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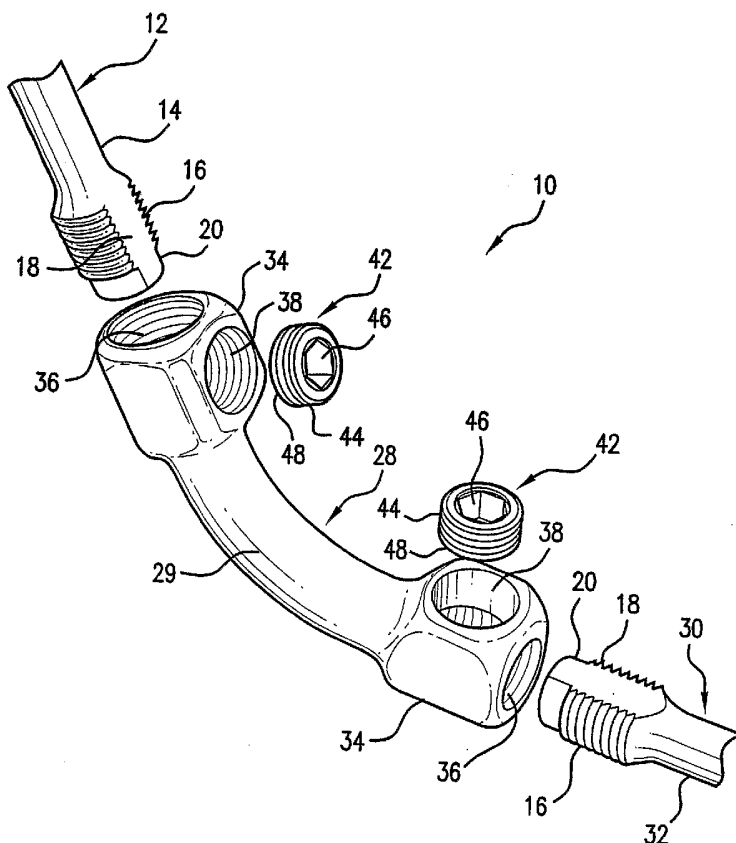
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[Continued on next page]

(54) Title: SPINAL ROD CONNECTOR



(57) Abstract: A spinal rod connection system includes a first rod for attachment to the spinal column and a second rod attachment to the skull releasably engaged to one another in end-to-end fashion by a coupling mechanism wherein the angle between the longitudinal axis of each of said first and second rods is variable.

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SPINAL ROD CONNECTOR

BACKGROUND

The spine is subject to various pathologies that compromise its load bearing and support capabilities. Such pathologies of the spine include, for example, degenerative diseases, the effects of tumors and, of course, fractures and dislocations attributable to physical trauma. In the treatment of diseases, malformations or injuries affecting spinal motion segments (which include two or more adjacent vertebrae and the disc tissue or disc space therebetween), and especially those affecting disc tissue, it has long been known to remove some or all of a degenerated, ruptured or otherwise failing disc. It is also known that artificial discs, fusion implants, or other interbody devices can be placed into the disc space after disc material removal. External stabilization of spinal segments alone or in combination with interbody devices also provides advantages. Elongated rigid plates, rods and other external stabilization devices have been helpful in the stabilization and fixation of a spinal motion segment, in correcting abnormal curvatures and alignments of the spinal column, and for treatment of other conditions.

In spinal rod fixation procedures extending to the base of the skull, the surgeon contours the rod to match the angle of the occiput and sub-axial spine. Bending the rod induces stress to the rod and decreases the fatigue strength of the material. In addition, the geometric and dimensional features of these rod systems and patient anatomy constrain the surgeon during surgery and prevent optimal placement and attachment along the spinal column and the occiput. For example, elongated, one-piece rods can be difficult to bend and maneuver into position between the upper end of the cervical spine and the occipital bone of the skull, and also provide the surgeon with only limited options in sizing and selection of the rod system to be placed during surgery.

SUMMARY OF THE INVENTION

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In one aspect, a spinal rod connection system having a first elongated rod for attachment to the spinal column. The first rod extends along a longitudinal axis between a coupling member at its first end and an opposite second end. The system further includes a second elongated rod for attachment to a skull. Similarly, the second rod also extends along a longitudinal axis between a coupling member at its first end and an opposite second end. The system further includes a coupling mechanism for releasably coupling the coupling member of the first rod and the coupling member of the second rod in an end-to-end fashion where the longitudinal axis of each of the first and second rods is at an angle to one another.

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In another aspect, a spinal rod connection system having a first elongated rod for attachment to the spinal column. The first rod extends along a longitudinal axis between a coupling member at its first end and an opposite second end. The system further includes a second elongated rod for attachment to the skull. Similarly, the second rod also extends along a longitudinal axis between a coupling member at its first end and an opposite second end. The system further includes a coupling mechanism for releasably coupling the coupling member of the first rod and the coupling member of the second rod in an end-to-end fashion, wherein an angle between the longitudinal axis of each of the rods can be temporarily varied and thereafter fixed so that the coupling mechanism axially and torsionally constrains the rods relative to one another.

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In another aspect, a method for assembling a spinal rod system extending to the skull. The method includes a first rod that extends along a longitudinal axis between a coupling member at its first end and an opposite second end. The method further includes a second elongated rod for attachment to the skull. Similarly, the second rod also extends along a longitudinal axis between a coupling member at its first end and an opposite second end. The method further includes providing a coupling mechanism for releasably coupling said first coupling member and said second coupling member in an end-to-end fashion, wherein said longitudinal axis of each of said first and second rods is at an angle to

one another. The method may further include temporarily varying the angle and thereafter
5 fixing it so that the coupling mechanism axially and torsionally constrains the first and
second rods relative to one another.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 is an exploded perspective view of one embodiment of the spinal rod
10 connection system.

Fig. 2 is a side view of the spinal rod connection system of Fig. 1 assembled.

Fig. 3 is an exploded perspective view of another embodiment of the spinal rod
connection system.

Fig. 4 is a side view of the spinal rod connection system of Fig. 3 assembled.

15 Fig. 5 is an exploded perspective view of another embodiment of the spinal rod
connection system.

Fig. 6 is a side view of the spinal rod connection system of Fig. 5 assembled.

Fig. 7 is an exploded perspective view of another embodiment of the spinal rod
connection system.

20 Fig. 8 is a side view of the spinal rod connection system of Fig. 7 assembled.

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DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention,
5 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. Any such alterations and further
modifications in the illustrated devices, and any such further applications of the principles of
the invention as illustrated herein being contemplated as would normally occur to one
10 skilled in the art to which the invention relates.

In Fig. 1 there is shown a spinal rod connection system 10 including a first rod 12
and a second rod 30. First rod 12 and second rod 30 are releasably coupled to one another in
end-to-end fashion with a coupling mechanism 28. The coupling mechanism 28 is
15 configured to secure rods 12, 30 to one another in end-to-end fashion while providing the
necessary angulation between the axis of the rods to conform to the angle of the occiput and
the sub-axial spine. This minimizes the footprint or intrusiveness of the coupling
mechanism into the tissue surrounding the rod system, and decreases or potentially
eliminates, the amount that each rod is contoured to conform to the angle of the occiput and
the sub-axial spine.
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First rod 12 includes a rod portion 14 and coupling member 16 at one end of rod
portion 14. Second rod 30 includes a rod portion 32 and coupling member 16 at one end of
rod portion 32. Coupling mechanism 28 includes a rod portion 29 and a coupling body 34 at
either end thereof. Rod portion 29 may be of any shape and can be configured in any
25 number of angles or configurations. Rod portions 14, 32 can be secured to vertebrae of the
spinal column system or to the occiput of the skull with any one or combination of plates,
hooks, screws, bolts, multi-axial screws, staples, cables or wires, sutures, clamps, and/or
other attachment devices and systems.

First rod portion 14 can be provided with a characteristic that differs from a
30 characteristic of second rod portion 32. The coupling mechanism 28 allows rods of differing
characteristics to be secured to one another in end-to-end fashion to provide a rod system

that is adapted for the anatomy, surgical condition, or surgical procedure. In one
embodiment, the characteristic includes a cross-sectional dimension of the rod portions 14,
32. Other embodiments contemplate selection criteria for selection and assembly of the rod
portion to include any one or combination of characteristics, including length, contouring,
flexibility, surface features, shape, section modulus, elasticity, materials and material
properties, and coatings, for example.

As shown in Figs. 1-2, rod portion 14 extends along longitudinal axis 11 and
includes a first cross-sectional dimension 22 between opposite sides thereof transverse to
longitudinal axis 11. Similarly, rod portion 32 extends along longitudinal axis 8 and
includes a second cross-sectional dimension 40 between opposite sides thereof transverse to
longitudinal axis 8. Cross-sectional dimension 22 corresponds to a diameter of a cylindrical
rod portion 14 that may be smaller, larger or the same as the diameter corresponding to
cross-sectional dimension 40 of a cylindrical rod portion 32. In one specific application, the
diameter of first rod portion 14 is sized to extend along a first portion of the spine, such as
the cervical region, and the diameter of second rod portion 32 is sized to extend up to the
skull region. As shown in Fig. 2, axis 11 is at an angle 6 from axis 8.

Coupling member 16 includes a threaded outer surface extending from rod portion
14 or 32 to an end member 20 lacking threads. Coupling member 16 further includes a
contact portion 18 along at least one side thereof, as also shown in Fig. 1. Contact portion 18
can be formed by a cutout providing a flat surface extending along coupling member 16.
Contact portion 18 can also include a concave surface, a convex surface, a receptacle, or
other suitable configuration for contacting an engaging member. The thread pattern of
coupling member 16 extends completely therearound between the opposite sides of contact
portion 18. Other embodiments contemplate that multiple contact portions are provided
along coupling member 16 to provide multiple engagement locations for engaging member
42, as discussed further below.

Coupling body 34 can be enlarged relative to rod portion 29 to provide a flange or
hub to which coupling member 16 can be releasably engaged. In the illustrated .

embodiment, coupling body 34 is a cubic block, although other shapes are also contemplated, such as rectangular and cylindrical shapes. Coupling body 34 includes a first bore 36 formed internally therein that opens away from rod portion 29 at an end of coupling body 34. Coupling body 34 further includes a second bore 38 extending therein transversely to first bore 36. As further shown in Fig. 1, second bore 38 can be internally threaded for receipt of an engagement member. Second bore 38 can also be orthogonal to first bore 36, although other orientations are also contemplated.

As shown in Fig. 2, rods 12, 30 can be assembled to coupling mechanism 28 whereby coupling members 16 are received in bores 36 and axially constrained by threaded engagement with coupling bodies 34. End members 20 facilitates positioning and alignment of coupling members 16 in bores 36, preventing or reducing the possibility of cross-threading coupling members 16 with coupling bodies 34. The axial load between rods 12, 30 is carried by the engagement of the coupling mechanism 28 to rods 12, 30. Accordingly, torsional loading of the components of rod system 10 is minimized since the rods 12, 30 are connected to one another by the coupling mechanism 28 in end-to-end fashion.

Furthermore, coupling mechanism 28 may be shaped such that when rod system 10 is assembled, axis 11 of rod 12 is at an angle 6 from axis 8 of rod 30, as seen in Fig. 2. Angle 6 may match the angle of the occiput and sub-axial.

Engaging member 42 is positionable in second bore 38 and engageable to coupling member 16 to prevent rod 12 or 30 from disengaging from coupling mechanism 28. In one embodiment, contact portion 18 of coupling member 16 is oriented toward second bore 38, and engaging member 42 is an externally threaded set screw 44 engageable in second bore 38. A tool engaging recess 46 is provided for engagement with a tool, such as a hex driver, to allow the set screw 44 to be driven into second bore 38. Set screw 44 is driven into second bore 38 so that end 48 is in contact with contact portion 18, preventing coupling member 16 from rotating in coupling body 34 and resisting torsional loading between rods 12, 30.

5 Other embodiments contemplate other arrangements for coupling mechanism 28. For example, engaging member 42 can be a pin that is received in a hole or recess in coupling member 16. Coupling body 34 can be a nut rotatably captured on the end of rod portion 32. Coupling body 34 can include a bayonet locking type device, or a spring-biased ball plunger in coupling member 16 that is received in a detent in coupling body 34. In 10 another embodiment, coupling body 34 does not include a second bore for an engaging member, and coupling member 16 can be provided completely threaded therearound. To torsionally constrain this type of coupling member 16 in coupling body 34, coupling member 16 can be provided with locking threads. In another embodiment, a simple threaded engagement is provided and relative rotation of rods 12, 30 is resisted by the 15 engagement of rods 12, 30 to the spinal column or the skull.

In Figs. 3-4, there is shown another embodiment of the spinal rod connection system 110. Many elements of this embodiment are identical to the elements found in the above embodiment and will not be repeated here. First rod 12 and second rod 30 are releasably 20 coupled to one another in end-to-end fashion with a coupling mechanism 128. The coupling mechanism 128 is configured to secure rods 12, 30 to one another in end-to-end fashion while providing the necessary angulation between the axis of the rods to conform to the angle of the occiput and the sub-axial spine. In this embodiment, coupling mechanism 128 comprises coupling bodies 34 that are directly connected to one another. This embodiment 25 further minimizes the footprint or intrusiveness of the coupling mechanism into the tissue surrounding the rod system while providing all of the same features of the embodiments described above.

As shown in Fig. 4, coupling mechanism 128 may be shaped such that when rod system 110 is assembled, axis 111 of rod 12 is at an angle 116 from axis 118 of rod 30. 30 Angle 116 may match the angle of the occiput and sub-axial spine.

In Figs. 5-6, there is shown another embodiment of the spinal rod connection system 210. Many elements of this embodiment are identical to the elements found in the above embodiments and will not be repeated here. First rod 12 and second rod 30 are releasably

coupled to one another in end-to-end fashion with a coupling mechanism 228. The coupling
5 mechanism 228 is configured to secure rods 12, 30 to one another in end-to-end fashion
while providing the necessary angulation between the axis of the rods to conform to the
angle of the occiput and the sub-axial spine. In this embodiment, coupling mechanism 228
comprises an articulating connector 205 and coupling bodies 34 at either end thereof. This
10 embodiment includes a articulating connector 205 which allows a surgeon to set and then fix
the necessary angulation between the axis of the rods to conform to the angle of the occiput
and the sub-axial spine while providing all of the same features and of the embodiments
described above.

In Fig. 5, there is shown articulating connector 205 comprising extension portions
15 270, 271 which are respectively located at the end of coupling bodies 34 opposite of first
bores 36. Extension portion 270 has a contact surface 202 that is planar and parallel to axis
218. Extension portion 271 has a contact surface 203 that is planar and parallel to axis 211.

Articulating connector 205 further includes a fastener 290 extendable through
aligned bores 204, 206. Aligned bore 204 extends through extension portion 270 and its axis
20 is perpendicular to contact surface 202. Aligned bore 206 extends through extension portion
271 and its axis is perpendicular to contact surface 203.

Fastener 290 is positionable through bore 204 and is engageable to bore 206 of
extension portion 271 to prevent contact surfaces 202 and 203 from moving relative to one
another. In one embodiment, fastener 290 has an externally threaded portion 291 engageable
25 in bore 206, which has internal threads. A tool engaging recess 246 is provided for
engagement with a tool, such as a hex driver, to allow the fastener 290 to be driven into bore
206. Fastener 290 is driven into bore 206 so that end 292 is in contact with extension
portion 270 and contact surfaces 202 and 203 are in contact with one another and are
30 prevented from moving relative to one another and resisting torsional loading between
coupling bodies 34. One or both of contact surfaces 202, 203 may include teeth, splines,
cams, roughened portions or any other movement prevention device to help prevent the
contact surfaces from moving relative to one another.

As shown in Fig. 6, spinal rod connection system 210 may be assembled so that axis 211 of rod 12 is at an angle 216 from axis 218 of rod 30. Prior to tightening fastener 290, angle 216 may be selected to match the angle of the occiput and sub-axial spine. Even after fastener 290 is tightened, it may be loosened so that another angle 216 can be selected and fastener 290 re-tightened.

In Figs. 7-8, there is shown another embodiment of the spinal rod connection system 310. Many elements of this embodiment are identical to the elements found in the above embodiments and will not be repeated here. First rod 12 and second rod 30 are releasably coupled to one another in end-to-end fashion with a coupling mechanism 328. The coupling mechanism 328 is configured to secure rods 12, 30 to one another in end-to-end fashion while providing the necessary angulation between the axis of the rods to conform to the angle of the occiput and the sub-axial spine. In this embodiment, coupling mechanism 328 comprises an articulating connector 305 and coupling bodies 34 at either end thereof. This embodiment includes a articulating connector 305 which allows a surgeon to set and then fix the necessary angulation between the axis of the rods to conform to the angle of the occiput and the sub-axial spine while providing all of the same features and of the embodiments described above.

In Figs. 7-8, there is shown articulating connector 305 comprising extension portions 370, 371 which are respectively located at the end of coupling bodies 34 opposite of first bores 36, not shown in this figure. Extension portion 370 has a contact surface 202 that is planar and parallel to axis 318. Extension portion 371 has a contact surface 203 that is planar and parallel to axis 311. Extension portion 370 is shaped such that the axis of bore 304 is offset from axis 318. Extension portion 371 is shaped such that the axis of bore 306 is offset from axis 311. This embodiment further minimizes the footprint or intrusiveness of the coupling mechanism, and more particularly the articulating connector, into the spinal column, the base of the skull and the surrounding tissue while providing all of the same features of the embodiments described above.

While the invention has been illustrated and described in detail in the drawings
5 and foregoing description, the same is to be considered as illustrative and not restrictive in
character. All changes and modifications that come within the spirit of the invention are
desired to be protected.

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What is claimed is:

- 5 1. A spinal rod connection system, comprising:
 a first elongated rod for attachment to the spinal column extending along a
longitudinal axis between a first end and an opposite second end, said first rod including a
first characteristic and a first coupling member at said first end;
 a second elongated rod for attachment to the skull extending along a longitudinal
10 axis between a first end and an opposite second end, said second rod including a second
characteristic and a second coupling member at said first end; and
 a coupling mechanism for releasably coupling said first coupling member and
said second coupling member in an end-to-end fashion, wherein said longitudinal axis of
each of said first and second rods is at an angle to one another.
15 2. The system of claim 1, wherein said coupling mechanism axially and
torsionally constrains said first and second rods relative to one another.
 3. The system of claim 1, wherein said first and second characteristics each
20 include a diameter of a respective one of said first and second rod portions, wherein the
first diameter is greater than the second diameter.
 4. The system of claim 1, wherein said first and second characteristics each
25 include a diameter of a respective one of said first and second rod portions, wherein the
second diameter is greater than the first diameter.
 5. The system of claim 1, wherein said coupling mechanism includes a first
end and an opposite second end, said first end including a first coupling body and said
30 second end including a second coupling body.

5 6. The system of claim 5, wherein said first coupling member is releasably engageable to said first coupling body and said second coupling member is releasably engageable to said second coupling body.

10 7. The system of claim 6, wherein said first coupling body includes an internally threaded first bore and said first coupling member is externally threaded for removable engagement in said first bore and wherein said second coupling body includes an internally threaded first bore and said second coupling member is externally threaded for removable engagement in said first bore.

15 8. The system of claim 7, wherein said first and second coupling members include an external thread pattern interrupted by a flattened surface portion extending along said coupling member.

 9. The system of claim 8 wherein said flattened surface lacks threads.

20 10. The system of claim 9, wherein at least one of said first and second coupling bodies includes a second bore transversely oriented to and intersecting said first bore, said second bore including an internal thread for engaging an externally threaded set screw, said set screw positionable in engagement with said flattened surface of said coupling member when said coupling member is engaged in said first bore to prevent said coupling member from rotating in said first bore.

 11. The system of claim 10, wherein said second bore is orthogonal to said first bore.

30 12. A spinal rod connection system, comprising:
a first elongated rod for attachment to the spinal column extending along a

longitudinal axis between a first end and an opposite second end, said first rod including a first characteristic and a first coupling member at said first end;

5 a second elongated rod for attachment to the skull extending along a longitudinal axis between a first end and an opposite second end, said second rod including a second characteristic and a second coupling member at said first end; and

10 a coupling mechanism for releasably coupling said first coupling member and said second coupling member in an end-to-end fashion, wherein an angle between said longitudinal axis of each of said first and second rods can be temporarily varied and thereafter fixed so that said coupling mechanism axially and torsionally constrains said first and second rods relative to one another.

13. The system of claim 12, wherein said first and second characteristics each
15 include a diameter of a respective one of said first and second rod portions, wherein the first diameter is greater than the second diameter.

14. The system of claim 12, wherein said first and second characteristics each
20 include a diameter of a respective one of said first and second rod portions, wherein the second diameter is greater than the first diameter.

15. The system of claim 12, wherein said coupling mechanism includes an articulating connector between a first end and an opposite second end, said first end including a first coupling body and said second end including a second coupling body.

25 16. The system of claim 15, wherein said first coupling member is releasably engageable to said first coupling body and said second coupling member is releasably engageable to said second coupling body.

30 17. The system of claim 16, wherein said first coupling body includes an internally threaded first bore and said first coupling member is externally threaded for

removable engagement in said first bore and wherein said second coupling body includes an internally threaded first bore and said second coupling member is externally threaded for removable engagement in said first bore.

18. The system of claim 17, wherein said first and second coupling members include an external thread pattern interrupted by a flattened surface portion extending along said coupling member.

19. The system of claim 18, wherein said flattened surface lacks threads.

20. The system of claim 19, wherein at least one of said first and second coupling bodies includes a second bore transversely oriented to and intersecting said first bore, said second bore including an internal thread for engaging an externally threaded set screw, said set screw positionable in engagement with said flattened surface of said coupling member when said coupling member is engaged in said first bore to prevent said coupling member from rotating in said first bore.

21. The system of claim 20, wherein said second bore is orthogonal to said first bore.

22. The system of claim 15, wherein said articulating connector comprises:
a first extension portion connected to said first coupling body, said first extension portion including a contact surface that is parallel to the axis of the first rod, wherein the first extension portion includes a bore perpendicular to the contact surface;

a second extension portion connected to said second coupling body, said second extension portion including a contact surface that is parallel to the axis of the second rod, wherein the second extension portion includes an internally threaded bore perpendicular to the contact surface;

5 a fastener including an external threaded portion for insertion through the bore of
said first extension portion and removable engagement in the bore of said second
extension portion, whereby said first extension contact surface and said second extension
contact surface engage one another and are prevented from articulating relative to one
another.

10 23. The system of claim 22, wherein at least one of the contact surfaces
include a movement prevention device.

24. The system of claim 23, wherein said movement prevention device
includes splines.

15 25. A method for assembling a spinal rod system extending to the skull,
comprising:

providing a first elongated rod for attachment to the spinal column extending
along a longitudinal axis between a first end and an opposite second end, said first rod
including a first characteristic and a first coupling member at said first end;

20 providing a second elongated rod for attachment to the skull extending along a
longitudinal axis between a first end and an opposite second end, said second rod
including a second characteristic and a second coupling member at said first end; and

providing a coupling mechanism for releasably coupling said first coupling
member and said second coupling member in an end-to-end fashion, wherein said
longitudinal axis of each of said first and second rods is at an angle to one another.

25 26. The method of claim 25, wherein said coupling mechanism axially and
torsionally constrains said first and second rods relative to one another.

27. The method of claim 25, wherein the angle can be temporarily varied and
thereafter fixed so that said coupling mechanism axially and torsionally constrains said
30 first and second rods relative to one another.

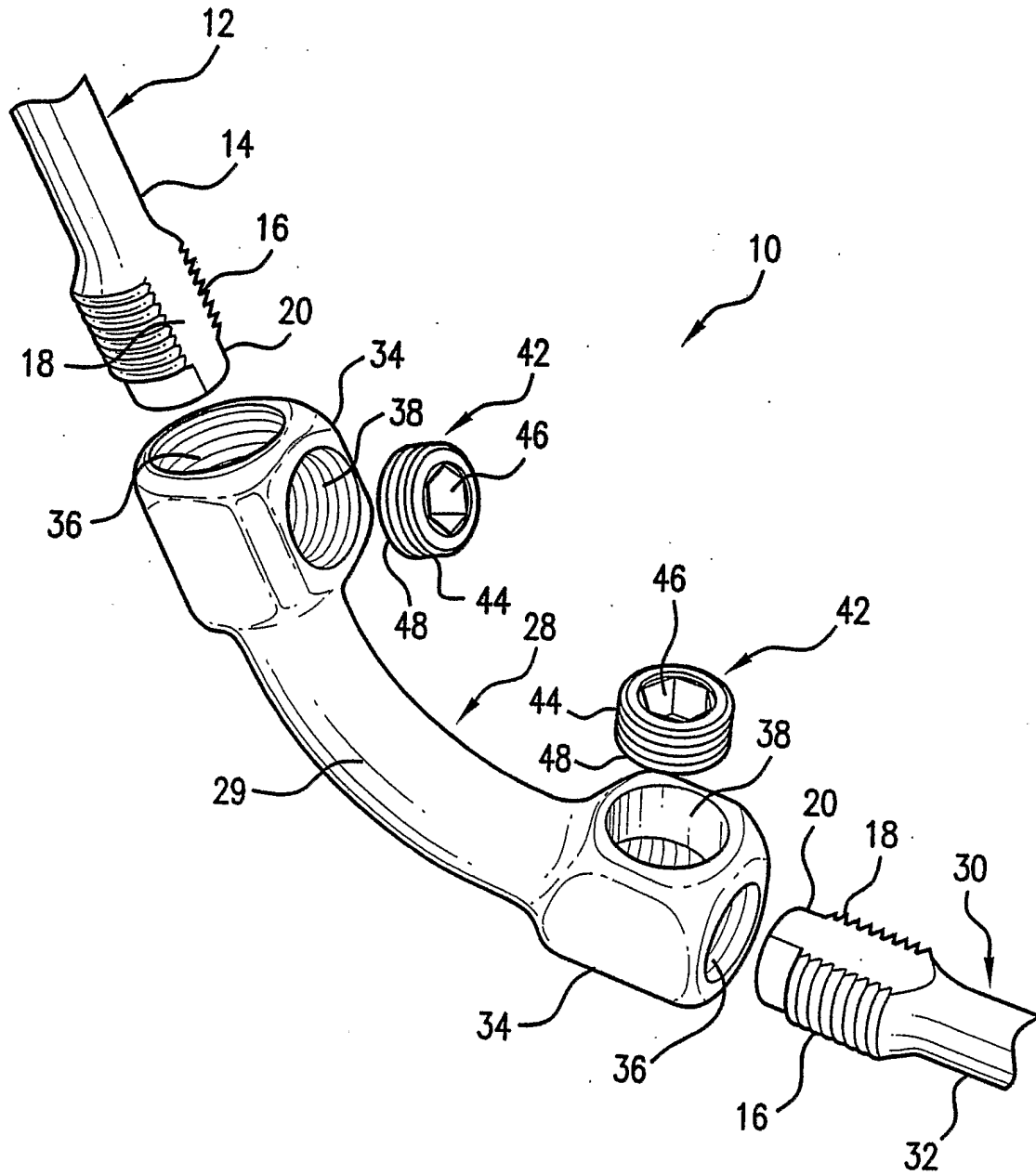


FIG. 1

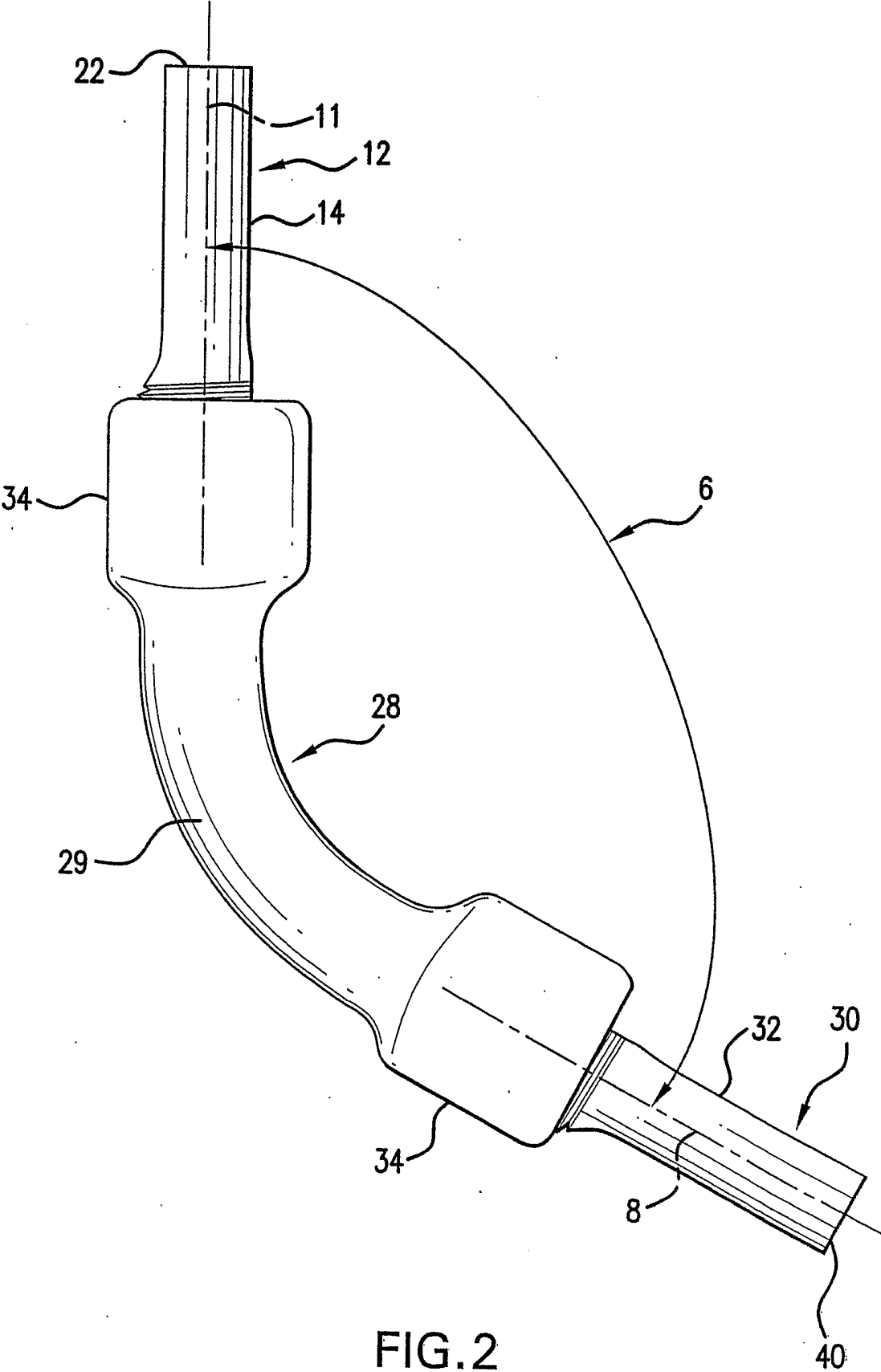


FIG. 2

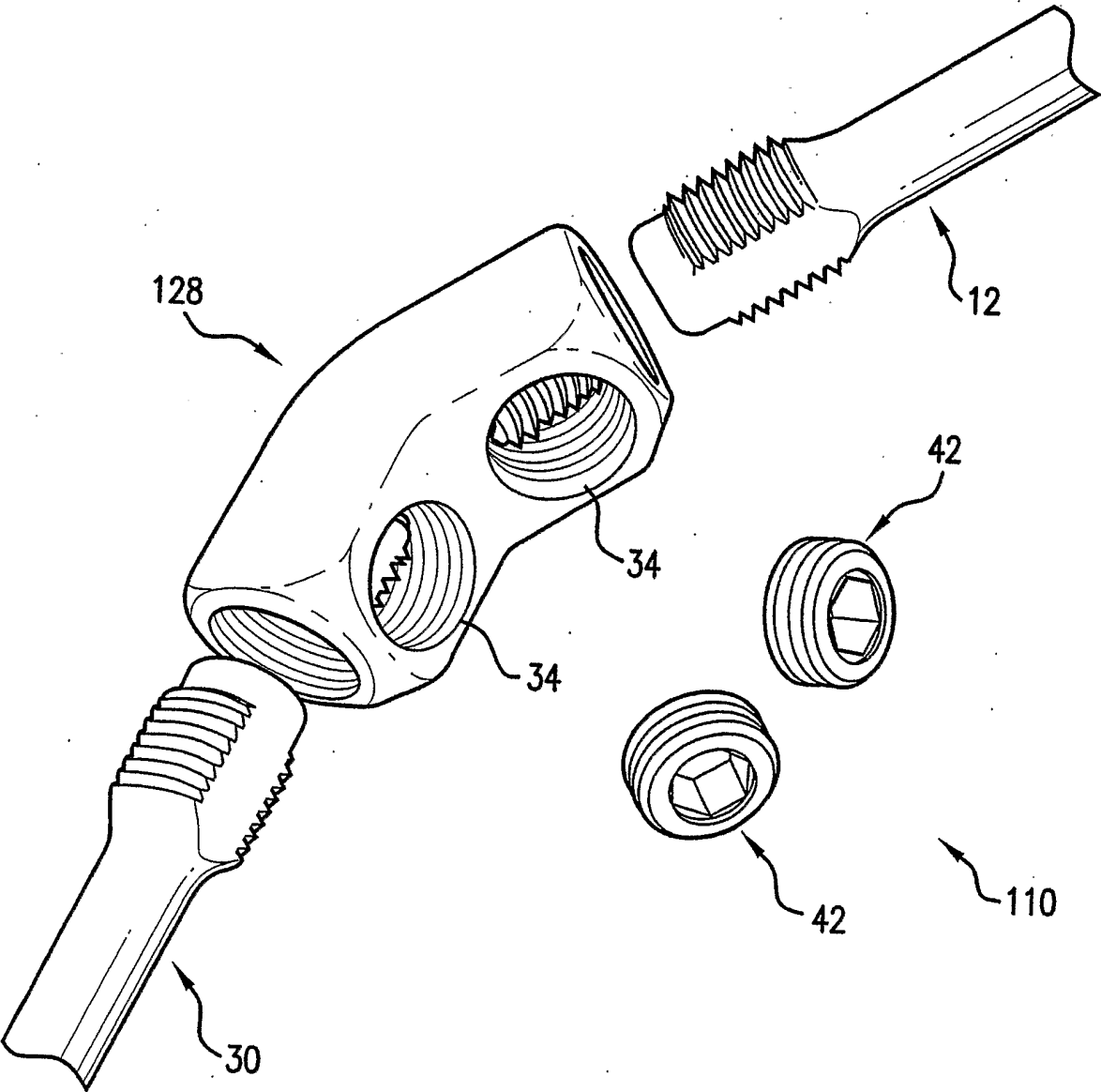


FIG.3

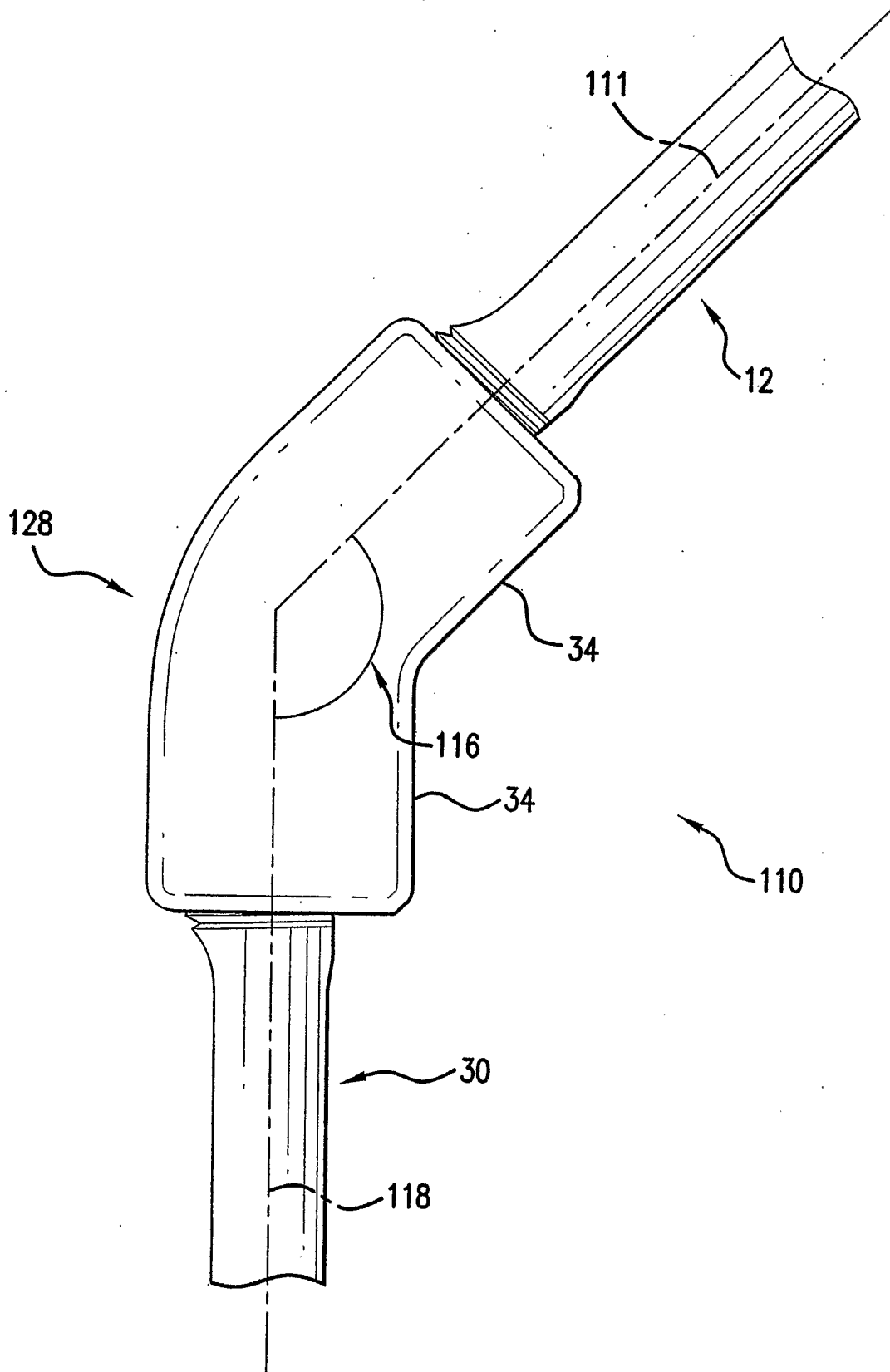


FIG. 4

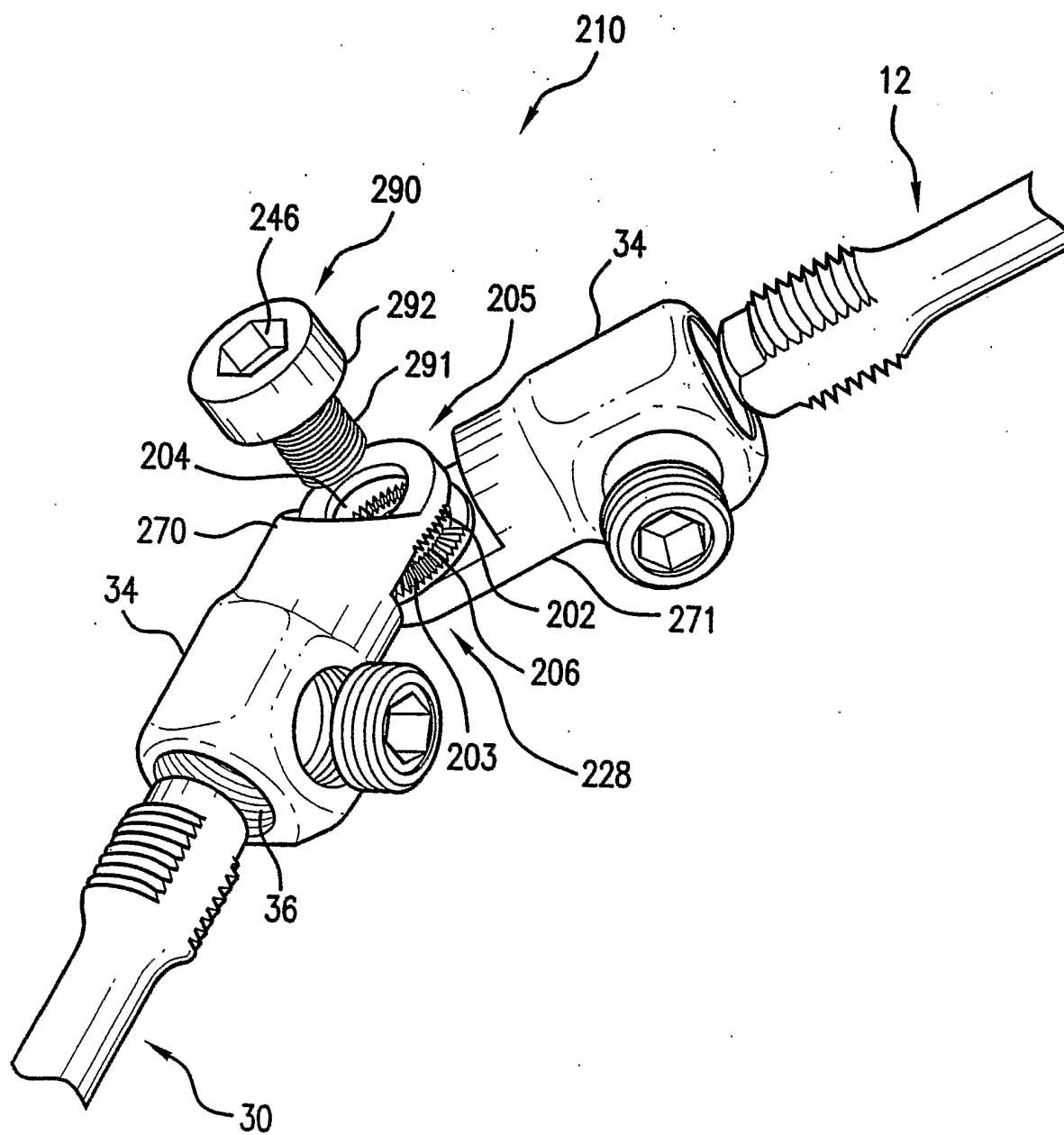


FIG. 5

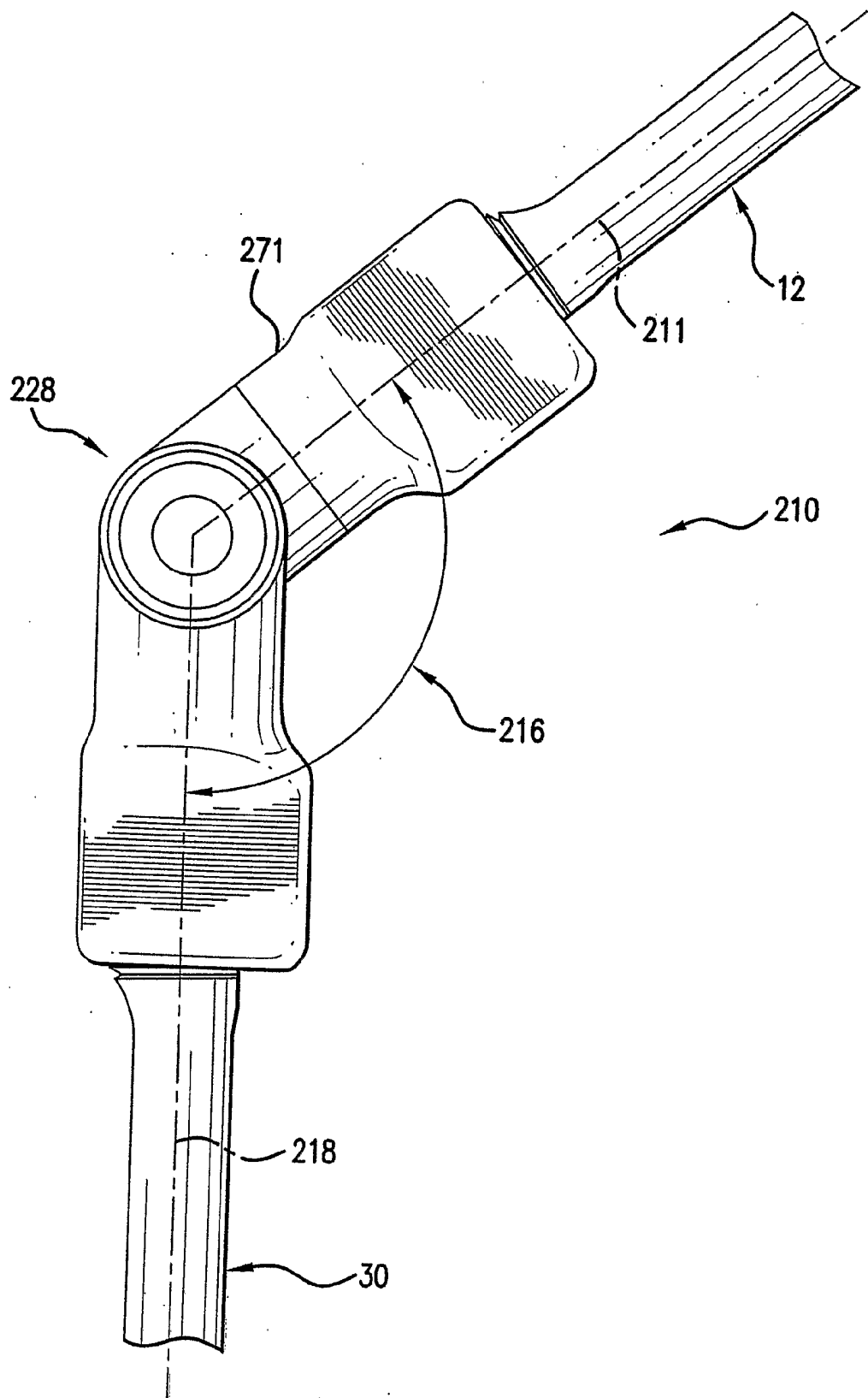


FIG. 6

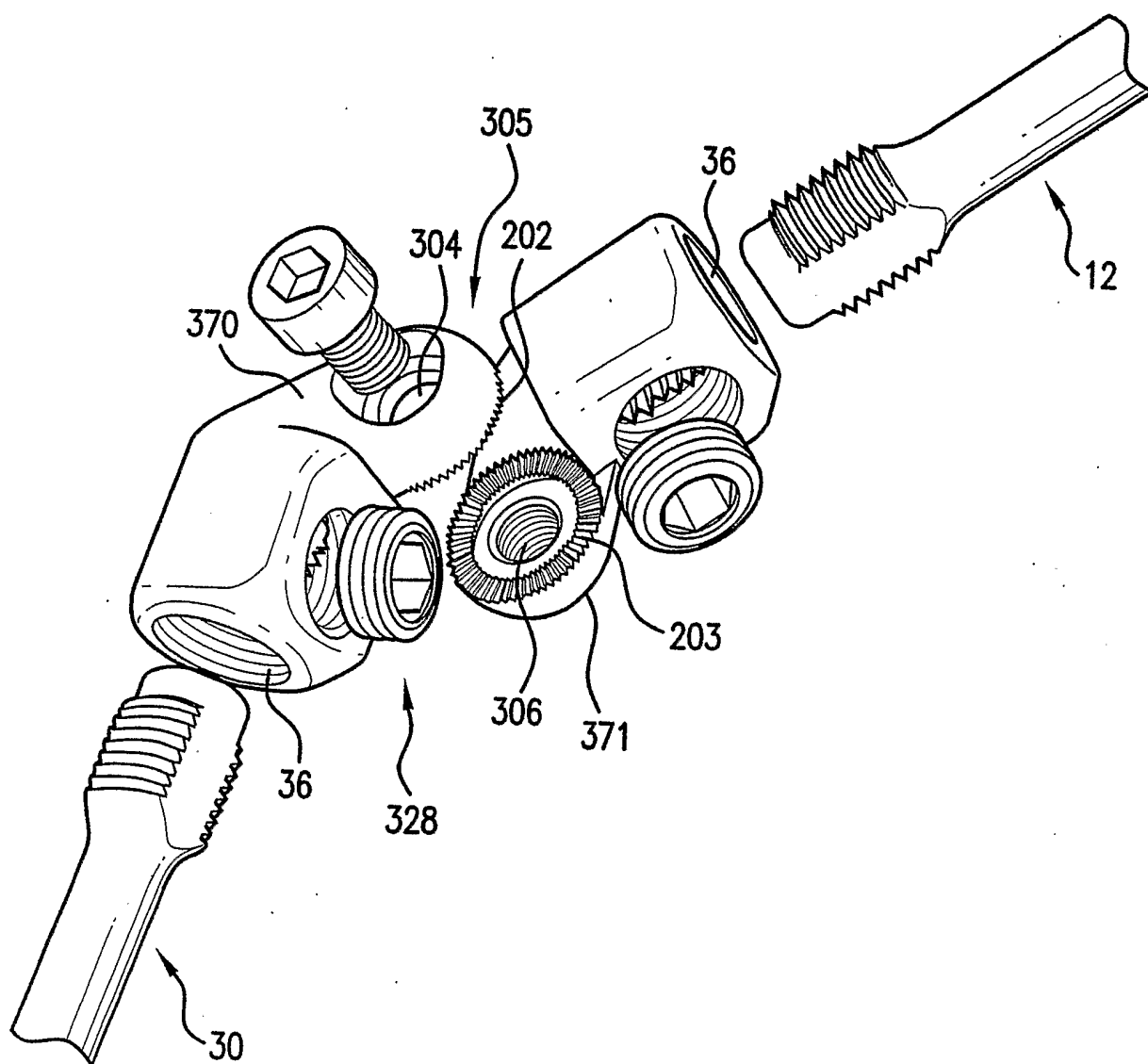


FIG. 7

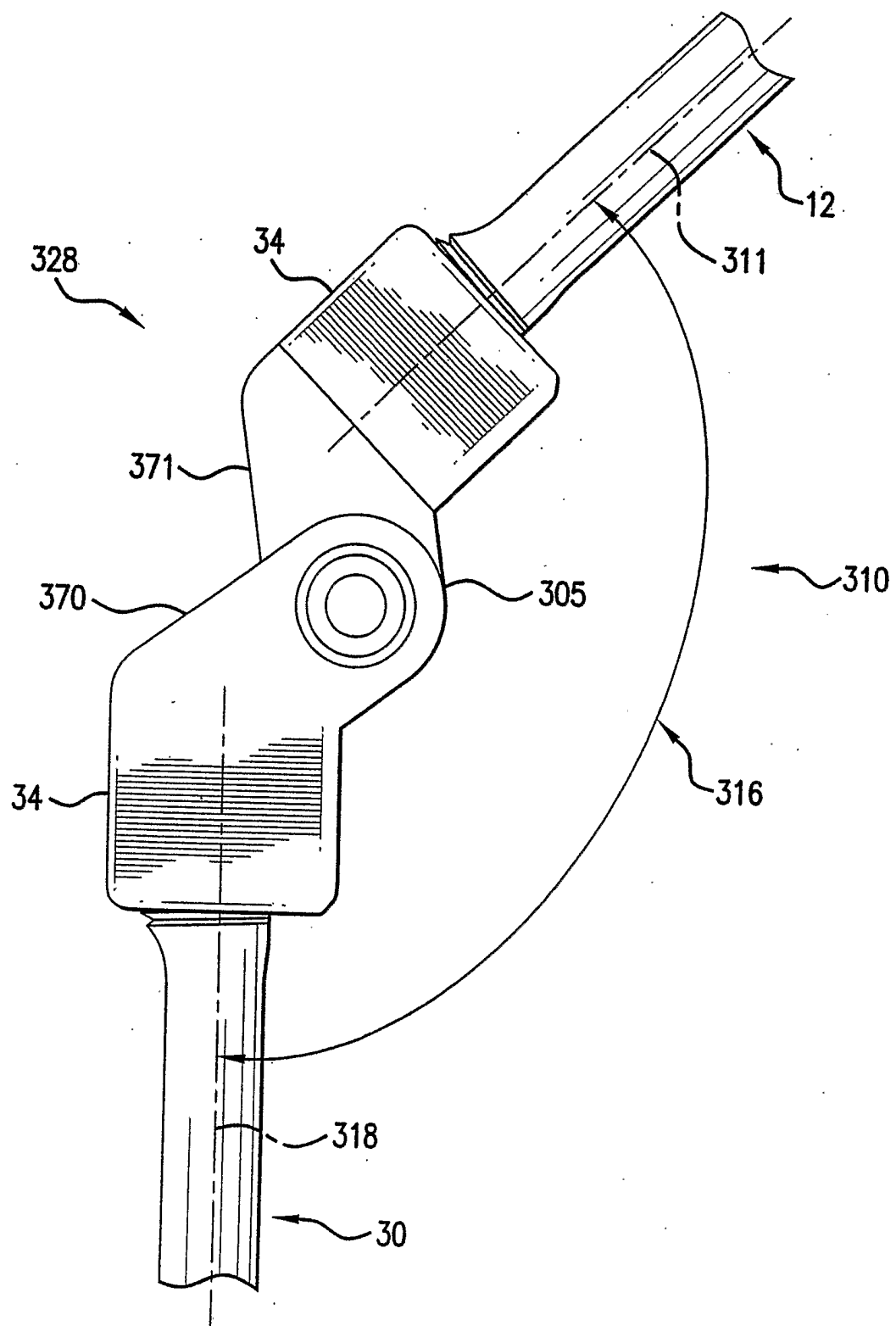


FIG. 8