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(54) Title: SHROUD OF A ROTOR BLADE

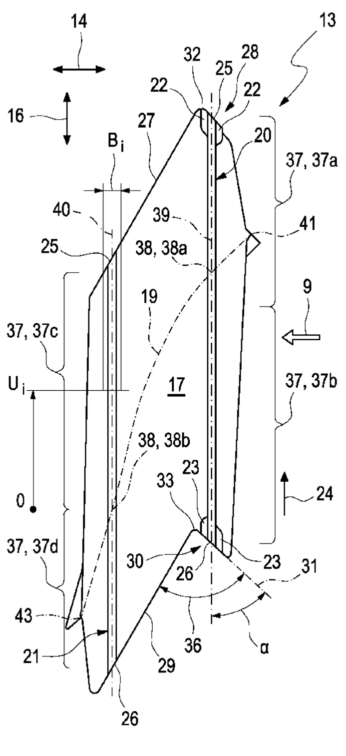

Fig. 3

(57) Abstract: The present invention relates to a shroud (13) of a rotor blade (8) of a rotor (3) of a gas turbine (1) or of a steam turbine (1), whereby, in the assembled state, a rotational axis (4) of the rotor (3) defines an axial direction (14) and a radial direction (15) and a circumferential direction (16) are in relation to the rotational axis (4). An improved efficiency can be achieved with a platform (17), which extends in the axial direction (14) over at least 80 % of the axial length (18) of an adjacent profile body (10) of the rotor blade (8), comprising at least two ribs (20, 21) which project in the radial direction (15) from the platform (17) and extend in the circumferential direction (16) and are spaced apart from one another in the axial direction (14), and having contact elements (22, 23) which are arranged at the circumferential ends (27, 29) of the platform (17), and which in operation of the turbine (1) are in contact with contact elements (22, 23) of adjacent shrouds (17) in the circumferential direction.

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Shroud of a rotor blade

Field of technology

The present invention relates to a shroud of a rotor blade for a rotor of a gas turbine or a steam turbine, in particular for a stationary turbo machine. The invention further relates to a rotor blade comprising such a shroud and to a turbine with rotor blades provided with such a shroud.

Prior art

A turbine of a turbo machine, which is e.g. used for producing electricity in a power plant, comprises a rotor, which rotates during operation of the turbine around an axis of rotation, and carries at least one row of rotor blades. In order to improve the performance of the turbine, the rotor blades of such a row can have a shroud at the tips of each blade. These shrouds reduce a gap flow, which flows in the axial direction through an annular gap formed radially between the rotor blades and a stator of the turbine, the annular gap extending in the circumferential direction. They can, in particular, be designed such that shrouds arranged adjacent to one another in the circumferential direction are touching, and so that the rotor blades in the region of their shrouds are supported against one another. Vibrations can be accordingly damped, which reduces the mechanical loads on the rotor blades. Furthermore the shrouds reduce undesired flow past the rotor blades, which can occur in the region of the tips of the blades, whereby a radial flow past the blade tips instead of a flow past the blade body occurs.

EP 1 890 008 A2 refers to rotor blades having tip shrouds with two circumferentially extended seal teeth and a circumferentially extended portion between said seal teeth wherein this portion has an increased cross-sectional thickness and lateral extensions at the edges between circumferentially abuting tip shrouds.

EP 2 180 142 A1 shows shrouds with seal teeth and a cross-sectional thickness varying in axial direction of the shroud.

Because the rotor blades are subjected during operation of the turbine to high temperatures and large centrifugal forces, there are certain limitations for the mounting and for the form of such shrouds. In particular, until now shrouds have only been able to be provided on rotor blades, which do not exceed a defined maximum length. The provision of longer rotor blades with a shroud is associated with very expensive measures, for example providing active cooling of the rotor blades in the area of the tips of the blades.

Summary of the invention

This is the starting point of the invention. The invention addresses the problem, of providing an improved design for a shroud of the type described above or for a rotor blade or a turbine provided with such a shroud, which is particularly characterized in that it leads to a better efficiency of the associated turbo machine. The shroud should notably be able to be used for uncooled rotor blades and/or without limitations regarding the length of the rotor blades.

According to the invention this problem is solved by the subject of the independent claims. Advantageous embodiments are subject of the dependent claims.

The directional terms used herein, that is, the axial direction, the radial direction and the circumferential direction, relate to the mounted condition of the rotor blades with shrouds in a respective rotor in a respective turbine. A rotational axis of the rotor defines the axial direction, and the radial direction as well as the circumferential direction is in relation to this rotational axis.

The invention is based on the general idea to vary the width in axial direction of at least one of the ribs in circumferential direction, wherein the varying width may have a maximum near the respective rotor blade.

The invention is additionally based on the idea to provide the shroud with a platform, which extends in the axial direction, that is a cylinder or cone with the same rotational axis of the rotor in the mounted state of the shroud, over at least 80% of the axial length of a profile body of the rotor blade, which is adjacent to the platform. In this way a substantial part of the respective blade tips are covered due to the shroud, whereby undesired flow in the area of the tips of the blades can be significantly reduced. The covering of the blade tips in the axial direction by the platform prevents a radial flow past the tips of the blades and supports consequently a flow past the profile body. More energy can therefore be transferred from the gas flow to the rotor blade, which increases the energy efficiency of the associated turbo machine. The platform extends, in a particularly advantageous embodiment, over the whole axial length of the blade body, that is, over at least 100% of its axial length.

In addition or alternatively, the invention is based upon the idea of providing the shroud with at least two ribs, which protrude in the radial direction from a platform of the shroud, which extend in the circumferential direction, which run parallel to one another and are spaced from one another in the axial direction. Such ribs serve on the one hand to provide a gap seal. They project radially into the annular gap between the shrouds and the stator and thus prevent effectively an axial flow through the annular gap. By the arrangement of at least two ribs arranged one behind the other the sealing effectiveness can be considerably improved. On the other hand, the ribs serve to stiffen the platform, so that the wall thickness of the platform measured in the radial direction can be reduced. At the same time the axial separation of the at least two ribs enables an increase in the size of the platform in the axial direction, whereby the previously mentioned axial covering of the blade tips can be improved.

In addition or alternatively, the invention is based upon the idea of providing the respective shroud with contact elements, which are arranged at circumferential ends of a platform of the shroud and in operation of the turbine are in contact with contact elements of shrouds, which are arranged adjacently in the circumferential direction. These contact elements provide a support in the circumferential direction and – depending on the orientation of the contact elements – also in the axial direction, which enables vibrations in the blades to be damped. The provision of contact elements specifically for the contacts reduces the loads on the shrouds, which enables these to be made lighter.

It is especially advantageous when at least two of the underlying ideas described above are combined. That is, on the one hand regarding the platform, which extends over at least 80% of the axial length of the respective rotor blade tip, and on the other hand, the provision of at least two ribs, and further, the provision of specific contact elements. An especially advantageous embodiment is when the three ideas above are combined, which are complementary synergetic. For example, the two ribs provide sufficient stability, so that for less weight, the platform can be made long enough in the axial direction such that the desired axial covering of the blade tips is achieved and such that sufficient space for accommodating specific contact elements is provided.

According to a particularly advantageous embodiment the contact elements can be arranged directly at the circumferential ends of a rib. Because the ribs have a good stability the forces on the contact elements can be supported by these ribs. In particular, the arrangement of the contact elements on a particular rib can be such that at a circumferential end of the platform the respective contact elements and the respective circumferential end of the ribs form an integral contact zone. In other words, the respective rib end in the circumferential direction is functionally integrated into the contact elements. This can alternatively be described in that the respective rib end in the circumferential direction is formed as a contact element. Through this the rib is provided with an additional function, that is, the function of a contact element. As there is no need for separate contact elements and an additional stiffening of the platform is not necessary, this construction results in a weight advantage.

The rib, on which the contact elements are arranged, can be appropriately the rib arranged upstream, which in the following is also referred to as a first rib. This first rib is subjected to substantially increased mechanical loads compared to the rib arranged downstream, which in the following may be referred to as the second rib. In this respect, the first rib is designed to be particularly robust, so that it can provide the addition function of the contact elements

According to another advantageous embodiment, the respective contact zone can lie on a contact plane, which lies inclined to the circumferential direction and which has, in particular, a contact plane angle in the range of 15° to 60°, and preferably in a range from 35° to 45°. By the inclination of the contact plane in relation to the circumferential direction, the forces transferred through the contact zones or contact elements have a circumferential as well as an axial component, which improves the damping of vibrations of the rotor blades.

According to another embodiment, one of the circumferential ends of the platform can have a positive sweepback (a generally arrow shaped form) while the other circumferential end of the platform has a negative sweepback, which is complimentary to the positive sweepback. In the assembled state the positive sweepback of the one platform engages positively in a negative sweepback of a following platform, which results in optimal support between neighboring platforms. The positive sweepback is conveniently arranged at the circumferential end of the platform, which is in front in the rotating direction of the rotor. The platform therefore moves in the circumferential direction in the direction of the positive sweepback.

According to another advantageous embodiment, the sweepback can be formed asymmetrically, such that an arrow tip is not arranged at the mid-point in the axial direction between the axial ends of the platform. The arrow tip is particularly arranged in the region of the upstream first rib. The centering effect of the engaging sweepback profiles is at its greatest in the region of the arrow tip, such that the largest forces also occur there. By moving the arrow tip into the region of the first rib the forces are concentrated on the contact elements, which are preferably located in the region of the circumferential ends of the first rib.

In another embodiment, the sweepback can have straight sweepback edges, which define a sweepback angle, which can lie in a range of 60° to 105° and preferably in a range of 85° to 95°. In this way the bearing of loads can be improved, which occur in the axial and the circumferential directions. One of the sweepback edges can, especially advantageously, lie on the previously mentioned contact plane, such that the sweepback actively aids the supporting of the neighboring shrouds, also in the region of the contact elements.

According to another embodiment, the height of the upstream first rib from the platform can be higher in the radial direction than the height of the downstream second rib. In particular, the first rib can be provided with a substantially greater stiffness than the second rib, so that the first rib can support more loads. The height of the first rib can, in particular, be chosen to be in a range of 1.3 to 1.5 times as big as the height of the second rib. Such a relationship of the rib heights has turned out to be particularly effective.

The upstream first rib can be located closer in the radial direction to the rotational axis than the downstream second rib. This leads to an inclination of the platform in an axial section in relation to the rotational axis or in relation to the axial direction. The increase of volume of the working gas due to its expansion in the respective turbine stage can therefore be accommodated.

According to an advantageous embodiment, at least one of the ribs can have a width in the axial direction, which decreases in the radial direction outwards. Preferably the width of both ribs decrease in the radial direction outwards. The width of the respective rib at 0% of the height of the rib in the radial direction can be in a range of 2.0 to 2.4 times the width of the rib at 100% of its height. In other words, the rib is at its root at least twice as wide as at its tip. Furthermore, the rib can have a width at 50% of its height, which is in the range of 1.5 to 1.9 times the width, which the rib has at 100% of its height.

According to an advantageous embodiment, both ribs may have a width which varies in the circumferential direction. In particular for a circumferential section which starts at an intersection between a profile centre line of the platform bordering profile body (rotor blade tip) and a center line of the respective rib, and ends at the circumferential end of the rib, at 50% of the height of the rib measured in the radial direction the width of the rib at 0% of the length measured in the circumferential direction of the circumferential section lies in a range of 1.8 to 2.1 times the width of the rib at 80% of the length of the circumferential section. In other words, the respective rib is substantially wider at the start of the circumferential section than in a region at the end of the circumferential section. Furthermore the width of the rib in a range from 20% to 40% of the length of the circumferential section is in a range of 1.8 to 2.1 times the width, which the rib has at 80% of the length of the circumferential section. Furthermore the width of the rib in a range of 30% to 50% of the length of the circumferential section can optionally be the same as the width, which the rib has at 80% of the length of the circumferential section.

Using the above relationships, a shape of the respective rib regarding the thickness profile in the circumferential direction can be chosen, which has proven to be particularly effective.

Furthermore, in a further embodiment, in a circumferential section of the respective rib, the length of which is measured in the circumferential direction, and which starts at an intersection of a profile center line of the platform bordering profile body (rotor blade tip) and a center line of a respective rib, and which ends at the circumferential end of the respective rib, at 50% of the height of the rib measured in the radial direction, the width of the rib in a range between 90% and 92% of the length of the circumferential section, and/or at 100% of the length of the circumferential section lies in a range of 1.5 to 2.5 times the width of the rib at in a range between 87% to 89% of the length of the circumferential section. Through the above relationships the respective circumferential end of the rib is thickened, whereby the stiffness of the rib in the area of the corresponding circumferential end is significantly increased. In particular, the integrated contact elements at the respective circumferential ends can be formed in this way.

In further embodiment the platform can be inclined relative to the circumferential direction at its axial ends running from an intersection of the longitudinal middle line of the profile body adjacent the platform and the respective axial end of the platform. Thereby the aerodynamic properties of the shroud rotating in the circumferential direction can be improved. In particular, inclination angles can be provided, which lie in a range of 1.2° to 9°.

The present invention relates therefore also to a rotor blade for a rotor of a gas turbine or of a steam turbine, whereby the rotor blade comprises a shroud as described above arranged at the blade tip. In particular, the shroud can be formed integrally with the profile body of the rotor blade. Alternatively an assembled variant is possible, whereby the shroud is made separately from the profile body and is mounted on the blade tip.

The invention further relates to a turbine, in particular to a gas turbine or a steam turbine, preferably of a turbo machine, which has at least one rotor, whereby at least one row of rotor blades is provided, the blades of which each have a shroud of the type described above at their blade tips. These shrouds can be supported on each other at least via the contact elements in the circumferential direction during operation of the turbine.

Further important features and advantages of the invention are evident from the dependent claims, from the drawings and from the associated description of the figures in view of the drawings.

The above described features and the features described in the following may not be restricted to the described combinations, but may also be used in other combinations or alone without departing from the scope of the present invention.

Short description of the drawings

Preferred embodiments of the invention are shown in the drawings and will be described in more detail in the following description, whereby the same reference numerals are used for the same or similar components or components having the same or similar function.

The figures show schematically in,

Detailed description of preferred embodiments

Referring to fig. 1 a turbine 1, which is preferably a gas turbine or a steam turbine of a turbo machine, preferably of power plant, comprises a stator 2 and a rotor 3, which is rotatably mounted around a rotation axis 4 in the stator 2. The stator 2 comprises a plurality of stator vane rows 5, which each comprise a plurality of vanes 6. The rotor 3 comprises a plurality of rotor blade rows 7, which each contain a plurality of rotor blades 8. A flow direction of the working gas is indicated in the figures by the arrow 9.

In the assembled state, which is seen in fig. 1, the rotational axis 4 of the rotor 3 defines an axial direction 14, which runs parallel to the rotational axis 4. Also in relation to the rotational axis 4, a radial direction 15 runs perpendicularly to the axial direction 14 and perpendicularly to the rotational axis 4. Furthermore a circumferential direction 16 is in relation to the rotational axis 4. For purposes of explanation the axial direction 14, the radial direction 15 and the circumferential direction 16 will also be used for the detailed description of the rotor blades 8 or of the shroud 13, regardless of whether the shroud 13 is arranged on the rotor blade or not, and regardless of whether the shroud 13 is mounted with the blade 8 on the rotor 3 of the turbine 1.

According to fig. 2 a rotor blade 8 comprises a radially extending profile body 10, which defines the profile past which the working gas 9 flows. The rotor blade 8 comprises a blade root 11 with which the rotor blade 8 is anchored to the rotor 3. The rotor blade 8 has furthermore a blade tip 12, which forms the radially outer end of the profile body 10. Finally, a shroud 13 is arranged at the blade tip 12. This shroud 13 can be mounted onto the profile body 10, that is, it can be formed as a separate component to the profile body 10, and is subsequently attached to the profile body 10. In another embodiment the shroud 13 can be integrally formed with the profile body 10, for example, it can be cast together with the profile body 10.

According to the figures 3 to 5 the shroud 13 comprises a platform 17, which extends plate-like in the circumferential direction 16 and in the axial direction 14. The platform 17 extends in the axial direction over at least 80% of an axial length 18 of the profile body 10 in the region of the blade tip 12. In figure 3 only a longitudinal centerline 19 of the profile body 10 or of the blade tip 12 is shown, which has a longitudinal section of the profile body 10 in the region of the blade tip 12 adjacent to the platform 17. In the example shown, the platform 17 extends over 100% of the axial length 18 of the profile body 10, which results in a complete covering of the profile body 10 or of the blade tip 12 in the axial direction 14. A radial flow past the blade tips 12 can thus be effectively prevented.

The shroud 13 also comprises at least two ribs 20, 21, that is, a first rib 20 on the side of the incoming flow and a second rib 21 on the side of the outgoing flow. The two ribs 20, 21 project in the radial direction 15 from the platform 17. The ribs 20, 21 extend respectively in the circumferential direction 16, so that they run parallel to each other. The two ribs 20, 21 are arranged on the platform 17 such that they are spaced apart in the axial direction 14. The two ribs 20, 21 each form a gap seal. They can, in particular, engage in a sealing contour formed in the stator 2, which can be formed as a carving contour.

The shroud 13 also comprises contact elements 22, 23, that is, front or first contact elements 22 and rear or second contact elements 23. The terms “front” and “rear” relate to a direction of movement 24, indicated by an arrow, in which the shroud 13 moves in the circumferential direction in operation of the turbine 1. In operation of the turbine 1 the front or first contact elements 22 of such a shroud 13 can be in contact with the back or second contact elements 23 of a shroud 13, which is preceding in the circumferential direction. Ideally all the shrouds 13 in the circumferential direction 16 are in contact with each other through the contact elements 22, 23, forming a closed ring, which results in a good stabilization of the respective rotor blade row 7.

The contact elements 22, 23 are arranged directly at circumferential ends 25 or 26 of the rib 20. In the example the contact elements 22, 23 are arranged on the upstream first rib 20. The front contact elements 22 are thereby arranged on the front circumferential end 25, whereas the rear contact elements 23 are located at the rear circumferential end 26. In the embodiment shown here, the front contact elements 22 and the circumferentially front end 25 of the first rib 20 at the circumferentially front end 27 of the platform 17 form an integral front contact zone 28. Similarly the rear contact elements 23 and the circumferentially rear end 26 of the first rib 20 at the circumferentially rear end 29 of the platform 17 form an integral rear contact zone 30. The respective contact zones 28, 30 are therefore formed by the contact elements 22, 23 and the respective circumferential end 25, 26 of the respective rib 20 together. The contact zones 28, 30 lie appropriately in a contact plane 31, which runs inclined to the circumferential direction 16. The contact plane 31 is particularly orientated such that it has an angle α relative to the circumferential direction 16. This contact plane angle α is in the example 45°. Preferably the contact plane angle α is within a range from 15° to 60° and preferably in a range from 35° to 45°.

One of the circumferential ends, here the circumferentially front end 27 of the platform 17 has a positive sweepback with a positive arrow tip 32. The other circumferential end, here the circumferentially rear end 29 of the platform 17, comprises a negative sweepback with a corresponding negative arrow tip 33, which is complementary to the positive sweepback. In the assembled state, the positive sweepback of one shroud 13 engages positively with the negative sweepback of the preceding shroud 13.

The sweepbacks can be seen to be configured asymmetrically, such that the respective arrow tip 32, 33 is arranged eccentrically to an axial centre of the platform 17. In the example, the respective arrow tip 32, 33 is arranged closer to the first rib 20 and is arranged accordingly further from the second rib 21.

The respective sweepback is provided here with straight sweepback edges 34 and 35, which define a sweepback angle 36, which can for example be in a range of 60° to 105° and is preferably in a range of 85° to 95°. This sweepback angle 36 can be twice as big as the contact plane angle α. It can however be larger or smaller than double the contact plane angle α. One of the sweepback edges 35, which the respective circumferential end 25, 26 of the first rib 20 comprises, lies appropriately in the respective contact plane 31.

According to figure 5 the upstream first rib 20 has a height h_1 in the radial direction 15, whereas the second rib 21 situated downstream has a height h_2 in the radial direction 15. The height h_1 of the first rib 20 is thus larger than the height h_2 of the second rib 21. The height h_1 of the first rib 20 is in particular about 1.3 to 1.5 times as big as the height h_2 of the second rib 21. It can be seen that the platform 17 runs inclined to the axial direction 14, such that the first rib 20 is located closer to the rotational axis 4 in the radial direction 15 than the second rib 21.

According to fig. 5, the ribs 20, 21 have a width B measured in the axial direction 14, which decreases outwards in the radial direction 15 that is with increasing distance from the rotational axis 4. The height h of the respective rib 20, 21 is given in the example for the first rib 20 as a percentage, such that a rib height h_i can have values from 0% to 100% of the height h_1 of the first rib. Therefore 0% corresponds to the height of the rib root, that is, at the interface between the platform 17 and the rib 20, 21, whereas 100% relates to the distance from the platform 17 to the distal end of the respective rib 20, 21 in the radial direction 15. At 0% of the measured height h of the respective rib 20, 21 in the radial direction 15 the width B_i of the respective rib 20, 21 is in a range of 2.0 to 2.4 times the width, which the respective rib 20, 21 has at 100% of its height h. At 50% of its height the respective rib 20, 21 has a width B_i, which is in a range of 1.5 to 1.9 times the width of the respective rib 20, 21 at 100% of its height h.

According to figures 3 and 4 the two ribs 20, 21 can again have an axial width B_i measured in the axial direction 14, which additionally or alternatively to the above varies in the circumferential direction 16. In order to describe this width distribution in the circumferential direction 16 the respective rib 20, 21 is divided into circumferential sections 37 or 37a, 37b, 37c and 37d. The respective circumferential section 37 starts at an intersection 38 or at an intersection 38a or 38b between the profile centerline 19 and a centerline 39 of the first rib 20 or of a center line 40 of the second rib 21. The respective circumferential section 37 ends at the circumferential end 25 or 26 of the respective rib 20, 21. With both ribs 20, 21 and both of the circumferential ends 25, 26 per rib 20, 21 there are therefore four circumferential sections 37a-37d. The length U_i of the respective circumferential section 37 is again measured in the circumferential direction 16 and is given as a percentage, whereby 0% length corresponds to the intersection 38, whereas 100% length corresponds to the respective circumferential end 25 or 26.

At 50 % of the height h of the respective rib 20, 21 measured in the radial direction 15 the width B_i of the respective rib 20, 21 at 0% of the length U_i of the respective circumferential section 37 lies in the range of 1.8 to 2.1 times the width, which the respective rib 20, 21 has at 80% of the length of the circumferential section 37. Furthermore the width B_i of the respective rib 20, 21 in an area between 20% to 40% of the length U_i of the respective circumferential section 37 lies in a range of 1.8 to 2.1 times the width, which the respective rib 20, 21 has at 80% of the length of the circumferential section 37. The width B_i of the respective rib 20, 21 in an area between 30% to 50% of the length U_i of the circumferential section 37 can be furthermore the same as the width, which the respective rib 20, 21 has at 80% of the length of the circumferential section 37.

In order to stiffen the first rib 20 in the region of the circumferential ends 25, 26, the width B_i of the first rib 20 in an area from 90% to 92% of the length U_i of the respective circumferential section 37 can be in a range from 1.5 to 2.5 times the width, which the first rib 20 has in an area from 87% to 89% of the length of the circumferential section 37. Furthermore, the width B_i of the first rib 20 at 100% of the length of the respective circumferential section 37 can lie in a range of 1.5 to 2.5 times the width, which the first rib 20 has in a range of 87% to 89% of the length of the circumferential section 37. This widening forms particularly the contact elements 22, 23.

According to figures 3 and 4 the longitudinal centerline 19 also has an upstream intersection 41 with the upstream axial end 42 of the platform 17 as well as a downstream intersection 43 with a downstream axial end 44 of the platform17. From these intersections 41, 43 the respective axial end 42, 44 of the platform 17 is inclined relative to the circumferential direction 16. This inclination has in fig. 4 an inclination angle β. There are altogether four inclination angles β_1 to β_4, which can be different and preferably are in the range of 1.2° to 9°.

List of reference signs

1	Turbine
2	Stator
3	Rotor
4	Rotational axis
5	Vane row
6	Vane
7	Rotor blade row
8	Rotor blade
9	Working gas flow
10	Profile body
11	Blade root
12	Blade tip
13	Shroud
14	Axial direction
15	Radial direction
16	Circumferential direction
17	Platform
18	Axial length of 17
19	Profile centerline
20	First rib
21	Second rib
22	Front contact element
23	Rear contact element
24	Direction of movement

25	Front circumferential end of 21
26	Rear circumferential end of 21
27	Front circumferential end of 17
28	Front contact zone
29	Rear circumferential end of 17
30	Rear contact zone
31	Contact plane
32	Positive arrow tip
33	Negative arrow tip
34, 35	Sweepback edge
36	Sweepback angle
37	Circumferential section
38	Intersection
39	Centerline of the first rib 20
40	Centerline of the second rib 21
41	Upstream intersection
42	Upstream axial end of the platform 17
43	Downstream intersection
44	Downstream axial end of the platform 17
α	Contact plane angle
β	Angle of inclination
B	Width of 20, 21
h	Height of 20, 21
U	Length of 37

Claims

1. A shroud of a rotor blade (8) of a rotor (3) of a gas turbine (1) or of a steam turbine (1),
- whereby, in the assembled state, a rotational axis (4) of the rotor (3) defines an axial direction (14), and a radial direction (15) and a circumferential direction (16) are in relation to the rotational axis (4),
- comprising a platform (17), which extends in the axial direction (14) over at least 80% of the axial length (18) of an adjacent profile body (10) of the rotor blade (8),
- comprising at least two ribs (20, 21), which project in the radial direction (15) from the platform (17), extend in the circumferential direction (16) and are spaced apart in the axial direction (14)
- comprising contact elements (22, 23), which are arranged at circumferential ends (27, 29) of the platform (17) and, in operation of the turbine (1), are in contact with the contact elements (22, 23) of adjacent shrouds (17) in the circumferential direction (16),

characterized in that,
at least one of the ribs (20, 21) has a width (B) in the axial direction (14) which varies in the circumferential direction (16).

2. A shroud according to claim 1,
characterized in that,
the contact elements (22, 23) are arranged directly at the circumferential ends (25, 26) of one rib (20), such that at the respective circumferential end (27, 29) of the platform (17) the respective contact elements (22, 23) and the respective cir-

cumferential end (25, 26) of the rib (20) form an integral contact zone (28, 30), whereby, in particular, the contact elements (22, 23) can be arranged on the upstream first rib (20).

3. A shroud according to claim 2,
characterized in that,
the respective contact zone (28, 30) lies in a contact plane (31), which is inclined relative to the circumferential direction (16) and, in particular, comprises a contact plane angle (α), which can be in a range from 15° to 60°, and preferably in a range from 35° to 45°.

4. A shroud according to any of claims 1 to 3,
characterized in that,
a circumferential end (27) of the platform (17) has a positive sweepback, whereas the other circumferential end (29) of the platform (17) has a negative sweepback which is complementary to the positive sweepback, whereby in particular it can be provided that the sweepbacks are formed asymmetrically, such that an arrow tip (32, 33) is arranged closer to the upstream rib (20).

5. A shroud according to claim 4,
characterized in that,
the sweepback has straight sweepback edges (34, 35) which define a sweepback angle (36), which is in a range from 60° to 105°, and preferably in a range from 85° to 95°, whereby in particularly, the sweepback edges (35) can lie on the contact plane (31).

6. A shroud according to any of claims 1 to 5,
characterized in that,

the upstream first rib (20) has a larger height (h) in the radial direction (15) than the downstream second rib (21), whereby in particular, the height (h_1) of the first rib (20) can be in a range of 1.3 to 1.5 times the height (h_2) of the second rib (21).

7. A shroud according to any of claims 1 to 6,
characterized in that,
the upstream first rib (20) is arranged closer to the rotational axis (4) in the radial direction (15) than the downstream second rib (21).

8. A shroud according to any of claims 1 to 7,
characterized in that,
at least one of the ribs (20, 21) has a width (B) in the axial direction (14), which decreases outwards in the radial direction (15), whereby in particular, the width (B) of the respective rib (20, 21) at 0% of the measured height (h) of the rib (20, 21) in the radial direction (15) can be in a range of 2.0 to 2.4 times the width, which the rib (20, 21) has at 100% of its height (h), whereby in particular, the rib (20, 21) at 50% of its height (h) can have a width (B), which is in a range of 1.5 to 1.9 times the width which the rib (20, 21) has at 100% of its height.

9. A shroud according to any of claims 1 to 8,
characterized in that in a circumferential section (37), which begins at an intersection (38) between a profile centerline (19) of the profile body (10) adjacent the platform (17) and the center line (39, 40) of the respective rib (20, 21), and ends at a circumferential end (25, 26) of the respective rib (20, 21), at 50% of the measured height (h) of the respective rib (20, 21) in the radial direction (15) the width (B) of this rib (20, 21) at 0% of the measured length (U) of the circumferential section (37) measured in the circumferential direction is in a range of 1.8 to 2.1 times the width (B), which the rib (20, 21) has at 80% of the length (U) of the circumferential section (37), whereby in particular, the width (B) of the rib (20, 21) in a range of 20% to 40% of the length (U) of the circumferential section (37) can

be in a range of 1.8 to 2.1 times the width, which the rib (20, 21) has at 80% of the length (U) of the circumferential section (37), whereby in particular, the width (B) of the rib (20, 21) in a range of 30% to 50% of the length (U) of the circumferential section (37) can be the same as the width, which the rib (20, 21) has at 80% of the length of the circumferential section (37).

10. A shroud according to any of claims 1 to 9,
characterized in that,
in a circumferential section (37) of the respective rib (20, 21), the length (U) of which is measured in the circumferential direction (16), and begins at an intersection (38) between a profile centerline (19) of the profile body (10) of the rotor blade (8) adjacent the platform (17) and the center line (39, 40) of the respective rib (20, 21), and ends at a circumferential end (25, 26) of the respective rib (20, 21), at 50% of the measured height (h) of the rib (20, 21) in the radial direction (15) the width (B) of the rib (20, 21) in a range of 90% to 92% of the length (U) of the circumferential section (37) and/or at 100% of the length (U) of the circumferential section (37) is in a range from 1.5 to 2.5 times the width (B) which the rib (20, 21) has in a range from 87% to 89% of the length (U) of the circumferential section (37).

11. A shroud according to any of claims 1 to 10,
characterized in that,
the platform (17) is inclined at its axial ends (42, 44) relative to the circumferential direction (16) from an interface (41, 43) between the longitudinal center line (19) of the profile body (10) adjacent the platform (17) and the respective axial end (42, 44) of the platform (17) and, in particular, with an inclination angle (β), which is in the range of 1.2° to 9°.

12. A rotor blade for a rotor (3) of a gas turbine (1) or of a steam turbine (1), comprising a shroud (13) according to one of the claims 1 to 11 arranged at the

rotor blade tip (12), whereby in particular, the shroud (13) is formed integrally with a profile body (10) of the rotor blade (8).

13. A turbine, in particular, a gas turbine or a steam turbine of a turbo machine, comprising at least one rotor (3), which has at least one rotor blade row (7), the rotor blades (8) of which each have a shroud (13) according to one of claims 1 to 11 at their blade tips (12), which at least in operation of the turbine (1) support one another in the circumferential direction (16) via contact elements (22, 23).

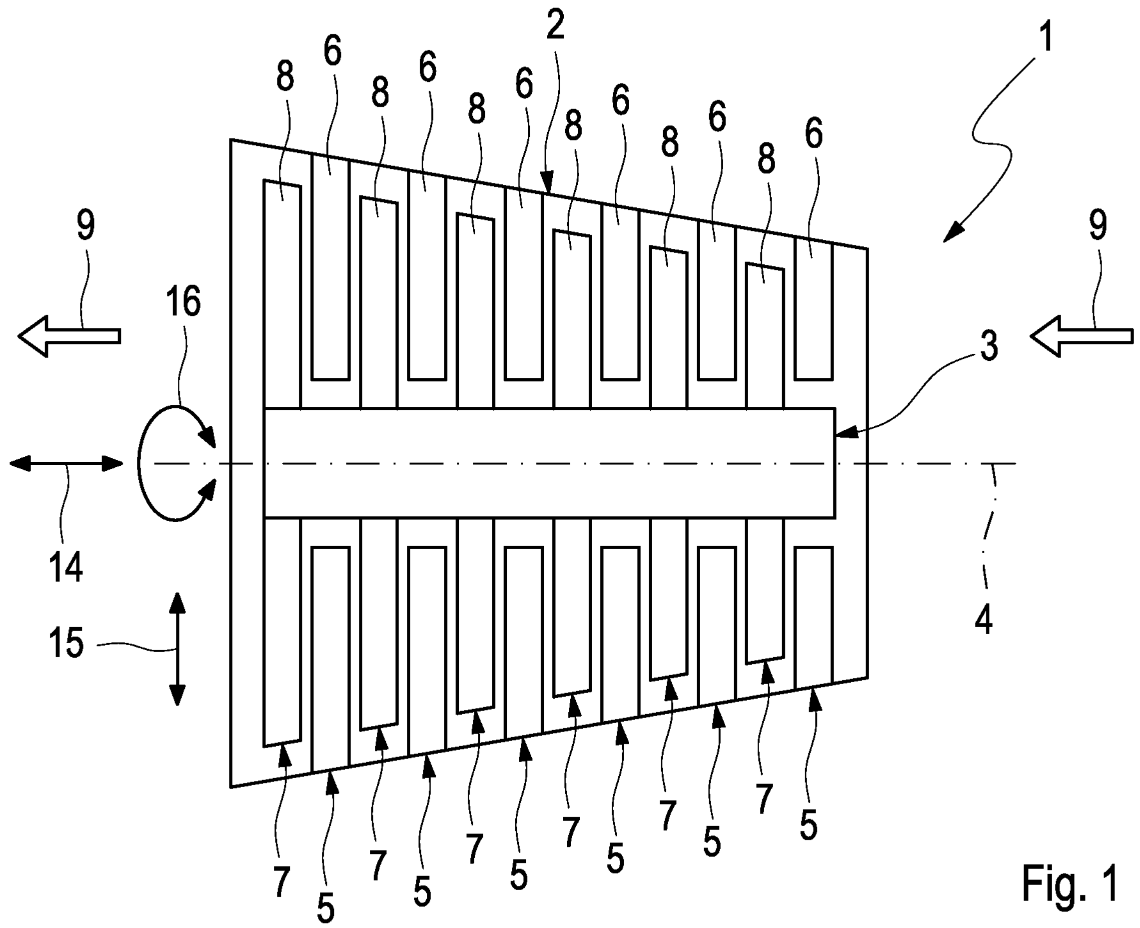


Fig. 1

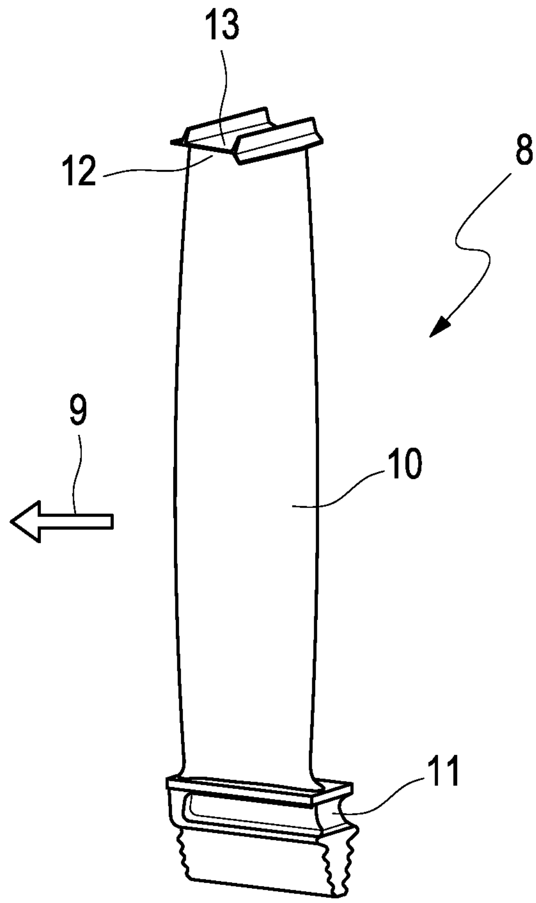
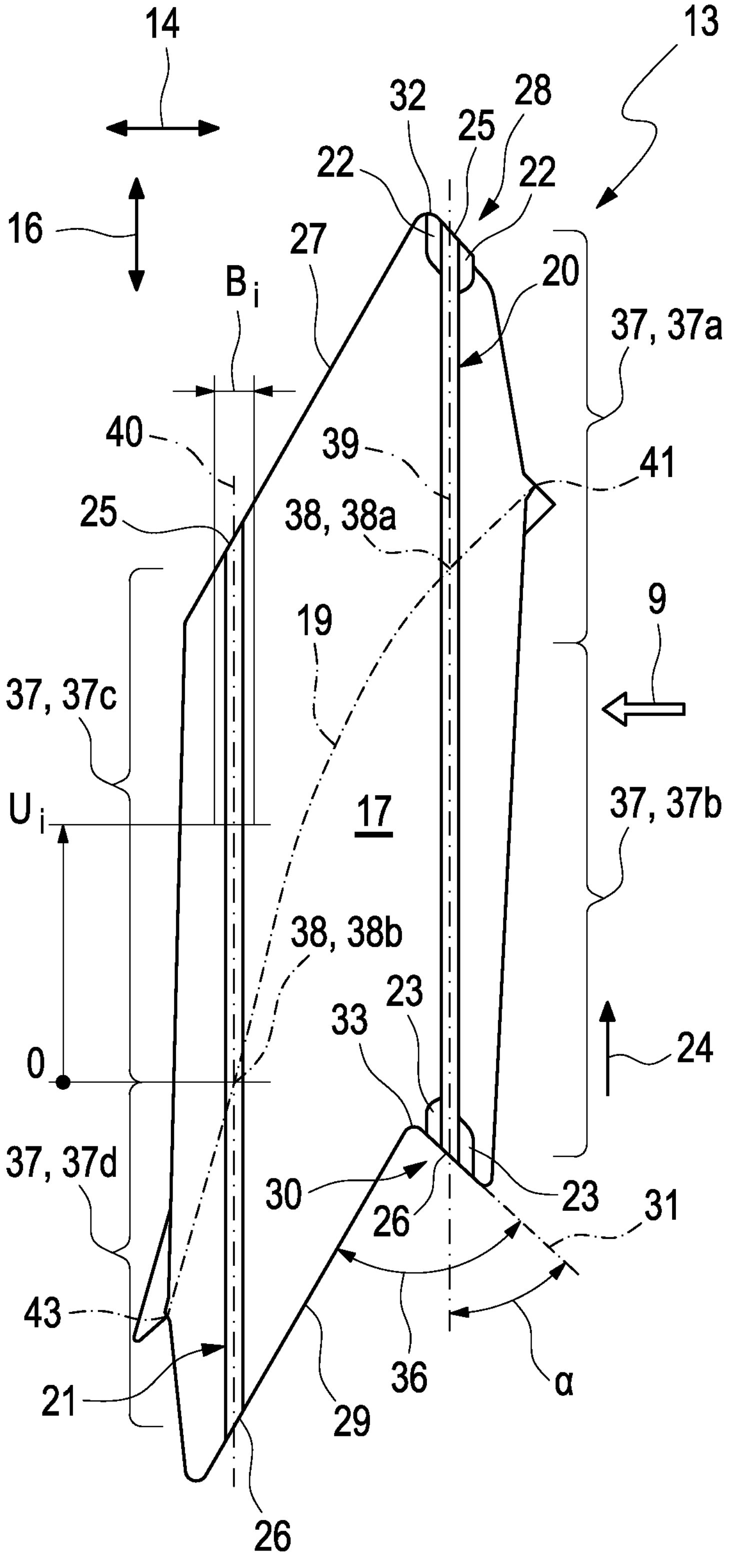


Fig. 2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13
16
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28
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22
27
Bi
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39
41
25
38, 38a
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37, 37c
17
37, 37b
Ui
38, 38b
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24
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30
23
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31
43
36
α
21
29
26

Fig. 3

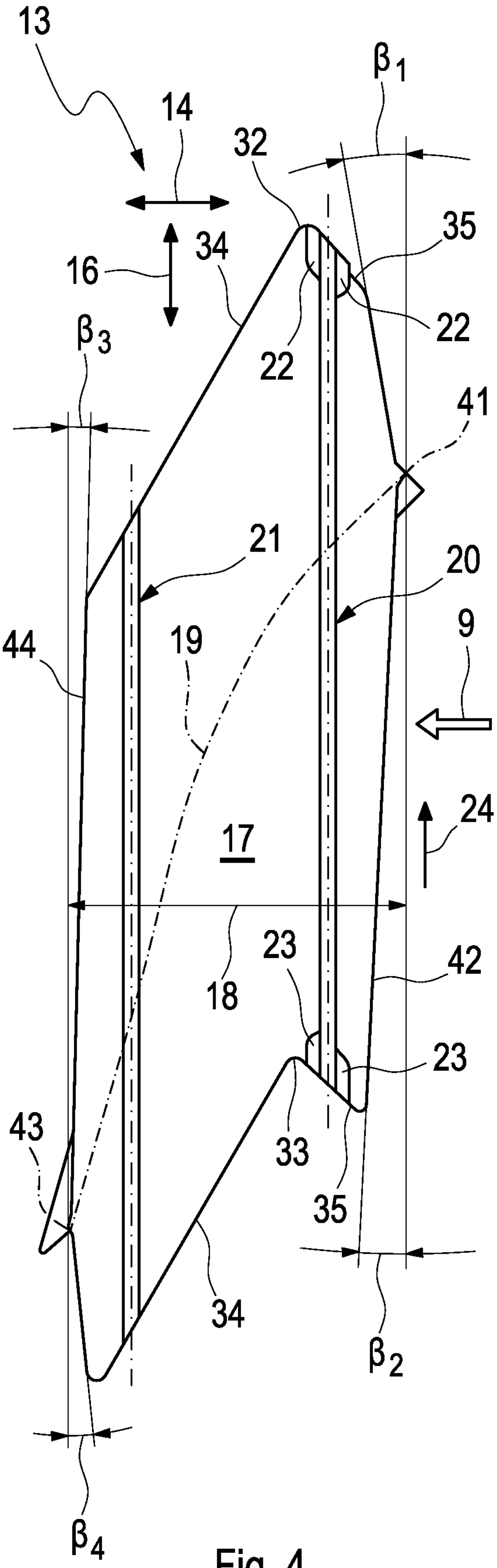
13
β1
14
32
35
34
16
22
22
β3
41
21
20
44
19
9
17
24
18
23
42
23
43
33
35
34
β2
β4

Fig. 4

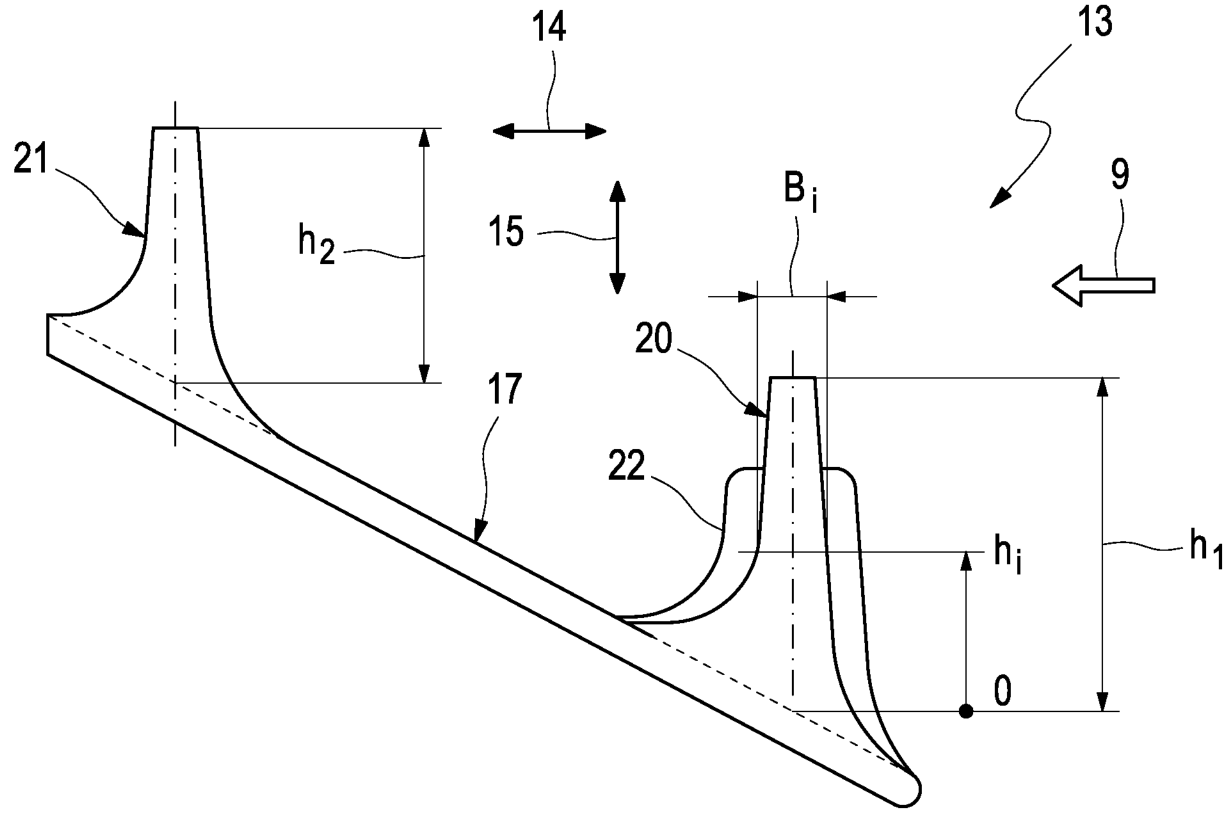

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/072043

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D5/20 F01D5/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 576 377 A (BEANLAND MICHAEL HARGREAVES ET AL) 27 April 1971 (1971-04-27) column 2, line 59 - line 75 figure 3 -----	1-3, 6-10,12, 13
X	GB 2 399 602 A (ALSTOM [CH]) 22 September 2004 (2004-09-22) abstract page 3, line 13 - line 21 -----	1-5, 7-10,12, 13
X	EP 1 262 633 A1 (SNECMA MOTEURS [FR]) 4 December 2002 (2002-12-04) paragraph [0021] - paragraph [0022] figure 2 -----	1-5, 7-10,12, 13

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 February 2012	07/03/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Burattini, Paolo

International application No
PCT/EP2011/072043

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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International application No
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US 2005106025	A1	19-05-2005	NONE			