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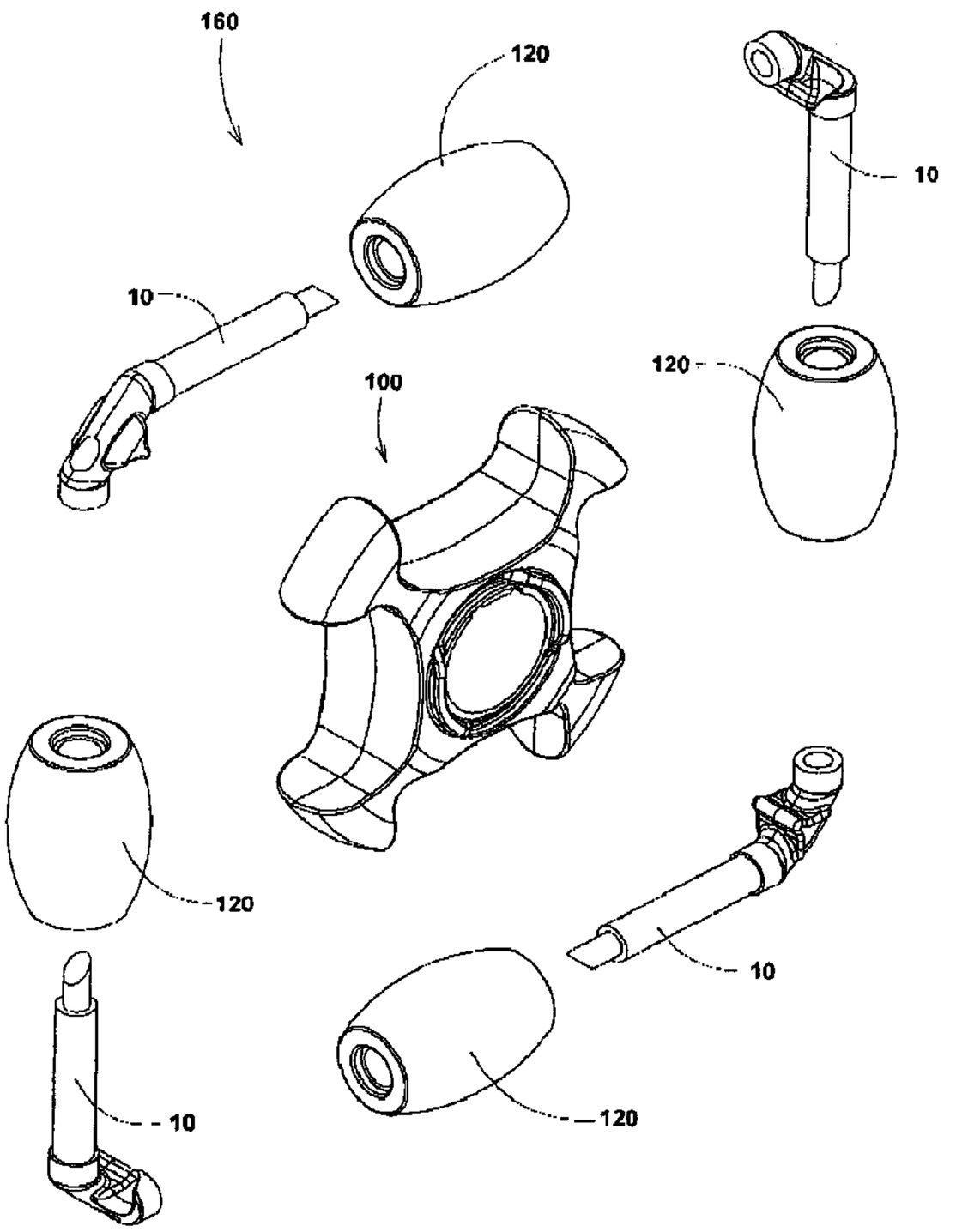

FIG. 8

(57) Abrégé/Abstract:
A method of assembling a wheel rotatable about a main axis and having a plurality of peripheral rollers mounted on peripheral axles aligned tangentially about said wheel and radially spaced from said main axis, each said peripheral axle joined to adjacent other

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(57) Abrégé(suite)/Abstract(continued):
peripheral axles to form a continuous ring comprising said peripheral axles, said method including the steps of: molding each peripheral axle in a die having a cylindrical cavity tor forming the axle shaft of said peripheral axle without longitudinal separation tines, Said peripheral axles each having a receiving head portion for receiving a free end of said axle shall of an adjacent peripheral axle; mounting a roller on each said axle shaft; joining said peripheral axles together to form a continuous ring of peripheral axles; and molding a wheel body including a support structure around said continuous ring.

ABSTRACT

A method of assembling a wheel rotatable about a main axis and having a plurality of peripheral rollers mounted on peripheral axles aligned tangentially about said wheel and radially spaced from said main axis, each said peripheral axle joined to adjacent other peripheral axles to form a continuous ring comprising said peripheral axles, said method including the steps of: molding each peripheral axle in a die having a cylindrical cavity tor forming the axle shaft of said peripheral axle without longitudinal separation tines, Said peripheral axles each having a receiving head portion for receiving a free end of said axle shall of an adjacent peripheral axle; mounting a roller on each said axle shaft; joining said peripheral axles together to form a continuous ring of peripheral axles; and molding a wheel body including a support structure around said continuous ring.

WHEEL FRAME

FIELD OF INVENTION

This invention relates to a wheel. More particularly, this invention relates to a wheel frame. Still more particularly, this invention relates to a wheel frame for a wheel having a plurality of peripheral rollers capable of rotating about peripheral axes aligned normal to the main axis of rotation of the wheel.

BACKGROUND ART

The following references to and descriptions of prior proposals or products are not intended to be, and are not to be construed as, statements or admissions of common general knowledge in the art. In particular, the following prior art discussion does not relate to what is commonly or well known by the person skilled in the art, but assists in the understanding of the inventive step of the present invention of which the identification of pertinent prior art proposals is but one part.

A type of wheel capable of multiple directional travel (whilst the main axis of rotation remains oriented in the same direction) has been described variously as an omniwheel and multi-directional wheel. Such wheels include a central hub rotatable about a main axis and a plurality of independently mounted rotatable rollers located about the rim of the hub. The rollers are each capable of rotation about an axis normal to and radially spaced from the main axis whereby the wheel is capable of moving in a first direction in which the wheel rotates about the main axis or in a transverse direction in which one or more rollers contacting the ground rotate about their corresponding axes.

One such wheel has been described in International Patent Application No. PCT/AU01/01175 (publication No. WO02/24471). The multiple directional wheel described therein comprised a circular wheel frame having a plurality of circumferentially spaced peripheral axles on which were mounted a pair of parallel rings of rollers offset relative to one another. The frame included an integrally formed polyaxled ring that required the rollers to be molded over the axles and limited the range of molding techniques that could be utilised. The rollers rotated about multiple axes normal to a main axis of the wheel. The roller axes were each aligned substantially normal to lines extending radially from the main axis through the midpoint of each roller axis. The rollers were positioned to provide a large overlap (20% - 35% in side view) of effective ground contacting surface between diagonally adjacent rollers.

Further improvement to such types of wheels has been described in International Patent Application No. PCT/AU2003/001002 (publication No. WO2004/014667), the entire contents of which is herein incorporated by reference. That disclosure described a method of construction of a frame on which was mounted a single row of rollers. The

single row frames were able to be joined to like frames, in offset orientation, to form multiple rowed wheels having good ground contacting overlap between diagonally adjacent rollers. The method of forming the wheel involved each roller being mounted on to a wrap-around bush which, in turn, was mounted to one of the multiple axles.

An object of the present invention is to ameliorate the aforementioned disadvantages of the prior art or to at least provide a useful alternative thereto.

STATEMENT OF INVENTION

Accordingly, in one aspect of the invention there is provided a wheel rotatable about a main axis and having a plurality of peripheral rollers mounted on peripheral axles aligned tangentially about the wheel and radially spaced from the main axis, each peripheral axle joined to adjacent other peripheral axles to form a continuous ring.

Each peripheral axle may be molded in a single molding process. The peripheral axle may include an axle shaft. In a particularly preferred embodiment, the peripheral axle die may configured to produce no mold parting or separation lines extending longitudinally along the axle shaft. The peripheral axle may be molded in a die that produces no mold parting or separation lines on or around the axle shaft. Preferably, all or part of the length of the axle shaft of each peripheral axle is molded in a die that defines a cylindrical cavity. Although not preferred, if the relevant portion of the die must include two or more components that combine to define the required cavity, the mold separation line should extend laterally, but not longitudinally, on the axle shaft, for example along an annular step portion at a location along the length of the axle shaft.

The peripheral axle may include a head. The head may be sized and configured to receive a free end of an axle shaft of an adjacent peripheral axle. A portion of the die for molding the head may comprise components that form a lateral or longitudinal separation line during molding of the peripheral axle.

The head may define a bore configured to receive a free end of an axle shaft of an adjacent peripheral axle. The bore may be defined by a mouth extending from the head. The mouth and the bore may be cylindrical and/or conical in shape. Preferably, the mouth and the bore are cylindrical.

In a particularly preferred embodiment, the mouth is molded in a component of the die that produces no mold parting lines along the length of the cylinder or cone forming the mouth. Accordingly, preferably the peripheral axle die further includes a component that defines a cylindrical or conical cavity to form the mouth without producing mold parting lines, and particularly mold parting lines extending longitudinally along the

mouth.

The mouth may be wholly or partially cylindrical and/or wholly or partially conical in internal and external shape. Similarly, the axle shaft may be uniformly cylindrical or may be frusto-conical in shape. The axle shaft may be partly conical in shape, particularly proximal to its free end. Accordingly, the axle shaft and mouth may be each be molded in a die component defining a cylindrical or conical structure, or a combination of both. This enables the axle shaft and mouth to be formed in a single die die component defining a cylindrical or conical cavity that completely surrounds the component to be formed. This die arrangement may have the affect that no mold parting lines extending longitudinally are formed on the axle shaft and mouth components so these components, having a closely circular cross-section at any point along their length, may be formed to have a round cross-section to a high degree of accuracy. This enables the axle shaft to mouth components to be uniformly and consistently molded accurately round without blemishes and shape inconsistencies, enabling manufacturing to low tolerances with resultant minimal play between moving parts.

The peripheral axle head portion may be separately formed from the peripheral axle shaft portion, although this is not preferred as it would add to the number of components required for a particular wheel.

Each head effectively forms a corner of the continuous ring. The head may include an annular shoulder at one end to retain the roller on the axle shaft. The other end of the head includes the mouth. The head includes a corner portion wherein the mouth bore has a longitudinal axis set at an angle θ (theta) relative to the longitudinal axis of the axle shaft. The general angle 0 (theta) may be determined by the algorithm 180-360/n, where n equals the number of peripheral rollers lying in a single plane on the continuous ring. Correspondingly, n equals the number of peripheral axles constituting the continuous ring.

Accordingly, the wheel may comprise three or more rollers up to a practical maximum of ten rollers. Based on the above formula, the angle 0 (theta) for a head of a triple roller wheel is about 60˚. The angle θ (theta) for a head of a four roller wheel is about 90˚.

The axle shaft may terminate in a free end that is the same radius as the remainder of the axle shaft. That is, the axle shaft has a consistently round cross section throughout its length. Alternatively, the axle shaft may include a stepped terminating portion that has a smaller or larger radius than the main body of the axle shaft. The terminating portion may be sized and configured to be received in the mouth. Accordingly, the radius of the mouth bore may be smaller than the radius of the main body of the axle shaft and the

external cylindrical or conical wall of the mouth may have a greater diameter than the diameter of the axle shaft main body at the juncture. In this way, the mouth may perform as an annular shoulder effective to retain a roller on the axle shaft between the head of the peripheral axle on which the roller is mounted and the head of an adjacent peripheral axle.

The mouth bore may be a through-bore extending through from the mouth to an open end at the back of the head. The through-bore may be effective to permit the terminal end of the axle shaft to be in contact with an over molded support of the wheel body. The through bore may thus provide an opening into which the over molded wheel body may extend during the molding process to reinforce the connection between the axle shaft and the head to provide the combined structure of the axles and the over molded wheel body that is of greater strength and rigidity than if the overmolding did not so extend into the interstitial spaces of the axle head. The terminal end butt of the axle shaft may be shaped at an angle transverse to the longitudinal axis of the axle shaft to permit a greater length of axle shaft to be inserted into the mouth bore whilst conforming to the corner portion shape. The join between the axle shaft and the head of an adjacent peripheral axle may be further strengthened by adhesive, heat fusion, ultrasonic or other known joining or welding techniques.

The wheel preferably further comprises a wheel body or frame. The wheel body may include a hub or central aperture defining a main axle or central bore. Extending from the hub or an inner rim of the wheel body may be plurality of outwardly extending supports. The outwardly extending supports may extend radially from the centre of the wheel body. The outer ends of the supports may secure the heads. Preferably, the wheel body is formed at least partially around the heads. The heads may be mounted on or in the outwardly extending supports. The outwardly extending supports may partially or wholly surround the heads, provided that the supports do not interfere with the movement of the rollers.

The wheel components may be made from a number of different materials and may comprise a composite of components made from different materials. However, the skilled person will appreciate that a wide variety of suitable materials may be employed, depending on the application and strength and wear demands on the wheels.

For example, the peripheral axles may be made from high strength molded plastic, cast steel, or a composite of two or more different materials. For example, axles may include a molded plastic casing reinforced with inner metal rods or other reinforcing structures.

Alternatively, the peripheral axle may be constructed such that the axle shaft consists of

a metal rod with no plastic overmold, except about the shaft end attached to the axle head, the head consisting of a plastic molded component.

The bushings may be made from high strength extruded plastic over which the rollers may be molded. Accordingly, the bushings may be inserts molded inside, for example, polyurethane elastomeric rollers.

The bushings may be shaped to follow the contours of the roller tyre. For example, the external surface of the bushing may have a plurality of annular ribs aligned laterally relative to the bushing's longitudinal axis to better grip the tyre (preferably overmolded) and be effective against against longitudinal slippage or movement of the tyre relative to the bushing. Preferably, however, the external surface has a plurality of longitudinal ribs. Advantageously, the longitudinal ribs are arc or bow shaped to follow the general cigar shape of the roller's external shape. The arched ribs are preferably solid and integral to the general cylindrical core of the bushing throughout their lengths, although they may be supported only at their ends and bowed in the middle. Longitudinally aligned ribs will reduce relative movement between the ribs and the tyre as the roller rolls about its longitudinal roller axis, strengthening the join and extending the life of the roller.

In another aspect, the invention provides a method of assembling a wheel rotatable about a main axes and having a plurality of peripheral rollers mounted on peripheral axles aligned tangentially about the wheel and radially spaced from the main axes. Each peripheral axle being joined to adjacent other peripheral axles to form a continuous ring, the method including the steps of:

molding each peripheral axle in a die having a cylindrical cavity for forming the axle shaft of the peripheral axle without longitudinal separation lines, the peripheral axles each having a receiving head portion for receiving a free end of the axle shaft of an adjacent peripheral axle;

mounting a roller on the axle shaft;

joining the peripheral axles together to form a continuous ring of peripheral axles; and

molding a wheel body including a support structure around the continuous ring.

The wheel body may include a central hub to be rotatably mounted on the main axle.

The support structure may include a plurality of outwardly extending arms that support the receiving heads in spaced relationship to the main axes.

The step of mounting a roller on each axle shaft may be preceded by the step of first forming a bush as a sleeve to be mounted on the axle shaft. The corresponding roller may be molded around the bush prior to mounting on the axle shaft. The step of mounting the roller on each axle shaft may include inserting the bush into a roller and then inserting the axle shaft into the corresponding bush and roller.

The head may further include spurs, ridges or other surface features that permit greater adherence to a structure molded about the head or a segment thereof. The spur or other surface features may serve to increase the surface area between the adhering wheel body and the receiving head thereby strengthening and reinforcing the join and increasing the strength and rigidity of the wheel structure.

The receiving head may include a mouth defining a short bore, the mouth forming an annular shoulder on the axle shaft to trap the corresponding roller on the shaft between the receiving head and the mouth.

The receiving head including the corner portion may be shaped so that the longitudinal axes of the axle shaft is set at an angle θ (theta) to the longitudinal axes of the short bore. The angle 0 (theta) may be determined by the algorithm 180-360/n, wherein n equals the number of peripheral rollers lying in a single plane on the continuous ring.

The die may include an additional cylindrical cavity for forming the mouth devoid of longitudinal separation lines thereon.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be better understood from the following non-limiting description of preferred embodiments, in which:

Figures 1a – 1i are various views of a peripheral axle according to one embodiment;

Figures 1j – 1p are various views of a peripheral axle according to another embodiment;

Figures 1q – 1w are various views of a peripheral axle according to yet another embodiment;

Figures 2a – 2c are various views of a bush according to one embodiment;

Figures 2d – 2f are various views of a bush according to another embodiment;

Figures 2g – 2i are various views of a bush according to another embodiment;

Figures 3a – 3d are various views of a roller;

Figures 4a – 4f are various views of a wheel body;

Figures 5a – 5d are various views of a wheel;

Figures 6a – 6d are various partially transparent views of the wheel shown in Figures 5a -5d;

Figures 7a and 7b are sectional views of the wheel shown in Figures 5a -5d;

Figure 8 is an exploded view of the wheel shown in Figures 5a -5d, noting intersections between the peripheral axles and the wheel body supports are not shown;

Figures 9a and 9b are perspective and ghosted views, respectively, of a continuous ring assembled without rollers;

Figures 10a – 10c are perspective and ghosted views of a continuous ring and rollers preassembly;

Figures 11a and 11b are cut-away and ghosted views, respectively, of a peripheral axle and roller preassembly;

Figure 12 is cut-away sectional view of the peripheral axle and roller preassembly shown in Figures 10a – 10c;

Figure 13 is a perspective view of a peripheral axle and a head of an adjacent peripheral axle;

Figure 14 is a perspective view of a pair of peripheral axles mated together without a roller;

Figure 15 is a ghosted perspective view of a pair of peripheral axles with mounted rollers and an unmated pair of peripheral axles with mounted rollers prior to complete assembly;

Figure 16 is a perspective view of the peripheral axles and rollers shown in Figure 15 assembled prior to insertion into a wheel body injection mold;

Figure 17 is a perspective ghosted view of the assembled wheel completed in an injection mold;

Figure 18 is a perspective view of the completed wheel after removal from an

injection mold;

Figure 19 is a perspective cut-away view of the join between a peripheral axle head, adjacent peripheral axle shaft and wheel body support; and

Figure 20 is a perspective view of a completed twin wheel made according to an aspect of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Preferred features of the present invention will now be described with particular reference to the accompanying drawings. However, it is to be understood that the features illustrated in and described with reference to the drawings are not to be construed as limiting on the scope of the invention.

Referring to Figures 1a to 1i, there is shown a peripheral axle 10 comprising a head 20 and an axle shaft 50. The peripheral axle 10 shown is one of four peripheral axles 10 shaped to form a continuous ring 80 (see below) with three other like peripheral axles 10. However, the skilled person will appreciate that the continuous ring 80 may be configured to comprise a lesser or greater number of peripheral axles, for example between three and ten axles making up the continuous ring of a wheel (see below). In each case, the peripheral axle 10 components may be identical, having a male end (the axle shaft 50) and a female end (the head 20), so that each peripheral axle 10 may mate with a like, adjacent peripheral axle 10 to form a continuous ring 80 comprising between three and eight peripheral axles 10.

The head 20 includes a mouth 30 and corner portion 40.

The mouth 30 is a short cylinder defining a bore 32. The bore 32 may be cup-shaped and may terminate in the corner body 42 of the corner 40. However, preferably, the bore 32 may be a through-bore extending fully through to the rear of the corner body 42. The bore 32 internal walls may be keyed with longitudinal surface features that cooperate with corresponding features on the axle shaft 50 to mitigate against rotation of the axle shaft 50 in the bore 32, but preferably the bore 32 and the corresponding axle shaft are round in cross section.

The corner portion 40 sets the angle 0 (theta) at which the cylindrical axis of the bore 32 is set relative to the longitudinal axis of the axle shaft 50. Based on the formula 180-360/n, where n equals the number of peripheral axles 10 lying in a single plane on the continuous ring 80, the corner angle θ (theta) for a head of a four axled embodiment is about 90°.

The corner portion 40 further comprises a generally cylindrical body 42 extending between the mouth 30 and an annular shoulder 44 aligned coaxially with the axle shaft 50. The corner body 42 includes surface features in the form of a spur 46 having two lateral triangular projections extending either side of the corner body 42, and bridged to each other in the elbow of the corner body 42.

The surface features may also be in the form of ridges, knobs, other protrusions or grooves that increase the surface area of the corner body 32. This increases the strength of the join between the peripheral axle 10 and an over-molded wheel body 100 as will be described below. The spur's 46 lateral projections 46a,b extending in opposed lateral directions, and the elbow bridge 46c extending inwardly toward a main axis of the wheel (see below), provide structures in three different directions for optimum rigidity and strength in the over-molded join between the peripheral axle 10 and the wheel body 100.

Coaxial with the annular shoulder 44 is the axle shaft 50. The axle shaft 50 comprises an elongate, uniformly cylindrical axle 52 stepped down in diameter relative to the shoulder 44, so that the shoulder 44 provides an annular retaining wall 45 for trapping one end of a roller 140 (see below).

It will be appreciated by the skilled person that in molding an axle shaft 50 or mouth 30 structure so that the structures are accurately round at any cross-section slice along their lengths, structures of either a conical or cylindrical shape may be utilised within the scope of this invention. The axle shaft 50 may be marginally truncated conical in shape, as may the mouth 30 and its bore 32. The conical shape may be useful to achieve length limiters that restrict the axial movement of the axle 50 relative to a roller 120, or the axle 50 relative to the bore 32. However, in the preferred arrangement shown, the structures are 50, 30 are shown as cylindrical.

The axle shaft 50 may be of consistent cross-section throughout its length and may be in the form of a cylinder. However, preferably the terminal end 52 of the axle shaft 50 terminates in an angled wall 54 having a plane lying at an angle α (alpha) to the longitudinal axis 56 of the axle shaft 50. The greater the number of rollers 120 (see below) in a single wheel plane, and the greater the corresponding number of corner portions 40, the larger the angle θ (theta). The angle α (alpha) is inversely proportional to the angle 0 (theta). For a four roller wheel, the angle α (alpha) is 90°.

Furthermore, the terminal end 52 may have a step down terminal portion 58 connected to the main cylinder 52 by an annular step 59. The terminal portion 58 is shaped and configured for insertion in the mouth bore 32, so that the angled wall 54 extends to the outer wall 43 of the corner body 42. The angled wall 54 preferably does not extend

beyond the outer wall 43, but may be flush therewith.

The axle shaft 50 is of a sufficient thickness to provide a structurally rigid and strong axle along its length. For example, in the embodiment shown in Figure 1a – 1i, the axle 50 diameter may be 3.8mm for a 48mm sized wheel 160, although the axle 50 diameter may vary depending on the application and wheel 160 size. The mouth 30 wall may be sufficiently thick for joint strength with the terminal portion 58, as well as to provide a step (in the form of mouth face 31) from the axle 50 to the mouth 30 outer wall. The spur 46 adds mass to the corner or bridge portion 20 and to increase the surface area for over-mould adhesion with the wheel body 100.

The axle shaft 50 may be solid or hollow in structure. The axle shaft 50 for heavy load applications is a composite structure having a metal rod extending centrally and longitudinally along a substantial proportion of its length to provide a central and longitudinal reinforcing beam. Alternatively, the axle shaft 50 may be wholly made of metal or wholly made of plastic.

Referring to Figures 1j-1p, there is shown an alternative embodiment of a peripheral axel 310. The peripheral axel 310 comprises a steel axel shaft 350 and a plastic over-molded head 320, but is otherwise of the same shape and configuration as the peripheral axel 10. Referring to Figures 1q-1w, there is shown an alternative peripheral axel 410 comprising a composite of steel and plastic over-molded materials, wherein the axel shaft 450 includes an inner steel core rod or pin 451 and a plastic over-molded sleeve 452. The steel core rod 451 is continuous with a terminal portion 458 and the outer extent of the plastic over-molded sleeve 452 forms an annular step 459. As best seen in Figure 1w, the plastic over-molded sleeve 452 is contiguous with the head 420. The head 420 is formed with plastic material integrally formed with the plastic over-moulded sleeve 452.

Referring to Figures 2a to 2c, there is shown a bush 140 in the form of a hollow cylinder having a longitudinal axis 142 and defining an internal cylindrical bore 144 shaped and configured to receive the axle shaft 50. The internal cylindrical bore 144 is preferably shaped and configured to receive the main cylinder 52. The bush 140 may be mounted on the main cylinder 52 between the annular step 59 and the annular retaining wall 45.

A first bush end 146 may abut, be flush with, or lie close to or in the same plane, as the annular retaining wall 45 and the other bush end 148 may, be flush with, or lie close to or in the same plane, as the annular step 59.

Instead of the bushing 140, there is shown in Figures 2j-2l an alternative bushing 340 comprising a plurality (in this case twelve) of longitudinal ribs 342. The longitudinal

ribs 342 are arced along their length whereby their respective mid sections 344 are radially spaced further away from the longitudinal axis 356 than the ridges' 342 respective ends 346. The longitudinal ridges 342 therefore form solid arcs extending longitudinally along the external surface of the bushing 340, whereby the bushing 340 generally has a longitudinally ribbed cigar shape that may correspond to the general cigar shape of roller tyres to be over-moulded thereon. The longitudinal ridges 342 are preferably integrally formed with the main body or core 341 of the bushing 340.

Turning to Figures 2m-2o, yet another alternative bushing embodiment is shown in the form of barrel shaped bushing 440. The internal bore 344, 444 is cylindrical whereby to conform to the general cylindrical shape of the axel shaft 50. However, the external surface 442 of the barrel shaped bushing 440 is, indeed, cigar or barrel shaped whereby to correspond to the generally cigar or barrel shaped rollers 120 that may be molded thereon. The provision of a cigar shaped bushing 440, made of necessarily hardened plastic, relative to the softer elastomeric plastics of which the tyre is made, may serve to strengthen the overall roller 120 construction, save on elastomeric material and give greater strength to the roller 120 throughout it's length relative to a straight cylindrical bushing 140. The arced curvature of the bushing 440 represents a stronger structure with regard to lateral forces to which a roller 120 may be subjected to transverse to the longitudinal roller axis 142, compared to the straight cylindrical bush 140.

Referring to Figure 3a to 3d, preferably the bush 140 is retained within a cylindrical cavity 122 in the roller 120. The roller 120 includes a pair of opposed openings at each end 124 that are coaxial with the cylindrical cavity 122. The bush 140 has a smaller internal diameter and a larger outer diameter than the openings 124. The roller tyre 126 may be over-molded on the bush 140 as will be described below.

The roller 120 is a bi-truncated fusiform, barrel or cigar-shape. The thickness of the roller tyre 126 at its respective ends as indicated by reference no. 128 is critical for a number of reasons. The end portion 128 of the roller 120 must be sufficiently thick to preclude failure through normal wear and tear as the stresses and potential for failure are greatest at the end portion 128. However, the thicker the end portion 128 is, the more difficult it is to achieve significant overlap between diagonally adjacent rollers in a wheel such as the twin wheel 180 shown in Figure 20. This is because the more elongate bi-truncated fusiform shape better accommodates greater overlap between diagonally adjacent rollers 120a,b, but a finely tapered end portion 128 will make the roller 120 less robust and likely to smoothly rotate, and more prone to failure and less resilient to normal wear and tear.

The dimensions of wheel 160 and the rollers 120 may vary for different applications.

The radius of curvature of the rollers 120 when viewed in side elevation generally will follow the radius of curvature of the wheel periphery. Larger wheels will have rollers having a larger radius of curvature. The number of rollers per frame may be determined according to criteria such as the relative strength of component materials and structures and the capacity of individual rollers to bear the load transferred through the main axle 15. High load wheels will require barrel-shaped, proportionally shorter rollers having thicker roller tyres to withstand the large forces, particularly those borne at the remotes ends of the rollers when in ground contact. Lighter load applications may utilise cigar-shaped, more elongate and small diameter rollers that may be employed to reduce production and raw material costs.

In Figures 4a-4f there is shown the wheel body 100 as it would be shaped without the intersecting peripheral axles 10. The wheel body 100 comprises a central hub 102 journaled for rotation about a main bearing 104 that is keyed by longitudinal slot 106 for mounting on a main axle 15 (see Fig. 20). The wheel body 100 further includes a plurality of outwardly extending arms 108. The arms are preferably extend radially. The arms 108 terminate in support heads 110 that are, in side elevation as shown in Figure 4a., substantially triangular in shape. Adjacent supports 110 present opposed substantially parallel planar faces 112 between which extend the axle shaft 50 when the wheel 160 is assembled. In the embodiment shown, the wheel body 100 is shaped to accommodate four rollers 120, thereby comprising four radial arms 108.

The wheel body 100 may be bi-symmetrical through a plane B as shown in Figure 4b. More preferably, the wheel body 100 includes an outer rim 114 and an inner rim 116. The inner rim 116 includes locking elements 118 comprising a pair of raised arc tracks 111, 113 that include complimentary grooves and ridges adapted to lockably engage each other when like wheel bodies 100 are abutted with their respected inner rims 116 facing each other. The respective wheel bodies 100 are positioned so that the raised arc locking elements 111, 113 are positioned in arc gaps 115 and rotated 90° so that the respective locking elements 111, 113 engage.

In another embodiment, the locking elements 111, 113 are identical in shape and configuration, but rotated 180° relative to each other. The locking element 111a, 113a shown in Figure 4d include a receding ramp117 including a trapped groove into which corresponding lead projections 119 enter to positively engage the respective wheel bodies 100. The respective wheel bodies 100 may be further chemically or mechanically bonded by subjecting the combined twin wheel body 180 to, for example, ultrasonic welding to provide a strong bond between the respective surfaces of the facing inner rims 116 so that they are locked in non-reversible engagement.

As shown in Figure 4f, the support ends 110 are slightly biased towards the inner side 101 of the wheel body 100 when viewed in transverse section along line A-A of Figure 4e.

In Figures 5a-5d a completed wheel 160 is shown with the wheel body 100 over molded onto the peripheral axles 10.

In Figures 6a-6d, the internal detail of the over-molded connection between the peripheral axles 10 and the supports 108 are shown in greater detail. It can be seen that the spurs 46 provide rigid internal structures around which the over-molded support 108 strongly contacts over a large surface area to ensure a strong and rigid connect between the peripheral axles 10 and the support 108. It can also be seen that the wheel body 100 is shaped and configured to provide a cradle or recess 105 within which the roller 120 is suspended by its mounting to the peripheral axle 10.

In Figures 7a-7b, sectioned views of the wheel 160 show the relationship between the over-molding of the support 108 and the terminal end 58 of the peripheral axle 10, together with the mouth bore 32. The terminal end 58 terminates just short of lying flush with the outer opening of the mouth bore 32, so that mold material of the support 108 penetrates into the mouth bore 32, strongly connecting with the peripheral axle 10, both at the head 20 and the peripheral end 58. Also indicated is the relationship between the axle shaft 50, the annular retaining wall 45 and the bush 140, stepped wall 59 and the mouth 30. It can be seen that the annular retaining wall 45 and mouth facing wall 31 are inserted into the openings 124 and abut the ends 146, 148 of the bush 140, so that the roller 120 is trapped for rotation within the recess 105 and able to freely rotate about the axle shaft 51.

In Figure 8 there is shown the components of the wheel 160 in exploded view. The wheel 160 comprises the wheel body 100, four peripheral axles 10 and four rollers 120. In Figures 9a and 9b show how the peripheral axles 10 join together to form a continuous ring 80 by the joining of four identical peripheral axles 10 by the insertion of the axle shaft 50 of each peripheral axle 10 into a mouth 30 of an adjacent peripheral axle so that the terminal end 58 extends almost, but not fully, through the mouth bore 32. It is noted that the rollers 120 may be over molded over the axle shafts 50, so that the continuous ring 80 may be formed before the rollers 120 are mounted to the continuous ring 80. However, it is preferred that the rollers 120 are first formed about a corresponding bush 140 and mounted on to the corresponding peripheral axle whilst the terminal end 58 is free and unattached to an adjacent peripheral axle 10. In Figure 9a, it can be seen that the annular shoulder 44 is integrally formed with the axle shaft 50.

In Figures 10a-10c, the rollers 120 are shown assembled onto the continuous ring 80

preparatory to the wheel body 100 being over molded onto the heads 20 of the preformed peripheral axles 10.

In Figure 11a the formation of the roller 120 and peripheral axle 10 is shown. The peripheral axle 10 is separately molded, as is the bush 140. The roller tyre 126 is then molded over the bushing 140 to form a roller module comprising the roller tyre 126 and bushing 140. The roller module 120, 140 is then mounted on to the axle shaft 50 by insertion of the axle shall 50 through either end of the roller module 120, 140. The roller module 120, 140 is mounted on to the axle shall 50 so that either end 146, 148 of the bush 140 abuts the annular retaining wall 45. The opening 124 may be of a marginally greater diameter than the annular shoulder 44 to minimise friction as the roller 120 rotates, although the gap between the end portions of the roller 128 and the annular shoulder 44 are minimal to reduce the effect of compressive forces applied to the end roller portions 128.

It will be appreciated that the external diameter of the mouth 30 is preferably identical to that of the annular shoulder 44, so that the insertion of the terminal end 58 in the mouth bore 32 until the mouth 30 open face 31 abuts the stepped wall 59, the end roller portion 128 partially extending over the mouth 30 as best seen in Figure 7b. In Figure 11b, the bushing 140 is shown mounted onto the peripheral axle 10. The peripheral axle 10 may be molded from high strength plastic material, the bushing 140 from high strength, low friction plastic material and the roller tyre 126 from a high strength and moderately high friction polymer.

As with Figures 7b, 12 and 19 clearly demonstrate the configuration of the join between the terminal end 58 and head 20, as well as the mounting of the roller 120 over the extruded plastic bushing 140.

Figures 13 and 14 demonstrate the insertion of the terminal portion 58 into the mouth bore 32 in a "line to line fit" that holds the adjacent peripheral axles 10 together. As should in Figure 14, the joining of the axle shall 50 with the mouth 30 creates a second annular step formed by mouth face 31 abutted against the stepped wall 59 whereby the mouth face 31 and annular retaining wall 45 are effective to trap the roller bushing 140 on the axle shaft 50.

In Figure 15 the step of joining pairs of sub assemblies of peripheral axle 10 and roller module 120,140 combinations is shown whereby to form pairs which are then joined to form a continuous ring 80 on which n number of rollers are mounted.

Figure 16 shows the assembled pairs of sub assemblies joined to form a continuous ring 80 prior to it being inserted into a wheel body 100 injection mold 200 whereby the

continuous ring 80 and rollers 120 are nestled into the mold 200 which is then shut as shown in Figure 17 to lock the continuous ring 80 and rollers 120 in place. Shut offs in the mold 200 secure the continuous ring 80 for molding and then the wheel body 100 is injected over the continuous ring 80.

The dye or mold 200 includes a central insert 202 that defines the cavity corresponding to the main axle bore 101 shown in Figure 4a and Figure 4f. The insert 202 also includes a longitudinal ridge 204 that forms the keyed slot 106. As shown in Figure 18, the completed wheel 160 may then be removed from the mold 200.

As shown in Figure 19, the terminal portion 58 extends through the mouth bore 32, but leaves a small area adjacent to the outer opening of the mouth bore 32 to permit the over molded wheel body 100 in the area of the support heads 110 to penetrate and mold into and around the mouth bore 32 to increase the adhesion of the wheel body 100 to the peripheral axle 10 and more particularly the head 20.

A pair of completed wheels 160 are shown as a pair of wheels joined to form a twin wheel 180 mounted to a main axle 15 having a hex cross-section bore. The twin wheel 180 is useful as a omni directional or multi directional wheel and may be used as a substitute, for example, in place of castor wheels.

Throughout the specification and claims the word "comprise" and its derivatives are intended to have an inclusive rather than exclusive meaning unless the contrary is expressly stated or the context requires otherwise. That is, the word "comprise" and its derivatives will be taken to indicate the inclusion of not only the listed components, steps or features that it directly references, but also other components, steps or features not specifically listed, unless the contrary is expressly stated or the context requires otherwise.

Orientational terms used in the specification and claims such as vertical, horizontal, top, bottom, upper and lower are to be interpreted as relational and are based on the premise that the component, item, article, apparatus, device or instrument will usually be considered in a particular orientation, with the context indicating which component is uppermost.

It will be appreciated by those skilled in the art that many modifications and variations may be made to the methods of the invention described herein without departing from the spirit and scope of the invention.

AMENDED CLAIMS
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04 January 2011 (04.01.11)

1. A wheel rotatable about a main axis and having a plurality of peripheral rollers mounted on peripheral axles aligned tangentially about said wheel and radially spaced from said main axis, each said peripheral axle:

aligned normal to a corresponding radial line extending from the main axis;

having a head portion engaged to a shaft of an adjacent other peripheral axle,

the peripheral axles together forming a continuous axle ring.

2. A wheel according to claim 1, wherein each said peripheral axle is molded in a die that produces no mold parting lines extending longitudinally along an axle shaft of said peripheral axle.

3. A wheel according to claim 1, wherein all or part of the length of an axle shaft of each said peripheral axle is molded in a die that defines a cylindrical cavity.

4. A wheel according to claim 3, wherein a mold separation line extends laterally on said axle shaft, not longitudinally.

5. A wheel according to claim 3, wherein each said peripheral axle comprises a head portion sized and configured to receive a free end of the axle shaft of an adjacent peripheral axle.

6. A wheel according to claim 5, wherein said head portion defines a short bore to receive said free end.

7. A wheel according to claim 1, wherein said peripheral axles are identical to one another.

8. A wheel according to claim 6, wherein the axes of said short bore of said peripheral axle and said axle shaft of said adjacent peripheral axle are coaxial.

9. A wheel according to claim 6, wherein the axes of the short bore of one of said

peripheral axles and the axle shaft of the same peripheral axle are set at an angle theta determined by the algorithm 180 – 360/n, where n equals the number of peripheral rollers lying in a single plane on said continuous ring.

10. A wheel according to claim 6, further comprising a wheel body with a hub defining a main axle bore and a plurality of outwardly extending supports on or in which said head portions are mounted.

11. A wheel according to claim 10, wherein said wheel body is formed over said head portions.

12. A method of assembling a wheel rotatable about a main axis and having a plurality of peripheral rollers mounted on peripheral axles aligned tangentially about said wheel and radially spaced from said main axis, each said peripheral axle joined to adjacent other peripheral axles to form a continuous ring comprising said peripheral axles, said method including the steps of:

molding each peripheral axle in a die having a cylindrical cavity for forming the axle shaft of said peripheral axle without longitudinal separation lines, said peripheral axles each having a receiving head portion for receiving a free end of said axle shaft of an adjacent peripheral axle;

mounting a roller on each said axle shaft;

joining said peripheral axles together to form a continuous ring of peripheral axles; and

molding a wheel body including a support structure around said continuous ring.

13. A method according to claim 12, wherein said wheel body includes a central hub to be rotatably mounted on a main axle.

14. A method according to claim 12, wherein said support structure includes a plurality of outwardly extending arms that support said receiving heads in spaced relationship to the main axis.

AMENDED SHEET (ARTICLE 19)

15. A method according to claim 12, wherein the step of mounting a roller on each said axle shaft is preceded by the step of mounting a bush as a sleeve over said axle shafts and the step of mounting the roller on each axle shaft includes inserting the axle shaft and the corresponding bush into a central longitudinal bore in said roller.

16. A method according to claim 12, wherein said receiving head includes a spur that strengthens the join between the receiving head and said wheel body.

17. A method according to claim 12, wherein said receiving head includes a mouth defining a short bore, said mouth forming an annular shoulder on said axle shaft to trap the corresponding roller on said shaft between said receiving head and said mouth.

18. A method according to claim 16, wherein said receiving head is in the form of a corner portion in which the longitudinal axis of the axle shaft is set at an angle theta to the longitudinal axis of the short bore, wherein theta is determined by the algorithm 180 – 360/n, where n equals the number of peripheral rollers lying in a single plane on said continuous ring.

19. A method according to claim 17, wherein said die includes an additional cylindrical cavity for forming said mouth without forming longitudinal separation lines thereon.

20. A wheel or method of manufacture therefor, substantially as hereinbefore described with reference to the accompanying drawings.

AMENDED SHEET (ARTICLE 19)

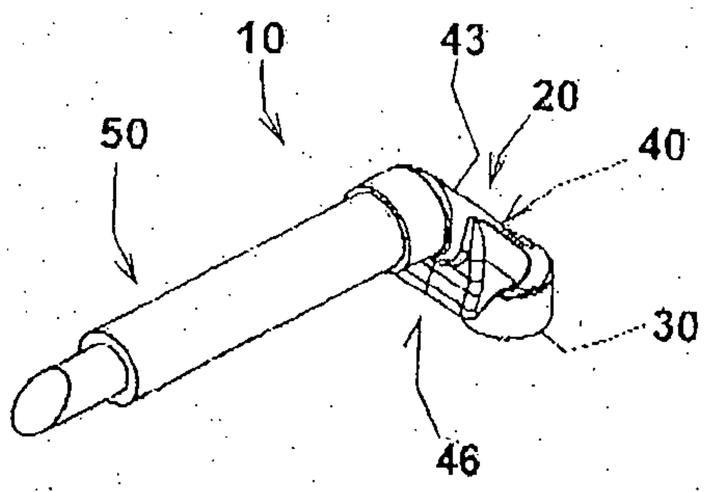


FIG. 1a

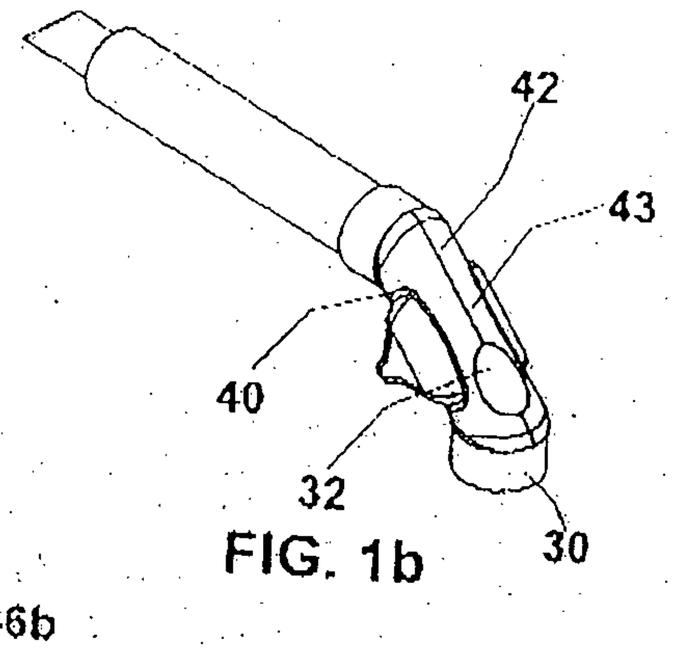


FIG. 1b

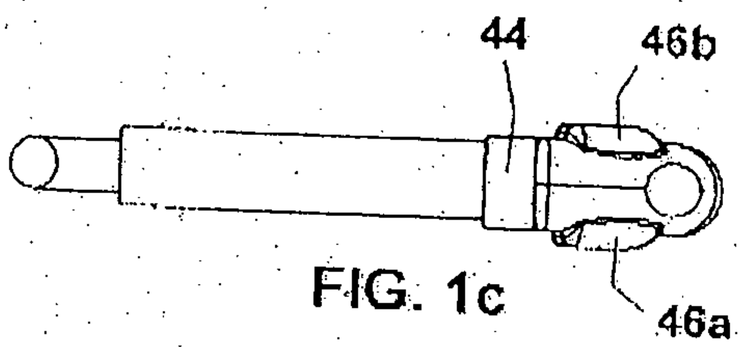


FIG. 1c

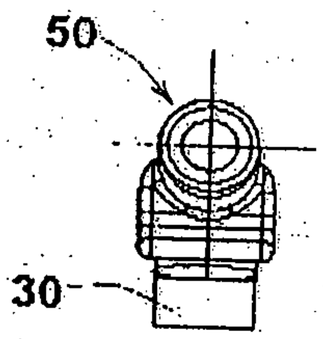


FIG. 1f

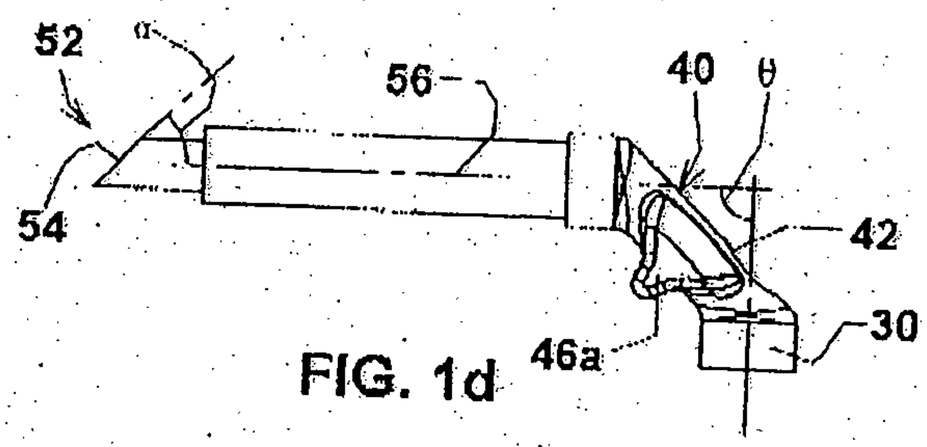


FIG. 1d

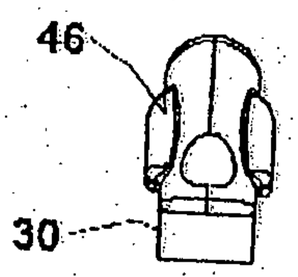


FIG. 1g

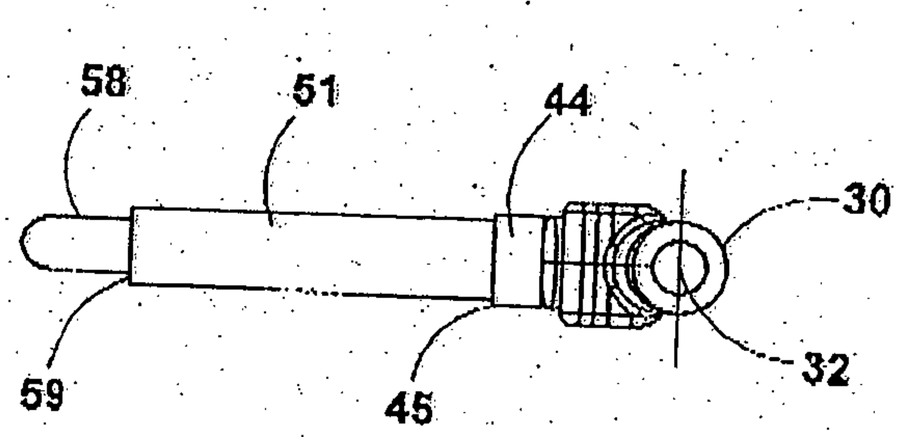


FIG. 1e

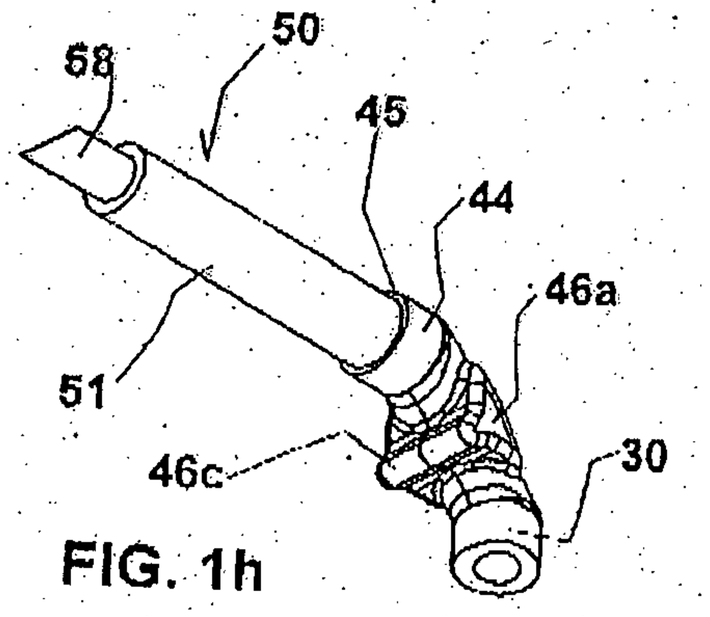


FIG. 1h

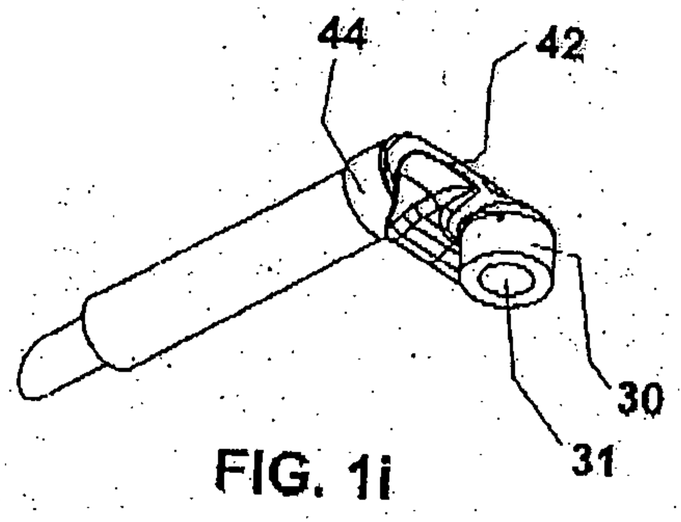


FIG. 1i

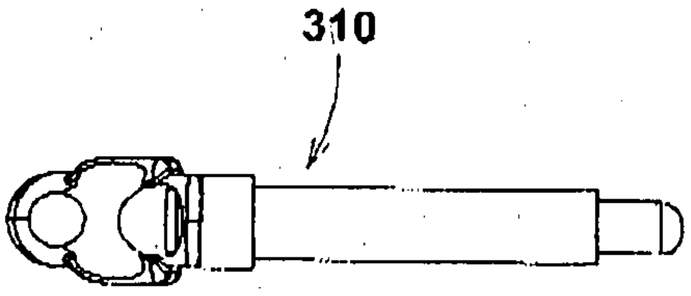


FIG. 1j

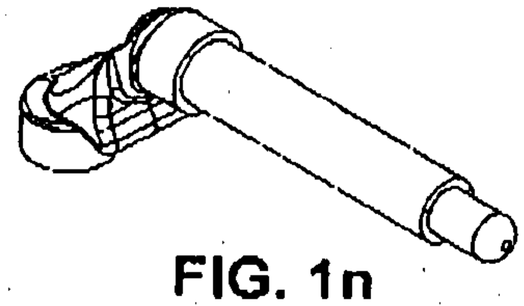


FIG. 1n

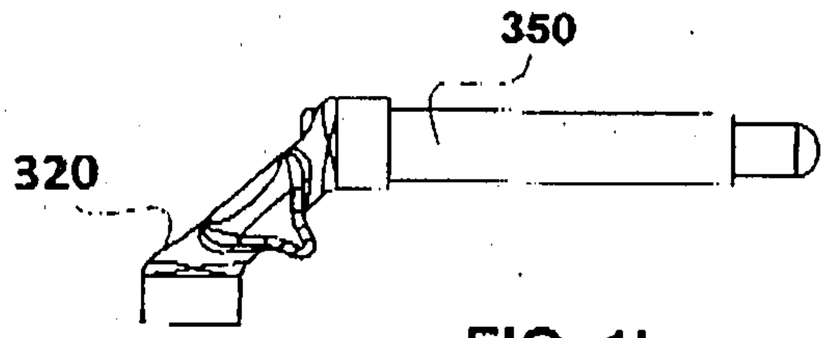


FIG. 1k

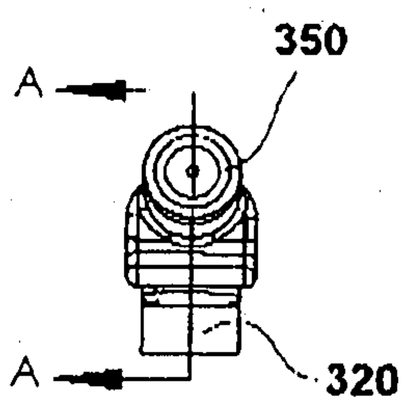
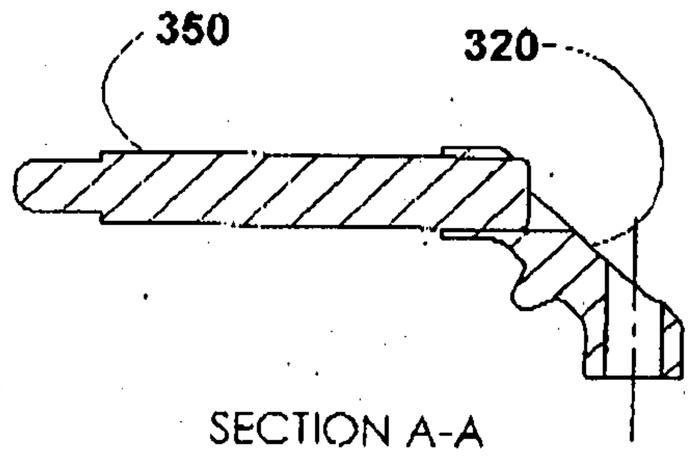


FIG. 1m



SECTION A-A

FIG. 1o

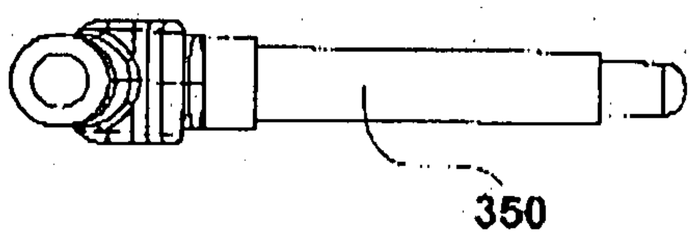


FIG. 1l

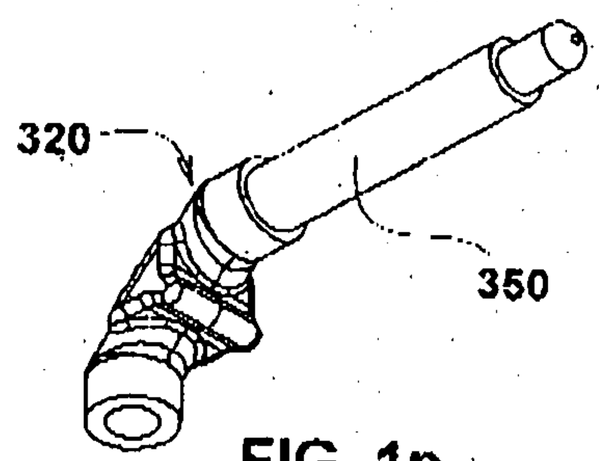


FIG. 1p

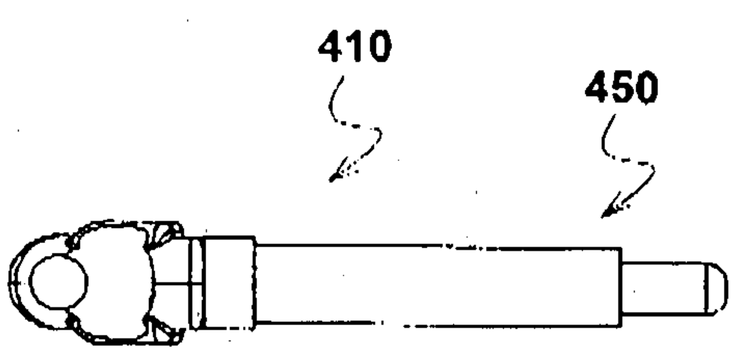


FIG. 1q

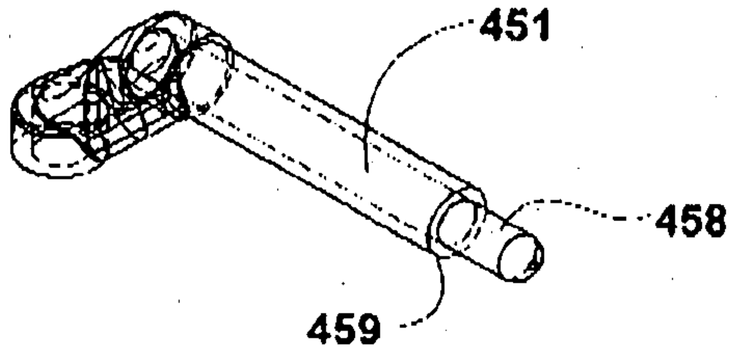


FIG. 1u

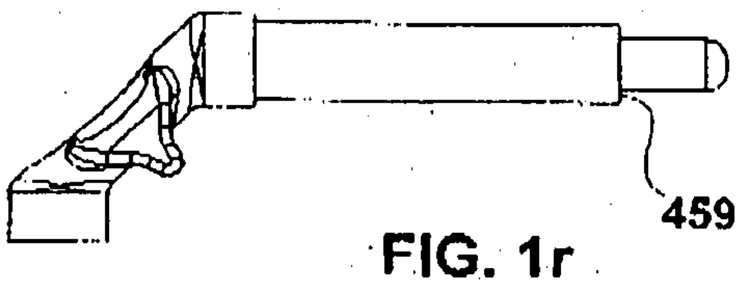


FIG. 1r

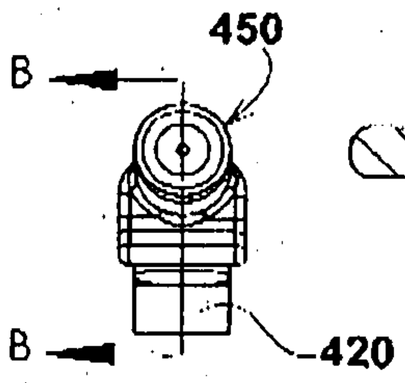


FIG. 1t

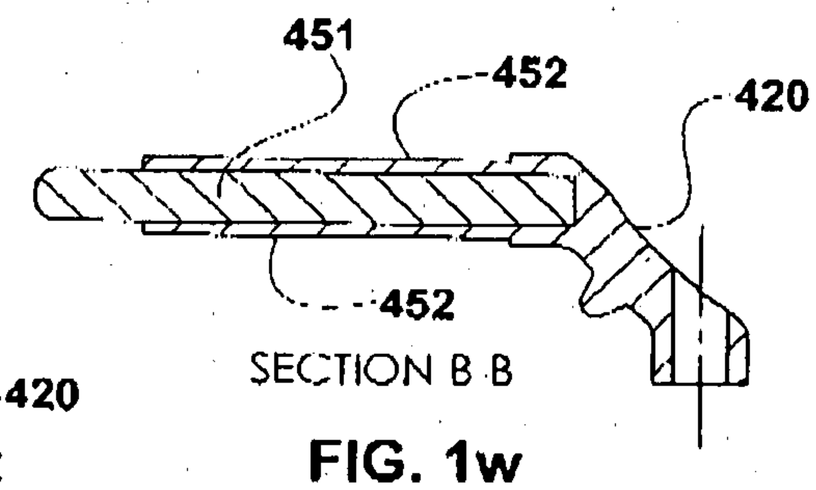


FIG. 1w

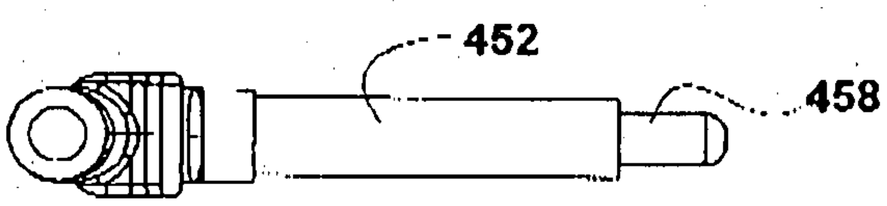


FIG. 1s

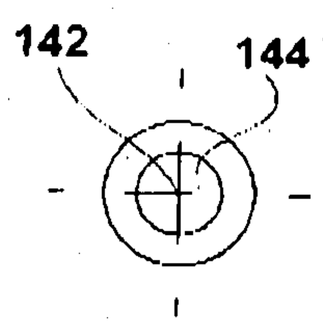


FIG. 2b

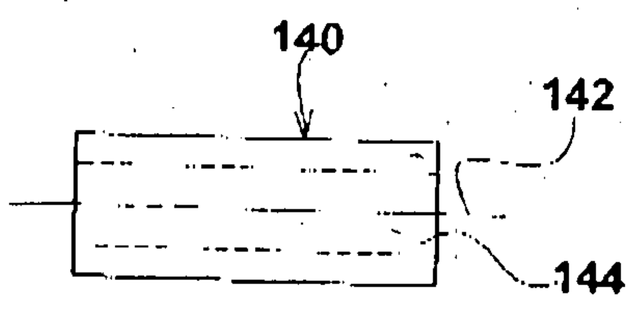


FIG. 2c

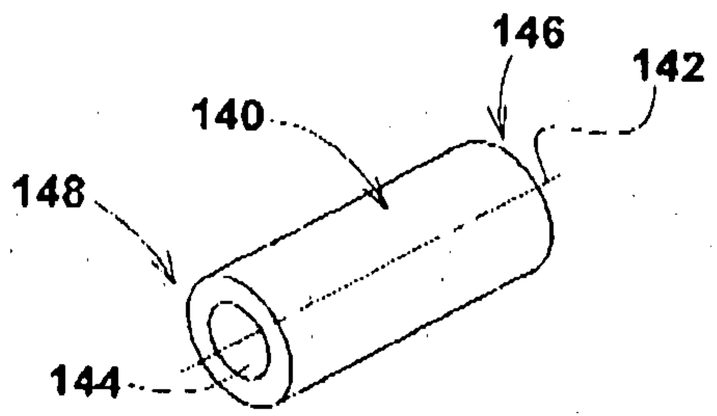


FIG. 2a

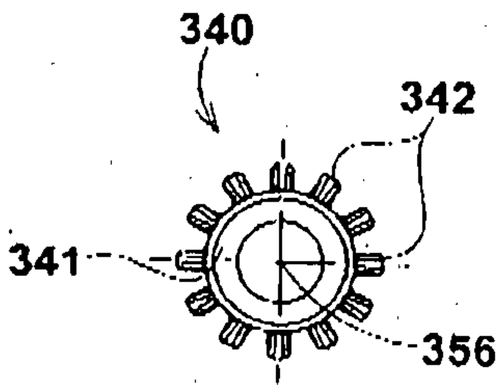


FIG. 2d

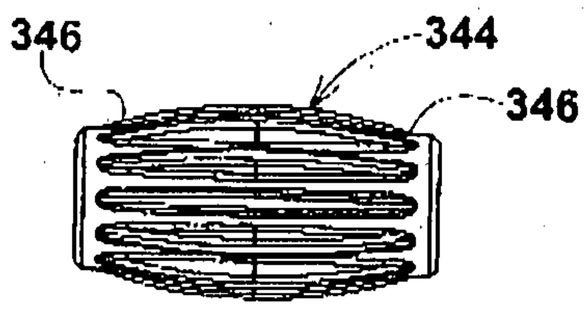


FIG. 2f

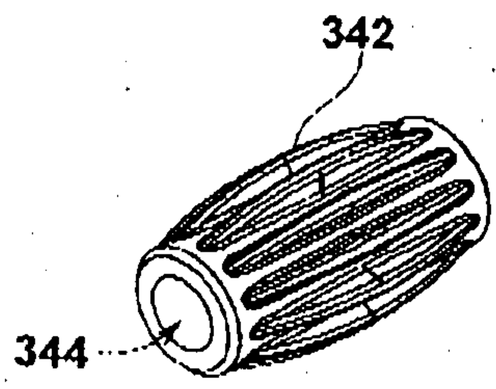


FIG. 2e

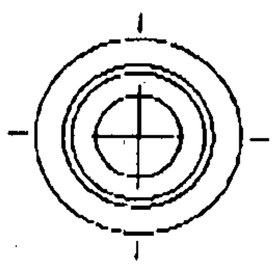


FIG. 2g

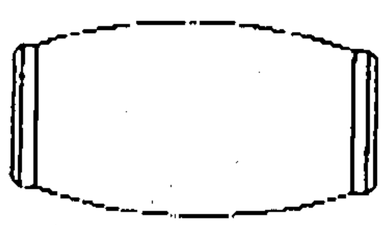


FIG. 2i

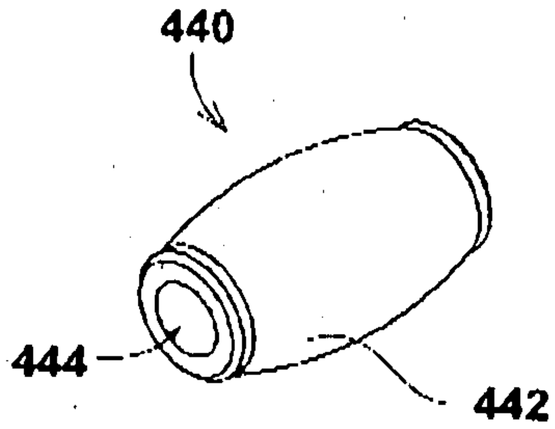


FIG. 2h

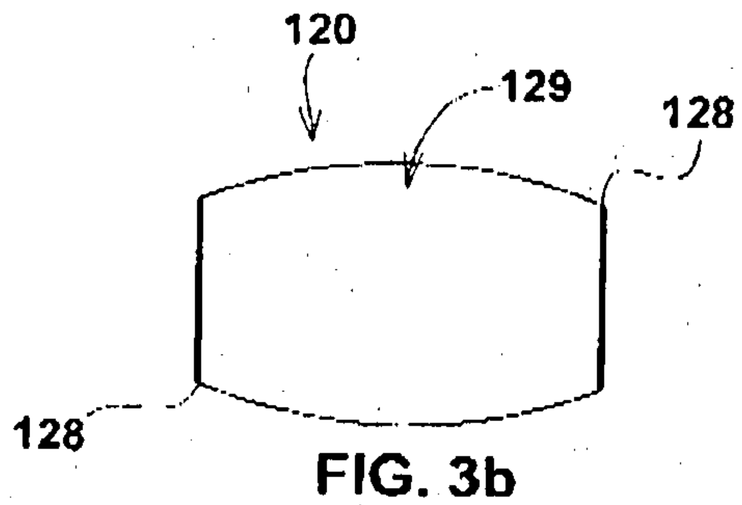


FIG. 3b

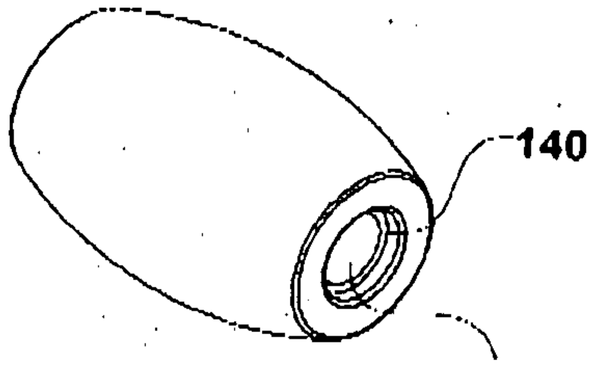


FIG. 3a

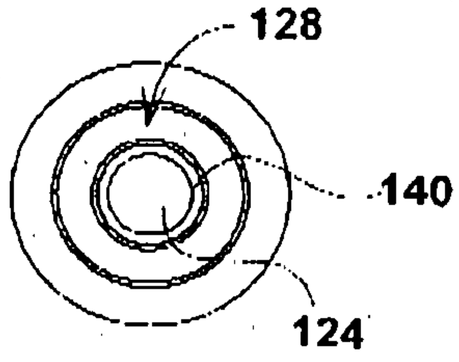


FIG. 3d

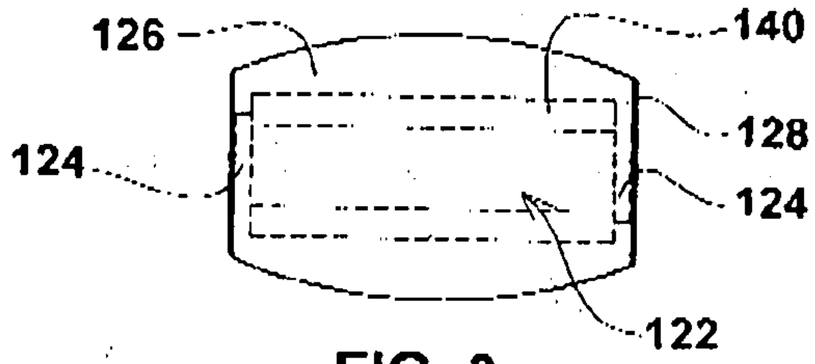


FIG. 3c

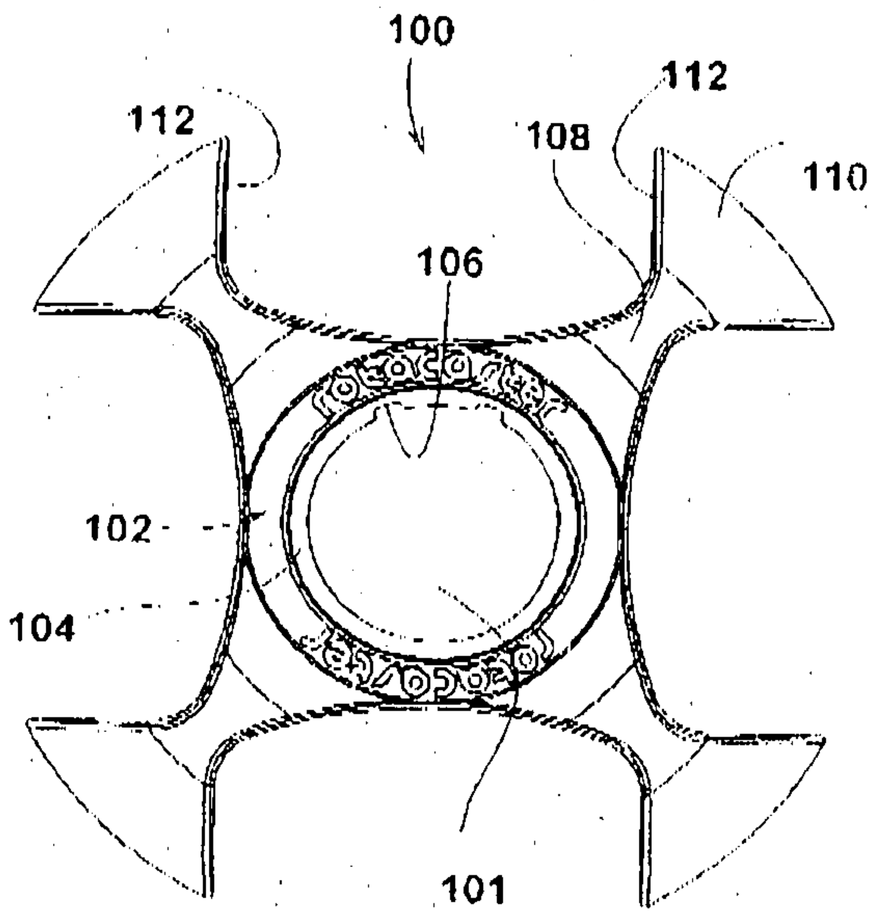


FIG. 4a

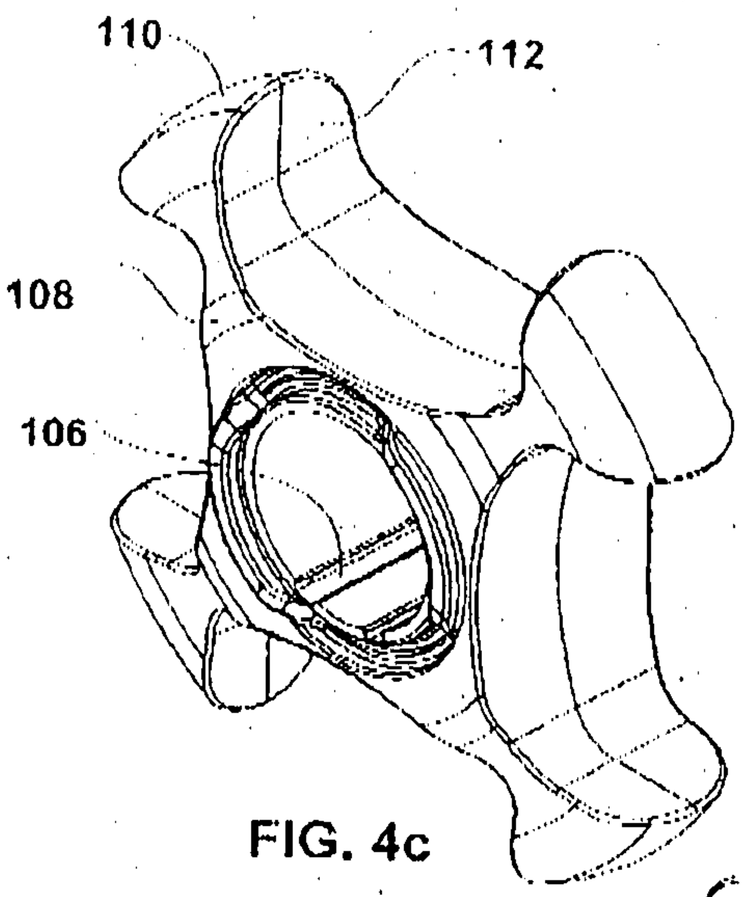


FIG. 4c

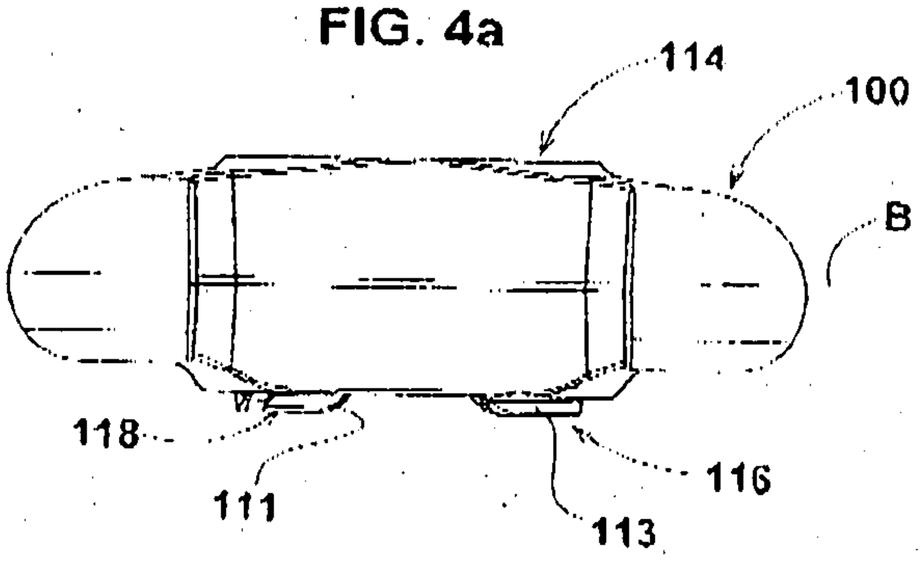


FIG. 4b

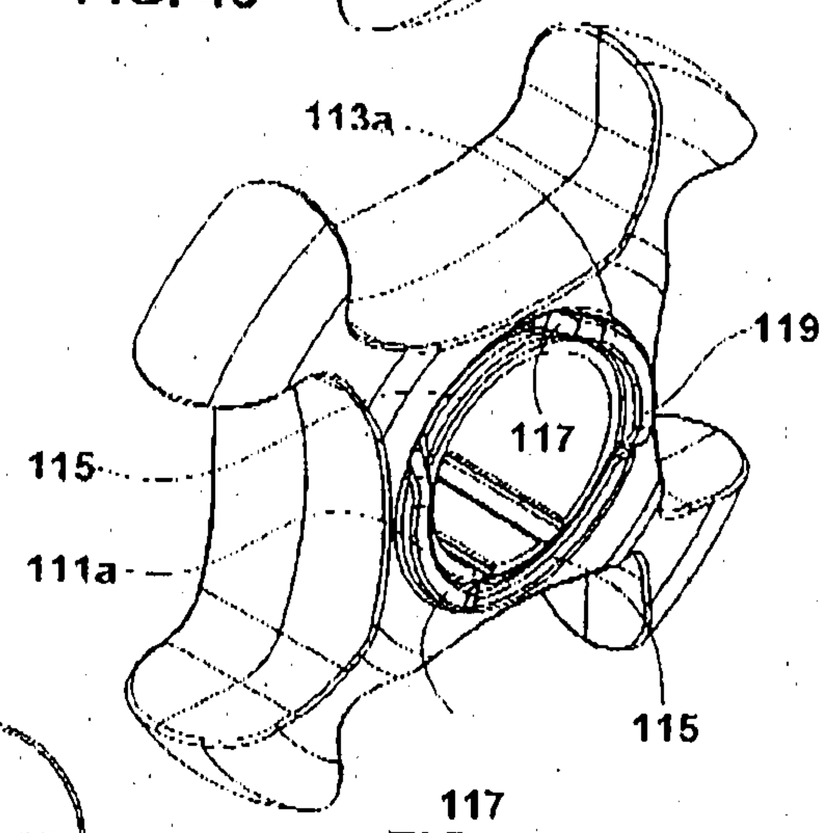


FIG. 4d

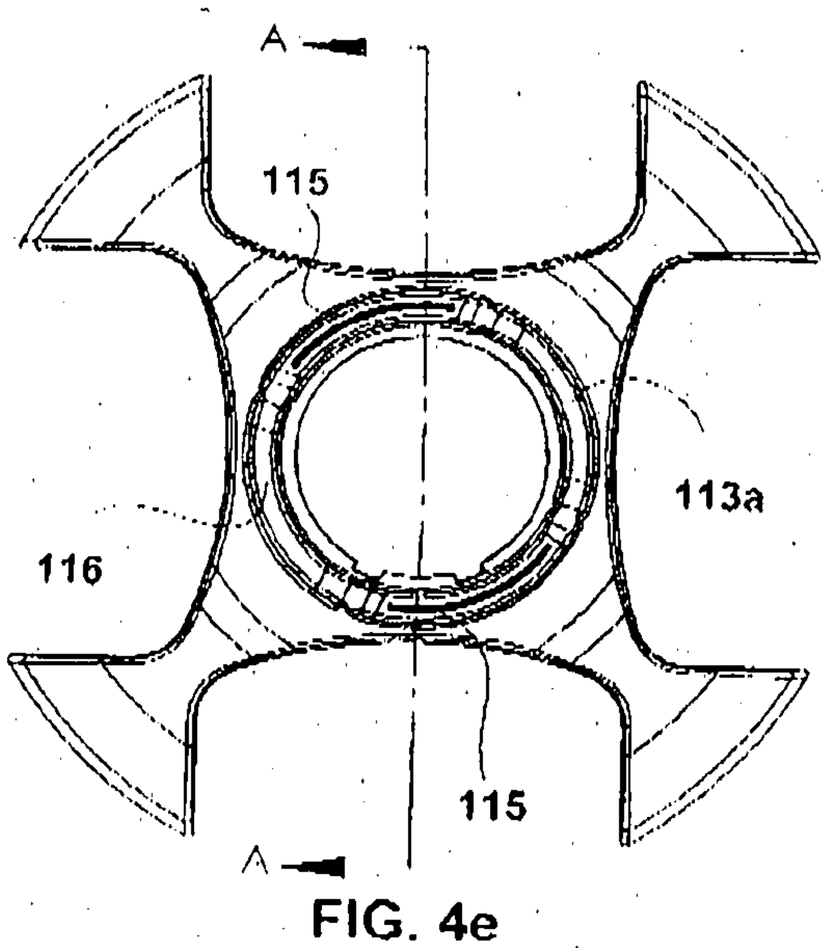
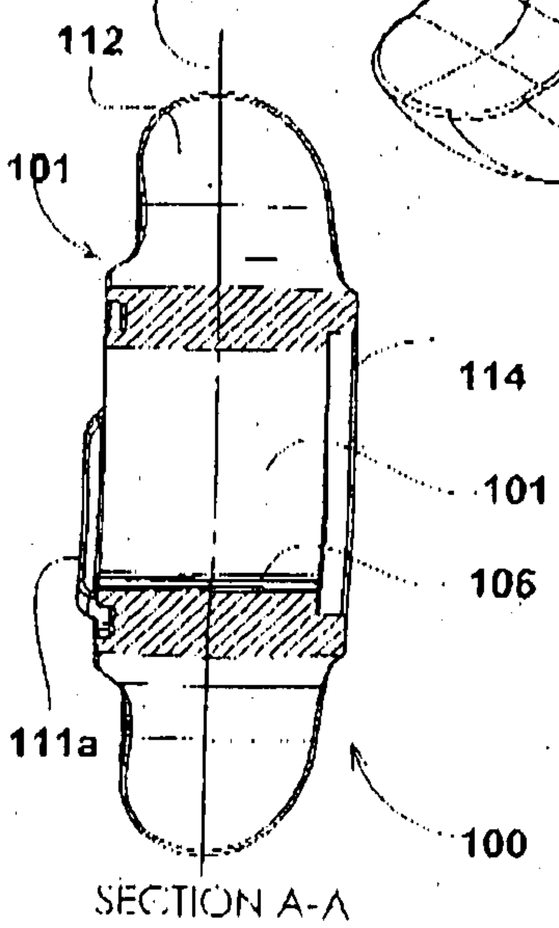


FIG. 4e



SECTION A-A

FIG. 4f

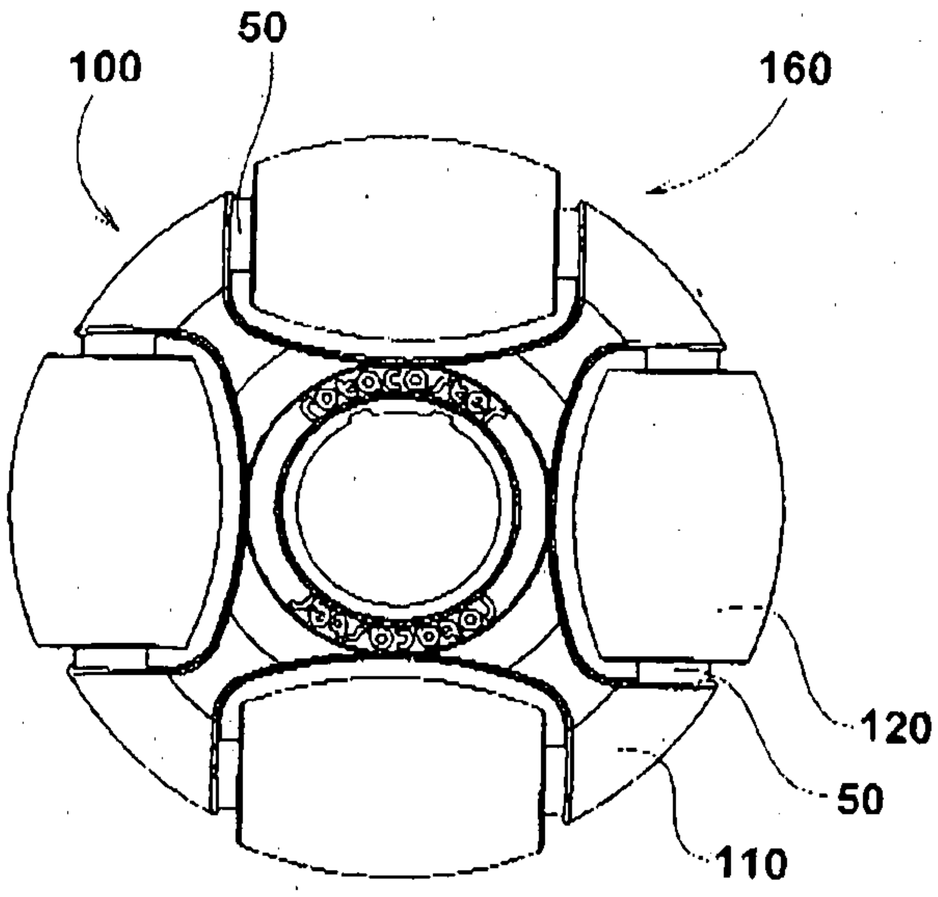


FIG. 5a

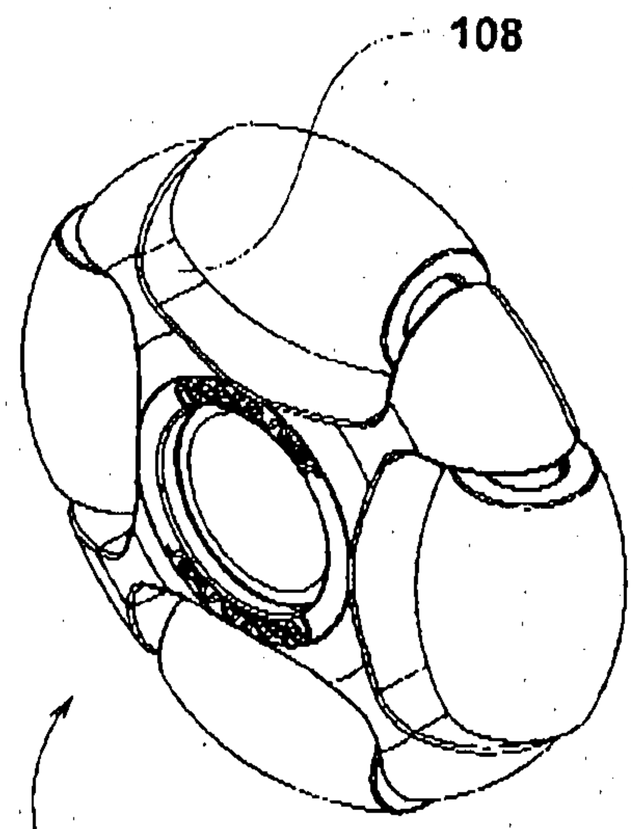


FIG. 5b

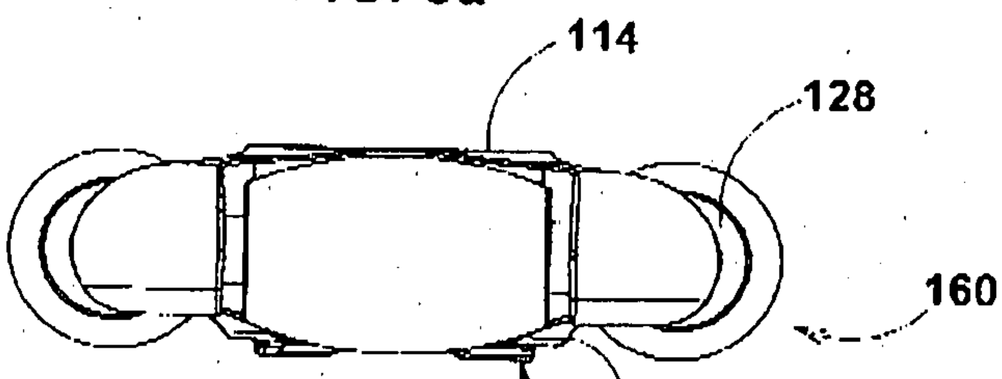


FIG. 5c

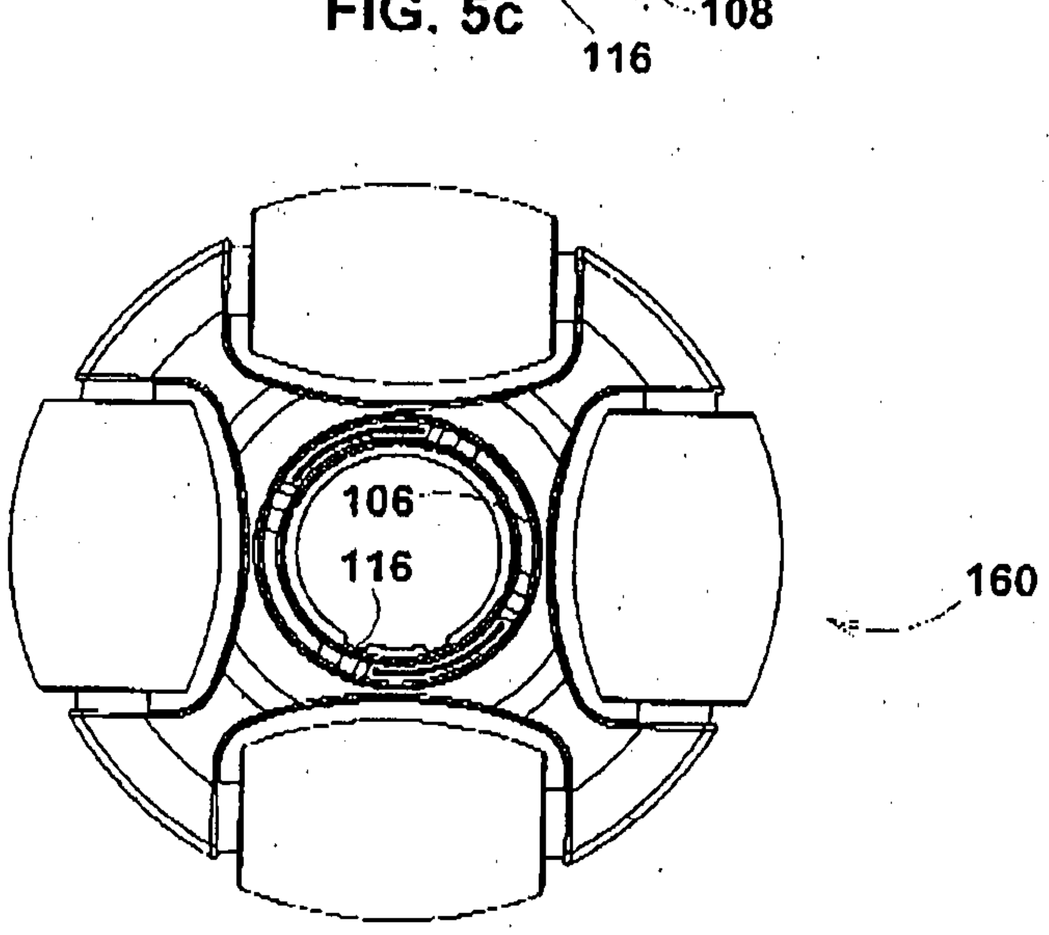


FIG. 5d

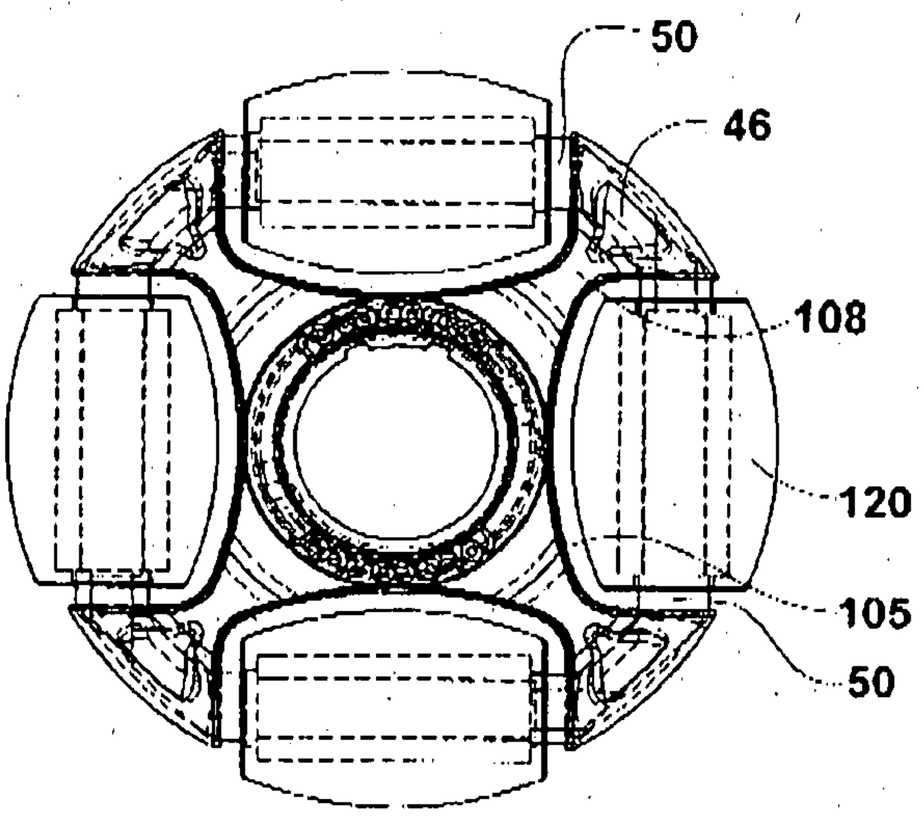


FIG. 6a

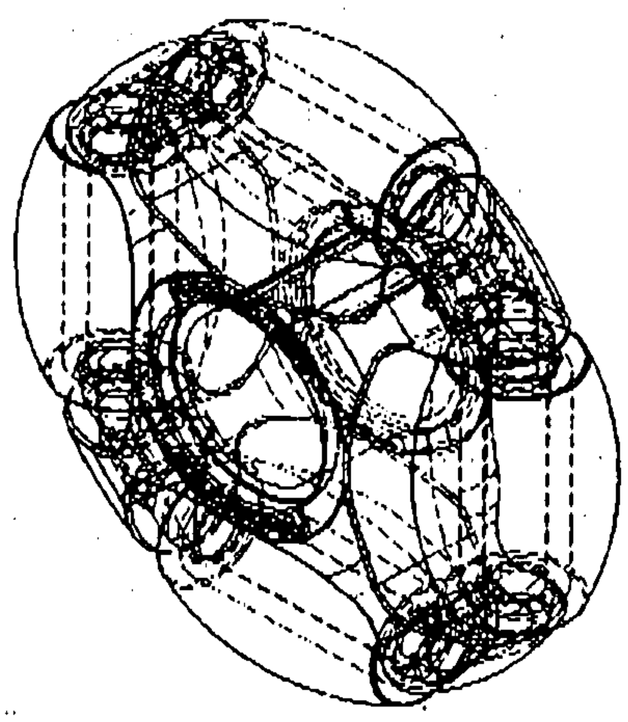


FIG. 6b

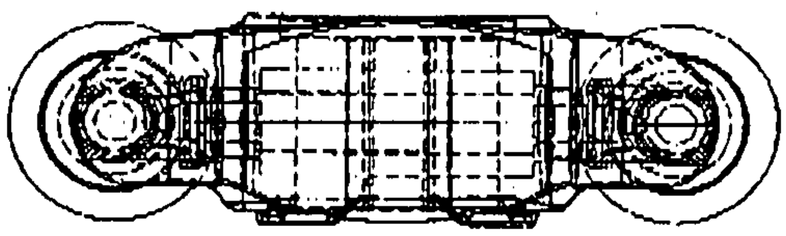


FIG. 6c

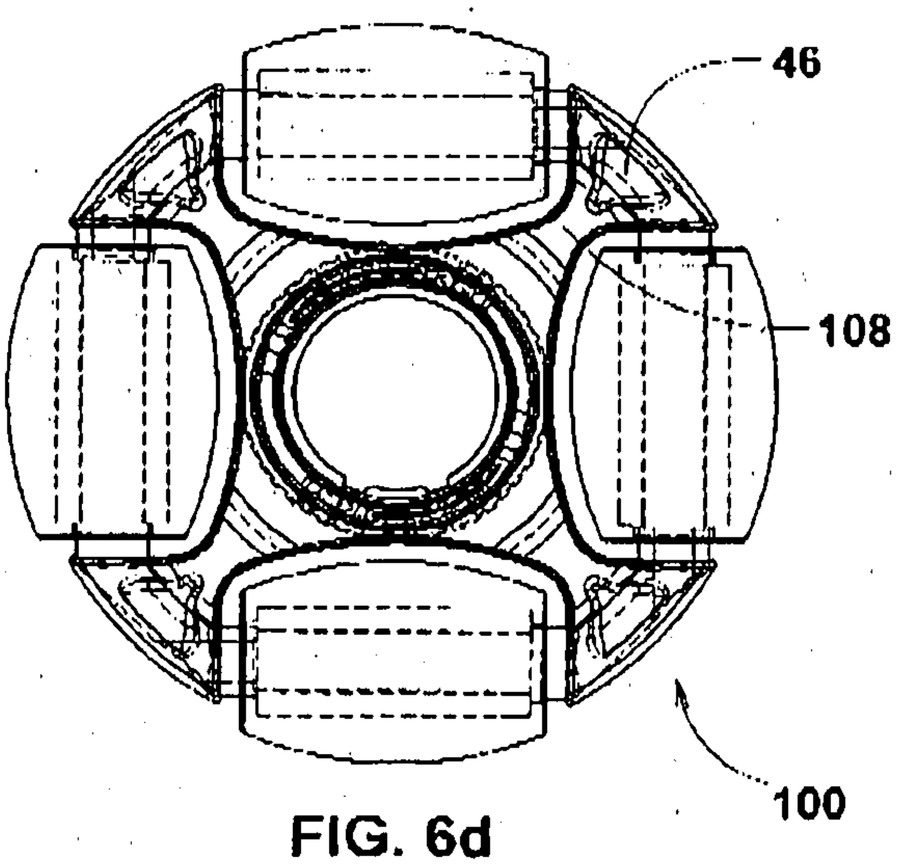


FIG. 6d

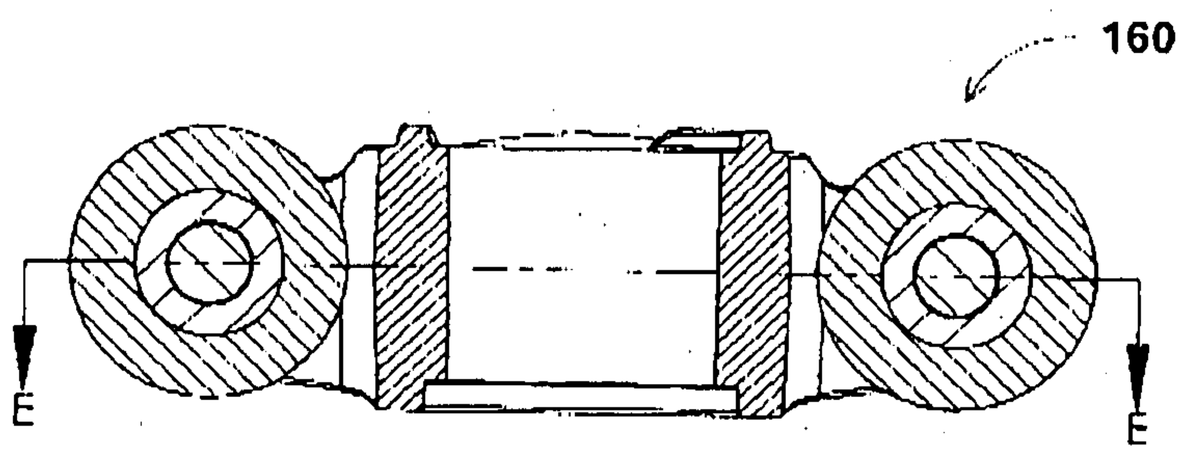


FIG. 7a

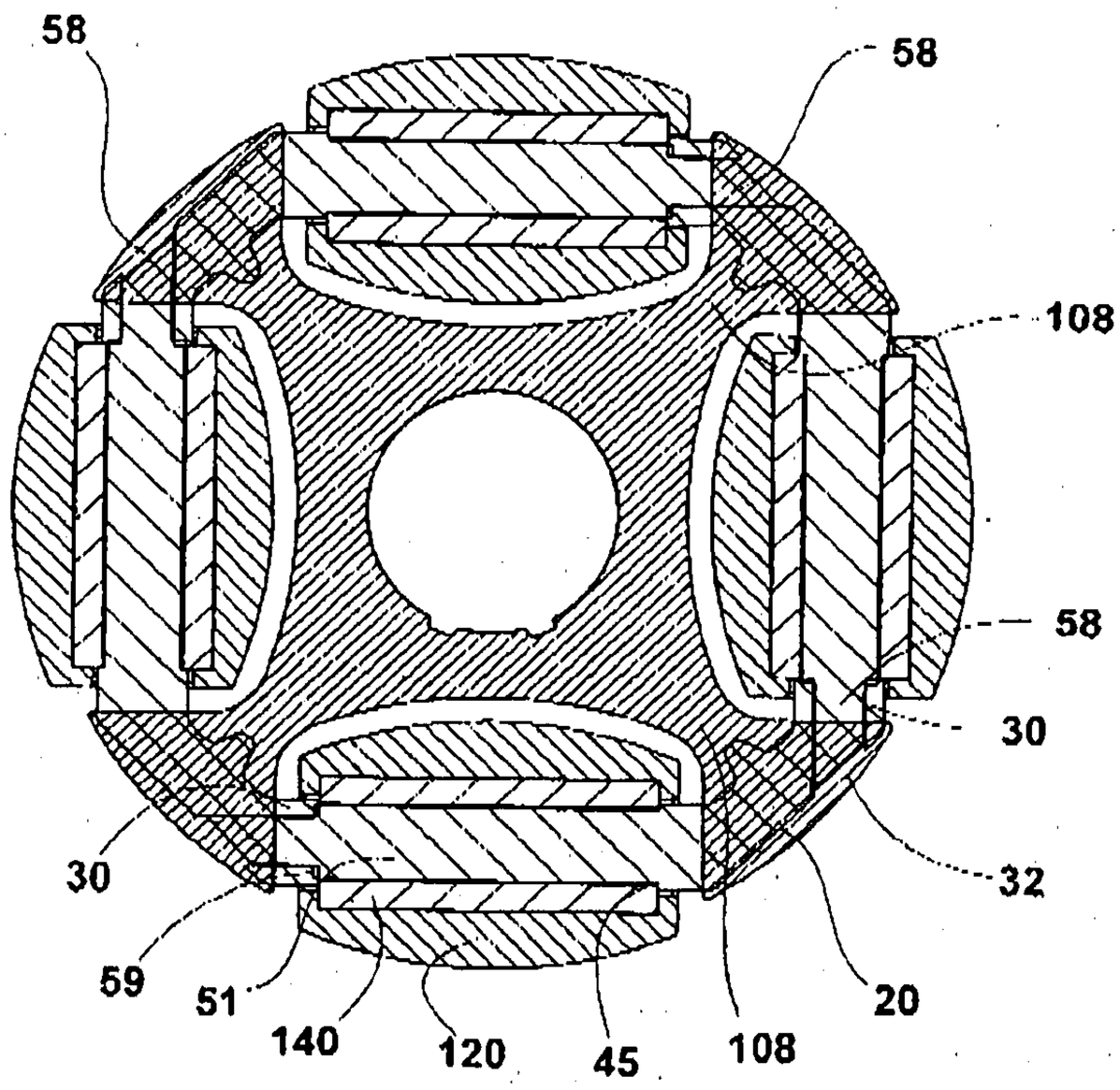


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FIG. 7b

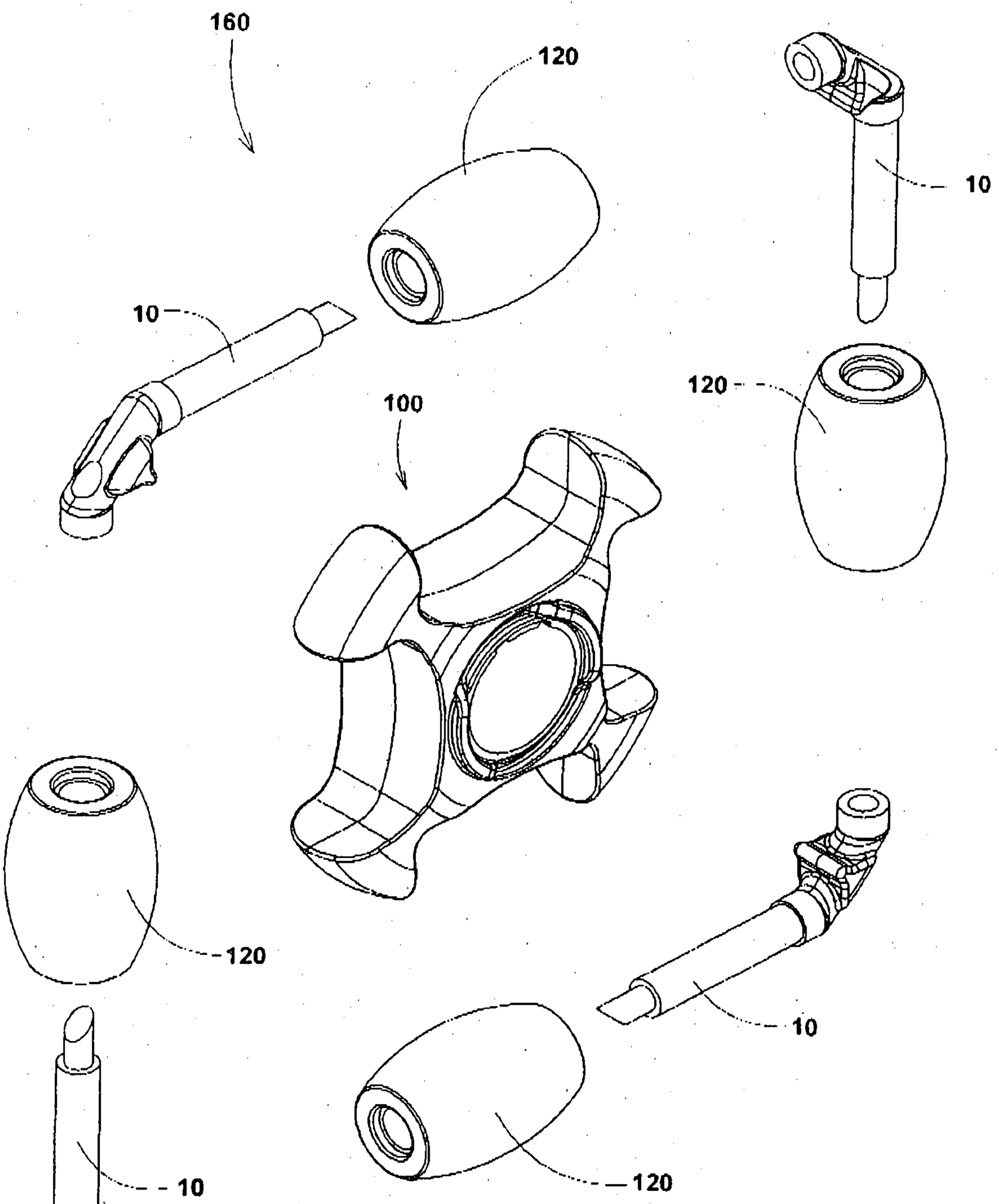

FIG. 8

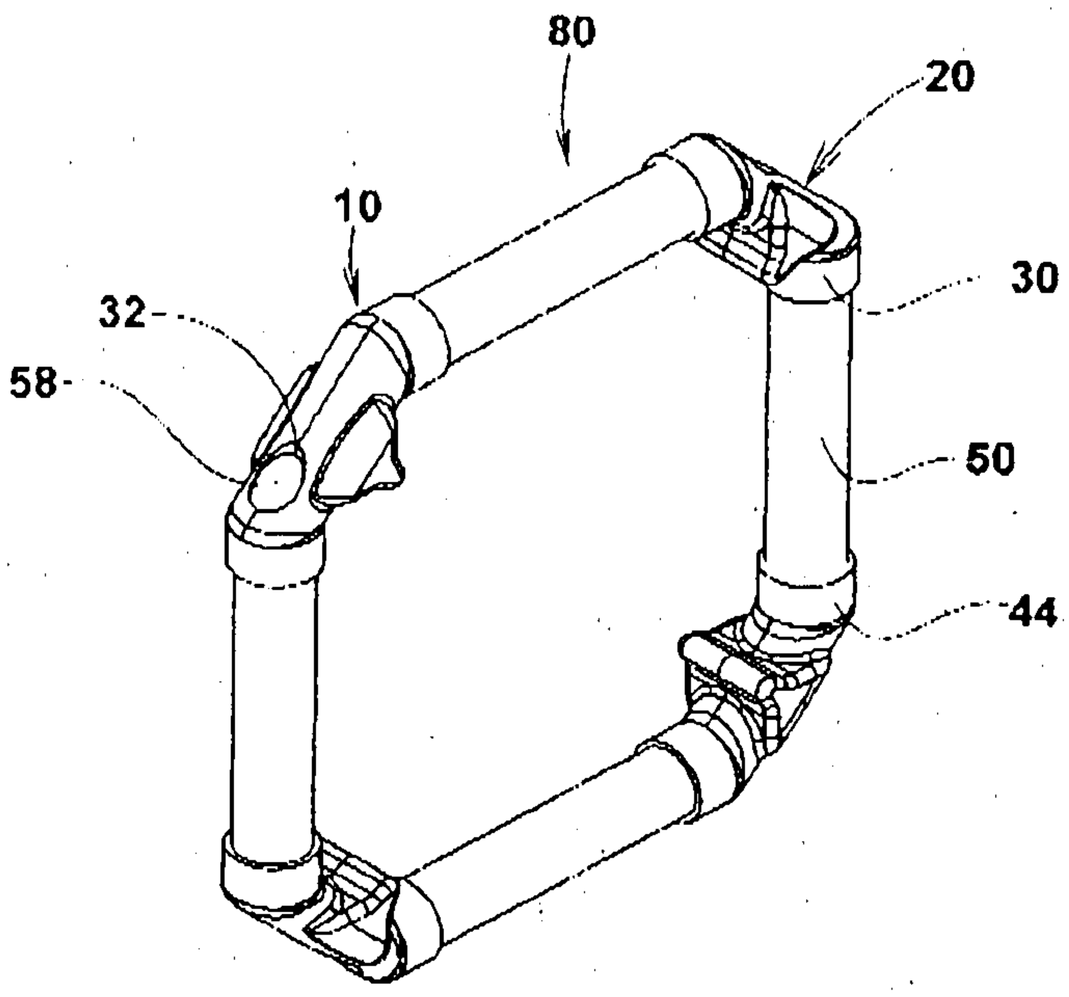

FIG. 9a

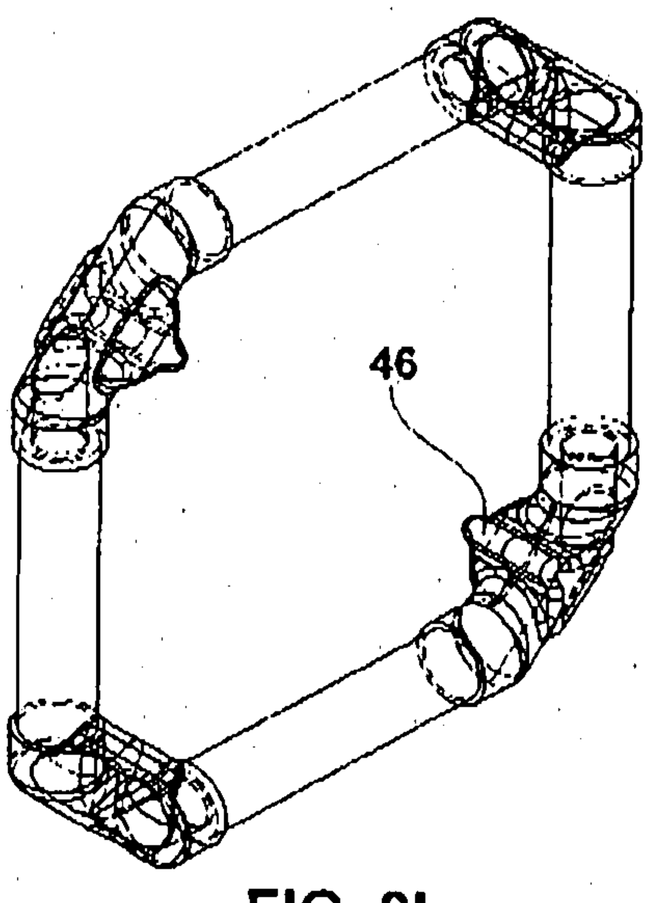

FIG. 9b

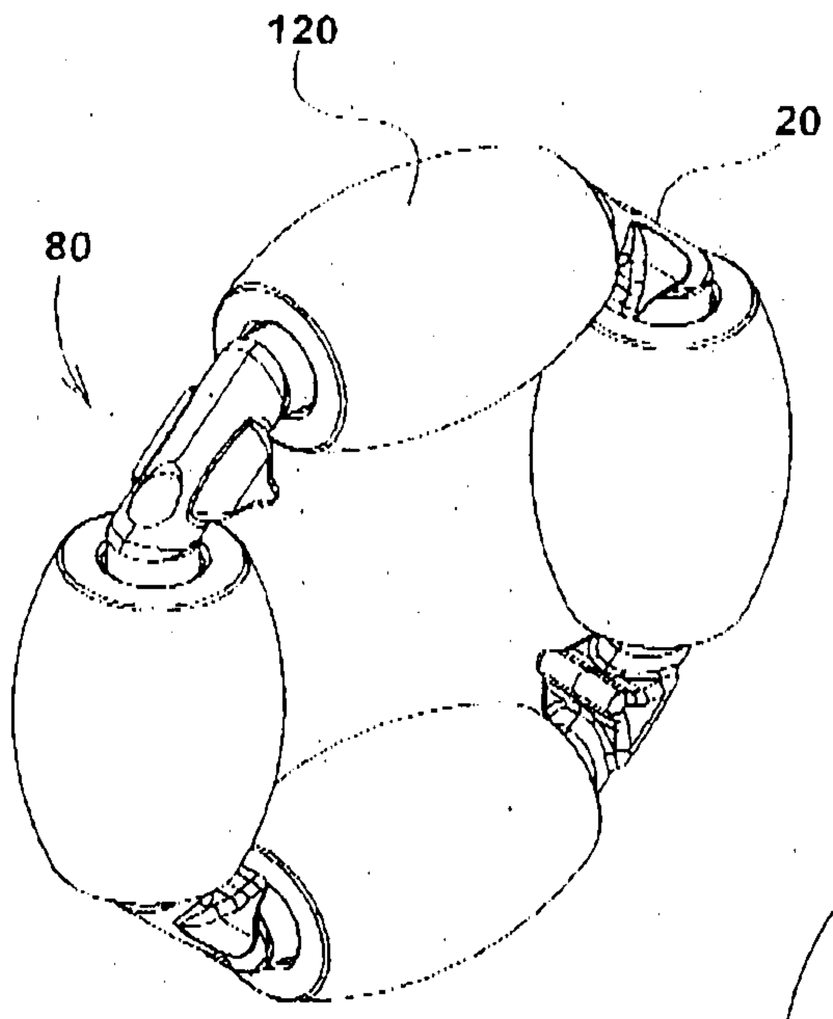

FIG. 10a

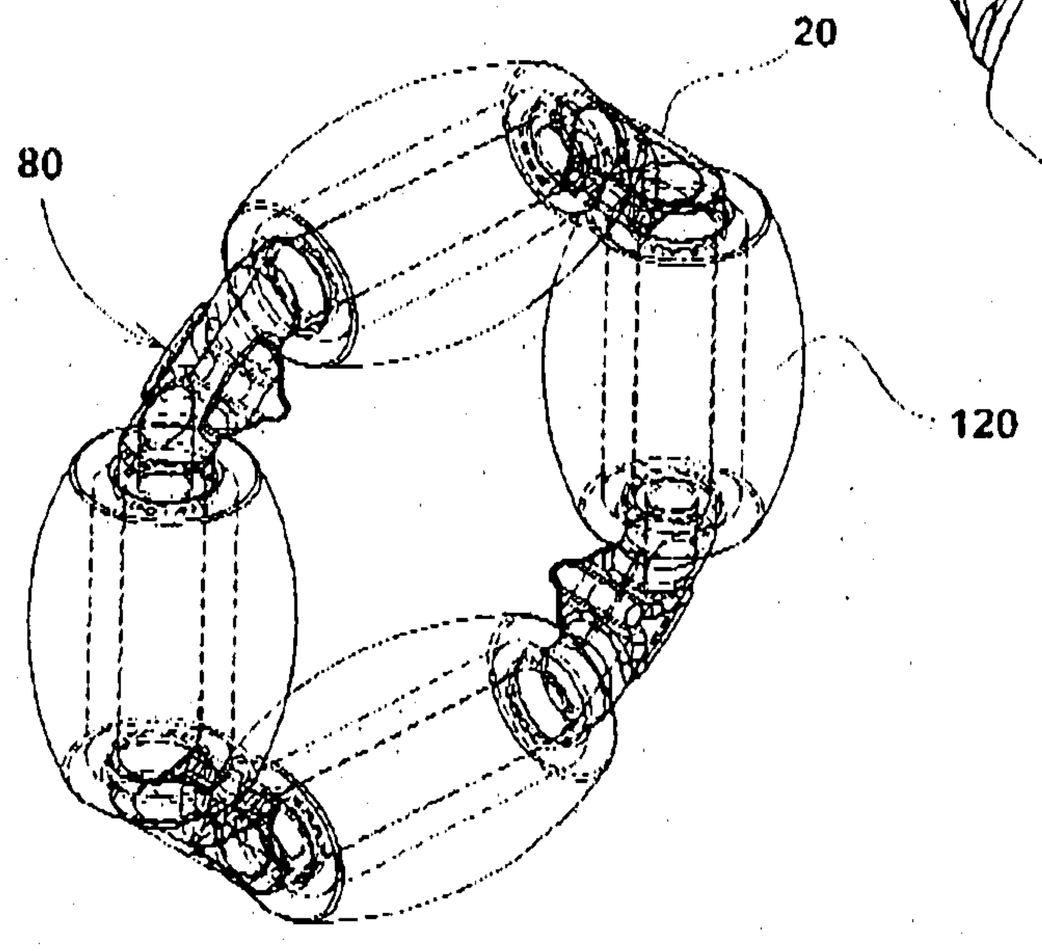

FIG. 10b

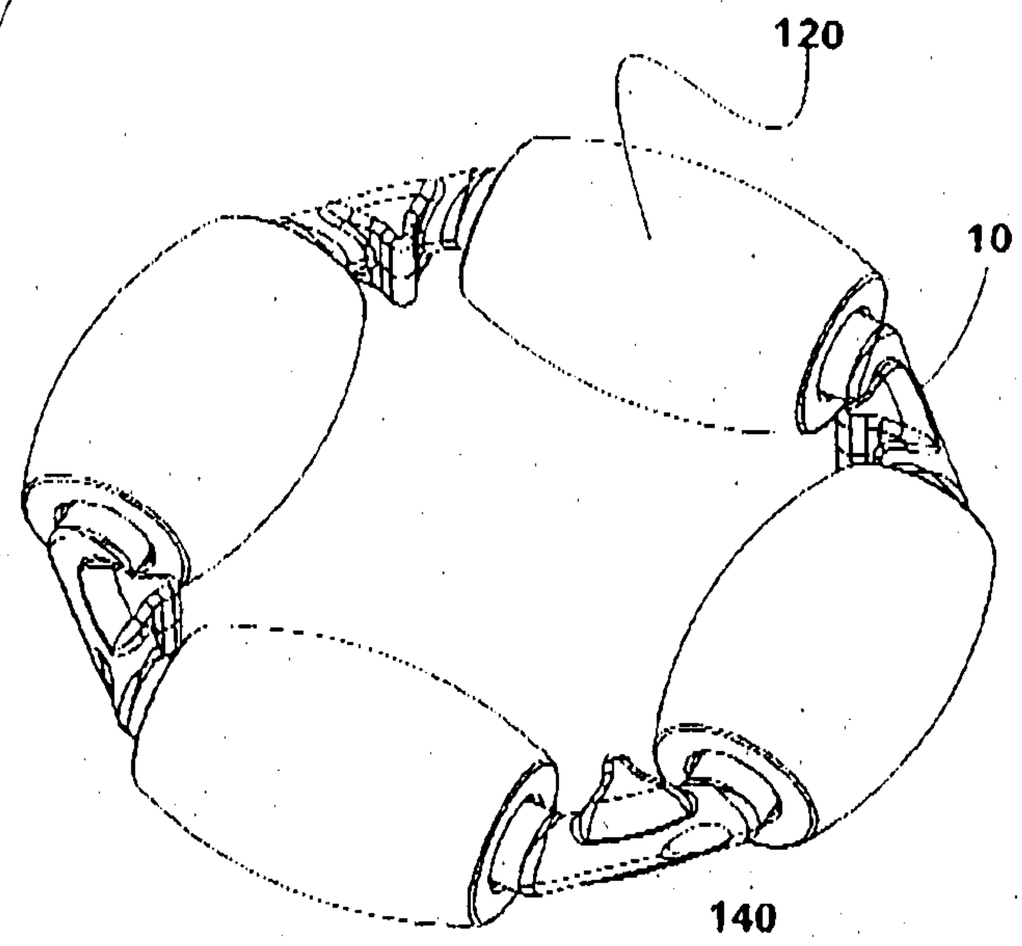

FIG. 10c

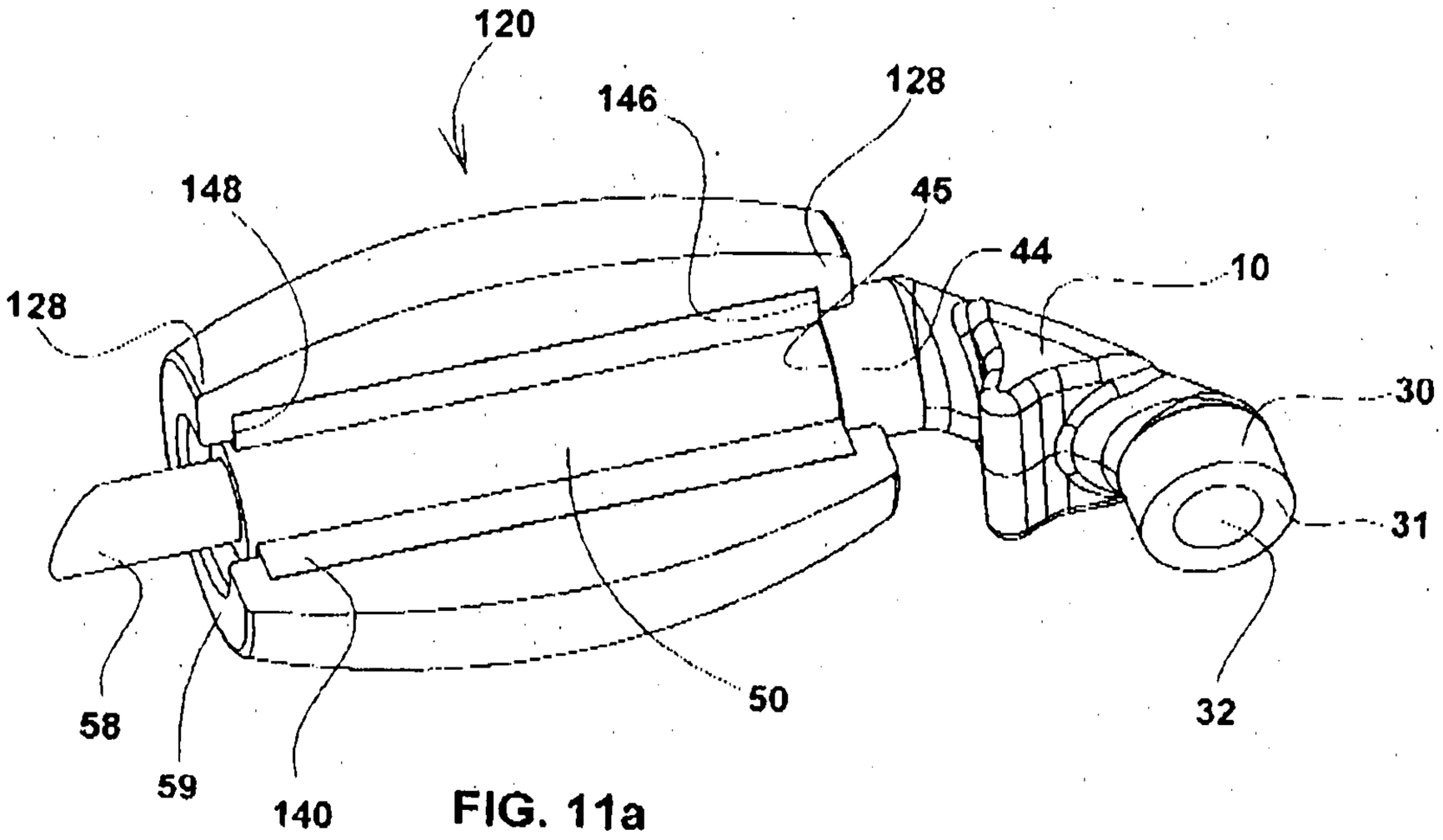

FIG. 11a

FIG. 11b

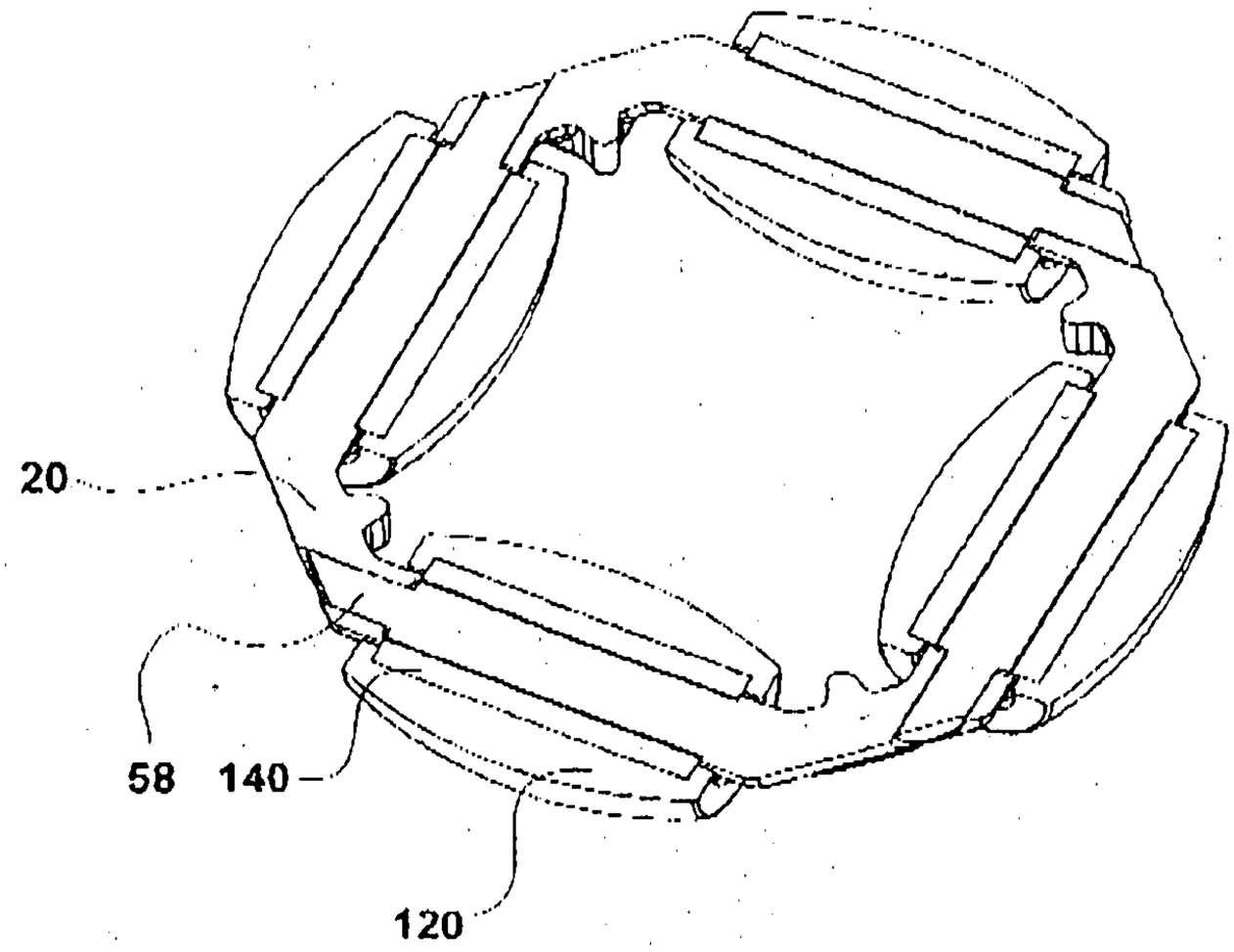

FIG. 12

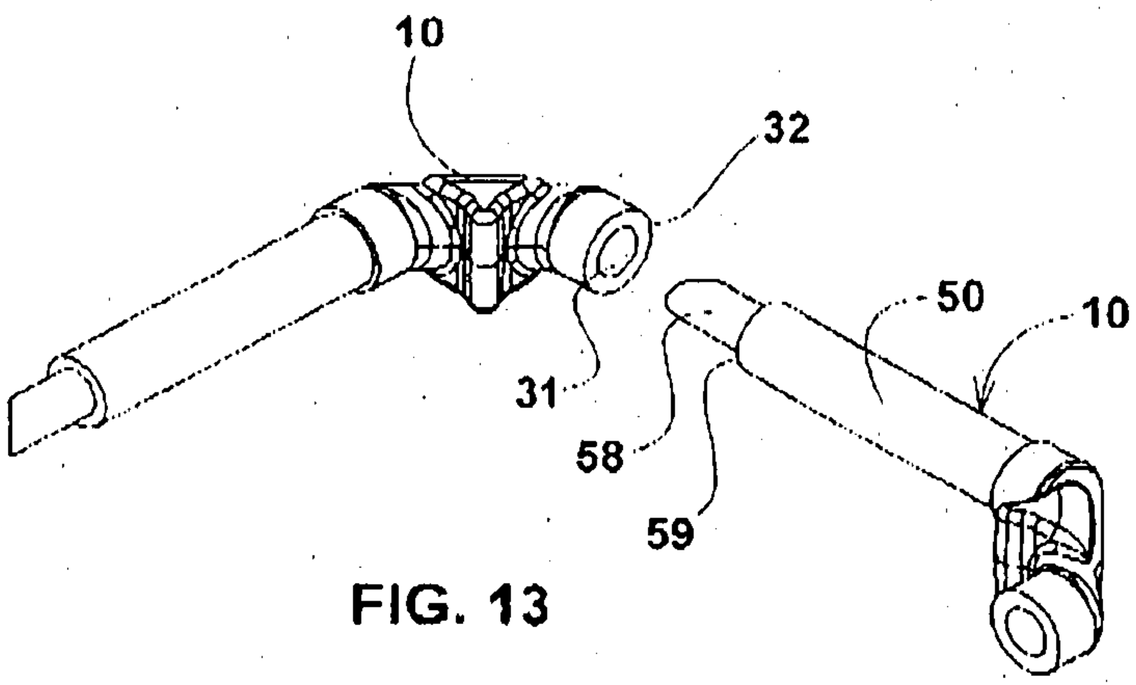

FIG. 13

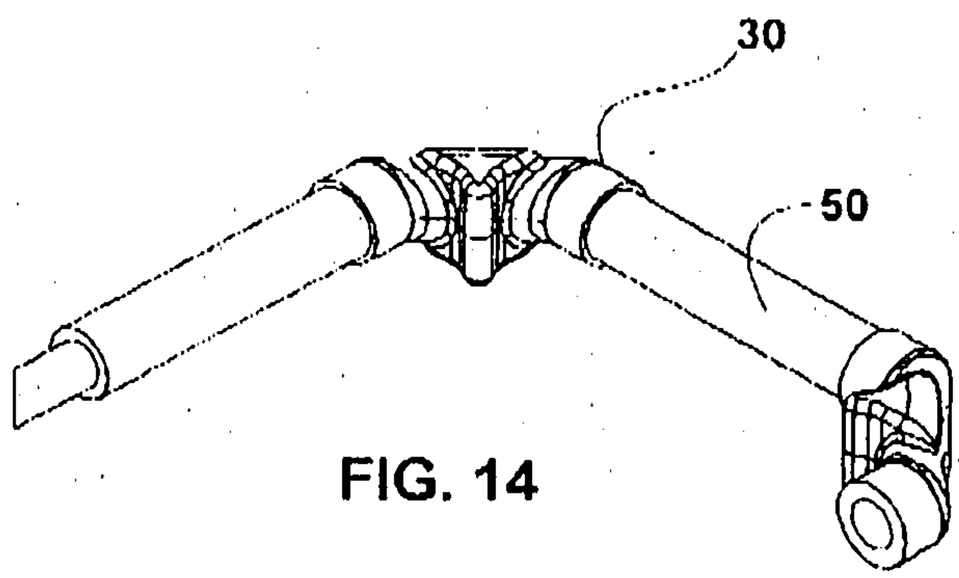

FIG. 14

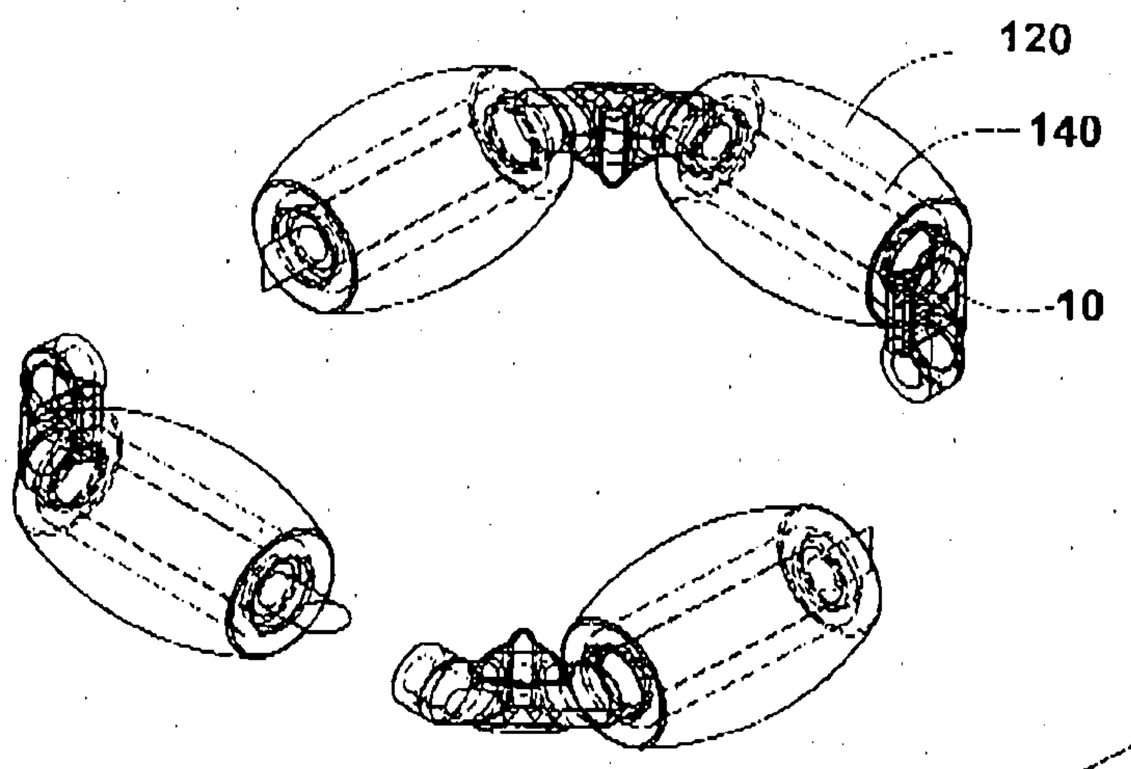

FIG. 15

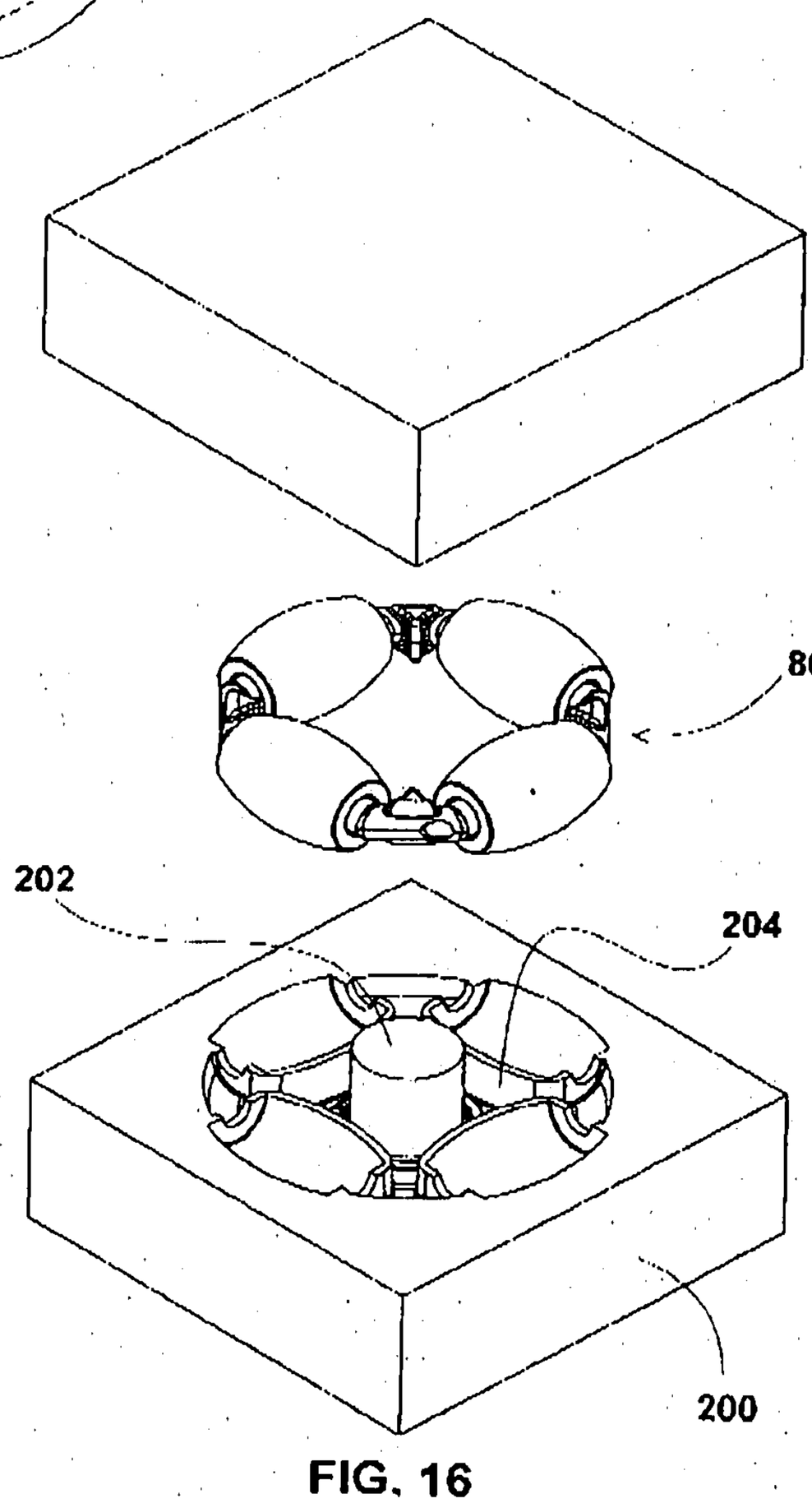

FIG. 16

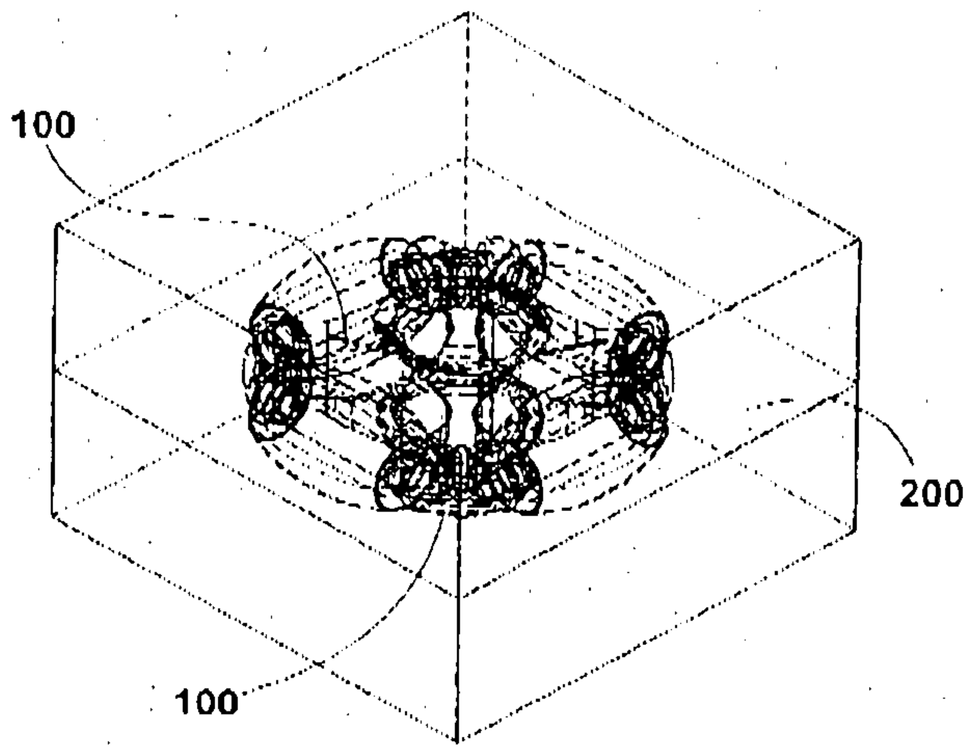

FIG. 17

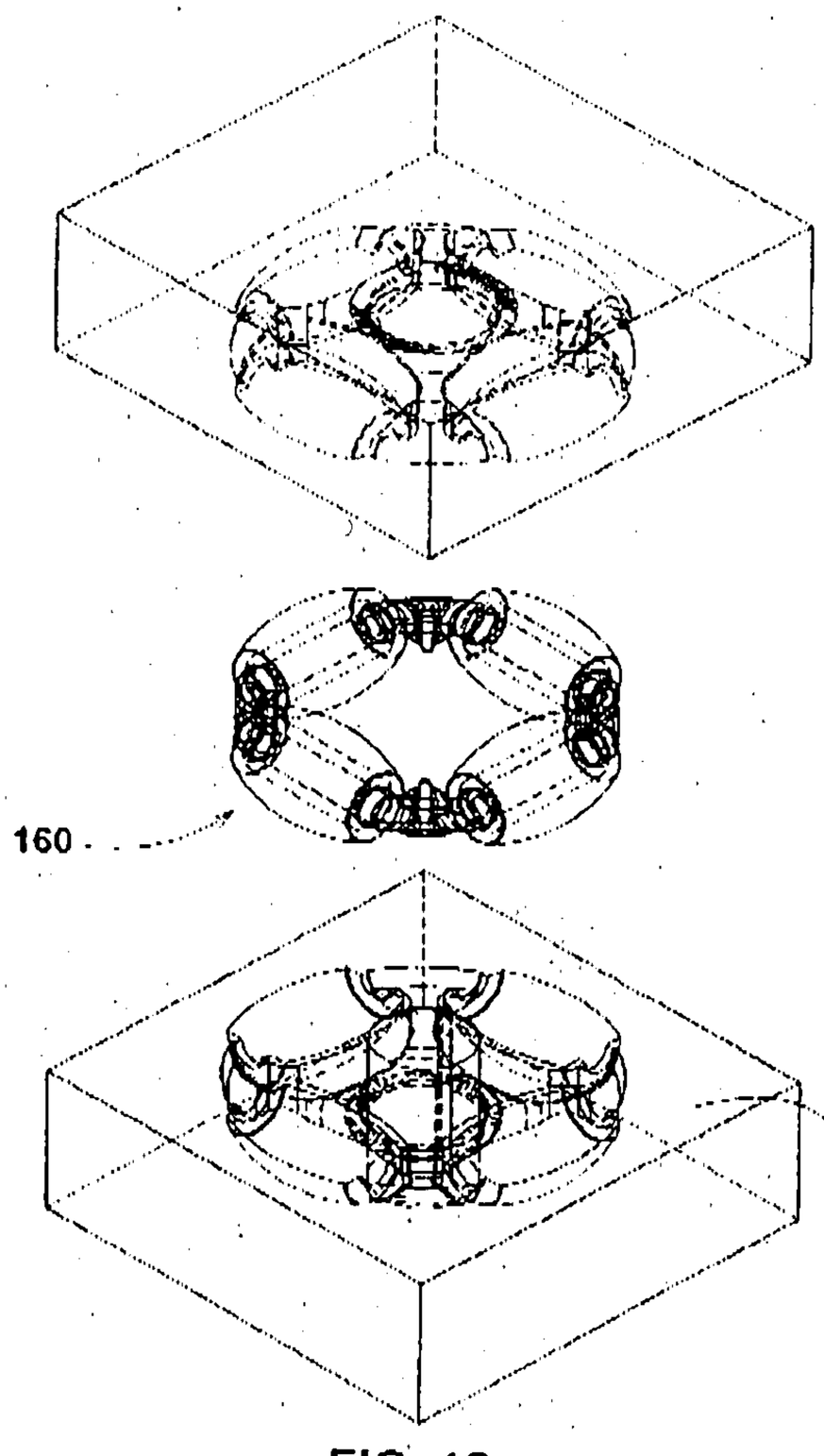

FIG. 18

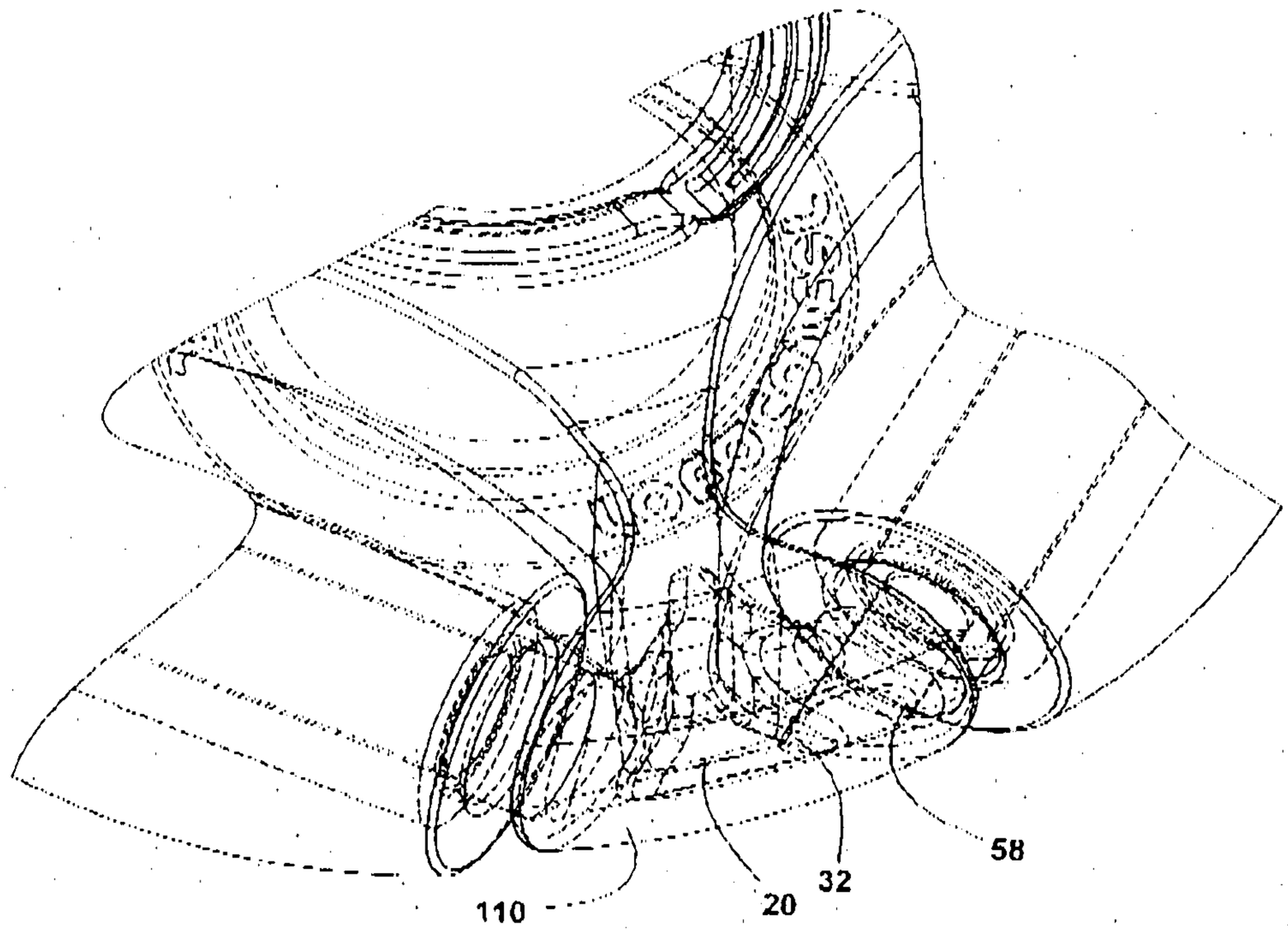

FIG. 19

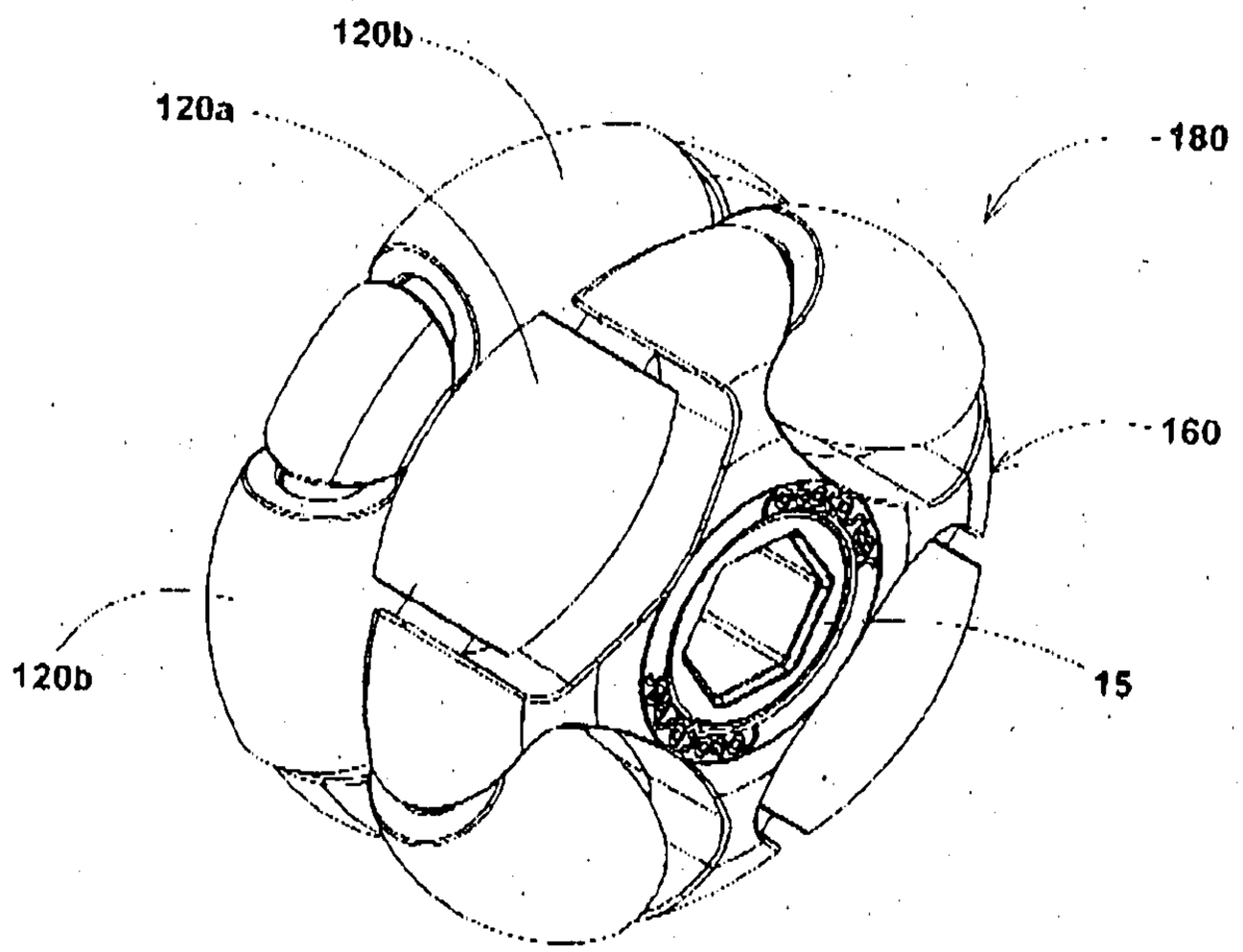

FIG. 20