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(54) Steam turbine and method for extracting moisture from a steam turbine

(57) The steam turbine comprises a casing (1) containing a plurality of expansion stages each comprising stator and rotor airfoils. Downstream of the stator airfoils of one or more expansion stages, the casing (1) comprises a slot (7) arranged to receive moisture that concentrates on an end wall (3) of the stator airfoils (2) and discharge it to the outside. Each end wall (3) has a side portion facing the slot (7) having a variable radial obstruction in a tangential direction, in order to define with the slot (7) a passage (10) through which the moisture may pass that is smaller or closed at the suction side (12) and larger at the pressure side (13) of the stator blades (4), to at least partially prevent the dry steam from entering the slot (7) at the suction side (12) of the blade (4). The present invention also relates to a method for extracting moisture from a steam turbine.

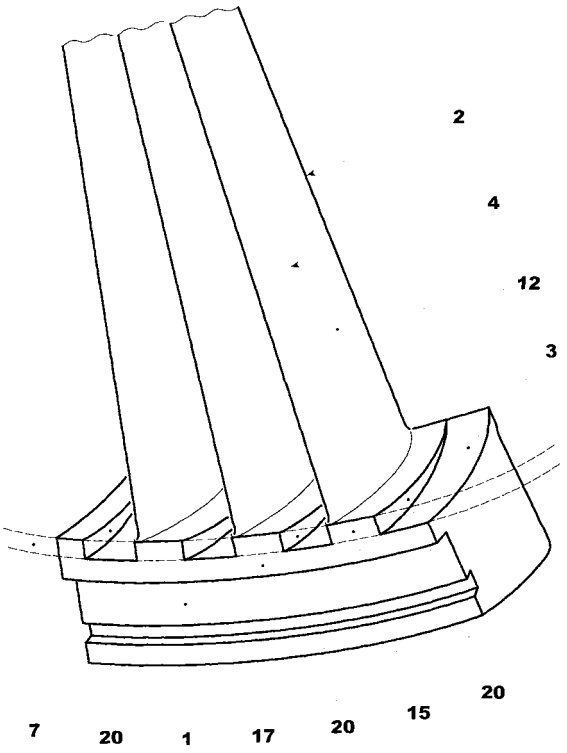

FIG. 5A

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Description

TECHNICAL FIELD

[0001] The present invention relates to a steam turbine and a method for extracting moisture from a steam turbine.

[0002] In particular, the present invention refers to low pressure steam turbines.

BACKGROUND ART

[0003] Steam turbine plants (in particular plants for electricity generation) are known to comprise a steam generator that feeds a turbine; the turbine expands the steam to operate an electrical generator and then discharges the exhausted steam in a condenser.

[0004] In order to extract from the steam the highest power as possible, steam is usually expanded far into the wet steam region.

[0005] Even if from the one hand this lets the power be increased, on the other hand this causes the generation within the steam of moisture that has a number of negative effects.

[0006] In fact, because of their high momentum of inertia, moisture droplets (in particular when they exceed a certain size) cannot follow the turning of the steam flow; thus they impinge on the following blade surface causing the so called wet steam erosion.

[0007] This problem is particularly relevant in low pressure turbines where expansion in the wet steam region takes place and often the amount of moisture is large.

[0008] In order to solve this problem, steam turbines (in particular low pressure stages of steam turbines) are often provided with devices that extract the moisture and discharge it to the outside.

[0009] With reference to the stator blades, such devices are often provided upstream of the stator blades and/or downstream of the stator blades.

[0010] In the following, the extraction devices downstream of the stator blades will be discussed in detail.

[0011] Steam turbines have a casing that carries the stator airfoils.

[0012] Each stator airfoil has an end wall that is connected to the casing and from which a stator blade extends.

[0013] Downstream of the stator airfoil the casing is provided with a circumferential slot arranged to receive the moisture that during operation (due to the centrifugal forces caused by the swirling steam flow and the rotating parts) concentrates near the end wall of the airfoils.

[0014] In order to protect the blades from erosion, the amount of moisture that is extracted trough the slot must be as high as possible; thus the slot should be as large as possible to let a large amount of moisture be seized therein.

[0015] Nevertheless, a large slot (in addition to a large amount of moisture) also seizes a large amount of dry steam.

[0016] This causes a loss in performance that should be avoided.

SUMMARY OF THE INVENTION

[0017] The technical aim of the present invention is therefore to provide a steam turbine and a method for extracting moisture from a steam turbine by which the said problems of the known art are eliminated.

[0018] Within the scope of this technical aim, an object of the invention is to provide a steam turbine and a method that let a large amount of moisture be extracted from the low pressure expansion stages with respect to traditional steam turbines, but at the same time that cause only a small extraction of dry steam.

[0019] Another object of the invention is to provide a steam turbine and a method that let both performance and reliability be increased with respect to traditional steam turbines.

[0020] The technical aim, together with these and further objects, are attained according to the invention by providing a steam turbine and a method for extracting moisture from a steam turbine in accordance with the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Further characteristics and advantages of the invention will be more apparent from the description of a preferred but non-exclusive embodiment of the steam turbine and the method according to the invention, illustrated by way of non-limiting example in the accompanying drawings, in which:

Figure 1 is a schematic perspective view of three stator airfoils according to the invention associated with a slot of the casing (the slot is shown in dashed line);

Figures 2-4 are schematic cross section through lines II-II, III-III and IV-IV of figure 1, in these figures a part of the casing defining the slot is also shown;

Figure 5 is a further schematic prospective view of three stator airfoils according to the invention; also in this figure the slot is shown in dashed line;

Figure 5A is a schematic prospective view of three stator airfoils according to the invention in a different embodiment; also in this figure the slot is shown in dashed line;

Figure 6 is a schematic longitudinal section of a portion of a turbine according to the invention;

Figure 7 is a perspective view of a stator airfoil row according to the invention; and

Figures 8 and 9 are details of figure 7, for sake of clarity they only show some of the stator airfoils.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The steam turbine comprises a casing 1 that contains a plurality of expansion stages.

[0023] Each expansion stage comprises a plurality of stator airfoils 2 downstream of which a plurality of rotor airfoils 5 are provided; in particular, each stator airfoil 2 comprises an end wall 3 that is connected to the casing 1 and from which a stator blade 4 extends.

[0024] In order to extract moisture from the steam turbine, downstream of the stator airfoils 2 of one or all the expansion stages (the enclosed figures show only one stage), the casing 1 has a circumferential slot 7 that is arranged to receive the moisture that concentrates on the end wall 3 of the stator airfoils 2 and discharge it to the outside of the steam turbine, for example via holes 8.

[0025] Each stator airfoil 2 has the end wall 3 that defines with the slot 7 a passage 10 through which the moisture may pass.

[0026] This passage 10 is smaller or closed at the suction side 12 and is larger at the pressure side 13 of each stator blade 4, to at least partially prevent the dry steam from entering the slot 7 at the suction side 12 of the blades 4.

[0027] In order to define a smaller or closed passage 10 at the suction side 12 of the stator blades 4, each end wall 3 has a portion facing the slot 7 having a variable radial obstruction in a tangential direction.

[0028] In this respect, the portion facing the slot 7 of the end wall 3 has at the suction side 12 a thick zone 15 that is located adjacent to the stator blade 4 and partially or completely obstructs the slot 7.

[0029] Moreover, the portion facing the slot 7 of the end wall 3 has a thin zone 17 that is adjacent to the thick zone 15 in a tangential direction.

[0030] Advantageously, the thin zone 17 has a thickness that, in a tangential direction, continuously decreases from that of the thick zone 15 towards the side of the end wall 3.

[0031] The thin zone 17 also has a thickness that, in an axial direction, continuously decreases from its portion opposite the portion facing the slot 7 toward the portion facing the slot 7.

[0032] The operation of the steam turbine of the invention is apparent from that described and illustrated and is substantially the following.

[0033] The steam flow flows in the axial direction (as shown by arrows F) and, when passing through the stator and rotor blades 4, 5, it turns to follow the curved channels.

[0034] Due to the centrifugal forces and the inertia, the moisture is forced to concentrate on the end walls 3 of the stator airfoils 2, at the pressure side 13 of their blades 4.

[0035] In addition, the particular shape of the end walls 3 forces the moisture to run towards the zone of the end walls 3 at the pressure side 13 of the blades 4 (see arrows M).

[0036] From this zone the moisture passes through the passages 10 and enters the slot 7 to be discharged to the outside of the steam turbine.

[0037] Naturally, in addition to the moisture, also dry steam is discharged through the passages 10.

[0038] Nevertheless, as the zones close to the suction sides 12 of the stator blades 4 are not provided with passages 10 (or in any case these passages are smaller than that at the pressure sides 13) neither moisture nor dry steam is discharged through these zones (or in any case only limited amounts are discharged).

[0039] Therefore, as the moisture is concentrated in the zones close to the pressure sides 13 of the blades 4, whereas the dry steam is almost uniformly distributed in the channels defined between two adjacent stator blades 4, the steam turbine of the invention lets the amount of moisture discharged be increased and/or the amount of dry steam discharged be reduced with respect to traditional steam turbines.

[0040] Figure 5A shows a different embodiment of the invention. In this embodiment the same reference numbers are used for elements already described.

[0041] In this embodiment the variable radial obstruction is defined by a slope at the end wall.

[0042] Moreover, between the thick zone 15 and the thin zone 17 there is provided a step. The step has a wall 20 perpendicular to the surfaces of the thick zone 15 and thin zone 17 or, alternatively, tilted with respect to them (or at least one of them).

[0043] Figures 7-9 show a further different embodiment of the invention. In this embodiment the same reference numbers are used for elements already described.

[0044] Even in this embodiment the variable radial obstruction is defined by a slope at the end wall; the slope projects inwardly from the leading edge 18 of each stator blade 4 to the trailing edge 19 of the same stator blade 4. Moreover the slope is adjacent to each stator blade 4 at its suction side 12.

[0045] The present invention also relates to a method for extracting moisture from a steam turbine that comprises a casing 1 containing a plurality of expansion stages each comprising stator and rotor airfoils and downstream of the stator airfoils of at least a stage the casing 1 is provided with a circumferential slot 7 arranged to receive the moisture that concentrates on an end wall 3 of the stator airfoils 2 and discharge it to the outside.

[0046] According to the method of the invention, the end wall 3 of the stator airfoils 2 drives the moisture away from the suction side 12 of its blade and at least partially prevents the dry steam from entering the slot 7 at the suction side 12 of the blade 4.

[0047] The steam turbine and the method conceived in this manner are susceptible to numerous modifications and variants, all falling within the scope of the inventive concept; moreover all details can be replaced by technically equivalent elements.

[0048] In practice the materials used and the dimen-

sions can be chosen at will according to requirements and to the state of the art.

REFERENCE NUMBERS

[0049]

1	casing
2	stator airfoil
3	end wall
4	stator blade
5	rotor blades
7	slot
8	holes
10	passage
12	suction side of the blades
13	pressure side of the blades
15	thick zone of the end wall
17	thin zone of the end wall
18	leading edge of the stator blade
19	trailing edge of the stator blade
20	wall of the step
F	steam flow
M	moisture

Claims

1. Steam turbine comprising a casing (1) containing a plurality of expansion stages each comprising stator and rotor airfoils, wherein downstream of the stator airfoils of at least an expansion stage the casing (1) comprises a slot (7) arranged to receive moisture that concentrates on an end wall (3) of the stator airfoils (2) and discharge it to the outside, **characterised in that** each end wall (3) has a side portion facing the slot (7) having a variable radial obstruction in a tangential direction, in order to define with the slot (7) a passage (10) through which the moisture may pass that is smaller or closed at the suction side (12) and larger at the pressure side (13) of the stator blades (4), to at least partially prevent the dry steam from entering the slot (7) at the suction side (12) of the blade (4).

2. Steam turbine as claimed in claim 1, **characterised in that**, said slot (7) is a circumferential slot.

3. Steam turbine as claimed in claim 1, **characterised in that** the portion facing the slot (7) of the end wall (3) has at its suction side (12) a thick zone (15) that is located adjacent to the stator blade (4) and partially obstructs the slot (7).

4. Steam turbine as claimed in claim 3, **characterised in that** said thick portion (15) completely obstructs the slot (7).

5. Steam turbine as claimed in claim 3, **characterised in that** said thick portion (15) is adjacent to each stator blade (4) at its suction side (12).

6. Steam turbine as claimed in claim 3, **characterised in that**, the portion facing the slot (7) of the end wall (3) has a thin zone (17) that is adjacent to the thick zone (15) in a tangential direction.

7. Steam turbine as claimed in claim 6, **characterised in that,** in a tangential direction, said thin portion (17) has a thickness that continuously decrease from that of the thick portion (15) toward the side of the end wall (3).

8. Steam turbine as claimed in claim 6, **characterised in that**, in an axial direction, the thin zone has a thickness that continuously decreases from its portion opposite the portion facing the slot (7) towards the portion facing the slot (7).

9. Steam turbine as claimed in claim 1, **characterised in that** the variable radial obstruction is defined by a slope at the end wall.

10. Steam turbine as claimed in claim 6 and 9, **characterised in that** between the thick zone (15) and the thin zone (17) there is provided a step.

11. Steam turbine as claimed in claim 10, **characterised in that** said step has a wall (20) perpendicular to the surfaces of the thick zone (15) and thin zone (17).

12. Steam turbine as claimed in claim 10, **characterised in that** said step has a wall (20) tilted with respect to the surfaces of the thick zone (15) and/or thin zone (17).

13. Method for extracting moisture from a steam turbine comprising a casing (1) containing a plurality of expansion stages each comprising stator and rotor airfoils, wherein downstream of the stator airfoils of at least a stage the casing (1) is provided with a slot (7) arranged to receive the moisture that concentrates on an end wall (3) of the stator airfoils (2) and discharge it to the outside, the method being **characterised in that** the end wall (3) of the stator airfoils (2) at least partially prevents the dry steam from entering the slot (7) at the suction side (12) of the blade (4).

14. Method as claimed in claim 13, **characterised in that** the end wall (3) of the stator airfoils (2) drives the moisture away from the suction side (12) of its blade (4).

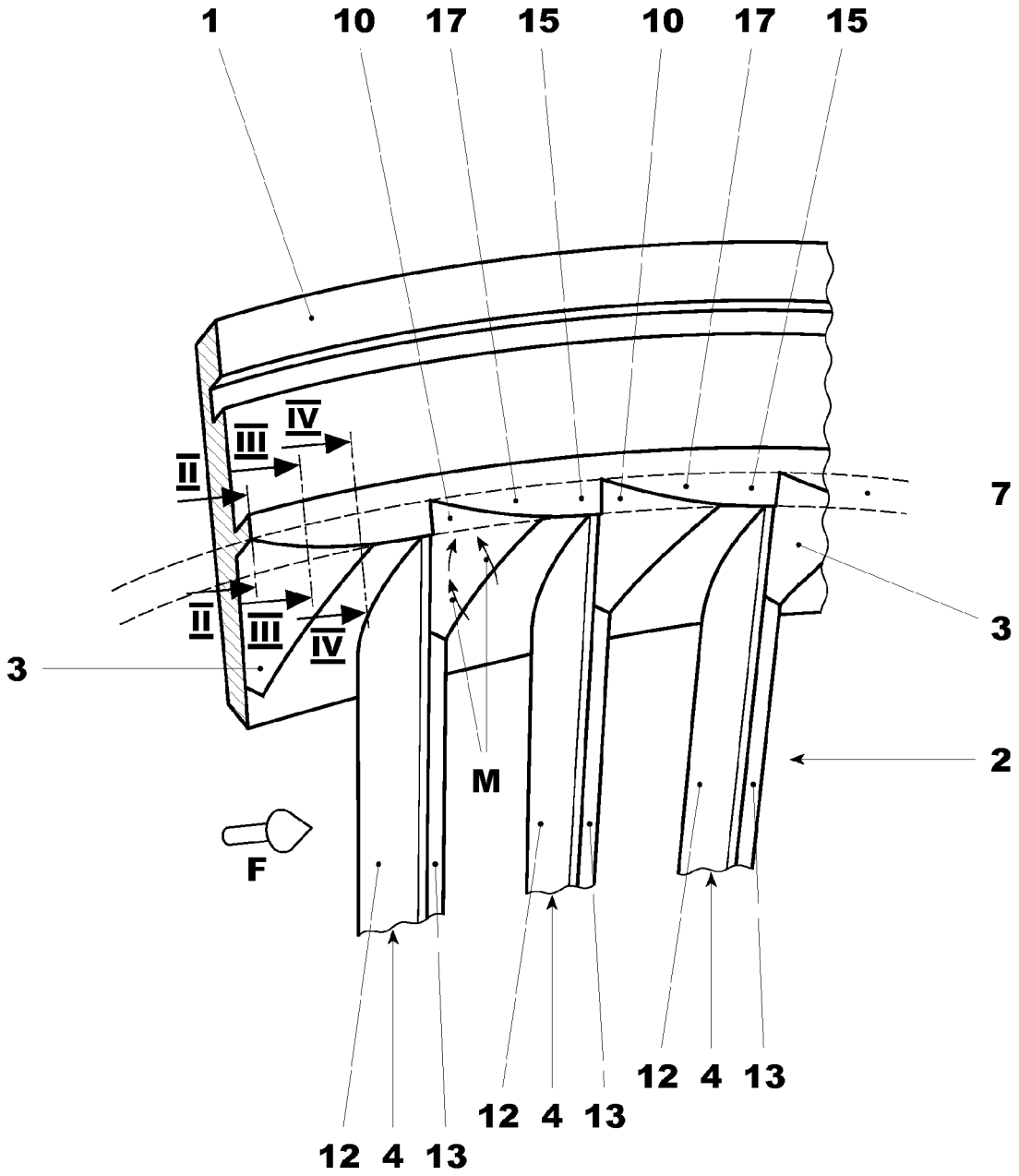

FIG. 1

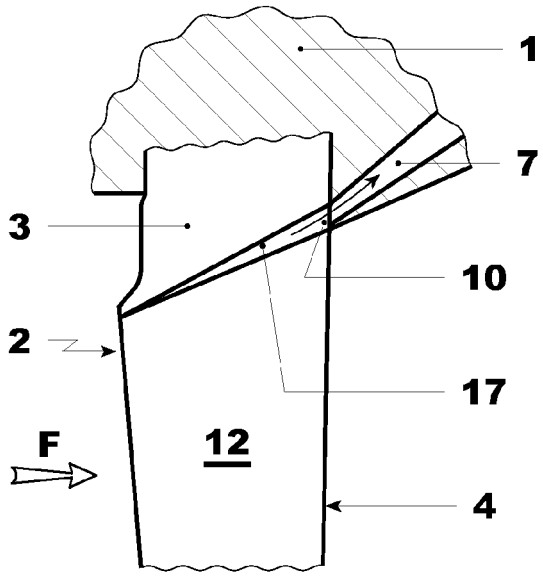

FIG. 2

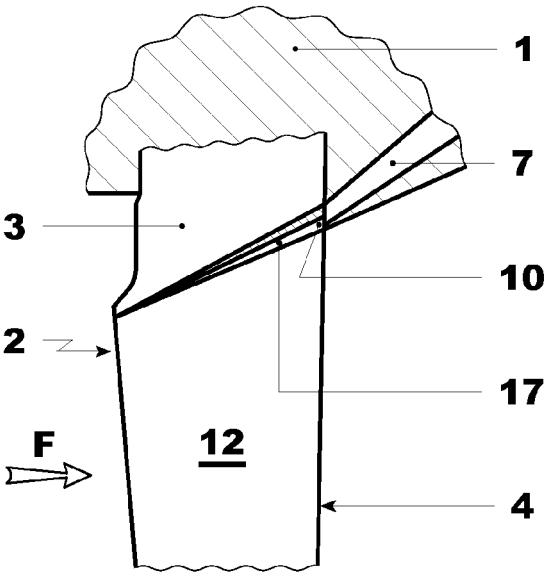

FIG. 3

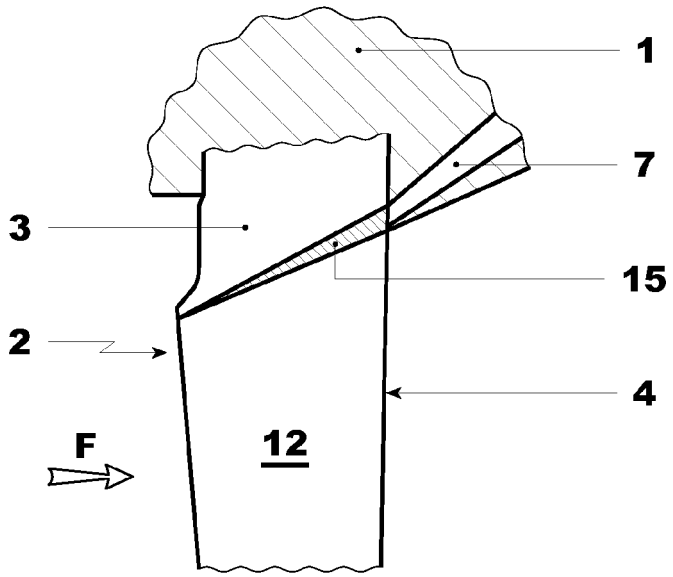

FIG. 4

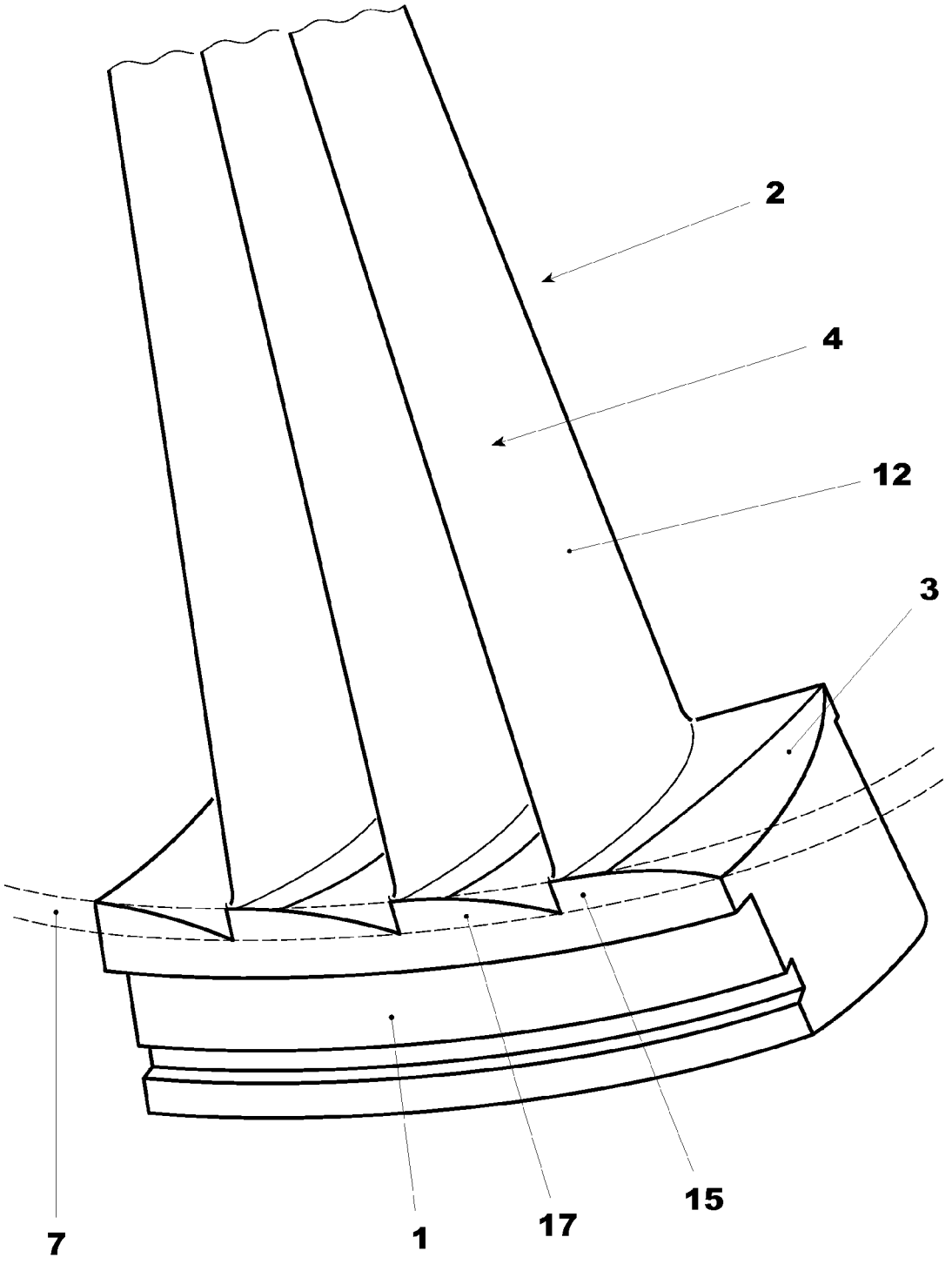

FIG. 5

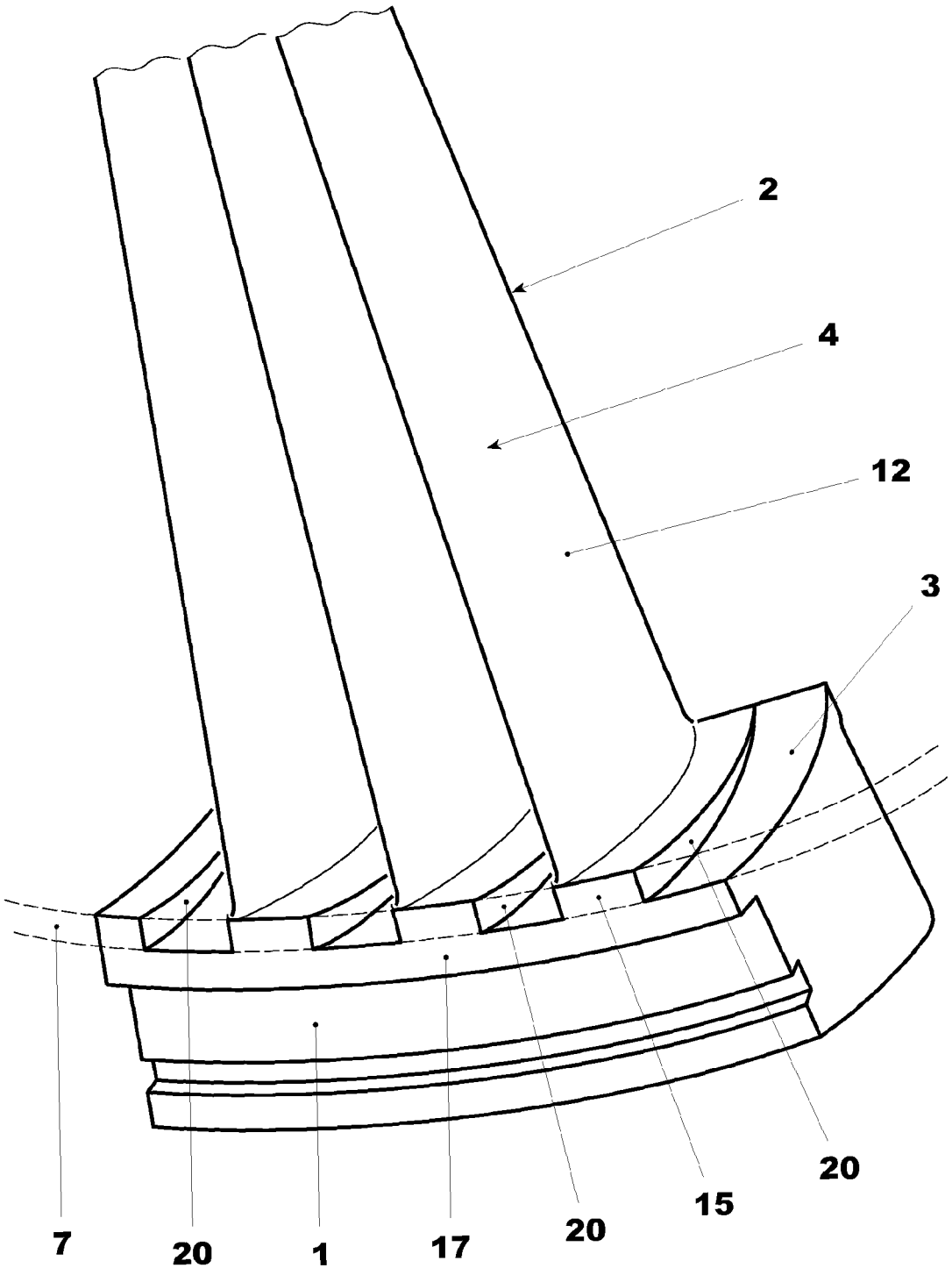

FIG. 5A

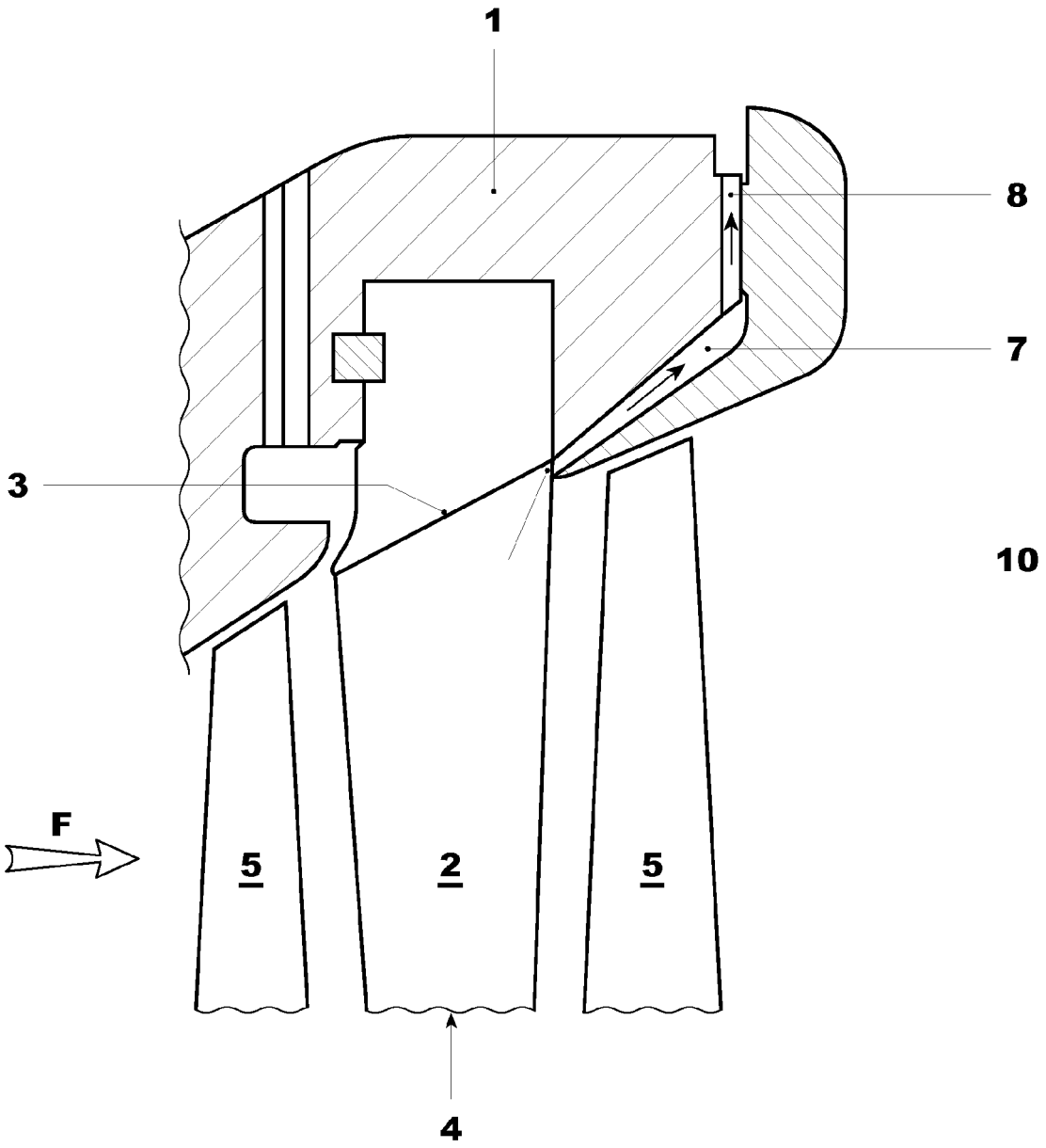

FIG. 6

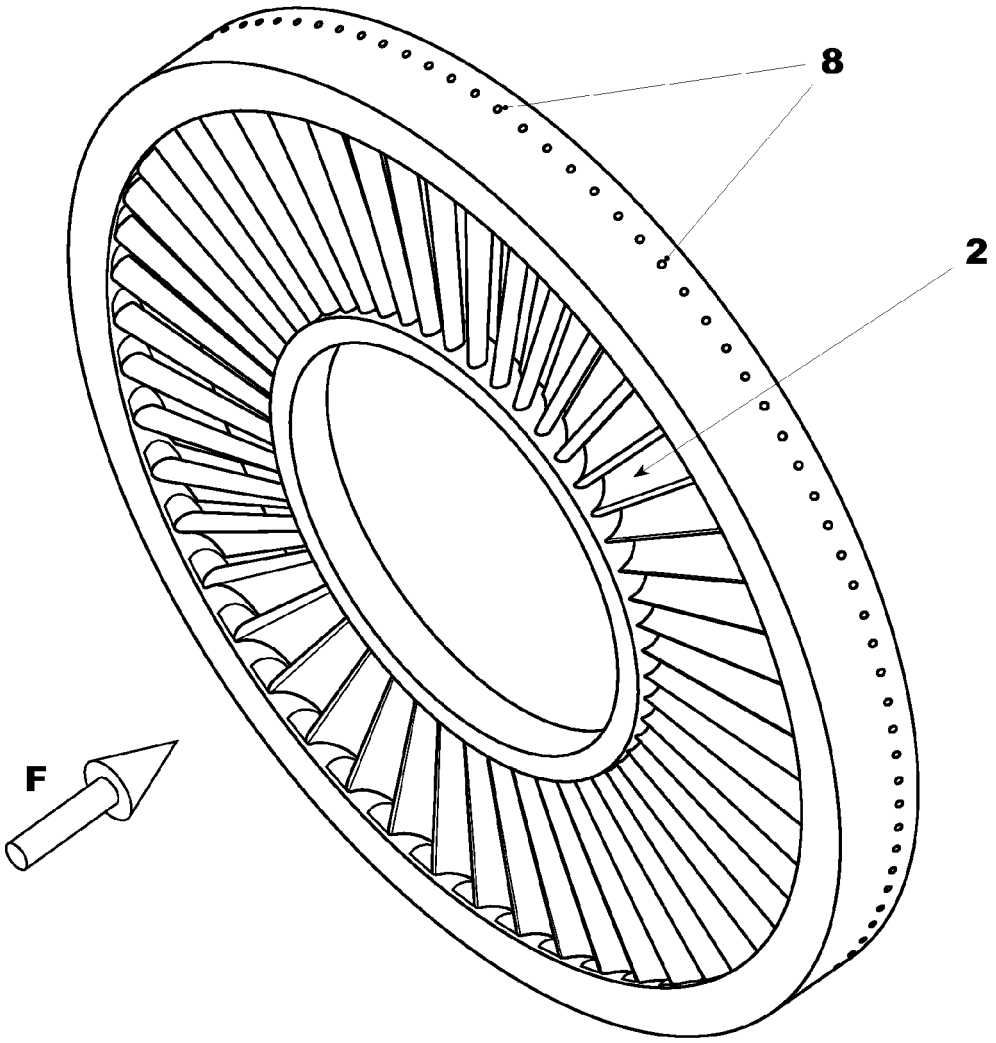

FIG. 7

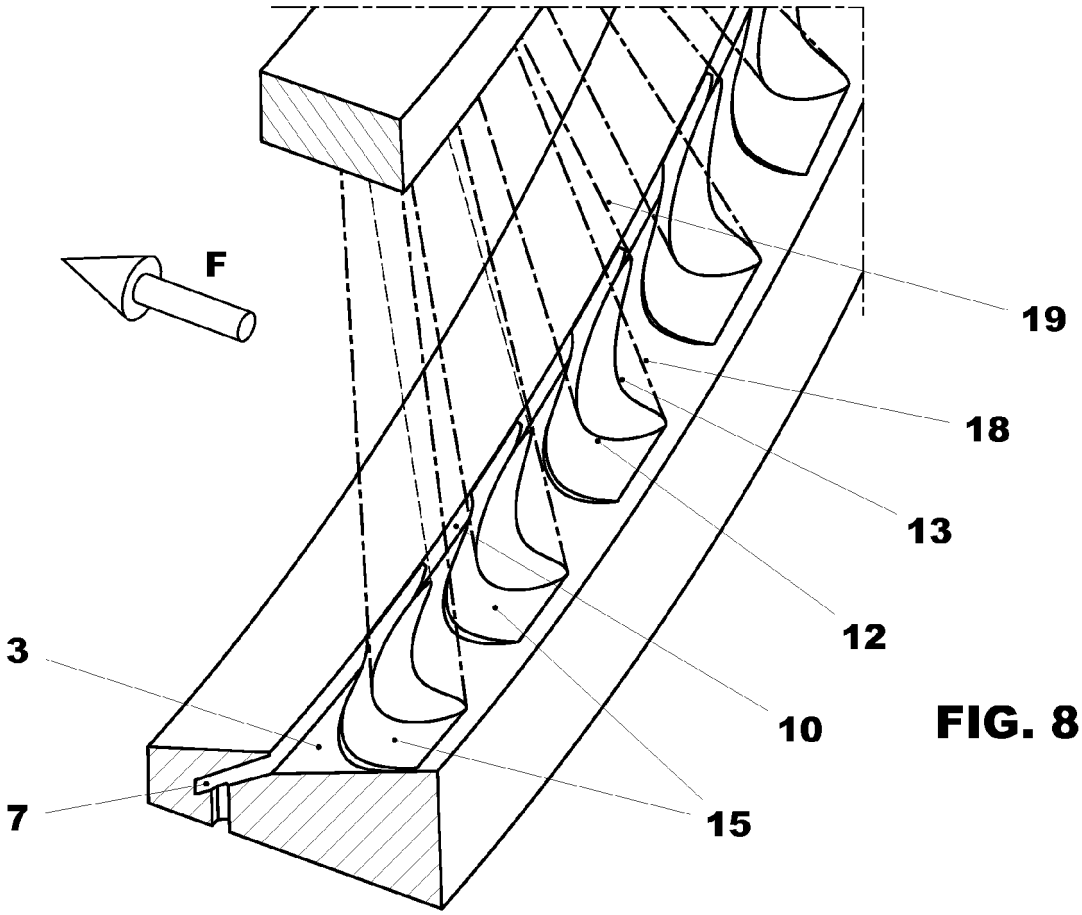

FIG. 8

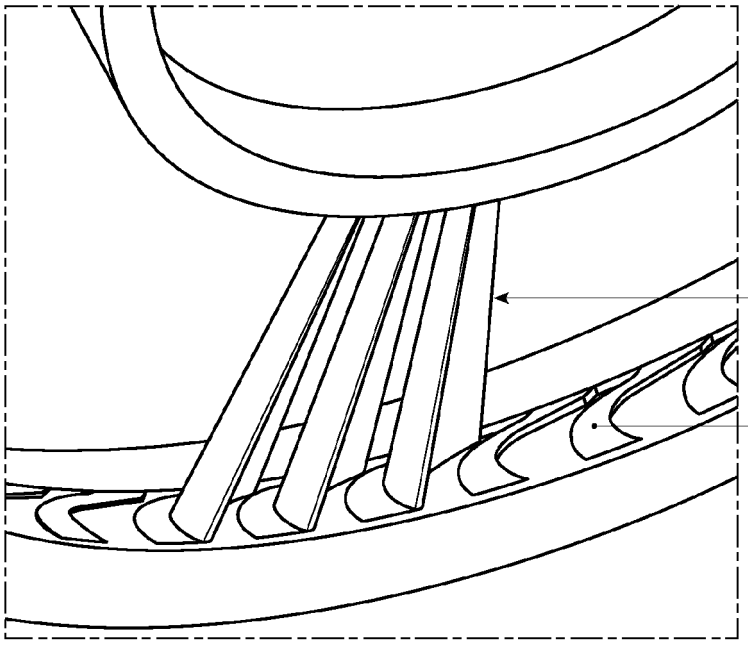

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 3874

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	5 June 2009	Klados, Iason

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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