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(54) **Cooled rotor blade**

Gekühlte Rotorschaukel

Aube de rotor refroidie

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Description

BACKGROUND OF THE INVENTION

1. Technical Field

[0001] This invention applies to gas turbine rotor blades in general, and to cooled gas turbine rotor blades in particular.

2. Background Information

[0002] Turbine sections within an axial flow turbine engine include rotor assemblies that each include a rotating disc and a number of rotor blades circumferentially disposed around the disk. Rotor blades include an airfoil portion for positioning within the gas path through the engine. Because the temperatures within the gas path very often negatively affect the durability of the airfoil, it is known to cool an airfoil by passing cooling air through the airfoil. The cooled air helps decrease the temperature of the airfoil material and thereby increase its durability.

[0003] Prior art cooled rotor blades very often utilize internal passage configurations that include a leading edge passage 10a that either dead-ends adjacent the tip (see FIG. 7), or is connected to an axially extending passage that dead-ends prior to the trailing edge. All of these internal passage configurations suffer from airflow stagnation regions, or regions of relatively low velocity flow that inhibit internal convective cooling. The airfoil wall regions adjacent these regions of low cooling effectiveness are typically at a higher temperature than other regions of the airfoil, and are therefore more prone to undesirable oxidation, thermal mechanical fatigue (TMF), creep, and erosion.

[0004] What is needed, therefore, is an airfoil having an internal passage configuration that promotes desirable cooling of the airfoil and thereby increases the durability of the blade.

[0005] A rotor blade having the features of the preamble of claim 1 is disclosed in EP-A-899425. A further rotor blade is disclosed in EP-A-896127.

DISCLOSURE OF THE INVENTION

[0006] According to the present invention, a rotor blade is provided that includes a root and a hollow airfoil. The hollow airfoil has a cavity, a leading edge, and a tip. An internal passage configuration is disposed within the cavity that includes a first radial passage, a second radial passage, and a rib disposed between the passages. The passages and the rib are contiguous with a tip endwall. The first radial passage is disposed contiguous with the leading edge. A plurality of crossover apertures are disposed in the rib. One of the crossover apertures is disposed flush with the tip endwall. A conduit is disposed within the root that is operable to permit airflow through the root and into the passages. An aperture is disposed

within the tip endwall aligned with the first radial passage.

[0007] One of the advantages of the present rotor blade is that airflow stagnation regions within the radial passages are decreased or eliminated adjacent the tip.

5 Another advantage is that the convective cooling of the tip endwall is improved relative to many prior art internal passage configurations. The crossover aperture disposed flush with the tip endwall permits cooling air to travel into the radial end of the leading edge radial passage. As a result, undesirable stagnation regions 12a (see FIG. 7) typically present in prior art dead-end radial passages 14a are eliminated. For the case where the cavity supplying the coolant air to the flush crossover does not dead-end, but feeds another cavity (e.g., axial extending cavity or aftward flowing serpentine), the stagnation/recirculation region 16a (see FIG. 7) typical in prior art is also eliminated. In addition, the cooling airflow through flush crossover aperture improves convective cooling of the tip endwall. The airfoil tip is consequently able to accommodate high temperature environments with greater resistance to oxidation, TMF, creep, and erosion.

[0008] Additional advantages are provided in the present invention since an aperture is disposed within the tip endwall aligned with the first radial passage, contiguous with the leading edge. The aperture provides a cooling air path out of the first radial passage, which facilitates the elimination of stagnation regions within the first radial passage. The position of the aperture relative to the first radial passage, leading edge, and tip also enables it to cool a region of the airfoil where cooling has historically been problematic. The position of the aperture at the radial end of the first radial passage also enables it to act as a debris purge. Debris that is carried within the cooling air or dislodged from a surface within the airfoil will be forced outward by centrifugal forces as the blade rotates. The aperture at the radial end of the first radial passage is positioned to receive and pass debris outside the airfoil.

40 **[0009]** These and other features and advantages of the present invention will become apparent in light of the detailed description of some preferred embodiments thereof, as illustrated in the accompanying drawings.

45 BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a diagrammatic perspective view of the rotor assembly section.

FIG. 2 is a diagrammatic sectional view of a rotor blade having an arrangement of the internal passage configuration.

50 FIG. 3 is a diagrammatic sectional view of a rotor blade having an arrangement of the internal passage configuration.

FIG. 4 is a diagrammatic sectional view of a rotor blade having an arrangement of the internal passage

configuration.

FIG. 5 is a diagrammatic sectional view of a rotor blade having an arrangement of the internal passage configuration.

FIG. 6 is an enlarged diagrammatic sectional view of part of a rotor blade having an embodiment of the internal passage configuration in accordance with the invention.

FIG. 7 is an enlarged diagrammatic sectional view of part of a prior art rotor blade.

DETAILED DESCRIPTION OF THE INVENTION

[0011] Referring to FIG. 1, a rotor blade assembly 10 for a gas turbine engine is provided having a disk 12 and a plurality of rotor blades 14. The disk 12 includes a plurality of recesses 16 circumferentially disposed around the disk 12 and a rotational centerline 18 about which the disk 12 may rotate. Each blade 14 includes a root 20, an airfoil 22, a platform 24, and a radial centerline 25. The root 20 includes a geometry (e.g., a fir tree configuration) that mates with that of one of the recesses 16 within the disk 12. As can be seen in FIGS. 2 - 5, the root 20 further includes conduits 26 through which cooling air may enter the root 20 and pass through into the airfoil 22.

[0012] Referring to FIGS. 1 - 5, the airfoil 22 includes a base 28, a tip 30, a leading edge 32, a trailing edge 34, a pressure side wall 36 (see FIG. 1), and a suction side wall 38 (see FIG. 1), and an internal passage configuration 40. FIGS. 2 - 5 diagrammatically illustrate an airfoil 22 sectioned between the leading edge 32 and the trailing edge 34. The pressure side wall 36 and the suction side wall 38 extend between the base 28 and the tip 30 and meet at the leading edge 32 and the trailing edge 34.

[0013] The internal passage configuration 40 includes a first conduit 42, a second conduit 44, and a third conduit 46 extending through the root 20 into the airfoil 22. The first conduit 42 is in fluid communication with one or more leading edge passages 48 ("LE passages") disposed adjacent the leading edge 32. The first conduit 42 provides the primary path into these LE passages 48 for cooling air, and therefore the leading edge 32 is primarily cooled by the cooling air that enters the airfoil 22 through the first conduit 42.

[0014] Referring to FIG. 2, in a first arrangement of the one or more LE passages 48, the first conduit 42 is in fluid communication with a single LE passage 50, and that passage 50 is contiguous with the leading edge 32. At the outer radial end of the LE passage 50 (i.e., the end of the LE passage 50 opposite the first conduit 42), the LE passage 50 is connected to an axially extending passage 52 ("AE passage") that extends between the LE passage 50 and the trailing edge 34 of the airfoil 22, adjacent the tip 30 of the airfoil 22. As can be seen from FIG. 2, the cross-sectional area within the transition between the passages 50,52 is approximately the same as or greater than the adjacent regions of the passages 50,52. Hence, there is no flow impediment within the tran-

sition that is attributable to a decrease in cross-sectional area. The LE passage 50 is connected to the exterior of the airfoil 22 by a plurality of cooling apertures 54 disposed along the leading edge 32.

[0015] Referring to FIG. 3, in a second arrangement of the one or more LE passages 48, the first conduit 42 is in fluid communication with a first LE passage 56 and a second LE passage 58. The first LE passage 56 is contiguous with the leading edge 32, and the second LE passage 58 is immediately aft and adjacent the first LE passage 56. The first LE passage 56 is connected to the exterior of the airfoil 22 by a plurality of cooling apertures 54 disposed along the leading edge 32. In some embodiments, the first LE passage 56 is also connected to the tip 30 or a tip pocket 60 by one or more apertures 62. At the outer radial end of the second LE passage 58 (i.e., the end of the second LE passage 58 opposite the first conduit 42), the second LE passage 58 is connected to an AE passage 52 that extends to the trailing edge 34 of the airfoil 22, adjacent the tip 30 of the airfoil 22. As can be seen from FIG. 3, the cross-sectional area within the transition between the passages 58,52 is approximately the same as or greater than the adjacent regions of the passages 58,52. Hence, there is no flow impediment within the transition that is attributable to a decrease in cross-sectional area.

[0016] Referring to FIG. 4, in a third arrangement of the one or more LE passages 48, the first conduit 42 is in fluid communication with a first LE passage 64 and a second LE passage 66. The first LE passage 64 is contiguous with the leading edge 32, and the second LE passage 66 is immediately aft and adjacent the first LE passage 64. The first LE passage 64 is connected to the exterior of the airfoil 22 by a plurality of cooling apertures 54 disposed along the leading edge 32. At the outer radial end of the first LE passage 64 (i.e., the end of the first LE passage 64 opposite the first conduit 42), the first LE passage 64 is connected to an AE passage 52 that extends to the trailing edge 34 of the airfoil 22, adjacent the tip 30 of the airfoil 22. As can be seen from FIG. 4, the cross-sectional area within the transition between the passages 64,52 is approximately the same as or greater than the adjacent regions of the passages 64,52. Hence, there is no flow impediment within the transition that is attributable to a decrease in cross-sectional area. The second LE passage 66 ends radially below the AE passage 52. One or more apertures 68 disposed in the rib between the AE passage 52 and the second LE passage 66 permits airflow therebetween.

[0017] Referring to FIG. 5, in a fourth arrangement of the one or more LE passages 48, the first conduit 42 is in fluid communication with a single LE passage 70. One or more cavities 72 are disposed forward of the LE passage 70, connected to the LE passage 70 by a plurality of crossover apertures 74. The one or more cavities 72 are contiguous with the leading edge 32. The one or more cavities 72 are connected to the exterior of the airfoil 22 by a plurality of cooling apertures 54 disposed along the

leading edge 32. In some embodiments, the cavity 72 (or the outer most radial cavity if more than one cavity) is also connected to the tip 30 or a tip pocket 60 by one or more apertures 76. At the outer radial end of the LE passage 70 (i.e., the end of the LE passage 70 opposite the first conduit 42), the LE passage 70 is connected to an

[0018] Referring to FIG. 6, in a preferred embodiment of an internal passage configuration like those shown in FIGS. 3 and 5, the internal passage configuration 40 includes a first radial passage 92 (e.g., first LE passage 56 - FIG. 3; cavity 72 - FIG. 5), a second radial passage 94 (e.g., second LE passage 58 - FIG. 3; LE passage 70 - FIG. 5), and a rib 96 disposed therebetween. The first radial passage 92, second radial passage 94, and rib 96 are contiguous with a tip endwall 98. A plurality of crossover apertures 74 are disposed in the rib 96, including a crossover aperture 100 that is disposed flush with the tip endwall 98. As stated above, in some applications an aperture 62,76 is disposed in the radial end of the first radial passage. This preferred embodiment of an internal passage configuration is not limited to the internal passage configurations shown in FIGS. 3 and 5.

[0019] Referring to FIGS. 2 - 5, the second conduit 44 is in fluid communication with a serpentine passage 78 disposed immediately aft of the LE passages, in the mid-body region of the airfoil 22. The second conduit 44 provides the primary path into the serpentine passage 78 for cooling air, and therefore the mid-body region is primarily cooled by the cooling air that enters the airfoil 22 through the second conduit 44. The serpentine passage 78 has an odd number of radial segments 80, which number is greater than one; e.g., 3, 5, etc. The odd number of radial segments 80 ensures that the last radial segment 82 in the serpentine 78 ends adjacent the AE passage 52. The "last radial segment" is defined as the last possible segment within the serpentine passage that can receive cooling air along the serpentine. The radial segments 80 are connected to one another by turns of approximately 180°; e.g., the first radial segment is connected to the second radial segment by a 180° turn, the second radial segment is connected to the third radial segment by a 180° turn, etc. The serpentine passage 78 shown in FIGS. 2 - 5 is oriented so that the path through the serpentine 78 directs the cooling air forward; i.e., toward the leading edge 32 of the airfoil 22. In alternative embodiments, the serpentine 78 can also be oriented so that cooling air is directed aft, toward the trailing edge 34 of the airfoil 22. In some embodiments, a cooling air sink 84, typically in the form of one or more cooling apertures, is disposed within the exterior wall (e.g., the suction side

wall) of the last segment 82, sized to permit cooling air-flow out of the airfoil 22. In a preferred embodiment, the one or more cooling apertures are film holes. One or more apertures 85 extend through the rib separating the last radial segment 82 and the AE passage, thereby permitting fluid communication therebetween.

[0020] The third conduit 46 is in fluid communication with one or more passages 86 disposed between the serpentine passage 78 and the trailing edge 34 of the airfoil 22. With the exception of portion of the trailing edge 34 adjacent the tip 30 of the airfoil 22, the third conduit 46 provides the primary path for cooling air into the trailing edge 34, and therefore the trailing edge 34 is primarily cooled by the cooling air that enters the airfoil 22 through the third conduit 46. As stated above, the portion of the trailing edge 34 adjacent the tip 30 of the airfoil 22 is cooled by cooling air passing through the AE passage 52.

[0021] The AE passage 52 includes a tapered segment 88 adjacent the trailing edge 34 that decrease in cross-sectional area. The rate of decrease in cross-sectional area is chosen to cause the cooling airflow exiting the AE passage 52 to choke. The specific rate of decrease in cross-sectional area is chosen to suit the application at hand.

[0022] In the arrangements shown in FIGS. 2 - 5, the transition between the LE passage(s) and the AE passage 52 is approximately a ninety degree (90°) turn that has been optimized to minimize pressure loss as cooling air travels between the LE passage(s) and the AE passage 52. For example, the LE passage 50,58,64,70 increases in width as it approaches the turn. As a result, the interior boundary 90 of the turn forms an angle that is greater than 90°. The obtuse angle facilitates the cooling airflow therethrough, and consequently causes a pressure loss which is less than would be in a similar channel having a 90° turn.

[0023] All of the foresaid passages may include one or more cooling apertures and/or cooling features (e.g., trip strips, pedestals, pin fins, etc.) to facilitate heat transfer within the particular passage. The exact type(s) of cooling aperture and/or cooling feature can vary depending on the application, and more than one type can be used. The present invention can be used with a variety of different cooling aperture and cooling feature types and is not, therefore, limited to any particular type.

[0024] Some embodiments further include a tip pocket 60 disposed radially outside of the AE passage 52. The tip pocket 60 is open to the exterior of the airfoil 22. One or more apertures extend through a wall portion of the airfoil 22 disposed between the tip pocket 60 and the LE passage and/or the AE passage 52.

[0025] The above-described rotor blade 14 can be manufactured using a casting process that utilizes a ceramic core to form the cooling passages within the airfoil 22. The ceramic core is advantageous in that it is possible to create very small details within the passages; e.g., cooling apertures, trip strips, etc. A person of skill in the art will recognize, however, that the brittleness of a ce-

ramic core makes it difficult to use. The above-described rotor blade internal passage configurations 40 facilitate the casting process by including features that increase the durability of the ceramic core. For example, the first and second LE passage embodiments permit the use of a rod extending from the tip pocket 60, through the AE passage 52, and into the serpentine passage 78. The rod supports: 1) the core portion that forms the tip pocket 60; 2) the core portion that forms the AE passage 52; and 3) the core portion that forms the serpentine passage 78. The rod is removed at the same time the ceramic core is removed, leaving apertures between the tip pocket 60 and the AE passage 52, and between the AE passage 52 and the serpentine passage 78. Core-ties can also be used between core portions.

[0026] Another feature of the present internal passage configurations that increases the durability of the ceramic core is the AE passage 52 adjacent the tip 30 of the airfoil 22. The extension of the passage 52 to the trailing edge 34 enables the passage 52 and the trailing edge 34 core portion to be tied together by a stringer that is disposed outside the exterior of the airfoil 22. The core portions representing internal cooling passages (e.g., one of more segments of the serpentine passage 78) may also be supported by the AE passage 52 via rods or core-ties.

[0027] In the operation of the invention, the airfoil 22 portion of the rotor blade 14 is disposed within the core gas path of the turbine engine. The airfoil 22 is subject to high temperature core gas passing by the airfoil 22. Cooling air, that is substantially lower in temperature than the core gas, is fed into the airfoil 22 through the conduits 42,44,46 disposed in the root 20.

[0028] Cooling air traveling through the first conduit 42 passes directly into the one or more LE passages 48 disposed adjacent the leading edge 32, and subsequently into the AE passage 52 adjacent the tip 30 of the airfoil 22. The relatively large and unobstructed LE passages 48 permit a volume rate of flow that provides a desirable amount of cooling to the leading edge 32, and yet still has sufficient heat transfer capacity to adequately cool other regions of the airfoil 22; e.g., the tip 30 and a portion of the serpentine passage 78. The first conduit 42 provides the primary path into these LE passages 48 for cooling air, although the exact path depends upon the particular LE passage 48 embodiment.

[0029] Cooling air traveling through the first conduit 42 into the first arrangement of the one or more LE passages 48 incurs relatively low pressure losses, and will enter the AE passage 52 at a relatively high pressure and velocity. Because the first embodiment of the one or more LE passages 48 is a single passage 50 contiguous with the leading edge 32, the cooling air is subject to heat transfer from the leading edge 32, the pressure side wall 36, and the suction side wall 38. In this embodiment, the AE passage 52 extends across the entire chord of the airfoil 22.

[0030] Cooling air traveling through the first conduit 42 into the second arrangement of the one or more LE pas-

sages 48 is divided between the first LE passage 56 and the second LE passage 58. The cooling air entering the first LE passage 56 travels contiguous with the leading edge 32, and is subject to heat transfer from the leading edge 32, the pressure side wall 36, and the suction side wall 38. The cooling air traveling within the first LE passage 56 exits via cooling apertures 54 disposed along the radial length of the leading edge 32, and through one or more cooling apertures 62 disposed between the radial end of the passage 56 and the tip 30 (or tip pocket 60). The apertures 62 disposed at the radial end prevent cooling airflow stagnation within the first LE passage 56. Cooling air traveling within the second LE passage 58 incurs relatively low pressure losses, and will enter the AE passage 52 at a relatively high pressure and velocity. Because the second LE passage 58 is aft of the first LE passage 56 (and therefore the leading edge 32), the cooling air traveling through the second LE passage 58 is subject to less heat transfer from the leading edge 32. As a result, the cooling air reaches the AE passage 52 typically at a lower temperature than it would be if it were in contact with the leading edge 32. In this embodiment, the AE passage 52 extends across nearly the entire chord of the airfoil 22.

[0031] Cooling air traveling through the first conduit 42 into the third arrangement of the one or more LE passages 48 is divided between the first LE passage 64 and the second LE passage 66. The cooling air entering the first LE passage 64 incurs relatively low pressure losses, and will enter the AE passage 52 at a relatively high pressure and velocity. The cooling air entering the second LE passage 66 will likewise flow substantially unobstructed until the radial end is reached. Cooling air can exit the second LE passage 66 through one or more cooling apertures 68 disposed in the rib separating the second LE passage 66 and the AE passage 52, or through cooling apertures disposed within the walls of the airfoil 22. The apertures 68 disposed at the radial end prevent cooling airflow stagnation within the second LE passage 66. In this embodiment, the AE passage 52 extends across the entire chord of the airfoil 22.

[0032] Cooling air traveling through the first conduit 42 into the fourth arrangement of the one or more LE passages 48 incurs relatively low pressure losses, and will enter the AE passage 52 at a relatively high pressure and velocity. A portion of the cooling air traveling within the LE passage 48 enters the cavity(ies) 72 disposed between the LE passage 70 and the leading edge 32. The cooling air traveling within the cavity 72 exits via cooling apertures 54 disposed along the radial length of the leading edge 32, and through one or more cooling apertures 76 disposed between the radial end of the cavity 72 and the tip 30 (or tip pocket 60). The apertures 76 disposed at the radial end prevent cooling airflow stagnation within the cavity 72. Because the LE passage 70 is aft of cavity(ies) 72 (and therefore the leading edge 32), the cooling air traveling through the LE passage 70 is subject to less heat transfer from the leading edge 32.

As a result, the cooling air reaches the AE passage 52 typically at a lower temperature than it would be if it were in contact with the leading edge 32.

[0033] In the preferred embodiment of the internal passage configuration shown in FIG. 6, a portion of the cooling air traveling within the second radial passage 94 (e.g., second LE passage 58 - FIG. 3; LE passage 70 - FIG. 5) exits the second radial passage 94 and enters the first radial passage 92 (e.g., first LE passage 56 - FIG. 3; cavity 72 - FIG. 5) via the crossover apertures 74 disposed in the rib 96. Cooling air traveling through the flush-mounted crossover aperture 100 passes along the surface of the tip endwall 98, providing desirable convective cooling. The cooling air entering the first radial passage 92 through the flush-mounted crossover aperture 100 helps to eliminate a stagnation/recirculation zone within the first radial passage 92 adjacent the tip endwall 98 (see flow 12a, FIG. 7) and within the second radial passage 94 adjacent the tip endwall 98 (see flow 16a, FIG. 7). In those applications wherein an aperture 62,76 is disposed in the radial end of the first radial passage 92, cooling air exiting via the aperture 62, 76 also facilitates the elimination of undesirable stagnation/recirculation zones within the first radial passage 92; and the aperture 62, 76 reduces the risk of plugging the region of the passage adjacent to the tip endwall 98 by providing foreign particles (e.g., dirt) a path through which to exit the airfoil. Additionally, these applications increase local heat transfer adjacent the leading edge portion 102 adjacent the tip 30 typically prone to distress (e.g., oxidation) in prior art.

[0034] In all of the above arrangements, a portion of the cooling air passing through the AE passage 52 typically exits the AE passage 52 via cooling apertures; e.g., the cooling apertures extending between the tip 30 and/or tip cavity and the AE passages 52. An advantage provided by the present internal passage configuration, and in particular by the AE passage 52 extending the length or nearly the length of the chord, is that manufacturability of the airfoil 22 is increased since cooling apertures can be drilled through the tip 30 without interference from ribs separating radial segments.

[0035] Cooling air traveling through the second conduit 44 enters the serpentine passage 78 at P_1 . The cooling air passes through each radial segment 80 and 180° turn. A portion of the cooling air that enters the passage 78, exits the passage 78 via cooling apertures disposed in the walls of the airfoil 22. The remainder of the cooling air that enters the serpentine passage 78 will enter the last radial segment 82 of the passage 78. With the present internal passage configurations, the cooling air that reaches the last radial segment 82 will typically be at a pressure P_3 that is lower than the pressure P_2 of the cooling air in the adjacent region of the AE passage 52 (e.g., because of head losses incurred within the serpentine passage 78), wherein $P_1 > P_2 > P_3$. In those instances, cooling air will enter the last radial segment 82 from the AE passage 52 via the one or more apertures 85

extending between the last radial segment 82 and the AE passage 52 ($P_2 > P_3$). To accommodate the inflow from the AE passage 52, a cooling air sink 84 (e.g., film holes) is disposed within the exterior wall of the last segment (e.g., the suction side wall 38), sized to permit cooling airflow out of the airfoil 22. The cooling air sink 84 prevents undesirable flow stagnation within the last radial segment 82 of the serpentine passage 78. The two opposing flows of cooling air within the serpentine passage 78 will come to rest at a location where the static pressure of each flow equals that of the other. Preferably, the cooling air sink 84 is positioned adjacent that rest location. The pressure P_1 of the cooling air entering the serpentine passage 78 prevents the AE passage 52 inflow from traveling completely through the serpentine passage 78 ($P_1 > P_2$).

[0036] Cooling air traveling through the third conduit 46 enters one or more passage(s) 86 disposed between the serpentine passage 78 and the trailing edge 34. All of the cooling air that enters these passages exits via cooling apertures disposed in the walls of the airfoil 22 or along the trailing edge 34.

[0037] Although this invention has been shown and described with respect to the detailed embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail thereof may be made without departing from the scope of the invention.

Claims

1. A rotor blade (14), comprising:

- a root (20);
- a hollow airfoil (22) having a cavity, a leading edge (32), and a tip (30);
- an internal passage configuration (40) disposed within the cavity, which configuration includes a first radial passage (56;72;92), a second radial passage (58;70;94), and a rib (96) disposed between the passages, wherein the passages and the rib are contiguous with a tip endwall (98), and the first radial passage is disposed contiguous with the leading edge, and a plurality of crossover apertures (74) are disposed in the rib, and
- a conduit (42) disposed within the root (20) that is operable to permit airflow through the root and into the passages:
- one of the crossover apertures (100) is disposed flush with the tip endwall (98); **characterised in that:**

at least one aperture (62;76) is disposed in the endwall (98), aligned with the first radial passage (56;72;92).

2. The rotor blade of claim 1, wherein the first radial

passage (56;72;92) is a cavity.

3. The rotor blade of claim 1 or 2, wherein the first radial passage (56;72;92) extends down and opens to the conduit (42).
4. The rotor blade of any preceding claim, further comprising a tip pocket (60) disposed in the tip (30) of the rotor blade (14).
5. The rotor blade of claim 4, wherein the aperture (62; 76) disposed in the endwall (98) aligned with the first radial passage (56;72;92) extends between the first radial passage and the tip pocket (60).

Patentansprüche

1. Rotorschaukel (14) umfassend:

eine Wurzel (20);
 ein hohles Strömungsprofil (22), das eine Aussparung, eine Vorderkante (32) und eine Spitze (30) aufweist,
 eine interne Wegausbildung (40), die innerhalb der Aussparung angeordnet ist, wobei die Ausbildung einen ersten radialen Weg (56; 72; 92), einen zweiten radialen Weg (58; 70; 94) und eine Rippe (96) beinhaltet, die zwischen den Wegen angeordnet ist, wobei die Wege und die Rippe mit einer Spitzenendwand (98) zusammenhängen sind, und der erste radiale Weg mit der Vorderkante zusammenhängend angeordnet ist, und eine Mehrzahl von Kreuzaussparungen (74) in der Rippe angeordnet sind, und eine innerhalb der Wurzel (20) angeordnete Leitung (42), die betreibbar ist, um Luftströmung durch die Wurzel und in die Wege zu erlauben, wobei eine der Kreuzaussparungen (100) eben mit der Spitzenendwand (98) angeordnet ist;

dadurch gekennzeichnet, dass

zumindest eine Aussparung (62; 76) in der Endwand (98) fluchtend mit dem ersten radialen Weg (56; 72; 92) angeordnet ist.

2. Rotorschaukel nach Anspruch 1, wobei der erste radiale Weg (56; 72; 92) eine Aussparung ist.
3. Rotorschaukel nach Anspruch 1 oder 2, wobei sich der erste radiale Weg (56; 72; 92) nach unten erstreckt und sich hin zu der Leitung (42) öffnet.
4. Rotorschaukel nach einem der vorangehenden Ansprüche, des Weiteren umfassend eine Spitzentasche (60), die in der Spitze (30) der Rotorschaukel (14) angeordnet ist.

5. Rotorschaukel nach Anspruch 4, wobei sich die Aussparung (62; 76), die in der Endwand (98) fluchtend mit dem ersten radialen Weg (56; 72; 92) angeordnet ist, zwischen dem ersten radialen Weg und der Spitzentasche (60) erstreckt.

Revendications

1. Aube de rotor (14), comprenant :

une base (20) ;
 une pale creuse (22) ayant une cavité, un bord d'attaque (32), et une pointe (30) ;
 une configuration de passage interne (40) disposée dans la cavité, laquelle configuration comporte un premier passage radial (56 ; 72 ; 92), un deuxième passage radial (58 ; 70 ; 94), et une nervure (96) disposée entre les passages, les passages et la nervure étant contigus avec une paroi d'extrémité de pointe (98), et le premier passage radial étant disposé de manière contiguë avec le bord d'attaque, et une pluralité d'ouvertures de transfert (74) étant disposées dans la nervure, et un conduit (42) disposé dans la base (20), qui peut être utilisé pour permettre un flux d'air à travers la base et dans les passages,
 l'une des ouvertures de transfert (100) étant disposée en alignement avec la paroi d'extrémité de pointe (98) ;

caractérisée en ce que :

- au moins une ouverture (62 ; 76) est disposée dans la paroi d'extrémité (98), en alignement avec le premier passage radial (56 ; 72 ; 92).
2. Aube de rotor selon la revendication 1, dans laquelle le premier passage radial (56 ; 72 ; 92) est une cavité.
3. Aube de rotor selon la revendication 1 ou 2, dans laquelle le premier passage radial (56 ; 72 ; 92) s'étend vers le bas et s'ouvre sur le conduit (42).
4. Aube de rotor selon l'une quelconque des revendications précédentes, comprenant en outre une poche de pointe (60) disposée dans la pointe (30) de l'aube de rotor (14).
5. Aube de rotor selon la revendication 4, dans laquelle l'ouverture (62 ; 76) disposée dans la paroi d'extrémité (98) alignée avec le premier passage radial (56 ; 72 ; 92) s'étend entre le premier passage radial et la poche de pointe (60).

FIG. 1

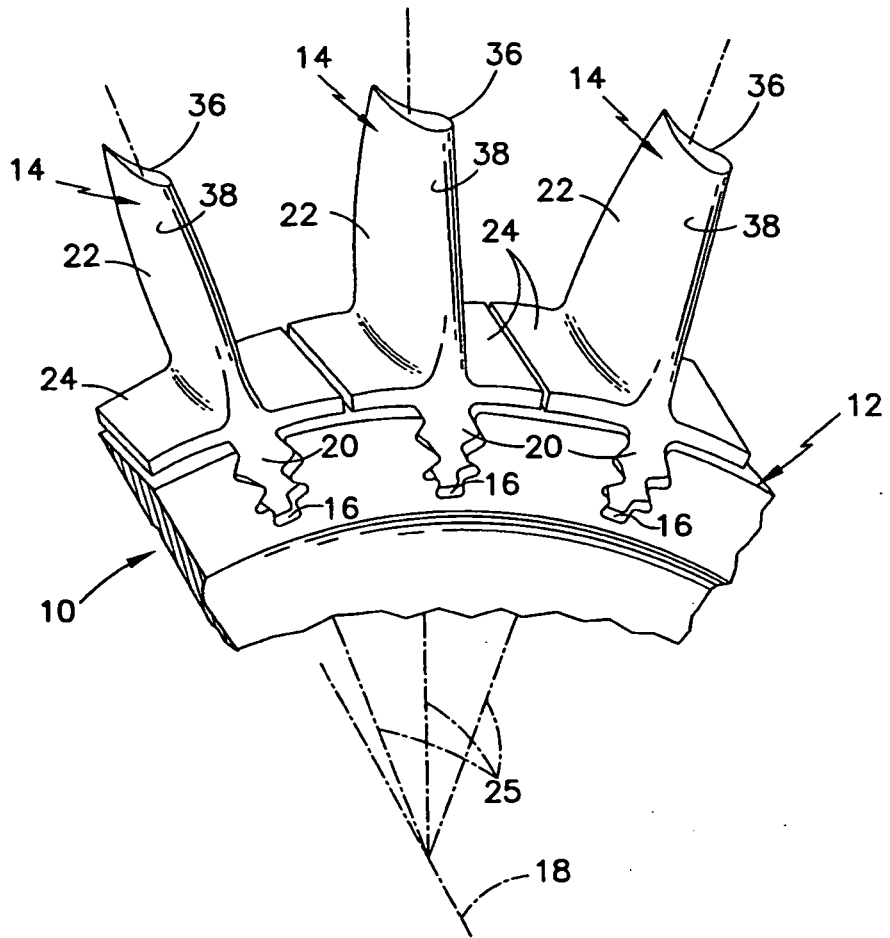


FIG.2

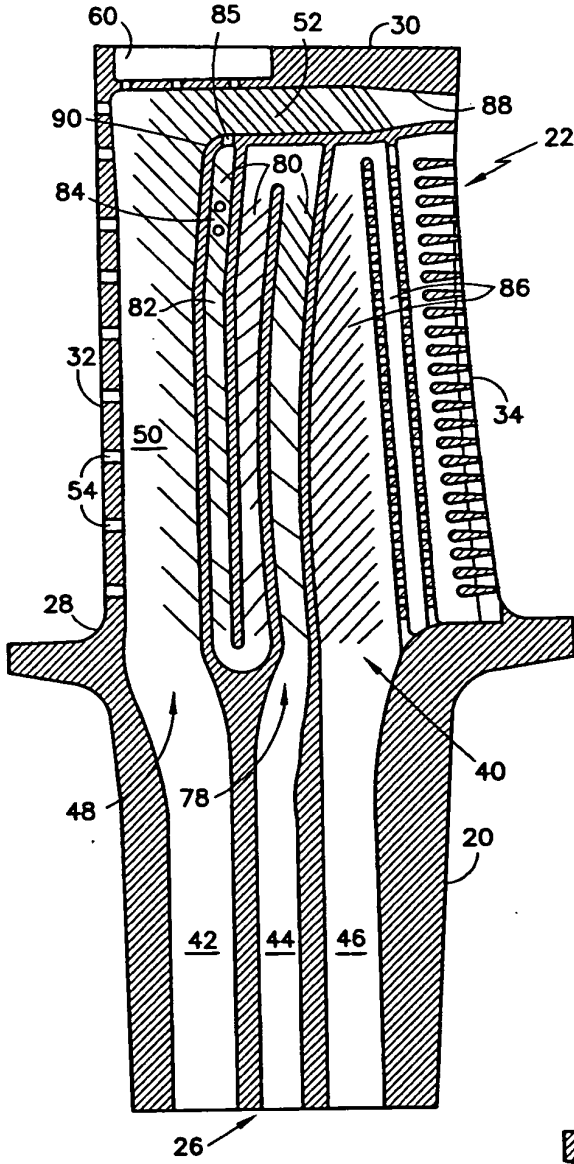


FIG.3

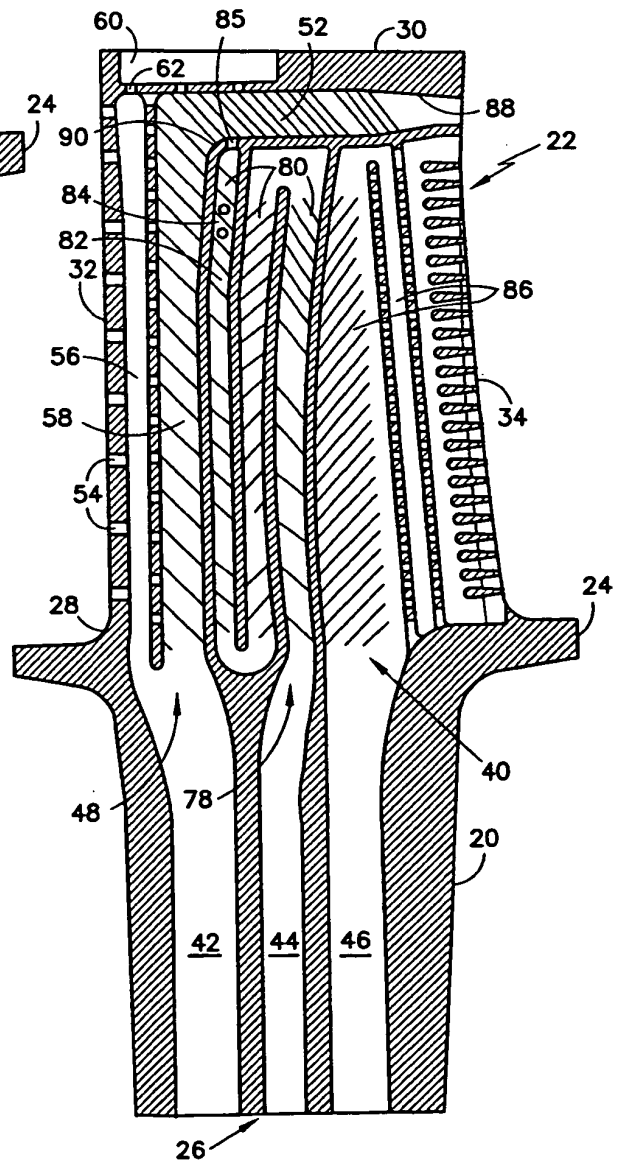


FIG.4

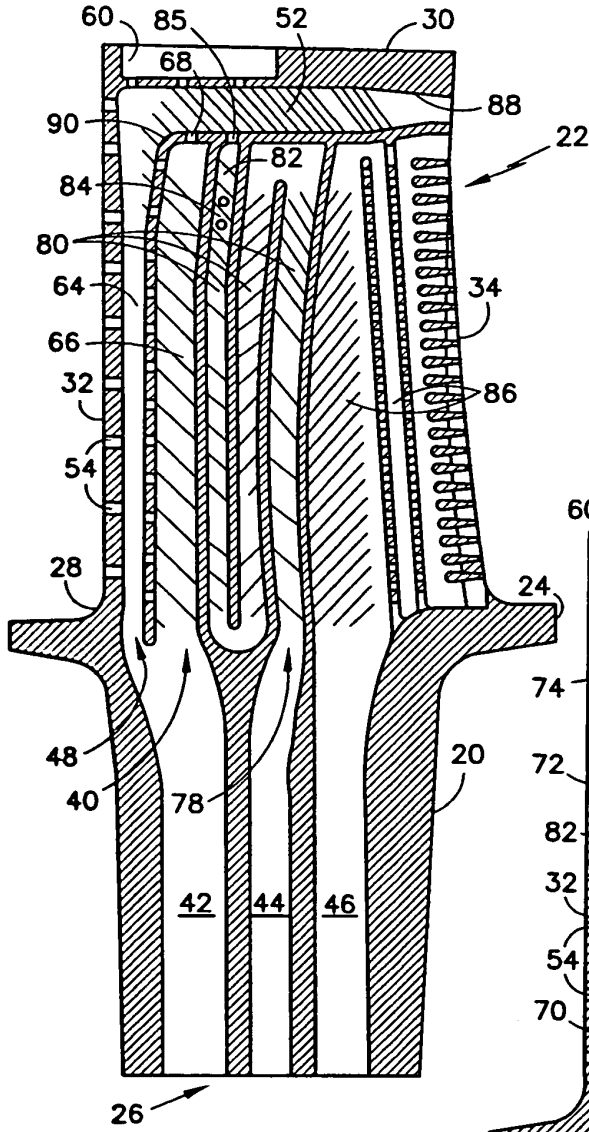


FIG.5

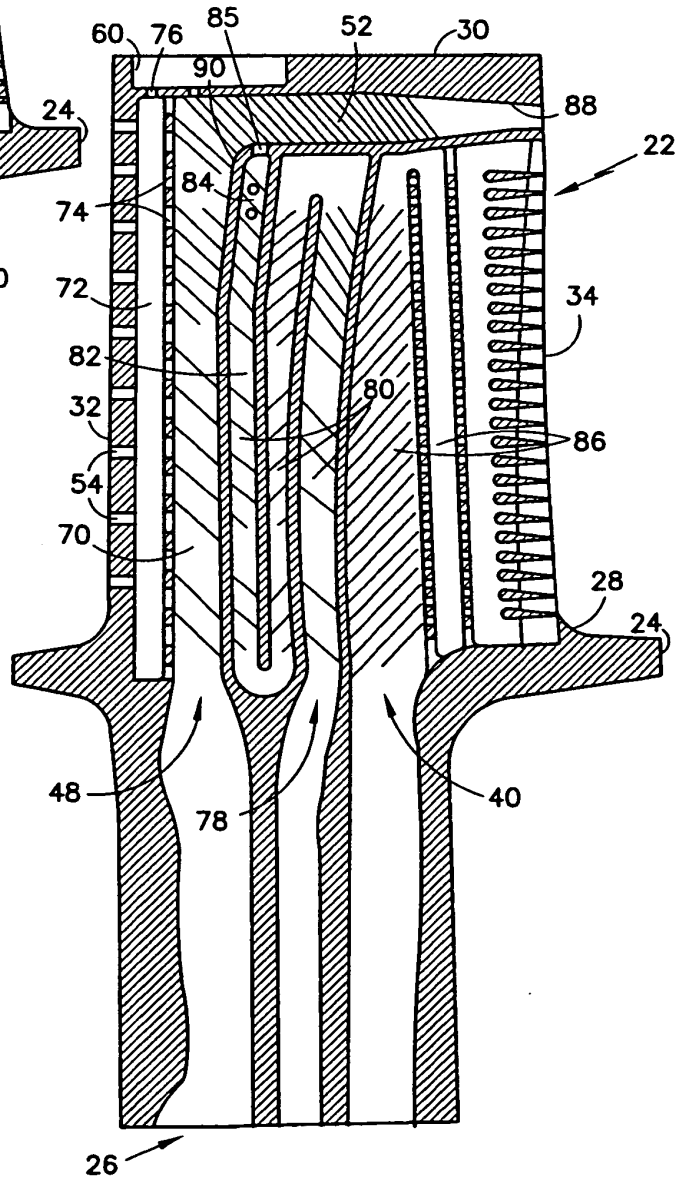


FIG.6

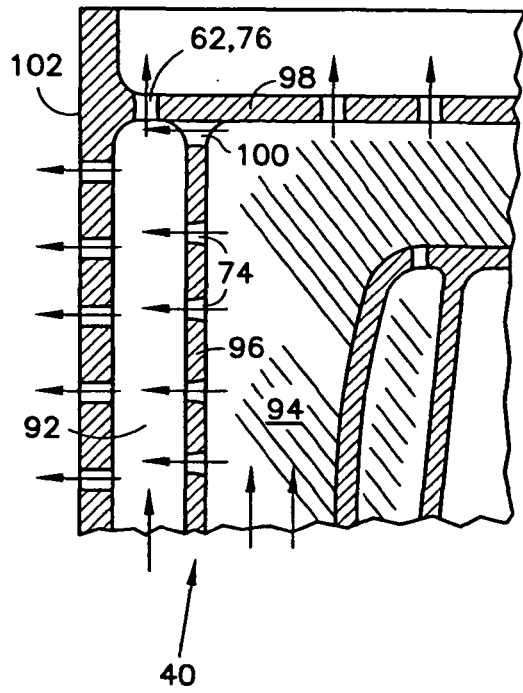
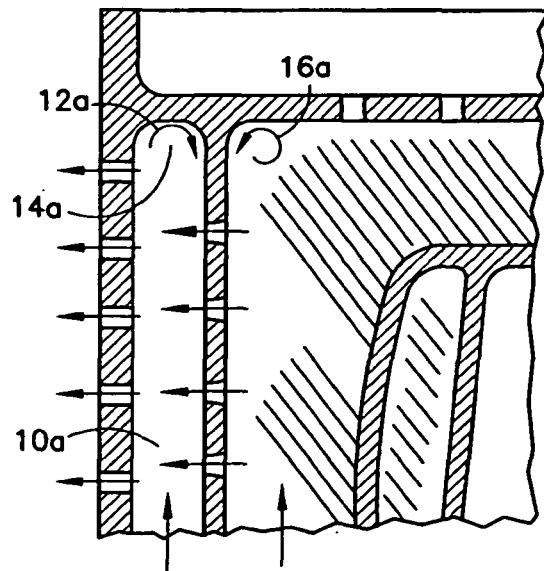


FIG.7
Prior Art



REFERENCES CITED IN THE DESCRIPTION

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