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Michelson

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[54] **APPARATUS INSTRUMENTATION, AND METHOD FOR SPINAL FIXATION**

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[21] Appl. No.: **08/926,334**

[22] Filed: **Sep. 5, 1997**

Related U.S. Application Data

[63] Continuation of application No. 08/589,787, Jan. 22, 1996, abandoned, which is a continuation of application No. 08/219,626, Mar. 28, 1994.

[51] **Int. Cl.⁷** **A61B 17/56**

[52] **U.S. Cl.** **606/61; 606/60; 606/69**

[58] **Field of Search** **606/75, 61, 69, 606/70, 71, 72, 73, 60; 623/17**

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Primary Examiner—Michael Buiz

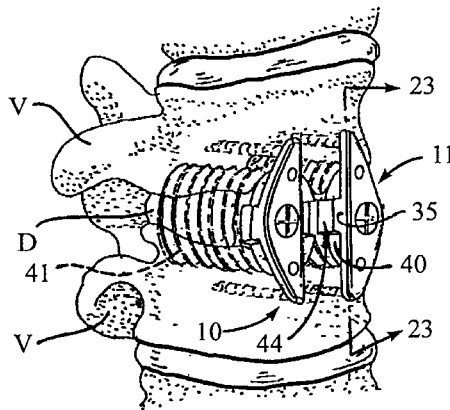
Assistant Examiner—(Jackie) Tan-Uyen T. Ho

Attorney, Agent, or Firm—Martin & Ferraro, LLP

[57] ABSTRACT

A spinal fixation device for stabilizing one or more segments of the human spine and for preventing the dislodgement of intervertebral spinal fusion implants, which remains permanently fixated once applied. The spinal fixation device of the present invention comprises of a staple member made of material appropriate for human surgical implantation which is of sufficient length to span the disc space between two adjacent vertebrae and to engage, via essentially perpendicular extending projections, the vertebrae adjacent to that disc space. A portion of the staple of the spinal fixation device interdigitates with an already implanted intervertebral spinal fusion implant which itself spans the disc space to engage the adjacent vertebrae, and the spinal fixation device is bound to the spinal fusion implant by a locking means. The spinal fixation device of the present invention is of great utility in restraining the vertebrae adjacent to the spinal fusion implant from moving apart as the spine is extended and also serves as an anchor for a multi-segmental spinal alignment means for aligning more that one segment of the spine.

144 Claims, 10 Drawing Sheets



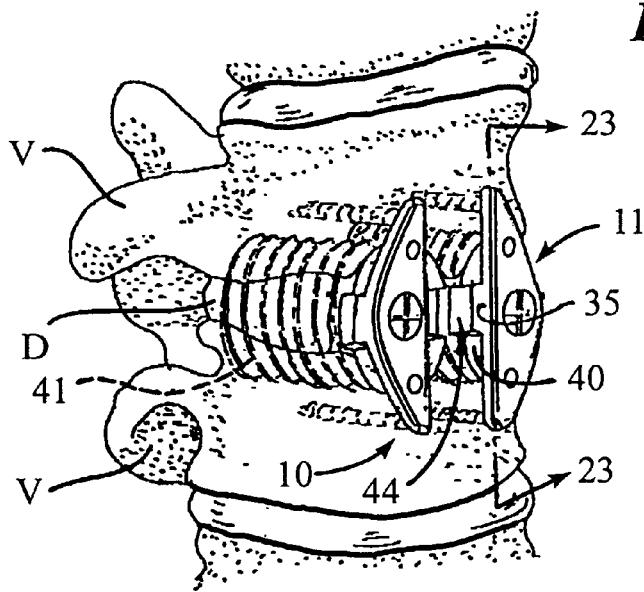


Fig. 1

Fig. 2
PRIOR ART

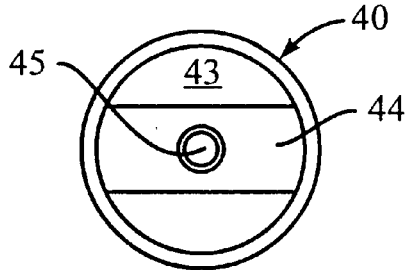
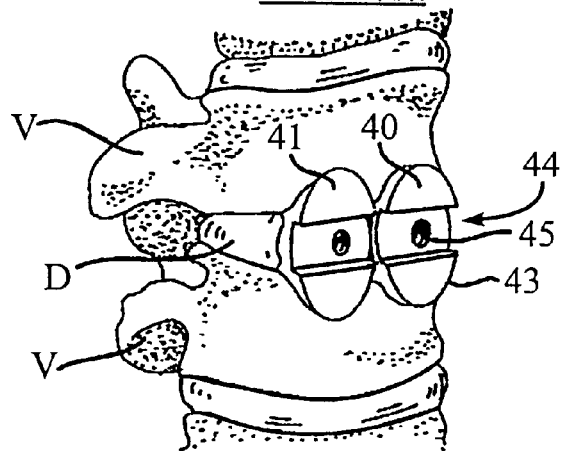


Fig. 4
PRIOR ART

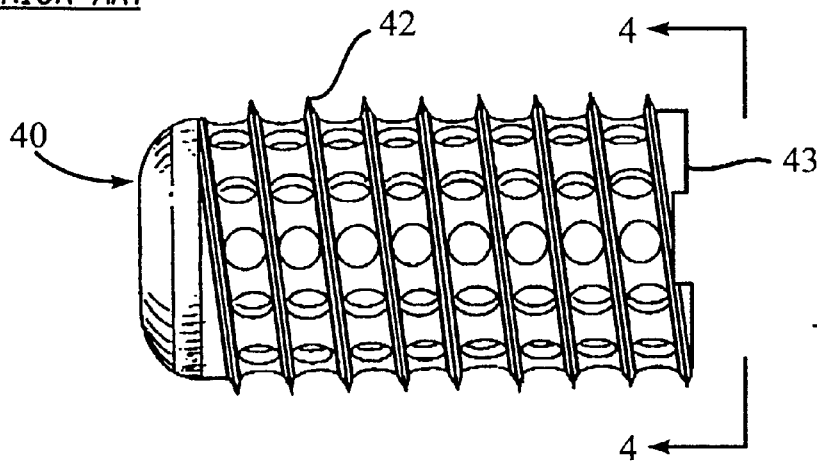


Fig. 3
PRIOR ART

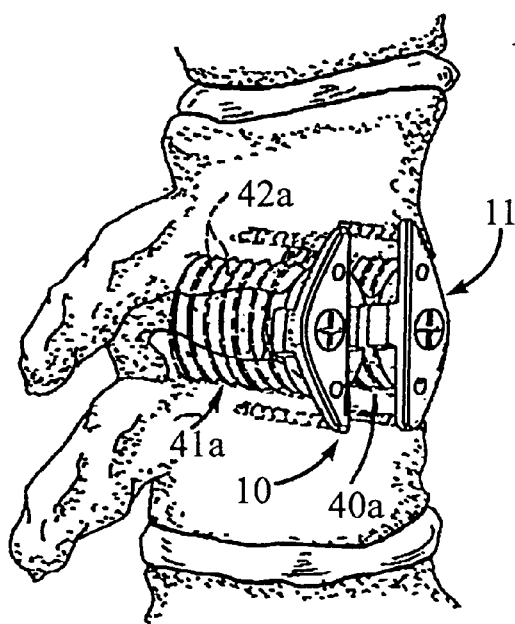


Fig. 5

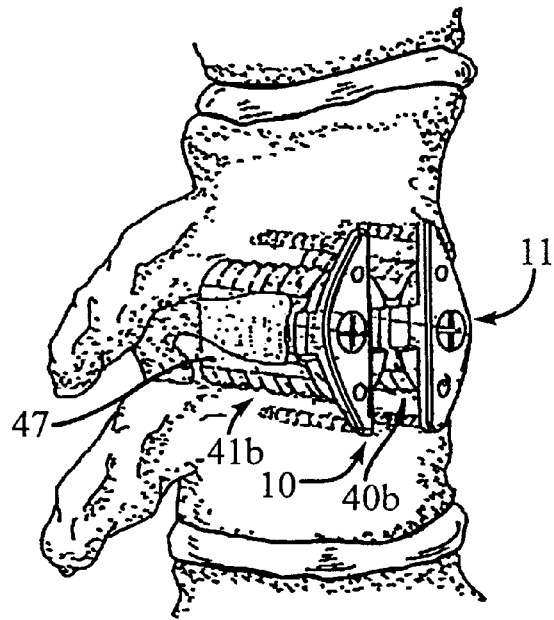


Fig. 6

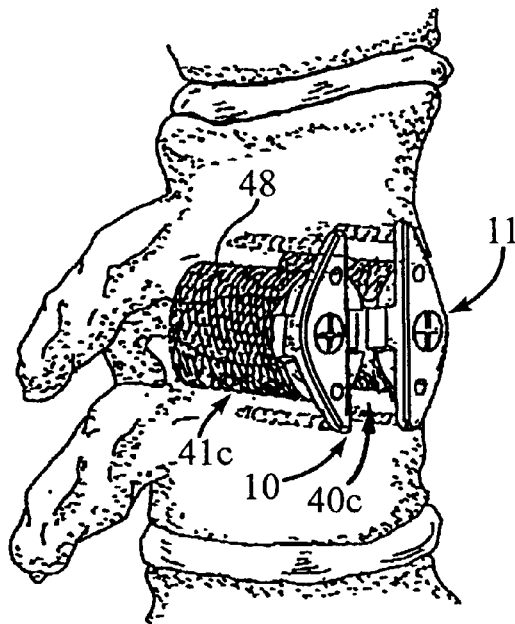


Fig. 7

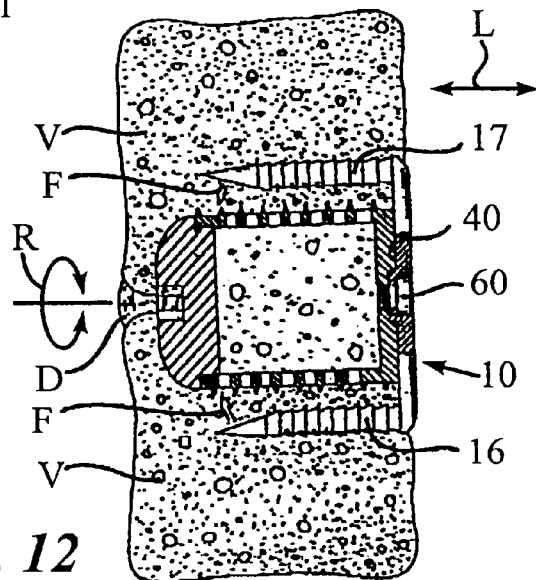


Fig. 12

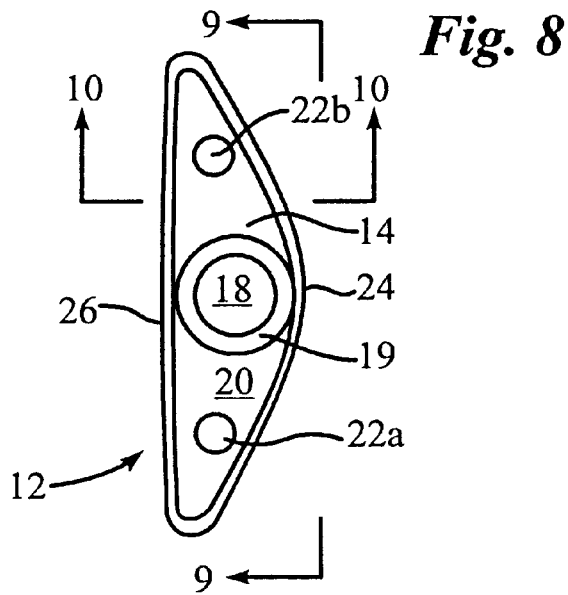


Fig. 8

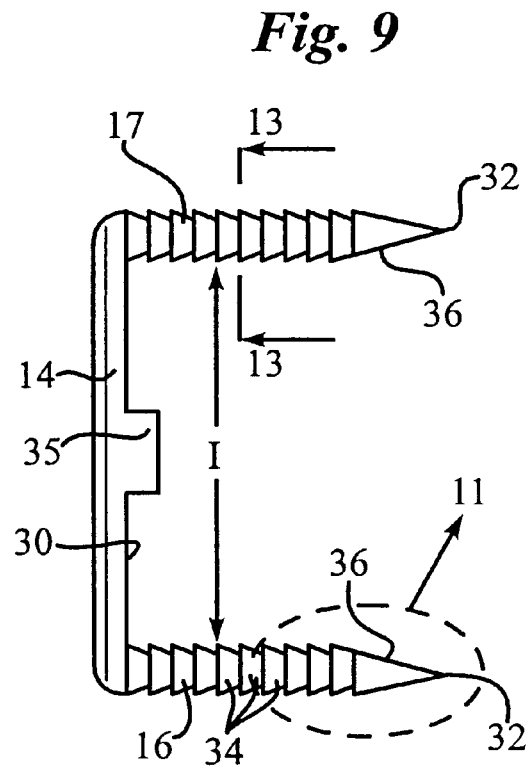


Fig. 9

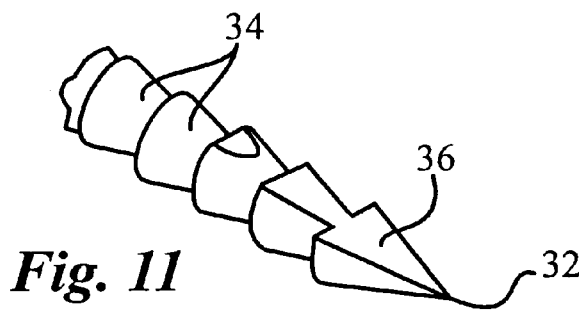


Fig. 10

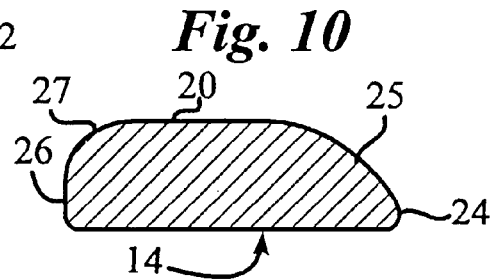


Fig. 11

Fig. 13F

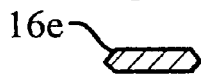


Fig. 13E



Fig. 13C

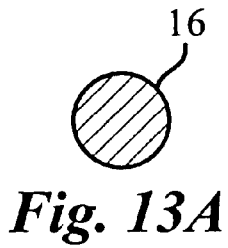


Fig. 13A



Fig. 13B



Fig. 13D

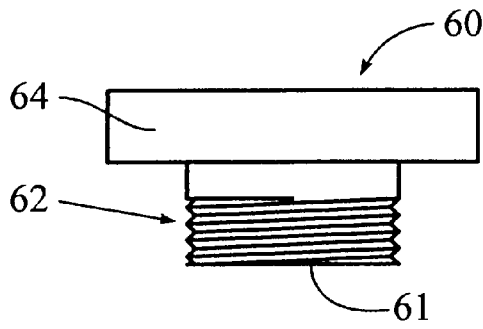


Fig. 14

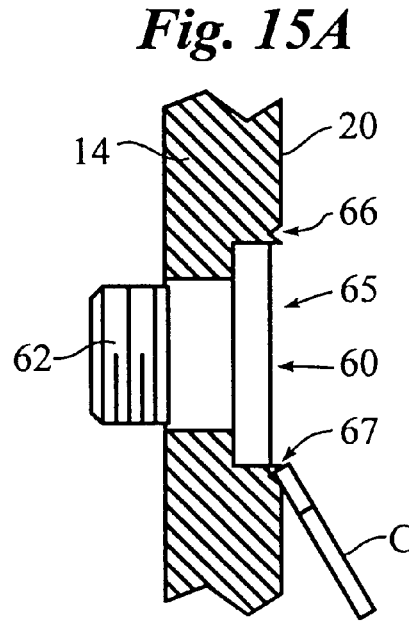


Fig. 15A

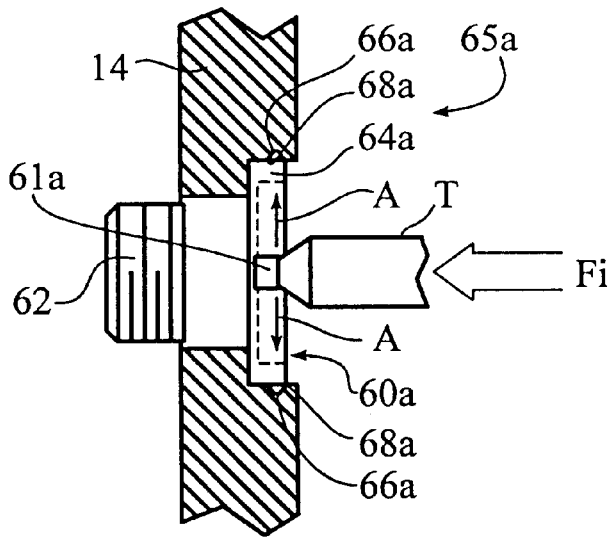


Fig. 15B

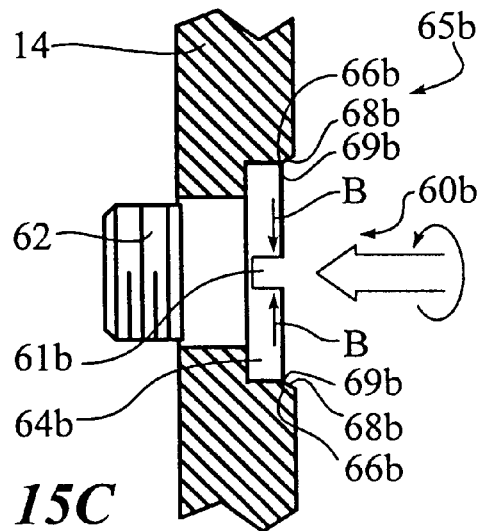


Fig. 15C

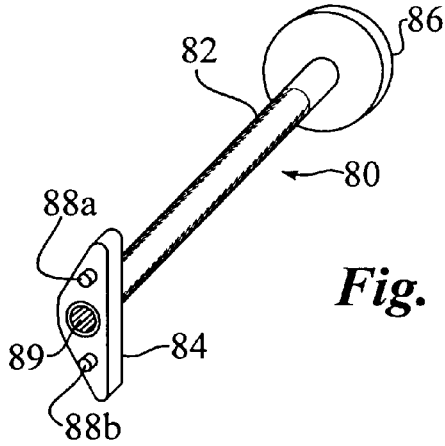


Fig. 16A

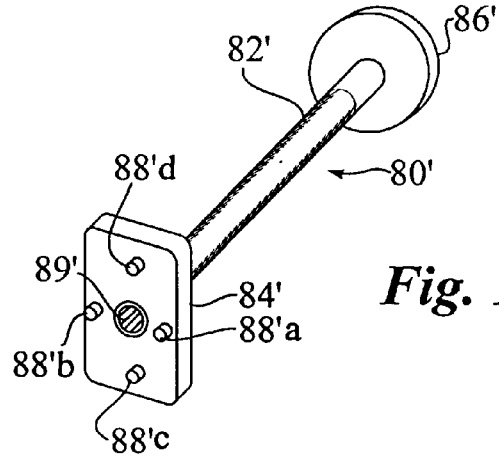


Fig. 16B

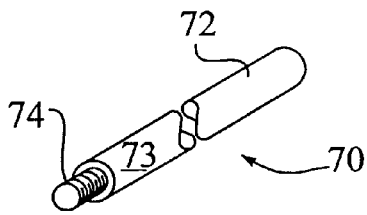


Fig. 17A

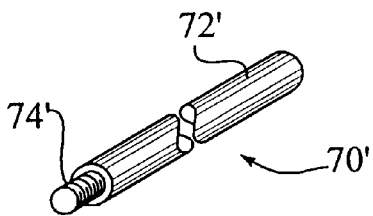


Fig. 17B

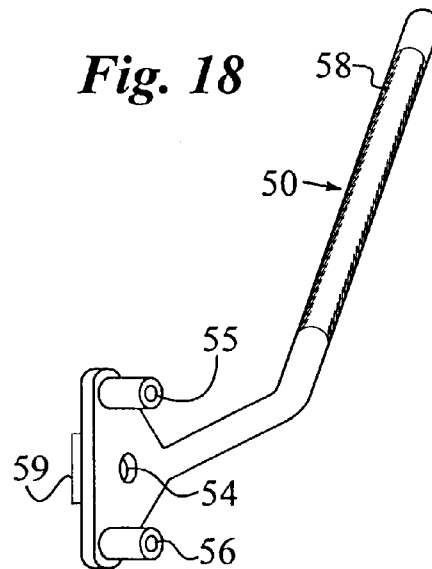


Fig. 18

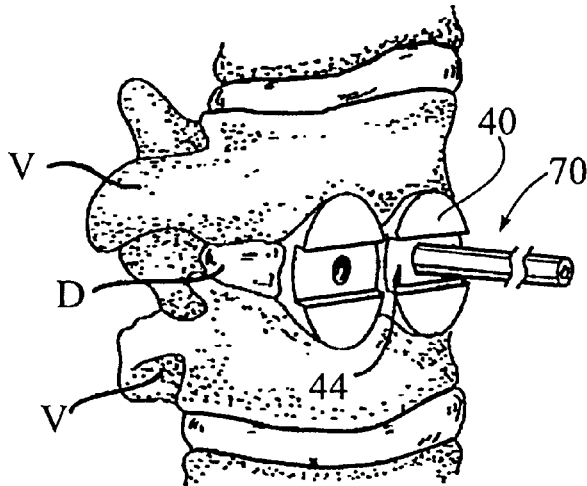


Fig. 19

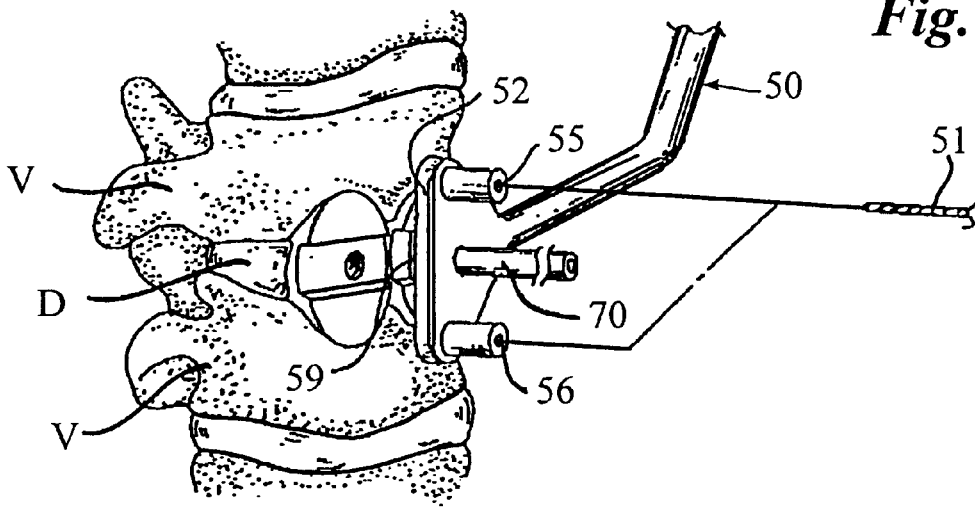


Fig. 20

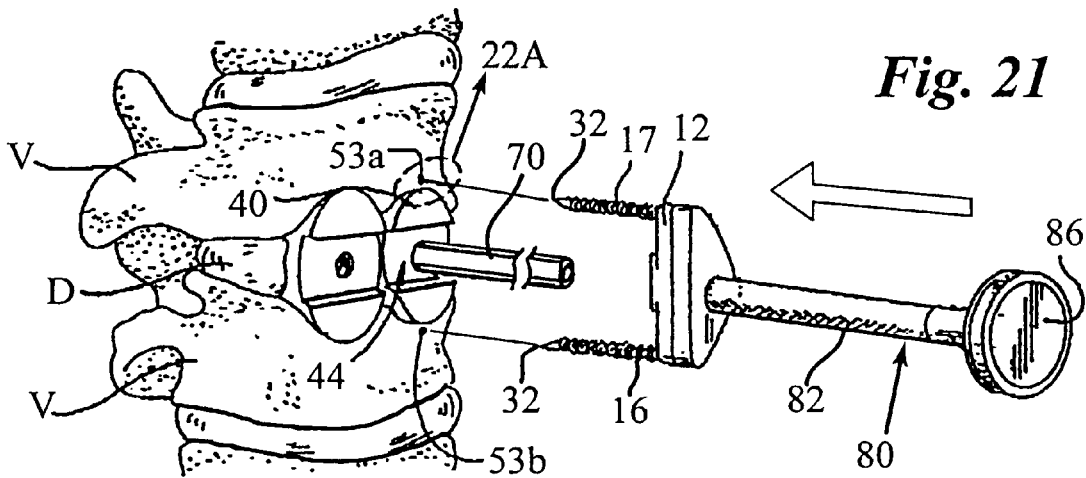


Fig. 21

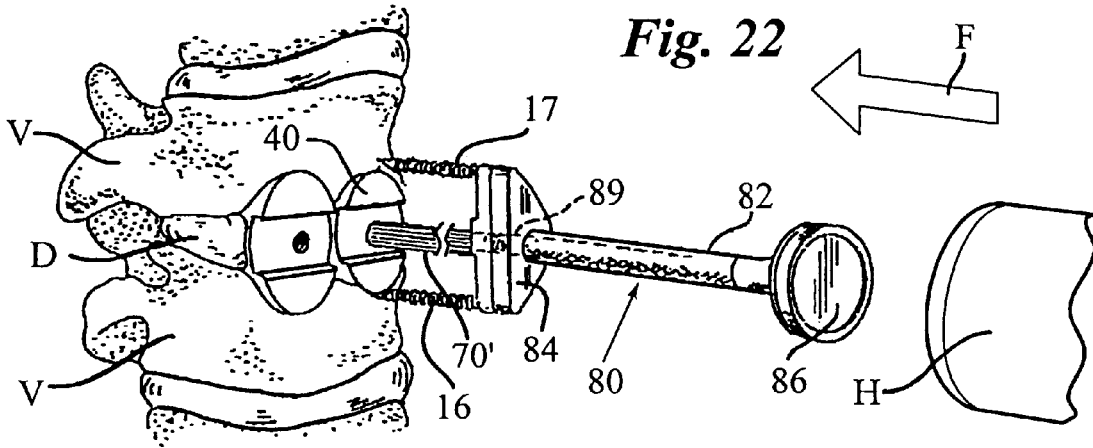


Fig. 22

Fig. 22A

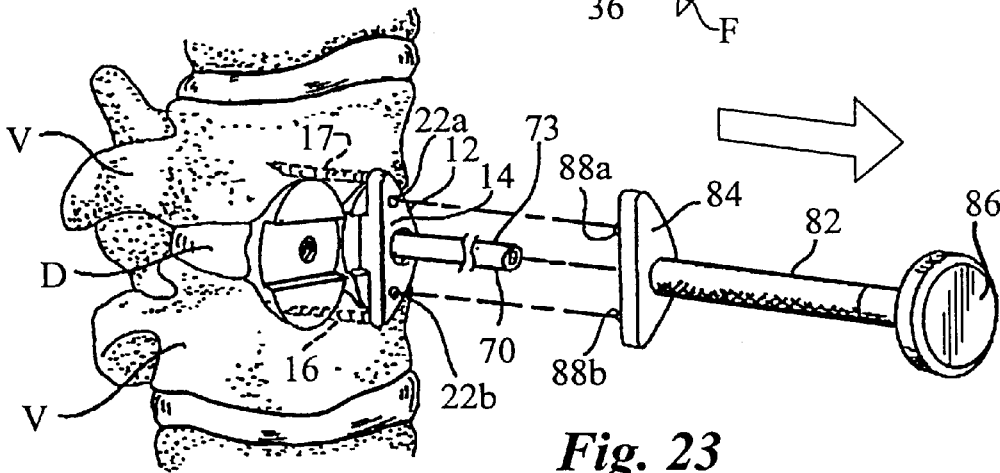
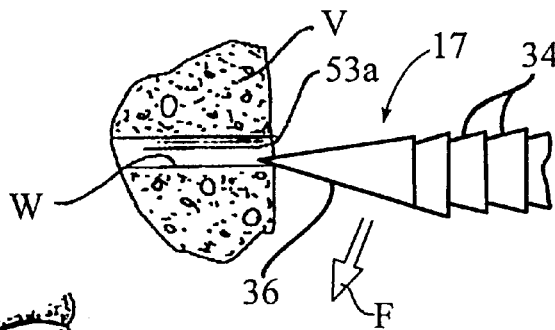


Fig. 23

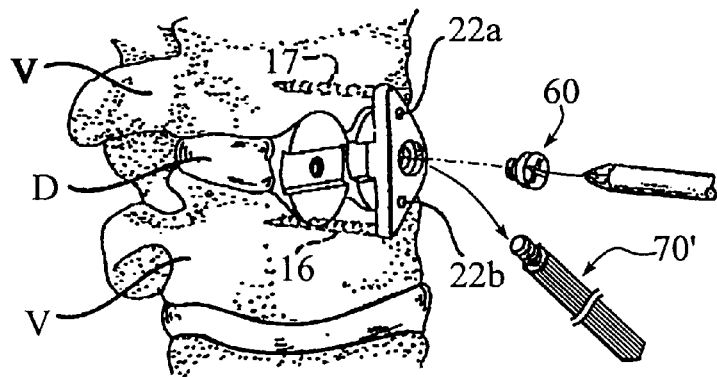


Fig. 24

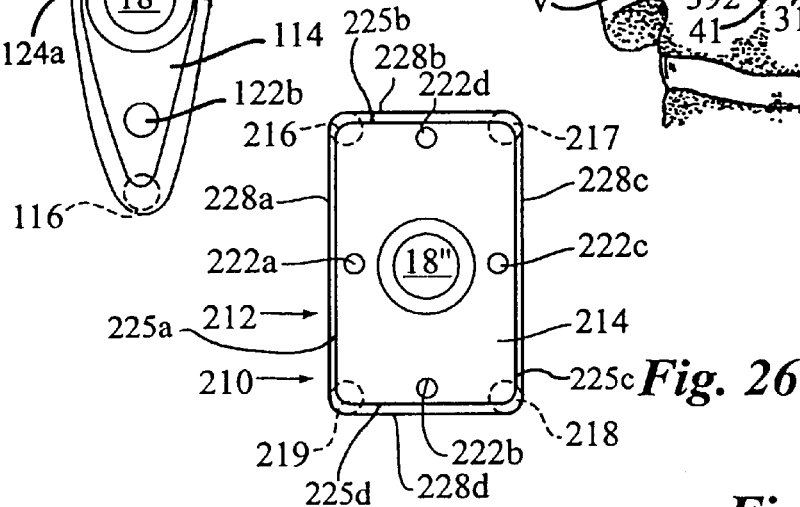
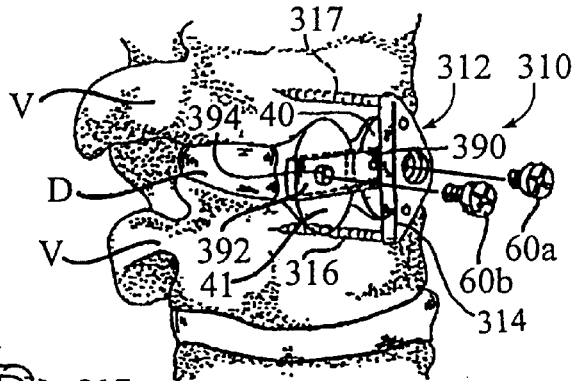
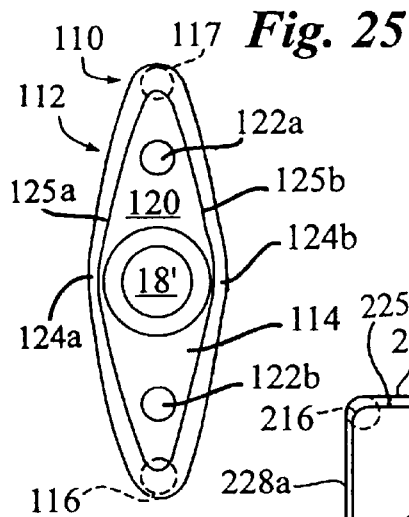


Fig. 27

Fig. 26

Fig. 28

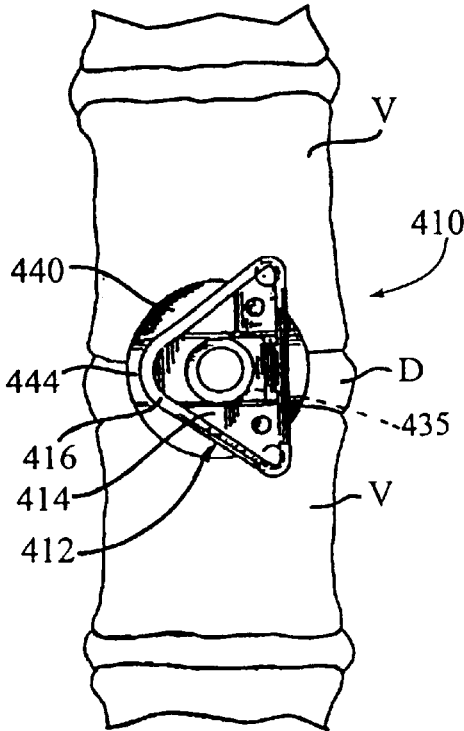
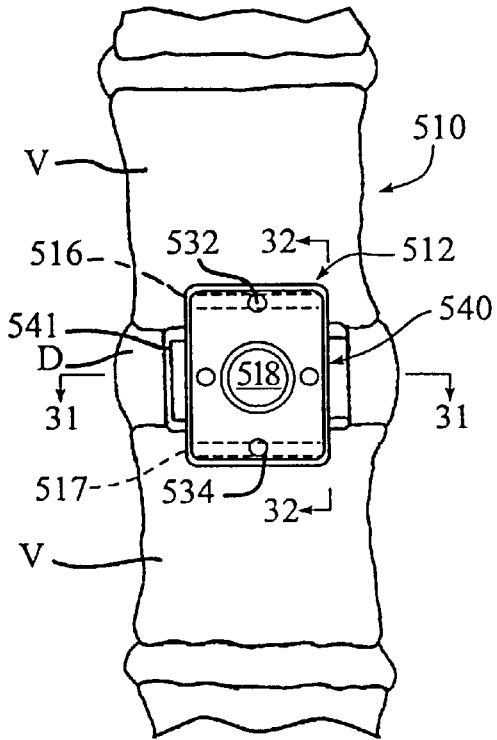


Fig. 29



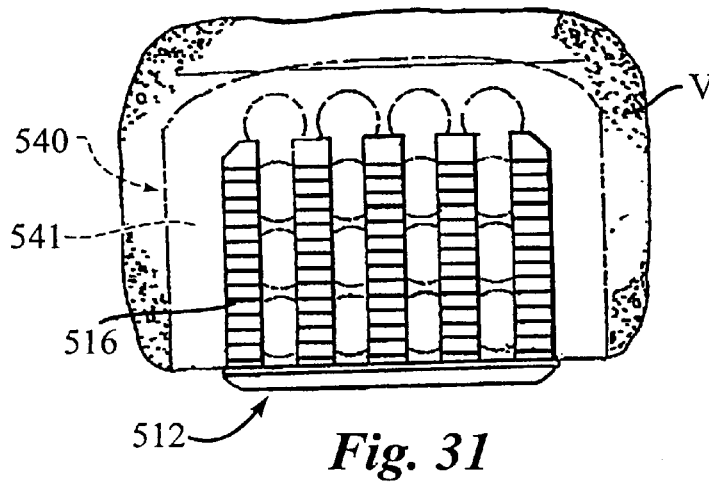
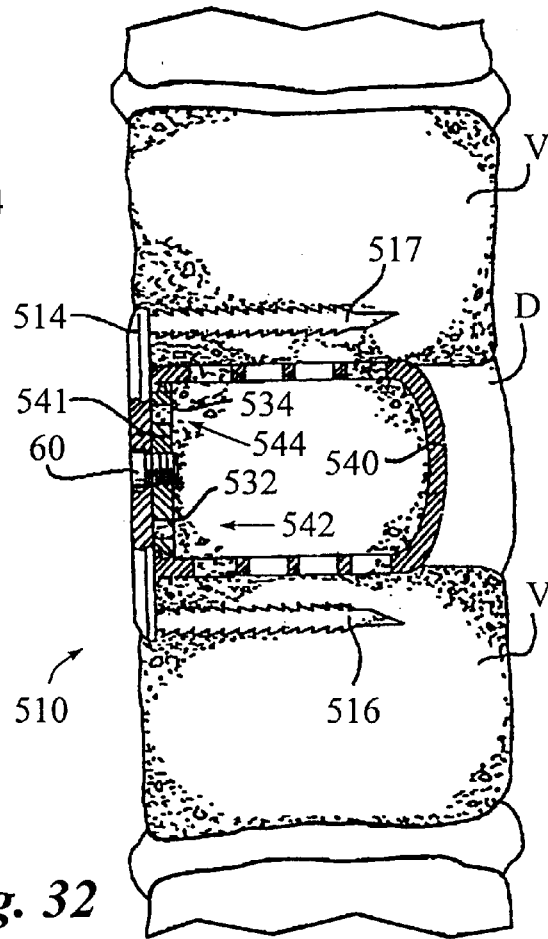
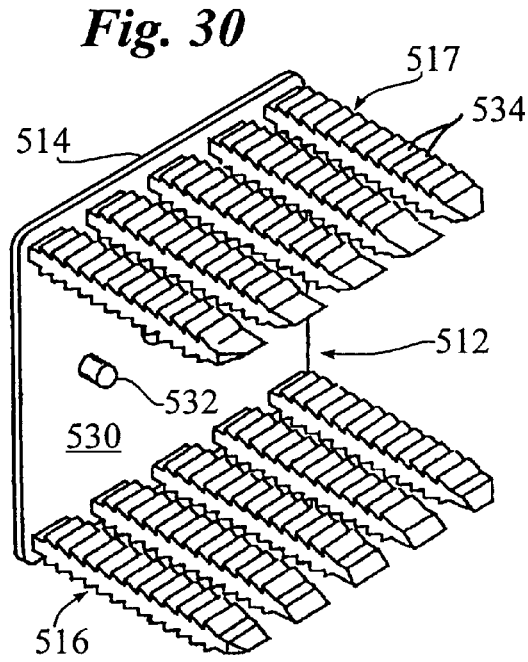


Fig. 33

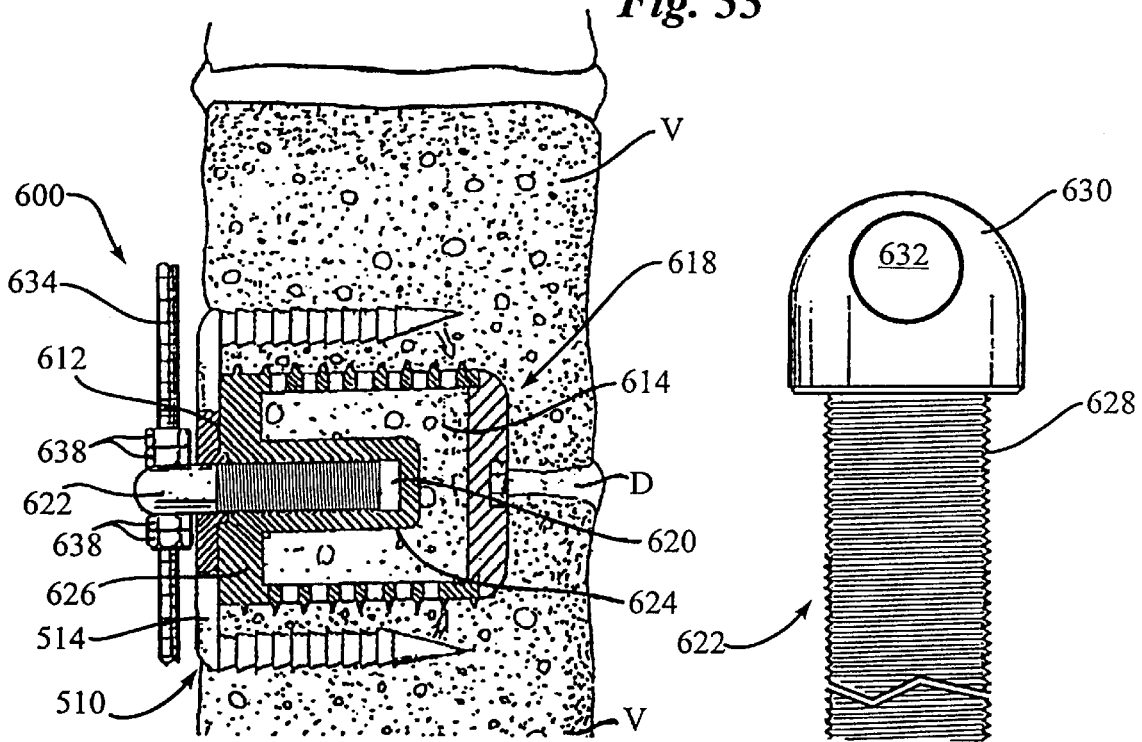


Fig. 34

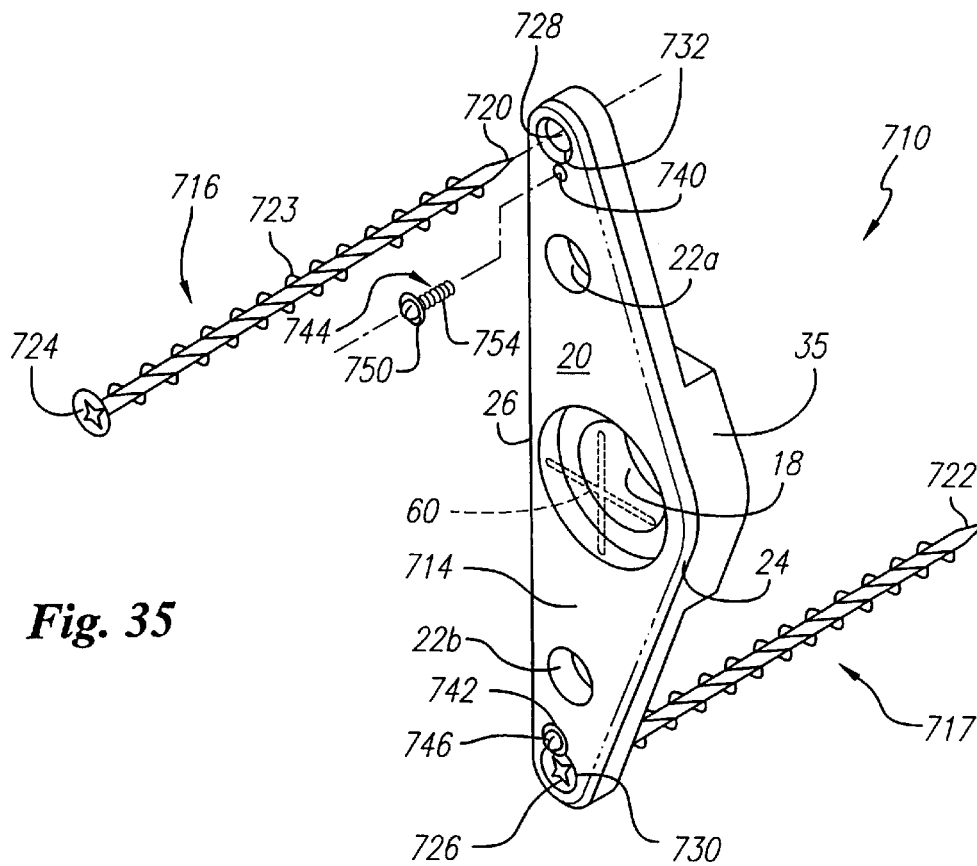


Fig. 35

APPARATUS INSTRUMENTATION, AND METHOD FOR SPINAL FIXATION

This application is a continuation of application Ser. No. 08/589,787, Jan. 22, 1996, now abandoned which is a continuation of application Ser. No. 08/219,626, filed on Mar. 28, 1994.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to surgical interbody fixation devices and in particular to a surgically implantable device for the stabilization of adjacent vertebrae of the human spine undergoing spinal arthrodesis and for the prevention of the dislodgement of spinal fusion implants used in the fusion process.

2. Description of the Related Art

When a segment of the human spine degenerates, or otherwise becomes diseased, it may become necessary to surgically remove the affected disc of that segment, and to replace it with bone for the purpose of obtaining a spinal fusion by which to restore more normal, pre-morbid, spatial relations, and to provide for enhanced stability across that segment. Performing such surgery of the spine from an anterior (front) approach offers the great advantage of avoiding the spinal cord, dural sac, and nerve roots. Unfortunately, in entering the disc space anteriorly a very important band-like structure called the anterior longitudinal ligament, is violated. This structure physiologically acts as a significant restraint resisting the anterior displacement of the disc itself and acting as a tension band binding the front portions of the vertebrae so as to limit spinal hyperextension.

Historically, various devices have been utilized in an attempt to compensate for the loss of this important stabilizing structure.

These devices have assumed the form of blocks, bars, cables, or some combination thereof, and are bound to the vertebrae by screws, staples, bolts, or some combination thereof. The earliest teachings are of a metal plate attached to adjacent vertebrae with wood-type screws. Dwyer teaches the use of a staple-screw combination. Brantigan U.S. Pat. No. 4,743,256 issued on May 10, 1988, teaches the use of a block inserted to replace the disc, affixed to a plate then screwed to the vertebrae above and below. Raezian U.S. Pat. No. 4,401,112 issued on Aug. 30, 1993, teaches the use of a turnbuckle affixed to an elongated staple such that at least one entire vertebral body is removed, the turnbuckle portion is placed within the spine, and the staple extends both above and below the turnbuckle and engages the adjacent vertebrae to the one removed.

Unfortunately, both staples and screws have quite predictably demonstrated the propensity to back out from the vertebrae. This is quite understandable as any motion, either micro or macro, tends to stress the interface of the metallic implant to the bone, and in doing so causes the bone to relieve the high stress upon it by resorbing and moving away from the metal. This entropic change is universally from the more tightened and thus well-fixated state, to the less tightened and less fixated state. For a staple, this is specifically from the more compressed and engaged state, to the less compressed and disengaged state. Similarly, screws in such a dynamic system loosen and back out.

The potential consequences of such loosening and consequent backing out of the hardware from the anterior aspect of the vertebral column may easily be catastrophic. Because

of the proximity of the great vessels, aortic erosions and perforations of the vena cava and iliac vessels have usually occurred with unfortunate regularity and have usually resulted in death.

Therefore, the need exists for a device which is effective in restoring stability to a segment of the spine such as, but not limited to, the anterior aspect of the human spine and which will without danger remain permanently fixated once applied.

SUMMARY OF THE INVENTION

The present invention is directed to a spinal fixation device for stabilizing a segment of the human spine and for preventing the dislodgement of intervertebral spinal fusion implants, which remains permanently fixated to the spine once applied. The spinal fixation device of the present invention comprises a staple member made of a material appropriate for human surgical implantation and which is of sufficient length to span the disc space between two adjacent vertebrae. The staple member engages, via essentially perpendicular extending projections, the vertebrae adjacent to that disc space. The projections are sharpened and pointed so as to facilitate their insertion into the vertebrae and are segmented or ratcheted to prevent the staple member from disengaging and backing out once inserted.

In the preferred embodiment of the spinal fixation device of the present invention, a portion of the staple member interdigitates with an already implanted intervertebral spinal fusion implant and the staple member is bound to the spinal fusion implant by a locking mechanism such as a screw with a locking thread pattern. The anchoring of the staple member via a locking mechanism to a spinal fusion implant protects the patient from the danger of the staple member itself disengaging and backing out. Further, if the spinal fusion implant is externally threaded, such as the spinal fusion implant taught by Michelson, U.S. Pat. No. 5,015,247 issued on May 14, 1991, then the staple member could only back out if the spinal fusion implant were free to rotate. However, the rotation of the spinal fusion implant in this instance is blocked by its connection to the staple member which is fixated across the disc space in such a way as to be incapable of rotation. Thus, the staple member is made safe against dislodgement by attachment to the spinal fusion implant and the stability of the spinal fusion implant is assured as it is also stabilized by the staple member and each works in connection with the other to remove the only remaining degree of freedom that would allow for the disengagement of either.

The spinal fixation device of the present invention is broadly applicable to the anterior, posterior and lateral aspects of the spinal column, be it the cervical, thoracic or lumbar area. In particular, the use of a staple member spanning the disc space and engaging the adjacent vertebrae which is applied to the anterior aspect of the spine is of great utility in restraining those vertebral bodies from moving apart as the spine is extended and thus is effective in replacing the anterior longitudinal ligament of the patient.

The spinal fixation device of the present invention provides the advantage of facilitating cross vertebral bony bridging (fusion via immobilization) which when achieved relieves all of the forces on the inserted spinal fusion implants. The spinal fixation device of the present invention may be coated with materials to promote bone fusion and thus promote the incorporation and ultimate entombment of the spinal fixation device into the bone fusion mass. The use of a bone fusion promoting material results in a speedier

vertebra to vertebra fusion as bone may grow along the coated spinal fixation device bridging the two vertebrae so that the spinal fixation device acts as a trellis and supplies essential chemical elements to facilitate the bone fusion process.

Another advantage provided by the spinal fixation device of the present invention is that as it is inserted it compresses the adjacent vertebrae together, thus increasing the compressive load on the spinal fusion implants or implants within the disc space, such compression being beneficial to fusion and further stabilizing the spinal fusion implants.

A further advantage of the spinal fixation device of the present invention is that it may be used as an anchor such that a multiplicity of spinal fixation devices may then be interconnected via a cable, rod, bar, or plate, so as to achieve or maintain a multi-segmental spinal alignment.

Alternatively, the spinal fixation device of the present invention could be made of resorbable materials, such as biocompatible resorbable plastics, that resorb at an appropriate rate such that once the spinal fixation device is no longer needed (i.e. when spinal fusion is complete) the body would resorb the spinal fixation device. The spinal fixation device could be only in part resorbable such that the projections of the staple member would be non-resorbable and would remain incarcerated in the vertebrae and sealed off once the resorbable portion of the staple is resorbed by the body.

As a further alternative, the spinal fixation device of the present invention could be made wholly of in part of ceramic and more particularly made of or coated with a ceramic such as hydroxyapatite that would actively participate in the fusion process.

OBJECTS OF THE PRESENT INVENTION

It is an object of the present invention to provide a spinal fixation device having a staple member spanning the disc space and engaging two adjacent vertebrae of the spine to restrain the vertebrae from moving apart as the spine is extended;

It is another object of the present invention to provide a spinal fixation device that is effective in replacing the function of the anterior longitudinal ligament of a patient;

It is a further object of the present invention to provide a means for protecting the patient from the danger of the spinal fixation device itself disengaging and backing out by its being anchored to an intervertebral spinal fusion implant;

It is still another object of the present invention to provide a spinal fixation device that blocks the rotation of an intervertebral spinal fusion implant by its connection to the staple member which is fixated across the disc space in such a way as to be incapable of rotation thereby preventing the spinal fusion implant from backing out;

It is yet another object of the present invention to provide a spinal fixation device that is broadly applicable to the anterior aspect of the spinal column, be it the cervical, thoracic or lumbar area;

It is another object of the present invention to provide a spinal fixation device which may be applied longitudinally at any point about the circumference of the anterior aspect of the spine;

It is also another object of the present invention to provide a spinal fixation device that stabilizes a surgically implanted spinal fusion implant and works in connection with the spinal fusion implant to prevent disengagement of either;

It is another object of the present invention to provide a spinal fixation device that achieves cross vertebral bony

bridging (fusion) which ultimately relieves all of the forces on intervertebral spinal fusion implants inserted within the disc space between two adjacent vertebrae, and provides for a permanently good result;

It is another object of the present invention to provide a spinal fixation device that serves as an anchor, such that a multiplicity of these anchors may then be interconnected via a cable, rod, bar, or plate, so as to achieve or maintain a multi-segmental spinal alignment; and

It is a further object of the present invention to provide a spinal fixation device that directly participates in the bony bridging of two adjacent vertebrae and participates in the spinal fusion process across those vertebrae.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective side view of a segment of the spinal column having two spinal fusion implants shown partially in hidden line inserted across the disc space between two adjacent vertebrae with each spinal fusion implant having a spinal fixation device of the present invention shown partially in hidden line secured thereto, spanning across the disc space and inserted into the vertebrae.

FIG. 2 is a perspective side view of a segment of the spinal column having two spinal fusion implants inserted across the disc space between two adjacent vertebrae.

FIG. 3 is an elevational side view of a cylindrical threaded spinal fusion implant.

FIG. 4 is an end view of the cylindrical threaded spinal fusion implant along lines 4—4 of FIG. 3.

FIG. 5 is a perspective side view of a segment of the spinal column having two non-threaded spinal fusion implants with external ratchetings, shown in hidden line, inserted across the disc space between two adjacent vertebrae with each spinal fusion implant having a spinal fixation device of the present invention, shown partially in hidden line, coupled thereto, spanning across the disc space and inserted into the vertebrae.

FIG. 6 is a perspective side view of a segment of the spinal column having two spinal fusion implants having truncated sides with external ratchetings shown in hidden line inserted across the disc space between two adjacent vertebrae with each spinal fusion implant having a spinal fixation device of the present invention shown partially in hidden line coupled thereto, spanning across the disc space and inserted into the vertebrae.

FIG. 7 is a perspective side view of a segment of the spinal column having two spinal fusion implants having a knurled external surface shown in hidden line inserted across the disc space between two adjacent vertebrae with each spinal fusion implant having a spinal fixation device of the present invention shown partially in hidden line coupled thereto, spanning across the disc space and inserted into the vertebrae.

FIG. 8 is a top plan view of the spinal fixation device of the present invention.

FIG. 9 is a side view of the spinal fixation device of the present invention along lines 9—9 of FIG. 8.

FIG. 10 is a cross sectional view taken along lines 10—10 of FIG. 8 showing the top member of the spinal fixation device of the present invention.

FIG. 11 is an enlarged fragmentary perspective side view of a projection of the spinal fixation device of the present invention taken along line 11 of FIG. 9.

FIG. 12 is a cross sectional view of the spinal fixation device of the present invention inserted into the vertebrae and secured to the spinal fusion implant with the arrows showing the forces exerted, the rotational axis and the longitudinal axis of the spinal fusion implant.

FIG. 13A is a cross sectional view along line 13—13 of FIG. 9 of the preferred embodiment of the projections of the present invention.

FIGS. 13B, 13C, 13D, 13E, and 13F are cross sectional views taken along line 13—13 of FIG. 9 showing alternative embodiments of the projections of the spinal fixation device of the present invention.

FIG. 14 is an enlarged elevational side view of the locking screw used to secure the spinal fixation device of the present invention to a spinal fusion implant.

FIG. 15A is a cross sectional view of a securing means for locking the locking screw of the present invention.

FIG. 15B is a cross sectional view of a first alternative embodiment of the securing means for locking the locking screw of the present invention.

FIG. 15C is a cross sectional view of a second alternative embodiment of the securing means for locking the locking screw of the present invention.

FIG. 16A is a perspective side view of the instrumentation used for driving the spinal fixation device of the present invention into the vertebrae.

FIG. 16B is a perspective side view of a first alternative embodiment of the instrumentation used for driving the spinal fixation device of the present invention into the vertebrae.

FIG. 17A is a perspective side view of an alignment rod used to align the spinal fixation device of the present invention.

FIG. 17B is a perspective side view of an alternative embodiment of the alignment rod having splines used to align the spinal fixation device of the present invention.

FIG. 18 is a front perspective view of the drill template instrument.

FIG. 19 is a perspective side view of the alignment rod attached to a spinal fusion implant inserted in the disc space between two adjacent vertebrae.

FIG. 20 illustrates the step of drilling guide holes in the vertebrae adjacent to the spinal fusion implant with the drill template instrument of FIG. 18.

FIG. 21 illustrates a step of the method of inserting the spinal fixation device of the present invention with the alignment rod attached to the spinal fusion implant and the spinal fixation device placed on the driver instrumentation.

FIG. 22 illustrates a step of the short method of inserting the spinal fixation device of the present invention with the driver instrument engaging the splined alignment rod and a hammer for applying an impaction force and driving the driver instrument.

FIG. 22A is an enlarged fragmentary view of a projection being inserted into an insertion hole drilled within a vertebra shown in cross section taken along line 22A of FIG. 21.

FIG. 23 illustrates another step of the method of inserting the spinal fixation device of the present invention in which the spinal fixation device has been driven into the vertebrae and the driver instrumentation has been removed.

FIG. 24 illustrates another step of the method of inserting the spinal fixation device of the present invention with the splined alignment rod being removed from the spinal fusion implant and the locking screw being inserted and secured the spinal fixation device to the spinal fusion implant.

FIG. 25 is a top plan view of a first alternative embodiment of the spinal fixation device of the present invention.

FIG. 26 is a top plan view of a second alternative embodiment of the spinal fixation device of the present invention.

FIG. 27 is a perspective side view of a third alternative embodiment of the spinal fixation device of the present invention coupled to two spinal fusion implants and inserted in adjacent vertebrae of the spinal column.

FIG. 28 is a top plan view of a fourth alternative embodiment of the spinal fixation device of the present invention inserted into the vertebrae of the spinal column having a spinal fusion implant inserted in the disc space.

FIG. 29 is a top plan view of a fifth alternative embodiment of the spinal fixation device of the present invention inserted into the vertebrae of the spinal column having a spinal fusion implant inserted in the disc space.

FIG. 30 is a perspective bottom view of the fourth alternative embodiment of the spinal fixation device of the present invention.

FIG. 31 is a cross sectional view along lines 31—31 of FIG. 29 showing the fifth alternative embodiment of the spinal fixation device of the present invention inserted into the adjacent vertebrae and coupled to a spinal fusion implant.

FIG. 32 is a cross sectional view along lines 32—32 of FIG. 29 showing the projections of the fifth alternative embodiment of the present invention with respect to a spinal fusion implant inserted within the disc space.

FIG. 33 is a cross sectional view of a spinal fixation device of the present invention engaging two adjacent vertebrae and being attached to a spinal fusion implant, shown being used as an anchor for a multi-segmental spinal alignment means.

FIG. 34 is an enlarged elevational side view of a threaded post used to connect the spinal fixation device of the present invention to a multi-segmental spinal alignment means.

FIG. 35 is an exploded perspective view of a sixth alternative embodiment of the spinal fixation device of the present invention having independent projection members that are screws.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG. 1 and 2, two identical spinal fixation devices of the present invention, each being generally referred to by the numerals 10 and 11, respectively, are shown inserted into two vertebrae V adjacent to a disc D of a segment of the human spine. Each spinal fixation device 10 and 11 is shown coupled to identical spinal fusion implants 40 and 41 that have been surgically implanted in the disc space between adjacent vertebrae V. In this manner, the spinal fixation devices 10 and 11 stabilize a segment of the spine, prevent the dislodgement of the spinal fusion implant 40, and remain permanently fixated to the spine once applied. The spinal fixation devices 10 and 11 are identical such that the description of one is equally applicable to the other. Thus, the description that follows will be directed to spinal fixation device 10.

Referring to FIGS. 3—4, the spinal fusion implant 40 such as, but not limited to, the spinal fusion implant described by Michelson, U.S. Pat. No. 5,015,247 issued on May 14, 1991, is shown. The spinal fusion implant 40 is cylindrical in shape and has external threads 42 at its outer perimeter for engaging the bone of the vertebrae V adjacent to the disc D. The spinal fusion implant 40 has an insertion end 43 having a

depression 44 and a threaded aperture 45 for engaging a portion of the spinal fixation device 10 and also for engaging a portion of an instrument used to insert the spinal fixation device 10 into the vertebrae V.

Referring to FIGS. 5–7, it is appreciated that the spinal fixation devices 10 and 11 of the present invention are not limited in use with a threaded spinal fusion implant 40 and 41, but may be used with different types of spinal fusion implants. For example, the spinal fixation devices 10 and 11 may be coupled to spinal fusion implants 40a and 41a, respectively, each having external ratchetings 42a instead of external threads 42 as shown in FIG. 5. Alternatively, the spinal fixation devices 10 and 11 may be coupled to spinal fusion implants 40b and 41b, respectively, each having a partially cylindrical shape with at least one truncated side 47 as shown in FIG. 6. As a further alternative, the spinal fixation devices 10 and 11 may be coupled to spinal fusion implants 40c and 41c, respectively, each having a knurled external surface 48 as shown in FIG. 7. It is also appreciated that the spinal fixation devices may be used with a variety of other bone fusion implants without departing from the scope of the present invention.

Referring to FIGS. 8–9, in the preferred embodiment, the spinal fixation device 10 of the present invention comprises a staple member 12 having a substantially planar top member 14 which is of sufficient length to span one intervertebral disc D and to engage, via a plurality of essentially perpendicular extending projections 16 and 17, the vertebrae V adjacent to that disc D. The top member 14 has a central opening 18 within a concentric, countersunk recess 19 for receiving therethrough a screw or similar coupling means for coupling the spinal fixation device 10 to the spinal fusion implant 40. The top member 14 has an upper surface 20 having a pair of openings 22a and 22b for receiving the posts 88a and 88b of a driving instrument 80 which is described in greater detail below in reference to FIGS. 16A and 16B.

Referring to FIG. 10, a cross sectional view of the top member 14 is shown. In the preferred embodiment, the top member 14 is generally triangularly shaped and is radiused along curved side 24 and straight side 26. The curved side 24 of the top member 14 is radiused at its upper edge 25 and at the upper edge 27 of straight side 26 to conform to the external curvature of the vertebrae V. In this manner, smooth surfaces are created at the upper edges 25 and 27 of the top member 14 that are contoured to the shape of the external curvature of the vertebrae V when the staple member 12 is in place. The smooth contoured surface of the upper edges 25 and 27 of the top member 14 prevent aortic erosions and perforations of the vessels proximate the vertebral column such as the vena cava and the iliac vessels which might otherwise result from friction.

In the preferred embodiment of the spinal fixation device 10, the top member 14 has a width ranging from 6.0 mm to 28.0 mm, with 10.0 mm being the preferred width, and having a thickness in the range of 2.0 mm to 4.0 mm, with 3.0 mm being the preferred thickness. The staple member 12 is made of material appropriate for human surgical implantation including all surgically appropriate metals such as but not limited to, titanium, titanium alloy, chrome molybdenum alloys, stainless steel; or non-metallic materials including permanent or resorbable substances or composites, carbon fiber materials, resins, plastics, ceramics or others.

Further, the staple member 12 of the present invention may be treated with, or even composed of, materials known to participate in or promote in the fusion process or bone growth. The spinal fixation device 10 may be coated with

materials to promote bone fusion and thus promote the incorporation and ultimate entombment of the spinal fixation device 10 into the bone fusion mass. The use of a bone fusion promoting material such as, but not limited to hydroxyapatite, hydroxyapatite tricalcium phosphate or bone morphogenic protein, results in a speedier vertebra V to vertebra V fusion as bone may grow along the coated spinal fixation device 10 bridging the two vertebrae V so that the spinal fixation device 10 acts as a trellis and supplies essential chemical elements to facilitate the bone fusion process.

Referring again to FIG. 9, the projections 16 and 17 are positioned at opposite ends of the top member 14 and depend downwardly and extend perpendicularly from the bottom surface 30 of the top member 14. The projections 16 and 17 each terminate in a distal end 32 that is pointed and sharpened to facilitate the insertion of the projections 16 and 17 into the vertebrae V.

The staple member 12 is most effective when the inter-projection distance I between projections 16 and 17 is at least 4.0mm and preferably 6.0 mm greater than the diameter of the particular spinal fusion implant 40 for which the spinal fixation device 10 is being used so that at least 2.0 mm and preferably 3.0 mm of bone from the vertebrae V will be present between the spinal fusion implant 40 and each of the projections 16 and 17. Typically, intervertebral spinal fusion implants have a diameter that ranges from 12.0 mm to 28.0 mm, therefore, the interprojection distance I typically will range from 18.0 mm to 34.0 mm for most applications.

In the preferred embodiment, the projections 16 and 17 comprise a series of segmented and ratcheted portions 34. The segmented and ratcheted portions 34 provide for a “one way” insertion of the staple member 12 to prevent the backing-out of the projections 16 and 17 once they are inserted into the bone of the vertebrae V. In the preferred embodiment, each segmented and ratcheted portion 34 of the projections 16 and 17 is conical in shape and the diameter of each segmented and ratcheted portion 34 increases in the direction from the distal end 32 toward the top member 14 so that the projections 16 and 17 resemble a stack of cones. The segmented and ratcheted portions 34 are spaced approximately 2.0 mm to 4.0 mm apart, with 3.0 mm being the preferred distance between each segmented and ratcheted portion 34.

Referring to FIG. 11–12, in the preferred embodiment of the spinal fixation device 10, in order to further facilitate the insertion of the projections 16 and 17 into the vertebrae V, the distal end 32 of each projection 16 has an eccentric, incline-planed inner surface 36 as shown in FIG. 11. The eccentric, incline-planed inner surface 36 of each of the projections 16 and 17 create a force F which pushes the bone of the vertebrae V toward the spinal fusion implant 40 as the staple member 12 is inserted into each of the vertebrae V as shown in FIG. 12.

Referring to FIGS. 13A–13F, in the preferred embodiment of the spinal fixation device 10, the projections 16 and 17 are cylindrical in shape having a circular cross section as shown for projection 16 in FIG. 13A. Alternatively, the projection 16a may have a triangular cross section as shown in FIG. 13B; the projection 16b may have a square cross section as shown in FIG. 13C; the projection 16c may have a rectangular cross section as shown in FIG. 13D; the projection 16d may have a trapezoidal cross section as shown in FIG. 13E; or the projection 16e may have a cross section with a configuration as shown in FIG. 13F.

In the preferred embodiment, the projections 16 and 17 each have a diameter of approximately 2.0 mm to 4.0 mm,

with 3.0 mm being the preferred diameter at the widest point. The projection **16** and **17** each have a length ranging from 16.0 mm to 28.0 mm, with 22.0 mm being the preferred length when the spinal fixation device **10** is implanted in the direction of the anterior aspect of the vertebra V to the posterior aspect of the vertebrae V. Alternatively, it is appreciated that the projections **16** and **17** each could have a longer length depending on the diameter of the vertebrae V in which the projections **16** and **17** are implanted.

Referring again to FIG. 9, the top member **14** of the staple member **12** has a central bar **35** extending from the center of its bottom surface **30**, for interdigitating and mating to an already implanted intervertebral spinal fusion implant **40**. In the preferred embodiment, the central bar **35** has a thickness in the range of 0.5 mm to 1.5 mm, with 0.5 mm being the preferred thickness.

Referring to FIG. 1, the central bar **35** is configured so that it complements and engages the depression **44** at the insertion end **43** of the spinal fusion implant **40**. Once engaged to the depression **44**, the bar **35** interdigitates with the depression **44** of the spinal fusion implant **40** to lock and prevent the rotation of the spinal fusion implant **40**.

Referring to FIG. 14, in the preferred embodiment, the staple member **12** is secured to the spinal fusion implant **40** by a screw **60** having threaded end **61** with a locking thread pattern **62** and screw head **64**. The locking thread pattern **62** has a reduced pitch at the bottom of the threaded end **61** such that the screw **60** is self-locking. However, it is appreciated that the threaded pattern **62** may be any of the means for locking a screw well known by those skilled in the art.

Referring to FIGS. 2 and 8, the threaded end **61** of the screw **60** passes through the central opening **18** of the top member **14** and the threaded pattern **62** threads into the threaded aperture **45** of the spinal fusion implant **40**. The screw head **64** fits within the countersunk recess **19** of the top member **14** such that the screw head **64** is at or below the plane of the upper surface **20** of the top member **14**. In the preferred embodiment, the central opening **18** has a diameter ranging from 4.5 mm to 5.5 mm, with 5.0 mm being the preferred diameter. The countersunk recess **19** has a diameter in the range of 6.0 mm to 8.0 mm with 7.0 mm being the preferred diameter.

Referring to FIGS. 15A, 15B, and 15C, an enlarged cross sectional view of three different embodiments of a securing means **65** for locking the screw **60** once it is threaded to the spinal fusion implant **40** are shown. In FIG. 15A, the securing means **65** comprises a notch **66** in the surface **20** of the top member **14** which is preferably made of metal. Once the screw **60** is threaded and securely tightened to the spinal fusion implant **40**, a chisel C is used to bend a portion **67** of the top member **14** into the central opening **18** and against the screw head **64** so as to prevent the outward excursion and any unwanted loosening of the screw **60**.

In FIG. 15B, a second embodiment of the securing means **65a** is shown comprising a central score **66a** concentric with the central opening **18**. A screw **60a** having a slot **61a** in the screw head **64a** is threaded and securely tightened to the spinal fusion implant **40**. An instrument T is partially inserted into slot **61a** after which an impaction force F_i is applied to the instrument T to spread apart the screw head **64a** in the direction of the arrows A so that the screw head **64a** becomes deformed from the impaction force F_i and fits within the central score **66a**. Once the screw head **64a** is in the central score **66a**, the outward excursion of the screw **60a** is prevented by the top lip **68** of the central score **66a**.

In FIG. 15C, a third embodiment of the securing means **65b** is shown comprising a screw **60b** having a screw head

64b with a slightly flanged portion **69b** near the top and a slot **61b**. The central opening **18** has along its circumference a recess **66b** for receiving the flanged portion **69b** of the screw head **64b**. The securing means **65b** relies on the natural resiliency of the metal screw head **64b** such that when the screw **60b** is being driven by a screw driver, the screw head **64b** flexes in the direction of the arrows B. In this manner, the flanged portion **69b** of the screw head **64b** slides along the interior of the central opening **18** so that the screw head **64b** is below the top lip **68b** of the recess **66b**. Once the screw driver is removed from the screw **60b**, the screw head **64b** returns to its natural state in the direction opposite to the arrows B so that the flanged portion **69b** is within the recess **66b**. The outward excursion of the screw **60** is thus prevented by the top lip **68b** which blocks the screw head **64b** by catching the flanged portion **69b**.

FIGS. 16A–18 show the instrumentation used for installing the spinal fixation device **10**. Referring to FIG. 16A, a driving instrument **80** used for inserting the spinal fixation device **10** into the vertebrae V is shown having a hollow tubular shaft **82** which terminates at one end to a bottom flat member **84** and terminates to a top flat member **86** at the other end. The bottom flat member **84** is preferably configured so that it conforms to the shape of the top member **14** of the staple member **12** and has a central hollow portion **89** for receiving the alignment rod **70**.

The driving instrument **80** has a pair of short posts **88a** and **88b** extending from the bottom flat member **84**. The posts **88a** and **88b** are oriented on the bottom flat member **84** so as to correspond to the position of the openings **22a** and **22b** in the upper surface **20** of the top member **14** of the staple member **12**. Each of the posts **88a** and **88b** fit into each of the openings **22a** and **22b** and keep the staple member **12** aligned on the bottom flat member **84** of the driving instrument **80**. It is appreciated that the openings **22a** and **22b** in the top member **14** may be depressions within the surface **20** of the top member **14** or may be holes that pass through the top member **14**. In the preferred embodiment, the openings **22a** and **22b** gave a diameter ranging from 1.5 mm to 3.5 mm, with 2.5 mm being the preferred diameter.

Referring to FIG. 16B, an alternative embodiment of the driving instrument **80'** which is used for inserting into the vertebrae V the spinal fixation device **210**, described in detail below in reference to FIG. 26, is shown having a hollow tubular shaft **82'** which terminates at one end to a bottom flat member **84'** and terminates to a top flat member **86'** at the other end. The bottom flat member **84'** is rectangular in shape so that it conforms to the shape of the top member **214** of the spinal fixation device **210** and has a central hollow portion **89'** for receiving the alignment rod **70**.

The driving instrument **80'** has a set of short posts **88'a**, **88'b**, **88'c** and **88'd** extending from the bottom flat member **84'**. The posts **88'a**–**88'd** are oriented on the bottom flat member **84'** so as to correspond to the position of the openings **222a**–**222d** of the spinal fixation device **210** and keep the spinal fixation device **210** aligned on the bottom flat member **84'** of the driving instrument **80'**.

Referring to FIG. 17A, an alignment rod **70** comprising a cylindrical shaft **72** having a smooth exterior surface **73** and a threaded end **74** may be threadably attached to the threaded aperture **45** of the spinal fusion implant **40** is shown. The alignment rod **70** fits through the central opening **18** of the spinal fixation device **10** and is used to properly align the projections **16** and **17** on each side of the spinal fusion implant **40** prior to engaging the vertebrae V. Further, the

alignment rod **70** also serves as a guide post for the drilling template instrument **50** described in greater detail below.

Referring to FIG. 17B, as an alternative embodiment of the alignment rod **70**, a splined alignment rod **70'** that has a finely splined surface **72'** along its longitudinal axis and a threaded end **74'** that may be attached to the threaded aperture **45** of the spinal fusion implant is shown.

Referring to FIG. 18, a drilling template instrument **50** for creating a pair of insertion holes **53a** and **53b** in each of the vertebrae **V** for receiving each of the projection **16** and **17** respectively is shown. The drilling template instrument **50** has a template **52** with a central aperture **54** therethrough and guide passages **55** and **56** for guiding a drill bit **51** of a drilling tool. Attached to the template **52** is a handle **58** which angles away from the template **52** so as not to obstruct the line of sight of the surgeon and to allow easy access to the template **52** and easy access to the guide holes **55** and **56** for the drill bit **51**. Extending from the center of the bottom surface of the template **52** is a central member **59** (similar in structure and function to the central bar **35**) for mating to an already implanted intervertebral spinal fusion implant **40**. The central member **59** interdigitates with the depression **42** of the spinal fusion implant **40** so that the template **52** is properly oriented about the spinal fusion implant **40** and the guide holes **55** and **56** are properly oriented with respect to the vertebrae **V** adjacent to the spinal fusion implant **40**. The alignment rod **70** serves as a guide post for the drill template instrument **50** as it fits through the central aperture **54** of the template **52** and aligns the template **52** with respect to the spinal fusion implant **40** and insures that it is coaxial. The central aperture **54** of the drilling template instrument **50** is smooth so that if it is placed over a splined alignment rod **70'** the drilling template instrument **50** may be easily rotated about the splined alignment rod **70'** into position such that the central member **59** is able to mate and interdigitate with the depression **44** of the spinal fusion implant **40**.

Referring to FIGS. 19–24, the spinal fixation device **10** of the present invention is inserted in the following manner: At least one spinal fusion implant **40** is surgically implanted so that it is substantially within the disc space between two adjacent vertebrae **V** and engages at least a portion of each of the two adjacent vertebrae **V**. Once the spinal fusion implant **40** is in place, the alignment rod **70** is attached to the threaded aperture **45** of the spinal fusion implant **40**. The alignment rod **70** serves as a guide post for the drilling template instrument **50** as it fits through the central aperture **54** of the template **52** and aligns the template **52** coaxially with respect to the spinal fusion implant **40**.

Referring to FIG. 20, once the template **52** is properly aligned and the drilling template instrument **50** is seated so that the central member **59** interdigitates with the spinal fusion implant **40**, the insertion holes **53a** and **53b** are drilled in each of the adjacent vertebrae **V** with a drilling instrument having a drill bit **51** with a diameter that is substantially smaller than the diameter of each of the projections **16** and **17** of the staple member **12**.

Once the drilling of the insertion holes **53a** and **53b** is completed, the drill template instrument **50** is removed from the spinal fusion implant **40** and from the alignment rod **70**. The alignment rod **70** is left in place attached to the threaded aperture **45** of the spinal fusion implant **40**.

Referring to FIG. 21, the staple member **12** is placed onto the driving instrument **80** used for driving and fixing the staple member **12** into the vertebrae **V** so that the bottom flat member **84** and the posts **88a** and **88b** are aligned with the top member **14** and the depressions **22a** and **22b** of the top

member **14**. The alignment rod **70** serves as a guide post for the staple member **12** as it fits through the central opening **18** of the staple member **12** and aligns the staple member **12** coaxially with respect to the spinal fusion implant **40**.

Referring to FIG. 22, once the staple member **12** is properly placed onto the bottom flat member **84** of the driving instrument **80**, the staple member **12** and the driving instrument **80** are aligned with respect to the alignment rod **70** so that the alignment rod **70** passes through the central opening **18** of the staple member **12** and is inserted into the central hollow portion **89** of the driving instrument **80**. The staple member **12** and the driving instrument **80** are then lowered along the alignment rod **70** so that the sharp distal end **32** of each of the projections **16** and **17** comes into contact with the external surface of the vertebrae **V** and is aligned with the previously drilled insertion holes **53a** and **53b**.

As shown in FIG. 22A, it is preferred that the insertion holes **53a** and **53b** be drilled so that when the projections **16** and **17** are inserted into the holes **53a** and **53b**, the inclined inner surface **36** of each of the projections **16** and **17** contacts the inner wall **W** of the insertion holes **53a** and **53b** that is closest to the spinal fusion implant **40**. In this manner a compression force **F** is created as each of the projections **16** and **17** of the staple member **12** is inserted into insertion holes **53a** and **53b**, respectively, compressing the bone of the vertebrae **V** toward the spinal fusion implant **40**.

Referring to FIG. 23, the staple member **12** is then driven into the vertebrae **V** by applying a high impact force to the driving instrument **80** with a hammer **H** or other impacting means against the top flat member **86** of the driving instrument **80**. The staple member **12** is driven into the vertebrae **V** such that the projections **16** and **17** are moved forward into the insertion holes **53a** and **53b**, respectively, until the bottom surface **30** of the top member **14** of the staple member **12** comes to rest against the surface of the vertebrae **V**.

Referring to FIGS. 23–24, the driving instrument **80** is lifted away from the alignment rod **70** so that the alignment rod **70** is no longer within the central hollow portion **89** of the driving instrument **80**. The alignment rod **70** is unthreaded from the threaded aperture **45** and is removed from the spinal fusion implant **40**. The staple member **12** is secured to the spinal fusion implant **40** with the locking screw **60** which has a threaded pattern **62** with a reduced pitch. The reduced pitch of the locking screw **60** locks the locking screw **60** to the spinal fusion implant **40** with minimal turning of the locking screw **60** and prevents any unwanted loosening. Further, any of the three embodiments of the securing means **65**, **65a** or **65b** described above in reference to FIGS. 15A–15C may be used to further prevent any unwanted loosening and outward excursion of the screw **60**.

Referring back to FIG. 12, once the staple member **12** is driven into the vertebrae **V** and is secured to the spinal fusion implant **40**, the spinal fusion implant **40** is prevented from rotating along its rotational axis **R** by its connection to the staple member **12** which is fixated across the disc space between the vertebrae **V**. The staple member **12** is prevented from backing out from the vertebrae **V** along the longitudinal axis **L** by its connection to the spinal fusion implant **40** and by the segmented and ratcheted portions **34** of the projections **16** and **17**. In this manner, the staple member **12** and the spinal fusion implant **40** interact to prevent the dislodgement of each other from the vertebrae **V** in which they are implanted. Thus, the staple member **12** is made safe

against dislodgement by attachment to the spinal fusion implant **40** and the stability of the spinal fusion implant **40** is assured as it is also stabilized by the staple member **12** and each works in connection with the other to remove the only remaining degree of freedom that would allow for the disengagement of either. In addition, the incline-planed inner surface **36** at the distal end **32** of the projections **16** and **17** forces bone toward the spinal fusion implant **40** along force lines F to further secure the spinal fusion implant **40** and further prevent the dislodgement of the spinal fusion implant **40**.

It is appreciated by those skilled in the art that when the bone of the vertebrae V is sufficiently soft, a shorter method (hereinafter referred to as the "Short Method") of inserting the spinal fixation device **10** is possible by omitting the steps of drilling the insertion holes **53a** and **53b** prior to inserting the staple member **12** into the vertebrae V.

Referring to FIG. 22, in the Short Method, the splined alignment rod **70'** that is finely splined along its longitudinal axis is used instead of the alignment rod **70**. Once the splined alignment rod **70'** has been attached to the spinal fusion implant **40**, the staple member **12** may be placed over the splined alignment rod **70'** so that the splined alignment rod **70'** passes through the aperture **18** and into the central aperture **89** of the driving instrument **80**. The central aperture **89** of the driving instrument **80** is correspondingly splined to the splines of the splined alignment rod **70'** so that the staple member **12** can be aligned with respect to the spinal implant **40**. The alignment of the staple member **12** and the driving instrument **80** is maintained as the corresponding splines of the central aperture **89** interdigitate with the splines of the splined alignment rod **70'** and prevent the rotation of the staple member **12** about the splined alignment rod **70'**. The prevention of rotation about the splined alignment rod **70'** is especially important when the Short Method is used to insert the spinal fixation device **10**, as no insertion holes **53a** and **53b** have been drilled in the vertebrae V. The staple **12** can be driven directly into the vertebrae V by the application of a high impaction force to the driving instrument **80** as described above and shown in FIG. 22.

Once the staple member **12** is driven into the vertebrae V, the steps of the longer method described above are used to secure the spinal fixation device to the spinal fusion implant **40** are the same. The Short Method of inserting the staple member **12** reduces the amount of time required to insert and secure the spinal fixation device **10** of the present invention and thus reduces the overall duration of the spinal fixation surgical procedure.

While the present invention has been described with respect to its preferred embodiment, it is recognized that alternative embodiments of the present invention may be devised without departing from the inventive concept.

For example, referring to FIG. 25, a first alternative embodiment of a spinal fixation device **110** having a staple member **112** with a top member **114** generally in the shape of an elongated oval having two curved sides **124a** and **124b** is shown. In this alternative embodiment, the curved sides **124a** and **124b** have upper edges **125a** and **125b**, respectively, that are radiused to conform to the external curvature of the vertebrae V thereby creating smooth contoured surfaces as described above for the spinal fixation device **10**, the preferred embodiment of the present invention. The top member **114** has openings **122a** and **122b** in the upper surface **120** of the top member **114** and has two projections **116** and **117** depending downwardly from the bottom surface **130** of the top member **114** at opposite ends

of the staple member **112**. The projections **116** and **117** are the same as the projections **16** described above for the preferred embodiment.

Referring to FIG. 26, a second alternative embodiment of the spinal fixation device **210** having a staple member **212** is shown with a top member **214** that is generally rectangular in shape and has an upper surface **220** with openings **222a**, **222b**, **222c**, and **222d**. The top member **214** has four projections **216**, **217**, **218**, and **219** depending from its bottom surface at each of its corners. The projections **216–217** are the same as the projections **16** and **17** described above in the preferred embodiment. The top member **214** has four straight sides **228a**, **228b**, **228c**, and **228d** having upper edges **225a**, **225b**, **225c**, and **225d**, respectively, that are radiused to conform to the external curvature of the vertebrae V create a smooth surface as described above for the preferred embodiment. The driving instrument **80'** shown in FIG. 16B is used to insert the spinal fixation device **210**.

Referring to FIG. 27, a third alternative embodiment of the spinal fixation device **310** having a staple **312** with a top member **314** that is generally triangular is shown. The top member **314** has two projections **316** and **317** depending from the bottom surface of the top member **314** that engage the vertebrae V. Extending from the center of the bottom surface of the top member **314** is a central member **390** which is similar to the central bar **35** of the preferred embodiment of the spinal fixation device **10** in that the central member **390** interdigitates with the depression **44** of the spinal fusion implant **40**. However, the central bar **390** also has an extension arm **392** that extends laterally from the top member **314** to span the diameter of an adjacent spinal fusion implant **41**. The extension arm **392** interdigitates with the depression **44** of the spinal implant **41**. The extension arm **392** has a central aperture **394** for receiving a screw **60b** used to couple the extension arm **392** to the spinal fusion implant **41**. In this manner, a single spinal fixation device **310** is capable of interdigitate with two adjacent spinal fusion implants **40** and **41** to lock and prevent the rotation and any excursion of the spinal fusion implants **40** and **41**. The fixation of two spinal fusion implants **40** and **41** is possible while leaving no protruding metal, such as the top member **314**, on the side of the spine where the vessels are located in close approximation to the vertebrae as is the case with the L₄ and L₅ vertebrae where the vessels are located over the left side of those vertebrae. It is appreciated that any of the securing means **65–65b**, described above may be used to lock the screw **60b** to the extension arm **392**.

Referring to FIG. 28, a fourth alternative embodiment of the spinal fixation device **410** having a staple member **412** with a top member **414** that is generally triangular in shape is shown in the installed position. The top member **414** is wider and larger than top member **14** as it is used with an implant **440** having a large diameter in the range of 22.0 mm to 28.0 mm. The top member **414** needs to be wider when used with implant **440** in order to provide a central bar **435** of sufficient length to interdigitate and mate with the depression **444** of the implant **440** in order to prevent its rotation. Further, the top member **414** is tapered at portion **416** so as not to cause erosion or pressure against the vessels that may be present in the area of the spine adjacent to the portion **416** of the top member **414**.

Referring to FIGS. 29–32, a fifth alternative embodiment of the spinal fixation device **510** with a staple member **512** having a generally rectangular top member **514** is shown. The staple member **512** is similar in structure to the staple **212** described above except that the top member **514** has

multi-pronged projection blades **516** and **517** depending from its lower surface **530** as shown in FIG. **30**. The multi-pronged projection blades **516** and **517** have the same function and similar structure as the projections **16** and **17** described above and include segmented and ratcheted portions **534** which are similar in design are function to segmented and ratcheted portions **34**. The multi-pronged blade projections **516** and **517** offer the added advantage of increasing the strength and stability of the staple member **514** once it is inserted into the bone of the vertebrae **V** providing a greater area of engagement of the staple member **512** to the vertebrae **V**.

The lower surface **530** has knobs **532** and **534** extending therefrom for engaging and interdigitating with a spinal implant **540** having an insertion end **541** with openings **542** and **544** for receiving knobs **532** and **534** respectively.

Referring to FIGS. **31** and **32**, the spinal fusion implant **540** is shown inserted within the disc space between two adjacent vertebrae **V**. The spinal implant **540** is generally rectangular in shape. The multi-prong blade projections **516** and **517** have a width that is approximately equal or slightly less than the width of the spinal fusion implant **540**. Once inserted, the spinal fixation device **510** compresses the bone of the vertebrae **V** towards the spinal fusion implant **540** as discussed above in reference to FIG. **12**. The spinal fixation device **510** may be secured to the spinal fusion implant **540** with a screw **60** as discussed above.

The spinal fixation device **510** having a staple member **512** is the preferred embodiment of the present invention for use with a multi-segmental spinal alignment means **600** described in greater detail below in that the staple **512** provides a more solid anchoring means that can resist greater torsion forces resulting from the application of the multi-segmental spinal alignment means **600** to align the spine.

Alternatively, for all of the embodiments described above, the spinal fixation device **10** of the present invention could be made of resorbable materials, such as bio-compatible resorbable plastics, that resorb at an appropriate rate such that once the spinal fixation device **10** is no longer needed (i.e. when spinal fusion is complete) the body would resorb the spinal fixation device **10**. One such resorbable material is polylactone, however any other resorbable plastic or other material safely usable within the human body are also within the scope of the present invention.

Further, the spinal fixation device could be only in part resorbable such that the projections **16** and **17** of the staple member **12** would be non-resorbable and would remain incarcerated in the vertebrae **V** and sealed off once the resorbable portion of the staple is resorbed by the body.

Referring to FIGS. **33** and **34**, as a further application, the spinal fixation device **510** of the present invention may be used as an anchor for a multi-segmental spinal alignment means **600**, such that a multiplicity of spinal fixation devices may then be interconnected via a cable, rod, bar, or plate, so as to achieve or maintain any desired multi-segment spinal alignment. In the preferred embodiment, the multi-segmental spinal alignment means **600** comprises more than one spinal fixation device **510** of the present invention placed in series along the spine such that each spinal fixation device **510** spans one disc **D** and engages two adjacent vertebrae **V**. The spinal fixation device **510** is preferred over the other embodiments of the present invention in that it has a greater area of engagement with the vertebrae **V** so as to provide a solid anchoring means for the multi-segmental spinal alignment means **600**. However, it is appreciated that

other embodiments including but not limited to those described herein may be utilized as anchoring means for the multi-segmental spinal alignment means **600**.

When used as an anchor, each spinal fixation device **510** interdigitates with and is connected to a spinal fusion implant **610** having an insertion end **612**, an interior chamber **614** and is inserted in the disc space between the two adjacent vertebrae. The spinal fusion implant **610** has a threaded blind hole **620** for receiving a threaded post **622** therein. The blind hole **620** has a casing that is made of strong surgically, implantable material such as, but not limited to titanium. The casing **624** extends from the insertion end **612** of the spinal fusion implant **610** into the interior central chamber **614**. The insertion end **612** has a rigid construction that is capable of withstanding high torsion forces resulting from the tensioning of the multi-segmental spinal alignment means to align segments of the spine. In the preferred embodiment, the insertion end **612** of the spinal fusion implant has an end portion **626** that closes the insertion end **612**. The end portion is substantially thicker than the rest of the spinal fusion implant **610** and in the preferred embodiment, the end portion **626** has thickness ranging from 1.5 mm to 4.0 mm, with 2.5 mm being the preferred thickness.

Referring to FIG. **34**, the threaded post **622** has a threaded end **628** with a locking thread pattern that is substantially longer than the locking thread pattern **62** of the screw **60** described above and a head portion **630** having a hole **632** for receiving a rod **634** or a cable therethrough. The head portion **630** has a rounded exterior surface to prevent any damage such as aortic erosion to the vessels in the area adjacent to the spine. In the preferred embodiment the threaded post has a diameter ranging from 3.0 mm to 6.0 mm, with 4.5 mm being the preferred diameter and has a length ranging from 15.0 mm to 25.0 mm, with 20.0 mm being the preferred length. The head portion **630** extends at a height above the top member **514** of the spinal fixation device **510** of approximately 8.0 mm to 16.0 mm, with 12.0 mm being the height preferred once it is threadably attached to the spinal fusion implant **610** such that it does not significantly protrude from the spinal column into the tissue and vessels adjacent thereto.

Once the threaded post **622** is attached to the spinal fusion implant **610**, the head portion **630** of each threaded post **622** are connected to one another by the rod **634** having a sufficient diameter to fit through the hole **632** of each head portion **630**. The rod **634** has at least a portion thereof that is threaded so that a plurality of lock nuts **638** may be used to secure the rod **634** to the head portions **630**. The lock nuts **638** may also be used as length adjusting means to adjust the length of the rod **634** between head portions **630** so that segmental portions of the spine may be held closer together or held further apart for the purposes of aligning the spine. It is appreciated that a plurality of multi-segmental spinal alignment means **600** may be placed in series either on one side or on opposite sides of the spine, such that one side of the spine may be extended while the other side may be held stationary or may be compressed in order to achieve proper spinal alignment. The multi-segment spinal alignment may be maintained by keeping the rod tensioned with the lock nuts **638** or by any other means well known by those skilled in the art. It is also appreciated that in place of a rod **634** a cable, a plate or any other means well known by those skilled in the art may be used to interconnect the multi-segmental spinal alignment means.

Referring to FIG. **35**, a sixth alternative embodiment of the spinal fixation device of the present invention is shown

and generally referred to by the numeral **710**. The spinal fixation device **710** comprises a top member **714** that is similar to the top member **14** described above, except that it does not have projections **16** and **17** extending from the bottom surface. Like numbers are being used to designate identical features of the top members **14** and **714**.

In the top member **714**, instead of having projections **16** and **17**, independent projection members **716** and **717** in the form of screws are used to secure the top member **714** of the spinal fixation device **710** to the vertebrae **V** of the spine. The projection screw members **716** and **717** each terminate in a sharp distal end **720** and **722** respectively, have a threaded portion **723**, and have screw heads **724** and **726** for engaging a screw driver or similar driving instrument.

The top member **714** has a hole **728** on one end and a hole **730** at its other end through which each of the projection screw members **716** and **717** respectively, may pass. The projections screw members **716** and **717** pass through the holes **728** and **730** to engage the vertebrae **V**. Each of the holes **728** and **730** has a concentric counter sunk recess **732** for receiving and seating the screw heads **724** and **726** of the projection screw members **716** and **717** so that the screw heads **724** and **726** are flush or below the top surface **20** of the top member **714** once inserted into the vertebrae **V**.

As the projection screw members **716** and **717** are threaded, they can be rotationally advanced into the vertebrae instead of by way of an impaction force such that the potential for damage to the vertebrae **V** is reduced. The threads of the threaded portion **723** follow one another as the projection screw members **716** and **717** are being screwed into the bone such that the integrity of the vertebrae **V** is preserved. Also, as the projection screw members **716** and **717** are independent from the top member **714**, the penetration depth of the spinal fixation device **710** into the bone of the vertebrae **V** may be easily altered by selecting different sized projection screw members **716** and **717** appropriate for the particular vertebrae being fused. Further, it is possible to configure the holes **728** and **730** in the top member **714** such that the projection screw members **716** and **717** may be inserted into the vertebrae **V** from a number of different angles relative to the top member **714**.

Adjacent and proximate to each of the holes **728** and **730** are threaded openings **740** and **742**, respectively, for receiving locking screws **744** and **746** respectively. Each of the locking screws **744** and **746** have a head portion **750** and a locking thread portion **754** for threadably and lockably engaging the threaded openings **740** and **742**. The locking screws **744** and **746** are attached to the top member **714** after the projection screw members **716** and **717** have been inserted into the vertebrae **V**. At least a part of the head portion **750** and **752** blocks and preferably makes contact with the screw projections **716** and **717** to prevent any unwanted loosening and outward excursion of the screw projections **716** and **717**.

It is appreciated that the projection members **716** and **717**, instead of being threaded screws, may have a number of other configurations such as, but not limited to, the configurations of the projections described above for the various embodiments of the present invention. If the projections members **716** and **717** are ratcheted instead of being threaded, they can be driven into the vertebrae **V** with a driving instrument and impaction force as described above for the method of the present invention.

While the present invention has been described with respect to its preferred embodiment and a number of alternative embodiments, it is recognized that additional varia-

tions of the present invention may be devised without departing from the inventive concept and scope of the present invention.

What is claimed is:

1. A spinal fixation apparatus for stabilizing a segment of a human spine, said apparatus comprising:

an interbody spinal fusion implant adapted to be surgically implanted at least in part within the disc space between the vertebral bodies of two adjacent vertebrae, said spinal implant having upper and lower surfaces for bearing upon, supporting, aligning, and spacing apart each of the adjacent vertebral bodies, said implant having at least one opening through each of said upper and lower surfaces to allow bone growth from adjacent vertebral body to adjacent vertebral body through said implant sufficient to permit spinal fusion; and

a spinal fixation device comprising:

a top member of sufficient length to span the disc space between the two adjacent vertebral bodies but not greater than the distance along a spinal segment defined by the two adjacent vertebral bodies and the disc space to be fused, said top member having an upper surface and a lower surface, said lower surface adapted for placement in close proximity to the spine, said lower surface of said top member having contact portions adapted to be in contact with the vertebral bodies of the two adjacent vertebrae;

at least a first projection and a second projection fixedly depending downwardly from said top member, said first projection adapted for insertion by an impaction force into a first of the two adjacent vertebral bodies, said second projection adapted for insertion by an impaction force into a second of the two adjacent vertebral bodies; and

means for coupling said top member to said spinal implant.

2. The spinal fixation apparatus of claim 1 in which each of said at least first and second projections has a distal end that is sharpened to facilitate insertion of said projections into the two adjacent vertebral bodies.

3. The spinal fixation device of claim 2 in which each of said first and second projections has a mid-longitudinal axis and wherein each of said sharpened distal ends end at a point offset from the mid-longitudinal axis of each of said first and second projections.

4. The spinal fixation apparatus of claim 1 further comprising means for preventing excursion of said projections from within the two adjacent vertebral bodies in a direction opposite to the direction of insertion of said projections once each of said projections is inserted into the vertebral bodies.

5. The spinal fixation apparatus of claim 4 in which said means for preventing excursion comprises said projections having a plurality of ratcheted portions.

6. The spinal fixation apparatus of claim 5 in which said plurality of ratcheted portions have a cross sectional area that increases in the direction toward said top member.

7. The spinal fixation apparatus of claim 1 further comprising means for interdigitating said spinal fixation device with said spinal implant, said interdigitating means being interposed between said first and second projections.

8. The spinal fixation apparatus of claim 7 in which said interdigitating means is capable of mating with a complementary portion of said spinal implant.

9. The spinal fixation apparatus of claim 7 in which said interdigitating means is capable of engaging more than one spinal implant surgically implanted in the same disc space between the two adjacent vertebral bodies.

19

10. The spinal fixation apparatus of claim 1 further comprising an extension arm extending from said top member.

11. The spinal fixation apparatus of claim 1 further comprising means for lockably securing said spinal fixation device to said spinal implant.

12. The spinal fixation apparatus of claim 1 in which said top member includes means for removably engaging a driver for driving said spinal fixation device.

13. The spinal fixation apparatus of claim 12 in which said means for removably engaging a driver comprises at least one opening in said top member for engaging said driver.

14. The spinal fixation apparatus of claim 1 in which said top member has at least one edge having a configuration that is selected from the group consisting of: radiused, chamfered, rounded, tapered, beveled and thinned.

15. The spinal fixation apparatus of claim 1 in which at least a portion of said spinal fixation device is made of a resorbable material.

16. The spinal fixation apparatus of claim 1 in which at least a portion of said spinal fixation apparatus comprises a bone fusion promoting material other than bone to facilitate the spinal fusion process.

17. A method for affixing a spinal fixation device, having a staple comprising of a top member with a plurality of downwardly depending projections and an aperture therebetween, to the vertebral bodies of the vertebrae adjacent to a spinal implant surgically implanted in the disc space between the adjacent vertebral bodies, said method comprising the steps of:

attaching to said spinal implant an alignment rod having an end portion capable of engaging the spinal implant; aligning said spinal fixation device with respect to said spinal implant by passing said alignment rod through the aperture of said staple, at least one of each of said plurality of projections contacting one of each of the vertebral bodies adjacent to the spinal implant;

engaging said alignment rod to a driving instrument having a hollow shaft for receiving said alignment rod, said shaft terminating at one end to a bottom member and terminating at its other end to a top portion, said bottom member having means for removably engaging the spinal fixation device, said top portion having an outer surface for receiving an impaction force applied thereto;

driving said spinal fixation device to insert said plurality of projections into the vertebral bodies of the vertebrae with said driving instrument by applying an impaction force to said driving instrument;

disengaging said driving instrument from said alignment rod;

removing said alignment rod from the spinal implant; and fixing said spinal fixation device to the spinal implant with means for lockably securing said spinal fixation device to the spinal implant.

18. The method of claim 17 in which said alignment rod and said driving instrument cooperate to prevent rotation therebetween.

19. The method of claim 17 further including the step of creating insertion holes into the vertebral bodies of the adjacent vertebrae for receiving said plurality of projections therein prior to driving said plurality of projections into the vertebral bodies.

20. The method of claim 19 in which the step of creating insertion holes includes the steps of providing a drilling template having means for aligning said drilling template

20

with the spinal implant and means for guiding a drill used to create the insertion holes; aligning said drilling template with the spinal implant; providing a drill; guiding the drill thereby creating the insertion holes.

21. A multi-segmental spinal alignment apparatus for aligning one or more segments of the spine, each segment having a disc space and two vertebrae adjacent the disc space, said apparatus comprising:

(a) a plurality of spinal fixation devices for stabilizing the spine inserted into the vertebrae of the spine, each of said plurality of spinal fixation devices comprising:

a staple member having a top member of sufficient length to span the disc space between the two adjacent vertebrae;

at least two projections depending downwardly from said top member, each of said projections capable of being inserted into one of the two adjacent vertebrae; coupling means for coupling said staple member to a spinal implant surgically implanted in the disc space between the two adjacent vertebrae;

(b) connecting means for connecting said plurality of spinal fixation devices;

(c) alignment means for aligning said plurality of spinal fixation devices; and

(d) a plurality of spinal implants surgically implanted in the disc spaces between a plurality of adjacent vertebrae, at least one of said plurality of spinal implants having upper and lower surfaces for bearing upon, supporting, and spacing apart two adjacent vertebrae, each of said plurality of spinal implants having a receiving means for receiving said connecting means for connecting said plurality of spinal fixation devices.

22. The apparatus of claim 21 in which said alignment means comprises tensioning means for tensioning said connecting means for connecting said plurality of spinal fixation devices to align segments of the spine.

23. The apparatus of claim 21 in which said connecting means comprises linking means for linking more than one connecting means, a plurality of post members each having a head portion and an end portion for coupling to said plurality of spinal implants, said head portion having means for engaging said linking means.

24. The apparatus of claim 23 in which each of said plurality of spinal implants has a means for receiving said end portion of each of said plurality of post members.

25. The apparatus of claim 21 in which said at least two projections comprise multipronged projection blades.

26. A spinal fixation apparatus for stabilizing a segment of a human spine, said apparatus comprising:

an interbody spinal fusion implant made of a material other than bone and adapted to be surgically implanted at least in part within the disc space between the vertebral bodies of two adjacent vertebrae, said spinal implant having upper and lower surfaces for bearing upon, supporting, aligning, and spacing apart each of the adjacent vertebral bodies, said implant having at least one opening through each of said upper and lower surfaces to allow bone growth from adjacent vertebral body to adjacent vertebral body through said implant sufficient to permit spinal fusion; and

a spinal fixation device comprising:

at least a first projection member capable of being inserted into a first of the two adjacent vertebral bodies, at least a second projection member capable of being inserted into a second of the two adjacent vertebral bodies;

a top member of sufficient length to span the disc space between the two adjacent vertebral bodies but not greater than the distance along a spinal segment defined by the two adjacent vertebral bodies and the disc space, said top member having an upper surface and a lower surface, said lower surface adapted for placement in close proximity to the spine, said lower surface of said top member having contact portions adapted to be in contact with the two adjacent vertebral bodies, and said top member having means for engaging said projection member; and means for coupling said top member to said spinal implant, said spinal implant having means for cooperatively engaging said coupling means.

27. The spinal fixation apparatus of claim 26 in which said projection members are insertable through at least one opening in said top member, said projection members passing at least in part through said top member and substantially protruding from said lower surface of said top member.

28. The spinal fixation apparatus of claim 26 including means for lockably securing said projection members to said top member.

29. The spinal fixation apparatus of claim 26 in which each of said projection members has a distal end that is sharpened to facilitate insertion of said projection members into a respective one of the two adjacent vertebral bodies.

30. The spinal fixation apparatus of claim 29 in which each of said first and second projections has a mid-longitudinal axis and wherein each of said sharpened distal ends end at a point offset from the mid-longitudinal axis of said first and second projections.

31. The spinal fixation apparatus of claim 26 further comprising means for preventing excursion of said projection members from within the two adjacent vertebral bodies in a direction opposite to the direction of insertion of said projection members into the vertebral bodies once each of said projection members is inserted into the vertebral bodies.

32. The spinal fixation apparatus of claim 31 in which said means for preventing excursion comprises said projection members having a plurality of ratcheted portions.

33. The spinal fixation apparatus of claim 32 in which said plurality of ratcheted portions have a cross sectional area that increases in the direction toward said top member.

34. The spinal fixation apparatus of claim 26 further comprising means for interdigitating said spinal fixation device with said spinal implant.

35. The spinal fixation apparatus of claim 34 in which said interdigitating means is capable of mating with a complementary portion of said spinal implant.

36. The spinal fixation apparatus of claim 34 in which said interdigitating means is capable of engaging more than one spinal implant surgically implanted in the same disc space between the two adjacent vertebral bodies.

37. The spinal fixation apparatus of claim 26 further comprising an extension arm extending from said top member.

38. The spinal fixation apparatus of claim 26 in which said coupling means comprises means for lockably securing said top member to said spinal implant.

39. The spinal fixation apparatus of claim 26 in which said top member has means for removably engaging a driver for driving said projection members into the vertebral bodies.

40. The spinal fixation apparatus of claim 39 in which said means for removably engaging a driver comprises at least one opening in said top member for engaging said driver.

41. The spinal fixation apparatus of claim 26 in which said top member has at least one edge having a configuration that

is selected from the group consisting of: radiused, chamfered, rounded, tapered, beveled and thinned.

42. The spinal fixation apparatus of claim 26 in which at least a portion of said top member is made of a resorbable material.

43. The spinal fixation apparatus of claim 26 in which at least a portion of said at least two projection members is made of a resorbable material.

44. The spinal fixation apparatus of claim 26 in which at least a portion of said spinal fixation apparatus comprises a bone fusion promoting material other than bone to facilitate the bone fusion process.

45. A spinal fixation device for stabilizing a portion of a human spine for use in combination with an interbody spinal fusion implant adapted to be placed at least in part across a disc space between two adjacent vertebral bodies, said spinal fixation device comprising:

at least a first projection member capable of being inserted into the vertebral body of a first of two adjacent vertebrae, at least a second projection member capable of being inserted into the vertebral body of a second of the two adjacent vertebrae;

a top member of sufficient length to span the disc space between the two adjacent vertebral bodies but not greater than the distance along a spinal segment defined by the two adjacent vertebral bodies and the disc space, said top member having means for engaging said projection members, and a bottom surface for contacting the adjacent vertebrae, said bottom surface having means for interdigitating said top member with the spinal implant, said interdigitating means located between said first and second projection members; and means for coupling said top member to a spinal implant adapted to be surgically implanted at least in part within the disc space between the two adjacent vertebral bodies.

46. The spinal fixation device of claim 45 in which said interdigitating means comprises a depending member capable of interdigitating with a spinal implant having a depression on one end for receiving and mating said depending member.

47. The spinal fixation device of claim 45 in which said interdigitating means is capable of interdigitating more than one spinal implant surgically implanted in the same disc space between the two adjacent vertebral bodies.

48. The spinal fixation device of claim 47 in which said interdigitating means couples to a second spinal implant adapted to be surgically implanted within the disc space adjacent to said spinal implant.

49. The spinal fixation device of claim 45 in which said coupling means comprises means for lockably securing said top member to the spinal implant.

50. A spinal fixation device for stabilizing a portion of a human spine, comprising:

a top member of sufficient length to span the disc space between the vertebral bodies of two adjacent vertebrae; at least a first projection and a second projection fixedly depending downwardly from said top member, said first projection for insertion with an impaction force into a first of the two adjacent vertebral bodies, said second projection for insertion with an impaction force into a second of the two adjacent vertebral bodies, said first and second projections having means for forcing and compressing the bone of the adjacent vertebral bodies toward a spinal implant adapted to be surgically implanted at least in part within the disc space between

the two adjacent vertebral bodies when said first and second projections are inserted into the two adjacent vertebral bodies; and

means for coupling said top member to the spinal implant.

51. A spinal fixation apparatus for stabilizing a portion of a human spine, said spinal fixation apparatus comprising:

an interbody spinal fusion implant adapted to be surgically implanted at least in part within the disc space between the vertebral bodies of two adjacent vertebrae, said spinal implant having upper and lower surfaces for bearing upon, supporting, aligning, and spacing apart each of the adjacent vertebral bodies, said implant having at least one opening through each of said upper and lower surfaces to allow bone growth from adjacent vertebral body to adjacent vertebral body through said implant sufficient to permit spinal fusion; and

a spinal fixation device for engaging said spinal implant, comprising:

at least a first projection member capable of being inserted into a first of the two adjacent vertebral bodies, and at least a second projection member capable of being inserted into a second of the adjacent vertebral bodies;

a top member of sufficient length to span the disc space between the two adjacent vertebral bodies but not greater than the distance along a spinal segment defined by the two adjacent vertebral bodies and the disc space, said top member having means for engaging said projection members; and

a fixed engagement member fixedly attached to and depending downwardly from said top member for engaging said spinal implant, said engagement member being interposed between said first and second projections.

52. The spinal fixation apparatus of claim **51**, in which said fixed member is adapted to engage said spinal implant after said spinal implant is implanted at least in part within the disc space.

53. A spinal fixation apparatus for stabilizing a portion of a human spine, comprising:

an interbody spinal fusion implant adapted to be surgically implanted within the disc space between the vertebral bodies of two adjacent vertebrae and in contact with the two adjacent vertebral bodies, said spinal implant having upper and lower surfaces for bearing upon, supporting, aligning, and spacing apart each of the adjacent vertebral bodies, said implant having at least one opening through each of said upper and lower surfaces to allow bone growth from adjacent vertebral body to adjacent vertebral body through said implant sufficient to permit spinal fusion; and

a spinal fixation device for engaging said spinal implant, comprising:

at least a first projection member capable of being inserted into a first of two adjacent vertebral bodies, at least a second projection member capable of being inserted into a second of the two adjacent vertebral bodies;

a top member of sufficient length to span the disc space between the two adjacent vertebral bodies but not greater than the distance along a spinal segment defined by the two adjacent vertebral bodies and the disc space;

means for engaging said projection members to said top member; and

said top member including means for cooperatively engaging said top member to said spinal implant,

said cooperatively engaging means interposed between said first and second projection members.

54. The spinal fixation device of claim **53** including means for preventing excursion in a direction opposite to insertion comprising said projection members having a plurality of ratcheted portions.

55. The spinal fixation device of claim **54** in which said plurality of ratcheted portions have a diameter that increases in the direction toward said top member.

56. The spinal fixation device of claim **53** in which said cooperatively engaging means includes a member fixedly depending downwardly from said top member.

57. The spinal fixation device of claim **53** in which said cooperatively engaging means is a bar capable of engaging a spinal implant having a depression on one end for receiving said bar.

58. The spinal fixation device of claim **53** in which said cooperatively engaging means is capable of engaging more than one spinal implant surgically implanted in the same disc space between the two adjacent vertebral bodies.

59. The spinal fixation device of claim **58** in which said cooperatively engaging means comprises an extension arm extending from said top member.

60. The spinal fixation device of claim **53** in which said top member includes means for removably engaging a driver for driving said spinal fixation device.

61. The spinal fixation device of claim **59** in which said means for removably engaging a driver comprises at least one opening in said top member for engaging at least one post member extending from the driver.

62. The spinal fixation device of claim **53** in which said top member has at least one edge that is radiused, said top member conforming to the external curvature of the adjacent vertebral bodies.

63. The spinal fixation device of claim **62** in which at least a portion of said top member is made of a resorbable material.

64. The spinal fixation device of claim **62** in which at least a portion of said at least two projection members is made of a resorbable material.

65. The spinal fixation device of claim **63** further comprising a bone fusion promoting material to facilitate the bone fusion process.

66. The spinal fixation apparatus of claim **1** in which said top member is configured to generally conformed to the surface of the segment of the spine to which said top member is applied such that said top member does not significantly protrude from the surface of the segment of the spine.

67. The spinal fixation apparatus of claim **66** in which said top member is a single piece.

68. The spinal fixation apparatus of claim **1** in which said coupling means is positioned sufficiently central between said first and second portions so as to be in alignment with said spinal implant in the disc space.

69. A spinal fixation device for stabilizing a portion of a human spine in combination with an artificial interbody spinal fusion implant, comprising:

a top member having a lower surface for placement facing the spine, said top member generally conforming to the surface of a segment of the spine spanning the vertebral bodies of two adjacent vertebrae to which said spinal fixation device is to be applied but not greater than the distance along a spinal segment defined by the two adjacent vertebral bodies and the disc space;

at least a first and a second projection fixedly depending downwardly from said top member, said first projection

for insertion with an impaction force into a first of two adjacent vertebral bodies, said second projection for insertion with an impaction force into a second of the two adjacent vertebral bodies;

said artificial spinal implant adapted to be surgically implanted at least in part within the disc space between the two adjacent vertebral bodies, said spinal implant having upper and lower surfaces for bearing upon, supporting, aligning, and spacing apart each of the adjacent vertebral bodies, said implant having at least one opening through each of said upper and lower surfaces to allow bone growth from adjacent vertebral body to adjacent vertebral body through said implant sufficient to permit spinal fusion; and

said top member having means for interdigitating said spinal fixation device to said artificial spinal implant, said interdigitating means being interposed between said first and said second projections.

70. The spinal fixation apparatus of claim 7 having means for engaging a second implant implanted in the spine.

71. The spinal fixation apparatus of claim 34 having means for engaging a second implant implanted in the spine.

72. The spinal fixation apparatus of claim 27 in which said projection members are threaded at least in part.

73. The method of claim 20 in which the creating step includes the sub-step of creating insertion holes each having a mid-longitudinal axis that is not coaxial with the mid-longitudinal axis of each of said plurality of projections.

74. The apparatus of claim 26 in which said spinal implant has a maximum width and said top member has a maximum width less than the maximum width of said spinal implant.

75. The apparatus of claim 53 in which said spinal implant has a maximum width and said top member has a maximum width less than the maximum width of said spinal implant.

76. The apparatus of claim 26 in which said first and second projection members have a fixed distance therebetween at said top member.

77. The method of claim 17 further comprising the step of disengaging said driving instrument from said spinal fixation device prior to disengaging said driving instrument from said alignment rod.

78. The apparatus of claim 1 in which said upper and lower surfaces are arcuate and adapted to protrude into the adjacent vertebral bodies.

79. The apparatus of claim 1 in which said spinal implant is made of an artificial material other than bone.

80. The apparatus of claim 21 in which said plurality of spinal implants include at least one interbody spinal fusion implant.

81. The apparatus of claim 80 in which said interbody spinal fusion implant includes at least one opening through each of said upper and lower surfaces to allow bone growth from adjacent vertebral body to adjacent vertebral body through said implant sufficient to permit spinal fusion.

82. The apparatus of claim 21 in which said upper and lower surfaces are arcuate and protrude into the adjacent vertebral bodies.

83. The apparatus of claim 21 in which at least one of said plurality of spinal implants is made of an artificial material other than bone.

84. The apparatus of claim 26 in which said upper and lower surfaces are arcuate and adapted to protrude into the adjacent vertebral bodies.

85. The apparatus of claim 26 in which said spinal implant is made of an artificial material other than bone.

86. The apparatus of claim 50 further in combination with a spinal fusion implant adapted to be surgically implanted at

least in part within the disc space, said spinal implant having upper and lower surfaces for bearing upon, supporting, aligning, and spacing apart each of the adjacent vertebral bodies.

87. The apparatus and implant combination of claim 86 in which said spinal implant is an interbody spinal fusion implant.

88. The apparatus and implant combination of claim 87 in which said spinal implant includes at least one opening through each of said upper and lower surfaces to allow bone growth from adjacent vertebral body to adjacent vertebral body through said implant sufficient to permit spinal fusion.

89. The apparatus and implant combination of claim 86 in which said upper and lower surfaces are arcuate and protrude into the adjacent vertebral bodies.

90. The apparatus and implant combination of claim 86 in which said spinal implant is made of an artificial material other than bone.

91. The apparatus of claim 51 in which said upper and lower surfaces are arcuate and adapted to protrude into the adjacent vertebral bodies.

92. The apparatus of claim 51 in which said spinal implant is made of an artificial material other than bone.

93. The apparatus of claims 1 wherein said coupling means is adapted to couple said top member to said spinal implant after said spinal implant is surgically implanted at least in part within the disc space.

94. The spinal fixation apparatus of claim 1, wherein said spinal implant does not protrude beyond the outer perimeter of said disc space along the exterior surface of the adjacent vertebral bodies.

95. The spinal fixation apparatus of claim 1, wherein said spinal implant has a cross sectional dimension greater than 12 mm.

96. The spinal fixation apparatus of claim 1, wherein said coupling means is a threaded connector.

97. The spinal fixation apparatus of claim 26, wherein said spinal implant does not protrude beyond the outer perimeter of said disc space along the exterior surface of the adjacent vertebral bodies.

98. The spinal fixation apparatus of claim 26, wherein said spinal implant has a cross sectional dimension greater than 12 mm.

99. The spinal fixation apparatus of claim 26, wherein said interbody spinal fusion implant has a leading end and an opposite trailing end, said trailing end having a trailing surface for contacting said lower surface of said top member.

100. The spinal fixation apparatus of claim 45, wherein said spinal fusion implant has a cross sectional dimension greater than 12 mm.

101. The spinal fixation apparatus of claim 51, wherein said spinal implant comprises an osteogenic material other than bone.

102. The spinal fixation apparatus of claim 69, wherein said spinal implant comprises an osteogenic material other than bone.

103. The spinal fixation apparatus of claim 1, wherein said spinal implant has preformed surface protrusions for engaging the bone of the adjacent vertebral bodies.

104. The spinal fixation apparatus of claim 103, further comprising means for preventing excursion of said projections from within the two adjacent vertebral bodies in a direction opposite to the direction of insertion of said projections once each of said projections is inserted into the vertebral bodies.

105. The spinal fixation apparatus of claim 103, further comprising means for interdigitating said spinal fixation

29

device with said spinal implant, said interdigitating means being interposed between said first and second projections.

141. The spinal fixation apparatus of claim **140**, wherein said interdigitating means is capable of engaging more than one spinal implant surgically implanted in the same disc space between the two adjacent vertebral bodies. 5

142. The spinal fixation apparatus of claim **138**, further comprising means for lockably securing said spinal fixation device to said spinal implant.

30

143. The spinal fixation apparatus of claim **140**, wherein said interdigitating means is capable of engaging more than one spinal implant surgically implanted in the same disc space between the two adjacent vertebral bodies.

144. The spinal fixation device of claim **140**, wherein said interdigitating means include s a member fixedly depending downwardly from said top member.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,120,503
DATED : September 19, 2000
INVENTOR(S) : Gary Karlin Michelson

Page 1 of 1

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

Title page.

Item [54], after "APPARATUS" insert -- , --.

Signed and Sealed this

First Day of January, 2002

Attest:

A handwritten signature in black ink, appearing to read "James E. Rogan", written over a horizontal line.

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,120,503
DATED : September 19, 2000
INVENTOR(S) : Gary Karlin Michelson

Page 1 of 1

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

Column 27,

Line 4, change "meal" to -- means --.

Line 57, change "118" to -- 119 --.

Column 30,

Line 6, change "include s" to -- includes --.

Signed and Sealed this

Eleventh Day of March, 2003

A handwritten signature in black ink, appearing to read "James E. Rogan", written over a horizontal line.

JAMES E. ROGAN
Director of the United States Patent and Trademark Office