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(54) SLIPRING HOUSING WITH BAYONET LOCK

SCHLEIFRINGGEHÄUSE MIT BAJONETTVERSCHLUSS

LOGEMENT DE BAGUE COLLECTRICE COMPORTANT UNE SERRURE À BAÏONNETTE

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(56) References cited:
EP-A1- 3 316 425
EP-A2- 3 096 175
CH-A- 246 799
US-A- 4 485 278
US-A1- 2008 192 975

EP 3 641 076 B1

Description

Field of the invention

[0001] The invention relates to slipring devices for transmission of electrical signals between rotating parts. Specifically, it relates to housings of such slipring devices.

Description of the related art

[0002] Electrical sliprings are used to transfer electrical power and/or signals between a rotating and a stationary part. Such sliprings are used in different applications, like wind energy plants or computer tomography scanners. There are also many industrial, military, and aerospace applications in which sliprings are used.

[0003] Specifically for industrial applications, the sliprings should have a housing which allows simple integration into complex machines. The housing further should provide a sufficient protection against dust, debris, and liquids. Furthermore, the housing should allow easy disassembly of the slipring device for maintenance purposes.

[0004] A very robust and complex multifunctional slipring housing is disclosed in EP 2 696 443 B1. It has a very high degree of sealing, but requires a large number of screws to be removed for opening the housing.

[0005] EP 1 026 794 B1 discloses a slipring in a plate-like arrangement. Due to the complex interior assembly and the multiply screwed housing, the disassembly is only possible with extremely high efforts.

[0006] US 4,485,278 discloses a device for automatically winding up a feeder cable. Here, a spring housing is attached by a bayonet lock to a drum. The housing parts are held by a snap lock connection (locking pawls 1.2). There is also no hollow shaft comprising at least one bayonet lock notch and no locking ring having at least one bayonet lock protrusion oriented in a radial direction to the center axis. EP 3 096 175 A2 discloses binoculars having a sliding contact connection. There is also no hollow shaft comprising at least one bayonet lock notch and no locking ring having at least one bayonet lock protrusion oriented in a radial direction to the center axis. Instead of the locking ring, there is a pin 6 (Figure 15) which protrudes into the tubular protrusion and interfaces with the first part (5).

[0007] US 2008/0192975 A1 discloses a sliding contact device having a printed circuit board.

[0008] EP 3 316 425 A1 discloses a 3D-printed slipring module.

[0009] CH 246 799 discloses a stacked slipring arrangement.

Summary of the invention

[0010] The problem to be solved by the invention is to provide a slipring device and a slipring housing which can easily be integrated in a complex environment and which further can easily be assembled in manufacturing and which can easily be disassembled for maintenance.

[0011] Solutions of the problem are described in the independent claim 1. The dependent claims relate to further improvement of the invention.

[0012] A slipring device comprises a first part and a second part which are rotatable against each other about a center axis. For example, the first part may be stationary, whereas the second part may be rotating relative thereto. Of course, the rotating and stationary parts may be exchanged or even both parts may be rotating with different speeds.

[0013] The first part comprises a first housing which may contain all necessary slipring components. Such a component may be at least one sliding track and/or one sliding brush. Preferably, the slipring component comprises a printed circuit board which may have a sliding track as a PCB trace, and/or a brush mounted and/or soldered to the PCB.

[0014] The second part arranged opposite to the first part also has a second housing and may further comprise slipring parts, like at least one a sliding track and/or one sliding brush. Preferably, the slipring component comprises a printed circuit board which may have a sliding track as a PCB trace, and/or a brush mounted and/or soldered to the PCB.

[0015] The slipring components in the first part and the second part are designed such that they interface in a way to form a sliding contact connection. Therefore, a contact brush at the first part interfaces with the sliding track at the second part and/or a contact brush at the second part interfaces with a sliding track at the first part. Preferably, multiple sliding contact connections are provided between the first part and the second part.

[0016] For holding the first part and the second part in a spatial relationship and allowing rotation there-between, at least one bearing is provided. Such a bearing may be a slide bearing, a ball bearing, a liquid bearing or any other suitable bearing. Preferably, a ball bearing and most preferably two ball bearings are provided. Furthermore, the first housing includes a hollow shaft which serves as a guidance for the second part and holds a locking means which is a locking ring. The hollow shaft preferably has a free inner bore over its total length. This may allow to feed cables, waveguides and pipes through the hollow shaft and may even allow to insert further rotary joints. The locking ring holds and locks the first part against the second part. According to the invention there is a spring between the locking ring and the first and/or second part to ensure a certain and preferably a constant pressure between the first and the second part to hold these parts in place. Preferably, the spring is a wave spring or plate spring or a disk spring.

[0017] Most preferably, the spring is formed as one part with the locking ring. In a preferred embodiment, the locking ring is a 3D printed part which has an integrated spring or multiple springs. This is a significant advantage

over standard manufacturing methods, as these do not allow to combine the spring with the locking ring. Anyway, any part of the device may be made by a 3-D printing process. High-volume manufacturing may be performed by injection-molding.

[0018] The locking ring has a bayonet lock which allows simple assembly and disassembly of the slipring device.

[0019] The hollow shaft has at least one notch or a plurality of notches, and the locking ring has at least one protrusion for interfacing with the notches of the hollow shaft. The protrusion is oriented in a radial direction to the center axis. The order of the notches and protrusions may be exchanged.

[0020] Assembly of the slipring device is very simple. The second part only has to be placed on the hollow shaft of the first part. In a next step, the locking ring has to be placed on the hollow shaft and to be locked. Locking is done by locking the bayonet lock by pressing the locking ring down in a locking position and then rotating the locking ring until the bayonet lock locks. To unlock and disassemble the housing e.g. for service the locking ring may be rotated in the opposite direction. The direction may be counter clockwise for disassembly and clockwise for assembly.

[0021] The housing parts when manufactured from plastic material e.g. in a 3D printing process or injection molding process might incorporate metal threaded inserts to allow stable mounting of the slipring to a customer interface or to mount a torque bridge. Also, a metal or absorbent coating might be applied to the inner housing surface for shielding of the slipring to reduce electromagnetic emissions or improve electromagnetic susceptibility of the slipring.

[0022] In another embodiment, the housing may comprise a metal, e.g. aluminum. Preferably, the first housing and/or the second housing are made of metal.

[0023] In another embodiment, the first bearing is arranged between the first housing and the second housing in a direction parallel to the center axis.

[0024] In a further embodiment, the hollow shaft holds the second part and/or the second housing.

[0025] A simple position encoder can also be integrated by 3-D-printing a resistive substrate formed as a circle with the center at the rotation axis onto the inner surface of one part of the housing. The substrate is contacted by at least one electrode static to the printed substrate and a metal brush that is mounted to the other part of the housing and that moves angularly with the rotation of the slipring so that an absolute or relative resistor value measured between the sliding brush and the at least one static electrode represents an angular position between the two housings to serve as an encoder. The housing might also only partially cover the slipring to reduce costs or mass or inertia of the slipring. Connectors might be mounted to the housing or to at least one of the printed circuit boards.

Description of Drawings

[0026] In the following the invention will be described by way of example, without limitation of the general inventive concept, on examples of embodiment with reference to the drawings.

Figure 1 shows a first embodiment of a slipring device.

Figure 2 shows a detail of the locking ring with bayonet lock.

Figure 3 shows the slipring in detail.

Figure 4 shows a further detail of the bayonet lock.

Figure 5 shows a detail of another bayonet lock.

Figure 6 shows a second embodiment of a slipring device.

Figure 7 shows a detail of the locking ring with bayonet lock and a slide bearing.

Figure 8 shows a third embodiment of a slipring device.

Figure 9 shows a detail of the locking ring with a modified slide bearing.

Figure 10 shows a further embodiment of a slipring device.

Figure 11 shows a detail of the locking ring of the previous embodiment.

[0027] In Figure 1, a first embodiment of a slipring device is shown. The slipring device basically comprises a first part 100 and a second part 200, which are rotatable against each other about a center axis 130. The first part 100 has a first housing 110 which holds a first printed circuit board (PCB) 180. This PCB may hold at least one first sliding track 182 and/or at least one contact brush 190.

[0028] The second part 200 has a second housing 210 with a second PCB 280. Preferably, the second PCB 280 has at least one second contact brush 290 and at least one second sliding track 282. The sliding tracks and brushes are arranged such that a sliding track of the first PCB interfaces with a sliding brush of the second PCB, and vice versa to accomplish an electrical contact. Between the first housing 110 and the second housing 210 is at least a first bearing 310 which provides mechanical support and allows rotation of the second housing against the first housing. It is preferred to have at least a second bearing 320. The first housing 110 has a hollow shaft 120 which may serve as a centering means. Attached to the

hollow shaft 120 is a locking ring 340 which is configured to press preferably in a direction of the center axis 130 against a spring 330 to hold the second housing against the first housing in a defined position. Preferably, the locking ring has a bayonet lock by which it is locked against the hollow shaft 120. The locking ring preferably is attached to the outside of the hollow shaft. Preferably, the inner diameter of the locking ring is larger than the outer diameter of the hollow shaft.

[0029] In Figure 2, a detail of the locking ring with bayonet lock is shown. The locking ring 340 preferably has a bayonet lock protrusion 342. This protrusion is guided in a bayonet lock notch 122 at the hollow shaft 120. The bayonet lock notches and the bayonet lock protrusions are arranged such that they match to each other. Preferably, there are at least two, and most preferably at least three or even more bayonet lock notches and adapted bayonet lock protrusions. Preferably, there are three such bayonet lock notches and bayonet lock protrusions under an angle of 120 degrees to each other. In general, it is preferred, if the bayonet lock notches are arranged equidistant.

[0030] For assembly, the locking ring is placed on the top of the hollow shaft and the bayonet lock protrusion 342 is inserted into the bayonet lock notch 122 and pushed downwards. In a next step, the locking ring is rotated such that the protrusion engages with the bayonet lock and the locking ring 340 is held in place.

[0031] In Figure 3 a slipring is shown in detail. A first printed circuit board (PCB) 180 is mounted to a first housing as shown in Fig 1. This PCB 180 may hold at least one first sliding track 182 and/or at least one contact brush 190. A first connector 170 may be mounted to the PCB and connector pins may be connected to the tracks. The connector may accessible by an opening of the first housing. There may also be at least one connector at the second PCB.

[0032] In Figure 4, a detail of the bayonet lock is shown. Basically, this is a side view of a section of the hollow shaft 120. Here, the bayonet lock notch 122 is shown in detail. This notch preferably has a first section 123 which goes into a direction such that the compression of the spring is increased. A second section 124 preferably is under a right angle to the first section. This section can be reached by the bayonet lock protrusion 342 by rotating the locking ring. To prevent loosening of the locking ring, there preferably is a notch 125 which prevents returning of the bayonet lock protrusion 342 into the first section. Normally, after the locking ring has been locked in the bayonet lock, the force of the spring 340 tends to press the locking ring outwards, which is upwards in this drawing such that the protrusion cannot pass the notch 125 without generating counter pressure against the spring.

[0033] In Figure 5, a detail of another embodiment of a bayonet lock is shown. Basically, this is similar to the previous embodiment, but has a modified second section 126. This second section 126 may have multiple sections with different heights. The bayonet lock protrusion 342 notch may engage with any of these sections resulting in a different position of the locking ring and therefore in different force of the spring 340. Here, by rotating the locking ring, the force may be adjusted.

[0034] In Figure 6, a second embodiment of a slipring device is shown. The slipring device is similar to the slipring device of figure 1, but has different bearings. Here, instead of ball bearings, slide bearings, also called friction bearings are used. Such bearings have surfaces sliding against each other. In this embodiment, the ball bearings are replaced by a first slide bearing 410 and a second slide bearing 420.

[0035] Figure 7 shows a detail of the locking ring with bayonet lock and a slide bearing. This is a detail of the previous figure.

[0036] Figure 8 shows a third embodiment of a slipring device. Here, no discrete slide bearings are used as in the previous embodiment. Instead, the second housing 210 is sliding within first housing 110 and hollow shaft 120. The first housing 110 and the hollow shaft 120 may also be one part. There is a bearing gap 510 between the second housing 210 slidably agaainst first housing 110 and hollow shaft 120. There may be a lubricant in the bearing gap.

[0037] Figure 9 shows a detail of the locking ring of the previous embodiment. There may be a counter bearing 520 to hold the second housing 210 in place.This counter bearing may also be part of the locking ring.

[0038] In Figure 10, a further embodiment of a slipring device is shown. The slipring device is similar to the slipring device of figure 1, but has only one ball bearing 620.

[0039] Figure 11 shows a detail of the locking ring of the previous embodiment.

List of reference numerals

[0040]

100	first part
110	first housing
120	hollow shaft
122	bayonet lock notch
123	first section
124	second section
125	notch
126	multi level notch
130	center axis
170	first connector
180	first printed circuit board
182	first sliding track
190	first contact brushes
200	second part
210	second housing
280	second printed circuit board
282	second sliding track
290	second contact brushes
310	first ball bearing

320 second ball bearing
330 spring
340 locking ring
342 bayonet lock protrusion
410 first bearing
420 second bearing
510 bearing gap
520 counter bearing
620 single ball bearing

Claims

1. Slipring device comprising a first part (100) and a second part (200) arranged rotatably against each other about a center axis (130),
the first part (100) comprises a first housing (110) holding at least a first slipring component (180),
the second part (200) comprises a second housing (210) holding at least a second slipring component (280), and
a first bearing (310) is arranged between the first housing (110) and the second housing (210),
characterized in, that
the first housing (110) comprises a hollow shaft (120) which holds the second part (200) and/or the second housing (210), the hollow shaft comprising at least one bayonet lock notch (122),
the first housing (110) further comprises a locking ring (340) having at least one bayonet lock protrusion (342) oriented in a radial direction to the center axis (130) matching to the at least one bayonet lock notch (122),wherein a second bearing (320) is arranged between the second housing (210) and the locking ring (340),
wherein the locking ring (340) is attached to the outside of the hollow shaft (120) and is configured to press against a spring (330) between the locking ring (340) and the second housing (210) into a direction of the center axis (130) to hold the second housing (210) against the first housing (110) in a defined position.

2. Slipring device according to claim 1,
characterized in, that
the second bearing (320) may be a ball bearing or a slide bearing.

3. Slipring device according to claim 2,
characterized in, that
the spring (330) is arranged between the second bearing (320) and the locking ring (340).

4. Slipring device according to any one of the previous claims,
characterized in, that
the spring (330) is a wave spring or plate spring or disk spring.

5. Slipring device according to any one of the previous claims,
characterized in, that
the first slipring component (180) comprises a first printed circuit board (PCB) (180) which comprises at least one sliding track (182) and/or sliding brush (190).

6. Slipring device according to any one of the previous claims,
characterized in, that
the second slipring component (280) comprises a second printed circuit board (PCB) (280) which comprises at least one sliding track (282) and/or sliding brush (290).

7. Slipring device according to any one of the previous claims,
characterized in, that
the first bearing (310) is a ball bearing or a slide bearing.

8. Slipring device according to any one of the previous claims,
characterized in, that
the hollow shaft (120) has at least 2 bayonet lock notches (122) or the hollow shaft (120) has 3 bayonet lock notches (122).

9. Slipring device according to claim 8,
characterized in, that
the bayonet lock notches (122) are equidistant distributed over the circumference of the hollow shaft (120).

10. Slipring device according to any one of the previous claims,
characterized in, that
at least one part of the slipring device, i.e. the locking ring (340) is made by a 3-D printing process.

11. Slipring device according to any one of the previous claims,
characterized in, that
the spring (330) is one piece with the locking ring (340).

12. Slipring device according to claim 11,
characterized in, that
the spring (330) and the locking ring (340) and both are made by a 3-D printing process.

13. Slipring device according to any one of the previous claims,
characterized in, that
at least one part of the slipring device is made by injection molding or comprises a metal.

14. Slipring device according to any one of the previous claims,
characterized in, that
the first bearing (310) is arranged between the first housing (110) and the second housing (210) in a direction parallel to the center axis (130).

Patentansprüche

1. Schleifringvorrichtung mit einem ersten Teil (100) und einem zweiten Teil (200), welche um eine Mittelachse (130) gegeneinander drehbar angeordnet sind, wobei
der erste Teil (100) ein erstes Gehäuse (110) umfasst, das mindestens eine erste Schleifringkomponente (180) hält,
der zweite Teil (200) ein zweites Gehäuse (210) umfasst, das mindestens eine zweite Schleifringkomponente (280) hält, und
ein erstes Lager (310) zwischen dem ersten Gehäuse (110) und dem zweiten Gehäuse (210) angeordnet ist,
dadurch gekennzeichnet, dass
das erste Gehäuse (110) eine Hohlwelle (120) umfasst, welche den zweiten Teil (200) und/oder das zweite Gehäuse (210)hält, wobei die Hohlwelle mindestens eine Bajonettverriegelungsaussparung (122) umfasst,
das erste Gehäuse (110) weiterhin einen Verriegelungsring (340) aufweist mit mindestens einem Bajonettverriegelungsvorsprung (342), der in radialer Richtung zur Mittelachse (130) ausgerichtet ist und zu der mindestens eine Bajonettverriegelungsaussparung (122) passt,
wobei ein zweites Lager (320) zwischen dem zweiten Gehäuse (210) und dem Verriegelungsring (340) angeordnet ist,
wobei der Verriegelungsring (340) an der Außenseite der Hohlwelle (120) angebracht ist und ist konfiguriert, um gegen eine Feder (330) zwischen dem Verriegelungsring (340) und dem zweiten Gehäuse (210) in eine Richtung der Mittelachse (130) zu drücken, um das zweite Gehäuse (210) gegen das erste Gehäuse (110) in einer definierten Position zu halten.

2. Schleifringvorrichtung nach Anspruch 1,
dadurch gekennzeichnet, dass
ein zweites Lager (320) ein Kugellager oder ein Gleitlager sein kann.

3. Schleifringvorrichtung nach Anspruch 2,
dadurch gekennzeichnet, dass
die Feder (330) zwischen dem zweiten Lager (320) und dem Verriegelungsring (340) angeordnet ist.

4. Schleifringvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
die Feder (330) eine Wellenfeder oder Plattenfeder oder Scheibenfeder ist.

5. Schleifringvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
die erste Schleifringkomponente (180) eine erste Leiterplatte (Printed Circuit Board, PCB) (180) umfasst, die mindestens eine Gleitschiene (182) und/oder eine Gleitbürste (190) umfasst.

6. Schleifringvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
die zweite Schleifringkomponente (280) eine zweite Leiterplatte (Printed Circuit Board, PCB) (280) umfasst, die mindestens eine Gleitschiene (282) und/oder eine Gleitbürste (290) umfasst.

7. Schleifringvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
das erste Lager (310) ein Kugellager oder ein Gleitlager ist.

8. Schleifvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
die Hohlwelle (120) mindestens 2 Bajonettverriegelungsaussparungen (122) oder die Hohlwelle (120) 3 Bajonettverriegelungsaussparungen (122) aufweist.

9. Schleifringvorrichtung nach Anspruch 8,
dadurch gekennzeichnet, dass
die Bajonettverriegelungsaussparungen (122) mit gleichen Abständen über den Umfang der Hohlwelle (120) verteilt sind.

10. Schleifringvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
mindestens ein Teil der Schleifringvorrichtung, d. h. der Verriegelungsring (340), durch ein 3-D-Druckverfahren hergestellt wird.

11. Schleifringvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
die Feder (330) einteilig mit dem Verriegelungsring (340) ist.

12. Schleifringvorrichtung nach Anspruch 11,
dadurch gekennzeichnet, dass
die Feder (330) und der Verriegelungsring (340) beide durch ein 3-D-Druckverfahren hergestellt sind.

13. Schleifringvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
mindestens ein Teil der Schleifringvorrichtung durch Spritzgießen hergestellt ist oder ein Metall umfasst.

14. Schleifringvorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
das erste Lager (310) zwischen dem ersten Gehäuse (110) und dem zweiten Gehäuse (210) in einer Richtung parallel zur Mittelachse (130) angeordnet ist.

Revendications

1. Dispositif de bague collectrice comprenant une première partie (100) et une seconde partie (200) agencées en rotation l'une contre l'autre autour d'un axe central (130),
la première partie (100) comprend un premier logement (110) maintenant au moins un premier composant de bague collectrice (180),
la seconde partie (200) comprend un second logement (210) maintenant au moins un second composant de bague collectrice (280), et
un premier palier (310) est agencé entre le premier logement (110) et le second logement (210),
caractérisé en ce que
le premier logement (110) comprend une tige creuse (120) qui maintient la seconde partie (200) et/ou le second logement (210),
la tige creuse comprenant au moins une encoche de verrou à baïonnette (122),
le premier logement (110) comprend en outre une bague de verrouillage (340) ayant au moins une saillie de verrou à baïonnette (342) orientée dans une direction radiale par rapport à l'axe central (130) concordant avec l'au moins une encoche de verrou à baïonnette (122), dans lequel un second palier (320) est agencé entre le second logement (210) et la bague de verrouillage (340),
dans lequel la bague de verrouillage (340) est attachée à l'extérieur de la tige creuse (120) et est configurée pour exercer une pression contre un ressort (330) entre la bague de verrouillage (340) et le second logement (210) dans une direction de l'axe central (130) pour maintenir le second logement (210) contre le premier logement (110) dans une position définie.

2. Dispositif de bague collectrice selon la revendication 1,
caractérisé en ce que
le second palier (320) peut être un roulement à billes ou un palier lisse.

3. Dispositif de bague collectrice selon la revendication 2,
caractérisé en ce que
le ressort (330) est agencé entre le second palier (320) et la bague de verrouillage (340).

4. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
le ressort (330) est un ressort ondulé ou un ressort à lames plates ou un ressort à disque.

5. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
le premier composant de bague collectrice (180) comprend une première carte de circuit imprimé (PCB) (180) qui comprend au moins une piste de coulissement (182) et/ou un balai de coulissement (190).

6. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
le second composant de bague collectrice (280) comprend une seconde carte de circuit imprimé (PCB) (280) qui comprend au moins une piste de coulissement (282) et/ou un balai de coulissement (290).

7. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
le premier palier (310) est un roulement à billes ou un palier lisse.

8. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
la tige creuse (120) a au moins 2 encoches de verrou à baïonnette (122) ou
la tige creuse (120) a 3 encoches de verrou à baïonnette (122).

9. Dispositif de bague collectrice selon la revendication 8,
caractérisé en ce que
les encoches de verrou à baïonnette (122) sont réparties à équidistance sur la circonférence de la tige creuse (120).

10. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
au moins une partie du dispositif de bague collectrice, c'est-à-dire la bague de verrouillage (340) est fabriquée par un processus d'impression 3D.

11. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
le ressort (330) est d'un seul tenant avec la bague de verrouillage (340).

12. Dispositif de bague collectrice selon la revendication 11,
caractérisé en ce que
le ressort (330) et la bague de verrouillage (340) sont tous deux fabriqués par un processus d'impression 3D.

13. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
au moins une partie du dispositif de bague collectrice est fabriquée par moulage par injection ou comprend un métal.

14. Dispositif de bague collectrice selon l'une quelconque des revendications précédentes,
caractérisé en ce que
le premier palier (310) est agencé entre le premier logement (110) et le second logement (210) dans une direction parallèle à l'axe central (130).

Fig. 1

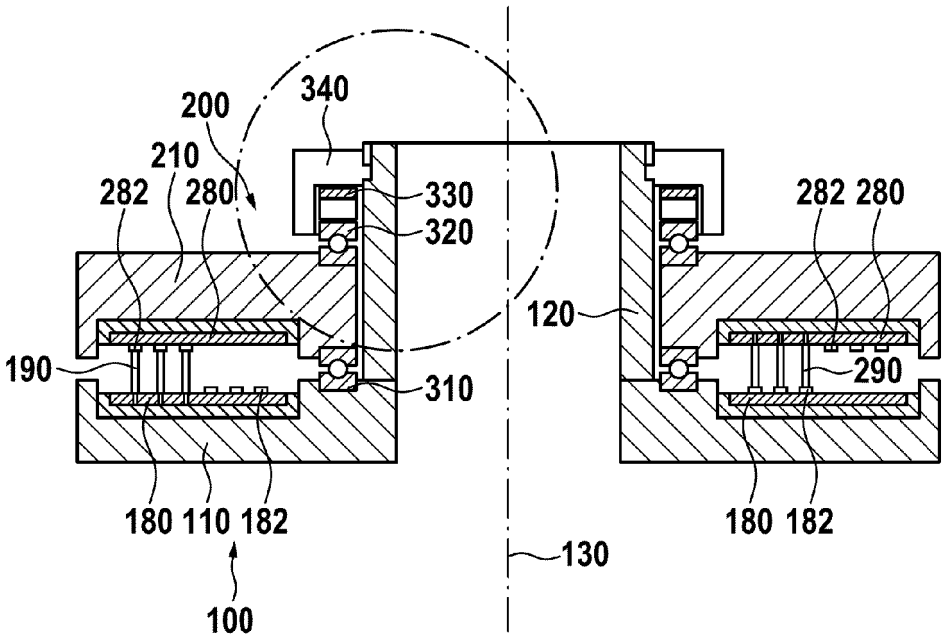
200
340
210
282
280
330
320
282 280
120
190
310
290
180 110 182
130
180 182
100

Fig. 2

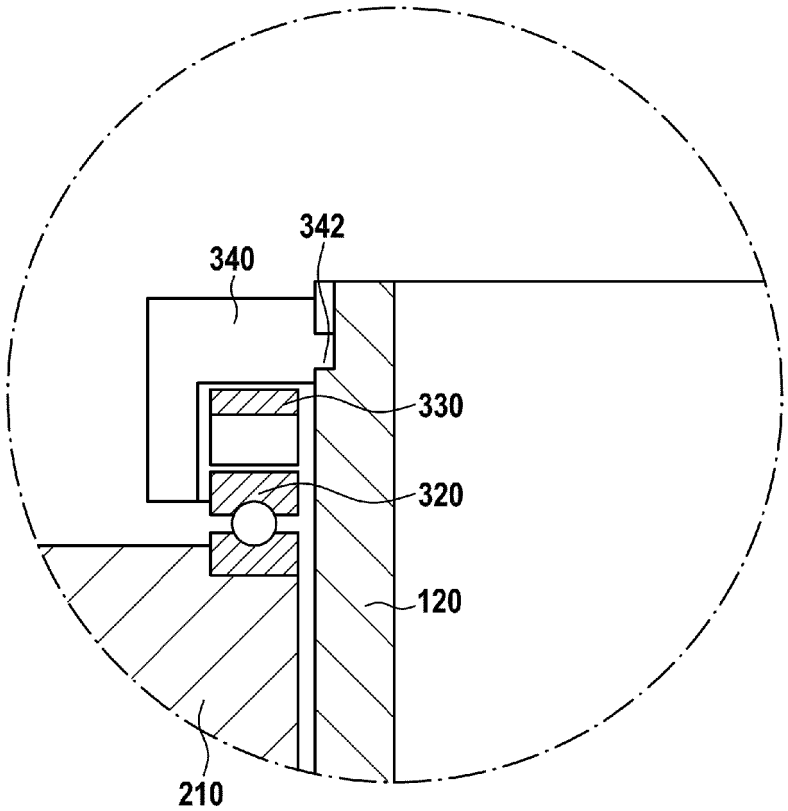
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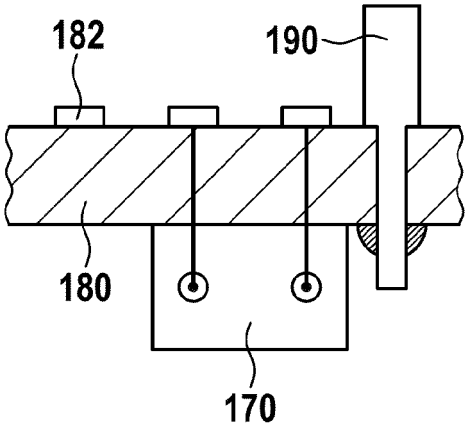
Fig. 3



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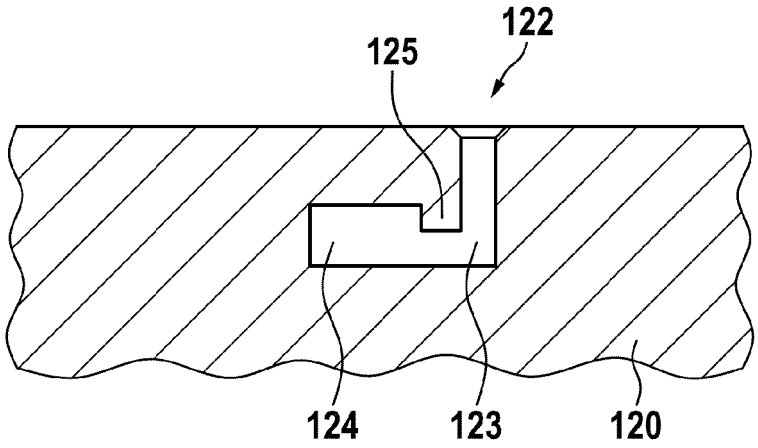
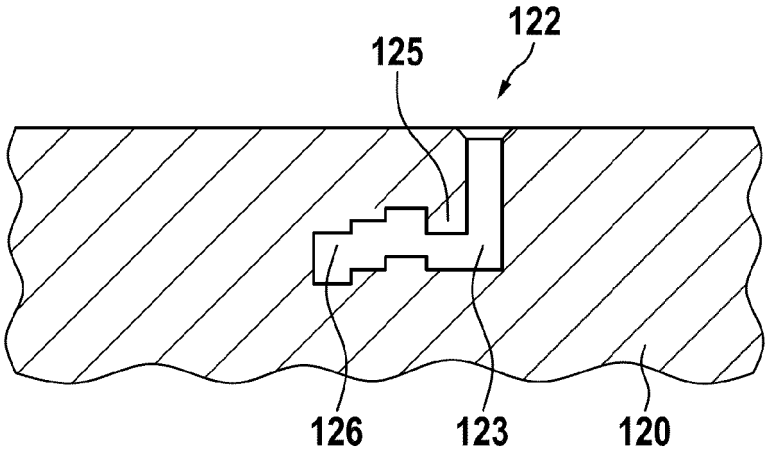


Fig. 5



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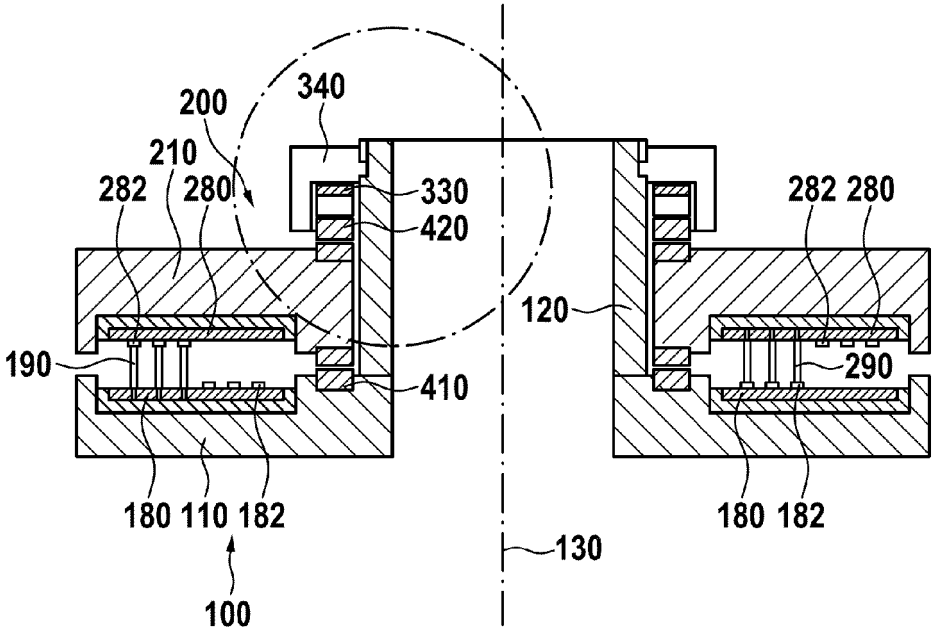
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Fig. 7

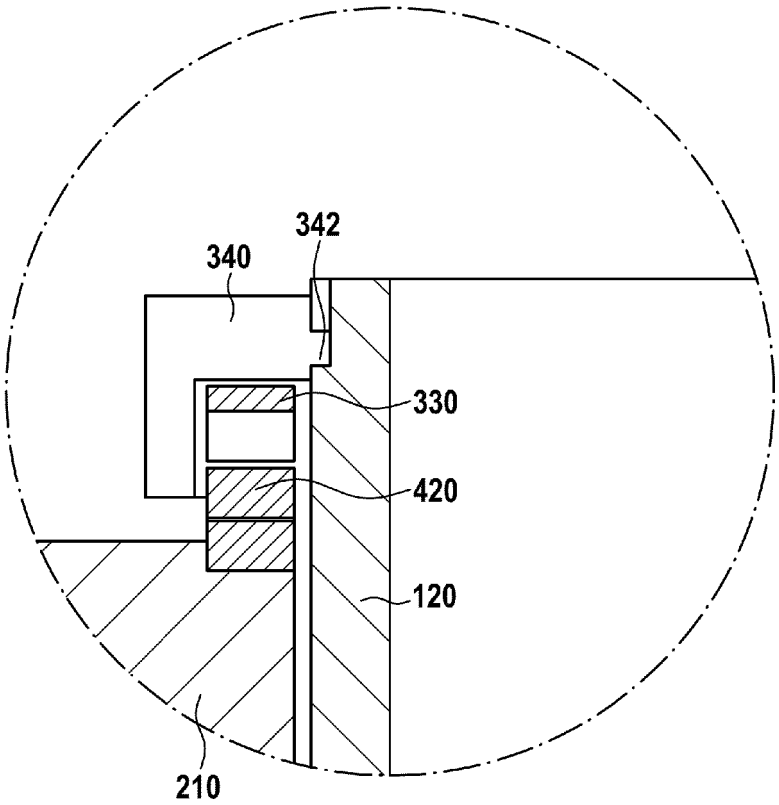
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Fig. 8

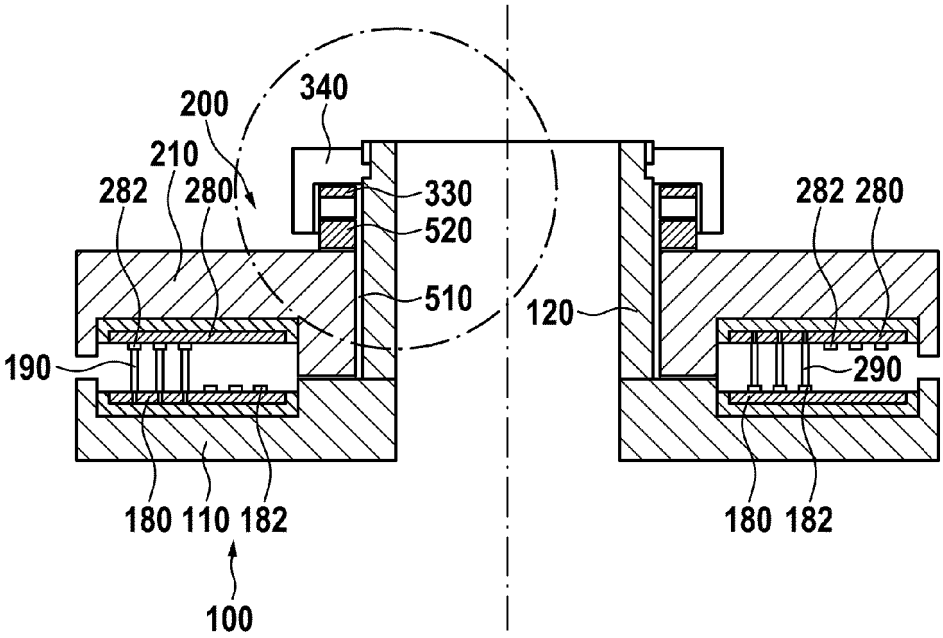
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Fig. 9

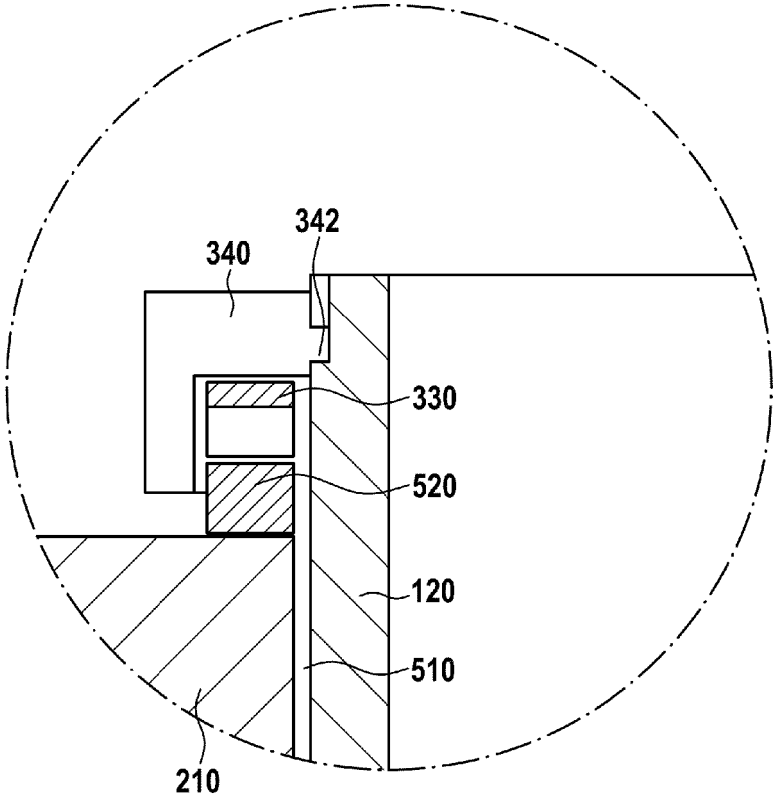
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Fig. 10

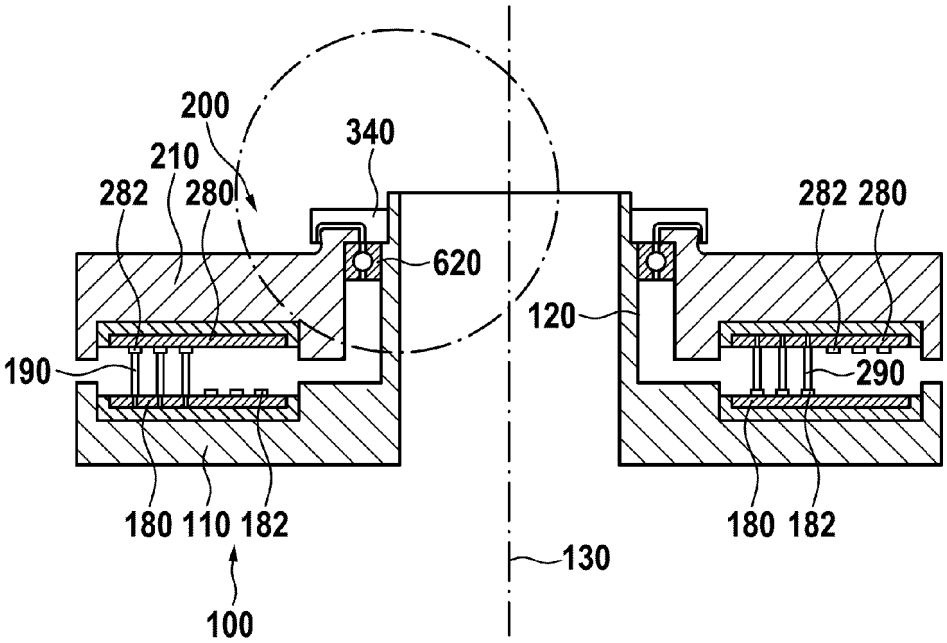
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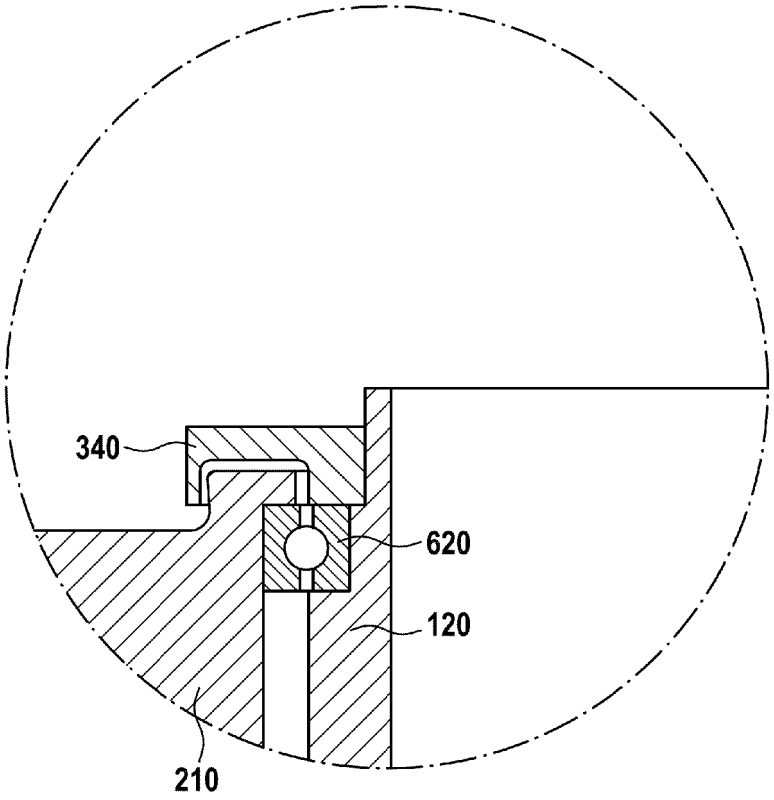
Fig. 11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210

REFERENCES CITED IN THE DESCRIPTION

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