(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 February 2025 (27.02.2025)

WIPO | PCT

(10) International Publication Number
WO 2025/041002 A1

(51) International Patent Classification:
F16C 19/26 (2006.01) *F16C 35/077* (2006.01)
F16C 27/04 (2006.01) *F16C 19/00* (2006.01)

(21) International Application Number:
PCT/IB2024/057852

(22) International Filing Date:
13 August 2024 (13.08.2024)

(25) Filing Language: Dutch

(26) Publication Language: English

(30) Priority Data:
2023/5699 23 August 2023 (23.08.2023) BE

(71) Applicant: **ATLAS COPCO AIRPOWER, NAAMLOZE VENNOOTSCHAP** [BE/BE]; Boomsesteenweg 957, 2610 Wilrijk, Belgium (BE).

(72) Inventors: **VERCAUTEREN, Nils**; Boomsesteenweg 957, 2610 Wilrijk (BE). **MEEUS, Hans**; Boomsesteenweg 957, 2610 Wilrijk (BE). **VERRELST, Björn**; Boomsesteenweg 957, 2610 Wilrijk (BE).

(74) Agent: **VAN MINNEBRUGGEN, Ewan Benito Agnes**; Boomsesteenweg 957, 2610 Wilrijk (BE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,

WO 2025/041002 A1

(54) Title: A DAMPING ELEMENT, AN ELEMENT FOR COMPRESSING OR EXPANDING A GAS, AND USE OF SUCH A DAMPING ELEMENT

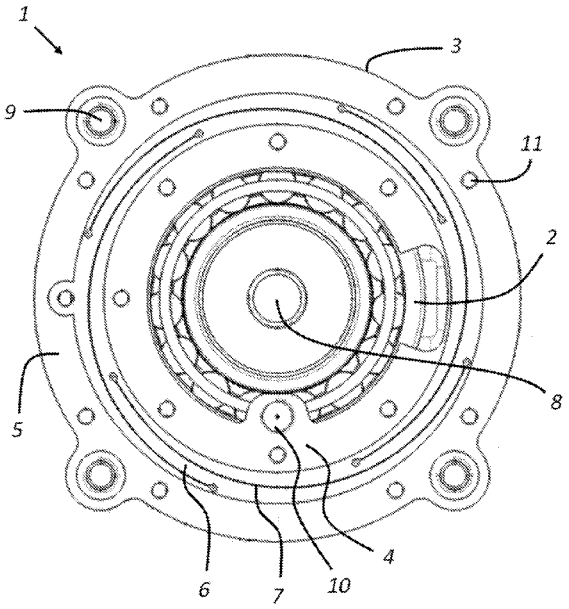

Fig. 1

(57) Abstract: A damping element, an element for compressing or expanding a gas, and use of such a damping element The invention relates to a damping element for a bearing, wherein the damping element (1) comprises a ring structure (3), which ring structure (3) comprises an inner ring (4) and an outer ring (5) around it, wherein the inner ring (4) and the outer ring (5) are connected by an intermediate structure (6) having a plurality of slots (7), which slots (7) extend through the ring structure (3) in an axial direction parallel to a rotationally symmetric axis (8) of the inner ring (4), wherein the damping element (1) is configured to secure the inner ring (4) to the bearing, characterized in that the damping element (1) is further configured to secure an annular side of the outer ring (5) to a supporting object laterally along the rotationally symmetric axis (8).

[Continued on next page]

TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

Description

Title of Invention: A damping element, an element for compressing or expanding a gas, and use of such a damping element

[0001] The present invention relates to

[0002] # a damping element for a bearing;

[0003] # an element for compressing or expanding a gas provided with such a damping element;

[0004] # a use of such a damping element to install a bearing in a supported object;

[0005] # a use of such a damping element in the aforementioned element.

[0006] More specifically, the invention is intended for applications in machines having a rotor, such as turbomachinery or screw compressors, in which an axle of the rotor is rotatably mounted in a housing of the machine by means of a number of bearings.

[0007] It is known that a machine having a rotor rotating at a high speed often has vibration problems in one or more speed ranges, especially if the machine resonates in these speed ranges.

[0008] In such speed ranges, a vibration level of the machine can become so high that the machine is damaged.

[0009] In some cases, it is possible to prevent or at least limit the vibration problems by avoiding these speed ranges as much as possible.

[0010] This means that when it is necessary for the rotor to rotate at a speed in the aforementioned speed ranges, for example when the machine is accelerating or decelerating, these speed ranges are passed through as quickly as possible in order to prevent or at least limit damage to the machine.

[0011] It goes without saying that it is more desirable to design a machine so that these vibration problems do not occur or occur only to a very limited extent.

[0012] This requires an adaptation of the dynamics of the rotor, which are primarily determined by the stiffness of the axle of this rotor and/or the stiffness of the bearings with which said axle is rotatably mounted in the machine.

[0013] Because the construction and assembly of the machine requires strict dimensions for the rotor, the possibilities for adapting the stiffness of the axle are very limited. As a result, adapting the stiffness of the bearings by means of suitable dimensioning is often a more obvious option provided that any limitations in the dimensioning of the bearings allow this.

[0014] Because vibration problems can never be completely eliminated, it is recommended to provide the bearings with certain damping properties to ensure that vibrations that occur in the bearings are limited to an acceptable level.

[0015] Fluid bearings are known that, due to the presence of a fluid film between an outer ring and the shaft, already have damping properties and allow the shaft to rotate at very high speeds, making them very suitable for use in turbomachinery.

[0016] However, fluid bearings generate higher energy losses than roller bearings. In addition, a fluid bearing may exhibit unstable behavior above a certain limit speed of the shaft, wherein a center point of the shaft moves eccentrically in the fluid bearing. This unstable behavior can be very harmful for the machine, especially, for example, in a screw compressor or screw expander element where a clearance between the rotor and a housing around it is typically small and must be maintained within a narrow interval to avoid frictional contact between the rotor and the housing.

[0017] Due to the potentially unstable behavior of fluid bearings, roller bearings are often also used. Roller bearings do not have a fluid film that can cause radial eccentric displacements of the axle, allowing the clearances between a housing and rotor of the machine to be chosen to be smaller when roller bearings are used for the bearing of the axle. However, such roller bearings exhibit no or very poor damping properties with regard to vibrations in the machine. For this reason, roller bearings are often used in combination with what are known as damping elements.

[0018] In this context, WO 2016/022875 describes a screw compressor in which radial and axial roller bearings are used to maintain a position of rotors in the screw compressor radially and axially, and in which a viscous fluid is used to dampen vibrations of the rotors. In this case, it can be useful to use a lubricant that is already used in the screw compressor for sealing clearances between the rotors as the viscous fluid. The viscous fluid is enclosed in a squeeze film damper that is arranged in parallel with respect to the radial or axial roller bearings, thereby providing viscous damping of the vibrations.

[0019] In this way, the squeeze film damper in WO 2016/022875 works similarly to a fluid bearing, wherein the aforementioned unstable behavior is avoided by means of the roller bearings. However, energy losses still occur in the squeeze film damper.

[0020] In US 11,041,495, a squeeze film damper for a displacement compressor is described that is arranged in series with respect to a roller bearing. However, it is a standard squeeze film damper whose stiffness is determined by elastic O-rings that also seal the viscous fluid in the squeeze film damper.

[0021] This stiffness, however, is not sufficient to dampen any displacement of the rotors in a screw element. Consequently, a mutual clearance between the rotors or a clearance between the rotors on the one hand and the housing of the screw element on the other hand cannot be maintained within a narrow interval, leading to inefficient operation and possibly damage to the screw element.

[0022] In US 5,421,655, US 5,531,522, or US 5,603,574, a squeeze film damper is described whose stiffness is not determined by elastic O-rings.

[0023] The squeeze film damper is designed as a preferably one-piece ring structure that comprises an inner ring and an outer ring around it, wherein the inner ring and the outer ring are integrally connected to one another by an intermediate structure having a plurality of slots, which slots extend through the ring structure in an axial direction parallel to a rotationally symmetrical axis of the inner ring.

[0024] The one-piece ring structure allows the squeeze film damper to be more easily and accurately installed in a machine by avoiding a tolerance stack-up that would be inevitable with a multi-part structure.

[0025] The outer ring of the ring structure is secured to a supporting object, while the inner ring is secured to a roller bearing, so that the squeeze film damper is arranged in series with respect to the roller bearing.

[0026] A disadvantage of the squeeze film dampers as described in US 5,421,655, US 5,531,522, and US 5,603,574 is that they are difficult to install in certain applications due to their inconveniently large and inflexible one-piece ring structure.

[0027] As a solution to this disadvantage, US 5,421,655, US 5,531,522, or US 5,603,574 proposes to make the ring structure of the squeeze film damper divisible into two halves.

[0028] However, by designing the ring structure in this way as a multi-part structure, the ring structure is less accurate to secure in the machine due to the tolerance stack-up than when the ring structure is designed as a one-piece structure, as explained above.

[0029] This invention aims at solving at least one of the aforementioned disadvantages and/or other disadvantages.

[0030] More specifically, the invention aims to provide a damping element for a bearing that can be installed in a machine in an accurate yet simple, quick, and flexible manner, in particular an element for compressing or expanding a gas.

[0031] A further object of the invention is to provide a simple, quick, and flexible way to secure the bearing to a supporting object in the machine.

[0032] Furthermore, the invention aims to effectively dampen vibrations of a rotor installed in a rotor bearing in an element for compressing or expanding a gas.

[0033] To this end, the present invention relates to a damping element for a bearing,

[0034] wherein the damping element comprises a ring structure, which ring structure comprises an inner ring and an outer ring around it,

[0035] wherein the inner ring and the outer ring are connected by an intermediate structure having a plurality of slots, which slots extend through the ring structure in an axial direction parallel to a rotationally symmetric axis of the inner ring,

[0036] wherein the damping element is configured to secure the inner ring to the bearing,

[0037] characterized in that the damping element is further configured to secure an annular side of the outer ring to a supporting object laterally along the rotationally symmetric axis.

[0038] An advantage of this invention is that the damping element can be accurately secured to the supporting object in a simple manner, for example, by means of a number of screws through a number of axial through screw holes in the outer ring along the rotationally symmetrical axis, wherein the screws can be tightened on a free side of the outer ring opposite and facing away from the annular side.

[0039] Because it is possible to secure the damping element according to the invention laterally to the supporting object, the concentricity between, on the one hand, the outer ring of the ring structure and, on the other hand, a bore in the supporting object for a rotor, whose radial displacements with respect to the supporting object are to be dampened by the damping element, can be easily controlled during the installation of the damping element on the supporting object.

[0040] This makes the damping element extremely suitable for installing a bearing in an element for compressing or expanding a gas, where a mutual clearance between rotors or a clearance between a rotor on the one hand and a housing of the element on the other hand must be maintained within a narrow interval, for example a screw compressor or screw expander element.

[0041] In a preferred embodiment of the damping element according to the invention, the damping element comprises a groove and each of the slots is provided with at least one fluid connection to the groove for conveying a viscous fluid between the groove and the slots.

[0042] In this way, viscous fluid can move in and out of the slots, providing a damping effect of the viscous fluid in the slots with respect to any displacements or vibrations of a bearing that may be secured to the inner ring.

[0043] The groove is preferably provided with a supply line for the viscous fluid.

[0044] Any leakage of viscous fluid that may occur at the damping element can be rectified via the supply line by supplying new viscous fluid into the groove.

[0045] In a further preferred embodiment of the damping element according to the invention, the damping element further comprises a lubricant supply means for supplying lubricant to the bearing.

[0046] In this way, a bearing lubrication functionality can be integrated into the damping element, and no separate lubricant supply means for lubricating the bearing needs to be provided in the machine next to the damping element.

[0047] Furthermore, the lubricant with which the bearing is lubricated can subsequently be directed into the groove as a viscous fluid via the supply line.

[0048] The lubricant supply means is preferably provided with a nozzle having a diameter of not more than 1.0 mm for spraying the lubricant onto the bearing.

[0049] This allows the bearing to be lubricated in a very uniform manner.

[0050] In a further preferred embodiment of the damping element according to the invention, the damping element is configured to provide a second annular side of the ring structure facing away from the aforementioned annular side of the outer ring with a locking plate for sealing the slots on the second annular side.

[0051] With this locking plate, the slots in the intermediate structure of the ring structure can be sealed to prevent viscous fluid from leaking out of the slots on the second annular side without the need to install elastic O-rings in the slots, which would negatively lower the stiffness of the damping element.

[0052] In this embodiment, the stiffness of the damping element can be largely determined by the forces of the bearing on the viscous fluid in the slots and the associated static displacements of the inner ring relative to the outer ring. These static displacements can be limited by securing the inner ring relative to the outer ring in a radial direction perpendicular to the rotationally symmetrical axis by means of the locking plate.

[0053] By radially securing the inner ring relative to the outer ring by means of the locking plate, a damping element can achieve twice the damping compared to a damping element without such a locking plate.

[0054] This allows the intermediate structure of the damping element to be designed with a smaller axial thickness along the rotationally symmetrical axis to achieve a minimal level of damping compared to when the ring structure of the damping element could not be radially secured with the locking plate.

[0055] This implies a reduction in material usage and material cost for manufacturing the damping element.

[0056] In a further preferred embodiment of the damping element of the invention, the damping element comprises a detection means for measuring or receiving a value for a relative displacement between the inner ring and the outer ring in a radial direction perpendicular to the rotationally symmetrical axis.

[0057] Based on this value, securing of the locking plate on the damping element can be regulated.

[0058] Preferably, the locking plate is configured to prevent a further relative displacement of the inner ring with respect to the outer ring in the radial direction when a measured or received value for the relative displacement exceeds a predetermined threshold value.

[0059] Thus, the locking plate can be used to prevent excessive deformation of the intermediate structure with too much compression of the slots due to radial bearing forces on the inner ring. Such excessive deformation of the intermediate structure

could lead to frictional contact between the supporting object and a rotor that is installed in the supporting object through the bearing, which could lead to damage to the supporting object and/or the rotor.

[0060] Furthermore, the present invention relates to an element for compressing or expanding a gas, comprising:

[0061] # a housing having

[0062] # an inlet side provided with an inlet for the gas;

[0063] # an internal space for compressing or expanding the gas, respectively; and

[0064] # an outlet side having an outlet for compressed or expanded gas in the internal space, wherein the outlet side faces away from the inlet side,

[0065] # a rotor in the internal space;

[0066] # a rotor bearing for rotatably securing the rotor with respect to the housing; and

[0067] # a rotor bearing damping element,

[0068] characterized in that

[0069] # the rotor bearing damping element is a damping element according to one of the above-described embodiments;

[0070] # the rotor bearing damping element and the rotor bearing are configured to secure the inner ring to the rotor bearing as a bearing; and

[0071] # the rotor bearing damping element and the housing are configured to secure the annular side of the outer ring to the housing as a supporting object laterally along the rotationally symmetric axis.

[0072] It goes without saying that such an element has the same advantages as the above-described embodiments of the damping element according to the invention.

[0073] In a preferred embodiment of the element according to the invention, the rotor bearing is a roller bearing.

[0074] This allows a clearance between the rotor on the one hand and the housing of the element on the other hand or, if the element comprises a plurality of rotors, a mutual clearance between the rotors of the element to be maintained within a narrow interval. This ensures efficient operation of certain machines, for example a screw compressor element or screw expander element.

[0075] In a further preferred embodiment of the element according to the invention, the element is a screw element having a screw rotor as the rotor.

[0076] Preferably, the rotor bearing is in this case located on the inlet side.

[0077] Typically, bearing forces in a screw element on the inlet side will be smaller than on the outlet side, so that for the rotor bearing damping element of the rotor bearing on the inlet side a lower damper stiffness is required than for a possible second damping element of a second rotor bearing on the outlet side. A damping element having lower

damper stiffness is generally easier to manufacture than a damping element having higher damper stiffness.

[0078] In a further preferred embodiment of the element according to the invention, the intermediate structure is preferably dimensioned with the slots of the rotor bearing damping element in such a way that a ratio between a radial damper stiffness of the rotor bearing damping element and a radial bearing stiffness of the rotor bearing is greater than 0.6, preferably 0.7.

[0079] Such a high ratio between the radial damper stiffness of the rotor bearing damping element and the radial bearing stiffness of the rotor bearing makes the rotor bearing damping element extremely suitable for installing a rotor bearing in an element for compressing or expanding a gas, where a mutual clearance between the rotors or a clearance between the rotors on the one hand and the housing of the element on the other hand must be maintained within a narrow interval, for example a screw compressor element or screw expander element.

[0080] The radial damper stiffness of the rotor bearing damping element can be increased by reducing a radial dimension of the slots as viewed from the rotationally symmetric axis and/or by increasing an axial thickness of the intermediate structure along the rotor bearing damping element and/or by reducing a mutual tangential overlap of the slots as viewed from the rotationally symmetric axis.

[0081] In a further preferred embodiment of the element according to the invention, the intermediate structure is dimensioned with the slots of the rotor bearing damping element so that a damping ratio for a deflection of the rotor that is radial relative to the rotationally symmetrical axis with respect to the housing is greater than 5.0%.

[0082] Here, the "damping ratio" is a well-known measure for damping a vibration, more specifically a ratio of a damping rate of the vibration relative to an angular frequency of the vibration, wherein a damping ratio of 0% implies that the vibration is not damped. The damping rate of the vibration is the inverse of a time constant of the vibration, wherein the time constant of the vibration is the time required for an amplitude of the vibration to decrease by a factor equal to the Euler's number.

[0083] Such a high damping ratio makes the rotor bearing damping element extremely suitable for installing a rotor bearing in an element for compressing or expanding a gas, where a mutual clearance between the rotors or a clearance between the rotors on the one hand and the housing of the element on the other hand must be maintained within a narrow interval, for example a screw compressor element or screw expander element.

[0084] The damping ratio can be increased by reducing a radial dimension of the slots as viewed from the rotationally symmetric axis and/or by increasing an axial thickness of

the intermediate structure along the rotor bearing damping element and/or by reducing a mutual tangential overlap of the slots as viewed from the rotationally symmetric axis.

[0085] Furthermore, the invention relates to a use of a damping element according to one of the above-described embodiments for installing a bearing in a supporting object, wherein

[0086] # the outer ring is secured to the supporting object; and

[0087] # the inner ring is secured to the bearing.

[0088] It goes without saying that such a use of the damping element produces the advantages implied by the above-described embodiments of the damping element according to the invention.

[0089] In a preferred embodiment of this use according to the invention, the damping element is used as a rotor bearing damping element in an element according to one of the above-described embodiments for installing the rotor bearing as a bearing in the housing as a supporting object.

[0090] It goes without saying that such a use of the damping element produces the advantages implied by the above-described embodiments of the element according to the invention.

[0091] Finally, the invention relates to a use of a damping element according to one of the above-described embodiments in an element according to one of the above-described embodiments for damping a movement of the rotor that is radial relative to the rotationally symmetric axis with respect to the housing as a supporting object, wherein

[0092] # the damping element serves as the rotor bearing damping element;

[0093] # the outer ring of the ring structure of the damping element is secured to the housing as a supporting object;

[0094] # the inner ring of the ring structure of the damping element is secured to the rotor bearing as a bearing; and

[0095] # the slots are filled with a viscous fluid.

[0096] It goes without saying that such a use of the damping element produces the advantages implied by the above-described embodiments of the element according to the invention.

[0097] It is the viscous fluid in the slots that gives the damping element its damping properties.

[0098] In a preferred embodiment of this use according to the invention, the viscous fluid is oil, which oil preferably has a same composition as a lubricant for the rotor bearing.

[0099] This preferred embodiment has the advantage that a same fluid can be used as the viscous fluid for the slots of the damping element and/or as a lubricant for the rotor bearing.

[0100] Consequently, only one fluid reservoir or fluid supply is needed for filling the slots of the damping element and/or for lubricating the rotor bearing.

[0101] To better demonstrate the features of the invention, the following describes, by way of example without any restrictive character, a number of preferred applications of a damping element for a bearing, and element for compressing or expanding a gas and a use of the damping element according to the invention, with reference to the accompanying drawings, in which:

[0102] Fig. 1 shows a damping element for a bearing according to the invention;

[0103] Fig. 2 shows a partial longitudinal cross section of an element for compressing or expanding a gas according to the invention;

[0104] Fig. 3 shows the part denoted by F3 in Fig. 2 in more detail; and

[0105] Fig. 4 shows an alternative embodiment of the damping element in Fig. 1 according to the perspective in Fig. 3.

[0106] Fig. 1 is a view of a damping element 1 according to the invention for a bearing 2.

[0107] The damping element 1 comprises a ring structure 3 that comprises an inner ring 4 and an outer ring 5 around it.

[0108] The inner ring 4 and the outer ring 5 are connected by an inner ring 6 having a plurality of slots 7. These slots 7 extend through the ring structure 3 in an axial direction parallel to a rotationally symmetric axis 8 of the inner ring 4.

[0109] The slots 7 can be arranged in the ring structure 3 by

[0110] # creating holes through the ring structure 3 in the axial direction by drilling, laser drilling and/or die-sink electrical discharge machining; and

[0111] # creating the slots 7 between the holes by wire electrical discharge machining or abrasive wire cutting.

[0112] The damping element 1 is configured to secure the inner ring 4 to the bearing 2.

[0113] Furthermore, the damping element 1 is configured to secure an annular side of the outer ring 5, in this case a rear side of the outer ring 5 in Fig. 1, to a supporting object laterally along the rotationally symmetric axis 8.

[0114] In this case, the outer ring 5 is provided with a number of through screw holes 9 in an axial direction along the rotationally symmetric axis 8. Screws can be screwed into these screw holes 9 on a free side of the outer ring 5 opposite and facing away from the annular side (in this case a front side of the outer ring 5 in Fig. 1) to secure the outer ring 5 to the supporting object.

[0115] As a result, the damping element 1 can be used to install the bearing 2 on the supporting object, wherein

[0116] # the outer ring 5 is secured to the supporting object; and

[0117] # the inner ring 4 is secured to the bearing 2.

[0118] By installing the bearing 2 on the supporting object using the damping element 1, vibrations of an axle supported in the bearing 2 can be dampened with respect to the supporting object by means of a viscous fluid in the slots 7.

[0119] In this case, the damping element 1 also comprises a lubricant supply means 10 for supplying lubricant to the bearing 2.

[0120] In this case, the lubricant supply means 10 is preferably provided with a nozzle having a diameter of not more than 1.0 mm for spraying the lubricant as fine droplets onto the bearing 2 (not shown in the figures).

[0121] In this case, the damping element 1 is also configured to provide a second annular side of the ring structure 3 facing away from the aforementioned annular side of the outer ring 5 with a locking plate for closing the slots 7 on the second annular side.

[0122] In this case, the second annular side of the ring structure 3 (in this case the front side of the ring structure 3 in Fig. 1) both in the inner ring 4 and in the outer ring 5 is provided with a number of boreholes 11 in an axial direction along the rotationally symmetric axis 8. When the locking plate is provided with a number of through round holes corresponding to the boreholes 11, screws can be screwed through said round holes and into said boreholes 11 on the free side of the locking plate to secure the locking plate to the ring structure 3.

[0123] The damping element 1 can comprise a detection means for measuring or receiving a value for a relative displacement between the inner ring 4 and the outer ring 5 in a radial direction perpendicular to the rotationally symmetric axis 8 (not shown in the figures).

[0124] In this case, the locking plate is configured to prevent a further relative displacement of the inner ring 4 with respect to the outer ring 5 in the radial direction when a measured or received value for the relative displacement exceeds a predetermined threshold value.

[0125] Fig. 2 shows a partial longitudinal cross section of an element 12 for compressing or expanding a gas according to the invention.

[0126] The element 12 comprises a housing 13 having

[0127] # an inlet side 14 provided with an inlet 15 for the gas;

[0128] # an internal space 16 for compressing or expanding the gas, respectively; and

[0129] # an outlet side 17 having an outlet 18 for the gas compressed or expanded in the internal space 16, wherein the outlet side 17 faces away from the inlet side 14.

[0130] Furthermore, the element 12 comprises a rotor 19 in the internal space 16 for compressing or expanding the gas in the internal space 16, a rotor bearing 20 for rotatably securing the rotor 19 with respect to the housing 13, and a rotor bearing damping element 21.

[0131] The rotor bearing damping element 21 is in this case the damping element 1 as shown in Fig. 1.

[0132] In this case, the rotor bearing damping element 21 and the rotor bearing 20 are configured to secure the inner ring 4 to the rotor bearing 20.

[0133] The rotor bearing 20 is in this case a roller bearing.

[0134] Furthermore, the rotor bearing damping element 21 and the housing 13 are configured to secure the annular side of the outer ring 5 to the housing 13 as a supporting object laterally along the rotationally symmetric axis 8.

[0135] As a result, the damping element 1, as shown in Fig. 1, can be used as a rotor bearing damping element 21 in element 12 to install the rotor bearing 20 as a bearing 2 in the housing 13 as a supporting object, wherein

[0136] # the outer ring 5 is secured to the housing 13; and

[0137] # the inner ring 4 is secured to the rotor bearing 20.

[0138] By using the damping element 1 as a rotor bearing damping element 21 for installing the rotor bearing 20 on the housing 13, vibrations of the rotor 19 supported in the rotor bearing 20 can be dampened with respect to the housing 13 by means of viscous fluid in the slots 7.

[0139] In this case, the element 12 is a screw element having a screw rotor as a rotor 19, and the rotor bearing 20 is located on the inlet side 14.

[0140] However, within the scope of the invention, it is not ruled out that the element is a different type of element and/or that the rotor bearing is located on the outlet side.

[0141] The intermediate structure 6 with the slots 7 of the rotor bearing damping element 21 is preferably configured in such a way that

[0142] # a ratio between a radial damper stiffness of the rotor bearing damping element 21 and a radial bearing stiffness of the rotor bearing 20 is greater than 0.6, preferably 0.7; and/or

[0143] # a damping ratio for a deflection of the rotor 19 that is radial relative to the rotationally symmetric axis 8 with respect to the housing 13 is greater than 5.0%.

[0144] The radial damper stiffness of the rotor bearing damping element 21 and the damping ratio can be increased by reducing a radial dimension of the slots 7 as viewed from the rotationally symmetric axis 8 and/or by increasing an axial thickness of the intermediate structure 6 along the rotor bearing damping element 8 and/or by reducing a mutual tangential overlap of the slots 7 as viewed from the rotationally symmetric axis 8.

[0145] Fig. 3 shows the part denoted by F3 in Fig. 2 in more detail.

[0146] In Fig. 3 it can be seen that the damping element 1 in the form of a rotor bearing damping element 21 comprises a groove 22 and that each of the slots 7 is provided

with at least one fluid connection 23 to the groove 22 for conveying a viscous fluid between the groove 22 and the slots 7.

[0147] In this case, the groove 22 is provided with a supply line 24 for the viscous fluid in order to be able to replenish any loss of viscous fluid from the slots 7 as a result of leaks.

[0148] As a result, the damping element 1 can be used as a rotor bearing damping element 21 in the element 12 to dampen a movement of the rotor 19 with respect to the housing 13 as a supporting object, wherein the damping is a result of

[0149] # securing the outer ring 5 of the damping element 1 to the housing 13 as a supporting object;

[0150] # securing the inner ring 4 of the damping element 1 to the rotor bearing 20 as a bearing 2; and

[0151] # a damping effect of viscous liquid with which the slots 7 are filled.

[0152] If the viscous fluid in the slots 7 is an oil having a same composition as a lubricant for the rotor bearing 20, the rotor bearing 20 can be lubricated and the slots 7 can be filled or refilled from a same fluid reservoir or fluid supply (not shown in the figures).

[0153] Fig. 4 shows an alternative embodiment of the damping element in Fig. 1 according to the perspective in Fig. 3.

[0154] In this alternative embodiment, the second annular side of the ring structure 3 is provided with an annular locking plate 25 for sealing the slots 7 on the second annular side and potentially preventing an excessive relative displacement between the inner ring 4 and the outer ring 5.

[0155] The invention is by no means limited to the damping element, the element, and the use of the damping element described by way of example and shown in the figures, but a damping element and element according to the invention can be realized in a variety of forms and dimensions, and a use of the damping element according to the invention can be realized in a wide variety of versions, without exceeding the scope of protection of the invention as defined in the claims.

Claims

[Claim 1] A damping element for a bearing,
wherein the damping element (1) comprises a ring structure (3), which ring structure (3) comprises an inner ring (4) and an outer ring (5) around it,
wherein the inner ring (4) and the outer ring (5) are connected by an intermediate structure (6) having a plurality of slots (7), which slots (7) extend through the ring structure (3) in an axial direction parallel to a rotationally symmetric axis (8) of the inner ring (4),
wherein the damping element (1) is configured to secure the inner ring (4) to the bearing (2),
characterized in that
the damping element (1) is further configured to secure an annular side of the outer ring (5) to a supporting object laterally along the rotationally symmetric axis (8).

[Claim 2] The damping element according to claim 1, wherein the damping element (1) comprises a groove (22) and wherein each of the slots (7) is provided with at least one fluid connection (23) to the groove (22) for conveying a viscous fluid between the groove (22) and the slots (7).

[Claim 3] The damping element according to claim 2, wherein the groove (22) is provided with a supply line (24) for the viscous fluid.

[Claim 4] The damping element according to any of preceding claims 1 to 3, wherein the damping element (1) further comprises a lubricant supply means (10) for supplying lubricant to the bearing (2).

[Claim 5] The damping element according to claim 4, wherein the lubricant supply means (10) is provided with a nozzle having a diameter of not more than 1.0 mm for spraying the lubricant onto the bearing (2).

[Claim 6] The damping element according to any of preceding claims 1 to 5, wherein the damping element (1) is configured to provide a second annular side of the ring structure (3) facing away from the aforementioned annular side of the outer ring (5) with a locking plate (25) for sealing the slots (7) on the second annular side.

[Claim 7] The damping element according to any of preceding claims 1 to 6, wherein the damping element (1) comprises a detection means for measuring or receiving a value for a relative displacement

between the inner ring (4) and the outer ring (5) in a radial direction perpendicular to the rotationally symmetric axis (8).

[Claim 8] The damping element according to claims 7 and 6, wherein the locking plate (25) is configured to prevent a further relative displacement of the inner ring (4) with respect to the outer ring (5) in the radial direction when a measured or received value for the relative displacement exceeds a predetermined threshold value.

[Claim 9] An element for compressing or expanding a gas, comprising
a housing (13) having
an inlet side (14) provided with an inlet (15) for the gas;
an internal space (16) for compressing or expanding the gas, respectively; and
an outlet side (17) having an outlet (18) for compressed or expanded gas in the internal space (16), wherein the outlet side (17) faces away from the inlet side (14),
a rotor (19) in the internal space (16);
a rotor bearing (20) for rotatably securing the rotor (19) with respect to the housing (13); and
a rotor bearing damping element (21),
characterized in that
the rotor bearing damping element (21) is a damping element (1) according to any of preceding claims 1 to 8;
the rotor bearing damping element (21) and the rotor bearing (20) are configured to secure the inner ring (4) to the rotor bearing (20) as a bearing (2); and
the rotor bearing damping element (21) and the housing (13) are configured to secure the annular side of the outer ring (5) to the housing (13) as a supporting object laterally along the rotationally symmetric axis (8).

[Claim 10] The element according to claim 9, wherein the rotor bearing (20) is a roller bearing.

[Claim 11] The element according to claim 9 or 10, wherein the element (12) is a screw element having a screw rotor as a rotor (19).

[Claim 12] The element according to claim 11, wherein the rotor bearing (20) is located on the inlet side (14).

[Claim 13] The element according to any of preceding claims 9 to 12, wherein the intermediate structure (6) is dimensioned with the slots (7) of the rotor bearing damping element (21) in such a way

that a ratio between a radial damper stiffness of the rotor bearing damping element (21) and a radial bearing stiffness of the rotor bearing (20) is greater than 0.6, preferably 0.7.

[Claim 14] The element according to any of preceding claims 11 to 13, wherein the intermediate structure (6) is dimensioned with the slots (7) of the rotor bearing damping element (21) in such a way that a damping ratio for a deflection of the rotor (19) that is radial relative to the rotationally symmetric axis (8) with respect to the housing (13) is greater than 5.0%.

[Claim 15] A use of a damping element according to any of preceding claims 1 to 8 for installing a bearing in a supported object, wherein
the outer ring (5) is secured to the supporting object; and
the inner ring (4) is secured to the bearing (2).

[Claim 16] The use according to claim 15, wherein the damping element (1) is used as a rotor bearing damping element (21) in an element (12) according to any of preceding claims 9 to 14 for installing the rotor bearing (20) as a bearing (2) in the housing (13) as a supporting object.

[Claim 17] A use of a damping element (1) according to any of preceding claims 1 to 8 in an element (12) according to any of preceding claims 9 to 14 for damping a movement of the rotor (19) that is radial in relation to the rotationally symmetric axis (8) with respect to the housing (13) as a supporting object, wherein
the damping element (1) serves as the rotor bearing damping element (21);
the outer ring (5) of the ring structure (3) of the damping element (1) is secured to the housing (13) as a supporting object;
the inner ring (4) of the ring structure (3) of the damping element (1) is secured to the rotor bearing (20) as a bearing (2); and
the slots (7) are filled with a viscous fluid.

[Claim 18] The use according to claims 17, wherein the viscous fluid is oil, which oil preferably has the same composition as a lubricant for the rotor bearing (20).

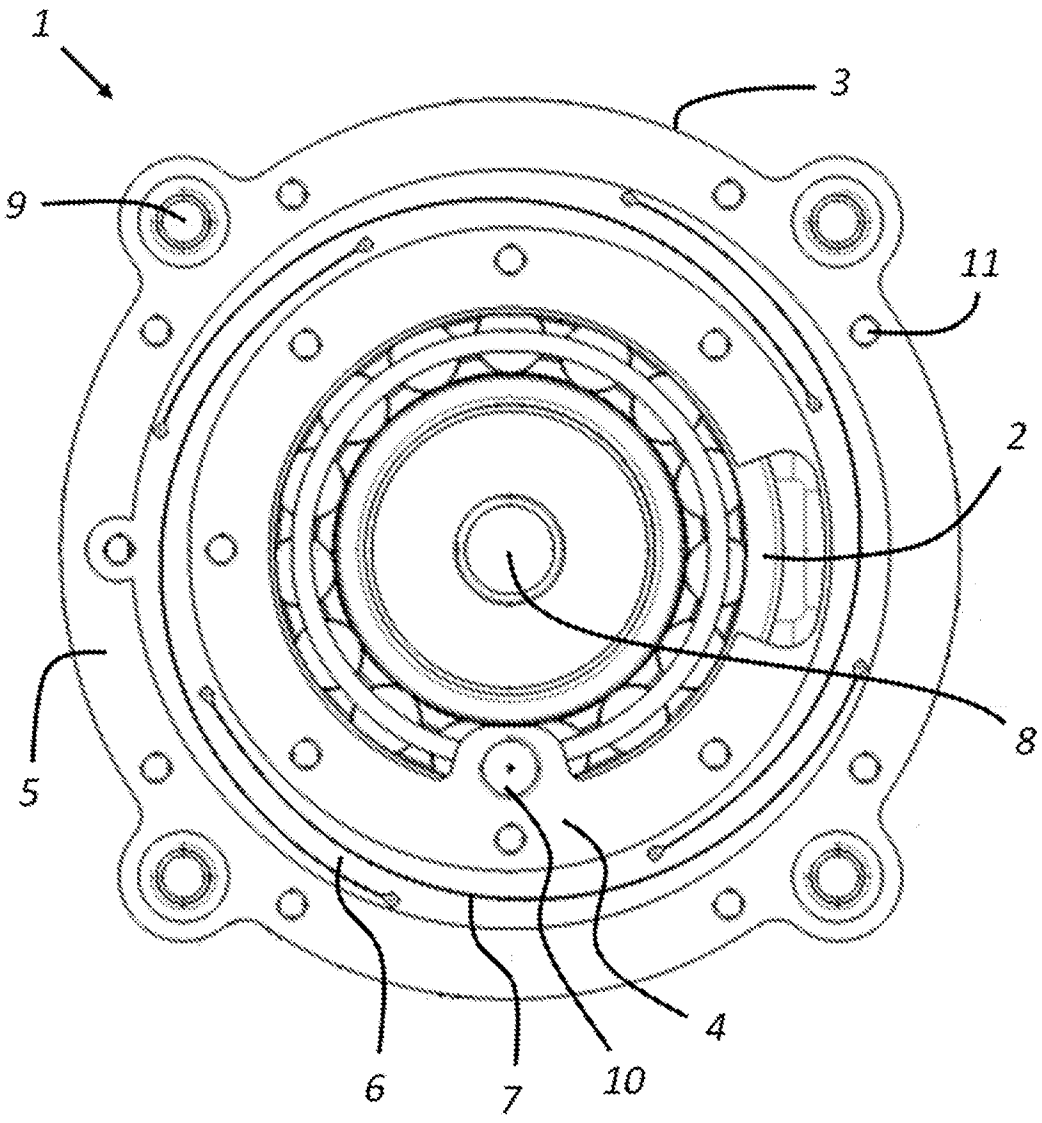

Fig. 1

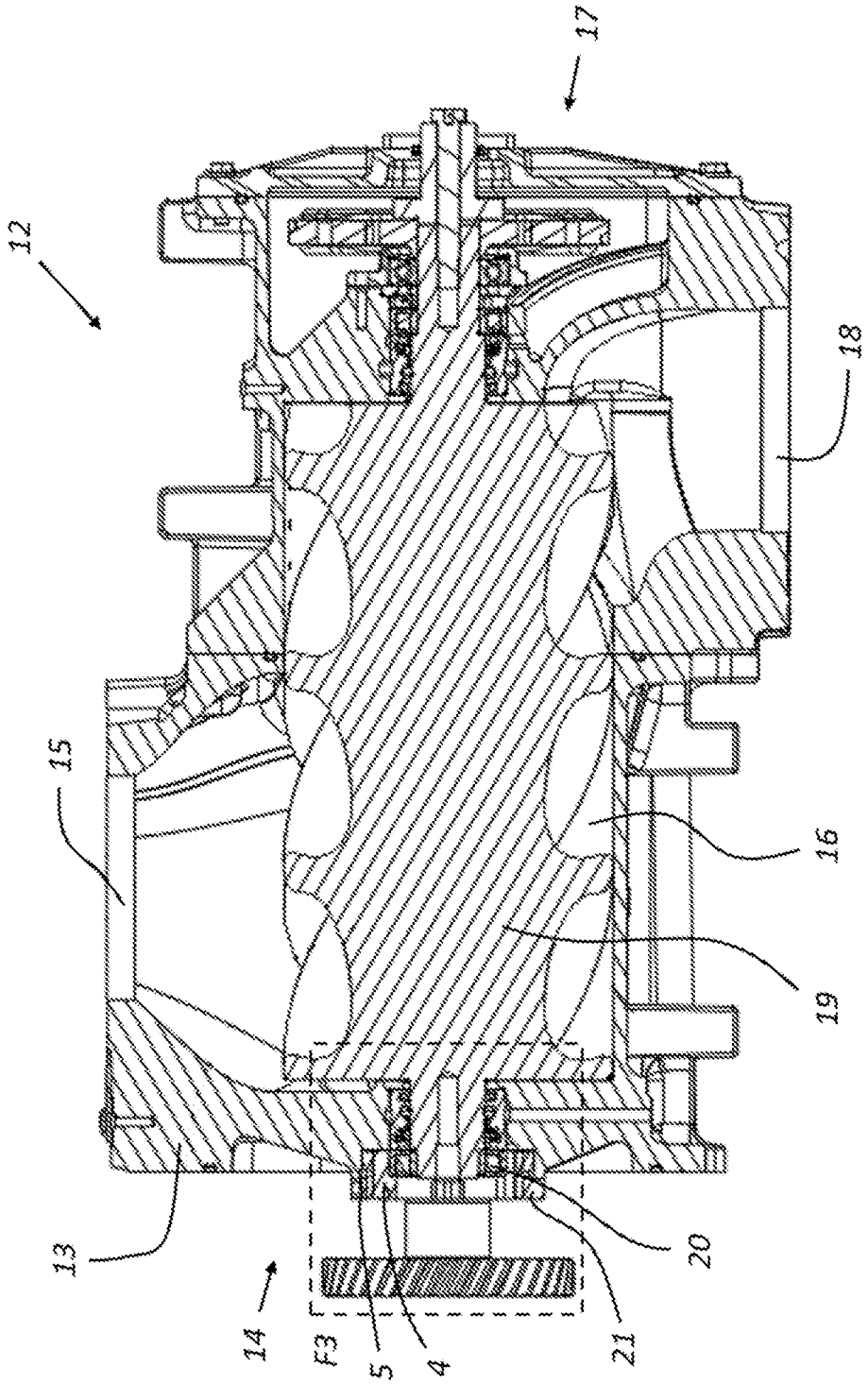

Fig. 2

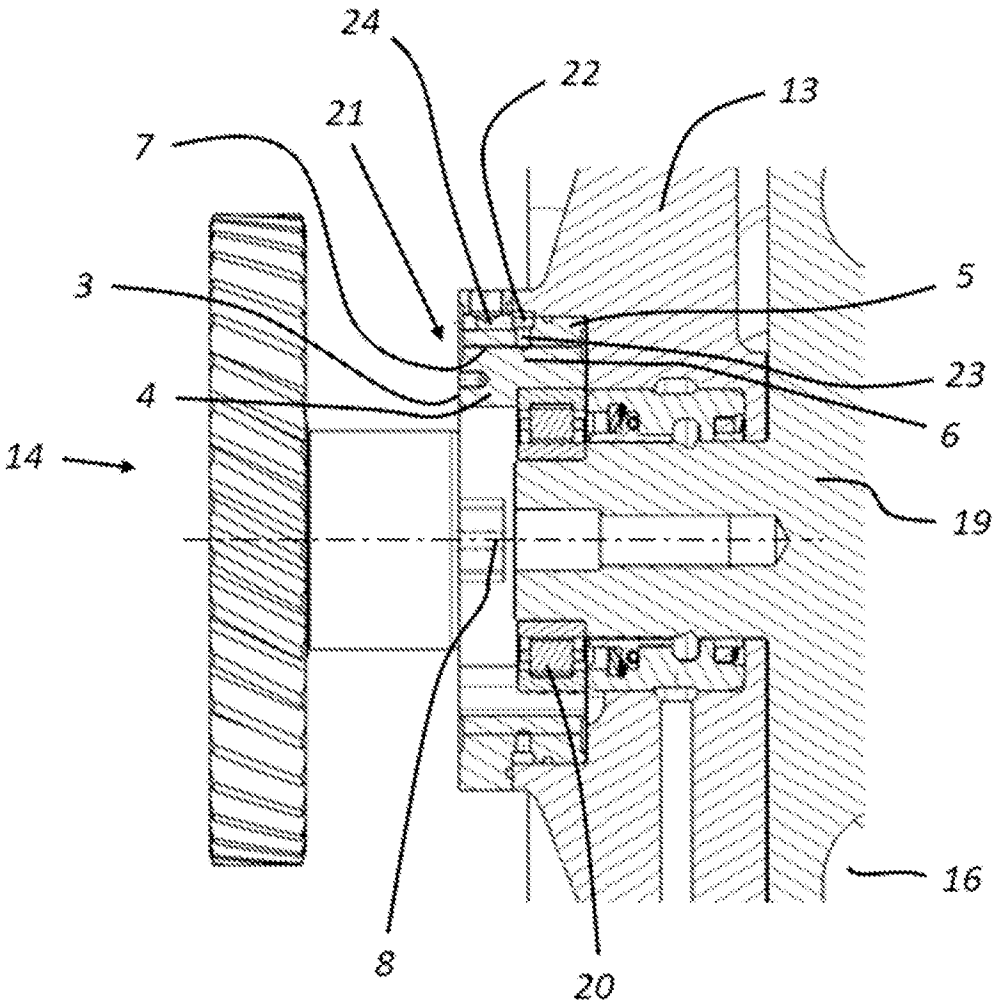

Fig. 3

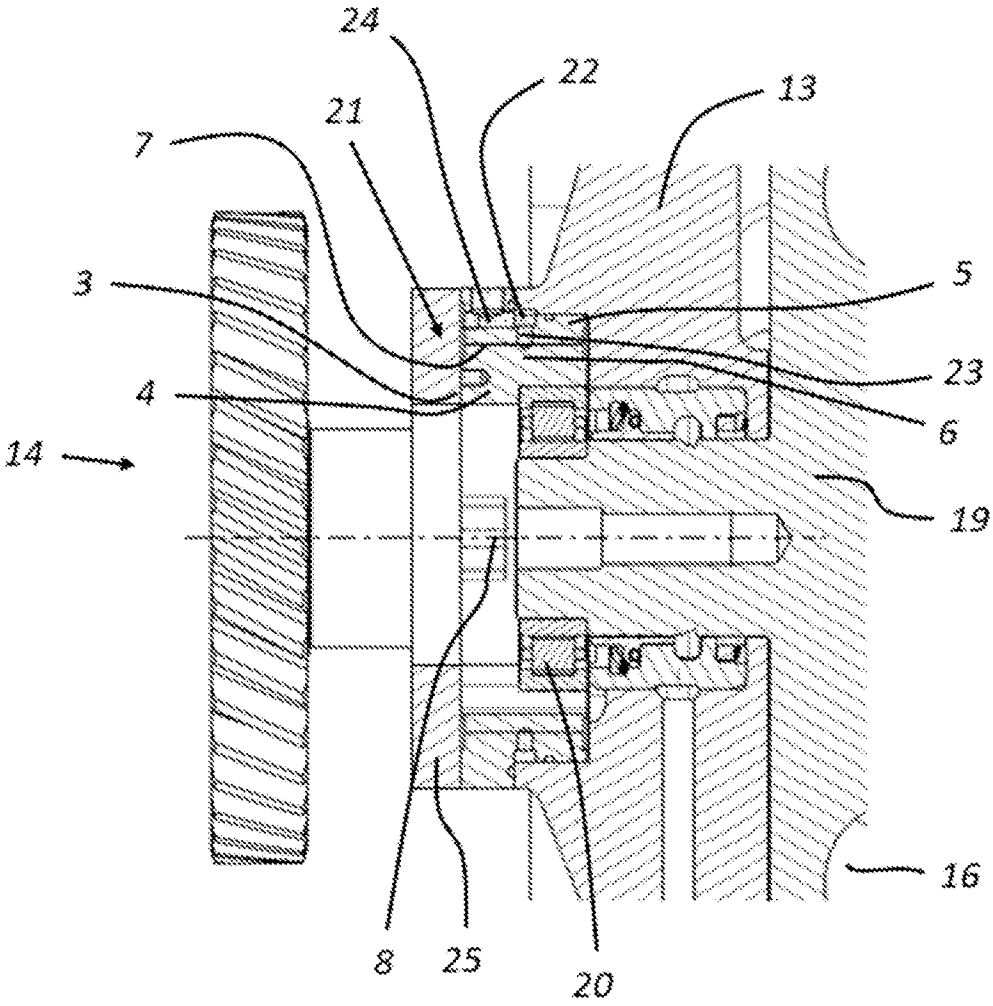

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/057852

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16C19/26 F16C27/04 F16C35/077
ADD. F16C19/00

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, 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 2009/263057 A1 (KANKI HIROSHI [JP] ET AL) 22 October 2009 (2009-10-22) paragraph [0060]; claim 4; figures 13, 15, 16, 17 paragraph [0080] -----	1-5,7-18
X	WO 2022/084777 A1 (ATLAS COPCO AIRPOWER NV [BE]) 28 April 2022 (2022-04-28) figures 1, 2, 3, 5, 6 -----	1,4-17

☐ 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	Date of mailing of the international search report
23 September 2024	08/11/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Vesselinov, Vladimir

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2024/057852

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009263057 A1	22-10-2009	CN 101243262 A	13-08-2008
		EP 1925833 A1	28-05-2008
		JP 2007056976 A	08-03-2007
		KR 20080040000 A	07-05-2008
		US 2009263057 A1	22-10-2009
		WO 2007023702 A1	01-03-2007
WO 2022084777 A1	28-04-2022	BE 1028709 A1	11-05-2022
		BR 112023003338 A2	09-05-2023
		CA 3189663 A1	28-04-2022
		CN 114382720 A	22-04-2022
		CN 216518800 U	13-05-2022
		EP 4229309 A1	23-08-2023
		JP 2023547071 A	09-11-2023
		KR 20230085938 A	14-06-2023
		US 2023323898 A1	12-10-2023
		WO 2022084777 A1	28-04-2022
		ZA 202302079 B	26-06-2024