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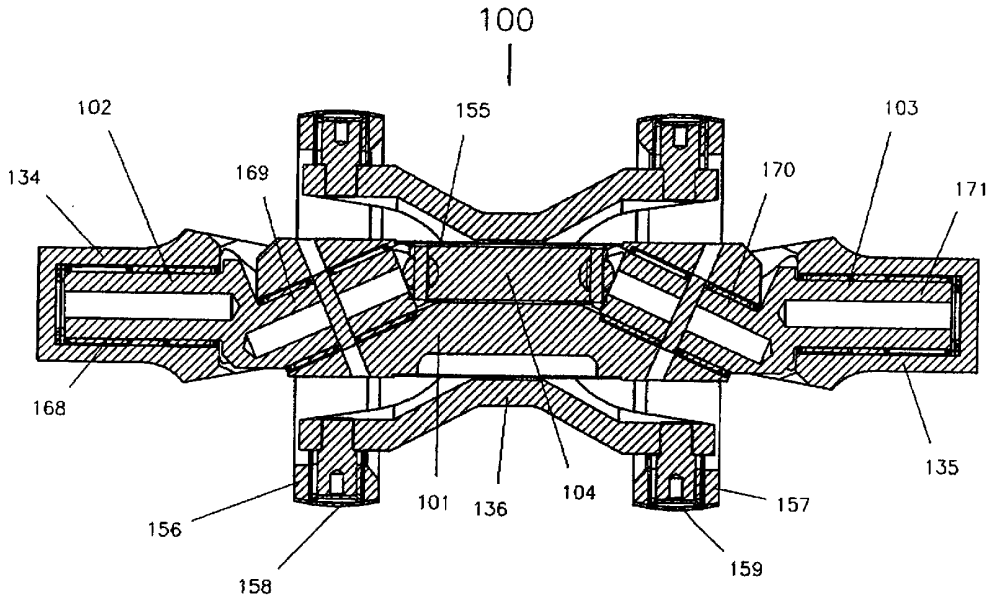
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[Continued on next page]

(54) Title: "CAM BAR CENTERING MECHANISM"



(57) Abstract: Universal joint (100) includes a centering mechanism (100A) for supporting the universal and forcing the two joint halves to operate at the same angle thereby causing the joint to operate at constant velocity at all angles. Each shaft (134, 135) of the joint (100) is rotatably connected to the centering mechanism (100A). Movement of one of the shafts (134, 135) at an angle relative to the longitudinal axis of the coupling yoke (136) is transmitted to the other shaft (135, 134) by the centering mechanism (100A) and the centering mechanism (100A) causes the other shaft (135, 134) to likewise move at the same angle relative to the longitudinal axis of the coupling yoke (136). The centering mechanism (100A) includes cam rods (102, 103) supported within a cam tube (101), which arrangement allows a full range of movement of the shafts (134, 135) at angles of 90°.

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PATENT APPLICATION

TITLE OF THE INVENTION

"Cam Bar Centering Mechanism"

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APPLICANT FOR ALL COUNTRIES BUT US: Drive Technologies, LLC (a Michigan, US, Limited Liability Company)

CROSS-REFERENCE TO RELATED APPLICATIONS

Priority of our US Provisional Patent Application Serial No. 60/267,017, filed 7 February 2001, incorporated herein by reference, is hereby claimed.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

REFERENCE TO A "MICROFICHE APPENDIX"

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates primarily to centering mechanisms. More particularly, the present invention relates primarily to centering mechanisms for universal joints.

2. General Background of the Invention

Universal joint designers have found it difficult to design constant velocity universal joints capable of operating at high angles, high speeds and high loads simultaneously, due to the limitations of existing constant velocity universal joint centering and supporting devices. This is due to the difficulty in packaging robust internal supporting devices that utilize rolling elements that are capable of operating at typical driveline speeds.

See US Patent No. 5,823,881 and all references cited therein for a background of the invention.

Hereby incorporated by reference are all prior patents and published applications of Paul J. Cornay, including US Patent No. 6,251,020; 6,139,435; 5,823,881; 5,425,676; Publication No. WO 00/36314; Publication No. WO 94/29604; Publication No. WO 91/00438; and all references cited therein.

BRIEF SUMMARY OF THE INVENTION

The apparatus of the present invention solves the problems confronted in the art in a simple and straightforward manner. What is provided is a cam rod centering mechanism. In a preferred embodiment of the present invention, the cam rod centering mechanism comprises a cam centering mechanism for universal joints. The invention is advantageous because it supports the universal joint with robust components in a relatively small package while allowing the universal joint to operate at high angles of misalignment from 0° through 90° while transmitting high torque loads at high speeds with low drive-line disturbances.

The self supported universal joints of the present invention are capable of operating at constant velocity at high angles, high speeds and high torque loads and provide design engineers with the following options: higher power transfer capability to driven members (e.g. wheels, power takeoffs); more options in drive-line placement; engines can be run at higher r.p.m. resulting in greater fuel economy; and tighter turning radiuses for vehicles.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For a further understanding of the nature, objects, and advantages of the present invention, reference should be had to the following detailed description, read in conjunction with the following drawings, wherein like reference numerals denote like elements and wherein:

Figure 1 is a perspective, partially sectional view of a first embodiment of the apparatus of the present invention with no angular joint displacement;

Figure 2 is a perspective, partially sectional view of the first embodiment of the apparatus of the present invention with angular joint displacement;

Figure 3 is a isometric perspective view of the first embodiment of the apparatus of the present invention with no angular joint displacement;

Figure 4 is a isometric perspective, partially sectional view of the first embodiment of the

apparatus of the present invention with angular joint displacement;

Figure 5 is an exploded view of the first embodiment of the apparatus of the present invention;

Figure 6 is a perspective, partially sectional view of the centering mechanism of the first embodiment of the apparatus of the present invention with no angular joint displacement;

Figure 7 is a perspective, partially sectional view of the centering mechanism of the first embodiment of the apparatus of the present invention with angular joint displacement;

Figure 8 is an exploded view of the centering mechanism of the first embodiment of the apparatus of the present invention.

Figure 9 is a perspective, partially sectional view of a second embodiment of the apparatus of the present invention with no angular joint displacement;

Figure 10 is an exploded view of the second embodiment of the apparatus of the present invention;

Figure 11 is a partially sectional view of the centering mechanism of the second embodiment of the apparatus of the present invention with no angular centering mechanism displacement;

Figure 12 is a partially sectional view of the centering mechanism of the second embodiment of the apparatus of the present invention with angular centering mechanism displacement;

Figure 13 is an exploded view of the centering mechanism of the second embodiment of the apparatus of the present invention;

Figure 14 is a perspective, partially sectional view of a third embodiment of the apparatus of the present invention with angular joint displacement;

Figure 15 is an exploded view of the third embodiment of the apparatus of the present invention;

Figure 16 is a partially sectional view of the centering mechanism of the third embodiment of the apparatus of the present invention with no angular centering mechanism displacement;

Figure 17 is a partially sectional view of the centering mechanism of the third embodiment of the apparatus of the present invention with angular centering mechanism displacement;

Figure 18 is an exploded view of the centering mechanism of the third embodiment of the apparatus of the present invention;

Figure 19 is a perspective, partially sectional view of a fourth embodiment of the apparatus

of the present invention with angular joint displacement;

Figure 20 is an exploded view of the fourth embodiment of the apparatus of the present invention;

Figure 21 is a partially sectional view of the centering mechanism of the fourth embodiment of the apparatus of the present invention with no angular centering mechanism displacement;

Figure 22 is a partially sectional view of the centering mechanism of the fourth embodiment of the apparatus of the present invention with angular centering mechanism displacement;

Figure 23 is an exploded view of the centering mechanism of the fourth embodiment of the apparatus of the present invention;

Figure 24 is an isometric perspective view of a fifth embodiment of the apparatus of the present invention with no angular joint displacement;

Figure 25 is a perspective view of the fifth embodiment of the apparatus of the present invention showing locations of sections 26-26 and 27-27;

Figure 26 is a perspective, partially sectional view, along section line 26-26, of the fifth embodiment of the apparatus of the present invention with no angular joint displacement;

Figure 27 is a perspective, partially sectional view, along section line 27-27, of the fifth embodiment of the apparatus of the present invention;

Figure 28 is a side view of a ring quadrant of the fifth embodiment of the apparatus of the present invention;

Figure 29 is a partially sectional view, along section line 29-29 in Figure 28, of a ring quadrant of the fifth embodiment of the apparatus of the present invention;

Figure 30 is an isometric perspective of a ring quadrant of the fifth embodiment of the apparatus of the present invention; and

Figure 31 is an exploded view of the fifth embodiment of the apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Universal joints 100, 200, 300, 400 and 500 include respective centering mechanisms 100A, 200B, 300C, 400D for supporting the universal joints and forcing the two joint halves to operate at the same angle thereby causing the joint to operate at constant velocity at all angles. For example, each shaft 134, 135 of the joint 100 is rotatably connected to the centering mechanism

100A. Movement of one of the shafts 134, 135 at an angle relative to the longitudinal axis of the connecting yoke 136 is transmitted to the other shaft 135, 134 by the centering mechanism 100A and the centering mechanism 100A causes the other shaft 135, 134 to likewise move at the same angle relative to the longitudinal axis of the connecting yoke 136. The centering mechanism 100A includes cam rods 102, 103 supported within a cam tube 101, which arrangement of bearings allows a full range of movement of the shafts 134, 135 at angles of 90°.

Universal joint 100 can be assembled by the following method:

First: Assembly of Centering mechanism 100A

Bearing assembly 113 is pressed into and to the bottom of hole 127 of cam tube 101. Bearing 116 is pressed into hole 127 of cam tube 101 so that the face of bearing 116 is flush with the opening of hole 127 of cam tube 101. This method is repeated with bearings 114 and 115 in hole 128 of cam tube 101. Cube 105 is inserted between yoke ears 141 of cam rod 102 so that hole 148 is in alignment with hole 143. Pin 109 is inserted through holes 143 and 148. Pin 109 has a press fit within hole 143 and a slip fit in hole 148. This method is repeated with cube 106 in yoke ears 142 with pin 110 in holes 144 and 147 on cam rod 103. Cam rod 102 with cube 105 and pin 109 is inserted into bearings 116 and 113 within cam tube 101. This same process is repeated with cam rod 103 and cube 106 and pin110 and bearings 114 and 115 within cam tube 101. Inner joint connecting yoke 104 is inserted into window 129 of cam tube 101 so that yoke ears 137 and 138 of inner joint connecting yoke 14 slip over cubes 15 and 16. With holes 151 and 145 and 149 aligned pin 107 is inserted thereby connecting cam rod 102 to inner joint connecting yoke 104 with pins 107 and 109 with cube 105. This same process is repeated with inner joint connecting yoke 104 and cube 106 and cam rod 103 with pins 108 and 110 in holes 146 and 152. This completes the assembly of the centering mechanism.

Angles 101A and 102B of cam tube 101 together with angles 103C and 104D of cam rods 102 and 103, of Figure 7, combine to create angles 105E and 106F of centering mechanism 100A. Angle 105E and angle 106F are always equal when cam rod 102 is rotated within cam tube 101 causing an equal magnitude of rotation of cam rod 103 within cam tube 101. In other words if angle 101A is equal to angle 102B of cam tube 101 and angle 103C is equal to angle 104D of cam rods 102 and 103 then when cam rod 102 is rotated with cam tube 101 thereby rotating cam rod 103 then angle 105E will equal angle 106F. The sum of angles 105E and 106F can range from 0° through a maximum angle which equals the sum of angle 101A, 102B, 103C and 104D (e.g.90°).

Assembly of joint 100 can be similar to assembly of prior art joints.

Even if not part of a universal joint (such as in robotics applications), centering mechanism 100A could also be used to join and support two tubes or beams, while allowing for angular misalignment of the two members. In such a case, centering mechanism 100A acts as a universal connector. Appropriate connection means (such bores in the first and second members) can be used for connecting the first cam rod to the first member and for connecting the second cam rod to a second member. The first and second members can be shafts, tubes, or construction members.

Universal joint 100 includes a first ring 156 and a second ring 157, a first yoke and a second yoke disposed within the first ring 156 and the second ring 157, respectively, and a first shaft 134 and a second shaft 135. The first yoke (on the left side of connecting yoke member 136 in Figure 5) and the second yoke (on the right side of connecting yoke member 136 in Figure 5) are connected with a coupling means (a short shaft member) as shown in Figures 1-5. The first and second yokes and the coupling means are all part of connecting member 136. First pin means (pins 164 and 166) pivotally interconnect the first yoke and the first ring 156, second pin means (pins 165 and 167) pivotally interconnect the first shaft 134 and the first ring 154, third pin means pivotally interconnect the second yoke and the second ring 157, and fourth pin means interconnect the second shaft 135 and the second ring 157. The coupling means (a short shaft member as shown in Figures 1-5) interconnects the first yoke and the second yoke. A plurality of bearing means (including bearing cups 160, 161, 162, 163) receive the pin means. Centering means 100A interconnects the first shaft 134 and the second shaft 135; centering means 100A includes a first cam rod 102 rotatably coupled to a second cam rod 103.

In the embodiments of the present invention shown in the drawings, each shaft of each universal joint is connected to a ring through a yoke, as shown. All joints shown are symmetrical, so parts not specifically numbered in the drawings are the same as their numbered counterparts on the other half of the joints.

As can be seen in Figures 1-5, there are bearing means in each ring 156, 157, the bearing means in the first ring 156 receiving the first second pin means, and the bearing means in the second ring 157 receiving the third and fourth pin means.

As can be seen in Figures 1 and 2, the first cam rod 102 includes a first section 168 having a first axis of rotation 175 and a second section 169, offset from the first section, having a second

axis of rotation 176; and the second cam rod 103 includes a first section 171 having a first axis of rotation 177 and a second section 170, offset from the first section, having a second axis of rotation 178.

The axes of rotation 175, 176 of the first cam rod 102 intersect the pivot center 172 of the first and second pin means and the axes of rotation 177, 178 of the second cam rod 103 intersect the pivot center 174 of the third and fourth pin means. The intersection of the axes 175 and 176 of cam rod 102 with axes 177 and 178 of cam rod 103 most preferably occurs at the joint's pivot center and bisecting angle plane 173 of the joint 100 for proper function.

Cam tube 101 receives and supports the cam rods 102 and 103 in a manner in which both cam rods 102, 103 are rotatably supported at equal angles within the cam tube 101.

Universal joints 100, 200, 300, 400, 500 include respectively a first shaft 134, 234, 334, 434, and 534, a second shaft 135, 235, 335, 435, and 535, coupling means 136, 236, 336, 436, 536, for transmitting torque from the first shaft to the second shaft, and centering means 100A, 200B, 300C, 400D, and 300C, interconnecting the first shaft and the second shaft for causing the second shaft to move at the same angle relative to the coupling means as does the first shaft, the centering means comprising a first cam rod 102, 202, 302, 402, and 302 and a second cam rod 103, 203, 303, 403, and 303 rotatably coupled to the first cam rod. Each cam rod 102, 103, 202, 203, 302, 303, 402, 403 includes a first straight section 168, 171, 239, 240, 343, 344, 441, 442, and a second straight section 169, 170, 241, 242, 345, 346, 443, 444, each straight section having a longitudinal axis, and the longitudinal axes of the two straight sections forming an angle, and the angle of the first cam rod is equal to the angle of the second cam rod. Both cam rods 102, 103, 202, 203, 302, 303, 402, 403 are rotatably supported at equal angles within cam tube 101, 201, 301, 401. The cam tubes includes bores 127, 128, 227, 228, 327, 328, 427, 428 which support the cam rods at equal angles to each other, and which are the same angle as the cam rods, such that when rotating the coupled cam rods within the cam tube, the axes of the second straight sections of the cam rods can align themselves to one another or can be misaligned with respect to one another up to an angle equal to four times the angle of the cam rod. First cam rod 102, 202, 302, 402 and second cam rod 103, 203, 303, 403 are longitudinally aligned at equal angles within cam tube 101, 201, 301, 301.

Universal joint 200 is substantially similar to universal joint 100 except that centering mechanism 200B has a single pin and cube universal joint coupling cam rod 202 to cam rod 203.

First cam rod 202 is rotatably coupled to the second cam rod 203 by a pin and cube universal joint which is supported within cam tube 201. The pin and cube universal joint of joint 200 is similar to the pin and cube universal joint of joint 100 but includes a single cube 207. Even if not part of a universal joint (such as in robotics applications), centering mechanism 200B could also be used to join and support two tubes or beams, while allowing for angular misalignment of the two members. Universal joint 200 does not provide for as much angular misalignment as does universal joint 100.

Universal joint 300 includes a centering mechanism 300C for supporting the universal joint and forcing the two joint halves to operate at the same angle thereby causing joint 300 to operate at constant velocity at all angles. Each shaft 334, 335 of the joint 300 is rotatably connected to the centering mechanism 300C. Movement of one of the shafts 334, 335 at an angle relative to the longitudinal axis of the connecting yoke member 336 is transmitted to the other shaft 335, 334 by the centering mechanism 300C and the centering mechanism 300C causes the other shaft 335, 334 to likewise move at the same angle relative to the longitudinal axis of the connecting yoke member 336. The centering mechanism B includes cam rods 302, 303 supported by bent rods 304, 305 and 306. Rotation of cam rod 302 along the axis of rotation of bent rods 304, 305 and 306 results in a corresponding rotation of cam rod 303 along the angulated axis of rotation of bent rods 304, 305 and 306. Cam rods 302 and 303 combine with bent rods 304, 305 and 306 to form a mechanism similar to a "bent pin coupling". Universal joint 300 can be assembled by the following method:

First: Assembly of the Centering mechanism 300C

Bearing seal assembly 307 is pressed into the bottom of hole 317 of cam tube 301. This method is repeated with bearing 308 hole 316 of cam tube 301. Cam rod 302 is inserted into bearing seal 307. Bent rod 304,305 and 306 are inserted into holes 318, 319 and 313 of cam rod 302. Cam rod 303 is inserted into bearing seal 308 so that thrust surfaces 320 and 321 are in contact. This completes the assembly of the centering mechanism 300C.

Bearings 309 and 310 are inserted into hole 323 of the yoke of shaft 334. This process is repeated with bearings 311 and 312 in hole 322 of the yoke of shaft 335. Centering mechanism 300C is installed into joint 300 in the same manner that centering mechanism 200B is installed into joint 200. The same method of assembly of joint 200 can be used for the assembly of joint 300.

Angles 301A and 302B of bent rods 304, 305, and 306 together with angles 303C and 304D of cam rods 302 and 303, of Figure 17, combine to create angles 305E and 306F of centering mechanism 300C. Angle 305E and angle 306F are always equal when cam rod 302 is rotated around bent rods 304, 305, and 306 causing an equal magnitude of rotation of cam rod 303. In other words if angle 301A is equal to angle 302B of bent rods 304, 305 and 306 and angle 303C is equal to angle 304D of cam rods 302 and 303 then when cam rod 302 is rotated around bent rod 304, 305 and 305 thereby rotating cam rod 303 then angle 305E will equal angle 306F. The sum of angles 305E and 306F can range from 0° through a maximum angle which equals the sum of angle 301A, 302B, 303C and 304D (e.g. 90°).

Universal joint 300 includes first shaft 334, second shaft 335, coupling means 336 for transmitting torque from the first shaft to the second shaft, and centering means 300C interconnecting the first shaft 334 and the second shaft 335 for causing the second shaft to move at the same angle relative to the coupling means as does the first shaft, the centering means comprising a first cam rod 302 and a second cam rod 303 longitudinally aligned with and rotatably connected to the first cam rod by a plurality of bent rods 304, 305, 306. The first cam rod 302 and the second cam rod 303 are connected at equal angles, and the axes of rotation of the first cam rod, bent rods and second cam rod intersect at the pivot points of the first and second shafts and the bisecting plane (shown schematically in universal joint 100 in Figure 2) of the universal joint 300 which is perpendicular to the rotation axes of the coupling means. Cam tube 301 rotatably supports the first cam rod 302 and the second cam rod 302, and the first cam rod 302, the second cam rod 303, and the cam tube 303rotatably support and interconnect the first shaft 334 and the second shaft 335 for causing the second shaft to move at the same angle relative the coupling means (connecting yoke member 336) as does the first shaft.

Universal joint 400 includes a centering mechanism 400D for supporting the universal joint and forcing the two joint halves to operate at the same angle thereby causing joint 400 to operate at constant velocity at all angles. Each shaft 434, 435 of the joint 400 is rotatably connected to the centering mechanism 400D. Movement of one of the shafts 434, 435 at an angle relative to the longitudinal axis of the connecting yoke member 436 is transmitted to the other shaft 435, 434 by the centering mechanism 400D and the centering mechanism 400D causes the other shaft 435, 434 to likewise move at the same angle relative to the longitudinal axis of the connecting yoke member 436.

Universal joint 400 can be assembled by the following method:

First: Assembly of the Centering mechanism 400D

Bearing seal assembly 407 is pressed into the bottom of hole 419 of cam tube 401. This method is repeated with bearing 408 in hole 420 of cam tube 401. Cam rod 402 is inserted into bearing seal assembly 407. Ball 404 is placed into socket 414 of cam rod 402. Cam rod 403 is inserted into bearing seal 408 so that gear teeth 415 and 416 are meshed together and so ball 404 is captured in sockets 413 and 414. This completes the assembly of the centering mechanism 400D.

Bearings 409 and 410 are inserted into hole 421 of the yoke of shaft 434. This process is repeated with bearings 411 and 412 in hole 422 of the yoke of shaft 435. Centering mechanism 400D is installed into joint 400 in the same manner that centering mechanism 300C is installed into joint 300. The same method of assembly of joint 300 can be used for the assembly of joint 400.

Angles 401A and 402B of cam tube 401 together with angles 403C and 404D of cam rods 402 and 403, of Figure 22, combine to create angles 405E and 406F of centering mechanism 400D. Angle 405E and angle 406F are always equal when cam rod 402 is rotated within cam tube 401 causing an equal magnitude of rotation of cam rod 403 within cam tube 401. In other words if angle 401A is equal to angle 402B of cam tube 401 and angle 403C is equal to angle 404D of cam rods 402 and 403 then when cam rod 402 is rotated with cam tube 4301 thereby rotating cam rod 403 then angle 405E will equal angle 406F. Angles 405E and 406F can range from 0° through a maximum angle which equals the sum of angles 401A , 402B, 403C and 404D (e.g. 90°).

Assembly of joint 400 can be similar to prior art.

Even if not part of a universal joint (such as in robotics applications), centering mechanism 400D could also be used to join and support two tubes or beams, while allowing for angular misalignment of the two members.

Universal joint 500 differs from joints 100, 200, 300 and 400 in the construction of the rings. The rings (or ring assemblies) 537 and 538 are each composed of four identical quadrants which can be fitted together end to end in a manner which mechanically retains or locks the ring quadrants together. This method of ring construction and joint assembly can be advantageous over other methods for the following reasons.

1. Bearing surfaces can be machined or formed integral with the ring quadrant eliminating the need for a bearing cup.

2. Trunnion pins can be formed integral with the yoke members eliminating the need for separate trunnion pins.
3. Use of ring quadrants provides a more compact and stronger joint.
4. Ring quadrants could be made out of moldable, castable or formable plastics and metals reducing or eliminating machining operations.
5. Ring quadrants can be affixed to one another by interference fit or adhesives or welding.

Universal joint 500 includes a first ring 537 made of a plurality of ring segments 501, 502, 503, 504 which are fitted together end-to-end in a manner to mechanically retain the ring segments together and a second ring 538 made of a plurality of ring segments 505, 506, 507, 508 which are fitted together end-to-end in a manner to mechanically retain the ring segments together, a first yoke and a second yoke disposed within the first and second rings, respectively; and a first shaft 534 and a second shaft 535. First pin means (including pins 511, 512) pivotally interconnect the first yoke and the first ring 537. Second pin means (including pins 509 and 510) pivotally interconnect the first shaft 524 and the first ring 537. Third pin means pivotally interconnect the second yoke and the second ring 538. Fourth pin means pivotally interconnect the second shaft and the second ring. A coupling means interconnects the first yoke and the second yoke. The coupling means, first yoke, and second yoke form the coupling yoke member 536. A plurality of bearing means receive the pin means. The ring segments 501-508 are quadrants which are substantially identical to one another. Centering means (centering mechanism 300C) interconnects the first shaft 534 and the second shaft 535. The centering mechanism 300C includes first cam rod 302 and second cam rod 303 rotatably coupled to the first cam rod 302. The second cam rod 303 is longitudinally aligned with and rotatably connected to the first cam rod 302 by a plurality of bent rods 304, 305, 306.

Universal joint 500 can be assembled by the following method.

Universal joint 500 can utilize centering mechanisms 100A, 200B, 300C, or 400D for internal support. Figure 26 shows universal joint 500 with centering mechanism 300C. Centering mechanism 300C is installed in universal joint 500 in the same manner as described in the assembly of universal joint 300 above. Universal joint 500 can be assembled in the same manner as universal joints 100, 200, 300 and 400 if ring quadrants 501, 502, 503 and 504 are affixed to one another to form a ring, as well as ring quadrants 505, 506, 507 and 508 are affixed to one another to form a second ring.

If trunnion pins 509 and 510 were integral with shaft 534 and trunnion pins 511, 521, 519 and 529 were integral with coupling yoke member 536 and trunnion pins 517 and 518 were integral with shaft 535 then joint 500 would be assembled by the following method: Ring quadrant 502 is installed over trunnion pin 509 and ring quadrant 504 is installed over trunnion pin 510. This process is repeated with ring quadrants 501, 503, 505, 506, 507 and 508 installed over trunnion pins 511, 512, 519, 520, 517 and 518. Centering mechanism 300C is placed within coupling yoke 536. Shaft 534 with ring quadrants 502 and 504 is affixed to coupling yoke member 536 with ring quadrants 501 and 503 by pressing the ends of ring quadrants 502 and 504 onto the ends of ring quadrants 501 and 503 as shown in Figure 27. This process is repeated with connecting yoke member 536 and trunnion pins 519, 520 and ring quadrants 506 and 508 along with shaft 535 and trunnion pins 517 and 518 and ring quadrants 505 and 507.

Universal joint 500 includes a centering mechanism 300C for supporting the universal joint and forcing the two joint halves to operate at the same angle thereby causing joint 500 to operate at constant velocity at all angles. Each shaft 534, 535 of the joint 500 is rotatably connected to the centering mechanism 300C. Movement of one of the shafts 534, 435 at an angle relative to the longitudinal axis of the connecting yoke member 536 is transmitted to the other shaft 535, 534 by the centering mechanism 300C and the centering mechanism 300C causes the other shaft 535, 534 to likewise move at the same angle relative to the longitudinal axis of the connecting yoke member 536.

How the cam rod centering mechanism works:

The kinematics of joints 100, 200, 300, 400, and 500 are substantially identical to that of a Double Cardan universal joint, a description of which can be found in the Universal Joint and Drive Shaft Design Manual, AE-7, Published by the Society of Automotive Engineers, Inc. Like the Double Cardan joint, joints 100, 200, 300, 400, and 500 require the use of an internal support or centering mechanism 100A, 200B, 300C, 400D so that joints 100, 200, 300, 400 and 500 are self-supporting and self- aligning. Unlike the Double Cardan joint, joints 100, 200, 300, 400 and 500 transmit true constant velocity output at all operating joint angles. The use of internal support is not necessary when end support bearings are supplied for the input/output shafts (shafts 134, 135) such as in a marine stern-drive system. However, when only one end support is provided such as in automotive drivelines, axle driveshafts, and steering applications, the use of an internal support or a centering mechanism is necessary.

The centering devices of joint 100, 200, 300, 400, and 500 are advantageous over other centering mechanisms in the following ways: Centering devices of Double Cardan universal joints allow the joint to operate at a constant velocity at a maximum of two joint angles only, 0° and some design operating angle. Because the ball and socket of the Double Cardan joint drifts out of the bisecting angle plane of the two joint halves an error or inequality between the two joint halves is produced causing the joint to operate at near but not true constant velocity at all but 0° and one other angle. The effects of Double Cardan centering device location and function can be found on page 112 of SAE's Universal Joint And Drive Shaft Design Manual. Additionally, centering mechanisms of Double Cardan universal joints are required to move laterally with respect to the central axis of the connecting yoke which requires the connecting yoke to be larger. The centering mechanism of joints 100, 200, 300, 400 and 500 allow the joints to operate at true constant velocity at all joint angles from 0 to the joint's maximum misalignment capability. True constant velocity operation is achieved as a result of maintaining, for example, angle 105E equal to angle 106F at all operating joint angles.

Like the connecting yoke of the Double Cardan joint the connecting yokes of joint 100, 200, 300, 400 and 500 do not rotate at a uniform speed when the joint is operating at an angle. This non-uniform motion can create objectionable noise, vibration, and harshness (NVH) in the drive train. It is therefore desirable to have a low mass moment of inertia of the connecting yoke member. Centering mechanisms 100A , 200B, 300C, 400D of joint 100, 200, 300, 400 and 500 allow for the design of a constant velocity universal joint which can have a coupling yoke member with a low mass moment of inertia without sacrificing high joint misalignment.

The centering devices 100A, 200B, 300C, 400D are advantageous over other universal joint centering mechanisms because they can provide support at high joint angles with no lateral movement of the centering mechanism within the coupling yoke member. Eliminating lateral movement of a centering mechanism allows designers to concentrate the mass of coupling yoke members closer to the joint's center of rotation thereby reducing the inertia excitation (vibration) caused by this component's non-uniform motion characteristics. Limitations in high operating angle are produced as a result of the large lateral displacement requirement of supporting mechanisms of Double Cardan joints resulting in increased package size, operating angle limitations and driveline disturbances.

Novel features of the present invention include: there is no lateral movement of the centering .mechanism with respect to the connecting yoke member; there is no axial displacement of the centering mechanism with respect to the input/output shafts; and each cam bar, in all three versions, have two axes in the same plane, which create the cam - the intersection of the two cam bar axes most preferably occurs at the joints' pivot center and bisecting angle plane of the joint for proper function.

PARTS LIST:

The following is a list of exemplary parts and materials suitable for use in the present invention:

101 cam tube (preferably made Aluminum 6061-T6)

102 cam rod (8620 steel hardness of 60 HRC)

103 cam rod (8620 steel hardness of 60 HRC)

104 centering mechanism connecting yoke (Apex-Cooper Power Tools, Part No. MS20271 B16)

105 centering mechanism cube (Apex-Cooper Power Tools, part no. MS20271 B16)

106 centering mechanism cube (Apex-Cooper Power Tools, part no. MS20271 B16)

107 centering mechanism pin (Apex-Cooper Power Tools, part no. MS20271 B16)

108 centering mechanism pin (Apex-Cooper Power Tools, part no. MS20271 B16)

109 centering mechanism pin (Apex-Cooper Power Tools, part no. MS20271 B16)

110 centering mechanism pin (Apex-Cooper Power Tools, part no. MS20271 B16)

111 retaining pin (Fastenal spring pin, part no. 28092)

112 retaining pin (Fastenal spring pin, part no. 28092)

113 needle bearing assembly (Torrington Bearing Co. part no. B2020)

114 needle bearing assembly (Torrington Bearing Co. part no. B2020)

115 needle bearing assembly (Torrington Bearing Co. part no. JT2017)

116 needle bearing assembly (Torrington Bearing Co. part no. JT2017)

117 needle bearing assembly (Torrington Bearing Co. part no. JT2017)

118 needle bearing assembly (Torrington Bearing Co. part no. JT2017)

119 needle bearing assembly (Torrington Bearing Co. part no. B2020)

120 needle bearing assembly (Torrington Bearing Co. part no. B2020)

121 thrust bearing washer (Garlock Bearing Co. part no. G 12 DU)

122 thrust bearing washer (Garlock Bearing Co. part no. G 12 DU)

123 o-ring/thrust spring (Apple Rubber Co. part no. AS686691-118, 122, 125)

124 o-ring/thrust spring (Apple Rubber Co. part no. AS686691-118, 122, 125)

125 hole in cam rod 102

126 hole in cam rod 103

127 first angled hole in cam tube 101

128 second angled hole in cam tube 101

129 window in cam tube 101

130 first pin access hole in cam tube 101

131 second pin access hole in cam tube 101

132 bearing spacer

133 bearing spacer

134 input/output shaft

135 input/output shaft

136 coupling yoke member

137 cover of cam tube 101

156 ring

157 ring

158 band

159 band

160 needle bearing assembly

161 needle bearing assembly

162 needle bearing assembly

163 needle bearing assembly

164 trunnion pin (E9310 alloy steel, 60 HRC)

165 trunnion pin (E9310 alloy steel, 60 HRC)

166 trunnion pin (E9310 alloy steel, 60 HRC)

167 trunnion pin (E9310 alloy steel, 60 HRC)

201 cam tube (Aluminum 6061-T6 or Steel)

202 cam rod (E9310 alloy steel, 60 HRC)

203 cam rod (E9310 alloy steel, 60 HRC)

204 needle bearing assembly (Torrington Bearing Co. part no. DB76557N)

205 needle bearing assembly (Torrington Bearing Co. part no. B1010)

206 needle bearing assembly (Torrington Bearing Co. part no. DD-76433)

207 centering mechanism cube (Apex-Cooper Power Tool, part no. MS-20271-B8)

208 cover for cam tube 201

209 thrust bearing (INA Bearing Co. part no. AXK-0414TN)

210 thrust washer (INA Bearing Co. part no. AS 0414)

211 plug seal

212 internal snap ring

213 bearing spacer

214 O-ring seal

215 O-ring seal

216 needle bearing assembly (Torrington Bearing Co, DB-76557N)

217 needle bearing assembly (Torrington Bearing Co, DB-76557N)

218 needle bearing assembly (Torrington Bearing Co, DB-76557N)

219 trunnion pin (E9310 alloy steel, 60 HRC)

220 needle bearing assembly (Torrington Bearing Co, part no.DD-76433)

221 bearing spacer

222 trunnion pin (E9310 alloy steel, 60 HRC)

224 needle bearing assembly (Torrington Bearing Co, part no.DD-76433)

225 needle bearing assembly (Torrington Bearing Co, part no.DD-76433)

226 trunnion pin (E9310 alloy steel, 60 HRC)

227 needle bearing assembly (Torrington Bearing Co, part no. B-1010)

228 needle bearing assembly (Torrington Bearing Co, part no. B-1010)

230 ring

231 ring

232 band

233 band

234 input/output shaft (alloy steel)

235 input output shaft (alloy steel)

236 coupling yoke member (alloy steel)

237 needle bearing assembly (Torrington Bearing Co, part no.DD-76433)

238 trunnion pin (E9310 alloy steel, 60 HRC

301 cam tube (aluminum or alloy steel)

302 cam rod (E9310 alloy steel, 60 HRC)

303 cam rod (E9310 alloy steel, 60 HRC)

304 bent rod (E4340 alloy steel, 50 HRC)

305 bent rod (E4340 alloy steel, 50 HRC)

306 bent rod (E4340 alloy steel, 50 HRC)

307 bearing seal (Garlock 18DP06)

308 bearing seal (Garlock 18DP06)

309 needle bearing assembly (Torrington Bearing Co, part no. JT-1813)

310 needle bearing assembly (Torrington Bearing Co, part no. JT-1813)

311 needle bearing assembly (Torrington Bearing Co, part no. JT-1813)

312 needle bearing assembly (Torrington Bearing Co, part no. JT-1813)

324 bearing cup

325 bearing cup

326 bearing cup

327 bearing cup

328 trunnion pin

329 trunnion pin

330 trunnion pin

331 trunnion pin

334 input/output shaft

335 input/output shaft

336 connecting yoke member

339 ring

340 ring

341 O-ring seal

342 O-ring seal

401 cam tube

402 cam rod

403 cam rod

404 ball (bearing steel, 60 HRC)

407 bearing seal

408 bearing seal

409 needle bearing assembly (Torrington Bearing Co, part no. JT-1813)

410 needle bearing assembly (Torrington Bearing Co, part no. JT-1813)

411 needle bearing assembly (Torrington Bearing Co, part no. JT-1813)

412 needle bearing assembly (Torrington Bearing Co, part no. JT-1813)

423 O-ring seal

424 O-ring seal

425 needle bearing assembly

426 bearing retaining ring

427 trunnion pin

428 ring

434 input/output shaft

435 input/output shaft

436 coupling yoke

437 spring

438 thrust bearing

439 spring

440 thrust bearing

501 ring quadrant

502 ring quadrant

503 ring quadrant

504 ring quadrant

505 ring quadrant

506 ring quadrant

507 ring quadrant

508 ring quadrant

509 trunnion pin

510 trunnion pin
511 trunnion pin
512 trunnion pin
513 bearing seal
514 bearing seal
515 bearing seal
516 bearing seal
517 trunnion pin
518 trunnion pin
519 trunnion pin
520 trunnion pin
534 input/output shaft
535 input/output shaft
536 coupling yoke member
537 ring assembly
538 ring assembly

All measurements disclosed herein are at standard temperature and pressure, at sea level on Earth, unless indicated otherwise. All materials used or intended to be used in a human being are biocompatible, unless indicated otherwise.

The foregoing embodiments are presented by way of example only; the scope of the present invention is to be limited only by the following claims.

CLAIMS:

1. A universal joint comprising:

(a) first and second rings;

(b) first and second yokes disposed within the first and second rings, respectively;

(c) first and second shafts;

(d) first pin means pivotally interconnecting the first yoke and the first ring;

(e) second pin means pivotally interconnecting the first shaft and the first ring;

(f) third pin means pivotally interconnecting the second yoke and the second ring;

(g) fourth pin means interconnecting the second shaft and the second ring;

(h) a coupling means interconnecting the first yoke and the second yoke;

(i) a plurality of bearing means receiving the pin means; and

(j) centering means interconnecting the first shaft and the second shaft, the centering means comprising a first cam rod rotatably coupled to a second cam rod.

2. The universal joint of claim 1, wherein there are bearing means in each ring, the bearing means in the first ring receiving the first second pin means, and the bearing means in the second ring receiving the third and fourth pin means.

3. The universal joint of claim 1, wherein:

the first cam rod includes a first section having a first axis of rotation and a second section, offset from the first section, having a second axis of rotation; and

the second cam rod includes a first section having a first axis of rotation and a second section, offset from the first section, having a second axis of rotation.

4. The universal joint of claim 3, wherein:

the first and second pin means have pivot centers and the third and fourth pin means have pivot centers; and

the axes of rotation of the first cam rod intersect the pivot centers of the first and second pin means and the axes of rotation of the second cam rod intersect the pivot centers of the third and fourth pin means.

5. The universal joint of claim 1, wherein the first and second pin means have pivot centers and the third and fourth pin means have pivot centers, the first cam rod has axes of rotation and the second cam rod has axes of rotation, and the axes of rotation of the first cam rod intersect the pivot

centers of the first and second pin means and the axes of rotation of the second cam rod intersect the pivot centers of the third and fourth pin means.

6. The universal joint of claim 1, further comprising a cam tube which receives and supports the cam rods, wherein both cam rods are rotatably supported at equal angles within the cam tube.

7. A universal joint comprising:

(a) first and second shafts;

(b) coupling means for transmitting torque from the first shaft to the second shaft;

(c) centering means interconnecting the first shaft and the second shaft for causing the second shaft to move at the same angle relative to the coupling means as does the first shaft, the centering means comprising a first cam rod and a second cam rod rotatably coupled to the first cam rod.

8. The universal joint of claim 7, wherein each cam rod includes a first straight section and a second straight section, each straight section having a longitudinal axis, and the longitudinal axes of the two straight sections forming an angle, and the angle of the first cam rod is equal to the angle of the second cam rod.

9. The universal joint of claim 8, further comprising a cam tube, and wherein both cam rods are rotatably supported at equal angles within the cam tube.

10. The universal joint of claim 9, wherein the cam tube includes bores which support the cam rods at equal angles to each other, and which are the same angle as the cam rods, such that when rotating the coupled cam rods within the cam tube, the axes of the second straight sections of the cam rods can align themselves to one another or can be misaligned with respect to one another up to an angle equal to four times the angle of the cam rod.

11. The universal joint of claim 1, wherein: the first cam rod is rotatably coupled to the second cam rod by a pin and cube universal joint which is supported within a cam tube.

12. A universal joint comprising:

(a) first and second shafts;

(b) coupling means for transmitting torque from the first shaft to the second shaft;

(c) centering means interconnecting the first shaft and the second shaft for causing the second shaft to move at the same angle relative to the coupling means as does the first shaft, the centering means comprising a first cam rod and second cam rod longitudinally aligned at equal angles within a cam tube.

13. A universal joint comprising:

(a) first and second shafts;

(b) coupling means for transmitting torque from the first shaft to the second shaft;

(c) centering means interconnecting the first shaft and the second shaft for causing the second shaft to move at the same angle relative to the coupling means as does the first shaft, the centering means comprising a first cam rod and a second cam rod longitudinally aligned with and rotatably connected to the first cam rod by a plurality of bent rods.

14. The universal joint of claim 13, wherein the first cam rod and the second cam rod are connected at equal angles, and the axes of rotation of the first cam rod, bent rods and second cam rod intersect at the pivot points of the first and second shafts and the bisecting plane of the universal joint which is perpendicular to the rotation axes of the coupling means.

15. The universal joint of claim 13, further comprising a cam tube rotatably supporting the first cam rod and the second cam rod, and whereby the first cam rod, the second cam rod, and the cam tube rotatably support and interconnect the first shaft and the second shaft for causing the second shaft to move at the same angle relative the coupling means as does the first shaft.

16. A universal connector comprising:

(a) a first cam rod;

(b) a second cam rod;

(c) a cam tube, wherein the first cam rod is rotatably coupled to the second cam rod, and wherein both cam rods are rotatably supported at equal angles within cam tube;

(d) connection means for connecting the first cam rod to a first member and for connecting the second cam rod to a second member.

17. The connector of claim 16, wherein the first and second members are shafts.

18. The connector of claim 16, wherein the first and second members are tubes.

19. The connector of claim 16, wherein the first and second members are construction members.

20. A universal joint comprising:

(a) first and second rings, each ring comprising a plurality of ring segments which are fitted together end-to-end in a manner to mechanically retain the ring segments together;

(b) first and second yokes disposed within the first and second rings, respectively;

(c) first and second shafts;

(d) first pin means pivotally interconnecting the first yoke and the first ring;

(e) second pin means pivotally interconnecting the first shaft and the first ring;

(f) third pin means pivotally interconnecting the second yoke and the second ring;

(g) fourth pin means interconnecting the second shaft and the second ring;

(h) a coupling means interconnecting the first yoke and the second yoke;

(i) a plurality of bearing means receiving the pin means.

21. The universal joint of claim 20, wherein the ring segments are quadrants.

22. The universal joint of claim 21, wherein the quadrants are substantially identical to one another.

23. The universal joint of any one of claims 20-22, further comprising centering means interconnecting the first shaft and the second shaft, the centering means comprising a first cam rod and a second cam rod rotatably coupled to the first cam rod.

24. The universal joint of claims 23, wherein the second cam rod is longitudinally aligned with and rotatably connected to the first cam rod by a plurality of bent rods.

25. A centering means for a universal joint comprising first and second shafts and a coupling means for transmitting torque from the first shaft to the second shaft, the centering means including means for interconnecting the first shaft and the second shaft for causing the second shaft to move at the same angle relative to the coupling means as does the first shaft, the centering means comprising a first cam rod and a second cam rod rotatably coupled to the first cam rod.

26. The centering means of claim 25, wherein each cam rod includes a first straight section and a second straight section, each straight section having a longitudinal axis, and the longitudinal axes of the two straight sections forming an angle, and the angle of the first cam rod is equal to the angle of the second cam rod.

27. The centering means of claim 26, further comprising a cam tube, and wherein both cam rods are rotatably supported at equal angles within the cam tube.

28. The universal joint of claim 27, wherein the cam tube includes bores which support the cam rods at equal angles to each other, and which are the same angle as the cam rods, such that when rotating the coupled cam rods within the cam tube, the axes of the second straight sections of the cam rods can align themselves to one another or can be misaligned with respect to one another up to an angle equal to four times the angle of the cam rod.

29. The invention of any preceding claim, wherein there are bearing means in each ring, the bearing means in the first ring receiving the first second pin means, and the bearing means in the second ring receiving the third and fourth pin means.

30. The invention of any preceding claim, wherein:

the first cam rod includes a first section having a first axis of rotation and a second section, offset from the first section, having a second axis of rotation; and

the second cam rod includes a first section having a first axis of rotation and a second section, offset from the first section, having a second axis of rotation.

31. The invention of claim 30, wherein:

the first and second pin means have pivot centers and the third and fourth pin means have pivot centers; and

the axes of rotation of the first cam rod intersect the pivot centers of the first and second pin means and the axes of rotation of the second cam rod intersect the pivot centers of the third and fourth pin means.

32. The invention of any preceding claim, wherein the first and second pin means have pivot centers and the third and fourth pin means have pivot centers, the first cam rod has axes of rotation and the second cam rod has axes of rotation, and the axes of rotation of the first cam rod intersect the pivot centers of the first and second pin means and the axes of rotation of the second cam rod intersect the pivot centers of the third and fourth pin means.

33. The invention of any preceding claim, further comprising a cam tube which receives and supports the cam rods, wherein both cam rods are rotatably supported at equal angles within the cam tube.

34. The invention of any preceding claim, wherein each cam rod includes a first straight section and a second straight section, each straight section having a longitudinal axis, and the longitudinal axes of the two straight sections forming an angle, and the angle of the first cam rod is equal to the angle of the second cam rod.

35. The invention of any preceding claim, further comprising a cam tube, and wherein both cam rods are rotatably supported at equal angles within the cam tube.

36. The invention of claim 35, wherein the cam tube includes bores which support the cam rods at equal angles to each other, and which are the same angle as the cam rods, such that when rotating the coupled cam rods within the cam tube, the axes of the second straight sections

of the cam rods can align themselves to one another or can be misaligned with respect to one another up to an angle equal to four times the angle of the cam rod.

37. The invention of any preceding claim, wherein: the first cam rod is rotatably coupled to the second cam rod by a pin and cube universal joint which is supported within a cam tube.

38. The invention of any preceding claim, wherein the first cam rod and second cam rod are longitudinally aligned at equal angles within a cam tube.

39. The invention of any preceding claim, wherein the second cam rod is longitudinally aligned with and rotatably connected to the first cam rod by a plurality of bent rods.

40. The invention of claim 39, wherein the first cam rod and the second cam rod are connected at equal angles, and the axes of rotation of the first cam rod, bent rods and second cam rod intersect at the pivot points of the first and second shafts and the bisecting plane of the universal joint which is perpendicular to the rotation axes of the coupling means.

41. The invention of claims 39 or 40, further comprising a cam tube rotatably supporting the first cam rod and the second cam rod, and whereby the first cam rod, the second cam rod, and the cam tube rotatably support and interconnect the first shaft and the second shaft for causing the second shaft to move at the same angle relative the coupling means as does the first shaft.

42. The invention of any preceding claim, wherein: each ring comprises a plurality of ring segments which are fitted together end-to-end in a manner to mechanically retain the ring segments together.

43. The invention of claim 42, wherein the ring segments are quadrants.

44. The invention of claim 43, wherein the quadrants are substantially identical to one another.

45. The invention of any preceding claim, further comprising centering means interconnecting the first shaft and the second shaft, the centering means comprising a first cam rod and a second cam rod rotatably coupled to the first cam rod.

46. The invention of any preceding claim, wherein the second cam rod is longitudinally aligned with and rotatably connected to the first cam rod by a plurality of bent rods.

47. The centering device substantially as shown and described herein.

48. The universal joint substantially as shown and described herein.

49. The universal connector substantially as shown and described herein.

50. The inventions substantially as shown and described herein.

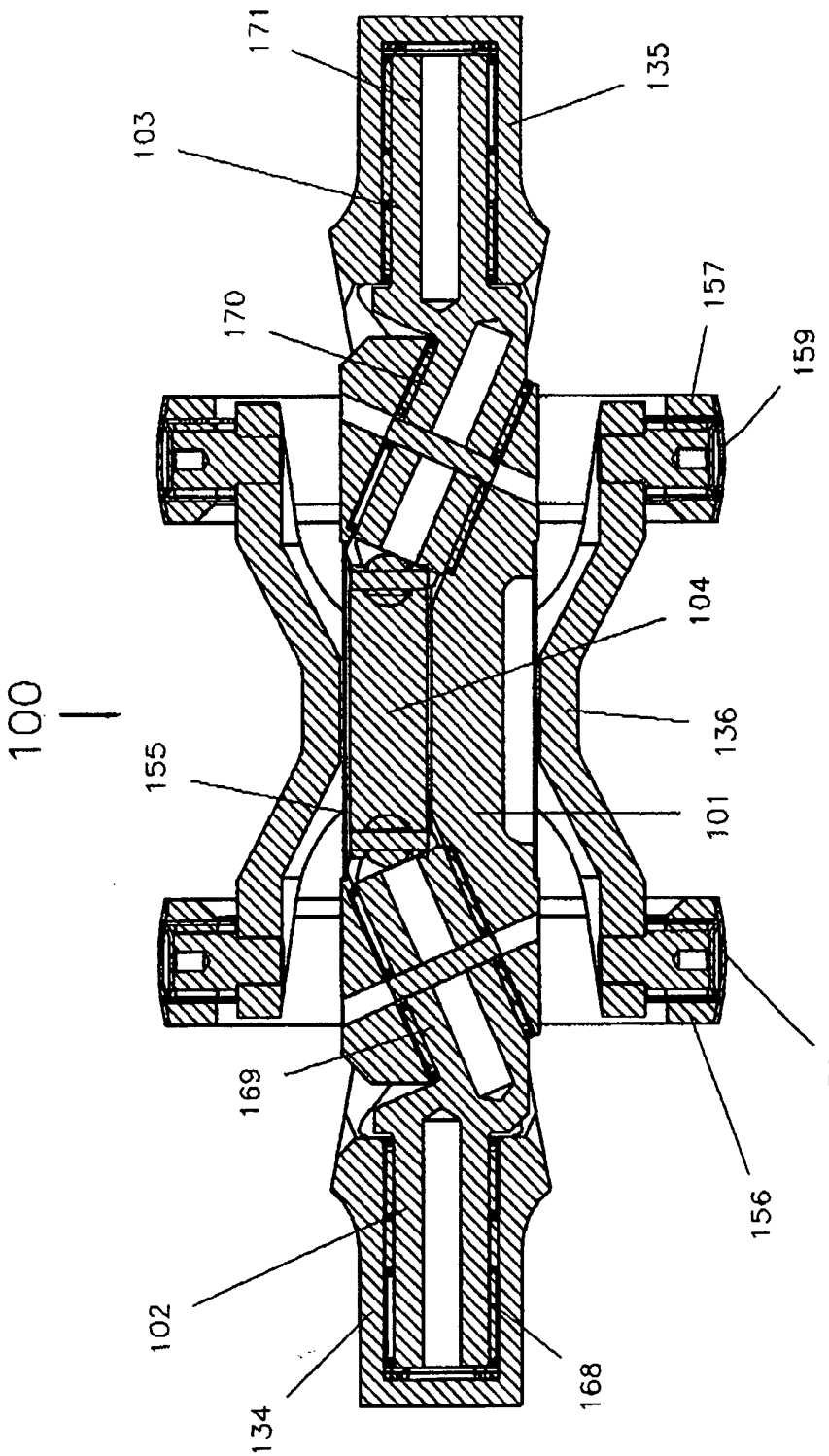

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FIG 1

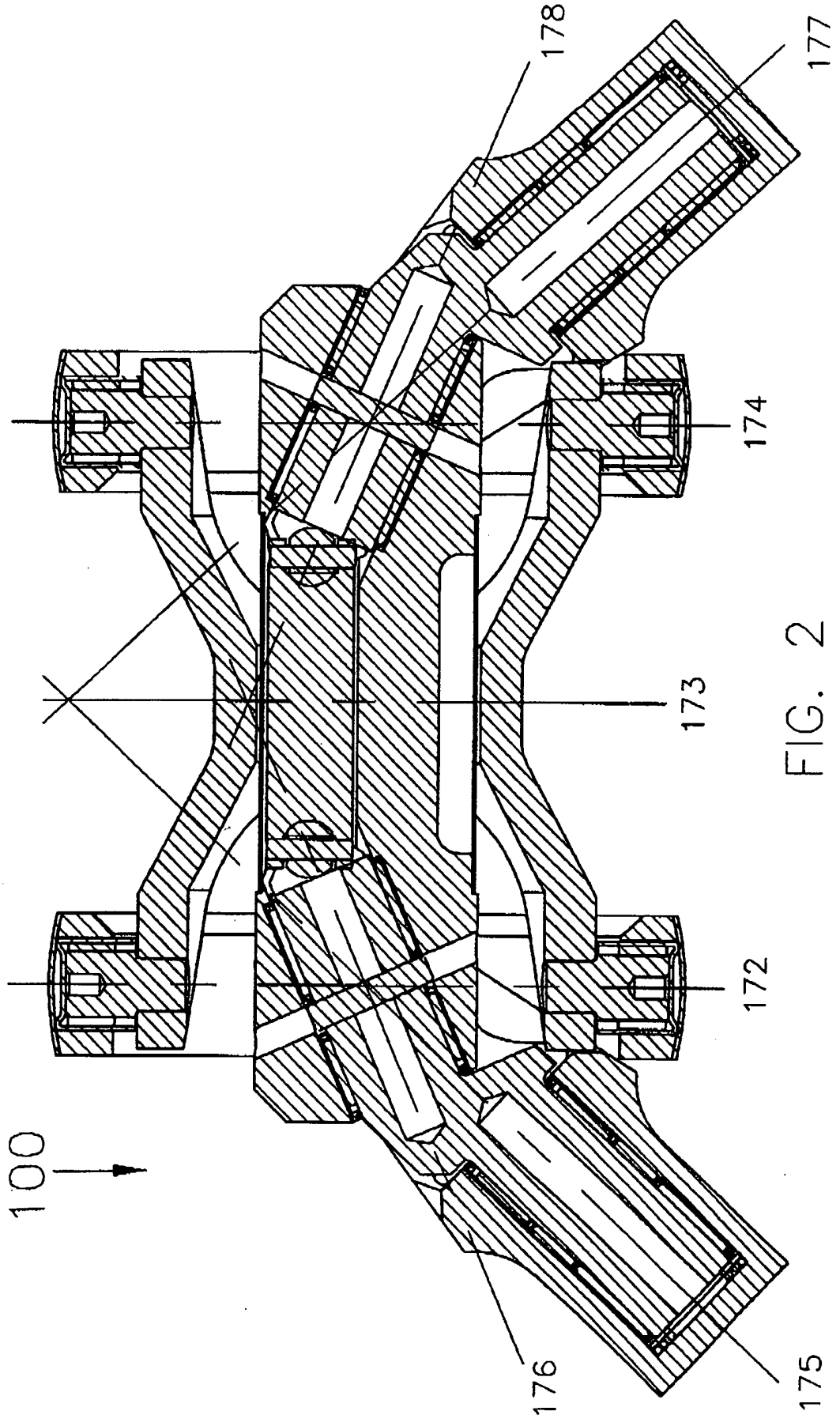


FIG. 2

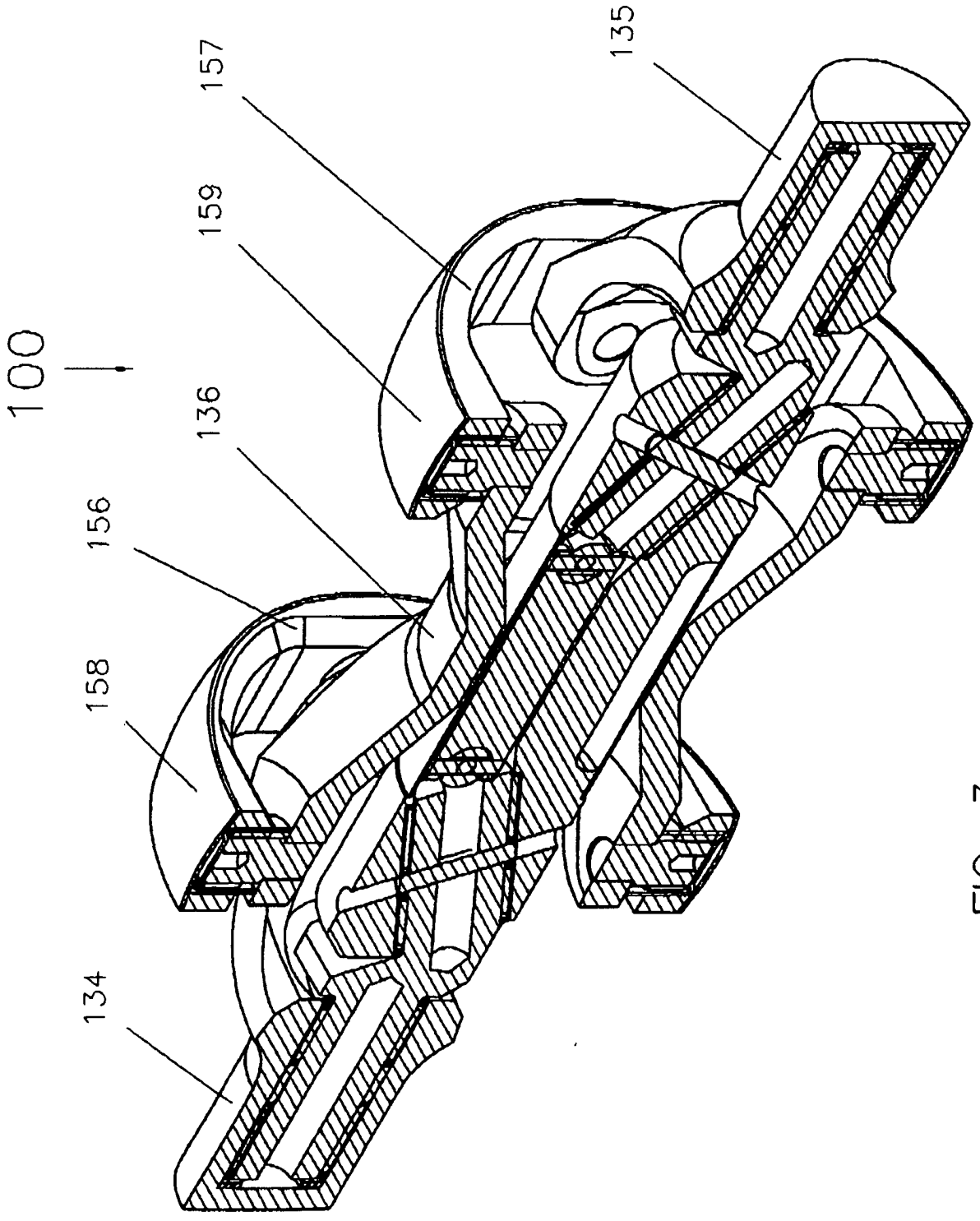


FIG. 3

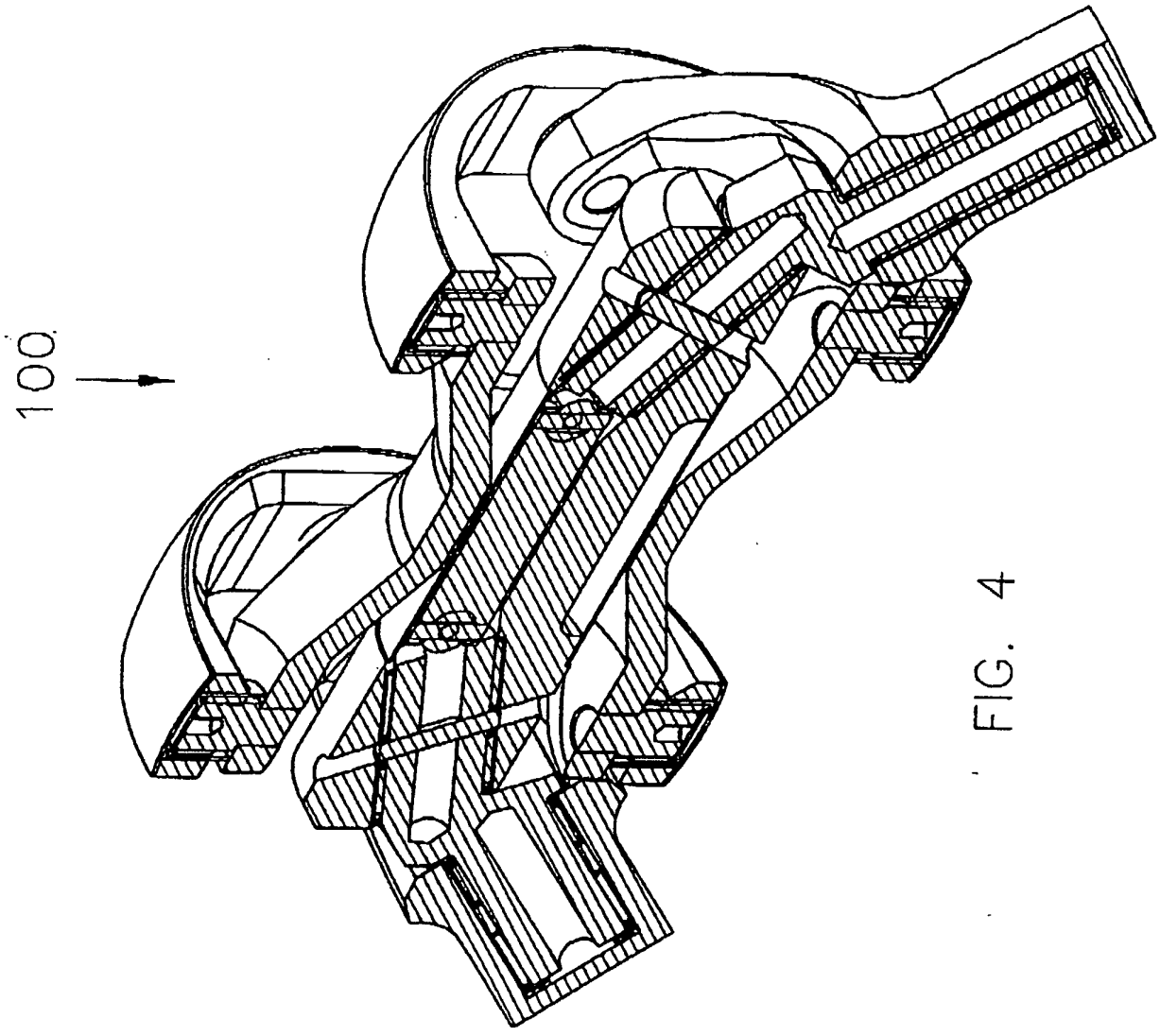


FIG. 4

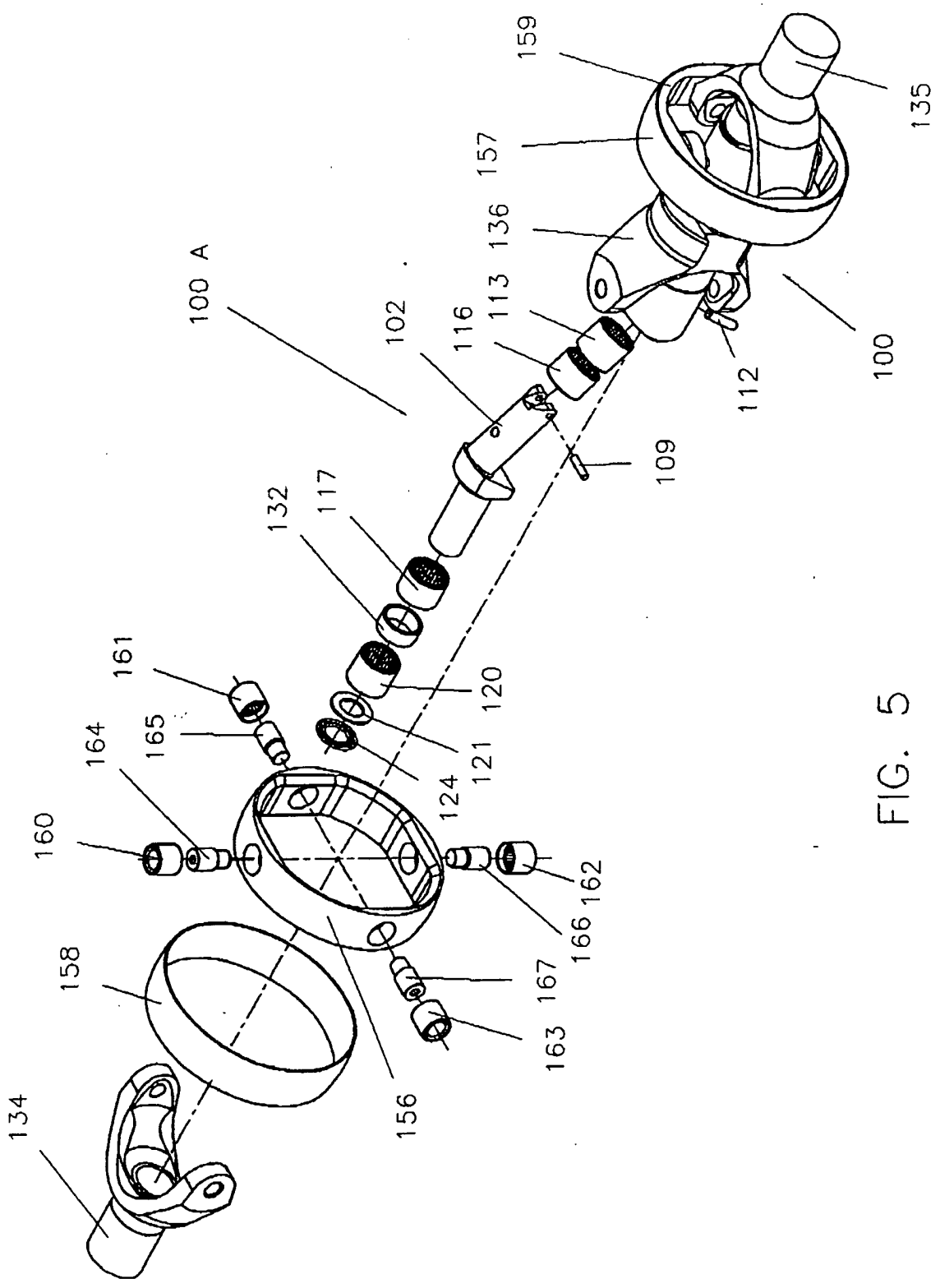
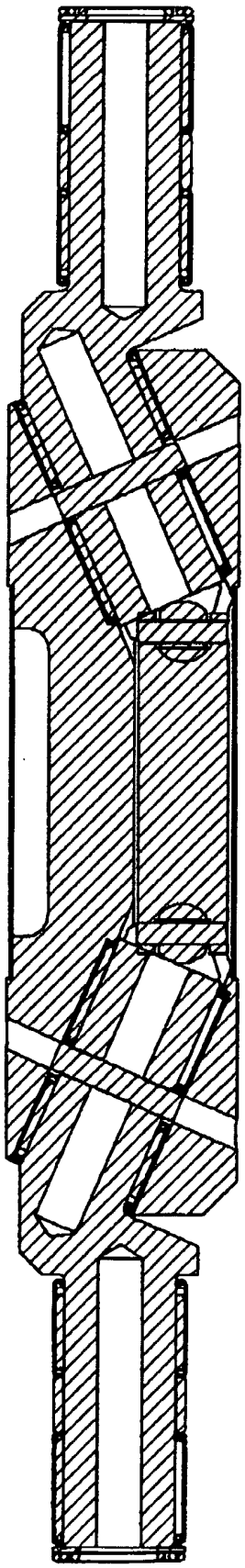

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100 A
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FIG. 5



100 A

FIG. 6

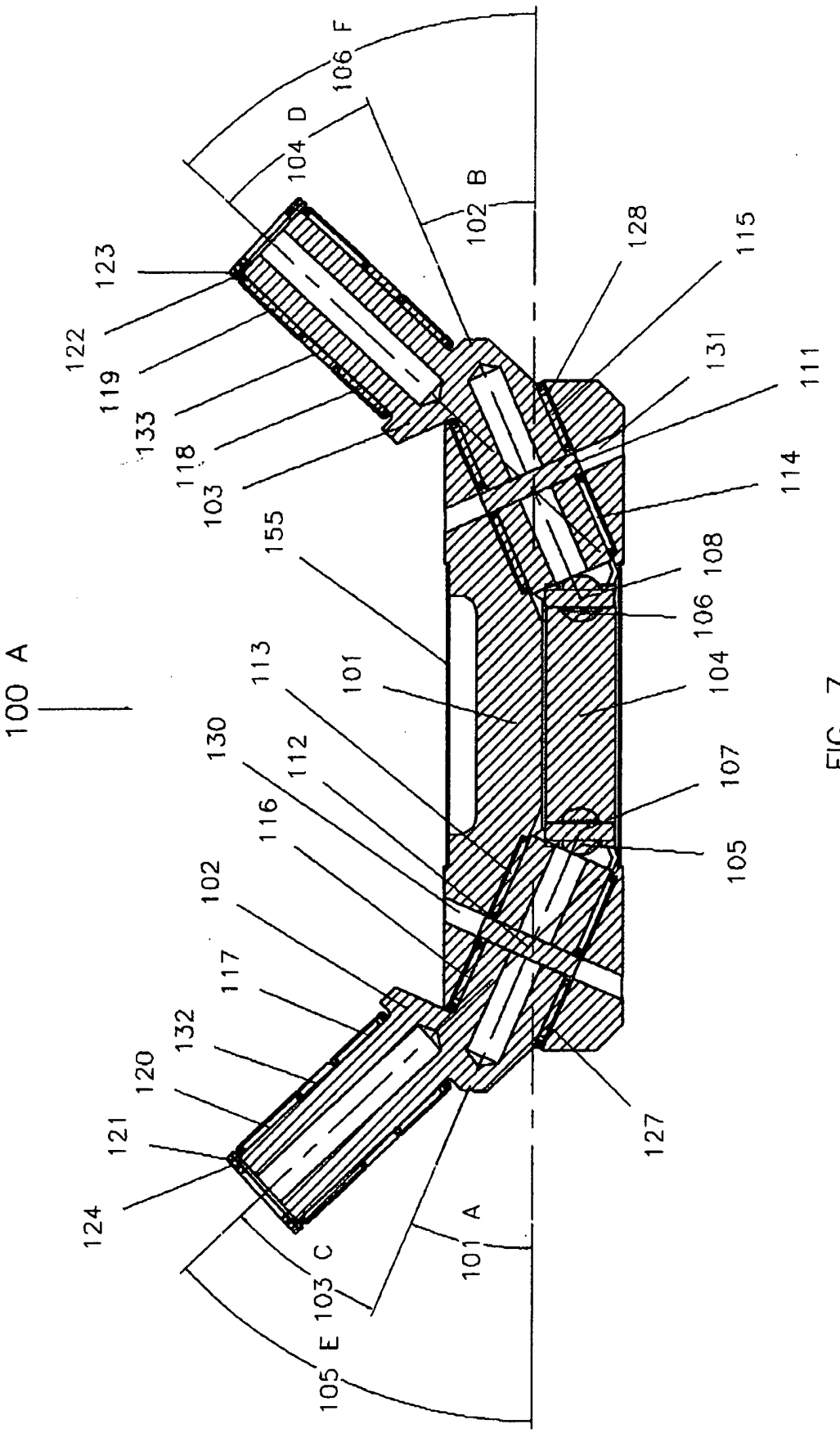

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FIG. 7

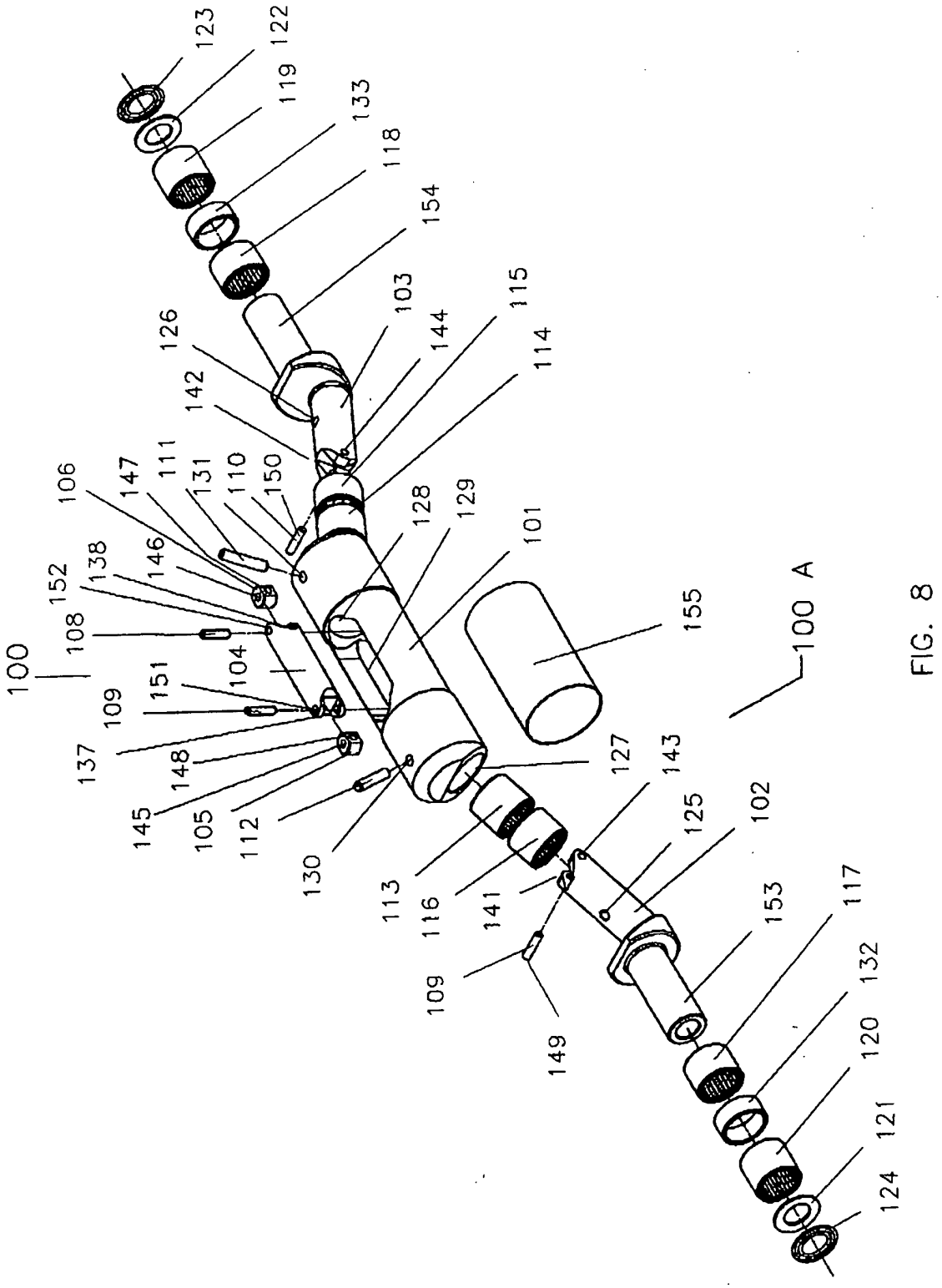

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FIG. 8

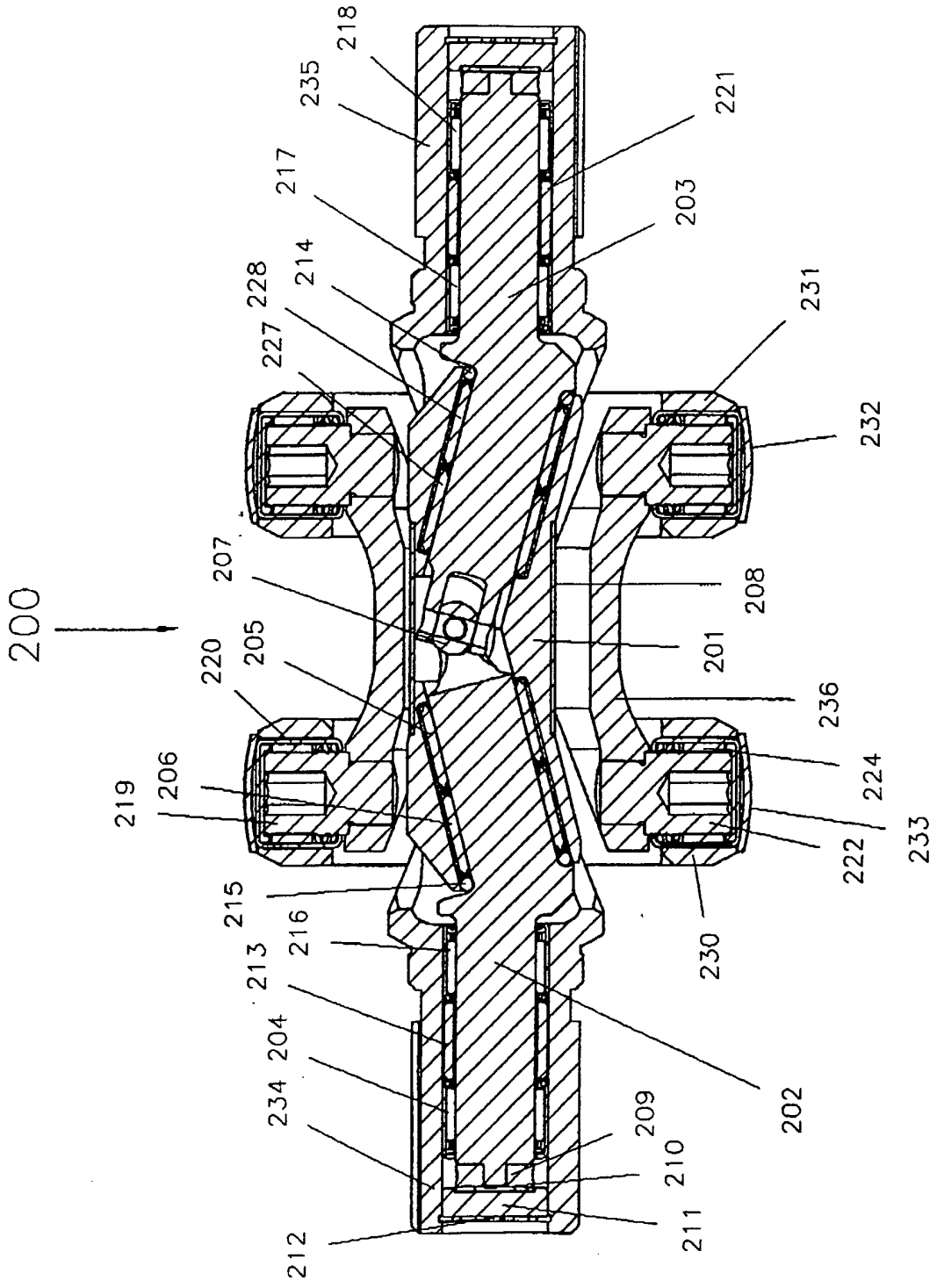

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FIG. 9

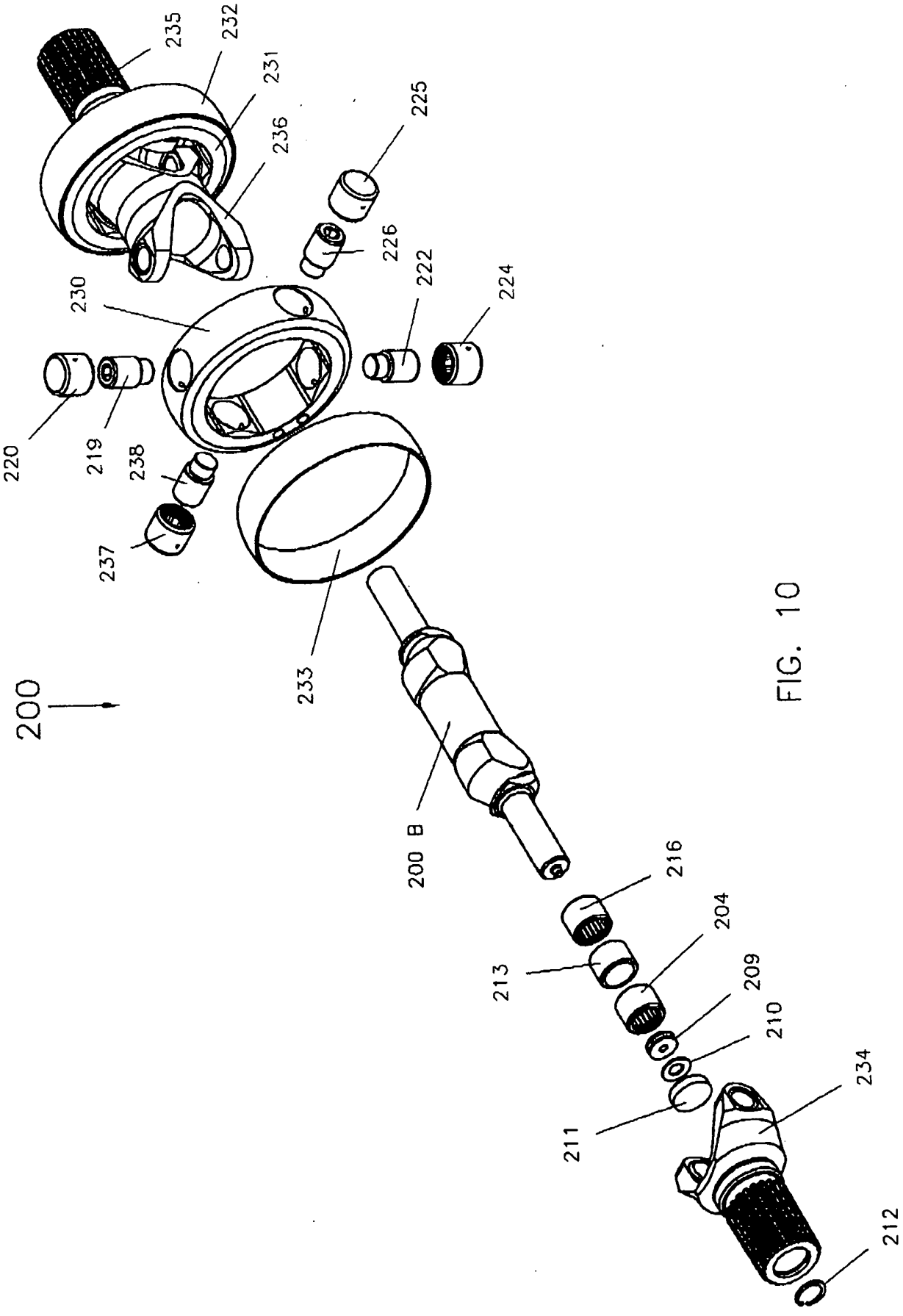

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FIG. 10

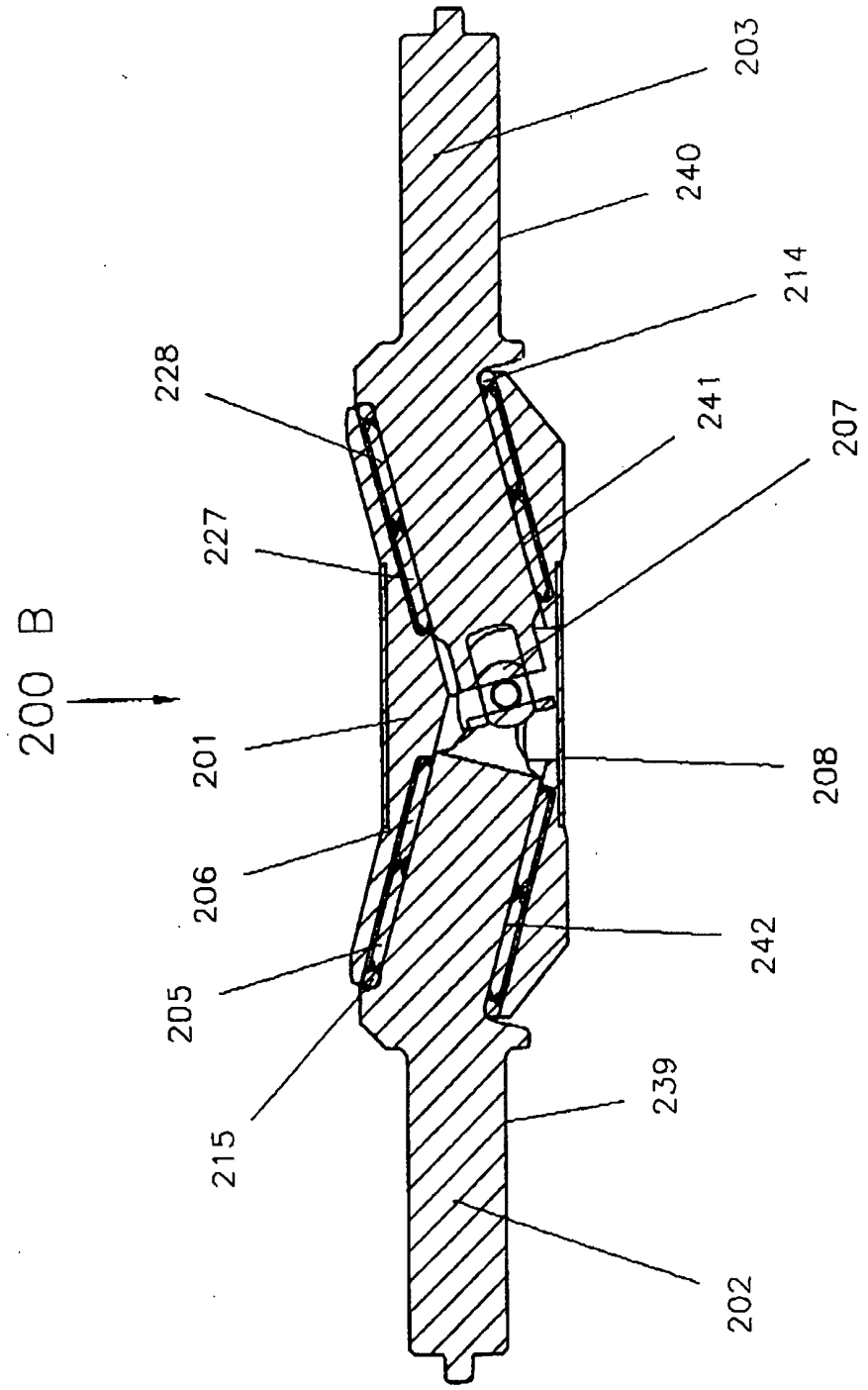


FIG. 11

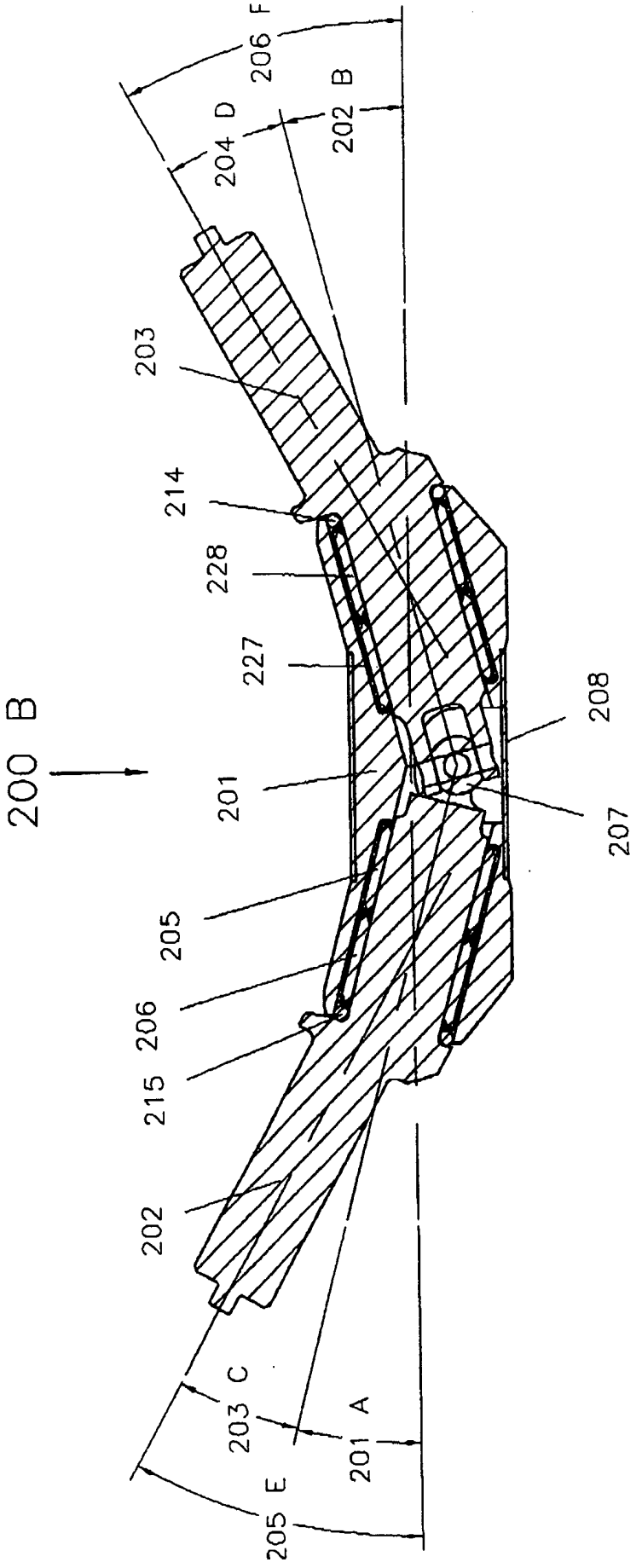

200 B
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204 D
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203 C
201 A
205 E

FIG. 12

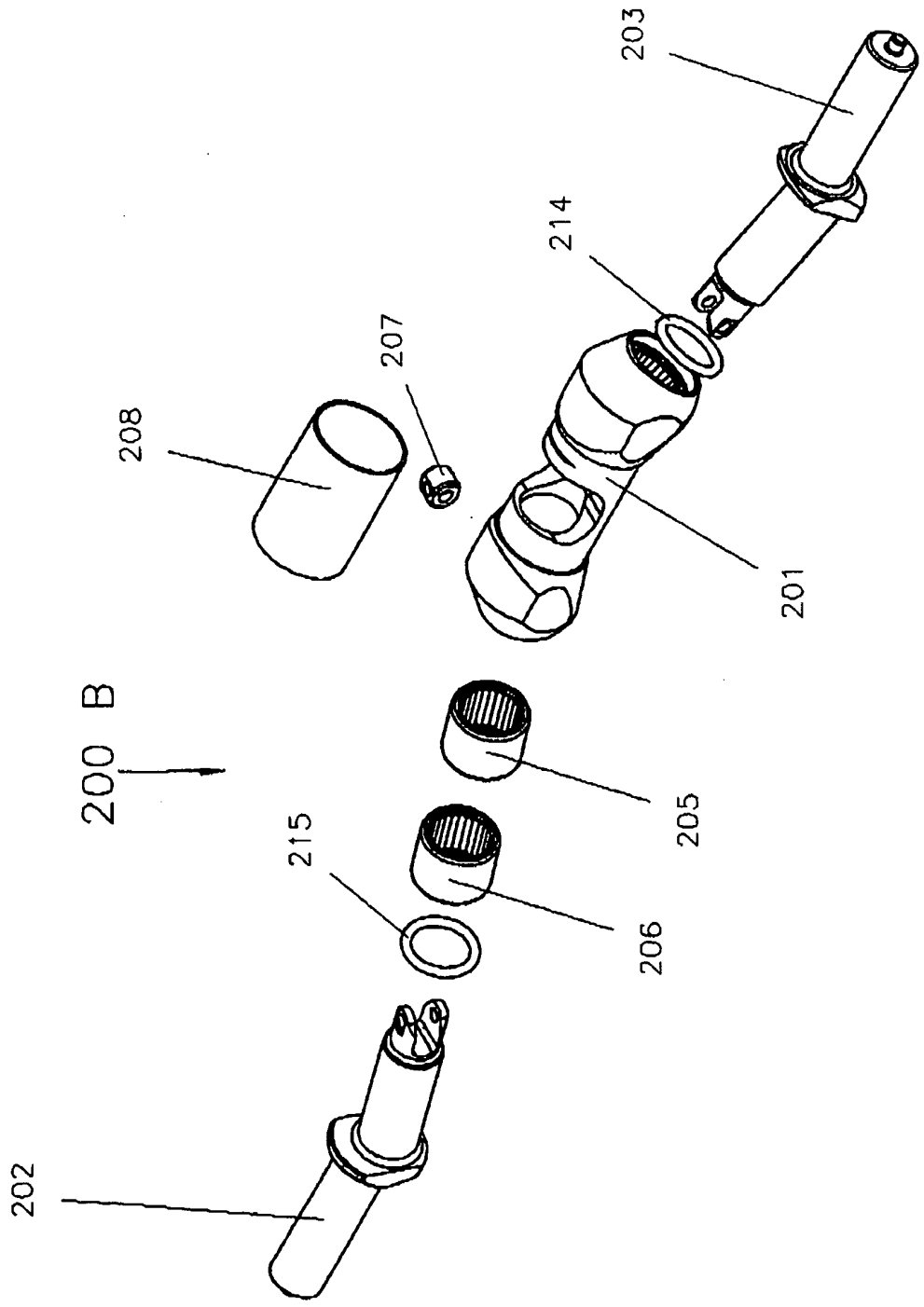


FIG. 13

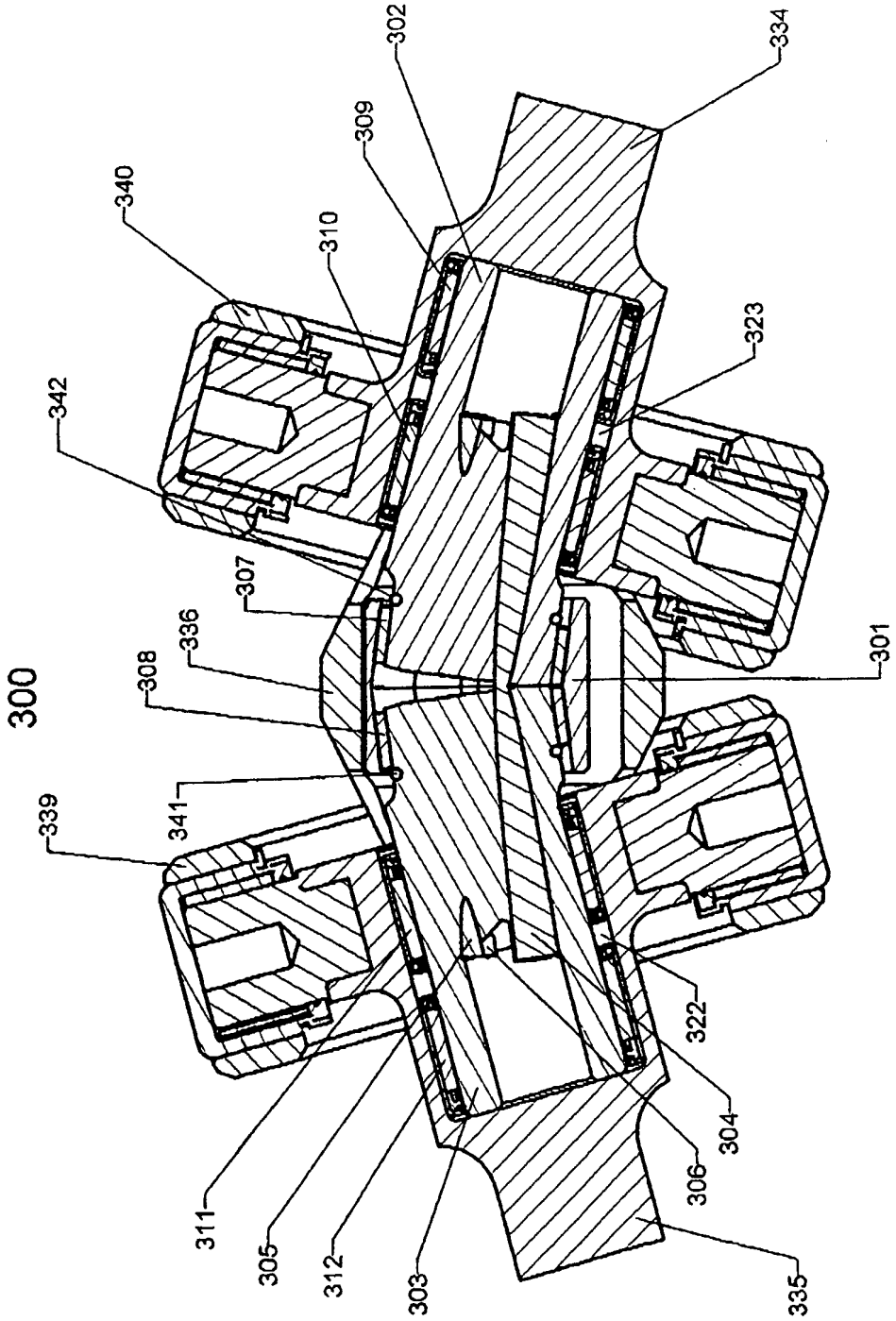

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FIG. 14

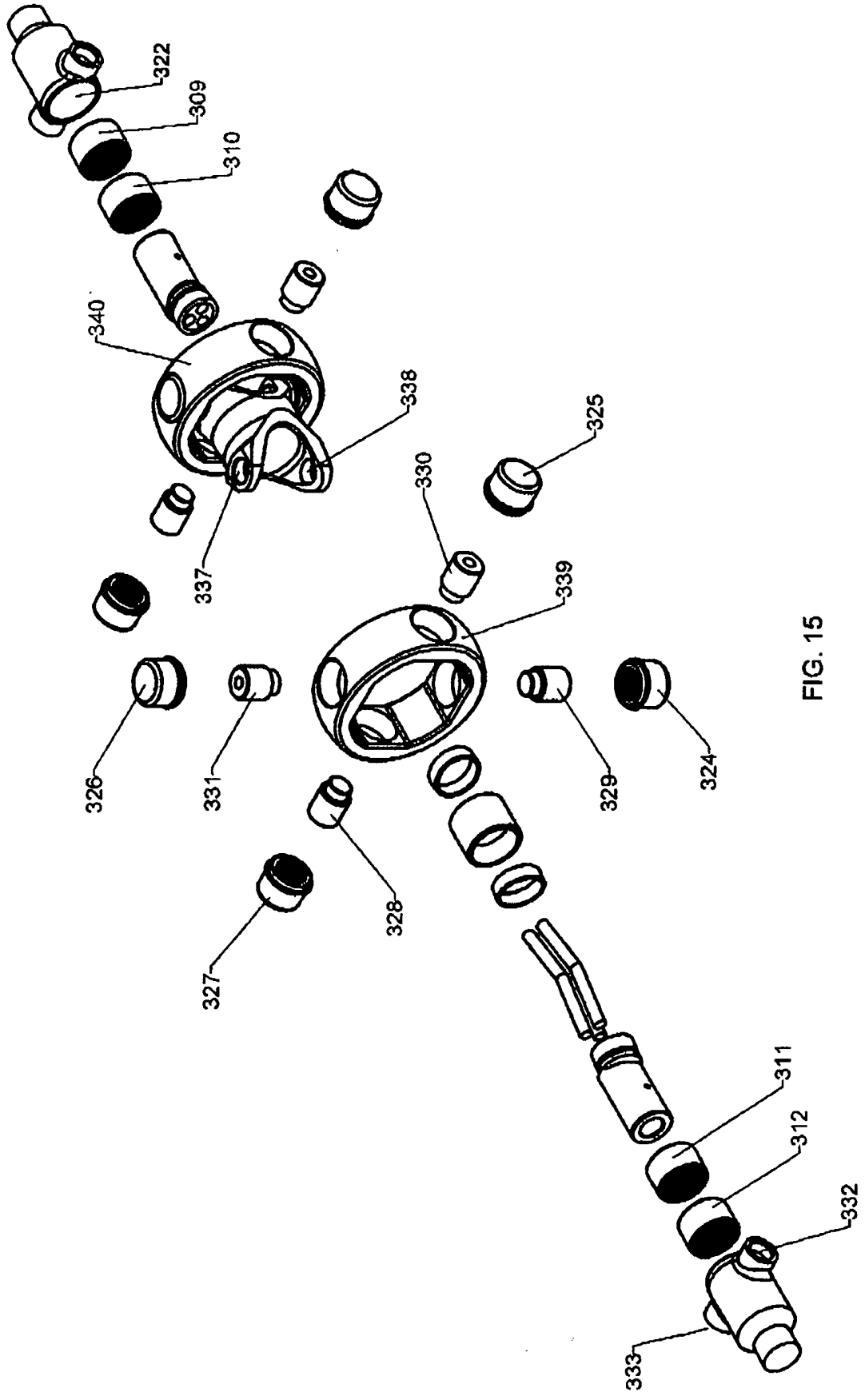

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FIG. 15

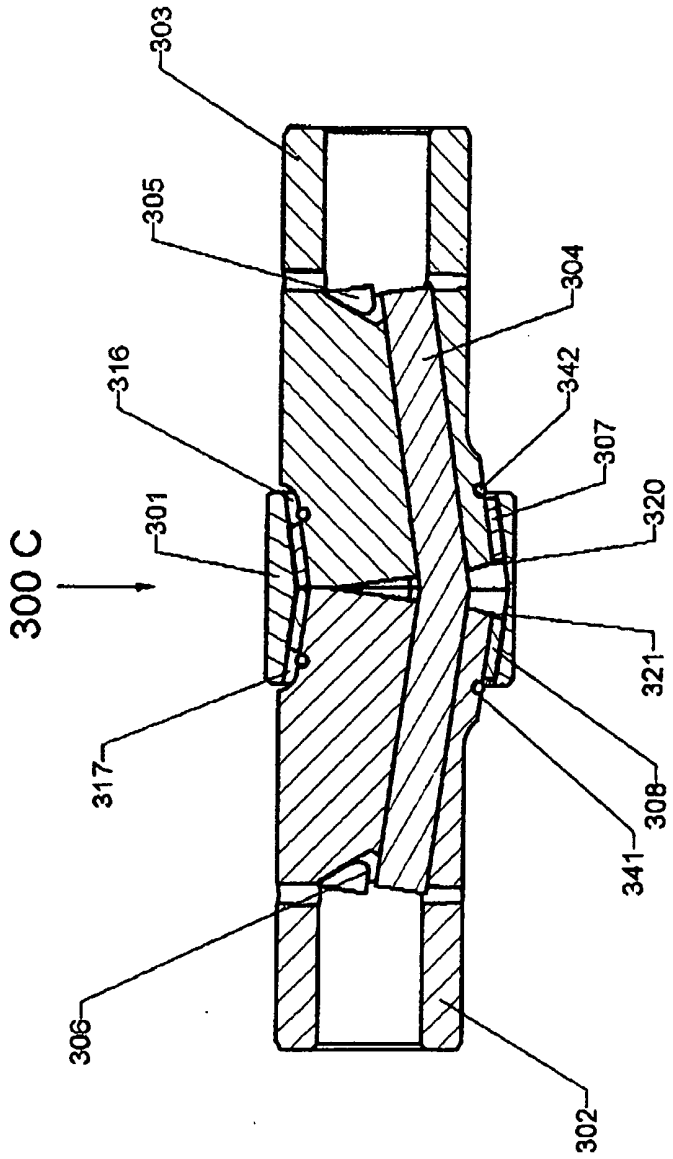


FIG. 16

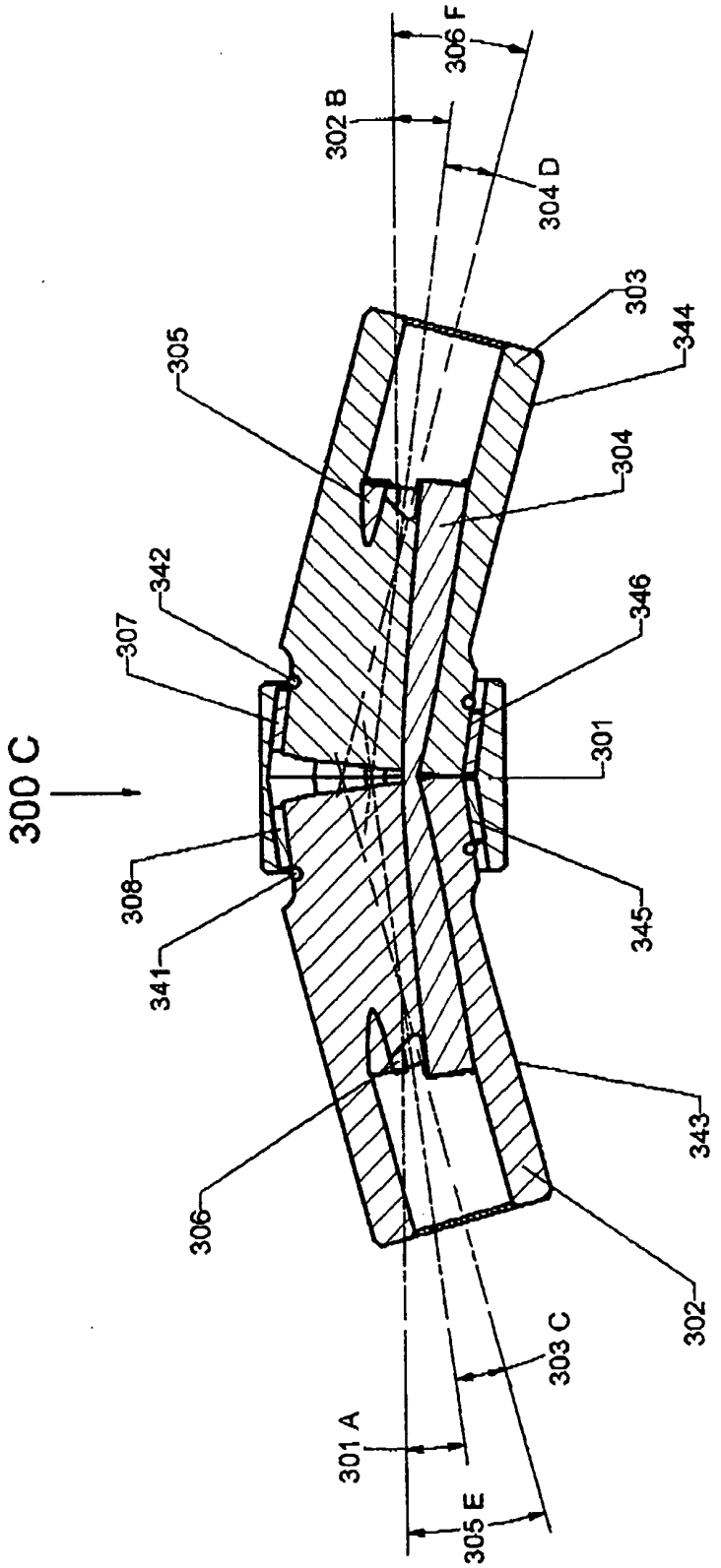

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FIG. 17

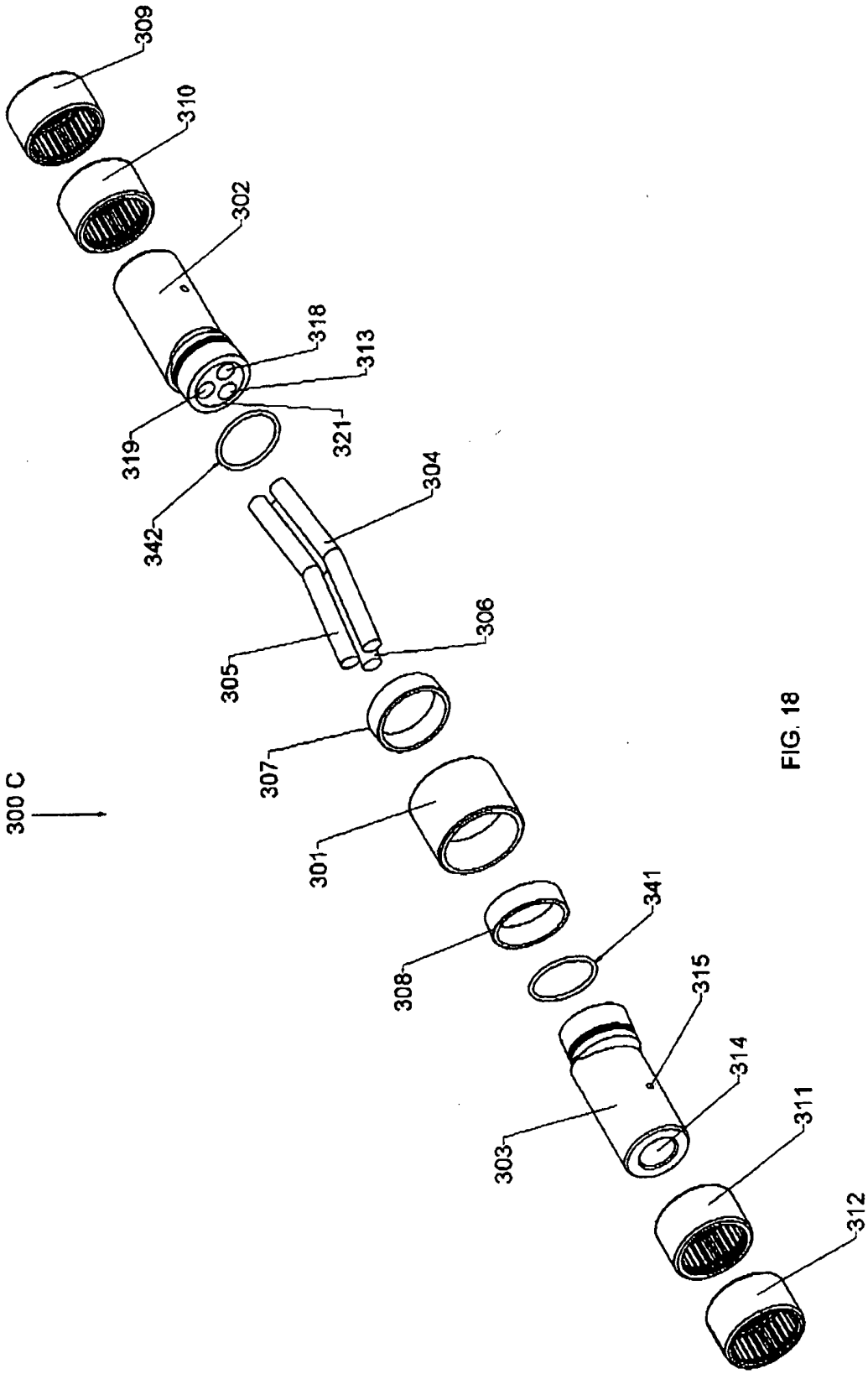

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FIG. 18

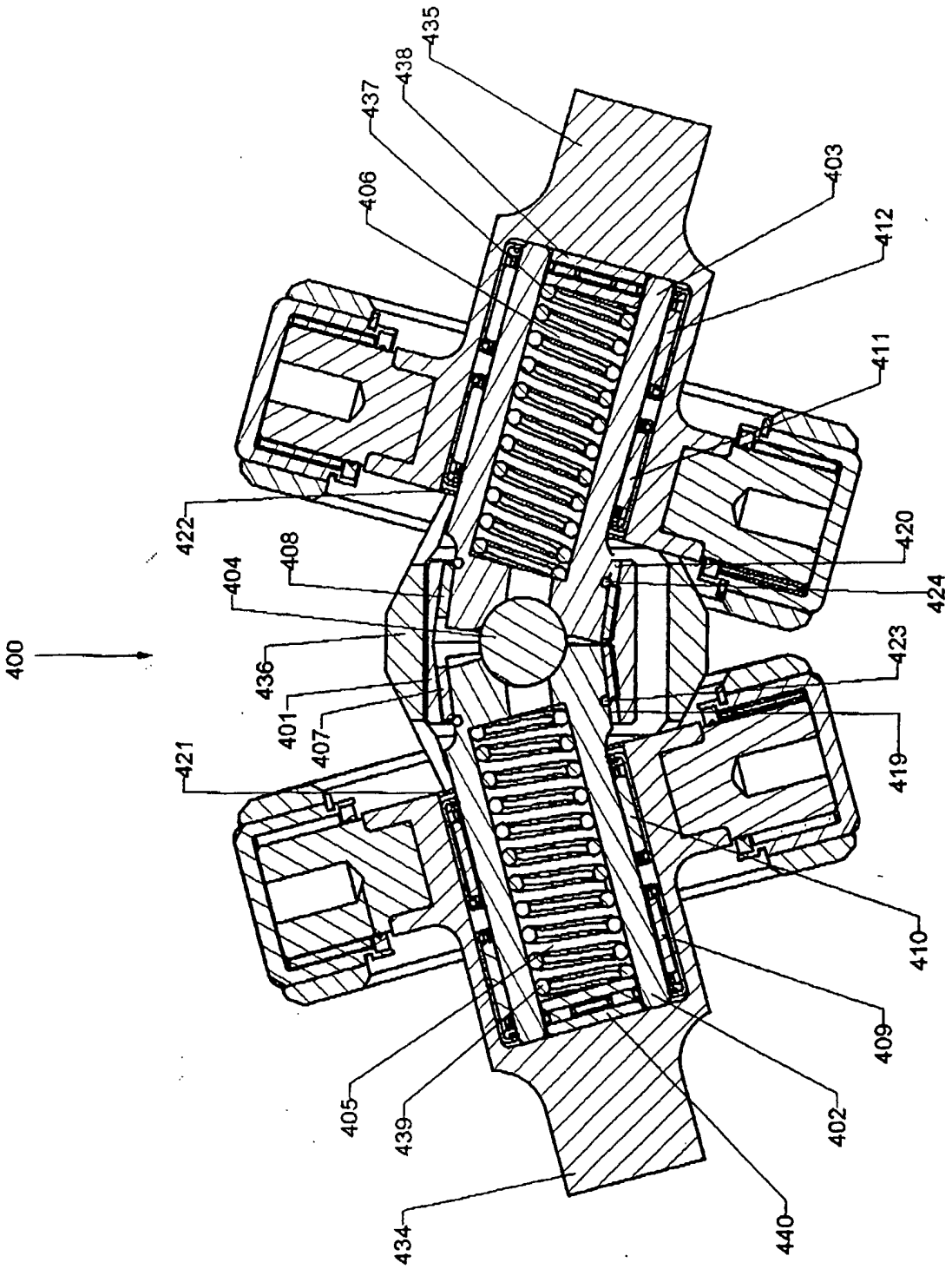

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FIG. 19

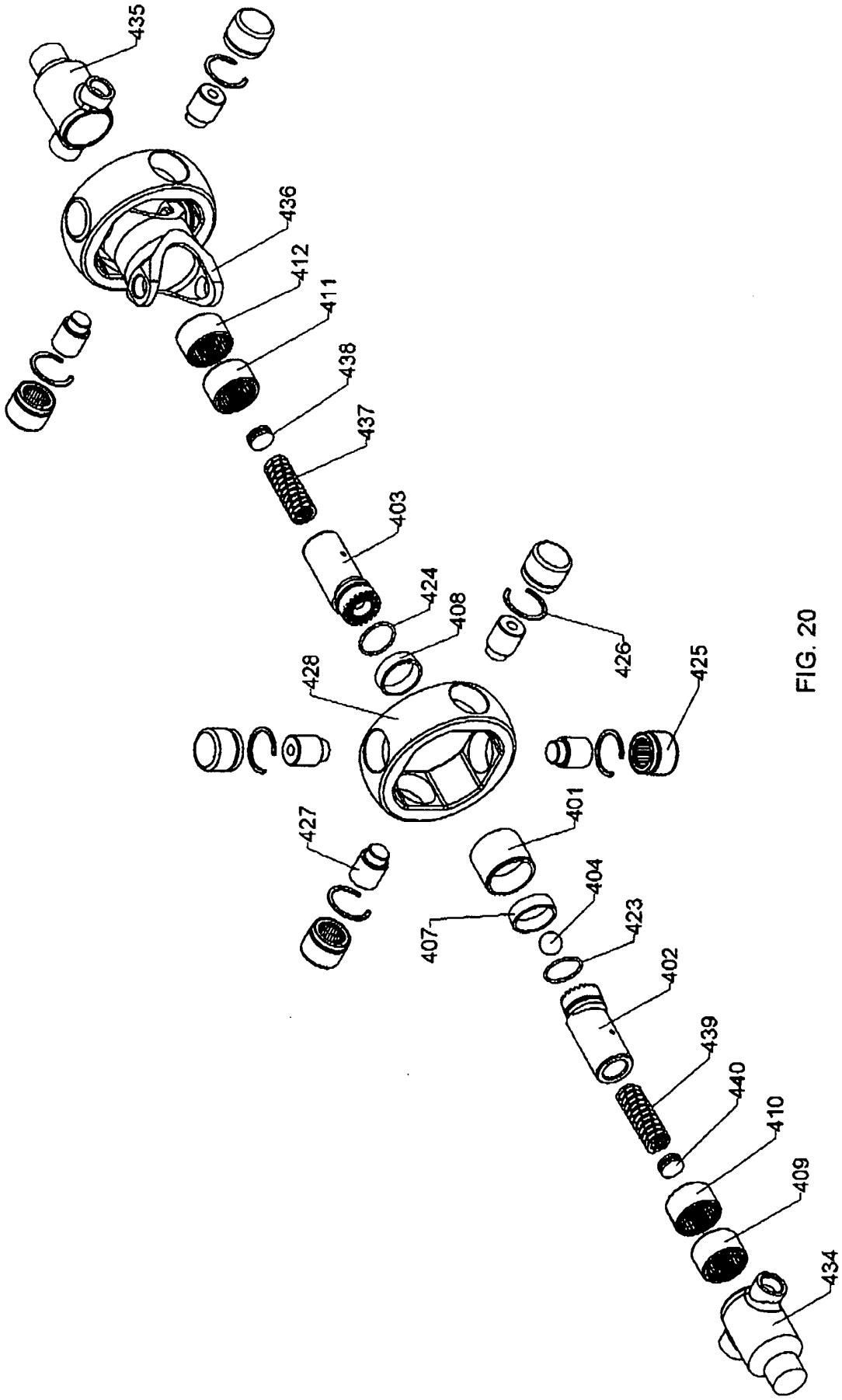

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FIG. 20

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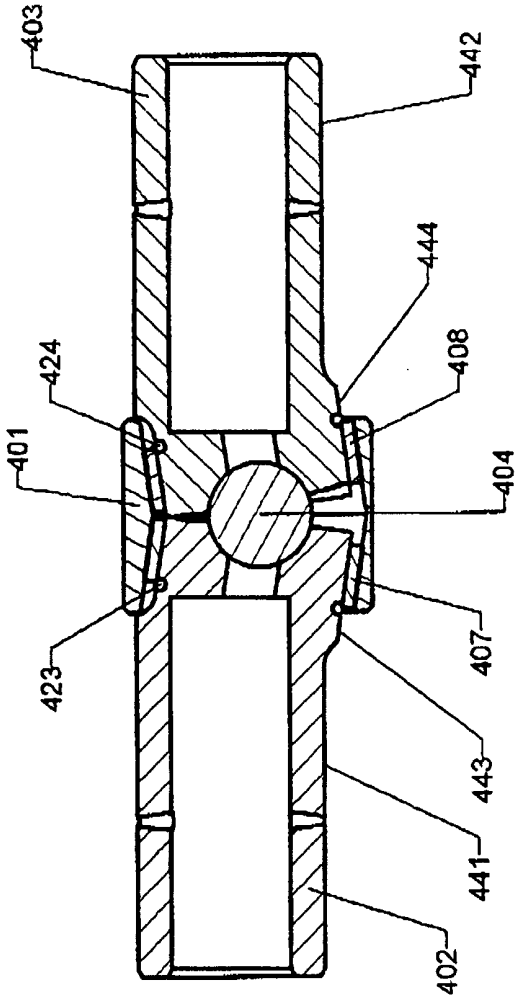


FIG. 21

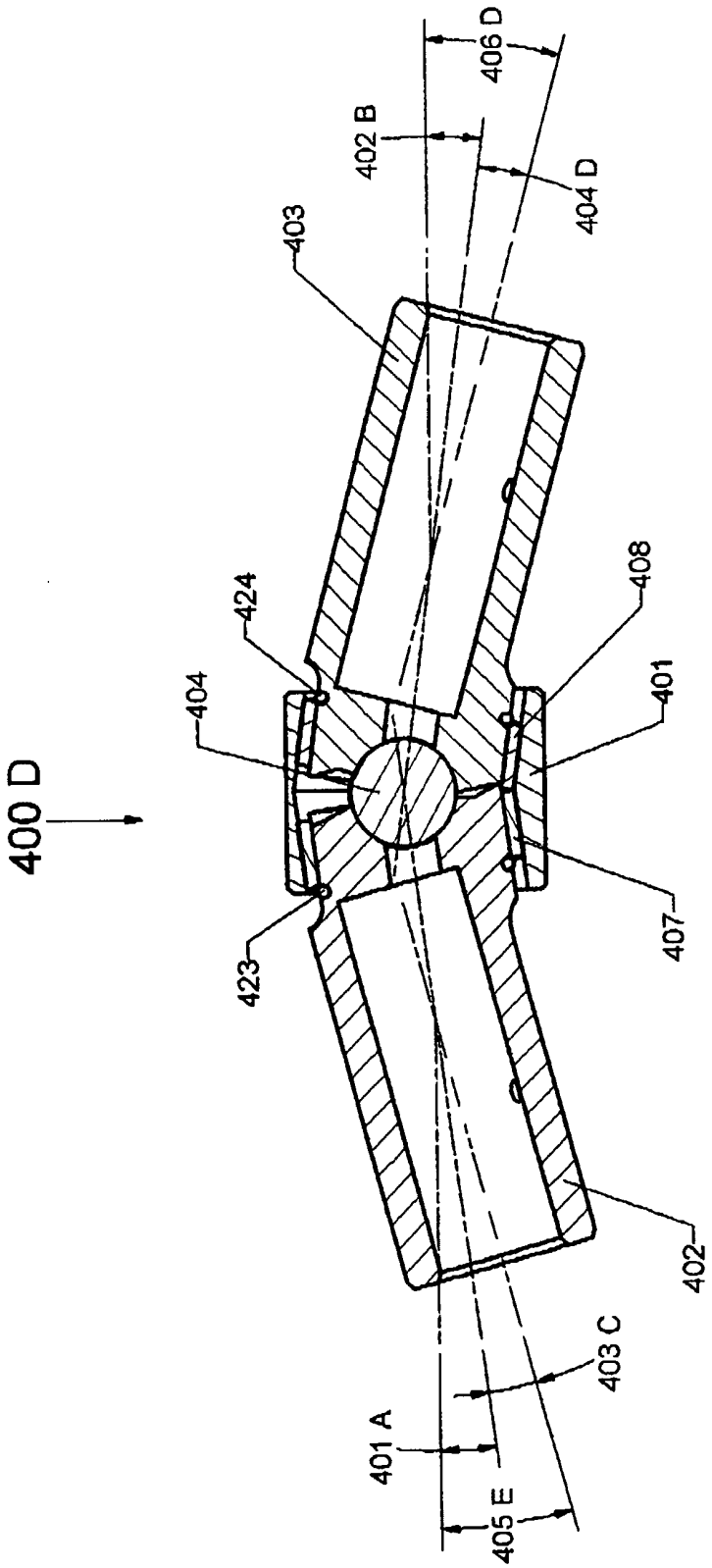

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FIG. 22

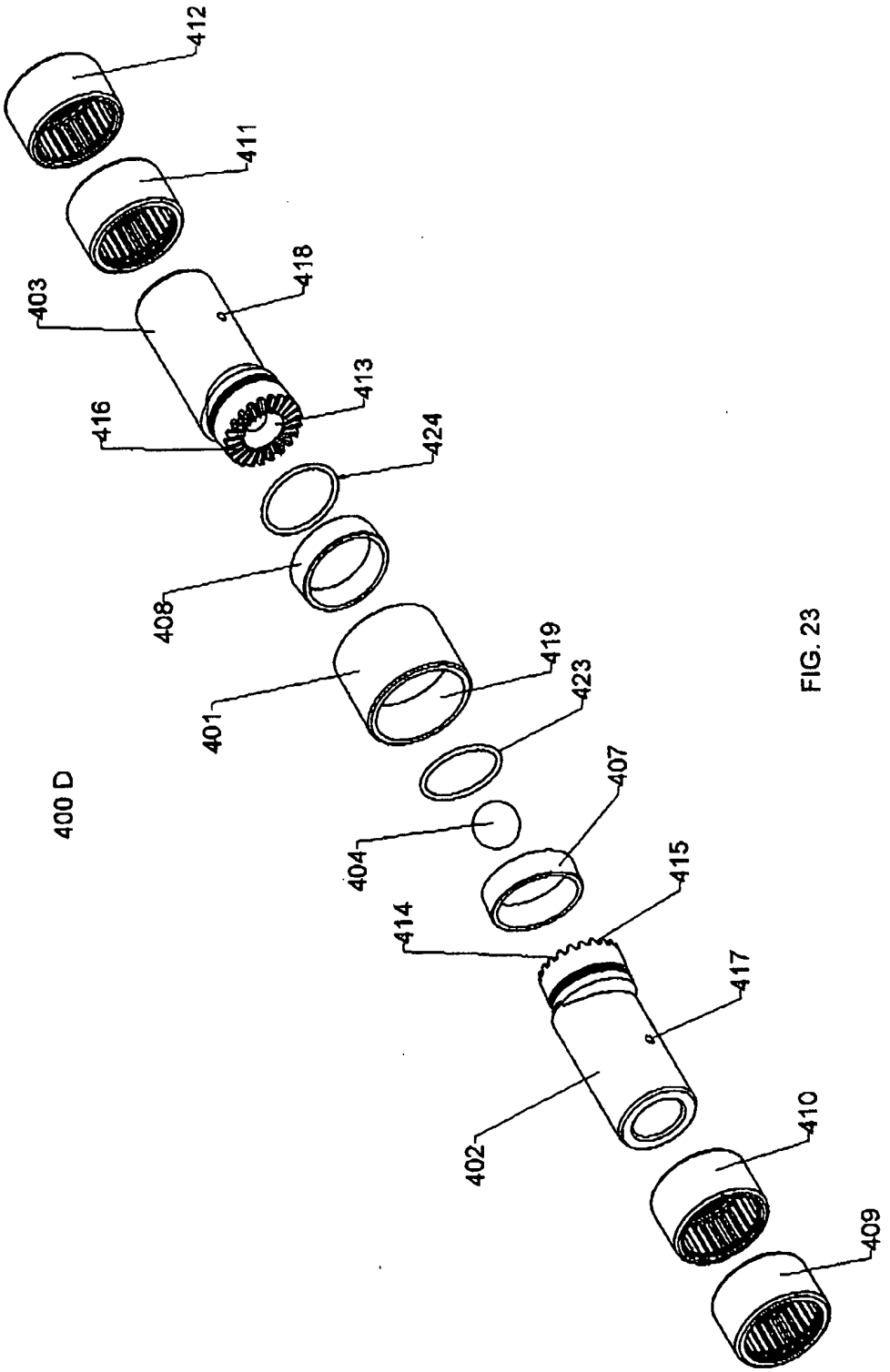

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FIG. 23

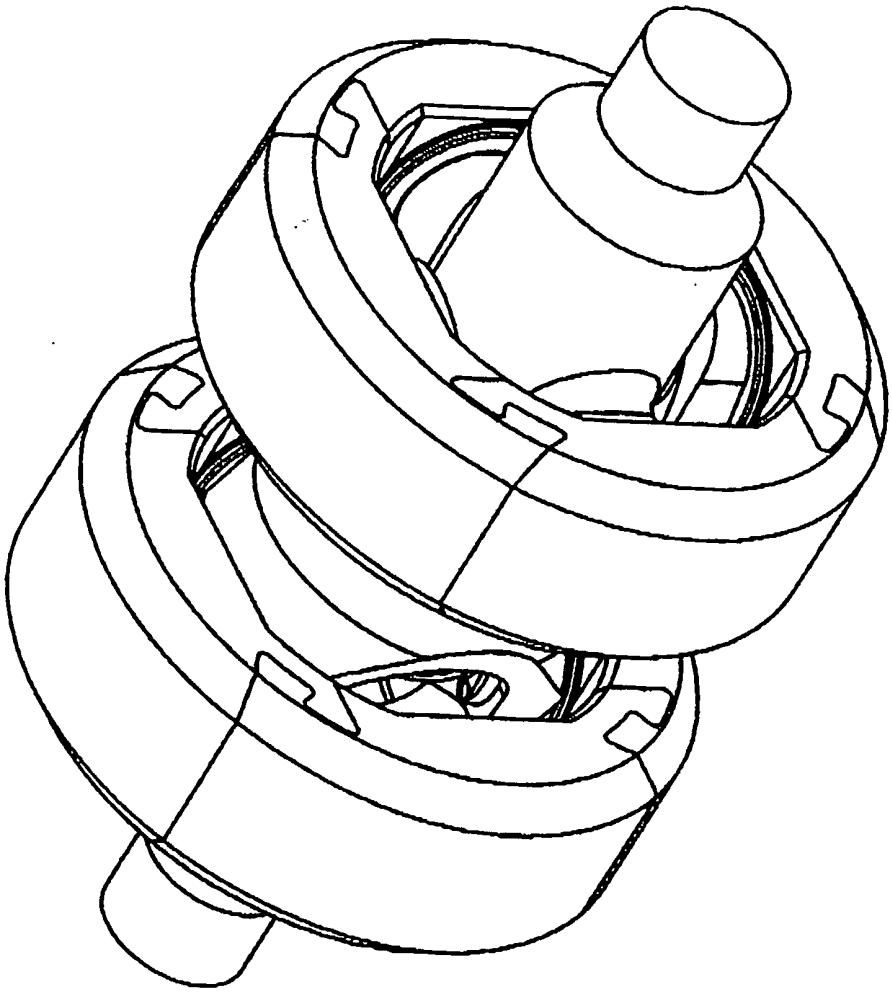


FIG. 24

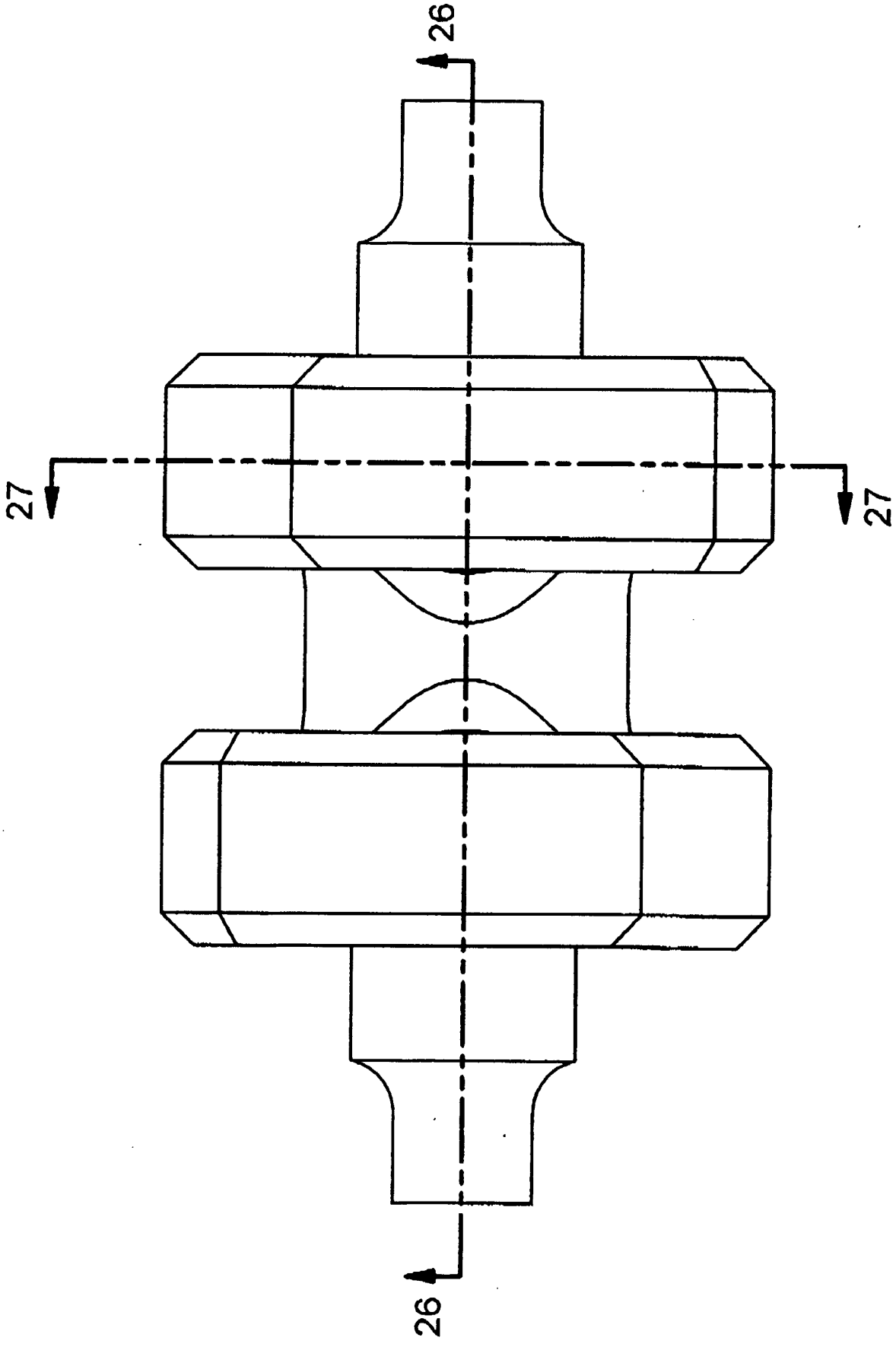


FIG. 25

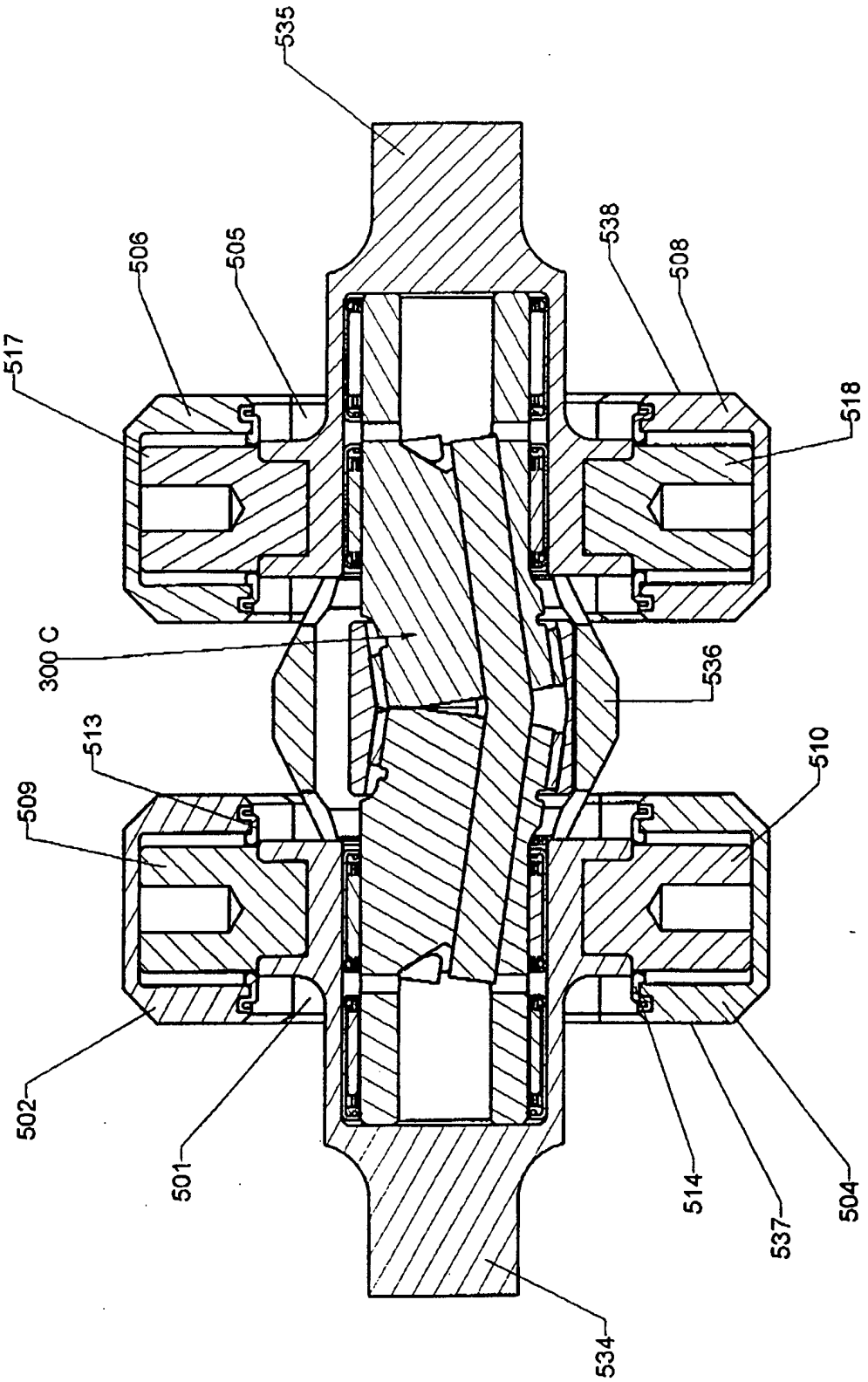

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FIG. 26

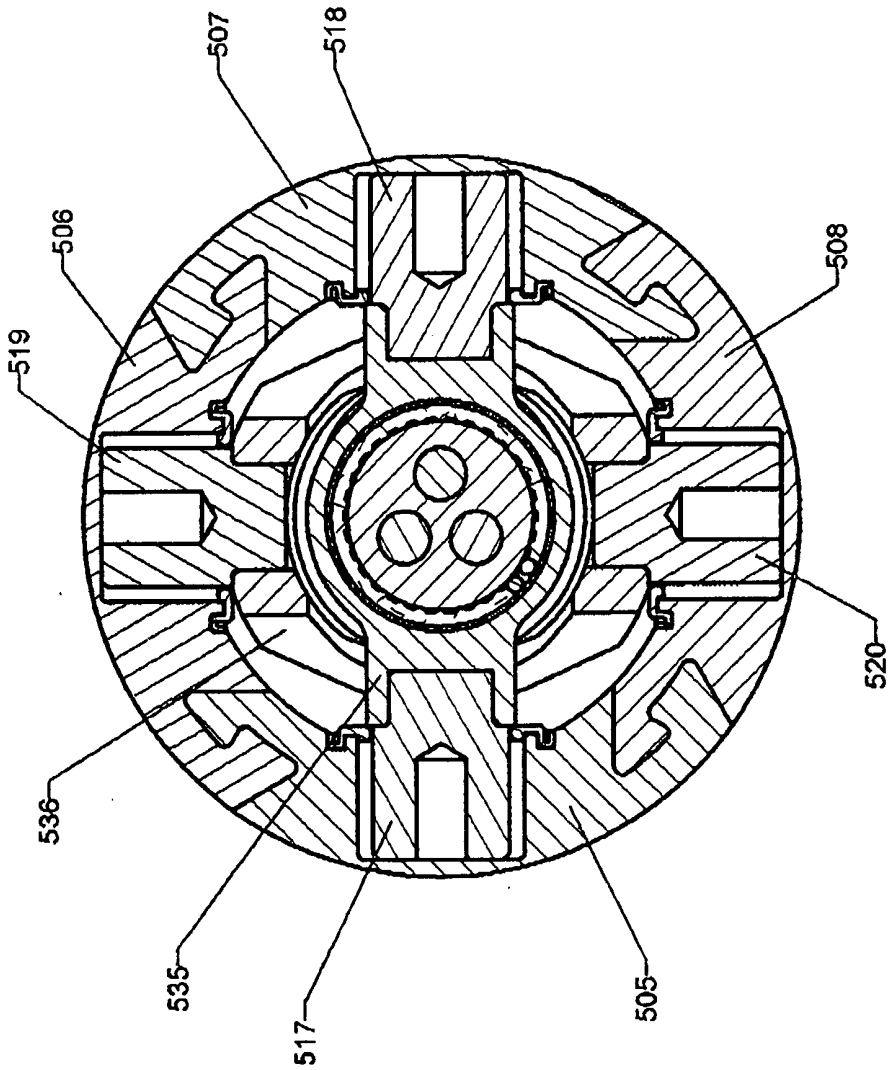


FIG. 27

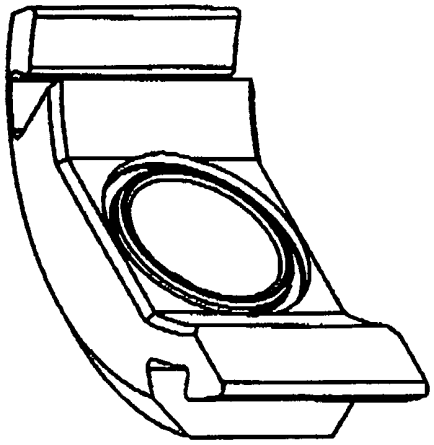


FIG. 30

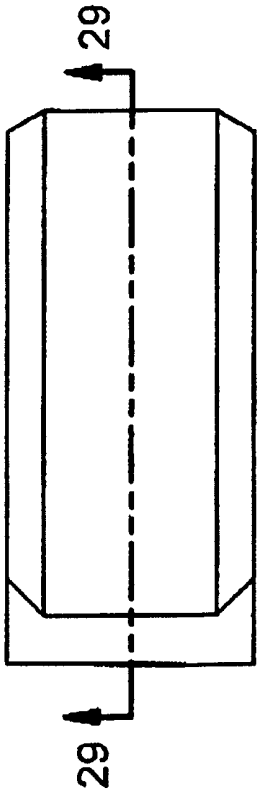


FIG. 28

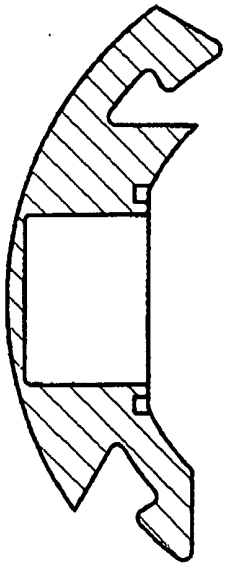


FIG. 29

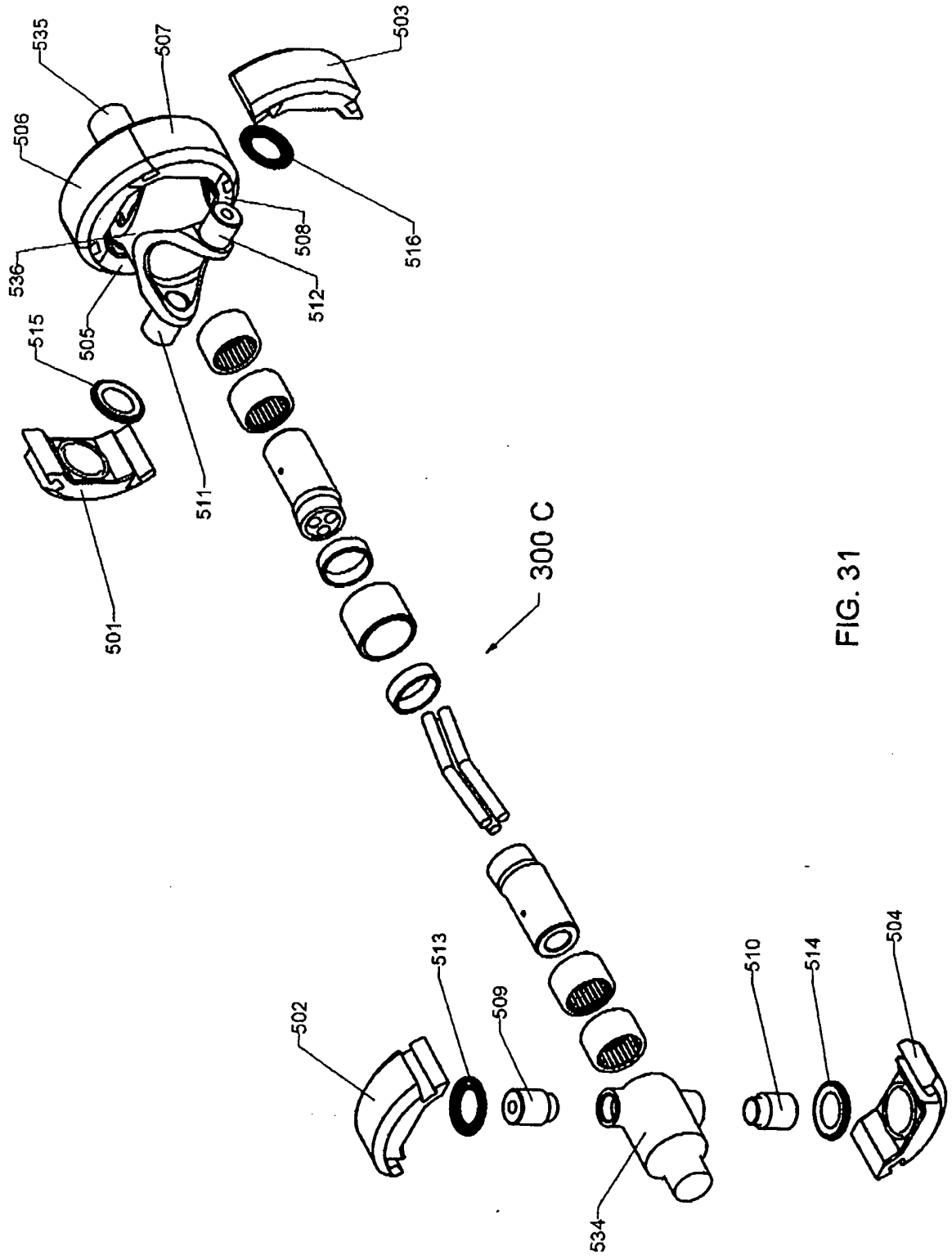

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FIG. 31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/03686

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :F16D 3/32
US CL :464/118

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 464/117, 118, 125, 126, 905

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3,429,144 A (MCINTOSH) 25 February 1969 (25.02.1969), figures 1-3.	7, 12, 16-19, 25, 27, 33, 35, 38, 45 and 47-50
X	US 3,792,597 A (ORAIN) 19 February 1974 (19.02.1974), figure 2.	7, 12, 16-19, 25, 27, 33, 35, 38, 45 and 47-50
A	US 1,702,363 A (PETERS) 19 February 1929 (19.02.1929), figure 2.	20, 21 and 42-44
A	US 1,670,175 A (WIKOFF) 15 May 1928 (15.05.1928), figure 2.	20, 21 and 42-44

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
20 MAY 2002

Date of mailing of the international search report
11 JUN 2002

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Form PCT/ISA/210 (second sheet) (July 1998)★