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(54) **GAS TURBINE COMPRISING A COMBUSTOR WITH A COMBUSTOR OUTLET AND A FIRST ROW OF ROCKING VANES**

(57) A gas turbine (10) comprises a combustor with a combustor outlet and a first row of rocking vanes (12) arranged at said combustor outlet in sealing relationship with said combustor outlet, whereby said rocking vanes (12) each comprise an airfoil (13) with a leading edge (13a) and a trailing edge (13b) extending between an inner platform (15) and an outer platform (14), and whereby said rocking vanes (12) are each hooked with their outer platform (14) into a turbine vane carrier (17) thereby defining a rotation point (19) for a rotational movement of said rocking vanes (12).

The rocking vane movements and the axial force on the inner platform are reduced by moving said rotation point (19) to the leading edge (13a) of said rocking vanes (12).

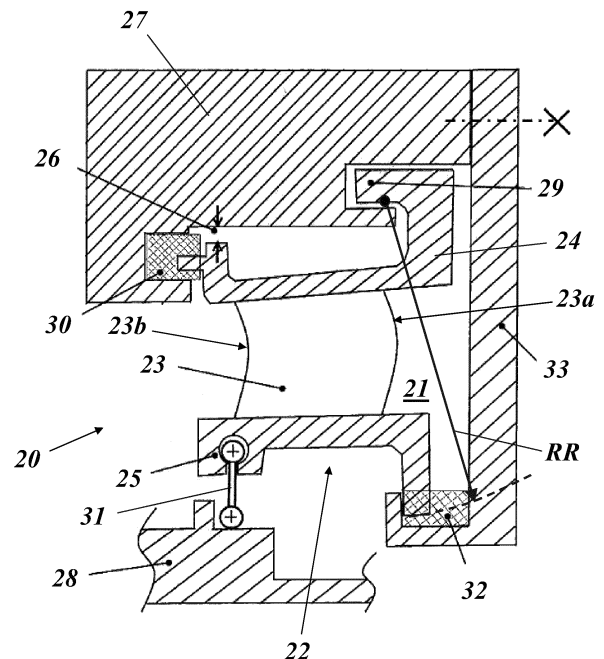


Fig.3

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to the technology of gas turbines. It refers to a gas turbine comprising a combustor with a combustor outlet and a first row of rocking vanes according to the preamble of claim 1.

PRIOR ART

[0002] Fig. 1 shows part of a gas turbine 40 according to the prior art at the transition between the combustor 35 of the turbine and the first row of rocking vanes 42 at the entrance of hot gas flow path 41. Hot gas 36 exits the combustor 35 through a plurality of openings, which are positioned around the machine axis in an annular arrangement and which are known as picture frames 35a.

[0003] Each rocking vane 42 comprises a radially oriented airfoil 43 extending between an outer platform 44 (outer diameter OD) and an inner platform 45 (inner diameter ID) and having a leading edge 43a and a trailing edge 43b. Vane 42 is hooked with its outer platform 44 into a turbine vane carrier 47. Inner platform 45 abuts a rotor cover 48 at a contact point 39, which covers the central rotor part of the machine. Outer platform 44 and inner platform 45 border the hot gas flow path 41 and are in sealing relation to picture frame 35a by means of seals 37 and 38.

[0004] During operation of the gas turbine each rocking vane 42 is loaded with a very high force under extreme boundary conditions (high temperature and high pressure). Therefore, modifications on the vane need to be carried out in a way that the lifetime of the vane on one hand and the hot gas flow after the vane on the other hand is not negatively affected.

[0005] Furthermore it is important that the leakage of hot gas from the hot gas path doesn't increase, because this would have a negative influence on the efficiency of the machine. In addition, the rocking vane movements caused by the thermal expansion of the rotor cover have an influence and need to be considered in the design.

[0006] The accessibility of the 1st vane and blade row (running blades behind the vane row) is essential for disassembly and assembly and needs to be considered in the design approach of the vane support and fixation. This maintenance process is part of gas turbine outage time, which is a well defined time period and therefore shall be as short as possible in order to reduce operating costs.

[0007] Prior art solutions like the one shown in Fig. 1 use a fixation of the rocking vanes 42 at the trailing edge 43b of the rocking vanes 42 so that a rotation point 46 is defined for a rotational movement of the rocking vane 42 with an extended rotational radius RR. This configuration results in pronounced rocking vane movements and axial forces on the ID (inner platform 45) of rocking vane 42. Document US 6,742,987 B2 discloses a turbine nozzle,

which includes a row of vanes in corresponding segmented outer and inner bands. The inner band of each segment includes a retention flange. A nozzle support includes forward and aft flanges defining a retention slot receiving the retention flange. The retention flange includes a radial lug trapped axially in the retention slot, and a tangential lug at an opposite circumferential end disposed on the forward flange. The aft flange includes an outer hinge, and the retention flange further includes an inner hinge for cradle mounting the retention flange in the nozzle support.

[0008] Document US 7,762,766 B2 is related to a support for the first row turbine vanes in a gas turbine engine, the support including a support framework. The support framework includes an outer vane carrier, and an inner vane carrier connected to the outer vane carrier by a plurality of struts. The outer vane carrier is mounted to an inner casing of the engine and the struts support the inner vane carrier in cantilevered relation to the outer vane carrier. An aft outer flange of each first row vane is supported on the outer vane carrier and a forward inner flange of the vane is supported on the inner vane carrier.

[0009] According to document US 8,356,981 B2, within gas turbine engines it is necessary to provide nozzle guide vanes between stages of the engine. These vanes are presented in vane segments and it is desirable to prevent leakage to retain engine operation efficiency as well as to avoid hot gas impingement on inappropriate parts of the engine. By use of anti-rotation blocks twisting between the segments can be prevented and therefore the segments retain in alignment. However, thermal distortion may open a chordal seal provided to inhibit gas flow leakage. By provision of chordal bumps it is possible to prevent forward rocking which will inhibit gaps between the chordal seal and an engaging support ring surface. Furthermore the anti-rotation blocks will generally incorporate appropriate mating surfaces to engage the chordal bumps across two or more vane segments to facilitate retention of vane segment alignment while achieving adjustment for thermal distortion.

SUMMARY OF THE INVENTION

[0010] It is an object of the present invention to provide a gas turbine with the rocking vanes of which are modified in a way so that the rocking vane movements and the axial force on the rocking vane are reduced and, at the same time, other benefits of the rocking vane will be kept.

[0011] This object is obtained by a gas turbine as claimed in Claim 1.

[0012] The gas turbine according to the invention comprises a combustor with a combustor outlet and a first row of rocking vanes arranged at said combustor outlet in sealing relationship with said combustor outlet, whereby said rocking vanes each comprise an airfoil with a leading edge and a trailing edge extending between an inner platform and an outer platform, and whereby said rocking vanes are each hooked with their outer platform

into a turbine vane carrier thereby defining a rotation point for a rotational movement of said rocking vanes.

[0013] The gas turbine according to the invention is characterized in that said rotation point is located at the leading edge of said rocking vanes.

[0014] An embodiment of the gas turbine according to the invention is characterized in that a means for limiting said rotational movement of said rocking vanes is provided on said outer platform at said trailing edge.

[0015] Specifically, said means for limiting said rotational movement comprises a stop collar on the outer side of said outer platform.

[0016] More specifically, a defined gap is provided between said stop collar and said turbine vane carrier.

[0017] According to another embodiment of the invention said gas turbine comprises a rotor with a rotor cover, and said rocking vanes are supported at said inner platform by said rotor cover.

[0018] According to a further embodiment of the invention said gas turbine comprises a central rotor part and a plurality of I-beams extending in radial direction between said turbine vane carrier and said central rotor part, and said rocking vanes are supported at said inner platform by said I-beams.

[0019] Specifically, a seal, especially honeycomb seal, is provided between said inner platform and said I-beam.

[0020] Specifically, a horizontal seal, especially honeycomb seal, is provided between said outer platform and said turbine vane carrier.

[0021] Specifically, said gas turbine comprises a rotor with a rotor cover, and a seal, especially dog-bone seal, is provided between said inner platform and said rotor cover.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The present invention is now to be explained more closely by means of different embodiments and with reference to the attached drawings.

Fig. 1 shows part of a gas turbine according to the prior art at the transition between the combustor of the turbine and the first row of rocking vanes;

Fig. 2 shows in comparison to Fig. 1 a first embodiment of a gas turbine according to the invention;

Fig. 3 shows in comparison to Fig. 1 a second embodiment of a gas turbine according to the invention;

Fig. 4 shows in comparison to Fig. 1 a third embodiment of a gas turbine according to the invention.

DETAILED DESCRIPTION OF DIFFERENT EMBODIMENTS OF THE INVENTION

[0023] The basic idea of the present invention is to

modify the rocking vane(s) in a way so that the rocking vane movements and the axial force on the ID (inner platform) are reduced (whereas some benefits of the rocking vane will be kept).

[0024] These changes have a direct influence on the sealing concept and enable to minimize the leakage of hot gas between 1st vane row and the combustor outlet. The modifications on the rocking vane can be used for the single rocking vane (support on the ID or inner platform with the rotor cover - see Fig. 2) or for the rocking vane together with an I-beam (support on the ID or inner platform with the I-beam - see Fig. 3).

[0025] Main features of the modified rocking vane are the change in position of the rotation hook (rotation point) and a stop collar on the OD or outer platform either with or without an additional honeycomb seal.

[0026] The starting point of the present invention is the gas turbine engine in closed condition, which has a pattern of several picture frames (35a in Fig. 1) or outlets of a sequential liner of a sequential combustor) spread around a rotational contour. A main target is to seal the interface between each picture frame and the 1st vane (in this case rocking vane) in order to reduce the leakage to a minimum.

[0027] Therefore, within the invention, three alternative rocking vane fixation concepts were developed in order to minimize the axial force on the vane and to reduce the rocking vane movements.

[0028] A first fixation concept is shown with gas turbine 10 in Fig. 2.

[0029] A single rocking vane 12, which comprises an airfoil 13 with leading edge 13a and trailing edge 13b, extending radially through hot gas flow path 11, and an inner platform (or ID) 15 and outer platform (or OD) 14, is supported at its inner platform 15 by a rotor cover 18.

[0030] The modified rocking vane 12 is now hooked with its outer platform 14 into turbine vane carrier (TVC) 17 at the leading edge 13a. Thus, it has a change in position of the rotation point 19 on the outer platform 14 (with a different rotation radius RR) in order to minimize the rocking vane movement and the axial force on the vane. The axial force on inner platform (ID) 15 will be reduced due to the additional moment over the vane, which results because of the different sizes of the inner and outer vane platform 15 and 14, respectively.

[0031] Furthermore, rocking vane 12 is supported at the inner platform (ID) 15 by the rotor cover 18.

[0032] Finally, a stop collar 16 on the outer platform (OD) 14 with a defined gap between stop collar 16 and turbine vane carrier 17 is provided in order to limit the rocking vane movement up to a defined maximum. If the maximum is reached the force on the vane will be directed into the turbine vane carrier (TVC) 17.

[0033] An advantage of this configuration is that the rocking vane 12 can be easily assembled axially.

[0034] A second fixation concept is shown with gas turbine 20 in Fig. 3.

[0035] In this concept, a single rocking vane 22, which

comprises an airfoil 23 with leading edge 23a and trailing edge 23b, extending radially through hot gas flow path 21, and an inner platform (or ID) 25 and outer platform (or OD) 24, has a support at inner platform 25 by means of an I-beam 33 (a radial strut between rotor cover and turbine vane carrier of the turbine)

[0036] Again, the modified rocking vane 22 has a change in position of the rotation point 29 at outer platform (OD) 24 in order to minimize the axial force on the rocking vane 22 (see rotation radius RR).

[0037] This leads to a decreased load on the I-beam 33, which has a positive outcome for the dimensions of the I-beam 33 (i.e. a reduction of the dimensions is possible).

[0038] A honeycomb seal 32 between inner platform (ID) 25 and I-beam 33 is provided to minimize the leakage in general and in case of vane twist.

[0039] Furthermore, a stop collar 26 on the outer platform (OD) 24 of the vane with a defined gap is provided in order to limit the rocking vane movement up to a defined maximum. In case that the rocking vane 22 reaches the limit and both, vane 22 and turbine vane carrier 27, are in contact, I-beam 33 will be relieved. The leakage between rocking vane outer platform (OD) 24 and turbine vane carrier (TVC) 27 is minimized by a honeycomb seal 30.

[0040] Sealing between 1st vane and rotor cover 28 is realized with an additional seal, e.g. a dog-bone seal 31.

[0041] A third fixation concept in a gas turbine is shown in Fig. 4.

[0042] According to this concept the modified rocking vane 52 is hooked with its outer platform 54 into the turbine vane carrier 57 at the leading edge 53a. Thus, it has a change in position of the rotation point 59 on the outer platform 54 (with a different rotation radius RR) in order to minimize the rocking vane 52 movements and the axial force on the vane. Furthermore, rocking vane 52 is supported on the leading edge 53a at the inner platform (ID) 55 by the rotor cover 58. Therefore, the rotational point 59 of the rocking vane 52 and the support on the inner platform 55 of the vane are in line.

[0043] A stop collar 56 on the outer platform (OD) 54 with a defined gap between stop collar 56 and turbine vane carrier 57 is provided in order to limit the rocking vane 52 movement up to a defined maximum. If the maximum is reached the force on the vane will be directed into the turbine vane carrier 57.

[0044] The sealing concept of this version is based on two seals, preferably honeycomb seals 30, 32 on the outer platform OD 54 and the inner platform ID 55 of the vane 52 at its trailing edge 53b. One seal 32 is located on the rotor cover 58 and is able to capture the axial and radial movements of the vane 52 and the rotor cover 58 itself. The second seal 30 is placed on the turbine vane carrier 57 and prevents leakage between the vane outer platform 54 and the hot gas flow.

Advantage of the invention:

[0045] The modified rocking vane enables to reduce the forces on the inner platform and the vane movements.

5 This has a positive impact on the leakage at the ID (leakage reduction) and improves also other sealing concepts, e.g. honeycomb seal or I-beam in terms of leakage due to the reduced vane movement.

10 LIST OF REFERENCE NUMERALS

[0046]

10,20,40	gas turbine
11,21,41,51	hot gas flow path
12,22,42,52	rocking vane
13,23,43,53	airfoil
13a,23a,43a,53a	leading edge
13b,23b,43b,53b	trailing edge
14,24,44,54	outer platform
15,25,45,55	inner platform
16,26,56	stop collar
17,27,47,57	turbine vane carrier (TVC)
18,28,48,58	rotor cover
19,29,46,59	rotation point (on outer diameter)
30,32	honeycomb seal
31	dog-bone seal
33	I-beam
35	combustor outlet
30a	picture frame
36	hot gas
37,38	seal
39	contact point
RR	rotation radius

Claims

1. Gas turbine (10, 20) comprising a combustor with a combustor outlet and a first row of rocking vanes (12, 22, 52) arranged at said combustor outlet in sealing relationship with said combustor outlet, whereby said rocking vanes (12, 22, 52) each comprises an airfoil (13, 23, 53) with a leading edge (13a, 23a, 53a) and a trailing edge (13b, 23b, 53b) extending between an inner platform (15, 25, 55) and an outer platform (14, 24, 54), and whereby said rocking vanes (12, 22, 52) are each hooked with their outer platform (14, 24, 54) into a turbine vane carrier (17, 27, 57), thereby defining a rotation point (19, 29, 59) for a rotational movement of said rocking vanes (12, 22, 52), **characterized in that** said rotation point (19, 29, 59) is located at the leading edge (13a, 23a, 53a) of said rocking vanes (12, 22, 52).
2. Gas turbine as claimed in Claim 1, **characterized in that** a means (16, 26, 56) for limiting said rotational movement of said rocking vanes (12, 22, 52) is pro-

vided on said outer platform (14, 24, 54) at said trailing edge (13b, 23b, 53b).

3. Gas turbine as claimed in Claim 2, **characterized in that** said means (16, 26, 56) for limiting said rotational movement comprises a stop collar (16, 26, 56) on the outer side of said outer platform (14, 24, 54). 5
4. Gas turbine as claimed in Claim 3, **characterized in that** a defined gap is provided between said stop collar (16, 26, 56) and said turbine vane carrier (17, 27, 57). 10
5. Gas turbine as claimed in one of the Claims 1 to 4, **characterized in that** said gas turbine comprises a rotor with a rotor cover (18), and said rocking vanes (12) are supported at said inner platform (15) by said rotor cover (18). 15
6. Gas turbine as claimed in one of the Claims 1 to 4, **characterized in that** said gas turbine comprises a central rotor part and a plurality of I-beams (33) extending in radial direction between said turbine vane carrier (27) and said central rotor part, and said rocking vanes (22) are supported at said inner platform (25) by said I-beams (33). 20 25
7. Gas turbine as claimed in Claim 6, **characterized in that** a seal, especially honeycomb seal (32), is provided between said inner platform (25) and said I-beam (33). 30
8. Gas turbine as claimed in Claim 6, **characterized in that** a horizontal seal, especially honeycomb seal (30), is provided between said outer platform (24) and said turbine vane carrier (27). 35
9. Gas turbine as claimed in Claim 6, **characterized in that** said gas turbine comprises a rotor with a rotor cover (28), and a seal, especially a dog-bone seal (31), is provided between said inner platform (25) and said rotor cover (28). 40
10. Gas turbine as claimed in one of the Claims 1 to 4, **characterized in that** said gas turbine comprises a rotor with a rotor cover (58) and said rocking vanes (52) are supported at their inner platforms (55) by said rotor cover (58). 45
11. Gas turbine as claimed in Claim 10, **characterized in that** a seal, especially a honeycomb seal (32), is provided between the inner platform (55) and the rotor cover (58). 50
12. Gas turbine as claimed in Claim 10, **characterized in that** a seal, especially a honeycomb seal (30), is provided between the outer platform (54) and the turbine vane carrier (57). 55

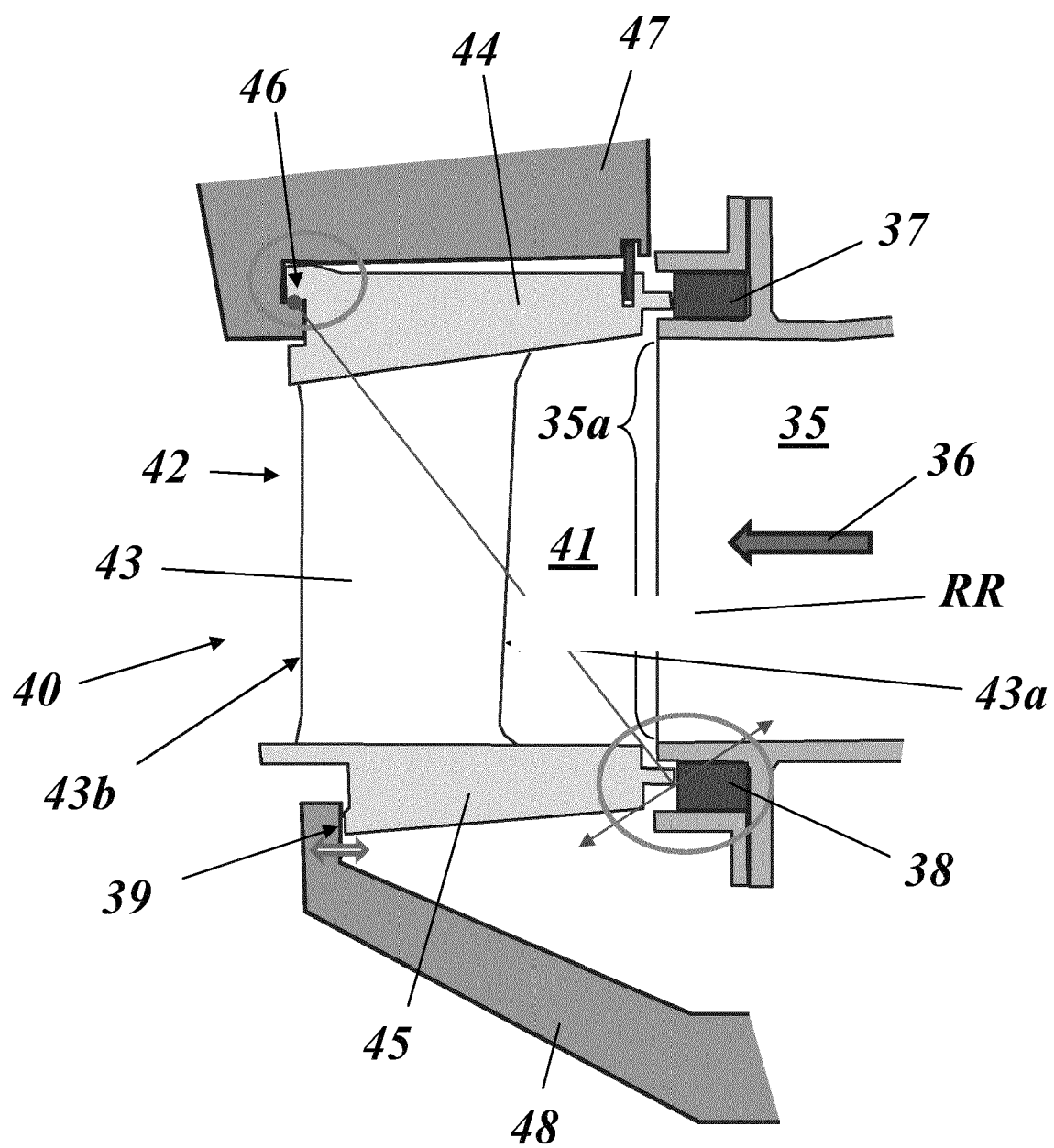


Fig.1

Prior Art

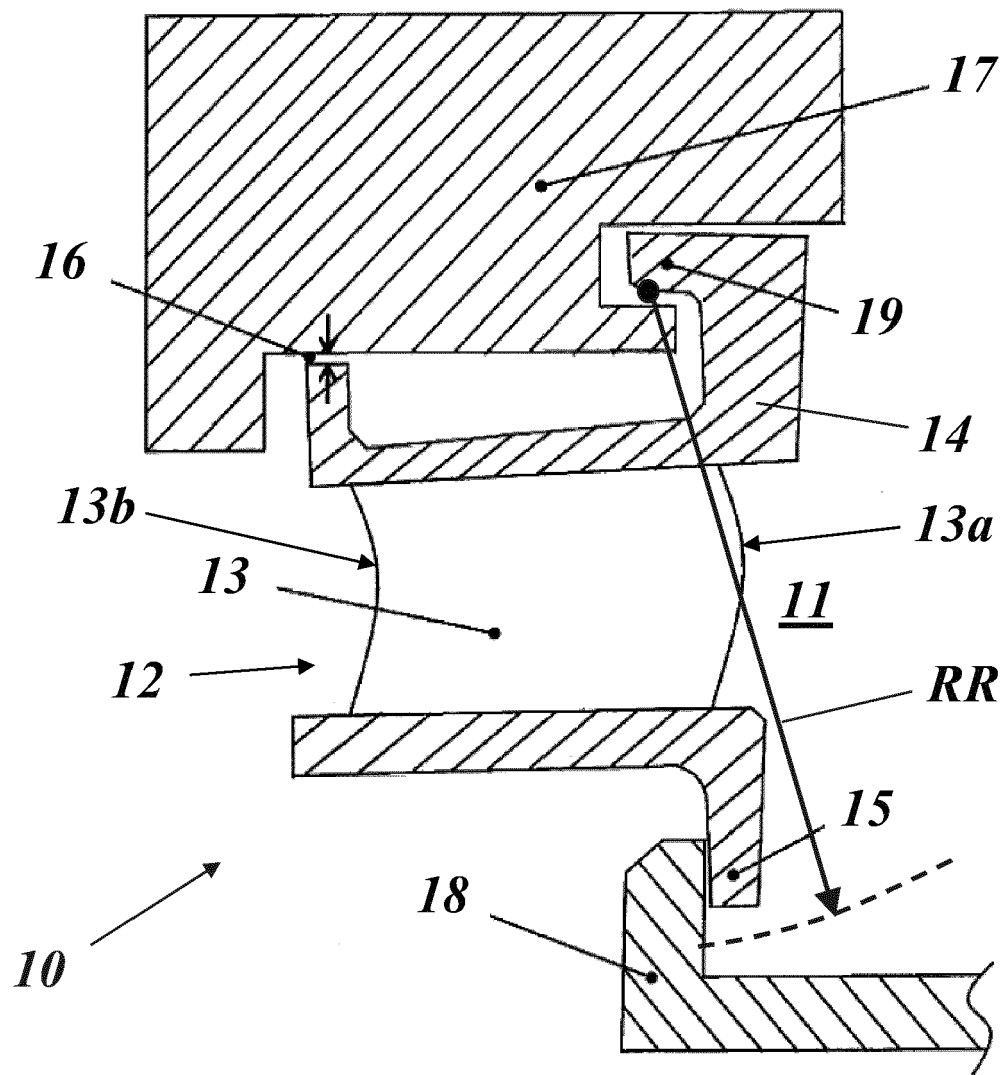


Fig.2

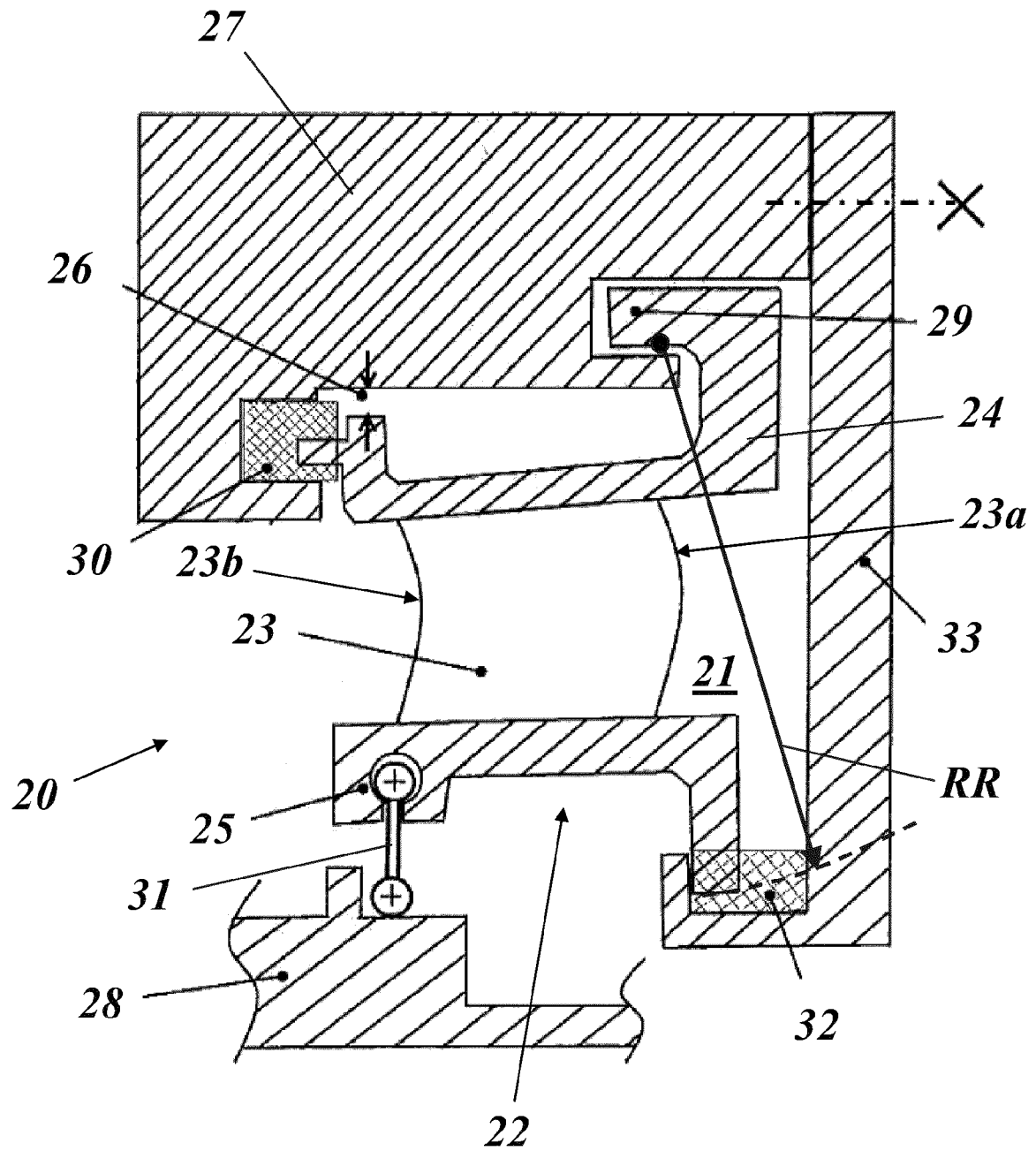


Fig.3

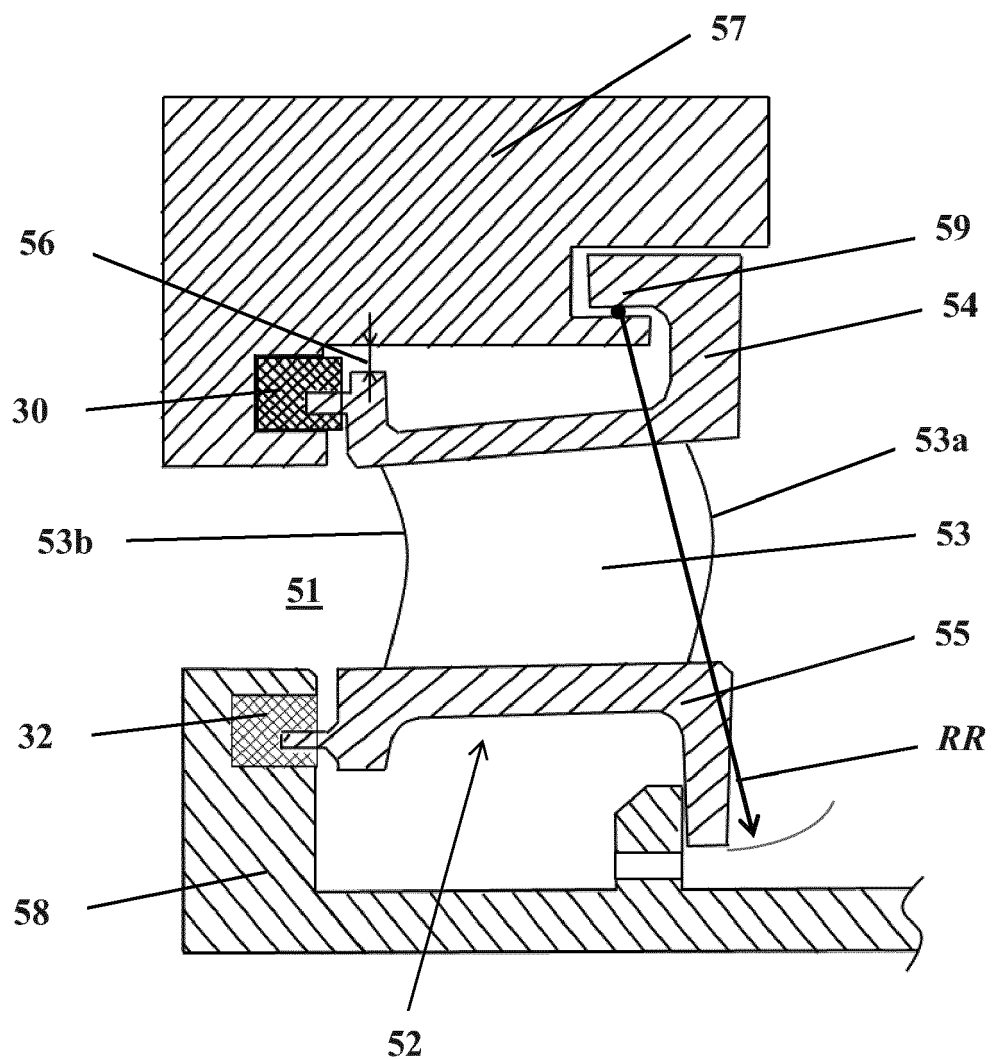


Fig.4



EUROPEAN SEARCH REPORT

Application Number
EP 15 16 1916

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A	----- EP 1 908 924 A2 (ROLLS ROYCE PLC [GB]) 9 April 2008 (2008-04-09) * paragraphs [0016] - [0028] * * figures 1-5 *	1-12	
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			TECHNICAL FIELDS SEARCHED (IPC)
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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 16 September 2015	Examiner de la Loma, Andrés
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			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 15 16 1916

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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