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(71) Applicant: VALEO SCHALTER UND SENSOREN
GMBH [DE/DE]; Laiernstr. 12, 74321 Bietigheim-Bissingen (DE).

(72) Inventors: BALAZS, Emil; Piramis street 1, 8200 Veszprém (HU). FODOR, Peter; Piramis street 1, 8200 Veszprém (HU).

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(54) Title: METHOD FOR MANUFACTURING A TORQUE SENSOR DEVICE FOR A MOTOR VEHICLE BY ULTRASONIC WELDING, TORQUE SENSOR DEVICE, STEERING DEVICE, AS WELL AS MOTOR VEHICLE

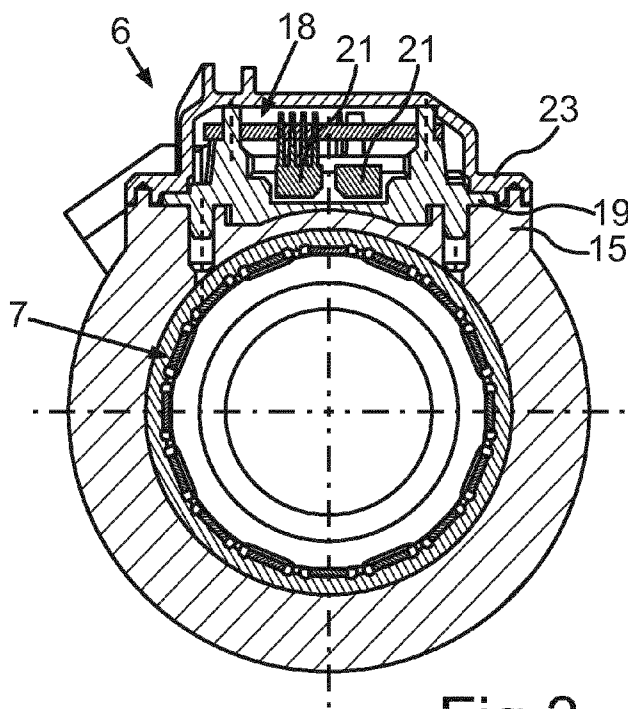


Fig.3

(57) Abstract: The invention relates to a method for manufacturing a torque sensor device (6) for capturing a torque on a shaft (3) of a motor vehicle (1), in which a holding device (15) is provided, on which a stator (7) and a magnet (13) are held, an electronics housing (19), on which an electronics unit (18) is arranged, with which the holding device (15) is connected, and a cover element (23) for covering the electronics unit (18) is connected with the holding device (15), wherein the cover element (23) is connected with the holding device (15) by way of ultrasonic welding.

Method for Manufacturing a Torque Sensor Device for a Motor Vehicle by Ultrasonic Welding, Torque Sensor Device, Steering Device, as well as Motor Vehicle

The present invention relates to a method for manufacturing a torque sensor device for capturing a torque on a shaft of a motor vehicle, in which a holding device is provided, on which a stator and a magnet are held, an electronics housing, on which an electronics unit is arranged, is connected with the holding device, and a cover element for covering the electronics unit is connected with the holding device. Moreover the present invention relates to a torque sensor device for capturing a torque on a shaft of a motor vehicle. Further, the present invention relates to a steering system for a motor vehicle as well as a motor vehicle with such a steering system.

Torque sensor devices are already known from the prior art and serve for capturing a torque applied to a shaft of the motor vehicle. Such torque sensor devices can for instance be employed in an electrical steering system of the motor vehicle and can measure the torque on a steering shaft of the motor vehicle. The captured torque can be provided as steering command to a control device of the steering system.

For capturing the torque the torque sensor device can comprise an annular magnet and an annular stator surrounding the annular magnet, wherein the stator is arranged on a first partial shaft of the shaft and the annular magnet is arranged on a second partial shaft of the shaft. The partial shafts in this connection are facing each other in the axial direction and are connected with each other via a torsion bar or a rotation rod spring. By applying a torque the stator and the annular magnet rotate relative to each other about a longitudinal axis of the torque sensor device orientated along the steering shaft. Via the stator, which commonly consists of two separate stator elements facing each other in the axial direction, the magnetic flux, which changes through relative torsion of the annular magnet relative to the stator and thus in dependency on the torque, is guided towards a magnetic flux conducting element. The magnetic flux conducting element transmits the magnetic flux to a magnetic field sensor, for instance a Hall sensor, by which the magnetic flux can be measured. Moreover the torque sensor device commonly has a corresponding electronics unit, which is connected with the magnetic field sensor.

In this connection it is commonly envisaged that the stator and the annular magnet are held in a corresponding holding device. The electronics unit is further held on a corresponding electronics housing. This electronics housing is connected with the holding

device. Moreover commonly a cover element is provided, which serves for covering the electronics unit. Thus the electronics unit can be protected against external environmental influences. In this connection from the prior art methods are known in which the cover element is connected by ultrasonic rivets with the holding device. By this connection then also the electronics housing can be held on the holding device.

It is the task of the present invention to provide a solution as how to manufacture a torque sensor device for a motor vehicle in a simpler and more cost-effective manner. Moreover a corresponding steering system as well as a motor vehicle is provided.

This task according to the invention is solved by a method by a torque sensor device, by a steering system, as well as by a motor vehicle having the features according to the respective independent claims. Advantageous further developments of the present invention are subject matter of the dependent claims.

In an embodiment of a method for manufacturing a torque sensor device for capturing a torque on a shaft of a motor vehicle preferably a holding device is provided, on which a stator and a magnet are held. Moreover, preferably an electronics housing, on which an electronics unit is arranged, is connected with the holding device. Moreover preferably a cover element for covering the electronics unit is connected with the holding device. Moreover it is preferably envisaged that the cover element is connected with the holding device by ultrasonic welding.

According to the invention in a method for manufacturing a torque sensor device for capturing a torque on a shaft of a motor vehicle a holding device, on which a stator and a magnet are held, is provided. Moreover, an electronics housing, on which an electronics unit is arranged, is connected with the holding device. Further, a cover element for covering the electronics unit is connected with the holding device. In this connection the cover element is connected with the holding device by way of ultrasonic welding.

By the method a torque sensor device is meant to be manufactured, which serves for capturing a torque on a shaft of the motor vehicle. Such shaft can for instance be a steering shaft of a steering system, in particular an electrical steering system, of a motor vehicle. Such a shaft can have two axially opposing partial shafts, which are connected with each other via a torsion bar. In this set up the stator of the torque sensor device can be connected with the first partial shaft and the magnet with the second partial shaft. In this connection the magnet is configured in particular as annular magnet or ring-shaped

magnet. The stator can for instance rotate along with the first partial shaft and the annular magnet can rotate along with the second partial shaft.

The stator and the magnet in this connection are held on a holding device. The stator can for instance have two axially opposing stator elements, which can be configured identically. In this connection each stator element can have a plurality of cog elements, which in a circumferential direction extending around the longitudinal axis are arranged spaced apart from each other and which extend in the axial direction. In this set up the cog elements of a stator element can extend in the direction of the respective other opposing stator element. Further, the cog elements of the two axially opposing stator elements can be arranged to be mutually engaged. The stator or the stator elements can be formed from a magnetically soft material and can serve for conducting the magnetic flux of the annular magnet.

Moreover an electronics unit is envisaged, which is arranged on an electronics housing. The electronics unit can at least comprise a magnetic field sensor which is for instance configured as Hall sensor. With the aid of the magnetic field sensor then in the case of a relative torsion between the stator and the annular magnet the change in the magnetic flux can be captured. On the basis of the change in the magnetic flux then with the aid of the electronics unit the torque acting upon the shaft can be determined. In this connection it is envisaged that the electronics housing is connected with the holding device. Further, a cover element is connected with the holding device. This cover element serves for covering the electronics unit or the magnetic field sensor. Thus, the electronics unit or the magnetic field sensor can be protected against external environmental influences.

According to the invention it is envisaged that the cover element is connected with the holding device by way of ultrasonic welding. In the known methods for manufacturing torque sensor devices commonly the ultrasonic riveting is employed, in order to connect the cover element with the holding device. In this connection commonly a production cycle time in the range of several seconds, for instance 20 seconds, is rendered. By employment of ultrasonic welding in connection with the cover element with the holding device the production cycle time can be clearly reduced. Thus, for instance manufacturing times of few seconds, for example five seconds, can be achieved. In this way the torque sensor device can be manufactured in a faster and thus more low-cost manner.

Preferably, the electronics housing and the holding device are connected in a form-fitting and/or force-fitting manner with each other and subsequently the cover element is

connected with the holding device. In the manufacturing process of the torque sensor device, to start with, the electronics housing can be connected with the holding device. In this connection it is in particular envisaged that the electronics housing upon connection with the holding device is in the predetermined end position. Subsequently the cover element and the holding device can be connected by ultrasonic welding. On the whole this facilitates a simple and low-cost manufacture of the torque sensor device.

In an embodiment for connecting the electronics housing with the holding device at least one protrusion of the electronics housing is inserted into at least one corresponding recess of the holding device. The electronics housing can comprise a protrusion that is for instance in the form of a pin. This protrusion can be inserted into the corresponding recess of the holding device, which for instance is configured as bore or as blind hole bore. The connection between the protrusion and the recess in this connection can be effected in a force-fitting and/or in a form-fitting way. The electronics housing can also comprise several protrusions, each of which are inserted into corresponding recesses of the holding devices. It may also be envisaged that the connection between the electronics housing and the holding device is effected in the manner of a snap-in connection or latch connection. In this way the electronics housing can be connected in a fast and reliable way with the holding device.

In a further embodiment, as the electronics housing is connected with the holding device, a movement of the electronics housing is controlled. The current position or the movement of the electronics housing can be continuously captured by means of a measuring device, for instance with the aid of a linear encoder during connecting of the electronics housing and the holding device. The movement of the electronics housing can then be controlled in dependency on the captured position. Thus the connecting of the electronics housing with the holding device can be checked or controlled. Thus damage to the electronics housing and/or to the electronics unit connected with the electronics housing and/or the magnetic field sensor can be prevented.

Further, it is advantageous if the electronics housing and the cover element are connected with the holding device in such a way that the electronics housing at least in portions is arranged spaced apart from the cover element. In other words, the electronics housing, the cover element, and/or the holding device can be configured or dimensioned in such a way that the electronics housing upon connecting the electronics housing with the holding device and upon connecting the cover element with the holding device is arranged at least in sections spaced apart from the cover element. In particular it is

envisaged that the electronics housing and the cover element do not touch each other upon the respective connecting to the holding device. During ultrasonic welding the cover element with the holding device the cover element can be set into mechanical vibrations. Due to the fact that the electronics housing is arranged spaced apart from the cover element, it can be achieved that the electronics housing is uncoupled from the cover element during ultrasonic welding and is not stimulated to vibrate. In this way it can be prevented that the electronics housing and/or the electronics unit can be damaged upon ultrasonic welding.

In a further embodiment prior to connecting the holding element with the cover device by the ultrasonic welding at least one protrusion of the holding device is inserted into at least one corresponding recess of the cover element. Prior to the ultrasonic welding of the cover element with the holding device, to start with, the cover element is arranged on the holding device. For this purpose at least one protrusion of the holding device is inserted into the at least one corresponding recess of the cover element. It may also be envisaged that the holding device has at least two protrusions, each of which is inserted into the corresponding recess of the cover element. Thus, the cover element can be held in a form-fitting and/or force-fitting way on the holding device. Thus, the cover element can be positioned prior to the ultrasonic welding can be positioned relative to the holding device and fixed to same. Subsequently, the ultrasonic welding can be effected. In this connection it is in particular envisaged that for connecting the cover element with the holding device by way of ultrasonic welding the cover element is stimulated by an ultrasonic vibration. For this purpose the cover element can for instance be coupled with a corresponding actor. Thus a precise positioning of the individual components of the torque sensor device relative to each other can be facilitated.

Further, it is advantageous if the holding device, the electronics housing, and/or the cover element are formed from a plastic material. In particular the holding device, the electronics housing, and/or the cover element can be formed or manufactured from a thermoplastics material. Thus, the holding device, the electronics housing, and/or the cover element can be manufactured in a simple and economic fashion.

A torque sensor device according to the invention serves for capturing a torque on a shaft of the motor vehicle. The torque sensor device preferably comprises a holding device, on which a stator and a magnet are held. Preferably, the torque sensor device comprises an electronics housing, on which an electronics unit is arranged. In particular the torque sensor device comprises a cover element for covering the electronics unit. Preferably the

electronics housing is connected with the holding device and the cover element is connected with the holding device. In this connection it is in particular envisaged that the cover element is connected with the holding device through ultrasonic welding.

According to the invention a torque sensor device for capturing a torque on a shaft of the motor vehicle comprises a holding device, on which a stator and a magnet are held. Moreover, the torque sensor device comprises an electronics housing, on which an electronics unit is arranged. Moreover, the torque sensor device comprises a cover element for covering the electronics unit, wherein the electronics housing is connected with the holding device and the cover element is connected with the holding device. In this set up the cover element is connected with the holding device by way of ultrasonic welding.

According to the invention a steering system for a motor vehicle comprises a steering shaft, which comprises a first partial shaft and a second partial shaft. In this connection the first partial shaft and the second partial shaft are connected with each other via a torsion bar. Further, the steering system comprises a torque sensor device according to the invention, wherein the stator of the torque sensor device is arranged on the first partial shaft and the magnet of the torque sensor device is arranged on the second partial shaft. The steering system can in particular be an electrical steering system.

A motor vehicle according to the invention comprises a steering system according to the invention. The motor vehicle is configured in particular as passenger car.

The preferred embodiments presented with reference to the method according to the invention and their advantages in analogy apply to the torque sensor device according to the invention, the steering system according to the invention, as well as the motor vehicle according to the invention.

Further features of the invention derive from the claims, the figures, and the description of the figures. The features and feature combinations mentioned previously in the description as well as the features and feature combinations named in the following in the description of the figures and/or shown in the figures alone are employable not only in the respective indicated combination, but also in other combinations or taken alone, without leaving the scope of the invention. Thus, also embodiments of the invention are to be considered as being comprised and disclosed by the invention, which are not explicitly shown and explained in the figures, however derive from and can be generated by sepa-

rated feature combinations from the explained embodiments. Also embodiments and feature combinations, which thus do not have all features of an originally formulated independent claim, are to be considered as being disclosed. Moreover embodiments and feature combinations are to be regarded as being disclosed in particular by the embodiments set out in the above, which go beyond or deviate from the feature combinations set out in the back-references of the claims.

The invention is now explained in more detail on the basis of preferred embodiments as well as by reference to the enclosed drawings.

These show in:

- Fig. 1 a motor vehicle according to an embodiment of the present invention, which comprises a steering system with a torque sensor device;
- Fig. 2 a torque sensor device according to a embodiment of the present invention in an exploded view;
- Fig. 3 the torque sensor device according to Fig. 2 in a sectional lateral view; and
- Fig. 4 a detailed view of Fig. 3

In the figures same elements and elements having the same function are equipped with the same reference signs.

Fig. 1 shows a motor vehicle 1 according to an embodiment of the present invention in a lateral view. The motor vehicle 1 in the present case is configured as a passenger car. The motor vehicle 1 comprises a steering system 2, which for instance can be configured as electrical steering system. The steering system 2 in turn comprises a shaft 3 comprising a first partial shaft 4 and a second partial shaft 5. Moreover, the steering system 2 comprises a torque sensor device 6, by means of which a torque acting upon the shaft 3 can be captured.

Fig. 2 shows an exploded view of a torque sensor 6 according to an embodiment of the present invention. The torque sensor device 6 comprises a stator 7, which comprises the two stator elements 8 and 9. The stator elements 8, 9 are designed to be annular and

each comprise a plurality of cog elements 10, 11, which are arranged spaced apart from each other in the circumferential direction. The cog elements 10, 11 in this connection protrude in the axial direction a from an edge portion of the respective stator elements 8, 9. The stator 7 in this connection is connected with the first partial shaft 4. Moreover, the torque sensor device 6 comprises an ring-shaped magnet 12 or an annular magnet, which is connected with the second partial shaft 5. The first partial shaft 4 and the second partial shaft 5 are connected with each other via a torsion bar 13 and thus are rotatable relative to each other.

The magnet 12 in the circumferential direction has several alternately magnetised poles 14. In this connection the annular magnet 12 is arranged on a holding device 15. The stator 7 or the stator elements 8, 9 are equally arranged on the holding device 15. Further the fastening device 16 as well as the holding rings 17 are envisaged in order to hold the stator elements 8, 9 on the holding device 15. The holding device 15 can be formed from a plastics material, in particular a thermoplastic material.

Moreover, the torque sensor device 6 comprises an electronics unit 18, which is arranged on an electronics housing 19. The electronics unit 18 can equally be made of a plastic material. Moreover the torque sensor device 6 has a magnetic field sensor device 20, which comprises at least one magnetic field sensor 21. In the present embodiment the magnetic field sensor device 20 comprises two magnetic field sensors 21, which are for instance configured as Hall sensors. In this connection the magnetic field sensor device 20 is electrically connected with the electronics unit 18. With the aid of the magnetic field sensor device 20 or with the aid of the magnetic field sensors 21 in the case of a relative rotational movement between the magnet 12 and the stator 7 the resulting change of the magnetic flux can be measured. With the aid of the electronics unit 18 then on the basis of the change of the magnetic flux the torque acting upon the shaft 3 can be determined. Moreover, a flux conduction element 22 is provided, which conducts the magnetic flux from the stator 7 or the stator elements 8, 9 to the magnetic field sensors 21. Finally the torque sensor device 6 comprises a cover element 23, which serves for covering the electronics unit 18 and the magnetic field sensor device 20. The cover element 23 is in particular formed from a thermoplastic material.

Fig. 3 shows the torque sensor device 6 according to Fig. 2 in a sectional lateral view. In this view it can be seen that the electronics housing 19 is connected with the holding device 15 and that the cover element 23 is connected with the holding device 15. In this

connection it is envisaged that the cover element 23 is connected by ultrasonic welding with the holding device 15.

Fig. 4 shows a detailed view of Fig. 3. In this view it can be seen that the holding device 15 comprises a recess 24 in the form of a blind hole. The electronics housing 19 comprises a protrusion 25 corresponding to the recess 24. As the electronics housing 19 is connected with the holding device 15, the protrusion 25 is inserted into the recess 24. During connecting the electronics housing 19 with the holding device 15 the movement of the electronics housing 19 can be controlled or the movement of the electronics housing be measured. In this connection the recess 24 and the protrusion 25 are configured in such a way that in the portion 26 a snap-in connection or a latch connection forms between the holding device 15 and the electronics housing 19.

During manufacture of the torque sensor device 6 thus, to start with, the electronics housing 19 can be connected with the holding device 15. Subsequently, the cover element 23 can be connected with the holding device 15. The holding device 15 has a protrusion 27, which is configured to correspond to a recess 28 of the cover element 23. Thus the cover element 23, to start with, can be arranged on the holding device 15. In this set up the electronics housing 19 and the cover element 23 are configured in such a way that these preferably do not touch. Thus, during ultrasonic welding, in the course of which an ultrasonic vibration is coupled into the cover element 23, damage to the electronics housing 19 or the electronics unit can be avoided. On the whole, by the ultrasonic welding of the cover element 23 and the holding device 15 the manufacture time of the torque sensor device 6 can be clearly reduced.

Claims

1. Method for manufacturing a torque sensor device (6) for capturing a torque on a shaft (3) of a motor vehicle (1), in which a holding device (15) is provided, on which a stator (7) and a magnet (13) are held, an electronics housing (19), on which an electronics unit (18) is arranged, is connected with the holding device (15), and a cover element (23) for covering the electronics unit (18) is connected with the holding device (15),
characterized in that
the cover element (23) is connected with the holding device (15) by ultrasonic welding.
2. Method according to claim 1,
characterized in that
the electronics housing (19) and the holding device (15) are connected with each other in a form-fitting and/or force-fitting way and subsequently the cover element (23) is connected with a holding device (15).
3. Method according to claim 1 or 2,
characterized in that
for connecting the electronics housing (19) with the holding device (15) at least one protrusion (25) of the electronics housing (19) is inserted into at least one corresponding recess (24) of the holding device (15).
4. Method according to any one of the preceding claims,
characterized in that
upon connecting the electronics housing (19) with the holding device (15) a movement of the electronics housing (19) is controlled.
5. Method according to any one of the preceding claims,
characterized in that
the electronics housing (19) and the cover element (23) are connected in such a way with the holding device (15) that the electronics housing (19) at least in portions is arranged spaced apart from the cover element (23).

6. Method according to any one of the preceding claims, characterized in that
prior to the connecting of the cover element (23) with the holding device (15) by ultrasonic welding at least one protrusion (27) of the holding device (15) is inserted into the at least one corresponding recess (28) of the cover element (23).
7. Method according to any one of the preceding claims, characterized in that
for connecting the cover element (23) with the holding device (15) by ultrasonic welding the cover element (23) is stimulated by an ultrasonic vibration.
8. Method according to any one of the preceding claims, characterized in that
the holding device (15), the electronics housing (19), and/or the cover element (23) are formed of a plastic.
9. Torque sensor device (6) for capturing a torque on a shaft (3) of a motor vehicle (1), with a holding device (15), on which a stator (7) and a magnet (12) are held, comprising an electronics housing (19), on which an electronics unit (18) is arranged, and comprising a cover element (23) for covering the electronics unit (18), wherein the electronics housing (19) is connected with the holding device (15) and the cover element (23) is connected with the holding device (15), characterized in that
the cover element (23) is connected with the holding device (15) by ultrasonic welding.
10. Steering system (2) for a motor vehicle (1), comprising a steering shaft (3), which comprises a first partial shaft (4) and a second partial shaft (5), wherein the first partial shaft (4) and the second partial shaft (5) are connected with each other via a torsion bar (13), and comprising a torque sensor device (6) according to any one of the preceding claims, wherein the stator (7) of the torque sensor device (6) is arranged on the first partial shaft (4) and the magnet (12) of the torque sensor device (6) is arranged on the second partial shaft (5).

11. Motor vehicle (1) with a steering system (2) according to claim 10.

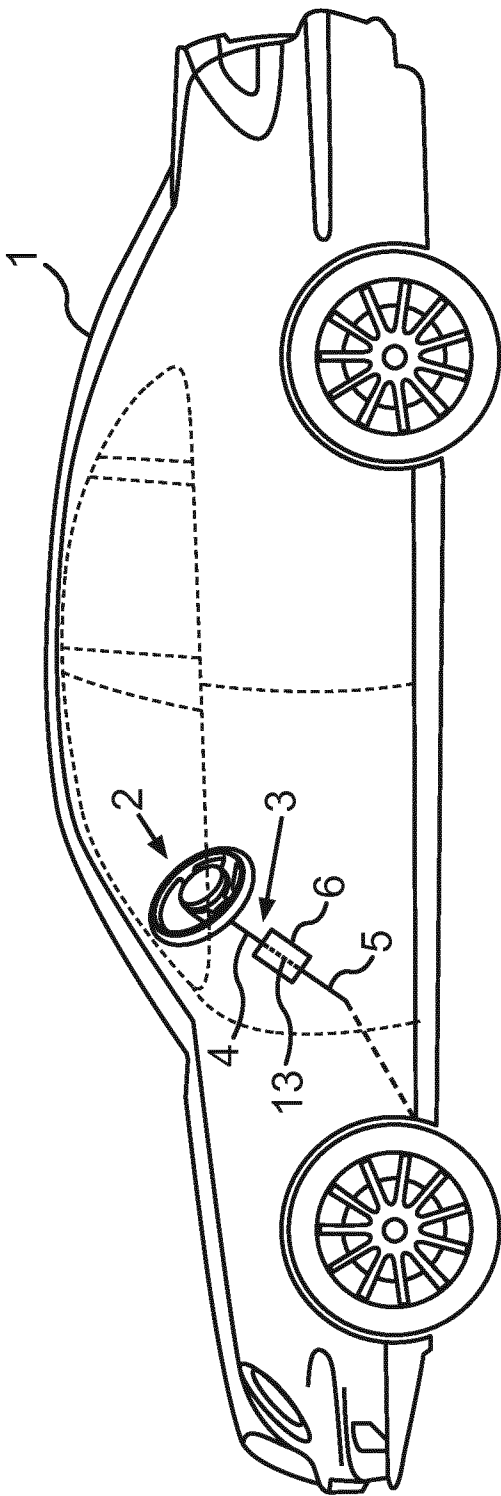


Fig. 1

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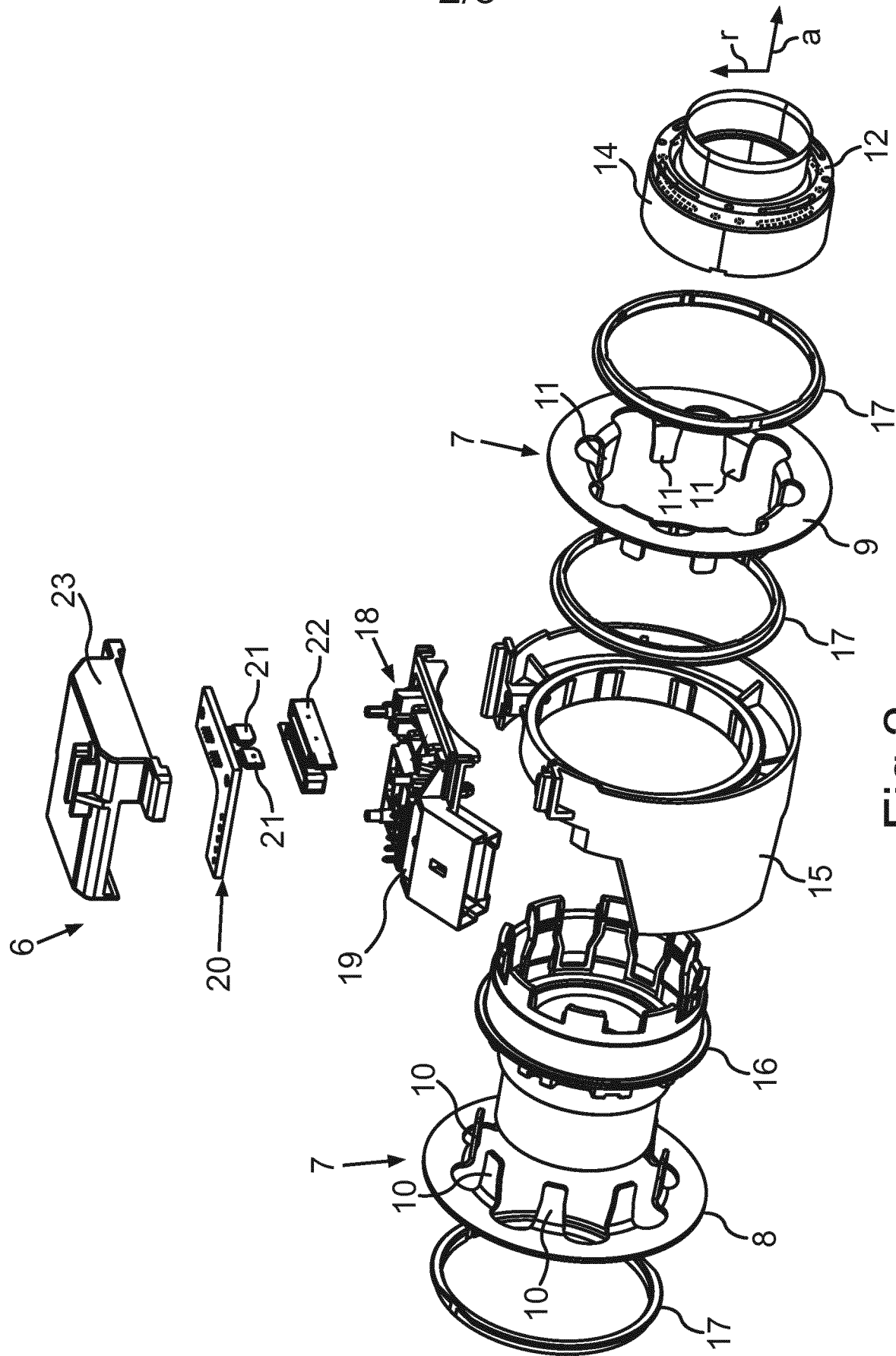


Fig.2

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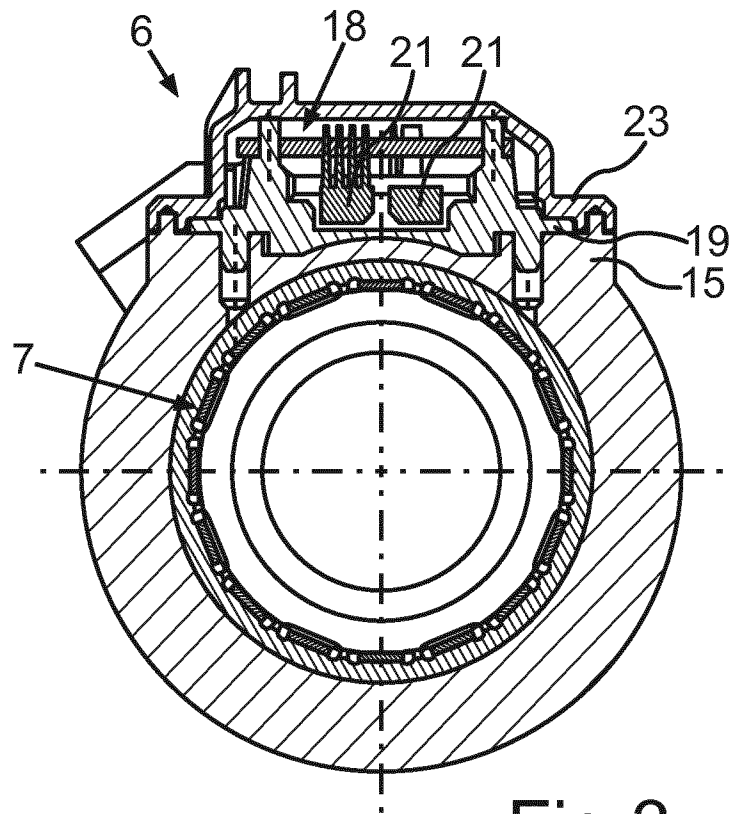


Fig.3

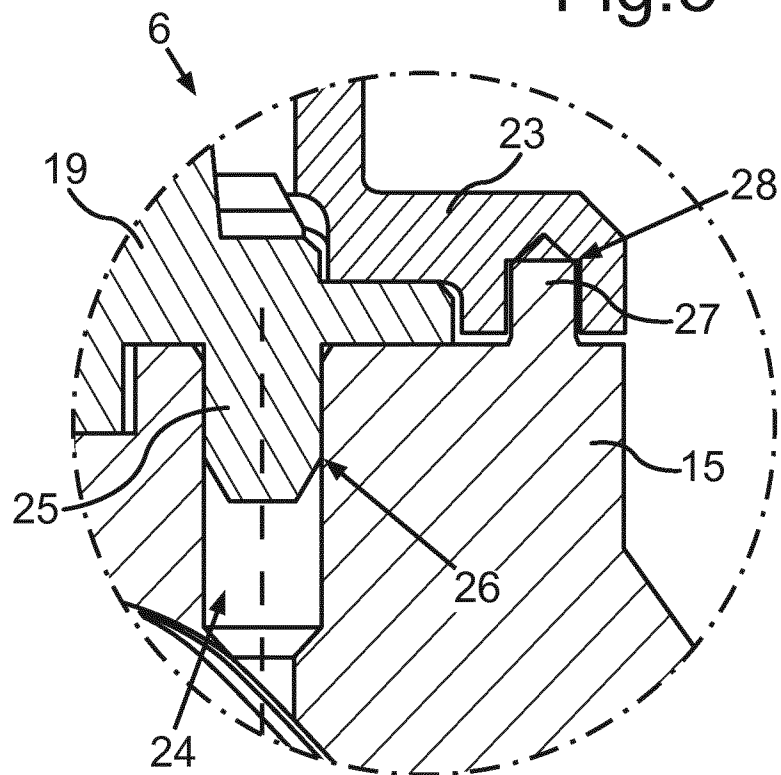


Fig.4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/055268

A. CLASSIFICATION OF SUBJECT MATTER

INV. B29C65/08 B62D6/10 G01L5/22 G01L3/10
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01L B62D B29C

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/055828 A1 (LU ENGELBERT [US] ET AL) 7 March 2013 (2013-03-07) paragraphs [0030], [0031]; figures 1,5 -----	1-11
A	US 5 661 466 A (PEARSON EARL C [US]) 26 August 1997 (1997-08-26) column 2, line 61 - line 64; figure 1 -----	1,9,10
A	US 2007/157740 A1 (JEREMS FRANK [DE] ET AL) 12 July 2007 (2007-07-12) paragraphs [0025] - [0028]; figure 1 -----	1,9,10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

4 May 2017

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Fax: (+31-70) 340-3016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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