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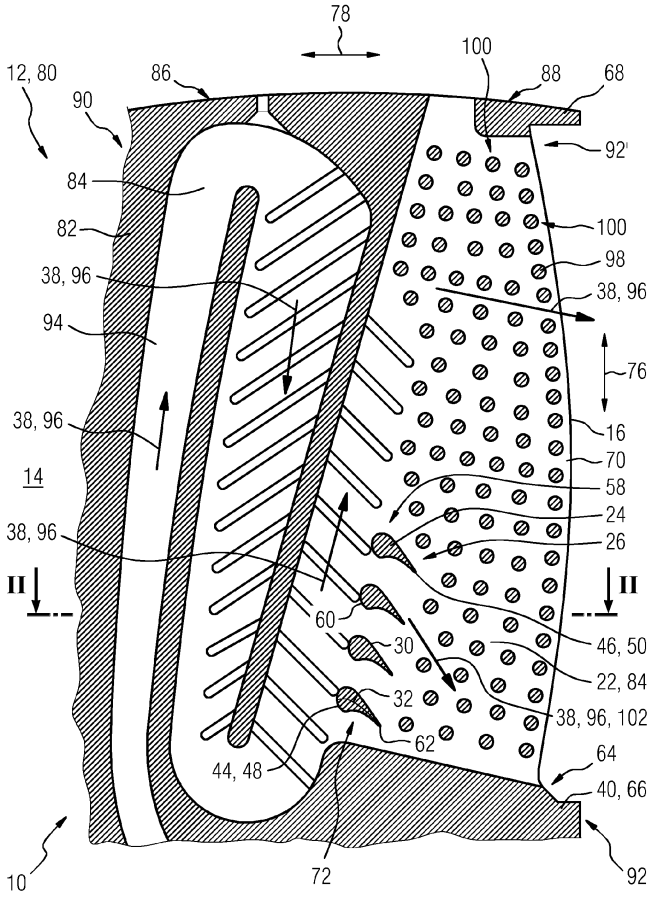
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(54) **Cooling of turbine blades or vanes**

(57) The present invention relates to a turbine assembly (10) comprising a basically hollow aerofoil (12, 12a-12d), with at least a leading edge (14), a trailing edge (16), a pressure side (18) and a suction side (20), which are forming at least a cavity (22) within the hollow aerofoil (12, 12a-12d), and with at least a deflection structure (24, 24e-241) that is arranged in the at least one cavity (22) and that has a cross section (26), which is oriented basically perpendicular to a direction (28) pointing from the pressure side (18) to the suction side (20).

According the invention the cross section (26) of the at least one deflection structure (24, 24e-241) has an aerofoil contour (30) and has a curved mean camber line (32).

FIG 1



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Description

Field of the Invention

[0001] The present invention relates to aerofoil-shaped turbine assembly such as turbine rotor blades and stator vanes, and to deflection structures used in such components for cooling purposes.

Background to the Invention

[0002] Modern turbines - particularly turbines within gas turbines engines - often operate at extremely high temperatures. The effect of temperature on the turbine blades and/or stator vanes can be detrimental to the efficient operation of the turbine and can, in extreme circumstances, lead to distortion and possible failure of the blade or vane. In order to overcome this risk, high temperature turbines may include hollow blades or vanes with deflection structures or so-called pin-fins for cooling purposes.

[0003] These so-called pin-fins are arranged in clusters at a trailing edge of the hollow aerofoil. Air is forced through these clusters and the pins as well as the pin spacing, on its way the air experience a significant amount of turbulence between the pins. This produces high convective thermal cooling of the blade or vane.

[0004] Normally, the clusters of the pin-fins are distributed homogenously over the trailing edge of the blade or vane, thus all sections of the aerofoil receive an equal amount of cooling air per unit area. This may result in that some sections are over-cooled whilst other sections do not receive sufficient cooling. Hence, problems, like a compromise of a service life of the aerofoil, may arise if all sections of the aerofoil obtain the same amount of cooling.

[0005] It is an objective of the present invention to provide an advantageous aerofoil-shaped turbine assembly such as a turbine rotor blade and a stator vane by which the above-mentioned shortcomings can be mitigated, and especially a more aerodynamic efficient aerofoil and gas turbine component is facilitated.

Summary of the Invention

[0006] Accordingly, the present invention provides a turbine assembly - particularly a gas turbine assembly - comprising a basically hollow aerofoil with at least a leading edge, a trailing edge, a pressure side and a suction side, which are forming at least a cavity within the hollow aerofoil, and with at least a deflection structure that is arranged in the at least one cavity and that has a cross section, which is oriented basically perpendicular to a direction pointing from the pressure side to the suction side.

[0007] It is provided that the cross section of the at least one deflection structure has an aerofoil contour and has a curved mean camber line. Due to the inventive matter a flow of cooling medium will be biased and purposefully directed to regions that need most cooling. Hence, the invention enables a satisfying control of temperatures of components or parts thereof, e.g. the aerofoil or the training edge or a hub etc. Furthermore, a better control than state of the art devices could be provided. Moreover, the service live of the component could be optimised. Consequently, an efficient turbine assembly or turbine, respectively, could advantageously be provided.

[0008] A turbine assembly is intended to mean an assembly provided for a turbine, like a gas turbine, wherein the assembly possesses at least an aerofoil. Preferably, the turbine assembly has a turbine cascade and/or wheel with circumferential arranged aerofoils and/or an outer and/or an inner platform arranged at opponent ends of the aerofoil(s).

[0009] In this context a "basically hollow aerofoil" means an aerofoil with a casing, wherein the casing encases at least one cavity. In a basic embodiment the casing comprises as its four sides, each extending in span wise direction, the leading edge, the trailing edge, the pressure side and the suction side. One could also say that the aerofoil has only two sides defined by the pressure side and the suction side, both connected via the leading edge and the trailing edge. A span wise direction of the hollow aerofoil is defined as a direction extending basically perpendicular, preferably perpendicular, to a direction from the leading edge to the trailing edge of the aerofoil, wherein the wording basically perpendicular should be understood as a divergence of the span wise direction from the direction from the leading edge to the trailing edge of about 30°. A structure, like a rib, rail or partition, which divides different cavities in the aerofoil from one another and for example extends in a span wise direction of the aerofoil, or a conduit structure, e.g. meandering through the aerofoil and building a flow channel for cooling medium, does not hinder the definition of "a basically hollow aerofoil". Thus, the at least one deflection structure may be arranged in a cavity that is encased at its four sides by parts of the suction and the pressure side, respectively, the trailing edge and a partition or a part of the conduit structure, each extending basically in span wise direction. In particular, the basically hollow aerofoil, referred as aerofoil in the following description, may have two cooling regions, e.g. a state of the art impingement cooling region at a side of the aerofoil that is arranged towards the leading edge of the aerofoil and a pin-fin/pedestal cooling region at a side arranged towards the trailing edge. These regions could be separated from one another through a rib or partition as well as through a part of the conduit structure.

[0010] A leading edge is intended to mean the "front" of the aerofoil or the (upstream) portion that meets the combustion medium, like combustion gases mixed with air, first, respectively, and the trailing edge is the back (the downstream portion) of the aerofoil or the place at which a flow of medium over the upper surface of the

aerofoil joins a flow the medium over the lower surface of the aerofoil. Moreover, the suction side is intended to mean the outer surface, e.g. upper surface, of the aerofoil that has a convex shape and the pressure side the outer surface, e.g. the lower surface, of the aerofoil that has a concave shape. A "deflection structure" is intended to mean a structure, which biases or deflects the flow and/or direction of cooling medium and/or which provokes a change of direction of the flow of cooling medium. Preferably, the at least one deflection structure is arranged at least partially and advantageously completely in the path of the cooling medium.

[0011] In the scope of an arrangement of the cross section as "basically perpendicular" to a direction pointing from the pressure side to the suction side should also lie a divergence of the cross section in respect to the direction pointing from the pressure side to the suction side of about 30°. Preferably, the cross section is oriented perpendicular to the direction pointing from the pressure side to the suction side.

[0012] In this context an aerofoil counter is intended to mean a contour, which resembles a shape of an aerofoil and/or has two portions that are arranged opposite to one another, wherein one portion is wider than the other portion. Further, in the scope of "an aerofoil contour" should also lie a shape with unround portions and/or with polygon portions. An aerofoil contour may be viewed as a "drop-like contour". Preferably, one portion has a bulbous shape and the other portion has a narrow tip or cusp. Moreover, a "mean camber line" is intended to mean a curve comprising of the locus of midway points on lines between the upper and lower surfaces or the suction and the pressure sides, respectively.

[0013] Furthermore, it is advantageous when a camber of the mean camber line determines a deflection angle of a cooling medium deflected by the at least one deflection structure towards a region to be cooled. Thus, due to an appropriate choice of the camber of the at least one deflection structure it is structurally simple to provide cooling for a region that needs a high amount of cooling.

[0014] Moreover, the mean camber line has a section with a maximal camber, wherein the maximal camber causes a deflection angle of the cooling medium from 10° to 110°, advantageously from 20° to 90° and preferably from 30° to 60°. Due to these possible and advantageous camber values the at least one deflection structure may be deployed in various cooling arrangements. Thus, the maximal camber encloses a (deflection) angle from 70° to 170°, advantageously from 90° to 160° and preferably from 120° to 150°. In addition to the change in direction of the cooling medium to a region to be cooled the at least one deflection structure may provide a surface for additional impingement cooling, thus resulting in a powerful cooling of the aerofoil.

[0015] Due to the inventive construction the at least one deflection structure has at least a direction change that is preferably embodied in a wall section of the at least one deflection structure, wherein the wall section is arranged basically perpendicular to the cross section of the at least one deflection structure. In the region of the at least one direction change the at least one deflection structure may act as a baffle for the cooling medium.

[0016] In an advantageous embodiment the at least one deflection structure has a first edge and at least a second edge, wherein the first edge is oriented towards the leading edge of the hollow aerofoil and the at least second edge is oriented basically towards the trailing edge of the hollow aerofoil. Thus, the at least one deflection structure could advantageously be aligned with the general flow direction of the cooling medium. The wording "oriented basically towards the trailing edge" is intended to mean the position of the at least second edge in respect to the first edge and the trailing edge of the aerofoil. It should not be interpreted as pointing towards the trailing edge of the aerofoil. Consequently, in a preferred embodiment the first edge of the at least one deflection structure is a leading edge side of the at least one deflection structure and the at least second edge is a trailing edge side of the at least one deflection structure.

[0017] The at least one deflection structure may be embodied with two wall sections, wherein the wall sections are arranged basically perpendicular to the cross section of the at least one deflection structure. Moreover, the two wall sections converge from the first edge or the leading edge side of the at least one deflection structure to the second edge or the trailing edge side of the at least one deflection structure. By means of this construction the at least one deflection structure can be manufactures in a cost, material and space saving manner. The approach of the two wall sections may be in regular or irregular steps or preferably in a continuously fashion. Hence, a homogenous flow path for the cooling medium may be provided.

[0018] Preferably, the at least one deflection structure is embodied with a tapered contour from its first edge to its second edge. Thus, a contour with different curvatures at the upper and lower surface or at the wall sections, respectively, is provided and subsequently a deflection structure with different aerodynamic properties at certain surfaces or sections. In this context a "tapered contour" should also be understood as a convergence of parts of the contour which extend from the first edge to the second edge of the at least one deflection structure. Favourably, the at least one deflection structure is embodied with a tapered contour from its leading edge side to its trailing edge side. Due to this construction, the at least one deflection structure is able to direct the flow of cooling medium purposefully towards the trailing edge of the aerofoil.

[0019] In a further advantageous embodiment a width of the first edge is more than two times wider, advantageously more than four times wider and preferably more than five times wider than a width of the at least second edge. Accordingly, the at least one deflection structure may be viewed as a stubby and/or compressed aerofoil in itself. Thus, aerodynamic characteristics and/or ad-

vantages of an aerofoil can beneficially be adapted to the at least one deflection structure.

[0020] According to an exemplary embodiment the at least one deflection structure has an unsymmetrical tear drop shape, wherein an axis of symmetry is coaxial to a direction from the first edge or the leading edge side of the at least one deflection structure to the second edge or the trailing edge side of the at least one deflection structure.

[0021] To advantageously increase the cooling efficiency of the aerofoil and hence the thermodynamic efficiency of the gas turbine the at least one deflection structure is located in a region of the hollow aerofoil that is arranged at the trailing edge of the hollow aerofoil. Hence, the deflection structure may be a part of the pin-fin cooling region. This advantageously increases the convective cooling of the aerofoil.

[0022] The at least one deflection structure could be arranged at or integrally moulded with any component of the turbine assembly or the aerofoil, respectively, that is feasible for a person skilled in the art, e.g. the casing or a part thereof, a partition, a dividing wall or a wall of the conduit structure or an inserted (impingement) tube or the like. Advantageously, the at least one deflection structure is arranged at the pressure and/or at the suction side of the aerofoil. Preferably, the at least one deflection structure is formed integrally with the casing of the aerofoil and especially with the pressure and/or the suction side of the aerofoil. Hence, the at least one deflection structure is loss proof connected with the casing. In this context the wording "formed integrally" is intended to mean, that the at least one deflection structure and the casing or the pressure and/or the suction side, respectively, are moulded out of one piece and/or that the at least one deflection structure and the casing or the pressure and/or the suction side, respectively, could only be separated with loss of function for at least one of the parts.

[0023] Preferably, the at least one deflection structure extends from the pressure side to the suction side of the hollow aerofoil. Thus, the at least one deflection structure connects the pressure side with the suction side of the aerofoil. Due to this, a significant amount of turbulence around the at least one deflection structure may be created. Generally, it would also be feasible that the at least one deflection structure extends only over a part of a distance from the pressure side to the suction side of the aerofoil.

[0024] Favourably, the first edge of the at least one deflection structure has a rounded contour, thus a smooth shape for directed cooling medium may be provided. To provide a smooth guidance for the cooling medium at the point of impact at the at least one deflection structure the leading edge side thereof has a rounded contour. Moreover, the second edge of the at least one deflection structure may be embodied with a sharp tip at its end. Hence, a piece with less need of space may be provided. Furthermore, the trailing edge side of the at least one deflection structure is embodied with a sharp tip at its end. By means of this, the medium flow parted by the leading edge of the at least one deflection structure can be efficiently rejoined.

[0025] The hollow aerofoil comprises a root portion that is connected to a hub, a tip that is arranged in span wise direction of the aerofoil opposite from the root portion and a middle section, which is located between the root portion and the tip of the hollow aerofoil. In a preferred realisation the at least one deflection structure is inclined towards the hub with its trailing edge side. According to the inventive solution cooling medium deflected by the at least one deflection structure is directed or aimed at the hub resulting of sufficient cooling of the latter. Consequently, the creep life of the hub could be favourably optimised. Moreover, the turbine assembly may be endowed with good cooling properties.

[0026] Alternatively and/or additionally, the at least one deflection structure is inclined towards the tip of the hollow aerofoil with its trailing edge side. Through this advantageous arrangement the cooling medium can be directed to the tip for proper cooling of the latter.

[0027] It is also possible, that the trailing edge side of the at least one deflection structure is oriented towards the middle section of the hollow aerofoil, thus providing direct cooling for this region. In this context "oriented towards" should be understood as "pointing towards".

[0028] Generally, it would also be possible to have at least one deflection structure, which is accordingly inclined or directed, for the cooling of each region, specifically, the hub, the tip and the middle section.

[0029] According to a preferred embodiment a plurality of deflection structures are arranged in at least one column that is arranged in a span wise direction and/or in a direction from the leading edge of the hollow aerofoil towards the trailing edge of the hollow aerofoil. By means of this construction, a considerable quantity of cooling medium, e.g. air, may be directed to a region, which needs most cooling. Moreover, a significant amount of turbulence between deflection structures can be created. This may usefully break up boundary layers around the deflection structures, creating high convective thermal co efficiencies.

[0030] In a further advantageous embodiment the hollow aerofoil is a turbine blade or vane.

[0031] The above-described characteristics, features and advantages of this invention and the manner in which they are achieved are clear and clearly understood in connection with the following description of exemplary embodiments which are explained in connection with the drawings.

Brief Description of the Drawings

[0032] The present invention will be described with reference to drawings in which:

FIG 1: shows a cross section of an inventive turbine assembly with a column of deflection struc-

tures that are inclined towards a hub of the aerofoil,

FIG 2: shows a cross section through the aerofoil of FIG 1 along line II-II in a schematically view,

FIG 3: shows a cross section of one of the deflection structures from FIG 1,

FIG 4: shows special features of the deflection structure from FIG 3,

FIG 5: shows a cross section through an alternative aerofoil with a column of deflection structures arranged at the trailing edge of the aerofoil,

FIG 6: shows a cross section through a further alternative aerofoil with a column of deflection structures that are inclined towards a tip of the aerofoil,

FIG 7: shows a cross section through a third alternative aerofoil with a column of deflection structures that are inclined either towards a hub or a tip or are directed towards a middle section of the aerofoil,

FIG 8: shows a cross section through a fourth alternative aerofoil with deflection structures arranged in columns in a span wise direction as well as in a direction from a leading edge to a trailing edge of the aerofoil,

FIG 9: shows a first alternative deflection structure,

FIG 10: shows a second alternative deflection structure,

FIG 11: shows a third alternative deflection structure,

FIG 12: shows a fourth alternative deflection structure,

FIG 13: shows a fifth alternative deflection structure,

FIG 14: shows a sixth alternative deflection structure,

FIG 15: shows a seventh alternative deflection structure and

FIG 16: shows an eighth alternative deflection structure.

Detailed Description of the Illustrated Embodiments

[0033] In the present description, reference will only be made to a blade, for the sake of simplicity, but it is to be understood that the invention is applicable to both blades and vanes of a turbine.

[0034] Particularly the disclosed embodiments may be present in a turbine section of a gas turbine engine, thus the aerofoils can be gas turbine blades or gas turbine vanes.

[0035] It has to be understood that such an aerofoil may be in contact with two different fluids during operation: a hot main fluid from a combustion chamber that is acting on the aerofoil by applying pressure and suction forces on the outer surfaces of the aerofoil and a cooling fluid - potentially substantially air or another gas - that is guided into a hollow interior of the aerofoil to cool the body of the aerofoil from the inside, i.e. to cool the body of the aerofoil which is heated by the hot main fluid from the outside.

[0036] FIG 1 shows a cross section through a rear of a basically hollow aerofoil 12 of a turbine assembly 10 of a not shown gas turbine. The hollow aerofoil 12, embodied as a rotor blade 80, comprises a casing 82 that encases a cavity 22 with several sub cavities 84 within the hollow aerofoil 12. Therefore, the casing 82 comprises four side sections, namely, a leading edge 14, a trailing edge 16, a pressure side 18 and a suction side 20, which are forming the cavity 22 and all extend in a span wise direction 76 for the aerofoil 12. This is shown in FIG 2, which shows in a schematically view a cross section along line II-II through the aerofoil 12. The aerofoil 12 further comprises two cooling regions, specifically, an impingement cooling region 86 and a fin-pin/pedestal cooling region 88. The former is located in a region 90 that is arranged at the leading edge 14 and the latter is located in a region 58 at that is arranged at the trailing edge 16 of the aerofoil 12.

[0037] Moreover, the aerofoil 12 comprises a root portion 64, a tip 68 and a middle section 70, which is located between the root portion 64 and the tip 68. The root portion 64 and the tip 68 are arranged in span wise direction 76 at opposed ends 92, 92' of the aerofoil 12. Further, the root portion 64 is connected to a hub 66, which extends in a circumferential direction of a not shown turbine wheel, wherein several aerofoils 12 could be arranged at the hub 66 and thus all aerofoils 12 are connected through the hub 66 with one another (not shown).

[0038] In an alternative, not shown embodiment the aerofoil 12 could be embodied as a vane, like a nozzle guide vane. In this case, the root portion of the vane may be connected to an inner platform, also functioning as a hub, and the tip, which is arranged at the opposed end to the root portion, may be connected to an outer platform, also known as a shroud.

[0039] The impingement cooling region 86 is endowed with a meandering cooling conduit 94 that provides a flow channel or path 96 for a cooling medium 38, e.g. air, intended to cool the aerofoil 12 during a working state of the turbine assembly 10 and the turbine. Generally, it would be also feasible to provide the impingement cooling region 86 with at least one so called impingement tube.

[0040] The pin-fin/pedestal cooling region 88 comprises a plurality of round pins 98, arranged in columns 100 in span wise direction 76 as well as in a direction 78 from the leading edge 14 towards the trailing edge 16. Furthermore, the pin-fin/pedestal cooling region 88 comprises a plurality of deflection structures 24 that are arranged in the cavity 22 or its sub-cavity 84 and at region 58 at the trailing edge 16 of the aerofoil 12. The plurality of deflection structures 24 are arranged in a column 72 that is arranged in span wise direction 76 of the hollow aerofoil 12. In direction 78 between the column 72 of the deflection structures 24 and the trailing edge 16 several columns 100 of pins 98 are arranged.

[0041] As can be seen in more detail in FIG 2 the pins 98 and the deflection structures 24 extend from the pressure side 18 or a lower surface of the aerofoil 12 to the suction side 20 or an upper surface of the aerofoil 12 and are moulded integrally with the casing 82.

[0042] Each deflection structure 24 has a first edge 44 that is oriented towards the leading edge 14 of the aerofoil 12 and thus is a leading edge side 48 of the deflection structure 24 (FIG 1). Further, each deflection structure 24 has a second edge 46, arranged opposed to the first edge 44, and wherein the second edge 46 is oriented basically towards the trailing edge 16 of the hollow aerofoil 12 and thus is a trailing edge side 50 of the deflection structure 24.

[0043] To provide a smooth impact surface for the cooling medium 38 the first edge 44 or the leading edge side 48, respectively, of the deflection structure 24 has a rounded contour 60. Moreover, the second edge 46 or the trailing edge side 50, respectively, of the deflection structure 24 is embodied with a sharp tip 62 at its end to efficiently rejoin the flow of cooling medium 38 parted by the leading edge side 48 of the deflection structure 24. Consequently, the deflection structure 24 is embodied with a tapered contour 52 from its first edge 44 or its leading edge side 48, respectively, to its second edge 46 or its trailing edge side 50, respectively. Moreover, a width 54 of the first edge 44 is several and approximately, 15 times wider than a width 56 of the at least second edge 46 (FIG 4).

[0044] Typically, the hub 66 of a blade 70 is most exposed to high mechanical loads and due to high temperatures needs a high amount of cooling. To direct the flow of cooling medium 38, which is discharged from the cooling conduit 94 of the impingement cooling region 86 towards the pin-fin/pedestal cooling region 88, purposefully towards the hub 66 each deflection structure 24 is inclined towards the hub 66 with its trailing edge side 50. Thus, cooling medium 38 is redirected from the direction 78, pointing from the leading edge 14 towards the trailing edge 16, to a direction 102 oriented generally towards the hub 66.

[0045] In FIG 3 one of the deflection structures 24 is shown in an enlarged view and in cross section. A cross section 26 of the deflection structure 24, which is oriented basically perpendicular to a direction 28 pointing from the pressure side 18 to the suction side 20 (FIG 2) has an aerofoil contour 30 or a drop-like contour and a curved mean camber line 32. A camber 34 of the mean camber line 32 determines a deflection angle 36 of the cooling medium 38 (FIG 4). Thus, the cooling medium 38 is deflected by the deflection structure 24 towards a region 40 to be cooled and specifically, towards the hub 66 (FIG 1). This deflection angle 36 is pictured in FIG 4 in more detail. The mean camber line 32 has a section 42 with the maximum camber 34 that causes the deflection angle 36 of the cooling medium 38 with a value of about 30°. This is emphasised via the sharp angle 36 enclosed by the two straight lines.

[0046] According to the curved mean camber line 32 the deflection structure 24 has a direction change 104 in one of its side walls 106, and specifically in its lower (or pressure) side wall 106 or the side wall 106 oriented toward the pressure side 18 of the aerofoil 12. The side walls 106 extend basically along the camber line 32 and basically perpendicular to the cross section 26 or to the pressure side 18 or the suction side 20 of the aerofoil 12. A region of the direction change 104 acts as a baffle 108 for the cooling medium 38.

[0047] In FIG 5 to 8 alternative embodiments of the aerofoil 12 and in FIG 9 to 16 alternative embodiments of the deflection structure 24 are shown. Components, features and functions that remain identical are in principle substantially denoted by the same reference characters. To distinguish between the embodiments, however, the letters "a" to "1" have been added to the different reference characters of the embodiments in FIG 5 to 16. The following description is confined substantially to the differences from the embodiment in FIG 1 to 4, wherein with regard to components, features and functions that remain identical reference may be made to the description of the embodiment in FIG 1 to 4.

[0048] FIG 5 shows a cross section through an alternative hollow aerofoil 12a. The aerofoil 12a differs from the aerofoil 12 from FIG 1 to 4 in that a column 72 of deflection structures 24 is directly arranged at the trailing edge 16 of the aerofoil 12a without intermediate pins.

[0049] In FIG 6 a cross section through a further alternative hollow aerofoil 12b is shown. The aerofoil 12b differs from the aerofoil 12 from FIG 1 to 4 in that a trailing edge side 50 of each deflection structure 24, arranged in a column 72, is inclined towards a tip 68 of the aerofoil 12b to direct a flow of cooling medium 38 purposefully towards the tip 68. It may also possible that the column 72 would be arranged with intermediate pins 98 like in FIG 1 to 4.

[0050] FIG 7 shows a cross section through a third alternative hollow aerofoil 12c. The aerofoil 12c differs from the aerofoil 12 from FIG 1 to 4 in that a column 72 of deflection structures 24 has three different sections 110, 110', 110", wherein in each section 110, 110', 110" the deflection structures 24 are oriented differently. In an upper section 110 a trailing edge side 50 of each deflection structure 24 is inclined towards a tip 68 of the aerofoil

12c. Further, in a middle section 110' the trailing edge side 50 of each deflection structure 24 is oriented towards a middle section 70 of the aerofoil 12c. Moreover, in a lower section 110" the trailing edge side 50 of each deflection structure 24 is inclined towards a hub 66 of the aerofoil 12c. It may also feasible that the column 72 would be arranged like in FIG 5 or 6 without intermediate pins.

[0051] In FIG 8 a cross section through a fourth alternative hollow aerofoil 12d is shown. The aerofoil 12d differs from the aerofoil 12 from FIG 1 to 4 in that two columns 72 are provided. Hence, the deflection structures 24 are additionally to an arrangement in columns 72 in a span wise direction 76 arranged in columns 74 in a direction 76 from a leading edge 14 to a trailing edge 16 of the aerofoil 12d.

[0052] It would be also possible if there were only one column 74.

[0053] Also feasible may be an arrangement of the columns 72, 74 with intermediate pins 98 between the columns 72, 74 and the adjacent columns 72, 74 and/or between the columns 72, 74 and a trailing edge 16 and/or a tip 68 and/or a hub 66 of the aerofoil 12d. Moreover, it may be also possible to choose an orientation of trailing edge sides 50 of the deflection structures 24 as disclosed in FIG 6 or 7. Further, the columns 72, 74 could be also arranged slightly offset from one another.

[0054] FIG 9 shows a cross section 26 through an alternative deflection structure 24e. The deflection structure 24e differs from the deflection structure 24 from FIG 1 to 4 in that a first edge 44 of the deflection structure 24e has two regions 112 that are parts of side walls 106 and that are arranged opposed to one another, wherein these regions 112 have the same directions of curvature. Hence, the first edge 44 is less bulbous. Further, the deflection structure 24 has a camber line with a maximal camber that causes a deflection angle of about 55° (not shown in detail). The deflection structure 24e resembles an aerofoil.

[0055] In FIG 10 a cross section 26 through a second alternative deflection structure 24f. The deflection structure 24f differs from the deflection structure 24e from FIG 9 in that the deflection structure 24f is compressed in direction from a first edge 44 to a second edge 46. Hence, it resembles a stubby or compressed aerofoil. Further, the deflection structure 24f has a camber line with a maximal camber that causes a deflection angle of about 70° (not shown in detail).

[0056] FIG 11 shows a cross section 26 through a third alternative deflection structure 24g. The deflection structure 24g differs from the deflection structure 24 from FIG 1 to 4 in that it has a broadened more rectangular-like first edge 44 and a curvature 114 ending in a sharp tip 62 at its second edge 46.

[0057] In FIG 12 a cross section 26 through a fourth alternative deflection structure 24h. The deflection structure 24h differs from the deflection structure 24g from FIG 11 in that it has a rectangular tip 62 at its second edge 46. Thus, a width 54 of a first edge 44 is more than approximately four times wider than a width 56 of the second edge 46.

[0058] FIG 13 shows a cross section 26 through a fifth alternative deflection structure 24i. The deflection structure 24i differs from the deflection structure 24g from FIG 11 in that it has a first edge 44 with a rectangular corner 116.

[0059] In FIG 14 a cross section 26 through a sixth alternative deflection structure 24j. The deflection structure 24j differs from the deflection structure 24 from FIG 1 to 4 in that it has a symmetrical first edge 44, wherein an axis of symmetry 118 is coaxial to a direction from the first edge 44 to a level 120 of a second edge 46 of the deflection structure 24j. Moreover, the deflection structure 24j is embodied with a half-moon curvature 114 ending in a sharp tip 62 at its second edge 46.

[0060] FIG 15 shows a cross section 26 through a seventh alternative deflection structure 24k. The deflection structure 24k differs from the deflection structure 24j from FIG 14 in that a first edge 44 of the deflection structure 24k has two regions 112 that are parts of side walls 106 and that are arranged opposed and in parallel to one another.

[0061] In FIG 16 a cross section 26 through a eighth alternative deflection structure 241. The deflection structure 241 differs from the deflection structure 24k from FIG 15 in that two regions 112 of a first edge 44 are parts of side walls 106 that are arranged opposed to one another and converge in a direction from a level 120 of the second edge 46 the first edge 44. Hence, the first edge 44 has a round tip 122.

[0062] Although the invention is illustrated and described in detail by the preferred embodiments, the invention is not limited by the examples disclosed, and other variations can be derived therefrom by a person skilled in the art without departing from the scope of the invention.

Claims

1. A turbine assembly (10) comprising a basically hollow aerofoil (12, 12a-12d), with at least a leading edge (14), a trailing edge (16), a pressure side (18) and a suction side (20), which are forming at least a cavity (22) within the hollow aerofoil (12, 12a-12d), and with at least a deflection structure (24, 24e-241) that is arranged in the at least one cavity (22) and that has a cross section (26), which is oriented basically perpendicular to a direction (28) pointing from the pressure side (18) to the suction side (20) and wherein the cross section (26) of the at least one deflection structure (24, 24e-241) has an aerofoil contour (30) and has a curved mean camber line (32).

2. A turbine assembly according to Claim 1, wherein a camber (34) of the mean camber line (32) deter-

mines a deflection angle (36) of a cooling medium (38) deflected by the at least one deflection structure (24, 24e-241) towards a region (40) to be cooled.

3. A turbine assembly according to Claim 1 or Claim 2, wherein the mean camber line (32) has a section (42) with a maximal camber (34), wherein the maximal camber (34) causes a deflection angle (36) of the cooling medium (38) from 10° to 110°.

4. A turbine assembly according to any preceding claim, wherein the at least one deflection structure (24, 24e-241) has a first edge (44) and at least a second edge (46), wherein the first edge (44) is a leading edge side (48) of the at least one deflection structure (24, 24e-241) and is oriented towards the leading edge (14) of the hollow aerofoil (12, 12a-12d) and the at least second edge (46) is a trailing edge side (50) of the at least one deflection structure (24, 24e-241) and is oriented basically towards the trailing edge (16) of the hollow aerofoil (12, 12a-12d).

5. A turbine assembly according to any preceding claim, wherein the at least one deflection structure (24, 24e-241) has a first edge (44) and at least a second edge (46), wherein the at least one deflection structure (24, 24e-241) is embodied with a tapered contour (52) from its first edge (44) to its second edge (46).

6. A turbine assembly according to any preceding claim, wherein the at least one deflection structure (24, 24e-241) has a first edge (44) and at least a second edge (46), wherein a width (54) of the first edge (44) is more than two times wider than a width (56) of the at least second edge (46).

7. A turbine assembly according to any preceding claim, wherein the at least one deflection structure (24, 24e-241) is located in a region (58) of the hollow aerofoil (12, 12a-12d) that is arranged at the trailing edge (16) of the hollow aerofoil (12, 12a-12d).

8. A turbine assembly according to any preceding claim, wherein the at least one deflection structure (24, 24e-241) extends from the pressure side (18) to the suction side (20) of the hollow aerofoil (12, 12a-12d).

9. A turbine assembly according to any preceding claim, wherein the at least one deflection structure (24, 24e-241) has a leading edge side (48) and a trailing edge side (50) and wherein the leading edge side (48) has a rounded contour (60).

10. A turbine assembly according to any preceding claim, wherein the at least one deflection structure (24, 24e-24g, 24j-241) has a leading edge side (48) and a trailing edge side (50) and wherein the trailing edge side (50) is embodied with a sharp tip (62) at its end.

11. A turbine assembly at least according to claim 5, wherein the hollow aerofoil (12, 12a-12d) comprises a root portion (64) that is connected to a hub (66), wherein the at least one deflection structure (24, 24e-241) is inclined towards the hub (66) with its trailing edge side (50).

12. A turbine assembly at least according to claim 5, wherein the hollow aerofoil (12, 12a-12d) comprises a tip (68), wherein the at least one deflection structure (24, 24e-241) is inclined towards the tip (68) of the hollow aerofoil (12, 12a-12d) with its trailing edge side (50).

13. A turbine assembly at least according to claims 5, 11 and 12, wherein the hollow aerofoil (12, 12a-12d) has a middle section (70), which is located between the root portion (64) and the tip (68) of the hollow aerofoil (12, 12a-12d), wherein the trailing edge side (50) of the at least one deflection structure (24, 24e-241) is oriented towards the middle section (70) of the hollow aerofoil (12, 12a-12d).

14. A turbine assembly according to any preceding claim, wherein a plurality of deflection structures (24, 24e-241) are arranged in at least one column (72, 74) that is arranged in a span wise direction (76) of the hollow aerofoil (12, 12a-12d) and/or in a direction (78) from the leading edge (14) of the hollow aerofoil (12d) towards the trailing edge (16) of the hollow aerofoil (12d).

15. A turbine assembly according to any preceding claim, wherein the hollow aerofoil (12, 12a-12d) is a turbine blade (80) or turbine vane, particularly of a gas turbine engine.

FIG 1

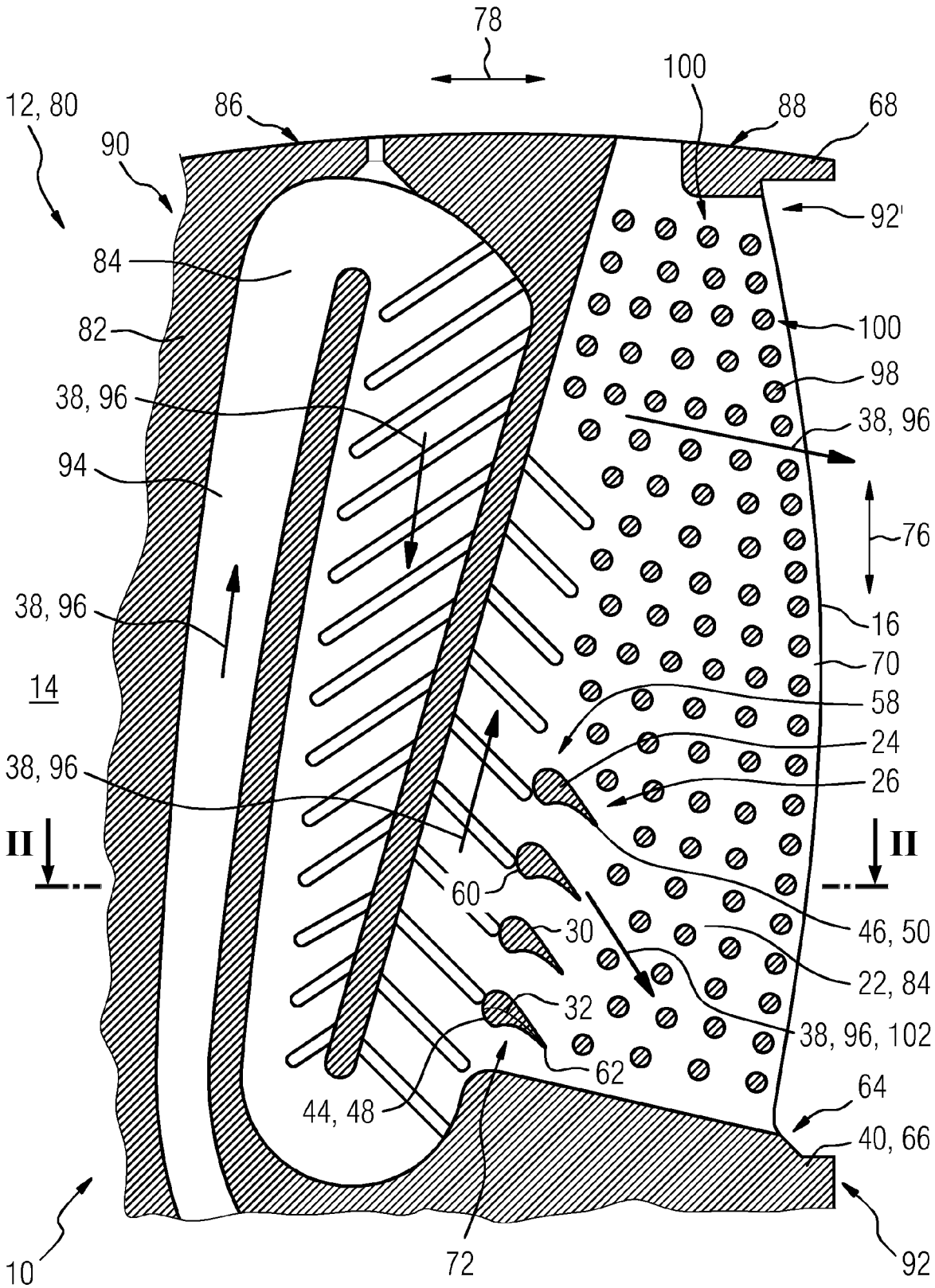

78
100
12, 80
86
88
68
90
92'
84
100
82
98
38, 96
38, 96
94
76
38, 96
16
70
14
58
24
38, 96
26
II
II
60
46, 50
30
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32
38, 96, 102
62
64
44, 48
40, 66
10
72
92

FIG 2

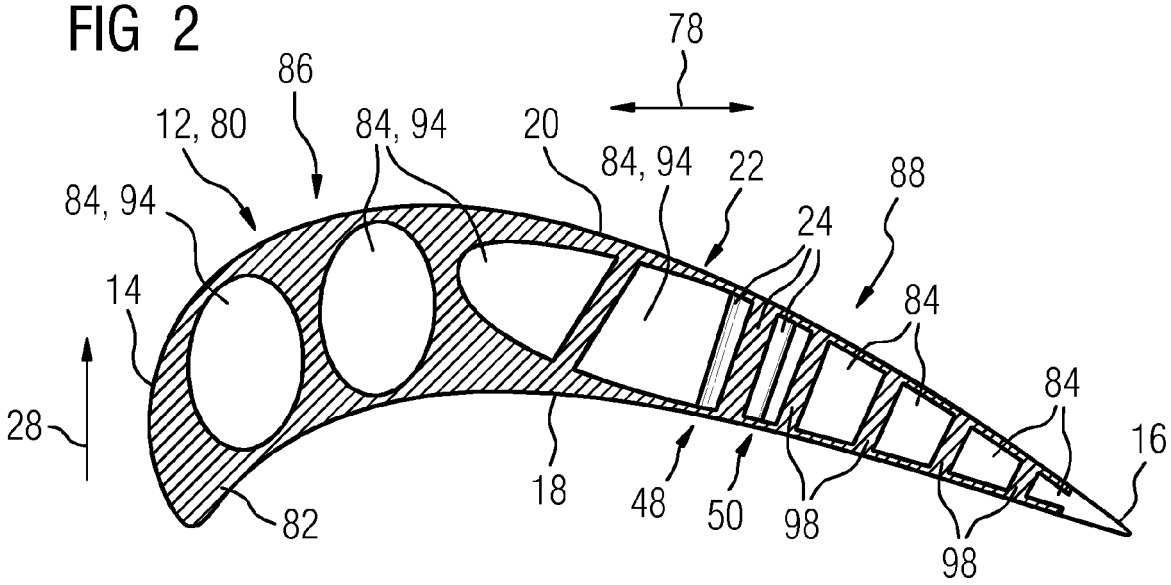


FIG 3

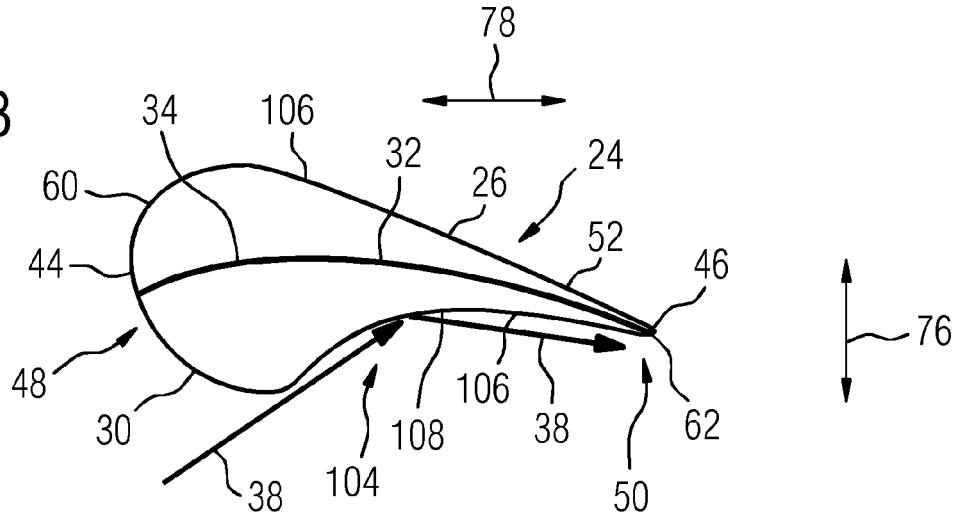


FIG 4

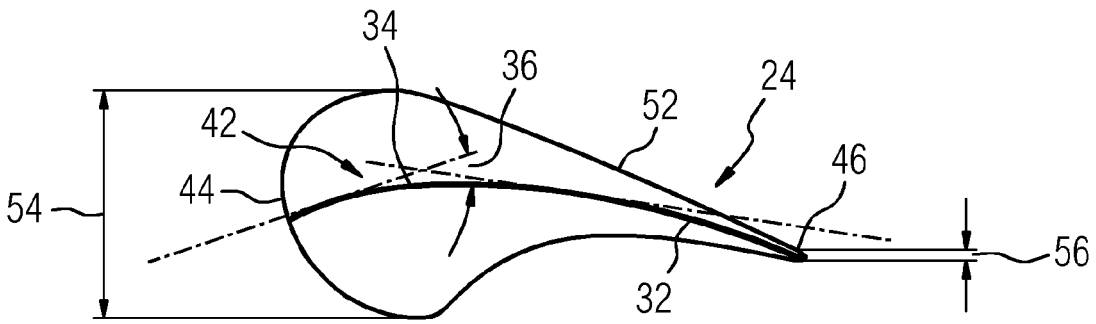


FIG 5

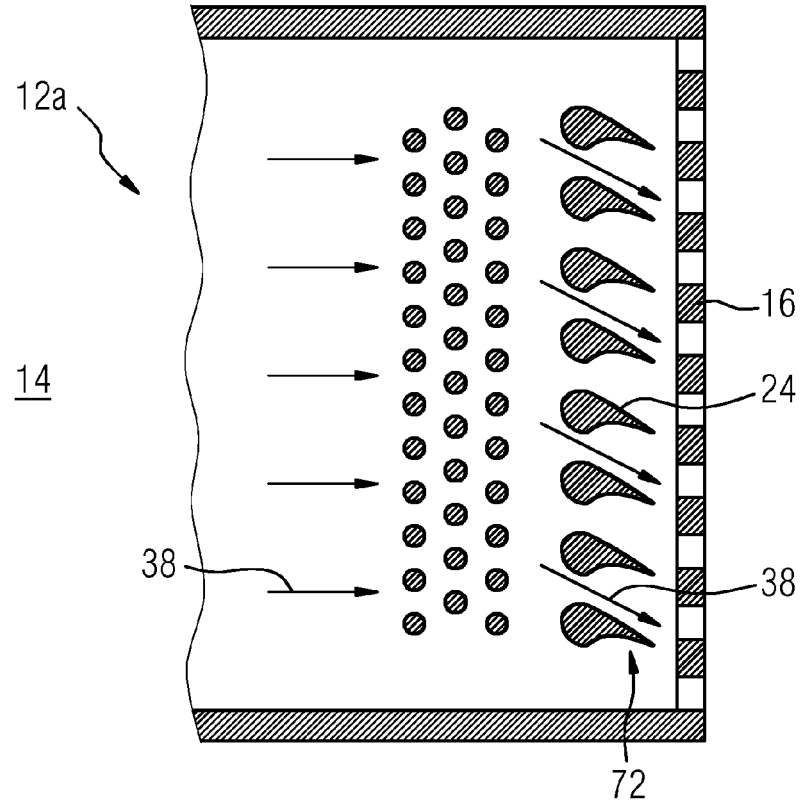


FIG 6

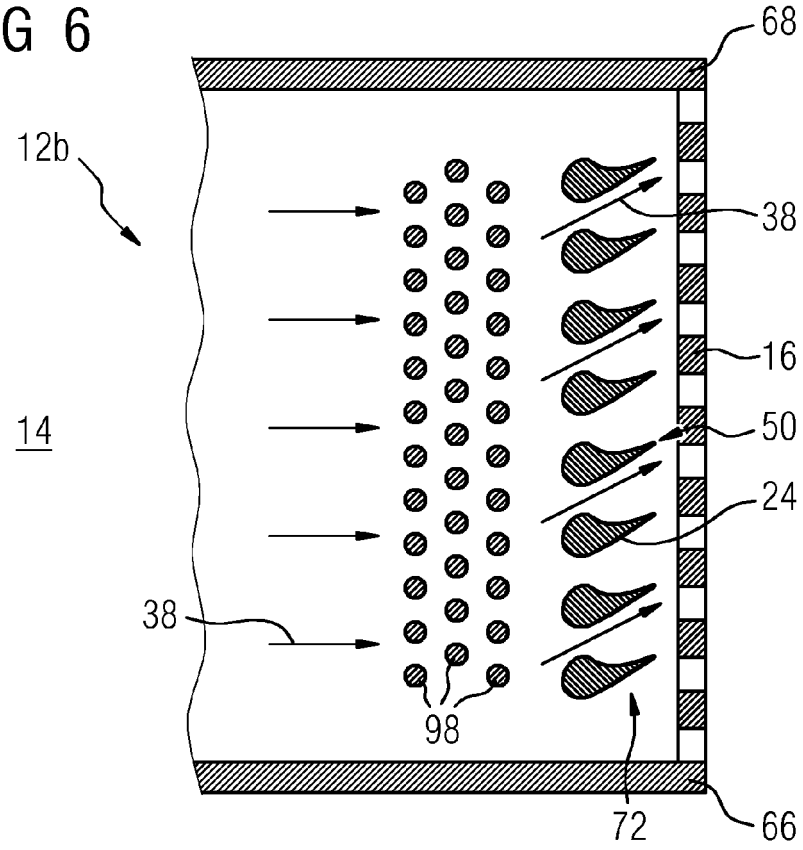


FIG 7

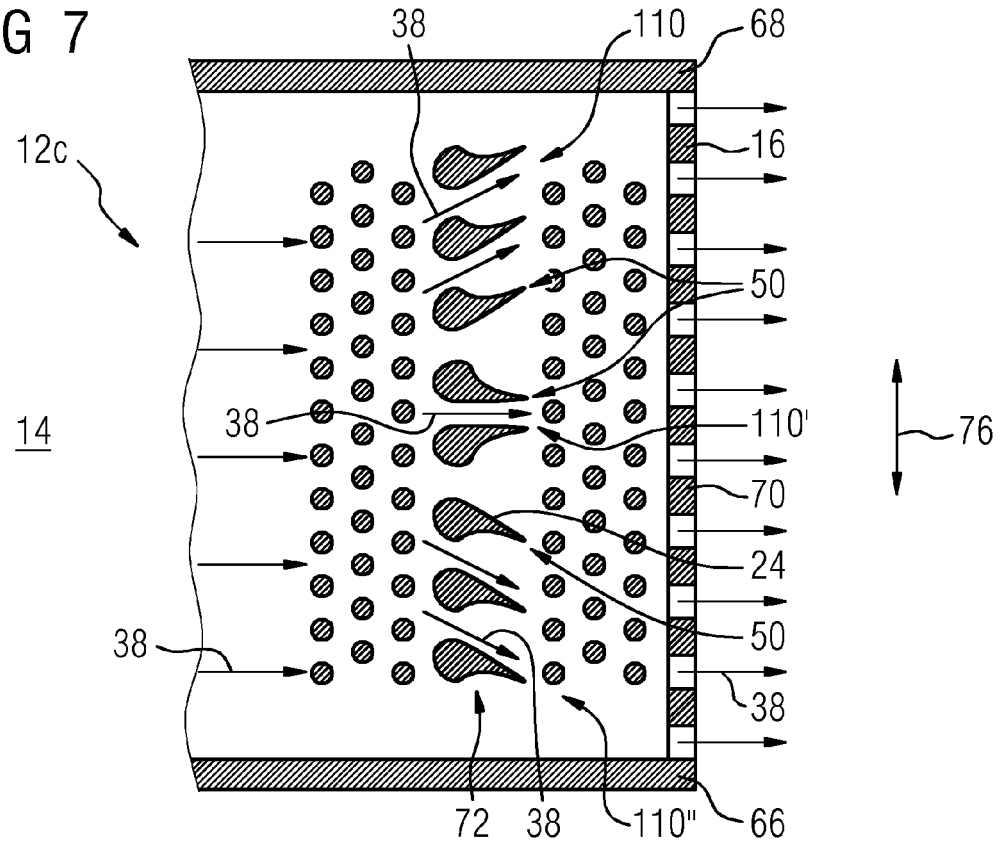

38
110
68
12c
16
50
14
38
110'
76
70
24
38
50
38
72
38
110"
66

FIG 8

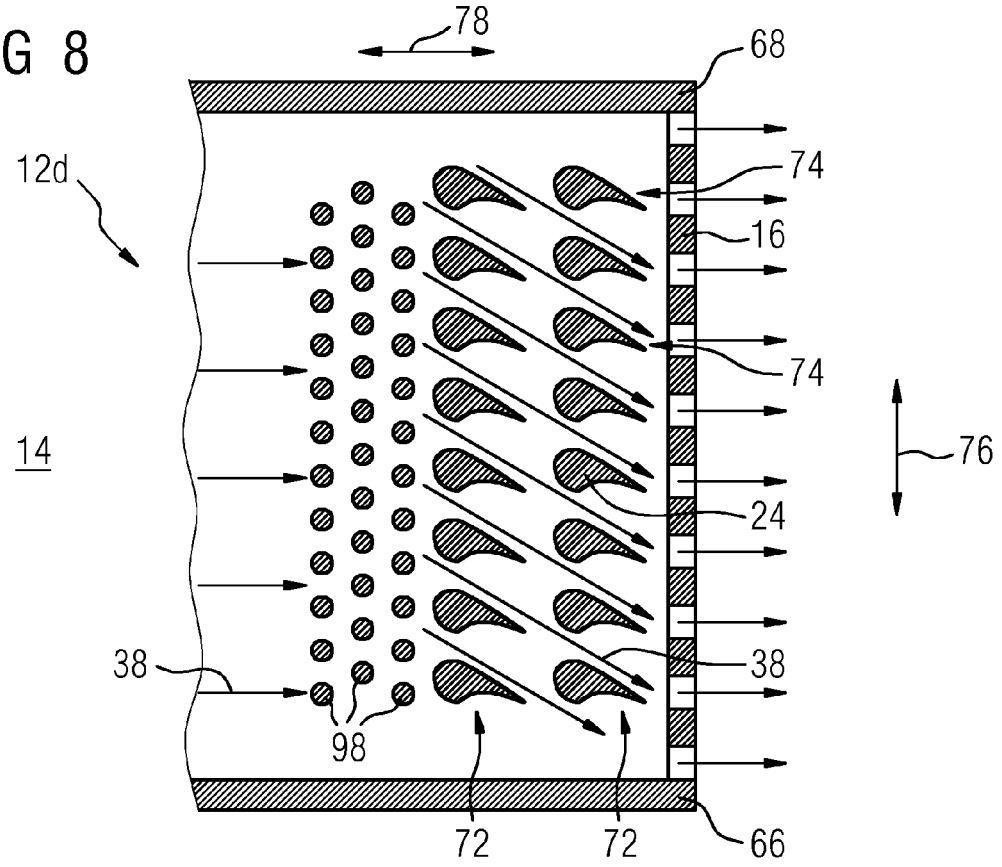

78
68
12d
74
16
74
14
76
24
38
38
98
72
72
66

FIG 9

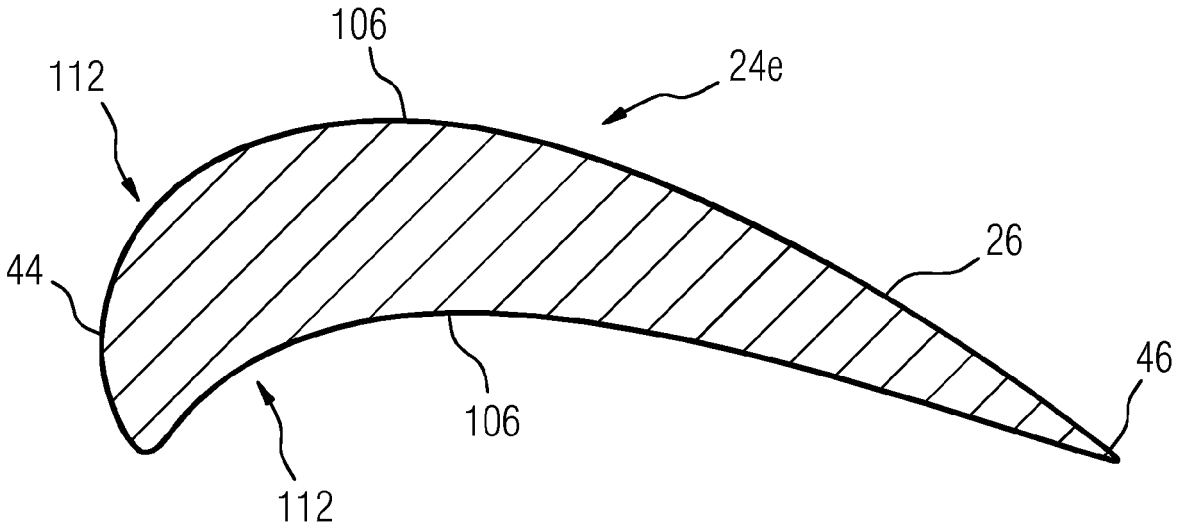


FIG 10

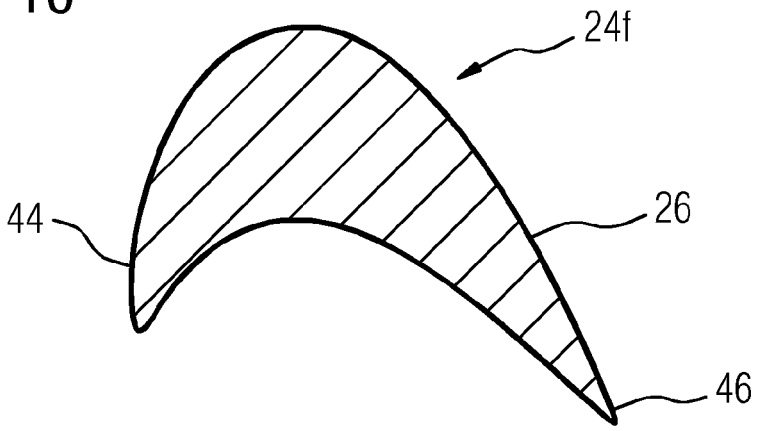


FIG 11

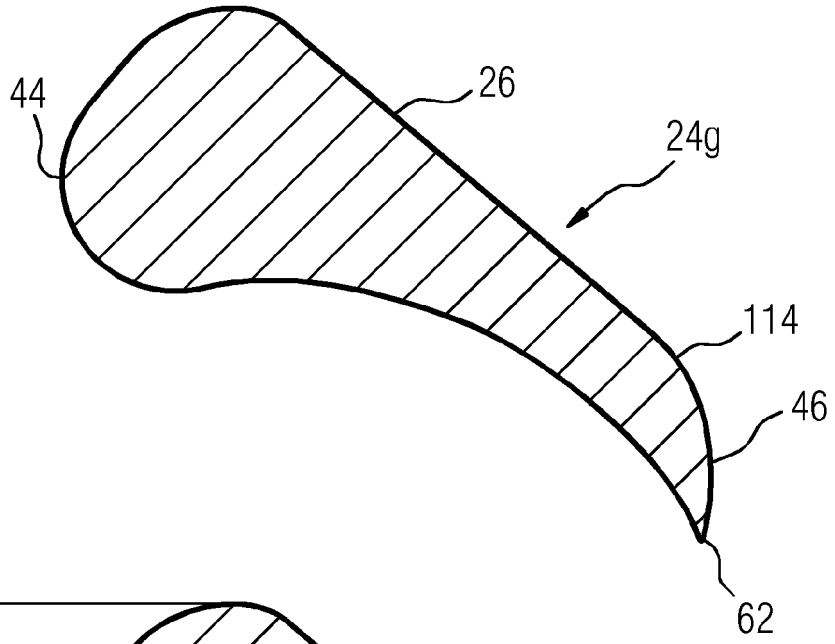


FIG 12

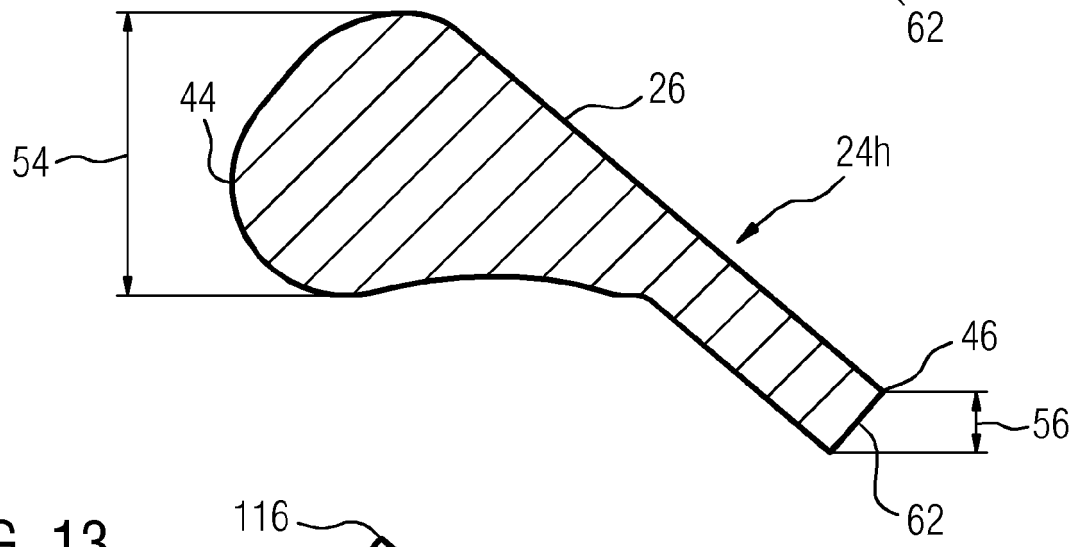


FIG 13

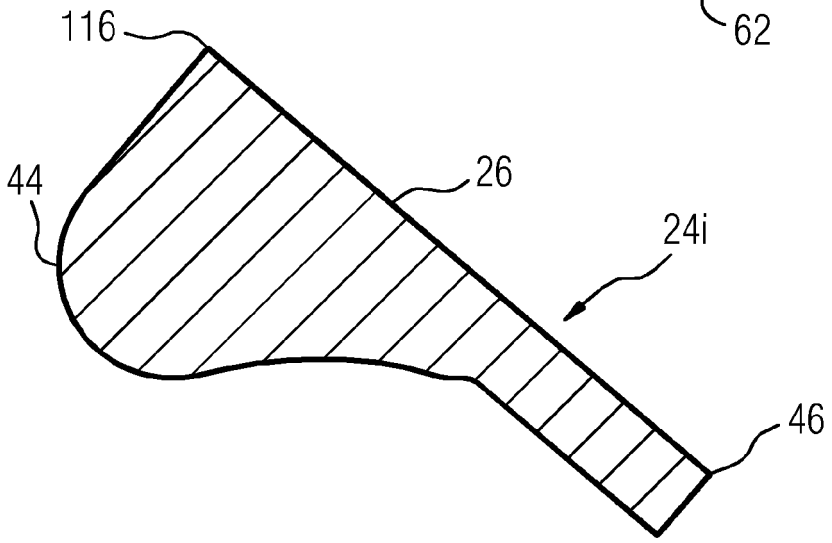


FIG 14

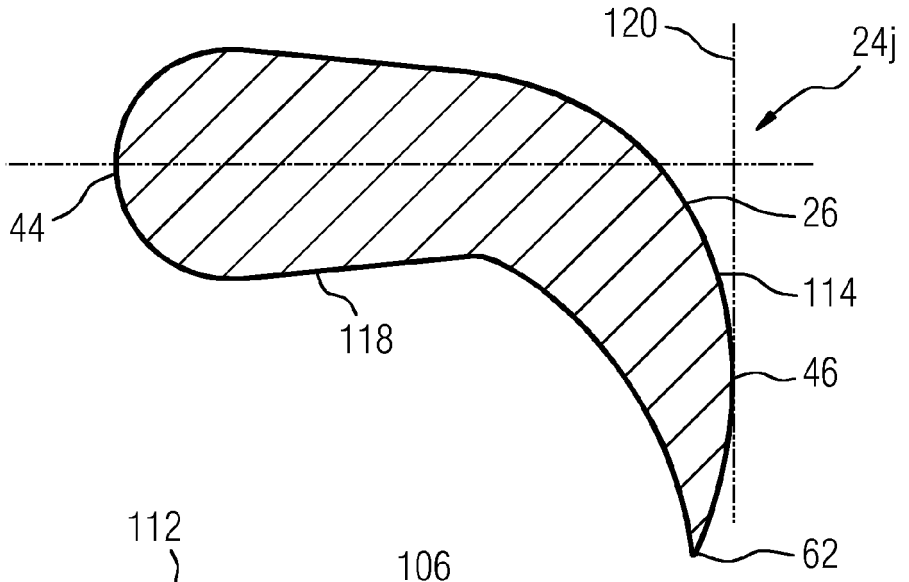


FIG 15

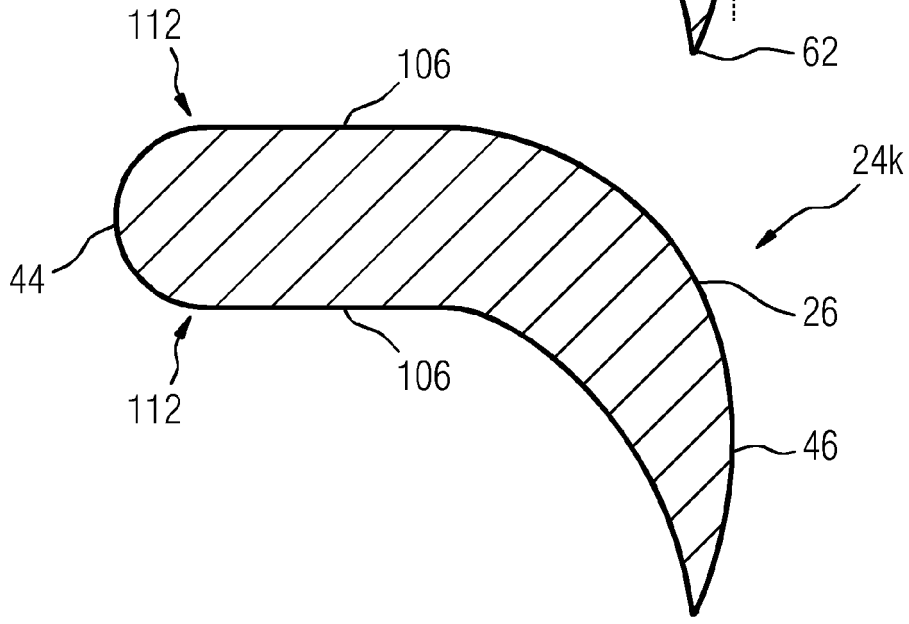
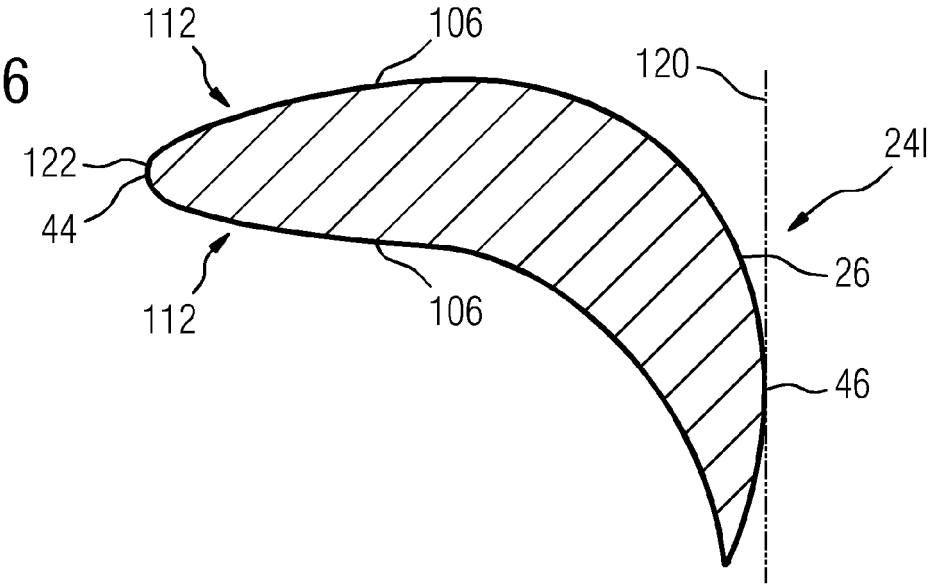


FIG 16



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EUROPEAN SEARCH REPORT

Application Number
EP 12 17 8885

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 056 505 A (CUNHA FRANCISCO JOSE [US] ET AL) 2 May 2000 (2000-05-02) * column 1, line 60 - column 3, line 45 * * column 4, line 10 - column 6, line 47 * * figures * * claims * -----	1-9, 11-15	INV. F01D5/18
X	US 5 246 341 A (HALL KENNETH B [US] ET AL) 21 September 1993 (1993-09-21) * column 2, line 59 - column 4, line 2 * * figures * * claims * -----	1-12	
X	GB 2 165 315 A (ROLLS ROYCE) 9 April 1986 (1986-04-09) * page 2, line 6 - page 3, line 109 * * figures * -----	1-9, 11-15	
X	US 5 536 143 A (JACALA ARIEL [US] ET AL) 16 July 1996 (1996-07-16) * abstract * * column 7, line 21 - column 12, line 41 * * figures * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) F01D
X A	SU 358 525 A1 (AVILOVA SHULGINA M V; ANDROPOV G K; GUROV S V; KANZEPOLSKI A A; KOPELE) 3 November 1972 (1972-11-03) * abstract * * figures * -----	1 2-15	
A	EP 1 544 413 A2 (UNITED TECHNOLOGIES CORP [US]) 22 June 2005 (2005-06-22) * abstract * * figures * -----	1-15	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 January 2013	Rini, Pietro

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1

EPO FORM 1503 03.82 (P04C01)

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11-01-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6056505 A	02-05-2000	EP 0835985 A2	15-04-1998
		JP 10159501 A	16-06-1998
		US 5842829 A	01-12-1998
		US 6056505 A	02-05-2000
		US 6183194 B1	06-02-2001
US 5246341 A	21-09-1993	NONE	
GB 2165315 A	09-04-1986	DE 3534905 A1	10-04-1986
		FR 2571428 A1	11-04-1986
		GB 2165315 A	09-04-1986
		JP 61089901 A	08-05-1986
		US 4604031 A	05-08-1986
US 5536143 A	16-07-1996	DE 69612319 D1	10-05-2001
		DE 69612319 T2	02-05-2002
		EP 0735240 A1	02-10-1996
		IN 186935 A1	15-12-2001
		JP 3894974 B2	22-03-2007
		JP 8319803 A	03-12-1996
		US 5536143 A	16-07-1996
SU 358525 A1	03-11-1972	NONE	
EP 1544413 A2	22-06-2005	AU 2004240221 A1	07-07-2005
		CA 2486988 A1	19-06-2005
		EP 1544413 A2	22-06-2005
		JP 4035131 B2	16-01-2008
		JP 2005201253 A	28-07-2005
		KR 20050062373 A	23-06-2005
		SG 112991 A1	28-07-2005
		TW I256435 B	11-06-2006
		US 2005135933 A1	23-06-2005

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