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(54) **SHIPLAP SEAL ARRANGEMENT**

(57) A shiplap arrangement for a gas turbine having an axis A; the shiplap arrangement comprising:
- a first and a second blade adjacent arranged along a circumferential direction (15) centered in the gas turbine axis A; each blade along a radial direction (14) comprising a foot configured for coupling the blade to a rotor, a shank portion provided with a downstream closing wall, a platform (19) and an airfoil (20); between the adjacent blades in the shank portion a cooling air cavity is provided that is outwardly sealed by an axial seal (22) arranged along the gap between the adjacent platforms and downstream sealed by a shiplap coupling (24) between the adjacent

shank closing walls (18); the shiplap coupling comprising a circumferential projecting portion of the shank closing wall of the first blade and a corresponding receiving recess portion in the adjacent shank closing wall;
- a radial seal (30) arranged along the gap between the projecting portion and the recess portion of the shiplap coupling (24) and housed at one side in a first radial groove realized in the projecting portion and at the other side in a second radial groove realized in the recess portion to provide a barrier against leakage flow passing through the shiplap coupling (24).

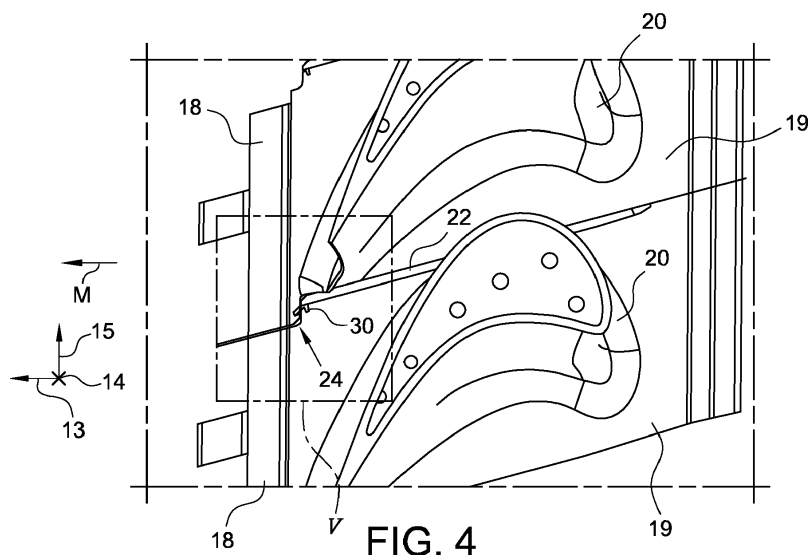


FIG. 4

Description

Field of the Invention

[0001] The present invention relates to a shiplap arrangement for a gas turbine

Description of prior art

[0002] Conventional sealing means for sealing inter-spaces, such as rubber seals, polymer seals, adhesive means, or engaging of a projection in a slot, as are especially to be encountered in the case of the seal between two static elements, are generally known. In gas turbines, a wide variety of elements are cooled by means of a cooling air flow for avoiding heat damage. This cooling air flow is to be effected with the lowest losses possible in order to maximize the cooling potential.

[0003] In order to achieve an efficient seal between two blade elements in a gas turbine, for example in order to prevent the loss of cooling air as a result of a leakage flow, a precise matching of the blade elements to each other is necessary. If, however, the wish is to make a certain "clearance" possible for the abutting components, which is indispensable for example between two rotor blades in a rotor of a gas turbine on account of the intense flow around the blade elements by hot operating medium during operation, a precise matching of two adjacent shrouds of blade elements is almost impossible since such a compact type of construction, as would be necessary for the complete sealing of the radial gap, can lead to problems, for example on account of thermal expansion. Also, the effect of centrifugal forces between the components after installation can be considerable, which can lead to severe wear of conventional sealing means. For these reasons, so-called "shiplaps" are used between blades in a gas turbine rotor according to conventional design for sealing the leakage flow in the axial direction. "Shiplaps" constitute a thermally resistant sealing means since they are designed essentially from the material of the blade elements themselves, form an integral component part of the blade elements, and therefore enable a sealing effect without additional material which is possibly sensitive to heat or has a different coefficient of thermal expansion.

[0004] Turbine blades, in most cases have at least one platform element radially on the inside and/or radially on the outside, which, with the blade row installed, abut on the respectively adjacent platform element of the respectively adjacent blade element by the two sides of the platform element which point in the circumferential direction, forming in each case an essentially circumferential gap. Such a turbine blade element, on at least one axial edge, especially the trailing edge, on a first side which points in the circumferential direction, can have a projection which extends in the circumferential direction and projects into the platform element of the abutting blade element, and on a second side which points in the cir-

cumferential direction can have a recess which accommodates this projection.

[0005] The sequential installation of such blade elements leads in each case to the forming of a so-called "shiplap" between two blade elements. Such a shiplap is an overlapping or engaging region, which is stepped in the flow direction of the operating gas, between the shroud element on an axial edge of a blade element and the shroud element on the same axial edge of the adjacent blade element. This shiplap seals the radially extending gap between the contiguous circumferential sides of two turbine blades against the escape of cooling air from the secondary air circuit, i.e. against the leakage flow in the axial direction. Such a shiplap comes into being as result of the covering of a recess on a first side, which points in the circumferential direction, of an adjacent blade element by means of a projection on the second side, which points in the circumferential direction, of a blade element, or by the engagement of the projection in the recess.

Disclosure of the invention

[0006] The invention is accordingly based on the object of providing an improved arrangement which has an improved sealing effect along the shiplap coupling that reduces the leakage flow from the cooling air cavity.

[0007] This is achieved by a shiplap arrangement according to claim 1. The claimed arrangement ensures that the gap in the shiplap coupling can be sealed.

[0008] It is a further object of the invention to provide an arrangement wherein the seal is rigid and mounted with a clearance in two facing grooves along the shiplap coupling. This lowers production costs and ensures an easy assembly.

[0009] It is a further object of the invention to provide an arrangement wherein the seal is hook-shaped defining a convex side pointing against the leakage flow and a concave side engaging a protrusion within one groove, the leakage flow pressing the seal against the protrusion. This ensures suitable and easy positioning and retention of the seal.

[0010] It is a further object of the invention to provide an arrangement wherein the grooves and the seal are located between two bends along the gap of the shiplap coupling. Bends are normally located in a stepped trailing region of the platforms and correspond to a circumferential projection of a platform extending into the platform of an adjacent blade segment. Bends decrease the velocity of leakage flow and the location of the seal further decreases the velocity of leakage flow.

[0011] The invention has been foregoing described with reference to the sealed shiplap arrangement. However, the present invention refers also to the blade row comprising such a sealed shiplap arrangement and, in general, a gas turbine for power plant provided with such a blade row.

[0012] It is to be understood that both the foregoing

general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed. Other advantages and features of the invention will be apparent from the following description, drawings and claims.

[0013] The features of the invention believed to be novel are set forth with particularity in the appended claims.

Brief description of drawings

[0014] Further benefits and advantages of the present invention will become apparent after a careful reading of the detailed description with appropriate reference to the accompanying drawings.

[0015] The invention itself, however, may be best understood by reference to the following detailed description of the invention, which describes an exemplary embodiment of the invention, taken in conjunction with the accompanying drawings, in which:

- figure 1 is a schematic view of a flow diagram of an embodiment of a gas turbine for power plants;
- figures 2 and 3 are schematic views of two adjacent turbine blades of the gas turbine of fig. 1;
- figure 4 is a schematic view of a portion of figure 3;
- figure 5 is a schematic enlarged view of the portion of figure 4 represented by reference V with an embodiment of the sealing arrangement according to the invention;
- figures 6 and 7 are schematic views of the sealing arrangement of figure 5 along the axial direction respectively in a standard condition and in the worst case of tolerances;
- figures 8 and 9 are schematic views of the sealing arrangement of figure 5 along the radial direction with respectively the seal arranged in a blade and in the adjacent blade.

Detailed description of preferred embodiments of the invention

[0016] In cooperation with attached drawings, the technical contents and detailed description of the present invention are described thereafter according to preferred embodiments, being not used to limit its executing scope. Any equivalent variation and modification made according to appended claims is all covered by the claims claimed by the present invention.

[0017] Reference will now be made to the drawing figures to describe the present invention in detail.

[0018] Reference is made to figure 1 which is a schematic view of a flow diagram of an embodiment of a gas turbine for power plants. Figure 1 discloses a gas turbine power plant 1 having an axis A and comprising in series along the main flow M:

- a compressor section 2, provided with an intake 11 for feeding air 10,

- a combustor section, provided with a burner 3 with a plurality of fuel nozzles 6 and a combustion chamber 4 wherein the compressed air is mixed with at least a fuel and this mixture is burnt to create a hot gas flow, and
- a turbine section 5 where the hot gas flow expands performing work on a rotor 7.

[0019] Preferably, the rotor 7 is single piece of a plurality of rotor wheels welded together and extends from the compressor 2 to the turbine 5. As known, the combustor section can be provided with an annular combustor or a plurality of can combustors. The exhaust gases leaving the turbine can be used in a steam generator 8 and the rotor 7 can be connected to load 9 that can be a stationary load such as an electrical generator in a power plant. As known, the compressor 2 and the turbine 5 comprises a plurality of stator vanes and a plurality of rotating blades. These rotating blades connected to the rotor 7 and arranged in parallel circumferential rows centered in the axis 7. Reference is made to figures 2 and 3 that are schematic views of adjacent blades of the gas turbine of fig. 1, in particular figures 2 and 3 refer to adjacent turbine blades 12. As known, the turbine blades are in contact with the hot gas and therefore need to be cooled by cooling air, i.e. compressed air. In particular, figure 2 discloses a legend of the main directions of the gas turbine filed. In this legend the reference 13 refers to the axial direction that is parallel to the rotor 7, to the axis A and in general to the hot gas flow direction M. the terms downstream and upstream refer to the axial direction 13 along the hot gas flow direction M. The reference 14 refers to the radial direction centered in the axis A; the terms inner/inwardly and outer/outwardly refer to the distance from the axis A along the radial direction 14. The reference 15 refers to the circumferential direction centered in the axis A. For reason of clarity, also the following figures 3-9 disclose this legend to allow the easy identification of the correct position of the represented gas turbine components. In view of the above figure 2 discloses an axial downstream view of two adjacent turbine blades 12 of a common row of blades. Blades 12 may be constructed of a metal, metal alloy, ceramic matrix composite (CMC), or other suitable material. Starting from the axis A and along the radial direction 14 each blade 12 comprises a foot 16 configured to be coupled with the rotor 7, a shank portion 17 provided with downstream or closing wall 18, a platform 19, and an airfoil 20. At the shank portion 17 between two adjacent blades a cavity is present, in particular a cooling air cavity that is partially disclosed in the figures 8 and 9 with the reference 21. From the shank cavity, the cooling air can enter in cooling duct realized inside the airfoil 20 that in operation are in contact with the hot gas flow. This cavity is outwardly limited along the radial direction 14 by the adjacent edges of the platforms 19 and downstream along the axial direction 13 by the adjacent edges of the closing walls 18. As known, in order to avoid losses of efficiency of turbine engine, this cooling air cavity has

to be sealed both in radial direction, i.e. to avoid leakages passing to the gap present between the adjacent platforms 19, and in axial direction, i.e. to avoid leakages passing to the gap present between the closing walls 18. The sealing in the radial direction is performed by an axial seal in form preferably of an axial seal strip arranged in axial seats of the facing adjacent edges of the platforms 19. Figure 2 and 3 disclose schematically this axial seal with the reference 22 and the figures 8 and 9 disclose the seats 23 of this axial seal 22 in the platforms 19. The sealing in the axial direction is performed by the so called shiplap coupling represented in figure 2 and 3 by the reference 24. As known, the shiplap coupling 24 comprises a radial edge of the closing wall 19 that is projecting to the adjacent closing wall 19 and a recess configured for housing the projecting edge realized in such an adjacent closing wall 19. In order to assembly the blade row each blade of the row, beside the last blade, comprise a closing wall wherein a first radial edge in provided with the projecting portion along the circumferential direction 15 and on the opposite radial edge with a radial recess suitable for housing the projecting portion of the adjacent blade.

[0020] Figure 3 schematically shows a top view along the radial direction 14 of some adjacent blades in order to clarify the shiplap coupling. The airfoil 20 comprises a leading edge 25 and a trailing edge 26. Figure 3 discloses the radial gap 27 between two adjacent platforms 19 sealed by the axial seal 22 and the shiplap coupling 24 configure for closing the axial gap between two adjacent closing walls 19. The projection portion of the shiplap coupling 24 has been represented by the reference 28 and the corresponding recess with the reference 29.

[0021] Reference is made to figure 4 that is a schematic enlarged view of a shiplap portion of figure 3. In particular, figure 4 discloses a seal 30 arranged in the shiplap region 24 foregoing described. This seal 30 is configured to provide a barrier against a leakage flow from the shank cavity passing through the gap present between the projection portion 28 and the recess portion 29.

[0022] Reference is made to figure 5 that is a schematic enlarged view of the portion of figure 4 represented by reference V and showing a top view along the radial direction of the shiplap region 24 provided with the seal 30.

[0023] According to the embodiment of figure 5, the seal 30 has axially extends from a first groove 31 realized in the projection portion 28 to a second groove 32 realized in the recessed portion 29. The references C1 and C2 in figure 5 represent the cooling air flow passing between two adjacent closing walls, in particular passing through the gap present between the projection portion 28 and the recess portion 29. C1 is the leakage flow along the axial direction and C2 the leakage flow along the circumferential direction. As disclosed in figure 5 the seal 30 allow to stop the flow C2. Seal 30 is preferably a rigid seal housed with play or clearance the grooves 31 and 32. The first 31 and the second groove 32 are substantially facing each other along the axial direction 13.

[0024] Reference is now made to figure 6 and 7 that are schematic views of the sealing arrangement of figure 5 respectively in a standard condition and in the worst case of tolerances.

[0025] Play of seal 30 in the relative grooves 21 and 32 ensures that manufacturing tolerances are recovered and, at the same time, proper seal is obtained. In particular, clearance is in a direction parallel to the leakage flow C2, i.e. along the circumferential direction 15, and/or in a direction transversal, preferably perpendicular, to the leakage flow C2, i.e. along the axial direction 13. This provides a floating mount of the rigid seal 30 in seat 31 32. Furthermore, the seal 30 has a hook shape defining a convex side 33 pointing against the leak flow C2 and a concave side 34 engaging a protrusion 35 within one the groove 32, in particular the groove 32 in the recess portion 29. Coupling between seal 30 and protrusion 35 is a floating coupling due to clearance of seal inside seat 31, 32. In use, leakage flow C2 presses seal 30 against protrusion 35 even if the centrifugal force is acting on the seal 30.

[0026] According to the embodiment disclosed, the seal 30 has a substantially 'L' cross section orthogonal to the radial direction 14 defining by a longer arm 36 crossing gap of the shiplap coupling and a shorter arm 37 housed in the groove 32 in the recess portion 29. L shape is simple to manufacture, e.g. by bending. It is however possible to obtain a similar function with other profiles, such as a 'T' profile that can be manufactured e.g. by extrusion. In use, leakage flow presses longer arm 36 against an internal surface of groove 31 in the recess portion 28 even if the centrifugal force is acting on the seal 30.

[0027] Reference is made to figures 8 and 9 that are schematic prospective views of the sealing arrangement of figure 5 along the axial direction showing respectively the seal arranged in a blade and in the adjacent blade. In particular, figure 8 and 9 disclose two prospective axial view of the seal 30 respectively from the shank cavity from outside the shank cavity. According this embodiment, the seal 30 and the grooves 31 32 extend radially along substantially the entire radial length of the projecting 28 and recess 29.

[0028] The seal 30 outwardly extends up to the axial seal arranged between the adjacent blades in the seats 23.

[0029] Finally, the inner ends of the groove are open to allow a sliding assembly of the seal 30 that is held in position at the opposite outer ends of the grooves. Preferably, the seal 30 is held by the axial seal 22 that is assembled after the seal 30.

[0030] Although the invention has been explained in relation to its preferred embodiment(s) as mentioned above, it is to be understood that many other possible modifications and variations can be made without departing from the scope of the present invention. It is, therefore, contemplated that the appended claim or claims will cover such modifications and variations that fall within

the true scope of the invention.

Claims

1. A shiplap arrangement for a gas turbine (1) having an axis (A); the shiplap arrangement (24) comprising:

- a first and a second blade (12) adjacent arranged along a circumferential direction (15) centered in the gas turbine axis (A); each blade (12) along a radial direction (14) comprising a foot (16) configured for coupling the blade (12) to a rotor (7), a shank portion (17) provided with a downstream closing wall (18), a platform (19) and an airfoil (20); between the adjacent blades (12) in the shank portion (17) a cooling air cavity (21) is provided that is outwardly sealed by an axial seal (22) arranged along the gap between the adjacent platforms (19) and downstream sealed by a shiplap coupling (24) between the adjacent shank closing walls (18); the shiplap coupling (24) comprising a circumferential projecting portion (28) of the shank closing wall (18) of the first blade (12) and a corresponding receiving recess portion (29) in the adjacent shank closing wall (18);

- a radial seal (30) arranged along the gap between the projecting portion (28) and the recess portion (29) of the shiplap coupling (24) and housed at one side in a first radial groove (31) realized in the projecting portion (28) and at the other side in a second radial groove (32) realized in the recess portion (29) to provide a barrier against leakage flow passing through the shiplap coupling.

2. Arrangement according to claim 1, **characterized in that** the seal (30) is rigid and housed with a clearance in the grooves (31, 32) to provide a floating mount of the seal (30) in the grooves (31, 32).
3. Arrangement according to claim 2, **characterized in that** clearance is in circumferential and/or in axial direction.
4. Arrangement according to any of the preceding claims, **characterized in that** the seal (30) is hook-shaped defining a convex side (33) pointing against the leakage flow and a concave side (34) engaging a protrusion (35) within one of said first and second groove (31, 32), the leakage flow pressing the seal (30) against the protrusion (35).
5. Arrangement according to claim 6, **characterized in that** the seal (30) comprises a longer arm (36) crossing the gap between the projecting portion (28) and

the recess portion (29) of the shiplap coupling (24) and a shorter arm (37) projecting from the longer arm (36) and housed in the second groove (32) together with the protrusion (35), the leakage flow pressing the longer arm (36) against an internal surface of the first groove (31).

6. Arrangement according to any of the preceding claims, **characterized in that** the groove (31, 32) and the seal (30) are located between two bends along the gap between the projecting portion (28) and the recess portion (29) of the shiplap coupling (24).
7. Arrangement according to any of the preceding claims, **characterized in that** the inner ends of the grooves (31, 32) are open to allow a sliding assembly of the seal (30).
8. Arrangement according to any of the preceding claims, **characterized in that** the seal (30) is held in position at the outer ends of the grooves (31, 32).
9. Arrangement according to any of the preceding claims, **characterized in that** the seal (30) is held in position by the axial seal (22) that is assembled after the seal (30).
10. A blade row assembly for a gas turbine having an axis (A), the blade row assembly comprising:

- a first and a second blade (12) adjacent arranged along a circumferential direction (15) centered in the gas turbine axis (A); each blade (12) along a radial direction (14) comprising a foot (16) configured for coupling the blade (12) to a rotor (7), a shank portion (17) provided with a downstream closing wall (18), a platform (19) and an airfoil (20); between the adjacent blades (12) in the shank portion (17) a cooling air cavity (21) is provided that is outwardly sealed by an axial seal (22) arranged along the gap between the adjacent platforms (19) and downstream sealed by a shiplap coupling (24) between the adjacent shank closing walls (18); the shiplap coupling (24) comprising a circumferential projecting portion (28) of the shank closing wall (18) of the first blade (12) and a corresponding receiving recess portion (29) in the adjacent shank closing wall (18);
- a radial seal (30) arranged along the gap between the projecting portion (28) and the recess portion (29) of the shiplap coupling (24) and housed at one side in a first radial groove (31) realized in the projecting portion (28) and at the other side in a second radial groove (32) realized in the recess portion (29) to provide a barrier against leakage flow passing through the ship-

lap coupling.

11. Blade row assembly as claimed in claim 10, wherein the seal (30) and the grooves (31, 32) are configured as claimed in any one of the foregoing claims from 1 to 9. 5

12. Gas turbine for power plant; the gas turbine (1) having an axis (A) and comprising: 10

- a compressor (2) for compressing air,
- a combustor (3, 4) for mixing and combusting the compressed air leaving the compressor (2) with at least a fuel,
- a turbine (3) for expanding the combusted hot gas flow leaving the combustor (3, 4) and performing work on a rotor (7) ; 15

wherein the turbine (3) comprises at least a blade row assembly as claimed in claim 10 or 11. 20

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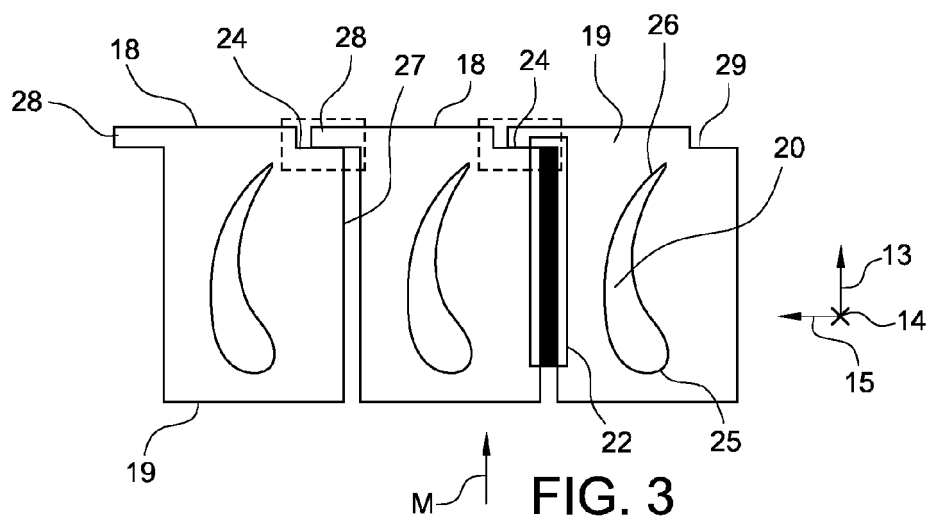
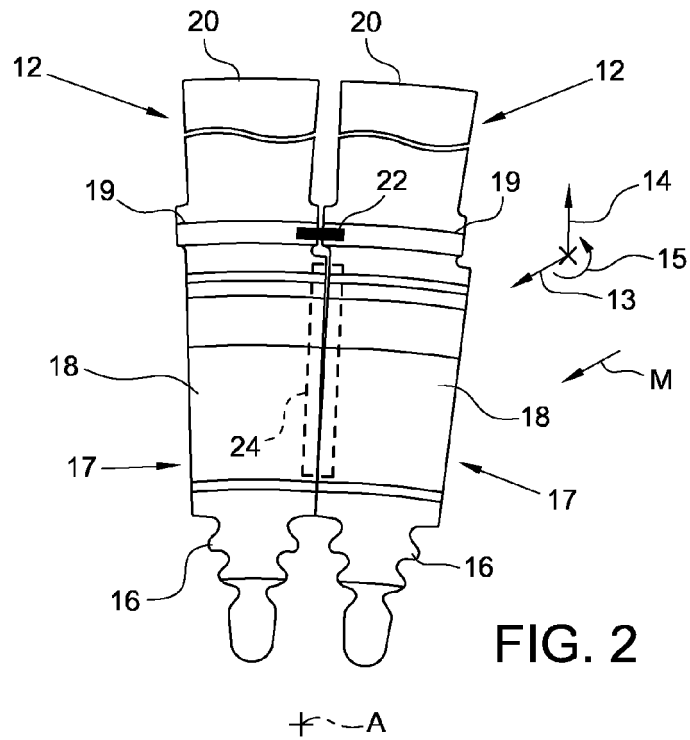
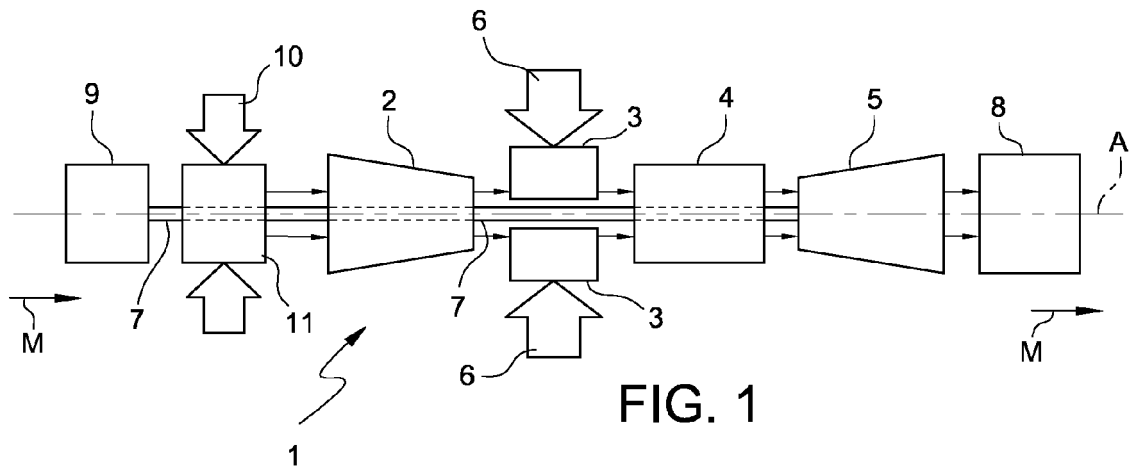
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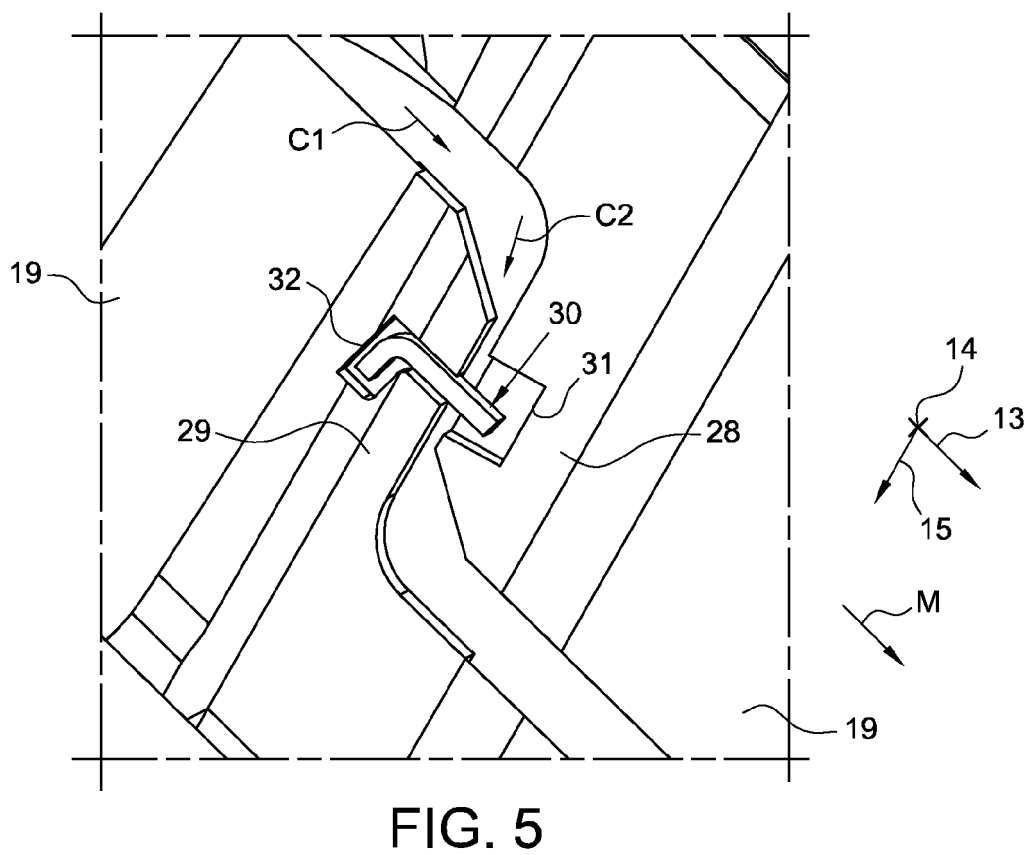
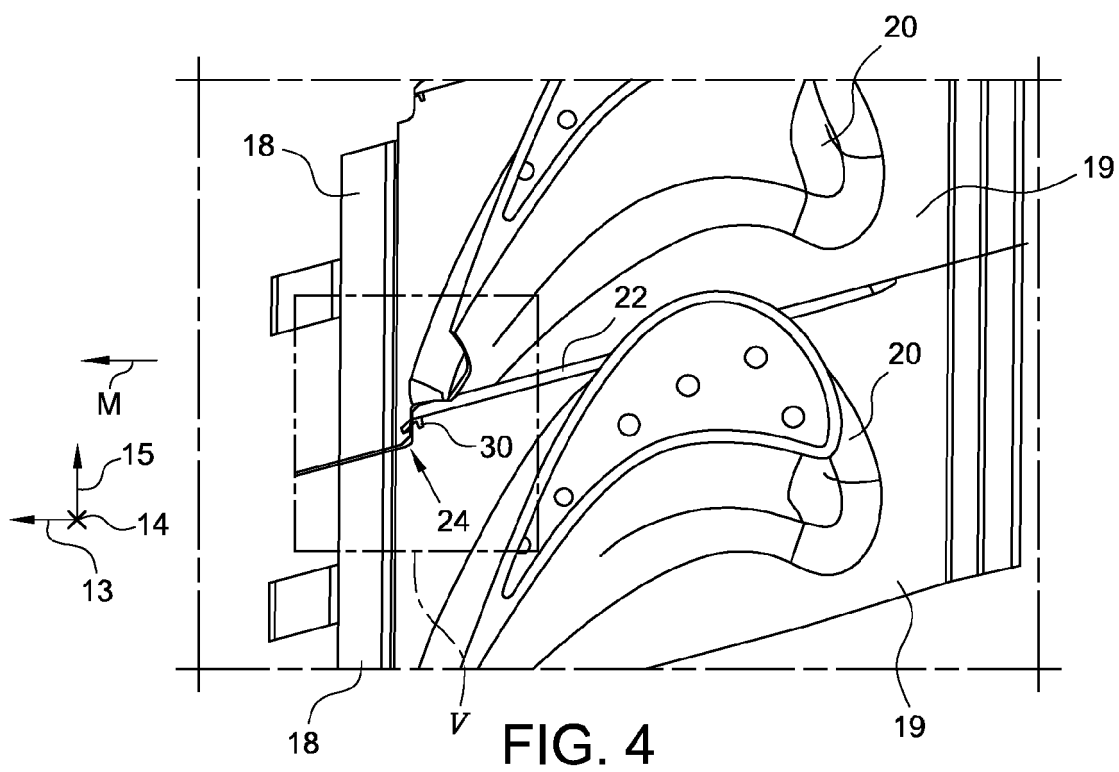
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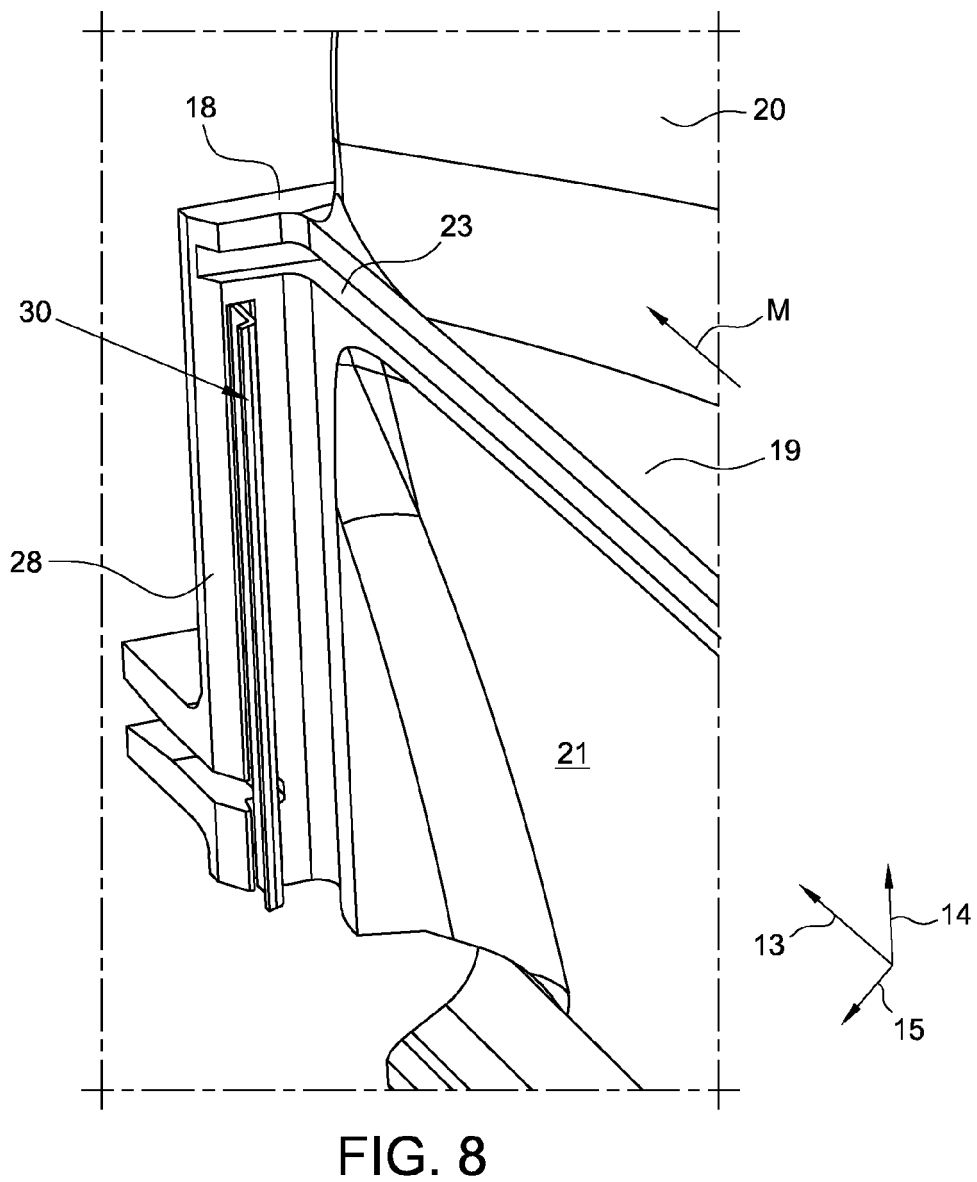
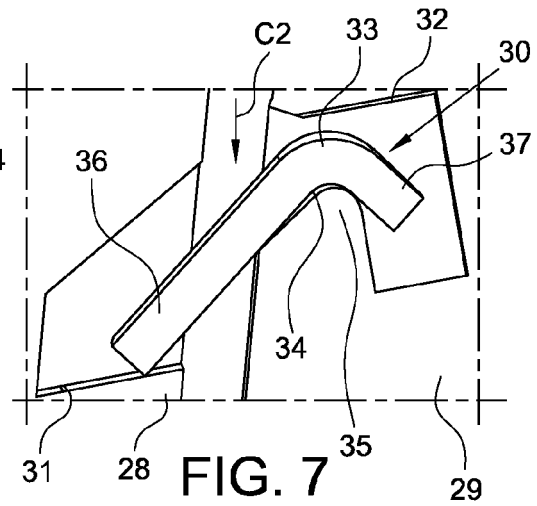
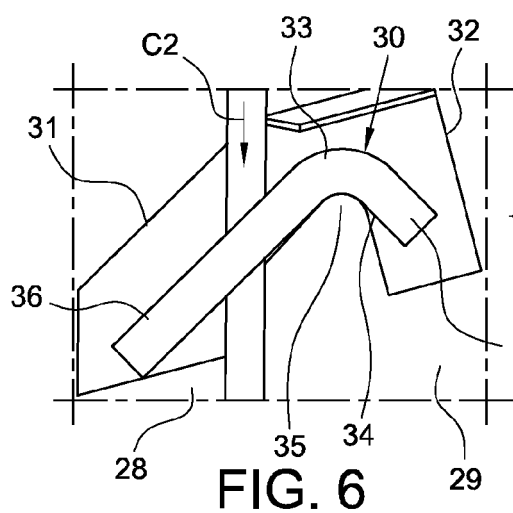
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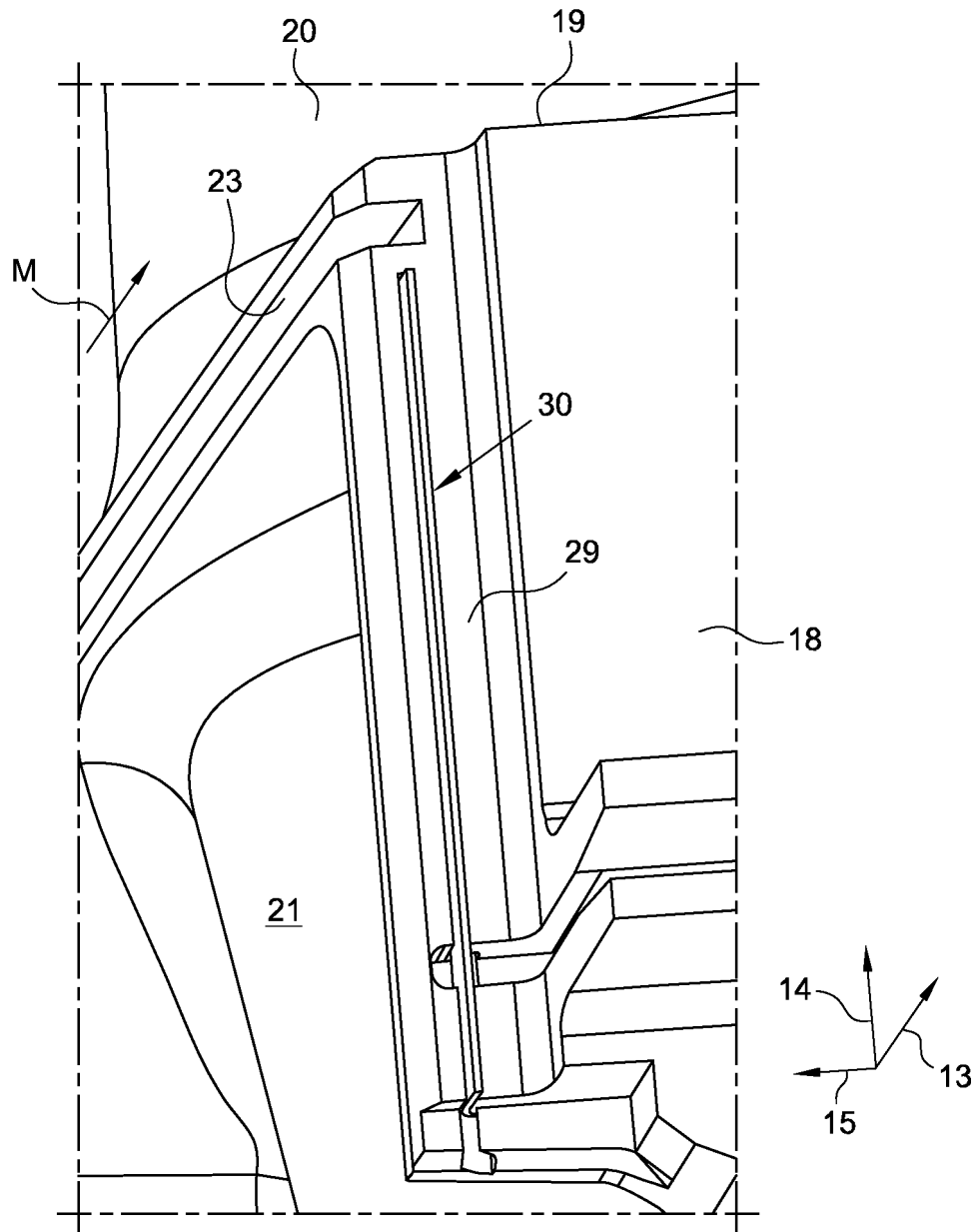


FIG. 9



EUROPEAN SEARCH REPORT

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 29 May 2018	Examiner Rau, Guido
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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