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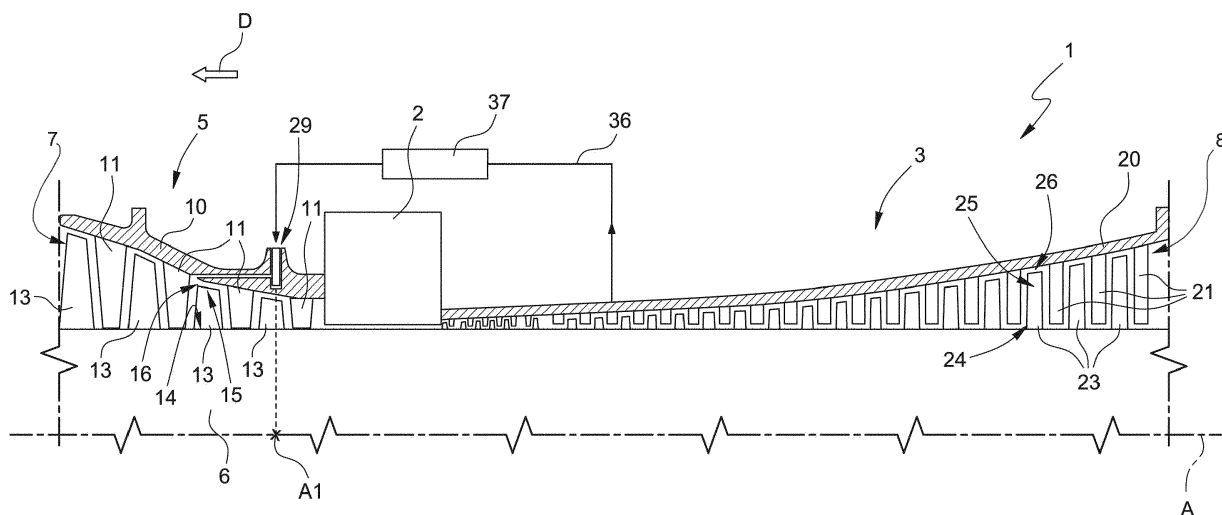
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(54) **VANE CARRIER FOR A GAS TURBINE PLANT AND GAS TURBINE PLANT COMPRISING SAID VANE CARRIER**

(57) Vane carrier for a gas turbine plant extending along a longitudinal axis (A) and comprising at least one clearance control cavity (29) which extends transversally with respect to the longitudinal axis (A).



Description

TECHNICAL FIELD

[0001] The present invention relates to a vane carrier for a gas turbine plant and to a gas turbine plant comprising said vane carrier. In particular, the gas turbine plant is an electric power production plant.

BACKGROUND

[0002] As is known, in gas turbines plants a clearance between rotating blades tips and the stator vane carrier is required in order to enable the relative movement between rotor blades tips and the stator vane carrier.

[0003] However, during the operation of the gas turbine plant, rotor parts and stator parts have different responses to temperature changes due to the fact that they are made of different materials and also due to the fact that they are exposed to different temperature gradients.

[0004] For these reasons, clearances between rotating blades tips and the stator vane carrier need to be designed such that they are maintained under any operation conditions.

[0005] In other words, under most operation conditions the tip clearances are larger than required in order to guarantee safe operation and avoid contact between rotating and stationary parts.

[0006] However leakage flows occurring between blade tips and stator vane carrier through said clearances cause a loss in terms of efficiency as said flows do not provide useful work for the gas turbine plant.

[0007] Therefore an active regulation of the clearance is required in order to find a balanced solution which avoids contacts and, at the same time, minimize leakages between said blades and stator vane carrier.

[0008] Examples of active control clearance solutions are disclosed in documents US 2006/0225430 or EP3023600. However these solutions are not sufficiently efficient.

SUMMARY

[0009] The object of the present invention is therefore to provide vane carrier for a gas turbine plant which enables avoiding or at least mitigating the described drawbacks.

[0010] In particular, it is an object of the present invention to provide a vane carrier for a gas turbine plant which is provided with an efficient active control clearance system. According to the present invention, there is provided a vane carrier for a gas turbine plant extending along a longitudinal axis and comprising at least one clearance control cavity which extends transversally with respect to the longitudinal axis. In this way the clearance control cavity can be oriented so as to optimize the occupation of the available space in the specific portion of the vane carrier which needs a clearance control and an influence

of the thermo-mechanical behaviour. Such a specific portion, in fact, can have a different position in the vane carrier in function of the kind of vane carrier to which the invention should be applied. Said solution therefore brings more flexibility and considerable benefits in terms of design space.

[0011] According to a preferred embodiment of the present invention, the clearance control cavity extends radially with respect to the longitudinal axis.

[0012] According to a preferred embodiment of the present invention, the vane carrier comprises at least one plurality of clearance control cavities distributed along a circumferential direction. In this way the clearance control is active along the entire circumferential portion of the vane carrier and the influence of the thermo-mechanical behaviour of the vane carrier is more effective. According to a preferred embodiment of the present invention, the plurality of clearance control cavities are evenly distributed along the circumferential direction. In this way a circumferentially homogeneous temperature field is obtained in the vane carrier.

[0013] According to a preferred embodiment of the present invention, the vane carrier has an inner surface facing a working channel provided with vanes and an outer surface opposite to the inner surface; the clearance control cavity being a blind hole made into the outer surface of the vane carrier. In this way the clearance control cavities are obtainable in a rapid, simple and economic way, for example by drilling the outer surface of the vane carrier.

[0014] According to a preferred embodiment of the present invention, the clearance control cavity has at least one inlet connected to a source of control fluid. In this way the clearance control cavity is supplied with a control fluid.

[0015] According to a preferred embodiment of the present invention, the clearance control cavity has at least one outlet connected to a respective discharge conduit. According to a preferred embodiment of the present invention, the discharge conduit flows into a working channel provided with vanes. In this way the control fluid discharged in the working channel can provide further useful work for the plant.

[0016] According to a preferred embodiment of the present invention, the discharge conduit connects the outlet of the clearance control cavity to a further inlet of a further adjacent clearance control cavity. In this way a sequential discharge configuration is obtained. Such a configuration is particularly useful if the available space does not allow the creation of a discharge conduit able to discharge the control fluid in a desired place.

[0017] According to a preferred embodiment of the present invention, the vane carrier comprises at least one insert which is arranged inside at least one clearance control cavity. In this way the thermal exchange between the control fluid and the vane carrier can be controlled in order to optimize the heat transfer and reduce the amount of control fluid required.

[0018] According to a preferred embodiment of the present invention, the insert is hollow. In this way the passage of control fluid through the insert is allowed.

[0019] According to a preferred embodiment of the present invention, the insert is shaped so as to define a gap between the insert and the inner surface of the clearance control cavity. In this way the maximum heat transfer area is kept.

[0020] It is furthermore another object of the present invention to provide a plant for the production of electrical power energy which is more efficient with respect to the plants of the prior art solutions.

[0021] In particular, it is an object of the present invention to provide a gas turbine plant for the production of electrical power energy comprising a compressor, a combustor and a gas turbine; the gas turbine comprising the vane carrier according to the present invention.

[0022] According to a preferred embodiment of the present invention, the clearance control cavity is connected to an extraction line configured to extract air from the compressor and feed it to the clearance control cavity. In this way, the control fluid is air extracted from the compressor.

[0023] It is a further object of the present invention to provide a gas turbine plant for the production of electrical power energy comprising a compressor, a combustor and a gas turbine; the compressor comprising a vane carrier according to the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] 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 representation of a gas turbine plant according to the present invention, with parts in section and parts removed for clarity;
- Figure 2 is a section lateral view of a first detail of the plant of figure 1, with parts in section and parts removed for clarity;
- Figure 3 is a section front view of a second detail of the plant of figure 1, with parts in section and parts removed for clarity;
- Figure 4 is an enlarged view of a selected detail of figure 3.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0025] In figure 1 reference numeral 1 indicates a gas turbine plant for electrical energy production extending along a longitudinal axis A (for the sake of simplicity only an half of the plant is illustrated in figure 1 as the plant being symmetrical with respect to axis A).

[0026] The plant 1 comprises a combustor 2, a compressor 3 and a gas turbine 5.

[0027] The gas turbine 5 extends along the longitudinal

axis A and is provided with a shaft 6 (also extending along axis A) to which compressor 3 is also connected.

Gas turbine 5 comprises a working expansion channel 7 wherein the hot gas working fluid coming from the combustor 2 flows in a direction D. The working expansion channel 7 has a section which radially increases along the axis A in the direction D.

Compressor 3 comprises a working compression channel 8 wherein external air is compressed and flows in direction D. The end of the working compression channel 8 is connected to combustor 2. The working compression channel 8 has a section which radially decreases along the axis A in the direction D.

[0028] The turbine 5 comprises an outer casing 9 (only visible in figures 2 and 3), a vane carrier 10, which extends about axis A and is static, a plurality of stator vanes 11 fastened at least to the vane carrier 10 and divided into arrays, and a plurality of rotor blades 13 divided into arrays coupled to the shaft 6 and arranged radially with respect to axis A. Each rotor blade 13 is provided with an end 14 coupled to the shaft 6 and a free end 15 facing the vane carrier 10. The gap between the free end 15 and the vane carrier 10 defines a turbine clearance 16 (indicated schematically in figure 1).

[0029] Along the working expansion channel 7 radial arrays of rotor blades 13 are alternated along axis A by radial arrays of stator vanes 11.

[0030] Analogously the compressor 3 comprises at least one vane carrier 20, which extends about axis A and is static, a plurality of stator vanes 21 fastened at least to the vane carrier 20 and divided into arrays, and a plurality of rotor blades 23 divided into arrays coupled to the shaft 6 and arranged radially with respect to axis A. Each rotor blade 23 is provided with an end 24 coupled to the shaft 6 and a free end 25 facing the vane carrier 20. The gap between the free end 25 and the vane carrier 20 defines a compressor clearance 26 (indicated schematically in figure 1).

[0031] Along the working compression channel 8 radial arrays of rotor blades 23 are alternated along axis A by radial arrays of stator vanes 21.

[0032] With reference to the non-limitative example illustrated in figures 1 and 2, the vane carrier 10 comprises at least one clearance control cavity 29 which extends transversally with respect to the longitudinal axis A for controlling the turbine clearance 16. In other words, the axis B of extension of the clearance control cavity 29 is transversal with respect to the longitudinal axis A.

[0033] The angular position of the axis B of the clearance control cavity 29 can vary from radially to axially (axially excluded) depending on the available space in the vane carrier 10 wherein a clearance control is needed.

[0034] In the non-limiting example here disclosed and illustrated, the clearance control cavity 29 extends radially with respect to the longitudinal axis A (configuration illustrated in figures 2 and 3).

[0035] According to a variant not illustrated, the vane

carrier 20 of the compressor 3 comprises at least one clearance control cavity which extends transversally with respect to the longitudinal axis A for controlling the compressor clearance 26.

[0036] In the following only the embodiment illustrated in figures 2, 3 and 4 regarding the presence of at least one clearance control cavity 29 into the vane carrier 10 will be described in detail. Obviously features described for the clearance control cavity 29 can be applied, mutatis mutandis, to the clearance control cavity realized into the vane carrier 20 of the compressor 3 for controlling the compressor clearance 26.

[0037] In a more preferred embodiment, the vane carrier 10 comprises a plurality of clearance control cavities 29 which are evenly or unevenly distributed along the vane carrier 10 circumferential direction in correspondence of at least one axial position A1 of the vane carrier 10.

[0038] In the non-limiting embodiment disclosed in figures 2 and 3, the plurality of clearance control cavities 29 are evenly distributed along the vane carrier 10 circumferential direction at one axial position A1. In this way the thermo-mechanical behaviour of the vane carrier 10 at the axial position A1 is influenced by the presence of the clearance control cavities 29 and the turbine clearance 16 can be opportunely controlled. The evenly distribution of the clearance control cavities 29 create a more homogeneous circumferential temperature field.

[0039] According to a variant not illustrated the vane carrier comprises more than one plurality of circumferentially arranged clearance control cavities at different axial positions of the vane carrier in order to influence the thermo-mechanical behaviour of the vane carrier in different zones of the vane carrier.

[0040] Preferably, the clearance control cavity 29 is a blind hole made into an outer surface of the vane carrier 10, which faces, in use, the outer casing 9 (see figures 2 and 3).

[0041] Preferably the clearance control cavity 29 is a cylindrical blind hole.

[0042] Preferably the vane carrier 10 is split into two half shells 10a 10b which are connected one to the other at a split plane S (indicated in figure 3).

[0043] With reference to figure 2, each clearance control cavity 29 has an inlet 30 connected to a feeding conduit 31 which is connected to a control fluid source.

[0044] At least one of the plurality of the clearance control cavities 29 has also an outlet 33 connected to a discharge conduit 34.

[0045] With reference to figures 2 and 3, the feeding conduits 31 are supported by the outer casing 9 and are preferably connected to a common manifold (not illustrated for sake of simplicity) supplied with the control fluid.

[0046] The control fluid may be air, steam or other media.

[0047] In the non-limiting example here disclosed and illustrated the control fluid is air extracted from the compressor 3 by a dedicated extraction line 36 (illustrated in

figure 1).

[0048] Along the extraction line 36 is preferably arranged a regulator 37 configured to regulate the temperature and/or the pressure and /or the flow rate of the control fluid before feeding it to the common manifold.

[0049] For example, the regulator 37 can regulate the temperature and the pressure of the control fluid in order to have a temperature and a pressure as required.

[0050] Obviously the turbine clearance 16 can be controlled by adjusting the temperature, the pressure and the flow rate of the control fluid fed to the clearance control cavity 29.

[0051] In other words, the regulator 37 is configured to regulate the temperature and/or the pressure and/or the flow rate of the control fluid on the basis of the plant parameters in order to keep the clearance 16 at the desired values.

[0052] For example the regulator 37 is configured to regulate the temperature and/or the pressure and/or the flow rate of the control fluid on the basis of at least one parameter such as local temperature and/or clearance measurements and/or load condition of the turbine 5 and/or the speed of load variations of the turbine 5 and/or temperature at the turbine inlet, etc.

[0053] According to the non-limitative embodiment disclosed in figure 2, the discharge conduit 34 connected to the outlet 33 of at least one of the clearance control cavities 29 extends substantially axially and flows into the working expansion channel 7. According to a variant not illustrated the discharge conduit 34 does not extend axially and are inclined at an angle with respect to the axis A

[0054] In this way the control fluid is discharged in the expansion channel 7 through a discharge port 38 and can provide a further useful work in the turbine 5, improving the overall efficiency of the plant 1. In particular, discharge port 38 is arranged on the vane carrier 10 between a radial array of rotor blades 13 and a radial array of stator vanes 11.

[0055] In the non-limiting example here disclosed and illustrated in figures 3 and 4, the discharge conduits 34a connected to the outlets 33a of the clearance control cavities 29a which are closer to the split plane S of the vane carrier 10 connects the clearance control cavities 29a with the adjacent clearance control cavities 29b in order to create a sequential discharge configuration. In this way, at the split plane, a minimized space occupation is obtained.

[0056] Preferably, clearance control cavities 29b have the outlets connected to respective discharge conduits extending substantially axially or are inclined at an angle with respect to the axis A and flowing into the expansion channel 7 (said discharge conduits are specifically not visible in the attached figures).

[0057] Discharge conduits 34a are preferably realized by drilling the vane carrier 10 at the split plane S. However said solution implies the presence of undesired service channels 39 which can be plugged up or joined.

[0058] According to a variant not illustrated at least one of the discharge conduits can discharge the control fluid directly or indirectly into components requiring cooling, such as vanes, stator platforms (not illustrated in the attached figures), heat shields (not illustrated in the attached figures). In this way the control fluid can be used for save dedicated cooling air (generally extracted from the compressor) thus improving the overall efficiency of the plant 1.

[0059] According to another variant not illustrated at least one of the discharge conduits can discharge the control fluid directly or indirectly into selected stator cavities (not illustrated in the attached figures) needing purging air for preventing entrance of hot fluid coming from the expansion channel 7.

[0060] With reference to figures 2-4, preferably inside at least a portion of one of the plurality of clearance control cavities 29 at least one insert 41 is arranged.

[0061] Said insert 41 can be shaped in order to guide the flow of the control fluid inside the clearance control cavity 29 allowing freedom in designing the position of the inlet 30 and of the outlet 33 along the axis B of the clearance control cavity 29.

[0062] Said insert 41 can furthermore enhance the heat transfer between the control fluid flowing in the clearance control cavity 29 and the material of the vane carrier 10 in order to influence the temperature of the vane carrier 10. The insert 41, in fact, allow to operate with moderate flow quantities.

[0063] Insert 41 can be one of the inserts disclosed in EP 2023600.

[0064] In the non-limiting example here disclosed and illustrated in figure 2, the insert 41 has mainly the shape of a cylindrical hollow tube so as the flow of control fluid can pass through the insert 41, in order to limit the heat transfer with the vane carrier 10, and in a gap 42 defined between the insert 41 and the respective inner surface of the clearance control cavity 29, in order to keep the maximum heat transfer area and increase the flow velocity.

[0065] According to a variant not shown, the insert is shaped so as the flow of control fluid can pass first through the insert 41 in one direction and then into the gap 42 defined between the insert 41 and the respective inner surface of the clearance control cavity 29 in the opposite direction. In this solution inlet and outlet of the clearance control cavity 29 can be positioned close together and at substantially the same position along the axis B of the clearance control cavity 29.

[0066] According to a variant not shown, the insert is shaped so as the flow of control fluid can pass first into the gap 42 defined between the insert 41 and the respective inner surface of the clearance control cavity 29 in one direction and then through the insert 41 in the opposite direction. Also in this solution inlet and outlet of the clearance control cavity 29 can be positioned close together and at substantially the same position along the axis B of the clearance control cavity 29.

[0067] Preferably the gap defined between the insert 41 and the respective inner surface of the clearance control cavity 29 has a thickness T (intended as the measure along a direction perpendicular to the axis B) which is a function of the diameter of the clearance control cavity 29. Preferably the ratio between the diameter of the clearance control cavity 29 and the thickness T is comprised between 1:200 to 1:2.

[0068] According to a variant not shown the insert is provided with turbulators on the outer surface in order to create turbulence inside the gap 42. In this way the flow velocity and the heat transfer is improved.

[0069] For example said turbulators may be helicoidally bended ribs protruding from the outer surface of the insert 41.

[0070] According to a variant not shown the insert is provided with impingement passing holes. In this way the flow of control fluid passing through the insert passes also though the impingement holes and impinges on the inner surface of the clearance control cavity 29, i.e. on the vane carrier 10.

[0071] According to a variant not shown the insert is not cylindrical and has a shape defined by a combination of conical and cylindrical part so that the thickness T of the gap 42 can vary along the length of the insert.

[0072] According to a variant not shown the insert is provided with damping means configured to resist vibrations.

[0073] According to a variant not shown the clearance control cavity comprises also a dirt trap configured to accumulate dirt.

[0074] Insert 41 can be fixed in the respective clearance control cavity 29 either by screwing it in the clearance control cavity 29 (in this case the insert 41 and the clearance control cavity 29 have threaded portions) or by shrinking it to the clearance control cavity 29 or by caulking it with the clearance control cavity 29 or by fixing it to the clearance control cavity 29 with a locking screw, or by welding it to the clearance control cavity 29 or by press fitting it into the clearance control cavity 29.

Finally, it is clear that modifications and variants can be made to the vane carrier and to the plant described herein without departing from the scope of the present invention, as defined in the appended claims.

Claims

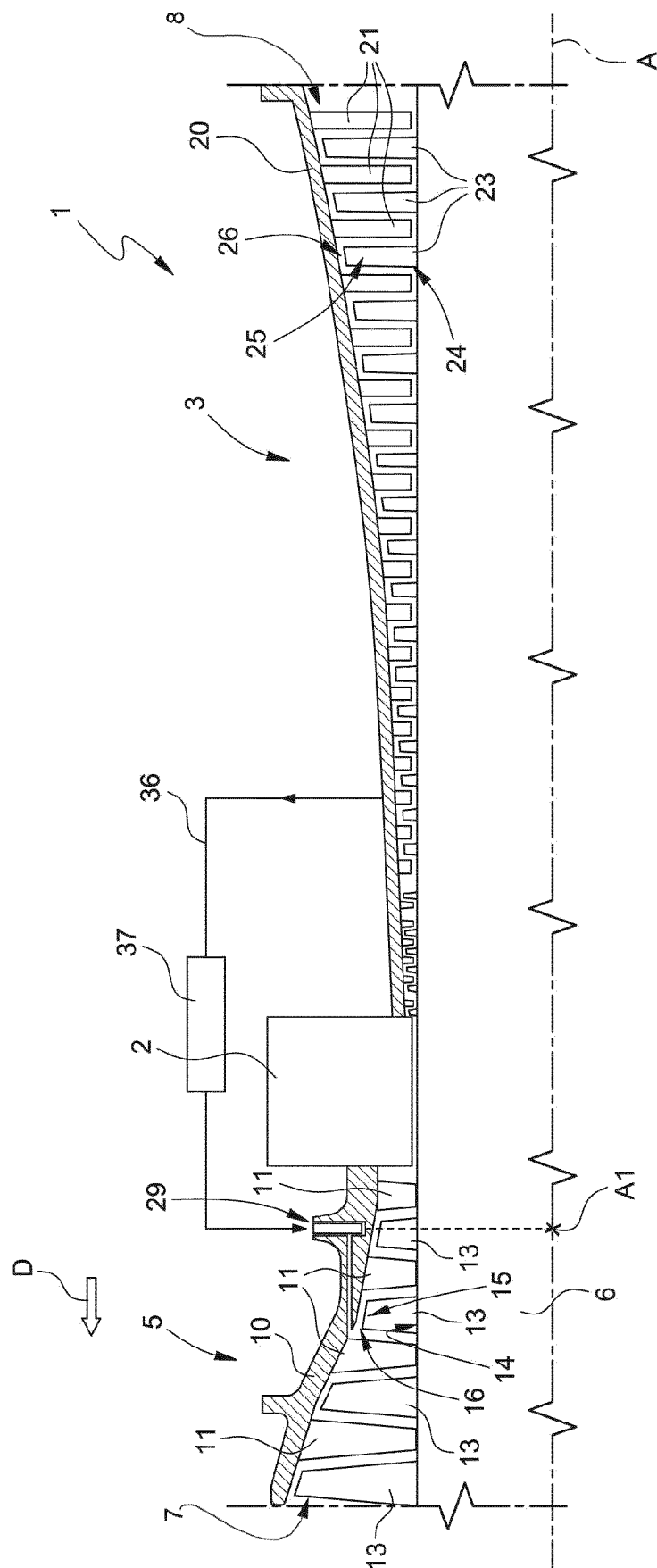
1. Vane carrier for a gas turbine plant extending along a longitudinal axis (A) and comprising at least one clearance control cavity (29) which extends transversally with respect to the longitudinal axis (A).
2. Vane carrier according to claim 1, wherein the clearance control cavity (29) extends radially with respect to the longitudinal axis (A).
3. Vane carrier according to anyone of the foregoing

claim, comprising at least one plurality of clearance control cavities (29) distributed along a circumferential direction.

4. Vane carrier according to claim 3, wherein the plurality of clearance control cavities (29) are evenly distributed along the circumferential direction. 5
5. Vane carrier according to anyone of the foregoing claims, having an inner surface (32b) facing a working channel (7; 8) provided with vanes (11; 21) and an outer surface (32a) opposite to the inner surface (32b); wherein the clearance control cavity (29) is a blind hole made into the outer surface (32a) of the vane carrier (10; 20). 10 15
6. Vane carrier according to anyone of the foregoing claims, wherein the clearance control cavity (29) has at least one inlet (30) connected to a source of control fluid (31, 16, 3). 20
7. Vane carrier according to anyone of the foregoing claims, wherein the clearance control cavity (29) has at least one outlet (33; 33a) connected to a respective discharge conduit (34; 34a). 25
8. Vane carrier according to claim 7, wherein the discharge conduit (34) flows into a working channel (7; 8) provided with vanes (11; 21). 30
9. Vane carrier according to claim 7, wherein the discharge conduit (34a) connects the outlet (33a) of the clearance control cavity (29a) to a further inlet of a further adjacent clearance control cavity (29b). 35
10. Vane carrier according to anyone of the foregoing claims, comprising at least one insert (41) which is arranged inside at least one clearance control cavity (29). 40
11. Vane carrier according to claim 10, wherein the insert (41) is hollow so as to allow the passage of control fluid through it.
12. Vane carrier according to claim 10 or 11, wherein the insert (41) is shaped so as to define a gap (42) between the insert (4) and the inner surface of the clearance control cavity (29). 45
13. Plant for the production of electrical power energy comprising a compressor (3), a combustor (4) and a gas turbine (5); the gas turbine (5) comprises at least one vane carrier (7) as claimed in anyone of the foregoing claims. 50 55
14. Plant according to claim 13, wherein the clearance control cavity (29) is connected to an extraction line (36), which is configured to extract air from the com-

pressor (3) and feed it to the clearance control cavity (29).

15. Plant for the production of electrical power energy comprising a compressor (3), a combustor (4) and a gas turbine (5); the compressor (3) comprises at least one vane carrier (8) as claimed in anyone of the foregoing claims.



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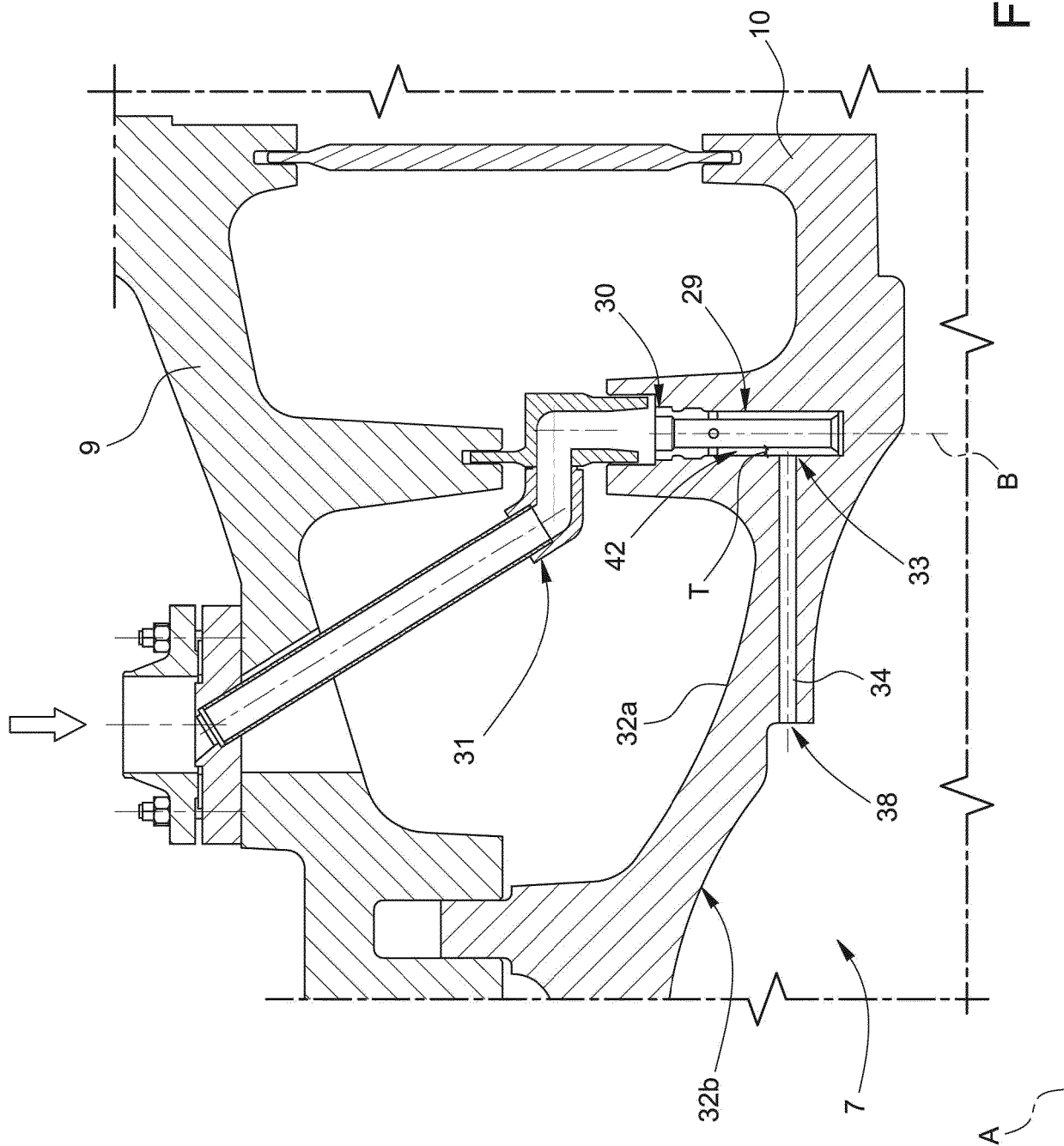
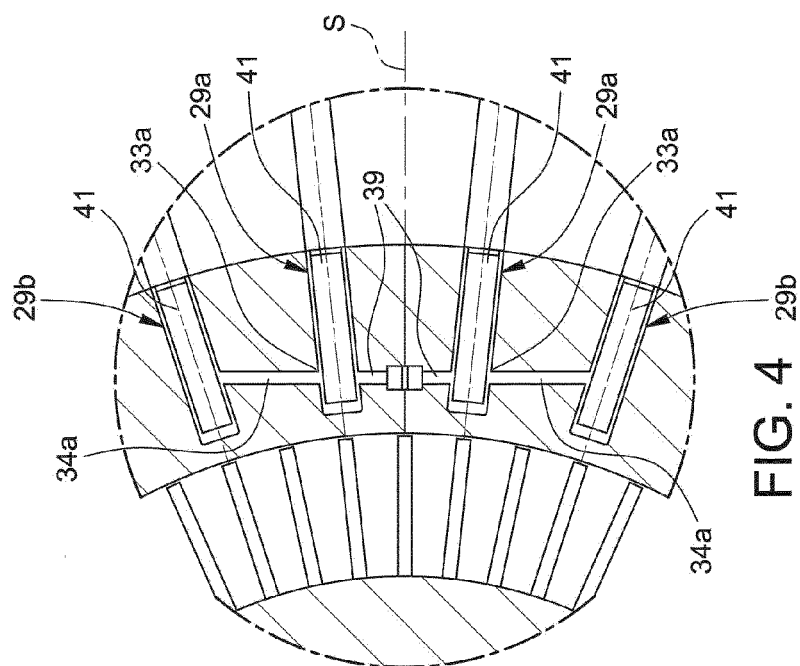
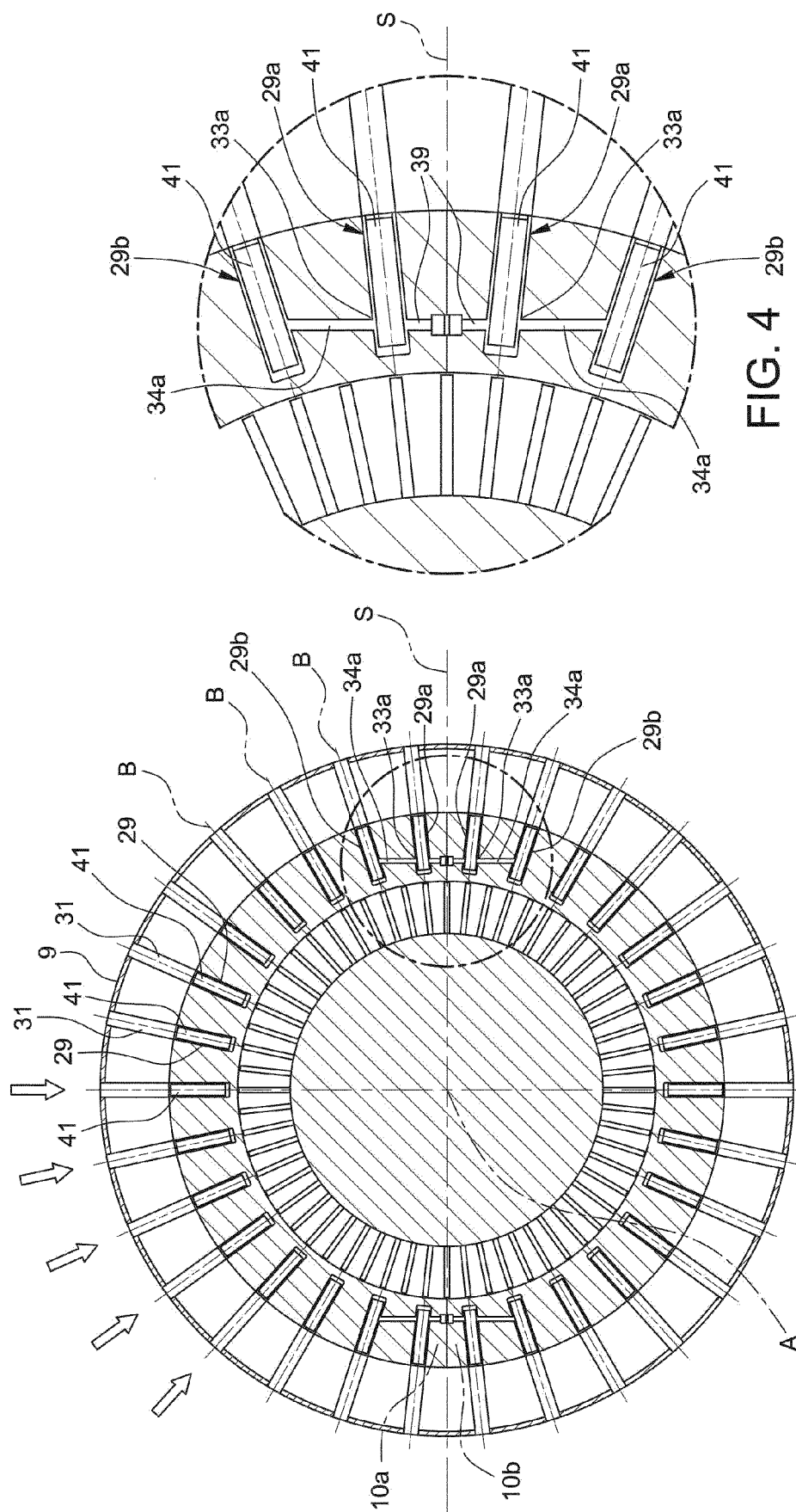


FIG. 2





EUROPEAN SEARCH REPORT

 Application Number
 EP 17 17 9199

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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