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(54) Title: ENCODER WASHER AND ASSEMBLY COMPRISING SUCH A WASHER

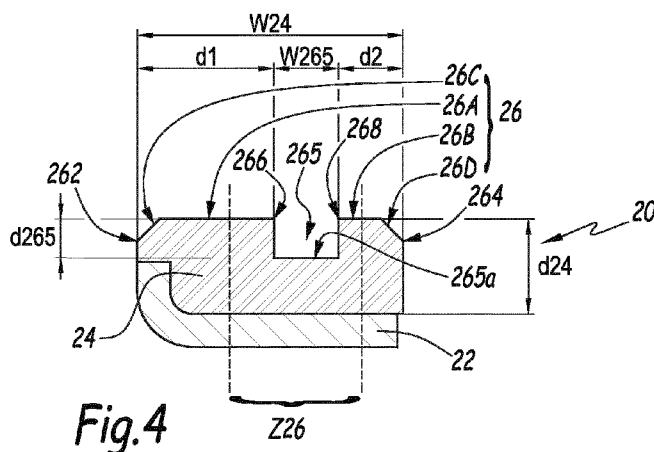


Fig. 4

(57) Abstract: This encoder washer comprises a magnetic body (24) and is adapted to be mounted on a rotatable ring of a bearing assembly in a position where a surface (26) of the magnetic body defines an air gap with a sensor of the bearing assembly. The surface (26) of the magnetic body is provided with one groove (265) defining two edges (266, 268) with this surface, wherein these two edges are located either between two lateral edges (262, 264) of the magnetic body (24) or between a radial inner edge and a radial outer edge of the magnetic body. The groove (265) has a rectangular cross section. A first distance (d1) measured between a first edge (266) of the groove (265) and an adjacent edge (262) of the magnetic body, in a direction parallel to the bottom surface (265a) of the groove, is larger than or equal to 0,5 millimeters. A second distance (d2) measured between a second edge (268) of the groove and an adjacent edge (264) of the magnetic body, is larger than or equal to 0,5 mm. The width (W25) of the groove, measured between its two edges (266, 268), is larger than or equal to 0,5 mm and smaller than or equal to a minimum value selected amongst $0,75 \times W24$, where W24 is the total width of the magnetic body (24), and W24 minus 1 mm. The depth (d265) of the groove, measured between one of its edges (266, 268) and its bottom surface (265a), is larger than or equal to a minimum value selected amongst 0,3 mm and the maximum depth of the magnetic body.

ENCODER WASHER AND ASSEMBLY COMPRISING SUCH A WASHER

TECHNICAL FIELD OF THE INVENTION

This invention relates to an encoder washer to be used with an assembly such as a sensor assembly or a bearing assembly, to a sensor assembly comprising such an encoder washer and to a bearing assembly comprising such an encoder washer.

BACKGROUND OF THE INVENTION

In the field of bearings, it is known to use a sensor to determine a rotation parameter of a rotating ring. The accuracy of this determination is highly dependent on the thickness of the air gap between an encoder washer, fast in rotation with the rotatable ring, and the sensor. On the other hand, because of the tolerances in the manufacturing of the respective parts of the bearing, of the encoder washer and of the sensor, the thickness of the air gap might vary substantially, by several tenth of a millimeter for an air gap having a nominal thickness of a few millimeters. This might lead to improper working of the sensing assembly constituted of the encoder washer and the corresponding sensor.

In order to tackle this issue, it is known from WO-A-2012/076926 to use an encoder washer including a magnetic body provided with a groove. With this kind of an encoder washer, the manufacturing tolerances still have a significant influence on the magnetic field generated between the magnetic body and the sensor. It may happen that this field is not strong enough to guarantee an efficient detection of the encoder washer position and/or rotation speed.

SUMMARY OF THE INVENTION

The invention aims at solving these problems with a new encoder washer with which variations of the thickness of an air gap can be accommodated, while the magnetic field between the encoder washer and the sensor is reliably established and does not substantially vary, even if thickness of the air gap varies.

To this end, the invention concerns an encoder washer, comprising a magnetic body and adapted to be mounted on a rotatable ring of a bearing assembly in a position where a surface of the magnetic body defines an air gap with a sensor of the bearing assembly, wherein the surface of the magnetic body is provided with one groove defining two edges with this surface, wherein these two edges are located either between two lateral edges of the magnetic body or between a radial inner edge and a radial outer edge of this magnetic body and wherein the groove has a rectangular cross-section. According to the invention,

- a first distance measured between a first edge of the groove and an adjacent edge of the magnetic body, in a direction parallel to the bottom surface of the groove, is larger than or equal to 0,5 millimeters (mm);
- a second distance measured between a second edge of the groove and the adjacent edge of the magnetic body, in a direction parallel to the bottom surface of the groove, is larger than or equal to 0,5 mm;
- the width of the groove, measured between its two edges, is larger than or equal to 0,5 mm and smaller than or equal to a first minimum value selected amongst $0,75 \times W24$, where W24 is the total width of the magnetic body, and W24 minus 1 mm;
- and
- the depth of the groove, measured between one of its edges and its bottom surface, is larger than or equal to a second minimum value selected amongst 0,3 mm and the maximum depth of the magnetic body.

Thanks to the invention, the strength or intensity of the magnetic field created between the magnetic body and the sensor of a bearing assembly is stable, even if the position of the magnetic body with respect to the sensor varies in a direction parallel or perpendicular to the thickness of the air gap. In other words, the specific geometry of the magnetic body makes the magnetic field less sensible to relative positions tolerances, between the encoder washer and the associated sensor.

According to further aspects of the invention, which are advantageous but not compulsory, the encoder washer might incorporate one or several of the following features:

- The first distance is larger than or equal to 1 mm and the second distance is larger than or equal to 1 mm.

- The magnetic body is made of a single piece and the depth of the groove is larger than or equal to 0,3 mm. The encoder washer can include an armature for holding the magnetic body with respect to the rotating ring.

- Alternatively, the encoder washer includes an armature for holding the magnetic body with respect to the rotating ring, the magnetic body is made of two distinct parts, the groove is an empty space between these two distinct parts and the depth of the groove is equal to the maximum depth of the magnetic body.

The invention also concerns a sensor assembly comprising an inner ring, an outer ring, at least one sensor integral in rotation with a first one of these rings and an encoder washer as mentioned here-above, which is integral with the second one of these rings.

Finally, the invention concerns a bearing assembly which comprises a bearing with an inner ring and an outer ring, at least one sensor integral in rotation with a first ring

amongst the inner and outer rings and an encoder washer as mentioned here-above, which is integral in rotation with the second one of the inner and outer rings.

Advantageously, the depth of a crystal air gap defined between the surface of the magnetic body and the sensitive element of the sensor is between 0,1 and 10 mm.

5

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood on the basis of the following description which is given in correspondence with the annexed figures and as an illustrative example, without restricting the object of the invention. In the annexed figures:

- 10 - figure 1 is a sectional view of a rolling bearing assembly according to the invention,
- figure 2 is an enlarged view of detail II on figure 1,
- figure 3 is a perspective view of an encoder washer according to the invention, used in the rolling bearing assembly of figures 1 and 2,
- 15 - figure 4 is an enlarged cross-section along line IV-IV on figure 3,
- figures 5 and 6 are cross-sections similar to figure 4 for a second and a third embodiment of the invention.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

20 The rolling bearing assembly 1 represented on figure 1 includes a rolling bearing 2 having a fixed outer ring 4 and an inner ring 6 rotatable around a central axis X2 of rolling bearing 2.

Several balls 8 are installed within a chamber 10 defined between rings 4 and 6 and held in position within this chamber by a cage 12. These balls constitute rolling bodies for rolling bearing 2. The invention can also be implemented with another type of rolling bearing, e.g. a roller bearing or a needle bearing, or with a plain bearing.

25 In the present description, unless otherwise specified, the words "axial", "radial", "axially" and "radially" are defined in relation to axis X2. A direction is "axial" when it is parallel to axis X2 and a direction or an axis is "radial" when it is perpendicular to and secant with such this axis.

30 An encoder washer 20 is integral or fast in rotation with inner ring 6. Encoder washer 20 includes a metallic armature 22 and a magnetic body 24 mounted on this armature. Armature 22 is used to hold encoder washer 20 onto inner ring 6. Magnetic body 24 is made in a magnetic material such as ferrite, plasto-ferrite, elasto-ferrite, rare earth, such as NdFeB or Sm₂Co₁₇, elasto-rare-earth or plasto-rare-earth. This magnetic body is
35 polarized in order to constitute several North and South magnetic poles distributed around

a central axis X20 of encoder washer 20 which is superimposed with axis X2 when encoder washer 20 is mounted on inner ring 6.

A sensor unit 40 is mounted on outer ring 4 and includes at least one sensor cell 42 arranged in a sensor body 44 and connected to a printed circuit board 46 which is connected to a non represented electronic control unit via a cable 47. An air gap G is defined between a radial outer surface 26 of magnetic body 24 and a face 48 of sensor cell 42 oriented towards encoder washer 20. e_G denotes the radial thickness of air gap G, that is the radial distance between surface 26 and face 48.

Surface 26 extends, axially along axis X20, between a first lateral edge 262 and a second lateral edge 264.

A peripheral groove 265 is formed in outer surface 26 in a central zone of this surface that is in a zone Z_{26} median between edges 262 and 264. Groove 265 forms with outer surface 26 two edges 266 and 268 which are circular and parallel to edges 262 and 264 and located between edges 262 and 264 along axis X20.

Thus, surface 26 is divided into two annular sub-surfaces 26A and 26B which extend on either side of groove 265, respectively between edges 262 and 266 and edges 264 and 268. A bevel 26C joins sub-surface 26A and edge 262. Similarly, a bevel 26D joins sub-surface 26B and edge 264. Surface 26 is made of sub-surfaces 26A and 26B and bevels 26C and 26D.

Groove 265 has a rectangular cross section and reference 265a denotes its bottom surface which is radial with respect to axis X20, thus parallel to this axis.

d_1 denotes an axial distance with respect to axis X20, which is parallel to surface 265a and measured between edges 262 and 266. Distance d_1 corresponds to the axial dimensions of sub-surface 26A and bevel 26C.

Similarly, d_2 denotes an axial distance, measured parallel to surface 265a and measured between edges 264 and 268. Distance d_2 is the axial dimension of sub-surface 26B and bevel 26D.

W_{265} denotes the axial width of groove 265 measured between edges 266 and 268, along a direction parallel to surface 265a and axis X20.

W_{24} denotes the total width of magnetic body 24 between edges 262 and 264, measured along a direction parallel to surface 265a and axis X20. The following equation shows the relationship between these distances and width:

$$W_{24} = d_1 + W_{265} + d_2. \quad (\text{Equation 1})$$

Distance d_1 is larger than or equal to 0,5 mm. Similarly, distance d_2 is larger than or equal to 0,5 mm. In other words, the axial dimension of surface 26 is large enough to

obtain a magnetic effect between magnetic body 24 and sensor cell 42. Thus, the following equations apply:

$$d1 \geq 0,5 \text{ mm} \quad (\text{Equation 2})$$

$$d2 \geq 0,5 \text{ mm} \quad (\text{Equation 3})$$

d24 denotes the total depth magnetic body 24 which is made of a single part. Depth d24 is measured between sub-surfaces 26A and 26B, on the one hand, and armature 22 on the other hand, in a direction parallel to the direction of measure of depth d265.

On the other hand, d265 denotes the depth of groove 265, that is the distance between one of edges 268 and 266 and bottom surface 265a, this distance being measured perpendicularly to surface 265a, along a direction radial with respect to axis X20.

In case where depth d24 is larger than 0,3 mm, as shown on figure 4, depth d265 is larger than or equal to 0,3 mm. The following equation applies:

$$d265 \geq 0,3 \text{ mm} \quad (\text{Equation 4})$$

Width W265 is larger than 0,5 mm, as distances d1 and d2. On the other hand, this width W265 is smaller than or equal to a minimum value min1 selected amongst

- $0,75 \times w24$ or
- W24 minus 1 mm.

Thus, the following equations apply:

$$W25 \geq 0,5 \text{ mm} \quad (\text{Equation 5})$$

$$\min 1 = \min (0,75 \times W24, W24 - 1 \text{ mm}) \quad (\text{Equation 6})$$

$$W25 \leq \min 1 \quad (\text{Equation 7})$$

Thanks to this configuration of magnetic body 24 defined by equations 1 to 7, the magnetic field created by the succession of its North and South poles rotating around axes X2 and X20 is less perturbed by variations of the radial thickness e_G , than in case where outer surface 26 would extend continuously between edges 262 and 264 or where the above listed relationships would not apply.

The second and third embodiments represented on figures 5 and 6 also embody the invention. On this figures, the same references are used to identify the same features as in the first embodiment. Here-after, only the differences between these embodiments and the first embodiment are mentioned.

In the second embodiment, the groove 265 extends up to a face 222 of the armature 22 of the encoder body oriented towards the sensor cell. In other words, the magnetic body 22 is divided by the groove 265 into two separate sub-bodies or distinct parts 24A and 24B.

In this embodiment, distances d1 and d2, widths W24 and W265 and depths d24 and d265 are defined as in the first embodiment. In this case, depth d265 equals depth d24, which corresponds to the fact that groove 265 extends up to face 222 of the armature 22 and that depth d24 is less than 0,3 mm. In this case, surface 222 forms the bottom surface of groove 265.

In this embodiment, equations 1 to 3 and 5 to 7 apply, together with the following equation:

$$d265 = d24 \quad (\text{Equation 4'})$$

In the embodiments of figures 1 to 5, the encoder washer 20 is adapted to a sensor cell 42 whose reading direction is radial with respect to axis X2. In these embodiments, the surface 26 defining the air gap G is the outer radial surface of the body 24.

In the embodiment of figure 6, the encoder washer 20 is adapted to cooperate with a not represented sensor cell whose reading direction is parallel to the central axis of the bearing. In such a case, the surface 26 of the magnetic body 24, which defines an air gap, is a lateral surface of this body which extends between a radial inner edge 262 and a radial outer edge 264. As in the first embodiment, a rectangular shaped groove 265 is defined between two edges 266 and 268 of surface 26 which is divided into two sub-surfaces 26A and 26B and one bevel 26D. Edges 266 and 268 are located in a median zone Z_{26} of surface 26, between edges 262 and 264 along an axis Y2 which is radial with respect to axes X2 and X20 defined as in the first embodiment.

Also in this embodiment, one can define distances d1 and d2, widths W24 and W265 and depths d24 and d265, the distances and widths being measured parallelly to axis Y2 and the depths parallel to axis X20. Equations 1 to 7 apply.

In all embodiments, one can define a minimum value min 2 selected amongst 0,3 mm and depth d24. min 2 equals 0,3 mm in the first and third embodiments and d24 in the second embodiment. The following equations apply:

$$\text{min } 2 = \min (0,3, d24) \quad (\text{Equation 8})$$

$$d25 \geq \text{min } 2 \quad (\text{Equation 9})$$

Thus, in all embodiments, equations 1 to 3 and 5 to 9 apply.

As mentioned here-above, in all embodiments, distances d1 and d2 are larger than or equal to 0,5 mm. Advantageously, these distances are respectively larger than or equal to 1 mm.

The crystal air gap of assembly 1 is defined as the distance between the sensor cell 42 and the washer 20.

The invention allows the magnetic field created between parts 24 and 42 to be stable with a crystal air gap thickness e_G between 0,1 and 10 mm. These boundary values

are particularly adapted for sensors, bearings or rotary electrical machines equipping motor vehicles such as motorbike or passenger cars. However, the invention would also work for components or systems of greater sizes, e.g. in trains and industrial compressors, generators or electrical motors.

5 The invention can be implemented with a sensor unit 40 having one or several sensor cells 42.

 The invention has been represented on the figures in case the rotatable ring of a bearing is its inner ring. The invention also applies to the case where the rotatable ring is the outer ring of a bearing.

10 The invention can be implemented with several types of sensors, namely a position sensor, a speed sensor, an ABS sensor, a crankshaft and transmission sensor and/or a motor control or commutation sensor.

 The invention can be implemented with a rolling bearing or a plain bearing, or even without a bearing if the washer 20 is mounted on a rotating part and the sensor unit 40 on
15 a fixed part.

 The respective features of the embodiments considered in this description can be combined.

CLAIMS

1.- An encoder washer (20), comprising a magnetic body (24) and adapted to be mounted on a rotatable ring (6), in a position where a surface (26) of the magnetic body defines an air gap (G) with a sensor (42), wherein the surface of the magnetic body is provided with one groove (265) defining two edges (266, 268) with this surface, wherein these two edges are located either between two lateral edges (262, 264) of the magnetic body or between a radial inner edge (262) and a radial outer edge (264) of the magnetic body and wherein the groove (265) has a rectangular cross section, characterized in that:

- a first distance (d1) measured between a first edge (206) of the groove (265) and an adjacent edge (262) of the magnetic body (24), in a direction parallel to the bottom surface (265a; 222) of the groove, is larger than or equal to 0,5 mm;
- a second distance (d2) measured between a second edge (268) of the groove and an adjacent edge (264) of the magnetic body, in a direction parallel to the bottom surface of the groove, is larger than or equal to 0,5 mm;
- the width (W265) of the groove, measured between its two edges (266, 268), is larger than or equal to 0,5 mm and smaller than or equal to a first minimum value (min 1) selected amongst
 - $0,75 \times W24$, where W24 is the total width of the magnetic body,
 - W24 minus 1 mm; and
- the depth (d265) of the groove, measured between one of its edges (266, 268) and its bottom surface (265; 222), is larger than or equal to a second minimum value (min 2) selected amongst
 - 0,3 mm,
 - the maximum depth (s24) of the magnetic body (24).

2. Encoder washer according to claim 1, characterized in that

- the first distance (d1) is larger than or equal to 1 mm ;
- the second distance (d2) is larger than or equal to 1 mm .

3. Encoder washer according to any preceding claim, characterized in that the magnetic body (24) is made of a single piece and the depth (d265) of the groove (265) is larger than or equal to 0,3 mm.

4. Encoder washer according to claim 3, characterized in that it includes an armature (22) for holding the magnetic body (24) with respect to the rotatable ring (6).

5 5. Encoder washer according to any one of claims 1 or 2, characterized in that it includes an armature (22) for holding the magnetic body with respect to the rotatable ring (6), the magnetic body is made of two distinct parts (24A, 24B), the groove (265) is an empty space between these two distinct parts and the depth (d265) of the groove is equal to the maximum depth (d24) of the magnetic body.

6. Sensor assembly (1) comprising

- an inner ring (6) and an outer ring (4),
- at least one sensor (42) integral in rotation with a first ring (4), amongst the inner and outer rings, and
- an encoder washer (20) integral in rotation with the second one (6) of the inner and outer rings,

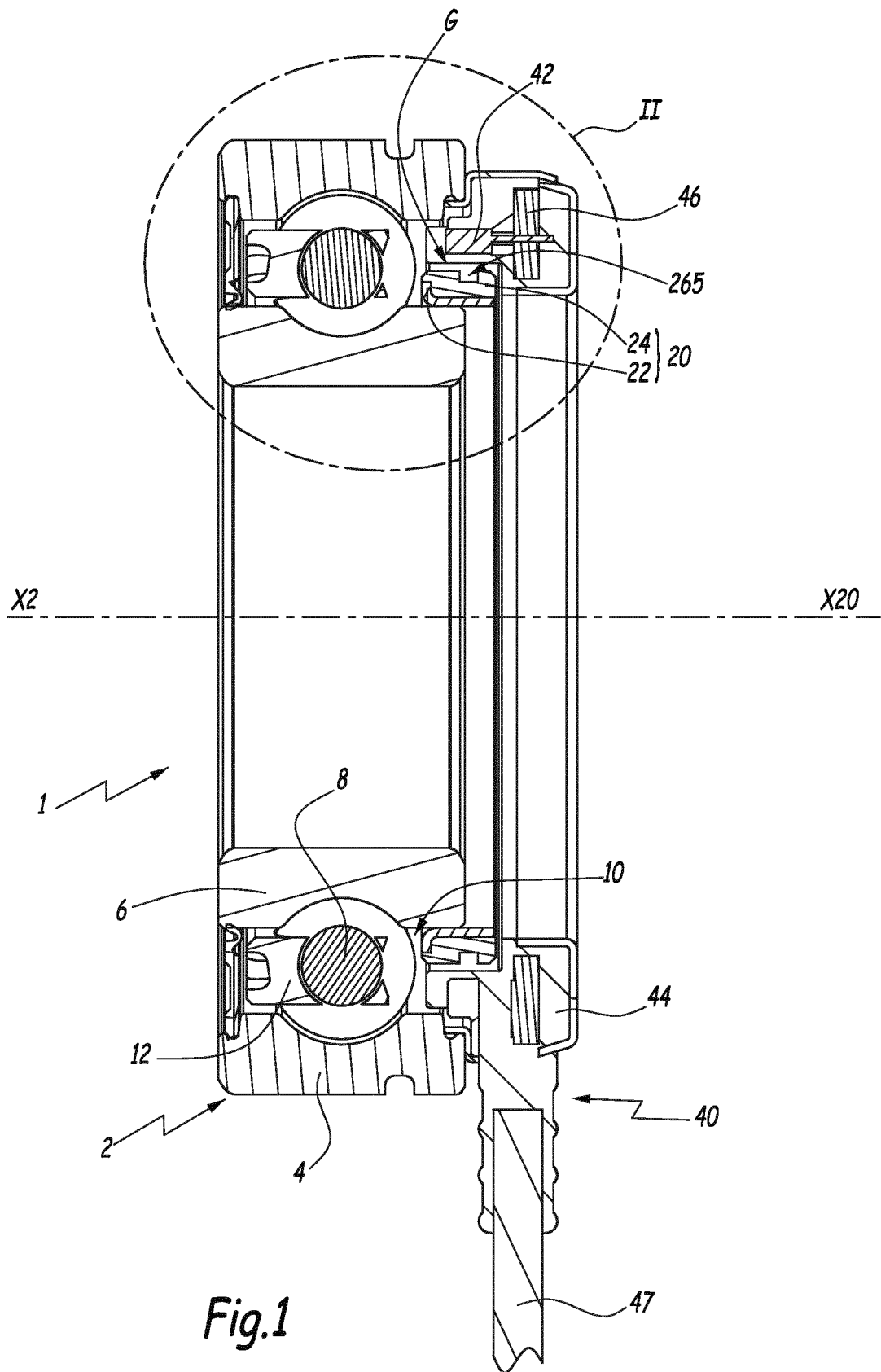
characterized in that the encoder washer (20) is according to at least one of the preceding claims.

7. Bearing assembly (1) comprising

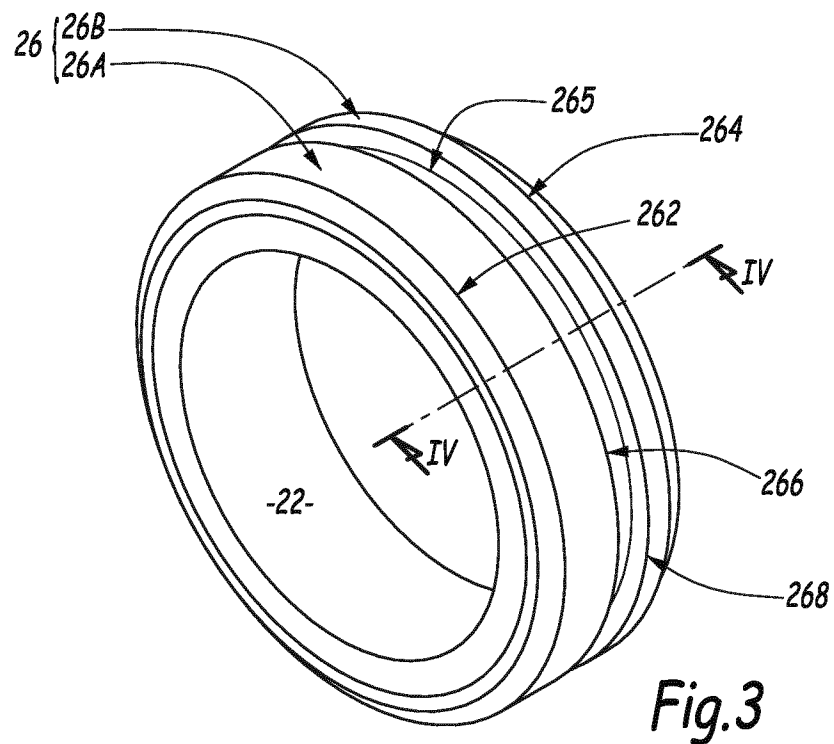
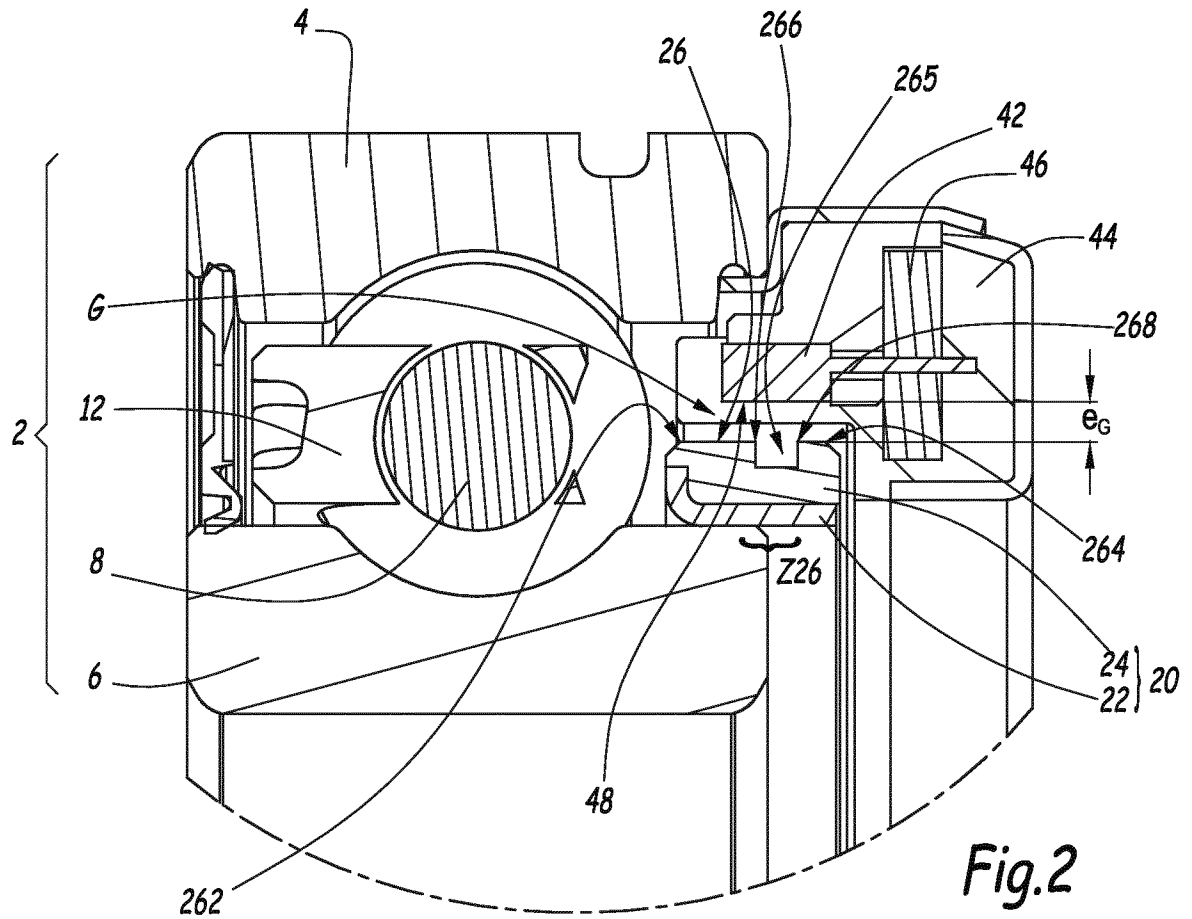
- a bearing (2), with an inner ring (6) and an outer ring (4),
- at least one sensor (42) integral in rotation with a first ring (4), amongst the inner and outer rings, and
- an encoder washer (20) integral in rotation with the second one (6) of the inner and outer rings,

characterized in that the encoder washer (20) is according to at least one of claims 1 to 5.

8.- Sensor or bearing assembly according to claim 6 or 7, characterized in that the depth (e_G) of a crystal air gap (G) defined between the surface (26) of the magnetic body (20) and the sensitive element (42) of the sensor (40) is between 0,1 and 10 mm .



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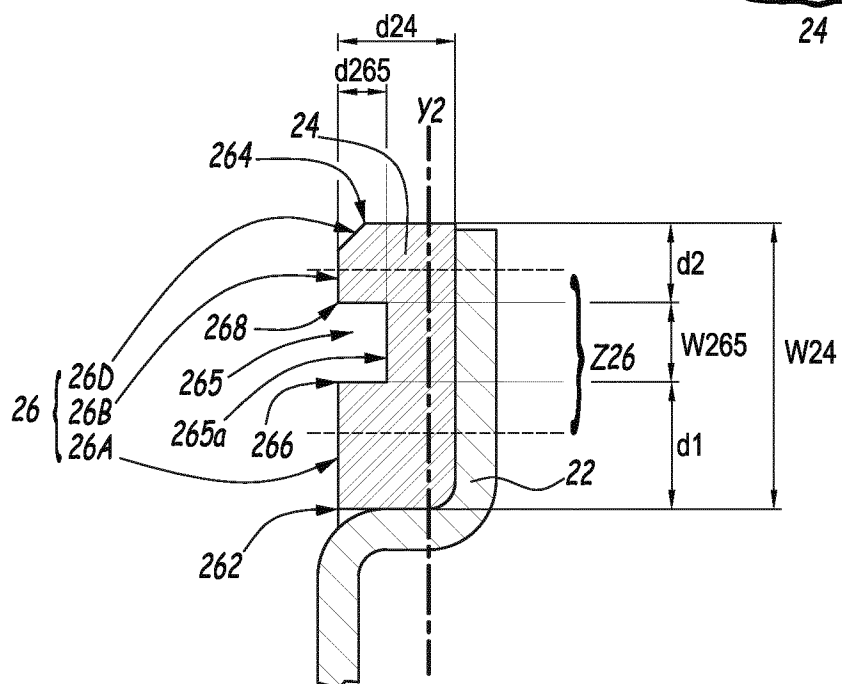
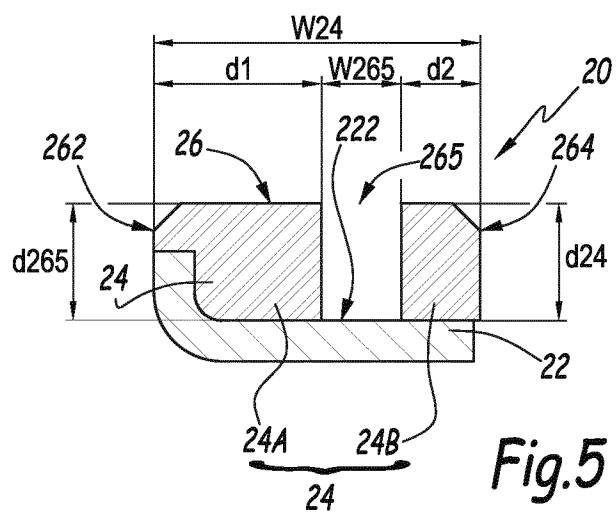
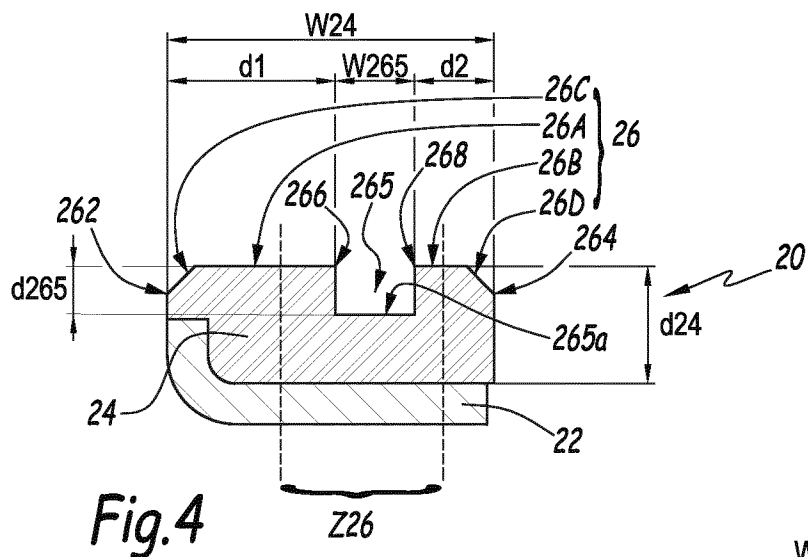


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/075285

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16C41/00 G01P3/44 G01P3/487 G01D5/14
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 F16J G01P G01D

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)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	page 1, lines 1-16 page 4, line 30 - page 5, line 26 figures 1-4	3,4,6-8
Y	----- EP 2 579 002 A1 (NTN TOYO BEARING CO LTD [JP]; NTN SNR ROULEMENTS [FR]) 10 April 2013 (2013-04-10)	6-8
A	the whole document figures 13A, 13B	1,2
Y	----- WO 2012/076926 A1 (SKF AB [SE]; GATESOUBE ALEXIS [FR]; HUBERT MATHIEU [FR]) 14 June 2012 (2012-06-14)	3,4
A	cited in the application the whole document	1,2,5-8
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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

24 July 2014

Date of mailing of the international search report

31/07/2014

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Dumont, Marie-Laure

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/075285

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2013/075285

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