PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : A61B 17/70

A2

(11) International Publication Number: **WO 00/54681**

(43) International Publication Date: 21 September 2000 (21.09.00)

(21) International Application Number: PCT/IB00/00281

(22) International Filing Date: 15 March 2000 (15.03.00)

(30) Priority Data:
99/03234 16 March 1999 (16.03.99) FR

(71) Applicant *(for all designated States except US)*: SOCIETE DE FABRICATION DE MATERIEL ORTHOPEDIQUE (SOFAMOR) [FR/FR]; 13, rue de la Perdrix, F-93290 Tremblay en France (FR).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: BARBERA-ALACREU, Jose Vicente [ES/ES]; Hospital General Universitario, Catedratico de Neurocirurgia, Avenida Tres Cruces, E-46014 Valencia (ES). GRAZIANI, Noel [FR/FR]; Clinique de la Residence du Parc, Service Neurochirurgie, Rue Gaston Berger, F-13362 Marseille Cedex 10 (FR). GOURNAY, Jose [FR/FR]; 36, avenue Drap d'Or, F-77230 Dammartin en Goele (FR). MALANDAIN, Hugues [FR/FR]; 149, rue des Hirondelles, F-13300 Salon de Provence (FR).

(74) Agent: MARTIN, Jean-Paul; Cabinet Lavoix, 2, place d'Estienne d'Orves, F-75441 Paris Cedex 09 (FR).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

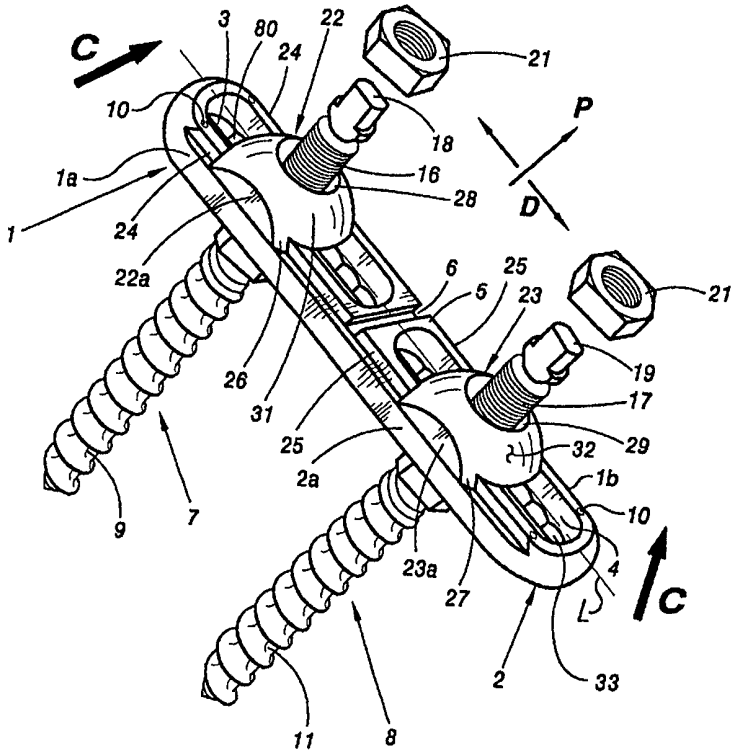
Published

Without international search report and to be republished upon receipt of that report.

(54) Title: SPINAL OSTEOSYNTHESIS INSTRUMENTATION

(57) Abstract

Spinal osteosynthesis instrumentation comprising at least one elongate vertebral plate (1, 2), at least one bone screw (7, 8) including a threaded shank (8, 9) and an opposite threaded end portion (16, 17) sized to be inserted through a longitudinal oblong opening (3) in the plate (1, 2), and means for locking the screw (7, 8) relative to the plate in a particular longitudinal position and at a particular angular orientation. The instrumentation comprises at least one shoe (22, 23) mounted to slide on slides (24, 25) formed on one face of the plate (1, 2) and being positively retained thereon. Each shoe (22, 23) has an opening (28, 29) through which passes the threaded end portion (16, 17) of the screw (7, 8). The threaded end portion (16, 17) is adapted to receive a locking nut (21). Each shoe (22, 23) has a spherical bearing surface (31, 32) corresponding to a spherical bearing surface of the locking nut (21) for locking the screw (7, 8) in the chosen angular orientation relative to the plate (1, 2). A large range of angular movement of the screw (7, 8) is thereby allowed relative to the plate (1, 2). The screw is fixed in a particular longitudinal position and at a particular angular orientation by tightening the nut (21) against the shoe (22, 23).



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

SPINAL OSTEOSYNTHESIS INSTRUMENTATION

The present application claims the benefit of French Patent Application No. 99 03 234, filed 16 March 1999, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

The present invention relates to an instrument for the osteosynthesis of a spinal segment, and more particularly to instruments for the connection of vertebral deformations and degradations. Among portions of the spine to which these devices may be particularly adopted include the thoracic, thoraco-lumbar, and lumbar spinal segments.

Systems are known in the art that employ elongated plates or rods to interconnect a series of bone anchors, such as, for example, pedicular screws, to correct spinal deformities or degradation.

European Patent No. 0,383,992 and U.S. Patent No. 4,611,581 each describe instruments in which spinal plates are bent to conform with the anatomy of a particular spinal segment, and include pedicular screws having heads extended at the end opposite their bone anchor portion by a threaded end adapted to receive a nut for rigidly securing the plate to the screw. An elongate opening in the spinal plates enables adjustability of the position of the screw relative to the plate.

Until now, most instruments of the above type have included 90º angular connections between the screw and the plates, with the plates typically being bent to conform to the local lordosis or cyphosis. The vertebral plates generally have a length spanning two or three vertebral levels. Larger spans are typically avoided due to difficulties encountered in bending the plates. Additionally, titanium alloy plates or titanium plates tend to weaken if they are bent at a sharp angle when cold. This weakening causes the appearance of splits and/or cracks, and commensurately reduces the fatigue resistance of the plates.

Thus, prior plate-type spinal osteosynthesis instrumentation is not well suited for spanning across several levels of vertebral bodies. Also, prior

instrumentation does not adequately accommodate for variations in the alignment of the screws in the frontal plane. Additionally, existing instrumentation is not capable of adequately conforming to the anatomy of the local lordosis or cyphosis. This difficulty can only be overcome by bending the plate into the desired configuration. Finally, existing instrumentation does not adequately accommodate for any angular variation in the convergence of the pedicular screws.

One object of the present invention is to provide spinal instrumentation that allows relative articulation between a screw and a plate to reduce the need to bend the plate into different configurations, consequently minimizing the disadvantages stemming from such bending.

Another object of the present invention is to provide spinal instrumentation that allows the screw to be oriented relative to the plate over a wide range of angles, and locked into a particular angular orientation by means of a locking device.

SUMMARY OF THE INVENTION

Further objects, forms, embodiments, aspects, benefits, features, and advantages of the invention will be clear from the following description with reference to the accompanying drawings which illustrate several embodiments of the invention by way of non-limiting examples.

In accordance with the present invention, spinal osteosynthesis instrumentation comprises at least one shoe mounted to slide on slides provided on one face of a member. The shoe is attached to the member in a direction perpendicular to the direction of sliding and defines a bore through which passes one end of a bone anchor adapted to receive locking means for securing the bone anchor to the member.

Also in accordance with the present invention, the instrumentation comprises at least one shoe mounted to slide on slides provided on the member, and in this shoe a bore is formed through which one end portion of a bone anchoring screw passes. The end portion of the screw is adapted to receive the locking means. The shoe has around its bore a spherical bearing surface complementary to a corresponding spherical bearing surface formed by the locking means. The shoe is mounted on the face of the member on the same side as the locking means, permitting a variable angular orientation of the screw relative to the member.

In accordance with one feature of the present invention, the bore in the shoe is circular or oblong. In the latter case, the oblong opening enables the screw to be oriented at a large angle relative to the plate along a sagittal plane.

In accordance with another feature of the present invention, the shoe has lateral edges having a profile conjugate to the profile of slides formed along the member on each side of the longitudinal oblong opening. These male-female profiles can be, for example, of the dovetail kind.

In one embodiment of the invention, the instrumentation comprises a pair of shoes mounted to slide on slides formed on opposite longitudinal faces of a plate, with one of the shoes having a spherical bearing surface complementary to a corresponding spherical surface defined on a locking nut. The locking nut

engages a threaded end portion of the screw opposite a bone anchor portion. The other shoe has a spherical bearing surface complementary to a corresponding spherical bearing surface defined on a shoulder of the screw. The shoulder can have a projecting shape, with a suitable profile to enable driving of the pedicular screw into a vertebral body.

In another embodiment of the invention, the instrumentation comprises a pair of plates disposed end-to-end and connected together to form a single piece, with each plate being equipped with at least one shoe and a corresponding screw. A weakened area is formed between the two plates intermediate elongate openings defined through each of the plates to facilitate bending of plates along a sagittal plane. The two plates are equivalent to a single plate, with the two elongate openings separated by a central bridge of material. The weaker area can be formed, for example, by a transverse notch on the face of the junction between the plates on the same side as the locking means (i.e., on the same side as the nut). When the pair of plates are fabricated, the plates can be slightly bent in the area where they join, and then annealed to relieve internal stresses. The surgeon can then apply any slight additional bending that may be needed, typically of a few degrees, for example 5°, when fitting the plate to the spine.

In yet another embodiment of the invention, a device for spinal osteosynthesis is provided, including a first member having a longitudinal axis and being positionable adjacent the spine, a second member having a first end portion configured to engage a vertebral body and a second end portion opposite the first end portion, a connector member interconnecting the second member to the first member in a variable longitudinal position with the connector member being positively retained on the first member in a direction transverse to the longitudinal axis, and a locking member cooperating with the connector member and the second end portion of the second member to lock the second member in a particular longitudinal position.

In a further embodiment of the invention, a device for spinal osteosynthesis includes a first member having a longitudinal axis and being positionable adjacent the spine, a second member having a first end portion configured to engage a vertebral body and an opposite second end portion, a connector member

interconnecting the second end portion with the first member and being positionable in an infinite number of positions along the longitudinal axis. The connector member defines a passage extending therethrough and sized to receive the second end portion therein at a variable angle relative to the first member, with the passage opening onto a first substantially spherical-shaped bearing surface. A locking member defines a second substantially spherical-shaped bearing surface complementary to the first substantially spherical-shaped bearing surface. The locking member cooperates with the connector member and the second end portion of the second member to tightly engage the first and second substantially spherical-shaped bearing surfaces and lock the second end portion at a particular position along the longitudinal axis and at a particular angle relative to the first member.

In still another embodiment of the invention, a device for spinal osteosynthesis includes a spinal plate having a longitudinal axis, a bone anchor having a first end portion configured to engage a vertebral body and an opposite second end portion, and a connector member interconnecting the second end portion of the bone anchor with the plate. The connector member is slidable along a longitudinally extending face of the plate to position the connector member in an infinite number of positions along the longitudinal axis of the plate. The connector member defines a pair of opposing laterally extending projections disposed on opposite sides of the longitudinally extending face of the plate to maintain the connector member in sliding engagement with the plate. A locking member cooperates with the connector member and the second end portion of the bone anchor to maintain the second end portion in a selected position along the longitudinal axis of the plate.

Other features and advantages of the present invention will become apparent in the course of the following description, given with reference to the accompanying drawings which show various embodiments of the invention by way of non-limiting examples.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a top perspective view of one embodiment of a plate-type spinal osteosynthesis instrumentation in accordance with one aspect of the present invention.

Figure 2 is a bottom perspective view of the instrumentation of Figure 1.

Figure 3 is a top perspective view, similar to Figure 1, of another embodiment of instrumentation in which the spinal plates are provided with a ball and a cup disposed at opposite ends thereof to constitute a module that can be articulated relative to another adjacent module of similar construction.

Figure 4 is a partial top perspective view of another embodiment of instrumentation in accordance with another aspect of the present invention.

Figure 5 is a partial bottom perspective view of another embodiment of instrumentation in accordance with another aspect of the present invention.

Figure 6 is a top perspective view of the instrumentation of Figure 5.

Figure 7 is a partial top perspective view of another embodiment of instrumentation in accordance with another aspect of the present invention.

Figure 8 is a partial bottom perspective view of the instrumentation of Figure 7.

Figure 9 is a top perspective view of another embodiment of instrumentation in accordance with the present invention.

Figure 10 is a side perspective view of another embodiment of instrumentation in accordance with another aspect of the present invention.

Figure 11 is a partial cross-section and front view of the instrumentation of Figure 10.

DESCRIPTION OF SELECTED EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is hereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated herein being contemplated as would normally occur to one skilled in the art to which the invention relates.

The spinal osteosynthesis instrumentation shown in Figures 1 and 2 comprises a pair of elongate vertebral plates 1 and 2 disposed end-to-end along a longitudinal axis L and positionable adjacent the spine. In the illustrated embodiment, plates 1 and 2 are integrally formed to define a single unitary piece. However, it should be understood that plates 1, 2 could be formed separately and interconnected by any method known to those of skill in the art, such as, for example, by fastening or welding. Each of the plates 1, 2 includes an oblong longitudinal opening 3, 4. The openings 3, 4 are separated by an intermediate junction area 5 in which is formed a transverse notch 6 constituting a weakened area. The notch 6 is intended to facilitate bending of the plates 1, 2, for example, in the direction of arrows C. Each plate 1, 2 is adapted to accept a bone anchor 7, 8 configured to be anchored in a vertebral body (not shown) to which the instrumentation is fitted.

Each bone anchor 7, 8, which in the illustrated embodiment is a bone screw, comprises a threaded shank 9, 11 configured to engage a vertebral body, a head 12, 13 having a polygonal portion, preferably contiguous with the threaded shank 9, 11 and adapted to drive the bone screw, a ball extending from the head 12, 13 and having a spherical bearing surface 14, 15, and a threaded end portion 16, 17 extending from the spherical bearing surface 14, 15. Each of the threaded end portions 16, 17 includes a smooth end portion 18, 19 for facilitating the guiding of a locking member, such as locking nut 21, along end portions 16, 17. Nut 21 is adapted to be screwed onto a respective threaded end portions 16, 17.

Each threaded end 16, 17 is adapted to be inserted through a corresponding oblong opening 3, 4, and the associated locking nut 21 is adapted to lock the screw 7, 8 relative to the plate 1, 2 in a specific longitudinal position and angular orientation within the opening 3, 4.

The instrumentation further comprises, for each plate 1, 2, a respective connecting member or shoe 22, 23 mounted to slide on shaped grooves or slides 24, 26 formed along at least a portion of the length of the plates 1, 2 and configured to interconnect plates 1, 2 and screws 7, 8. In the illustrated embodiment, the shoes 22, 23 are mounted on the same side of the plates 1, 2 as the locking nuts 21 are disposed on. However, it should be understood that the shoes 22, 23 can alternatively be mounted on the opposite side of plates 1, 2. Each pair of slides 24, 25 is formed adjacent opposite longitudinal sides of the respective oblong opening 3, 4 and has a suitable profile to allow the shoe 22, 23 to slide along a longitudinal direction D while positively retaining the shoe 22, 23 on the plate 1, 2 in a transverse direction P. Thus, shoe 22, 23 is maintained or captured on a face of the plate 1, 2 in a transverse direction P, preferably substantially perpendicular to the direction of sliding D, without the aid of additional components, such as nuts or other types of fasteners. In the embodiment illustrated in Figures 1 and 2, the slides 24, 25 and the conjugate edges or shaped projections 26, 27 of the shoes 22, 23 have a male-female dovetail configuration. The shaped projections 26, 27 of the shoes 22, 23 are slidably engaged within the shaped grooves 24, 25 of plate 1, 2 to allow the shoes 22, 23 to slide relative to the plates 1, 2 along the longitudinal axis L. However, other suitable profiles are also contemplated as would occur to one of ordinary skill in the art.

A passage or bore 28, 29 is defined through each shoe 22, 23, through which extends the threaded end portion 16, 17 of the screw 7, 8, respectively. Preferably, each bore 28, 29 has a diameter sized larger than that of the threaded end portion 16, 17 of the screw 7, 8 to allow a certain degree of angular movement of the screw 7, 8 relative to shoe 22, 23. In the illustrated embodiment, the bore 28, 29 is cylindrical; however, bore 28, 29 can also take on other shapes, such as, for example, a conical or circular shape. Alternatively, the bore 28, 29

can be oblong-shaped, having a length extending in a direction substantially parallel to the longitudinal direction D of the oblong openings 3, 4 to allow angular movement of the screws 7, 8 in the direction of sliding. Each shoe 22, 23 defines around its bore 28, 29 an outer coaxial spherical bearing surface 31, 32, configured substantially complementary to a corresponding inner spherical bearing surface (not shown) defined on the inner face of the nut 21. The nut 21 can therefore be engaged tightly against the spherical bearing surface 31, 32 when nut 21 is tightened onto threaded end portions 16, 17 to retain the screw 7, 8 in a particular angular orientation relative to shoe 22, 23. The shoes 22, 23 are preferably mounted on the face of the plate 1, 2 on the same side as the nut 21, and have lateral flats 22a, 23a generally lying in the same plane as the lateral edges 1a, 2a of the plates 1, 2.

The shaped grooves on slides 24, 25 extend substantially the entire length of the plates 1, 2, thus allowing the shoes 22, 23, and consequently the screws 7, 8 that pass through shoes 22, 23, to be variably adjusted in the direction of sliding D over virtually the entire length of the openings 3, 4. Formed on a lower portion of the longitudinally extending inside walls of oblong openings 3, 4 are concave spherical recesses or housings 80, 33 configured substantially complementary to the convex spherical bearing surfaces 14, 15 of screws 7, 8. The spherical bearing surfaces 14, 15 are configured to bear against the spherical housings 80, 33 to aid in maintaining the longitudinal position and angular orientation of screws 7, 8 relative to the plates 1, 2. It should be understood that the spherical housings 80, 33 could alternatively be replaced with conical housings to inhibit the axial sliding of screws 7, 8 when the nut 21 is tightly engaged against the shoe 22, 23. Abutments are provided on opposite ends of the slides 24, 25 along the longitudinal axis L to prevent the shoe 22, 23 from sliding off of slides 24, 25 and disengaging plates 1, 2. In the illustrated embodiment, stamped bosses 10 are provided at the ends of plates 1, 2 to maintain the shoes 22, 23 in sliding engagement with the plates 1, 2. In one embodiment, the stamped bosses 10 are formed in plates 1, 2 by punching or embossing.

The use of the spinal instrumentation described above is substantially as follows. It should be understood, however, that the following description of use is

exemplary, and that other methods of using the instrumentation are also contemplated as being within the scope of the invention. The surgeon first drives the pedicular screws 7, 8 into the vertebral bodies by way of the hexagonal portions 12, 13, orienting the screws 7, 8 as close as possible to the appropriate angular orientation. The surgeon then inserts the threaded end portions 16, 17 of the screws 7, 8 into the bores 28, 29 of the shoes 22, 23, orienting the plates 1, 2 as required. The appropriate position of the screws 7, 8 along the sagittal plane of the patient (i.e., along the direction of sliding D) is obtained by virtue of the shoes 22, 23. The shoes 22, 23 can be slid along the plate 1, 2 in the direction of sliding D to accommodate a range of positions of screws 7, 8 within oblong openings 3, 4, with the spherical bearing surfaces 14, 15 being positioned in a corresponding spherical housings 80, 33. If the cylindrical bores 28, 29 are replaced by oblong bores, the surgeon has an additional means for adjusting the position and orientation of screws 7, 8 along the sagittal plane.

When the relative positions and orientations of the plates 1, 2 and the pedicular screws 7, 8 have been selected, the surgeon engages the nuts 21 onto the threaded end portions 16, 17. The smooth end portions 18, 19 define lateral flats which facilitate the guiding of the nuts 21 onto the screws 7, 8 and the initial threading of the nuts 21 onto the threaded end portions 16, 17. Without lateral flats 18, 19, it would be more difficult for the surgeon to thread the nuts 21 onto the screws 7, 8. As the nuts 21 are threaded along end portions 16, 17, the inner spherical bearing surfaces (not shown) of the nuts 21 are firmly engaged against the outer spherical bearing surfaces 31, 32 of the shoes 22, 23. Preferably, the inner and outer bearing surfaces have the same radius of curvature, thus having the effect of automatically centering the shoes 22, 23 relative to the screws 7, 8 when the nuts 21 are tightened due to the geometrical match between the complementary male and female bearing surfaces. The connection between the plates 1, 2 and the screws 7, 8, by virtue of the shoes 22, 23, allows for variable positioning and angular movement therebetween, with the screws being affixed to the plates in a particular position and at a particular angular orientation by the locking nut 21. More particularly, the tightening of nuts 21 onto the upper surfaces 31, 32 of shoes 22, 23 firmly engages the shoes 22, 23 against the plates 1, 2,

and also firmly engages the spherical bearing surfaces 14, 15 of screws 7, 8 against the spherical recesses 80, 33.

Depending on the specific geometry of the screws 7, 8, there can be one shoe 22, 23 associated with each plate 1, 2 and oblong opening 3, 4, or alternatively two shoes 22, 23 if the openings 3, 4 are of a sufficient length. Additionally, asperities or surface roughness can be formed along at least a portion of the length of the slides 24, 25 and/or along the facing surfaces of the edges 26, 27 of the shoes 22, 23 to create resistance to sliding of the shoe 22, 23 in the direction of sliding D. The respective asperities must be of concordant or complementary form and must be limited in depth to allow for the free sliding of the shoes 22, 23 along the plates 1, 2 when the nuts 21 are not firmly engaged against the shoes 22, 23.

In Figures 1 and 2, the plates 1, 2 are illustrated in an unbent configuration, and therefore have a substantially rectilinear configuration. However, the transverse notch 6 between plates 1, 2 defines a weakened area which facilitates the bending of the single-piece plate 1, 2 along the direction of sliding D. The weakened area is preferably restricted to the location of the junction area or bridge of material 5 between the plates 1, 2 in order to maintain strength elsewhere along the length of the plates 1, 2. The bending of the plates 1, 2 along the sagittal plane of the patient, if required, is likely to be limited (for example, approximately 5º) because of the possibility of angulation of the screws 7, 8 relative to the plates 1, 2. The bending area is localized and is positioned intermediate the oblong openings 3, 4 to prevent damage to other functional parts of plates 1, 2, such as the slides 24, 25.

Because the above-described instrumentation allows for variable longitudinal and angular positioning of screws 7, 8 relative to plates 1, 2 and the selective fixation thereof, all of the usual spinal correction maneuvers and procedures are possible; such as, for example, compression, traction, and adjustment along the sagittal plane (lordosis).

Another embodiment of instrumentation in accordance with the invention is illustrated in Figure 3. The embodiment illustrated in Figure 3 differs from the previous one illustrated in Figures 1 and 2 in that the plates 1, 2 are equipped at

their opposite ends with connecting means 35, 36 that allow for articulation relative to other adjacent plates provided with similar connecting means. More particularly, in the embodiment of the invention illustrated in Figure 3, the end of plate 1 is provided with a ball 35, and the opposite end of plate 2 is equipped with a cup 36. Preferably, the ball 35 and the cup 36 are formed integral with the plates 1, 2; however, it should be understood that ball 35 and cup 36 may be formed separate from plates 1, 2 and attached thereto by any method known to those of skill in the art. Ball 35 is configured to be accommodated or received in a cup 36 of an adjacent plate (not shown). In this manner, adjacent plates can be connected together to form a string of plates that can be articulated relative to one another. Alternatively, the plates 1, 2 could be provided with a ball 35 only or a cup 36 only, in which case only one end of the module could be articulated relative to another adjacent module. In another variant, the instrumentation may consist of a single plate 1 or 2 configured to accept at least one pedicular screw 7, 8. A short plate of this kind could be provided with a ball 35 only, or a cup 36 only, or both a ball 35 and a cup 36 to allow for articulation relative to an adjacent module.

Vertebral plates 1, 2 equipped with a ball 35 and/or a cup 36 constitute a module that can be variably articulated relative to other adjacent modules in three dimensions. The modules may then be rigidly fixed or locked in a selected orientation relative to adjacent modules by appropriate means, such as, for example, by shape-memory alloy clamping rings (not shown) disposed about the exterior of cups 36. Shape-memory rings of an appropriate type are described in French Patent Application 97 10 722 filed on 27 August 1997, the contents of which are hereby incorporated by reference. The ball 35 and the cup 36 assure a retentive articulation between adjacent modules, each module including a plate 1, 2 equipped with at least one pedicular screw 7, 8 and at least one shoe 22, 23. Such articulation allows for variable orientation of the modules relative to adjacent modules in all three dimensions, thus assuring a close fit of the resulting articulated chain of modules to the anatomy of a chosen section of the spine. The variable articulation of adjacent modules reduces the amount of bending which

may otherwise be required if a single, one-piece plate were used to span several vertebral levels.

In another embodiment of the invention shown in Figure 4, the spinal instrumentation comprises a single, unbent vertebral plate 37 extending along a longitudinal axis L and defining a longitudinal opening 3, a bone anchor screw 38 and two shoes 39, 41 disposed on opposite sides of plate 37. The shoes 39, 41 are configured to slide along upper and lower sides of plate 37 by means of respective pairs of upper and lower longitudinal slides 42, 43. Each shoe 39, 41 has a central oblong bore 81 (only one of which can be seen in Figure 4) which is oriented substantially perpendicular to the longitudinal axis L and the oblong opening 3. The length of oblong bore 81 extends substantially along the sagittal plane of the patient when the instrumentation is fitted to a particular spinal segment (not shown). Each shoe 39, 41 also defines around its bore 81 an outer convex spherical bearing surface 44, 45, respectively, limited laterally by a pair of opposing flats 46 extending in the same plane as the opposing lateral faces 37a, 37b of plate 37.

The spherical bearing surface 44 of the upper shoe 39 cooperates with a locking nut configured similar to nut 21 (Figures 1 and 2). The threaded end portion 16 of the screw 38 includes a smooth end part 47 for facilitating the guiding of the nut 21 onto the threaded end portion 16. The threaded shank 9 of the screw 38 is extended by a flange 48, delimiting a concave spherical annular bearing surface 49 corresponding to the convex spherical bearing surface 45 of lower shoe 41. The concave spherical bearing surface 49 of the screw 38 is extended by the threaded end portion 16. The threaded end portion 16 is inserted through the openings 81 in the upper and lower shoes 39, 41, and when the screw 38 is positioned in a desired position along oblong opening 3 and at a desired angular orientation relative to plate 37, nut 21 is tightened against the upper shoe 39. The tightening of the nut 21 onto the threaded end portion 16 causes the convex bearing surface 45 to be pressed tightly against the concave bearing surface 49 of the screw 38. Additionally, the nut 21 bears on the convex bearing surface 44 and locks the screw 38 in a particular angular orientation relative to plate 37. Tightening the nut 21 onto the threaded end portion 16 also causes the

shoes 39, 41 to be compressed tightly against the slides 42, 43, thereby locking the shoes 39, 41 and the screw 38 in a particular longitudinal position along oblong opening 3. As in the previously described embodiments, tightening the nut 21 onto the upper shoe 39 automatically centers the shoes 39, 41 relative to the screw 38 and positions the shoes 39, 41 in the correct longitudinal position relative to plate 37.

In another embodiment of the invention shown in Figures 5 and 6, the screw 51 includes a pair of opposite shoulders 54 projecting laterally outward from a head 53. Shoulders 54 each define a substantially cylindrical bearing surface 52. The cylindrical bearing surfaces 52 are adapted to cooperate with substantially complementary cylindrical-shaped surfaces or grooves 55 machined onto a longitudinally extending face of the plate 56. In one embodiment, cylindrical bearing surfaces 52 are convex and cylindrical bearing surfaces 55 are concave; however, a reverse embodiment is also contemplated as being within the scope of the invention. Cylindrical bearing surfaces 52 are configured to bear against cylindrical bearing surfaces 55 to allow angulation of the screw 51 relative to plate 56 in a direction substantially parallel with the longitudinal axis L and to aid in retaining the screw 51 in a selected longitudinal position along oblong opening 3. Preferably, the cylindrical surfaces 55 and the corresponding bearing surfaces 52 have axes extending substantially perpendicular to the longitudinal axis L of the plate 56. In this manner, the angulation of screw 51 relative to plate 56 will be limited to a plane oriented substantially parallel with longitudinal axis L.

On the face of the plate 56 opposite the cylindrical bearing surfaces 55 is disposed a shoe 57, mounted to slide on lateral slides 60 disposed along the opposing walls of the opening 3. As in previously described embodiments of the invention, the shoe 57 has a spherical bearing surface 58 adapted to cooperate with a substantially complementary spherical bearing surface (not visible in Figures 5 and 6) of a locking nut 59 that is configured to engage the threaded end portion 16 of screw 51. As illustrated, the nut 59 can be of a type having a middle area 61 which breaks or fractures upon application of a predetermined tightening torque, thereby creating a first portion 61a that remains tightly engaged against the shoe 57, and a second portion 61b that can be discarded after the nut

fractures along the weakened area 61. A "self-breaking" nut of the above type is described in French Patent 94 10 377 (2 723 837), the contents of which are hereby incorporated by referenced into the subject application.

Another embodiment of instrumentation in accordance with the present invention is illustrated in Figures 7 and 8. A plate 62 differs from the plate 56 illustrated in Figures 5 and 6 in that it is equipped at one end with a ball 35 configured to be inserted into a cup 36 of a second adjacent vertebral plate (not shown). The second plate can be identical to any of the plates of the embodiments described above, including the plates 1, 2, with one end of the second plate being equipped with a cup 36 for articulating connection with the ball 35 on plate 62 to thereby form a string of articulating modules.

Figure 9 illustrates yet another embodiment of the present invention, comprising a plate 63 equipped at its opposite ends with a ball 35 and a cup 36. In one embodiment, the ball 35 and cup 36 are integrally formed with plate 63. The elongate opening 3 is straddled by a shoe 64 having a spherical bearing surface 65, on which bears a self-breaking nut 59. The shoe 64 is mounted to slide in slides 66 disposed on opposite sides of the opening 3 along the longitudinal axis L. A pedicular screw 7 is engaged in the shoe 64 in a manner similar to that described above with regard to other embodiments of the invention. Plate 63 may be articulated relative to other similarly configured plates by way of cooperation between adjacent balls 35 and cups 36 in a manner similar to that described above with regard to other embodiments of the invention. Thus, a plurality of plates 63 can be connected to each other in particular orientations and thereafter made rigid, as previously indicated, by using, for example, shape memory alloy rings. Of course, it is also possible to provide plates, such as plate 62, with cups 36 complementary to balls 35 to enable construction of a string of modules having retentive articulations, with each module oriented in a particular orientation relative to adjacent modules in all three dimensions.

In all of the embodiments of the invention illustrated and discussed above, the diameter or width of the openings (28, 29, ...) extending through the shoes (22, 23, ...) is greater than the diameter of the threaded end portion 16 of the screws (7, 8, ...). This feature, coupled with the interaction between the spherical

bearing surfaces of the shoes and the nuts (21, 59, ...), allow the angular orientation of the screws (7, 8 ...) to be varied in all three directions relative to the plate (1, 2, ...).

It should be understood that it is possible to produce in the context of the invention instrumentation consisting of plates 1, 2, 37, 56, 62, provided with or without balls 35 and/or cups 36. Also, each plate (1, 2 ...) can be equipped with one or more pedicular screws, and with a corresponding number of shoes configured to slide along the longitudinal opening 3. Additionally, each screw can be associated with a single sliding shoe disposed on one side of the plate, or with two shoes disposed on opposite sides of the plate.

Another embodiment of the present invention is illustrated in Figures 10 and 11, comprising a vertebral rod 70 and a connector 71 transversely connecting rod 70 to a pedicular screw 7. The connector 71 defines a bore 73 sized to receive rod 70 therethrough. Rod 70 can be locked into position by means of a threaded plug or set screw 74 engaged within a threaded hole intersecting the bore 73. Connector 71 also defines a longitudinal axis L and an oblong opening 75 extending therethrough and being elongated in the direction of the longitudinal axis L and transverse to the rod 70. The internal walls of the opening 75 are preferably inclined so as to define a conical surface; however, other configurations of opening 75 are also contemplated, such as a cylindrical configuration. Along each side of the opening 75, slides 76 are formed. A shoe 77 is slidably mounted to the slides 76 so as to allow the shoe 77 to freely glide in a direction along longitudinal axis L and transverse to rod 70. The shoe 77 is configured similar to shoes 22, 23 illustrated and discussed above. Shoe 77 can alternatively be configured similar to the shoes associated with any of the preceding embodiments of the invention, with the connector 71 being correlatively adapted.

In the embodiment of Figures 10 and 11, shoe 77 has dovetail-shaped edges or projections 78, slidably received within complementary mortises or grooves which form slides 76. Thus, the shoe 77 can slide along a certain length of the connector 71 in a direction transverse to the rod 70, while also allowing angulation of screw 7 relative to the connector 71. The convex spherical bearing surface 32 of shoe 77 cooperates with a corresponding concave bearing surface

(not shown) formed on nut 21. The screw 7 is locked at a particular angle relative to the shoe 32, and the shoe 32 is locked in a particular longitudinal position relative to connector 71, by tightening the nut 21 onto the spherical bearing surface 32. The connector 71 is itself fixed to the rod 70 by tightening the set screw 74 against an outer surface of rod 70.

The screws, plates, shoes and other components of the present invention are preferably made from a bio-compatible material of suitable strength, such as, for example, stainless steel, titanium, or other compositions as would occur to one of ordinary skill in the art.

All publications, patents, and patent applications cited in this specification are herein incorporated by reference as if each individual publication, patent, or patent application were specifically and individually indicated to be incorporated by reference and set forth in its entirety herein. Any theory of operation or finding described herein is merely intended to enhance understanding of the present invention and should not be construed to limit the scope of the present invention as defined by the claims that follow to any stated theory or finding.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes, modifications, and equivalents that come within the spirit of the invention as defined by the following claims are desired to be protected. For example, the features disclosed in reference to the embodiments of the invention illustrated in Figures 1-9 and discussed in detail above, and in particular the provision of the two shoes slidably mounted on opposite faces of the plate, may be incorporated into the embodiment of the invention illustrated in Figures 10-11.

CLAIMS

What is claimed is:

1. A device for spinal osteosynthesis, comprising:

a first member having a longitudinal axis and being positionable adjacent the spine;

a second member having a first end portion configured to engage a vertebral body and a second end portion;

a connector member interconnecting said second end portion of said second member with said first member in a variable position along said longitudinal axis, said connector member being positively retained on said first member in a direction transverse to said longitudinal axis; and

a locking member cooperating with said connector member and said second end portion to lock said second end portion in a particular position along said longitudinal axis.

2. Device according to claim 1, wherein said connector member has a passage extending therethrough and being configured to receive said second end portion of said second member therein at a variable angle relative to said first member, said passage opening onto a first substantially spherical-shaped bearing surface, said locking member defining a second substantially spherical-shaped bearing surface substantially complementary to said first spherical-shaped bearing surface, said locking member cooperating with said connector member and said second end portion to tightly engage said first and second spherical bearing surfaces and lock said second end portion at a particular angle relative to said first member.

3. Device according to claim 2, wherein said passage is cylindrical-shaped.

4. Device according to claim 2, wherein said passage is conical-shaped.

5. Device according to claim 1, wherein one of said first member and said connector member includes at least one shaped groove extending along said longitudinal axis, and another of said first member and said connector member includes at least one shaped projection configured substantially complementary to said shaped groove, said shaped projection being slidably engaged within said shaped groove to allow said connector member to slide relative to said first member in a direction along said longitudinal axis.

6. Device according to claim 5, wherein said first member defines a pair of abutments disposed along said longitudinal axis on opposite sides of said connector member for maintaining said connector member in sliding engagement with said first member.

7. Device according to claim 6, wherein said abutments are pressed bosses.

8. Device according to claim 5, wherein said shaped groove and said shaped projection define asperities to resist sliding of said connector member relative to said first member.

9. Device according to claim 5, wherein said one of said first member and said connector member includes a pair of said shaped grooves and said another of said first member and said connector member includes a pair of said shaped projections, said pair of said shaped grooves and said pair of shaped projections having a dovetail configuration and cooperating to allow said connector member to slide along a longitudinal face of said first member while being captured on said first member in a direction substantially perpendicular to said longitudinal axis.

10. Device according to claim 1, wherein said first member defines an oblong opening extending therethrough and having a length extending along said longitudinal axis, said connector member defining a passage extending therethrough, said second end portion of said second member passing through said oblong opening and said passage and being positionable along said length of said oblong opening in an infinite number of positions, a portion of said second end portion extending from said connector member, said locking member engaging said portion of said second end portion to lock said second end portion in a particular position along said length of said oblong opening.

11. Device according to claim 10, wherein said first member defines pair of slides extending along said longitudinal axis, each of said slides being disposed on opposite sides of said opening, said connector member defining a pair lateral edges, each of said lateral edges having a profile substantially complementary to a corresponding one of said slides, said pair of lateral edges being slidably engaged with said pair of slides to allow said connector member to slide relative to said first member in a direction along said longitudinal axis.

12. Device according to claim 11, wherein said pair of lateral edges are engaged with said pair of slides in a dovetail configuration, said dovetail configuration allowing said connector member to slide relative to said first member in said direction along said longitudinal axis while capturing said connector member on a longitudinally extending face of said first member.

13. Device according to claim 10, wherein said passage of said connector member is configured to receive said second end portion of said second member at a variable angle relative to said first member, said passage opening onto a first substantially spherical-shaped bearing surface, said locking member defining a second substantially spherical-shaped bearing surface substantially complementary to said first substantially spherical-shaped bearing surface, said locking member engaging said portion of said second end portion and tightly compressing said first and second substantially spherical bearing

surfaces to lock said second end portion at a particular angle relative to said first member.

14. Device according to claim 10, wherein said portion of said second end portion is threaded and said locking member is a lock nut.

15. Device according to claim 14, wherein said lock nut includes a break-off portion that is separated from the remaining portion of said lock nut upon application of a predetermined amount of torque to said break-off portion.

16. Device according to claim 10, wherein said second member has a shoulder disposed between said first and second end portions, said shoulder facing a first side of said first member when said second end portion is passed through said oblong opening, said connector member being disposed on an opposite second side of said first member, said shoulder being configured to bear against said first side of said first member to lock said second member in said particular position along said length of said oblong opening.

17. Device according to claim 10, further comprising another of said connector members positively retained on an opposite side of said first member in a direction transverse to said longitudinal axis, said second end portion of said second member passing through said oblong opening and each of said passages in said pair of connector members and being variably positionable along said length of said oblong opening, said locking member engaging said portion of said second end portion to lock said second end portion in said particular position along said length of said oblong opening.

18. Device according to claim 1, wherein said first member is an elongate plate having a length extending along said longitudinal axis and being positionable along the spine.

19. Device according to claim 1, further comprising an elongate rod member positionable along the spine, said first member defining an opening extending therethrough in a direction transverse to said longitudinal axis and being sized to receive said elongate member therein to transversely connect said rod member to said second member.

20. Device according to claim 1, further comprising a plurality of said first members, said plurality of first members being integrally formed to define a single piece extending along said longitudinal axis, said single piece defining a weakened area intermediate adjacent ones of said plurality of said first members to facilitate bending of said single piece along said longitudinal axis, each of said plurality of first members being associated with corresponding ones of said second member, said connector member and said locking member.

21. Device according to claim 20, wherein said weakened area comprises a notch extending across said single piece in a direction substantially perpendicular to said longitudinal axis.

22. Device according to claim 21, wherein said notch is disposed on the same side of said single piece as said locking member.

23. Device according to claim 1, wherein said first member defines upper and lower surfaces and a pair of laterally facing sides extending therebetween, said connector member being disposed adjacent said upper surface and including a pair of laterally facing flattened portions lying substantially in the same plane as said pair of laterally facing sides.

24. Device according to claim 1, wherein said first member is positionable along the spine with said longitudinal axis being oriented substantially parallel with a sagittal plane.

25. Device according to claim 1, further comprising at least two of said first members disposed end to end along said longitudinal axis, one of said first members including a ball portion and another adjacent one of said first members including a socket portion configured to receive said ball portion therein, said ball portion being inserted within said socket portion to provide relative articulation between said at least two or said first members in three dimensions.

26. Device according to claim 25, wherein each of said at least two of said first members includes one of said ball portions disposed adjacent one end thereof and one of said socket portions disposed adjacent an opposite second end thereof.

27. Device according to 25, further comprising means for retaining said ball portion in said socket portion and maintaining said at least two of said first members in a particular orientation relative to one another.

28. Device according to claim 27, wherein said retaining means comprises a ring sized to receive said socket portion therein and being at least partially formed of a shape-memory material.

29. Device according to claim 1, wherein said connector member is positionable in an infinite number of positions along said longitudinal axis of said first member.

30. A device for spinal osteosynthesis, comprising:

a first member having a longitudinal axis and being positionable adjacent the spine;

a second member having a first end portion configured to engage a vertebral body and a second end portion;

a connector member interconnecting said second end portion of said second member with said first member, said connector member being positionable in an infinite number of positions along said longitudinal axis, said

connector member defining a passage extending therethrough and being sized to receive said second end portion of said second member therein at a variable angle relative to said first member, said passage opening onto a first substantially spherical-shaped bearing surface; and

a locking member defining a second substantially spherical-shaped bearing surface substantially complementary to said first substantially spherical-shaped bearing surface, said locking member cooperating with said connector member and said second end portion to tightly engage said first and second substantially spherical-shaped bearing surfaces and lock said second end portion at a particular
position along said longitudinal axis and at a particular angle relative to said first member.

31. Device according to claim 30, wherein said first member defines an oblong opening extending therethrough and having a length extending along said longitudinal axis, said second end portion of said second member passing through said oblong opening and said passage in said connector member, a portion of said second end portion extending from said connector member, said locking member engaging said portion of said second end portion to lock said second end portion in a particular position along said length of said oblong opening.

32. Device according to claim 30, wherein said connector member is positively retained on said first member in a direction transverse to said longitudinal axis.

33. Device according to claim 32, wherein said connector member is mounted to said first member in a dovetail mounting arrangement.

34. Device according to claim 30, wherein said first member has a first side and an opposite second side each extending along said longitudinal axis, said first member defining an opening extending between said first and second sides, said connector member being disposed adjacent said first side with said

passage being alignable with said opening; and

wherein said second member has a shoulder disposed between said first and second end portions, said shoulder being configured to bear against said second side of said first member when said second end portion is passed through said oblong opening and said passage to aid in retaining said second end portion in said particular position along said longitudinal axis.

35. Device according to claim 34, wherein said shoulder defines at least one cylindrical-shaped bearing surface projecting laterally from said second member, said second side of said first member defining a plurality of cylindrical-shaped bearing surfaces substantially complementary to said at least one cylindrical-shaped bearing surface, said plurality of cylindrical-shaped bearing surfaces being disposed along said longitudinal axis adjacent said opening and extending in a direction substantially perpendicular to said longitudinal axis; and

wherein said at least one cylindrical-shaped bearing surface is configured to bear against a corresponding one of said plurality of cylindrical-shaped bearing surfaces to aid in retaining said second end portion at said particular position along said longitudinal axis and to limit angulation of said second member relative to said first member in a plane oriented substantially parallel to said longitudinal axis.

36. Device according to claim 35, wherein said shoulder defines a pair of said at least one cylindrical-shaped bearing surface each extending from said second member in opposite directions, said first member defining corresponding pairs of said plurality of cylindrical-shaped bearing surfaces each disposed along opposite sides of said opening; and

wherein said pair of said at least one cylindrical-shaped bearing surface is configured to bear against a respective one of said corresponding pairs of said plurality of cylindrical-shaped bearing surfaces to aid in retaining said second end portion at said particular position along said longitudinal axis and to limit

angulation of said second member relative to said first member in a plane oriented substantially parallel to said longitudinal axis.

37. Device according to claim 35, wherein said at least one cylindrical-shaped bearing surface is convex and said plurality of cylindrical-shaped bearing surfaces are concave.

38. Device according to claim 34, wherein said shoulder defines a spherical-shaped bearing surface, said first member defining a plurality of recesses substantially complementary to said spherical-shaped bearing surface, said recesses being disposed along said opening adjacent said second side of said first member; and

wherein said spherical-shaped bearing surface is configured to bear against a corresponding one of said plurality of recesses to aid in retaining said second end portion at said particular position along said longitudinal axis.

39. Device according to claim 30, further comprising another of said connector members, said first member having opposite sides and defining an opening extending therebetween, said connector members being disposed on said opposite sides of said first member;

said another of said connector members defining a second passage extending therethrough and being sized to receive said second end portion of said second member therein at a variable angle relative to said first member, said second passage opening onto a third substantially spherical-shaped bearing surface facing generally opposite said first substantially spherical-shaped bearing surface;

said second member having a shoulder disposed between said first and second end portions, said shoulder defining a forth substantially spherical-shaped bearing surface substantially complementary to said third substantially spherical-shaped bearing surface; and

said second end portion extending through said oblong opening and said passages in said connector members, said locking member cooperating with said

connector member and said second end portion to tightly engage said first and second substantially spherical bearing surfaces and said third and forth substantially spherical bearing surfaces to lock said second end portion at a particular position along said longitudinal axis and at a particular angle relative to said first member.

40. Device according to claim 39, wherein said another of said connector members is positively retained on said first member in a direction transverse to said longitudinal axis.

41. A device for spinal osteosynthesis, comprising:

a plate having a longitudinal axis and being positionable adjacent the spine;

a bone anchor having a first end portion configured to engage a vertebral body and a second end portion;

a connector member interconnecting said second end portion of said bone anchor with said plate, said connector member being slidable along a longitudinally extending face of said plate to position said connector member in an infinite number of positions along said longitudinal axis, said connector member defining a pair of opposing laterally extending projections disposed on opposite sides of said longitudinally extending face of said plate to maintain said connector member in sliding engagement with said plate; and

a locking member cooperating with said connector member and said second end portion to maintain said second end portion in a selected position along said longitudinal axis.

42. Device according to claim 41, wherein said connector member is positively retained on said plate in a direction substantially perpendicular to said longitudinal axis.

43. Device according to claim 42, further comprising means for maintaining said connector member in sliding engagement with said plate in a direction along said longitudinal axis.

44. Device according to claim 41, wherein said connector member defines a passage extending therethrough and being configured to receive said second end portion of said bone anchor therein at an infinite number of angles relative to said plate, said locking member cooperating with said connector member and said second end portion to maintain said second end portion in a selected angular orientation relative to said longitudinal axis.

45. Device according to claim 44, wherein said connector member has a first substantially spherical-shaped bearing surface surrounding said passage; and

wherein said locking member defines a second substantially spherical-shaped bearing surface substantially complementary to said first substantially spherical-shaped bearing surface, said locking member cooperating with said connector member and said second end portion to tightly engage said first and second substantially spherical-shaped bearing surfaces and maintain said second end portion at said selected position along said longitudinal axis and at said selected angular orientation relative to said longitudinal axis.

46. Device according to claim 41, wherein said laterally extending projections of said connector member cooperate with substantially complementary laterally extending grooves defined in said plate to provide a dovetail-type mounting arrangement between said connector member and said plate.

47. Device according to claim 41, wherein said connector member and said plate include cooperating surface means for positioning said connector member in said infinite number of positions along said longitudinal axis while positively retaining said connector member on said face of said plate.

48. Device according to claim 41, wherein said bone anchor and said plate include means for pivoting said bone anchor through a range of angles relative to said longitudinal axis of said plate.

49. Device according to claim 41, further comprising means for articulately connecting a plurality of said plates end-to-end along said longitudinal axis.

50. Spinal osteosynthesis instrumentation, comprising:

a member defining an oblong opening having a length extending in a longitudinal direction;

a screw having a bone anchoring shank and an opposite end portion, said bone anchoring shank being configured to engage a vertebral body, said opposite end portion being sized to pass through said oblong opening; and

means for locking said screw with respect to said member in a particular longitudinal position and with a particular angular orientation, said means for locking including at least one shoe configured to slide on corresponding slides provided on said member in said longitudinal direction, said at least one shoe defining a bore sized to receive said end portion of said screw therein, said end portion of said screw being configured to cooperate with said means for locking to lock said screw in said particular longitudinal position and with said particular angular orientation.

51. Instrumentation according to claim 50, wherein said at least one shoe is positively retained on said member.

52. Instrumentation according to claim 51, wherein said at least one shoe and said slides cooperate to positively retain said at least one shoe on said member in a direction substantially perpendicular to said longitudinal direction.

53. Instrumentation according to claim 50, wherein said shoe defines a first spherical bearing surface, said bore opening onto to said first spherical bearing surface, said means for locking including a locking member defining a second spherical bearing surface substantially complementary to said first spherical bearing surface, said first and second spherical bearing surfaces

cooperating to permit said screw to be oriented in said particular angular orientation.

54. Instrumentation according to claim 53, wherein said end portion of said screw is threaded and said locking member is a lock nut configured to threadingly engage said end portion and press said second spherical surface tightly against said first bearing surface to lock said screw in said particular longitudinal position and with said particular angular orientation.

55. Instrumentation according to claim 53, wherein said locking member is disposed on the same side of said member as said shoe.

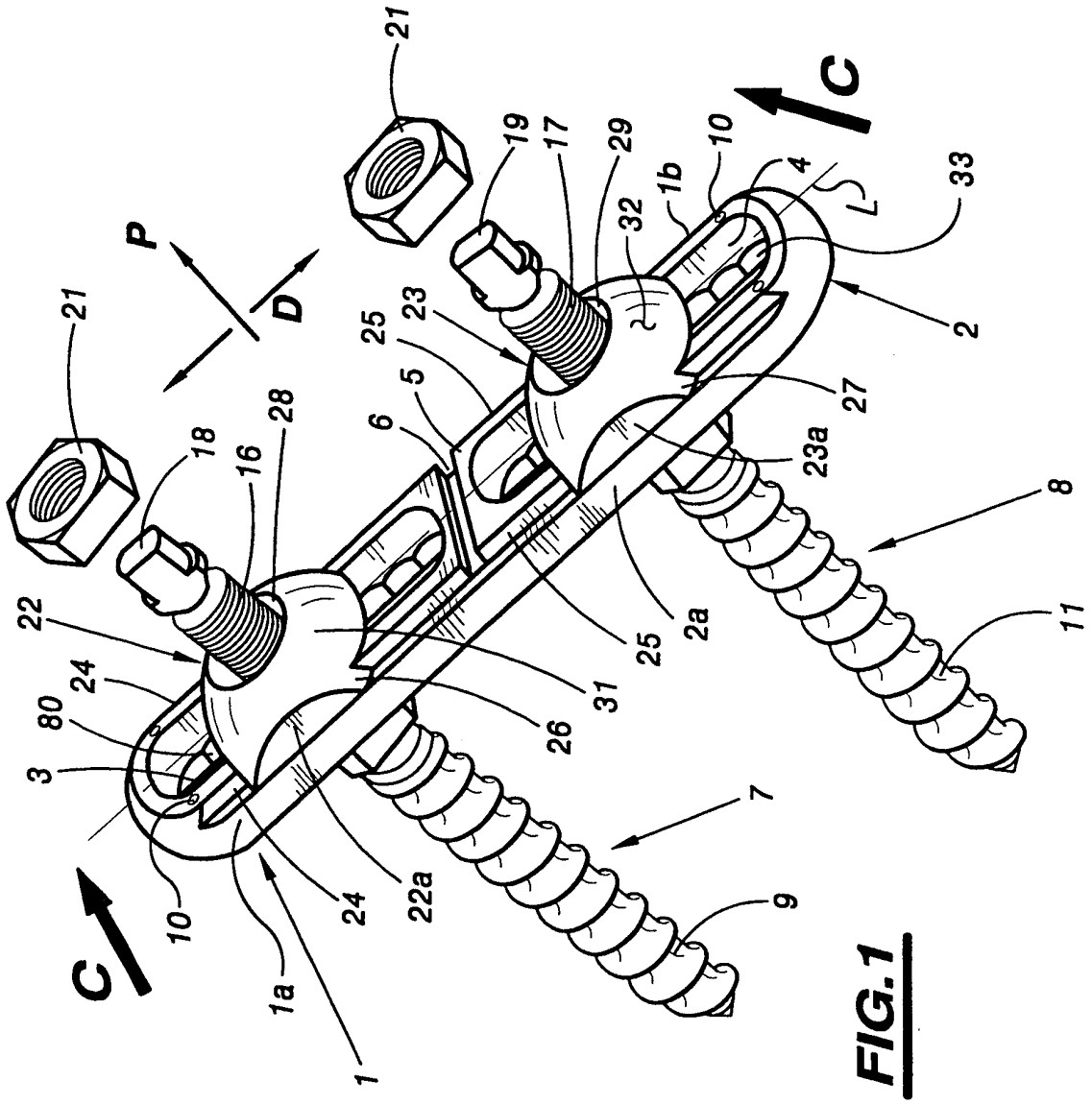

21
19
17
29
10
4
1b
33
32
L
C
P
D
21
25
23
2
5
27
6
28
18
16
23a
8
22
25
2a
11
24
31
80
26
3
7
10
24
22a
9
C
1a
1

FIG.1

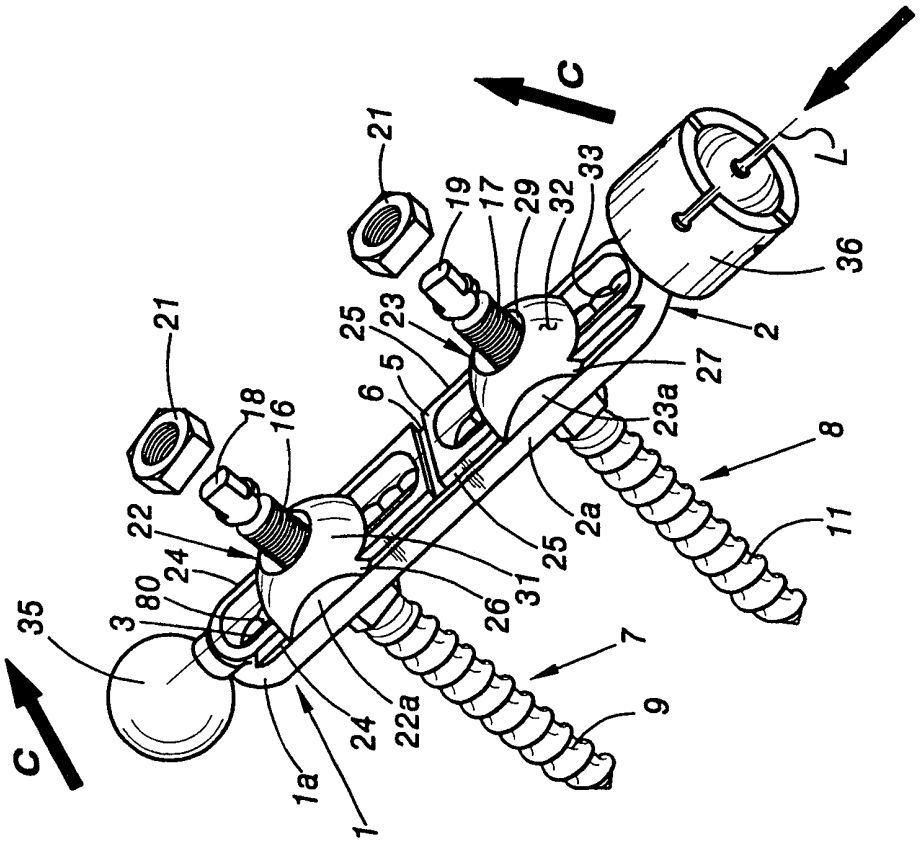

C
C
21
19
17
29
32
33
36
L
2
25
23
5
6
27
23a
8
11
21
18
16
22
24
80
3
35
25
2a
31
26
7
9
22a
24
1a
1

FIG.3

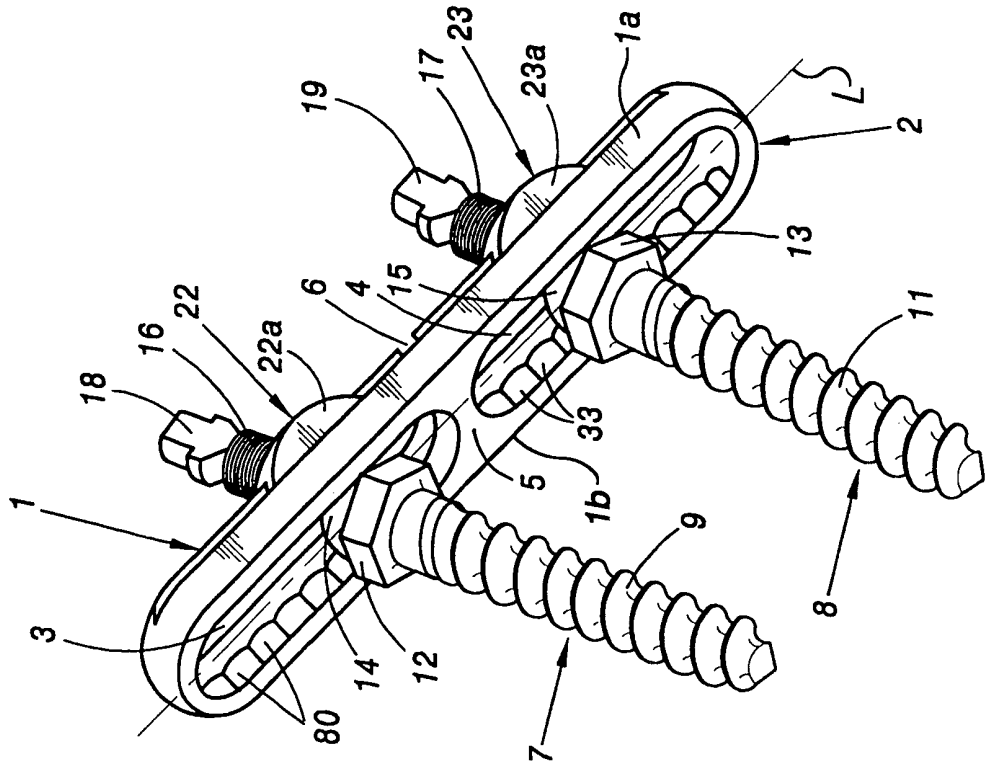

19
17
23
23a
1a
L
2
13
6
4
15
22
16
22a
18
11
33
5
1b
1
9
8
3
14
12
80
7

FIG.2

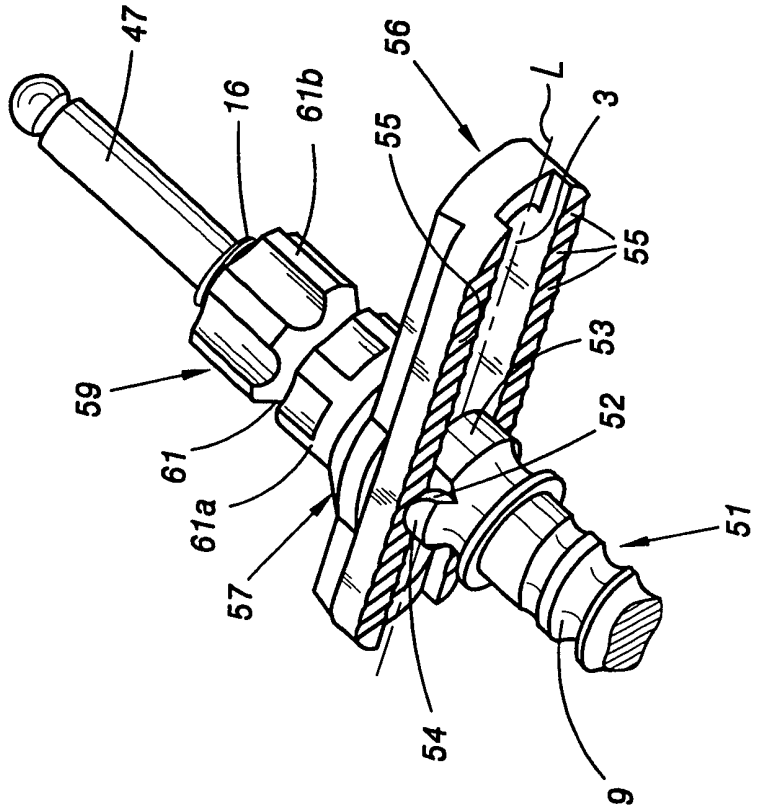

47
16
61b
56
L
3
55
55
53
52
59
61
61a
57
51
54
9

FIG.5

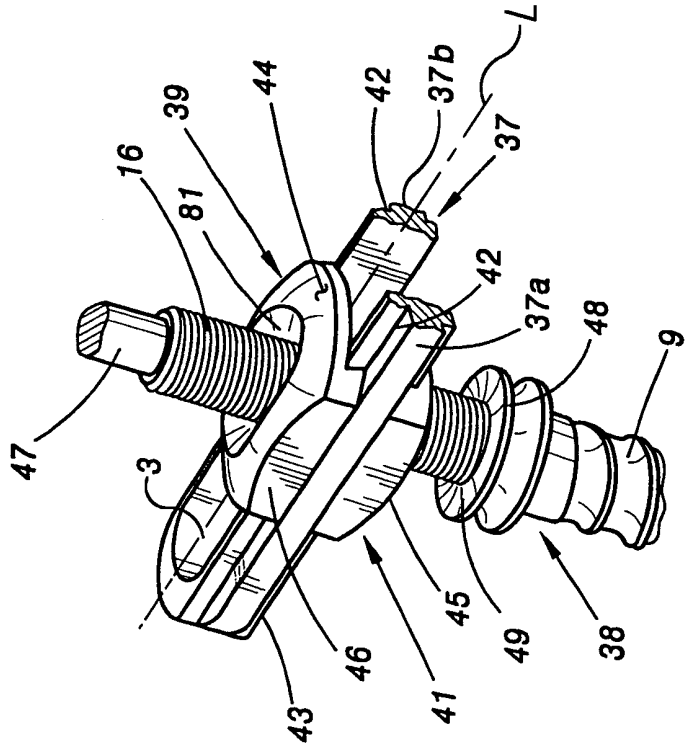

L
39
44
42
37b
37
16
81
42
37a
48
9
47
3
45
49
38
46
41
43

FIG.4

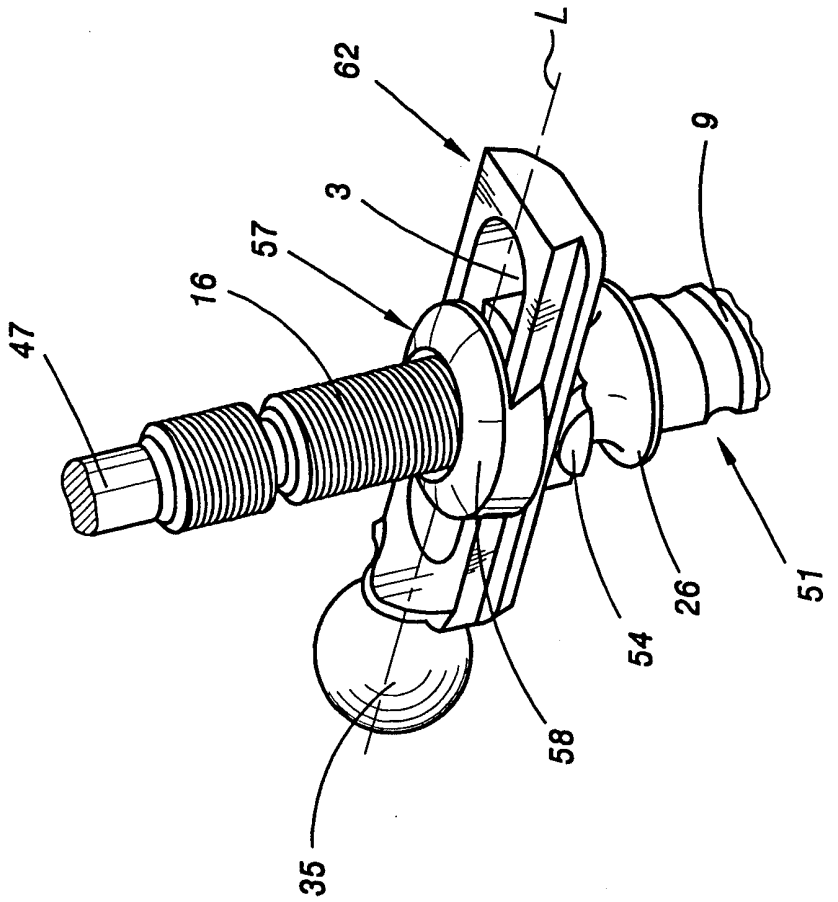

L
62
3
57
16
47
9
26
51
54
58
35

FIG.7

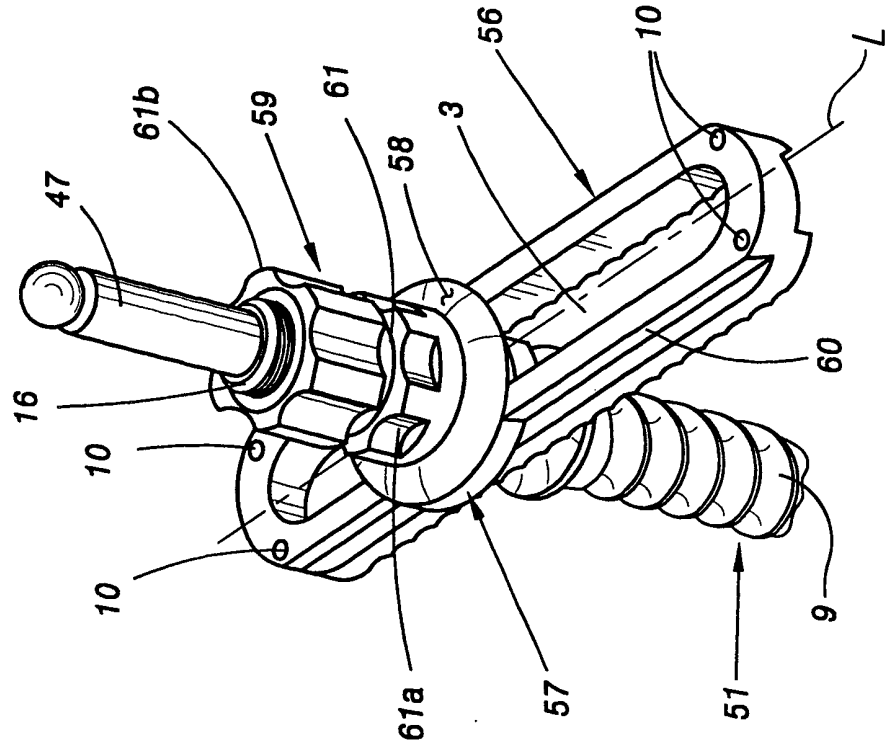

56
10
L
61b
59
61
3
58
47
60
16
10
10
9
61a
57
51

FIG.6

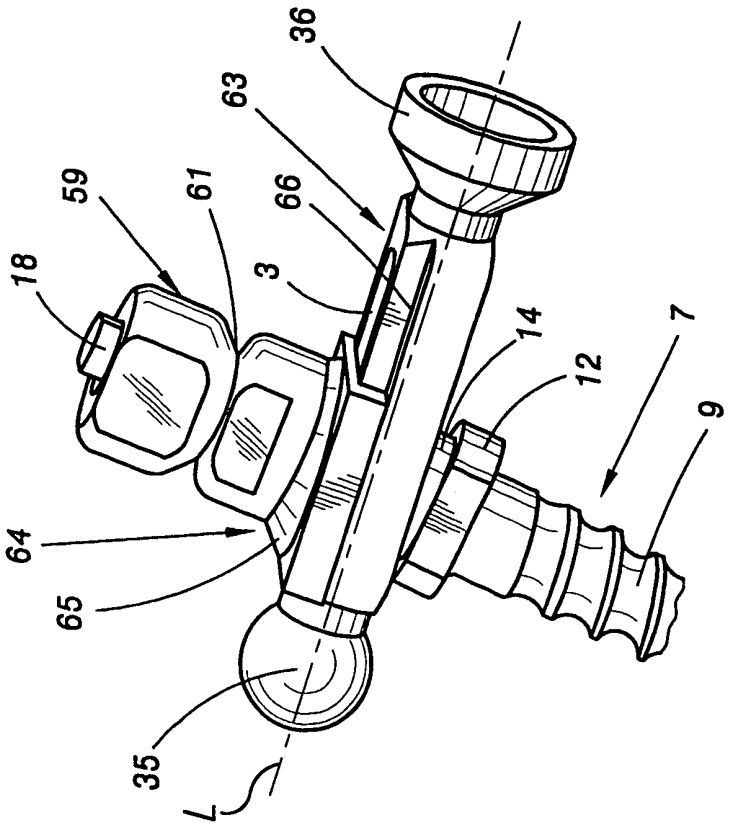


FIG.9

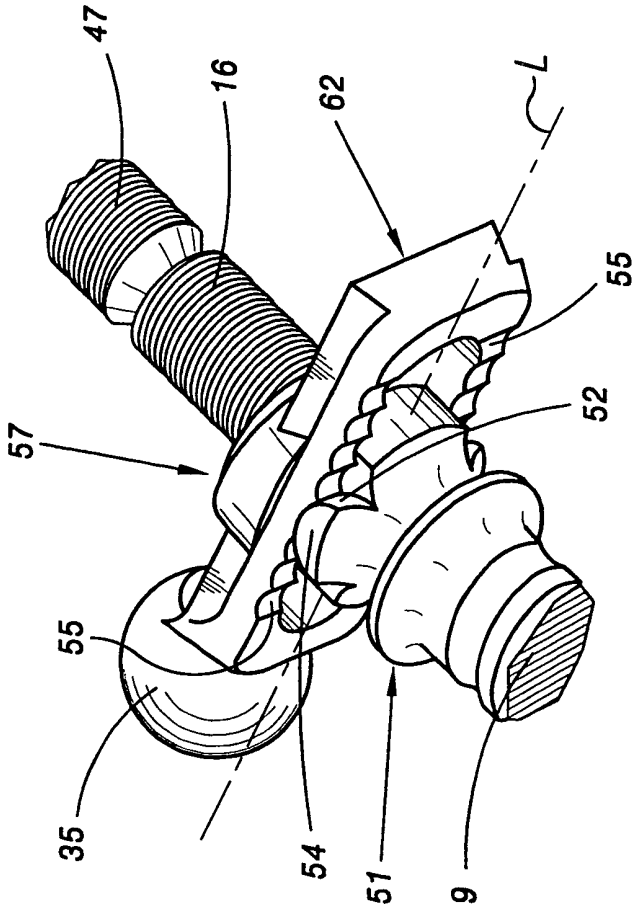


FIG.8

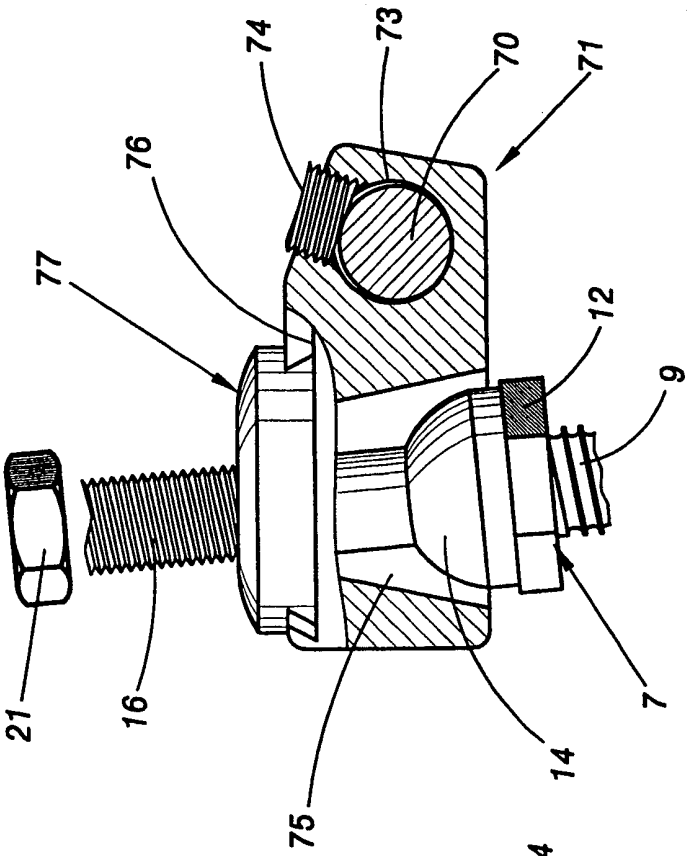


FIG.11

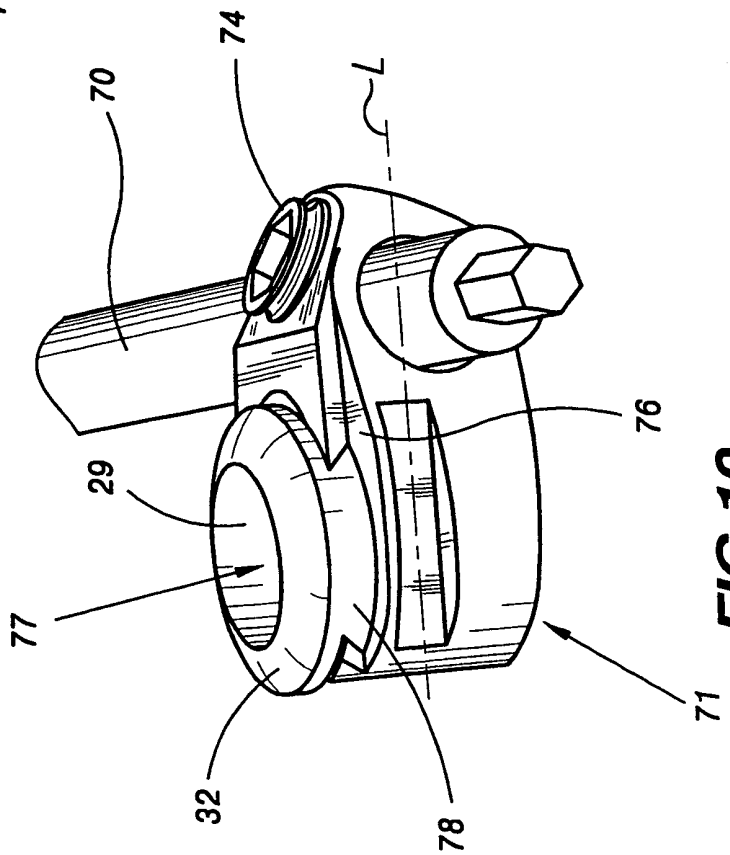


FIG.10