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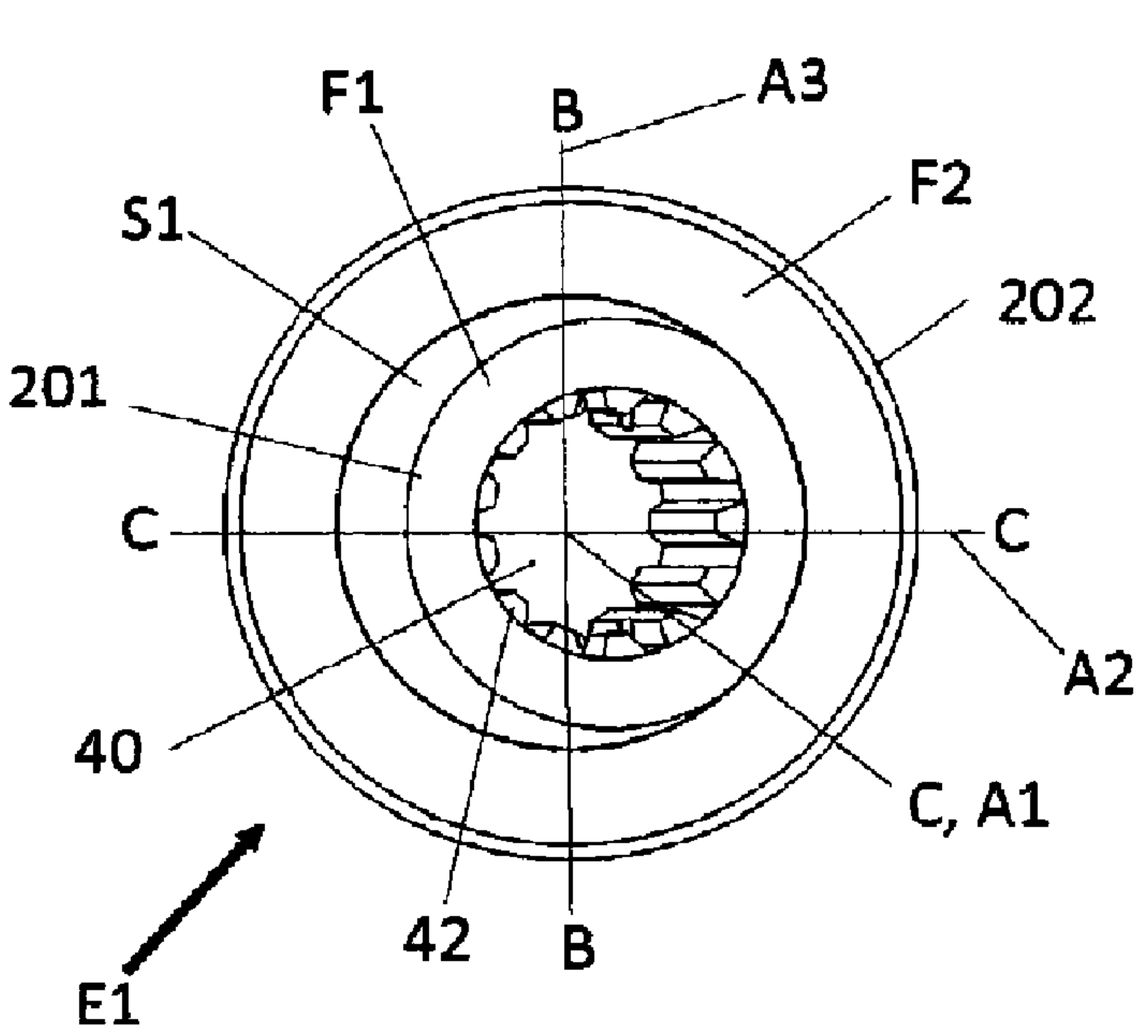

FIG 2A

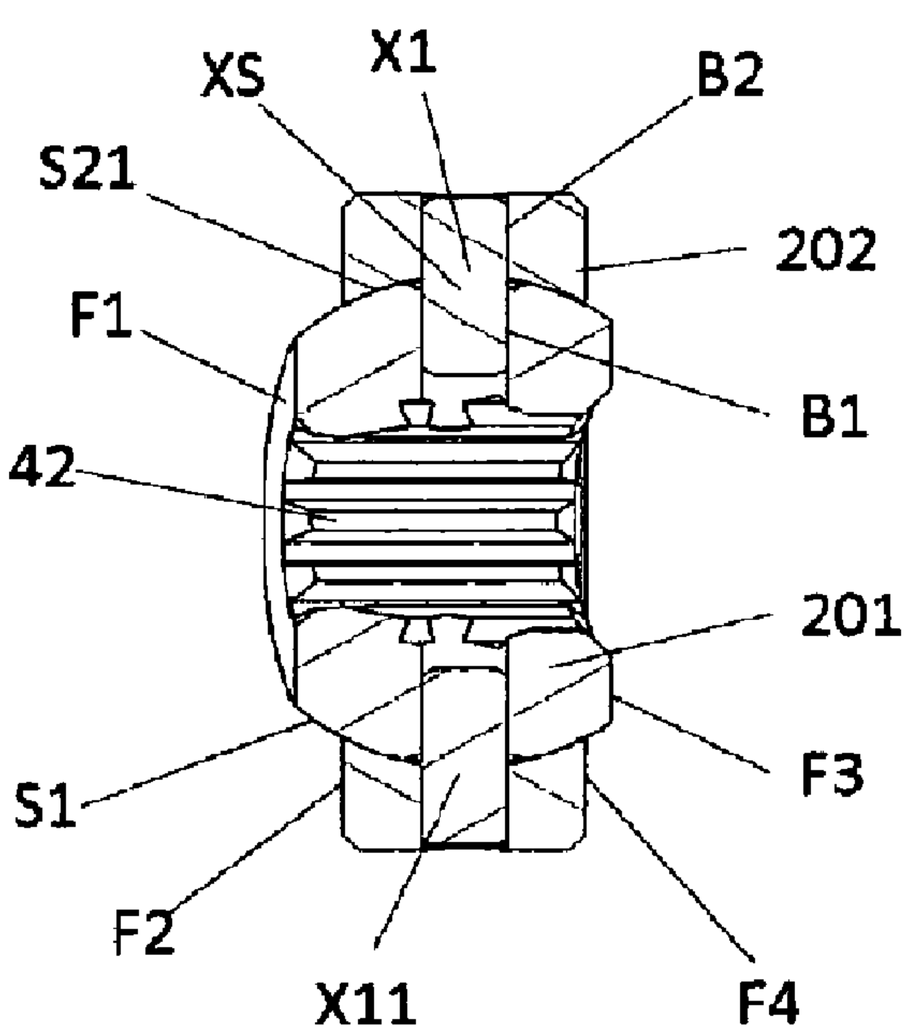

FIG 2B

(57) **Abrégé/Abstract:**
A coupling comprises a pair of members: a first member having an outer convex spherical periphery centred about a central point and a torsional axis extending through the central point, and a second annular member has an inner concave spherical periphery

(21) **2 932 041**

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(57) **Abrégé(suite)/Abstract(continued):**
centred on the central point and complementary to the outer periphery of the inner first member. The spherical surfaces of the inner and outer members co-act to transmit radial loads there between and to transmit loads acting along the torsional axis there between. An axle arrangement extends radially of the central point and couples the first and second annular for transmitting torsional load from one to the other. The each of the pair of members is rotatable one relative to the other about the said central point in a direction constrained by the axle arrangement.

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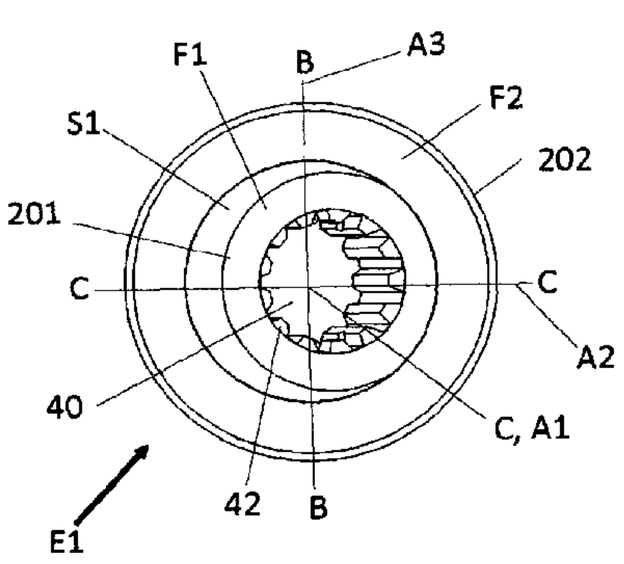

FIG 2A

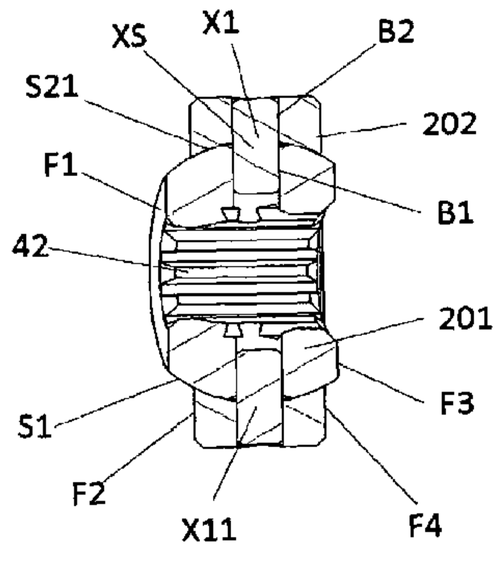

FIG 2B

(57) Abstract: A coupling comprises a pair of members: a first member having an outer convex spherical periphery centred about a central point and a torsional axis extending through the central point, and a second annular member has an inner concave spherical periphery centred on the central point and complementary to the outer periphery of the inner first member. The spherical surfaces of the inner and outer members co-act to transmit radial loads there between and to transmit loads acting along the torsional axis there between. An axle arrangement extends radially of the central point and couples the first and second annular for transmitting torsional load from one to the other. The each of the pair of members is rotatable one relative to the other about the said central point in a dir - ection constrained by the axle arrangement.

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Description

Title of Invention: COUPLING

[0001] The present invention relates to a coupling.

[0002] Mechanical couplings are well known. Examples include couplings for coupling angularly misaligned shafts, universal joints, constant velocity joints, couplings for coupling a drive shaft to a driven shaft; couplings for connecting a torque shaft to a structural element of for example a suspension system.

[0003] According to the present invention a coupling has an inner member and an outer annular member and comprises:

- one or more pairs of members, which may or may not include one or both the inner and outer members, each pair being a first member and a second annular member with a common axis and having a common first centre on the axis;
- the first member having an outer convex spherical periphery;
- the second annular member having an inner spherical concave periphery in which the outer convex periphery of the first annular member is received;
- the outer convex periphery and the inner concave peripheries being concentric about the first centre and complementary to one another and co-acting with one another to transmit axial loads acting along the torsional axis between them;
- one or a diametrically opposed pair of axles disposed radially of the common centre of the pair of members coupling the first and second members for transmitting torsional load from one of the members to the other; the first and second annular members being constrained by the axle(s) to be rotatable one relative to the other about the axle(s).

[0004] For most practical applications the said members, other than the outer member, comprise spherical segments including a common centre. A spherical segment is a portion of a sphere between with a pair of parallel planes. However, it is possible to consider, in some circumstances, situations in which a segment of a sphere is used in which the planes are not parallel but non-intersecting or which is cut by cones whose apexes are on the common axis - such alternatives would have disadvantages both in manufacture, assembly and use and seem less likely to be adopted.

[0005] The inner member and the outer annular member may comprise a pair of members coupled by the at least one axle, or there may be one or more intermediate members disposed between the inner and outer members, each pair of adjacent members comprising a pair of members coupled together by axles.

[0006] The axle(s) carries torque and the spherical surfaces of the first and second members carry axial and radial loads. Most of any axial load is carried by the spherical surfaces.

The axle(s) may also carry some of the axial load. Thus radial and axial loads are separated from torsional loads. In an embodiment, the axle(s) are configured to not transmit radial loads between the members coupled thereby so that radial loads are not carried by the axles. Thus radial loads are carried mostly or wholly by the spherical surfaces.

[0007] Other features of the invention are set out in the claims and, without limitation in the examples below.

[0008] Couplings according to various embodiments the present invention described may be used for coupling any two structural elements that must be coupled with at least one rotational degree of freedom. Some examples are useful as 'structural static couplings' coupling an element to a fixed structure. Other examples are useful as rotational 'flexible couplings' coupling two rotational elements. Couplings according to the invention, for example, may be used to couple angularly misaligned shafts, or as universal joints, constant velocity joints, couplings for coupling a drive shaft to a driven shaft, and as couplings for connecting steered hub to a fixed structural element such as a suspension arm in a suspension system.

[0009] Some examples of the invention are described below with reference to the accompanying drawings, in which:

[0010] Figure 1 illustrates a reference frame of operation of couplings according to embodiments of the invention;

[0011] Figures 2A to 2C show an example of a coupling according to the invention, of which Figure 2A is an axial view with the elements of the coupling un-aligned, Figure 2B is a cross-sectional view of Figure 2A along axis A3 and Figure 2C is a cross-sectional view of Figure 2A along axis A2;

[0012] Figures 3A and 3B show a hub centre steering mechanism including an example of a coupling according to Figure 2, of which Figure 3A is an isometric view and Figure 3B is a cross-sectional view.;

[0013] Figures 4A to 4F show another example of a coupling according to the invention, of which Figure 4A is an axial view along axis A1 of Figure 1, Figure 4B is a cross-sectional view along plane A-A in Figure 4A, Figure 4C is a cross-sectional view along plane B-B in Figure 4A, Figure 4D is an axial view showing the elements of the coupling un-aligned, Figure 4E is an axial cross-sectional view of the coupling of in Figure 4A and Figure 4F is a cross sectional view along plane A-A of Figure 4D;

[0014] Figures 5A and 5B are cross-sectional views of a pair of the couplings of Figure 4 connected together;

[0015] Figures 6A to 6F show a further example of a coupling according to the invention, of which Figure 6A is an axial view along axis A1 of Figure 1, Figure 6B is a cross-sectional view along plane A-A in Figure 6A, and Figure 6C is a cross-sectional view

on plane B-B of Figure 6A, Figure 6D is a side view; Figure 6E is a cross-sectional view along plane C-C of Figure 6D; and Figure 6F is a side cross-sectional view of the coupling along plane D-D of Figure 6D;

[0016] Figures 7A, 7B and 7C show bearings on one representative member of a coupling according to the invention, in which Figure 7A is an isometric view of the coupling, and Figure 7B is a cross sectional axial view, and Figure 7C is an exploded view;

[0017] Figure 8 shows means for limiting relative rotation of elements of a coupling according to the invention;

[0018] Figure 9 is a cross-sectional view of a modification which may be applied to couplings in accordance with the invention;

[0019] Figure 10 is across-sectional view of a representative coupling in accordance with the invention within a bearing; and

[0020] Figures 11A and 11B illustrate a way of assembling the coupling described in the previous examples.

[0021] The examples of the invention in the drawings are described in relation to a reference frame as shown in Figure 1.

[0022] The reference frame has a first axis A1 defining an axial direction. A second axis A2 is perpendicular to the first axis A1. At the intersection of the first and second axes is a central point C of concentric spherical surfaces of concentric members of the couplings. The first and second axis and the central point lie in first plane P1 and the first axis and central point lie in a second plane P2 perpendicular to the first plane. A third plane P3 through the centre point C is perpendicular to the other planes. A third axis A3 defines is perpendicular to axes A1 and A2, lies in the third plane and passes through the central point C.

[0023] The first axis A1 is a torsional axis on which, for example, a drive shaft or driven shaft is connected to the coupling and the second A2 and third A3 axes are axes of relative rotation of members of the couplings.

[0024] In further examples, couplings have some members centred on the central point C and other members centred on a further central point C2 offset from C along the first axis A1 when the members are aligned. The offset of C2 from C may be slight, for example a fraction of a millimetre. Further axes A21 and A31, parallel to axes A2 and A3 respectively pass through the central point C2.

[0025] In Figure 2, a coupling comprises an inner annular member 201 around the first axis A1. The inner member 201 comprises a spherical segment about central point C and has an outer peripheral surface S1 which is convexly spherical centred on the central point C on the first axis. The inner member 201 has a central cylindrical bore 40 which in this example has splines 42 for engaging a correspondingly splined shaft.

[0026] An outer annular member 202 has an inner peripheral surface S21 which is convexly

spherical complementary to the outer surface S1 of the inner member 201. The concave spherical surface S21 is centred on the same central point C on the axis as the spherical surface of the inner ring. In this example the inner spherical surface S21 of the outer ring and the outer spherical surface S1 of the inner member 201 are contiguous plain bearing surfaces.

[0027] The inner and outer annular members 201, 202 are coupled by an axle arrangement comprising a diametrically opposed pair of axles X1 and X11 which are on a common axis through the central point C, in this case on axis A3. The pair of axles constrains the inner and outer rings to be rotatable, one relative to the other, about axis A3.

[0028] Each of the axles X1 and X11 comprises an axle shaft XS fixed in a bore B2 in the outer annular member 202 and extending into a bore B1 in the inner member 201 in which it is free to rotate. The shafts are arranged so that they do not transmit radial loads between the inner and outer rings. That is done by providing radial clearance between the ends of the axles and the radially adjacent spherical surfaces and by allowing some radial freedom of movement in the bore B1 between the shaft XS and the inner member 201: these arrangements isolate the axles from both radial and axial loads.

[0029] The shafts may be fixed in the outer annular member 202 by an interference fit or be otherwise fixed by for example a cold weld.

[0030] The axles may take other forms. The shaft XS may have a head in a recess in the outer surface of the outer member 202 so as to not protrude above the outer surface and be fixed in the outer member 202 by a screw-threaded engagement in the bore B2 in the outer member.

[0031] The axles retain the inner member 201 axially within the outer member 202. In addition, the spherical surfaces of the inner and outer members co-act to retain the inner member axially within the outer member.

[0032] The central point C of the adjacent convex and concave spherical surfaces lies between the axial facing faces F1 and F3 of the inner member 201 and between the faces F2 and F4 of the outer member 202. As a result of that, the periphery of the inner convex spherical surface mid-way between the axially facing faces F1 and F3 is at a greater radius than the periphery of the concave surface of the outer member 202 at the axially facing faces thereof F2 and F4. Thus the inner member 201 is retained axially in the outer annular outer member 202 over an operational range of rotation of the inner annular member 201 about the second axis and/or about the first axis.

[0033] In the example in Figure 2, the inner member 201 has splines in its central cylindrical bore for engaging a shaft. Splines (not shown) may additionally or alternatively be provided on the outer periphery of the outermost member (in this case outer annular member 202) for engaging another shaft. The coupling may be allowed to slide relative

to the shaft(s) providing an axial degree of freedom.

[0034] The first and second annular members are each a section of a sphere centred on the central point C at the intersection of the first A1 and second A2 axes.

[0035] In figure 2 as shown there are two diametrically opposite axles X1 and X11 which share loads on the coupling. One could be omitted if a coupling is being designed to operate under light loads.

[0036] The example of figure 2 has static applications such as Hub Centre Steering as shown in Figure 3.

[0037] In Figure 3 a steered wheel hub 62 of a wheel is supported by a support member 64 which in this example is a suspension arm. The coupling E1, as described with reference to figure 2 couples the suspension arm 64 to the steered wheel hub 62. The arm 64 is engaged, for example by splines, in the central bore 40 of the inner ring 201 of the coupling E1. The axles(s) X1, X11 (only X1 shown) allow the outer annular member 202 to rotate about one axis (the steering axis) relative to the inner annular member 201 and arm 64. The outer annular member 202 supports the wheel 62 which is free to rotate on bearings 63. A steering arm 60 is fixed to the outer annular member 202 to rotate it relative to the inner ring and arm 64.

[0038] In this example the axle(s) X1, X11 provide support to allow relative rotation but do not drive the wheel hub 62.

[0039] A further example of a coupling is shown in figure 4 comprising an inner annular member 401 centred on a first axis, the inner annular member 401 having an outer peripheral surface S1 which is convexly spherical centred on the point C on the axis A1. The inner annular member 401 has a central cylindrical bore 40 has splines for engaging a correspondingly splined shaft.

[0040] An intermediate annular member 402 has an inner peripheral surface S21 which is concavely spherical complementary to the outer surface S1 of the inner member 402. In this example the inner spherical surface S21 of the second member and the outer spherical surface S1 of the inner member 401 are contiguous plain bearing surfaces.

[0041] A first pair of diametrically opposed axles X1 and X11 extend radially of, the first axis A1 on the third axis A3 to couple the inner member 401to the intermediate member 402. The first and second axles constrain the inner and intermediate members to rotate one relative to the other about the third axis A3. The intermediate member 402 has an outer periphery S22 which is convexly spherical. An outer annular member 403 has an inner peripheral surface S31 which is concavely spherical complementary to the outer surface S22 of the intermediate member 402. In this example the inner spherical surface S31 of the outer member 403 and the outer spherical surface S22 of the intermediate member 402 are contiguous plain bearing surfaces.

[0042] A second pair of diametrically opposed axles X2 and X21 extend radially of, the first

axis A1 along the second axis A2 perpendicular to the third axis A3 to couple the intermediate member 402 to the outer member 403. The axles X2 and X21 constrain the intermediate 402 and outer 403 members to be rotatable one relative to the other about the second axis A2 of rotation (see Figure 1) through the centre point C, and perpendicular to the first axis A1 and perpendicular to the third axis A3. The second pair of axles allows relative rotation of the pair of members comprising intermediate and outer members 402 and 403 independently of the pair of members comprising inner and intermediate members 401 and 402.

[0043] In similar manner as described with reference to figure 2, the spherical surfaces S1, S21, S22 and S31 bear loads acting radially of the axis A1 and in the direction of the axis A1. The axles transmit torque between the inner 401, intermediate 402, and outer 403 members.

[0044] The inner member 401 is retained in the intermediate member 402, and the intermediate member 402 is retained in the outer member 403 in the same way that the inner member 201 in figure 2 is retained in the outer member 202.

[0045] A first shaft or other structural element may be engaged in the central bore in the first annular member 401 and a second shaft or other structural element may be engaged with the outer member 403. For that purpose the outer member 403 may be fixed to or integral with a flange (not shown) or it may comprise other means, for example external splines, for coupling to a structural element.

[0046] One use of couplings of Figure 4 is as a universal joint. The coupling allows angular misalignment of the shafts by virtue of the relative rotation of the intermediate member 402 and outer member 403 about the third axisA3 and second axis A3 respectively.

[0047] Both the inner member 401 and the intermediate member 402 comprise spherical segments about the central point C.

[0048] In figures 5A and 5B coupling arrangements comprising two couplings of the kind illustrated in figure 4 are shown.

[0049] In figure 5A the comprising two couplings E2 of figure 4 connected together by a connecting structure 66. The structure rigidly connects the two couplings. The connecting structure 66 is a tube coupling the outer members 403. In another example, instead of the tube, the outer member 403 of one coupling is connected by a connecting structure 67 to the first member 401 of the other as shown for example in Figure 5B.

[0050] The coupling arrangement of Figure 5A is an approximation to a double Cardan joint, if the axle pairs of one of the individual couplings E2 are non-orthogonal to corresponding axle pairs of the other.

[0051] If instead of using the couplings E2 of figure 4, the couplings of figure 2 are used, the coupling arrangement is a crank handle if the axles of the two couplings are in the same orientation. In other examples the axle(s) of one coupling are orthogonal to the

projection(s) of the other.

[0052] One of the couplings may be free to move axially in the tube 66.

[0053] The coupling of Figure 6 comprises an inner annular member 601, first, second third intermediate annular members 602, 603, 604 and outer annular member 605.

[0054] It has been found that the third intermediate 604 and outer member 605 must be offset relative to the inner and first intermediate members 601 and 602 along the axis A1 when the members are aligned (see figure 6D).The offset may be slight. This may be achieved by offsetting the outer spherical surface S32 of the second intermediate member 603 axially of the inner spherical surface S31 of the second intermediate member 603. Thus using the frame reference of Figure 1, the inner and first intermediate members 601 and 602 are centred on central point C and the second and third intermediate members 603 and 604 are centred on point C2.

[0055] The first annular member 601 has an outer peripheral surface S1 which is convexly spherical centred on the central point C on the first axis A1. The first annular member 601 has a central cylindrical bore 40 which in this example has splines 42 for engaging a correspondingly splined shaft.

[0056] A first intermediate annular member 602 has an inner peripheral surface S21 which is concavely spherical complementary to the outer surface S1 of the inner member 601. Surfaces S1 and S21 are contiguous plain bearing surfaces.

[0057] A first pair of diametrically opposed axles X1, X11 extends along the third axis A3 radially of the first axis A1 to couple the inner member 601 and first intermediate member 602. The first pair of axles constrains the pair of members comprising inner and first intermediate members 601 and 602 to be rotatable one relative to the other about the third axis A3 of rotation through and perpendicular to the first axis A1.

[0058] The first intermediate member 602 has an outer periphery S22 which is convexly spherical. A second intermediate annular member 603 has an inner peripheral surface S31 which is concavely spherical complementary to the outer surface S22 of the first intermediate member 602. In this example the inner spherical surface S31 of the second intermediate member 603 and the outer spherical surface S22 of the first intermediate member 602 are contiguous, plain, bearing surfaces.

[0059] A second pair of diametrically opposed axles X2, X21 extend along the second axis A2 radially of the first axis A1 coupling the pair of members comprising the first and second intermediate members 602 and 603. The second axle pair constrains the first intermediate member 602 and second intermediate member 603 to be rotatable one relative to the other about the second axis A2 of rotation through the central point C, and perpendicular to the first axis and perpendicular to the third axis A3. The second pair of axles allows relative rotation of the pair of members 602 and 603 members independently of the pair of members 601 and 602.

[0060] The second intermediate member 603 has an outer periphery S32 which is convexly spherical. A third intermediate annular member 604 has an inner peripheral surface S41 which is concavely spherical complementary to the outer surface S32 of the second intermediate member 603. In this example the inner spherical surface S41 of the third intermediate member 604 and the outer spherical surface S32 of the second intermediate member 603 are contiguous, plain, bearing surfaces.

[0061] A third pair of diametrically opposed axles X3, X31 extend along the second axis A2 radially of the first axis A1 coupling the pair of members comprising the second and third intermediate members 603 and 604. The third axle pair constrains the members 603 and 604 to be rotatable one relative to the other about the axis A21 of rotation through the central point C2, parallel to axis A2. They thus constrain the pair of members 603 and 604 to be rotatable one relative to the other about axis A21. The third pair of axles allows relative rotation of the second and third intermediate members independently of the first and second intermediate members.

[0062] The third intermediate member 604 has an outer periphery S42 which is convexly spherical.

[0063] An outer annular member 605 has an inner peripheral surface S51 which is concavely spherical complementary to the outer surface S42 of the third intermediate member 604. In this example the inner spherical surface S51 of the outer member 605 and the outer spherical surface S42 of the third intermediate member 604 are contiguous, plain, bearing surfaces.

[0064] A fourth pair of diametrically opposed axles X4, X41 extends along axis of rotation A31 parallel to axis A3 but though centre point C2. The fourth axle pair constrains members 604 and 605 to be rotatable one relative to the other about A31 and perpendicular to axis A21. They thus constrain the members 604 and 605 to be rotatable one relative to the other about axis A31. The fourth pair of axles allows relative rotation of the pair of members 604 and 605 independently of the pair of members 603 and 604.

[0065] The members are retained in the coupling in the same way as described hereinabove with reference to Figure 2.

[0066] The axles X1 to X41 are identical to the axles X1 and X11 of Figure 2.

[0067] In figures 6A to 6F the inner and first intermediate members 601 and 602 comprises spherical segments about the central point C, the second and third intermediate members 603 and 604 also comprises spherical segments but about point C2. However, the central aperture of second intermediate member 603 is a spherical segment about the central point C, the first intermediate member 602 is received into this aperture.

[0068] One illustrative use of the coupling of Figure 6 is as a double Cardan joint.

[0069] In the examples of Figures 2 to 6, the spherical surfaces are all contiguous plain

bearing surfaces. Rolling element bearings may be provided between the adjacent spherical surfaces. In Figure 7, ball bearings 100 held in one or more cages 101 may be provided at the surface of a member of a coupling. In the example of Figure 7, the balls are held in two ball baskets, which are half spherical pieces, between the axles X, which may be axles X1 and X11 of the inner member 701 and outer member 702. Thus the spherical surfaces have rolling elements for carrying radial and axial loads. The radial load path is independent of the torque load being applied. This approach is more efficient than using balls in grooves to carry both the torsion and the radial load. As shown figure 7 is a two member coupling, however, the principles of figure 7 can be extended to a bearing having one or more intermediate members as shown in figure 4 or 6.

[0070] As an alternative or in addition rolling element bearing 102 may also be mounted on the axles to reduce friction.

[0071] The inner member 701 comprises a spherical segment about the central point C. In figure 7 the axles X1 and X11 have heads H inset into outer member 702 and screw threads engaging threads in the bores of outer member 702.

[0072] The spherical surfaces of adjacent members in the examples co-operate to bear radial and axial loads. To ensure that the coupling can bear a desired axial and radial load the spherical surfaces need to overlap sufficiently. Thus in embodiments of the invention, means may be provided to limit the relative rotation of adjacent members. Such limiting means also assists the retention of each inner ring in its associated outer ring. Examples of such limiting means include a stop within the coupling. As shown for example in Figure 8, in one example a fixed pin N projecting from an outer member 2 into a slot L in an inner member 1. It will be appreciated that any other suitable means of limiting relative may be used. In some examples the coupling is supported by a support structure which limits relative rotation. In others the structural elements coupled by the coupling limit the relative rotation.

[0073] As shown in Figure 9, to increase the operational range of relative rotation, the outer 2 or 3 of adjacent members 1 and 2 or 2 and 3 may be larger in the axial direction than the inner one 1 or 2. Figure 9 shows three annular members 1, 2 and 3 as in figure 4. The principle of this Figure 9 may be applied to any of the pairs of annular members of the examples of the invention.

[0074] Referring to Figure 10, any of the examples of figures 2, 4 and 6 may be fixed within a bearing 110 which may be fixed to a fixed structure 112 for example a bulkhead, floor or wall. That allows the coupling to couple to any two structural elements, one each side of the fixed structure 112, that must be coupled with at least two rotational degrees of freedom. For example the fixed structure may be a bulkhead of a vehicle and the coupling couples section of a steering mechanism of the vehicle.

[0075] The bearing 110 allows the coupling E of Figure 10 to rotate within the fixed structure 112.

[0076] Figures 11A and 11B illustrate the assembly of a coupling. The coupling comprises a pair of annular members 1 and 2, an outer member 2 being outside an inner member 1. Member 2 has two diametrically opposite loading slots L1 and L2. The loading slots extend halfway across the width of the outer member 2 (the loading slots can also be seen in figure 7C). The slots are dimensioned so that the diametrically opposite floors 6 of the slots are spaced by the diameter of the outer surface S1 (including if provided the cages101 as in figures 7) of inner member 1. The width of each slot is equal to or slightly greater than the width of the inner member. The inner member 1 is introduced sideways into the slots as shown in Figure 11A and then rotated into the same plane as the outer member 2. The axle bore (s) of the pair of members 1 and 2 are brought into alignment at a suitable stage in the assembly process.

[0077] This option enables each member to be machined from a solid piece of material and minimises the risk of failure as a result of joining to halves together. The method described enables all the bearing surfaces described in this specification to be continuous, ie avoiding any joins (and thus weak areas) at the join of a member assembled in two halves bolted or welded together.

[0078] In figure 11 the pair of members 1 and 2 are representative of each member respectively of the pairs of members 201 and 202 in figure 2, 401 and 402, 402 and 403 in figure 4, 601 and 602, 602 and 603, 603 and 604, 604 and 605 in figure 6, 701 and 702 in figure 7.

[0079] In the examples above, for plain bearing surfaces, the mating convex and concave spherical surfaces should match accurately. That requires appropriately precise manufacture of the couplings.

[0080] A lining material may be injected between the spherical bearing surfaces. The convex spherical surfaces may be accurately machined. The concave spherical surfaces may be roughly machined to form a rough surface which is also a piece-wise linear approximation to a curved surface also known as cathedraling, and lining material injected between an accurately machined convex surface and the rough concave surface to form an accurately matched concave spherical surface. The convex spherical surface is coated with a release agent before the lining is injected into the coupling.

[0081] The lining material may be of plastic. The compositions of some of the plastics are not publically known as the suppliers are often commercially sensitive about their compositions. However Delrin® is one known product that could be used or PTFE based materials could be used.

[0082] In an alternative embodiment to those shown above, a structural element such as a shaft is fixed to or is integral with the inner member of a coupling. In an alternative

embodiment, a structural element such as a shaft is fixed to or is integral with the outer member of a coupling. Structural elements may be fixed to or be integral with both the inner and outer members of a coupling.

[0083] The examples described above may have splines in the inner ring and or on the outer most peripheral surface of the coupling for connecting the coupling to structural elements to be coupled.

[0084] Alternatively any other suitable means of connecting the coupling to structural elements may be used. For example the outer periphery may have screw thread for connecting it to a correspondingly threaded structural element. Likewise the inner member may have a central bore which is screw threaded or employ keys to engage a shaft. The inner member may be integral with a shaft which is screw threaded for connection to another structural element. The outer member of the coupling may be connected to a structural element by any suitable means.

[0085] Couplings as described above may be made of any suitable material. The examples having plain bearing surfaces may be of metal, e.g. high performance steels, brass, bronze, aluminium, titanium etc. or of plastic, e.g. nylon, glass filled nylon, acetal, ABS, Delrin®.

[0086] It should be noted that the inner and outer annular members 401 and 403 of the coupling of Figure 4 may be connected to respective shafts or other structural members so the intermediate member 402 is the only part which moves relative to the other two; this might lead a designer to select brass or bronze for the moving middle ring and steel for the inner and outer rings. The same philosophy could be applied to the other examples of the couplings.

[0087] Metal annular members rings may be lubricated by conventional lubricants for example grease. Alternatively, dry lubricant surfaces may be provided such as plastic liners as discussed above. The choice of materials and lubricants depends on the intended use of the coupling.

[0088] The inner member in all the examples comprises an annular spherical member with a central aperture for receiving a shaft. However, it may not have a central aperture but, for example, be bolted to a flange on a shaft.

[0089] In the examples shown, for maximum compactness, in each member of a pair of members comprising spherical segments has parallel sides in common planes when the segments are aligned. In particular:

- in the arrangement of figure 2 each member of a pair of members comprises spherical segments has parallel sides in common planes when aligned.
- in the arrangement of figure 4 each member comprises spherical segments having parallel sides in common planes when aligned.
- in the arrangement of figure 6 the first pair of members (601, 602) each

comprise spherical segments having parallel sides in common planes when aligned and the third pair of members (603, 604) and fourth pair of members (604, 605) each comprise spherical segments having parallel sides in common planes when aligned. Although this does not apply to the second pair of members (602, 603).

Claims

[Claim 0001] A coupling comprising an inner member and an outer annular member comprising one or more pairs of members which may or may not include one or both the inner and outer members, each pair being a first member and a second annular member with a common axis (A1) and having a common first centre (C) on the axis; a first member having an outer convex spherical periphery (S1); the second annular member having an inner spherical concave periphery (S21) in which the outer convex periphery of the first annular member is received; the outer convex periphery and the inner concave peripheries being concentric about the first centre (C) and complementary to one another and co-acting with one another to transmit axial loads acting along the torsional axis (A1) between them; one or a diametrically opposed pair of axles (X) disposed radially of the common first centre for transmitting torsional load from one of the members to the other; the first and second members being constrained by the axle(s) to be rotatable one relative to the other about the axle(s).

[Claim 0002] A coupling according to claim1 in which the members, other than the outer member, comprise spherical segments including a common centre (C, C2).

[Claim 0003] A coupling according to claim 1 or 2 wherein the convex and concave spherical surfaces (S1, S21) are contiguous which bear radial loads of the coupling and loads acting along the said torsional axis (A1).

[Claim 0004] A coupling according to any one of claims 1 to 3, further comprising a rolling element bearing (100,102) between the convex and concave spherical surfaces and/or around the axle(s) (X).

[Claim 0005] A coupling according to any preceding claim, wherein the second annular (202, 402, 403, 602, 603, 604, 605) member of a pair of members retains the first member of a pair of members (201, 401, 402, 601, 602, 603, 604) within the coupling.

[Claim 0006] A coupling according any preceding claim in which the second annular member of a pair of members has a pair of diametrically opposed loading slots (L1,L2) by which the first member of the pair of members may be inserted to be retained within the coupling.

[Claim 0007] A coupling according to any preceding claim, comprising an innermost member (401), an intermediate member (402) and an outer-most member (403), the innermost member (401) and intermediate member

(402) comprising a first pair of members and the intermediate (402) and outermost member (403) comprising a second pair of members and in which the axle(s) (X2, X21) coupling the second pair of members (402, 403) is perpendicular to the axle(s) (X1,X11) coupling the first pair of members (401, 402), the second pair of members being rotatable one relative to one another independently of the first pair of members.

[Claim 0008] A coupling according to any one of claims 1 to 5 having first (602), second (603) and third (604) intermediate members, the inner (601) and first intermediate members (602) forming one pair of members, first (602) and second (603) intermediate members being a second pair of members, the second (603) and third intermediate (604) members being a third pair of members, and the third intermediate (604) and outermost (605) members being a fourth pair of members.

[Claim 0009] A coupling according to claim 8 in which in the case of the third pair of members the plane containing their axles (X3, M31) is perpendicular the plane containing the axles (X1, X11) of the first pair of members and coincident with the plane containing the axles (X2, X21) of the second pair of members.

[Claim 0010] A coupling according to claim 8 or 9 wherein the convex outer surface of the second intermediate member (603) has an outer periphery (S32) which is convexly spherical about a common second centre (C2) which is offset from the common first centre (C) in the direction of the common axis (A1) when the members are aligned.

[Claim 0011] A coupling according to any one of claims claim 8 to 10 in which and wherein the third intermediate member (603) has its outer convex periphery (S32) centred on the second common centre and its inner concave periphery centred on the first common centre (C).

[Claim 0012] A coupling according to any one of claims 8 to 11 in which the axle(s) (X4, X41) connecting the fourth pair of members are parallel to the axle(s) (X3, X31) connecting the third pair of members and in which the fourth pair of members (604, 605) are rotatable relative to one another about the second common centre in a direction independently of the first, second and third pairs of members.

[Claim 0013] A coupling arrangement comprising two couplings according to any preceding claim connected by a connecting structure (66, 67), the coupling structure coupling the outermost members of each coupling, or the outermost member of one coupling to the innermost member of the other coupling, in addition optionally provision is or is not be made

for one of the couplings is free to move axially relative to the connecting structure.

[Claim 0014] A coupling or coupling arrangement according to any preceding claim, wherein the axle(s) do not transmit radial and axial loads between the each member of a pair of members.

[Claim 0015] A coupling according to any preceding claim, wherein one of the innermost member and the outermost member is fixed against rotation about the torsional axis.

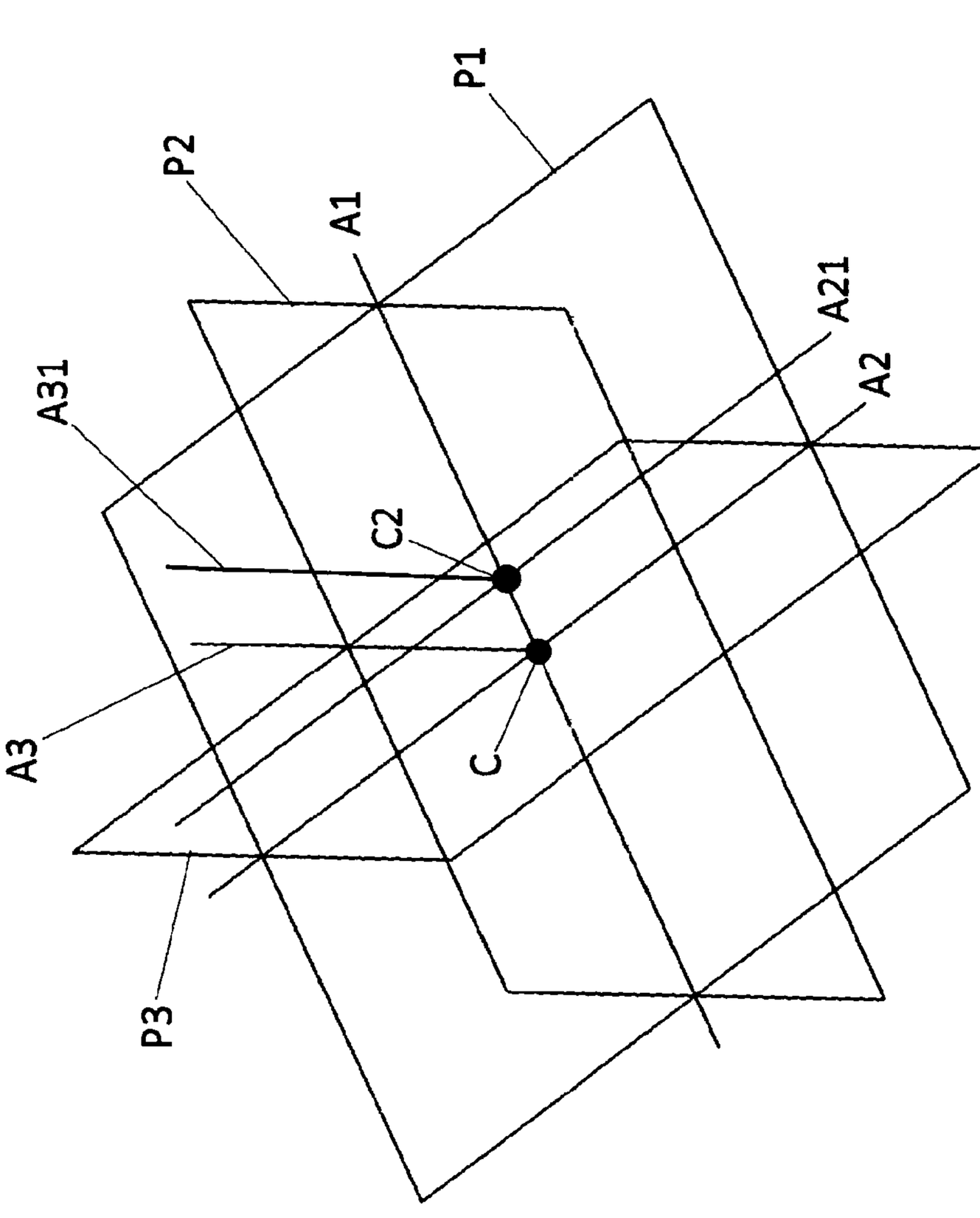

FIG 1

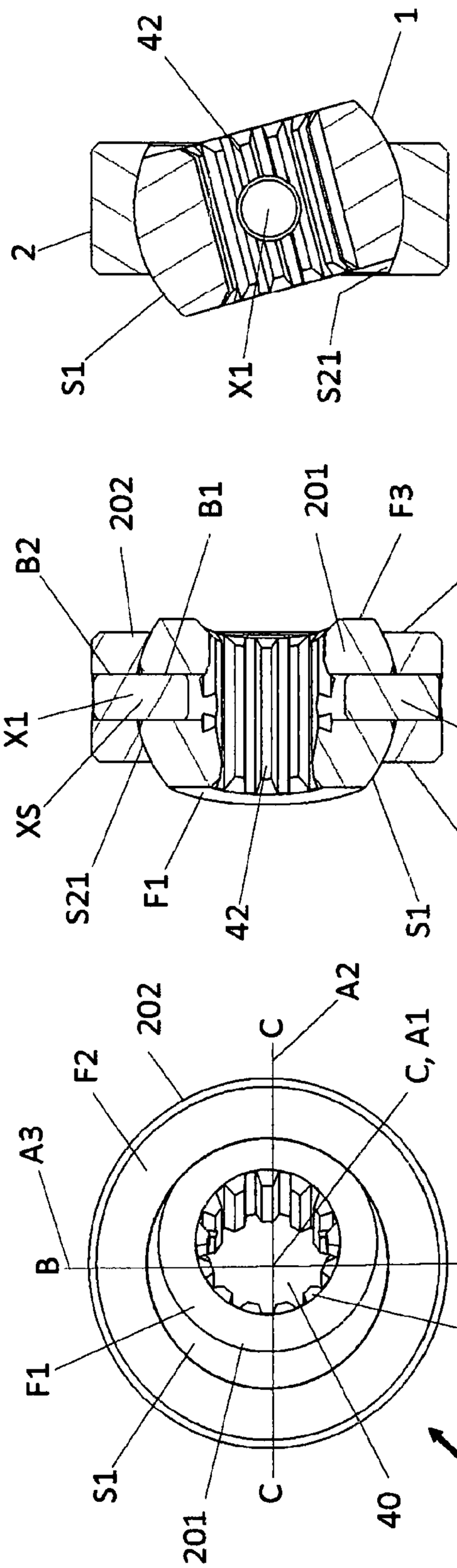

FIG 2C

FIG 2B

FIG 2A

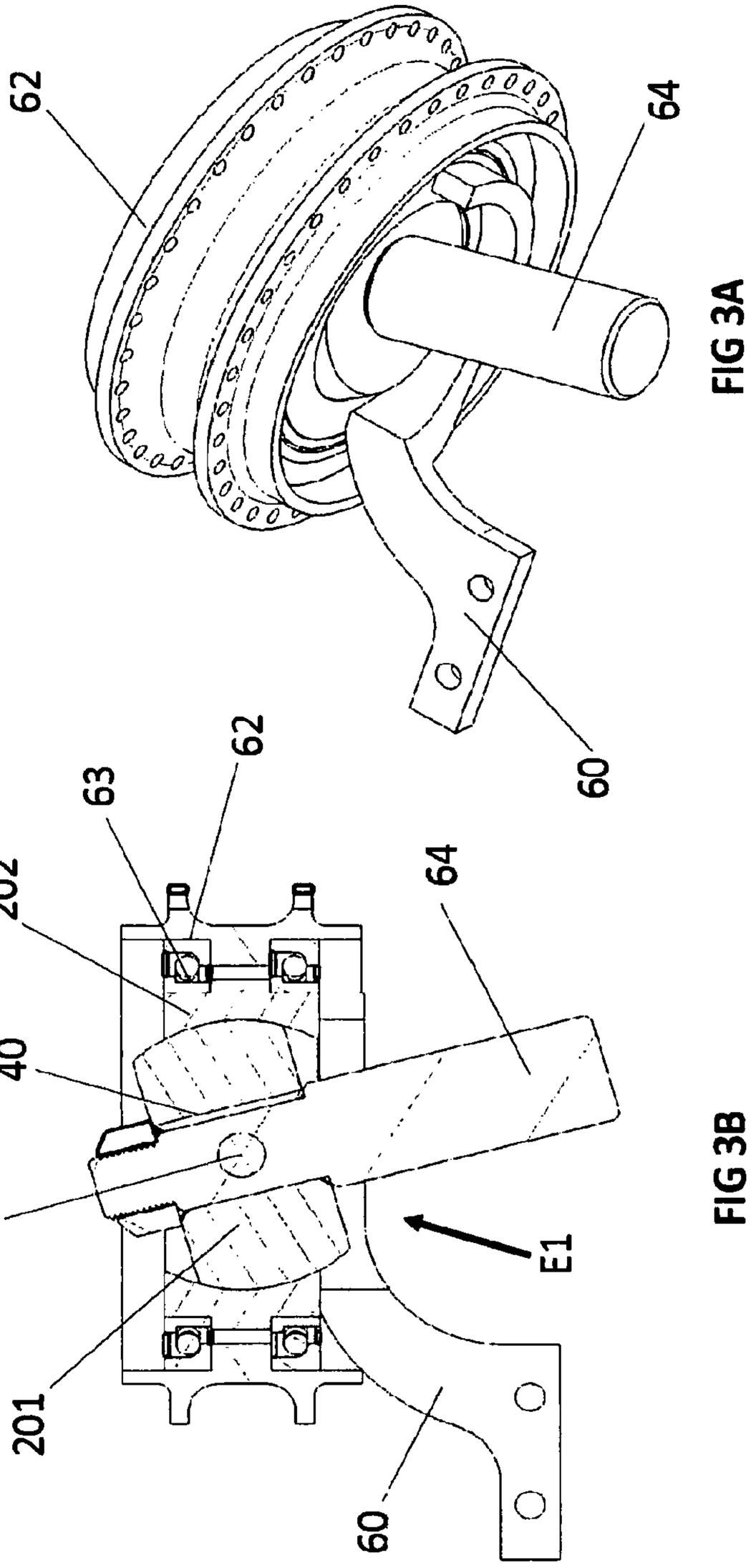

FIG 3A

FIG 3B

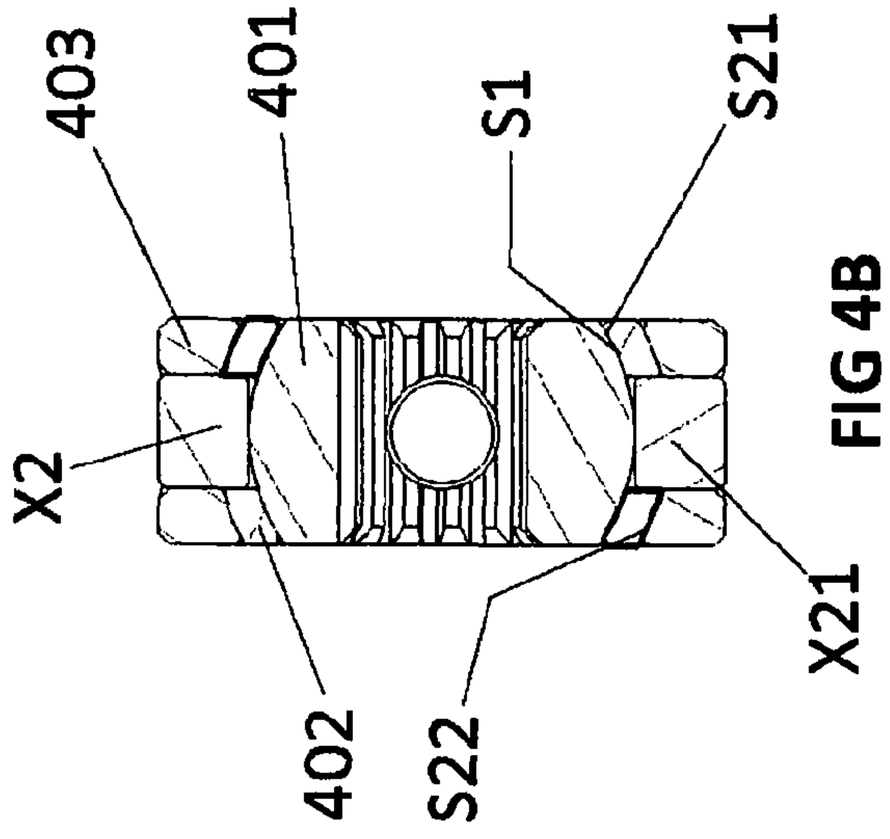

FIG 4B

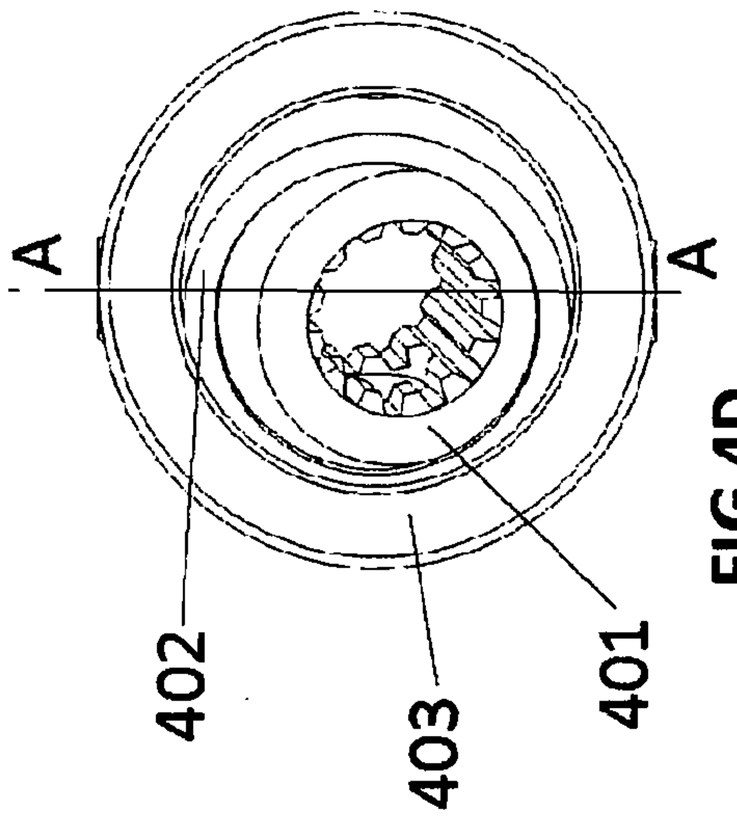

FIG 4D

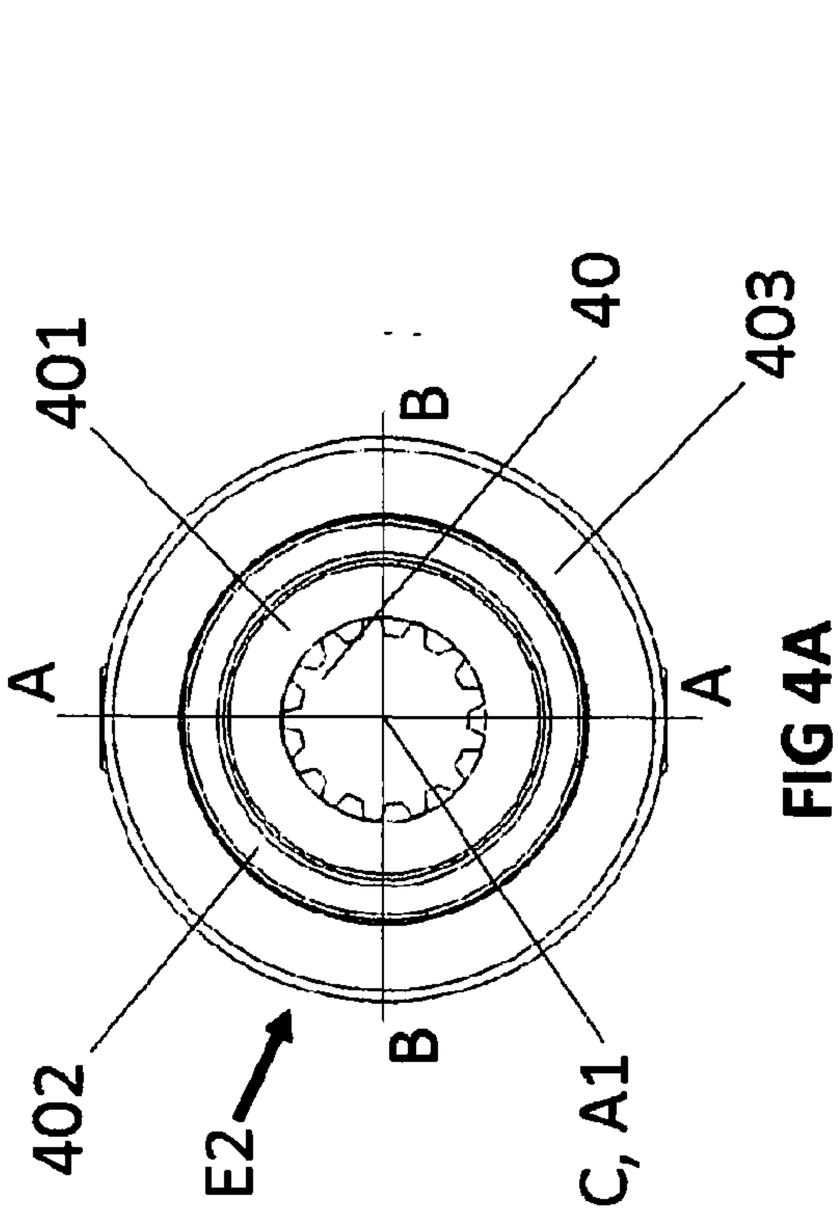

FIG 4A

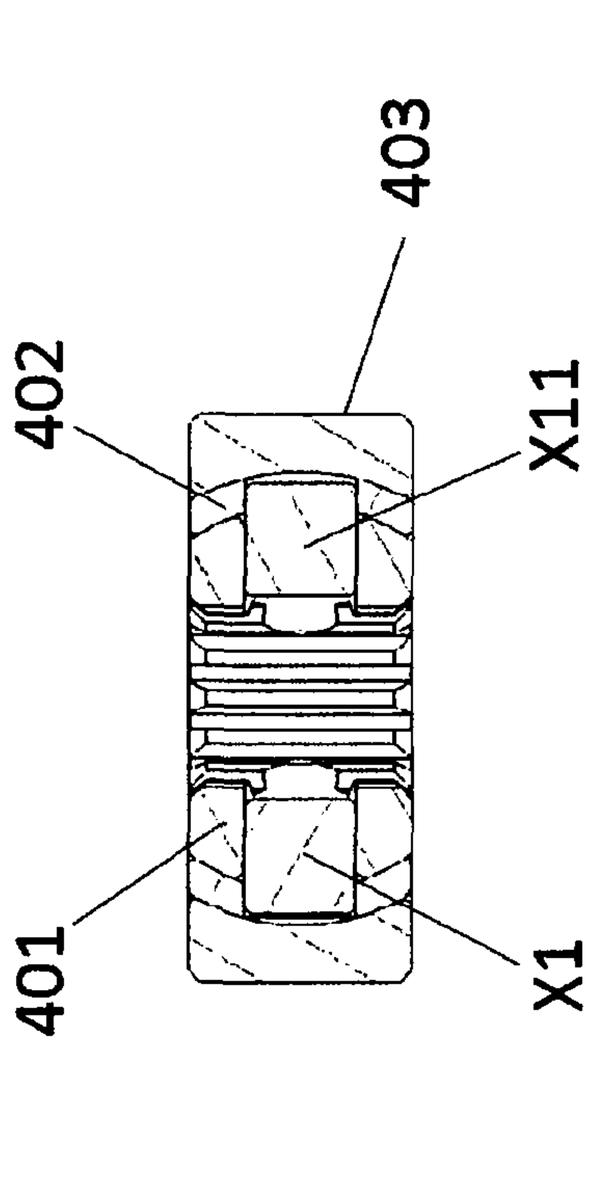

FIG 4C

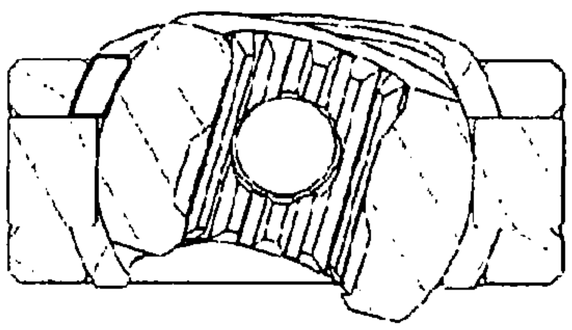

FIG 4F

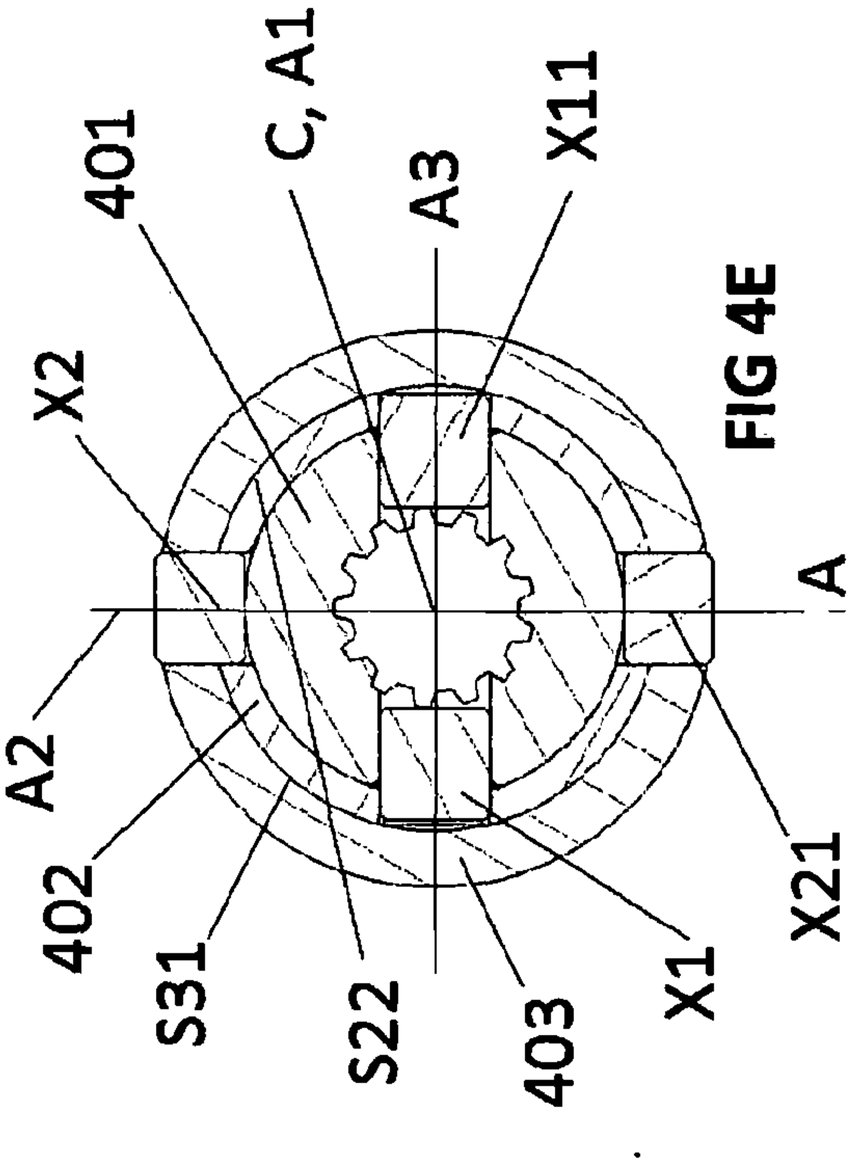

FIG 4E

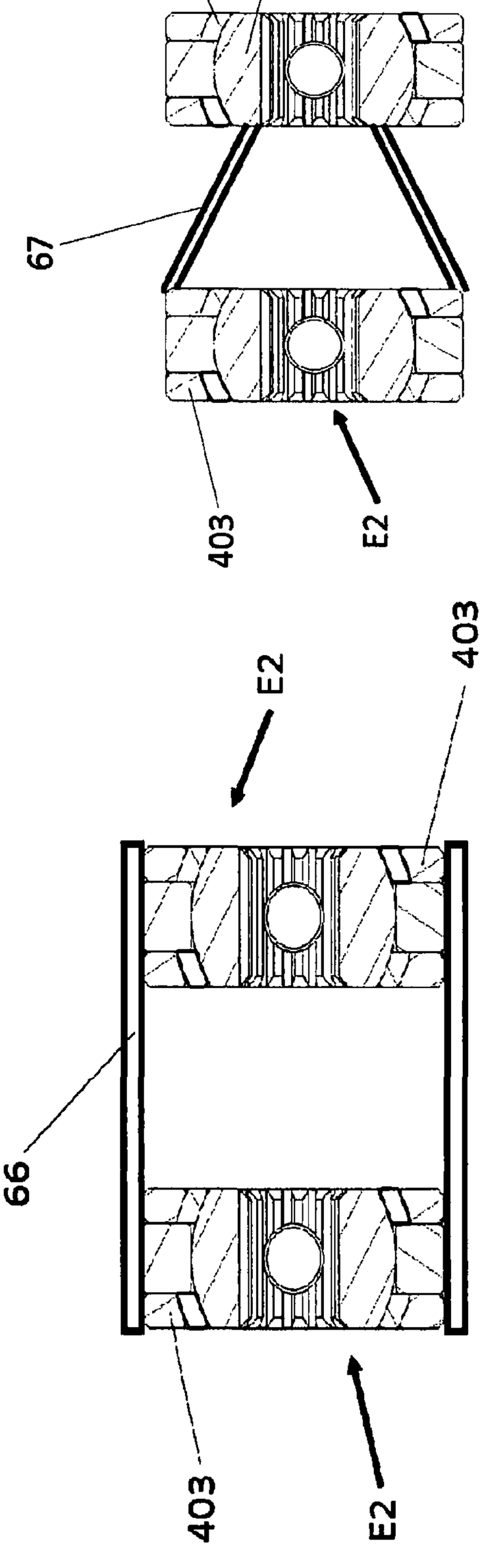

FIG 5B

FIG 5A

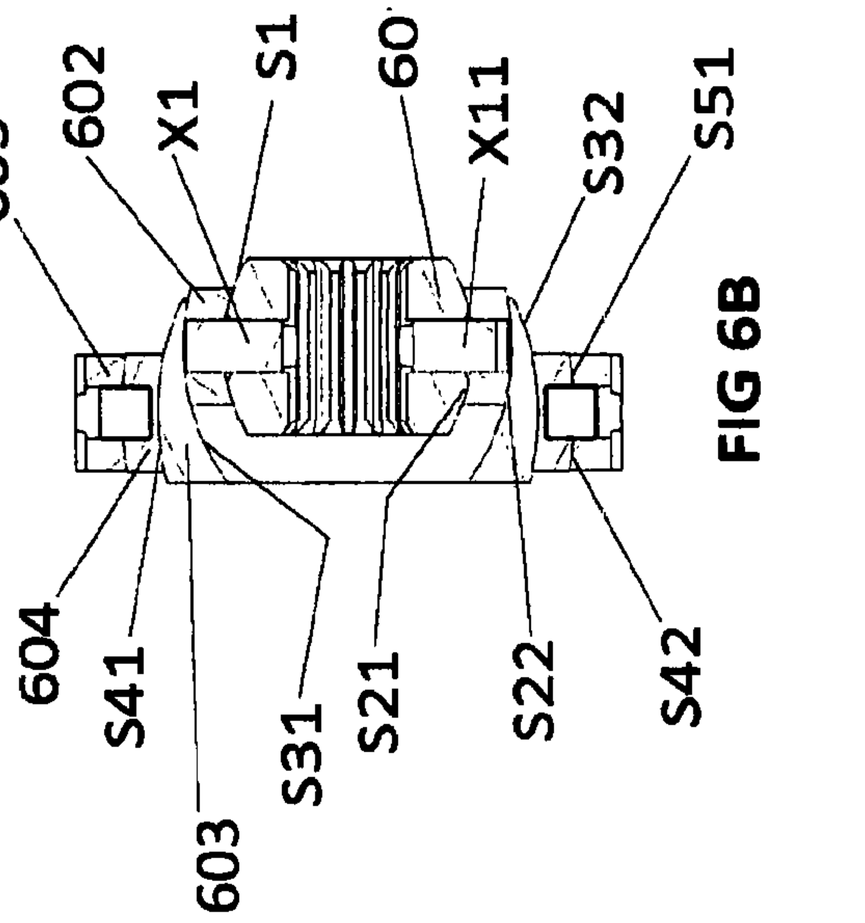

FIG 6B

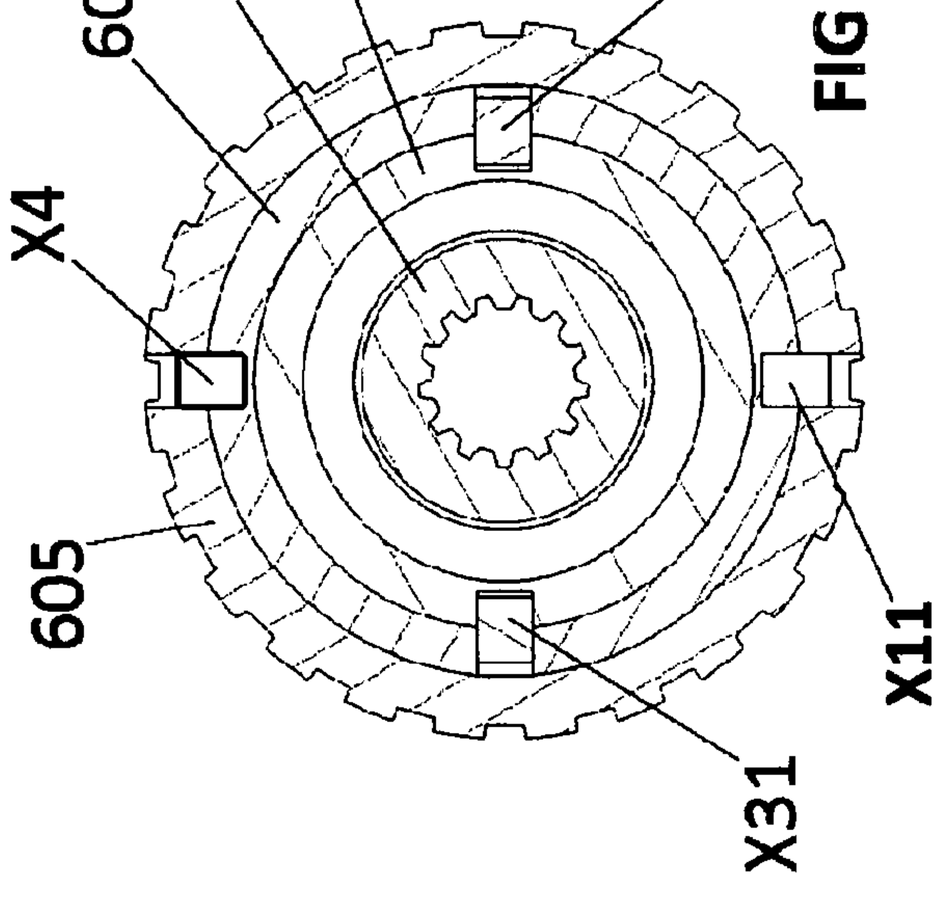

FIG 6E

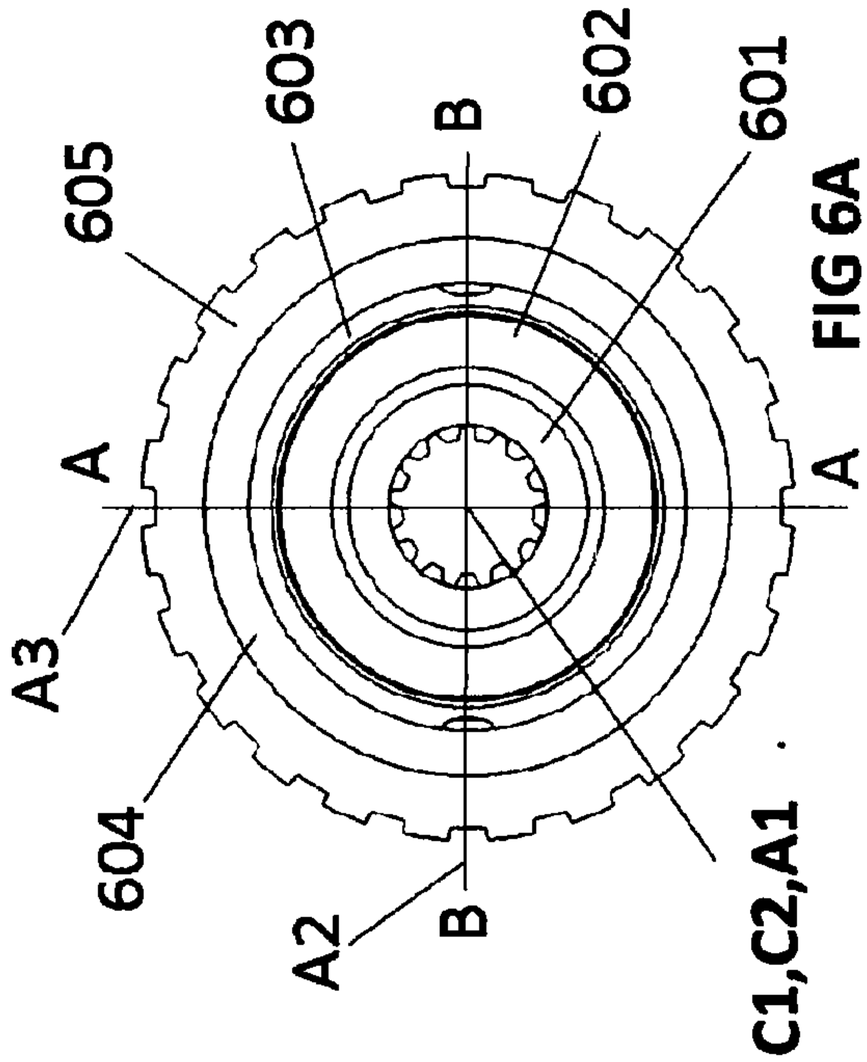

FIG 6A

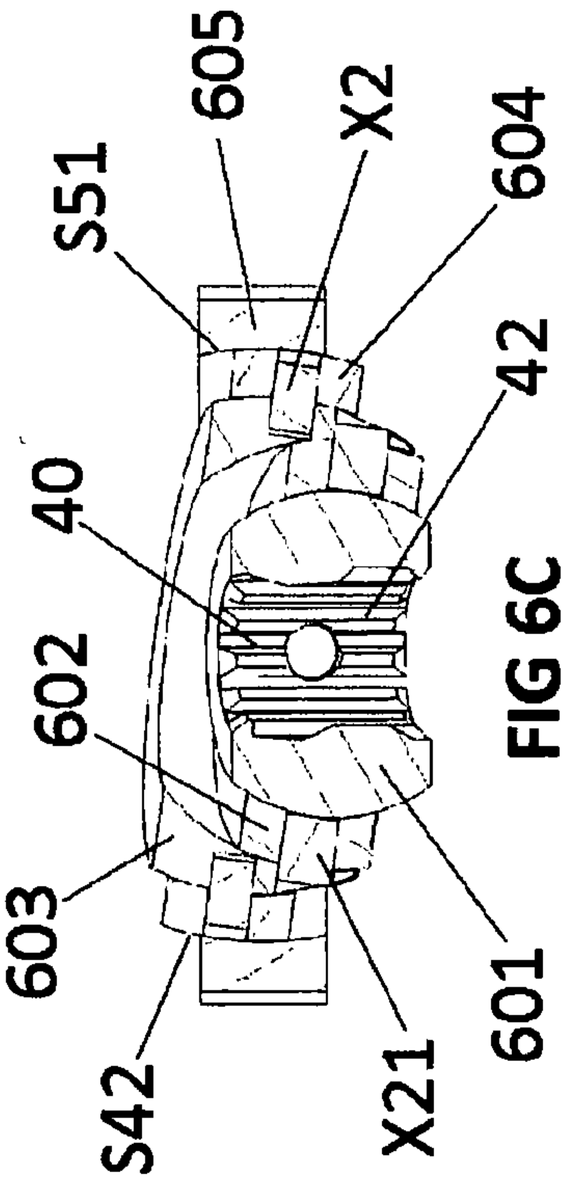

FIG 6C

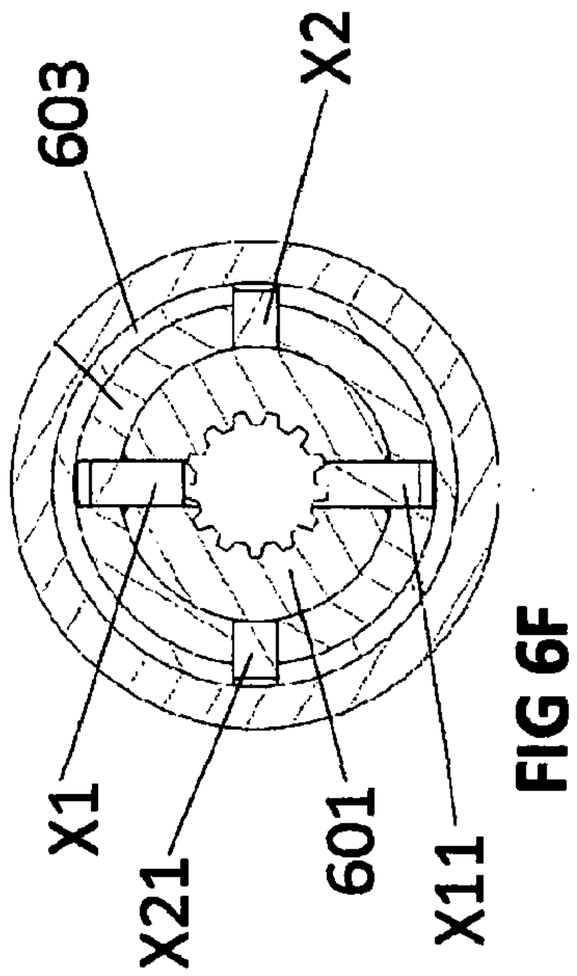

FIG 6F

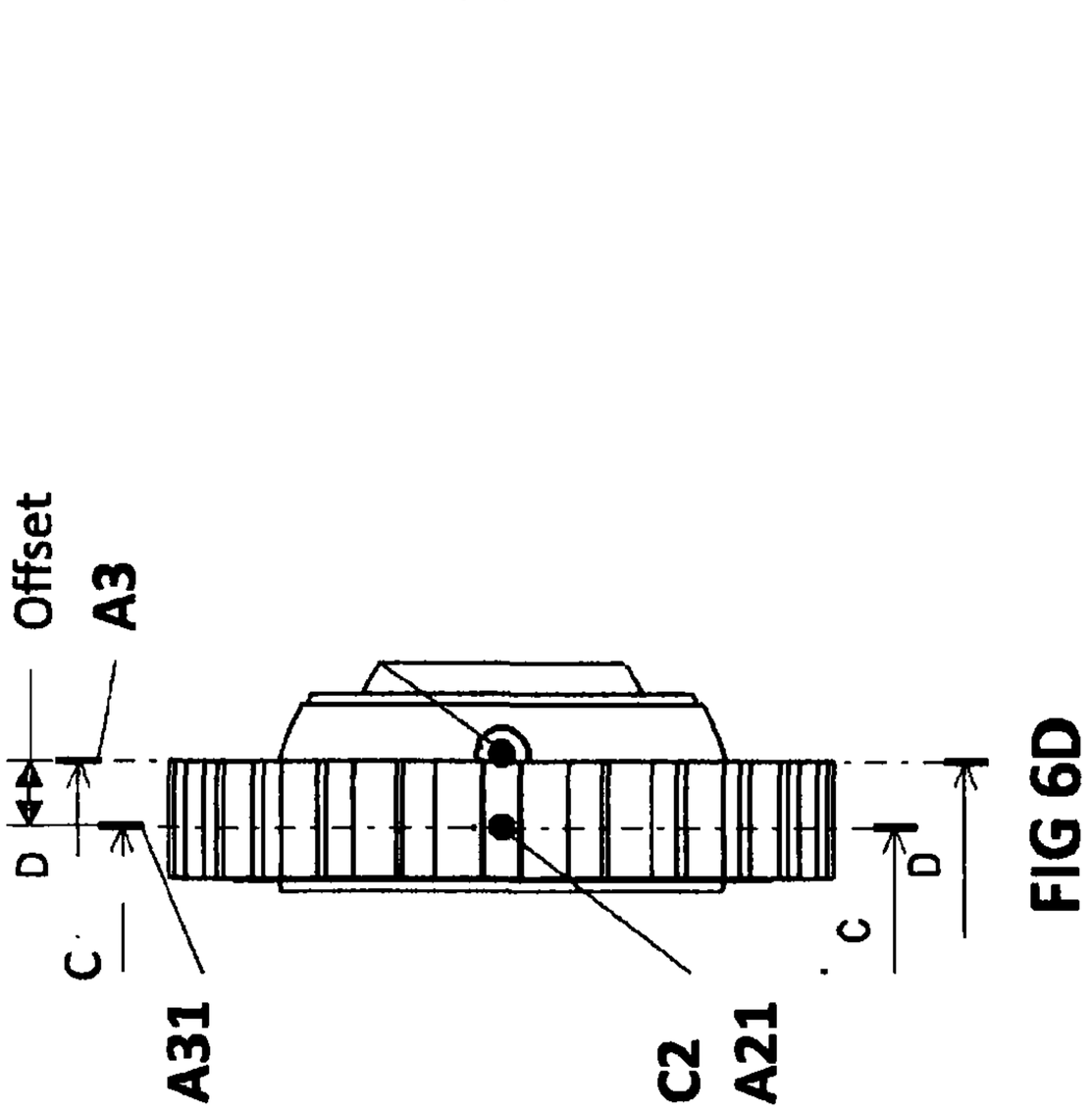

FIG 6D

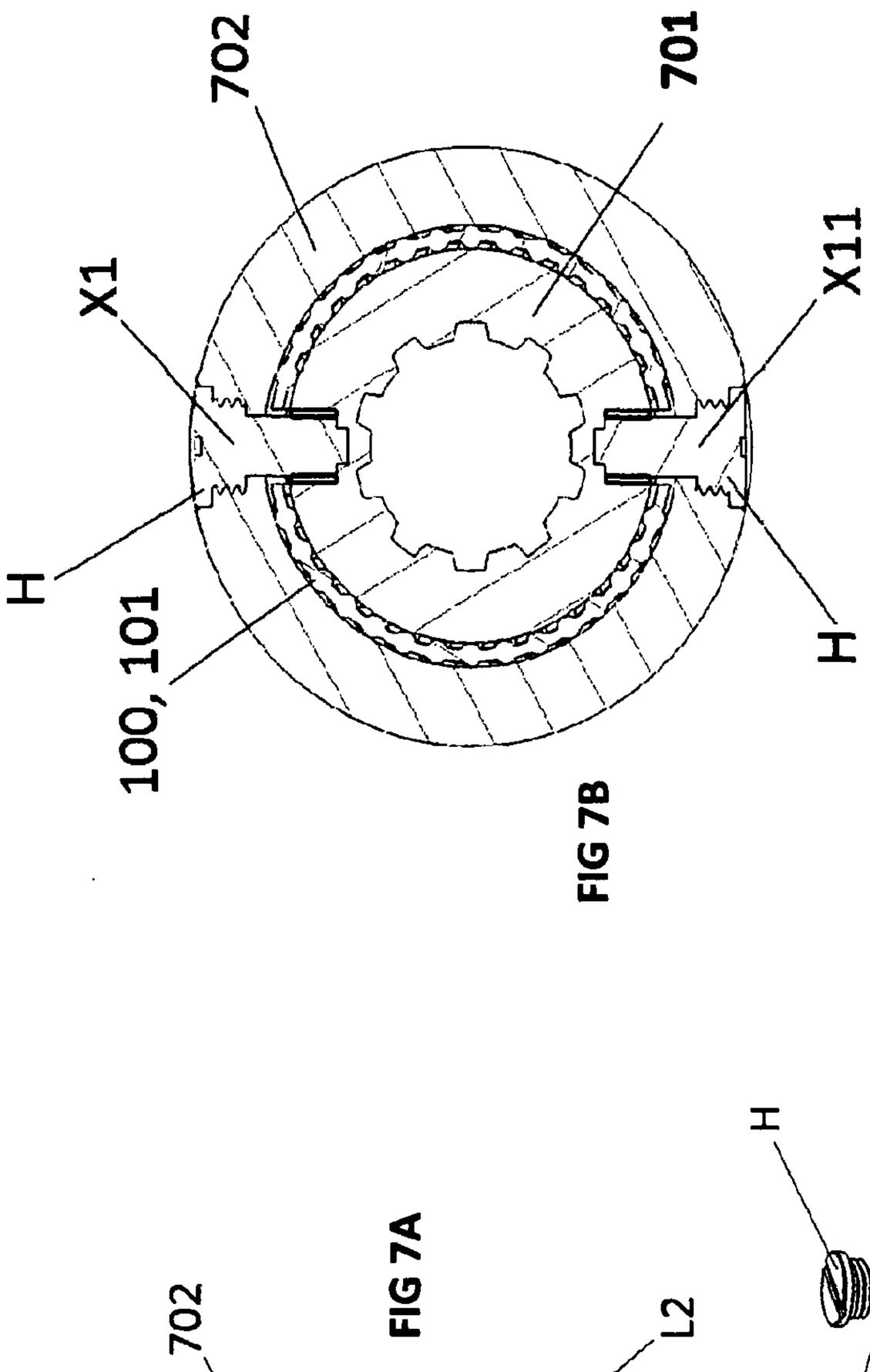

FIG 7B

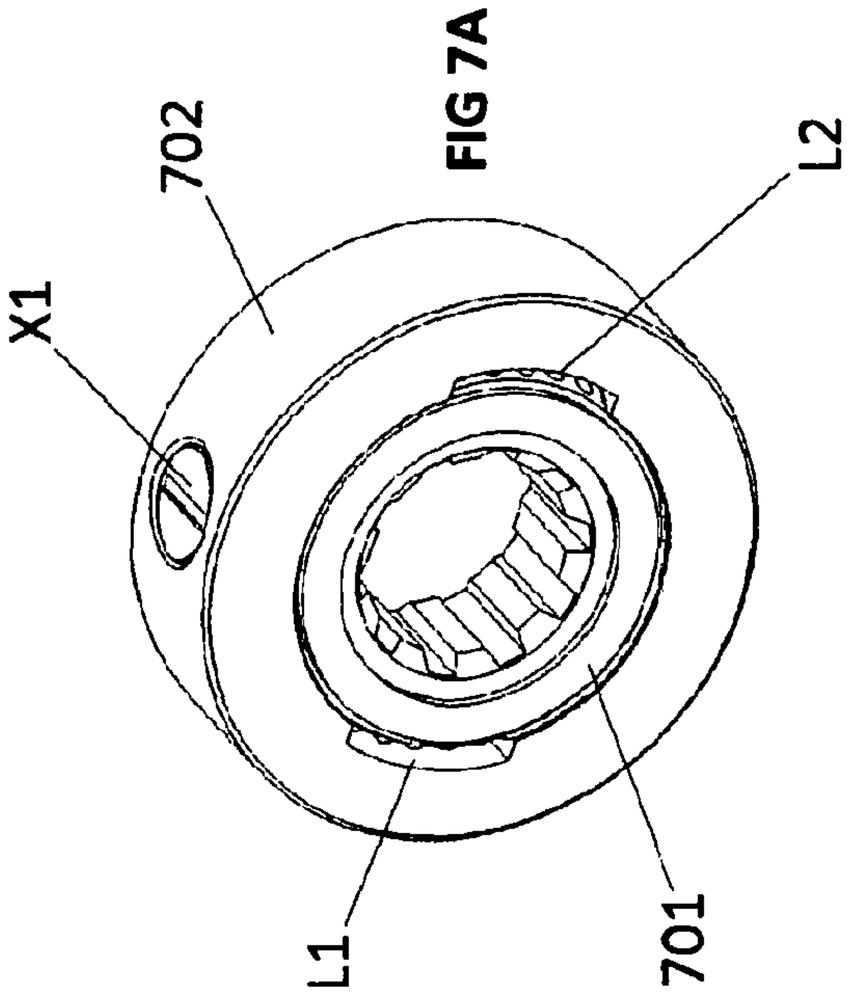

FIG 7A

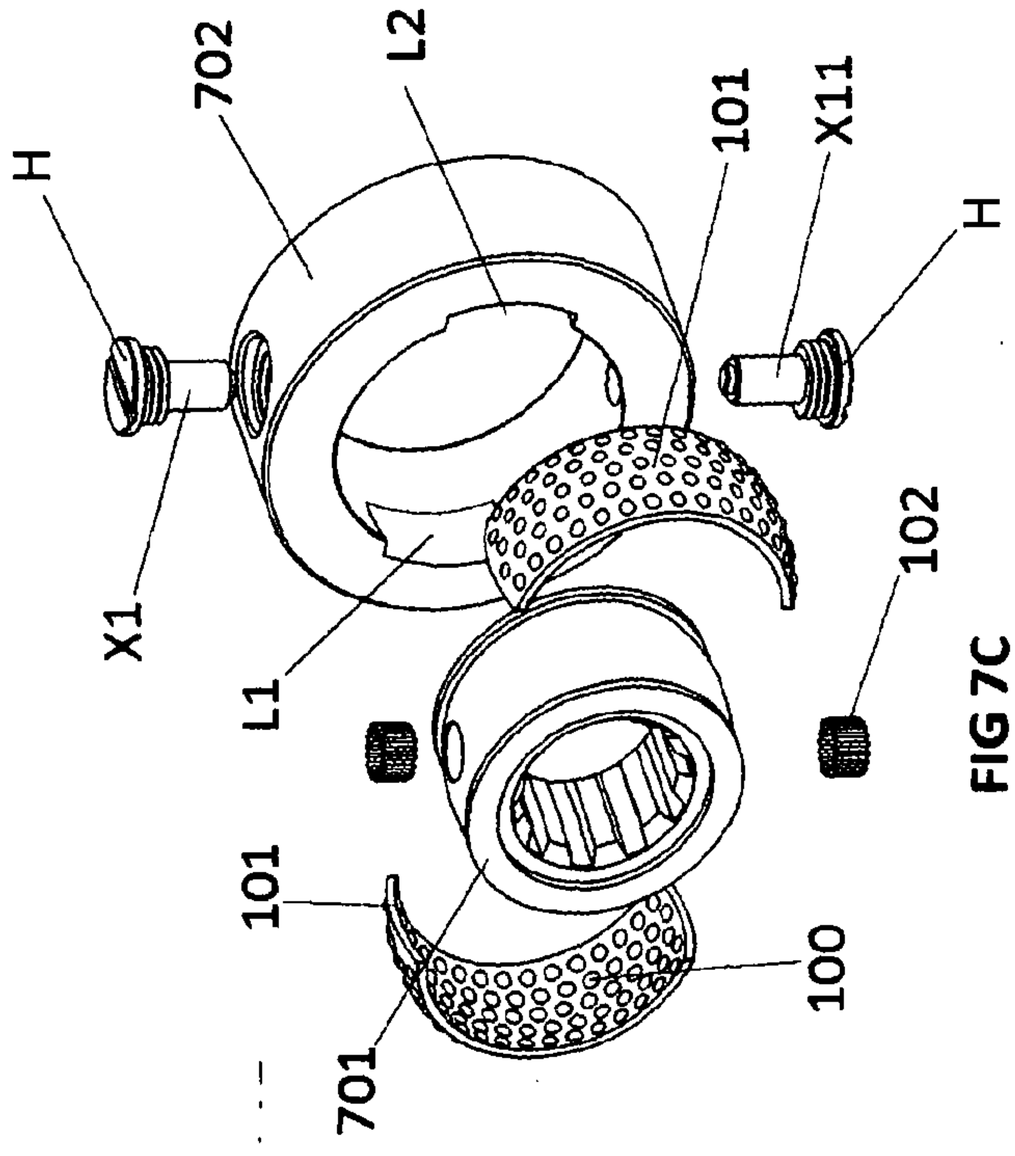

FIG 7C

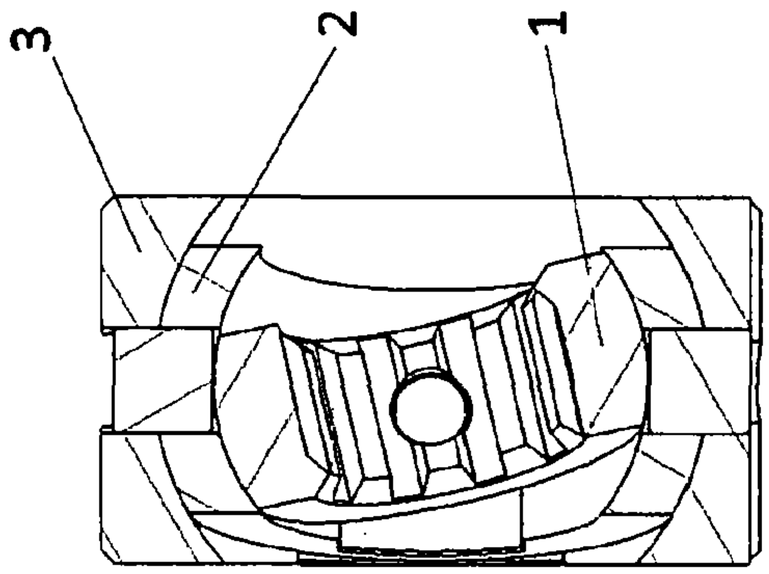

FIG 9

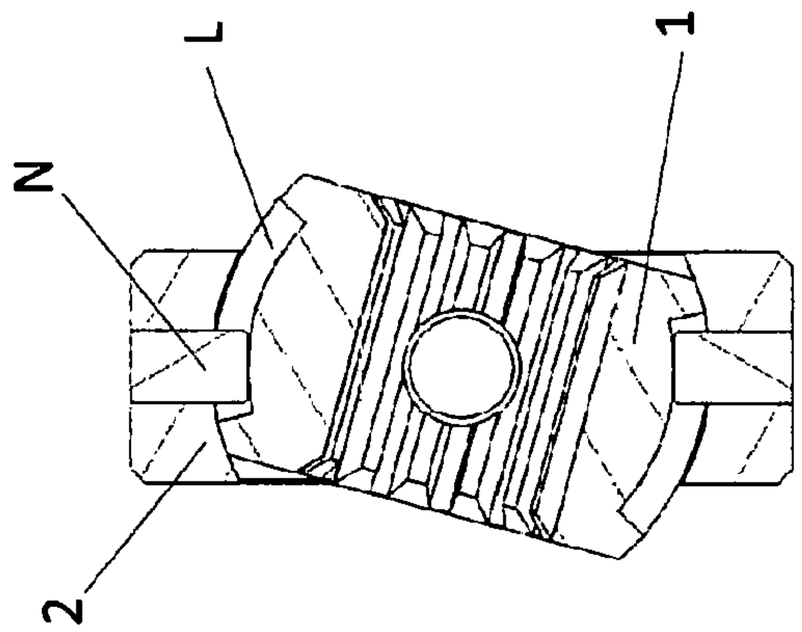

FIG 8

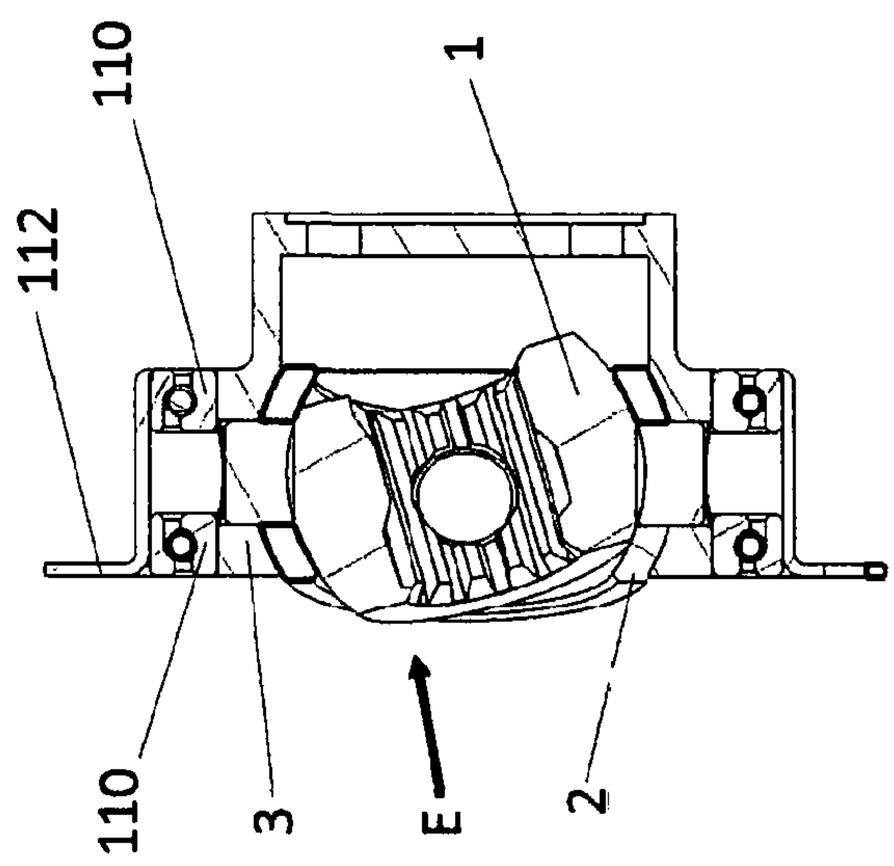

FIG 10

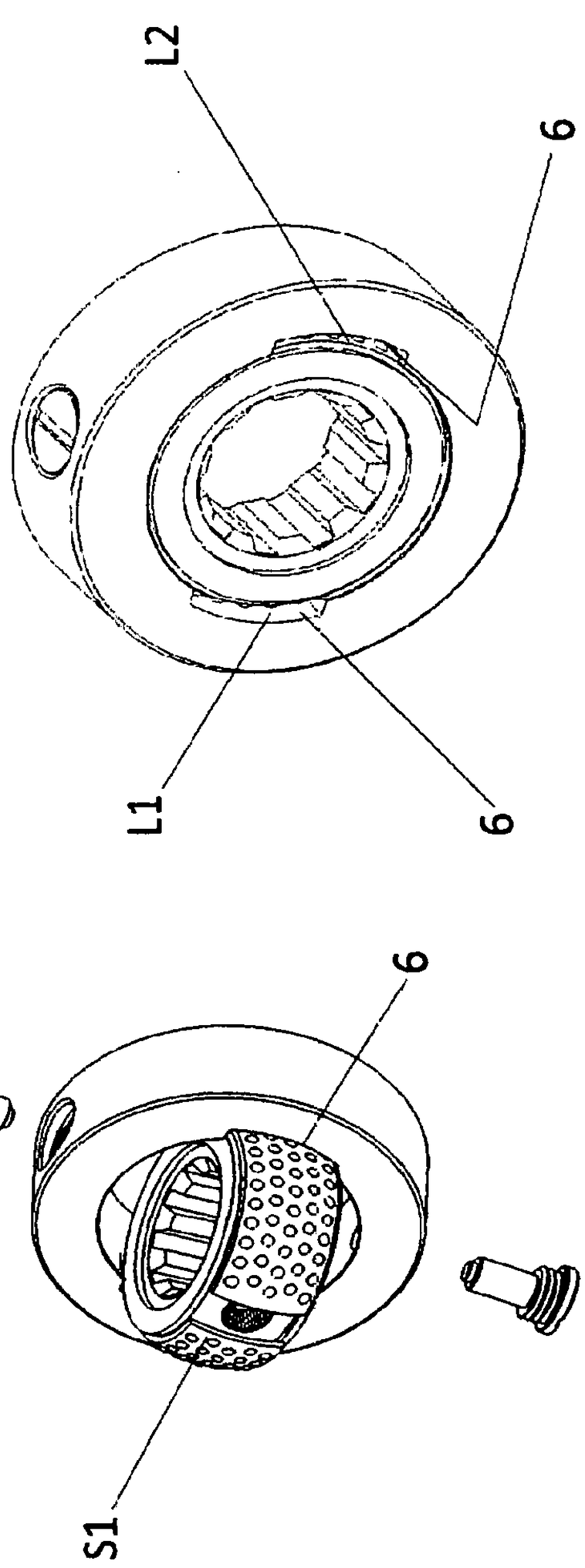

FIG 11B

FIG 11A

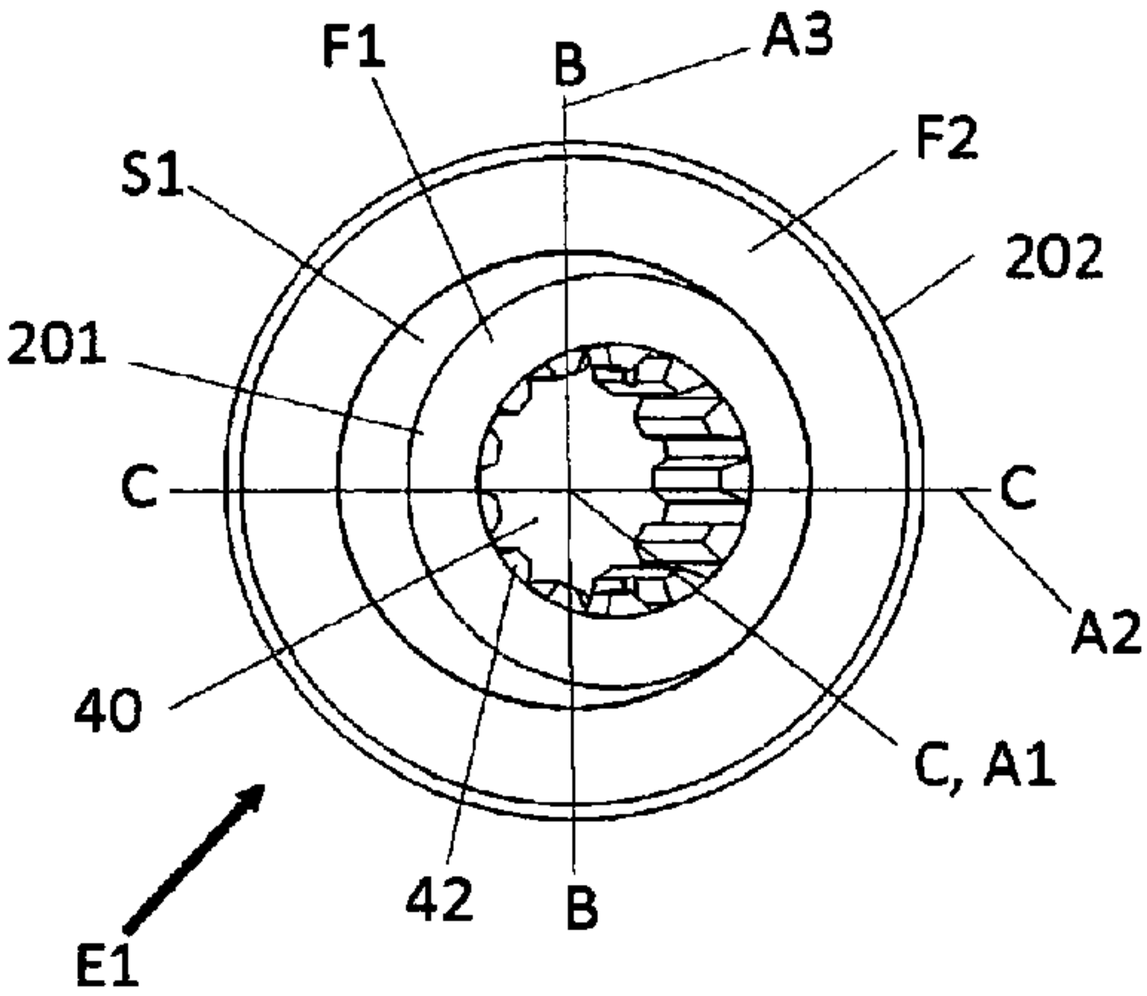
F1
B
A3
F2
S1
202
201
C
C
A2
40
C, A1
42
B
E1

FIG 2A

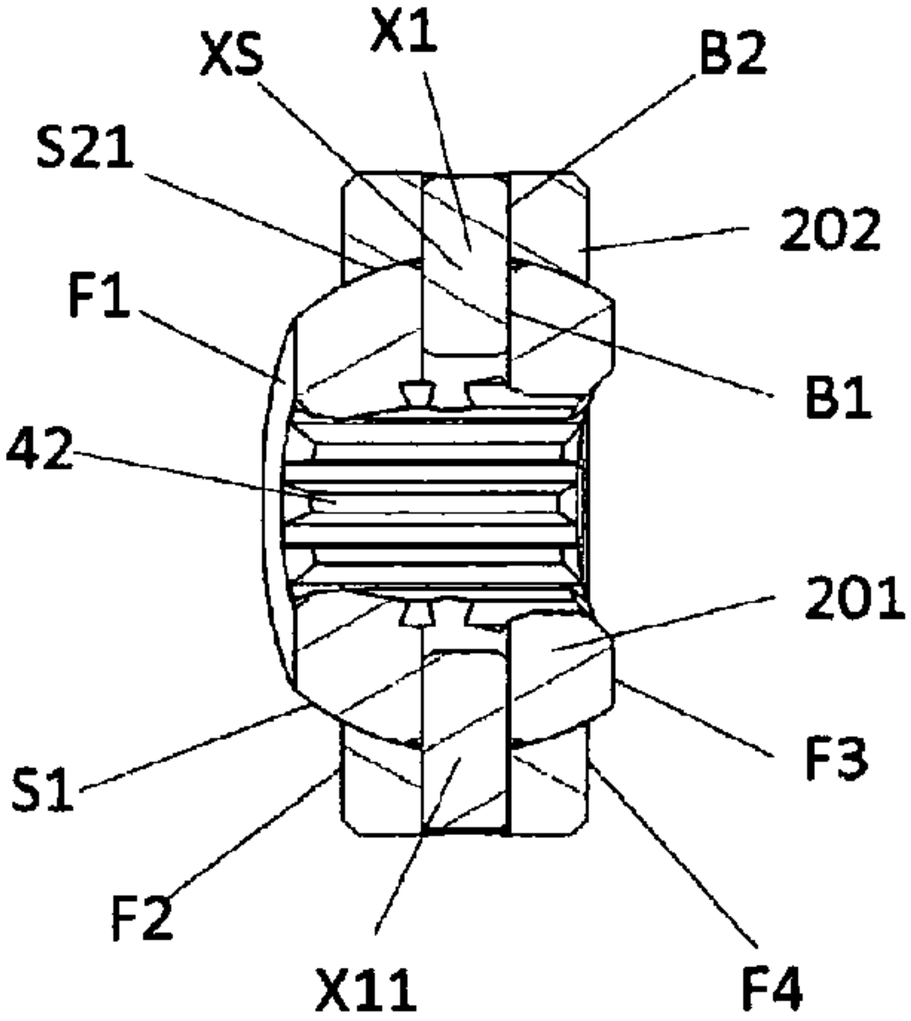
XS
X1
B2
S21
202
F1
B1
42
201
F3
S1
F2
X11
F4

FIG 2B