The crossbar 60 may be either integrally formed in housing 32, as shown in Fig. 26, or separate as illustrated in Figs. 11, 29 and 30, as illustrated in Figs. 7, 12 and 14, for example. As illustrated in the exploded view in Figs. 10 and 11, the surface 60a of crossbar 60 engages and cooperates with surface 42c of cover 42 to prevent anterior migration in the direction of arrow B). Thus, the spinal fusion system 24 of the embodiment being described provides means for preventing insertion of the housing 32 to a point where it might engage the spinal cord S (Fig. 3) or other neurological elements, such as dura mater, thecal sac, and also means for facilitating prevention of migration of the housing 32 in an anterior direction or in the direction of arrow B in Fig. 10 after the housing 32 is situated as described herein and the cover 42 is mounted to one or more of the spinal bones 10-16.

It should be understood that a plurality of the migration stops or cross bars 60 may be used alone or in combination with the migration preventers 48b, 48c, 50b and 50c. It should be understood that the stops 60 could be detachable, as shown in Fig. 26, or they could be integrally formed in housing 32 (as shown in Fig. 26). Also, these cross bars 60 may be removably received in the notched receiving areas 94 (Figs. 29 – 30). For example, in anatomy that provided limited space, the surgeon may elect not to use a housing with cross bars 60 or use a housing that does not have integrally formed cross bars.

The system 24 further comprises a system or means for preventing retraction or back out of the screws 46 after they are screwed into the spinal bones 10-16 in order to secure the cover 42 thereto. The spinal fusion system 24 of the present invention may be used with conventional screw lock devices or with a unique locking mechanism and system, which will now be described relative to Figs. 21-23.

As illustrated in Figs. 21-23, the spinal fusion system 24 and, more particularly, cover 42 may be provided with at least one or a plurality of resilient detents 62 which are generally L-shaped as shown and are resilient so that they can move laterally in the direction of double arrow C in Figs. 21-22 towards and away from a home position (Fig. 21) to permit the screws 46 first received in the apertures 44, and, second, locked into the cover 42. Thereafter, the screws 46 may be screwed into a spinal bone, such as spinal bone 10, and when a screw head 46a of the screw 46 engages a detent portion 62a of the resilient lock 62, the resilient lock 62 moves in a direction away from the apertures 44 until the screw head 46a clears the portion 62a. After a top surface 46b of the screw head 46a has cleared the bottom surface 62a1 (as viewed in Fig. 23) of portion 62a, the resilient lock 62 moves back toward aperture 44 to the home position until the portion 62a and surface 62a1 are operatively positioned over surface 46b of screw 46, thereby retaining and preventing the screws 46 from backing out of the cover 42 and thereby preventing the screws 46 from backing out of the spinal bone 10.

In the embodiment being described, the components of the spinal fusion system 24, such as the housing 32, first channel wall portion 48 and second channel wall portion 50, crossbar 60, cover 42 and screws 46 may be made of any desired composition or material such as a polymer, composite polymer, titanium, stainless steel, carbon fiber or other suitable material.

A method for fusing spinal bones together will now be described relative to Fig. 22. It should be understood that this procedure may be used during a vertebrectomy or discectomy or other neurological

procedure during which it is desired to fuse spinal bones together. For ease of illustration, the embodiment will be described as used during a discectomy procedure during which the discs 18-22 (Fig. 1) are removed so that spinal bones 10-16 may be fused together. The procedure begins by situating a patient P on an operating table (not shown) and providing an appropriate incision as conventionally known to expose the spinal bones such as the bones 10-16 illustrated in the side view shown in Fig. 1 and in the anterior view illustrated in Fig. 15. (Block 70 in Fig. 22). At Block 72, the vertebrae or discs, such as discs 18-22 in Figs. 1 and 15, are surgically removed revealing the areas 26-30 in Figs. 2 and 16. At Block 74, the housings 32 are inserted in the direction of arrow A (Fig. 3) into the areas 26, 28 and 30 until the migration preventers 40b, 48c, 50c and 50d engage the surfaces of the spinal bones 10-16, such as the surfaces 10a and 12a illustrated in Fig. 3. (Block 74 in Fig. 22). As mentioned earlier herein, the migration preventers facilitate preventing inserting the housing 32 to a point which would cause the wall 32c to engage the spinal column S.

As illustrated in Figs. 3 and 17, the housing 32 cooperates with adjacent spinal bones, such as bones 10 and 12 to define the graft receiving area or cavity 34 in which the graft material 38 (Fig. 4) may be inserted. As mentioned earlier herein, these graft areas 34-36 may comprise a shape which is generally rectangular, as defined by the shape of the housing 32, but it could comprise another shape by simply providing a housing 32 having a different predetermined shape. Thus, the housing 32 may be provided in a circular or arcuate shape in which case the graft area 34 would define a generally circular or arcuate area, which would cause the graft material to form a similar shape. Other curved or multi-sided shapes may be defined by providing an appropriately or correspondingly shaped housing 32, depending on the selected or desired shape that the physician would like the fused graft material 38 to assume after it has fused to the adjacent spinal bones.

At Block 76, the graft material 48 is inserted and at Block 78, the cover 42 is situated in the slot or area 52 defined by the walls 48 and 50.

As mentioned earlier herein, the cover 42 facilitates covering the openings, such as openings 34a and 36a of the graft areas 34 and 36, respectively. The surgeon secures the cover 42 to one or more of the bones, as illustrated in Figs. 5-6 and 19-20 and then closes the patient (Block 80).

Again, and as mentioned earlier, a feature of the invention is that it provides a fixing system for fixing the location of the bones 12-16 relative to each other. Simultaneously, the system 24 permits the housing 32 to "float" between adjacent bones, such as bones 10 and 12 in Figs. 3 and 6. This is advantageous for reasons mentioned earlier herein. Another advantage on this feature of the invention is that if it is necessary to operate on the same patient at a later time (Block 82 in Fig. 24) and, for example, add one or more housings 32 in order to fuse other spinal bones together, then the cover 42 can simply be removed at a later time, another discectomy or vertebrectomy performed and another housing 32 inserted. Another cover 42, or perhaps a second cover may then be used to seal the additional housing 32 after it is situated in the manner described herein. Thus, this invention provides a system and method, which is flexible and will permit the addition or insertion of additional housings 32 of the same or different sizes during a second operating procedure as illustrated in Block 82.

Figs. 1-8 and 15-20 illustrate the general procedure and use of the invention in an illustrative discectomy wherein three discs are removed, replaced with housing 32, and graft material 38 inserted as described and cover 42 situated and mounted as described herein. In the illustration shown in Figs. 1-8 and 15-20, three discs 18-22 are removed and the spinal bones 12-16 are fused together using the system and method as shown and described. It should be appreciated, however, that this system and method may be used with fewer or more housings 32 and with one or a plurality of covers 42 as may be desired or required. For example, if only one of the discs 18-22 needed to be excised and only two of the spinal bones 10-16 fused together, then only one housing 32 and cover 42 may be necessary. Likewise, as

mentioned earlier herein, the housings 32 may comprise a different dimension or different height H (Fig. 14) to span a greater area, such as the area H4 illustrated in Figs. 13 and 14. For example, Figs. 13 and 14 illustrates a vertebrectomy wherein the spinal bone 12 has been removed along with the disc between spinal bones 14 and 16. This provides areas 80 and 81 in which an elongated housing 32', such as the housing 32' illustrated in Fig. 14 may be inserted. After the housings 32 and 32' are inserted between the spinal bones 10-14 and 14-16 as shown in Fig. 13, graft areas 82 and 84 are provided for receiving the graft material 38. As illustrated in Fig. 13, the cover 42 would have a corresponding elongated shape for fixing the bones 10 and 14 together and for covering both openings 82 and 84 or housings 32 and 32'.

It is also anticipated that the invention may be used in a multitude of procedures, such as a vertebrectomy (Figs. 8 and 9), discectomy (Figs. 1-7, 13-20, or even a combination of a vertebrectomy and discectomy as illustrated in Figs. 13-14. As mentioned and described earlier herein, a combination of different sizes of housings 32 and covers 42 may be used as shown. Although it is preferred that a single cover 42 be used, it may be desired in some applications to use multiple covers 42, such as where the removed discs are not adjacent.

In the illustrations being described, the housings 32 comprise the crossbar 60 which cooperate with the cover 42 to prevent anterior migration of the housing after the screws 46 are secured to the spinal bones as illustrated in Figs. 6, 9 and 13.

Figs. 25-30 illustrate other embodiments of the invention. In Fig. 25, a generally U-shaped housing 32 is provided without the walls 48 and 50 or crossbar 60. This embodiment may be useful. This may be useful if it were desired to insert housing 32 in local anatomy so that it could be loaded from the side or laterally, rather than anteriorly, as previously described.

In Fig. 26 a housing 32''' is provided with the crossbars 60, but without the walls 48 and 50. In this embodiment it may be useful to use such a housing design when the local anatomy provides limited space.

Fig. 27 illustrates yet another embodiment of the invention illustrating a housing 32 that is provided with a plurality of protrusion 86, 88, 90 and 92 that do not span completely between the walls 32b or 32a together but yet provide the protrusions 86-92 which will engage the cover 42 if the housing attempts to migrate anteriorly as described earlier herein. Figs. 1-24, 29 and 30 show embodiments of the invention where the crossbars 60 are not integrally formed with the housing 32, but received in the notched areas 90 as shown. As mentioned earlier, the crossbars 60 may be separate or may be integrally provided with the housing 32. Providing detachable crossbars 60, such as is shown in the embodiments illustrated in Figs. 25, 28 and 29, enable the walls 32a and 32b to flex towards and away from each other. The housing 32 may be provided with a malleable material in which case the surgeon can change the general U-shape of the housing 32 to accommodate the size or shape of the areas 34 and 36 (Fig. 17). In the embodiment described, housing 32 and cover 42 may be made of titanium, polymer or a bioresorbable material.

Fig. 31 illustrates the walls 48 and 50 having notched areas 49 and 51 for receiving the cover 42 which is dimensioned to fit, thereby eliminating the need for cross bars 60.

Figs. 32 – 36 illustrate another embodiment of the invention. In this embodiment, those parts that are the same or similar to the parts illustrated in Figs. 1 – 30 are identified with the same part number. except that the parts in Figs. 31 – 36 have an apostrophe (" ' ") mark added thereto.

In this embodiment, the cage system 10 comprises a cover 400 for situating in the channel area 52 (Fig. 11) to facilitate preventing interior migration of the graft material 38. In order to secure the cover 400 over the graft area 38, a locking system, means and method are provided for retaining the cover 400 on the housing 32. In the embodiment being described, the locking system 402 comprises a plurality of screws, fastening means or fasteners 404, 406, 408 and 410 that are received in openings, such as openings 405 in the cover plate

400 as shown. Note that the fasteners 404 – 410 comprise a plurality of female openings or slots 404a, 406a, 408a and 410a for receiving a tool, such as a hex wrench for tightening and loosening the fasteners 404 – 410.

In the embodiment being described, the fasteners 404 and 408 comprise a head 404b and 408b that have a planar or flat portion 404b1 and 408b1 as shown. As best illustrated in Figs. 34 and 35, note that the fasteners 408 and 410 each comprise threads or a threaded portion, such as threads or portions 408c and 410c of fasteners 408 and 410, respectively. Note that a distance or small radius D1 between center C1 and edge, 408b1 in Fig. 34 is smaller than the distance or large radius D2 measured by the distance between center C1 and edge 408b1 in Fig. 34. The difference in the distances D1 and D2 facilitates defining a cam surface or lobe on the wall 408b2 whose use and purpose will be defined later herein.

In the embodiment being described, one or more of the heads 404b, 406b, 408b and 410b may comprise an indicia, such as a grind mark or other indicator 412 and 414 (Fig. 32), to facilitate and assist a user, such as a doctor, to identify the small radius portion D1 during a surgical procedure. Thus, the indicia 412 and 414 facilitate defining the surface associated with the flat portion, such as portion 404b1.

It should be understood that when the pairs of fasteners 404 – 406 and 408-410 are aligned such that the surfaces 404b1 and 408b1 and short or small radius portion D1 are situated in opposite or closest to wall 406b of screw 406 and wall 410b of screw 410 the adjacent fasteners 406 and 410 respectively, may be rotated and screwed into, for example, vertebrae 10, which will secure and retain the cover 400 over the graft area 38. Although not shown, the locking system of the present invention may comprise eccentric fasteners of screws having eccentric heads (i.e. where a head center is offset from a thread axis) and fasteners that are used with non-eccentric fasteners. For example, and as illustrated in Fig. 33, fasteners 404 and 408 may comprise the

aforementioned eccentric, while adjacent fasteners 406 and 410, respectively, may be non-eccentric fasteners or screws.

In any event, the small radius portion D1 permits the adjacent fastener or screw such as screw 410, whether it has an eccentric or not, to be turned when the small radius portion D1 or flat portion 408b1 is situated in opposed relationship to the adjacent screw (as illustrated in Figs. 32 and 34). For example, Fig. 34 illustrates that when the fasteners are aligned such that the indicia 414 are aligned as illustrated in Fig. 32, a gap G exists between the portions 408d1 and wall 410d of screw 410 as shown. The gap G permits either or both of the fasteners 408 and 410 to rotate in either a counter-clockwise or clockwise direction during fastening and unfastening of the fasteners to the vertebrae as described earlier herein with the prior embodiments.

When it is desired to secure the cover 400 over the housing 32, the fasteners 404 – 408 are placed in the cover and aligned as illustrated in Fig. 32. The fasteners 404 – 408 are rotated and screwed into vertebrae 10 in a clockwise direction until it is seated. These fasteners 404 and 408 are then "backed out" less than a full turn until flat surface 404b1 and 408b1 are aligned as shown in Fig. 32. The surgeon may use the indicator 412 and 414 to perform this alignment. This alignment presents the gap G (Fig. 34), which permits the fastener 410 to be rotated in a clockwise direction until completely screwed into vertebrae 10.

Next, the adjacent fastener (406 for the 404-406 pair and 410 for the 408-410 pair) is inserted into opening 405 in cover 400 and in Fig. 32 and 34 until they are fully seated into the vertebrae 10. For example, in the illustration shown in Figs. 32 and 34, the fastener 408 is rotated in a clockwise direction with a tool, such a hex wrench (not shown) until it is fully seated into the vertebrae 10.

The fastener 408 is again rotated in the clockwise direction (as viewed) until the large radius portion D2 and the wall portion 408b2 engages and comes against the wall 410b of the fastener 410.

It should be appreciated that when the fasteners 404 – 410 are secured in the locked position in the manner described, they facilitate retaining themselves in the locked position. For example, if fastener 410 begins to rotate in a counterclockwise direction (as viewed in Fig. 33) it will cause fastener 408 to rotate in a clockwise direction which, in turn, causes fastener 408 to tighten and resist the counterclockwise rotation of fastener 410. If fastener 410 would rotate, fastener 408 would screw deeper into the vertebrae 10.

Fig. 36 is an illustration similar to Fig. 11 showing the orientation and alignment of the cover 400 and fasteners 404-410 to the housing 32.

Advantageously, the various embodiments of the invention illustrated in Figs. 1, provide a system and method for inserting graft material 32 into a graft area 34 and 36 (Fig. 17) to fuse a plurality of bones such as bones 10-18 together. The system and method also provide means for fixing the bones 10-18 relative to each other, while permitting the housing 32 to cooperate with adjacent bones 10-18 to define a graft area 34 and 36 (Fig. 17) and to also float relative to the cover 42. The locking system illustrated in Figs. 21-23 further facilitates providing a locking system that does not require the use of any tools, yet prevents back out of the screws 46.

While the apparatus and method described constitute preferred embodiments of this invention, it is to be understood that the invention is not limited to this precise apparatus and method, and that changes may be made in either without departing from the scope of the invention, which is defined in the appended claims.

What is claimed is:

CLAIMS

1. A prosthetic implant system for use as a prosthetic implant comprising:

a housing dimensioned to be situated in a graft area between adjacent vertebrae;

said housing comprising at least one wall that defines an opening after said housing is situated between said adjacent vertebrae to permit anterior loading of graft material;

a prosthetic implant cover for covering said opening to facilitate preventing anterior migration of said graft material;

a locking system for retaining said prosthetic implant cover over said opening, said locking system comprising:

a first fastener for securing said prosthetic implant cover to a first vertebrae; and

at least one second fastener that engages said first fastener to retain at least one of said first fastener or said at least one second fastener in a tightened position.

2. The prosthetic implant system as recited in claim 1 wherein said at least one second fastener comprises a camming head for engaging and camming against said first fastener.

3. The prosthetic implant system as recited in claim 1, wherein said at least one second fastener comprises a head having a flat portion.

4. The prosthetic implant system as recited in claim 1, wherein both said first fastener and said at least one second fastener comprise flat portions which permit said at least one second fastener and said first fastener, respectively, to rotate.

5. The prosthetic implant system as recited in claim 1 wherein both said first fastener and said at least one second fastener each comprise a camming head for engaging and camming against said camming head of said at least one second fastener and said first fastener, respectively.

6. The prosthetic implant system as recited in claim 1 wherein said system further comprises a third fastener and at least one fourth fastener that engages said third fastener, said third fastener comprising a third camming head for engaging and camming against a camming head of said at least one fourth fastener.

7. The prosthetic implant system as recited in claim 6 wherein both said third fastener and said at least one fourth fastener each comprise a camming head for engaging and camming against said camming head of said at least one fourth fastener and said third fastener, respectively.

8. The prosthetic implant system as recited in claim 1 wherein both said first fastener and said at least one second fastener are situated adjacent each other, each of said first fastener and said at least one second fastener comprising a head having a large radius portion and a small radius portion,

said small radius portion permitting said at least one second fastener to rotate when said small radius portion is situate toward a head of said at least one second fastener;

said large radius portion being moveable to a cam position such that said first fastener and said at least one second fastener becoming locked into position.

9. The prosthetic implant system as recited in claim 1 wherein said at least one second fastener comprises an eccentric head comprising a large radius portion and a small radius portion;

said small radius portion permitting said first fastener to rotate during tightening,

said large radius portion permitting said eccentric head to cam against said first fastener in order to retain said first fastener and said at least one second fastener in said tightened position.

10. The prosthetic implant system as recited in claim 1 wherein said system comprises a third fastener and a fourth fastener, said third fastener and said fourth fastener being situated adjacent each other, each of said third fastener comprising a head having a large radius portion and a small radius portion,

said small radius portion permitting said fourth fastener to rotate when said small radius portion is situated toward a head of said fourth fastener;

said large radius portion being moveable to a cam position such that said third and fourth fasteners become locked into position.

11. The prosthetic implant system as recited in claim 1 wherein said first fastener and said at least one second fastener are titanium screws.

12. The prosthetic implant system as recited in claim 10 wherein said first fastener, said at least one second fastener, said at least one third fastener and said fourth fastener are titanium screws.

13. The prosthetic implant system as recited in claim 8 wherein at least one of said first fastener and said at least one second fastener comprise an indicator to identify said small radius portion.

14. The prosthetic implant system as recited in claim 1 wherein said cover is secured to at least one of said adjacent vertebrae.

15. The prosthetic implant system as recited in claim 1 wherein said cover is secured to said housing.

16. The prosthetic implant system as recited in claim 1 wherein said housing comprises migration preventors for preventing said housing from migrating toward a spinal column after said housing is situated between said adjacent vertebrae.

17. The prosthetic implant system as recited in claim 16 wherein said migration preventors comprise a plurality of tabs that engage said adjacent vertebrae when said housing is situated there between.

18. The prosthetic implant system as recited in claim 17 wherein said housing further comprises:

a first wall portion and a second wall portion, said first and second wall portions being integrally formed into said housing and defining a channel area for receiving said cover.

19. The prosthetic implant system as recited in claim 18 wherein said first and second wall portions extend beyond said housing and define a plurality of migration preventors for preventing said housing from migrating toward a spinal column after said housing is situated between said adjacent vertebrae.

20. The prosthetic implant system as recited in claim 1 wherein said system further comprises at least one migration stop for preventing anterior migration of said housing.

21. A locking system for retaining a prosthetic implant to a vertebrae comprising:

a first fastener for securing said prosthetic implant to said vertebrae; and

at least one second fastener for securing said prosthetic implant to said vertebrae; said at least one second fastener engaging said first fastener to retain at least one of said first fastener or said at least one second fastener in a tightened position.

22. The locking system as recited in claim 21 wherein said at least one second fastener comprises a head having an eccentric for engaging said first fastener.

23. The locking system as recited in claim 21 wherein said first fastener and said at least one second fastener each comprise a generally flat portion and an eccentric portion.

24. The locking system as recited in claim 21 wherein said system further comprises a third fastener and at least one fourth fastener that engages said third fastener and secures said prosthetic implant to said vertebrae.

25. The locking system as recited in claim 24 wherein said at least one of said third fastener and said at least one fourth fastener comprises a flat portion.

26. The locking system as recited in claim 21 wherein said first fastener and said at least one second fastener are situated adjacent each other, said first fastener comprising a head having a large radius portion and a small radius portion,

said small radius portion permitting said at least one second fastener to rotate when said small radius portion is situated toward a head of said at least one second fastener;

said large radius portion being moveable to a cam position such that said head of said first fastener engages said head of said at least one second fastener, thereby retaining said first fastener and said second fastener in said tightened position.

27. The locking system as recited in claim 21 wherein said at least one second fastener comprises an eccentric head comprising a large radius portion and a small radius portion;

said small radius portion permitting said first fastener to rotate during tightening,

said large radius portion permitting said eccentric head to cam against said first fastener in order to retain said fasteners in a locked position.

28. The locking system as recited in claim 26 wherein system comprises a third fastener and a fourth fastener, both said third fastener and said fourth fastener being situated adjacent each other, at least one of said third fastener and said fourth fastener comprising a head having a large radius portion and a small radius portion.

29. The locking system as recited in claim 21 wherein said first fastener and said at least one second fastener are titanium screws.

30. The locking system as recited in claim 28 wherein said first fastener, said at least one second fastener, said third fastener and said at least one fourth fastener are titanium screws.

31. The locking system as recited in claim 26 wherein said first fastener comprises an indicator to identify said small radius portion.

32. The locking system as recited in claim 23 wherein said at least one second fastener comprises an indicia to identify said flat portion.

33. A locking system for retaining a prosthetic implant plate on a spinal column, said locking system comprising:

at least one pair of adjacent screws;

at least one of said at least one pair of adjacent screws comprising a camming head for engaging a head of the other of said at least one pair of adjacent screws to facilitate retaining said at least one pair of adjacent screws in a locked position.

34. The locking system as recited in claim 33 wherein both of said at least one pair of adjacent screws comprise a camming head having a flat surface that does not engage and a screw surface that does engage the adjacent fastener during locking.

35. The locking system as recited in claim 34 wherein each of said adjacent screws comprises a camming head comprising a large radius portion and a small radius portion;

said small radius portion on a first of said at least one pair of adjacent screws permitting the other said adjacent screws to be turned when said small radius portion is situated in opposed relationship to said other of said adjacent screws.

36. The locking system as recited in claim 34 wherein said system comprises a plurality of pairs of adjacent screws situated adjacent each other;

each of said plurality of pairs of adjacent screws comprising a first screw and a second screw, said first and second screws each comprising a camming head for engaging a head of the other of said adjacent screws after said screws are mounted to secure said implant to said spinal column.

37. The locking system as recited in claim 36 wherein each of said camming heads comprising a large radius portion and a small radius portion;

said small radius portion permitting the other of said screws to be turned when said small radius portion is situated in opposed relationship to said other of said adjacent screws.

38. The locking system as recited in claim 37 wherein said first and second screws are titanium.

39. The locking system as recited in claim 37 wherein said camming heads each comprise an indicator to identify said small radius portion.

40. The locking system as recited in claim 34 wherein said at least one second fastener comprises an indicia to identify said flat surface.

41. A medical screw for use in association with a medical implant in a patient; said medical screw comprising,

a threaded portion; and

a head integral with said threaded portion,

said head having a first portion permitting an adjacent screw to be screwed and an engaging portion for engaging said adjacent screw when said head is rotated, thereby facilitating preventing said medical screw and said adjacent screw from unscrewing.

42. The medical screw as recited in claim 41 wherein said head comprises:

a large radius portion and a small radius portion;

said small radius portion defining said first portion and permitting said adjacent screw to be turned when said small radius portion is situated in opposed relationship to said adjacent screw.

43. The medical screw as recited in claim 41 wherein said medical screw is titanium.

44. The medical screw as recited in claim 41 wherein said head comprises an indicator to identify said first portion.

45. A locking screw for use in a prosthetic implant procedure, comprising:

a threaded portion;

a head portion integral with said threaded portion; and

said head portion comprising a non-camming area and a camming area.

46. The locking screw as recited in claim 45 wherein said head portion comprises indicia associated with said non-camming area.

47. A spinal fusion system for use as a prosthetic implant comprising:

a housing dimensioned to be situated between adjacent spinal bones, said housing defining a graft area for receiving a graft or graft-like material for generating a fusion between said adjacent spinal bones;

said housing comprising at least one wall that defines an opening after said housing is situated between said adjacent spinal bones to permit post-placement loading of graft material;

wherein said spinal fusion system further comprises a cover for covering said opening to facilitate preventing anterior migration of said graft material; and

wherein said housing further comprises:

a first wall portion and a second wall portion, said first and second wall portions being integrally formed into said housing and defining a channel area for receiving said cover.

48. A prosthetic implant plate system comprising:

a plate member; and

a lock system for preventing withdrawal of at least one screw after said at least one screw is received in an opening in the plate member and screwed into a spinal bone.

49. The prosthetic implant plate system as recited in claim 48 wherein said lock system comprises an elongated resilient member integrally formed in said plate-member;

said resilient member retaining said at least one screw in a secured position in said spinal column.

50. The prosthetic implant plate system as recited in claim 48 wherein said resilient member is biased radially towards a head of said at least one screw such that a portion of said resilient member becomes situated over a head of said at least one screw.

51. The prosthetic implant plate system as recited in claim 48 wherein said plate member is titanium.

52. The prosthetic implant plate system as recited in claim 48, wherein said lock system comprises:

at least one pair of screws situated adjacent each other;

at least one of said at least one pair of adjacent screws comprising a camming head for engaging a head of the other of said at least one pair of screws to facilitate retaining said screws in a tightened position.

53. The prosthetic implant plate system as recited in claim 52, wherein said camming head comprises a camming surface that engages said head and a non-camming surface; said non-camming surface not engaging the adjacent screw when said adjacent screw is screwed into said spinal bone.

54. The prosthetic implant plate system as recited in claim 52, wherein said camming head comprises a large radius portion and a small radius portion;

said small radius portion permitting the other said at least one pair of screws to be screwed when said small radius portion is situated in opposed relationship to said other of said adjacent screws.

55. The prosthetic implant plate system as recited in claim 48, wherein said lock system comprises:

a first screw and a second screw, at least one of said first screw and second screw comprising a head having a wall surface for engaging a head of the other of at least one of said adjacent screws after said screws are received in an opening in said plate member and screwed into said spinal bone.

56. The prosthetic implant plate system as recited in claim 55, wherein said head of at least one of said first screw or said second screw comprises an eccentric.

57. The prosthetic implant plate system as recited in claim 55, wherein a head said first screw comprises a head having a side wall at least a portion of which is generally flat to permit said second screw to rotate during tightening and a non-flat portion for engaging a head of said second screw to facilitate preventing untightening.

58. The prosthetic implant plate system as recited in claim 55 wherein said first and second screws are titanium.

59. The prosthetic implant plate system as recited in claim 55 wherein said camming head comprises an indicator associated with said non-camming surface.

60. The locking system as recited in claim 23 wherein said at least one second fastener comprises an indicia to identify said generally flat portion.

61. The medical screw at recited in claim 41 wherein said first portion comprises a flat area.

62. The locking screw as recited in claim 45 wherein said non-camming area comprises either a flat area or a small radius area.

63. The medical screw as recited in claim 41 wherein said head comprises an eccentric.

64. The locking screw as recited in claim 45 wherein said head portion comprises indicia to identify said non-camming area.

65. The locking system as recited in claim 21 wherein said first fastener comprises an eccentric head.

66. The locking system as recited in claim 65 wherein said eccentric head has a small radius portion associated with said flat portion.

67. The locking system as recited in claim 21, wherein said first fastener comprises a flat portion.

68. The locking system as recited in claim 21 wherein said at least one fastener comprises an eccentric head.

69. A locking screw for use with a prosthetic implant plate, comprising:

a threaded portion; and

a head portion integral with said threaded portion;

said head portion comprising a non-camming area for permitting an adjacent screw to be screwed and engaging portion for engaging said adjacent screw when said locking screw and said adjacent screw are screwed into a spinal bone to facilitate retaining said locking screw and said adjacent screw in a tightened position.

70. A plate system for mounting on a spinal column, said plate system comprising:

a plate having a plurality of openings; and

a plurality of screws for receipt in said plurality of openings, respectively, and screwed into a spinal bone of said spinal column;

said plurality of screws having heads that engage to retain said plurality of screws in a tightened position.

71. The plate system as recited in claim 70 wherein said plurality of screws comprise:

a first screw having a first head, said first head comprising a wall having a first portion and a second portion; and

a second screw having a second head having a second wall;

said first portion being dimensioned such that when said first portion is situated opposite said second wall, said second head may be rotated to screw said second screw into said spinal bone of said spinal column, said first portion of said first screw may thereafter be rotated so that said second portion may engage said second wall in order to facilitate retaining said first and second screws in a tightened position.

72. The plate system as recited in claim 71 wherein said first screw comprises an eccentric defining both said first portion and said second portion.

73. The plate system as recited in claim 71 wherein said first portion comprises a generally flat area.

74. The plate system as recited in claim 71 wherein said first portion comprises a small radius portion and said second portion defines a second radius portion that is larger than said small radius portion.

75. The plate system as recited in claim 70 wherein said plate is dimensioned for receipt between a first cage wall and a second cage wall of a cage.

76. The plate system as recited in claim 70 wherein said plurality of screws comprises:

a first screw having a first head; and

a second screw having a second head;

said first head having a wall having a first portion that is dimensioned to permit said second head to rotate and a second portion dimensioned to engage said second head when said first screw is rotated to facilitate preventing said first and second screws from backing out.

77. The plate system as recited in claim 76 wherein said first portion comprises a generally flat area.

78. The plate system as recited in claim 76 wherein said first portion comprises a first radius portion and said second portion defines a second radius portion that is larger than said first radius portion.

79. The plate system as recited in claim 70 wherein at least one of said first screw or said second screw comprises an eccentric.

80. The plate system as recited in claim 76 wherein said plurality of screws comprises:

a third screw having a third head; and

a fourth screw having a fourth head;

said third head having a wall having a portion that is dimensioned to permit said fourth head to rotate and a second portion dimensioned to engage said fourth head when said third screw is rotated to facilitate preventing said third and fourth screws from backing out.

81. A method for fastening a plate to a spinal column comprising the steps of:

situating the plate in proximity to the spinal column;

positioning a first screw through an aperture in the plate;

screwing said first screw into a spinal bone in the spinal column;

positioning a second screw through the plate;

screwing a second screw into the spinal bone until it becomes tightened; and

tightening said first screw until a portion of a head of the first screw engages a head of the second screw to retain the first and second screws in a tightened position.

82. The method as recited in claim 81 wherein said first screwing step comprises the step of:

backing out said first screw less than a full turn before said second screwing step.

83. The method as recited in claim 81 wherein said first screwing step comprises the step of:

backing out said first screw less than a full turn until a portion of a head of said first screw becomes situated opposed to a head of the second screw.

84. The method as recited in claim 81 wherein said first screwing step comprises the step of:

using an indicia on said head of said first screw to perform said backing out step.

85. The method as recited in claim 81 wherein said first screw comprises a cam head.

FIG-1

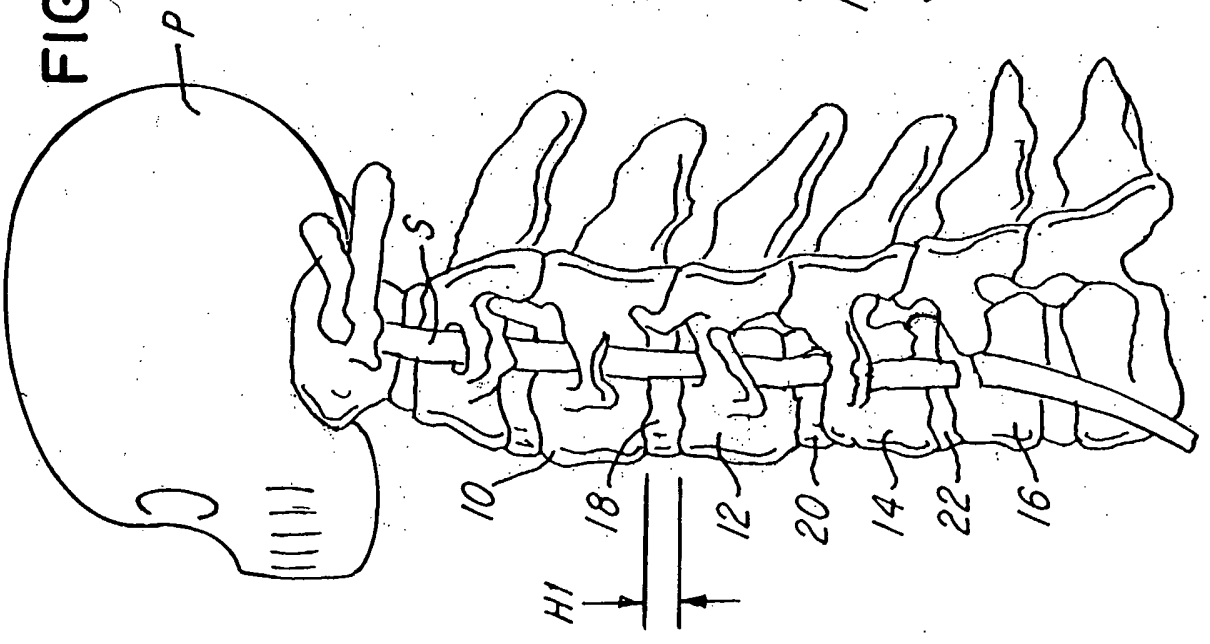


FIG-2

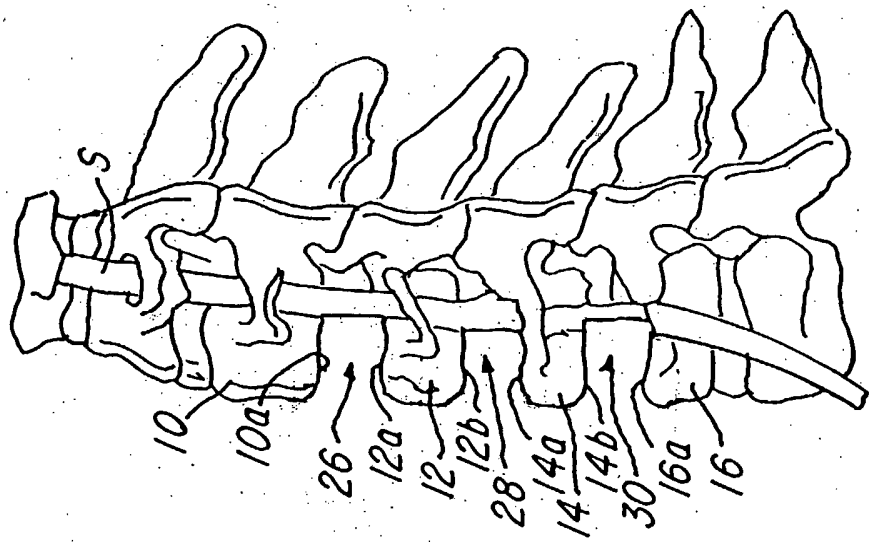


FIG-3

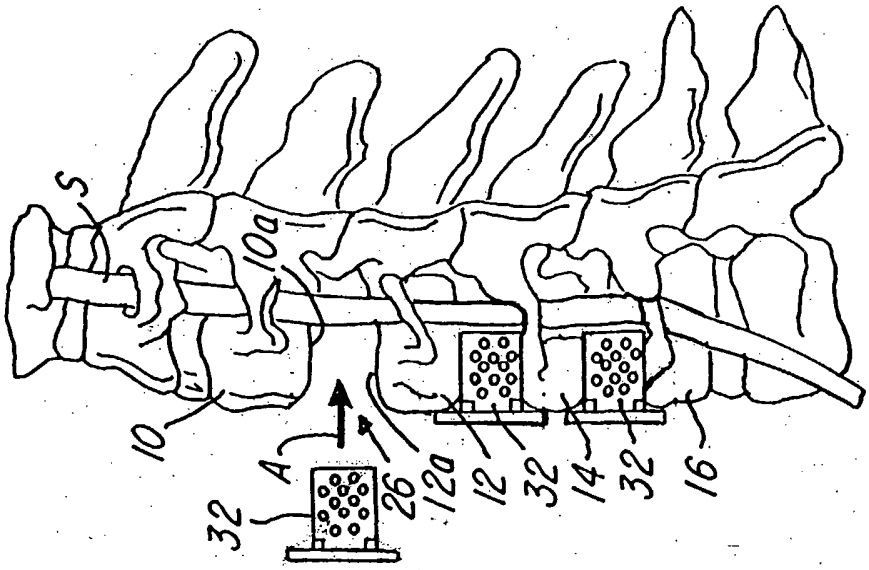


FIG-6

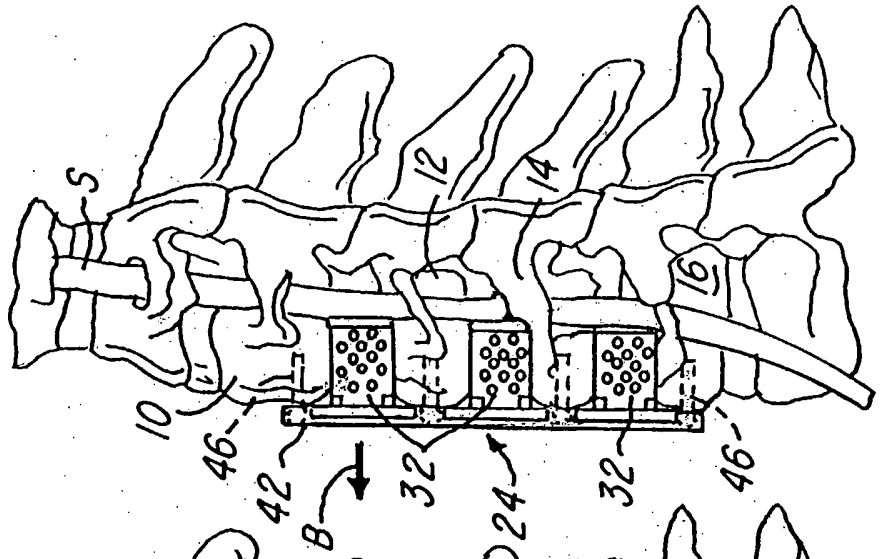


FIG-5

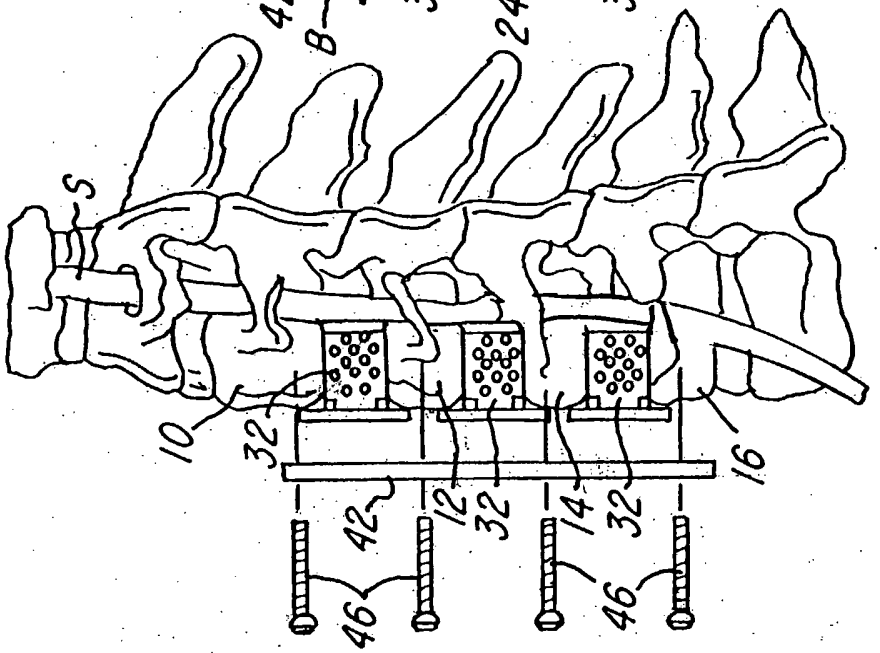


FIG-4

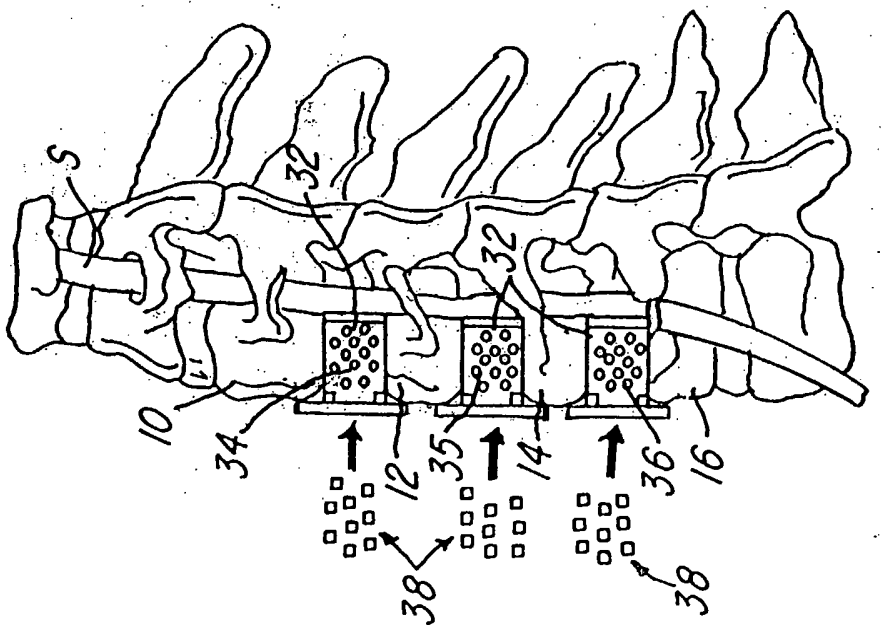
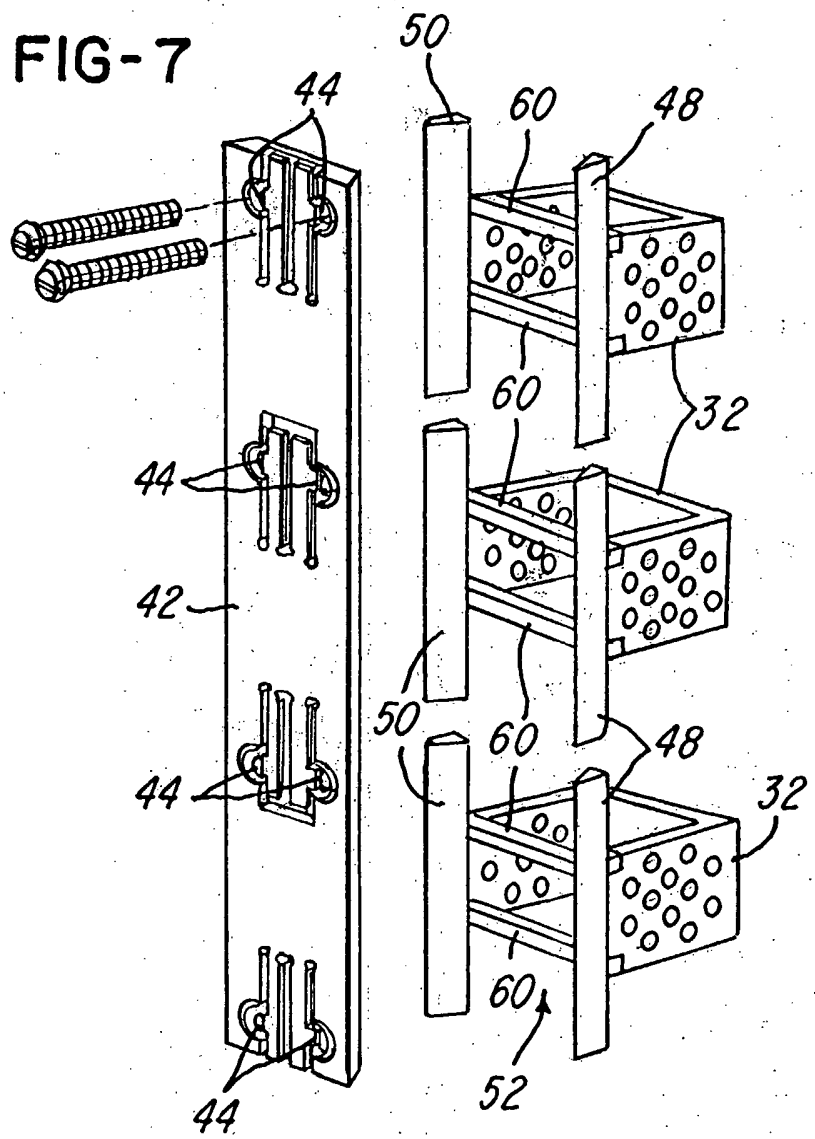


FIG-7



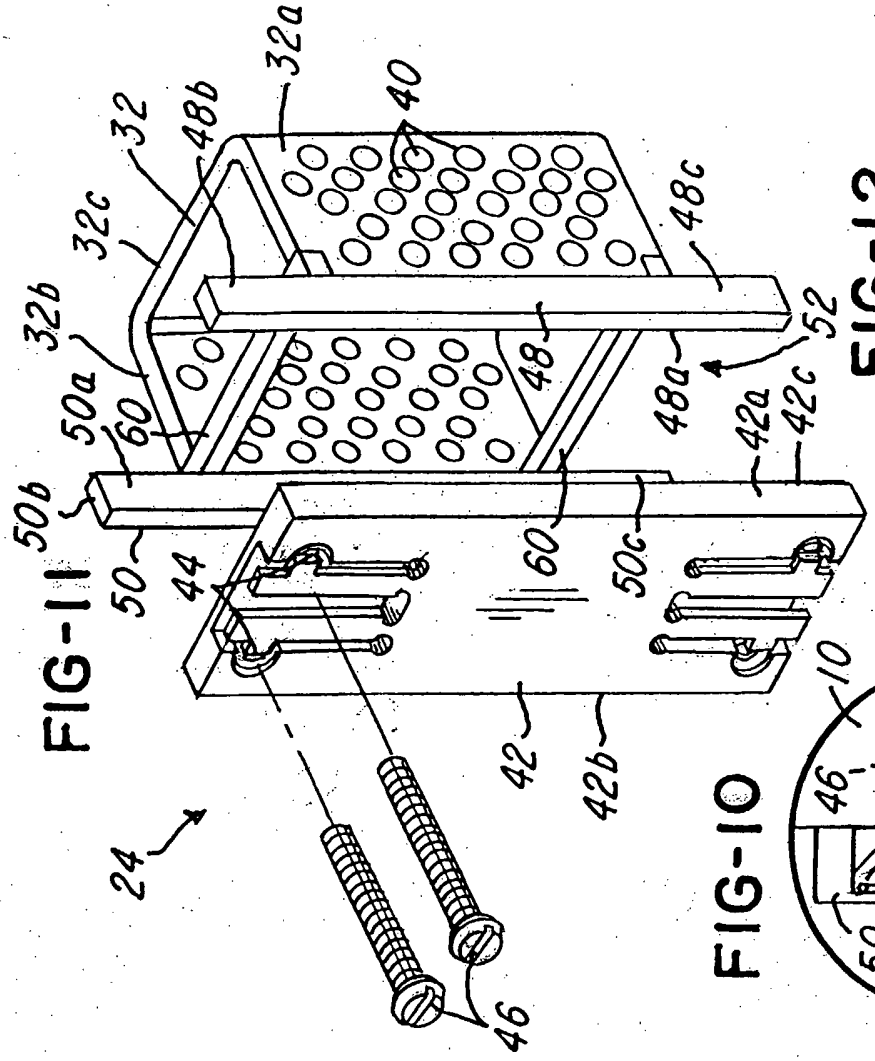


FIG-11

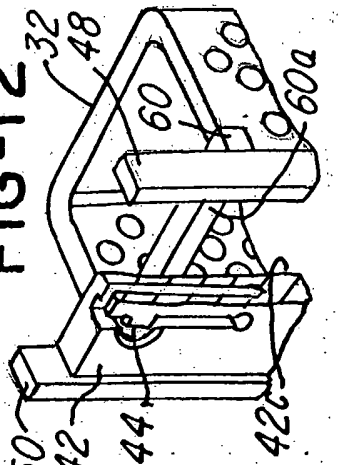


FIG-12

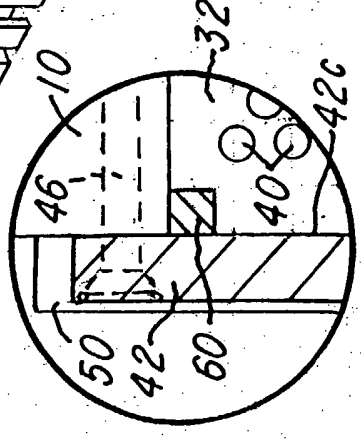


FIG-10

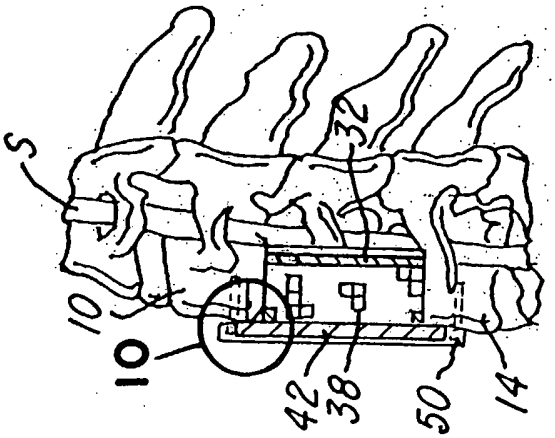


FIG-8

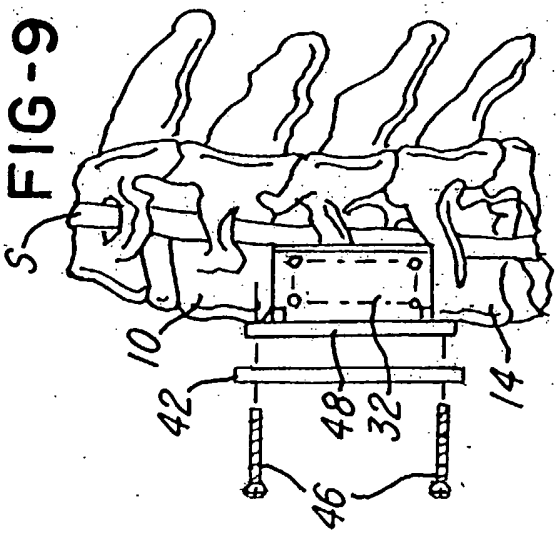


FIG-9

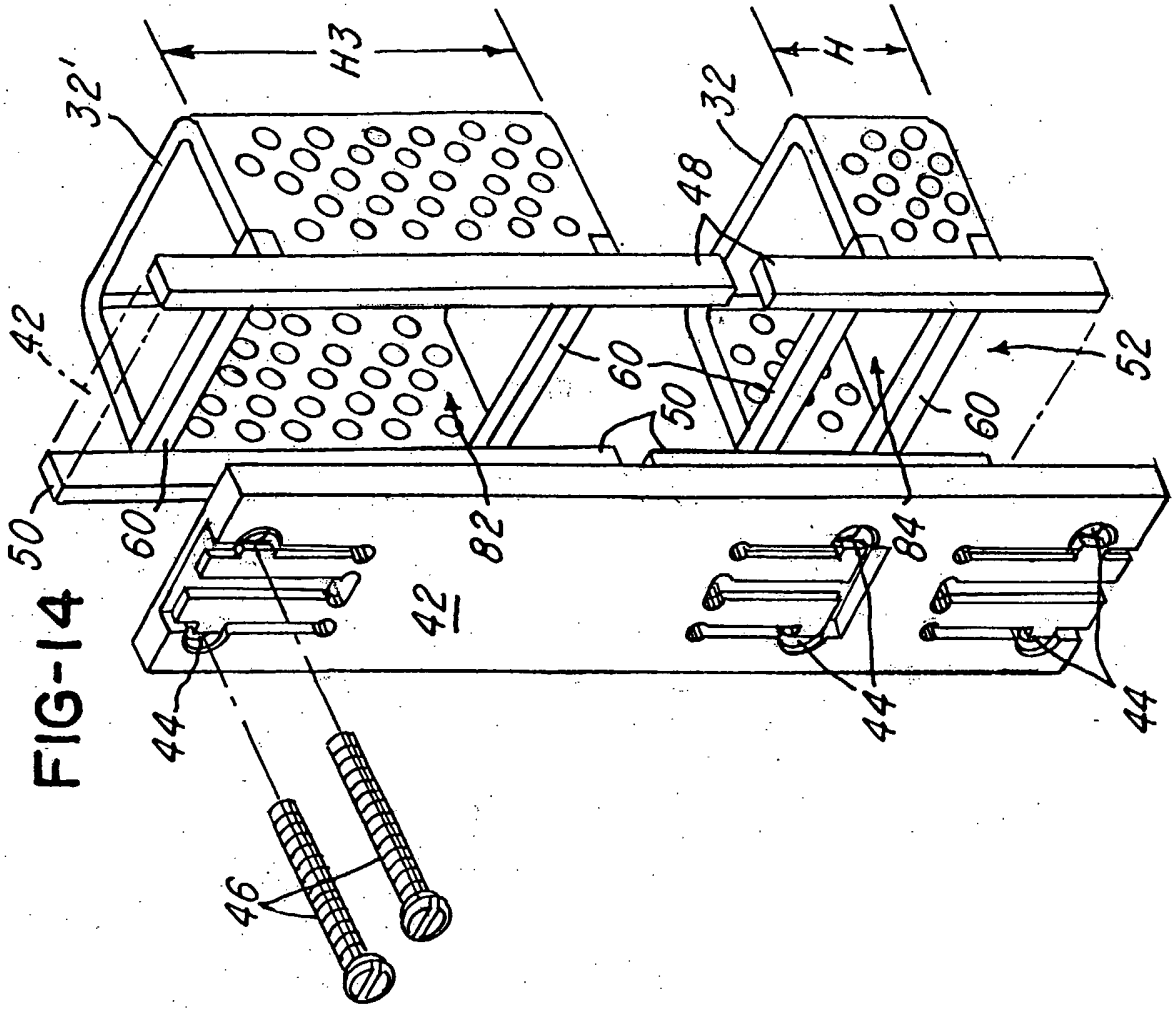


FIG-14

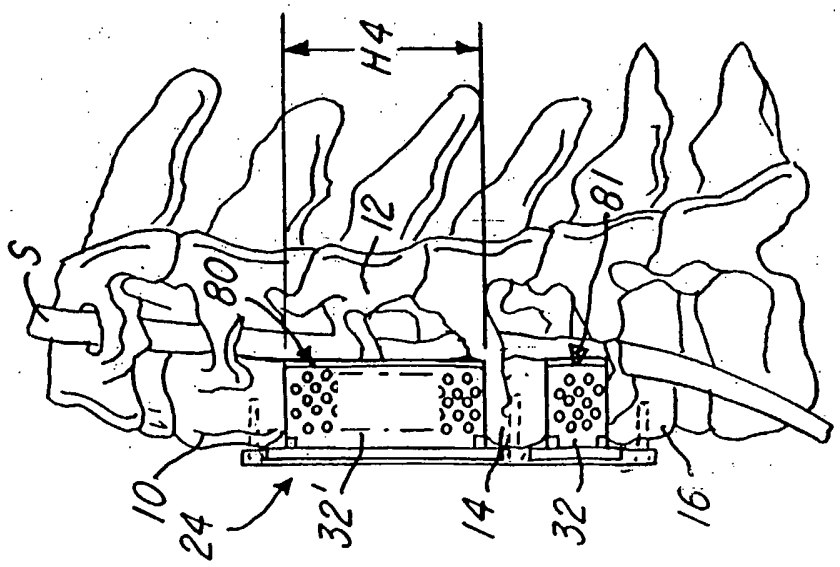


FIG-13

FIG-17

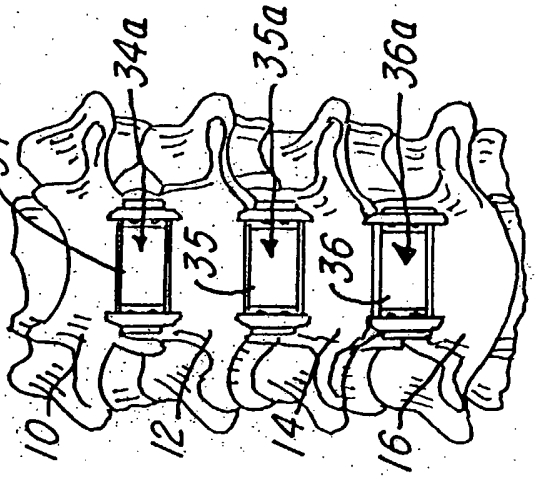


FIG-20

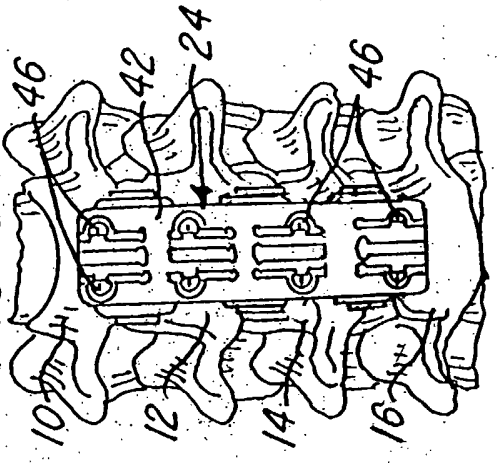


FIG-16

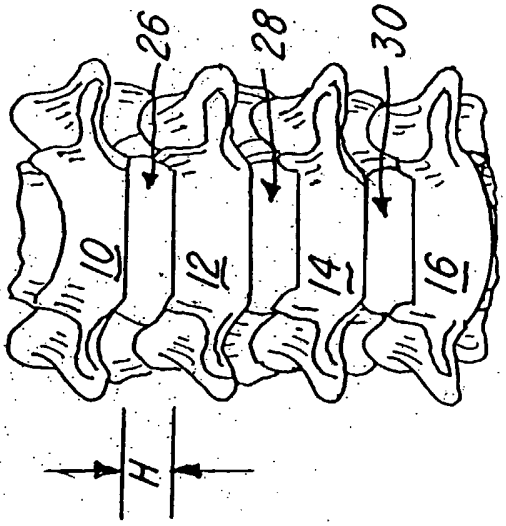


FIG-19

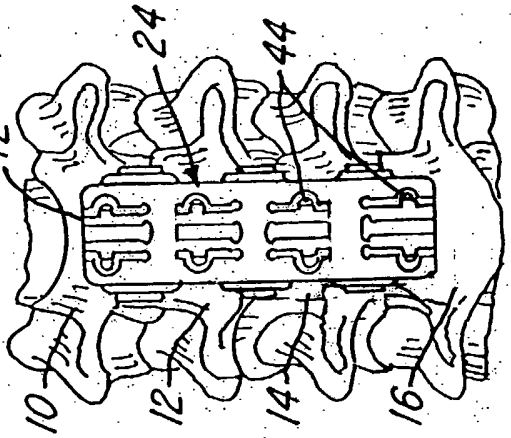


FIG-15

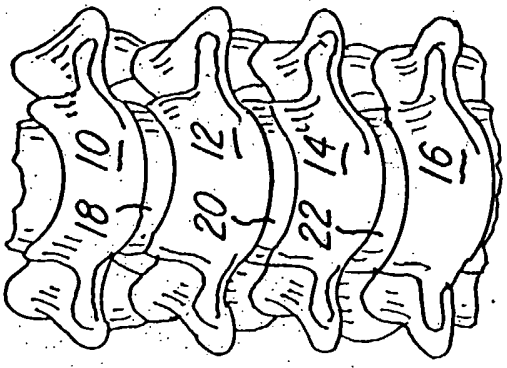
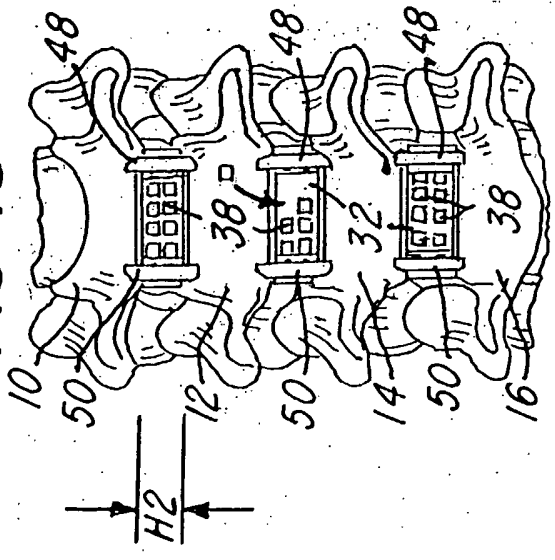


FIG-18



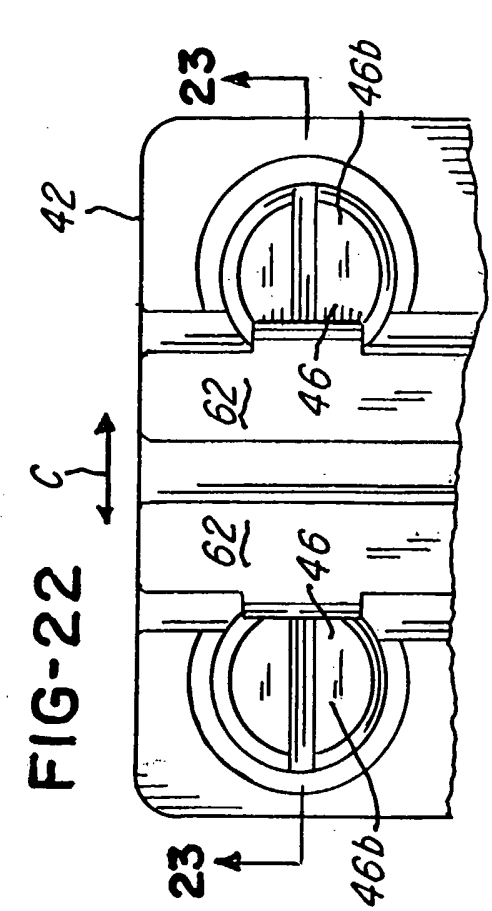


FIG-22

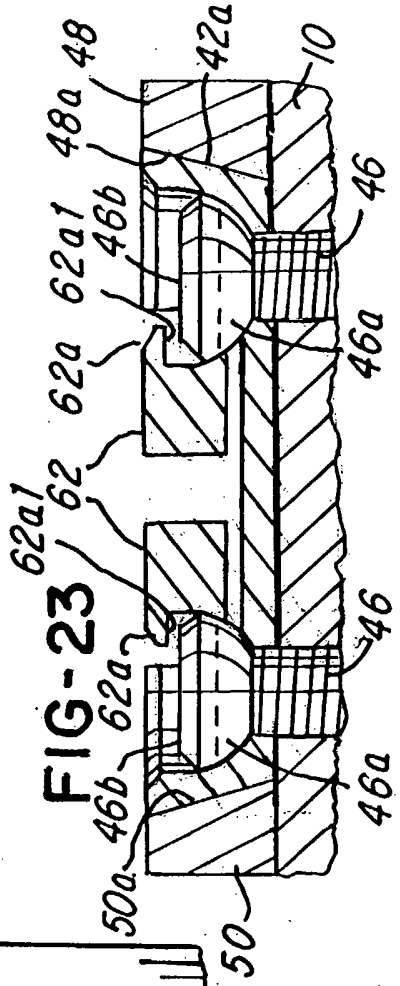


FIG-23

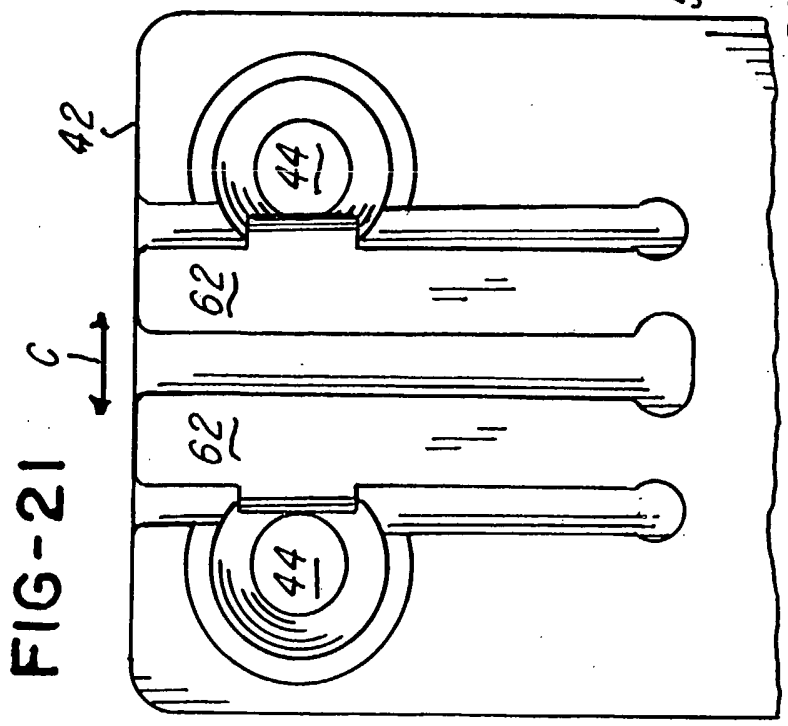


FIG-21

FIG. 24

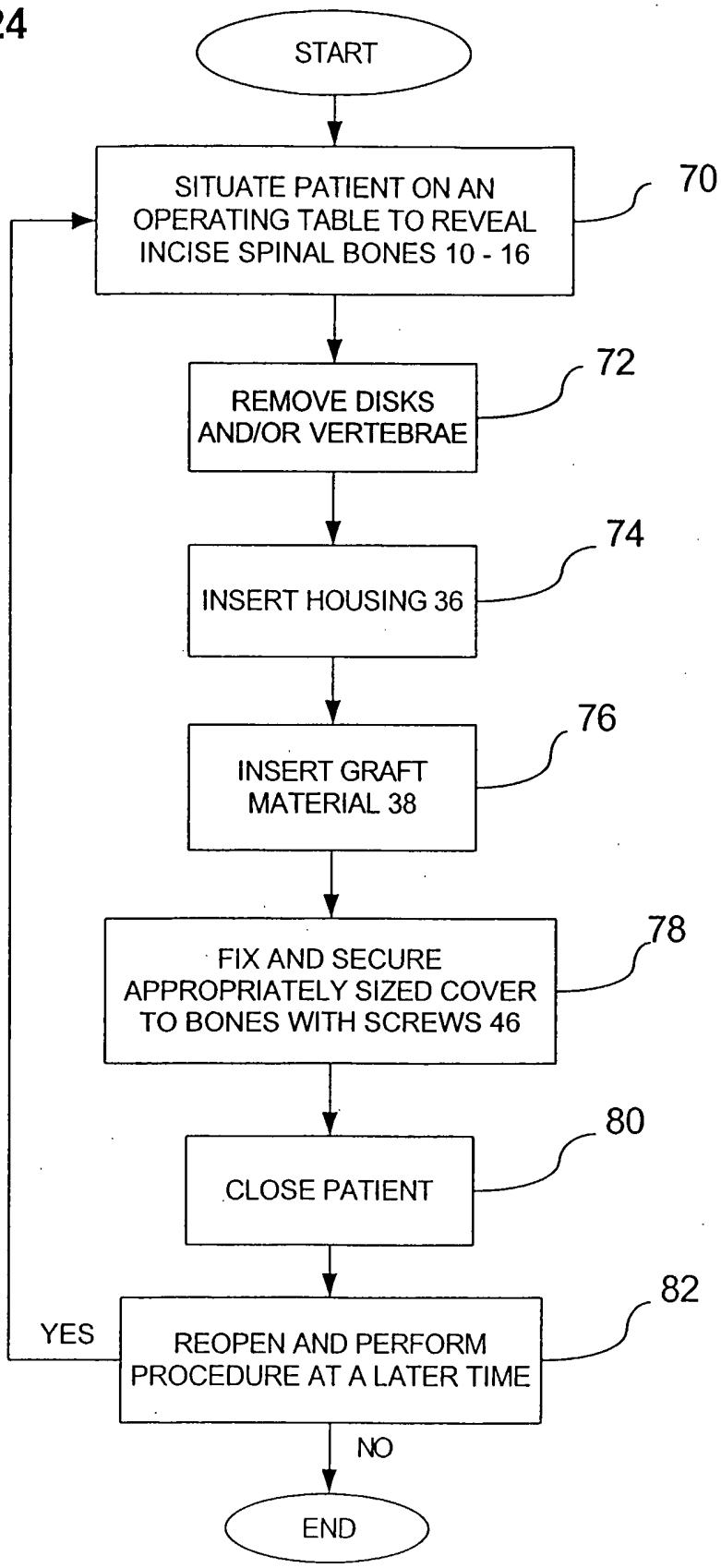

START
SITUATE PATIENT ON AN OPERATING TABLE TO REVEAL INCISE SPINAL BONES 10 - 16
70
REMOVE DISKS AND/OR VERTEBRAE
72
INSERT HOUSING 36
74
INSERT GRAFT MATERIAL 38
76
FIX AND SECURE APPROPRIATELY SIZED COVER TO BONES WITH SCREWS 46
78
CLOSE PATIENT
80
REOPEN AND PERFORM PROCEDURE AT A LATER TIME
82
YES
NO
END

FIG-25

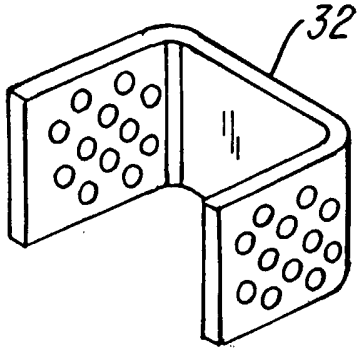


FIG-26

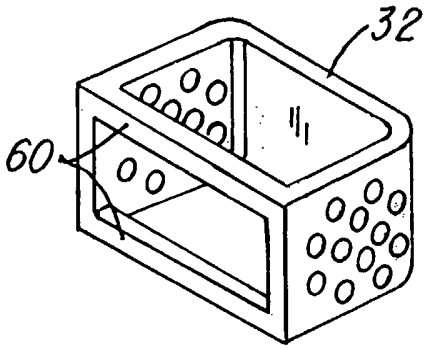


FIG-27

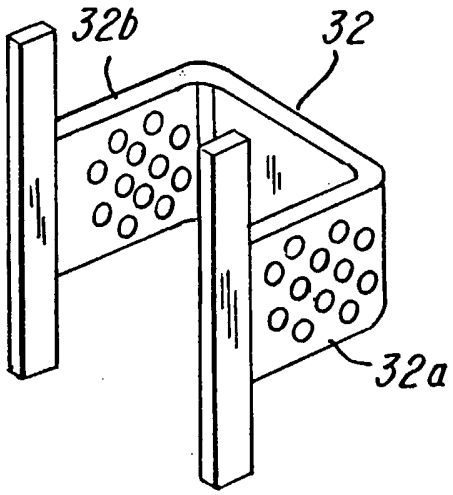


FIG-28

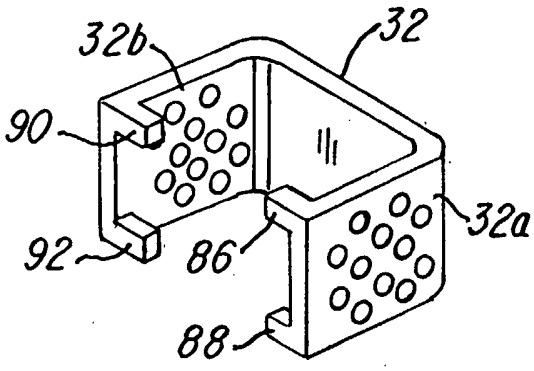


FIG-29

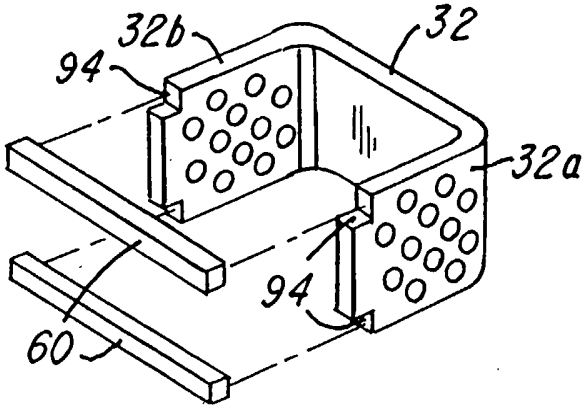


FIG-30

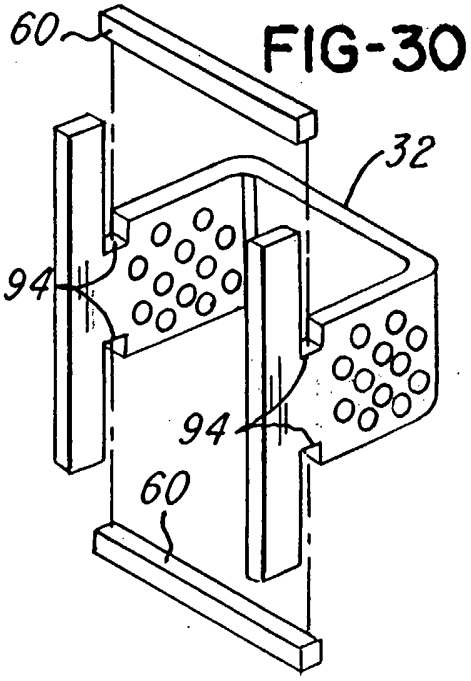


FIG-32

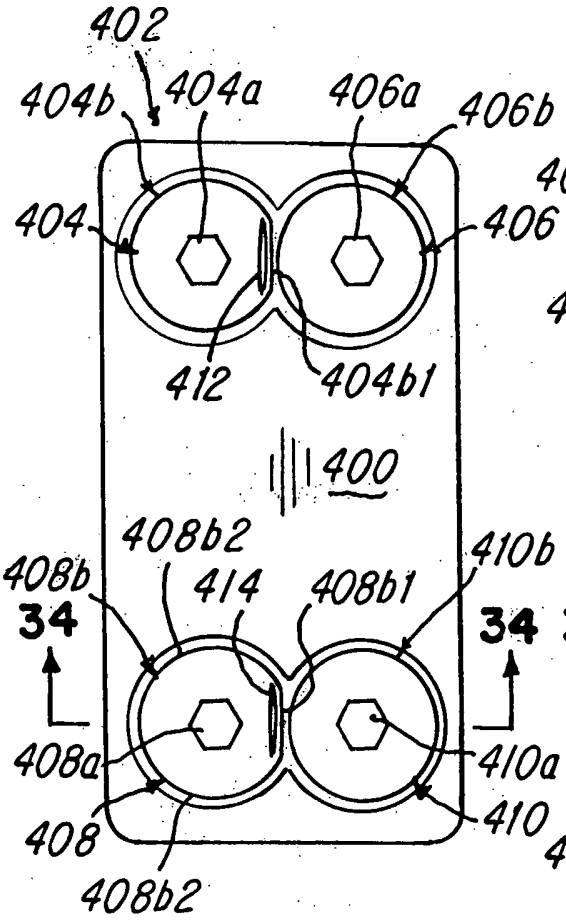


FIG-33

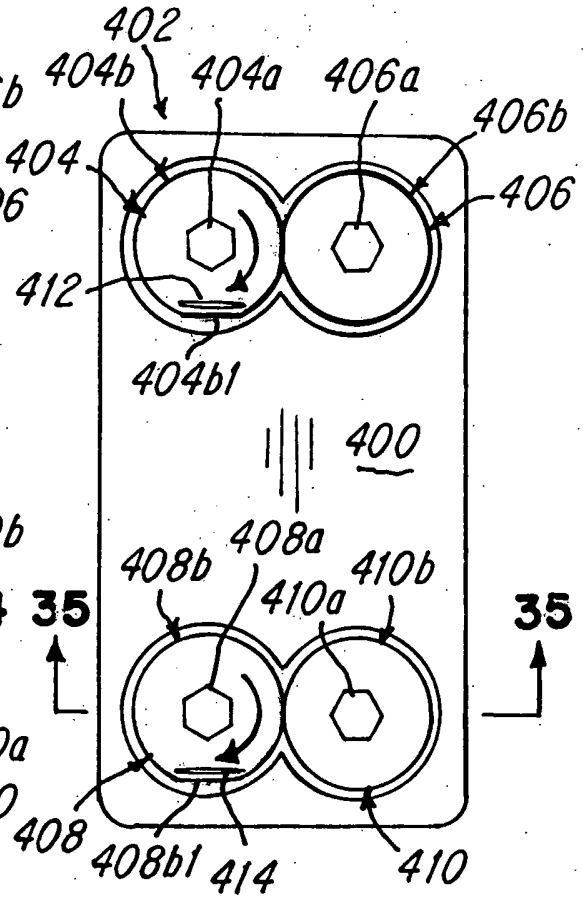


FIG-34

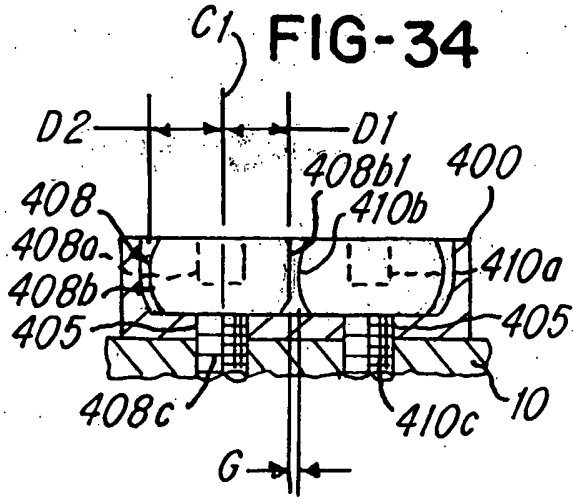


FIG-35

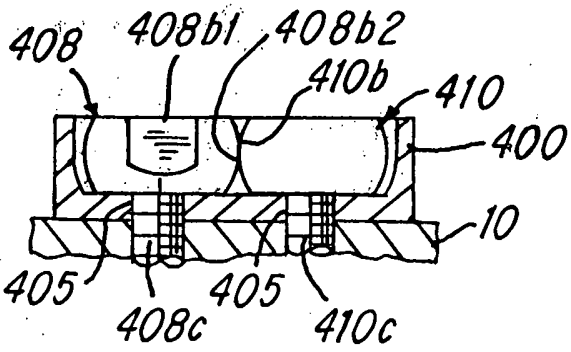


FIG-36

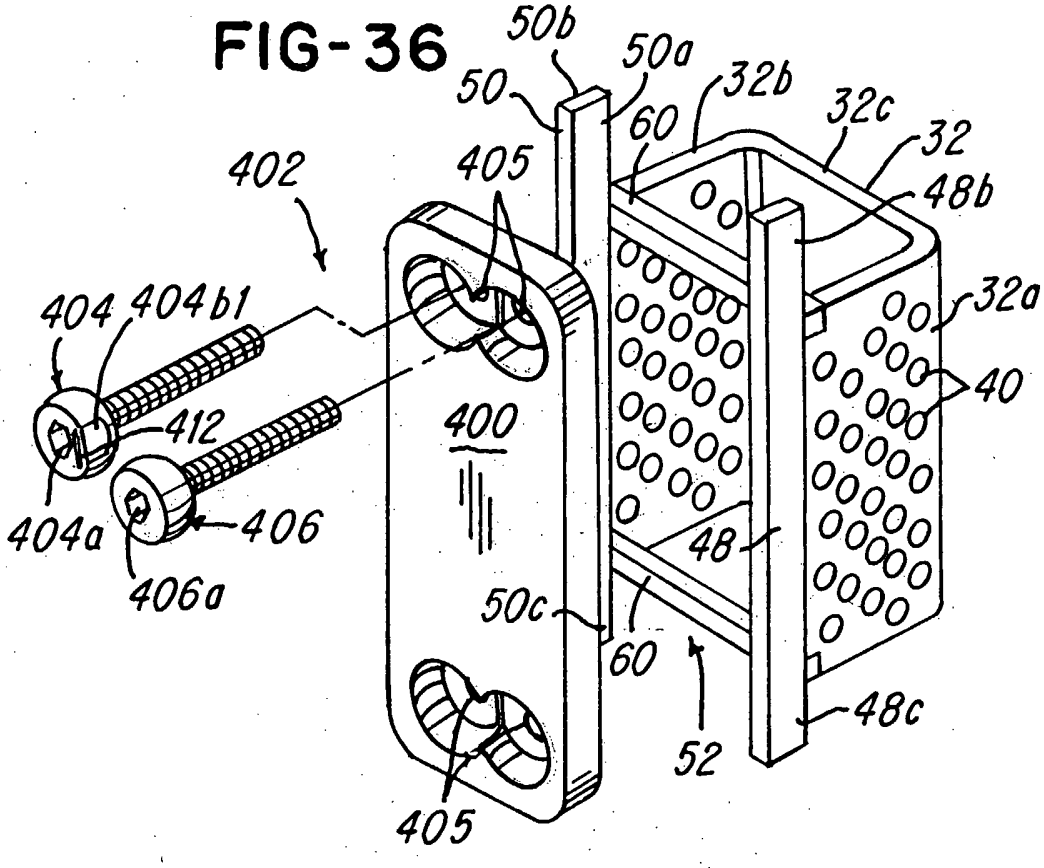
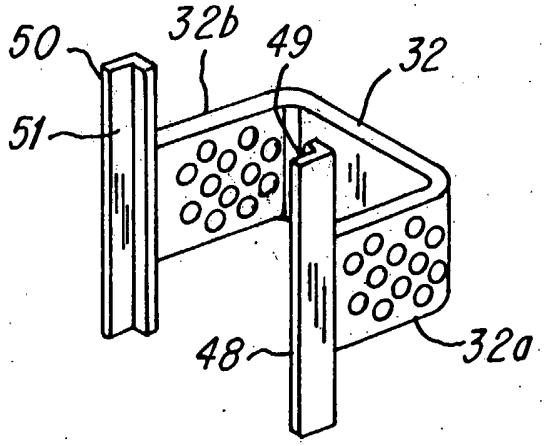

50b
50a
50
32b
32c
32
60
405
402
48b
404
404b1
32a
40
412
400
404a
406
48
406a
50c
60
48c
52
405

FIG-31


50
32b
49
32
51
48
32a