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- (71) Applicants: **AKTIEBOLAGET SKF** [SE/SE]; S-41550 Göteborg (SE). **SEMCON AB** [SE/SE]; S-417 80 Göteborg (SE).
- (72) Inventors: **SCHAAKE, Richard**; Violenstraat 29, NL-3551 BA Utrecht (NL). **SCHRAMM, Edo**; Koekoeklaan 18, NL-2566 JS Den Haag (NL). **PETERS, Gilbert**; Kroonstraat 172, NL-6511 DX Nijmegen (NL). **VISSERS, Cornelius Petrus Antonius**; Litsersstraat 67, NL-5275 BT Den Dungen (NL). **GOMEZ, Marc**; Tjarnvägen 4, S-43351 Öjersjö (SE).
- (74) Agents: **TWEEDLIE, Diane** et al.; SKF B.V., Kelvinbaan 16, NL-3439MT Nieuwegein (NL).

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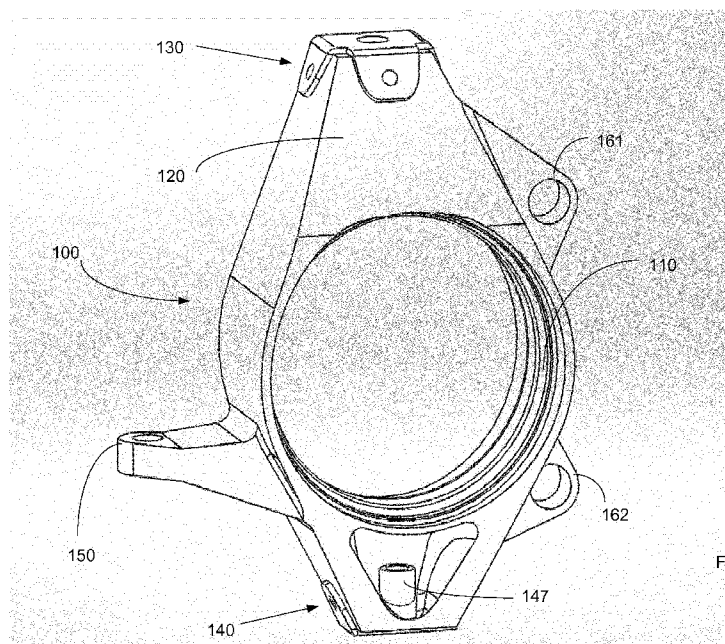


Figure 1a

(57) Abstract: The present invention resides in a composite part (100) comprising a bearing connection interface (110) for connecting a bearing to the composite part and comprising a further connection (130, 140) point for connecting the composite part to a further component. The bearing connection interface is formed by a first insert (110) and the further connection interface is formed by a second insert (130, 140), which are joined via a composite body (120) comprising a fibre-reinforced material that is overmoulded to the first and second inserts. According to the invention, the bearing connection interface and the further connection interface are additionally joined by one or more continuous fibre tows that are wound around parts of an outer surface of the first and second inserts.



Composite part for connecting a bearing to a further component

FIELD OF THE INVENTION

The present invention relates to a composite part, comprising a fibre-reinforced material, which serves as an interface between a bearing and a further component.

BACKGROUND TO THE INVENTION

In the interests of fuel economy, there is an increasing drive within the automotive industry towards weight reduction of the component parts of vehicles. A vehicle wheel bearing is one example of an automotive component where weight reduction is desirable, also in view of the fact that the wheel bearings belong to the unsprung weight of a vehicle. Raceways of the bearings need to be made from a material of sufficient hardness in order to withstand the stresses of rolling contact.

Titanium and certain ceramics are materials that possess the necessary mechanical properties and are also low in weight. They are also expensive and, consequently, bearing steel is more commonly used. Bearing steel has excellent hardenability but cannot be viewed as a lightweight material. Thus, one solution for reducing the weight of a wheel bearing comprising bearing steel is to form the bearing rings from bearing steel and to form further structural elements of the wheel bearing from a fibre-reinforced polymer.

An example of such a wheel bearing is disclosed in JP2011178314. The wheel bearing has a flanged inner ring, for connecting a vehicle wheel and brake disc to the bearing, and has a flanged outer ring for connecting the bearing to e.g. a steering knuckle. Each bearing flange is made of a laminated body of a carbon-fibre prepreg, formed by e.g. braiding the fibres and binding them in resin around a cylindrical surface of the bearing inner ring or outer ring.

A steering knuckle is another example of an interface component for a bearing that may be reduced in weight by manufacturing the component from a fibre-reinforced polymer. An example of such a steering knuckle is disclosed in DE102007053120 A1. The steering knuckle is formed from a laminar textile comprising fibres bound in a matrix.

These examples of composite parts that form an interface between a bearing and a further component achieve a weight reduction. In use, however, a bearing can experience high forces, which are transmitted through the composite part. This part must therefore possess sufficient strength and stiffness to withstand the application loads.

There is still room for improvement.

SUMMARY OF THE INVENTION

The present invention resides in a composite part as specified in claim 1, whereby the dependent claims describe advantageous embodiments and further developments of the invention.

Specifically the invention resides in a composite part comprising a bearing connection interface for connecting a bearing to the composite part and comprising a further connection interface for connecting the composite part to a further component. The bearing connection interface comprises a first insert and the further connection interface comprises a second insert, which are radially spaced from each other and which are joined via a composite body comprising a fibre-reinforced material that is overmoulded to a radially outer surface of the first insert and to a radially outer surface of the second insert. According to the invention, the bearing connection interface and the further connection interface are additionally joined by a continuous fibre tows that is wound around part of the radially outer surface of the first and second inserts.

The forces acting on the composite part are introduced via the connection interfaces. In bearing applications, e.g. wheel bearing applications, the forces concerned can be substantial. A force acting on one connection interface results in a reaction force on the other connection interface. The resulting load path runs between the connection interfaces, meaning that a composite part according to the invention comprises fibre-reinforcement located at, and in alignment with, the load path. As a result, the composite part has improved strength and stiffness where it is needed most.

The continuous fibre tows provide strength and stiffness in tension. Advantageously, the fibres are pre-tensioned as they are wound around the first and second inserts, to obtain optimal performance from the fibre properties.

- 5 A composite part according to the invention is manufactured in two main steps. In a first step, a pre-form is manufactured by winding the continuous fibre tow around part of the radially outer surface of the first and second inserts. In a second step, the pre-form is placed in a mould and the overmoulding process occurs, whereby the first and second inserts are fixedly attached to the mould.

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In a further development of the invention, the radially outer surface of one or both of the first and second inserts is provided with retaining means for holding the continuous fibre tow in place during and after the manufacture of the pre-form, such that fibre pretension is maintained.

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- In one example, the first and/or second insert has grooves in the radially outer surface with a depth and width that is essentially equal to the diameter of the fibre tow. Typically, the fibre tow has a diameter of 0.5 – 1.5 mm. Preferably, each insert is provided with grooves. During the winding process, the fibre tow is wound
20 around the grooves, which helps to keep the fibre tow in place, thereby facilitating pre-tensioning. In a further example, the outer surface of the first and/or second insert is provided with pegs that protrude from the outer surface, for guiding and retaining the fibre tows.

- 25 As mentioned, the bearing forces are transmitted to the composite part via the bearing connection interface and are transmitted to the further component via the composite body and the further connection interface. It is therefore also important that the first insert of the bearing connection interface and the second insert of the further connection interface are securely embedded within the composite body.

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Thus, in a further development, the radially outer surface of the first and/or second insert comprises a recessed portion into which the overmoulded composite material flows. This mechanically locks the first and/or second insert to the composite body in an axial direction, enhancing the robustness of the connection.

Preferably, the recessed portion is a continuous annular groove and has a depth and width that is larger than a groove that is provided as retaining means for the continuous fibre tow. In this way, a large volume of the overmoulded composite body is recessed relative to a maximum outside diameter of the first and/or second insert. Again, this helps ensure a robust connection between the inserts and the composite body.

In some embodiments, to further improve the strength and stiffness of the interface between the inserts and the composite body, the radially outer surface of the first and/or second insert is roughened. Knurling and lettering are examples of suitable roughening operations, which generate a texture on the surface to which the composite body is overmoulded. This not only increases the effective surface area of the radially outer joining surface, but also creates indentations into which the reinforcing fibres of the overmoulded composite body can enter.

The fibre-reinforced material that forms the composite body preferably comprises a long fibre moulding compound having fibres with a length of 5 – 50 mm, embedded in a polymer matrix. Suitable materials for the fibres include glass, carbon, aramid, PBO (polybenzoxazole) and HDPE (high-density polyethylene). Suitable matrix materials include epoxy resin, phenolic resin, bismaleimide resin, polyimide resin and thermoplastic polymer material.

The continuous fibre tows which connect the first and second inserts in a composite part according to the invention may also be made from carbon, glass, aramid, HBO or HDPE fibres. Advantageously, different types of fibre are selected, depending on the properties required. For example, an aramid fibre such as Kevlar® may be selected to provide energy absorption and safety in response to impact loads. A high-modulus carbon fibre may be selected to enhance stiffness. Alternatively or additionally, a high-strength carbon fibre may be selected to increase strength and load-carrying capacity.

As will be understood, the type of fibre, the number of fibres in the continuous fibre tow and the number of loops around the bearing connection interface and the

further connection interface are selected depending on the application loads in question.

In a first embodiment, the bearing connection interface is formed by a bore for receiving the bearing. The first insert is then a sleeve element, which can be e.g. a steel part to which an outer ring of the bearing is connected. Alternatively, the sleeve element may serve as the bearing outer ring. Preferably, the sleeve element is then made of a bearing grade steel, whereby at least a radially inner surface of the sleeve element has a hardened portion for forming a raceway for at least one row of rolling elements. A sleeve element that serves as the bearing outer ring may also be made from a suitable ceramic material or from titanium.

In a second embodiment, the bearing connection interface is formed by a plurality of bolt inserts, to enable a flanged bearing ring to be bolted to the composite part. Typically, a flanged bearing ring has four or five bolt holes and the composite part has an equal number of bolt inserts. Suitably, the bolt inserts are made of a metal such as steel and have a tubular geometry provided with an internal thread.

In one example of the second embodiment, the first insert is formed by at least one of the bolt inserts and is joined to the second insert of the further connection interface by a continuous fibre tow that is looped around the radially outer surface of the bolt insert and of the second insert. Preferably, each bolt insert is joined to the second insert in this way. In addition, to provide extra strength and stiffness, adjacent bolt inserts may be joined to each other by a continuous fibre tow that is wound around the radially outer surface of each fibre tow.

In a second example of the further embodiment, the plurality of bolt-inserts are joined by a connection element. The connection element may be a ring or have another suitable geometry with a smoothly curved outer surface. The first insert of the bearing connection interface comprises the connection element and is joined to the second insert of the further connection interface by looping the continuous fibre tow around part of the radially outer surface of the connection element and of the second insert.

The second insert may also comprise one or more bolt inserts for enabling the composite part to be bolted to the further component.

In a third embodiment, the first insert comprises an inner ring of a rolling element bearing. In one example, the composite part is a flanged inner ring comprising a flange part that is overmoulded to a ring part. The ring part has a radially outer joining surface that constitutes the bearing connection interface. Suitably, a plurality of bolt inserts constitute the further connection interface, for connecting e.g. a vehicle wheel and brake disc to the flange part. Suitably, each bolt insert is joined to the ring part by a separate continuous fibre tow that is wound around part of the radially outer surface of the insert and of the ring part.

The composite part may also be a flanged outer ring of e.g. a wheel bearing unit. In other examples, the composite part is a steering knuckle for connecting a wheel bearing to a vehicle suspension. The wheel forces are transmitted to the suspension mainly through an upper and a lower connection interface for connecting the knuckle to an upper and a lower control arm of the suspension. Suitably, the second insert is formed by a bracket for attaching a ball joint to the upper and lower connection interface. In a preferred example, the bracket has a tubular portion for receiving a stem of the ball joint and further comprises one or more stubs, arranged around the tubular portion. The first insert may be formed by a sleeve element as described above. Preferably, each stub portion of the bracket is joined to the sleeve element by means of a separate continuous fibre tow. The stubs may have a cylindrical outer surface or other suitable shape, such that the continuous fibre tow is wound around parts of the outer surface that have a smooth, curved surface. In a further example, the second insert comprises stub portions which are adapted for the connection of a separate ball joint bracket.

As mentioned, the continuous fibre tows in a composite part according to the invention are located within the composite body in the load path between connection interfaces. The load path is an ideal site for measuring application loads. Thus in a further development of the invention, at least one of the continuous fibre tows that join the first and second inserts comprises a sensing fibre. An optical fibre comprises one or more fibre Bragg gratings is one example

of a suitable sensing fibre. The sensing fibre may also be a piezoelectric fibre. Thus, the loads that act on the bearing, and which are transferred to the further component through the composite body, can be accurately measured in a composite part according to the invention.

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Other advantageous of the present invention will become apparent from the details description and accompanying drawings.

DRAWINGS

10 The invention will now be described in more detail, with reference to the following Figures, in which:

Fig. 1a shows a perspective view of an example of a composite part according to the invention, executed as a steering knuckle;

15 Fig. 1b shows a side view of a pre-form of the composite part, prior to moulding;

Fig. 1c shows a perspective view of a bracket used in the composite part of Fig. 1a; and

20 Fig. 1d shows an example of a bearing outer ring that may be used in the composite part of Fig. 1a;

Fig. 2a shows a perspective view of a further example of a composite part according to the invention, executed as a steering knuckle;

Fig. 2b shows a front view of a pre-form of the composite part of Fig. 2a, prior to moulding;

25 Fig. 3a shows a perspective view of a still further example of a composite part according to the invention, executed as a steering knuckle;

Fig. 3b, 3c show a perspective view and a front view of a pre-form of the composite part of Fig. 3a, prior to moulding.

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DETAILED DESCRIPTION

An example of a composite part according to the invention is shown in Fig. 1a. The composite part is a steering knuckle for connecting a wheel bearing to a vehicle suspension. The knuckle 100 comprises a bore for receiving a wheel bearing unit.

The bore is formed in a sleeve element 110, to which an outer ring of the bearing unit may be mounted. In the depicted example, the sleeve element serves as the bearing outer ring and is made of a bearing-grade steel, whereby at least an inner circumference of the outer ring 110 comprises hardened portions to act as a raceway for a first row and a second row of rolling elements of the bearing unit.

The knuckle further comprises a composite body 120 that is made of a long fibre moulding compound comprising e.g. carbon fibres in an epoxy resin matrix. In addition to the bore for connection of the bearing unit, the knuckle 100 comprises a number of further connection interfaces. In use, the knuckle is mounted to the vehicle suspension via an upper control arm, a lower control arm and a steering arm. The upper and lower control arms are connected via a ball joint, and the knuckle 100 comprises a corresponding upper connection interface 130 and a lower connection interface 140 in the form of a bracket comprising a tubular portion 147 for receiving a stem of the ball joint. The steering arm is connected to the knuckle 100 at an intermediate connection interface 150. At an opposite side from the connection interface 150, the knuckle further comprises first and second connection interfaces 161, 162 for attaching a brake calliper device to the knuckle.

In use, a variety of forces act on the knuckle. The largest forces are the wheel forces, which are transferred to the knuckle through the bearing unit. These forces are transferred to the vehicle suspension mainly through the upper and lower connection interfaces 130, 140, via the knuckle body 120. As mentioned, the knuckle body is made from a long-fibre moulding compound. This material may not provide the knuckle with sufficient strength and stiffness to withstand the application forces.

According to the invention, the knuckle 100 further comprises continuous fibre tows which are wound around the bearing outer ring 110 and the upper and lower connection interfaces 130, 140. The fibre tows are thus concentrated at, and are in alignment with, a load path that runs through the knuckle body 120 from the bearing connection interface (i.e. the outer ring 110) to the upper and lower suspension connections points 130, 140. The optimal alignment and location of the fibres results in optimal strength and stiffness of the knuckle 100.

The winding of the continuous fibre tows takes place prior to moulding of the knuckle body 120. A pre-form is thus produced, which is then overmoulded with the long-fibre moulding compound. Fig. 1b shows a side view of an example of the

5 pre-form 105, during the winding process

The bearing outer ring 110 is fixed on a rig (not shown). The upper bracket 130 and the lower bracket 140 are likewise fixed to the rig, at locations relative to the bearing outer ring 120 suitable for connection of the upper and lower control arm

10 ball joints. A perspective view of the upper bracket 130 is shown in Fig. 1c.

As mentioned, the upper bracket and the lower bracket comprise a tubular part 147 for receiving the stem of a ball joint. This part 147 may be threaded, may have a tapered bore, or may have a straight bore such that the ball joint stem can be

15 bolted to the bracket 130, 140. A centre axis of the tubular part is perpendicular to or translationally perpendicular to a rotation axis of the bearing. To facilitate the connection of the bearing outer ring 110 with the upper and lower brackets via continuous fibre tows, each bracket 130, 140 further comprises stub portions 135 around which a continuous fibre tow may be wound. The stub portions 135 also

20 facilitate the connection of the brackets 130, 140 to the overmoulded composite body 120, and provide locking in a radial direction. In the depicted example, each of the upper and lower bracket has three stub portions 135 with a cylindrical outer surface, which are arranged around the tubular portion 147. A section of the cylindrical surface that is radially farthest from the bearing ring 110 forms the

25 surface around which the continuous fibre tow is looped.

The tubular portion 147 and the stub portions 135 are joined by a connecting portion 137, such that the bracket forms a single piece. This facilitates the positioning of the bracket on the winding rig.

The pre-form 105 is made using e.g. an automated fibre placement machine or robot. In Fig.1b, four continuous fibre tows are depicted. A first tow 171 is wound around part of an outer circumference of a first stub portion of the upper bracket 130 and then around part of an outer circumference of the bearing outer ring 110.

A second tow 172 is wound around part of the outer circumference of a second stub portion 135 of the upper bracket and then around part of the bearing outer ring outer circumference. A third stub portion of the upper bracket 130 is connected in a similar fashion to the bearing outer ring 110 via a further continuous fibre tow (not shown). For connecting the bearing outer ring and the lower bracket, a third tow 173 is wound around part of the outer circumference of a first stub portion 135 of the lower bracket 140 and then around part of the outer circumference of the bearing outer ring 110. A fourth tow 174 is wound around part of the outer circumference a second stub portion of the lower bracket 140. A further tow (not shown) connects the third stub of the lower bracket and the bearing ring in a similar fashion. Suitably, each fibre tow is looped a number of times around the bearing outer ring 110 and a stub 135, depending on the magnitude of the loads acting on the connection interfaces. The thickness of the fibre tow may also vary depending on the loads. Furthermore, fibre tows made from different fibre materials may be used to impart different advantageous properties to the knuckle 100.

In a steering knuckle according to the invention, the bearing connection interface 110 and the upper and lower suspension connection interfaces 130, 140 serve as placeholders for the continuous fibre tows 171, 172, 173, 174 during the winding process. Advantageously, the fibre tows are pretensioned during the winding process. To assist fibre-pretensioning and to help guide and retain the fibre tows, the outer circumference of the bearing outer ring 110 and of the stub portions 135 on the upper and lower brackets are preferably provided with retention means. In the example of Fig. 1b, grooves are provided in the outer surface of the bearing outer ring 110 and in the outer surface of the stub portions 135. The fibre tows are then provided in these grooves during the winding process.

The fibre-retaining grooves are more clearly depicted in Figure 1d, which shows a radial cross-section of the bearing outer ring 110. In the depicted example, the outer ring will form part of a double-row angular contact bearing and a radially inner surface of the outer ring has first and second angled raceways 111, 112 for two rows of balls. At a radially outer side of the ring 110, opposite from the angled raceways, the outer ring has circumferential grooves 117 for retaining a

continuous fibre tow. Loads are transmitted to the outer ring 110 at the raceways 116, 117, which loads are thus led directly to the upper and lower suspension connection interfaces via the continuous fibre tows. Additional retaining grooves 118 are provided on the outer circumference of the outer ring 110, to provide
5 additional connection places for additional fibre tows. The retaining grooves 117, 118 have a depth and width that is essentially equal to the diameter of the continuous fibre tow that is retained therein.

As may be seen in Fig. 1b and Fig. 1d, the bearing outer ring 110 also has a
10 central annular groove or recessed portion 115. During the overmoulding process, the moulding compound flows into the recessed portion, which mechanically locks the bearing ring 110 to the composite body 120 in an axial direction. Suitably, the recessed portion 115 has curved surfaces its axial peripheries, to avoid stress concentrations that could damage the composite body. The radially outer surface
15 of the stub portions 135 can also be provided with such an annular recess. In addition, the radially outer surface of the outer ring 110 and of the stub portions can be roughened by means of knurling or lettering, to enhance the strength and stiffness of the interface with the composite body.

20 In the depicted examples, the continuous fibre tows comprise dry carbon fibres. These fibres will become impregnated with matrix material that is absorbed from the long-fibre moulding compound, when the knuckle body 120 is overmoulded. It is also possible to use pre-impregnated fibres, which may be cured prior to placing the preform in the mould or which may be cured simultaneously with the moulding
25 compound.

When the pre-form is finished, it is placed in a mould. Suitably, the bearing outer ring 110, the upper bracket 130 and the lower bracket 140 are precisely located and fixed to the mould during the moulding process. This helps to maintain the
30 pretension in the fibre tows, which was achieved during the winding process. Maintaining fibre pretension is advantageous in terms of optimizing the fibre properties and thus the performance of the finished component.

After moulding and curing, the knuckle body may be machined. In the example shown in Fig. 1a, the connection interfaces 161, 162 for the brake calliper and the intermediate connection interface 150 for the steering arm are mounting holes machined into the knuckle body 120. As will be understood, these connection
5 interfaces may also be formed by inserts that are connected to the bearing outer ring or to the upper and lower brackets 130, 140 by continuous fibre tows.

A further example of a composite part according to the invention, executed as a steering knuckle, is shown in Figure 2a. The associated pre-form 205 is shown in
10 Fig. 2b.

In the second embodiment, the bearing connection interface is formed by first, second, third and fourth bolt inserts 211, 212, 213, 214 for enabling a wheel bearing unit with a flanged outer ring to be bolted to the knuckle 200. The knuckle
15 further comprises an upper bracket 230 and a lower bracket 240, for connection of the upper and lower control arms respectively. The upper and lower brackets 230, 240 are joined to the bolt inserts 211, 212, 213, 214 by an overmoulded composite body 220. Again, long-fibre moulding compound is used in the depicted example to form the composite body.

In accordance with the invention, each bolt insert is additionally joined to one of the upper and lower brackets by a continuous fibre tow that is looped around the threaded insert and around a stub portion of the bracket.

With reference to Fig. 2b, a first continuous fibre tow 271 is looped around part of an outer circumference of the first bolt insert 211 and around part of an outer circumference of a first stub portion (not visible) on the upper bracket 230. A second continuous fibre tow 272 is looped around part of an outer circumference of the second bolt insert 212 and around part of an outer circumference of a
25 second stub portion 232 on the upper bracket 230. A third continuous fibre tow 273 is looped around part of an outer circumference of the third bolt insert 213 and around part of an outer circumference of a third stub portion 233 on the lower bracket 240. A fourth continuous fibre tow 274 is looped around part of an outer
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circumference of the fourth bolt insert 214 and around part of an outer circumference of a fourth stub portion 234 on the lower bracket 240.

The steering knuckle 200 is provided with further strength and stiffness in that
5 adjacent bolt inserts are joined to each other by a continuous fibre tow. A fifth continuous fibre tow 275 is looped around part of the outer circumference of the first and second bolt inserts 211, 212. A sixth continuous fibre tow 276 is looped around part of the outer circumference of the second and third bolt inserts 212, 213. A seventh continuous fibre tow 277 is looped around part of the outer
10 circumference of the third and fourth bolt inserts 213, 214. Finally, an eighth continuous fibre tow 378 is looped around part of the outer circumference of the first and fourth bolt inserts 211, 214.

A further example of a composite part according to the invention is shown in Fig.
15 3a, whereby views of the associated pre-form are depicted in Figs. 3b and 3c.

The composite part is a flanged bearing ring 300 that will form part of a hub bearing unit adapted for inner ring rotation, and comprises a radially extending wheel mounting flange 320 and an axially extending inner ring part 310. The ring
20 part is made of bearing steel in the depicted example and comprises a raceway portion 312 with a hardened surface for receiving a row of rolling elements. The bearing will further comprise a separate inner ring (not shown) that is mounted on an axially inner portion 313 of the ring part. In addition, the ring part 310 comprises a spigot portion 315, to facilitate centring of a wheel rim that is mounted to the
25 flange part 320 of the bearing ring 300. The flange part is at least partly made of a fibre-reinforced matrix material.

In conventional wheel bearing units, the flanged inner and/or outer ring is made entirely of bearing steel and bolt holes for attaching the brake disc and wheel rim
30 are machined into the flange. When the flange is made of fibre-reinforced matrix material, the bolt holes are suitably formed by bolt inserts that are overmoulded with the fibre-reinforced material.

As can be more clearly seen in Figures 3b and 3c, the flange 320 has five bolt inserts 331, 332, 333, 334, 335 arranged at regular intervals, at a radial distance from the ring part 310. The bolt inserts are made of a metal such as steel and have a tubular geometry provided with an internal thread. The flange part 310 is made of a long-fibre moulding compound that is overmoulded to a joining surface 317 on the ring part 320. The joining surface is arranged between the raceway portion 322 and the spigot portion 325. During the overmoulding process, the bolt inserts 331, 332, 333, 334, 335 become embedded in the flange part 320 and are thus joined to the ring part 310 via the composite body of the flange part 320.

According to the invention, the ring part is additionally joined to at least one of the bolt inserts by a continuous fibre tow that is wound around a section of the joining surface 317 and around a section of a radially outer surface of the at least one bolt insert. Preferably, as shown in Figures 3b and 3c, the ring part 310 is joined in this manner to each of the bolt inserts.

A first continuous fibre tow 371 is looped around a section of the radially outer surface of the first bolt insert 331 and around a section of the ring part joining surface 317. Second 372, third 373, fourth 374 and fifth 375 continuous fibre tows respectively join the second 332, third 333, fourth 334 and fifth 335 bolt inserts to the ring part 310 in a similar manner.

The loads on the vehicle wheel are transmitted to the hub bearing unit through the flange 320. The bolt inserts constitute load introduction points, and the load is then transmitted to the ring part 310 of the bearing through the joining surface 317. Therefore, the continuous fibre tows, 373, 372, 373, 374 and 375 follow the load path, which provides the flange 310 with excellent strength and stiffness.

The flange 320 is provided with further strength and stiffness in that adjacent bolt inserts are also joined to each other by a continuous fibre tow. A sixth continuous fibre tow 376 is looped around a section of the radially outer surface of the first and second bolt inserts 333, 332. A seventh continuous fibre tow 377 joins the second and third bolt inserts 332, 333 in the same manner. An eight continuous fibre tow 378 joins the third and fourth bolt inserts 333, 334 in the same manner. A

ninth continuous fibre tow 379 joins the fourth and fifth bolt inserts 334, 335 in the same manner. Finally, a tenth continuous fibre tow 380 joins the fifth and first bolt inserts 335, 331 in the same manner.

- 5 The pre-form 305 is made using e.g. an automated fibre placement machine or robot. Advantageously, the fibre tows are pretensioned during the winding process. To assist fibre-pretensioning and to help guide and retain the fibre tows, the joining surface 317 of the ring part and the radially outer surface of each bolt insert are preferably provided with a circumferential groove 319 with a depth and
10 width essentially equal to the diameter of the fibre tow.

When the pre-form is finished, it is placed in a mould. Suitably, the ring part 310 and each bolt insert 333, 332, 333, 334, 335 are precisely located and fixed to the mould during the moulding process. This helps to maintain the pretension in the
15 fibre tows, which was achieved during the winding process. Maintaining fibre pretension is advantageous in terms of optimizing the fibre properties and thus the performance of the finished component.

To facilitate the moulding of the flange part 320 to the ring part 310, the joining
20 surface 317 is preferably provided with an indentation or a continuous groove that is larger than the one or more fibre-retaining grooves 319. The moulding compound will flow into this indentation, to provide mechanical locking between the flange part and ring part in an axial direction.

- 25 Each bolt insert preferably also has such an indentation for mechanically locking the bolt insert in an axial direction within the overmoulded flange 310. In the example depicted in Fig. 3b, each bolt insert has the shape of a reel. Taking the first bolt insert 331 as an example, a radially extending rim 340 is provided at each axial end of the insert. The moulding compound flows around the radial surface
30 343 between the rims 340, thereby locking the bolt insert 331 in a radial direction and an axial direction relative to the flange 320. The radially outer joining surfaces 317, 341 are additionally provided with a surface texture, such that fibres of the long-fibre moulding compound can enter into indentation of the surface texture, to further improve the strength and stiffness of the interface with the flange 320.

Thus, a flanged bearing ring is another example of a composite part according to the invention which is lightweight and has sufficient strength and stiffness to withstand high application loads.

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A number of aspects/embodiments of the invention have been described. It is to be understood that each aspect/embodiment may be combined with any other aspect/embodiment. Moreover the invention is not restricted to the described embodiments, but may be varied within the scope of the accompanying patent

10 claims.

Claims

1. Composite part (100, 200, 300) comprising a bearing connection interface for connecting a bearing to the composite part and comprising a further connection interface for connecting the composite part to a further component, wherein:

- the bearing connection interface is formed by a first insert (110, 211, 212, 213, 214, 310);
- the further connection interface is formed by a second insert (130, 140, 230, 330, 331, 332, 333, 334, 335), which is radially spaced from the first insert ; and
- the bearing connection interface and the further connection interface are joined via a composite body (120, 220, 320) comprising a fibre-reinforced material that is overmoulded to a radially outer surface of the first insert and to a radially outer surface of the second insert,

characterized in that

the bearing connection interface and the further connection interface are additionally joined by a continuous fibre tow (171, 172, 173, 174, 271, 272, 273, 274, 371, 372, 373, 374, 375) that is wound around part of the radially outer surface of the first and second inserts.

2. Composite part according to claim 1, wherein the radially outer surface of the first and/or second insert comprises a recessed portion (115, 341) into which the overmoulded fibre-reinforced material flows, to mechanically lock the first and/or second insert to the composite body (120, 220, 320) in an axial direction of the insert.

3. Composite part according to claim 1 or 2, wherein the radially outer surface of the first and/or second insert is roughened to create a surface texture.

4. Composite part according to any preceding claim, wherein the radially outer surface of the first and/or second insert is provided with retaining means for guiding and retaining the continuous fibre tow and wherein the continuous fibre tow is wound under pre-tension, using the retaining means

5. Composite part according to claim 4, wherein the retaining means are formed by one or more grooves (117, 118, 319) having a depth and width essentially equal to a diameter of the continuous fibre tow.

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6. Composite part according to claim 4, wherein the retaining means are formed by one or more pegs which protrude from the radially outer surface of the insert.

- 10 7. Composite part according to any preceding claim, wherein the first insert comprises a sleeve element (110, 210), whereby a bore of the sleeve element is adapted to receive an outer ring of the bearing or is adapted to serve as an outer raceway (111, 112) of the bearing.

- 15 8. Composite part according to any of claims 1 – 6, wherein the first insert comprises an inner ring part (310) of a rolling element bearing.

9. Composite part according to any of claims 1 – 6, wherein the bearing connection interface is formed by a plurality of bolt inserts (211, 212, 213, 20 214) to enable a flanged bearing ring to be bolted to the composite part (200), and wherein the radially outer surface of the first insert is a radially outer surface of at least one of the bolt inserts.

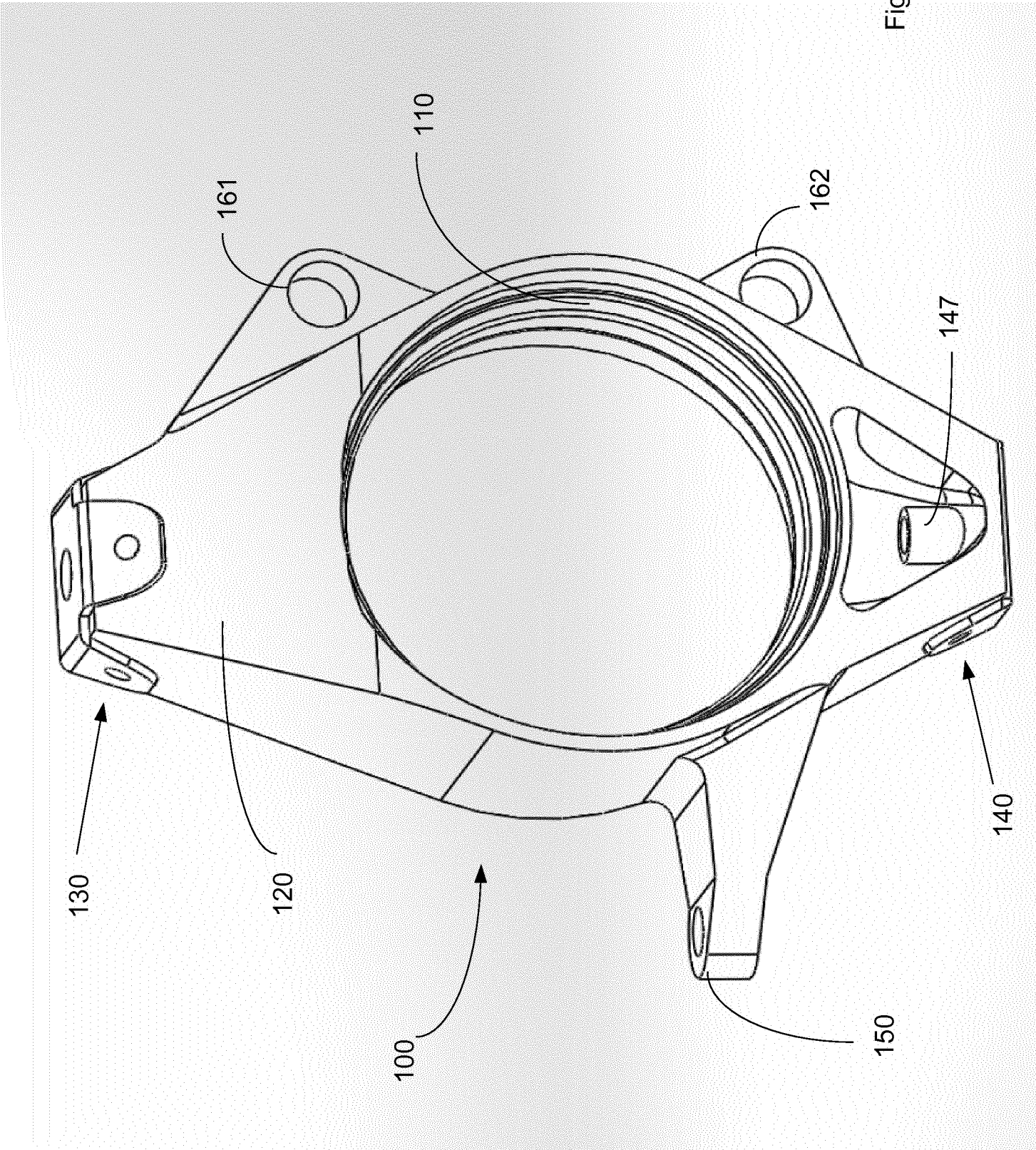
10. Composite part according to any of claims 1 – 6, wherein the bearing connection interface is formed by a plurality of bolt inserts which are 25 interconnected by a connection element, and wherein the radially outer surface of the first insert is formed by a radially outer surface of the connection element.

- 30 11. Composite part according to any preceding claim, wherein the second insert comprises a bracket (130, 140, 230, 240) with two or more stub portions (135, 222, 223, 224) and wherein each stub portion is joined to the bearing connection interface by a separate continuous fibre tow that is wound around part of the radially outer surface of the stub portion and of the first insert.

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12. Composite part according to any preceding claim, wherein the continuous fibre tow comprises a sensing fibre for measuring a load on the composite part.
- 5 13. Composite part according to claim 12, wherein the sensing fibre is an optical fibre with a fibre-Bragg grating strain sensor.
14. Composite part according to any preceding claim, wherein the composite body (120, 220, 320) is made from a long fibre moulding compound.

Figure 1a



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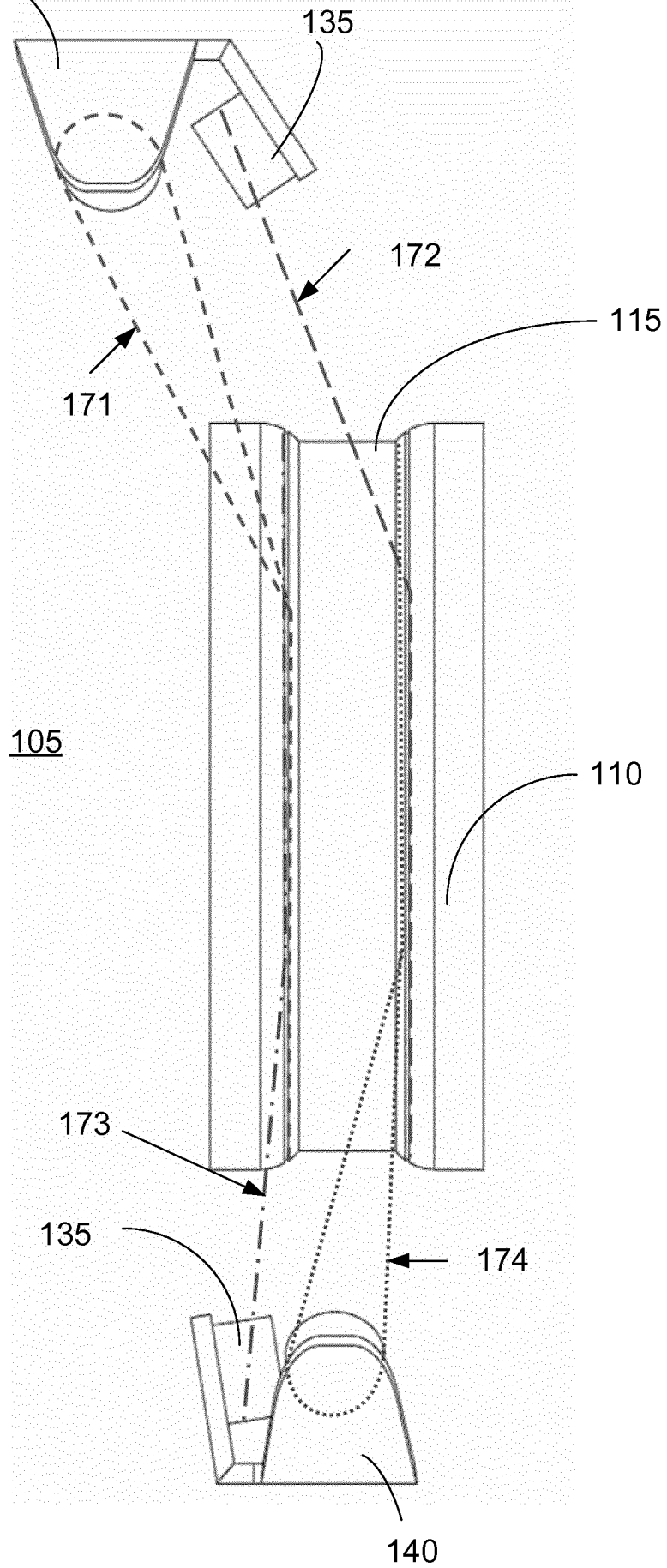


Figure 1b

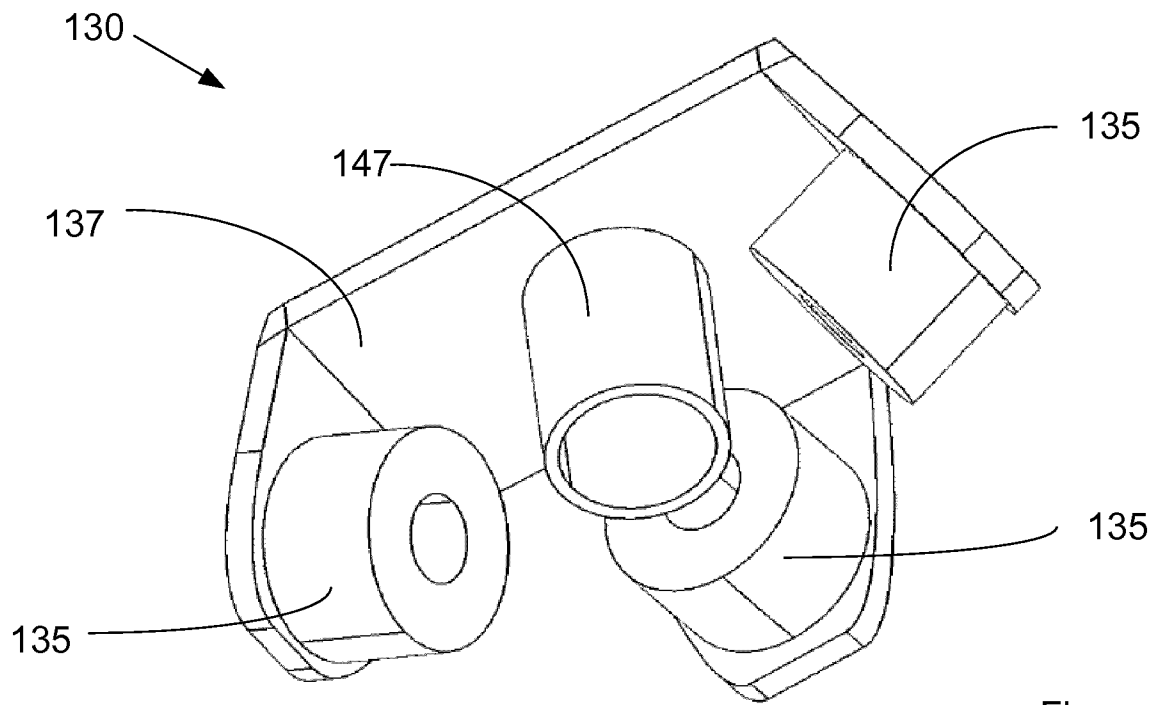


Figure 1c

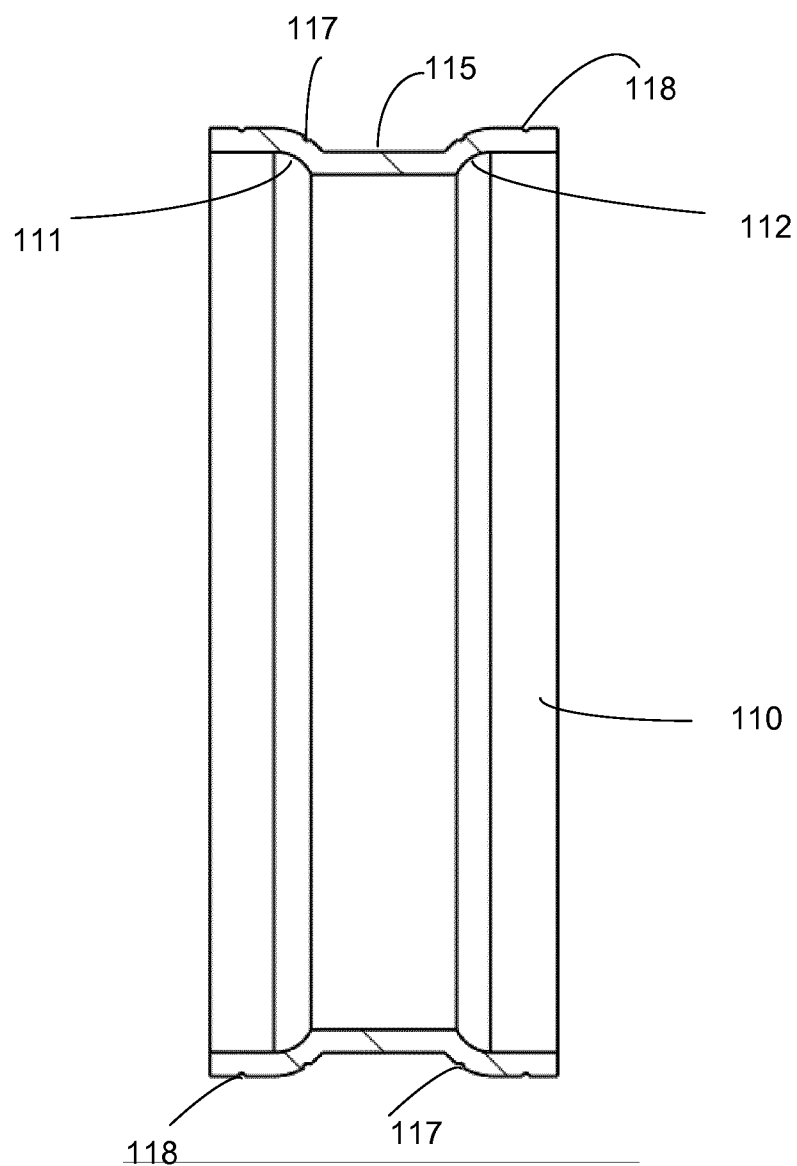


Figure 1d

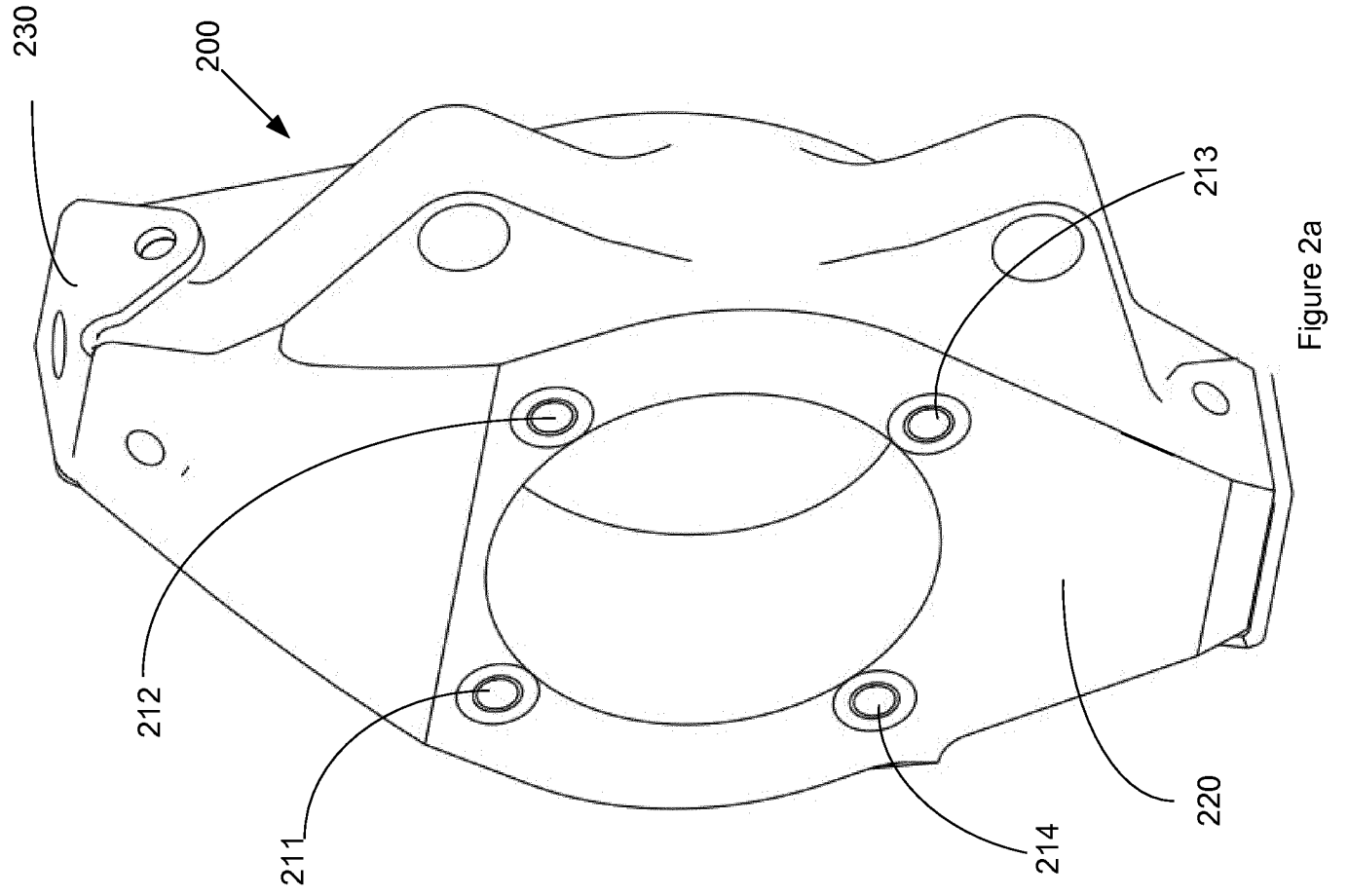


Figure 2a

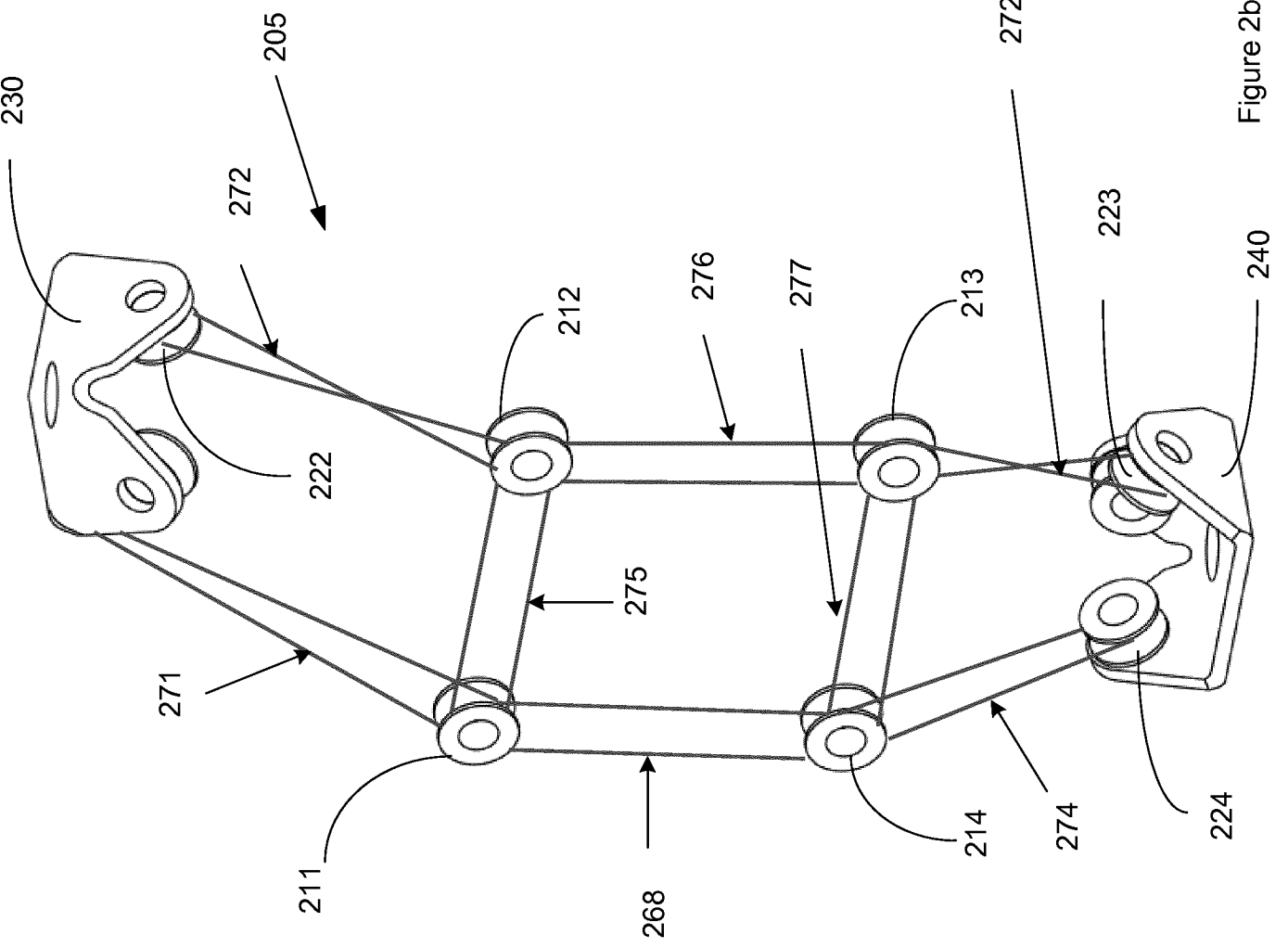


Figure 2b

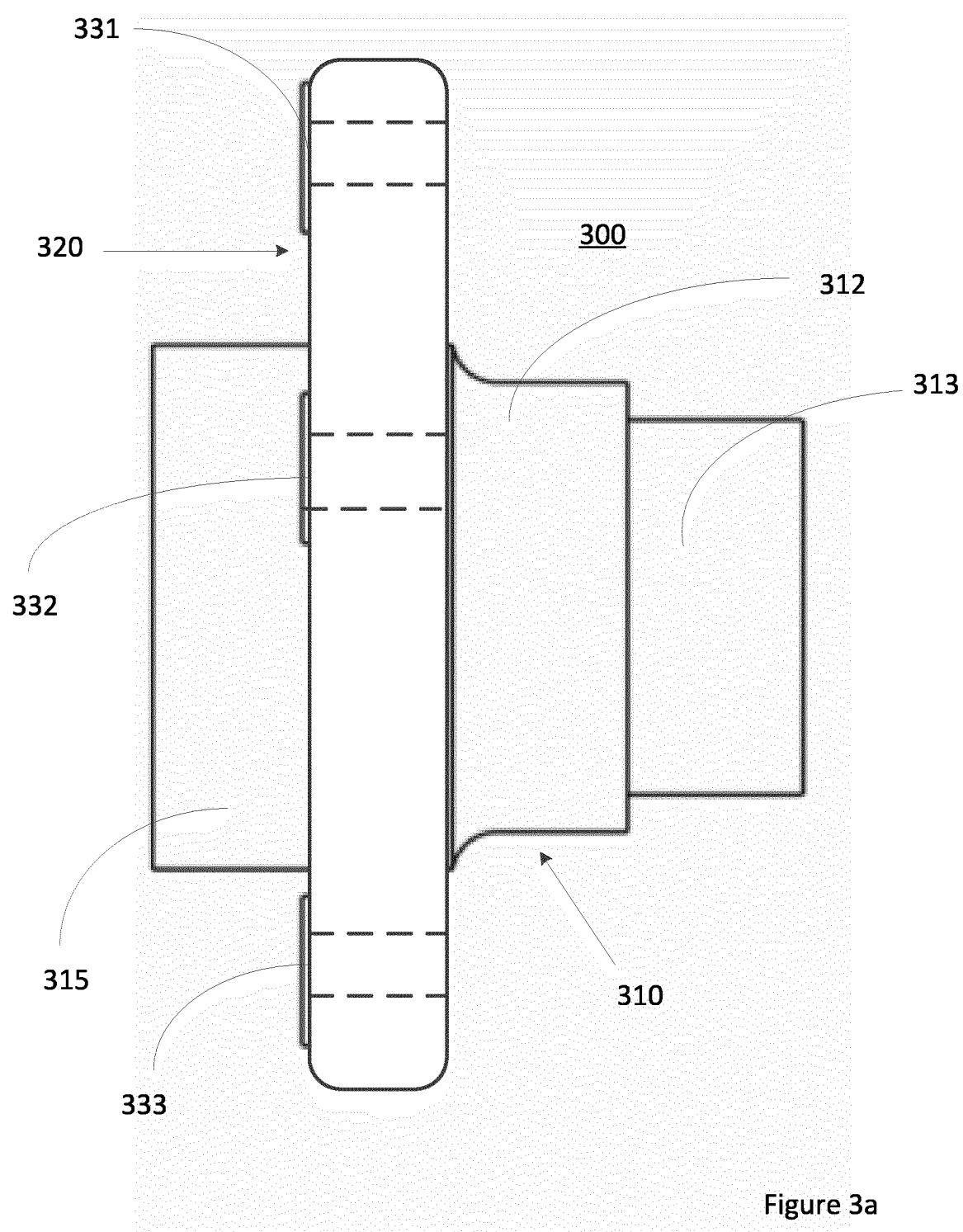


Figure 3a

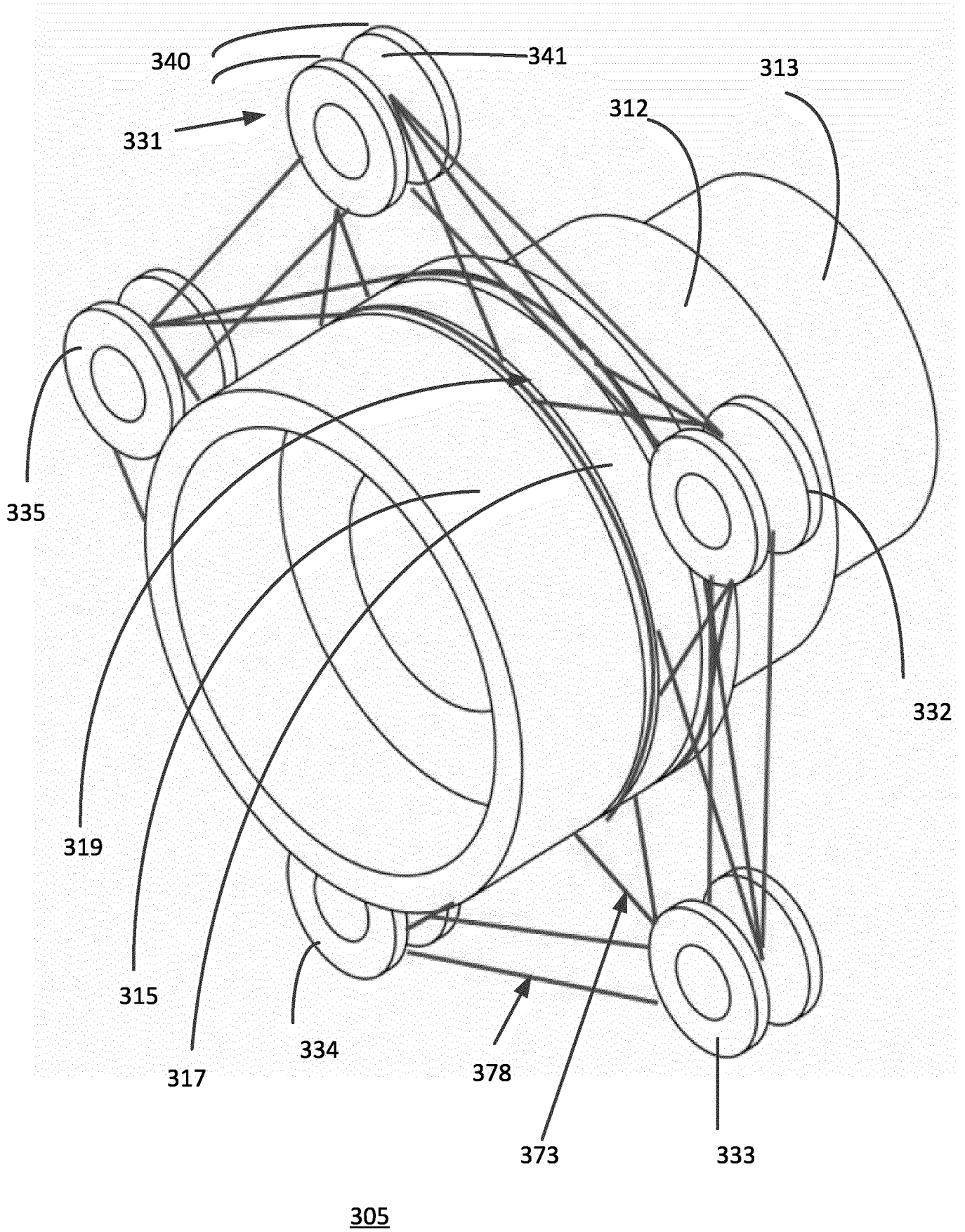


Figure 3b

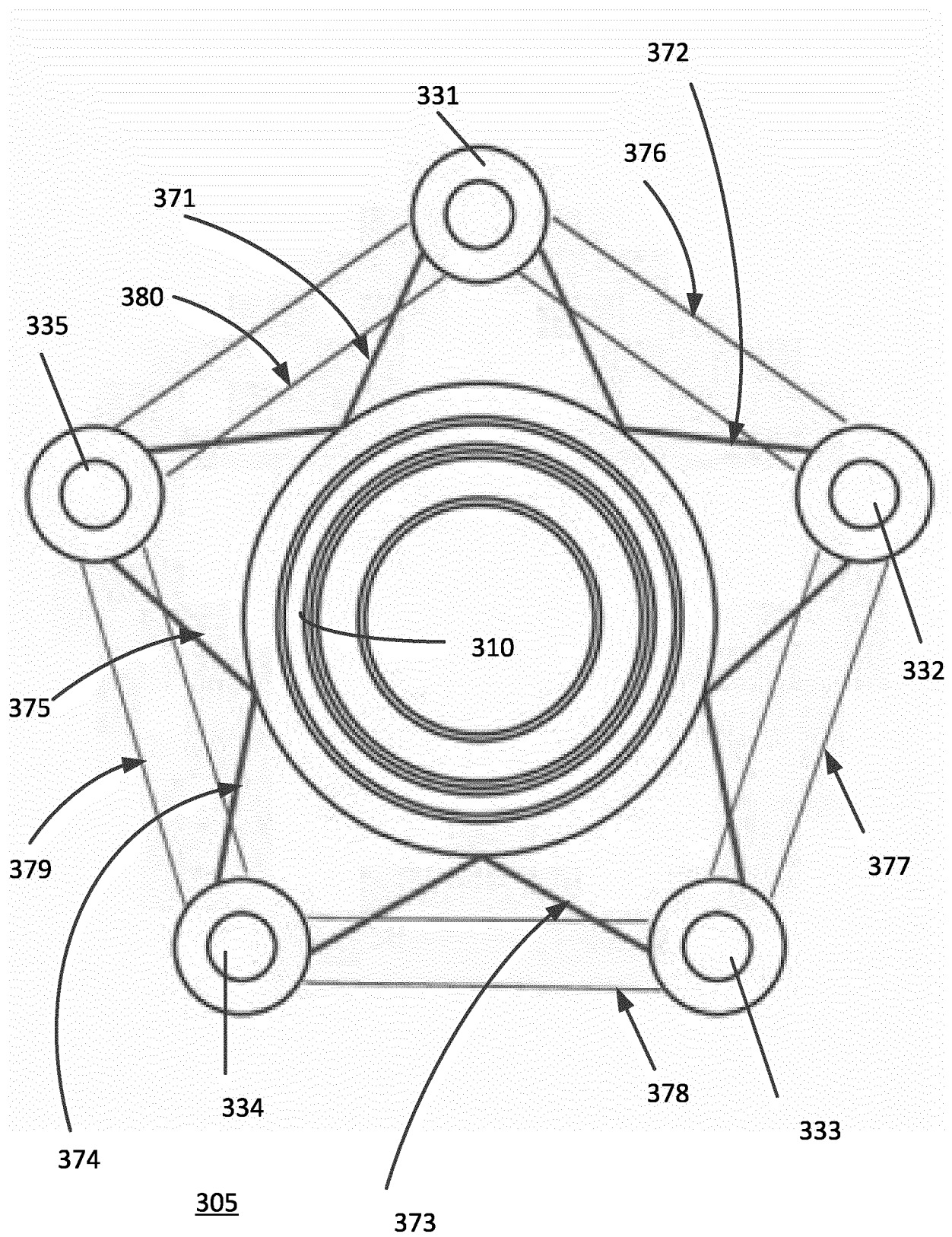


Figure 3c