



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.03.2022 Bulletin 2022/09

(51) International Patent Classification (IPC):
F01D 5/06 (2006.01)

(21) Application number: **20193629.1**

(52) Cooperative Patent Classification (CPC):
F01D 5/066; F05D 2260/31

(22) Date of filing: **31.08.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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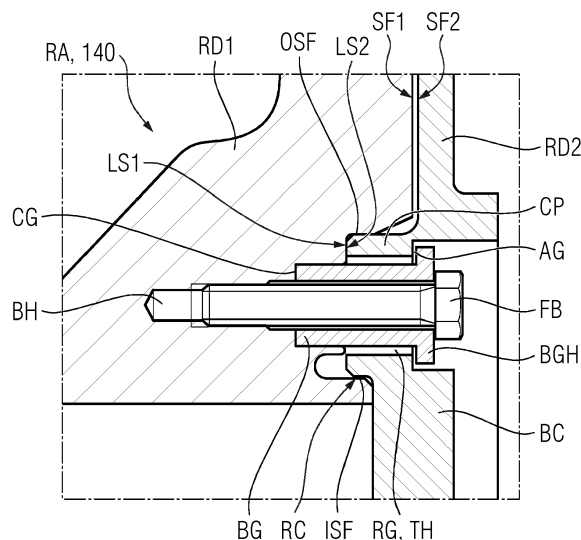
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(54) **A ROTOR ASSEMBLY FOR A ROTOR OF A GAS TURBINE AND GAS TURBINE COMPRISING SUCH A ROTOR ASSEMBLY**

(57) The invention relates to a rotor assembly (RA) comprising:
at least a first and a second rotor disk (RD1, RD2),
a number of through holes (TH) in the second rotor disk (RD2) which extends co-axially to the rotational axis (RX),
a set of bolt connections (BC) for fastening the first rotor disk (RD1) with the second rotor disk (RD2), each bolt connections (BC) comprising a fixing bolt (FB), wherein each fixing bolt (FB) extends through one of the through holes (TH) and is screwed into the first rotor disk (RD1) for attaching the second rotor disk (RD2) onto the first

rotor disk (RD1). For providing an rotor assembly that enables sufficient axial and radial movement of two adjacent rotor disks releasably connected by a set of bolt connections (BC) for providing an extended lifetime, is proposed that each bolt connection (BC) comprises a bushing (BG) for the corresponding fixing bolt (FB), each fixing bolt (FB) clamps its corresponding bushing (BG) against the first rotor disk (RD1) while the second rotor disk (RD2) is axially movable retained by the bolt connection, and that for each bushing (BG) a radial clearance (RG) is provided in its corresponding through hole (TH).

FIG 3



Description

Field of the invention

[0001] The invention relates to a rotor assembly for a rotor of gas turbine and a gas turbine comprising a rotor having such a rotor assembly.

Background to the invention

[0002] Modern gas turbine often comprises a rotor having multiple turbine disks, compressor disks, torque disk or the like, that are stacked along and tied together by either a central tie bolt or several decentralized tie bolts. On the lateral sides of a such a rotor disk an annular cover plate may attached for securing the position of blades carried by the disk. For assembling these rotor elements or the like together different types of connections are known. One example of these connections is disclosed in EP 0 169 801 A1, which describes the retaining of a rear disk rim side plate onto an appropriate turbine disk by having several bolt connections.

[0003] The assembly mentioned above need to maintain adequate alignment between its rotor elements during the whole gas turbine running cycle, especially, when the disks and/or cover plates may have different thermal expansions due to different temperatures and different materials. Further, this fixed type of attachment can cause some technical problems during operation. As the disks resp. the cover plates are clamped directly together using appropriate bolts, there will be friction between these two rotor elements that provides resistance against the relative motion between them induced by different thermal grow. When the friction may vary around the circumference, there can be large asymmetric forces during radial expansions between the disks. If this ends in a relative radial motion between these two rotor elements, the bolt heads will need to move with one of the disks they are clamped to during the gas turbine cycle, resulting in bolt bending and low cyclic life of the bolts.

[0004] Hence, a rotor design is required that allows some expansions between the rotating elements while maintaining adequate alignment during the gas turbine running cycle.

[0005] It is an objective of the invention to provide from a constructive perspective a simple rotor assembly having an improved low cyclic life.

Summary of the invention

[0006] Accordingly, the present invention provides a rotor assembly for a rotor of a gas turbine, which rotor assembly is rotatable about a rotational axis, the rotor assembly comprising at least a first rotor disk and a second rotor disk, a number of through holes in the second rotor disk which extends coaxially to the rotational axis, a set of bolt connections for fastening releasably the first rotor disk with the second rotor disk, each bolt connec-

tions comprising a fixing bolt, wherein each fixing bolt extends through one of the through holes and is screwed into the first rotor disk for attaching the second rotor disk onto the first rotor disk, wherein each bolt connection comprises a bushing for the corresponding fixing bolt, each fixing bolt clamps its corresponding bushing against the first rotor disk while the second rotor disk is axially movable hold by the bolt connection, and that for each bushing a radial clearance is provided in its corresponding through hole.

[0007] Due to the inventive matter the two rotor disks can assembled while maintain sufficient relative movability in both radial and axial direction such that a fixing bolt stress can be reduced while a proper alignment of the two rotor disks is achieved.

[0008] In this context the radial direction, the axial direction and a circumferential direction relate to the rotational axis about which the rotor assembly will rotate during its conventional operation.

[0009] A rotor disk is intended to mean a compressor disk or turbine disk either carrying on its outer rim compressor rotor blades or turbine rotor blades. Further, the rotor disk may further be embodied as an annular cover plate or as an intermediate disk, the latter does not carry any rotor blades on its outer rim. Usually intermediate disks are arranged between two conventional turbine disks. Also, other annular elements of the rotor should covered by the term rotor disks as long as the element is a monolithic ring or tube having a central bore or is a monolithic ring-shaped plate having no central bore but intended to rotate about its central rotational axis.

[0010] The axially movable releasable jointing of the two rotor disks can be achieved by having an axial gap therebetween and/or between the second rotor disk and the bolt connections. This enables the relative radial expansion between these two rotor disks to take place without the need to overcome large frictional forces between the rotor disks. This decreases the stress on the fixing bolts and extends its lifetime and with that the lifetime of the rotor assembly also.

[0011] In a further realization of the invention the rotor assembly comprises a pair of spigot fits for aligning the two rotor disks radially, the pair having an inner spigot fit and an outer spigot fit in relation to the rotational axis, wherein the spigot fits are established by a circumferential groove being located on a first lateral surface of one of the first rotor disk or second rotor disk, a circumferential protrusion protruding from a second lateral surface of the other of the first rotor disk and second rotor disk, and wherein the protrusion extends axially into the groove.

[0012] The spigot fits are beneficial for these types of a second rotor disk that, due to their rather flat shape of cross section, must be carried partly from the neighboring first rotor disk mostly needed because of large centrifugal forces that attack both rotor disks during operation of the gas turbine. Further, these spigot fits support the mutually radial alignment of the two rotor disks without the need to overcome large frictional forces between the rotor

disks, leading therefore to reduced asymmetric forces on the spigot fits during the gas turbine running cycle.

[0013] According to an advantageous embodiment of the invention the inner spigot fit and the outer spigot fit provides a radial clearance between a side surfaces of the circumferential groove and a side surfaces of the circumferential protrusion for allowing a radial displacement of the rotor disks during transient operational regimes that may lead to different thermal expansions.

[0014] According to a preferred realisation of the invention at least one of the through holes is oval in the radial direction. This feature maintains a circumferential alignment between the first rotor disk and second rotor disk and allows at the same time radial expansion between the rotor disks as happens at the other through hole positions. Further, it reduces asymmetric forces on the spigot fits on both disks resulting in longer rotor disk lives. Also, it reduces bending of the fixing bolts resulting in increased life. Beneficially the radial clearance is in total not larger than 0,25 mm. Otherwise a not acceptable radial offset between the two rotor disks may appear that could finish in an inadmissible unbalancing of the rotor assembly.

[0015] In a further advantageous embodiment the maximum axial movement of the second rotor disk in reference to the first rotor disk is in total not larger than 0,4 mm, preferably not larger than 0,25 mm. Hence, only a very slight axial movement is required to achieve the beneficial effect on the rotor assembly lifetime.

[0016] According to a further aspect of the invention the bushing comprises a bushing head, wherein the second rotor disk is held axially movable between the first rotor disk and the bushing head. With this a compact construction can be provided, which is easy to assemble and disassemble because of the low numbers of parts being involved.

[0017] Another preferred realisation of the invention proposes that each through hole is radially located between the inner spigot fit and the outer spigot fit. In a further advantageous embodiment each fixing bolt is screwed into a corresponding blind hole of the first rotor disk. Again, both preferred embodiments lead to a compact construction of the rotor assembly.

[0018] When the bolt connections are distributed uniformly along a tangential direction of the rotor disks a homogeneous balancing of the rotor assembly can be achieved.

[0019] Beneficially a gas turbine having a rotor comprising a rotor assembly comprising one or multiple of the above-mentioned features provides an increased lifetime with less service interruptions or longer service intervals.

[0020] The previously given description of advantageous embodiments of the invention contains numerous features which are partially combined with one another in the dependent claims. Expediently, these features can also be considered individually and be combined with one another into further suitable combinations. Further-

more, features of the method, formulated as apparatus features, may be considered as features of the assembly and, accordingly, features of the assembly, formulated as process features, may be considered as features of the method.

[0021] The above-described characteristics, features and advantages of the invention and the manner in which they are achieved can be understood more clearly in connection with the following description of exemplary embodiments which will be explained with reference to the drawings. The exemplary embodiments are intended to illustrate the invention but are not supposed to restrict the scope of the invention to combinations of features given therein, neither with regard to functional features. Furthermore, suitable features of each of the exemplary embodiments can also be explicitly considered in isolation, be removed from one of the exemplary embodiments, be introduced into another of the exemplary embodiments and/or be combined with any of the appended claims.

Brief Description of the Drawings

[0022] The present invention will be described with reference to drawings in which:

FIG 1 shows a schematically a gas turbine,

FIG 2 shows a combined sectional and perspective view of two rotor disks attached to one another according to the prior art,

FIG 3 shows a combined sectional and perspective view of two rotor disks attached to one another according to the invention and

FIG 4 shows a plan view of a segment of the second rotor disk.

Detailed description of the illustrated exemplary embodiments

[0023] Figure 1 shows schematically a gas turbine 100 with a compressor 110, a combustion chamber 120 and a turbine unit 130. According to this exemplary embodiment, an electrical generator 150 for generating electricity is coupled to a rotor 140 of the gas turbine. During Operation ambient air L is sucked in by the axial compressor 110. The ambient air is conveyed through the compressor while getting compressed along the way. The compressed air VL is then mixed with a fuel F in the combustion chamber 120 and burned to a hot gas HG. The hot gas HG expanded in the turbine unit 130 and leaves it as flue gas RG. The expansion of the hot gas HG generates torque in the turbine unit 130 onto the rotor 140, which then drives the compressor 110 and the generator 150.

[0024] Conventionally, the rotor 140 comprises several

rotor disks from which only two, a first rotor disk RD1 and a second rotor disk RD2, are displayed in figure 2.

[0025] Conventionally and in accordance with the prior art, the first rotor disk RD1 and the second rotor disk RD2 establish a rotor assembly which is part of the rotor 140. In this example, the two rotor disks RD1, RD2 are located between the downstream end of the compressor 110 and the beginning of the turbine unit 130. The rotor 140 is rotatable about the rotational axis RX.

[0026] The second rotor disk RD2 is monolithic, rather flat or plate-shaped and releasably attached to the first rotor disk RD1 by a set of circumferentially equidistant distributed fixing bolts FB, from which only one is shown in cross-section. Each fixing bolt FB extends through a corresponding through hole TH, which are present in the second rotor disk RD2. For aligning the first and second rotor disks RD1, RD2 radially and co-axially, an outer spigot fit OSF and an inner spigot fit ISF is provided.

[0027] In figure 3, which shows the same perspective of a rotor assembly of figure 2, the invention regarding the rotor assembly RA is displayed. Instead of clamping the second rotor disk RD2 directly onto the first rotor disk RD1 by the fixing bolt FB, a bushing BG is used additionally. As displayed, the fixing bolt FB extends through the bushing BG and is screwed into a blind hole BH that is provided in the first rotor disk RD1. The bushing BG comprises also a bushing head BGH, which is located at that end of the fixing bolt, that also comprises a bolt head.

[0028] For establishing the outer spigot fit OSF and the inner spigot fit ISF the first rotor disk RD1 comprises at its first lateral surface SF1 a circumferential groove CG. Further, the second rotor disk RD2 has on its second lateral surface SF2 a circumferential protrusion CP, which is also displayed in figure 4. All through holes TH extends through the circumferential groove CG. Both, the circumferential groove CG and the circumferential protrusion CP comprises a width, which is determined parallel to the radial direction. The width of the circumferential groove CG, which is determined in radial direction, is slightly larger than the corresponding width of the circumferential protrusion CP in such a way, that, when the circumferential protrusion CP extends into the circumferential groove CG, (a) radial clearance(s) RC between the side surfaces SIS of the circumferential protrusion CP and the side surfaces of the circumferential groove CG exist(s) allowing relative radial expanding between the two disks during the gas turbine running cycle. the size of the radial clearance at the inner spigot fit ISF and the outer spigot fit OSF depends on the status of the gas turbine, i.e. baseload operation, part load operation, transient operation and the temperatures being present.

[0029] The bushing BG including its bushing head BGH has a total axial length which is slightly larger than the local width of second turbine disk RD2 next to the through hole. Hence, the bushing BG is pressed by the bolt head of the fixing bolt FB against a first region LS1 of the first lateral surface SF1 of the first rotor disk RD1 while an axial gap AG for the second rotor disk RD2 is

maintained. The axial gap AG of course appears next to either or both lateral surfaces of the second rotor disk RD2: a) between the second rotor disk RD2 and the bushing head BGH and/or b) between the first lateral surface LS1 of the first rotor disk RD1, i.d. a bottom of the circumferential groove CG, and a second region LS2 of the second lateral surface SF2 of the second rotor disk RD2, i.d. the top of the circumferential protrusion CP.

[0030] As displayed in figure 4, one through hole THO of the through holes TH can have an oval shape.

[0031] In summary the invention relates to a rotor assembly RA of a rotor 140 the gas turbine 100 comprising at least a first and a second rotor disk RD1, RD2, a number of through holes TH in the second rotor disk RD2 which extends co-axially to the rotational axis RX, a set of bolt connections BC for fastening releasably the first rotor disk RD1 with the second rotor disk RD2, each bolt connections BC comprising a fixing bolt FB, wherein each fixing bolt FB extends through one of the through holes TH and is screwed into the first rotor disk RD1 for attaching the second rotor disk RD2 onto the first rotor disk RD1. For providing an rotor assembly that enables sufficient axial and radial movement of two adjacent rotor disks releasably connected by a set of bolt connections BC for providing an extended lifetime, is proposed that each bolt connection BC comprises a bushing BG for the corresponding fixing bolt FB, each fixing bolt FB clamps its corresponding bushing BG against the first rotor disk RD1 while the second rotor disk RD2 is axially movable retained by the bolt connection, and that for each bushing BG a radial clearance RG is provided in its corresponding through hole TH.

Claims

1. A rotor assembly (RA) for a rotor (140) of a gas turbine (100), which rotor assembly (RA) is rotatable about a rotational axis (RX), the rotor assembly comprising:

at least a first rotor disk (RD1) and a second rotor disk (RD2),
a number of through holes (TH) in the second rotor disk (RD2) which extends co-axially to the rotational axis (RX),
a set of bolt connections (BC) for fastening releasably the first rotor disk (RD1) with the second rotor disk (RD2), each bolt connections (BC) comprising a fixing bolt (FB), wherein each fixing bolt (FB) extends through one of the through holes (TH) and is screwed into the first rotor disk (RD1) for attaching the second rotor disk (RD2) onto the first rotor disk (RD1),

characterized in

that each bolt connection (BC) comprises a bushing (BG) for the corresponding fixing bolt (FB), each fix-

- ing bolt (FB) clamps its corresponding bushing (BG) against the first rotor disk (RD1) while the second rotor disk (RD2) is axially movable held by the bolt connection, and
that for each bushing (BG) a radial clearance (RG) is provided in its corresponding through hole (TH). 5
2. Rotor assembly (RA) according to claim 1, comprising a pair of spigot fits for aligning the two rotor disks (RD1, RD2) radially, the pair having an inner spigot fit (ISF) and an outer spigot (OSF) fit in relation to the rotational axis (RX), wherein the spigot fits are established by a circumferential groove (CG) being located on a first lateral surface (SF1) of one of the first rotor disk and second rotor disk, a circumferential protrusion (CP) protruding from a second lateral surface (SF2) of the other of the first rotor disk and second rotor disk, and wherein the protrusion (CP) extends axially into the groove (CG). 10 20
 3. Rotor assembly (RA) according to claim 1 or 2, wherein the inner spigot fit (ISF) and the outer spigot fit (OSF) enables a radial clearance (RC) between a side surfaces of the circumferential groove (CG) and a side surfaces (SIS) of the circumferential protrusion (CP) for allowing a radial displacement of the rotor disks (RD1, RD2) . 25 30
 4. Rotor assembly (RA) according to claim 3, wherein at least one of the through holes (THO) is oval.
 5. Rotor assembly (RA) according to claim 3 or 4, wherein the total radial clearance (RC) is not larger than 0,25 mm. 35
 6. Rotor assembly (RA) according to one of the preceding claims, wherein the maximum axial movement of the second rotor disk (RD2) in reference to the first rotor disk (RD1) is not larger than 0,4 mm, preferably not larger than 0,25 mm. 40 45
 7. Rotor assembly (RA) according to one of the preceding claims, wherein the bushing (BG) comprises a bushing head (BGH), and wherein the second rotor disk (RD2) is held axially movable between the first rotor disk (RD1) and the bushing head (BGH). 50
 8. Rotor assembly (RA) according to one of the preceding claims, wherein each through hole (TH) is radially located between the inner spigot fit (ISF) and the outer spigot fit (OSF). 55
 9. Rotor assembly (RA) according to one of the preceding claims, wherein each fixing bolt (FB) is screwed into a corresponding blind hole (BH) of the first rotor disk.
 10. Rotor assembly (RA) according to one of the preceding claims, wherein the bolt connections (BC) are distributed uniformly along a tangential direction of the rotor disks (RD1, RD2) .
 11. Gas turbine (100) having a rotor assembly (RA) according to one of the preceding claims.

FIG 1

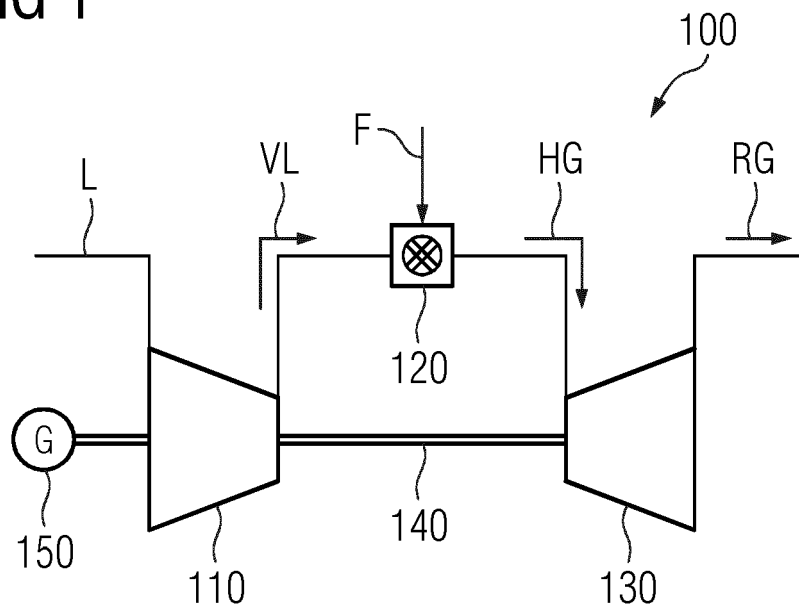


FIG 2

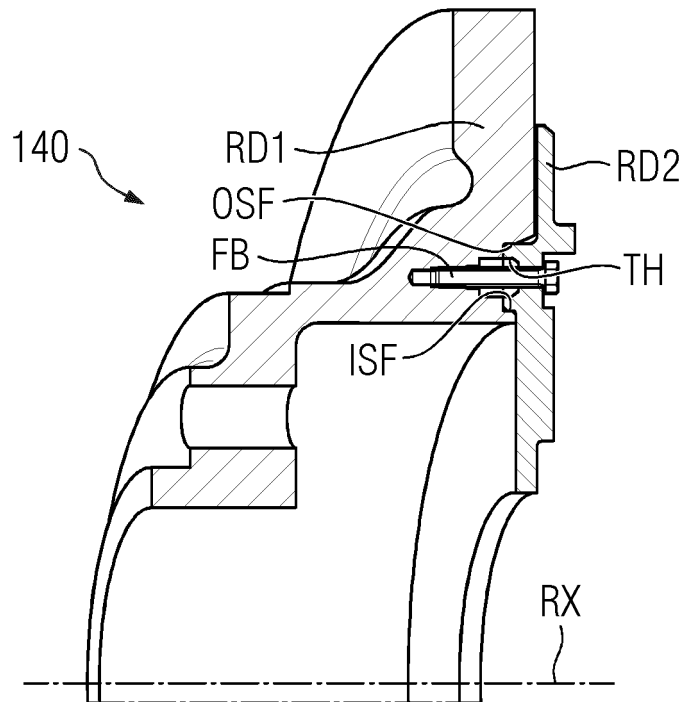


FIG 3

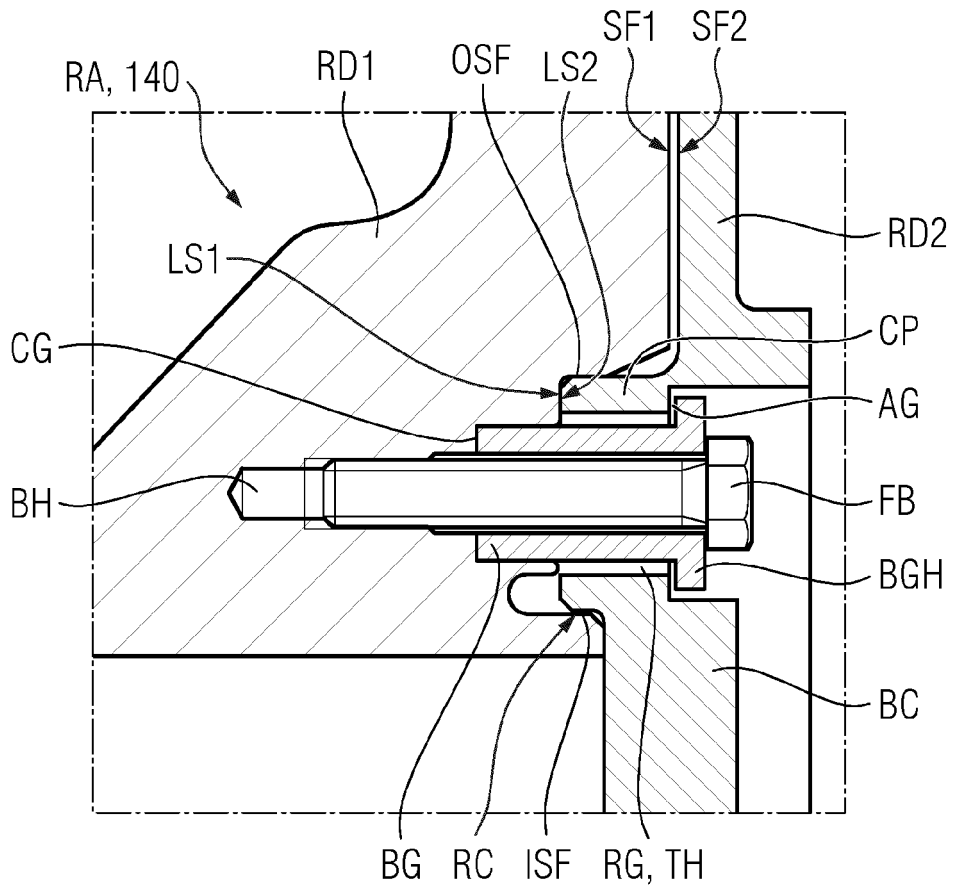
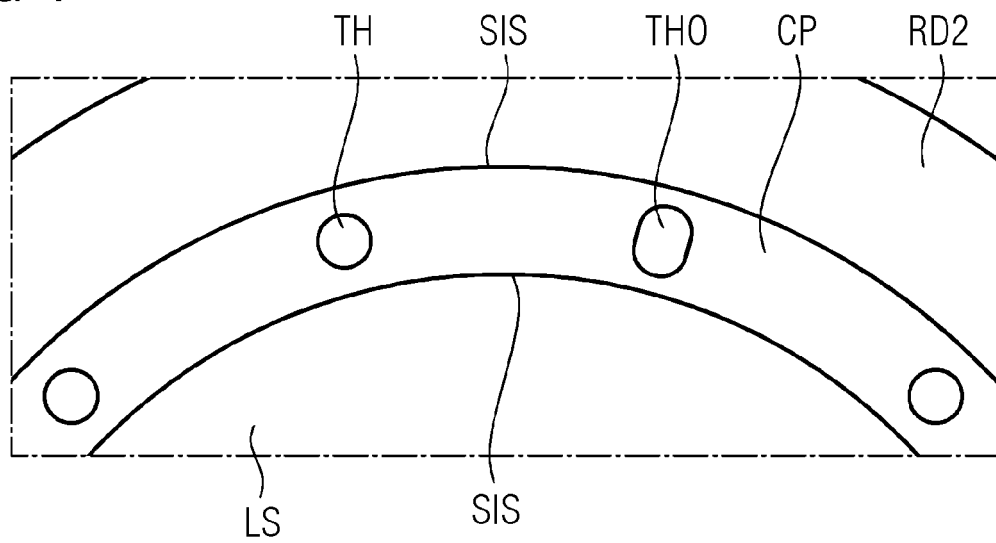


FIG 4





EUROPEAN SEARCH REPORT

Application Number
EP 20 19 3629

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 18 November 2020	Examiner Rau, Guido
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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