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(54) GAS TURBINE ASSEMBLY AND METHOD FOR OPERATING SAID GAS TURBINE ASSEMBLY

(57) A gas turbine assembly extending along a longitudinal axis (A) comprises:
a stator (6) defining a working channel (8, 9);
a rotor (11) comprising a plurality of rotor stages (13);
each rotor stage (13) comprising a plurality of blades (17) rotatable in the working channel (8, 9) about the longitudinal axis (A);
each blade (17) being provided with a tip (29);
at least one movable element (30) which is coupled to the stator (6) by means of at least one retaining device (32) and moves radially between the stator (6) and at least one tip (29) of the blades (17) for regulating a clearance gap (33) between the at least one tip (29) and the movable element (30);
wherein the movable element (30) is coupled to the stator (6) by means of a retaining device (32) so as to create a regulating gap (35) between the stator (6) and the movable element (30) which is in fluidic communication with the working channel (8, 9); the movable element (30) being provided with at least one first sealing element (37) dividing the regulating gap (35) in at least two chambers (38); one first chamber (38a) of the at least two chambers (38) being in fluidic communication with the working channel (8, 9) upstream the rotor stage (13) and one second chamber (38b) of the at least two chambers (38) being in fluidic communication with the working channel (8, 9) downstream the rotor stage (13).

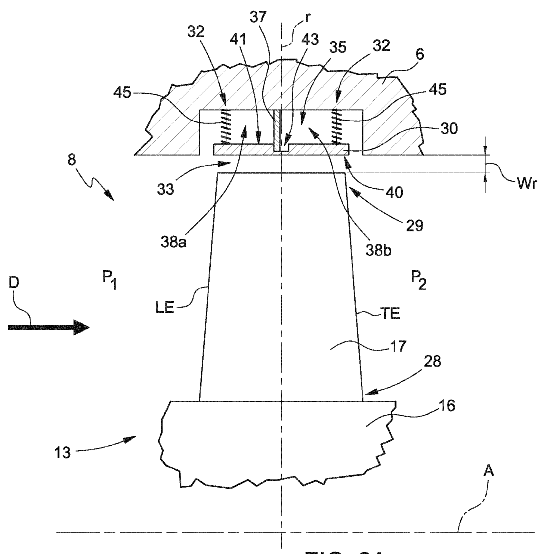

FIG. 2A

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Description

TECHNICAL FIELD

[0001] The present invention relates to a gas turbine assembly and to a method for operating said gas turbine assembly. In particular, the gas turbine assembly of the present invention can be part of a plant for the production of electrical energy.

BACKGROUND

[0002] As is known, a gas turbine assembly 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 then the fuel is 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 stator assembly comprises a plurality of stator vanes supported by a respective stator structure (casing or carrier) and a stator ring arranged about the rotor.

[0006] Each rotor assembly comprises a rotor disk rotating about a main axis and a plurality of blades supported by the rotor disk.

[0007] During rotation, the tips of the blades are spaced from the stator. However, said spacing can change due to thermal expansions and mechanical backlashes depending on the operational conditions of the gas turbine assembly.

[0008] It is therefore necessary to properly control the dimensions of said gap in order to avoid an excessive spacing between the tips of the blades and the stator or a dangerous excessive reduction of the gap that may lead to a contact between the tips and the stator.

[0009] A proper control of the gap between the tip of the blades and the stator improves the reliability and the efficiency of the gas turbine assembly.

SUMMARY

[0010] The object of the present invention is therefore to provide a gas turbine assembly, wherein the gap between the tip of the blades and the stator is controlled in a simple and reliable way.

[0011] In particular, it is an object of the present invention to provide a gas turbine assembly extending along a longitudinal axis and comprising:

- a stator defining a working channel;
- a rotor comprising a plurality of rotor stages; each rotor stage comprising a plurality of blades rotatable in the working channel about the longitudinal axis; each blade being provided with a tip;
- at least one movable element which is coupled to the stator by means of at least one retaining device and moves radially between the stator and at least one tip of the blades for regulating a clearance gap between the at least one tip and the movable element;
- wherein the movable element is coupled to the stator so as to create a regulating gap between the stator and the movable element, which is in fluidic communication with the working channel; the movable element being provided with at least one first sealing element dividing the regulating gap in at least two chambers; one first chamber of the at least two chambers being in fluidic communication with the working channel upstream the rotor stage and one second chamber of the at least two chambers being in fluidic communication with the working channel downstream the rotor stage.

Thanks to presence of the first sealing element, the resulting force acting on the movable element is regulated by the pressures in the chambers of the regulating gap and by the pressures in the clearance gap.

The pressures in the chambers of the regulating gap are strictly linked to the pressures upstream and downstream of the rotor stage. In this way, the clearance gap is regulated naturally, without the need of active control means. This implies low realization costs and high performances of the gas turbine assembly.

[0012] According to a variant of the present invention, the movable element is provided with an inner face, facing, in use, the at least one tip of the blade and with an outer face, facing, in use, the regulating gap; on the outer face the movable element being provided with at least one first recess housing the first sealing element.

[0013] Preferably, the axial dimension of the first recess is greater than the axial dimension of the sealing element.

[0014] According to a variant of the present invention, the first sealing element is transversal to a longitudinal plane containing the longitudinal axis, preferably orthogonal to the longitudinal plane containing the longitudinal axis.

[0015] According to a variant of the present invention, the the first sealing element is a brush seal.

[0016] According to another variant of the present invention, the first sealing element comprises a metal sheet.

[0017] According to a variant of the present invention, the movable element is provided with a second sealing element arranged at a distance from the first sealing element so as to create an intermediate chamber between the first sealing element and the second sealing element; the intermediate chamber being arranged between the first chamber and the second chamber.

[0018] Preferably, the intermediate chamber is in fluidic communication with the clearance gap.

[0019] More preferably, the intermediate chamber is in fluidic communication with the clearance gap by means of a through hole made in the movable element.

[0020] According to a variant of the present invention, the intermediate chamber is in fluidic communication with the first chamber and/or the second chamber through at least one passage at the first sealing element and/or at the second sealing element.

[0021] According to a preferred embodiment of the present invention, the retaining device is configured to reduce the regulating gap when the turbine assembly is not operating.

[0022] More preferably, the retaining device is configured to limit the radial movement of the movable element between a minimum displacement and a maximum displacement.

[0023] The retaining device can comprises at least one spring, or at least one bimetallic element, or at least one bellow filled with heat-sensitive material or a magnet, or a combination thereof.

[0024] It is also an object of the present invention to provide a method for operating a gas turbine assembly, which is able to properly control the gap between the tip of the blades and the stator in a simple and reliable way.

[0025] In particular, it is an object of the present invention to provide a method for operating a gas turbine assembly according to claim 15.

[0026] In this way the pressure fields acting on the movable element regulates the position of the movable element so that a proper clearance control is obtained (i.e. the net force acting on the movable element and determined by the pressure fields is zero at a target radial width of the clearance gap).

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] 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 assembly according to the present invention;
- Figure 2A is a schematic sectional front view, with parts removed for clarity, of a first detail of Figure 1;
- Figure 2B is a schematic sectional lateral view, with parts removed for clarity, of a second detail of Figure 1;
- Figure 3A is a schematic representation of the pressure trends along the axial direction acting on a movable element of the first detail of figure 2 in a first operating condition (large clearance condition);
- Figure 3B is a schematic representation of the resulting force acting on the movable element of the first detail of figure 2 in the first operating condition of figure 3a;
- Figure 4A is a schematic representation of the pressure trends along the axial direction acting on a movable element of the first detail of figure 2 in a second operating condition (very small clearance condition);
- Figure 4B is a schematic representation of the resulting force acting on the movable element of the first detail of figure 2 in the second operating condition of figure 4A;
- Figure 5 is a schematic sectional front view, with parts removed for clarity, of a first detail of Figure 1 according to a variant of the present invention;
- Figure 6A is a schematic representation of the resulting force acting on the movable element of the first detail of figure 5 in a first operating condition (large clearance);
- Figure 6B is a schematic representation of the resulting force acting on the movable element of the first detail of figure 5 in a second operating condition (very small clearance condition).

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0028] In figure 1 reference numeral 1 indicates a gas turbine assembly (schematically shown in Figure 1).

[0029] The gas turbine assembly 1 comprises a compressor 3, a combustion chamber 4, a turbine 5.

[0030] In particular, the gas turbine assembly 1 comprises a stator 6, defining at least a compression working channel 8 and an expansion working channel 9.

[0031] The compressor 3 and the turbine 5 are mounted on a same shaft to form a rotor 11, which is housed in the stator 6 and extends along an axis A.

[0032] In greater detail, the rotor 11 comprises a front shaft 12, a plurality of rotor stages 13 and a rear shaft 14.

[0033] Each rotor stage 13 comprises a rotor disk 16 and a plurality of rotor blades 17 coupled to the rotor disk 16 and radially arranged.

[0034] The plurality of rotor disks 16 are arranged in succession between the front shaft 12 and the rear shaft 14 and preferably clamped as a pack by a central tie rod 18. As an alternative, the rotor disks may be welded together.

[0035] A central shaft 20 separates the rotor disks 16 of the compressor 3 from the rotor disks 16 of the turbine 5 and extends through the combustion chamber 4.

[0036] Further, stator stages 22 are alternated with the compressor rotor stages 13.

[0037] Each stator stage 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 a respective structure of the stator 6.

[0038] In figure 2A an enlarged view of a rotor stage 13 is illustrated. The rotor stage 13 illustrated in figure

2A is housed in the compression working channel 8 of the compressor 3. However, the same features here below detailed can be applied, mutatis mutandis, to a rotor stage 13 housed in the expansion working channel 9 of the turbine 5 wherein a hot gas flows.

[0039] The rotor blade 17 extends along a radial direction r with respect to longitudinal axis A and is provided with a base 28 coupled to the rotor disk 15 and with a free tip 29, arranged radially opposite to the base 28.

[0040] The blade 17 comprise a leading edge LE, which is the edge first meeting the incoming flow and which separates the flow, and a trailing edge TE, which is the edge at which the air divided by the leading edge LE meets again.

[0041] Arrow D indicates the direction of the air flow flowing in the compression working channel 8.

[0042] The gas turbine assembly 1 comprises at least one movable element 30, which is coupled to the stator 6 by means of at least one retaining device 32 and moves radially between the stator 6 and at least one tip 29 of the blades 17 for regulating a clearance gap 33 between the at least one tip 29 and the movable element 30.

[0043] In particular, the movable element 30 is coupled to the stator 6 so as to create a regulating gap 35 between the stator 6 and the movable element 30, which is in fluidic communication with the expansion working channel 8.

[0044] With reference to figure 2B, the gas turbine assembly 1 preferably comprise a plurality of movable elements 30 for each rotor stage 13. The plurality of movable elements 30 are preferably arranged circumferentially about the longitudinal axis A at a distance.

[0045] Each movable element 30 has a radial length Lr and circumferential length Lc.

[0046] With reference again to figure 2A, the movable element 30 is provided with at least one first sealing element 37 dividing the regulating gap 35 in at least two chambers 38: one first chamber 38a is in fluidic communication with the working channel 8 upstream the rotor stage 13 and one second chamber 38b is in fluidic communication with the working channel 8 downstream the rotor stage 13.

[0047] The movable element 30 is provided with an inner face 40, facing, in use, the at least one tip 29 of the blade 17 and with an outer face 41, facing, in use, the regulating gap 35.

[0048] Preferably, on the outer face 41 the movable element 39 is provided with at least one recess 43 housing the first sealing element 37.

[0049] Preferably, the axial dimension of the recess 43 is greater than the axial dimension of the sealing element 37 in order to allow the sealing element 37 to move inside the recess 43.

[0050] In use, in fact, the sealing element 37 should maintain the division between the chambers 38 in all the positions of the movable element 30.

[0051] Therefore, when the movable element 30 moves radially, the sealing element 37 can consequently slide radially in the recess 43. For example, when the movable element 30 is in the position closest to the stator 6 (i.e. radial width of the regulating gap 35 is at the minimum and radial width of the clearance gap 33 is at the maximum) the sealing element 37 substantially engages completely the recess 43 touching the bottom of the recess 43. When the movable element 30 is in the position farthest to the stator 6, the sealing elements 37 is radially spaced from the bottom of the recess 43. Said radially spacing between the sealing element 37 and the bottom of the recess 43 defines the maximum radial width variation of the regulating gap 35.

[0052] The sealing element 37 can be a brush seal having inclined movable bristles or a sheet metal that can slide radially at the shoulder of the recess 43.

[0053] As we will see in detail later, due to the pressure difference between the chambers 38, in use, the sealing element 37 is pressed against one shoulder of the recess 43.

[0054] Preferably, the sealing element 30 extends transversal to a longitudinal plane containing the longitudinal axis A.

[0055] More preferably, the sealing element 30 is arranged orthogonal to a longitudinal plane containing the longitudinal axis A.

[0056] According to a variant not shown, the outer face of the movable element is not provided with a recess and the first sealing element is coupled to the outer face.

[0057] The retaining device 32 is preferably configured to limit the radial movement of the movable element 30 between a minimum displacement and a maximum displacement.

[0058] In other words, the retaining device 32 is configured to safely limit the movement of the movable element 30 in order to avoid an excessive approaching of the movable element 30 towards the tip 29 of the blade 17 (in order to avoid dangerous rubbing between the tip 29 and the movable element 30) or an excessive approaching of the movable element 30 towards the stator 6 (in order to avoid an excessive reduction of the regulating gap 35).

[0059] The retaining device 32 is also preferably configured to reduce the regulating gap 35 when the gas turbine assembly 1 is not operating. In other words, when no pressures field is acting on the movable element 30 the retaining device 32 moves the movable element 30 away from the tip 29 of the blade 17 in order to avoid rubbing between the tip 29 and the movable element 30.

[0060] Thus, at standstill conditions, in fact, a clearance gap 33 is provided and it is possible to turn the rotor slowly (e.g. rotor barring) without rubbing of the tip 29 of the blade 17.

[0061] The retaining device 32 is also preferably configured to damp the potential oscillations of the movable element 30.

[0062] In the non-limiting example here disclosed and illustrated, the retaining device 32 comprises two springs 45 coupled to the stator 6 and to the outer face 41 of the movable element 30.

[0063] The movable element 30 has eigenfrequencies due to the presence of the springs 45 and therefore can vibrate due to flow induced excitation. A damping device is therefore advantageous. The damping can be obtained by the friction of the sealing element 37 on the shoulders of the recess 43. Other methods to create friction are possible.

[0064] According to a first variant not shown, the retaining device may comprise at least one bimetallic element.

[0065] According to a second variant not shown, the retaining device may comprise at least one bellow filled with heat-sensitive material.

[0066] According to a further variant not shown, the retaining device may comprise at least one magnet or a combination of the options above.

[0067] With reference to figure 3A-3B 4A-4B, the movable element 30, in operation moves under the effect of the pressure field acting on it.

[0068] In particular, on the inner face 40 of the movable element 30, the pressure field depends mainly on the dimensions of the clearance gap 33 and on the operating conditions.

[0069] On the outer face 41, the pressure field depends on the dimensions of the chambers 38 created by the sealing element 37.

[0070] In the first chamber 38a, in fact, the pressure is identical to the pressure P1 in the working channel upstream of the rotor stage 13.

[0071] In the second chamber 38b, the pressure is identical to the pressure P2 in the working channel downstream of the rotor stage 13.

[0072] In figure 3A it is represented the pressure trend on the inner face 40 (dashed lines) and on the outer face 41 (continuous line) when the radial width of the clearance gap 33 is large. With the expression "large" it is intended that the radial width is greater than a threshold.

[0073] In this situation, on the inner face 40 there is approximately a linear pressure increase from value P1 to value P2 from the leading edge LE to the trailing edge TE.

[0074] The pressure trend on the inner face 40 depends on several factors, i.e. the shape of the airfoil of the blade 17.

[0075] On the outer face 41, the pressure in the first chamber 38a is P1 and the pressure in the second chamber 38b is P2.

[0076] Looking at the diagram in figure 3B, the resulting net force acting on the movable device 30 is greater towards the tip 29.

[0077] Therefore, if the clearance gap 33 is large, the movable element 30 is moved radially inward by the pressure field in order to reduce the radial width of the clearance gap 33.

[0078] The resulting net force is calculated according the following formula:

$$Fnet = \int (Pouter - Pinner)\, dA$$

wherein:

Pouter is the pressure on the outer face 41;
Pinner is the pressure on the inner face 40;
A is the area on which the pressure field acts.

[0079] In figure 4A it is represented the pressure trend on the inner face 40 and on the outer face 41 when the radial width of the clearance gap 33 is small. With the expression "small" it is intended that the radial width is lower than a further threshold.

[0080] In this situation, on the inner face 40 the pressure starts from value P1 and increases strongly close to the leading edge LE and then the pressure trend tends to value P2, which is reached at the trailing edge TE.

[0081] On the outer face 41, the pressure in the first chamber 38a is P1 and the pressure in the second chamber 38b is P2.

[0082] Looking at the diagram in figure 4B, the resulting net force acting on the movable device 30 is greater radially outward (away from the tip 29).

[0083] Therefore, if the clearance gap 33 is small, the movable element 30 is moved radially outward by the pressure field in order to increase the radial width of the clearance gap 33.

[0084] If the net force is zero, the clearance gap 33 has a radial width corresponding to the operational one and is not changed by the pressure field acting on the movable element.

[0085] The positioning of the sealing element 37 is, therefore, designed specifically in order to obtain the above behaviour in use.

[0086] The positioning of the sealing element 37, in fact, determines the areas on which the outer pressures act in the chambers 38.

[0087] In the non-limiting example here disclosed and illustrated, the axial position of the sealing element 37 is designed in order to obtain the proper adjustment of the radial width Wr of the clearance gap 33.

[0088] In particular, the positioning of the sealing element 37 is defined so that the net force acting on the movable element 30 and determined by the pressure fields is zero at a target radial width Wr of the clearance gap.

[0089] In the non-limiting example here disclosed and illustrated, the axial position of sealing element is designed so as the second chamber 38b insists on an area of the outer face 41 greater than the area on which insists the first chamber 38a.

[0090] Figure 5 shows a variant of the present invention, wherein the movable element 30 is provided with a further sealing element 47 arranged at a distance from the sealing element 37 so as to create an intermediate chamber 48 between the sealing element 37 and the sealing element 47.

[0091] The intermediate chamber 48 is arranged between the first chamber 38a and the second chamber 38b.

[0092] In the non-limiting example here disclosed and illustrated, the intermediate chamber 48 is in fluidic communication with the clearance gap 33, preferably by means of a through hole 50 made in the movable element.

[0093] According to a variant not shown, the intermediate chamber 48 can be in fluidic communication with the first chamber 38a and/or the second chamber 38b through at least one passage at the sealing element 37 and/or at the sealing element 47.

[0094] Preferably, the sealing element 37 and the sealing element 47 are substantially identical.

[0095] Similarly, the sealing element 47 is housed in a recess 53 having axial dimensions greater that the axial dimensions of the sealing element 47.

[0096] In figure 6A it is represented the pressure trend on the inner face 40 (dashed lines) and on the outer face 41 (continuous line) when the radial width of the clearance gap 33 is large. With the expression "large" it is intended that the radial width is greater than a threshold.

[0097] In this situation, on the inner face 40 there is approximately a linear pressure increase from value P1 to value P2 from the leading edge LE to the trailing edge TE.

[0098] On the outer face 41, the pressure in the first chamber 38a is P1 and the pressure in the second chamber 38b is P2, the pressure in the intermediate chamber 48 is P3.

[0099] The resulting net force acting on the movable device 30 is greater towards the tip 29.

[0100] Therefore, if the clearance gap 33 is large, the movable element 30 is moved radially inward by the pressure field in order to reduce the radial width Wr of the clearance gap 33.

[0101] In figure 6B it is shown the pressure trend on the inner face 40 and on the outer face 41 when the radial width of the clearance gap 33 is small. With the expression "small" it is intended that the radial width Wr is lower than a further threshold.

[0102] In this situation, on the inner face 40 the pressure starts from value P1 and increases strongly close to the trailing edge TE and then the pressure trend tends to value P2, which is reached at the trailing edge TE. As already stated, the pressure trend on the inner face 40 depends on several factors, i.e. the shape of the airfoil of the blade 17.

[0103] On the outer face 41, the pressure in the first chamber 38a is P1, the pressure in the second chamber 38b is P2 and the pressure in the intermediate chamber 48 is P3.

[0104] The resulting net force acting on the movable device 30 is greater radially outward (away from the tip 29).

[0105] Therefore, if the clearance gap 33 is small, the movable element 30 is moved radially outward by the pressure field in order to increase the radial width Wr of the clearance gap 33.

[0106] If the net force is zero, the clearance gap 33 has a radial width Wr corresponding to the operational one and is not changed by the pressure field acting on the movable element.

[0107] In order to obtain a proper clearance control of the radial width Wr of the clearance gap 33, in this embodiment, both the positioning of the sealing element 37 and the sealing element 47 must be designed properly depending on the pressure field.

[0108] Moreover, also the positioning of the through hole 50 should be properly placed in order to have a desired pressure field in the intermediate chamber 48. As we will see later, the pressure in the intermediate chamber 48 is equal to the pressure in the clearance gap 33 substantially at the axial position of the through hole 50. Therefore, the positioning of the through hole 50 determines the pressure in the intermediate chamber 48.

[0109] In particular, the positioning of the sealing elements 37, 47 and the through hole 50 is defined so that the net force acting on the movable element 30 and determined by the pressure fields is zero at a target radial width Wr of the clearance gap.

[0110] Other solutions not shown may comprise a plurality of sealing elements in order to create several chambers whose pressure can be adjusted properly in order to obtain the desired clearance control.

[0111] Finally, it is clear that modifications and variants can be made to the gas turbine assembly and to the method described herein without departing from the scope of the present invention, as defined in the appended claims.

Claims

1. Gas turbine assembly extending along a longitudinal axis (A) and comprising:

a stator (6) defining a working channel (8, 9);
a rotor (11) comprising a plurality of rotor stages (13);
each rotor stage (13) comprising a plurality of blades (17) rotatable in the working channel (8, 9) about the longitudinal axis (A); each blade (17) being provided with a tip (29);
at least one movable element (30) which is coupled to the stator (6) by means of at least one retaining device (32) and moves radially between the stator (6) and at least one tip (29) of the blades (17) for regulating a clearance gap (33) between the at least one tip (29) and the movable element (30);
wherein the movable element (30) is coupled to the stator (6) by means of a retaining device (32) so as to create a regulating gap (35) between the stator (6) and the movable element (30)

which is in fluidic communication with the working channel (8, 9); the movable element (30) being provided with at least one first sealing element (37) dividing the regulating gap (35) in at least two chambers (38); one first chamber (38a) of the at least two chambers (38) being in fluidic communication with the working channel (8, 9) upstream the rotor stage (13) and one second chamber (38b) of the at least two chambers (38) being in fluidic communication with the working channel (8, 9) downstream the rotor stage (13).

2. Gas turbine assembly according to claim 1, wherein the movable element (30) is provided with an inner face (40), facing, in use, the at least one tip (29) of the blade (17) and with an outer face (41), facing, in use, the regulating gap (35); on the outer face (41) the movable element (30) being provided with at least one first recess (43) housing the first sealing element (37) .

3. Gas turbine assembly according to claim 2, wherein the axial dimension of the first recess (43) is greater than the axial dimension of the sealing element (37).

4. Gas turbine assembly according to anyone of the foregoing claims, wherein the first sealing element (37) is transversal to a longitudinal plane containing the longitudinal axis (A).

5. Gas turbine assembly according to anyone of the foregoing claims, wherein the first sealing element (37) is orthogonal to a longitudinal plane containing the longitudinal axis (A).

6. Gas turbine assembly according to anyone of the foregoing claims, wherein the first sealing element (37) is a brush seal.

7. Gas turbine assembly according to anyone of the claims 1-6, wherein the first sealing element (37) comprises a metal sheet.

8. Gas turbine assembly according to anyone of the foregoing claims, wherein the movable element (30) is provided with a second sealing element (47) arranged at a distance from the first sealing element (37) so as to create an intermediate chamber (48) between the first sealing element (37) and the second sealing element (47); the intermediate chamber (48) being arranged between the first chamber (38a) and the second chamber (38b) .

9. Gas turbine assembly according to claim 8, wherein the intermediate chamber (48) is in fluidic communication with the clearance gap (33).

10. Gas turbine assembly according to claim 9, wherein the intermediate chamber (48) is in fluidic communication with the clearance gap (33) by means of a through hole (50) made in the movable element (30).

11. Gas turbine assembly according to claim 8, wherein the intermediate chamber (48) is in fluidic communication with the first chamber (38a) and/or the second chamber (38b) through at least one passage at the first sealing element (37) and/or at the second sealing element (47).

12. Gas turbine assembly according to anyone of the foregoing claims, wherein the retaining device (32) is configured to reduce the regulating gap (35) when the turbine assembly (1) is not operating.

13. Gas turbine assembly according to anyone of the foregoing claims, wherein the retaining device (32) is configured to limit the radial movement of the movable element (30) between a minimum displacement and a maximum displacement.

14. Gas turbine assembly according to anyone of the foregoing claims, wherein the retaining device (32) can comprises at least one spring (45), or at least one bimetallic element, or at least one bellow filled with heat-sensitive material or a magnet, or a combination thereof.

15. Method for operating a gas turbine assembly (1) extending along a longitudinal axis (A); the gas turbine assembly (1) comprising:

a stator (6) defining a working channel (8, 9);
a rotor (11) comprising a plurality of rotor stages (13);
each rotor stage (13) comprising a plurality of blades (17) rotatable in the working channel (8, 9) about the longitudinal axis (A); each blade (17) being provided with a tip (29);
at least one movable element (30) which is coupled to the stator (6) and moves radially between the stator (6) and at least one tip (29) of the blades (17) for regulating a clearance gap (33) between the at least one tip (29) and the movable element (30);
wherein the movable element (30) is coupled to the stator (6) so as to create a regulating gap (35) between the stator (6) and the movable element (30) which is in fluidic communication with the working channel (8, 9); the movable element (30) being provided with at least one first sealing element (37) dividing the regulating gap (35) in at least two chambers (38); one first chamber (38a) of the at least two chambers (38) being in fluidic communication with the working channel (8, 9) upstream of the rotor stage (13) and one second chamber (38b) of the at least two cham-

bers (38) being in fluidic communication with the working channel (38b) downstream of the rotor stage (13);
the method comprising positioning the at least one first sealing element (37) so that the net force acting on the movable element (30) and determined by the pressure fields is zero at a target radial width (Wr) of the clearance gap (33) .

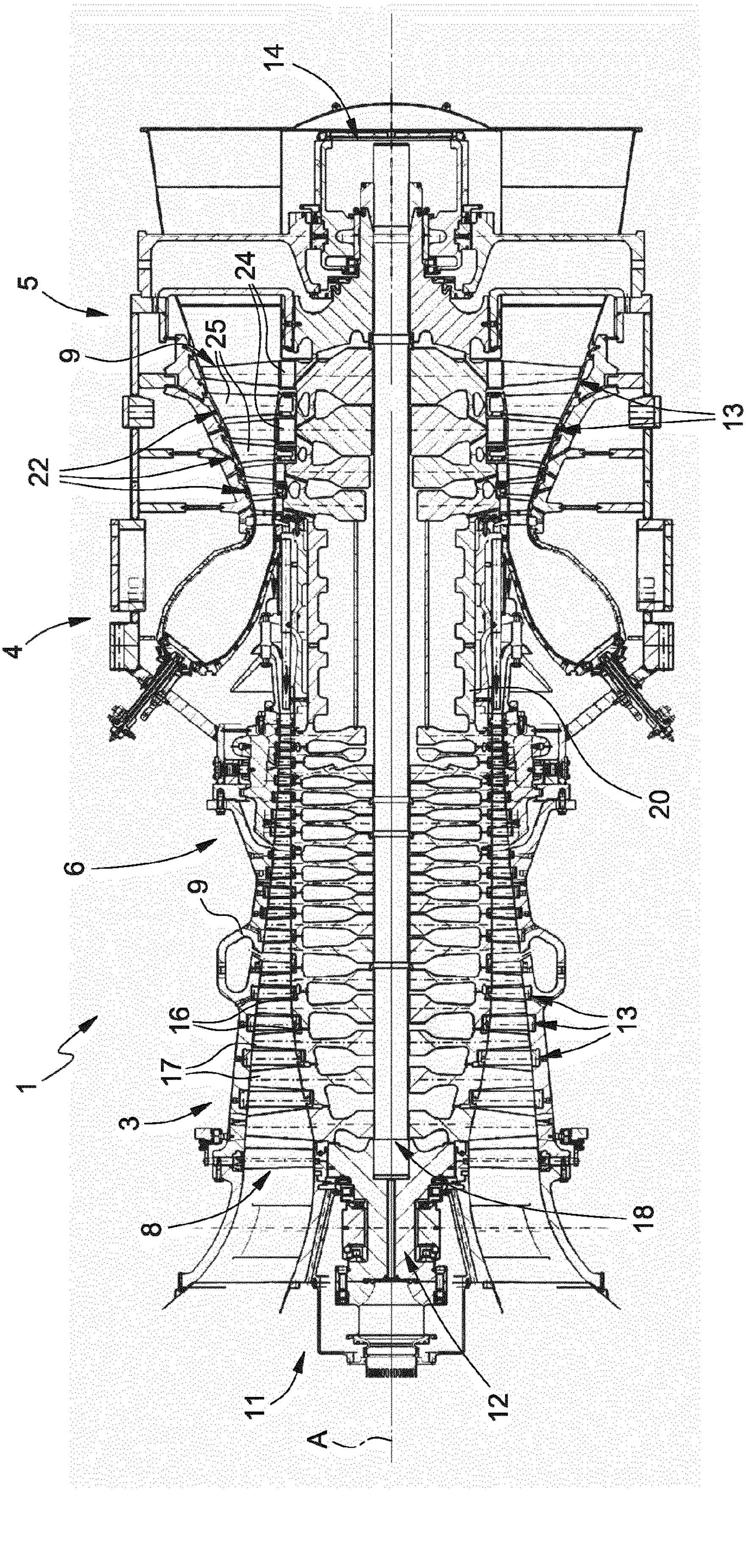
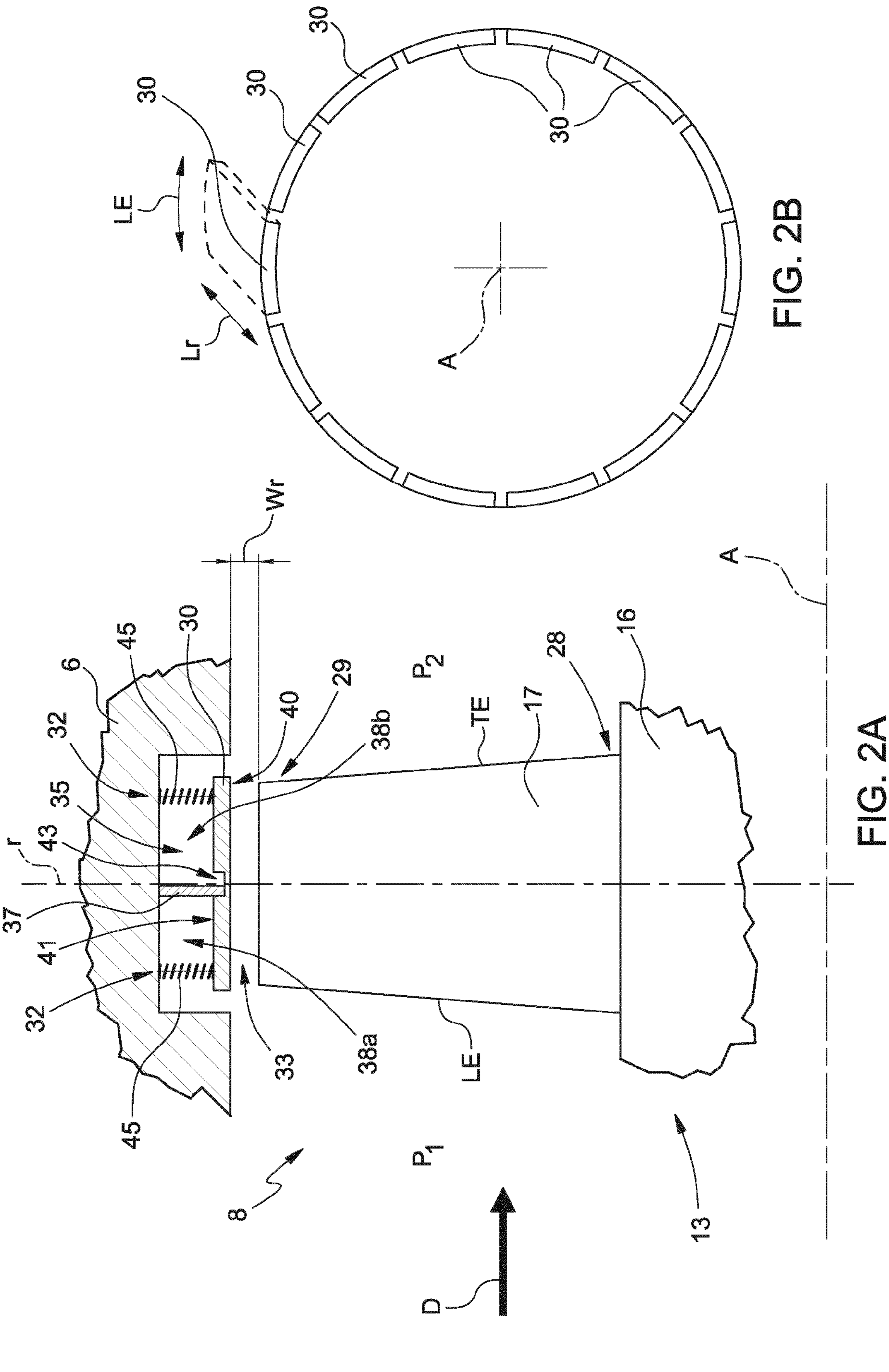


FIG. 1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38a
38b
40
29
P2
TE
17
28
16
LE
P1
8
13
D

FIG. 2A

FIG. 2B

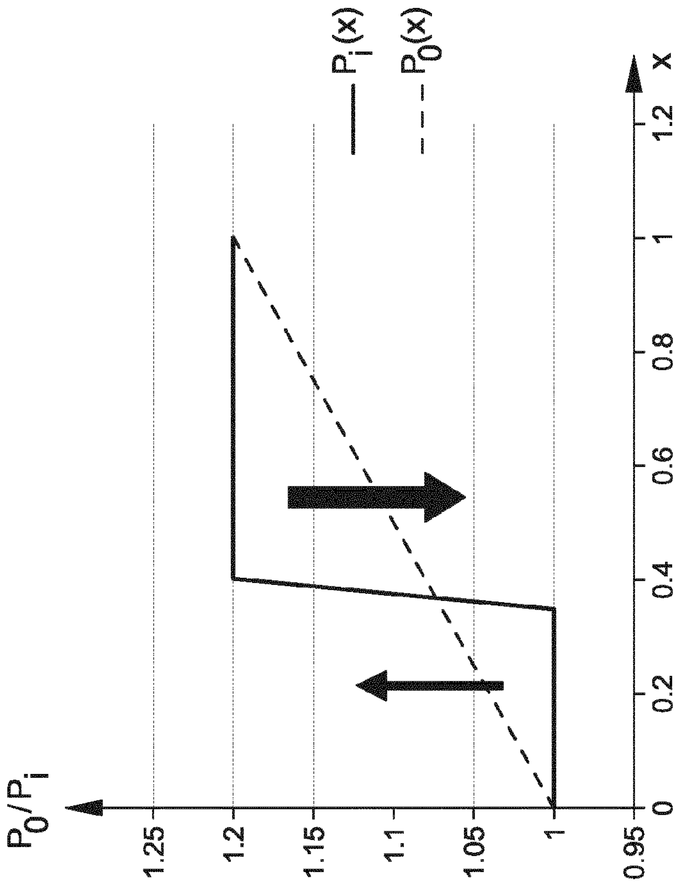
P0/Pi
1.25
1.2
1.15
1.1
1.05
1
0.95
0
0.2
0.4
0.6
0.8
1
1.2
x
Pi(x)
P0(x)

FIG. 3B

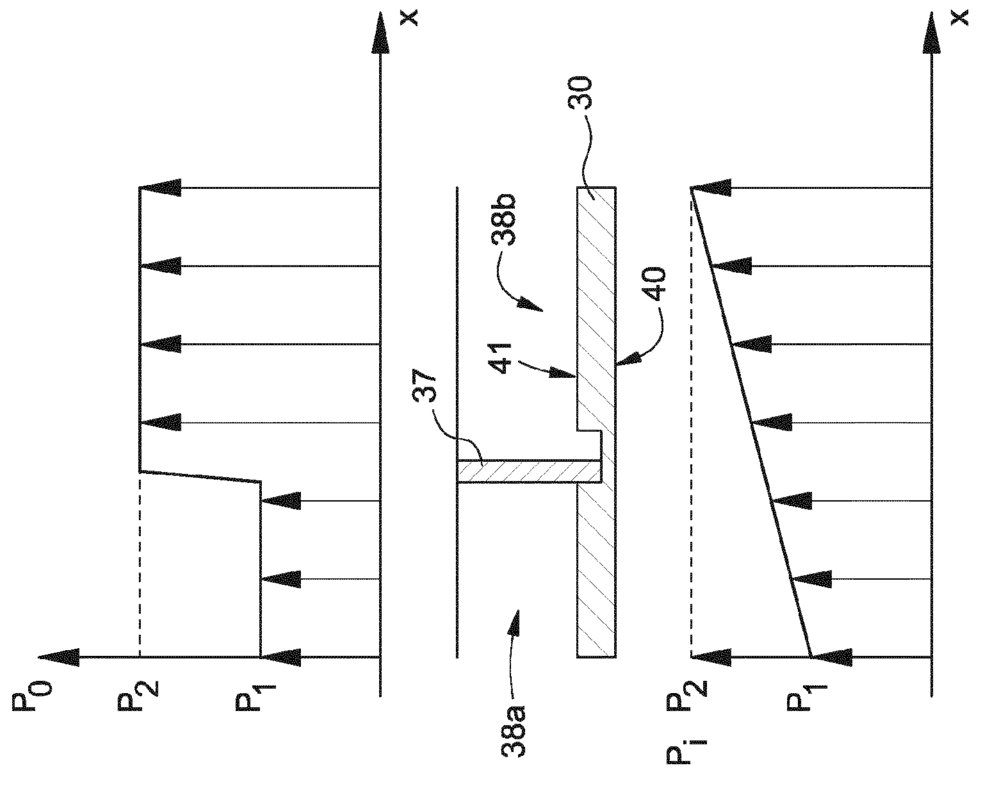
P0
P2
P1
x
38a
37
41
38b
40
30
Pi
P2
P1
x

FIG. 3A

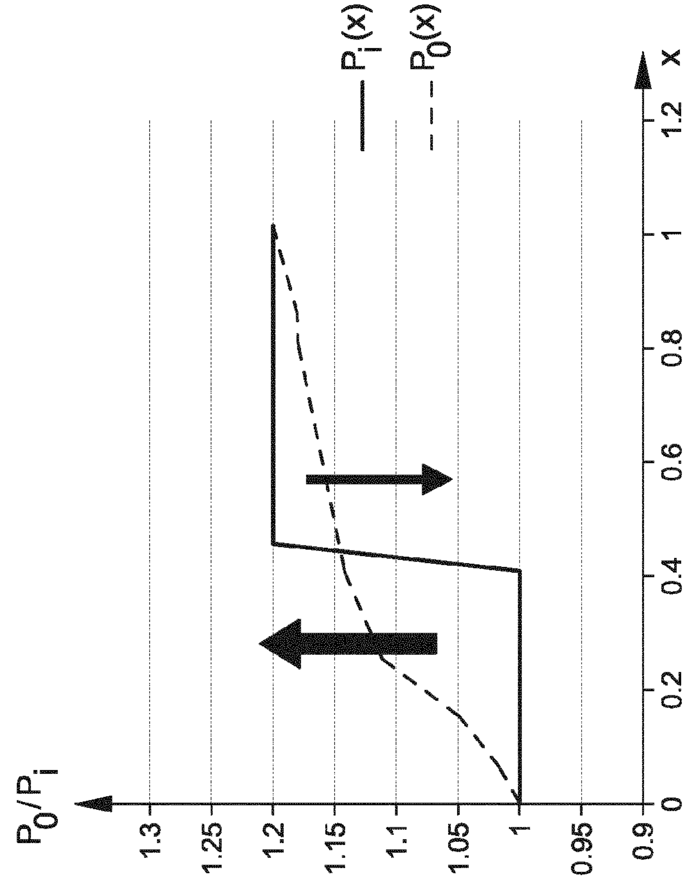
P_0/P_i
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6
0.8
1
1.2
x
$P_i(x)$
$P_0(x)$

FIG. 4B

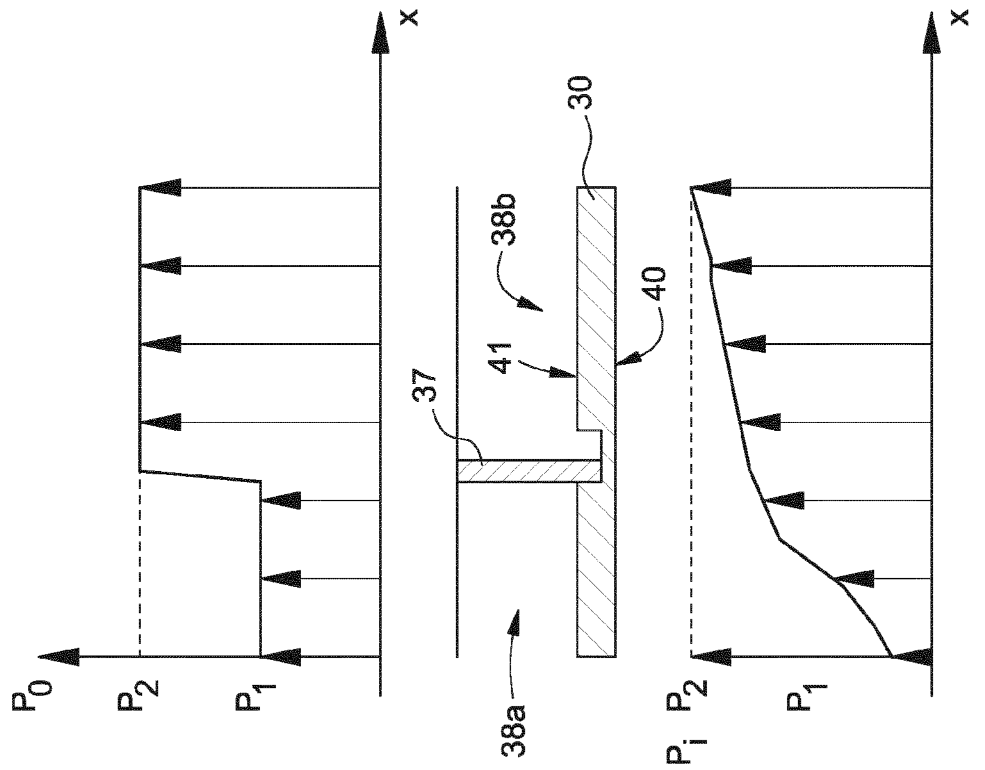
P_0
P_2
P_1
x
38a
38b
37
41
40
30
P_i
P_2
P_1
x

FIG. 4A

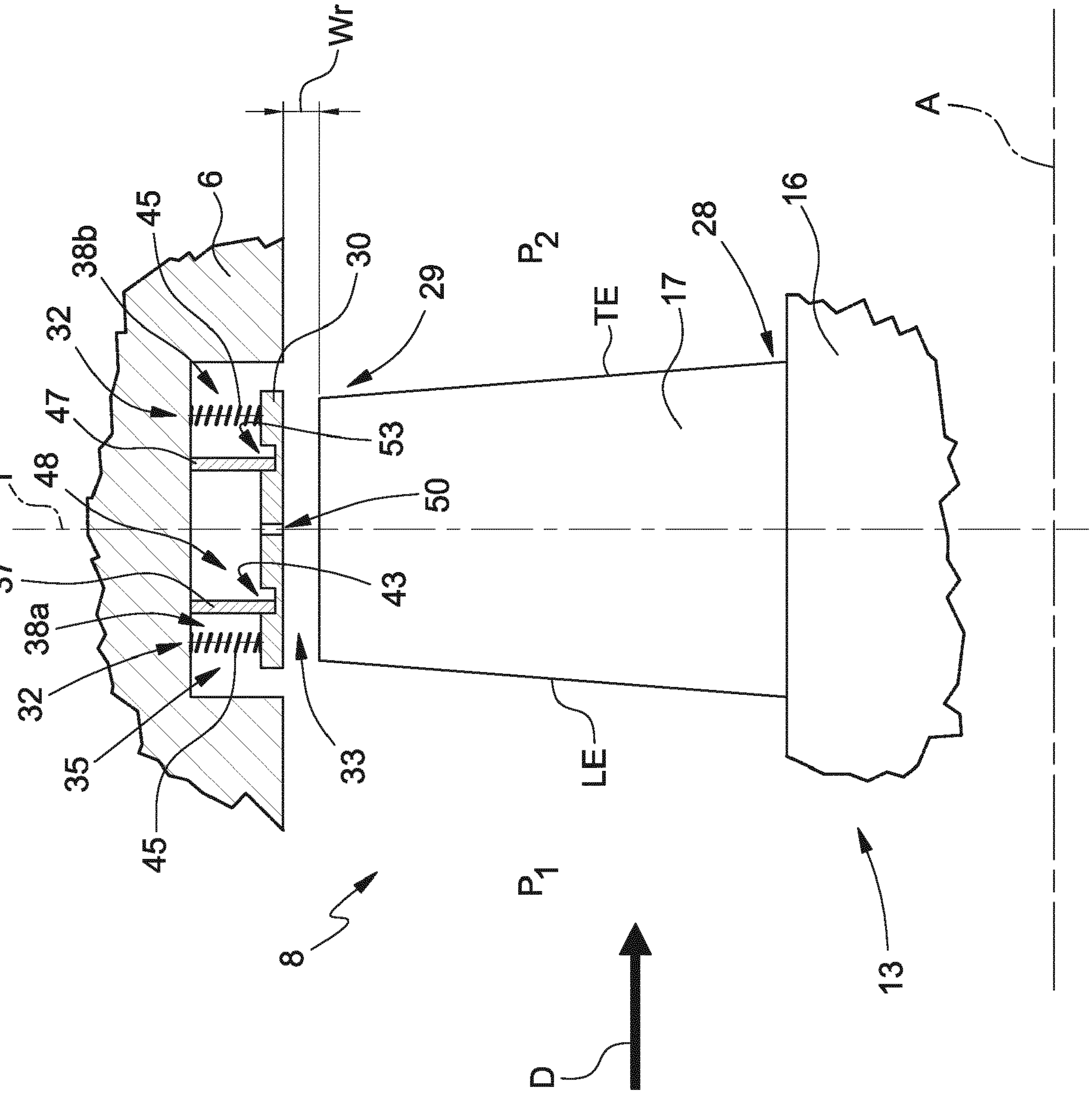
Wr
6
45
38b
32
47
r
48
37
38a
32
35
45
33
8
P_1
P_2
D
30
29
53
50
43
TE
17
LE
28
16
13
A

FIG. 5

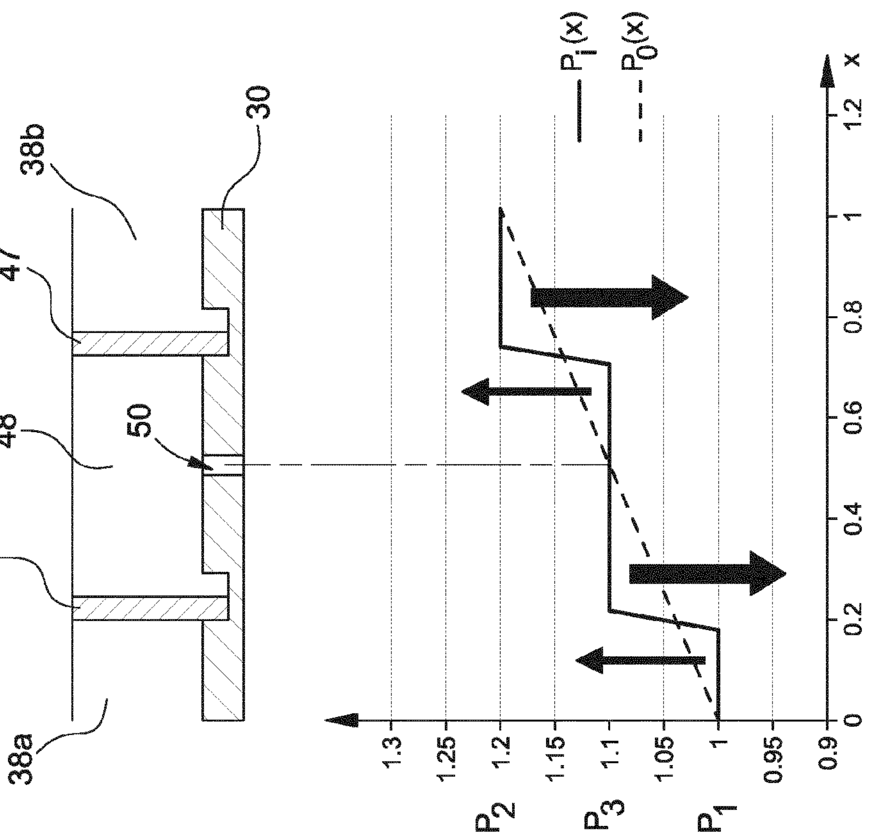
38a
37
48
50
47
38b
30
P2
P3
P1
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6
0.8
1
1.2
x
Pi(x)
P0(x)

FIG. 6A

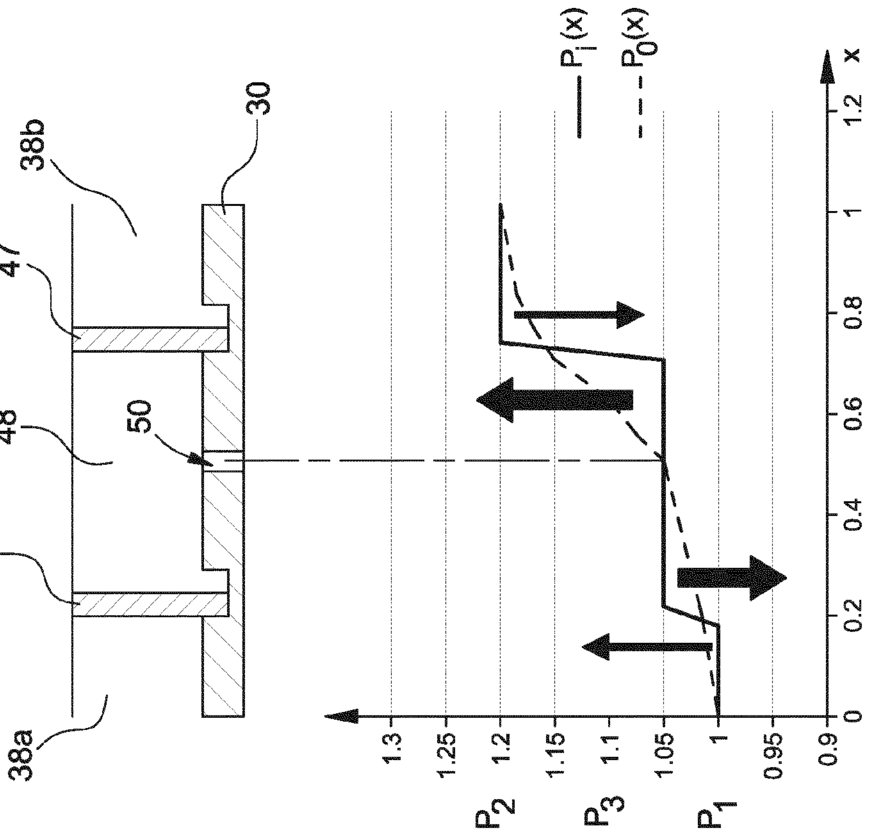
38a
37
48
50
47
38b
30
P2
P3
P1
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6
0.8
1
1.2
x
Pi(x)
P0(x)

FIG. 6B

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EUROPEAN SEARCH REPORT

Application Number
EP 20 21 7259

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2015/337852 A1 (KLINGLER BRETT DARRICK [US]) 26 November 2015 (2015-11-26) * figure 3 * * paragraphs [0015] - [0030] * -----	1-15	INV. F01D11/16
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TECHNICAL FIELDS SEARCHED (IPC)

F01D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
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