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Bonutti

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(54) **JOINT SPACER WITH COMPARTMENT FOR ORTHOBIOLOGIC MATERIAL**

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Related U.S. Application Data

(63) Continuation of application No. 10/163,480, filed on Jun. 5, 2002, which is a continuation of application No. 09/569,020, filed on Mar. 11, 2000, now Pat. No. 6,423,063, which is a continuation of application No. 09/137,443, filed on Aug. 20, 1998, now Pat. No. 6,099,531.

(51) **Int. Cl.**
A61B 17/68 (2006.01)

(52) **U.S. Cl.** **606/60**; 606/61; 606/76; 623/17.16

(58) **Field of Classification Search** 606/61, 606/60, 86; 623/16.11, 17.11, 17.16
See application file for complete search history.

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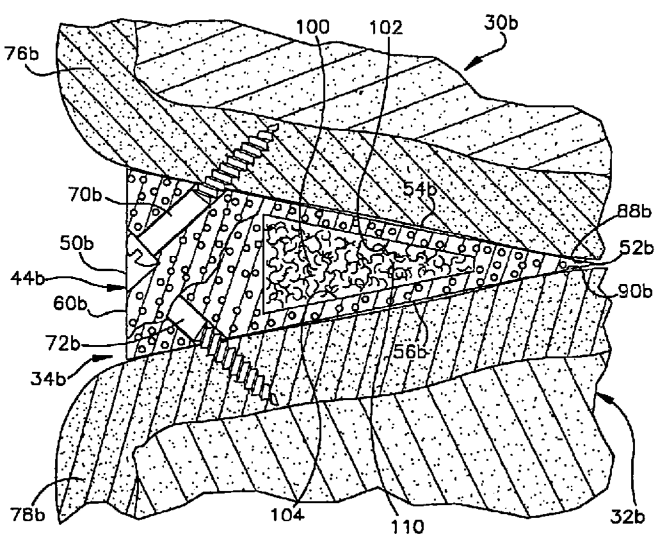
(57) **ABSTRACT**

To change a spatial relationship between two or more bones in a patient's body, a wedge member is moved into a joint between the bones. As the wedge member enters the joint, pivotal movement occurs between the bones to change the orientation of the bones relative to each other. The wedge member may have a circular cross sectional configuration and be moved into the joint by rotating the wedge member about an axis which extends between a thin leading edge portion and a thick trailing edge portion of the wedge member. Alternatively, the wedge member may have a cam-shaped configuration and be rotated through less than a revolution to apply force against the bones. The wedge member may have a porous construction which enables bone to grow through the wedge member and immobilize the joint. The wedge member may be coated with and/or contain bone growth promoting material. The wedge member may be connected to only one of the bones or may be connected to two adjacent bones. If the wedge member is connected to only one bone, the joint may be capable of being flexed after the wedge member is inserted into the joint.

41 Claims, 9 Drawing Sheets



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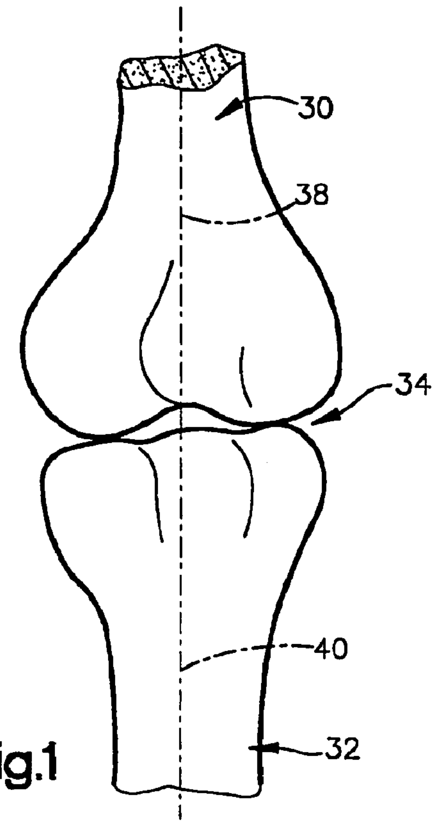

Fig.1

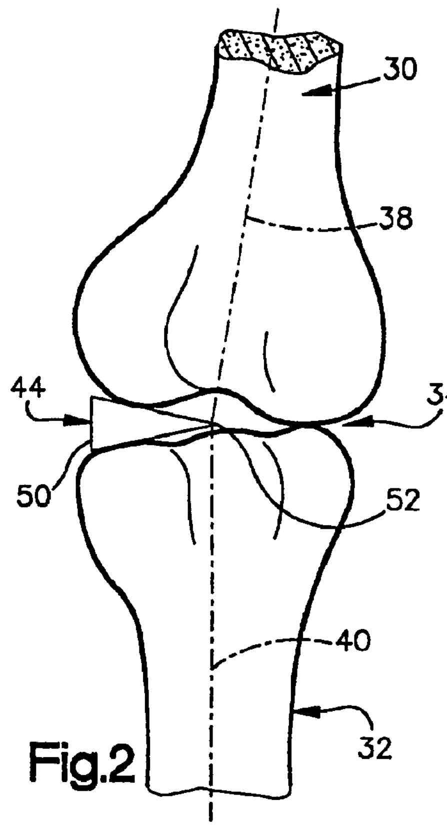

Fig.2

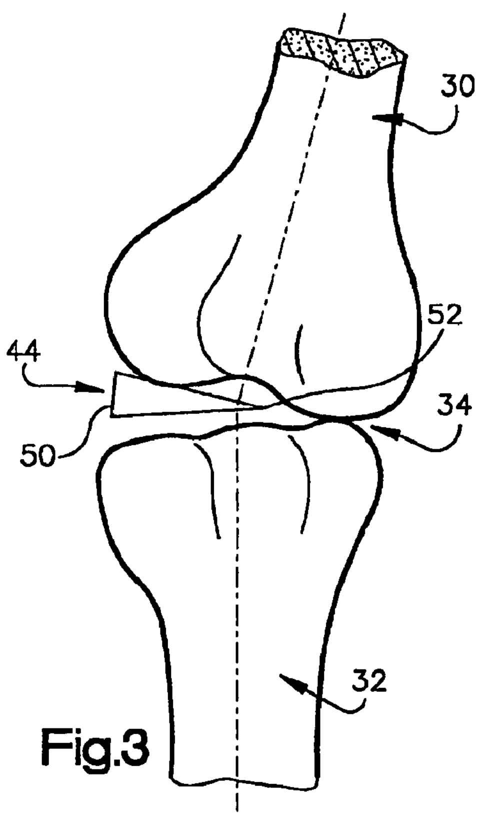

Fig.3

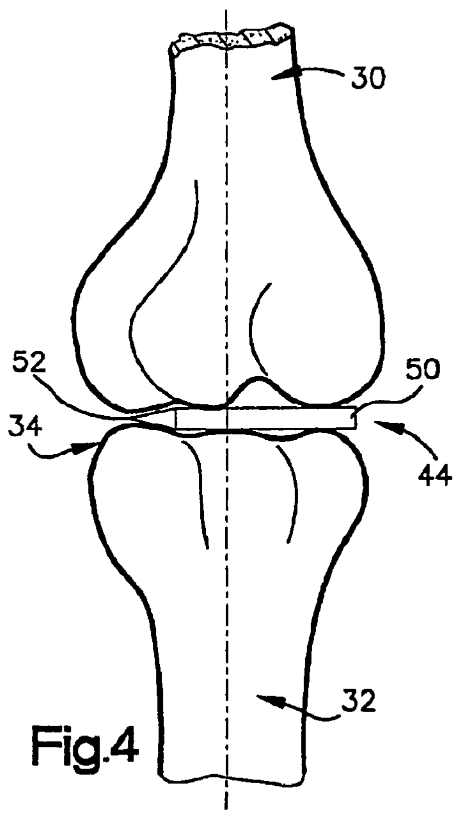

Fig.4

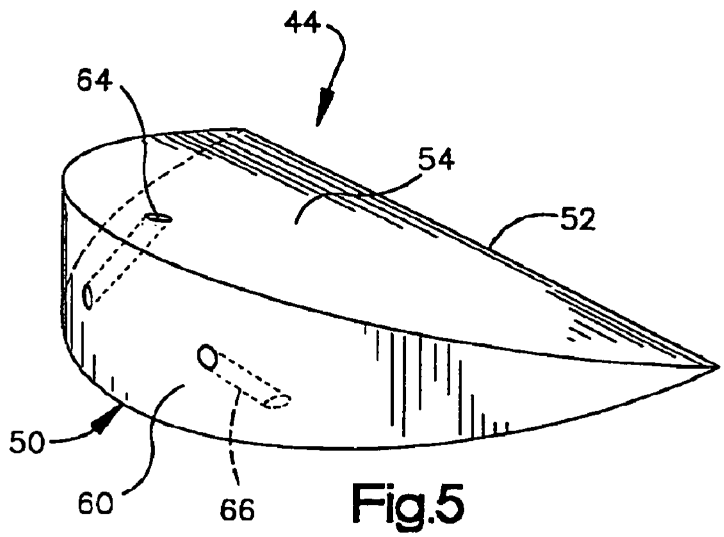

Fig.5

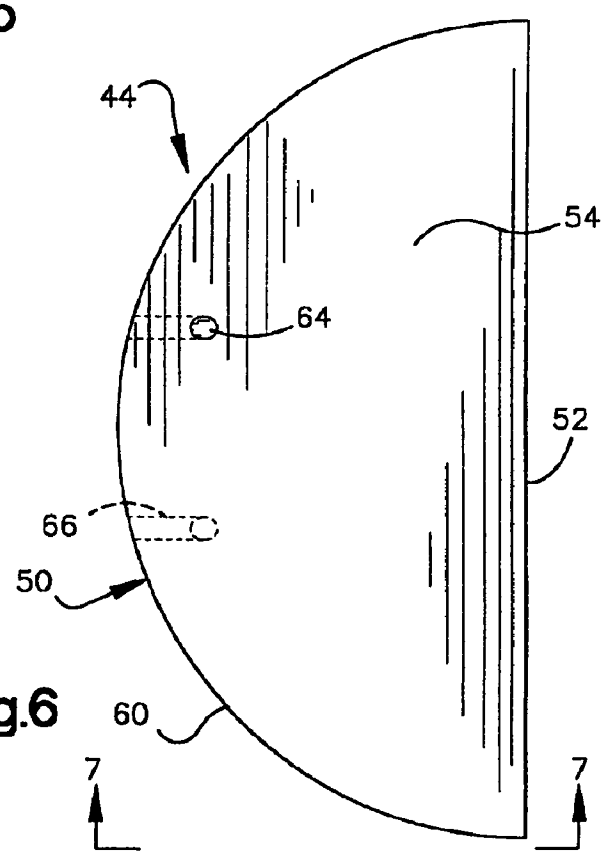

Fig.6

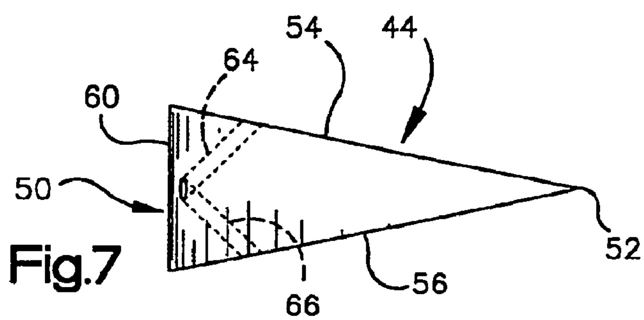

Fig.7

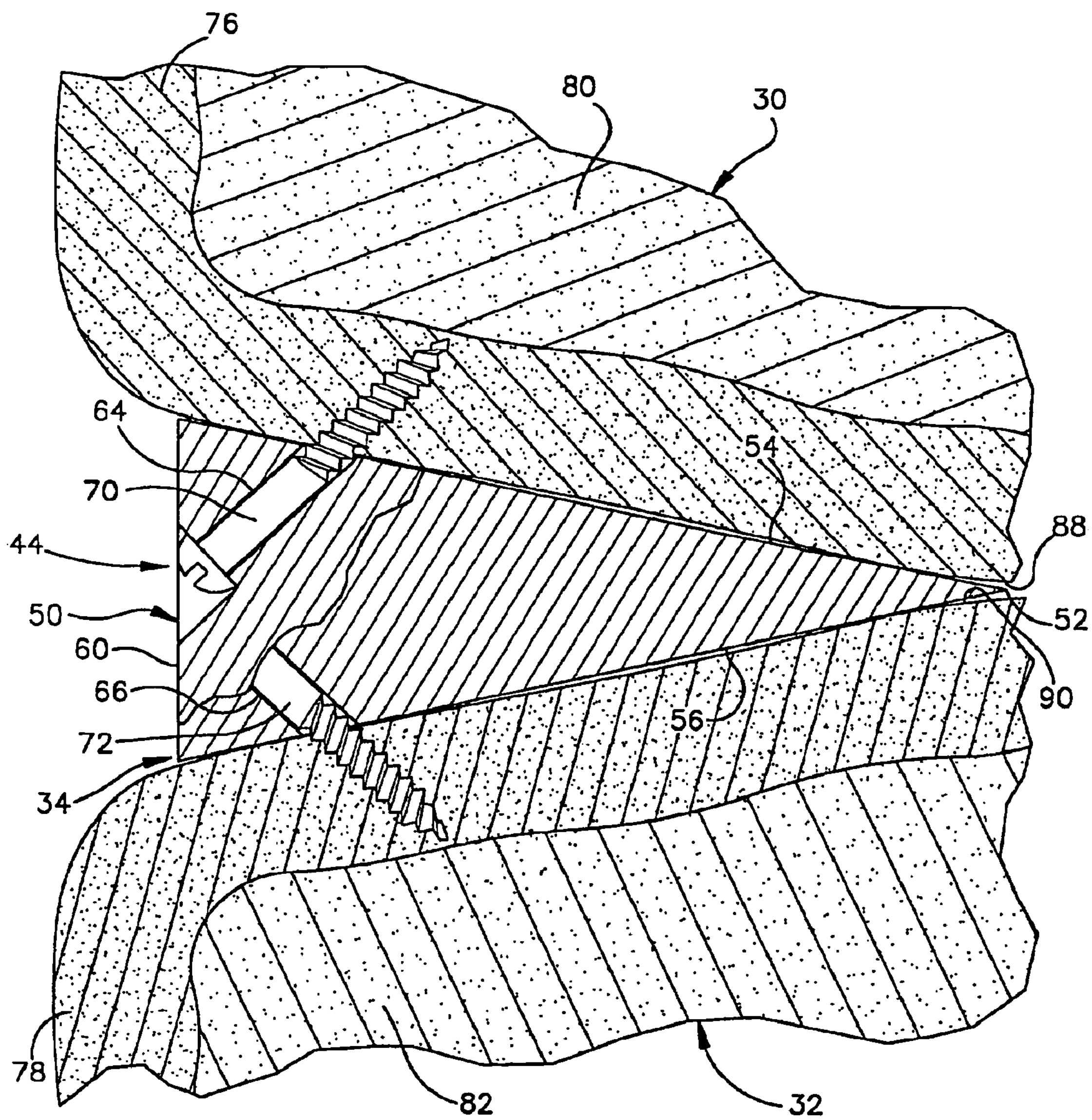

Fig.8

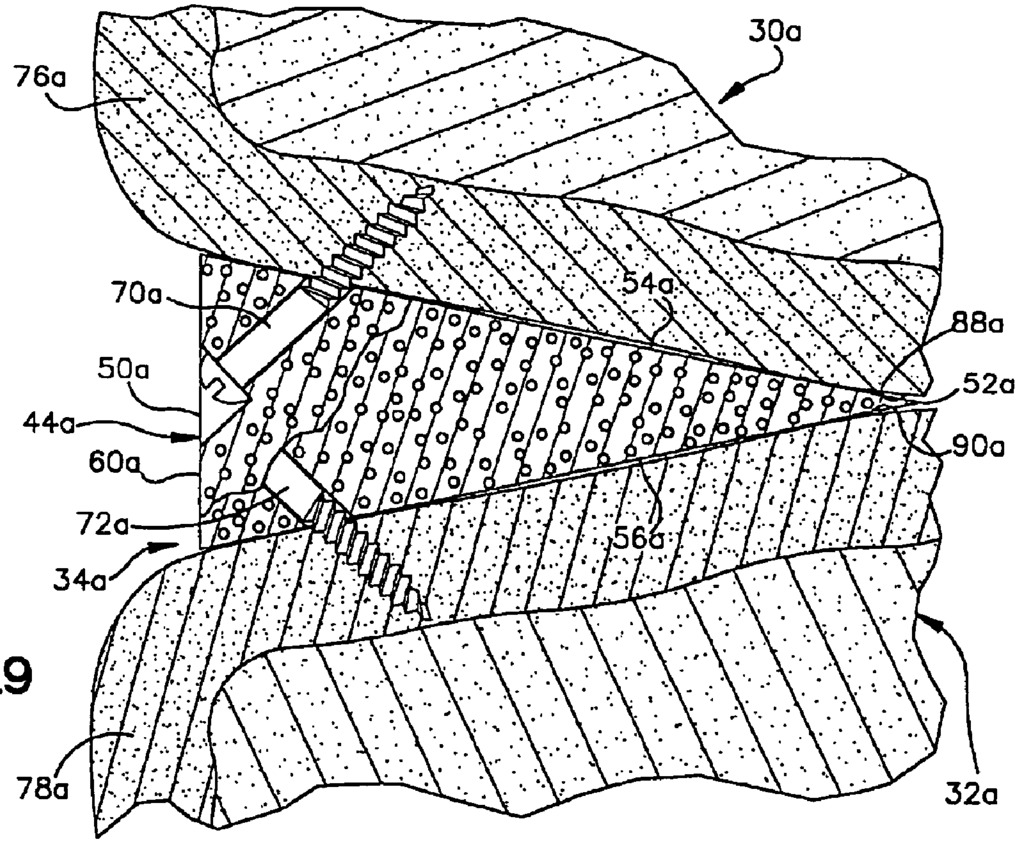
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Fig.9

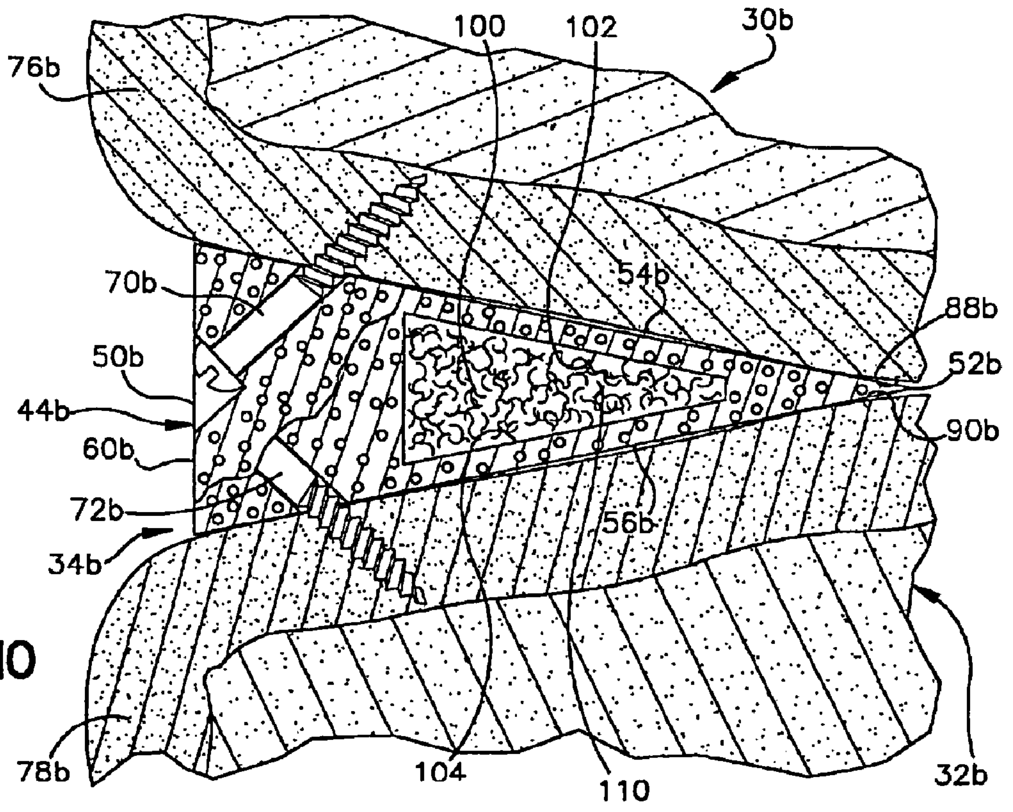
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Fig.10

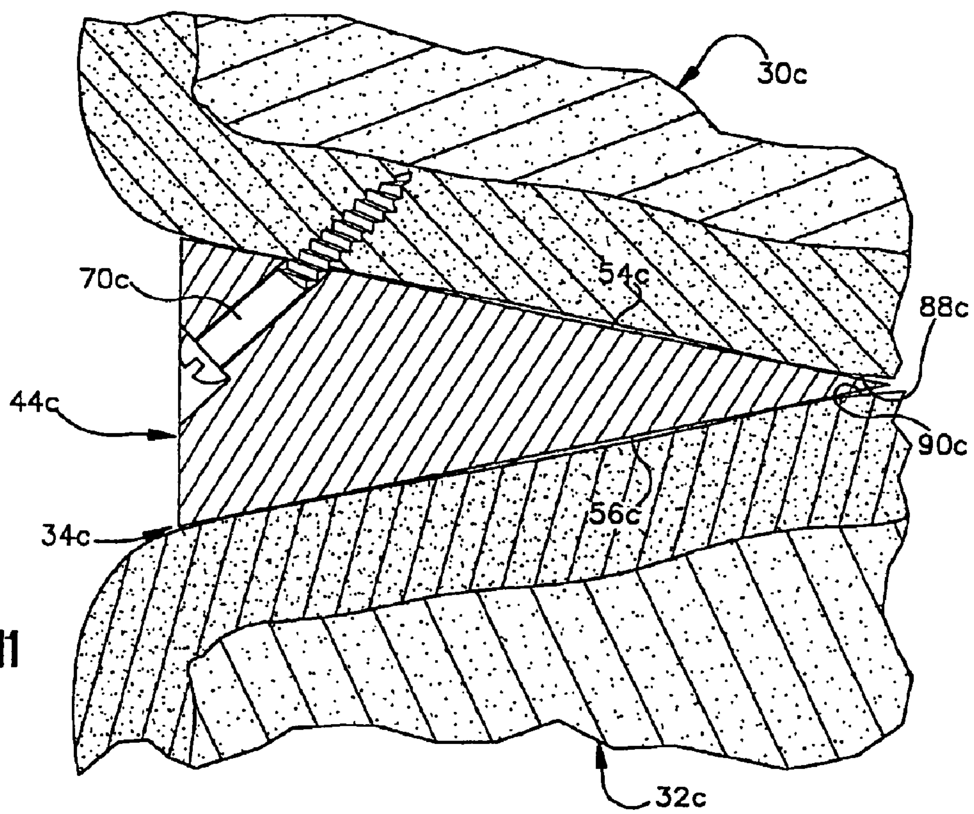

Fig.11

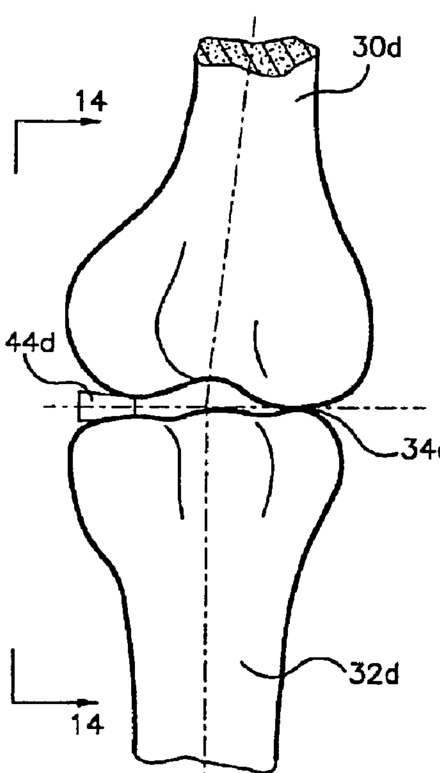

Fig.12

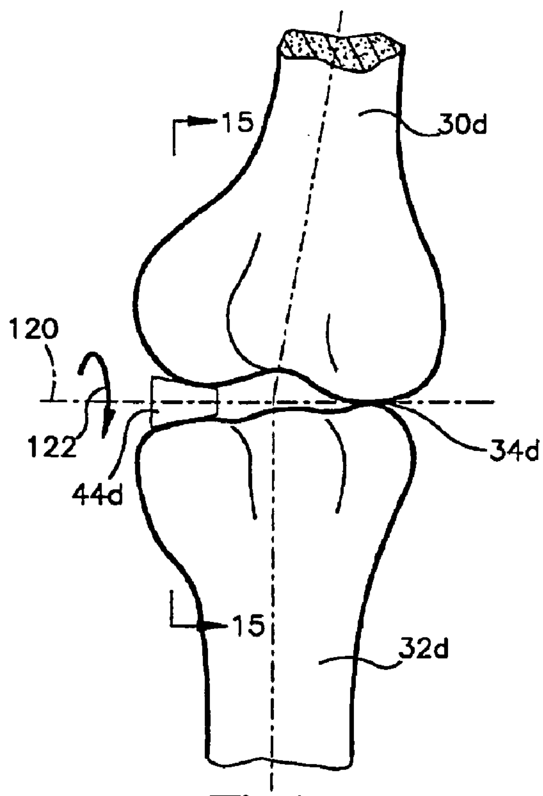

Fig.13

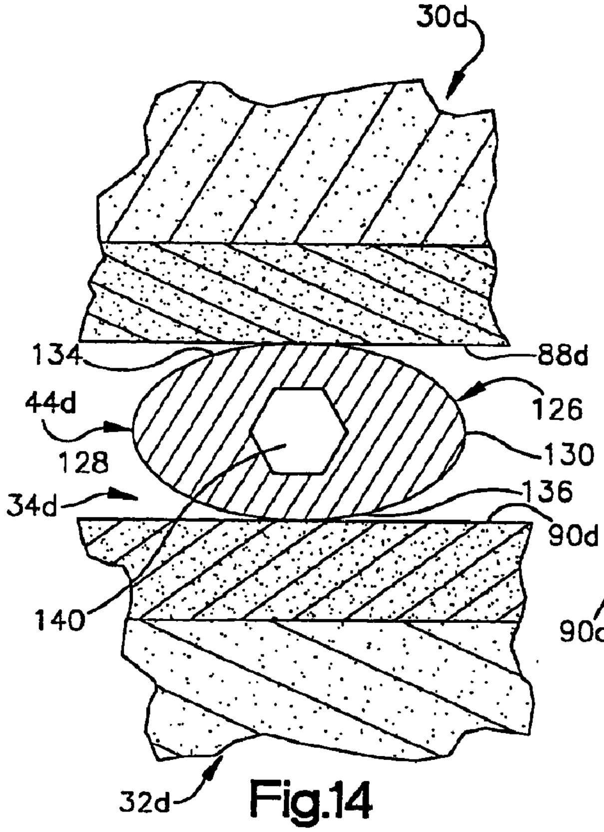

Fig.14

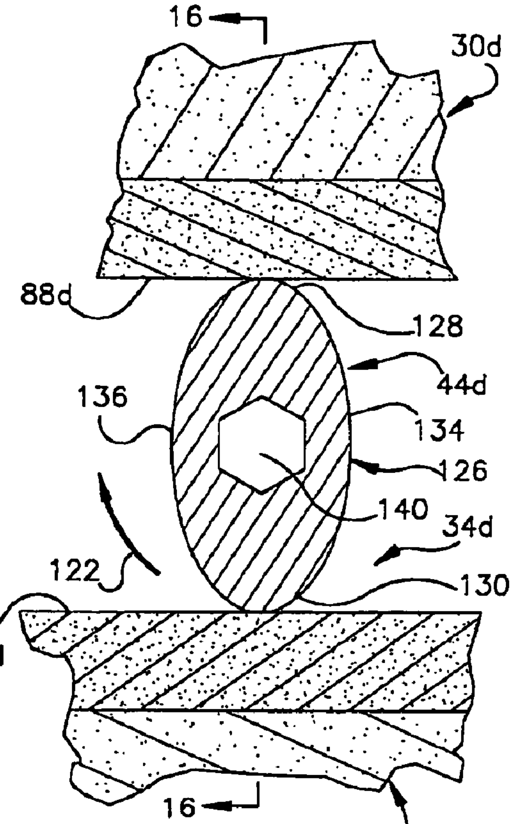

Fig.15

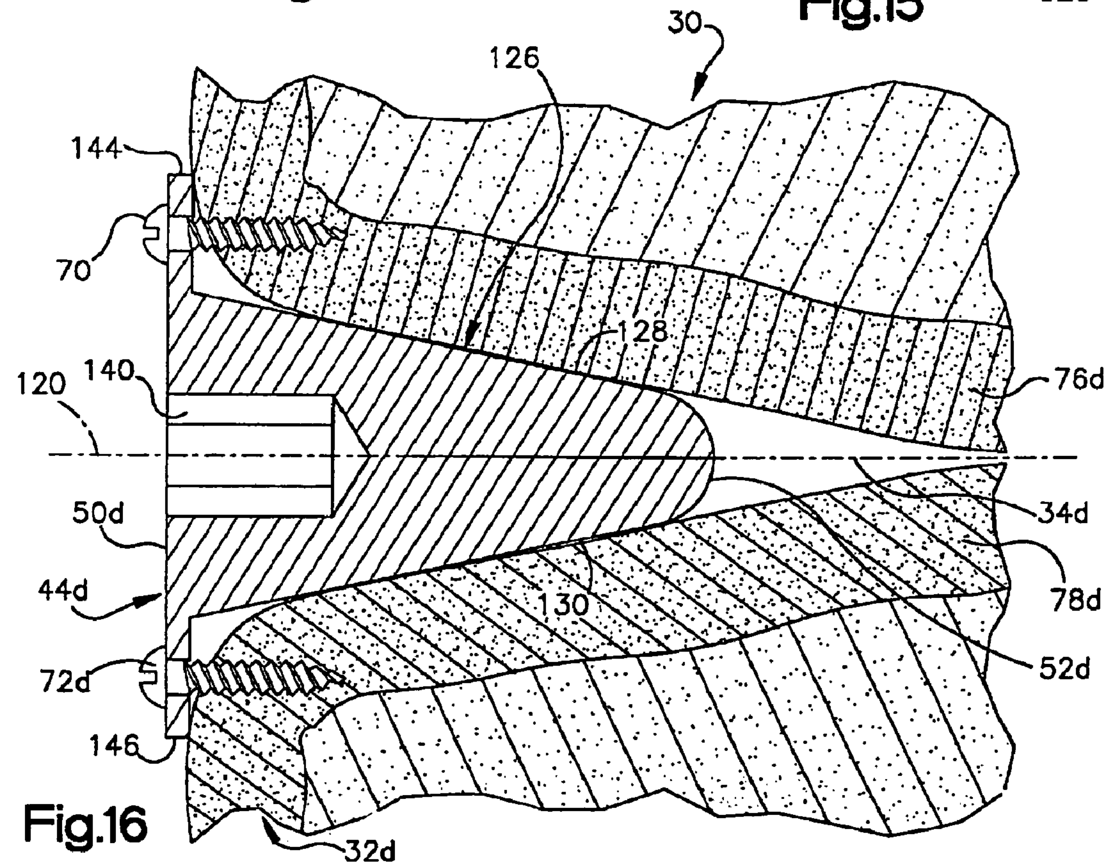

Fig.16

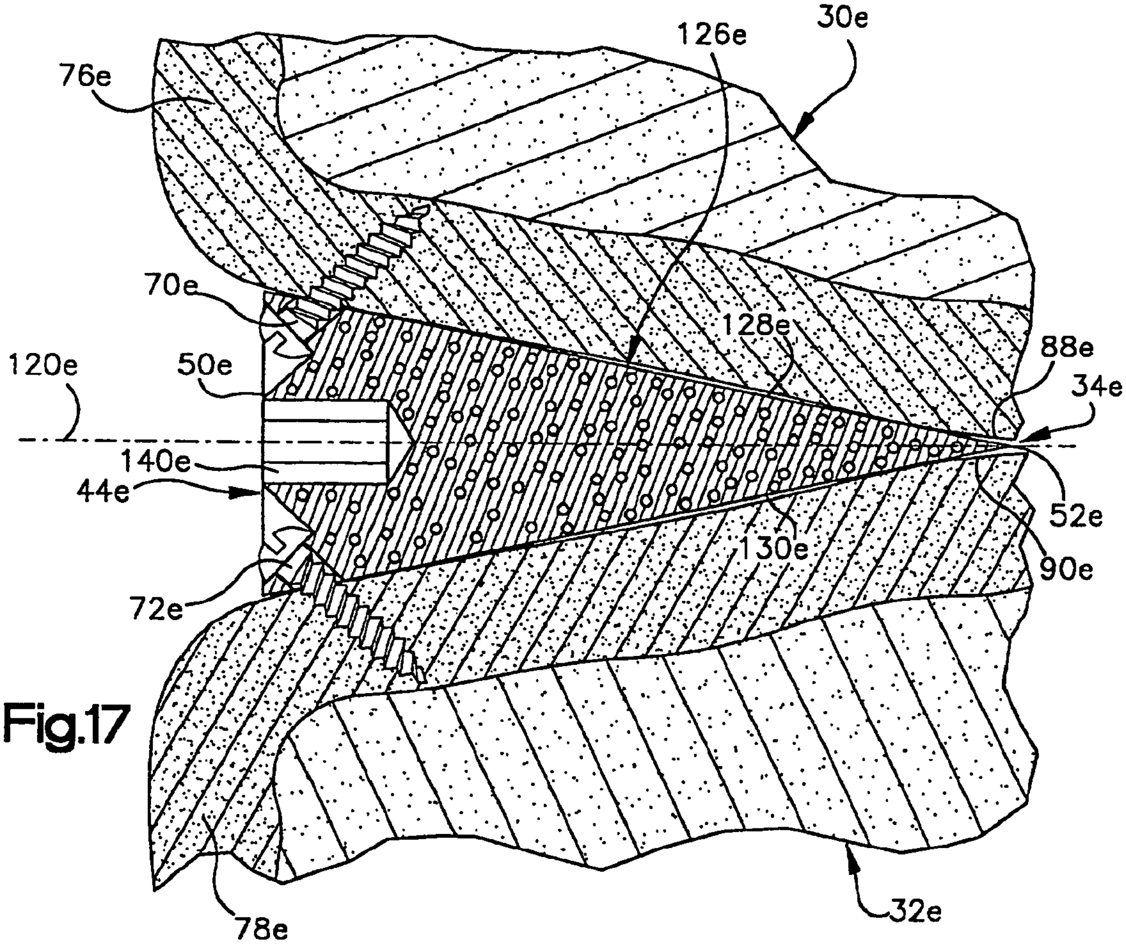
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Fig.17

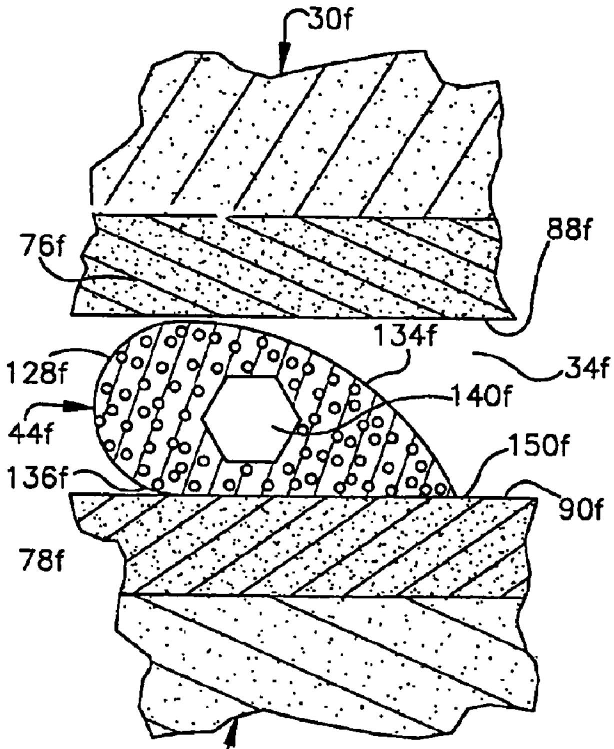


Fig.18

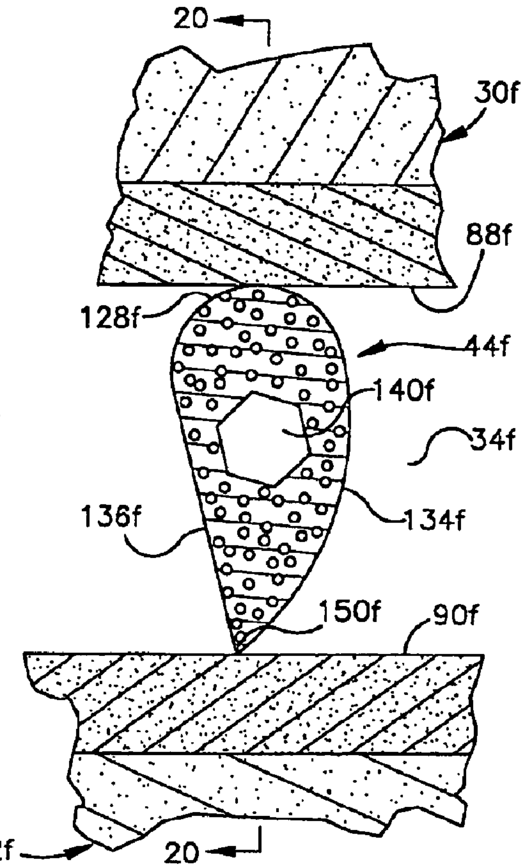


Fig.19

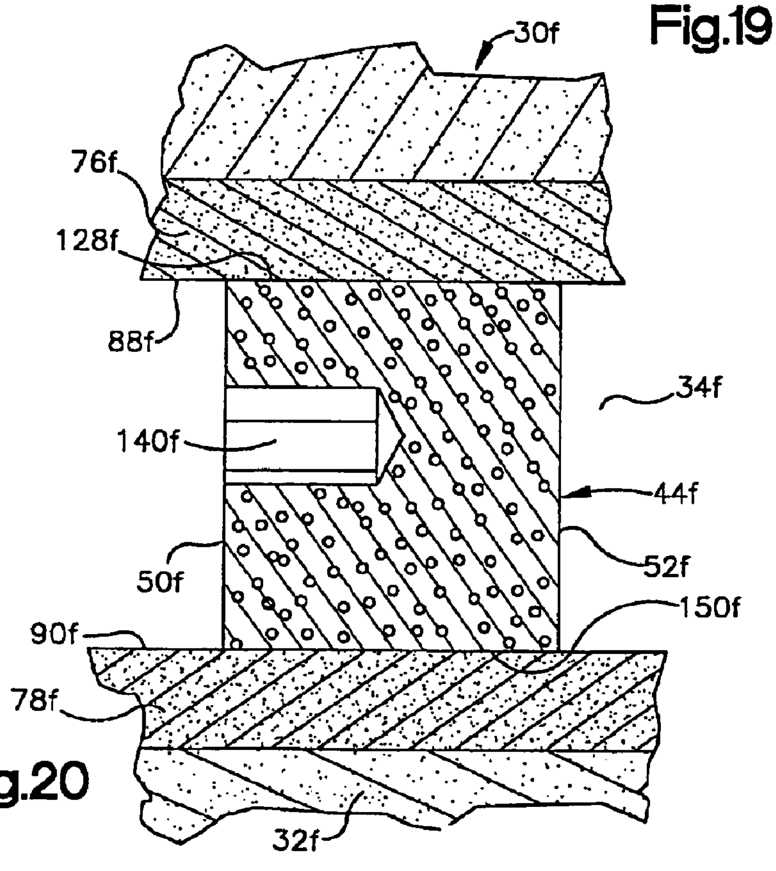


Fig.20

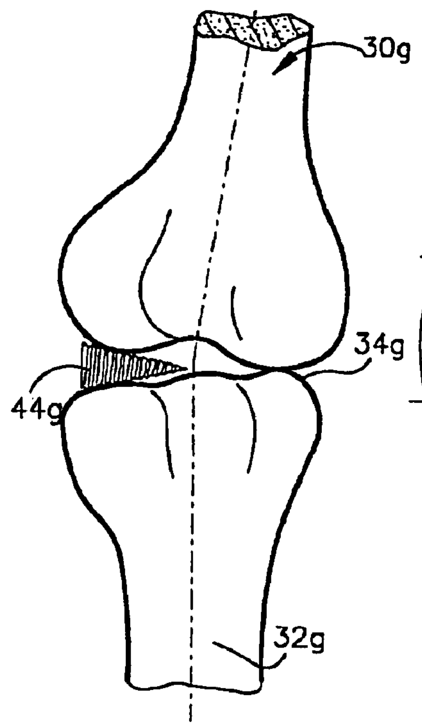


Fig.21

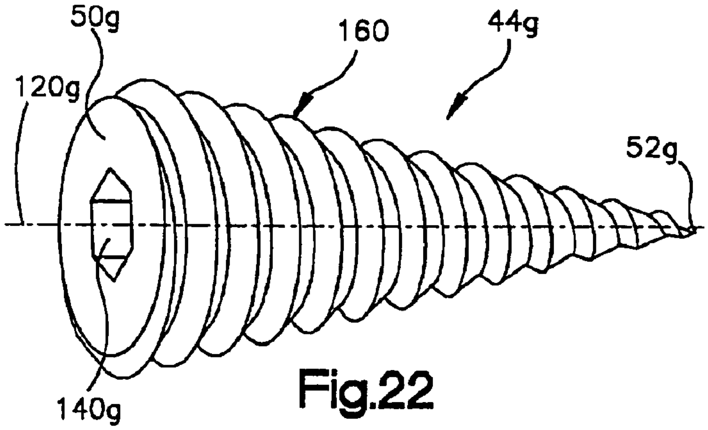


Fig.22

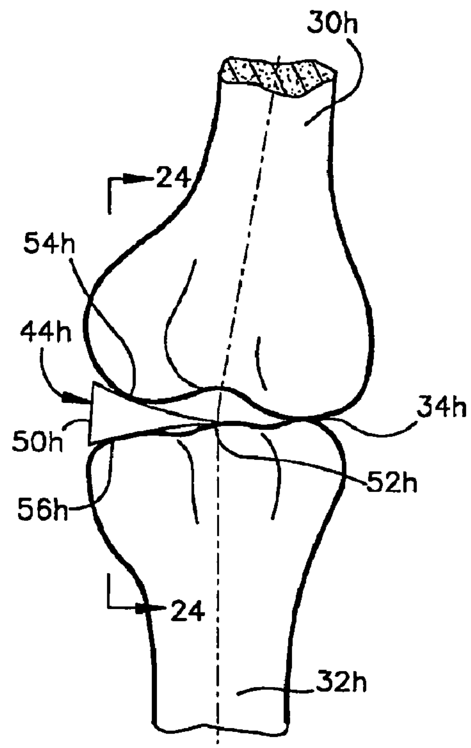


Fig.23

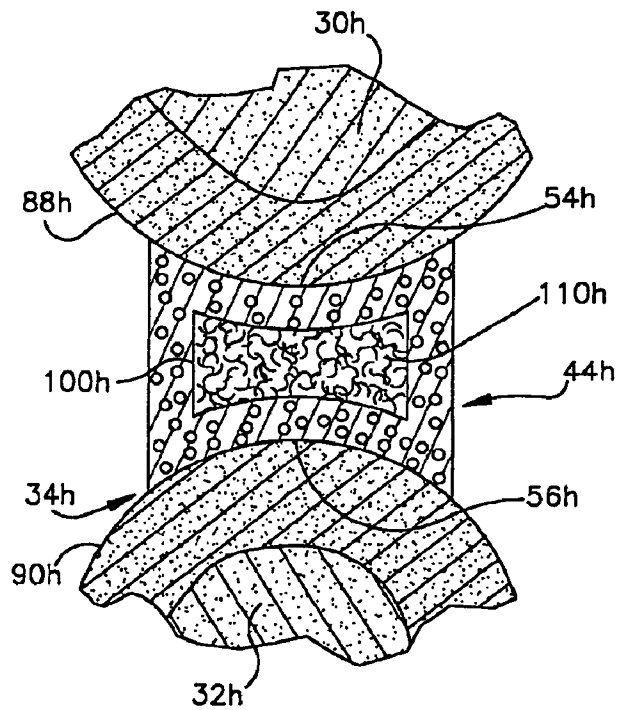


Fig.24

JOINT SPACER WITH COMPARTMENT FOR ORTHOBIOLOGIC MATERIAL

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 10/163,480, filed on Jun. 5, 2002, which is a continuation of U.S. patent application Ser. No. 09/569,020, filed on Mar. 11, 2000, now U.S. Pat. No. 6,423,063, which is a continuation of U.S. patent application Ser. No. 09/137,443, filed on Aug. 20, 1998, now U.S. Pat. No. 6,099,531.

FIELD OF THE INVENTION

The present invention relates to a new and improved method of changing a spatial relationship between bones which are interconnected at a joint in a patient's body.

BACKGROUND OF THE INVENTION

It has previously been suggested that joints between bones be fused, that is, surgically immobilized, to promote patient comfort. Thus, U.S. Pat. No. 5,026,373 suggests that a fusion cage be positioned between adjacent vertebrae. Perforations are formed in the cage. The cage is packed with a bone-inducing substance. A method for immobilizing vertebrae is also disclosed in U.S. Pat. No. 5,015,255.

It has previously been suggested that the spatial relationship between portions of a bone in a patient's body be changed to correct deformities. This may be done by removing a wedge-shaped piece of bone in the manner disclosed in U.S. Pat. No. 5,601,565.

Another method of changing the spatial relationship between portions of a bone in a patient's body includes forming a slot in the bone. A forked wedge tool is inserted into the slot. A plate is then placed in a central opening in the forked wedge tool and positioned against the bone. The plate is secured to the bone. The forked wedge tool is then removed from the opening. This method of changing the spatial relationship between portions of a bone in a patient's body is disclosed in U.S. Pat. No. 5,620,448.

A method and apparatus for use in changing a spatial relationship between portions of a bone in a patient's body is also disclosed in co-pending U.S. patent application Ser. No. 09/109,126, filed Jun. 30, 1998 by Peter M. Bonutti and entitled Method And Apparatus For Use In Operating On A Bone. This application discloses the use of a wedge member to expand a slot formed in a bone. The wedge member is porous and may be coated with and/or contain bone growth promoting material. The wedge member may have a configuration which corresponds to a configuration of a portion of the bone which is engaged by the wedge member. Alternatively, the wedge member disclosed in the aforementioned application Ser. No. 09/109,126 may have a circular cross sectional configuration with an external thread convolution to enable the wedge member to be moved into an opening in a bone by rotating the wedge member

SUMMARY OF THE INVENTION

A new and improved method and apparatus is provided to change a spatial relationship between bones which are interconnected at a joint in a patient's body. When this is to be done, an opening is formed in a portion of the patient's body to expose the joint interconnecting the bones. One of the bones is moved relative to the other by expanding at least

a portion of the joint with a wedge member. The wedge member is moved into the joint and applies force against the bones. The opening is closed with the wedge member still disposed in the joint between the bones. Force is then transmitted between the bones through the wedge member to maintain the joint in an expanded condition.

If the joint is to be flexed after being expanded by the wedge member, the wedge member may be connected with only one of the bones. Alternatively, if the joint is to be immobilized (fused) after inserting the wedge member, the wedge member may be fixedly connected with the bones interconnected at the joint. The wedge member may be porous and may be coated with and/or contain bone growth promoting material.

One embodiment of the wedge member has major side surfaces extending between thick and thin end portions of the wedge member. The wedge member is moved into the joint with the thin end portion leading. As the wedge member is moved into the joint, the thick trailing end portion of the wedge member expands the joint.

In another embodiment of the invention, the wedge member is rotated relative to the joint to expand the joint. The wedge member may have a circular cross sectional configuration and an external thread convolution which extends from a thin leading end of the wedge member to a thick trailing end of the wedge member. The wedge member is pressed into the joint and rotated to cause the wedge member to expand the joint.

In another embodiment of the invention, the wedge member has surface areas which are relatively close together and other surface areas which are relatively far apart. The wedge member is moved into the joint with the surface areas which are close together engaging the adjacent bones. The wedge member is then rotated to apply force against the adjacent bones to expand the joint. The wedge member may be rotated about its central axis to apply forced against the bones and expand the joint. Alternatively, the wedge member may be rotated about a location where the wedge member engages one of the bones.

Regardless of which embodiment of the wedge member is selected, the wedge member may be used with any one of the many different bones and joints in a patient's body. The wedge member may be utilized at joints in a patient's wrist, ankle, hand, foot, back or other portions of the patient's body. The wedge member may be particularly advantageous when a joint between vertebrae in patient's back is to be immobilized. One or more wedge members may be used to expand a joint and transmit force between bones.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features of the present invention will become more apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. **1** is a schematic illustration depicting the spatial relationship between bones at a joint in a patient's body;

FIG. **2** is a schematic illustration depicting the manner in which a wedge member is inserted into the joint between the bones of FIG. **1** to expand a portion of the joint and change the spatial relationship between the bones;

FIG. **3** is a schematic illustration of another embodiment of the invention in which the joint of FIG. **1** is flexed after the wedge member has been inserted into the joint and connected with only one of the bones;

FIG. **4** is a schematic illustration depicting an alternative manner of inserting the wedge member into the joint between the bones of FIG. **1**;

FIG. **5** is a schematic pictorial illustration of the wedge member of FIGS. **2** and **3**;

FIG. **6** is a plan view further illustrating the construction of the wedge member of FIG. **5**;

FIG. **7** is a side view, taken generally along the line **7—7** of FIG. **6**, of the wedge member of FIG. **5**;

FIG. **8** is an enlarged fragmentary schematic sectional view depicting the manner in which the wedge member of FIGS. **5–7** is positioned, as shown in FIG. **2**, in a joint between bones;

FIG. **9** is a fragmentary schematic sectional view, generally similar to FIG. **8**, but on a reduced scale, illustrating an embodiment of the invention in which the wedge member is porous;

FIG. **10** is a fragmentary schematic sectional view, generally similar to FIG. **9**, illustrating an embodiment of the wedge member which is porous and has a chamber which holds bone growth promoting material;

FIG. **11** is a fragmentary schematic sectional view, generally similar to FIGS. **8–10**, illustrating the manner in which the wedge member of FIG. **3** is connected with only one bone to enable the joint between bones to be flexed;

FIG. **12** is a schematic illustration depicting the manner in which a rotatable wedge member is moved into a joint between bones;

FIG. **13** is a schematic illustration depicting the wedge member of FIG. **12** after the wedge member has been rotated to expand a portion of the joint between the bones;

FIG. **14** is an enlarged fragmentary schematic sectional view, taken generally along the line **14—14** of FIG. **12**, illustrating the relationship of the rotatable wedge member to the bones prior to rotation of the wedge member;

FIG. **15** is an enlarged fragmentary schematic sectional view, taken generally along the line **15—15** of FIG. **13**, illustrating the relationship of the rotatable wedge member of FIG. **14** to the bones after rotation of the wedge member;

FIG. **16** is a fragmentary schematic sectional view, taken generally along the line **16—16** of FIG. **15**, illustrating the manner in which the rotatable wedge member is connected with the bones;

FIG. **17** is a fragmentary schematic sectional view, generally similar to FIG. **16**, illustrating an embodiment of the rotatable wedge member which is porous;

FIG. **18** is a fragmentary sectional view, generally similar to FIG. **14**, illustrating the relationship between the bones at a joint when another embodiment of the rotatable wedge member is in the initial orientation illustrated in FIG. **12** relative to the bones;

FIG. **19** is a fragmentary schematic sectional view, generally similar to FIG. **15**, illustrating the relationship of the rotatable wedge member of FIG. **18** to the bones after the wedge member has been rotated;

FIG. **20** is a fragmentary schematic sectional view, taken generally along the line **20—20** of FIG. **19**, further illustrating the construction of the rotatable wedge member;

FIG. **21** is a schematic illustration, generally similar to FIG. **2**, depicting the manner in which another embodiment of the rotatable wedge member is moved into a joint between bones in a patient's body; FIG. **22** is an enlarged schematic pictorial illustration of the rotatable wedge member of FIG. **21**;

FIG. **23** is a fragmentary schematic illustration, generally similar to FIG. **2**, depicting the manner in which another embodiment of the wedge member is moved into a joint between bones in a patient's body; and FIG. **24** is an enlarged fragmentary schematic sectional view, taken generally along the line **24—24** of FIG. **23**, further illustrating the relationship of the wedge member to the bones.

DETAILED DESCRIPTION OF THE INVENTION

General Description

An upper or first bone **30** in a patient's body is illustrated schematically in FIG. **1**. A lower or second bone **32** is connected with the upper bone **30** at a joint **34**. The bones **30** and **32** and joint **34** have been illustrated schematically to represent any one of many bones and joints in a patient's body. Thus, the bones **30** and **32** and joint **34** may be disposed in a patient's hand, foot, back, or other portion of the patient's body. It should be understood that the bones **30** and **32** and joint **34** have been illustrated schematically in FIG. **1** as being representative of any one of the many joints in a human patient's body and it is not intended to limit the present invention to any particular joint.

In order to correct deformities, improve patient comfort or other reasons, it may be desired to change the spatial relationship between the upper and lower bones **30** and **32**. Thus, it may be desired to change the angular relationship between longitudinal central axes **38** and **40** from the relationship illustrated schematically in FIG. **1** to the relationship illustrated schematically in FIG. **2**.

In order to change the spatial relationship between the longitudinal central axes **38** and **40** of the bones **30** and **32**, an opening is formed in a portion of the patient's body to expose the joint **34**. A wedge member **44** (FIG. **2**) is moved into the exposed joint **34** between the bones **30** and **32**. The wedge member **44** applies force against the outer side surfaces of the bones **30** and **32** at the joint **34** to expand a portion of the joint.

As the wedge member **44** is moved into the joint **34**, in the manner illustrated schematically in FIG. **2**, the lower bone **32** is pivoted relative to the upper bone **30** about an axis extending through the joint **34**. This changes the angular orientation of the lower bone **32** relative to the upper bone **30**. Thus, the spatial relationship between the upper and lower bones **30** and **32** is changed from the spatial relationship illustrated in FIG. **1** to the spatial relationship illustrated in FIG. **2** by the wedge member **44**.

In FIG. **2**, the wedge member **44** has been illustrated schematically as having an extent which corresponds to approximately one-half of the extent of the joint **34**. However, it is contemplated that the wedge member **44** could have an extent which is either smaller than or greater than the extent illustrated in FIG. **2**. Thus, the distance between the thick and thin end portions of the tapered wedge member **44** may be less than one-half of the width of the joint **34**. Similarly, the distance between the thin leading end portion and thick trailing end portion of the wedge member **44** may be greater than one-half of the width of the joint **34**.

The wedge member **44** may be relatively narrow, as measured along the thin end portion of the wedge member. This would enable a plurality of narrow wedge members **44** to be used to expand a single joint **34**. If the wedge member **44** is relatively wide, only a single wedge member may be required to expand a joint **34**, as shown in FIG. **2**.

In the embodiment of the invention illustrated in FIG. **2**, the joint **34** is fused after the joint has been expanded by the wedge member **44** to change the spatial relationship between the bones **30** and **32**. Thus, after the joint **34** has been expanded by the wedge member **34**, the joint is immobilized with the upper and lower bones **30** and **32** in the spatial relationship illustrated in FIG. **2**. When the wedge member **44** is utilized in association with joints between vertebrae in a patient's back, it is believed that it may be particularly advantageous to immobilize the joint **34**.

Immobilization of the joint **34** may be accomplished by connecting the wedge member **44** with both the upper bone **30** and the lower bone **32**. Immobilization of the joint **34** may also be accomplished by the growth of bone and/or other body tissue between the two bones **30** and **32** at the joint **34**. Known bone growth promoting materials may be provided at the joint **34** if desired. The bone growth promoting materials may include bone morphogenic proteins and/or other osteoinductive materials.

In the embodiment of the invention illustrated in FIG. **3**, the joint **34** is capable of being flexed after the wedge member **44** has been utilized to expand a portion of the joint. Thus, once the wedge member **44** has been inserted into the joint **34**, in the manner illustrated in FIG. **2**, the patient may flex the joint under the influence of force transmitted to the bones **32** and **30** from muscle tissue in the patient's body.

When the joint **34** is flexed, as illustrated schematically in FIG. **3**, the bone **32** moves away from the wedge member **44**. The wedge member **44** is fixedly connected to only the bone **30**. This allows the bone **32** to move away from the wedge member. It is believed that it will be particularly advantageous to enable the joint **34** to be flexed when the wedge member is utilized to correct deformities occurring in hands, feet, wrists or ankles of a patient. However, it should be understood that the wedge member could be attached to a single bone at any joint in a patient's body which is to be flexed after the wedge member has been used to expand the joint.

In the embodiment of the invention illustrated in FIGS. **1–3**, the wedge member **44** has been shown as being moved into the joint **34** in a direction which is perpendicular to an axis about which the joint is flexed. Thus, the wedge member **44** is moved into the joint **34** (FIG. **2**) in a direction perpendicular to the axis about which the joint **34** is schematically illustrated in FIG. **3** as being flexed.

In the embodiment of the invention illustrated in FIG. **4**, the wedge member **44** is inserted into the joint **34** in a direction parallel to the axis about which the joint is normally flexed. Thus, the wedge member **44** is illustrated in FIG. **4** as being inserted into the joint **34** in a direction perpendicular to the plane of the drawing of the joint **34** in FIGS. **1** and **3**. It should be understood that the wedge member **44** could be inserted into a joint, such as the joint **34**, in any desired direction in order to obtain a desired expansion of the joint. Thus, the wedge member **44** could be moved into the joint **34** along a path which is neither perpendicular to or parallel to the axis about which the joint is flexed.

After one or more wedge members **44** have been positioned in a joint **34**, in the manner previously explained, the opening in the patient's body is closed. When the opening in the patient's body is closed, the wedge member **44** remains in the joint **34** between the bones **30** and **32**. The wedge member **44** is formed of a rigid material which is capable of transmitting force between the bones **30** and **32** immediately after being positioned in the joint **34**. Therefore, the wedge member **44** is effective to maintain the changed spatial relationship, such as the spatial relationship illustrated in FIG. **2**, between the bones **30** and **32** during loading of the joint **34** immediately after positioning of the wedge member in the joint.

Wedge Member

The wedge member **44** (FIGS. **5–7**) tapers from a thick end portion **50** to a thin end portion **52**. The wedge member **44** has flat upper and lower major side surfaces **54** and **56** (FIG. **7**) which slope toward each other from the thick end portion **50** to the thin end portion **52**. The major side surfaces **54** and **56** intersect at the thin end portion **52**. The pointed thin end portion **52** of the wedge member **44** facilitates moving the wedge member into the joint **34** between the bones **30** and **32** (FIG. **2**).

In the illustrated embodiment of the wedge member **44** (FIGS. **5–7**), the thick end portion **50** has an outer side surface **60** which forms a portion of a cylinder. The thin end portion **52** extends diametrically across the cylinder (FIG. **6**). Therefore, the wedge member **44** has a semi-circular configuration. However, it should be understood that the configuration of the upper and lower major side surfaces **54** and **56** of the wedge member **44** corresponds to the configuration of the joint with which the wedge member is to be associated.

The semi-circular outer side surface **60** will, for many joints at least, have an irregular configuration other than the semi-circular configuration illustrated in FIGS. **5** and **6**. This enables the outer side surface **60** to be aligned with the outer side surfaces of the bones **30** and **32** at the joint **34**. Since most bones do not have outer side surfaces which form portions of a semi-circular, it is believed that in all probability, the wedge member **44** will have an outer side surface **60** with an irregular configuration rather than the semi-circular configuration illustrated in FIG. **5**.

The extent of the thin end portion **52** of the wedge member **44** may be substantially less than shown in FIG. **6**. Thus, the extent of the thin end portion **52** of the wedge member **44** may be less than one-half of the extent shown in FIG. **6**. This would result in the major side surfaces **54** and **56** of the wedge member **44** having a generally U-shaped configuration. Parallel triangular side surfaces would extend between the outer side surface **50** of the wedge member **44** and opposite ends of the thin end portion **52**. These triangular side surfaces would be spaced from opposite sides of the joint **34** when the wedge member **44** is inserted into the joint.

When the wedge member **44** has a relatively narrow, generally U-shaped configuration, a plurality of the wedge members may be inserted into a single joint **34** (FIG. **1**). When a plurality of narrow wedge members **44** are used at one joint **34**, the wedge members may have different configurations. Thus, the wedge members **44** may have different lengths and/or different angles between the upper and lower major side surfaces **54** and **56** of the wedge members.

The upper and lower major side surfaces **54** and **56** of the wedge member **44** slope toward each other from the thick end portion **50** to the thin end portion **52** of the wedge member. It is contemplated that a plurality of wedge members **44** having different acute angles between the upper and lower major side surfaces **54** and **56** may be provided. This would enable a surgeon to select the wedge member **44** having a desired thickness at the thick end portion **50**. Thus, if a surgeon determines that a joint should be expanded to either a lesser or greater amount than would be accomplished by a wedge member having one angle, the surgeon may select a wedge member having a different angle and thickness to effect the desired expansion of the joint **34**. It is also contemplated that a plurality of wedge members **44** having different widths, as measured along the thin end portion **52**, may be provided.

The acute angle between the flat upper and lower major side surfaces **54** and **56** is determined by the extent to which the joint **34** is to be expanded, that is, the extent to which the spatial relationship between the bones **30** and **32** is to be changed by insertion of the wedge member **44**. Of course, the specific angle provided between the upper and lower major side surfaces **54** and **56** of the wedge member **44** will vary depending upon the size of the joint with which the wedge member is used and the extent to which the spatial relationship between the bones **30** and **32** is to be changed by use of the wedge member. In addition, the length and width of the wedge member **44** inserted into a particular joint will be determined by the extent to which the joint is to be expanded and the total number of wedge members to be inserted into the joint.

It is believed that it may be desired to have the acute angle between the upper and lower major side surfaces **54** and **56** (FIG. **6**) of the wedge member **44** within a range between one and thirty degrees. Although it is difficult to be certain, it is believed that it may be preferred to have the acute angle between the upper and lower major side surfaces **54** and **56** of the wedge member **44** vary within a range of five degrees to twenty degrees. It should be understood that the foregoing specific ranges of sizes for the angle between the upper and lower major side surfaces **54** and **56** of the wedge member **44** have been set forth herein for purposes of clarity of description and it is contemplated that the angle between the upper and lower major side surfaces **54** and **56** may be any one of many angles other than these specific angles.

The size of the wedge member relative to a specific joint **34** may vary depending upon the deformity to be corrected. Thus, a narrow wedge member **44** may have a thin end portion **52** (FIG. **6**) with a length which is relatively small compared to the width of a joint. The thin end portion **52** of the narrow wedge member **44** could have a length of less than one fourth the distance across the joint. This would result in opposite ends of the thin end portion **52** being spaced from the periphery of the joint. It is contemplated that a plurality of narrow wedge members **44** could be used to expand a single joint.

The wedge member **44** may be formed of any one of many different known materials which are compatible with a patient's body. For example, the wedge member may be formed of human or animal bone, stainless steel, tantalum, a porous ceramic, or a polymeric material. If desired, the wedge member may be formed of a biodegradable material. However, it is preferred to have the wedge member **44** formed of a rigid material which is capable of enabling force to be transmitted through the joint **34** between the bones **30** and **32** immediately after installation of the wedge member in the joint.

In the embodiment of the invention illustrated in FIG. **2**, the joint **34** is immobilized. To facilitate immobilization of the joint **34**, the wedge member **44** is fixedly connected with the bone **30** and with the bone **32**. To facilitate fixedly connecting the wedge member **44** with the bones **30** and **32**, a pair of passages **64** and **66** are formed in the wedge member **44** (FIGS. **6** and **7**). When the wedge member **44** is positioned in the joint **34** (FIG. **2**), suitable fasteners, that is screws **70** and **72** extend through the passages **64** and **66** into the bones **30** and **32** in the manner indicated schematically in FIG. **8**. The screws **70** and **72** engage hard cortical outer layers **76** and **78** of the bones **30** and **32**. If desired, the screws **70** and **72** could extend into the relatively soft cancellous bone **80** and **82**.

Although the wedge member **44** has been illustrated in FIG. **8** as being connected with the bones **30** and **32** by a pair of screws **70** and **72**, it should be understood that the wedge member **44** may be connected with only one of the bones **30** or **32** by only one of the screws **70** or **72** if desired. For example, if the wedge member **44** is connected with the bone **30** by the screw **70**, the joint **34** could be flexed in the manner illustrated schematically in FIG. **3**, after the wedge member **44** has been moved into the joint.

Positioning of Wedge Member

When the wedge member **44** is to be inserted in to the joint **34** to change the spatial relationship between the bones **30** and **32** in the manner illustrated schematically in FIG. **2**, a location for insertion of the wedge member into the joint **34** is selected by a surgeon. The specific location at which the wedge member **44** is inserted into the joint **34** to expand the joint will be selected by the surgeon as a function of the desired result from a particular operation. In addition, the size of the wedge member **44** will be selected by the surgeon as a function of the joint and the result to be obtained from a particular operation.

The configuration of the wedge member **44** will be selected by the surgeon as a function of the location where the wedge member is to be inserted into the joint **34**. The wedge member **44** may be relatively wide and have a long thin end portion **52**, as shown in FIG. **6**, to enable the thin end portion to extend between opposite sides of the joint. Alternatively, the wedge member **44** may be relatively narrow and have a thin end portion **52** which is short. If this is done, the thin end portion **52** would not extend between opposite sides of the joint **34**. A plurality of the narrow wedge members **44** may be inserted into a single joint **34** to expand the joint and transmit force between the bones **30** and **32**.

The surgeon makes an incision in soft body tissue surrounding the joint **34** to expose the joint. Once the joint **34** has been exposed, the thin end portion **52** (FIGS. **5** and **6**) of the wedge member **44** is moved into the joint **34**. When the wedge member **44** is to be inserted into a joint in the manner illustrated schematically in FIG. **2**, the longitudinal central axis of the thin end portion **52** of the wedge member is aligned with an axis about which the joint pivots. The wedge member is then moved into the joint **34** along a linear path which extends perpendicular to the axis about which the joint pivots. The wedge member **44** is moved into the joint **34** by applying force against the trailing thick end portion **50** of the wedge member.

As the wedge member **44** is moved into the joint **34**, the upper major side surface **54** (FIGS. **5** and **7**) of the wedge member slides along an outer side surface **88** (FIG. **8**) of the outer layer **76** of hard cortical bone. The lower major side surface **56** of the wedge member **44** slides along an outer side surface **90** of the outer layer **78** of hard cortical bone.

The outer side surfaces **88** and **90** of the bones **30** and **32** are in their naturally occurring conditions. Thus, the outer side surfaces **88** and **90** of the bones **30** and **32** are not cut away to prepare for insertion of the wedge member **44** into the joint **34**. However, it should be understood that under certain circumstances that it may be necessary to abrade or otherwise cut the outer side surfaces **88** and **90** of the outer layers **76** and **78** of hard cortical bone to prepare the joint **34** for insertion of the wedge member **44**.

As the thin leading end portion **52** (FIG. **8**) of the wedge member **44** moves into the joint **34**, the upper and lower major side surfaces **54** and **56** apply force against the outer side surfaces **88** and **90** on the bones **30** and **32**. As this occurs, the joint **34** is expanded. As the joint **34** is expanded, the bone **32** is pivoted, relative to the bone **30**, from the initial orientation, shown in FIG. **1**, to the improved orientation shown in FIG. **2**. As this occurs, the longitudinal central axis **40** of the bone **32** moves relative to the longitudinal central axis **38** of the bone **30**. Therefore, the angular relationship between the bones **30** and **32** is changed by expansion of a portion of the joint **34** by insertion of the wedge member **44** into the joint.

When the wedge member **44** has been pressed the desired distance into the joint **34**, by the application of force against the thick end portion **50** of the wedge member **44**, the outer side surface **60** on the wedge member moves slightly inward of the outer side surfaces on the bones **30** and **32** (FIG. **8**). The outer side surface **60** on the wedge member **44** has a configuration which corresponds to the configurations of the outer side surfaces on the bones **30** and **32** adjacent to the joint **34**. Therefore, the wedge member **44** does not project outward from the joint. This minimizes any tendency of the wedge member to subsequently abrade body tissue adjacent to the joint **34**.

Once the wedge member **44** has been moved into the desired orientation relative to the bones **30** and **32**, as illustrated schematically in FIG. **8**, the wedge member **44** is fixedly connected with the bones **30** and **32** by the screws **70** and **72** to immobilize the joint. The area surrounding and directly adjacent to the wedge member **44** is packed with bone growth promoting material and/or bone chips. The bone growth promoting materials may include bone morphogenic proteins and/or other osteoinductive materials. This promotes fusion of the bones **30** and **32** for remedial immobilization of the joint **34**.

Since the wedge member **44** is rigid, it can immediately transmit loads between the bones **30** and **32**. Therefore, after the incision which exposed the joint **34** has been closed, the patient can begin to load the joint **34**. The wedge member **44** is effective to maintain the joint **34** in an expanded condition during loading of the joint. Therefore, the bones **30** and **32** remain in the improved spatial relationship illustrated in FIG. **2** during loading of the joint **34**.

Wedge Member—Second Embodiment

In the embodiment of the invention illustrated in FIGS. **1–8**, a solid wedge member has been utilized to expand the joint **34**. In the embodiment of the invention illustrated in FIG. **9**, a porous wedge member is utilized to expand a joint. Since the embodiment of the invention illustrated in FIG. **9** is generally similar to the embodiment of the invention illustrated in FIGS. **1–8**, similar numerals will be utilized to designate similar components, the suffix letter "a" being associated with the numerals of FIG. **9** in order to avoid confusion.

A wedge member **44***a* is positioned in a joint **34***a* between bones **30***a* and **32***a*. The wedge member **44***a* engages outer side surfaces **88***a* and **90***a* on layers **76***a* and **78***a* of hard cortical bone. The outer side surfaces **88***a* and **90***a* are in their naturally occurring conditions.

As the wedge member **44***a* is moved into the joint **34***a*, flat upper and lower major side surfaces **54***a* and **56***a* on the wedge member **44***a* slide along the outer side surfaces **88***a* and **90***a* on the bones **30***a* and **32***a*. The upper and lower major side surfaces **54***a* and **56***a* of the wedge **44***a* apply force against the outer side surfaces **88***a* and **90***a* of the bones **30***a* and **32***a* to expand the joint **34***a* as the wedge member is moved into the joint. The wedge member **44***a* is moved into the joint **34***a* under the influence of force applied against an outer side surface **60***a* on a trailing thick end portion **50***a* of the wedge member **44***a*.

Once the joint **34***a* has been expanded to change the spatial relationship between the bones **30***a* and **32***a*, suitable fasteners (screws) **70***a* and **72***a* are inserted through passages in the wedge member **44***a*. The screws **70***a* and **72***a* engage the hard cortical outer layers **76***a* and **78***a* of bone to fixedly secure the wedge member **44***a* with the bones **30***a* and **32***a*.

A single wedge member **44***a* is used to expand the joint **34***a*. However, a plurality of narrow wedge members **44***a* may be inserted into the joint at spaced apart locations about the periphery of the joint if desired.

In accordance with a feature of this embodiment of the invention, the wedge member **44***a* is porous so that bone can grow through the wedge member. It is contemplated that the wedge member could be provided with a porous construction by having passages extend through the wedge member between the upper and lower major side surfaces **54***a* and **56***a* of the wedge member. The open ends of the passages would enable bone to grow through the wedge member **44***a*.

In the embodiment of the wedge member **44***a* illustrated in FIG. **9**, the wedge member is formed of a rigid open cell material. The open cell material provides cavities in which bone can grow through the wedge member **44***a*. Thus, the wedge member **44***a* (FIG. **9**) has a cellular construction similar to coral.

It is contemplated that the wedge member **44***a* may be coated with a material which promotes the growth of bone. The cells in the wedge member **44***a* may be at least partially filled with bone growth promoting material. The bone growth promoting materials may be bone morphogenic proteins and other osteoinductive materials. In addition to bone growth promoting material associated with the wedge member **44***a*, the space around and adjacent to the wedge member **44***a* in the joint **34***a* may be packed with bone growth promoting material and/or bone chips.

The wedge member **44***a* is rigid and can be subject to normal loading immediately after being positioned in the joint **34***a*. This enables the patient to subject the bones **30***a* and **32***a* to normal loading without waiting for fusion to occur through and around the wedge member **44***a*. Of course, with the passage of time, the growth of bone through the wedge member **44***a* and around the wedge member will strengthen the immobilization of the joint **34***a*.

In the embodiment of the invention illustrated in FIG. **9**, the passages through the wedge member **44***a* are formed by the open cell structure of the wedge member This results in the passages through the wedge member **44***a* having an irregular configuration. If desired, linear passages could be formed in the wedge member **44***a*. The linear passages may be drilled, cast, or formed in other ways in the wedge member **44***a*.

Hollow Wedge Member

In the embodiment of the invention illustrated in FIGS. **1–8**, the wedge member **44** is formed by a solid piece of material. In the embodiment of the invention illustrated in FIG. **9**, the wedge member **44***a* is formed by a continuous piece of porous material. In the embodiment of the invention illustrated in FIG. **10**, the wedge member is formed by a hollow piece of porous material. Since the embodiment of the invention illustrated in FIG. **10** is generally similar to the embodiments of the invention illustrated in FIGS. **1–9**, similar numerals will be utilized to designate similar components, the suffix letter "b" being associated with the numerals of FIG. **10** to avoid confusion.

In the embodiment of the invention illustrated in FIG. **10**, a wedge member **44***b* is inserted into a joint **34***b* between bones **30***b* and **32***b* to expand the joint. Expansion of the joint **34***b* by the wedge member **44***b* changes the spatial relationship between the bones **30***b* and **32***b*. The wedge member **44***b* is held against movement relative to the bones **30***b* and **32***b* by fasteners (screws) **70***b* and **72***b*. The fasteners **70***b* and **72***b* extend through passages in the wedge member **44***b* into layers **76***b* and **78***b* of hard cortical bone on bones **30***b*, **32***b*. The layers **76***b* and **78***b* are in their naturally occurring condition.

When the wedge member **44***b* is to be moved into the joint, a thin end portion **52***b* of the wedge member **44***b* is pressed into the joint **34***b* by applying force against an outer side surface **60***b* at a thick end portion **50***b* of the wedge member **44***b*. The force applied against the trailing thick end portion **50***b* of the wedge member **44***b* causes flat upper and lower major side surfaces **54***b* and **56***b* to slide along outer side surfaces **88***b* and **90***b*. As the upper and lower major side surfaces **54***b* and **56***b* on the wedge member **44***b* slide along the outer side surfaces **88***b* and **90***b* of the bones **30***b* and **32***b*, the wedge member applies force against the bones to expand the joint **34***b* in the manner previously explained.

In accordance with a feature of this embodiment of the invention, the wedge member **44***b* (FIG. **10**) is hollow. Therefore, a compartment or cavity **100** is formed in the wedge member **44***b*. The compartment **100** has upper and lower inner side surfaces **102** and **104** which are smaller than the upper and lower major side surfaces **54***b* and **56***b* of the wedge member **44***b*. However, the inner side surfaces **102** and **104** of the compartment **100** have the same general configuration as the upper and lower major side surfaces **54***b* and **56***b* of the wedge member **44***b*.

The compartment **100** is filled with bone growth inducing material **110**. The bone growth inducing material **110** is positioned in the compartment **100** through a suitable opening (not shown) formed in either the upper major side surface **54***b* or the lower major side surface **56***b* of the wedge member **44***b*. Once the compartment **100** has been filled with bone growth inducing material **110**, the opening to the compartment is closed. However, the wedge member **44***b* is formed of a porous material which enables bone to grow through the wedge member.

The growth of bone through the wedge member **44***b* is promoted by the bone growth inducing material **110** in the compartment **100**. The bone growth inducing material **110** in the compartment **100** may be any of many known bone morphogenic proteins and osteoinductive materials. For example, apatite compositions with collagen may be utilized. Demineralized bone powder may also be utilized. Regardless of which of the known bone growth inducing materials are selected, the presence of the bone growth promoting material **110** in the compartment **100** will promote a growth of bone through openings in the porous wedge member **44***b*.

The wedge member **44***b* may, itself, be formed of a suitable rigid material, such as tantalum, stainless steel, or ceramic materials. In addition to the bone growth inducing material **110**, the surfaces of the wedge member **44***b* and openings in the porous material of the wedge member may be coated with suitable bone growth promoting materials.

The wedge member **44***b* is porous so that bone can grow through the wedge member. In the embodiment of the invention illustrated in FIG. **10**, the wedge member is formed of an open cell material having a construction similar to coral. The open cell material provides irregular passages which extend through the wedge member **44***b* and enable the bone to grow through the wedge member. However, it should be understood that the wedge member **44***b* could be formed of a solid material with passages drilled or cast in the wedge member. Regardless of which of the materials the wedge member is formed, it is believed that it will be advantageous to have the material be sufficiently rigid to enable the joint **44***b* to be load bearing immediately after an operation installing the wedge member in the joint.

Single Connection for Wedge Member

In the embodiments of the invention illustrated in FIGS. **8–10**, the wedge members **44**, **44***a*, and **44***b* are connected with bones on opposite sides of a joint by suitable fasteners (screws). In the embodiment of the invention illustrated in FIG. **11**, the wedge member is connected with only one of the bones. Since the embodiment of the invention illustrated in FIG. **11** is generally similar to the embodiments of the invention illustrated in FIGS. **1–10**, similar numerals will be utilized to designate similar components, the suffix letter "c" being associated with the numerals of FIG. **11** to avoid confusion.

A wedge member **44***c* is inserted into a joint **34***c* between upper and lower bones **30***c* and **32***c*. The wedge member **44***c* has the same general configuration and construction as the wedge member **44** of FIGS. **5–8**. However, the wedge member **44***c* is connected with only one of the bones **30***c* and **32***c*. Thus, rather than utilizing a pair of fasteners to secure the wedge member **44***c* to the upper and lower bones **30***c* and **32***c*, only a single fastener **70***c* is utilized to connect the wedge member **44***c* with the upper bone **30***c*. Therefore, installation of the wedge member **44***c* in the joint **34***c* does not result in immobilization of the joint.

Since the wedge member **44***c* is connected with the bone **30***c* by the fastener **70***c*, the bone **32***c* may be moved away from the wedge member during flexing of the joint **34***c*. This may result in the upper major side surface **54***c* on the wedge member **54***c* remaining in engagement with the outer side surface **88***c* on the bone **30***c* while the outer side surface **90***c* on the bone **32***c* moves away from the lower major side surface **56***c* on the wedge member **44***c*. Of course, a single fastener **70***c* may be utilized to hold the wedge member in the joint **34***c* where the outer side surfaces **88***c* and **90***c* on the upper and lower bones **30***c* and **32***c* remain in engagement with the upper and lower major side surfaces **54***c* and **56***c* of the wedge member **44***c*.

In the embodiment of the wedge member **44***c* illustrated in FIG. **11**, the wedge member is formed of a solid material through which bone does not grow. However, it is contemplated that a single fastener, corresponding to the fastener **70***c* of FIG. **11**, may be used to connect a porous wedge member with a bone. Of course, bone may grow through the porous wedge member. The porous wedge member may have the same construction as shown in FIGS. **9** and **10**, with the exception of being held in place by only a single fastener **70***c*.

Rotatable Wedge Member

In the embodiment of the invention illustrated in FIGS. **1–11**, the wedge member **44** is moved into the joint **34** between the upper and lower bones **30** and **32** along a linear path. The wedge member **44** is moved into the joint **34** with the thin end portion **52** of the wedge member leading and the thick end portion **50** of the wedge member trailing. The tapered configuration of the wedge member results in the application of force against the upper and lower bones **30** and **32** to expand the joint **34** in the manner previously explained.

In the embodiment of the invention illustrated in FIGS. **12–16**, the wedge member is moved into the joint between the upper and lower bones and then rotated. During initial movement of the wedge member into the joint between the bones, there may be some expansion of the joint. During rotation of the wedge member in the joint, there is further expansion of the joint. Since the embodiment of the invention illustrated in FIGS. **12–15** is generally similar to the embodiments of the invention illustrated in FIGS. **1–11**, similar numerals will be utilized to designate similar components, the suffix letter "d" being associated with the numerals of FIGS. **12–15** to avoid confusion.

Upper and lower bones **30***d* and **32***d* are interconnected at a joint **34***d* (FIG. **12**). Prior to insertion of a wedge member **44***d*, the upper and lower bones **30***d* and **32***d* are in the same spatial orientation relative to each other as is illustrated in FIG. **1**. Upon insertion of the wedge member **44***d* into the joint **34***d*, in the manner illustrated in FIG. **12**, there may be a slight expansion of the joint **34***d* and a slight change in the orientation of the upper bone **30***d* relative to the lower bone **32***d*. There is a relatively small change in the spatial relationship between the upper bone **30***d* and the lower bone **32***d* because the wedge member **44***d* is inserted into the joint **34***d* in an orientation in which the wedge member **44***d* is relatively thin as viewed in FIG. **12**, that is, in a direction transverse to the joint **34***d*.

After the wedge member **44***d* has been inserted into the joint **34***d* in the manner indicated schematically in FIG. **12**, the wedge member **44***d* is rotated, through less than one revolution, about an axis **120** in the manner indicated schematically by an arrow **122** in FIG. **13**. As the wedge member **44***d* is rotated through approximately ninety degrees about the axis **120**, the wedge member applies force against the upper and lower bones **30***d* and **32***d* to expand the joint **34***d*. As the joint **34***d* is expanded by rotation of the wedge member **44***d*, the spatial relationship between the upper and lower bones **30***d* and **32***d* changes from the spatial relationship illustrated schematically in FIG. **12** to the spatial relationship illustrated schematically in FIG. **13**. Thus, by the combined effect of insertion of the wedge member **44***d* into the joint **34***d* and rotation of the wedge member in the joint, the spatial relationship of the upper and lower bones **30***d* and **32***d* was changed from the spatial relationship illustrated in FIG. **1** for the bones **30** and **32** to the spatial relationship illustrated in FIG. **13** for the upper and lower bones **30***d* and **32***d*.

The bones **30***d* and **32***d* illustrated schematically in FIGS. **12** and **13** should be considered as being representative of bones at many different locations in a patient's body. Thus, the bones **30***d* and **32***d* may be any of the many bones in a patient's wrist, ankle, hand, foot, back, or other portion of a patient's body. The bones **30***d* and **32***d* may be vertebrae in a patient's back. It should be understood that the wedge member **44***d* may be used with any one of the many different types of joints in a patient's body.

The wedge member **44***d* has a generally oval, cross-sectional configuration (FIGS. **14** and **15**), as viewed in a plane perpendicular to a longitudinal central axis of the wedge member. Thus, the wedge member **44***d* has an outer side surface **126** (FIG. **14**) with a pair of arcuate nose portions **128** and **130**. The arcuate nose portions **128** and **130** of the outer side surface **126** are interconnected by a pair of arcuate side portions **134** and **136**.

The arcuate outer side surface **126** tapers from a thick end portion **50***d* (FIG. **16**) to a thin end portion **52***d*. In the illustrated embodiment of the wedge member **44***d*, the thin end portion **52***d* is blunt or truncated. Thus, the thin end portion **52***d* of the wedge member **44***d* does not come to a sharp point as does the thin end portions of the wedge members **44**, **44***a*, **44***b* and **44***c*.

It should be understood that the wedge members **44***a*, **44***b* and **44***c* (FIGS. **5–11**) could be constructed with a blunt thin end portion corresponding to the blunt thin end portion **52***d* (FIG. **16**) on the wedge member **44***d* if desired. However, it is believed that by having the thin end portion of the wedge members of FIGS. **5–11** taper to a sharp point, insertion of the wedge members into a joint is facilitated. Similarly, if desired, the wedge member **44***d* could be provided with a thin end portion **52***d* (FIG. **16**) which comes to a sharp point in the same manner as the wedge members **44**, **44***a*, **44***b* and **44***c*.

When the wedge member **44***d* is inserted into the joint **34***d* (FIG. **14**), the arcuate side portion **134** engages the outer side surface **88***d* of the upper bone **30***d* and the arcuate side portion **136** engages the outer side surface **90***d* of the lower bone **32***d*. The arcuate side portions **134** and **136** are relatively close together so that minimal expansion of the joint **34***d* occurs when the wedge member **44***d* is inserted into the joint. As the wedge member **44***d* is inserted into the joint **34***d*, the arcuate side portions **134** and **136** slide along and are effective to apply force against the outer side surfaces **88***d* and **90***d* of the upper and lower bones **30***d* and **32***d* to effect some expansion of the joint **34***d*. The outer side surfaces **88***d* and **90***d* of the bones **30***d* and **32***d* are in their naturally occurring conditions.

After the wedge member **44***d* has been inserted into the joint **34***d*, in the manner shown in FIGS. **12** and **14**, a suitable tool is inserted into a hexagonal socket **140** (FIG. **14**) in the wedge member **44***d*. Torque is transmitted from the tool to the wedge member **44***d* to rotate the wedge member through less than one revolution in the direction indicated by the arrow **122** in FIGS. **13** and **15**. This results in the wedge member **44***d* being rotated through approximately ninety degrees in a clockwise direction from the position shown in FIG. **14** to the position shown in FIG. **15**. As the wedge member **44***d* is rotated, the wedge member applies force against the upper and lower bones **30***d* and **32***d* and expands the joint **34***d*.

Upon initiation of rotation of the wedge member **44***d* from the position shown in FIG. **14** toward the position shown in FIG. **15**, the arcuate side portions **134** and **136** slide along the outer side surfaces **88***d* and **90***d* on the bones. As the rotation of the wedge member **44***d* continues, the arcuate nose portions **128** and **130** of the wedge member **44***d* approach the outer side surfaces **88***d* and **90***d* of the upper and lower bones **30***d* and **32***d*. As this is occurring, the joint **34***d* is expanded by the force applied against the upper and lower bones **30***d* and **32***d* by the wedge member **44***d*. When the wedge member **44***d* reaches the position shown in FIG. **15**, the arcuate nose portions **128** and **130** engage the outer side surfaces **88***d* and **90***d* on the upper and lower bones **30***d* and **32***d* to hold the joint **34***d* in the expanded condition illustrated in FIGS. **15** and **16**.

A pair of mounting tabs **144** and **146** (FIG. **16**) are integrally formed with the wedge member **44***d*. The mounting tabs **144** and **146** project outwardly from the end portion **50***d* of the wedge member **44***d*. The mounting tabs **144** and **146** are aligned with the arcuate nose portions **128** and **130** of the outer side surface **126** on the wedge member **44***d*. Therefore, the mounting tabs **144** and **146** are disposed adjacent to the bones **30***d* and **32***d* in the manner illustrated schematically in FIG. **16**.

A pair of retaining screws **70***d* and **72***d* extend through the mounting tabs **144** and **146** into the outer layers **76***d* and **78***d* of hard cancellous bone on the upper and lower bones **30***d* and **32***d*. The mounting screws or fasteners **70***d* and **72***d* are effective to hold the wedge member **44***d* against rotation relative to the upper and lower bones **30***d* and **32***d*. Bone growth promoting material and/or bone chips may be packed in the joint **34***d* around the wedge member **44***d*. The wedge member **44***d* is rigid and can transmit force between the bones **30***d* and **32***d* as soon as it is rotated to the position shown in FIGS. **15** and **16**.

As is perhaps best seen in FIG. **15**, the wedge member **44***d* is narrower than the distance across the joint **34***d*. Therefore, a plurality of wedge members **44***d* may be utilized to hold the joint **34***d* in the expanded condition of FIGS. **15** and **16**. The plurality of wedge members **44***d* could be positioned in the joint **34***d* with their rotational axes **120** (FIG. **16**) in a parallel relationship or with their rotational axes **120** skewed relative to each other. If a plurality of wedge members **44***d* are utilized, they could be of different sizes or have different angles of taper along the axis **120**.

It should be understood that the wedge members **44**, **44***a*, **44***b* and **44***c* of FIGS. **5**–**11** could also be relatively narrow. A plurality of wedge members of FIGS. **5**–**11** could be positioned in a joint with their longitudinal axes either parallel or skewed relative to each other.

Porous Rotatable Wedge Member

In the embodiment of the invention illustrated in FIGS. **12**–**16**, the wedge member **44***d* is formed as a solid body of rigid material, such as stainless steel. The wedge member in the embodiment of the invention illustrated in FIG. **17** is formed of a rigid porous material. Since the embodiment of the invention illustrated in FIG. **17** is generally similar to the embodiments of the invention illustrated in FIGS. **1**–**16**, similar numerals will be utilized to designate similar components, the suffix letter "e" being associated with the numerals of FIG. **17** to avoid confusion.

The wedge member **44***e* is disposed in a joint **34***e* between upper and lower bones **30***e* and **32***e*. The wedge member **44***e* applies force against the outer side surfaces **88***e* and **90***e* of the upper and lower bones **30***e* and **32***e* to expand the joint **34***e* and change the orientation of the upper and lower bones relative to each other. In the embodiment of the invention illustrated in FIG. **17**, the wedge member **44***e* tapers from a thick end portion **50***e* to a thin end portion **52***e*. In the illustrated embodiment of the invention, the thin end portion **52***e* of the wedge member **44***e* has a pointed configuration rather than the blunt configuration of the wedge member **44***d* of FIG. **16**. However, the wedge member **44***e* could have the same configuration as the wedge member **44***d* if desired.

The wedge member **44***e* (FIG. **17**) has an oval cross sectional configuration, as viewed on a plane extending perpendicular to a central axis **120***e* of the wedge member **44***e*. Thus, the wedge ember **44***e* has an outer side surface **126***e* with arcuate nose portions **128***e* and **130***e*. The arcuate nose portions **128***e* and **130** are interconnected by arcuate side portions corresponding to the arcuate side portions **134** and **136** of the wedge member **44***d* (FIGS. **14** and **15**). A socket **140***e* (FIG. **17**) is provided in the wedge member **44***e* to facilitate the application of torque to the wedge member.

In accordance with a feature of the embodiment of the invention illustrated in FIG. **17**, the wedge member **44***e* is formed of a rigid porous material having an open cell construction. The porous open cell construction of the wedge member **44***e* enables bone to grow through the wedge member. The wedge member **44***e* may have an open cell construction similar to the construction of coral.

The wedge member **44***e* may be coated with bone growth promoting materials to promote the growth of bone through the wedge member. The open cells in the porous wedge member **44***e* could be at least partially filled with the bone growth promoting material. In addition, bone growth materials and/or bone chips may be packed in the joint **34***e* around the wedge member **44***e*. The bone growth promoting materials may include bone morphogenic proteins and/or other osteoinductive materials.

A pair of fasteners **70***e* and **72***e* are provided to connect the wedge member **44***e* with the upper and lower bones **30***e* and **32***e*. Thus, the fasteners **70***e* extends into the outer layer **76***e* of hard cortical bone on the upper bone **30***e*. Similarly, the fastener **72***e* extends into the outer layer **78***e* of hard cortical bone on the lower bone **32***e*. In the illustrated embodiment of the invention, the fasteners **70***e* and **72***e* extend through passages in the wedge member **44***e* into the upper and lower bones **30***e* and **32***e*. However, if desired, the wedge member **44***e* could be provided with mounting tabs, similar to the mounting tabs **144** and **146** of FIG. **16**.

When the wedge member **44***e* is to be used to change the spatial relationship between the upper and lower bones **30***e* and **32***e*, the wedge member is inserted into the joint **34***e* with the arcuate nose portions **128***e* and **130***e* of the wedge member spaced from the outer side surfaces **88***e* and **90***e* on the upper and lower bones **30***e* and **32***e*. At this time, the wedge member **44***e* is in the same orientation as is illustrated in FIG. **14** for the wedge member **44***d*. Arcuate side portions of the arcuate outer side surface **126***e* on the wedge member **44***e* engage the outer side surfaces **88***e* and **90***e* on the upper and lower bones **30***e* and **32***e* in the same manner as is illustrated for the wedge member **44***d* in FIG. **14**.

Although inserting the wedge member **44***e* into the joint **32***e* may effect an initial, relatively small expansion of the joint, the majority of the expansion of the joint **34***e* is obtained by rotating the wedge member **44***e* about its central axis **120***e*. To rotate the wedge member **44***e* about its central axis **120***e*, a suitable tool is inserted into the socket **140***e*. Force is transmitted from the tool to the wedge member **44***e* to rotate the wedge member. As the wedge member is rotated relative to the upper and lower bones **30***e* and **32***e*, the wedge member further expands the joint **34***e* and effects further change in the spatial relationship between the upper and lower bones **30***e* and **32***e*.

Once the wedge member **44***e* has been moved to the position illustrated in FIG. **17**, that is, to a position corresponding to the position of the wedge member **44***d* in FIG. **15**, the wedge member is connected to the upper and lower bones **30***e* and **32***e*. To connect the wedge member with the upper and lower bones **30***e* and **32***e*, the screws **70***e* and **72***e* are inserted through passages in the wedge member into the bone. Bone growth promoting material and/or bone chips may be packed in the joint **34***e* around the wedge member **44***e*.

Although a single wedge member **44***e* is utilized to expand the joint **34***e*, a plurality of wedge members could be utilized if desired. When a plurality of wedge members **34***e* are held to expand the joint **34***e*, the wedge members may all be of the same size and configuration or may have different sizes and configurations.

Rotatable Wedge Member Alternative—Embodiment

The wedge members **44***d* and **44***e* are rotated about their central axes **120***d* and **120***e* (FIGS. **16** and **17**) to effect expansion of the joints **34***d* and **34***e*. In the embodiment of the invention illustrated in FIGS. **18** through **20**, the wedge member is rotated about a location where the wedge member engages one of the bones. Since the embodiment of the invention illustrated in FIGS. **18**–**20** is generally similar to the embodiments of the invention illustrated in FIGS. **1**–**17**, similar numerals will be utilized to designate similar components, the suffix letter "f" being associated with the numerals of FIGS. **18–20** to avoid confusion.

Upper and lower bones **30***f* and **32***f* are interconnected at a joint **34***f*. A wedge member **44***f* is illustrated inserted into the joint **34***f* between the upper and lower bones **30***f* and **32**. The wedge member **44***f* is positioned in the joint **34***f* (FIG. **18**) with a relatively narrow width of the wedge member between outer side surfaces **88***f* and **90***f* on hard cortical outer layers **76***f* and **78***f* of the upper and lower bones **30***f* and **32***f*. Although the outer side surfaces **88***f* and **90***f* of the upper and lower bones **30***f* and **32***f* are in their naturally occurring conditions, it is contemplated that a surgeon may want to prepare the surfaces of the bone for the wedge member **44***f* by cutting away extraneous material to promote seating of the wedge member **44***f* on the upper and lower bones **30***f* and **32***f*.

The wedge member **44***f* has an arcuate nose portion **128***f* and a pivot end portion **150***f*. The nose portion **128***f* and pivot end portion **150***f* are interconnected by side portions **134***f* and **136***f*. The side portion **134***f* has a continuously curving arcuate configuration. The side portion **136***f* may have a linear configuration.

The side portion **136***f* has a relatively flat area which engages the outer side surface **90***f* on the lower bone **32***f* when the wedge member **44***f* is oriented as illustrated in FIG. **18** If desired, the side portion **136***f* could have an arcuate configuration corresponding to the arcuate configuration of the side portion **134***f*. If the side portion **136***f* had the same configuration as the side portion **134***f*, the wedge member **44***f* would have a symmetrical configuration about an axis extending through the relatively sharply defined pivot end portion **150***c*.

The wedge member **44***f* has the same size and configuration throughout its length. Thus, the end portion **150***f* of the wedge member is the same size as the end portion **52***f* (FIG. **20**). However, if desired, the wedge member **44***f* could taper from a relatively thick end portion **50***f* to a relatively thin or small end portion **52***f* in the manner illustrated in FIGS. **16** and **17** for the wedge members **44***d* and **44***e*. It should be understood that any one of the wedge members illustrated in FIGS. **1** through **17** could be formed with the same configuration as the wedge member **44***f* if desired. However, it is believed that in most instances it will probably be preferred to provide the wedge members of FIGS. **1–17** with an axially tapered configuration to facilitate insertion of the wedge members into the joint between the upper and lower bones.

The wedge member **44***f* (FIGS. **18**, **19** and **20**) is formed of a rigid porous open cell material. The rigid porous open cell material of the wedge member **44***f* has a construction generally similar to coral. However, the wedge member **44***f* could be formed of a nonporous material if desired.

It is contemplated that the wedge member **44***f*, like the wedge members illustrated in FIGS. **1–17**, may be formed of human or animal bone, metal, ceramic, or a polymeric material. While it may be preferred to form the wedge member **44***f* of a porous material to enable bone to grow through the wedge member, the wedge member **44***f* may be formed of a solid material through which bone can not grow.

The wedge member **44***f* may be coated with or packed with bone growth promoting materials. The bone growth promoting materials may be bone morphogenic proteins and/or other osteoinductive materials. Bone chips may be included with the bone morphogenic proteins and/or other osteoinductive materials packed around the wedge member **44***f*.

Of course, the wedge member **44***f* may be provided with a tapered configuration to facilitate insertion into the joint **34***f*. When the wedge member **44***f* is to be utilized to change the spatial relationship between the upper and lower bones **30***f* and **32***f*, the wedge member is inserted into the joint **34***f*. The illustrated embodiment of the wedge member **44***f* has the same size and configuration throughout its length. Therefore, the wedge member **44***f* does not taper to a thin end portion to facilitate insertion of the wedge member into the joint **34***f*. Therefore, the joint **34***f* may be initially expanded with a suitable tool to enable the wedge member **44***f* to be inserted into the joint, in the orientation illustrated in FIG. **18**.

When the wedge member **44***f* is inserted into the joint **34***f*, there will be a slight initial expansion of the joint. As was previously mentioned, the wedge member **44***f* may have an axially tapered configuration, similar to the configuration of the wedge members **44***d* and **44***e* (FIGS. **16** and **17**), to facilitate insertion of the wedge member **44***f* into the joint **34***f*.

As the wedge member **44***f* is initially inserted into the joint **34***f*, the side portions **134***f* and **136***f* on the wedge member **44***f* slide along the outer side surfaces **88***f* and **90***f* on the upper and lower bones **30***f* and **32***f*. At this time, the arcuate nose portion **128***f* of the wedge member **44***f* is spaced from the outer side surface surfaces **88***f* and **90***f* of the upper and lower bones **30***f* and **32***f*.

To further change the spatial relationship between the upper and lower bones **30***f* and **32***f*, the wedge member **44***f* is rotated about an axis extending through a location where the pivot end portion **150***f* of the wedge member **44***f* engages the outer side surface **90***f* of the lower bone **32***f*. To effect rotation of the wedge member **44***f*, a suitable tool is inserted into a socket **140***f*. Force is transmitted through the tool to the wedge member **44***f* urging the wedge member **44***f* to rotate in a clockwise direction from the position shown in FIG. **18** to the position shown in FIG. **19**.

Upon initial application of the force to the wedge member **44***f* urging the wedge member to rotate in a clockwise direction (as viewed in FIG. **18**), the pivot end portion **150***f* of the wedge member **44***f* is pressed against the outer side surface **90***f* of the lower bone **32***f*. At the same time, the side portion **134***f* of the wedge member **44***f* begins to slide along the outer side surface **88***f* on the upper bone **30***f*.

Continued application of force (torque) to the wedge member **44***f* results in the wedge member pivoting about an axis which extends through a location where the end portion **150***f* of the wedge member **44***f* engages the outer side surface **90***f* on the lower bone **32***f*. As the wedge member **44***f* pivots about the end portion **150***f*, the arcuate nose portion **128***f* moves into engagement with and slides along the outer side surface **88***f* on the upper bone **30***f*. As the wedge member **44***f* approaches the orientation shown in FIG. **19**, the joint **34***f* is expanded and the spatial relationship between the upper and lower bones **30***f* and **32***f* is changed with a resulting change in the angular orientation of the upper and lower bones relative to each other.

When the wedge member **44***f* reaches the orientation shown in FIG. **19**, the joint **34***f* has been expanded to the maximum extent possible by the wedge member. The wedge member **44***f* is then connected with the upper and lower bones **30***f* and **32***f* by suitable fasteners. The fasteners may extend through mounting tabs, similar to the mounting tabs **144** and **146** illustrated in FIG. **16** or the fasteners may extend through the wedge member in the manner illustrated schematically in FIG. **17**. Of course, the wedge member **44***f* could be held in the upright (as viewed in FIG. **19**) orientation in any one of many different manners by a suitable fastener arrangement.

Although only a single wedge member **44***f* has been shown in FIGS. **18–20**, a plurality of the wedge members **44***f* could be used to expand the joint **34***f* and to transmit force between the bones **30***f* and **32***f*. Whether a single wedge member **44***f* or a plurality of wedge members **44***f* are used to expand the joint, the joint may be packed with bone growth promoting material.

Screw Type Wedge Member

In the embodiment of the invention illustrated in FIGS. **12–16**, the wedge member **44***d* has a relatively smooth outer side surface **126**. In the embodiment of the invention illustrated in FIGS. **21** and **22**, the wedge member has a configuration similar to the configuration of a screw and has a irregular outer side surface. Since the embodiment of the invention illustrated in FIGS. **21** and **22** is generally similar to the embodiments of the invention illustrated in FIGS. **12–20**, similar numerals will be utilized to designate similar components, the suffix letter "g" being associated with the numerals of FIGS. **21** and **22** to avoid confusion.

An upper bone **30***g* is connected with a lower bone **32***g* in a patient's body at a joint **34***g*. It should be understood that the joint **34***g* has been illustrated schematically in FIG. **21** and may be any joint in a patient's body. A rigid wedge member **44***g* is utilized to change the spatial relationship between the upper and lower bones **30***g* and **32***g*. The wedge member **44***g* is effective to expand at least a portion of the joint **34***g* when the wedge member **44***g* is inserted into the joint **34***g*.

The wedge member **44***g* has a thick end portion **50***g* and a thin end portion **52***g*. The wedge member **44***g* has an overall conical configuration. An external thread convolution **160** is formed on the wedge member **44***g*. The external thread convolution **160** has a spiral configuration and extends from the thick end portion **50***g* to the thin end portion **52***g* of the wedge member **44***g*.

Although the external thread convolution **160** could have many different configurations, the illustrated thread convolution has generally V-shaped crests and roots. The general configuration of the external thread convolution **160** is an American National Form Screw Thread and has a pitch cone with an angle of between five degrees and twenty degrees. Although one specific external thread convolution has been illustrated and described herein, it should be understood that the external thread convolution **160** could have a configuration of any one of many different known thread convolutions. It is believed that it may be desired to use known bone screw thread configurations for the configuration of the external thread convolution **160**.

The rigid wedge member **44***g* may be formed of metal, ceramic, human or animal bone, or suitable polymeric materials. It is believed that it will be desirable to form the wedge member **44***g* of a material which is sufficiently rigid to withstand the forces transmitted between the upper and lower bones **30***g* and **32***g*. If desired, the wedge member **44***g* may be formed of a porous material having openings through which bone may grow. It is believed that it may be desired to coat the wedge member **44***g* with a bone growth promoting material.

When the wedge member **44***g* is to be utilized to change the spatial relationship between the upper and lower bones **30***g* and **32***g*, the thin end portion **52***g* of the wedge member **44***g* is pressed into the joint **34***g* between the upper and lower bones **30***g* and **32***g*. The wedge member **44***g* is then rotated about its longitudinal central axis **120***g*. A hexagonal recess **140***g* is provided in the wedge member **44***g* to facilitate the transmission of force from a suitable tool to the wedge member **44***g*.

As the wedge member **44***g* is rotated through a plurality of revolutions about its longitudinal central axis **120***g*, the external thread convolution **160***g* engages the upper and lower bones **30***g* and **32***g*. As the wedge member **44***g* is rotated about its longitudinal central **120***g*, the external thread convolution **160** engages the upper and lower bones **30***g* and **32***g* and pulls the wedge member into the joint **34***g*. As this occurs, the joint **34***g* is expanded and the spatial relationship between the upper and lower bones **30***g* and **32***g* is changed.

Once the wedge member **44***g* has moved into the joint **34***g* and the spatial relationship between the upper and lower bones **30***g* and **32***g* has been changed, the joint **34***g* may be packed with bone growth promoting materials and/or bone chips. It is contemplated that various known bone morphogenic proteins may be used with other osteoinductive materials to induce bone growth in the joint **34***g*. Although only a single wedge member **44***g* is illustrated in FIG. **21**, a plurality of wedge members may be used if desired.

Bone Fitting Wedge Member

In the embodiments of the invention illustrated in FIGS. **1–11**, the wedge members have flat upper and lower major side surfaces **54** and **56** (FIG. **6**). In the embodiment of the invention illustrated in FIGS. **23** and **24**, the wedge member has nonlinear side surfaces which have been shaped to correspond to the configuration of end portions of the bone at a joint between the bones. Since the embodiment of the invention illustrated in FIGS. **23** and **24** is generally similar to the embodiments of the invention illustrated in FIGS. **1–11**, similar numerals will be utilized to designate similar components, the suffix letter "h" being associated with the numerals of FIG. **9** to avoid confusion.

Upper and lower bones **30***h* and **32***h* are interconnected at a joint **34***h*. The joint **34***h* is a schematic representation of any one of many joints in a patient's body. The joint **34***h* may be in a patient's wrist, ankle, hand, foot, back, or other portion of the patient's body.

When the spatial relationship between the upper and lower bones **30***h* and **32***h* is to be changed, a wedge member **44***h* is moved into the joint **34***h*. The wedge member **44***h* is moved into the joint with a thick end portion **50***h* of the wedge member trailing and a thin end portion **52***h* of the wedge member leading. As the wedge member **44***h* is pressed into the joint **34***h*, upper and lower major side surfaces **54***h* and **56***h* are pressed against outer side surfaces **88***h* and **90***h* on the upper and lower bones **30***h* and **32***h*. This results in expansion of the joint **34***h* in the manner previously described in conjunction with the embodiments of the invention illustrated in FIGS. **1–11**.

In accordance with a feature of this embodiment of the invention, the upper and lower major side surfaces **54***h* and **56***h* on the wedge member **44***h* are configured to match the configuration of the outer side surfaces **88***h* and **90***h* on the upper and lower bones **30***h* and **32***h*, in the manner illustrated schematically in FIG. **24**. By having the upper and lower major side surfaces **54***h* and **56***h* configured to match the configuration of the outer side surfaces **88***h* and **90***h* on the upper and lower bones **30***h* and **32***h*, the wedge member **44***h* is firmly seated against the bone and held against sidewise (as viewed in FIG. **24**) movement relative to the bones. The arcuate configuration of the upper and lower major side surfaces **54***h* and **56***h* on the wedge member **44***h* extends from the thick end **50***h* of the wedge member **44***h* to the thin end **52***h* of the wedge member.

In the embodiment of the invention illustrated in FIG. **24**, the wedge member **44***h* is formed of a rigid porous material having an open cell construction. A compartment or cavity **100***h* in the wedge member **44***h* holds bone growth inducing materials **110***h*. The bone growth inducing materials **110***h* may include bone morphogenic proteins and other osteoinductive materials. The joint **34***h* may be packed with bone growth promoting materials and/or bone chips.

The wedge member **44***h* is fixedly connected to the upper and lower bones **30***h* and **32***h* by suitable fasteners (not shown). The wedge member **44***h* may be connected with the upper and lower bones **30***h* and **32***h* by screws corresponding to the screws **70** and **72** of FIG. **8**. Alternatively, the wedge member **44***h* may be connected with the upper and lower bone **30***h* and **32***h* by screws which extends through mounting tabs, corresponding to the mounting tabs **144** and **146** of FIG. **16**. If desired, the wedge member **44***h* may be connected with only the upper bone **30***h* or only the lower bone **32***h*.

It is believed that by having the side surfaces **54***h* and **56***h* configured to correspond to the configuration of the surfaces **88***h* and **090***h* on the bones **30***h* and **32***h*, the joint **34***h* will be particularly stable when the joint has been immobilized by connecting the wedge member **44***h* to the bones. Although only a single wedge member **34***h* has been illustrated in FIGS. **22** and **24**, a plurality of wedge members could be used to expand the joint. It is believed that the wedge member **44***h* may be particularly advantageous when vertebrae in a patient's back are to be interconnected.

CONCLUSION

In view of the foregoing description it is apparent that a new and improved method and apparatus is provided to change a spatial relationship between bones **30** and **32** which are interconnected at a joint **34** in a patient's body. When this is to be done, an opening is formed in a portion of the patient's body to expose the joint **34** interconnecting the bones **30** and **32**. One of the bones **30** and **32** is moved relative to the other by expanding at least a portion of the joint **34** with a wedge member **44**. The wedge member **44** is moved into the joint and applies force against the bones **30** and **32**. The opening is closed with the wedge member **44** still disposed in the joint between the bones. Force is then transmitted between the bones **30** and **32** through the wedge member **44** to maintain the joint **34** in an expanded condition.

If the joint **34** is to be flexed after being expanded by the wedge member **44**, the wedge member may be connected with only one of the bones **30** and **32**. Alternatively, if the joint **34** is to be immobilized (fused) after inserting the wedge member **44**, the wedge member may be fixedly connected with the bones **30** and **32** interconnected at the joint. The wedge member **44** may be porous and may be coated with and/or contain bone growth promoting material.

One embodiment of the wedge member **44** has major side surfaces **54** and **56** extending between thick and thin end portions **50** and **52** of the wedge member. The wedge member **44** is moved into the joint **34** with the thin edge portion **52** leading. As the wedge member **44** is moved into the joint **34**, the thick trailing end portion **50** of the wedge member expands the joint.

In another embodiment of the invention, the wedge member **44***d*, **44***e*, **44***f*, or **44***g* may be rotated relative to the joint. In one embodiment of the invention, the wedge member **44***g* has a circular cross sectional configuration and has an external thread convolution **160** which extends from a thin leading end **52***g* of the wedge member to a thick trailing end **50***g* of the wedge member. The wedge member **44***g* is pressed into the joint **34***g* and rotated to cause the wedge member to expand the joint.

In another embodiment of the invention, the wedge member **44***d*, **44***e* or **44***f* has surface areas **134** and **136** which are relatively close together and other surface areas **128** and **130** which are relatively far apart. The wedge member **44***d*, **44***e*, or **44***f* is moved into the joint **34** with the surface areas **134** and **136** which are close together engaging the adjacent bones **30** and **32**. The wedge member **44***d*, **44***e* or **44***f* is then rotated to apply force against the adjacent bones to expand the joint. The wedge member **44***d* or **44***e* may be rotated about its central axis **120** to apply forced against the bones **30** and **32** and expand the joint. Alternatively, the wedge member **44***f* may be rotated about a location where the wedge member engages one of the bones.

Regardless of which embodiment of the wedge members **44**, **44***a*, **44***b*, **44***c*, **44***d*, **44***e*, **44***f*, **44***g* or **44***h* is selected, the wedge member may be used with any one of the many different bones and joints in a patient's body. The wedge member may be utilized at joints in a patient's wrist, ankle, hand, foot, back, or other portions of the patient's body. The use of the wedge member may be particularly advantageous when a joint between vertebrae in a patient's back is to be immobilized. One or more wedge members may be used to expand a joint to transmit force between bones.

What is claimed is:

1. An implantable device for changing the spatial relationship between first and second bones, the device comprising a wedge body configured and dimensioned for insertion into a joint located between the first and second bones, the wedge body having a thin end portion, a thick end portion, a first major side surface which extends from the thin end portion to the thick end portion, a second major side surface which intersects the first major side surface to form an edge at the thin end portion and extends from the thin end portion to the thick end portion, and a minor side surface which extends between the first and second major side surfaces and tapers from the thick end portion to the thin end portion, the wedge body having a compartment containing a bone growth inducing material.

2. The device of claim **1** wherein the bone growth inducing material includes demineralized bone.

3. The device of claim **2** wherein the demineralized bone is a powder.

4. The device of claim **1** wherein the bone growth inducing material includes collagen.

5. The device of claim **4** wherein the collagen is in the form of apatite compositions with collagen.

6. The device of claim **4** wherein the bone growth inducing material includes demineralized bone.

7. The device of claim **6** wherein the demineralized bone is a powder.

8. The device of claim **4** wherein the wedge body is made of a porous material.

9. The device of claim **8** wherein the porous material includes cavities with at least some of the cavities containing a bone growth promoting material.

10. The device of claim **1** further including fastener means for fixedly connecting the wedge body to at least one of the first and second bones.

11. The device of claim **10** wherein the fastener means includes at least one screw.

12. The device of claim 10 wherein the fastener means includes a first connector configured and dimensioned to connect the wedge body to the first bone and a second connector configured and dimensioned to connect the wedge body to the second bone.

13. The device of claim 1 wherein the bone growth inducing material includes a bone morphogenic protein.

14. A spinal implant for insertion in a joint located between first and second vertebrae, the implant comprising a wedge member configured and dimensioned for insertion into the joint, the wedge member having a thin end portion, a thick end portion, a first major side surface which extends from the thin end portion to the thick end portion, a second major side surface which intersects the first major side surface to form an edge at the thin end portion and extends from the thin end portion to the thick end portion, and a minor side surface which extends between the first and second major side surfaces and tapers from the thick end portion to the thin end portion, the wedge member having a compartment containing a bone growth inducing material.

15. The implant of claim 14 wherein the bone growth inducing material includes demineralized bone.

16. The implant of claim 15 wherein the demineralized bone is a powder.

17. The implant of claim 14 wherein the bone growth inducing material includes collagen.

18. The implant of claim 17 wherein the collagen is in the form of apatite compositions with collagen.

19. The implant of claim 17 wherein the bone growth inducing material includes demineralized bone.

20. The implant of claim 19 wherein the demineralized bone is a powder.

21. The implant of claim 17 wherein the wedge member is made of a porous material.

22. The implant of claim 21 wherein the porous material includes cavities with at least some of the cavities containing a bone growth promoting material.

23. The implant of claim 14 further including fastener means for fixedly connecting the wedge member to at least one of the first and second vertebrae.

24. The implant of claim 23 wherein the fastener means includes at least one screw.

25. The implant of claim 23 wherein the fastener means includes a first connector configured and dimensioned to connect the wedge member to the first vertebra and a second connector configured and dimensioned to connect the wedge member to the second vertebra.

26. The implant of claim 14 wherein the wedge member tapers from the thick end portion to the thin end portion.

27. The implant of claim 26 wherein the wedge member is made of a biocompatible metallic material.

28. The implant of claim 14 wherein a bone growth promoting material is disposed on the wedge member.

29. The implant of claim 14 wherein the bone growth inducing material includes a bone morphogenic protein.

30. A method of changing the spatial relationship between first and second bones, the method comprising:

providing an implantable device including an internal compartment, the implantable device having a thin end portion, a tick end portion, a first major side surface which extends from the thin end portion to the thick end portion, a second major side surface which intersects the first major side surface to form an edge at the thin end portion and extends from the thin end portion to the thick end portion, and a minor side surface which extends between the first and second major side surfaces and tapers from the thick end portion to the thin end portion;

placing a bone growth inducing material into the internal compartment, the bone growth inducing material including a bone morphogenic protein; and

inserting the implantable device into a joint located between the first and second bones.

31. The method of claim 30 further comprising connecting the implantable device to at least one of the first and second bones.

32. The method of claim 30 wherein inserting the implantable device into the joint located between the first and second bones comprises:

positioning the thin end portion of the implantable device in the joint located between the first and second bones; and

expanding at least a portion of the joint by moving the implantable device into the joint to apply a force against the first and second bones with the implantable device such that the spatial relationship between a first central longitudinal axis of the first bone and a second central longitudinal axis of the second bone changes as the implantable device is moved into the joint.

33. The method of claim 30 wherein the bone growth inducing material includes demineralized bone.

34. The method of claim 33 wherein the demineralized bone is a powder.

35. The method of claim 33 wherein the bone growth inducing material includes collagen.

36. The method of claim 35 wherein the collagen is in the form of apatite compositions with collagen.

37. The method of claim 35 wherein the implantable device is made of a porous material.

38. The method of claim 37 wherein the porous material includes cavities with at least some of the cavities containing a bone growth promoting material.

39. The method of claim 30 wherein the thick end portion has a first thickness and the thin end portion has a second thickness less than the first thickness.

40. The method of claim 39 wherein inserting the implantable device into the joint located between the first and second bones comprises:

positioning the thin end portion of the implantable device in the joint located between the first and second bones; and

expanding at least a portion of the joint located between the first and second bones by moving the implantable device into the joint to apply a force against the first and second bones with the implantable device, such that the spatial relationship between a first central longitudinal axis of the first bone and a second central longitudinal axis of the second bone changes as the implantable device is moved into the joint.

41. The method of claim 30 wherein the first and second bones are first and second vertebrae.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,001,385 B2 Page 1 of 1
APPLICATION NO. : 10/755995
DATED : February 21, 2006
INVENTOR(S) : Peter M. Bonutti

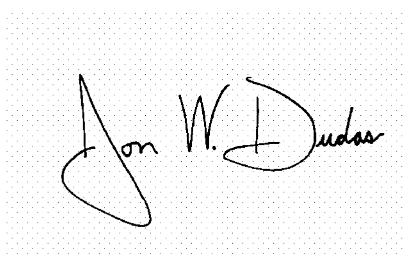
It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 23

Line 60, change "tick" to --thick--

Signed and Sealed this

First Day of August, 2006



JON W. DUDAS
Director of the United States Patent and Trademark Office