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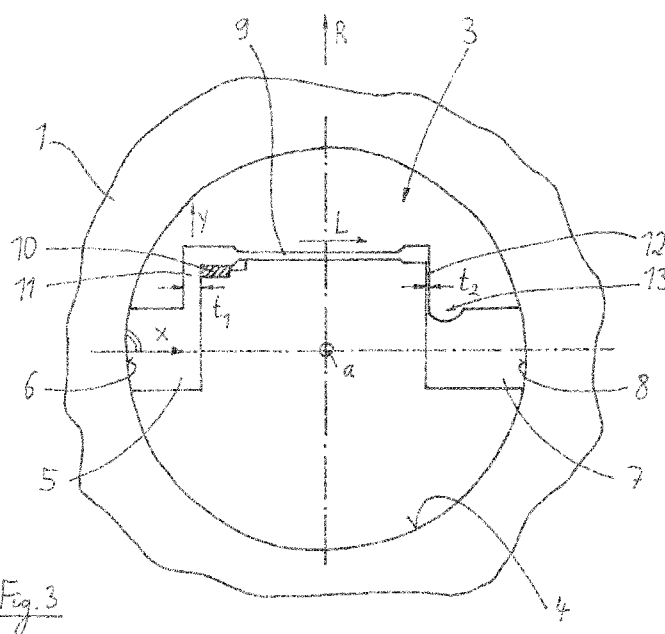
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(54) Title: ROLLER ELEMENT OF A ROLLER BEARING



(57) Abstract: The invention relates to a roller element (1) of a roller bearing (2), wherein the roller element (1) is equipped with a device (3) for detecting the load (F) which is acting radially (R) onto the roller element (1). To establish a cost-effective possibility for a load detection the roller element is characterized in that the device (3) is arranged in a bore (4) in the roller element (1) and comprises: a first anchor element (5) which is in contact with a first surface portion (6) of the bore (4), a second anchor element (7) which is in contact with a second surface portion (8) of the bore (4), a Piezo element (9) or a bending element which is equipped with at least one strain gauge which is arranged between the first anchor element (5) and the second anchor element (7) and means for measurement (10) of a voltage (U) or charge (Q) which is created by the Piezo element (9) due to a deformation of the same or for measurement of a resistance of the at least one strain gauge due to the bending of the bending element.

Roller Element of a Roller Bearing

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Technical Field

The invention relates to a roller element of a roller bearing, wherein the roller element is equipped with a device for detecting the load which is acting radi-
10 ally onto the roller element.

Background

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Roller elements of the generic kind are known for example from **DE 10 2010 005 476 A1**. Here, the measurement of a force which is exerted onto the roller bearing is detected by means which measure the change of the circumference of the body of the roller element.

20

In general, the load sensing in roller bearings (rolling element bearings) is quite costly and labour intensive. As becomes apparent from the mentioned citation there is no easy way to measure the load; to the contrary, there are always extensive FEA simulations or modifications to the bearing required.

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Thus, it is an object of the present invention to propose a roller element which allows a cost-effective possibility for a load detection. Thus, it is aimed

to develop a new solution which is cost-effective, easy to install and does not require extensive modifications to the surrounding.

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Summary of the invention

A solution according to the invention is characterized in that the device is arranged in a bore in the roller element and comprises:

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- a first anchor element which is in contact with a first surface portion of the bore,

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- a second anchor element which is in contact with a second surface portion of the bore,

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- a Piezo element or a bending element which is equipped with at least one strain gauge which is arranged between the first anchor element and the second anchor element and

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- means for measurement of a voltage or charge which is created by the Piezo element due to a deformation of the same or for measurement of a resistance of the at least one strain gauge due to the bending of the bending element.

The first surface portion and the second surface portion are preferably arranged diametrically in the bore.

The first anchor element and/or the second anchor element are preferably positive substance joint on the first and/or second surface portion. Here, a welding or soldering or glueing connection is preferred. Alternatively, the first anchor element and/or the second anchor element can be frictionally engaged at
5 the first and/or second surface portion.

The first anchor element and/or the second anchor element have preferably a supporting arm, wherein the Piezo element or the bending element with the at least one strain gauge is arranged at the supporting arm. Preferably, the Piezo
10 element or the bending element with the at least one strain gauge is arranged at the end of the supporting arm. The supporting arms can extend in a direction which is perpendicular to the direction which in turn is perpendicular onto the surface of the bore at the surface portion where the anchor elements are arranged. Supporting arms are preferably arranged at both anchor elements,
15 wherein the dimensions of the supporting arms are preferably different. The different dimension relates specifically and preferably to the thickness of the supporting arms measured in a direction perpendicular onto the surface of the bore at the surface portion where the anchor elements are arranged. The thickness of one of the supporting arms is preferably at least five times of the
20 thickness of the other one of the supporting arms.

A further embodiment of the invention is characterized in that the transition zone between the smaller supporting arm and the anchor element has at least partially a concave, especially a semi-circular, shape seen in the axial direc-
25 tion of the roller element.

The Piezo element has preferably a rod-shaped design. In this case a longitudinal axis of the Piezo element can be directed into the direction perpendicu-

lar onto the surface of the bore at the surface portion where the anchor elements are arranged.

The Piezo element has preferably a circular or rectangular cross section in a cut perpendicular to the longitudinal axis.

The means for measurement are preferably designed for a wireless communication with a receiver which is located outside of the roller element.

The roller element is preferably a cylindrical roller or taper roller.

Thus, the concept according to the invention is basing on a Piezo bending load sensor for a sensorized bearing roller. A Piezo bending load cell is used to measure deformation of the through hole in the roller element under load. The dimorph Piezo bending sensor is preferably suspended between two points opposite to each other on the inner diameter of the through hole within the rolling element. During bending of the Piezo element a voltage or an electrical charge is generated which is measured to conclude to the load onto the bearing.

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Alternatively to the Piezo element, a bending arm can be employed which is equipped with at least one strain gauge. Here, the resistance of the strain gauge is measured by the means for measurement to conclude to the load which is acting onto the roller element and thus onto the roller bearing.

25

The sensor design is compensating for the "radial motion" which is exerted onto the roller element as this element is deformed from a circular shape into an elliptical shape, wherein the deforming forces run around the circumference of the roller element when regarded from a coordinate system which is

connected with the roller element. Another, less obvious motion of the first surface portion relative to the opposite second surface portion – when the forces run around the circumference of the roller element – is a motion in y direction (see below) further referred to as "chewing motion".

5

The "radial motion" component is eliminated from the total relative motion of the first and second surface portions using the thin supporting art (acting as a leaf spring). This thin supporting arm prevents excessive longitudinal forces (in x direction, see below) onto the Piezo element. The thin supporting arm (leaf spring) will transfer a up/down motion in y direction to one of the ends of the Piezo element, causing an alternating bending in this element.

10

The preferred applications of the proposed concept are large bearings like for example in the field of wind energy systems and industrial machines in the pulp and paper and steel industry.

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The rotation of the rolling element will deform the bore within the rolling element. The Piezo sensor will bend and generate a voltage or electrical charge which can be correlated with the load on the rolling element. A calibration measurement allows the correlation of measured voltages / electrical charges of the Piezo element and the force which acts onto the bearing.

20

A maximum displacement with an amplitude of approximately 12.5 μm can be expected. The frequency of the movement is double the rolling element frequency. This corresponds for example to a rolling element frequency of 4.5 Hz at a large size bearing with an inner ring rotational speed of 15 rpm. The Piezo sensor will deflect in S-shape which means that the maximum free deflection is the half of the cantilever motion and thus 12.5 μm .

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So, a cost-effective load sensing is established which demands only minor modifications of existing bearing arrangements.

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Brief description of the drawings

The drawings show an embodiment of the invention.

10 Fig. 1 shows a side view of a roller bearing,

Fig. 2 shows a side view of a roller element of the roller bearing according to Fig. 1,

15 Fig. 3 shows an enlarged view of the side view according to Fig. 2 and

Fig. 4 shows the voltage detected by a Piezo element in the roller element, measured over the time.

20

Detailed description of the invention

In Fig. 1 a roller bearing 2 is shown. The bearing 2 has an outer bearing ring
25 14 and an inner bearing ring 15. Between the bearing rings 14, 15 roller elements 1 are located. The roller bearing is under a certain load F which is transferred via the roller elements 1 from the outer bearing ring 14 to the inner bearing ring 15 or vice versa.

At least one of the roller elements 1 – or only one of the roller elements 1 – is equipped with a device 3 for detecting the load which is transferred via the roller element 1. Such a roller element 1 is shown in Fig. 2. More specifically, the device 3 for detecting the load is arranged in a central bore 4 which is machined in the roller element 1. The bore 4 and the roller element 1 have the same axis, marked by the axial direction a in Fig. 2. When a load is transferred through the roller element 1 the force acts in radial direction R onto the element 1.

10 In Fig. 3 an enlarged depiction is shown from which it becomes apparent how the device 3 for detecting the load is designed.

In the bore 4 of the roller element 1 two anchor elements 5 and 7 are fixed at two opposing surface portions 6 and 8 which are arranged diagonally in the bore 4. In the present case the anchor elements 5, 7 are fixed by welding or soldering.

Each of the two anchor elements 5, 7 have a supporting arm 11 and 12 which extend from the anchor element 5, 7 in a direction y which is perpendicular on a direction x which in turn is arranged perpendicular on the surface of the bore 4 at the first and second surface 6 and 8. Between the ends of the supporting arms 11, 12 a Piezo element 9 is arranged.

The two supporting arms 11, 12 have different thicknesses t_1 and t_2 measured in the direction x .

That is, the supporting arm 12 can transfer a movement of the second surface portion 8 onto the Piezo element 9 in the direction y , but not in direction x . In direction x the supporting arm 12 acts like a spring element.

By doing so the “chewing effect” as mentioned above is eliminated as far as the charge of a force onto the Piezo element 9 is concerned which results from this effect. Thus, only forces due to the load onto the roller element 1 are forwarded to the Piezo element 9 which is subject to bending forces when the roller element 1 is charged with a load.

The intensity of the bending torque onto the Piezo element 9 can be measured by means 10 for measurement of a voltage U or of an electrical charge Q .

10

To make sure that the Piezo element 9 is acting basically as a pure beam in bending it has a longitudinal axial L which is directed in direction x . Its cross section is e. g. circular or rectangular.

15 The transition zone 13 between the supporting arm 12 and the second anchor element 7 is presently provided with a semi-circular shape.

In Fig. 4 it is shown schematically which signals are received from the means 10 for measurement of a voltage U over the time t . When the roller element 1 rotates and is charged with a load the voltage signal U has a periodic run over the time U . A whole 360° rotation of the roller element 1 takes place during the time t_0 .

By measurement the maximum voltage $U_{\max}$ and the minimum voltage $U_{\min}$ it is possible by means of a reference or calibration measurement to conclude to the load which is exerted onto the roller element 1 and thus onto the roller bearing 2.

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Thus, it is possible to detect the load situation onto the roller bearing in a quite easy way.

The following example and summary should be given:

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The through hole 4 in a roller element 1 is in certain applications deforming up to 25 μm under a maximum load of 140 kN. That means a deflection of 12.5 μm at nominal load of 70 kN.

10 The Piezo sensor 9 is integrated in the through hole 4 of the roller element 1 to transform the movement according to the deformation into voltage which can then be measured. The expected voltage is in the range of +/- 290 mV at nominal load.

15 In an example a Piezo sensor (type: T215-A4-103X) is employed with a free deflection of 12.5 μm which corresponds to an open circuit voltage of +/- 290 mV which is a considerable signal amplitude suitable for load sensing.

As already mentioned above, instead of a Piezo element a bending element
20 with one or more strain gauges can be mounted between the supporting arms 11, 12. Then, the resistance is measured by the means 10.

Reference Numerals:

	1	Roller element
	2	Roller bearing
5	3	Device for detecting the load
	4	Bore
	5	First anchor element
	6	First surface portion
	7	Second anchor element
10	8	Second surface portion
	9	Piezo element
	10	Means for measurement of a voltage / charge / resistance
	11	Supporting arm
	12	Supporting arm
15	13	Transition zone
	14	Outer bearing ring
	15	Inner bearing ring
	F	Load
20	R	Radial direction
	a	Axial direction of the roller element
	t ₁	Thickness
	t ₂	Thickness
	x	Direction perpendicular onto the surface of the bore
25	y	Direction perpendicular to the direction x
	L	Longitudinal axis of the Piezo element
	U	Voltage
	Q	Electrical Charge

Patent Claims:

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1. Roller element (1) of a roller bearing (2), wherein the roller element (1) is equipped with a device (3) for detecting the load (F) which is acting radially (R) onto the roller element (1),

10

characterized in that

the device (3) is arranged in a bore (4) in the roller element (1) and comprises:

15

- a first anchor element (5) which is in contact with a first surface portion (6) of the bore (4),

- a second anchor element (7) which is in contact with a second surface portion (8) of the bore (4),

20

- a Piezo element (9) or a bending element which is equipped with at least one strain gauge which is arranged between the first anchor element (5) and the second anchor element (7) and

25

- means for measurement (10) of a voltage (U) or charge (Q) which is created by the Piezo element (9) due to a deformation of the same

or for measurement of a resistance of the at least one strain gauge due to the bending of the bending element.

- 5 2. Roller element according to claim 1, characterized in that the first surface portion (6) and the second surface portion (8) are arranged diametrically in the bore (4).
- 10 3. Roller element according to claim 1 or 2, characterized in that the first anchor element (5) and/or the second anchor element (7) are positive substance joint on the first and/or second surface portion (6, 8).
- 15 4. Roller element according to claim 3, characterized in that the positive substance joint is a welding or soldering or glueing connection.
- 20 5. Roller element according to claim 1 or 2, characterized in that the first anchor element (5) and/or the second anchor element (7) are frictionally engaged at the first and/or second surface portion (6, 8).
- 25 6. Roller element according to one of claims 1 to 5, characterized in that the first anchor element (5) and/or the second anchor element (7) have a supporting arm (11, 12), wherein the Piezo element (9) or the bending element with the at least one strain gauge is arranged at the supporting arm (11, 12), preferably at the end of the supporting arm (11, 12).

7. Roller element according to claim 6, characterized in that the supporting arms (11, 12) extend in a direction (y) which is perpendicular to the direction (x) which in turn is perpendicular onto the surface of the bore (4) at the surface portion (6, 8) where the anchor elements (5, 7) are arranged.
8. Roller element according to claim 6 or 7, characterized in that supporting arms (11, 12) are arranged at both anchor elements (5, 7), wherein the dimensions of the supporting arms (11, 12) are different.
9. Roller element according to claim 8, characterized in that the different dimension relates to the thickness (t_1 , t_2) of the supporting arms (11, 12) measured in a direction (x) perpendicular onto the surface of the bore (4) at the surface portion (6, 8) where the anchor elements (5, 7) are arranged.
10. Roller element according to claim 9, characterized in that the thickness (t_1) of one of the supporting arms (11) is at least five times of the thickness (t_2) of the other one of the supporting arms (12).
11. Roller element according to one of claims 8 to 10, characterized in that the transition zone (13) between the smaller supporting arm (12) and the anchor element (7) has at least partially a concave, especially a semi-circular, shape seen in the axial direction (a) of the roller element (1).

12. Roller element according to one of claims 1 to 11, characterized in that the Piezo element (9) has a rod-shaped design.

5

13. Roller element according to claim 12, characterized in that a longitudinal axis (L) of the Piezo element (9) is directed into the direction (x) perpendicular onto the surface of the bore (4) at the surface portion (6, 8) where the anchor elements (5, 7) are arranged.

10

14. Roller element according to claim 13, characterized in that the Piezo element (9) has a circular or rectangular cross section in a cut perpendicular to the longitudinal axis (L).

15

15. Roller element according to one of claims 1 to 14, characterized in that the means for measurement (10) are designed for a wireless communication with a receiver outside of the roller element (1).

20

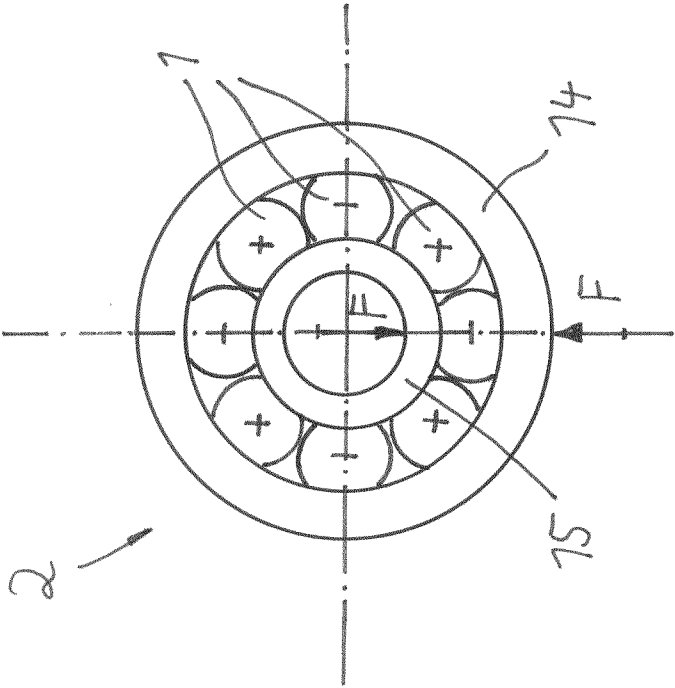


Fig. 1

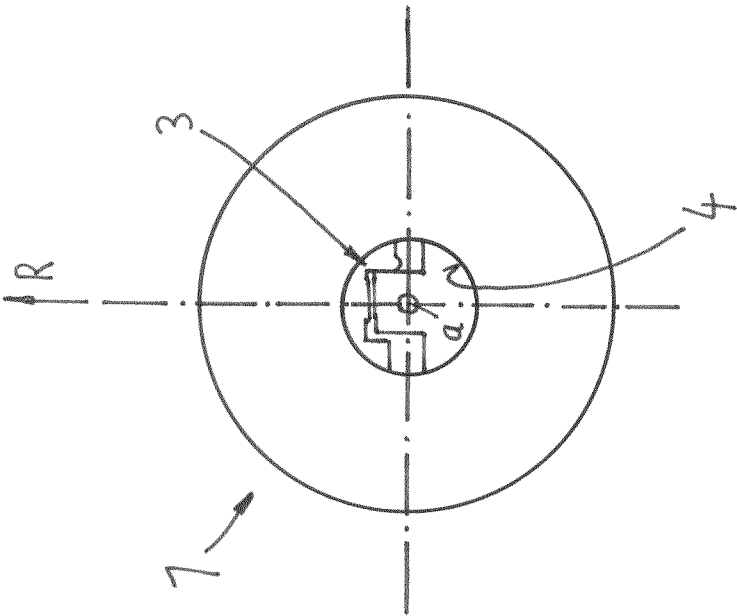


Fig. 2

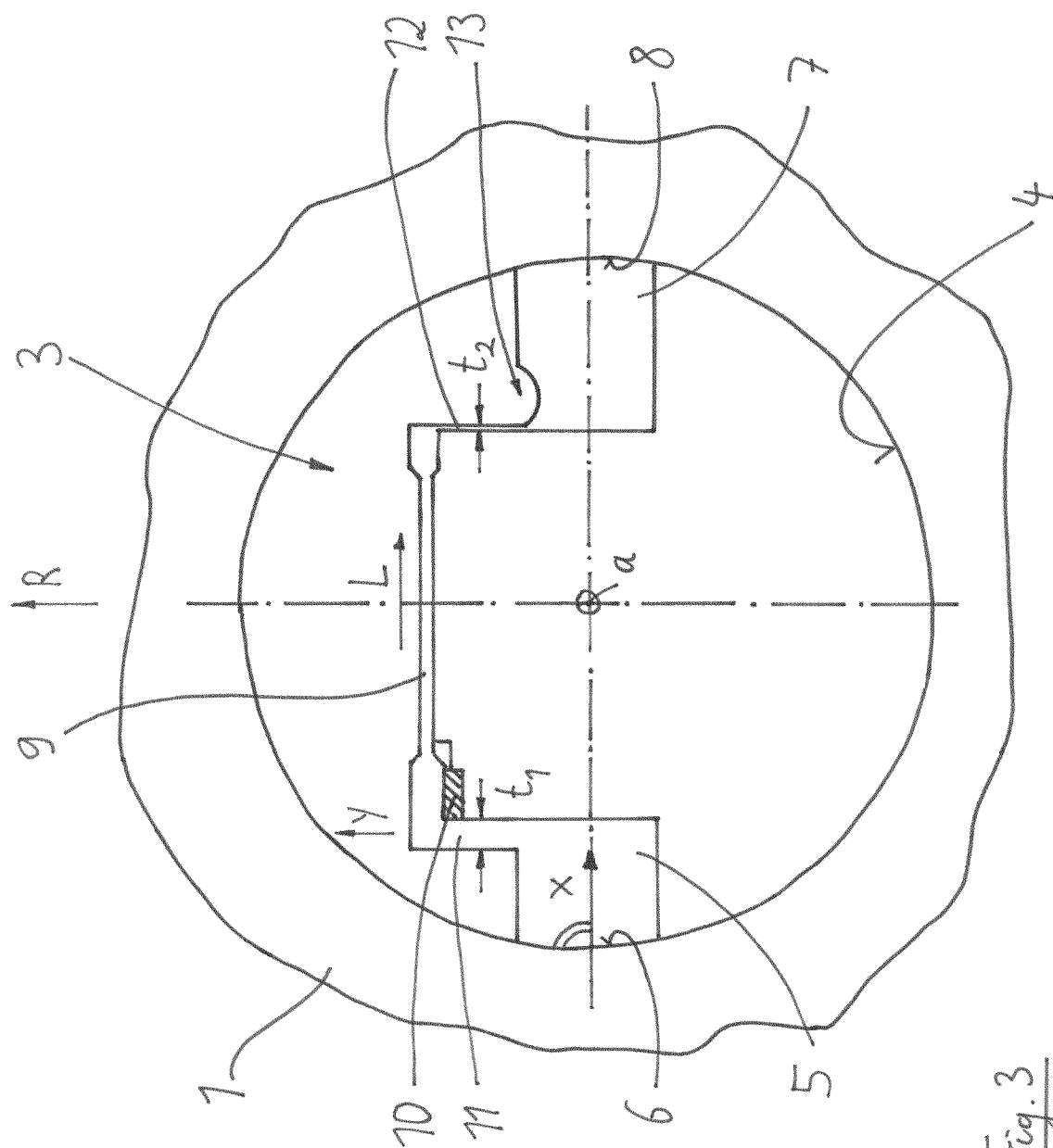


Fig. 3

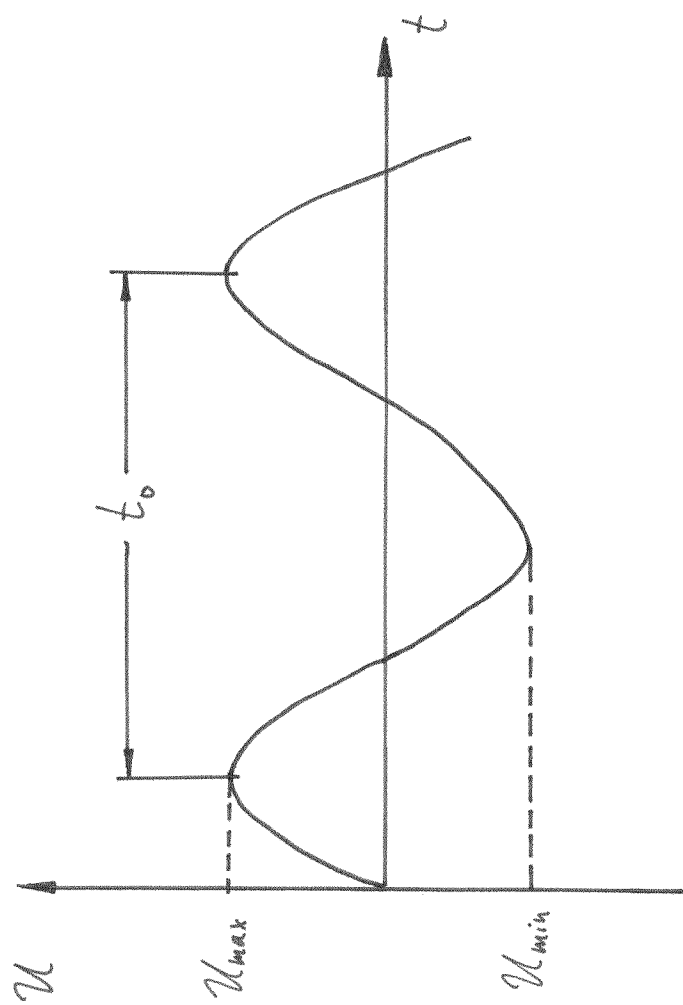


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/066703

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16C33/34 F16C19/52 G01L5/00
ADD. F16C19/26

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 G01L

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2011 006907 A1 (SCHAEFFLER TECHNOLOGIES GMBH [DE]) 11 October 2012 (2012-10-11) paragraph [0007] - paragraph [0012]; figure 1	1-15
A	DE 10 2004 026246 A1 (FAG KUGELFISCHER AG & CO OHG [DE]) 15 December 2005 (2005-12-15) paragraph [0003] - paragraph [0022]; figures	1-15
A	DE 698 28 236 T2 (RKS SA [FR]) 8 December 2005 (2005-12-08) paragraph [0005] - paragraph [0015]; figures	1-15
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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

5 October 2015

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11/11/2015

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/066703

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

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