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(54) Method for operating a gas turbine and rotor of a gas turbine

(57) The rotor (1) of a gas turbine has a plurality of rotor blade rows comprising a plurality of rotor blades (2). Each rotor blade is provided with a root (3) connected to a rotor body (4), a platform (5) that defines, with the platforms (5) of the other rotor blades (2) and a casing (6), a duct (7) in which the hot gases flow, and an airfoil (8) which exchanges mechanical power with the hot gases flow. Each rotor blade (2) also comprises beneath the platform (5) and at opposite side zones towards the root

(3), a seat (9) housing a couple element (10) arranged to lie between two adjacent rotor blades (2) to couple the rotor blades (2) and additionally to seal the duct (7). During operation, the rotor blades (2) are all connected by the couple elements (10) and vibrate together as a coupled system, such that the natural frequencies of the rotor blades (2) vibrating together as a coupled system are away from the excitation vibrations. The present invention also relates to a method for operating a gas turbine.

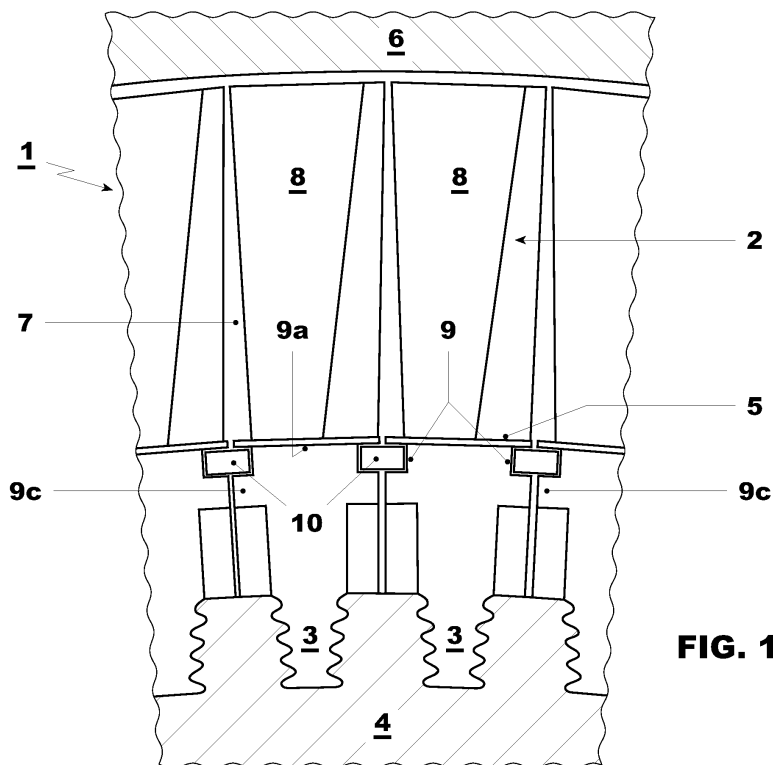


FIG. 1

EP 2 280 151 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a rotor of a gas turbine and a method for operating a gas turbine.

[0002] In particular the present invention addresses the problem of rotor blade vibrations during operation.

BACKGROUND OF THE INVENTION

[0003] Gas turbines are known to comprise a compressor, a combustion chamber and a turbine. During operation a main air flow is compressed and mixed with a fuel to form a mixture that is combusted in the combustion chamber; the hot gases are then expanded in the turbine.

[0004] In different embodiments (the so called sequential combustion gas turbines) the gas turbine comprises a compressor, a combustion chamber and a high pressure turbine; downward of the high pressure turbine this gas turbine comprises a second combustion chamber and a low pressure turbine. During operation the main air flow is compressed and mixed with a fuel to form a mixture that is combusted in the first combustion chamber; the hot gases are then only partially expanded in the high pressure turbine; afterwards the hot gases partially expanded are fed to the second combustion chamber, where further fuel is injected and combusted; the hot gases generated in the second combustion chamber are expanded in the low pressure turbine.

[0005] Each turbine comprises a plurality of stages, each comprising stator vanes and rotor blades.

[0006] The rotor blades have a root connected to the rotor body, a platform and an airfoil extending from the platform and arranged to exchange mechanical power with the hot gases.

[0007] The platforms of the rotor blades (with the turbine casing that contains the stages) define an annular duct in which the hot gases flow; in particular the platforms define the inner surface of the duct and the turbine casing defines the outer surface of the duct.

[0008] In order to prevent the hot gases from passing between two adjacent platforms and entering the rotor body area, thin sealing plates are arranged between two adjacent platforms.

[0009] The sealing plates are housed in seats placed at the two opposite sides of the platforms in a zone towards the root.

[0010] Each sealing plate has a part housed in a seat of a rotor blade, and the other part housed in a seat of the adjacent rotor blade.

[0011] Usually the sealing plates are housed in the seats very loosely and, during operation, centrifugal forces press them against the platforms and guarantee the sealing.

[0012] Thus there is no need for accurate dimensions of the seats and a perfect fitting of the plates within the seats.

[0013] Moreover, during operation, rotor blades are excited by forces that make them vibrate.

[0014] If the rotor blades are excited in or close to their natural frequencies (i.e. resonance frequencies), fatigue forces are relevant and impair the blades, sensibly reducing their working life.

[0015] The natural frequencies of each rotor blade can be measured and/or calculated, and the frequencies of the forces that during operation excite the blades can be foreseen such that a correct design of the rotor blades can keep the natural frequencies of the same rotor blade away from the frequencies of the exciting forces.

[0016] Nevertheless, in some cases, in order to fulfil other design constraints, it cannot be avoided that these two frequencies are the same or are very close. For that cases blades are to be reworked or modified in order to switch the natural frequencies of the blade away from the excitation frequencies.

[0017] Nevertheless, reworking and modification of the blades is very costly and time consuming.

[0018] Alternatively, blades are in some cases provided with damping systems that absorb the vibrations.

[0019] It is anyhow clear that damping systems are both expensive and not fully reliable, as they are not able to completely absorb the vibrations.

SUMMARY OF THE INVENTION

[0020] The technical aim of the present invention is therefore to provide a rotor and a method by which the said problems of the known art are eliminated.

[0021] Within the scope of this technical aim, an object of the invention is to provide a rotor and a method that let reliable rotor blades, with a long working life, be manufactured.

[0022] Another object of the invention is to provide a rotor and a method that let rotor blades be manufactured having costs lower than equivalent traditional reworked rotor blades.

[0023] A further object of the present invention is to provide a rotor and a method that let rotor blades be manufactured in a short time (when compared to the corresponding traditional rotor blades that need reworking).

[0024] The technical aim, together with these and further objects, are attained according to the invention by providing a rotor and a method in accordance with the accompanying claims.

[0025] Advantageously, according to the invention the excitation vibrations are not absorbed as usual in the prior art, but on the contrary the natural frequencies of the rotor blades are shifted away from the excitation vibrations during operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Further characteristics and advantages of the invention will be more apparent from the description of a preferred but non-exclusive embodiment of the invention,

illustrated by way of non-limiting example in the accompanying drawings, in which:

Figure 1 is a schematic front view partially sectioned of two rotor blades with couple elements according to the invention;

Figure 2 is a partial schematic side view of a rotor blade according to the invention;

Figure 3 is a schematic front view partially sectioned of two rotor blades with couple elements according to the invention in a different embodiment;

Figure 3a is an enlarged particular of figure 3;

Figures 4-7 show a couple element according to the invention in a first embodiment; and

Figures 8-11 show the couple element according to the invention in a second embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0027] With reference to the figures, a rotor of a gas turbine is shown identified by the reference number 1.

[0028] The rotor 1 has a plurality of rotor blades row comprising a plurality of rotor blades 2.

[0029] Each rotor blade 2 is provided with a root 3 connected to a rotor body 4, a platform 5 that defines, with the platforms 5 of the other rotor blades 2 and the casing 6 of the turbine, a duct 7 in which the hot gases flow flows (the duct 7 has an annular cross section, the platforms 5 define the inner surface of the duct and the casing 6 defines the outer surface of the duct 7).

[0030] The rotor blades 2 also comprise an airfoil 8 which exchanges mechanical power with the hot gases flow.

[0031] The rotor blades 2 comprise beneath the platform 5 and at opposite side zones towards the root 3, a seat 9 housing a couple element 10 arranged to lie between two adjacent rotor blades 2 to connect them each other and seal the duct 7.

[0032] During operation, the rotor blades 2 are all connected each other by the couple elements 10 and vibrate together as a coupled system, such that the natural frequencies of the rotor blades 2 vibrating together are different from the natural frequencies of each free rotor blade (i.e. not connected to other rotor blades) and are away from the excitation vibrations.

[0033] Advantageously, the plates 10 perfectly fit the seats 9.

[0034] The couple elements 10 vary in weight and/or shape from traditional sealing elements and, in particular, they are heavier than traditional sealing elements.

[0035] Preferably, the couple elements 10 are twice as heavy as traditional sealing plates or more.

[0036] The couple elements 10 (see figures 4-7) have an elongated shape, with diagonal end walls 13.

[0037] In addition, the couple elements 10 have a symmetrical cross section with respect to a transversal axis 12.

[0038] In this embodiment, the couple elements 10

have a rectangular cross section.

[0039] The couple elements 10 also have a projection 15 that has a diagonal base 16 that is inserted in a recess 17 of the seat 9.

[0040] Alternatively, the couple elements 10 have no projection 15.

[0041] In a different embodiment (figures 8-11), the couple elements 10 have similar features to the couple elements already described but, in addition, they have a side with two sloped walls 20, 22 defining a thicker portion 23 at its centre.

[0042] As shown in figure 3, the side with the two sloped portions 20, 22 of the couple element 10 is that towards the platforms 5 and the duct 7.

[0043] In this respect, each seat 9 has one sloped wall 25 that fits one sloped wall 20 or 22 of the couple element 10.

[0044] In particular, the sloped wall 25 of each seat 9 defines a bottom surface 26 of the seat 9 that is smaller than an open surface 27 of the same seat 9.

[0045] In the embodiment shown in the figures, the seat 9 is defined by the inner surface 9a of the platform 5, by a first elements 9b (defining the recess 17) and by a second element 9c placed at the opposite ends on the seat 9. It is anyhow clear that the seat may also have different shapes; for example the seat can be a slot or the first element 9b can define a recess arranged to house the whole cross section of the couple element 10 (i.e. without the need of the projection 15).

[0046] The operation of the rotor of the invention is apparent from that described and illustrated and is substantially the following.

[0047] During manufacturing, the rotor blades 2 are housed with their root 3 inserted in the seats of the rotor body 4 and the couple elements 10 housed in the seats 9 of the platforms 5.

[0048] This lets the platforms 5 (and the casing 6) define the duct 7 with the couple elements 10 housed between two adjacent platforms 5.

[0049] During operation, the rotor body 4 rotates and the centrifugal forces that are generated by the rotation urge the couple elements 10 outwardly, towards the platforms 5.

[0050] This lets the couple elements 10 couple all single blades together to a coupled system.

[0051] In addition, this also lets the zones between two adjacent platforms 5 be sealed preventing the hot gases flowing within the duct 7 from passing through the slots defined between two adjacent platforms 5 and entering the rotor body area.

[0052] In addition, as the plates 10 are fitted within the seats 9 and have an increased and optimised mass (with respect to traditional sealing couple elements), the couple elements 10 let a rigid connection between adjacent blades 2 be achieved such that the blades react to forces together (as a coupled system), whereas using traditional sealing plates each blade reacts to forces independently from one another.

[0053] As all the blades react to forces together as a coupled system, they define a very stiff element (stiffer than traditional rotor blade row).

[0054] Moreover, the natural frequencies are shifted away from the excitation frequencies with respect to equivalent traditional rotors.

[0055] Therefore, during operation, vibrations are not amplified and the blades are subjected to less fatigue than traditional rotors.

[0056] The present invention also relates to method for operating a gas turbine.

[0057] According to the method, during operation the rotor blades 2 are connected each other by the couple elements 10 and vibrate together as a coupled system.

[0058] Moreover the natural frequencies of the rotor blades vibrating together as a coupled system are shifted away from the excitation vibrations.

[0059] In particular, each couple element 10 is urged by the centrifugal forces against the platforms 5 of two adjacent rotor blades 2.

[0060] The rotor 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.

[0061] In practice the materials used and the dimensions can be chosen at will according to requirements and to the state of the art.

REFERENCE NUMBERS

[0062]

1	rotor
2	rotor blade
3	root
4	rotor body
5	platform
6	casing of the turbine
7	duct
8	airfoil
9	seat
9a	inner surface of the platform
9b	first element
9c	second element
10	couple element
12	transversal axis
13	diagonal end walls
15	longitudinal projection
16	diagonal base
17	recess
20, 22	sloped walls of the couple element
23	thick portion
25	sloped wall of the seat
26	bottom surface of the seat
27	open surface of the seat

Claims

- Method for operating a gas turbine having at least a rotor blade row comprising a plurality of rotor blades (2) each provided with a root (3) connected to a rotor body (4), a platform (5) that defines, with the platforms (5) of the other rotor blades (2) and a casing (6), a duct (7) in which the hot gases flow, and an airfoil (8) which exchanges mechanical power with the hot gases flow, each rotor blade (2) also comprising beneath the platform (5) and at opposite side zones towards the root (3), a seat (9) housing a couple element (10) arranged to lie between two adjacent rotor blades (2) to seal the duct (7), **characterised in that**, during operation the rotor blades (2) are connected each other by the couple elements (10) and vibrate together as a coupled system, and **in that** the natural frequencies of the rotor blades (2) vibrating together are away from the excitation vibrations.
- Method as claimed in claim 1, **characterised in that**, during operation, each couple element (10) is urged by the centrifugal forces against the platforms (5) of two adjacent rotor blades (2).
- Rotor (1) of a gas turbine having at least a rotor blade row comprising a plurality of rotor blades (2) each provided with a root (3) connected to a rotor body (4), a platform (5) that defines, with the platforms (5) of the other rotor blades (2) and a casing (6), a duct (7) in which the hot gases flow, and an airfoil (8) which exchanges mechanical power with the hot gases flow, each rotor blade (2) also comprising beneath the platform (5) and at opposite side zones towards the root (3), a seat (9) housing a couple element (10) arranged to lie between two adjacent rotor blades (2) to seal the duct (7), **characterised in that**, during operation, said rotor blades (2) are all connected each other by said couple elements (10) and vibrate together as a coupled system, such that the natural frequencies of the rotor blades (2) vibrating together are away from the excitation vibrations.
- Rotor (1) as claimed in claim 3, **characterised in that** during operation the couple elements (10) perfectly fit the seats (9).
- Rotor (1) as claimed in claim 3, **characterised in that** said couple elements (10) has a symmetrical cross section with respect to a transversal axis (12).
- Rotor (1) as claimed in claim 5, **characterised in that** said couple elements (10) have a rectangular cross section.
- Rotor (1) as claimed in claim 3, **characterised in that** said couple elements (10) have a projection (15)

inserted in a recess (17) of the seat (9).

8. Rotor (1) as claimed in claim 3, **characterised in that** said couple elements (10) have a side with two sloped walls (20, 22) defining a thicker portion (23) at its centre. 5
9. Rotor (1) as claimed in claim 8, **characterised in that** the side with two sloped portions (20, 22) of the couple element (10) is that towards the duct (7), wherein each seat (9) has one sloped wall (25) that fits one sloped wall (20, 22) of the couple element (10). 10
10. Rotor (10) as claimed in claim 9, **characterised in that** the sloped wall (25) of each seat (9) defines a bottom surface (26) of the seat (9) that is smaller than an open surface (27) of the same seat (9). 15
11. Rotor (1) as claimed in claim 3, **characterised in that** said seat (9) is defined by the inner surface of the platform (5) and by a first and second elements (28, 29) placed at its opposite ends. 20
12. Rotor (1) as claimed in claim 3, **characterised in that** said seat (9) is defined by a slot. 25

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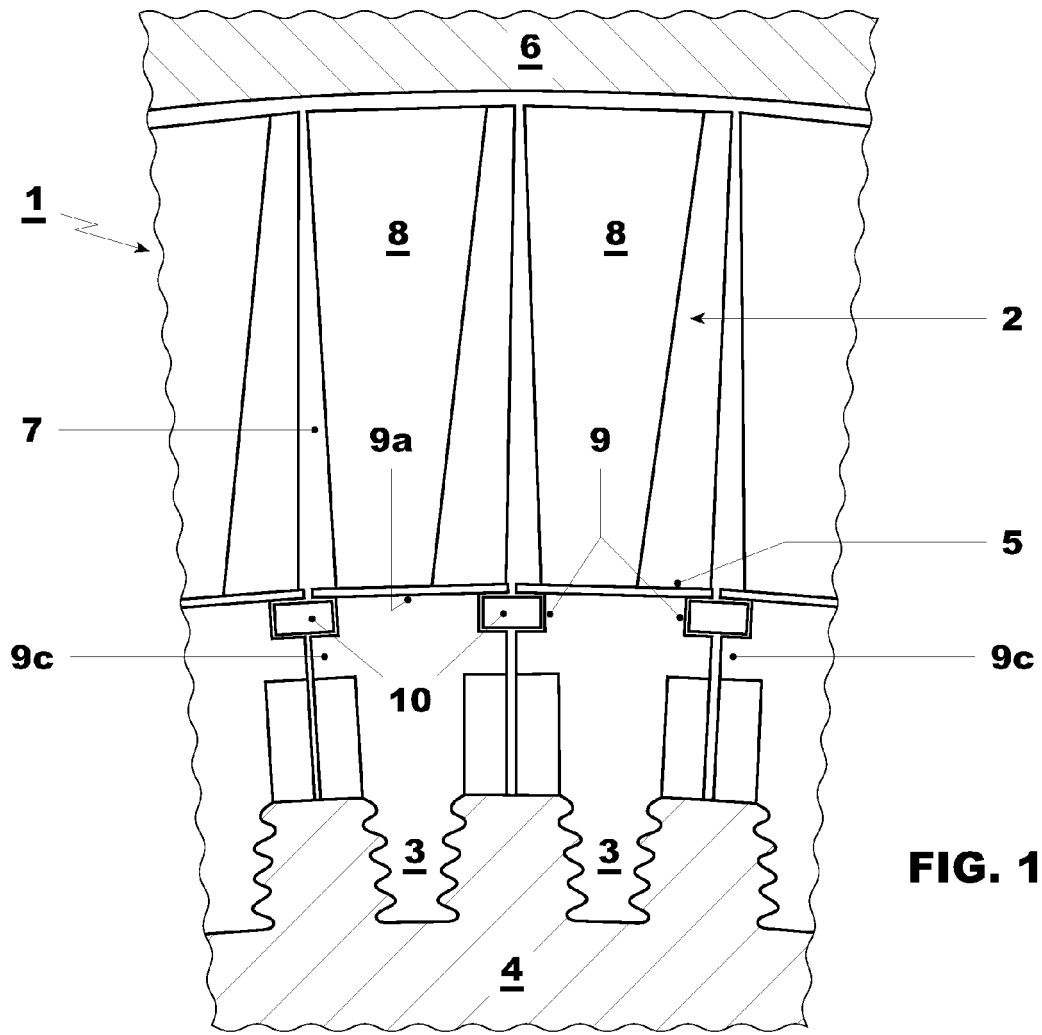


FIG. 1

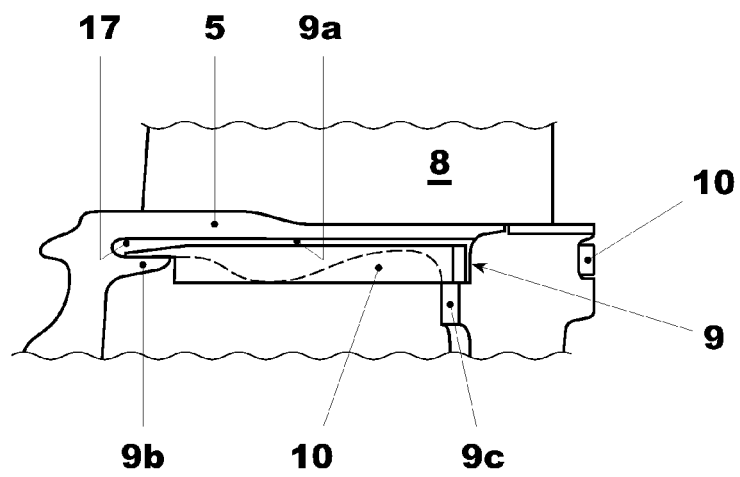


FIG. 2

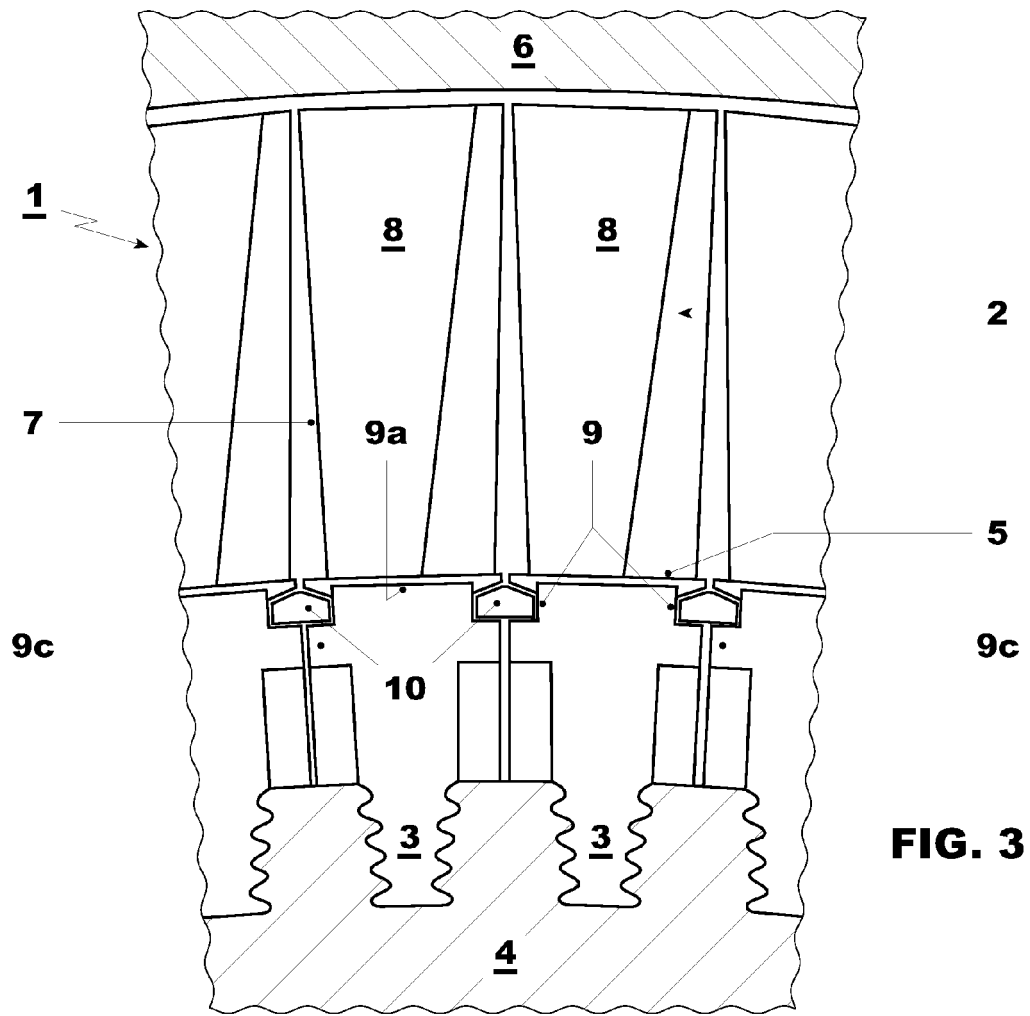


FIG. 3

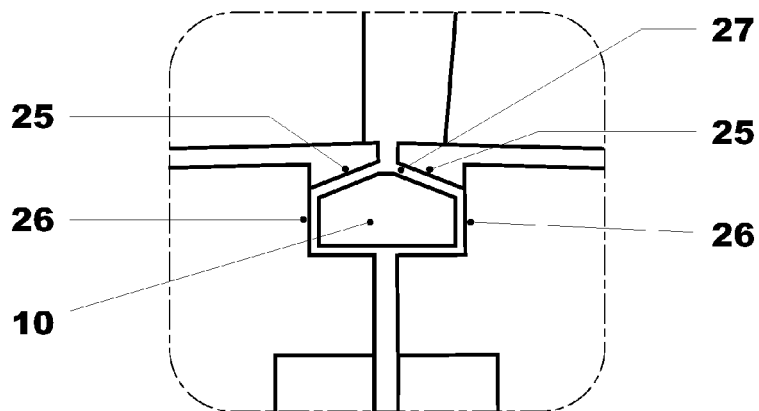
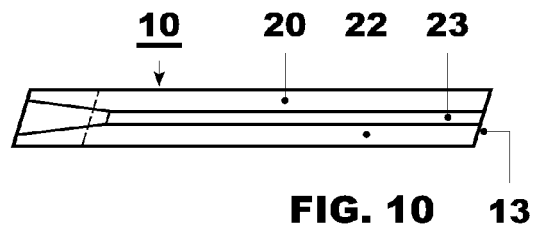
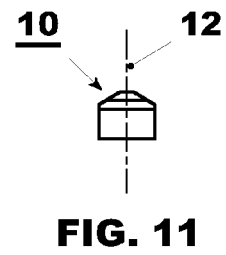
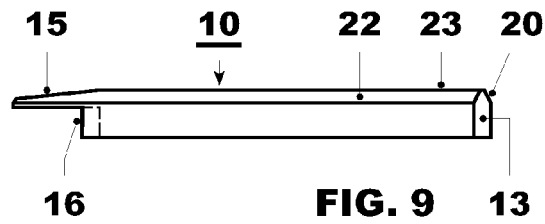
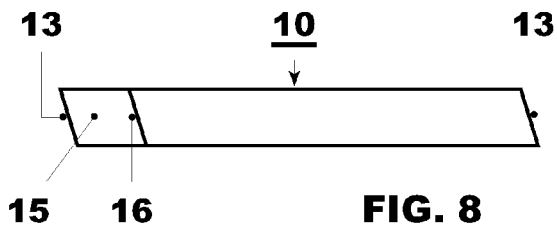
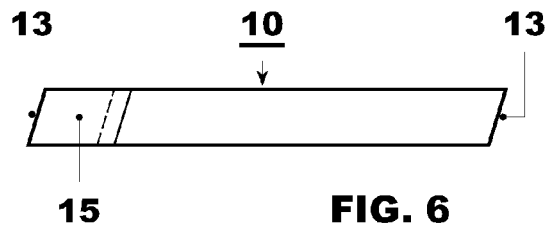
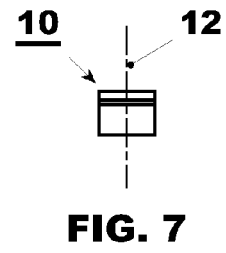
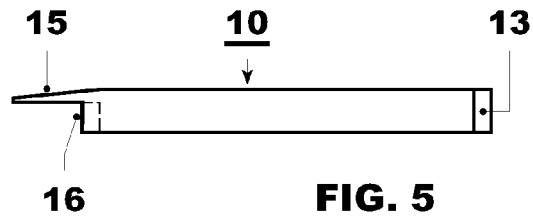
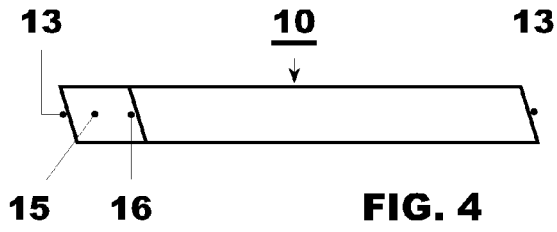


FIG. 3a





EUROPEAN SEARCH REPORT

Application Number
EP 09 16 3488

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Place of search		Date of completion of the search		Examiner
Munich		2 March 2010		Raspo, Fabrice
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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		

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