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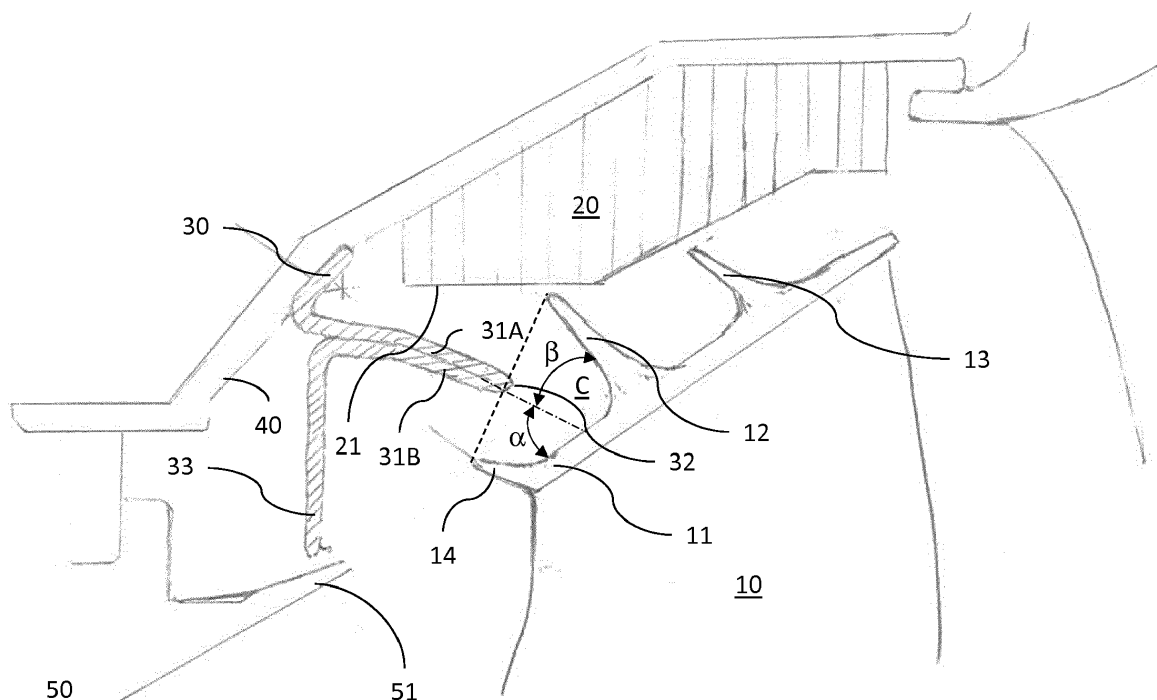
(54) **AXIAL TURBOMACHINE SEALING SYSTEM**

(57) A sealing system for an axial turbomachine comprises:

- a circle of blades (10) with an outer shroud (11) and a first sealing fin (12; 13) projecting away from said outer shroud;
- a seal surface (21) opposite to said first sealing fin; and

- an, in particular grooved, static fin (30; 60) with at least one fin flange (31A, 31B; 61) for restricting flow between the seal surface (21) and the outer shroud (11), wherein the static fin (30; 60) is stationary with respect to the seal surface (21).

Fig. 1



Description

[0001] The present invention refers to a sealing system for an axial turbomachine, to an axial turbomachine, in particular a gas turbine, comprising the sealing system and to a method for sealing using the sealing system.

[0002] Leakage between outer shrouds of blades rotating within a surrounding wall of an axial turbomachine impairs efficiency of the turbomachine.

[0003] Therefore gas turbines may comprise outer air seals comprising honeycomb seal(structure)s which encompass radially opposite sealing fins projecting away from said outer shroud and towards said honeycomb seal(structure)s, thus forming labyrinth seals.

[0004] One object of the present invention is to improve performance of an axial turbomachine, in particular a gas turbine.

[0005] Said object is solved in particular by the feature combination of present claim 1. Claims 12, 13 refer to an axial turbomachine comprising a sealing system as described herein and a method for sealing using a sealing system as described herein respectively. Sub-claims refer to advantageous embodiments.

[0006] According to one aspect of the present invention a sealing system for, in particular of, an axial turbomachine, comprises:

- a circle of blades with an (radially) outer shroud and at least one sealing fin projecting away from said outer shroud;
- a seal surface opposite, preferably radially opposite, to said sealing fin; and
- a static fin with at least one fin flange which at least in some operating conditions, in particular during a normal or design operating mode respectively, restricts flow, in particular of a working fluid of the turbomachine, between said seal surface and said outer shroud, or is adapted and/or used thereto respectively, wherein the static fin is stationary, in particular fixed, with respect to the seal surface.

[0007] Said sealing fin is denoted as a first sealing fin herein without loss of generality. Said first sealing fin is an, in particular most, downstream or, an, in particular most, upstream sealing fin of the circle of blades according to an embodiment.

[0008] According to an embodiment said static fin improves the sealing between the seal surface and the outer shroud, in particular first sealing fin, thus improving performance of the turbomachine. This may in particular apply to a static fin which according to an embodiment is arranged on an upstream side of the first sealing fin.

[0009] Additionally or alternatively such static fin may improve, in particular flatten, (in)flow of leakage downstream of the first or a further sealing fin respectively, thus improving performance of the turbomachine. This may in particular apply to the or an, according to an embodiment further, static fin respectively which according to an

embodiment is arranged on a downstream side of the first/a further sealing fin.

[0010] The (circle of) blades rotate(s) during operation of the turbomachine (rotating (circle of) blades) while the seal surface is static or stationary with respect to a (stationary) stator (wall), in particular a ring (wall), an outer air seal ("OAS") (wall), a casing (wall) or the like, of the turbomachine respectively according to an embodiment.

[0011] The seal surface is arranged radially outside of the outer shroud and first sealing fin, preferably encompasses the first sealing fin, according to an embodiment. The first sealing fin projects radially outwards and/or towards the seal surface according to an embodiment. The (encompassing) seal surface overlaps the outer shroud axially at both (axial) ends according to an embodiment which may improve sealing characteristics. According to another embodiment the outer shroud overlaps the (encompassing) seal surface axially at both (axial) ends which may reduce weight and/or installation space. According to yet another embodiment the outer shroud overlaps the (encompassing) seal surface axially at one (axial) end while the (encompassing) seal surface overlaps the outer shroud axially at the other (axial) end which may improve sealing characteristics and weight and/or installation space. Thus encompassing is to be understood as encompassing in radial and/or circumferential direction according to an embodiment.

[0012] According to an embodiment an axial direction referred to herein is or denotes a direction parallel to a rotating axis of the turbomachine or (circle of) blades respectively, a circumferential direction is or denotes a rotational direction around said rotating axis respectively, and a radial direction is or denotes a direction perpendicular to both the axial and circumferential direction respectively, in particular away from said rotating axis. "Out(er)" may thus in particular mean radially outer or radially (further) away from the rotating axis respectively.

[0013] According to an embodiment the static fin is grooved. This may improve restricting flow between the seal surface and the outer shroud or improve (in)flow of leakage downstream of the first/a further sealing fin respectively, thereby further improving performance of the turbomachine.

[0014] According to an embodiment the fin flange of the static fin projects towards a cavity which is defined between, preferably by, the outer shroud, in particular its upstream or downstream boundary, in particular (most) upstream or downstream edge respectively, and the first sealing fin, in particular its (outer) tip.

[0015] Additionally or alternatively the fin flange of the static fin comprises a fin tip (which is) located within a cavity defined between, preferably by,

- the outer shroud, in particular its upstream or downstream boundary, in particular (most) upstream or downstream edge respectively,
- the seal surface, in particular its upstream or downstream boundary, in particular (most) upstream or

- downstream edge respectively, and
- the first sealing fin, in particular its upstream or downstream (oriented) surface respectively, according to an embodiment. According to a preferred embodiment said fin tip is located within a cavity defined between, preferably by,
- the outer shroud, in particular its upstream or downstream boundary, in particular (most) upstream or downstream edge respectively, and
- the first sealing fin, in particular its (outer) tip.

[0016] Thus, the outer shroud and first sealing fin with the intermediate static fin may provide or function as a fish mouth sealing or are provided or designed thereto respectively according to an embodiment.

[0017] This may further improve restricting flow between the seal surface and the outer shroud or improve (in)flow of leakage downstream of the first/a further sealing fin respectively, thereby further improving performance of the turbomachine.

[0018] According to an embodiment there is a gap (provided or designed respectively) between an, in particular the (above-mentioned), fin tip of the fin flange and the outer shroud and a gap (provided or designed respectively) between said fin tip and the first sealing fin, at least in some operating conditions, in particular during a normal or design operating mode respectively. At least in said operating conditions said gap is less than 100% of a height of the first sealing fin and/or more than 5% of said height according to an embodiment.

[0019] This may reduce wear, thereby further improving performance of the turbomachine.

[0020] According to an embodiment the seal surface is arranged at, in particular established by, a honeycomb seal (structure), in particular a stepped honeycomb seal (structure). Thus the seal surface comprises one or more radial steps according to an embodiment. According to an embodiment the first sealing fin may contact the seal surface and/or said fin tip may be contact-free at least in some operating conditions, in particular during a normal or design operating mode respectively, or be designed accordingly respectively.

[0021] Additionally or alternatively according to an embodiment the circle of blades comprises one or more further sealing fins (radially) opposite to, in particular radially inside/ encompassed by, the seal surface and projecting away from the outer shroud, preferably radially outwards and/or towards the seal surface, in particular one or more further sealing fins downstream of the first sealing fin.

[0022] Thus the first and/or further sealing fin(s) of the circle of blades and the seal surface form a labyrinth seal according to an embodiment.

[0023] The present invention may in particular (further) improve performance of such a labyrinth seal, in particular by providing a further labyrinth or overlapping seal respectively, thereby (further) improving the turbomachine's performance.

[0024] According to an embodiment an upstream

boundary of the outer shroud comprises a deflector (which is) inclined towards the seal surface preferably. Said deflector protrudes axially over an upstream or downstream edge of the blades at the outer shroud according to an embodiment. Additionally or alternatively said deflector is grooved according to an embodiment.

[0025] This may further improve restricting flow between the seal surface and the outer shroud by the static fin, thereby further improving performance of the turbomachine.

[0026] According to an embodiment the fin flange is inclined with respect to the axial and/or radial direction. Additionally or alternatively an angle between the fin flange and the outer shroud and/or an angle between the fin flange and the first sealing fin is less than 90°, preferably less than 60°, more preferably less than 45°.

[0027] This may further improve restricting flow between the seal surface and the outer shroud or improve (in)flow of leakage downstream of the first/a further sealing fin respectively, thereby further improving performance of the turbomachine.

[0028] According to an embodiment the static fin comprises at least one restricting flange which projects towards a vane platform of a vane of the turbomachine adjacent to the circle of blades and/or is inclined with respect to the fin flange of the static fin according to an embodiment, preferably by 10° at least, more preferably by 25° at least, and/or 120° at most, more preferably by 100° at most.

[0029] Thus, according to an embodiment the static fin may be used to also reduce leakage towards a cavity defined between said vane platform and a stator wall, thereby further improving performance of the turbomachine.

[0030] According to an embodiment the static fin, in particular its fin flange, comprises, preferably is (made from), metal.

[0031] Additionally or alternatively the static fin is (formed as) one(-)piece(d) and/or ring-like according to an embodiment. According to another embodiment the static fin comprises two or more, preferably one-piece(d), ring segments which together form a ring-like static fin.

[0032] Additionally or alternatively according to an embodiment the static fin, in particular its fin flange, comprises at least two layers which according to an embodiment at least partially contact each other. Alternatively, at least the fin flange is single-layer according to an embodiment.

[0033] Additionally or alternatively the static fin is attached detachably or non-detachably to a stator, preferably to a ring, OAS, casing or the like, in particular (stator, in particular ring/OAS/casing) wall, of the turbomachine, in particular up- or downstream and/or adjacent to the seal surface, in particular honeycomb seal, according to an embodiment. According to an embodiment the static fin is arranged adjacent to the seal surface and/or outer shroud.

[0034] Thus, according to a preferred embodiment the

static fin comprises, in particular is, one or more metal pad(s) which is/are bend to form the fin flange and also the restricting flange (if such restricting flange is provided).

[0035] These features, in particular combination of two or more of said features, may in particular provide a lightweight, compact and/or robust static fin, thus further improving performance of the turbomachine. Therein, a single-layer fin flange may reduce weight while at least two layers, in particular when at least partially contacting each other, may increase stiffness according to an embodiment.

[0036] According to an embodiment the static fin is at least partially located at an upstream side of the outer shroud and/or seal surface. In particular the static fin may be fixed to the stator, in particular ring, OAS or casing, (wall) upstream or downstream of the outer shroud and/or seal surface. According to an embodiment the static fin is located at least partially at an upstream or downstream side of the first sealing fin.

[0037] As already mentioned this may in particular provide an additional labyrinth and/or fish mouth sealing, thus further improving performance of the turbomachine.

[0038] According to an embodiment the sealing system comprises a further static fin with at least one (further) fin flange for restricting flow between the seal surface and the outer shroud, wherein said further static fin also is stationary with respect to the seal surface, and wherein both static fins, i.e. the static fin described above and said further static fin, are located at, in particular axially, opposite sides of the circle of blades.

[0039] According to an embodiment one or more of the features described herein with respect to the static fin described above may additionally or alternatively apply to this further static fin, in particular (in combination) with one of the further sealing fins instead of the first sealing fin. Thus in particular

- the fin flange of one of said static fins projects towards a cavity defined between the outer shroud and the first sealing fin and the fin flange of the other of said static fins projects towards a cavity defined between the outer shroud and the first or further sealing fin; and/or
- the fin flange of one of said static fins comprises a fin tip located within a cavity defined between the outer shroud, the seal surface and the first sealing fin, in particular within a cavity defined between the outer shroud and the first sealing fin, and the fin flange of the other of said static fins comprises a fin tip located within a cavity defined between the outer shroud, the seal surface and the first or further sealing fin, in particular within a cavity defined between the outer shroud and the first or further sealing fin; and/or
- there is a gap between the fin tips of both static fins and the outer shroud and a gap between the fin tip of one of said static fins and the first sealing fin and

a gap between the fin tip of the other of said static fins and the first or further sealing fin; and/or

- one of said static fins is at least partially located on an upstream side of the first sealing fin and the other of said static fins is at least partially located on a downstream side of the first or further sealing fin; and/or
- an angle between the fin flange of one of said static fins and the, preferably adjacent, first sealing fin is less than 90° , preferably less than 60° , more preferably less than 45° , and an angle between the fin flange of the other of said static fins and the, preferably adjacent, first or further sealing fin is less than 90° , preferably less than 60° , more preferably less than 45° .

[0040] The present invention may be applied with great advantage to compressor or turbine stages of gas turbines, in particular aero engine gas turbines, without being restricted thereto.

[0041] Further features of the present invention are disclosed in the sub-claims and the following description of preferred embodiments. The present invention will be further explained below by way of example with reference to the figures in which corresponding features are denoted by identical reference signs and in which:

Fig. 1 shows, partially schematically, a sectional view of a sealing system of an axial turbomachine according to an embodiment of the present invention;

Fig. 2 shows likewise a sealing system of an axial turbomachine according to another embodiment of the present invention;

Fig. 3 shows likewise a sealing system of an axial turbomachine according to another embodiment of the present invention; and

Fig. 4 shows likewise a sealing system of an axial turbomachine according to another embodiment of the present invention.

Fig. 1 shows a (partial) sectional view of a sealing system of an axial turbomachine according to an embodiment of the present invention.

[0042] The sealing system comprises a circle of blades 10 rotating around a horizontal rotation axis, comprising an outer shroud 11 and a first sealing fin 12 and a further sealing fin 13 downstream of the first sealing fin 12, both sealing fins 12, 13 projecting (radially) away from said outer shroud 11.

[0043] Flow of a working fluid is from left to right, i.e. (more) left is upstream and (more) right is downstream in Fig. 1.

[0044] The system further comprises a stepped honeycomb seal 20 with a (stepped) ring-like seal surface

21 radially opposite to and outside of said outer shroud 11 and the sealing fins 12, 13 which together form a labyrinth seal.

[0045] The outer shroud 11 comprises a deflector 14 inclined towards the seal surface.

[0046] The system further comprises a static fin in the form of one or more one-piece(d) metal pad(s) 30 fixed to a stator wall 40 upstream of the outer shroud 11 and upstream and adjacent to the honeycomb seal 20, thereby being stationary with respect to the seal surface 21.

[0047] Said static fin/metal pad(s) 30 comprise(s) a double-layer fin flange 31A, 31B for restricting flow between the seal surface 21 and the outer shroud 11 which projects towards a cavity C which is defined between an upstream edge of the outer shroud 11 or its deflector 14 respectively and a top tip of the first sealing fin 12 and which is indicated by a dashed line in Fig. 1.

[0048] A fin tip 32 of said fin flange 31A, 31B is located within said cavity C with a gap between the fin tip 32 and the outer shroud 11 as well as between the fin tip 32 and the first sealing fin 12.

[0049] The fin flange 31A, 31B is inclined both with respect to the axial direction (horizontal in Fig. 1) as well as with respect to the radial direction (vertical in Fig. 1), an angle α between the fin flange 31A, 31B and the outer shroud 11 and an angle β between the fin flange 31A, 31B and the first sealing fin 12 both being less than 60° .

[0050] The fin flange 31A, 31B improves restricting flow between the seal surface 21 and the outer shroud 11, acting as an additional labyrinth or fish mouth seal respectively supporting the labyrinth seal provided by honeycomb seal surface 21 and sealing fins 12, 13.

[0051] The static fin/metal pad(s) 30 comprise(s) a restricting flange 33 projecting towards a vane platform 51 of an adjacent vane 50 of the turbomachine.

[0052] The fin flange comprises two layers 31A, 31B contacting each other. Both layers 31A, 31B may be folded to form a single element.

[0053] Fig. 2 shows likewise a sealing system of an axial turbomachine according to another embodiment of the present invention. Reference is made to the foregoing description while differences will be addressed in the following.

[0054] In the embodiment of Fig. 2 the deflector 14 is absent. While the fin flange 31A, 31B still projects towards a cavity defined between an upstream edge of the outer shroud 11 and a top tip of the first sealing fin 12, the fin tip 32 is located within a cavity C' defined between an upstream edge of the outer shroud 11 and an upstream edge of the seal surface 21 (dashed line in Fig. 2), thus restricting flow between the seal surface 21 and the outer shroud 11.

[0055] Fig. 3 shows likewise a sealing system of an axial turbomachine according to another embodiment of the present invention. Again reference is made to the foregoing description while differences will be addressed in the following.

[0056] In the embodiment of Fig. 3 the sealing system

comprises a further static fin in the form of one or more further one-piece(d) metal pad(s) 60 fixed to stator wall 40 downstream of the outer shroud 11 and downstream and adjacent to the honeycomb seal 20, with a fin flange 61 for restricting flow between the seal surface 21 and the outer shroud 11.

[0057] Said further static fin (flange) improves, in particular flattens, (in)flow of leakage downstream of the further sealing fin 13.

[0058] Fig. 4 shows likewise a sealing system of an axial turbomachine according to another embodiment of the present invention. Reference is made to the foregoing description while differences will be addressed in the following.

[0059] In the embodiment of Fig. 4 the restricting flange is absent. Moreover, the fin flange comprises only one layer 31A.

[0060] This may reduce weight and installation space.

[0061] While at least one exemplary embodiment has been presented in the foregoing summary and detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration in any way. Rather, the foregoing summary and detailed description will provide those skilled in the art with a convenient road map for implementing at least one exemplary embodiment, it being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope as set forth in the appended claims and their legal equivalents.

REFERENCE NUMBERS

10	(circle of) blade(s)
11	outer shroud
12	first sealing fin
13	further sealing fin
14	deflector
20	honeycomb (structure)
21	seal surface
30	static fin
31A, 31B	(layer of) fin flange
32	fin tip
33	restricting flange
40	stator (wall)
50	vane
51	vane platform
60	further static fin

(continued)

61	fin flange
C, C'	Cavity
α , β	angle

Claims

1. A sealing system for an axial turbomachine, the system comprising:

- a circle of blades (10) with an outer shroud (11) and a first sealing fin (12; 13) projecting away from said outer shroud;
 - a seal surface (21) opposite to said first sealing fin; and
 - an, in particular grooved, static fin (30; 60) with at least one fin flange (31A, 31B; 61) for restricting flow between the seal surface (21) and the outer shroud (11), wherein the static fin (30; 60) is stationary with respect to the seal surface (21).

2. The sealing system according to claim 1, wherein the fin flange (31A, 31B; 61) projects towards a cavity (C) defined between the outer shroud (11) and the first sealing fin (12; 13) and/or comprises a fin tip (32) located within a cavity (C') defined between the outer shroud (11), the seal surface (21) and the first sealing fin (12; 13), in particular within a cavity (C) defined between the outer shroud (11) and the first sealing fin (12; 13).

3. The sealing system according to one of the preceding claims, wherein there is a gap between a, in particular the, fin tip (32) of the fin flange (31A, 31B; 61) and the outer shroud (11) and a gap between said fin tip (32) and the first sealing fin (12; 13).

4. The sealing system according to one of the preceding claims, wherein the circle of blades (10) comprises at least one further sealing fin (13) opposite to the seal surface (21) and projecting away from the outer shroud (11), in particular at least one further sealing fin (13) downstream of the first sealing fin (12).

5. The sealing system according to one of the preceding claims, wherein an upstream boundary of the outer shroud (11) comprises an, in particular grooved, deflector (14) inclined towards the seal surface (21).

6. The sealing system according to one of the preceding claims, wherein the static fin (30; 60) is at least partially located at an upstream or downstream side of the first sealing fin (12; 13).

7. The sealing system according to one of the preceding

claims, wherein the fin flange (31A, 31B; 61) is inclined with respect to the axial and/or radial direction and/or an angle (α) between the fin flange (31A, 31B; 61) and the outer shroud (11) and/or an angle (β) between the fin flange (31A, 31B; 61) and the first sealing fin (12; 13) is less than 90°.

8. The sealing system according to one of the preceding claims, wherein the static fin (30; 60) comprises at least one restricting flange (33) projecting towards a vane platform (51) of an adjacent vane (50) of the turbomachine.

9. The sealing system according to one of the preceding claims, wherein the seal surface (21) is arranged at an, in particular stepped, honeycomb seal (20).

10. The sealing system according to one of the preceding claims, wherein the static fin (30; 60), in particular its fin flange (31A, 31B; 61), comprises metal and/or at least two, in particular at least partially contacting, layers (31A, 31B) and/or is one-pieced and/or ring-like and/or attached detachably or non-detachably to a stator (40) of the turbomachine, in particular upstream and/or adjacent to the seal surface (21), in particular honeycomb seal (20), or downstream and/or adjacent to the seal surface (21), in particular honeycomb seal (20).

11. The sealing system according to one of the preceding claims, comprising an, in particular grooved, further static fin (60) with at least one fin flange (61) for restricting flow between the seal surface (21) and the outer shroud (11), wherein said further static fin (60) is stationary with respect to the seal surface (21), wherein both static fins (30, 60) are located at opposite sides of the circle of blades.

12. An axial turbomachine, in particular a gas turbine, comprising the sealing system according to one of the preceding claims.

13. A method for sealing between a circle of blades (10) with an outer shroud (11) and a first sealing fin (12; 13) projecting away from said outer shroud (11) and a seal surface (21) of an axial turbomachine opposite to said first sealing fin (12; 13), comprising using a sealing system according to one of the preceding claims, in particular restricting flow between the seal surface (21) and the outer shroud (11) by its static fin (30) or static fins (30, 60) respectively.

File 1

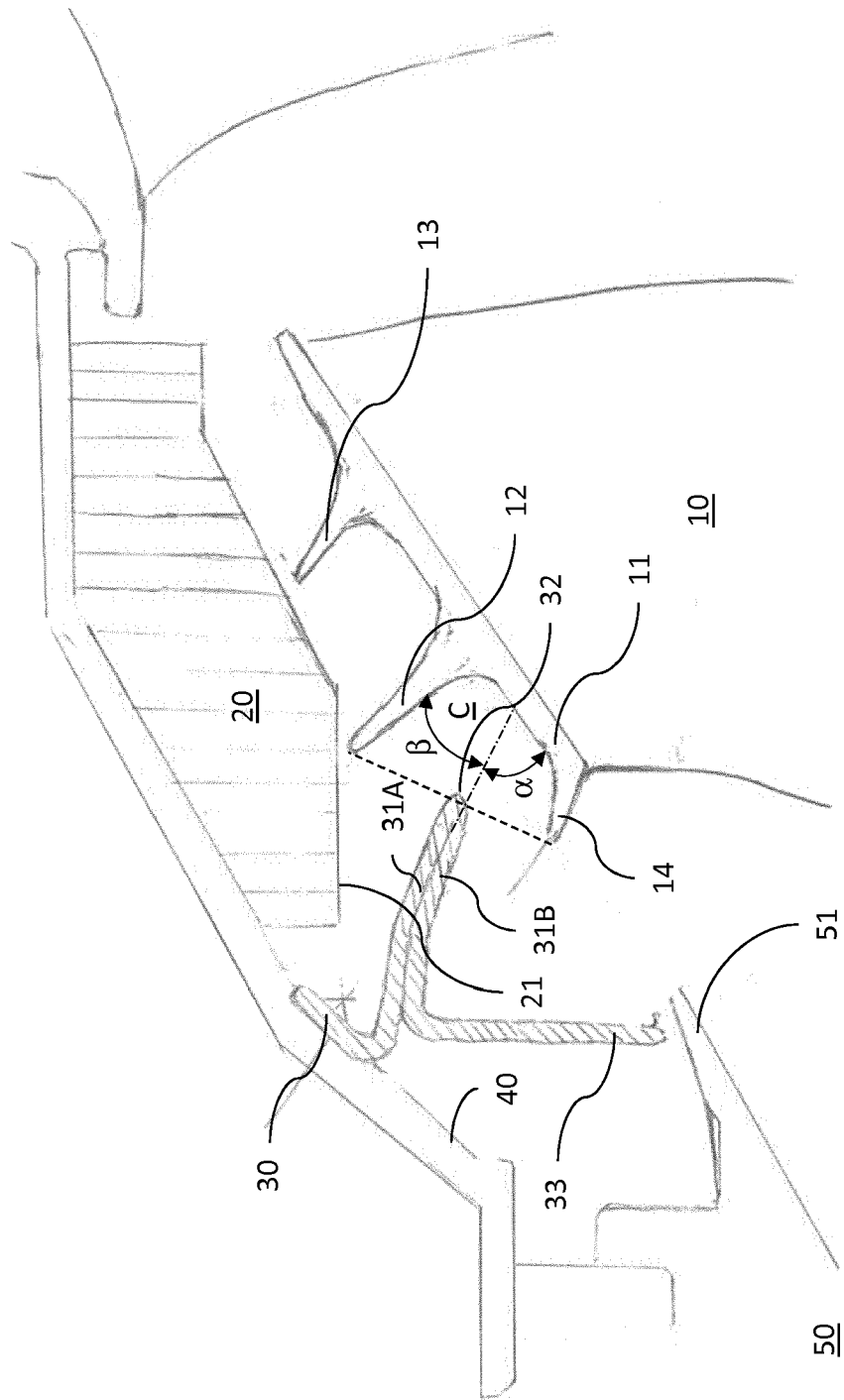
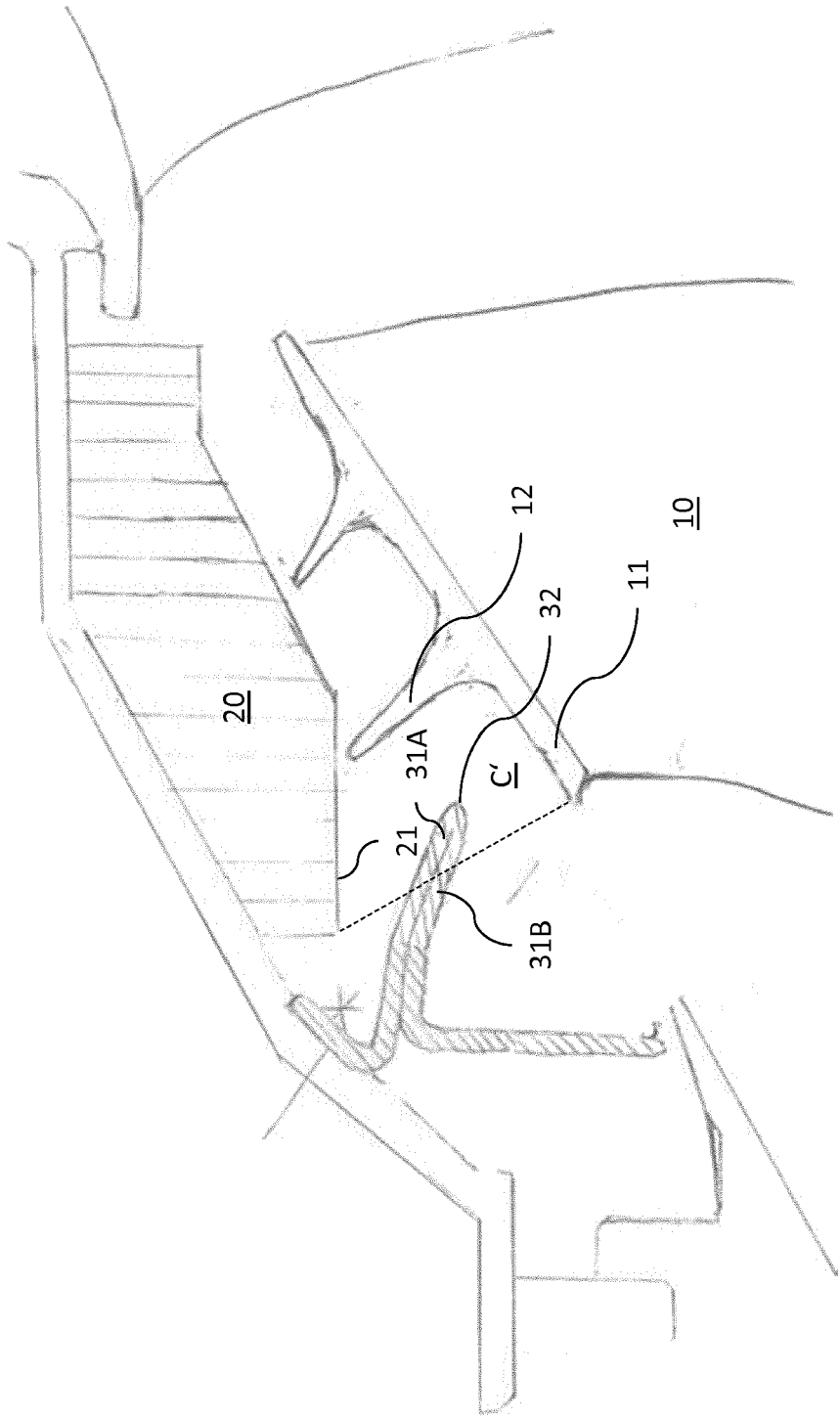
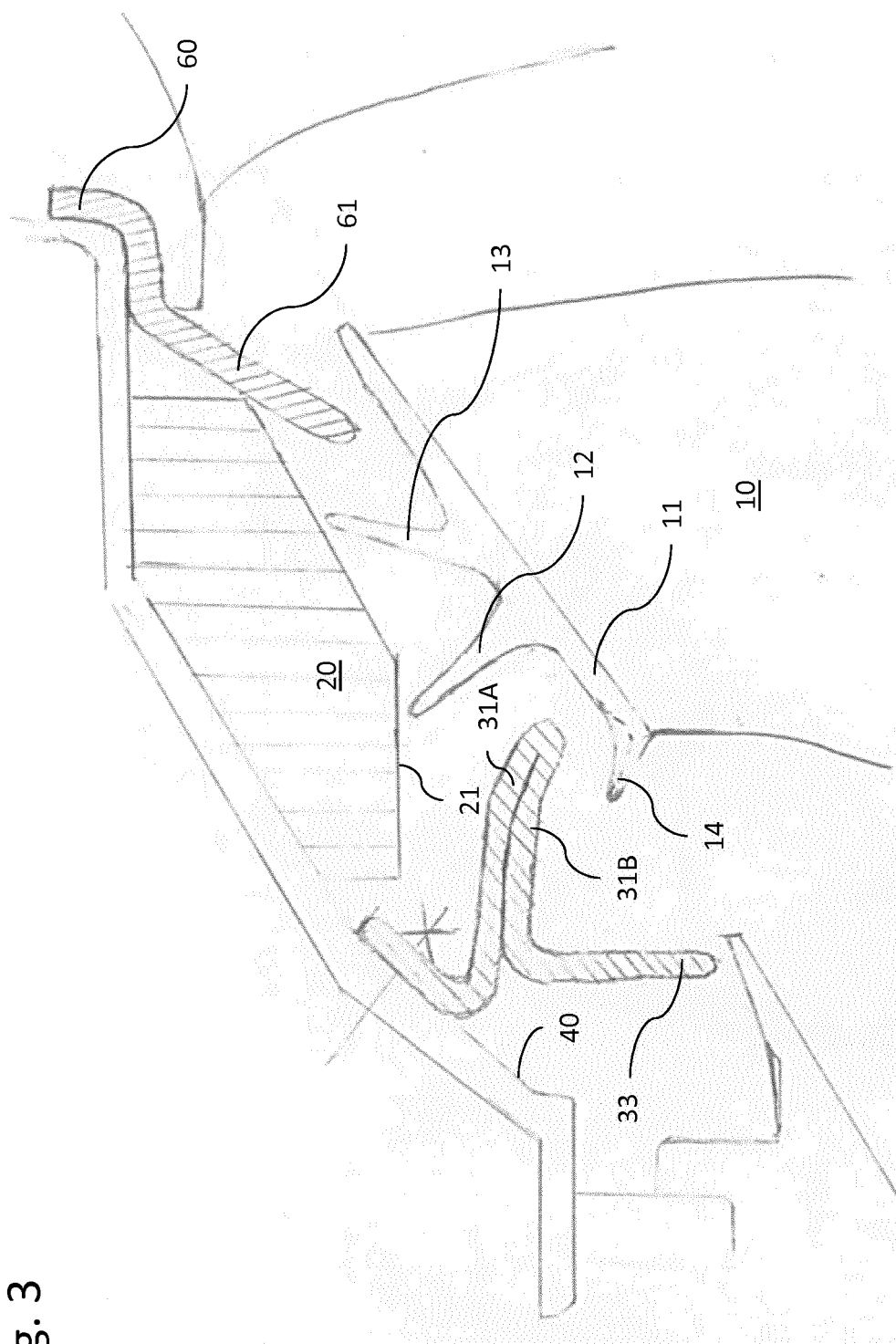


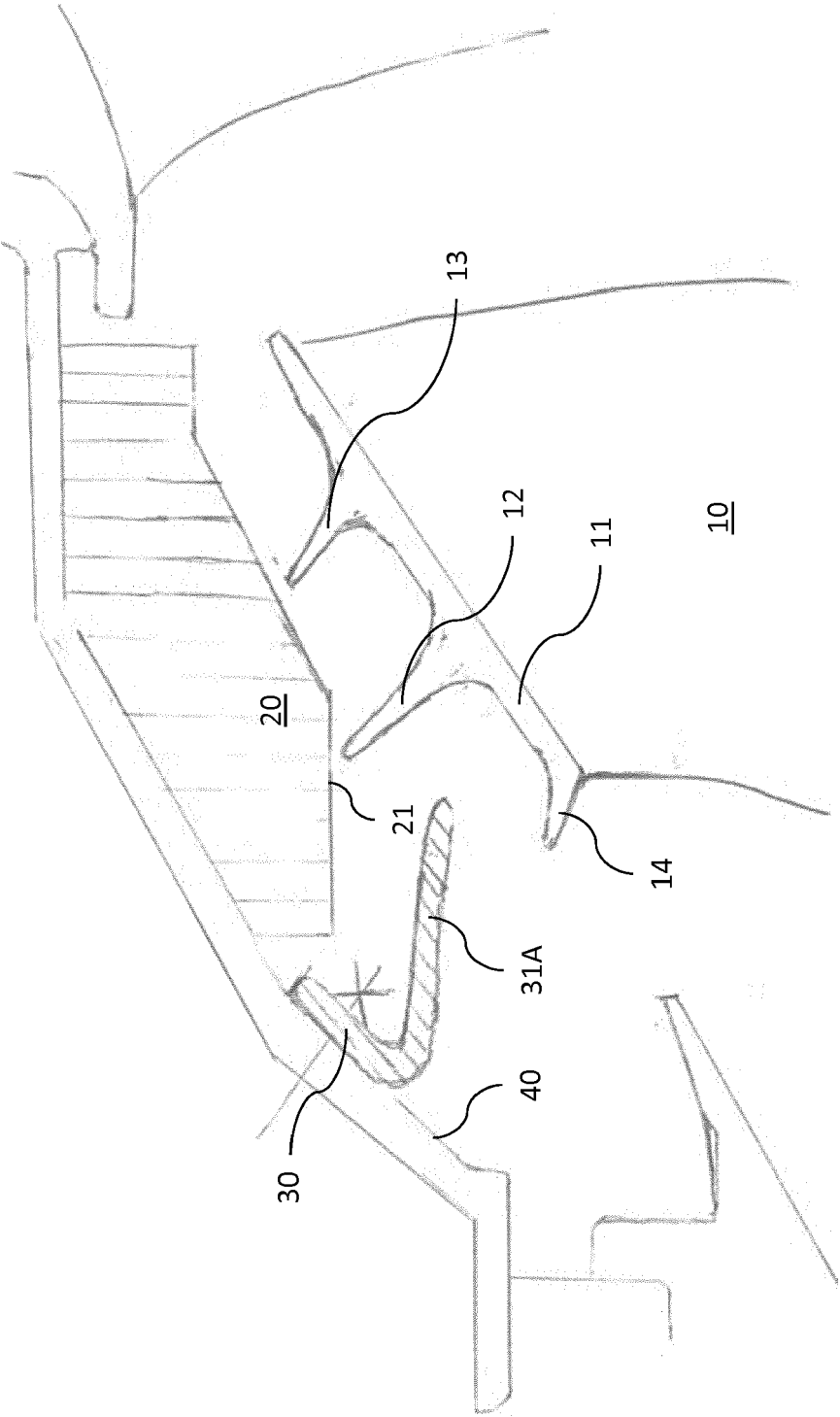
Fig. 2





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Fi.

Fig. 4





EUROPEAN SEARCH REPORT

Application Number
EP 19 20 9602

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2019/131011 A1 (MITSUBISHI HEAVY IND AERO ENGINES LTD [JP]) 4 July 2019 (2019-07-04)	1-4,6,7,9,10,12,13	INV. F01D11/02 F01D5/22 F01D11/12 F01D11/08
A	* paragraph [0028] - paragraph [0044] * * figures 2,3 *	5,8,11	

X	EP 3 324 002 A1 (MTU AERO ENGINES AG [DE]) 23 May 2018 (2018-05-23)	1-13	
	* abstract * * paragraph [0049] - paragraph [0055] * * figure 2 *		

X	EP 2 302 174 A2 (ROLLS ROYCE DEUTSCHLAND [DE]) 30 March 2011 (2011-03-30)	1-7,10,12,13	
A	* abstract * * paragraph [0022] - paragraph [0027] * * figures 1,2 *	8,9,11	

X	WO 2018/155636 A1 (MITSUBISHI HEAVY IND LTD [JP]) 30 August 2018 (2018-08-30)	1-4,6,7,10-13	TECHNICAL FIELDS SEARCHED (IPC)
A	* abstract * * figures 2,3 * * paragraph [0031] - paragraph [0036] *	5,8,9	F01D

X	EP 2 647 795 A1 (MTU AERO ENGINES AG [DE]) 9 October 2013 (2013-10-09)	1,3,4,6,7,9,10,12,13	
A	* abstract * * paragraph [0014] - paragraph [0017] * * figure 2 *	2,5,8,11	

The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 April 2020	Examiner Payr, Matthias
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
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 20 9602

5 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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30-04-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2019131011 A1	04-07-2019	JP 2019120140 A WO 2019131011 A1	22-07-2019 04-07-2019
EP 3324002 A1	23-05-2018	DE 102016222720 A1 EP 3324002 A1 US 2018142567 A1	24-05-2018 23-05-2018 24-05-2018
EP 2302174 A2	30-03-2011	DE 102009042857 A1 EP 2302174 A2 US 2011070074 A1	31-03-2011 30-03-2011 24-03-2011
WO 2018155636 A1	30-08-2018	JP 2018135847 A WO 2018155636 A1	30-08-2018 30-08-2018
EP 2647795 A1	09-10-2013	EP 2647795 A1 ES 2700788 T3 US 2013266426 A1	09-10-2013 19-02-2019 10-10-2013