



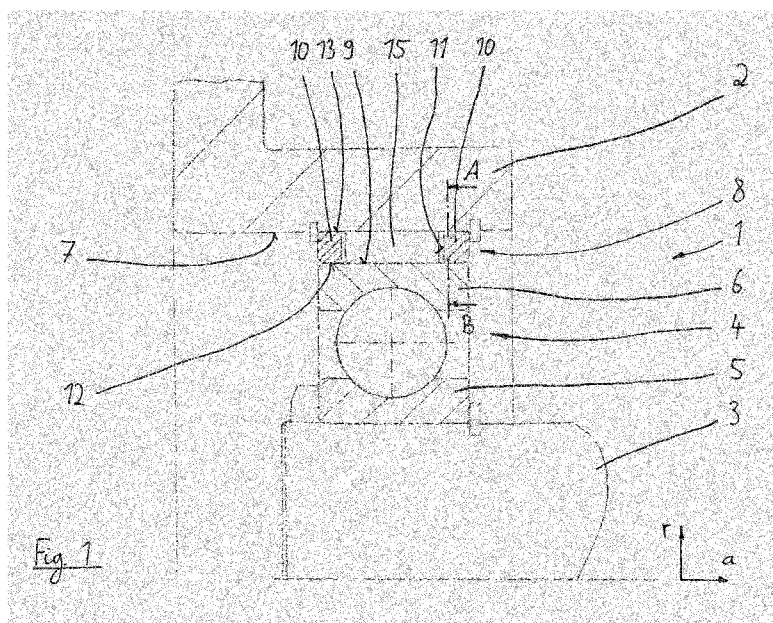
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AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) **Title:** MACHINE ARRANGEMENT

(57) **Abstract:** The invention relates to a machine arrangement (1) comprising a housing element (2) and a rotor element (3), wherein the rotor element (3) is rotatable supported in the housing element (2) by at least one bearing (4), wherein the at least one bearing (4) has an inner ring (5) and an outer ring (6), wherein the housing element (2) has a reception (7) for the bearing (4). To improve the rotor dynamic behavior of a high speed machine the invention proposes that a spring and/or damping element (8) is arranged between the outer circumference (9) of the outer ring (6) and the reception (7) of the housing element (2) and/or between the inner circumference of the inner ring (5) and the rotor element (3), wherein the spring and/or damping element (8) comprises a ring element (10), wherein a number of recesses (11) is machined in the ring element (10) which extend from the inner circumference (12) of the ring element (10) to the outer circumference (13) of the ring element (10) and which form reception pockets (14), wherein a spring element (15) is arranged in at least a number of reception pockets (14), wherein

the spring element (15) is designed to exert a radial (r) spring force (F) between the bearing ring (5, 6) and the housing element (2) and/or the rotor element (3) in the mounted state of the machine arrangement (1).

Machine Arrangement

Technical Field

The invention relates to a machine arrangement comprising a housing element and a rotor element, wherein the rotor element is rotatable supported in the housing element by at least one bearing, wherein the at least one bearing has an inner ring and an outer ring, wherein the housing element has a reception for the bearing.

Background

Machine arrangements of this kind are well known in the art. They are employed for example in an electric machine like an electric compressor or a turbine generator. Here, a rotor is supported by bearings relatively to a housing.

In those machines the rotor is rotating during regular use. The rotor does not only maintain a certain constant revolution speed. Also, the rotary speed of the rotor varies. When starting the machine the rotor has to be driven from a

revolution speed of zero to the required number of revolutions. Thus, the rotor will have to passage critical rotation frequencies where vibration will be excited. Due to the design of the machine is can be that during transition of critical frequencies, i. e. when the rotor passes a rotational speed which is a resonance frequency of the rotor system, vibrations reach critical magnitudes which can damage the machine arrangement and which at least cause loud noises.

It is known in the art to employ elastic O-rings or oil squeeze film dampers to improve the dynamical behavior of the arrangement when passing critical rotations speeds of the rotor.

Thus, it is an object of the present invention to propose a machine arrangement which allows a silent and safe passage of critical frequencies. So, vibrations and noises should be reduced which can occur during operation of the machine arrangement.

Summary of the invention

A solution according to the invention is characterized in that a spring and/or damping element is arranged between the outer circumference of the outer ring and the reception of the housing element and/or between the inner circumference of the inner ring and the rotor element, wherein the spring and/or damping element comprises a ring element, wherein a number of recesses is machined in the ring element which extend from the inner circumference of the ring element to the outer circumference of the ring element and which form reception pockets, wherein a spring element is

arranged in at least a number of reception pockets (preferably in all pockets), wherein the spring element is designed to exert a radial spring force between the bearing ring and the housing element and/or the rotor element in the mounted state of the machine arrangement.

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Preferably, the mentioned spring and/or damping element is arranged between the outer ring of the bearing and the housing element.

The spring element is preferably a leaf spring. Preferably, between 3 and 12
10 pockets with respective spring elements are arranged in the ring element. Such pockets are preferably distributed along the circumference of the ring element equidistantly.

The shape of the reception pocket can correspond to the shape of the spring
15 element, especially seen in radial direction. The shape of the reception pocket is preferably rectangular seen in radial direction.

The ring element can be made from steel, especially from ball bearing steel. The spring element can also be made from steel, especially from spring steel.

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The stiffness of the at least one spring element (measured in N/mm) in radial direction is preferably smaller than the radial stiffness of the bearing. Specifically, the stiffness of the at least one spring element in radial direction can be at a maximum 25 % of the radial stiffness of the bearing.

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The ring element has – according to a preferred embodiment of the invention – conduit means for piping a fluid, preferably oil, from a fluid source into the reception pockets. By doing so a damping effect can be created. The conduit means can be established by at least one groove which is machined into the

ring element and which runs in circumferential direction of the ring element; thereby, the groove is preferably arranged at the outer circumference of the ring element.

- 5 With respect to the kind of fluid which can be employed it can be said that oil is preferred, but also grease, foam, wax and a visco-elastic material can be used.

Alternatively, the ring element can have at least one groove which is
10 machined into its outer circumference and/or into its inner circumference, wherein an elastic element, preferably an O-ring made from rubber or elastomere material, is inserted into at least a section of the groove. Thus, an alternative solution contemplates that the mentioned groove in the ring element is not used for piping a fluid but for inserting a damping element into
15 the groove which then runs in circumferential direction around at least a section of the circumference of the ring element. With respect to this damping element an O-ring which is solid or which is hollow and which is made from a rubber or an elastomere material is preferred.

- 20 The spring and/or damping element has preferably substantially the same axial extension as the bearing ring which is in contact with the spring and/or damping element.

Preferably, the ring element contacts the reception of the housing element or
25 the outer circumference of the outer ring and leaves a radial clearance to the outer circumference of the outer ring or the reception of the housing element.

Also it can be provided that the ring element contacts the rotor element or the inner circumference of the inner ring and leaves a radial clearance to the inner circumference of the inner ring or the rotor element.

- 5 The bearing is preferably a roller bearing.

The machine arrangement is preferably a part of an electrical machine, especially of an electric compressor or of a turbine generator.

- 10 Accordingly and preferably a metal ring is mounted on the outer diameter of the roller bearing which has elastic leaf springs that provide a predefined stiffness to the roller bearing supported rotor on an electrical machine. The leaf springs operate in small chambers (pockets). When a fluid, preferably oil, is supplied a damping mechanism is created that reduces the vibration
15 amplitudes in the system.

- The leaf spring support is very compact due to the described design and provides specifically in combination with a fluid, preferably with oil, stiffness and damping at the same time with well-defined tunable parameters. That is, a
20 very compact elastic radial spring support is given to provide and tune the optimum rotor dynamic behavior of a high speed electrical machine like an electric compressor or a turbine generator; in addition with the supply of the fluid (oil) the flexible elements can also provide damping to the rotor system to allow a secure passage of critical frequencies and reduce noise and
25 vibrations.

Thus, a flexible damping support is established for a roller bearing system.

Brief description of the drawings

The drawings show an embodiment of the invention.

5

Fig. 1 shows a radial cross section through a part of a machine arrangement which is an electrical machine,

Fig. 2 shows a part of the section A-B according to Fig. 1 and

10

Fig. 3 shows a perspective view of a part of the machine arrangement in partial section.

15

Detailed description of the invention

In Fig. 1 a machine arrangement 1 is shown which is for example an electric compressor or turbine generator. A rotor element 3 is arranged in a housing element 2; the rotor element 3 rotates around an axis a. For supporting the rotor element 3 in the housing element 2 a bearing 4 is employed (a further bearing is not depicted which is necessary to support the rotor element 3).

The bearing 4 has an inner ring 5 and an outer ring 6. The bearing 4 is a deep groove ball bearing and thus has radial and axial bearing properties.

25

The housing element 2 has a reception 7 for the bearing 4, i. e. a cylindrical bore.

Essentially, a spring and/or damping element 8 is arranged between the outer circumference 9 of the outer ring 6 and the reception 7 of the housing element 2. This spring and/or damping element 8 comprises a ring element 10. A number of recesses 11 (see also Fig. 2) is machined in the ring element 10 which extend from the inner circumference 12 of the ring element 10 to the outer circumference 13 of the same; thus, reception pockets 14 are formed which are distributed along the circumference of the ring element 10. Spring elements 15 being leaf springs are arranged in the reception pockets 14.

10 As it is illustrated in Fig. 2, the spring elements 15 are designed to exert a spring force F in radial direction r between the outer ring 6 and the housing element 2 when the machine arrangement 1 is – as shown – in the mounted state.

15 As can be seen specifically from Fig. 2, the ring element 10 is located in such a manner that it contacts (preferably with press fit) the reception 7 (bore) of the housing element 2, i. e. the outer circumference of the ring element 10 contacts the bore surface in the housing element 2. However, the inner circumference 12 of the ring element 10 is distanced by a radial clearance s (e. g. between 0.1 mm and 0.5 mm) from the outer circumference 9 of the outer ring 6. By this design it is made sure that (only) the leaf springs 15 transmit the radial forces from the outer ring 6 to the housing element 2.

25 A further additional aspect of the present invention is shown in Fig. 3. Here it can be seen that conduit means 16 – being a groove – are machined into the outer circumference 13 of the ring element 10 (this groove 13 is here even machined in the outer side of the spring elements 15). The groove 16 is fluidically connected with a fluid source 17 (preferably with an oil source) which is shown only schematically.

Thus, a fluid can be piped from the fluid source 17 via the groove 16 into the pockets 14 in which the spring elements 15 are located. By doing so, the damping property of the system can be influenced beneficially.

Reference Numerals:

5	1	Machine arrangement
	2	Housing element
	3	Rotor element
	4	Bearing
	5	Inner ring
10	6	Outer ring
	7	Reception
	8	Spring and/or damping element
	9	Outer circumference of the outer ring
	10	Ring element
15	11	Recess
	12	Inner circumference of the ring element
	13	Outer circumference of the ring element
	14	Pocket
	15	Spring element
20	16	Conduit means (groove)
	17	Fluid source (oil source)
	r	Radial direction
	a	Axial direction
25	F	Spring force
	s	Radial clearance

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Patent Claims:

1. Machine arrangement (1) comprising a housing element (2) and a rotor
10 element (3), wherein the rotor element (3) is rotatable supported in the
housing element (2) by at least one bearing (4), wherein the at least one
bearing (4) has an inner ring (5) and an outer ring (6), wherein the
housing element (2) has a reception (7) for the bearing (4),

15 **characterized in that**

a spring and/or damping element (8) is arranged between the outer
circumference (9) of the outer ring (6) and the reception (7) of the
housing element (2) and/or between the inner circumference of the inner
20 ring (5) and the rotor element (3), wherein the spring and/or damping
element (8) comprises a ring element (10), wherein a number of recesses
(11) is machined in the ring element (10) which extend from the inner
circumference (12) of the ring element (10) to the outer circumference
(13) of the ring element (10) and which form reception pockets (14),
25 wherein a spring element (15) is arranged in at least a number of
reception pockets (14), wherein the spring element (15) is designed to
exert a radial (r) spring force (F) between the bearing ring (5, 6) and the
housing element (2) and/or the rotor element (3) in the mounted state of
the machine arrangement (1).

2. Machine arrangement according to claim 1, characterized in that spring
5 elements (15) are arranged in all reception pockets (14).
3. Machine arrangement according to claim 1 or 2, characterized in that the
spring element (15) is a leaf spring.
10
4. Machine arrangement according to one of claims 1 to 3, characterized in
that between 3 and 12 pockets (14) are arranged in the ring element (10),
which pockets (14) are distributed along the circumference of the ring
15 element (10).
5. Machine arrangement according to one of claims 1 to 4, characterized in
that the shape of the reception pocket (14) corresponds to the shape of
20 the spring element (15), especially seen in radial direction (r).
6. Machine arrangement according to one of claims 1 to 5, characterized in
that the shape of the reception pocket (14) is rectangular seen in radial
25 direction (r).

7. Machine arrangement according to one of claims 1 to 6, characterized in that the ring element (10) is made from steel, especially from ball bearing steel.

5

8. Machine arrangement according to one of claims 1 to 7, characterized in that the spring element (15) is made from steel, especially from spring steel.

10

9. Machine arrangement according to one of claims 1 to 8, characterized in that the stiffness of the at least one spring element (15) in radial direction (r) is smaller than the radial stiffness of the bearing (4), wherein the stiffness of the at least one spring element (15) in radial direction (r) is preferably at a maximum 25 % of the radial stiffness of the bearing (4).

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10. Machine arrangement according to one of claims 1 to 9, characterized in that the ring element (10) has conduit means (16) for piping a fluid from a fluid source (17) into the reception pockets (14).

20

11. Machine arrangement according to claim 10, characterized in that the conduit means (16) are established by at least one groove which is machined into the ring element (10) and which runs in circumferential direction of the ring element (10), wherein the groove (16) is preferably arranged at the outer circumference (13) of the ring element (10).

25

12. Machine arrangement according to one of claims 1 to 9, characterized in that the ring element (10) has at least one groove (16) which is machined into its outer circumference (13) and/or into its inner circumference, wherein an elastic element, preferably an O-ring made from rubber or elastomere material, is inserted into at least a section of the groove (16).
13. Machine arrangement according to one of claims 1 to 12, characterized in that the spring and/or damping element (8) has substantial the same axial extension as the bearing ring (5, 6) which is in contact with the spring and/or damping element (8).
14. Machine arrangement according to one of claims 1 to 13, characterized in that the ring element (10) contacts the reception (7) of the housing element (2) or the outer circumference (9) of the outer ring (6) and leaves a radial clearance (s) to the outer circumference (9) of the outer ring (6) or the reception (7) of the housing element (2).
15. Machine arrangement according to one of claims 1 to 14, characterized in that the ring element (10) contacts the rotor element (3) or the inner circumference of the inner ring (6) and leaves a radial clearance (s) to the inner circumference of the inner ring (5) or the rotor element (3).
16. Machine arrangement according to one of claims 1 to 15, characterized in that the bearing (4) is a roller bearing.

17. Machine arrangement according to one of claims 1 to 16, characterized in that the machine arrangement is a part of an electrical machine, especially of an electric compressor or of a turbine generator.

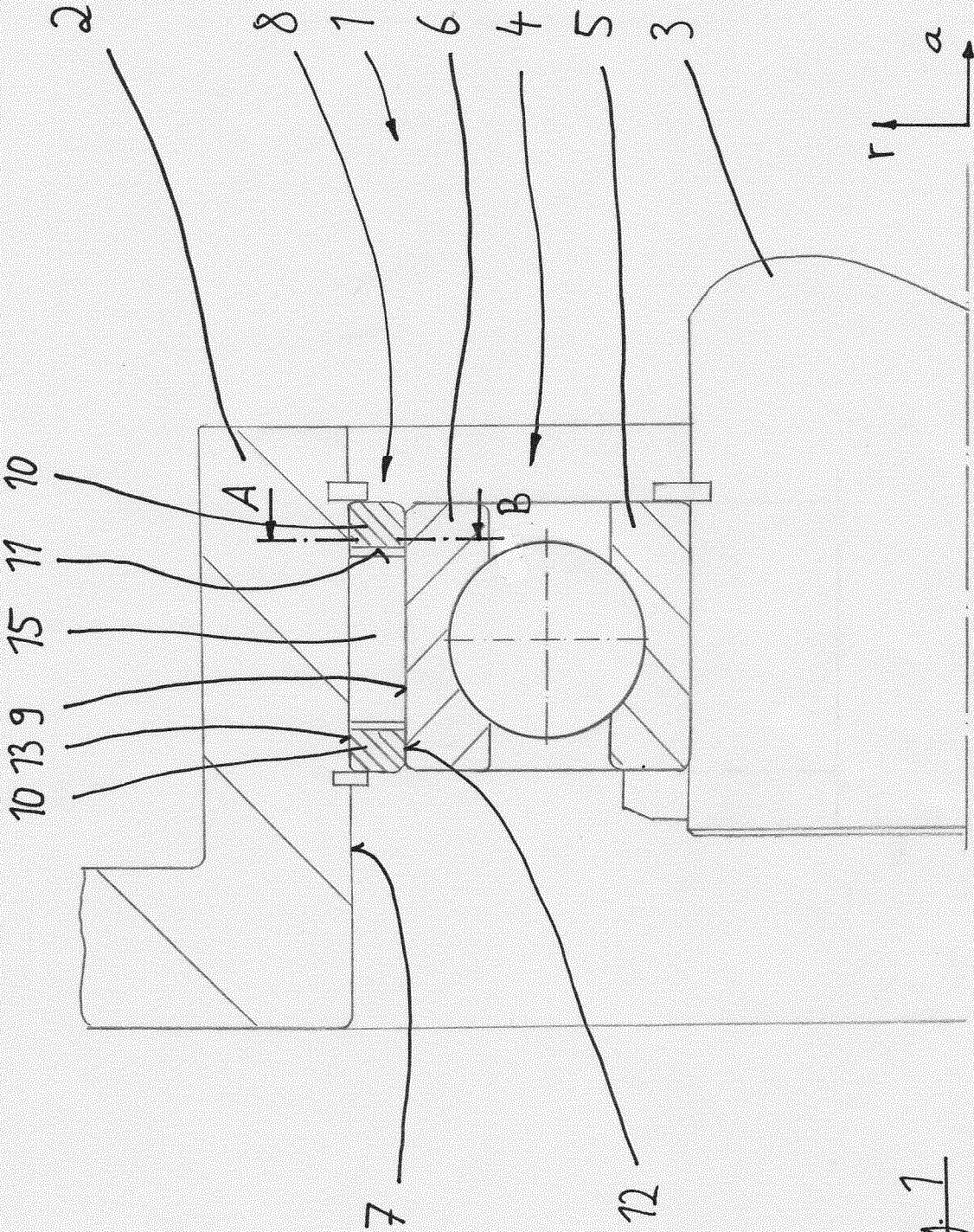
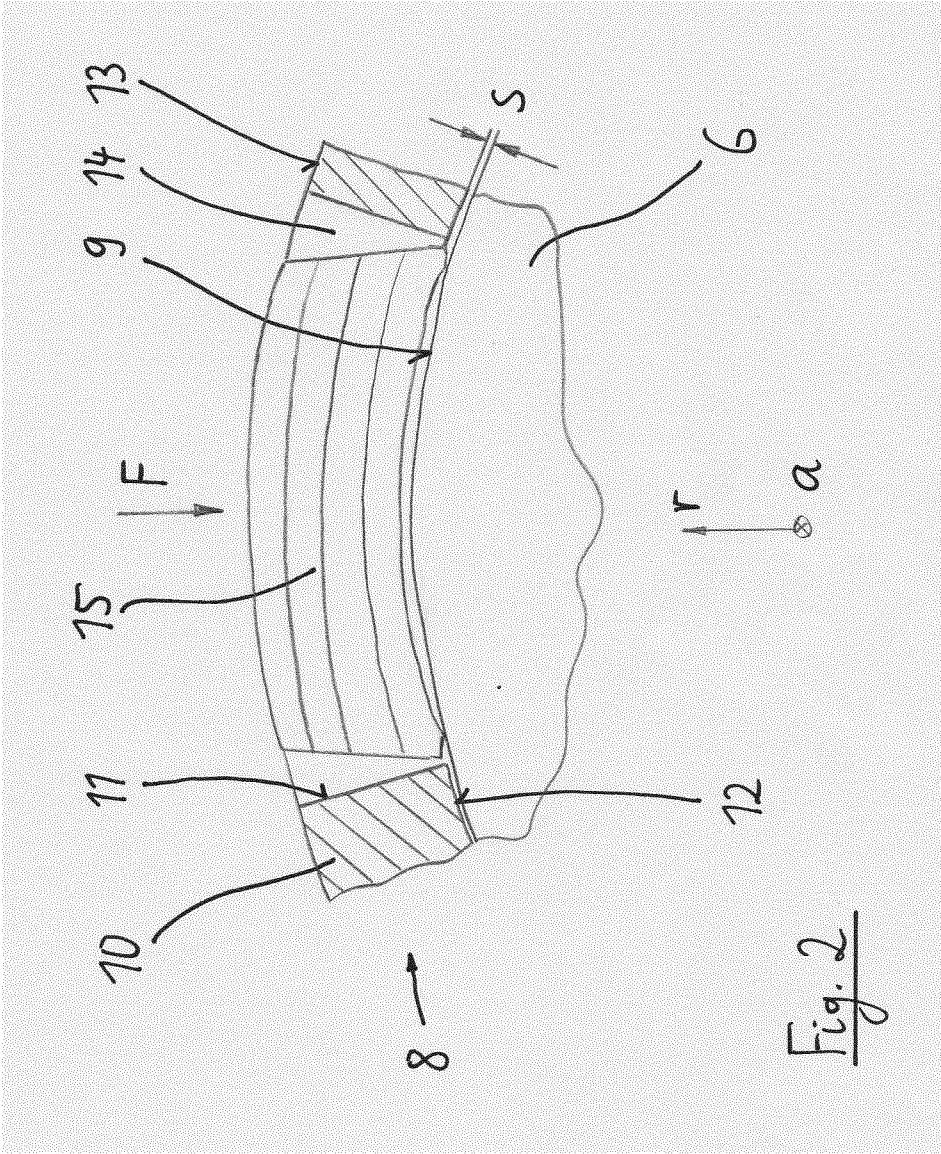
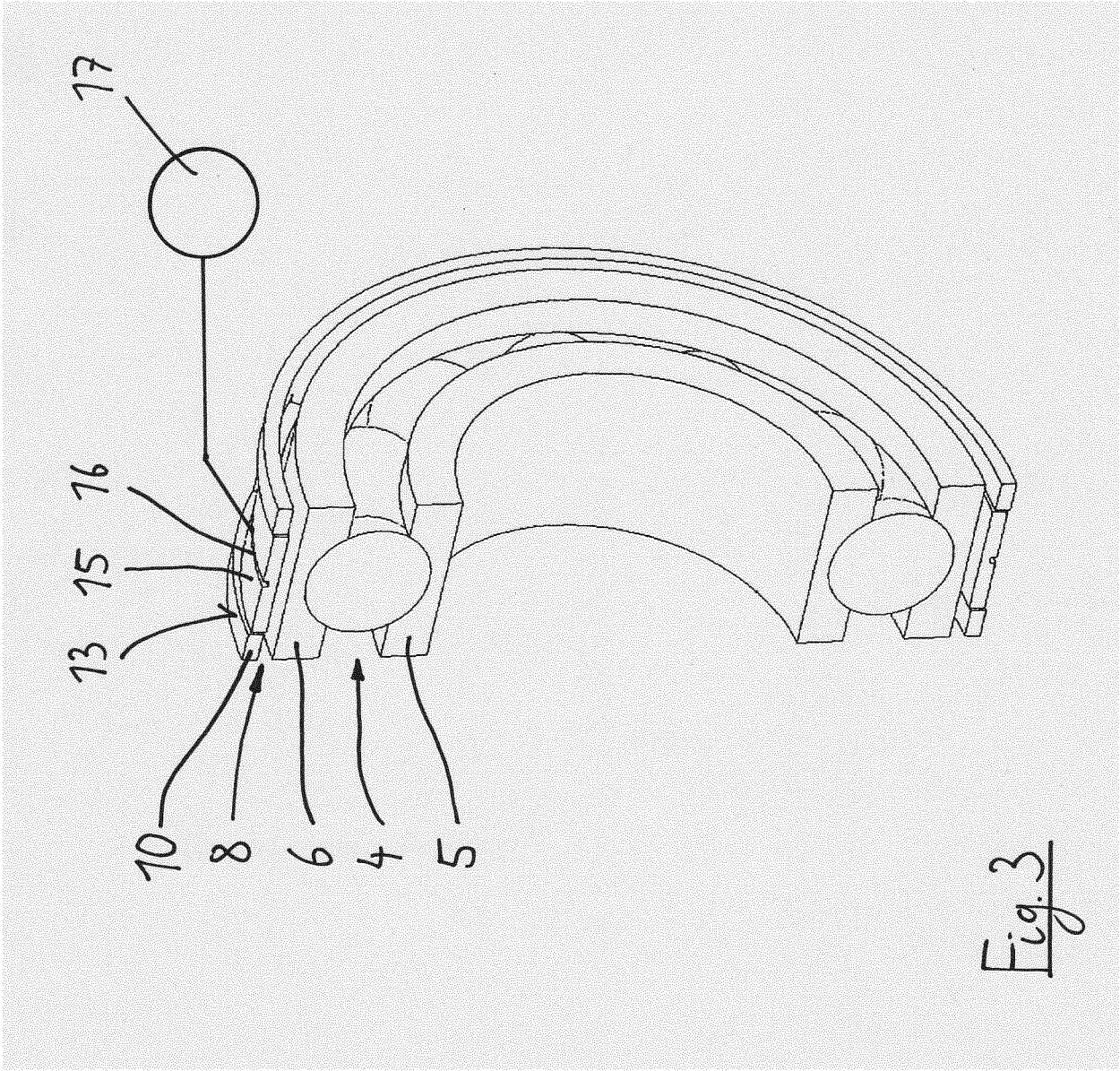


Fig. 1





INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/062539

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16C27/04 F16C27/06
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 F04B F03B F02C

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.
X	US 5 553 834 A (JE YANG-GYU [KR] ET AL) 10 September 1996 (1996-09-10) figures 2,3 column 1, line 41 - line 53 column 2, line 10 - line 65 -----	1-14,16, 17
X	EP 2 224 103 A2 (GEN ELECTRIC [US]) 1 September 2010 (2010-09-01) paragraph [0009] - paragraph [0017] figures 1-3 -----	1,2,5-7, 9-17
X	FR 2 767 870 A1 (G PREDPR K BJUROKHIMICHESKOI A [RU]) 5 March 1999 (1999-03-05) page 19, line 25 - page 20, line 23 figures 3,4 -----	1-3,5-9, 13,14, 16,17



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/062539

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5553834	A	10-09-1996	NONE

EP 2224103	A2	01-09-2010	CA 2693625 A1 27-08-2010
			EP 2224103 A2 01-09-2010
			US 2010220948 A1 02-09-2010

FR 2767870	A1	05-03-1999	NONE
