



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.12.2021 Bulletin 2021/51

(51) Int Cl.:
F01D 5/14 (2006.01) **F01D 9/04** (2006.01)
F01D 11/00 (2006.01) **F01D 25/24** (2006.01)

(21) Application number: **20425018.7**

(22) Date of filing: **15.06.2020**

(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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(54) **GAS TURBINE STATOR VANE WITH SEALING MEMBER AND METHOD FOR MODIFYING A GAS TURBINE STATOR VANE**

(57) A gas turbine stator vane includes, an airfoil (13), having a leading edge (13a) and a trailing edge (13b), an outer platform (14), connected to an outer end of the airfoil (13), and an inner platform (15), connected to an inner end of the airfoil (13). The inner platform (15) has a front edge (15a) and an aft edge (15b) at the leading edge (13a) and at the trailing edge (13b) of the airfoil (13), respectively and includes a stator aft sealing portion

(19) at the aft edge (15b) and at least one aft sealing rib (20), integral with the inner platform (15) and delimited by adjacent aft grooves (21) that extend parallel to each other all along the aft edge (15b) in the stator aft sealing portion (19), whereby in use the stator aft sealing portion (19) contacts a respective adjacent rotor portion of a gas turbine rotor (3) in response to thermal expansion only at the at least one aft sealing rib (20).

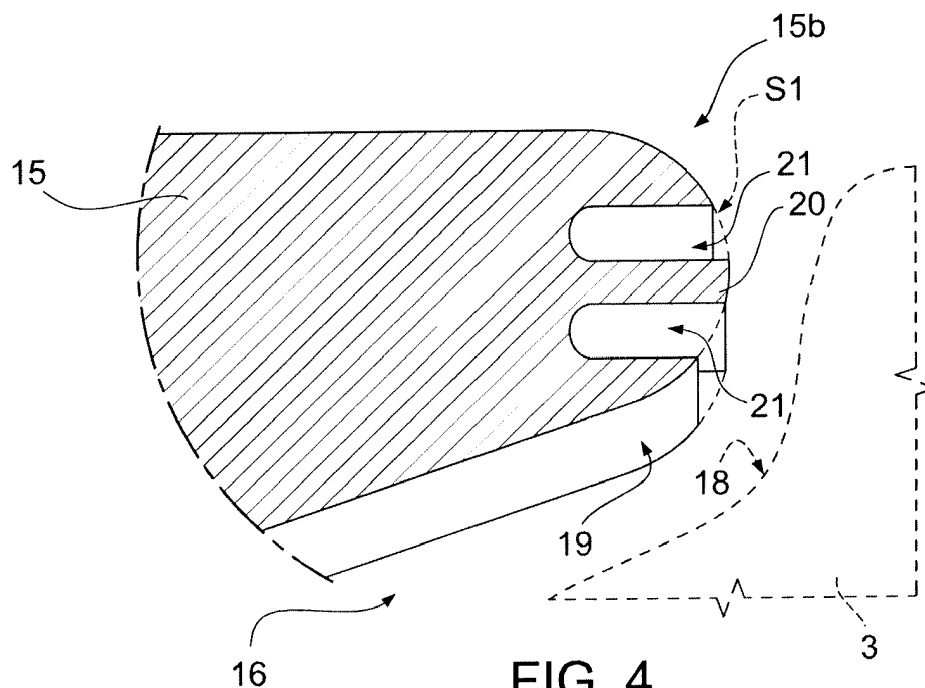


FIG. 4

Description

TECHNICAL FIELD

[0001] The present invention relates to a gas turbine stator vane with sealing member and to a method for modifying a gas turbine stator vane.

BACKGROUND

[0002] As known, gas turbines are provided with sealing systems that prevent hot gas generated by combustion from leaking and reaching components out of the hot gas path. In fact, while components directly facing the hot gas are designed to withstand extremely high temperatures, the other components are not, because manufacturing cost would be too high. Sealing systems are normally configured to supply a sealing airflow of relatively fresh air at high pressure through narrow passages between stator components and rotor components. The sealing airflow confines the hot gas within the hot gas path, thus protecting components which would suffer from exposure to high temperature.

[0003] In order to be effective, rotor and stator components that define sealing systems need be spaced apart of a very little distance, so that sufficiently narrow passages are formed and sealing conditions are maintained in any operating condition. However, gas turbine components surrounding the hot gas path are subject to large thermal expansion, as they may be exposed to temperatures that range from room temperature to over 1000 °C. It is therefore possible that, in some circumstances, stator and rotor components that form the sealing system come into contact with one another. Even though such a condition need be accounted for, contact between static and rotating parts may cause damages and in any case friction that results in a loss of efficiency. Known solutions are not effective in meeting the conflicting needs of reducing contact of stator and rotor portions and maintaining sufficiently narrow passages for sealing airflow in all operating conditions. Some solutions that yield more encouraging results are however costly, as they require additional components that need be assembled, welded or brazed, such as brush or honeycomb seals.

SUMMARY OF THE INVENTION

[0004] It is thus an object of the present invention to provide a gas turbine stator vane and a method for modifying a gas turbine stator vane that allow to overcome or at least attenuate the above described limitations.

[0005] According to the present invention, there is provided a gas turbine stator vane comprising:

an airfoil, having a leading edge and a trailing edge; an outer platform, connected to an outer end of the airfoil, and an inner platform, connected to an inner end of the airfoil, wherein the inner platform has a

front edge and an aft edge at the leading edge and at the trailing edge of the airfoil, respectively and comprises:

a stator aft sealing portion at the aft edge; and at least one aft sealing rib, integral with the inner platform and delimited by adjacent aft grooves that extend parallel to each other all along the aft edge in the stator aft sealing portion, whereby in use the stator aft sealing portion contacts a respective adjacent rotor portion of a gas turbine rotor in response to thermal expansion only at the at least one aft sealing rib.

[0006] The contact region of the stator and the rotor is thus minimized. Accordingly, friction and risk of damages are substantially reduced without affecting the sealing function of the stator aft sealing portion. The sealing rib is also provided as a sacrificial element, as it may be partly eroded by wear due to the small contact area and exactly to the extent required to accommodate thermal expansion. Erosion of the aft sealing rib does not significantly change the overall shape of the aft edge of the platform and the sealing effect is not altered.

[0007] Moreover, the aft sealing rib is integral with the inner platform and there is no need to apply additional components. Cost is therefore lower compared to known solutions.

[0008] According to an aspect of the invention, a thickness of the at least one aft sealing rib is between 0.3 mm and 3 mm.

[0009] According to an aspect of the invention, a depth of the aft grooves is between 3 mm and 20 mm.

[0010] According to an aspect of the invention, at least a portion of the aft edge is defined by an envelope surface and a distal margin of the at least one aft sealing rib lies in the envelope surface.

[0011] According to an aspect of the invention, at least a portion of the aft edge is defined by an envelope surface and a distal margin of the at least one aft sealing rib projects outwards from the envelope surface.

[0012] The shape of the aft edge of the platform favors delivery of the sealing air as a film flow, which is also beneficial to cooling of rotor components in the hot gas path.

[0013] According to an aspect of the invention, the envelope surface is a surface of revolution having a radius of curvature between 3 mm and 15 mm, or the envelope surface is a flat surface.

[0014] According to an aspect of the invention, the stator vane comprises a plurality of parallel aft sealing ribs delimited by respective pairs of adjacent aft grooves that extend parallel to each other all along the aft edge in the stator aft sealing portion, whereby in use the stator aft sealing portion contacts an adjacent rotor portion of a gas turbine rotor in response to thermal expansion only at the plurality of aft sealing ribs.

[0015] Flexible design can be achieved accordingly, to

meet the requirements of reduction of contact area between rotor and stator and of sealing effectiveness in special conditions when a tradeoff is needed.

[0016] According to an aspect of the invention, the inner platform comprises:

a stator front sealing portion at the front edge; and at least one front sealing rib delimited by adjacent front grooves that extend parallel to each other all along the front edge in the stator front sealing portion, whereby in use the stator front sealing portion contacts a respective adjacent rotor portion of a gas turbine rotor in response to thermal expansion only at the at least one front sealing rib.

[0017] According to an aspect of the invention, there is also provided a gas turbine comprising:

a rotor, having a plurality of rotor stages;
a stator, having a plurality of stator stages alternated with rotor stages in an axial direction;
wherein at least one of the stator stages comprises a plurality of stator vanes as defined above.

[0018] According to an aspect of the invention, the gas turbine comprising a sealing structure between the stator vanes of the at least one of the stator stages and a corresponding adjacent rotor stage, wherein the sealing structure is in part defined by the stator aft sealing portion of the stator vanes.

[0019] According to an aspect of the invention, the sealing structure comprises a rotor sealing portion of one of the rotor stages facing the at least one of the stator stages and the stator aft sealing portion is configured to contact the rotor sealing portion in response to thermal expansion only at the at least one aft sealing rib.

[0020] According to an aspect of the invention, the aft sealing ribs of adjacent stator vanes of the at least one of the stator stages join to one another without discontinuity.

[0021] According to an aspect of the invention, there is also provided a method for modifying a stator vane blade of a gas turbine, the stator vane comprising:

an airfoil, having a leading edge and a trailing edge;
an outer platform, connected to an outer end of the airfoil, and an inner platform, connected to an inner end of the airfoil, wherein the inner platform has a front edge and an aft edge at the leading edge and at the trailing edge of the airfoil, respectively; and
a stator aft sealing portion at the aft edge;
the method comprising forming adjacent aft grooves that extend parallel to each other all along the aft edge in the stator aft sealing portion, whereby adjacent aft grooves delimit at least one aft sealing rib integral with the inner platform and in use the stator aft sealing portion contacts a respective adjacent rotor portion of a rotor of the gas turbine in response

to thermal expansion only at the at least one aft sealing rib.

[0022] The method allows to adapt existing stator vanes to reduce limitations associated with relatively large contact areas between stator and rotor components of sealing systems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The present invention will now be described with reference to the accompanying drawings, which illustrate some non-limitative embodiments thereof, in which:

- figure 1 is a cross-sectional view through a gas turbine engine;
- figure 2 is a side view of a stator vane in accordance to an embodiment of the present invention, included in the gas turbine engine of figure 1;
- figure 3 is an enlarged perspective view of a portion of the stator vane of figure 2;
- figure 4 is an enlarged side cross-sectional view of a first detail of the stator vane of figure 2;
- figure 5 is an enlarged side cross-sectional view of a second detail of the stator vane of figure 2;
- figure 6 is a side cross-sectional view of a detail of a stator vane in accordance with another embodiment of the present invention;
- figure 7 is a side cross-sectional view of a detail of a stator vane in accordance with a further embodiment of the present invention;
- figure 8 is a side cross-sectional view of a detail of a stator vane in accordance with another embodiment of the present invention; and
- figure 9 is a side cross-sectional view of a detail of a stator vane in an intermediate step of a method in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0024] With reference to figure 1, a gas turbine engine in accordance with an embodiment of the present invention is indicated by numeral 1 and comprises a stator 2 and a rotor 3, which is rotatably coupled to the stator 2 about a machine axis A. The stator 2 and the rotor 3 form a compressor section 4 and an expansion or turbine section 5 of the gas turbine engine 1, which further comprises a combustor assembly 7. The combustor assembly 7 may be of annular type, as in the example of figure 1, or may be of can-annular, can or silo type. The compressor section 4 feeds the combustor assembly 7 with an airflow drawn from outside. The combustor assembly 7 mixes air from the compressor section 4 and fuel from a fuel supply system (not shown) to form a mixture which is ignited and burned. The gas turbine engine 1 may be

structured to use different types of fuel, both gaseous and liquid. The turbine section 5 receives and expands a flow of hot gas from the combustor assembly 7 to extract mechanical work, which is transferred to an external user, typically an electric generator, here not shown.

[0025] The stator 2 and the rotor 3 of the gas turbine engine 1 have a plurality of stator stages 8, each including an array of radial stator vanes 11, and rotor stages 10, each including an array of radial rotor blades 12. The stator stages 8 and the rotor stages 10 are alternated in an axial direction of the gas turbine engine 1.

[0026] Figures 2 and 3 shows a stator vane 11 of one of the stator stages 8 in the turbine section 5. It is understood that all the stator vane 11 of the same stator stage 8 have identical structure and features described hereinafter in relation to figure 2 may apply also to the stator vanes 11 of the other stator stages 8 in accordance with design preferences.

[0027] The stator vane 11 comprises an airfoil 13, having a leading edge 13a and a trailing edge 13b, an outer platform 14, connected to an outer end of the airfoil 13, and an inner platform 15, connected to an inner end of the airfoil 13. The outer platform 14 and the inner platform 15 are curved, specifically in the form of respective concentric annular sectors extending about a common axis, which is coincident with the machine axis A, whereas the airfoil 13 extends in a radial direction. Here and in what follows, the terms "inner" and "outer" are to be generally understood in relation to the common axis of the outer platform 14 and of the inner platform 15, i.e. as meaning "closer to" and "farther from" the common axis, respectively.

[0028] The outer platform 14 is connected to a vane carrier (not shown) of the stator 2 and supports the stator vane 11 in a work position.

[0029] The inner platform 15 is configured to join the inner platforms 15 of adjacent stator vanes 11, so that the inner platforms 15 of all the stator vanes 11 in the same stator stage 8 form a ring around the rotor 3 that inwardly delimits a hot gas path and provides mechanical strength.

[0030] The inner platform 15 has a front edge 15a and an aft edge 15b at the leading edge 13a and at the trailing edge 13b of the airfoil 13, respectively.

[0031] As illustrated in figure 4, a sealing structure 16 is formed as an air passage between the inner platforms 15 of the stator vanes 11 of the stator stage 8 considered and the rotor 3, specifically a corresponding adjacent rotor stage 10 in a downstream direction. High-pressure sealing air coming from the compressor section 4 is fed into the hot gas path through the sealing structure 16 and prevents ingestion of hot gas that may cause damage to components not intended and designed to be exposed to high temperature. On the rotor side, the sealing structure 16 is defined by a rotor sealing portion 18 adjacent to the stator vane 11. On the stator side, the sealing structure 16 is defined by a stator aft sealing portion 19 of the inner platform 15 of each of the stator vanes 11. The

sealing structure 16 comprises at least one aft sealing rib 20 formed integrally with the inner platform 15 in the stator aft sealing portion 19, specifically in a region that is expected to first contact the adjacent rotor sealing portion 18 on case of large thermal expansion. The aft sealing rib 20 is delimited by adjacent aft grooves 21 that extend parallel to each other all along the aft edge 15b. Due to the absence of material at the aft grooves 21, in use the stator aft sealing portion 19 may contact the adjacent rotor sealing portion 18 in response to thermal expansion only at the aft sealing rib 20.

[0032] In one embodiment, a thickness of the aft sealing rib 20 is between 0.3 mm and 3 mm and a depth of the aft grooves 21 is between 3 mm and 20 mm. At least a portion of the aft edge 15b is defined by an envelope surface, e.g. a surface of revolution S1 with radius of curvature between 3 mm and 15 mm, and a distal margin of the at least one aft sealing rib 20 lies in the envelope surface. The aft sealing ribs 20 of adjacent stator vanes 11 of the stator stage 8 considered join to one another without discontinuity.

[0033] In one embodiment (figure 5), the inner platform 15 of the stator vane 8 comprises also a stator front sealing portion 24 at the front edge 15a and at least one front sealing rib 25 delimited by adjacent front grooves 26 that extend parallel to each other all along the front edge 15a in the stator front sealing portion 24. In use, the stator front sealing portion 24 contacts a respective adjacent portion of the rotor 3 in response to thermal expansion only at the at least one front sealing rib 25.

[0034] In one embodiment, shown in figure 6, at least a portion of the aft edge 15b is defined by an envelope surface, here again the surface of revolution S1, and a distal margin of the aft sealing rib, here indicated by 20', projects outwards from the envelope surface.

[0035] In one embodiment (figure 7), the envelope surface is a flat surface S2. The distal margin of the aft sealing rib 20 may lie in the envelope surface, as in figure 8, or project outwards therefrom.

[0036] In one embodiment, shown in figure 8, the inner platform 15 comprises a plurality of parallel aft sealing ribs 20" delimited by respective pairs of adjacent aft grooves 21" that extend parallel to each other all along the aft edge 15b in the stator aft sealing portion 19. In use the stator aft sealing portion 19 contacts rotor sealing portion 18 in response to thermal expansion only at the plurality of aft sealing ribs 20".

[0037] The stator vanes in accordance with the invention may be obtained directly by casting or by modifying existing stator vanes. In the latter case, modification is achieved by forming the adjacent aft grooves 21 in the initially solid stator aft sealing portion 19 of the inner platform 15 (see figure 9, dashed lines). The grooves 21 may be formed by any suitable technique, such as machining or electroerosion.

[0038] It is finally apparent that changes and variations may be made to the gas turbine and method described and illustrated without departing from the scope of pro-

tection of the accompanying claims.

Claims

1. A gas turbine stator vane comprising:

an airfoil (13), having a leading edge (13a) and a trailing edge (13b);
an outer platform (14), connected to an outer end of the airfoil (13), and an inner platform (15), connected to an inner end of the airfoil (13), wherein the inner platform (15) has a front edge (15a) and an aft edge (15b) at the leading edge (13a) and at the trailing edge (13b) of the airfoil (13), respectively and comprises:

a stator aft sealing portion (19) at the aft edge (15b); and
at least one aft sealing rib (20; 20'; 20''), integral with the inner platform (15) and delimited by adjacent aft grooves (21; 21'') that extend parallel to each other all along the aft edge (15b) in the stator aft sealing portion (19), whereby in use the stator aft sealing portion (19) contacts a respective adjacent rotor portion of a gas turbine rotor (3) in response to thermal expansion only at the at least one aft sealing rib (20; 20'; 20'').

2. The stator vane according to claim 1, wherein a thickness of the at least one aft sealing rib (20; 20'; 20'') is between 0.3 mm and 3 mm.

3. The stator vane according to claim 1 or 2, wherein a depth of the aft grooves (21; 21'') is between 3 mm and 20 mm.

4. The stator vane according to any one of the preceding claims, wherein at least a portion of the aft edge (15b) is defined by an envelope surface (S1; S2) and a distal margin of the at least one aft sealing rib (20) lies in the envelope surface (S1; S2).

5. The stator vane according to any one of claims 1 to 3, wherein at least a portion of the aft edge (15b) is defined by an envelope surface (S1; S2) and a distal margin of the at least one aft sealing rib (20') projects outwards from the envelope surface (S1; S2).

6. The stator vane according to claim 4 or 5, wherein the envelope surface is a surface of revolution (S1) having a radius of curvature between 3 mm and 15 mm or the envelope surface is a flat surface (S2).

7. The stator vane according to any one of the preceding claims, comprising a plurality of parallel aft sealing ribs (20'') delimited by respective pairs of adja-

cent aft grooves (21'') that extend parallel to each other all along the aft edge (15b) in the stator aft sealing portion (19), whereby in use the stator aft sealing portion (19) contacts an adjacent rotor portion of a gas turbine rotor (3) in response to thermal expansion only at the aft sealing ribs (20'').

8. The stator vane according to any one of the preceding claims, wherein the inner platform (15) comprises:

a stator front sealing portion (24) at the front edge (15a); and
at least one front sealing rib (25) delimited by adjacent front grooves (26) that extend parallel to each other all along the front edge (15a) in the stator front sealing portion (24), whereby in use the stator front sealing portion (24) contacts a respective adjacent rotor portion of a gas turbine rotor (3) in response to thermal expansion only at the at least one front sealing rib (25).

9. A gas turbine comprising:

a rotor (3), having a plurality of rotor stages (10);
a stator (2), having a plurality of stator stages (8) alternated with rotor stages (10) in an axial direction;
wherein at least one of the stator stages (8) comprises a plurality of stator vanes (11) according to any one of claims 1 to 8.

10. The gas turbine according to claim 9, comprising a sealing structure (16) between the stator vanes (11) of the at least one of the stator stages (8) and a corresponding adjacent rotor stage (10), wherein the sealing structure (16) is in part defined by the stator aft sealing portion (19) of the stator vanes (11).

11. The gas turbine according to claim 10, wherein the sealing structure (16) comprises a rotor sealing portion (18) of one of the rotor stages (10) facing the at least one of the stator stages (8) and the stator aft sealing portion (19) is configured to contact the rotor sealing portion (18) in response to thermal expansion only at the at least one aft sealing rib (20; 20'; 20'').

12. The gas turbine according to claim 10 or 11, wherein the aft sealing ribs (20; 20'; 20'') of adjacent stator vanes (11) of the at least one of the stator stages (8) join to one another without discontinuity.

13. A method for modifying a stator vane (11) of a gas turbine, the stator vane (11) comprising:

an airfoil (13), having a leading edge (13a) and a trailing edge (13b);

an outer platform (14), connected to an outer end of the airfoil (13), and an inner platform (15), connected to an inner end of the airfoil (13), wherein the inner platform (15) has a front edge (15a) and an aft edge (15b) at the leading edge (13a) and at the trailing edge (13b) of the airfoil (13), respectively; and
a stator aft sealing portion (19) at the aft edge (15b);
the method comprising forming adjacent aft grooves (21; 21") that extend parallel to each other all along the aft edge (15b) in the stator aft sealing portion (19), whereby adjacent aft grooves (21; 21") delimit at least one aft sealing rib (20; 20'; 20") integral with the inner platform (15) and in use the stator aft sealing portion (19) contacts a respective adjacent rotor portion of a rotor (3) of the gas turbine in response to thermal expansion only at the at least one aft sealing rib (20; 20'; 20").

14. The method according to claim 13, wherein a thickness of the at least one aft sealing rib (20; 20'; 20") is between 0.3 mm and 3 mm.

15. The method according to claim 13 or 14, wherein a depth of the aft grooves (21; 21") is between 3 mm and 20 mm.

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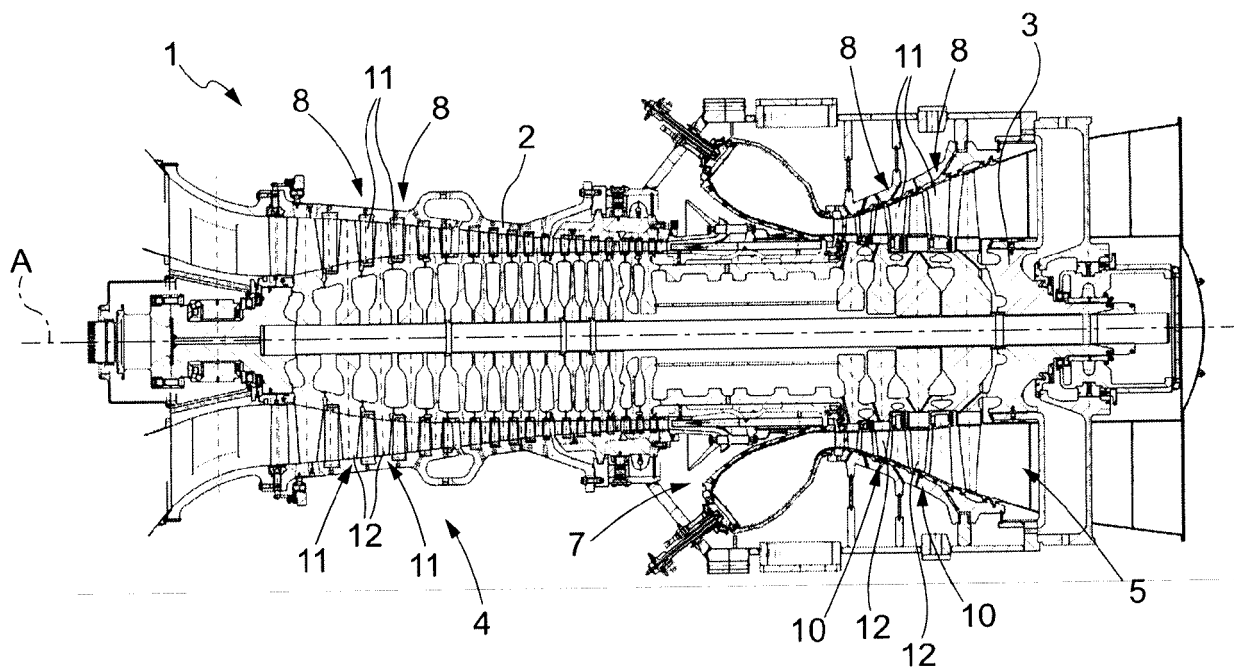


FIG. 1

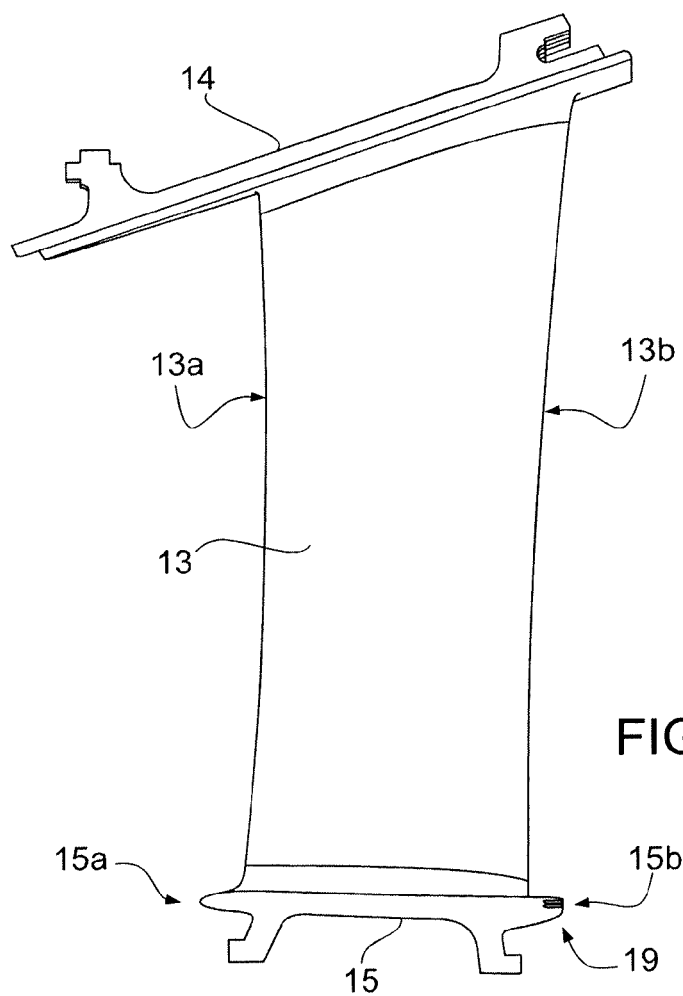


FIG. 2

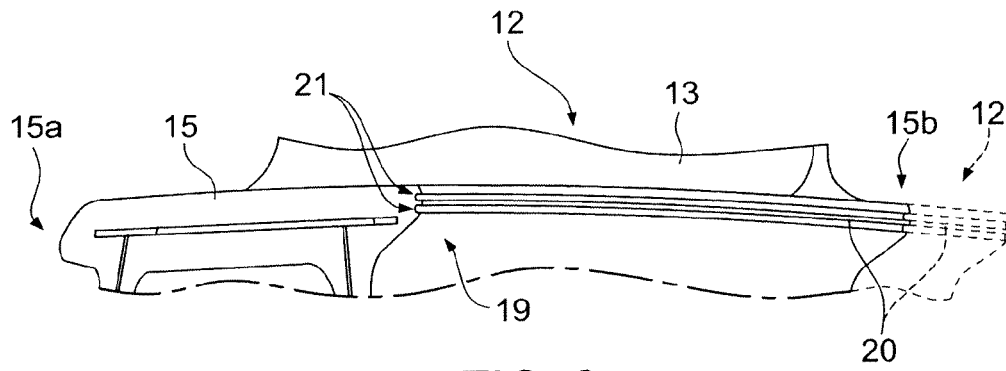


FIG. 3

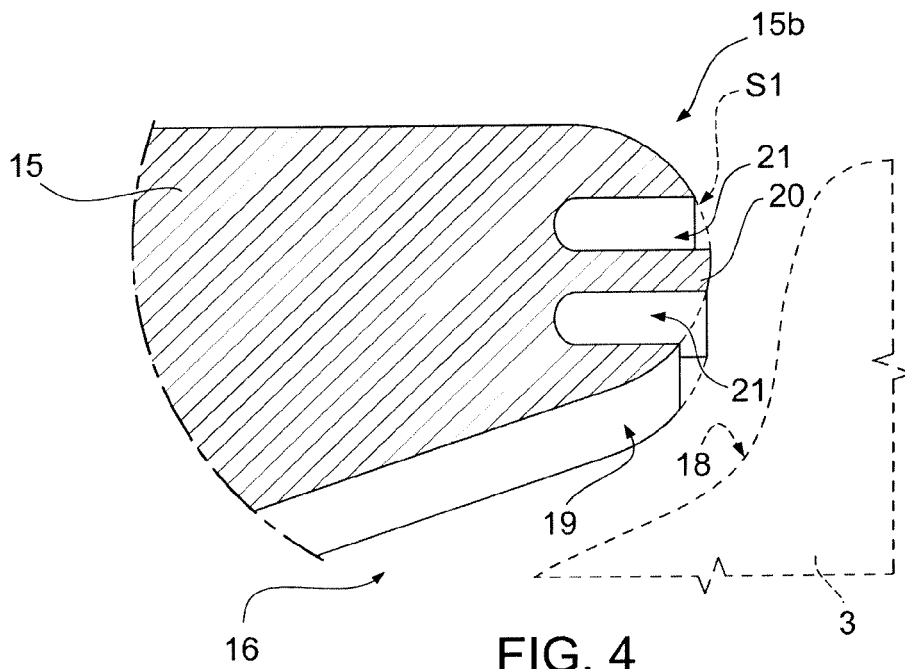


FIG. 4

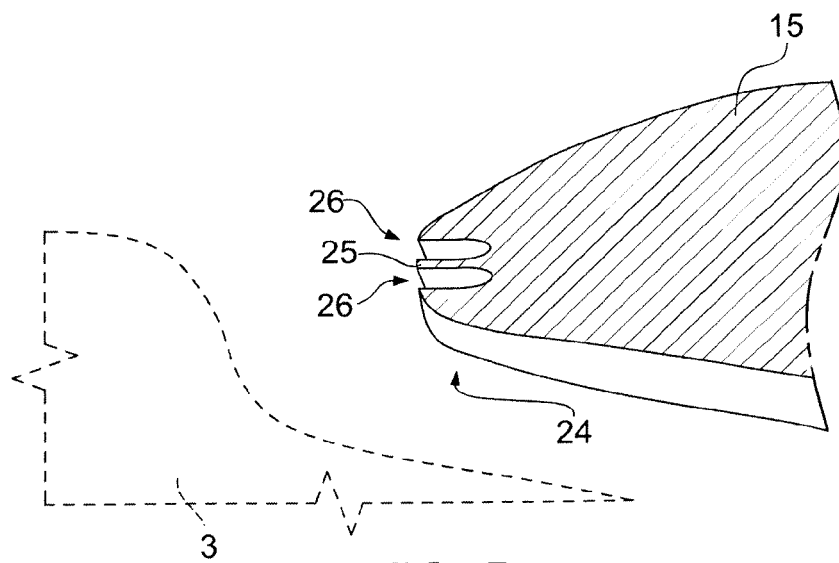


FIG. 5

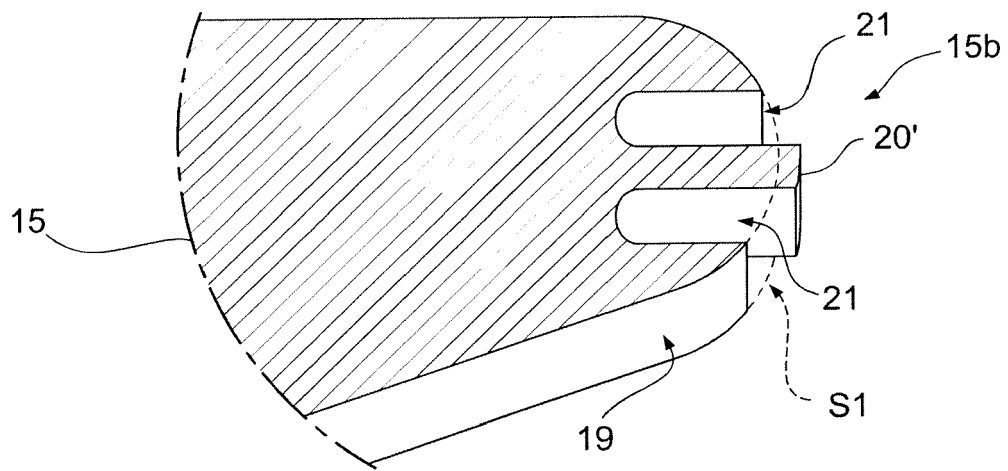


FIG. 6

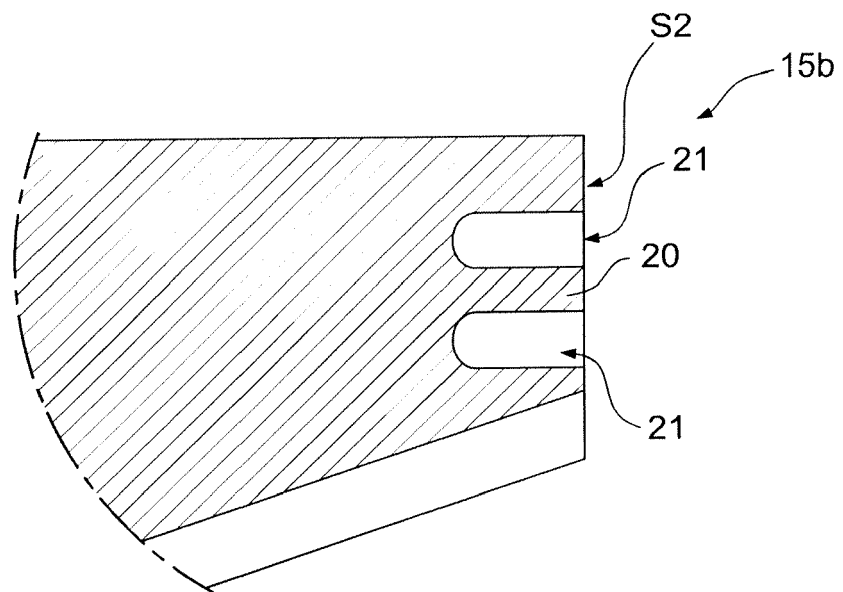


FIG. 7

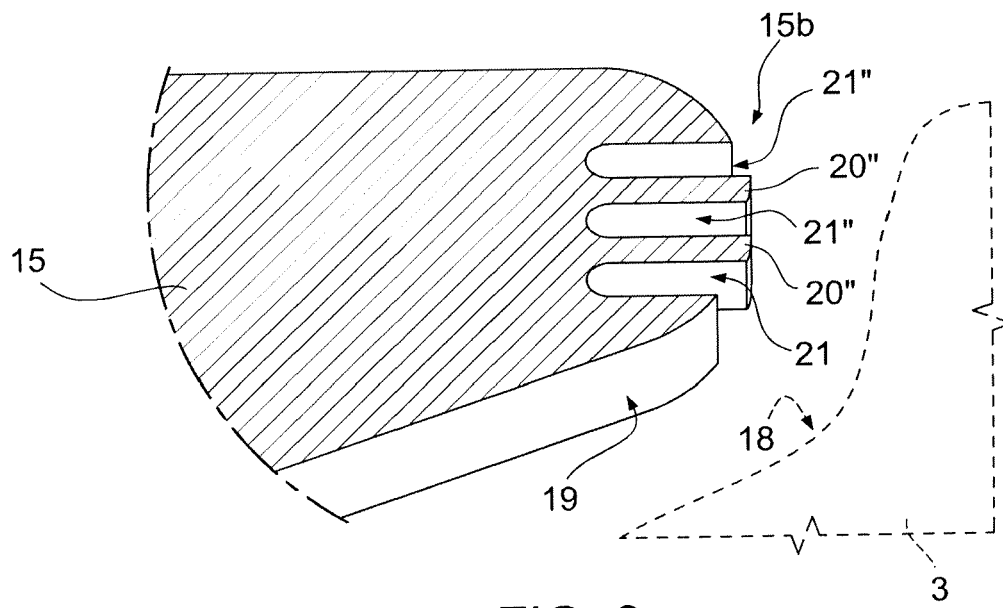


FIG. 8

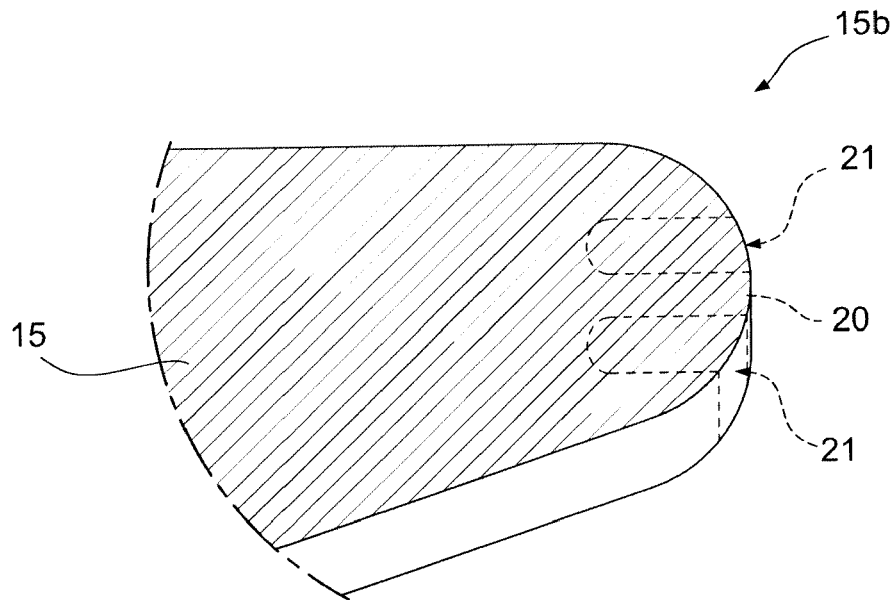


FIG. 9



EUROPEAN SEARCH REPORT

Application Number
EP 20 42 5018

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 42 5018

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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