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(54) **STATOR ASSEMBLY FOR A GAS TURBINE AND GAS TURBINE COMPRISING SAID STATOR ASSEMBLY**

(57) A stator assembly (22) for a gas turbine is provided with a stator ring (24), which extends about a longitudinal axis (A) and comprises an outer edge (29) provided with an annular groove (30); the annular groove (30) defining a leading wall (34) and a trailing wall (35); the leading wall (34) being provided with an annular leading radial face (56) and with an annular leading axial face (57); and with a plurality of stator vanes (25) radially arranged and coupled alongside one another to the outer edge (29) of the stator ring (24) so as to close the annular groove (30) and define an annular cooling channel (32); each stator vane (25) comprises an airfoil (38), an outer shroud (39) and an inner shroud (40) coupled to the stator ring (24); the inner shroud (40) comprising a platform (42), a leading flange (43) and a trailing flange (44) extending radially inward from the platform (42); the leading flange (43) being coupled to the leading wall (34) and the trailing flange (44) being coupled to the trailing wall (35); the leading flange (43) being coupled to the leading wall (34) so as to leave a primary radial gap (48) between the leading wall (34) and the platform (42) and define a leading surface (50) of the leading flange (43); the platform (42) having a leading border (54a) and a trailing border (54b), both extending circumferentially; the leading border (54a) comprising at least one first surface (61) facing the primary radial gap (48); the first surface (61) being curved.

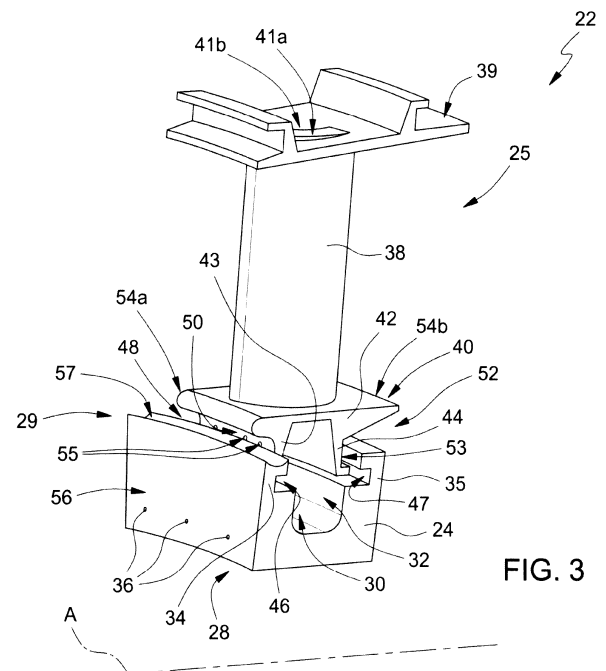


FIG. 3

Description

TECHNICAL FIELD

[0001] The present invention relates to a stator assembly for a gas turbine and to a gas turbine comprising said stator assembly. In particular, the gas turbine of the present invention is part of a plant for the production of electrical energy.

BACKGROUND

[0002] As is known, a gas turbine for power plants comprises a compressor, a combustor and a turbine.

[0003] In particular, the compressor comprises an inlet supplied with air and a plurality of rotating blades compressing the passing air. The compressed air leaving the compressor flows into a plenum, i.e. a closed volume delimited by an outer casing, and from there into the combustor. Inside the combustor, the compressed air is mixed with at least one fuel and combusted. The resulting hot gas leaves the combustor and expands in the turbine. In the turbine the hot gas expansion moves rotating blades connected to a rotor, performing work.

[0004] Both the compressor and the turbine comprise a plurality of stator assemblies axially interposed between rotor assemblies.

[0005] Each rotor assembly comprises a rotor disk rotating about a main axis and a plurality of blades supported by the rotor disk.

[0006] Each stator assembly comprises a plurality of stator vanes supported by a respective vane carrier and a stator ring arranged about the rotor.

[0007] A plurality of inter-assembly cavities are defined between the stator assemblies and the rotor assemblies.

[0008] In the turbine, sealing air is normally bled from the compressor and introduced in said inter-assembly cavities in order to avoid or limit the hot gas ingestion from the hot gas path in the inter-assemblies cavities.

[0009] The minimization of the amount of air spent to seal and cool the inter-assembly cavities is beneficial to the power plant performance. However, said minimization implies the use of expensive advanced materials and/or the adoption of arrangements having a very complex geometry.

SUMMARY

[0010] The object of the present invention is therefore to provide a stator assembly for a gas turbine, which enables avoiding or at least mitigating the described drawbacks.

[0011] In particular, it is an object of the present invention to provide a stator assembly having an improved structure able to minimize the amount of sealing air and guaranteeing, at the same time, a sufficient protection from thermal damages.

[0012] According to said objects the present invention

relates to a stator assembly for a gas turbine comprising:

a stator ring, which extends about a longitudinal axis and comprises an outer edge provided with an annular groove; the annular groove defining a leading wall and a trailing wall; the leading wall being provided with an annular leading radial face and with an annular leading axial face;

a plurality of stator vanes radially arranged and coupled alongside one another to the outer edge of the stator ring so as to close the annular groove and define an annular cooling channel; each stator vane comprises an airfoil, an outer shroud and an inner shroud coupled to the stator ring; the inner shroud comprising a platform, a leading flange and a trailing flange extending radially inward from the platform; the leading flange being coupled to the leading wall and the trailing flange being coupled to the trailing wall; the leading flange being coupled to the leading wall so as to leave a primary radial gap between the leading wall and the platform and define a leading surface of the leading flange; the platform having a leading border and a trailing border, both extending circumferentially; the leading border comprising at least one first surface facing the primary radial gap; the first surface being curved.

[0013] Advantageously the curved shape of the surface of the leading border facing the primary radial gap deflects the hot gas ingested flow into a confined area: the primary radial gap, where the gas ingested flow can be cooled, managed and washed out again.

[0014] Traditional thin platform leading border, on the contrary, generates a flow separation on the ingested flow that directs hot gases radially down to the bottom part of the leading inter-assembly cavity, with dangerous results for both stator and rotor sides.

[0015] The ingestion of hot gas can therefore be accepted, purged and deflected away. This leads to less overall consumption of sealing air therefore improving the engine global performance and the thermal status and integrity of the components of the stator assembly.

[0016] In other words, instead of completely avoiding hot gas ingestion by using high flow rate of sealing air, the present invention allows to confine hot gas inlet in the upper part of the inter-assembly cavity.

[0017] According to an embodiment of the present invention, the first surface is convex and is curved with a first radius of curvature.

[0018] According to an embodiment of the present invention, the radius of curvature of the surface is comprised between the 10% and 50% of the distance between the outer axial surface of the platform and the lower point of the annular leading axial face.

[0019] According to an embodiment of the present invention, the leading border comprises a second surface facing the airfoil, which is curved.

[0020] According to an embodiment of the present in-

vention, the second surface is convex and is curved with a second radius of curvature.

[0021] According to an embodiment of the present invention, the stator assembly comprises a connecting surface, which connects the platform and the leading surface; the connecting surface being concave with a third radius of curvature.

[0022] In this way, the hot gas ingested is forced to recirculate inside the primary radial gap creating a vortex.

[0023] According to an embodiment of the present invention, the annular leading axial face of the leading wall is concave with a fourth radius of curvature.

[0024] According to an embodiment of the present invention, the leading flange is provided on the leading surface with at least one primary cooling hole in fluid communication with the annular cooling channel.

[0025] The presence of at least primary cooling hole in the leading flange improves the thermal status of the upper part of the inter-assembly leading cavity. In particular, the primary cooling hole improves the thermal status of the annular leading axial face of the leading wall, which is normally made of a material having poorer properties as compared to the vane.

[0026] Instead of providing a lot of air as usually done in the prior art solutions, cooling air is provided where it is more needed.

[0027] According to an embodiment of the present invention, the leading flange is provided with a plurality of primary cooling holes circumferentially aligned, which are preferably evenly distributed.

[0028] According to an embodiment of the present invention, the primary cooling hole extends along a primary extension axis; on a longitudinal axial plane defined by the longitudinal axis and a radial direction orthogonal to the longitudinal axis and intersecting the primary extension axis, a first angle defined by the projection of the primary extension axis on the longitudinal axial plane and the radial direction is comprised between 70° and 110°.

[0029] According to an embodiment of the present invention, the primary cooling hole extends along a primary extension axis; on a circumferential plane defined by the longitudinal axis and a circumferential direction, which is orthogonal to the longitudinal axis and orthogonal to a radial direction in turn orthogonal to the longitudinal axis, a second angle is defined by the projection of the primary extension axis on the circumferential plane and the axial direction is comprised between 100° and 200°.

[0030] It is also an object of the present invention to provide a gas turbine which is reliable and wherein the consumption of sealing air is reduced. According to said objects the present invention relates to a gas turbine as claimed in claim 15.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] The present invention will now be described with reference to the accompanying drawings, which illustrate some non-limitative embodiment, in which:

- Figure 1 is a schematic sectional front view, with parts removed for clarity, of a gas turbine electric power plant according to the present invention;
- Figure 2 is a schematic sectional front view, with parts removed for clarity, of a first detail of Figure 1;
- Figure 3 is a schematic perspective view, with parts in section and parts removed for clarity, of a second detail of Figure 1;
- Figure 4 is a schematic sectional lateral view, with parts removed for clarity, of a third detail of Figure 1;
- Figure 5 is a schematic up view, with parts in section and parts removed for clarity, of the detail of Figure 4;
- Figure 6 is a schematic sectional lateral view, with parts removed for clarity, of the detail of figure 4.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0032] In figure 1 reference numeral 1 indicates a gas turbine electric power plant (schematically shown in Figure 1).

[0033] The plant 1 comprises a compressor 3, a combustion chamber 4, a gas turbine 5 and a generator (for simplicity, not shown in the attached figures).

[0034] The compressor 3, turbine 5 and generator (not shown) are mounted on the same shaft to form a rotor 8, which is housed in stator casings 9 and extends along an axis A.

[0035] In greater detail, the rotor 8 comprises a front shaft 10, a plurality of rotor assemblies 11 and a rear shaft 13.

[0036] Each rotor assembly 11 comprises a rotor disk 15 and a plurality of rotor blades 16 coupled to the rotor disk 15 and radially arranged.

[0037] The plurality of rotor disks 15 are arranged in succession between the front shaft 10 and the rear shaft 13 and preferably clamped as a pack by a central tie rod 14. As an alternative, the rotor disks may be welded together.

[0038] A central shaft 17 separates the rotor disks 15 of the compressor 3 from the rotor disks 15 of the turbine 5 and extends through the combustion chamber 4.

[0039] Further, stator assemblies 22 are alternated with the compressor rotor assemblies 11.

[0040] Each stator assembly 22 comprises a stator ring 24 and a plurality of stator vanes 25, which are radially arranged and coupled to the stator ring 24 and to the respective stator casing 9.

[0041] In figure 2 an enlarged view of a stator assembly 22 between two rotor assemblies 11 in the turbine 5 is shown.

[0042] Arrow D indicates the direction of the hot gas flow flowing in a hot gas channel 18 of the turbine 5.

[0043] Between the rotor assemblies 11 and the stator assembly 22 inter-assembly cavities 27 are arranged.

[0044] In particular, each stator assembly 22 defines a leading inter-assembly cavity 27a and a trailing inter-assembly cavity 27b, wherein the leading inter-assembly

cavity 27a is upstream the trailing inter-assembly cavity 27b along the hot gas flow direction D.

[0045] With reference to figure 3 and figure 4, the stator ring 24 (only a part of which is visible in figures 3 and 4) extends about the longitudinal axis A and comprises an inner edge 28 and an outer edge 29, which is provided with an annular groove 30.

[0046] The plurality of stator vanes 25 are coupled alongside one another to the outer edge 29 of the stator ring 24 so as to close the annular groove 30 and define an annular cooling channel 32.

[0047] The annular cooling channel 32 is fed with air preferably coming from the compressor 3.

[0048] The annular groove 30 defines a leading wall 34 and a trailing wall 35. The leading wall 34 is upstream the trailing wall 35 along the hot gas flow direction D.

[0049] Preferably, the leading wall 34 is provided with a plurality of cooling openings 36 in fluidic communication with the annular cooling channel 32.

[0050] Preferably, the cooling openings 36 are arranged in the proximity of the inner edge 28.

[0051] In the non-limiting example here disclosed and illustrated, the cooling openings 36 are circumferentially aligned and evenly distributed.

[0052] According to a variant not illustrated, also the trailing wall is provided with the cooling openings in fluidic communication with the annular cooling channel.

[0053] Each stator vane 25 comprises an airfoil 38, an outer shroud 39 and an inner shroud 40 coupled to the stator ring 24.

[0054] The airfoil 38 is provided with a cooling air duct 41a fed by a dedicated opening 41b on the outer shroud 39.

[0055] The outer shroud 39 is coupled to the respective stator casing 9.

[0056] The inner shroud 40 comprises a platform 42, a leading flange 43 and a trailing flange 44 extending radially inward from the platform 42. The leading flange 43 is upstream the trailing flange 44 along the hot gas flow direction D.

[0057] The leading flange 43 is coupled to the leading wall 34, while the trailing flange 44 is coupled to the trailing wall 35. In the non-limiting example here disclosed and illustrated, the leading flange 43 engages a respective annular seat 46 of the leading wall 34, while the trailing flange 44 engages a respective annular seat 47 of the trailing wall 35.

[0058] In particular, the leading flange 43 is coupled to the leading wall 34 so as to leave a primary radial gap 48 between the leading wall 34 and the platform 42 and to define a leading surface 50 of the leading flange 43 facing said primary radial gap 48.

[0059] Preferably, also the trailing flange 44 is coupled to the trailing wall 35 so as to leave a secondary radial gap 52 between the trailing wall 35 and the platform 42 and to define a trailing surface 53 of the trailing flange 44 facing said secondary radial gap 52.

[0060] The platform 42 comprises a leading border 54a

and a trailing border 54b extending circumferentially. The leading border 54a is upstream the trailing border 54b along the hot gas flow direction D.

[0061] The leading flange 43 is provided, on the leading surface 50, with at least one primary cooling hole 55 in fluid communication with the annular cooling channel 32.

[0062] Preferably, the leading flange 43 is provided, on the leading surface 50, with a plurality of primary cooling holes 55 circumferentially aligned.

[0063] In the non-limiting example here disclosed and illustrated, the primary cooling holes 55 are evenly distributed.

[0064] With reference to figure 5 and figure 6, each primary cooling hole 55 extends along a primary extension axis Op.

[0065] With reference to figure 6, on a longitudinal axial plane defined by the longitudinal axis A and a radial direction orthogonal to the longitudinal axis A and intersecting the primary extension axis Op, an angle α is defined by the projection of the primary extension axis Op on the longitudinal axial plane A-R and the radial direction R. The angle α is measured from the radial direction R to the projection of the primary extension axis Op in accordance with the hot gas flow direction D. Preferably the angle α of the primary cooling holes 55 is comprised between 70° and 110°.

[0066] With reference to figure 5 on a tangential plane defined by the longitudinal axis A and a circumferential direction C, which is orthogonal to the longitudinal axis A and orthogonal to the radial direction R (in turn orthogonal to the longitudinal axis A), an angle θ is defined by the projection of the primary extension axis Op on the circumferential plane A-C and the axial direction A.

[0067] The angle θ is measured from the axial direction A to the projection of the primary extension axis Op on the tangential plane A-C in a clockwise direction looking radially inward. Preferably, the angle θ is comprised between 100° and 200°.

[0068] Preferably, the primary cooling holes 55 have different angles α and/or different angles θ .

[0069] According to a variant, primary cooling holes can be substantially identical to each other.

[0070] With reference to figure 3, 4 and 6, the leading wall 34 is provided with an annular leading radial face 56 and with an annular leading axial face 57.

[0071] Preferably, the annular leading axial face 57 of the leading wall 34 is concave with radius of curvature r4.

[0072] With particular reference to figure 6, the leading border 54a comprises at least one surface 61 facing the primary radial gap 48 and at least one surface 60 facing the air words, the surface 61 faces, in use, the leading inter-assembly cavity 27a and the surface 60 faces the hot gas channel 18.

[0073] Preferably, the surface 60 and the surface 61 are curved.

[0074] Preferably, surface 60 and surface 61 are contiguous.

[0075] Preferably, the surface 60 has a radius of curvature r_1 and is convex.

[0076] Preferably, the surface 61 has a radius of curvature r_2 and is convex too.

[0077] The stator assembly 22 comprises also a connecting surface 65, which connects the platform 42 and the leading surface 50. Preferably, the connecting surface 65 is concave with a third radius of curvature r_3 .

[0078] According to a variant not illustrated, the connecting surface is not rounded and has a triangular section along the longitudinal axial plane.

[0079] Preferably, the radius of curvature r_1 of the surface 60 is comprised between the 5% and 40% of the distance h between the outer axial surface 59 of the platform and the lower point T of the annular leading axial face 57.

[0080] Preferably, the radius of curvature r_2 of the surface 61 is comprised between the 10% and 50% of the distance h between the outer axial surface 59 of the platform and the lower point T of the annular leading axial face 57.

[0081] Preferably, the radius of curvature r_3 of the connecting surface 65 is comprised between the 20% and 40% of the distance h between the outer axial surface 59 of the platform and the lower point T of the annular leading axial face 57.

[0082] Preferably, the radius of curvature r_4 of the annular leading axial face 57 is comprised between the 45% and 60% of the distance h between the outer axial surface 59 of the platform and the lower point T of the annular leading axial face 57.

[0083] Preferably the axial distance s between the outermost point P of the leading border 54a and the outermost point Q of the annular leading axial face 57 is comprised between - 50% and +50% of the axial length L of the leading inter-assembly cavity 27a (figure 2).

[0084] Preferably the leading surface 50 has a planar and radially arranged portion arranged radially inward. While the portion of the leading surface 50 arranged radially outward the primary cooling holes 55 and connected to the connecting surface 65 is tangential to the connecting surface 65.

[0085] In use, the hot gas flowing in the hot gas channel 18 is ingested in the leading and flows in to the primary radial gap 48. In particular, the hot gas ingested flow is first deflected by the leading border 54a, then is forced to recirculate inside the primary radial gap 48 creating a vortex.

[0086] The primary cooling holes 55 cool the hot gas ingested flow and push it back outside the inter-assembly cavity 27a, by energizing the vortex recirculation and exploiting the pumping effect on the rotor side. Secondary cooling openings 36 on the leading wall 34 provide also a film-cooling effect on the upper edge of the stator ring 24.

[0087] Finally, it is clear that modifications and variants can be made to the stator assembly and to the gas turbine described herein without departing from the scope of the

present invention, as defined in the appended claims.

Claims

1. Stator assembly (22) for a gas turbine comprising:
 - a stator ring (24), which extends about a longitudinal axis (A) and comprises an outer edge (29) provided with an annular groove (30); the annular groove (30) defining a leading wall (34) and a trailing wall (35); the leading wall (34) being provided with an annular leading radial face (56) and with an annular leading axial face (57); a plurality of stator vanes (25) radially arranged and coupled alongside one another to the outer edge (29) of the stator ring (24) so as to close the annular groove (30) and define an annular cooling channel (32); each stator vane (25) comprises an airfoil (38), an outer shroud (39) and an inner shroud (40) coupled to the stator ring (24); the inner shroud (40) comprising a platform (42), a leading flange (43) and a trailing flange (44) extending radially inward from the platform (42); the leading flange (43) being coupled to the leading wall (34) and the trailing flange (44) being coupled to the trailing wall (35); the leading flange (43) being coupled to the leading wall (34) so as to leave a primary radial gap (48) between the leading wall (34) and the platform (42) and define a leading surface (50) of the leading flange (43); the platform (42) having a leading border (54a) and a trailing border (54b), both extending circumferentially; the leading border (54a) comprising at least one first surface (61) facing the primary radial gap (48); the first surface (61) being curved.
2. Stator according to claim 1, wherein the first surface (61) is convex.
3. Stator assembly according to claim 2, wherein the first surface (61) is curved with a first radius of curvature (r_2).
4. Stator assembly according to claim 3, wherein the radius of curvature (r_2) of the surface (61) is comprised between the 10% and 50% of the distance (h) between the outer axial surface (59) of the platform and the lower point (T) of the annular leading axial face (57).
5. Stator assembly according to anyone of the foregoing claims, wherein the leading border (54a) comprises a second surface (60) facing the airfoil (18), which is curved.
6. Stator according to claim 5, wherein the second sur-

face (60) is convex.

7. Stator assembly according to claim 6, wherein the second surface (60) is curved with a second radius of curvature (r1). 5
8. Stator assembly according to anyone of the foregoing claims, comprising a connecting surface (65), which connects the platform (42) and the leading surface (50); the connecting surface (65) being concave with a third radius of curvature (r3) . 10
9. Stator assembly according to anyone of the foregoing claims, wherein the annular leading axial face (57) of the leading wall (34) is concave with a fourth radius of curvature (r4) . 15
10. Stator assembly according to anyone of the foregoing claims, wherein the leading flange (43) is provided on the leading surface (50) with at least one primary cooling hole (55) in fluid communication with the annular cooling channel (32) . 20
11. Stator assembly according to anyone of the foregoing claims, wherein the leading flange (43) is provided on the leading surface (50) with a plurality of primary cooling holes (55) circumferentially aligned. 25
12. Stator assembly according to claim 11, wherein the primary cooling holes (55) are evenly distributed. 30
13. Stator assembly according to anyone of the foregoing claims, wherein the primary cooling hole (55) extends along a primary extension axis (Op); on a longitudinal axial plane (A-R) defined by the longitudinal axis (A) and a radial direction (R) orthogonal to the longitudinal axis (A) and intersecting the primary extension axis (Op) , a first angle (α) defined by the projection of the primary extension axis (Op) on the longitudinal axial plane (A-R) and the radial direction (R) is comprised between 70° and 110°. 35 40
14. Stator assembly according to anyone of the foregoing claims, wherein the primary cooling hole (55) extends along a primary extension axis (Op); on a circumferential plane defined by the longitudinal axis (A) and a circumferential direction (C) , which is orthogonal to the longitudinal axis (A) and orthogonal to a radial direction (R) in turn orthogonal to the longitudinal axis (A), a second angle (θ) is defined by the projection of the primary extension axis (Op) on the circumferential plane and the axial direction (A) is comprised between 100° and 200°. 45 50
15. Gas turbine extending along a longitudinal axis (A) and comprising: 55

a plurality of rotor assemblies (11), each of which

comprises a rotor disk (15) and a plurality of rotor blades (16) radially arranged and coupled to the rotor disk (15);
a plurality of stator assemblies (22); the stator assemblies (22) and the rotor assemblies (11) are alternated along the axial direction (A);
at least one of the stator assemblies (22) being of the type claimed in anyone of the foregoing claims.

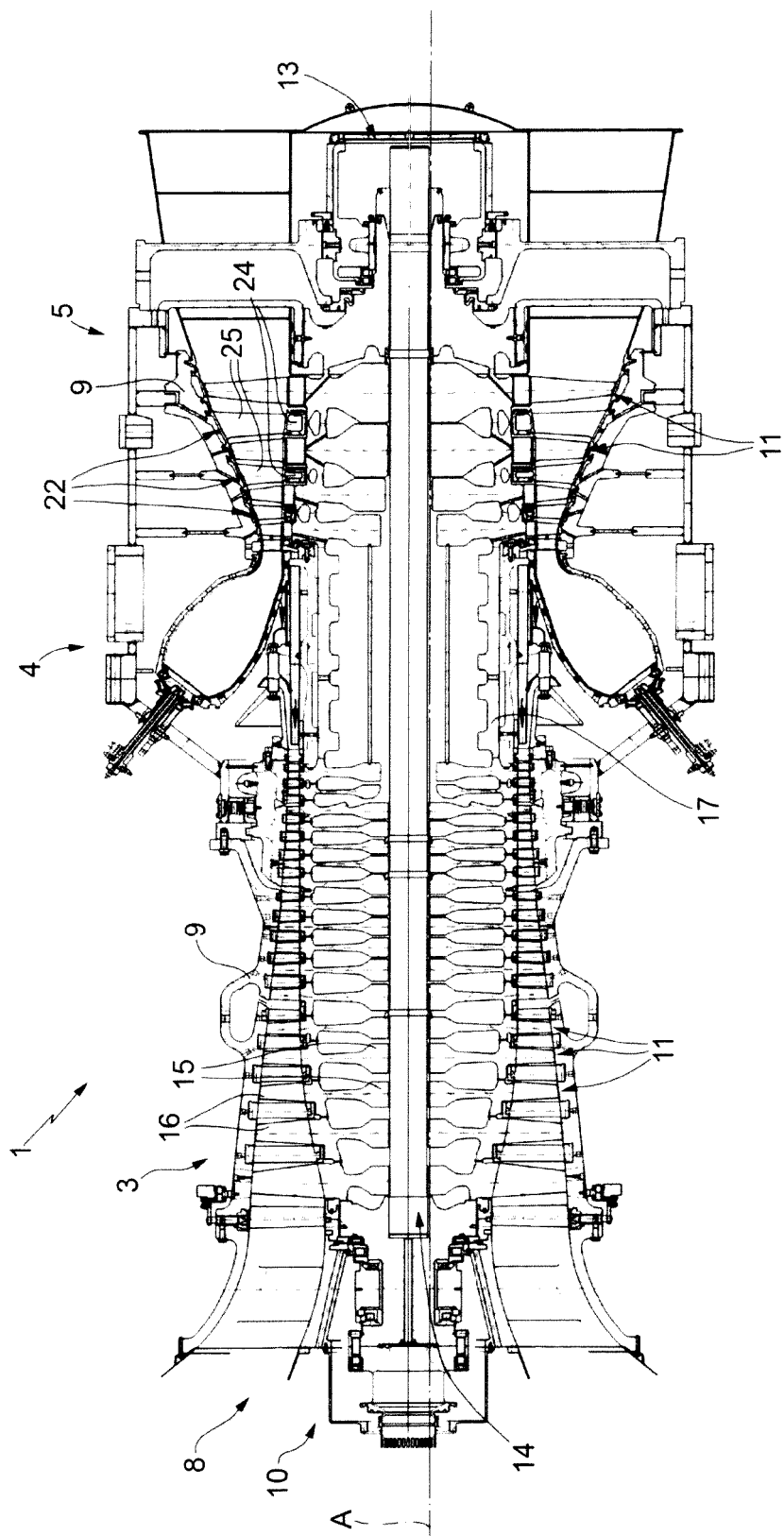
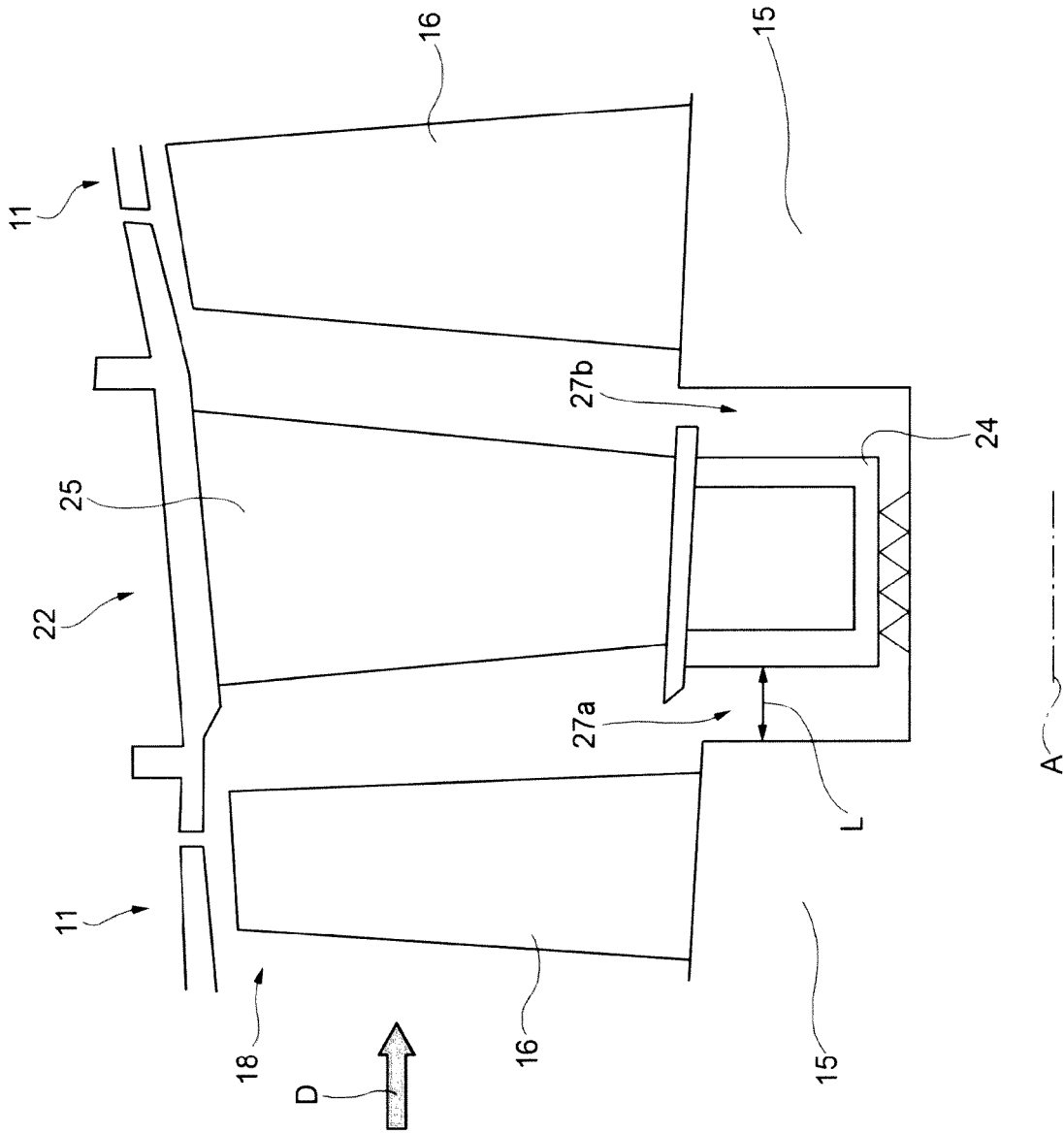
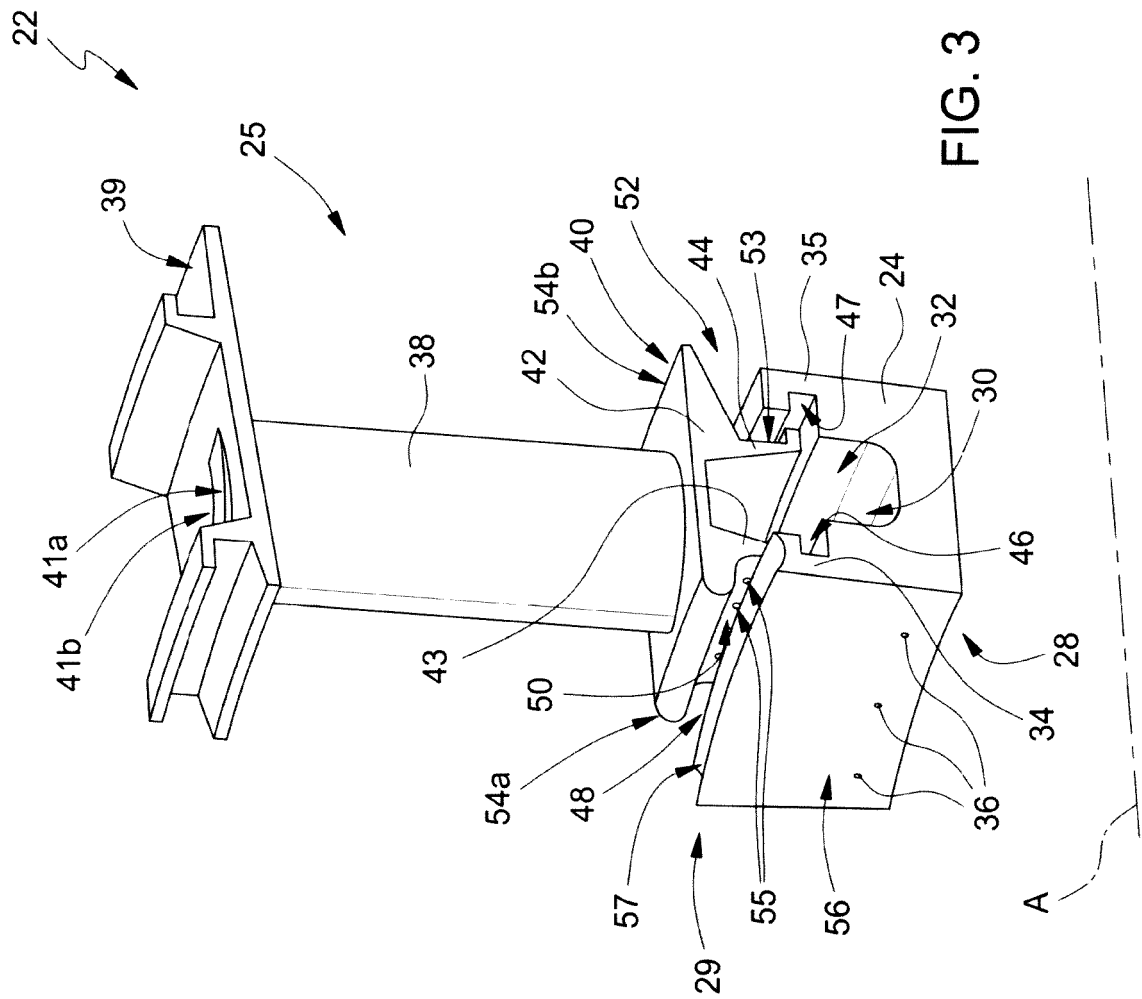


FIG. 1





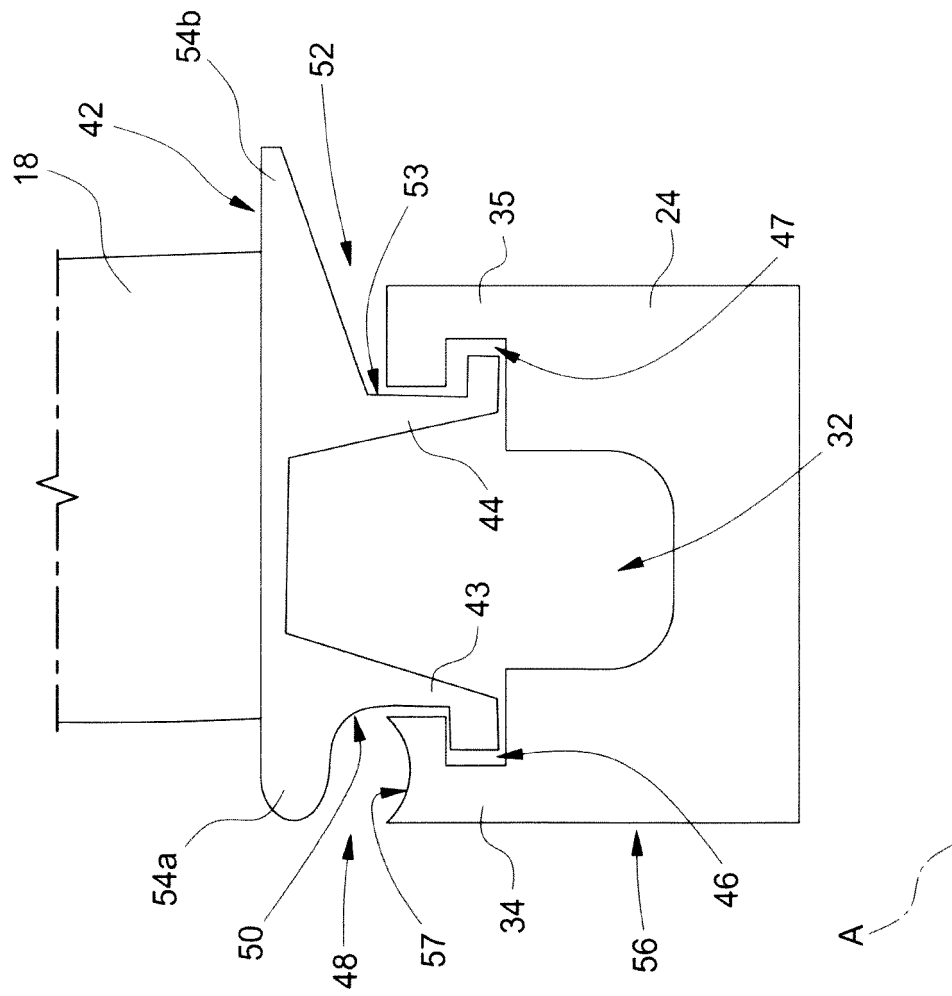


FIG. 4

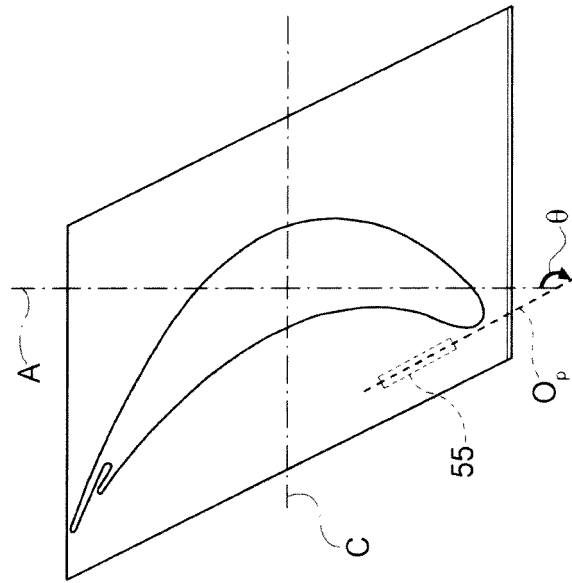


FIG. 5

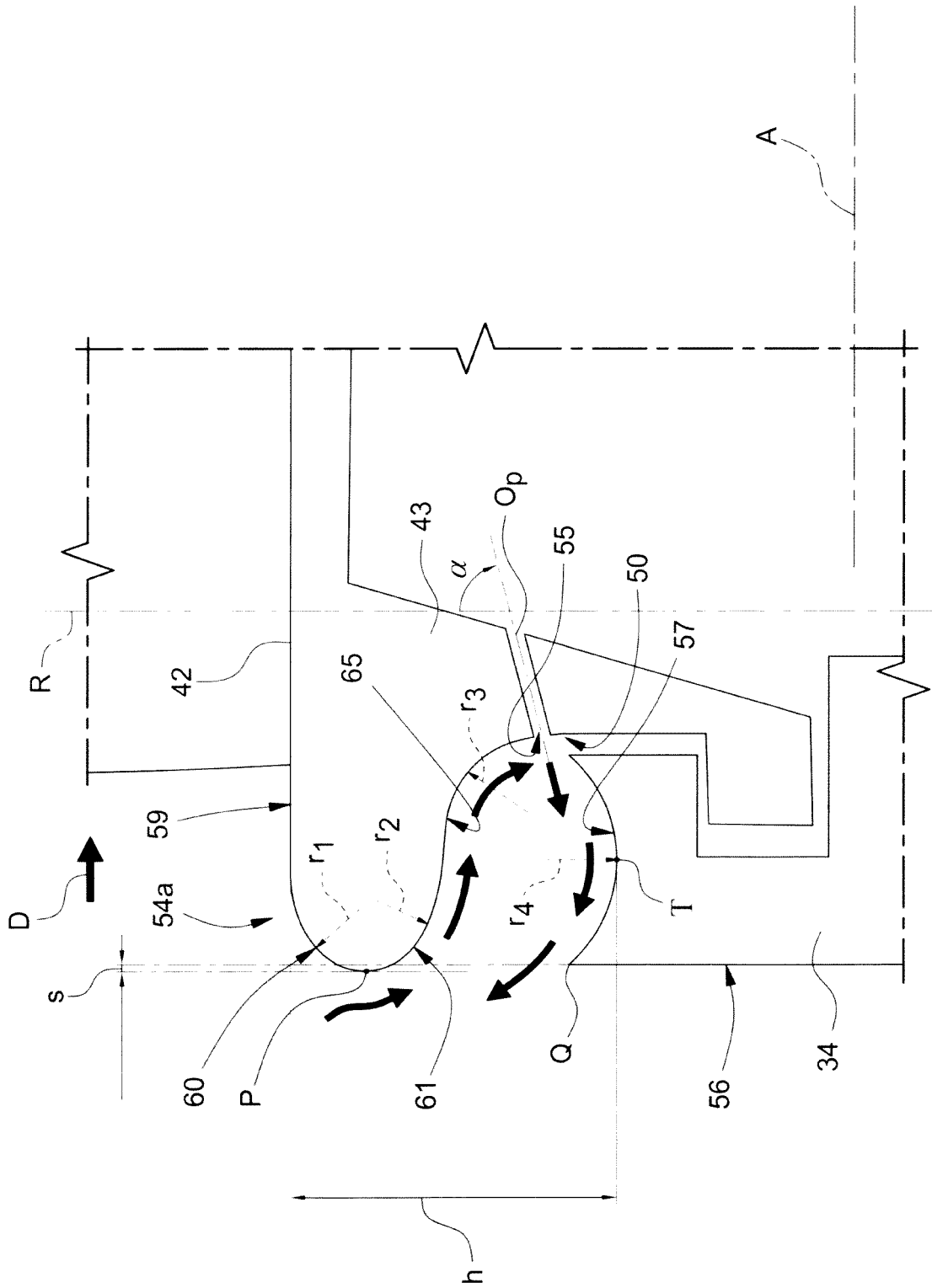


FIG. 6



EUROPEAN SEARCH REPORT

Application Number
EP 19 42 5078

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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)
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A	----- US 2010/008760 A1 (MORRIS MARK C [US] ET AL) 14 January 2010 (2010-01-14) * paragraph [0022] - paragraph [0031]; figures 1, 2 *	10-14	TECHNICAL FIELDS SEARCHED (IPC)
			F01D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 April 2020	Examiner Georgi, Jan
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EP 19 42 5078

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20-04-2020

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