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BEARING COVER WITH INTEGRATED SENSOR TECHNOLOGY
AS WELL AS GEARBOX, METHOD OF ACQUIRING DATAS AND
USE OF THE BEARING COVER

Technical field

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The present invention refers to bearing covers for gearboxes, exhibiting at least one predefined position for arranging at least one sensor, wherein the bearing cover exhibits at least one sealing part/section. The present invention also refers to gearboxes exhibiting at least one such bearing cover. Furthermore, the present invention refers to such bearing
10 covers exhibiting at least one sealing section integrally provided at the bearing cover. Furthermore, the present invention also refers to a method for acquiring data of at least one operating parameter of a gearbox by means of (resp. via) at least one bearing cover. Furthermore, the present invention refers to the use of a bearing cover for/on gearboxes for providing at least one sensor (resp. sensor arrangement) of the following group:
15 temperature sensor, speed sensor, vibration sensor, torque sensor. In particular, the present invention refers to bearing covers exhibiting features according to the present independent claim.

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Background of the invention

In many applications of all kinds of gearboxes, e.g. industry gearboxes and wind energy plant gearboxes, it is important to monitor/measure or to control at least some of the operating parameters of the gearbox. In particular, wireless communication technology
25 allows for remote monitoring of operating parameters, by transmitting corresponding data via a wireless network. Therefore, many gearboxes are equipped with at least one sensor measuring at least one gearbox operating parameter, and optionally, further equipment is provided by at least one wireless (or wire-connected) communication unit configured for transmitting sensor data resp. measurement data.

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Previously known gearboxes may exhibit at least one sensor for at least one parameter like temperature, speed or vibration, wherein the sensor(s) usually is/are installed at different/several positions at the gearbox(es). It has been found that those installation

conditions established in prior art could/should be improved; in particular, there is a need for further advantageous means and measures/methods for providing such monitoring/measuring or controlling functions to gearboxes.

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Description of the invention

Starting from this situation, it is an object of the present invention to provide for gearboxes resp. for gearbox components which allow for acquiring at least one gearbox
10 operating parameter in advantageous manner, especially in the field of industry gearboxes and wind energy plant gearboxes. In particular, a/the object of the present invention is to provide for an advantageous manner of equipping such gearboxes with at least one sensor and optionally also with further components especially in view of improved measurement and monitoring functionality.

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The object of the invention is solved by the features of the independent main claims. Advantageous features are indicated in the subclaims. If technically possible, the teachings of the subclaims can be combined arbitrarily with the teachings of the main and subclaims.

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In particular, the object is therefore solved by a bearing cover for gearboxes, exhibiting at least one predefined position for arranging at least one sensor, wherein the bearing cover exhibits at least one sealing part configured for sealing the gearbox; wherein the bearing cover is configured for accommodating at least one sensor of the following group:
25 temperature sensor, speed sensor, vibration sensor, torque sensor; wherein the bearing cover is configured for arranging the at least one sensor in the at least one predefined position, especially in an inner position (at an inner side of the bearing cover) in communication with the inner gearbox cavity encompassed by a/the gearbox housing, and the bearing cover is further configured for sealing the gearbox. This design allows
30 for providing multi-functional bearing covers which may also facilitate gearbox design, especially design of gearbox housings. In particular, there is no need for provision of predefined sensor fixations/positions at the gearbox housing. Rather, sensor technology can be integrated (at least partly, i.e., at least some of preferred sensor types) in the

bearing cover. Thus, such bearing covers allow for functional integration and also for favorable slight design of the gearbox itself and also for favorable ease in view of any specific variation in sensor technology. Thereby, optionally, also the sealing function of the bearing cover can be improved, as further described below. In particular, the at least
5 one sealing part allows for sealing the gearbox, especially also sealing of the at least one sensor or sealing the gearbox in the region of the at least one sensor and/or at a/the shaft of the gearbox.

In other words: The present invention provides for integration of at least one sensor,
10 preferably at least two sensors or even at least three or four different types of sensors into a/the bearing cover, and optionally, also the integration of further parts (especially wireless communication units and/or energy supply/generation units and/or sealing parts/sections) into the bearing cover can be realized. The present invention especially allows for a compact design, and/or for integration of different functions in only one
15 main part (bearing cover) which can also be upgraded/retrofitted in already existing gearboxes afterwards, and/or for advantageous access and maintenance configurations (installation situation), and/or for reduction of assembly efforts, and/or for reduction of logistic efforts (especially due to printing on demand or likewise production methods). Also, electric supply can be facilitated. Not least, the present invention also favors
20 scaling, i.e., conserving the sensor design/arrangement even in case of constructive amendments or changes of size.

The at least one sealing part configured for sealing the gearbox can also be provided in the form of a contact sealing which can be assembled later also.

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Prior art bearing covers also fulfil a sealing function; but, prior art bearing covers did not provide for both (integrated) sensor technology and at the same time also the sealing function. Thus, according to the present invention, the sealing function is a feature which is a part/characteristic of the present invention.

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The concept of the present invention can be summarized as follows: The inventive bearing cover provides for integrated sensor technology, thereby ensuring main advantages of the present invention, and optionally, the inventive bearing cover also

provides for integrated electric connection and/or electric supply resp. power supply, and optionally, the inventive bearing cover also provides for integrated electric connection to external components (electric conjunction), and optionally, the inventive bearing cover also provides for an integrated communication function (especially in view of an IoT
5 function, i.e., a remote/wireless Internet of Things-function). In other words: Not only sensor technology, but also electric components and energy supply and at least one communication unit can be integrated in the bearing cover.

In particular, as an example, a temperature sensor and/or speed sensor (especially
10 inductive or hall sensor) are integrated into the bearing cover, wherein wires are preferably connected to/in an electrical conjunction box which (optionally) can also be provided in the bearing cover. As an alternative, wire connection is provided to an electrical conjunction box which is arranged at an outer side of the bearing cover. As an alternative, at least one of the sensors is autarkic in view of energy and data transmission.
15 Also, a wireless IoT device with a flexible PCB (printed circuit board) can be provided in an electrical conjunction box, especially in an arrangement over/along the circumference of the bearing cover. The flexible PCB can be used for different bearing cover sizes. In case no power supply be available, a small energy generator can be installed, especially around a/the shaft of a/the gearbox. As an alternative, an energy harvesting unit
20 (especially based on vibration) can be installed, e.g. also on the gearbox housing.

In addition, it is preferred to provide for integrated sealing(s) also, especially at the intersection to a/the shaft of the gearbox. In particular, a/the labyrinth sealing's outer ring can be machined in the bearing cover such that outer ring and bearing cover are provided
25 in one part. A/the inner labyrinth sealing part can/may remain a second part; the inner labyrinth sealing part can be extended with a bush which can/may also provide for a carrier (element) for a trigger signal for a/the speed sensor; for an inductive sensor, that carrier/element it is a metal part/element, and for a hall sensor, it is a magnet (element). In other words: the inner labyrinth sealing part can be provided by additive
30 manufacturing in conjunction with a bush, and that bush may also provide for a recess for accommodation a carrier/element providing a trigger signal for rotational speed of the shaft.

It has been found that for such a preferred design, it is advantageous to produce/manufacture both the bearing cover (especially the bearing cover's sealing part, especially an outer sealing ring) and a/the inner sealing ring in one single process, especially also in view of favorable assembly. According to the present invention, additive manufacturing has been found most favorable production process for the inner sealing part, especially based on plastic or metallic materials. Modern plastic materials also are oil resistant and can be used at/for inner parts of a/the gearbox. In particular, the inner sealing part/ring can be provided in conjunction with a bush arranged on the shaft, and that bush may also accommodate a carrier element providing for a trigger signal.

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In other words, in particular, it is provided that the at least one sensor's position and arrangement with respect to the gearbox is defined by the bearing cover. Mounting of the bearing cover at the gearbox housing can be carried out, e.g., by means of a flange or the like. Preferably, at least one sensor is arranged, by means of the bearing cover, in an inner position (at an inner side of the bearing cover) in communication with the inner gearbox cavity encompassed by a/the gearbox housing.

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In contrast, in previous designs, sensors for temperature, sensors for speed (of rotation) and/or sensors for vibration were installed separately at different positions at the gearbox resp. outside at the gearbox enclosure/housing.

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The present invention is also based on the concept/idea of providing for a compact construction and predefined sensor arrangement, thereby also facilitating assembly/mounting of the gearbox or at least of involved sensor technology. Also, the present invention allows for a design which facilitates replacement of bearing covers of different kinds, especially bearing covers including different kinds of sensor technology or sensor arrangements. Thus, as an example, further sensor data can be provided by non-contact torque sensors, especially telemetric resistance strain gauges or magnetic strain gauges (especially so called torque and more sensors, particularly measuring torque, bending, and axial load forces.) or temperature sensors specifically referring to oil sump temperature. In context with at least partially autarkic energy supply, the sensor technology resp. sensor arrangement described herein does not necessarily require any power connection to the gearbox.

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According to the present disclosure, the term “integrated” designates an arrangement on or within the bearing cover, especially in the sense of functional integration. In a narrower sense, the term "integrated" describes an arrangement inside resp. on the inside
5 of the bearing cover and/or at least partially inside a cavity/groove/recess of the bearing cover.

In the following, the advantageous aspects of the claimed invention are explained and further below, preferred embodiments of the invention are described, especially by
10 referring to “embodiment(s)”. Explanations, in particular on advantages and definitions of features, are basically descriptive and preferred, but not limiting examples. If an explanation is limiting, this is expressly mentioned.

According to one embodiment of the invention, it is provided that the bearing cover
15 provides for a predefined sensor arrangement and exhibits the at least one sensor of the following group: temperature sensor, speed sensor, vibration sensor, torque sensor; wherein the at least one sensor is integrated/arranged within at least one recess, preferably in predefined alignment, especially in radial or axial direction. This also allows for predefined positioning, wherein the respective recess may/can be designed
20 such that different sensor designs or sensor sizes can be accommodated, especially by providing an adapter ring or the like, e.g. for a temperature sensor being aligned axially in parallel to a/the shaft of the gearbox.

According to one embodiment of the invention, it is provided that the bearing cover
25 exhibits at least one recess accommodating the at least one sensor, wherein the at least one recess is preferably aligned in radial or axial direction, especially at least an axial recess accommodating a/the temperature sensor and/or a radial recess accommodating a/the speed sensor and/or a/the torque sensor. The respective recess can ensure correct/reliable alignment of the respective sensor, and may/can also facilitate
30 maintenance or replacement, if desired/required.

The present invention also facilitates coping with difficulties and challenges of sensor installations and electrical sensor connections of prior art gearboxes. For example, there

were difficulties in provision of energetic supply, or there was a high risk of damaging any sensor component protruding of the gearbox housing. In particular, the present invention allows for complete renunciation/abandonment of any sensor being directly coupled to the gearbox housing. Rather, main/all sensor components can be integrated in
5 the at least one bearing cover of the gearbox.

Not least, the present invention also allows for provision of a broad sensor portfolio for each individual gearbox in cost-effective manner, especially based on types of sensors which can/may realize savings in costs of sensor purchase of factor 10 and more. The
10 present invention therefore also paves the way to better/enhanced (especially remote) monitoring or even control of several (many) gearbox operating parameters at the same time, e.g. in context with damage analysis or lifetime prognosis. The present invention provides for devices (bearing covers) which allow for retrofitting of and providing (supplemental) sensor equipment to existing gearboxes in an easy and cost-effective
15 manner.

The present invention is also based on the finding that modern sensor technology can be provided in a configuration only requiring little space (e.g. in fingernail size or with a diameter of a pencil only) and quite low amounts of energy. Use of such modern sensor
20 technology facilitates realization of the inventive concept of providing a compact and multifunctional bearing cover which also allows for easy retrofitting of existing gearboxes or for any modifications in view of sensor portfolio and/or of measured operating parameters.

25 In particular, the bearing cover exhibits a lead-through for accommodating a/the shaft of the gearbox. But, the present invention can also be realized for bearing covers covering any further/other opening of a gearbox or the like, i.e., a lead-through for accommodating a/the shaft of the gearbox is not necessarily required for implementation of the present invention. In particular, temperature and vibration measurement can be realized
30 irrespective of any relative arrangement with respect to a/the shaft.

When providing for a lead-through for accommodating a/the shaft of the gearbox, it should be noted that the present invention can be implemented both for a drive shaft and for an output shaft, i.e., at different positions of a power train.

- 5 Preferably, at least one of the sensors is configured and arranged for being in measurement communication with at least one shaft of the gearbox. I.e., by means of the bearing cover, said at least one sensor is/can be relatively positioned such that at least one operating parameter (especially torque and/or rotational speed) can be measured even in exact and reliable manner.

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According to one embodiment (of the invention), it is provided that at least one of the at least one sealing part(s) is provided at the bearing cover integrated in one part (integrally) as a sealing section of the bearing cover, especially by an outer sealing ring, especially by an outer sealing ring of a labyrinth sealing of the bearing cover, especially by material
15 removal (e.g. machined, milled) at/on the bearing cover. This also allows for functional integration and for synergetic effects, especially also in view of efficient production of the bearing cover and any further components required in that context.

Preferably, an inner labyrinth sealing ring will remain a second part and is extended with
20 a bush which may also provide for the carrier for the trigger signal for a/the speed sensor. Preferably, a/the inner labyrinth sealing ring is provided by additive manufacturing.

According to one embodiment at least (a further) one of the at least one sealing part(s) is provided by means of additive manufacturing, especially an inner sealing ring, especially
25 an inner sealing ring of a labyrinth sealing at least partially provided by the bearing cover, especially an inner sealing ring provided integrally in conjunction with a bush (which may also provide for a carrier element for a trigger signal for a (rotational) speed parameter), especially an inner sealing ring provided integrally in conjunction with a bush which is configured for being arranged on a/the shaft of the gearbox. This design
30 also facilitates reliable fixation/positioning of this (inner) sealing part/section.

In context with provision of sealing part, additive manufacturing technology may advantageously provide for individual adjustment of predefined positions according to specific demands and applications.

- 5 According to one embodiment the bearing cover exhibits an integral sealing section (especially integrally in one piece with the bearing cover) providing for a sealing part interacting with a corresponding sealing section (which can be) provided by a bush arranged on a/the shaft of the gearbox, especially also as an integral sealing part. This kind of functional integration also favors reliable adjustment of interacting sealing
10 parts/sections.

The present invention is also based on the concept of functional integration of at least two functions in one single component/part, especially by providing at least a positioning function and a sealing function and optionally also a sensor function (especially a trigger
15 for a speed sensing function).

- According to one embodiment, it is provided that the at least one sensor is accommodated in a mechanically preloaded manner within the bearing cover, especially spring-based, especially a/the temperature sensor, especially preloaded in axial direction.
20 In particular, this configuration also for exact (axial) positioning of the sensor and at the same time also for tolerant axial support, especially in case of thermal variations. This configuration also allows for an installation situation which favors easy access and which is tolerant in view of easy replacement and adaptation or changing/modification of sensor design/technology.

- 25 According to one embodiment, it is provided that the bearing cover is configured for accommodating at least one speed sensor and/or at least one torque sensor, especially in radial direction/alignment (respectively), wherein the bearing cover exhibits the at least one speed sensor, especially an inductive speed sensor or hall speed sensor, especially a
30 speed sensor configured for receiving a trigger signal based on a metallic/magnetic element (which itself can be arranged on a/the shaft, especially in a ring on a/the shaft, e.g. in a gearbox), especially a metallic/magnetic element configured for rotating around a/the shaft of the gearbox, and/or the bearing cover exhibits at least one torque sensor.

This kind of sensor integration also allows for further function enhancement of the bearing cover and renders dispensable any additional intervention at any further position of the gearbox housing. In particular, an inductive speed sensor interacts with a metal part, and a hall speed sensor interacts with a magnet (magnetic element).

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For example, the at least one torque sensor is provided in conjunction with a telemetric system, wherein a strain gauge with corresponding system components is installed on the shaft.

- 10 According to one embodiment the bearing cover exhibits a torque sensor arranged and configured for being positioned in measurement communication with at least one shaft of the gearbox.

- According to one embodiment, it is provided that the bearing cover is configured for
15 accommodating at least one vibration sensor, especially a three axis vibration sensor, especially at a face side of the bearing cover, especially in a face side recess of the bearing cover. Vibration measurement provides for enhanced monitoring of operating conditions of the gearbox. Accommodation of the vibration sensor can be carried out at a surface section of the bearing cover which is, according to individual designs of the
20 bearing cover and the vibration sensor, more or less recessed resp. deepened with respect to the face side/surface of the bearing cover. Since vibrations are transmitted via/within the bearing cover, that position for accommodating the vibration sensor can be defined in a section of the (integral) material of an/the outside bearing cover surface.

- 25 According to one embodiment the bearing cover exhibits at least three recesses and accommodates at least three of the following sensors: temperature sensor, speed sensor, vibration sensor, torque sensor. Preferably, the temperature sensor is accommodated within an inner recess (especially axial cavity or (drill/bore) hole), and the speed sensor is accommodated within an inner recess (especially radial cavity or (drill/bore) hole), and
30 the vibration sensor is accommodated within an outer recess or at the face side of the bearing cover (on the outside/outer face, i.e., not necessarily within the gearbox housing). Optionally, the bearing cover also exhibits a torque sensor.

According to a modified embodiment of the invention, it is provided that the bearing cover exhibits a recess for accommodating an electrical conjunction box, and optionally the bearing cover comprises said electrical conjunction box, especially providing for wired connection to/with a wireless IoT device, wherein the bearing cover preferably exhibits a connection line connecting said recess or electrical conjunction box with/to power supply. Preferably, the electrical conjunction box is accommodated within an outer recess or at the face side of the bearing cover (on the outside/outer face, i.e., not necessarily within the gearbox housing), wherein that recess preferably is in wired connection to the inner side/area of the bearing coupling (e.g. via an inner bore or channel, for connecting at least one of the sensors).

According to one embodiment, it is provided that the bearing cover exhibits a recess or (at least a) fixation position for accommodating a wireless communication unit, and optionally the bearing cover comprises said wireless communication unit (especially IoT device for wireless data transfer in a network or cloud). This further enhances functional integration and also allows for remote monitoring.

According to one embodiment the bearing cover exhibits a flexible PCB connected to the wireless communication unit, especially with the flexible PCB arranged on an outer surface of the bearing cover or within a groove in the outer surface.

According to one embodiment the bearing cover exhibits a recess for accommodating an energy generator (especially on a/the shaft) or for accommodating an energy harvesting unit (especially energy harvesting by vibration), and optionally the bearing cover comprises said energy generator and/or energy harvesting unit. This also favors energetic autarky of at least one of the sensors. In particular, the energy generator or energy harvesting unit can be arranged within a recess circumferentially extending around a/the shaft of the gearbox.

In particular, the above mentioned object is also solved by a bearing cover for a gearbox, exhibiting at least one sealing part, and exhibiting at least one sensor of the following group: temperature sensor, speed sensor, vibration sensor, torque sensor; and exhibiting at least one recess for accommodating the at least one sensor and for arranging the at

least one sensor in a predefined position within the gearbox; especially bearing cover as described above; wherein the at least one recess of the bearing cover is processed by material removal at/on the bearing cover, and wherein one of the at least one sealing part(s) is provided integrated in one part at the bearing cover as a sealing section of the bearing cover, especially by material removal (especially an outer sealing ring, especially an outer sealing ring of a labyrinth sealing at least partially provided by the bearing cover), and/or wherein one (further) of the at least one sealing part(s) is provided by means of additive manufacturing, especially an inner sealing ring provided integrally in conjunction with a bush which is configured for being arranged on a/the shaft of the gearbox. This provides for above mentioned advantages, especially also in view of lean manufacturing and effective provision of individual bearing covers on demand.

The inner sealing ring also allows for coping with quite severe installation accuracy demands e.g. in context with labyrinth sealings.

In particular, the above mentioned object is also solved by a gearbox with a bearing cover as described above, especially an industry gearbox or wind energy plant gearbox. This provides for above mentioned advantages. The present invention can be applied for any kind of gearbox, especially one-, two- or three-stage gearboxes. Also, optionally, more than one bearing cover can be provided to/for one individual gearbox.

According to one embodiment a (further) sealing part is provided on a/the shaft of the gearbox for interacting with a/the sealing part provided at the bearing cover, wherein the further sealing part on the shaft is processed by additive manufacturing, especially by additive manufacturing of an inner sealing ring on a bush configured for being arranged on the shaft, especially an inner sealing ring of a labyrinth sealing, especially in conjunction with a bush preferably also providing for a carrier (element) for a trigger signal for a/the speed sensor. This provides for above mentioned advantages, especially also in view of integrated sealing functionality (and thereby less effort for sealing the gearbox).

In particular, the above mentioned object is also solved by a method for acquiring data of at least one operating parameter of a gearbox by means of at least one sensor of the

following group: temperature sensor, speed sensor, vibration sensor, torque sensor; wherein the at least one sensor is accommodated in a predefined position in/on a bearing cover of the gearbox, especially in/on a bearing cover as described above, wherein the bearing cover exhibits at least one sealing part sealing the gearbox; wherein the data of the at least one operating parameter is acquired by the at least one sensor in the predefined position in/on a bearing cover. This provides for above mentioned advantages, especially also in view of both good/extensive/substantial data acquisition of operating parameters and reliable and facilitated sealing of the gearbox even in case multiple sensors are involved.

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According to one embodiment, data of the at least one operating parameter is acquired by the at least one sensor in the predefined position within a recess of the bearing cover accommodating the sensor, especially a temperature sensor and/or a speed sensor, wherein the at least one sealing part sealing the gearbox is provided by the bearing cover integrated in one part as a sealing section of the bearing cover, especially by an outer sealing ring, especially by an outer sealing ring of a labyrinth sealing of the bearing cover, and/or the at least one sealing part sealing the gearbox is provided by an inner sealing ring (especially of a labyrinth sealing), wherein the inner sealing ring is preferably provided integrally in conjunction with a bush arranged on a/the shaft of the gearbox, especially such that the bearing cover provides for an integral sealing section interacting with a corresponding sealing section provided by the bush arranged on a/the shaft of the gearbox for sealing the gearbox. This also provides for a sealing function in conjunction with arrangement/accommodation of the sensors.

25 According to one embodiment the at least one sensor is connected to an electrical conjunction box or to a wireless IoT device respectively arranged at the bearing cover, such that data of the at least one operating parameter is wirelessly transmitted from the bearing cover. This also provides for enhanced connection and supply of the sensors.

30 According to one embodiment the at least one sensor is connected to an energy generator or to an energy harvesting unit respectively arranged at or at least partly within the bearing cover. This also ensures functioning of parameter monitoring via the bearing

cover even in case external electric supply may not be ensured or would evoke unreasonable effort and costs.

In particular, the above mentioned object is also solved by use of a bearing cover for gearboxes, especially a bearing cover as described above, for providing at least one sensor of the following group to the gearbox: temperature sensor, speed sensor, vibration sensor, torque sensor; wherein at least one sensing/measurement position at/within the gearbox is predefined by means of the bearing cover, and wherein at least one sealing function for sealing the gearbox and the at least one sensor is provided by means of the bearing cover, especially for monitoring at least two or three operating parameters of the gearbox by means of the bearing cover, especially remote monitoring via an IoT device provided by the bearing cover, especially in a data acquisition method (resp. operating parameter acquisition method) as described above. This provides for above mentioned advantages, especially also in view of improved/enhanced monitoring or even control of gearboxes. Based on desired/required sensor technology, the skilled person can/may decide about advantageous degree/grade of functional integration of further components (as energetic and/or communicative components) in each individual application.

Brief description of the drawings

In the following, the invention is explained in more detail with reference to the attached drawings, using preferred design examples. The word figure is abbreviated in the drawings as Fig.; the drawings show in

- Fig. 1 a schematic view of an arrangement according to prior art;
- Fig. 2A, 2B a schematic view and a detailed view of a further arrangement according to prior art;
- Fig. 3A, 3B a schematic view of a bearing cover arrangement according to one design example of the invention, by referring to a gearbox design according to prior art, as shown in Fig. 2A, 2B, and a schematic view of a ring arrangement providing for a trigger signal for a/the speed sensor;

- Fig. 4 a detailed view of a first sensor arrangement, especially including a temperature sensor, according to one design example of the invention;
- Fig. 5 a detailed view of a second sensor arrangement, especially including a speed sensor, according to one design example of the invention;
- 5 Fig. 6 a detailed view of a third sensor arrangement, especially including a vibration sensor, according to one design example of the invention;
- Fig. 7A, 7B, 7C, 7D a detailed view and schematic views of a power/energy generator which can be integrated/included in an arrangement as described in Fig. 3, 4, 5 or 6;
- 10 Fig. 8A, 8B a detailed view of a bearing cover arrangement according to one design example of the invention and a schematic view of a PCB which can be integrated/included in an arrangement as described in Fig. 3, 4, 5, 6 or 7;

15 Detailed description of the design examples

The described design examples are only examples which can be modified and/or supplemented in many ways within the scope of the claims. Each feature described for a/the specific design example can be used independently or in combination with other

20 features in any other design example. Each feature described for the design example of a particular claim category can also be used in a corresponding way in a design example of another claim category.

First, the reference signs are described in general terms; individual reference is made in

25 connection with respective figures.

The present invention provides for a bearing cover 10 for gearboxes 100, wherein the bearing cover 10 exhibits at least one predefined position for arranging at least one sensor 11, 12, 13, wherein the bearing cover 10 exhibits at least one sealing part 17,

30 wherein the bearing cover 10 is configured for accommodating at least one sensor of the following group: temperature sensor 11, speed sensor 12, vibration sensor 13, torque sensor; wherein the bearing cover 10 is configured for arranging the at least one sensor in the at least one predefined position and configured for sealing the gearbox 100. In

particular, the at least one sealing part 17 allows for sealing the gearbox 100, especially also sealing of the at least one sensor and/or sealing of the gearbox in the region of the at least one sensor and/or of a/the shaft of the gearbox.

- 5 For example, in one specific configuration, the gearbox 100 exhibits a gearing mechanism 110 and at least one shaft 2 which is supported in at least one bearing 1 (especially a drive shaft and/or an output shaft). In some arrangements, the bearing cover 10 can/may provide for fixation of at least one part of the bearing 1, especially by means of a clip ring 3, especially in axially prestressed/preloaded bearings.

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The bearing cover 10 provides for at least one sealing function, especially for sealing the gearbox by means of a labyrinth sealing 5, as shown in Fig. 3A. The bearing cover 10 can be relatively positioned with respect to the bearing 1 in axial distance by including/providing a gap sealing 4.

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According to prior art, operating parameter data of the respective gearbox are/were acquired by means of some sensors which are usually installed at different/several positions at the gearbox housing, especially by means of a temperature sensor arrangement 6, a speed sensor arrangement 7 and a vibration sensor arrangement 8, as e.g. illustrated in Fig. 1. Each sensor arrangement is/was provided at a different position on/at the housing of the gearbox. In addition, a wire connection or IoT device 9 may/can be provided also at the housing.

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In the following, a sensor arrangement according to the present invention is described in more detail. As an example, the bearing cover 10 exhibits three sensors: a temperature sensor 11, a speed sensor 12, and a vibration sensor 13; optionally, a torque sensor is provided (in addition or as alternatively). The sensors 11, 12, 13 can be arranged in a recess 10.1, 10.2, 10.3, respectively.

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- 30 Preferably, the temperature sensor 11 is arranged/aligned in axial direction and is sealed by means of an O-ring fixation 11.1 provided by means of an adapter ring 11.2, wherein the temperature sensor 11 is arranged in axially pretensioned/preloaded manner by means of a spring 15; assembly can be facilitated by means of a click ring 18.

Preferably, the speed sensor 12 comprises the following components: ring 12.1 for shaft assembly; bush 12.2 (preferably also including a sealing section, e.g. an inner ring of a labyrinth sealing; alternatively, e.g., a radial shaft seal can be provided); carrier element
5 12.3 for trigger signal, especially metallic part or magnet; fixation 12.4 of the bush (especially adhesive joint at the shaft); fixation 12.5 of the sensor (sensor housing), especially adhesive joint in radial recess provided in predefined position.

The bearing cover 10 can be fixed at the gearbox housing, especially by means of a
10 flange 10.9 and at least one O-ring fixation 16. Also, a ring 20 can be provided at the external face side of the bearing cover, for even more secure assembly.

The bearing cover 10 can also provide for a sealing section 17, especially an integral sealing section, e.g. an outer ring of a labyrinth sealing. The bearing cover 10 exhibits a
15 lead-through 10.7 for accommodating a/the shaft 2 of the gearbox 100. A separation, partition, shield 10.5 (especially in order to protect against oil) can be provided, especially in conjunction with a gap sealing 4.

In order to facilitate electrical connection and/or remote monitoring, the bearing cover 10
20 may further comprise an electrical conjunction box 19, and/or a wireless IoT device resp. wireless communication unit (here same reference sign, since those functionalities may also be provided by one single box). At least some of electrical components and communication unit components can also be provided by means of at least one PCB (part) provided on the bearing cover. I.e., further functionality can be provided/integrated via
25 a/the PCB 30 or via a plurality of separate PCB parts 31 which can preferably be arranged on an outer face side of the bearing cover.

Further functionality can be provided/integrated by means of a power/energy generator 40 or energy harvesting unit (here same reference sign, since those functionalities may
30 also be provided by one single box). In particular, the power/energy generator exhibits the following components: ring 41 for shaft assembly, power generating elements 43, stator 45, rotor 47.

Each sensor 11, 12, 13, 14 can/may be arranged in a predefined position P1, P2, P3 being exactly predefined in at least one spatial direction, especially in a first predefined position P1 at least being predefined in axial direction and in a second and third predefined position P2, P3 at least being predefined in radial direction respectively
5 (wherein numbering of said predefined positions does not necessarily correlate with numbering of the sensors presented further above).

Figure 1 shows a sensor arrangement according to prior art. Each place/point of measurement requires an individual approach for arranging, aligning and fixing and
10 connection the respective sensor.

Fig. 1 also illustrates the fact that sensor technology according to prior art is/was fragile/susceptible as to external impact and/or in context with energetic supply. In particular, at least in some installation situations, there is/was a high risk for the operator
15 to get in trouble due to any conflicts/defects in context with (external) sensor technology at the gearbox housing. Also, each sensor (each measurement point) according to prior art often requires considerable efforts and costs.

Figures 2A, 2B show one embodiment resp. one application of a gearbox for applying
20 the present invention: The bearing cover arrangement shown in Fig. 2A, 2B is a bearing cover arrangement according to prior art, especially one with labyrinth sealing and separate shield (protection against oil flush). The present invention can/may also be applied to gearbox housings which are sealed by at least one sealing other than labyrinth sealings.

25

Figures 3A, 3B show one embodiment by referring to a specific kind of rotational speed sensor technology. **Fig. 3A** schematically illustrates the concept of the present invention: the sensor arrangement (here comprising a temperature sensor 11 and a speed sensor 12) is fully integrated in the bearing cover and is devoid of any (mechanical or electrical)
30 interfaces to any further parts or sections of the gearbox housing. Fig. 3A also illustrates a labyrinth sealing 5 being provided as separate part (prior art).

Figure 4 shows the temperature sensor 11 in detail; as shown, the axial position P1 can be predefined in exact manner and the sensor can be accessed easily via the clip ring 18, especially without any tools. Optionally, a torque sensor 14 can be integrated in the bearing cover (additionally or alternatively), wherein the torque sensor's position can be adapted individually according to specific applications/designs. A bush (not shown in Fig. 4, but in Fig. 5) may provide for arrangement of a/the inner sealing part/section 12 with respect to the shaft.

Fig. 4 also illustrates optional implementation of a torque sensor 14, wherein the relative sensor position is only schematic/exemplary and may depend on specific gearbox designs.

Figure 5 shows the speed sensor 12 in detail; in that specific embodiment, bush 12.2 is provided with several functions, namely at least: accommodation of carrier element 12.3, fixation at the shaft 2, provision of integral part of sealing, especially an inner sealing ring of a labyrinth sealing. In particular, such a bush 12.2 is preferably processed by additive manufacturing.

Figure 6 shows an arrangement of a/the third sensor 13. Optionally, an electrical conjunction box and/or wireless IoT device 19 is arranged at the same section or surface or at least partly within a cavity of the bearing cover, especially on the face side, especially in a recess.

The sensors resp. components shown in Fig. 4, 5 and 6 can/may also be provided in conjunction, i.e., together at one single bearing cover. In the present design example, the skilled person can/may decide, individually for each application, which of these sensors/components should be integrated in the bearing cover.

Figures 7A, 7B, 7C, 7D show a power/energy generator 40 which can optionally be integrated to the bearing cover and sensor arrangement and which exhibits the following components: ring 41 for shaft assembly, power generating elements 43, stator 45, rotor 47.

Figures 8A, 8B show an arrangement including an optional PCB 30 or separate PCB parts 31.

5 Fig. 8B illustrates that at least some of above mentioned components can be provided in the form of separate PCB parts also, especially on the external side of the bearing cover. Providing for a PCB which is subdivided in several parts (which can be connected via electrical lines, e.g.) also allows for advantageous arrangement of all these PCB components at/in favorable positions on the bearing cover surface or at least partially within at least one recess of the bearing cover.

10

While several aspects of the bearing cover are shown in the accompanying figures and described in detail hereinabove, other aspects will be apparent to, and readily made by, those skilled in the art without departing from the scope and spirit of the disclosure. Accordingly, the foregoing description is intended to be illustrative rather than restrictive.

15 The invention described hereinabove is defined by the appended claims and all changes to the invention that fall within the meaning and range of equivalency of the claims are to be embraced within their scope.

Reference list

- 1 bearing
- 2 shaft
- 5 3 clip ring
- 4 gap sealing
- 5 labyrinth sealing
- 6 temperature sensor arrangement according to prior art
- 7 speed sensor arrangement according to prior art
- 10 8 vibration sensor arrangement according to prior art
- 9 wire connection or IoT device, resp. according to prior art
- 10 bearing cover
- 10.1, 10.2, 10.3 recess
- 10.5 separation, partition, shield
- 15 10.7 lead-through for accommodating a/the shaft of the gearbox
- 10.9 flange
- 11 first sensor, especially temperature sensor
- 11.1 O-ring fixation for temperature sensor
- 11.2 adapter ring
- 20 12 second sensor, especially speed sensor
- 12.1 ring for shaft
- 12.2 bush with sealing section, especially with inner ring of labyrinth sealing
- 12.21 inner ring of labyrinth sealing
- 12.3 carrier element for trigger signal, especially metallic part or magnet
- 25 12.4 fixation, especially adhesive joint at the shaft
- 12.5 fixation, especially adhesive joint in radial recess
- 13 third sensor, especially vibration sensor, especially three axis vibration sensor
- 14 torque sensor
- 15 spring
- 30 16 O-ring fixation for bearing cover
- 17 sealing section, especially outer ring of labyrinth sealing, especially integrally
- 18 click ring for temperature sensor
- 19 electrical conjunction box, or wireless IoT device

	20	ring for assembly
	30	PCB
	31	PCB part (separate/individual portion of PCB)
	40	power/energy generator or energy harvesting unit
5	41	ring for shaft
	43	power generating element
	45	stator
	47	rotor
	100	gearbox
10	110	gearing mechanism
	P1	first predefined position
	P2	second predefined position
	P3	third predefined position

Claims

1. Bearing cover (10) for gearboxes (100), exhibiting at least one predefined position for arranging at least one sensor (11, 12, 13, 14), wherein the bearing cover (10) exhibits
5 at least one sealing part (4, 16, 17);
characterized in that the bearing cover (10) is configured for accommodating at least one sensor of the following group: temperature sensor (11), speed sensor (12), vibration sensor (13), torque sensor;
wherein the bearing cover (10) is configured for arranging the at least one sensor in the at
10 least one predefined position and configured for sealing the gearbox (100).
2. Bearing cover (10) according to claim 1, characterized in that the bearing cover (10) provides for a predefined sensor arrangement and exhibits the at least one sensor of the following group: temperature sensor, speed sensor, vibration sensor, torque sensor;
15 wherein the at least one sensor is integrated/arranged within at least one recess (10.1, 10.2, 10.3), preferably in predefined alignment, especially in radial or axial direction; and/or wherein the bearing cover (10) exhibits at least one recess accommodating the at least one sensor, wherein the at least one recess is preferably aligned in radial or axial direction, especially at least an axial recess accommodating a/the temperature sensor
20 and/or a radial recess accommodating a/the speed sensor and/or a/the torque sensor.
3. Bearing cover (10) according to at least one of claims 1 or 2, characterized in that the bearing cover (10) exhibits a lead-through (10.7) for accommodating a/the shaft (2) of the gearbox; and/or wherein at least one of the sensors is configured and arranged for
25 being in measurement communication with at least one shaft of the gearbox.
4. Bearing cover (10) according to at least one of the preceding claims, characterized in that at least one of the at least one sealing part(s) (4, 16, 17) is provided at the bearing cover integrated in one part as a sealing section of the bearing cover, especially by
30 material removal at/on the bearing cover; and/or wherein at least one of the at least one sealing part(s) is provided by means of additive manufacturing, especially an inner sealing ring (12.21) provided integrally in conjunction with a bush (12.2) which is configured for being arranged on a/the shaft of the gearbox.

5 5. Bearing cover (10) according to at least one of the preceding claims, characterized in that the at least one sensor is accommodated in a mechanically preloaded manner within the bearing cover, especially spring-based, especially a/the temperature sensor (11), especially preloaded in axial direction.

10 6. Bearing cover (10) according to at least one of the preceding claims, characterized in that the bearing cover (10) is configured for accommodating at least one speed sensor (12) and/or at least one torque sensor (14), especially in radial direction/alignment, wherein the bearing cover exhibits the at least one speed sensor, especially an inductive or hall speed sensor, especially a speed sensor configured for receiving a trigger signal based on a metallic/magnetic element configured for rotating around a/the shaft (2) of the gearbox, and/or wherein the bearing cover (10) exhibits at least one torque sensor (14); and/or wherein the bearing cover exhibits a torque sensor (14) arranged and configured for being positioned in measurement communication with at least one shaft (2) of the gearbox (100).

20 7. Bearing cover (10) according to at least one of the preceding claims, characterized in that the bearing cover (10) is configured for accommodating at least one vibration sensor (13), especially a three axis vibration sensor, especially at a face side of the bearing cover, especially in a face side recess (10.3) of the bearing cover; and/or wherein the bearing cover exhibits at least three recesses and accommodates at least three of the following sensors: temperature sensor, speed sensor, vibration sensor, torque sensor.

25 8. Bearing cover (10) according to at least one of the preceding claims, characterized in that the bearing cover (10) exhibits a recess for accommodating an electrical conjunction box (19), and optionally the bearing cover comprises said electrical conjunction box (19), especially providing for wired connection to/with a wireless IoT device, wherein the bearing cover preferably exhibits a connection line connecting said recess or electrical conjunction box (19) with/to power supply.

9. Bearing cover (10) according to at least one of the preceding claims, characterized in that the bearing cover (10) exhibits a recess or fixation position for accommodating a

wireless communication unit, and optionally the bearing cover comprises said wireless communication unit; and/or wherein the bearing cover exhibits a flexible PCB (30) connected to a/the wireless communication unit; and/or wherein the bearing cover (10) exhibits a recess for accommodating an energy generator or for accommodating an
5 energy harvesting unit (40), and optionally the bearing cover comprises said energy generator and/or energy harvesting unit.

10. Bearing cover (10) for a gearbox (100), exhibiting at least one sealing part (4, 16, 17), and exhibiting at least one sensor of the following group: temperature sensor (11),
10 speed sensor (12), vibration sensor (13), torque sensor (14); and exhibiting at least one recess for accommodating the at least one sensor and for arranging the at least one sensor in a predefined position within the gearbox; especially bearing cover according to at least one of the preceding claims; wherein the at least one recess of the bearing cover is processed by material removal at/on the bearing cover, and wherein one of the at least
15 one sealing part(s) is provided integrated in one part at the bearing cover (10) as a sealing section (17) of the bearing cover (10), especially by material removal, and/or wherein one (further) of the at least one sealing part(s) is provided by means of additive manufacturing, especially an inner sealing ring (12.21) provided integrally in conjunction with a bush (12.2) which is configured for being arranged on a/the shaft of the gearbox.

20

11. Gearbox (100) with a bearing cover (10) according to at least one of the preceding claims, especially industry gearbox or wind energy plant gearbox.

12. Gearbox (100) according to the previous claim, wherein a (further) sealing part
25 (12.21) is provided on a/the shaft (2) of the gearbox (100) for interacting with a/the corresponding sealing part/section (17) provided at the bearing cover (10), wherein the further sealing part (12.21) on the shaft is processed by additive manufacturing, especially by additive manufacturing of an inner sealing ring on a bush (12.2) configured for being arranged on the shaft, especially in conjunction with a/the bush (12.2)
30 preferably also providing for a carrier (12.3) for a trigger signal for a/the speed sensor (12).

13. Method for acquiring data of at least one operating parameter of a gearbox (100) by means of at least one sensor of the following group: temperature sensor (11), speed sensor (12), vibration sensor (13), torque sensor (14); wherein the at least one sensor is accommodated in a predefined position in/on a bearing cover (10) of the gearbox (100),
5 especially in/on a bearing cover according to at least one of the claims 1 to 10, wherein the bearing cover (10) exhibits at least one sealing part (4, 16, 17) sealing the gearbox; wherein data of the at least one operating parameter is acquired by the at least one sensor in the predefined position in/on the bearing cover (10).
- 10 14. Method according to previous method claim, characterized in that data of the at least one operating parameter is acquired by the at least one sensor in the predefined position within a recess of the bearing cover (10) accommodating the sensor, especially a temperature sensor (11) and/or a speed sensor (12), wherein the at least one sealing part sealing the gearbox is provided by the bearing cover integrated in one part as a sealing
15 section (17) of the bearing cover, and/or the at least one sealing part sealing the gearbox is provided by an inner sealing ring (12.21); and/or wherein the at least one sensor is connected to an electrical conjunction box or to a wireless IoT device (19) respectively arranged at the bearing cover, such that data of the at least one operating parameter is wirelessly transmitted from the bearing cover (10); and/or wherein the at least one sensor
20 is connected to an energy generator or to an energy harvesting unit (40) respectively arranged at or at least partly within the bearing cover (10).
15. Use of a bearing cover (10) for gearboxes (100) for providing at least one sensor of the following group to the gearbox: temperature sensor (11), speed sensor (12), vibration
25 sensor (13), torque sensor (14); wherein at least one sensing/measurement position at/within the gearbox (100) is predefined by means of the bearing cover (10), and wherein at least one sealing function for sealing the gearbox (100) and the at least one sensor is provided by means of the bearing cover (10), especially for monitoring at least two or three operating parameters of the gearbox (100) by means of the bearing cover
30 (10), especially for remote monitoring via an IoT device (19) provided by the bearing cover.

FIG 1

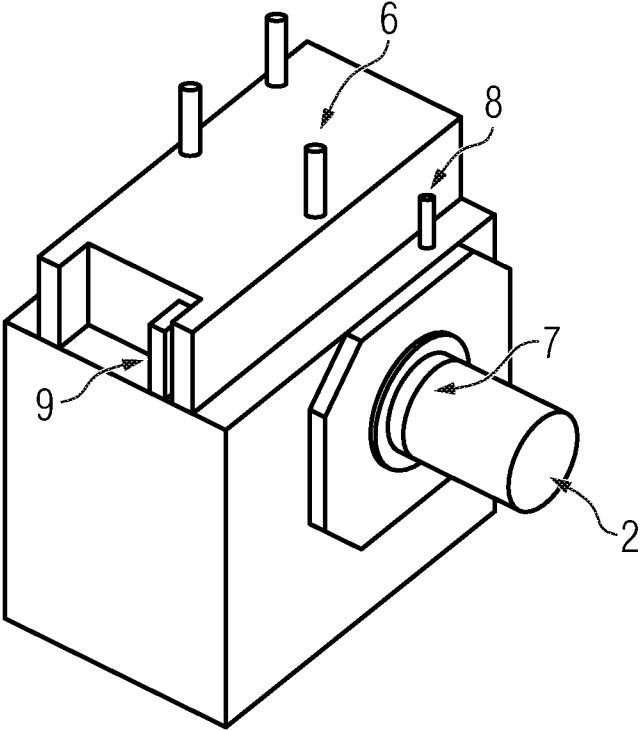


FIG 2A

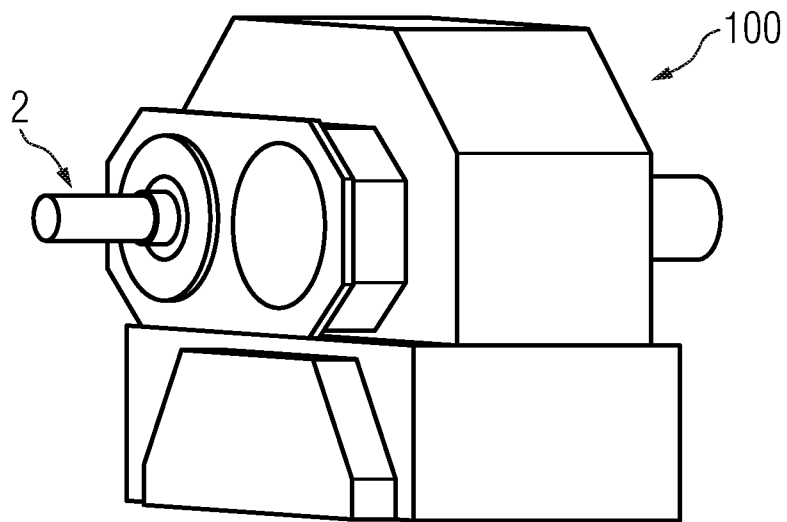


FIG 2B

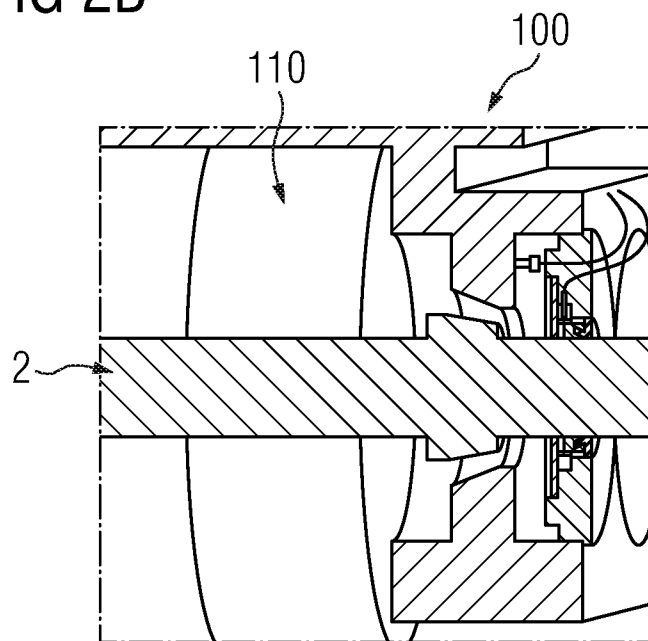


FIG 3A

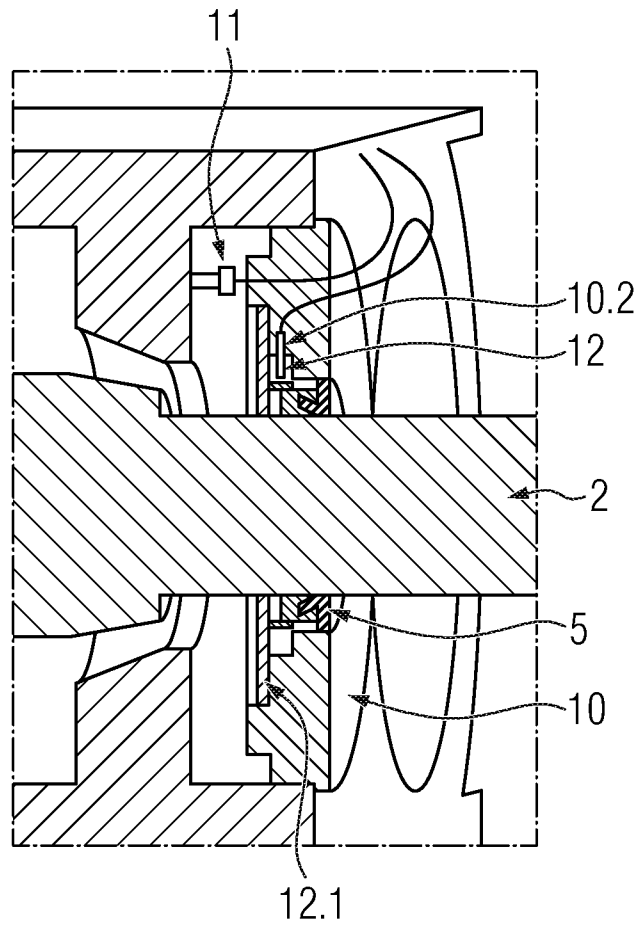


FIG 3B

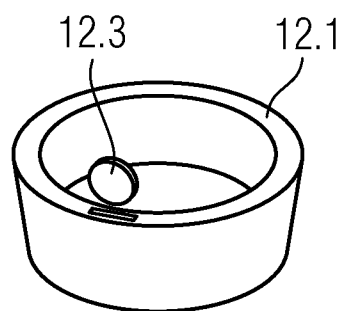


FIG 6

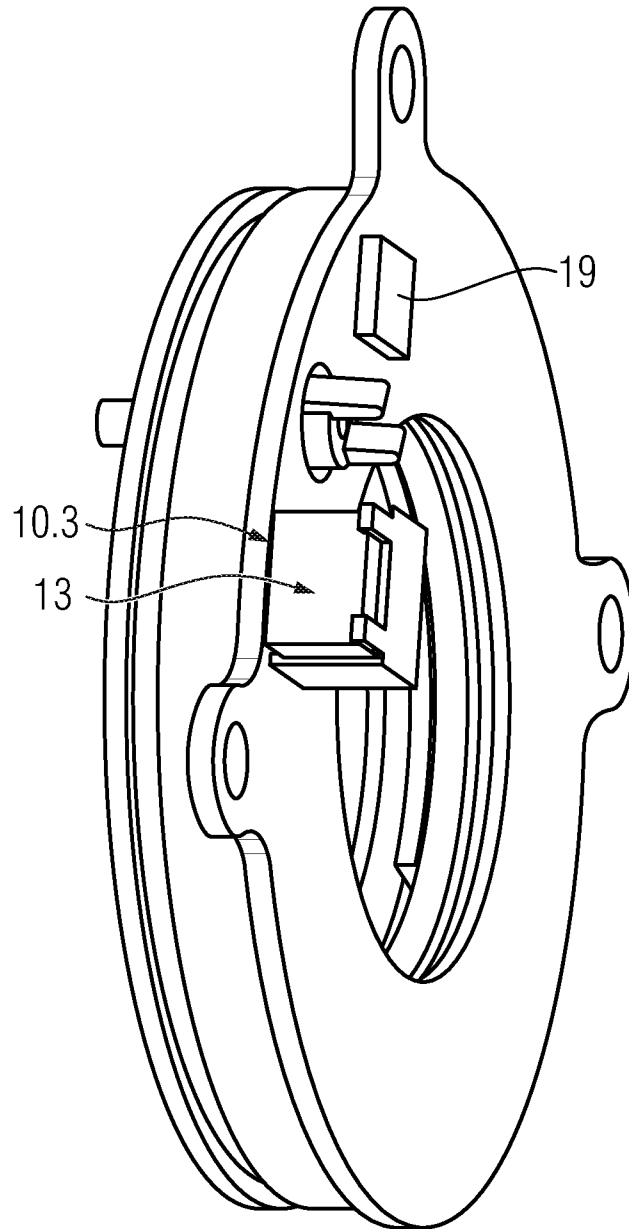


FIG 7A

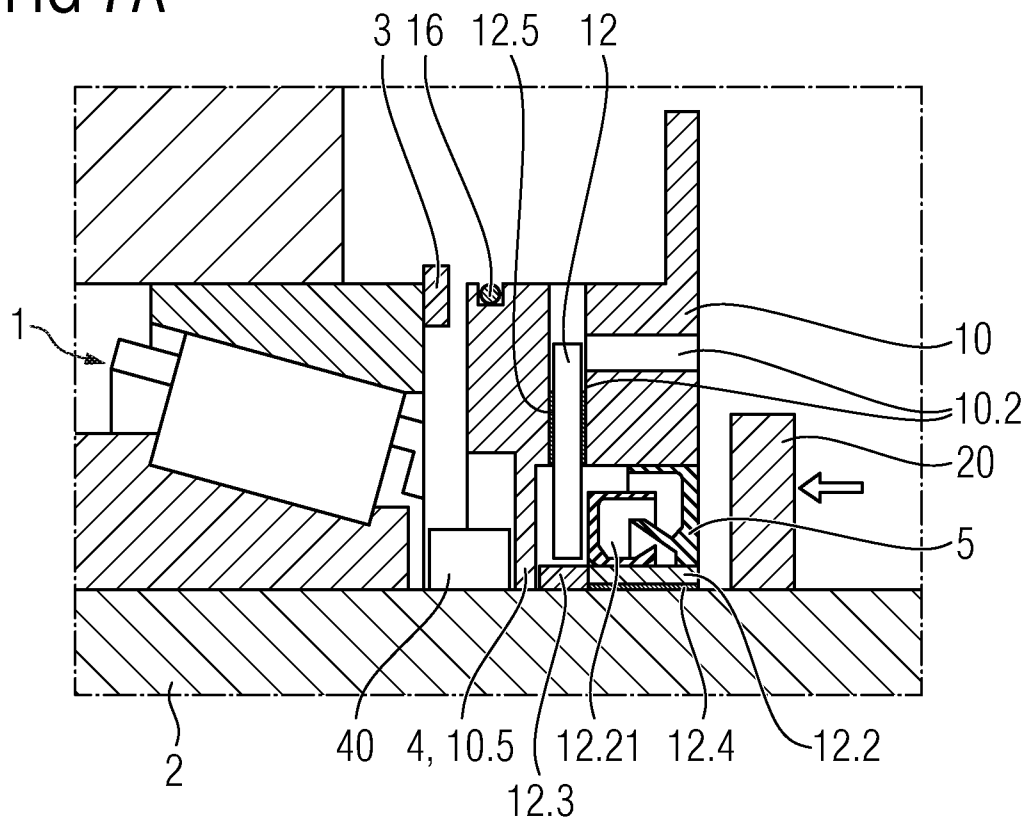


FIG 7B

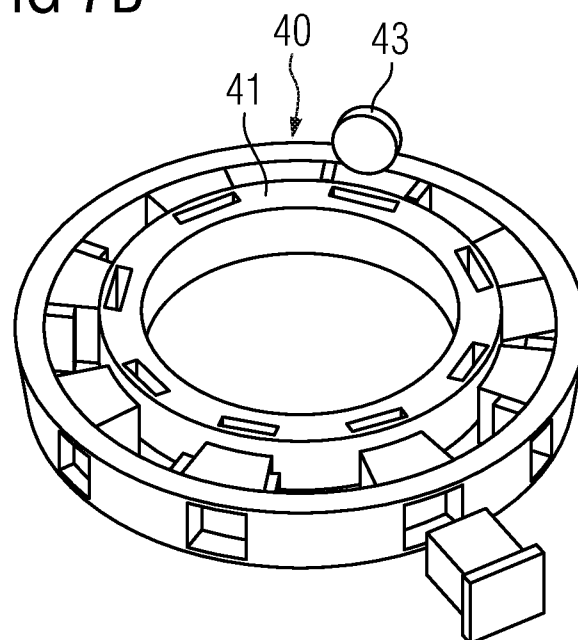


FIG 7C

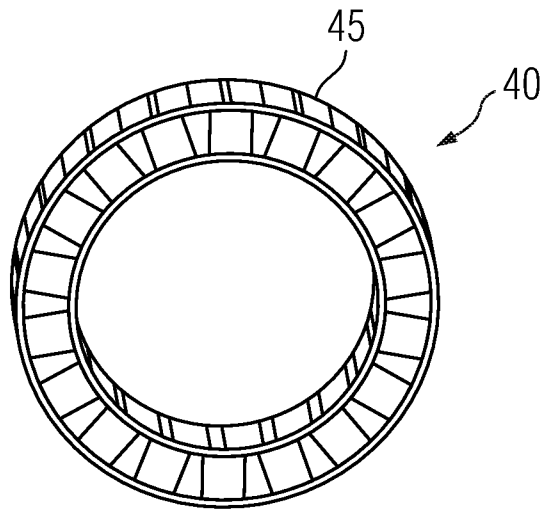


FIG 7D

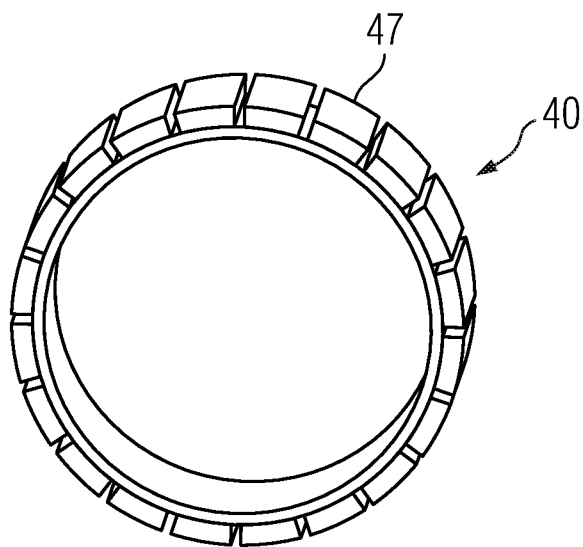


FIG 8A

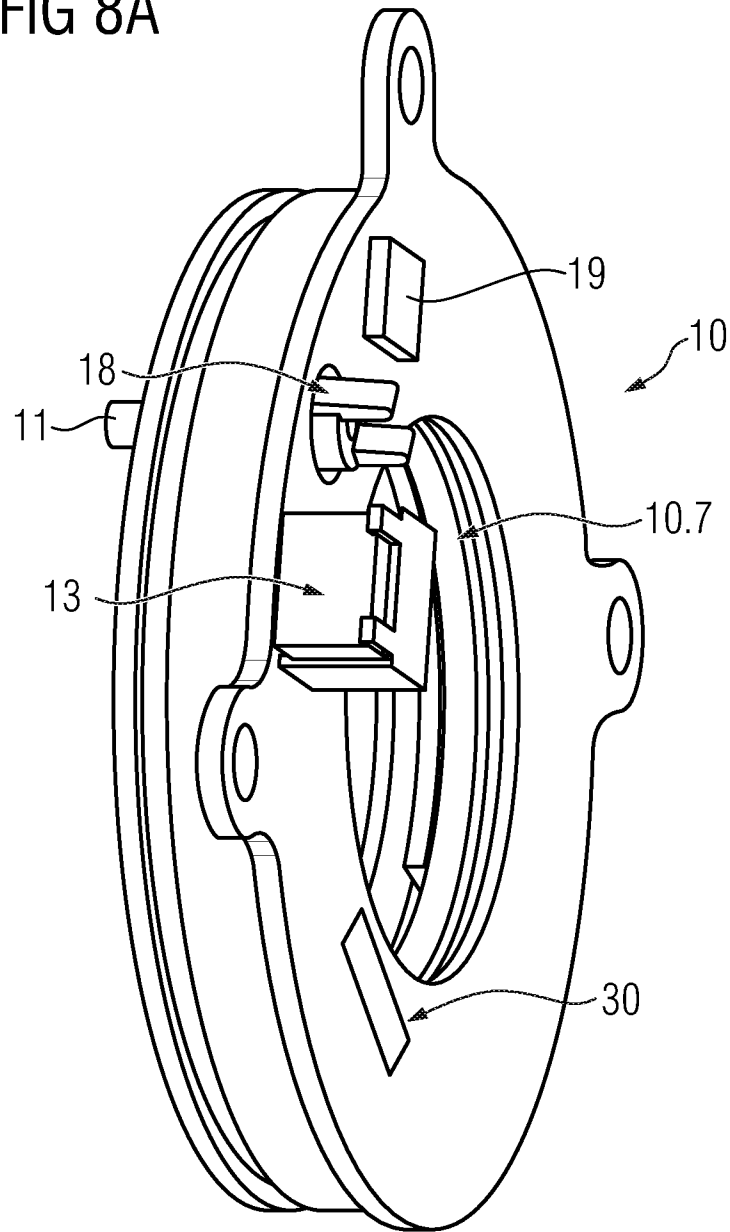
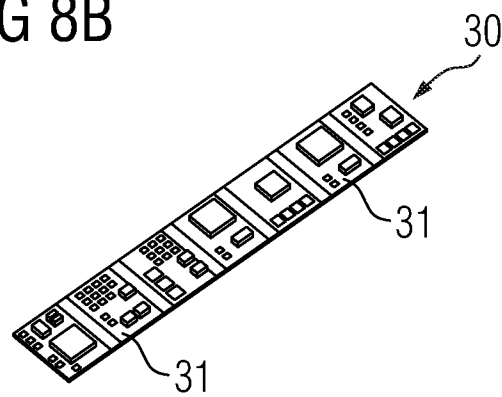


FIG 8B



INTERNATIONAL SEARCH REPORT

International application No
PCT/CN2022/085792

A. CLASSIFICATION OF SUBJECT MATTER INV. F16C19/52 F16C33/78 F16C41/00 F16C35/00 F16C33/80 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) F16C		
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	JP 2005 344842 A (NSK LTD)	1-4, 6-15
Y	15 December 2005 (2005-12-15)	5
	figure 1	
	paragraphs [0001], [0021], [0031]	
	The references cited refer to the annexed automated translation of this document.	

X	US 7 011 451 B2 (NTN TOYO BEARING CO LTD	1-4, 6,
	[JP]) 14 March 2006 (2006-03-14)	10, 13, 15
A	figure 2	5

X	US 2002/157470 A1 (NOETZEL JENS [DE] ET	1, 3, 4, 6,
	AL) 31 October 2002 (2002-10-31)	8-10,
		13-15
A	figure 4	5
	paragraph [0031]	

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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 22 September 2022		Date of mailing of the international search report 04/10/2022
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Frechard, Fabrice

INTERNATIONAL SEARCH REPORT

International application No

PCT/CN2022/085792

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2016/299016 A1 (CAMPBELL ANDREW [GB]) 13 October 2016 (2016-10-13) figure 1 paragraph [0060] -----	5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/CN2022/085792

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		US 2016299016 A1	13-10-2016
		WO 2015071453 A1	21-05-2015