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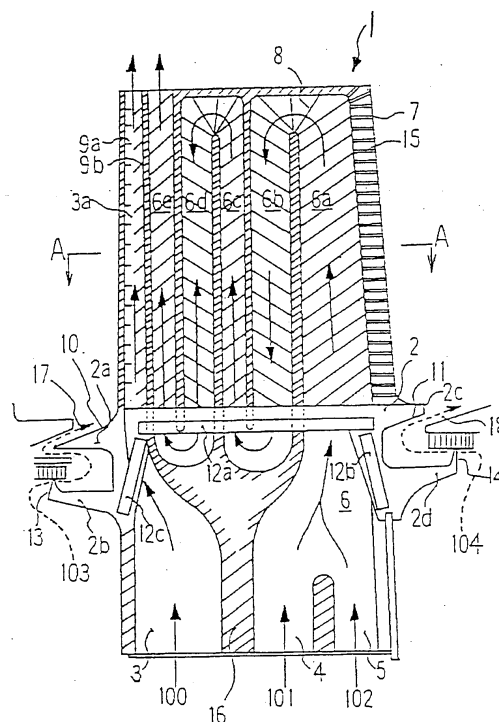
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(54) **Gas turbine cooled moving blade**

(57) Gas turbine cooled moving blade is improved to have enhanced cooling efficiency by cooling air and enhanced sealing performance by sealing air. Cooling air 100, 101, 102 enters moving blade 1 from cooling passages 3, 4, 5. The air 100 becomes turbulent by turbulators 9a, 9b to enhance cooling effect for cooling of blade leading edge portion and flows out of blade tip portion. The air 101, 102 enters from blade trailing edge side to flow through serpentine passage having portions 6a, 6b, 6c, 6d, 6e and to become turbulent by turbulators 8 for cooling of the blade and flows out of the blade tip portion. Cooling efficiency is enhanced by the cooling air led into the blade leading edge side and trailing edge side. Sealing air 103, 104 passes through portions formed by knife edges 13, 14 to flow in serpentine form to then flow out into combustion gas flow obliquely upwardly. Sealing performance is enhanced and end portion 2a of platform 2 and inner shroud end portion of rear stage stationary blade are cooled as well by the cooling air which flows out.

Fig. 1



Description

BACKGROUND OF THE INVENTION:

Field of the Invention:

[0001] The present invention relates generally to a cooled moving blade of gas turbine and more particularly to a cooled moving blade made in a structure to improve flow of cooling air to enhance cooling efficiency as well as to improve flow of sealing air to enhance sealing performance and cooling performance.

Description of the Prior Art:

[0002] Fig. 3 is a cross sectional view of a representative first stage moving blade of gas turbine in the prior art. In Fig. 3, numeral 20 designates a moving blade, numeral 21 designates a blade root portion and numeral 22 designates a platform. In the blade root portion 21, there are provided cooling passages 23, 24, 25, 26 independently of each other. The cooling passage 23 is a passage provided on a leading edge side of the blade to communicate with a cooling passage 23a provided in the blade, and while cooling air 40 entering the cooling passage 23 from rotor side flows through the cooling passage 23a, it cools a leading edge portion of the blade and at the same time flows out of cooling holes 29 to effect a shower head film cooling on and around the leading edge portion. Cooling air 41 entering the cooling passage 24 passes through a cooling passage 24a in the blade to turn at a tip portion of the blade to flow through a cooling passage 24b and then turns again at a base portion of the blade to flow through a cooling passage 24c and flows out of the blade tip portion. At this time, the cooling air 41 flows out of a blade surface through cooling holes to effect a film cooling of the blade surface, as described later with respect to Fig. 4.

[0003] Cooling air 42 entering the cooling passage 25 and that 43 entering the cooling passage 26 join together to flow through a cooling passage 25a and turn at the blade tip portion to flow through a cooling passage 25b and then turn again at the blade base portion to flow into a cooling passage 25c. While the cooling air 42, 43 so flows through the cooling passage 25c, a part thereof flows out of the blade surface through cooling holes to effect a film cooling, as described later in Fig. 4, and remainder thereof flows out of a trailing edge 27 of the blade through between cooling fins 28 to effect a pin fin cooling.

[0004] Fig. 4 is a cross sectional view taken on line B-B of Fig. 3. As shown there, a portion of the cooling air 40 in the cooling passage 23a on the blade leading edge side flows out of the blade through cooling holes 29 to effect a shower head film cooling for cooling of the blade leading edge portion. Also, a portion of the cooling air 41 flowing through the cooling passage 24c flows out obliquely through cooling holes 30 to effect a film cooling

of the blade surface. Likewise, a portion of the cooling air 42, 43 flowing through the cooling passage 25c flows out of the blade surface obliquely through cooling holes 31 to effect a film cooling of the blade trailing edge portion. It is to be noted that although the cooling holes 29, 30, 31 only are illustrated in the figure, there are provided actually a multiplicity of cooling holes in the blade other than those mentioned here.

[0005] Fig. 5 is an explanatory view showing flow of sealing air in a gas turbine in the prior art. In Fig. 5, a stationary blade 50 is arranged in a rear stage of the moving blade 20. Numeral 51 designates an inner shroud and numeral 52 designates an outer shroud. Numeral 53 designates a cavity, which is formed on an inner side of an end portion of the inner shroud 51 and numeral 54 designates a seal holding ring, which holds a labyrinth seal 58. The labyrinth seal 58 together with a rotor disc 80 forms a seal portion. Numeral 55 designates a hole, which is bored in the seal holding ring 54 and through which sealing air flows out, as described later. Numeral 56 designates a space, which is formed by and between the mutually adjacent moving blade 20 and stationary blade 50, numeral 57 designates a honeycomb seal, which is provided at a front end portion of the inner shroud 51 of the stationary blade 50 and numeral 59 designates a space, which is formed by and between the stationary blade 50 and a rear stage moving blade adjacent thereto.

[0006] In the seal structure mentioned above, sealing air 70 entering a sealing air tube 71 provided in the stationary blade 50 flows into the cavity 53 formed on the inner side of the inner shroud 51 to elevate pressure therein higher than that in a combustion gas path outside thereof and flows out through the hole 55 of the seal holding ring 54 to flow into the space 56 and then passes through a gap of a seal portion formed by a rear end portion 22b of the platform 22 of the moving blade 20 and the honeycomb seal 57 of the front end portion 57a of the inner shroud 51 of the stationary blade 50 to flow out into the combustion gas path as sealing air 70a. On the other hand, a portion of the sealing air which has flown out of the hole 55 of the seal holding ring 54 passes through a gap of a seal portion formed by the labyrinth seal 58 and the rotor disc 80 to flow into the space 59 and then passes through a seal portion formed by a rear end portion 57b of the inner shroud 51 and a platform front end portion of the rear stage moving blade to flow out into the combustion gas path as sealing air 70b, like in the case of the front stage.

[0007] The same seal structure is applied between the moving blade 20 and a front stage stationary blade thereof, that is, sealing air passes through a seal portion formed by a front end portion 22a of the platform 22 of the moving blade 20 and an inner shroud rear end portion of the front stage stationary blade and flows out into the combustion gas path as sealing air 70c. Using such seal structures as mentioned above, the spaces on the inner side of the inner shroud 51 of the stationary blade

50 and the platform 22 of the moving blade 20 are held in a higher pressure than in the combustion gas path so that a high temperature combustion gas may be prevented from flowing into these spaces on the inner side.

[0008] As mentioned above, in the first stage moving blade of gas turbine, cooling air is led into the blade for cooling thereof and while the cooling air flows through cooling passages in the blade, it flows out of the blade surface through cooling holes to effect a shower head film cooling of the blade leading edge portion and a film cooling of the blade ventral and dorsal side portions. In the recent gas turbines wherein combustion gas temperature is being elevated higher, combustor outlet temperature of approximately 1150°C has been realized and moreover a plant comprising that of as high as 1300°C or more is being developed. As the first stage moving blade is a portion that is highly exposed to the high temperature combustion gas, cooling of the blade needs to be done most efficiently and further improvement of the cooling structure is desired.

[0009] Also, as to the sealing by air accompanying with the higher temperature of the combustion gas, it is desired for further enhancement of the sealing performance that a sufficient sealing pressure is ensured so that the combustion gas may not come into the inner side of the platform and of the inner shroud as well as a more efficient use of the sealing air is attained.

SUMMARY OF THE INVENTION:

[0010] It is an object of the present invention, therefore, to provide a gas turbine cooled moving blade, especially a first stage moving blade, which comprises improved cooling air passages in which cooling air flows efficiently as well as comprises a seal structure in which sealing air flows also efficiently, so that both of the cooling performance and the sealing performance may be enhanced.

[0011] In order to achieve said object, the present invention provides the following means of (1) and (2).

(1) A gas turbine cooled moving blade comprising a cooling air passage provided in the moving blade for leading therethrough cooling air supplied from below a platform for cooling of the moving blade and a seal portion formed between an inner shroud end each of a front stage stationary blade and a rear stage stationary blade both adjacent to the moving blade and each end of said platform and constructed such that sealing air having passed through said seal portion flows out into a combustion gas path, characterized in that said cooling air passage comprises a first passage constructed such that the cooling air flows on a leading edge side of the moving blade to flow out of a tip portion of the moving blade and a second passage constructed such that a portion of the cooling air supplied to a trailing edge side of the moving blade flows out of a multiplicity

of slots provided in a trailing edge of the moving blade and a remainder thereof flows in a serpentine form toward the leading edge side to flow out of the tip portion of the moving blade.

(2) A gas turbine cooled moving blade as mentioned in (1) above, characterized in that said seal portion comprises a seal structure formed by a knife edge provided on each said end of the platform and said inner shroud end each of the front stage stationary blade and the rear stage stationary blade and the sealing air having passed through said seal portion flows in a serpentine form to flow out into the combustion gas path obliquely upwardly so as to go along a flow direction of combustion gas therein.

[0012] In the invention of (1) above, the cooling air passing through the first passage cools the blade leading edge portion which is exposed to the combustion gas of the highest temperature to be under the severe thermal influence and then flows out of the blade tip portion as it is, thereby the blade leading edge portion can be cooled effectively by the cold cooling air. In the second passage of the cooling air, the blade trailing edge portion is cooled first by the cold air, thereby the blade hub portion which receives the thermal influence to deteriorate the fatigue strength is cooled effectively so as to prevent deterioration of the fatigue strength. Then, the cooling air partially flows out of the slotted portion provided in the blade trailing edge for cooling therearound and the remaining portion flows through the passage formed in the serpentine shape toward the blade leading edge side for cooling of the blade main portions and flows out of the blade tip portion. By the structure so constructed, the blade leading edge portion is cooled effectively by the first passage of the cooling air and the blade trailing edge portion and main portions are cooled effectively by the second passage, respectively, and the cooling efficiency can be enhanced.

[0013] In the invention of (2) above, in addition to that of (1) above, the seal portion is constructed by the knife edge provided on each end of the platform and the inner shroud end each of the front stage and rear stage stationary blades adjacent to the moving blade and the sealing air carries out a sealing with the effect of the knife edge, thereby the sealing pressure which is elevated enough can be obtained at this portion. Further, the sealing air after having passed through the seal portion flows in the serpentine form with less quantity of air leakage and with increased resistance of the flow passage by the serpentine shape, thereby the sealing performance can be enhanced. Also, the sealing air flows out into the combustion gas path obliquely upwardly so as to go along the flow direction of combustion gas therein, thereby the sealing air flows out to strike the end portion of the platform of the moving blade and the inner shroud end of the stationary blade and the effect to cool these portions can be obtained as well.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0014] Fig. 1 is a cross sectional view of a gas turbine cooled moving blade of an embodiment according to the present invention.

[0015] Fig. 2 is a cross sectional view taken on line A-A of Fig. 1.

[0016] Fig. 3 is a cross sectional view of a gas turbine cooled moving blade in the prior art.

[0017] Fig. 4 is a cross sectional view taken on line B-B of Fig. 3.

[0018] Fig. 5 is an explanatory view showing flow of sealing air in a gas turbine in the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

[0019] Herebelow, embodiments according to the present invention will be described concretely with reference to figures. Fig. 1 is a cross sectional view of a gas turbine cooled moving blade, especially as an example of a first stage moving blade, of an embodiment according to the present invention and Fig. 2 is a cross sectional view taken on line A-A of Fig. 1.

[0020] In both of Figs. 1 and 2, numeral 1 designates a moving blade and numeral 2 designates a platform thereof. Numerals 3, 4, 5 designate cooling passages, respectively, which are provided in a blade root portion 16 and into which cooling air supplied from rotor side is led. The cooling passage 3 communicates with a cooling passage 3a provided in the blade and the cooling passages 4, 5 join together in the blade root portion 16 to form a cooling passage 6. That is, as compared with the cooling passages 23 to 26 in the prior art shown in Fig. 3, the cooling passages 3 to 5 shown in Fig. 1 are made in a less number of pieces and also the flow passage of the cooling passages 4, 5 is throttled by a rib so as to adjust flow rate of air entering there.

[0021] The cooling passage 6 is provided on a trailing edge side of the blade to communicate sequentially with cooling passages 6a, 6b, 6c, 6d, 6e provided in the blade so as to form a serpentine cooling passage. Numeral 7 designates a trailing edge of the blade and a multiplicity of slots 15 are provided there substantially along a turbine axial direction. Numeral 8 designates a multiplicity of oblique turbulators provided on inner walls of the cooling passages 6a to 6e. Numerals 9a, 9b designate a multiplicity of turbulators provided on an inner wall of the cooling passage 3a on a leading edge side of the blade.

[0022] Numeral 10 designates an upper surface sloping portion of a front end portion 2a of the platform 2, which slopes upward so as to go along a gas flow direction in a gas path and forms a passage 17 between itself and an inner shroud rear end portion of a front stage stationary blade adjacent thereto. Numeral 11 designates a lower surface sloping portion of a rear end portion 2c of the platform 2, which slopes upward so as to

go along the gas flow direction in the gas path and forms a passage 18 between itself and an inner shroud front end portion of a rear stage stationary blade adjacent thereto. Numerals 12a, 12b, 12c designate seal pins, respectively, which are provided for sealing a portion between the platform 2 of the moving blade 1 and a platform of a moving blade provided adjacently to the moving blade 1 in a turbine circumferential direction.

[0023] Numerals 13, 14 designate knife edges, respectively. The knife edge 13 is provided on a front end lower portion 2b of the platform 2 adjacently to a seal portion of the front stage stationary blade so as to seal an inner side of that seal portion. The knife edge 14 is likewise provided on a rear end lower portion 2d of the platform 2 adjacently to a seal portion of the rear stage stationary blade so as to seal an inner side of that seal portion. Numerals 100, 101, 102 designate cooling air, respectively, which is supplied from the rotor side to enter the cooling passages 3, 4, 5, respectively. The moving blade 1 is applied to its surface by a TBC (thermal barrier coating), such as a ceramics coating, so as to stand a thermal influence of a high temperature combustion gas in the gas path.

[0024] In the cooled moving blade constructed as mentioned above, the cooling air 100 entering the cooling passage 3 flows into the cooling passage 3a linearly and, while becoming turbulent by the turbulators 9a, 9b so as to enhance a heat transfer rate, cools a leading edge portion of the blade, which is exposed to a high temperature to be in the thermally severest state, and then flows out of a tip portion of the blade to flow into the combustion gas path.

[0025] The cooling air 101, 102 entering the cooling passages 4, 5, respectively, join together in the cooling passage 6 to flow toward the blade tip portion through the cooling passage 6a, and, while becoming turbulent by the turbulators 8 so as to enhance the heat transfer rate, cools a trailing edge portion of the blade. At the same time, a portion of the cooling air flowing through the cooling passage 6a flows out of the multiplicity of slots 15 provided in the trailing edge 7 substantially in the turbine axial direction for cooling therearound.

[0026] Remaining portion of the cooling air flowing through the cooling passage 6a turns at the blade tip portion to enter the cooling passage 6b to flow toward the platform 2 for cooling that portion of the blade and then turns below the platform 2 to enter the cooling passage 6c to flow therethrough and further through the cooling passages 6d and 6e, turning at the blade tip portion and below the platform 2, respectively, and flows outside of the blade tip portion. While the cooling air 101, 102 so flows through the serpentine cooling passage comprising the cooling passages 6a, 6b, 6c, 6d, 6e, it becomes turbulent by the turbulators 8 provided obliquely for enhancement of the cooling effect and cools main portions of the blade and then flows out of the blade tip portion.

[0027] As mentioned above, as the cooling air 101,

102 is led into the trailing edge side of the moving blade 1 so that a cold air may flow into a hub portion of the blade trailing edge portion or especially so that a fatigue strength against heat of the trailing edge hub portion may be enhanced and further as the cold air enters the cooling passage 6a first, slotted portion of the blade trailing edge 7 is cooled efficiently, the oblique turbulators 8 in the cooling passage 6a can be made less in the number of pieces than in other cooling passages and the cooling passage 6a itself can be made larger than other cooling passages. Also, in the moving blade 1 having the cooling system so constructed, the cooling holes 29, 30, 31 (Fig. 4) in the prior art become unnecessary and the shower head film cooling there becomes also unnecessary.

[0028] Sealing air 103 on a front end side of the platform 2, which is supplied through the adjacent front stage stationary blade as described with respect to Fig. 5, flows through between the knife edge 13 and the seal portion of the front stage stationary blade to flow in a serpentine form and then to flow out obliquely upwardly through the passage 17 formed by the upper surface sloping portion 10, hence by the flow of the serpentine form, sealing performance is enhanced resulting in reducing leaking loss of air. Also, as the sealing air having so flown out flows obliquely upwardly along the direction of the combustion gas flow, it strikes the front end portion 2a of the platform 2 with the effect to cool that portion as well.

[0029] Further, sealing air 104 on a rear end side of the platform 2, which is likewise supplied through the adjacent rear stage stationary blade, flows through between the knife edge 14 and the seal portion of the rear stage stationary blade to flow in the serpentine form and then to flow out through the passage 18 obliquely upwardly along the direction of the combustion gas flow, thus sealing performance there is likewise enhanced and by the sealing air so flowing outside, there is obtained the effect to cool the inner shroud front end portion of the adjacent rear stage stationary blade.

[0030] According to the present embodiment described as above, the cooling air 100 flows linearly through the cooling passage 3a on the blade leading edge side, becoming turbulent by the turbulators 9a, 9b, to cool the blade leading edge portion only. The cooling air 101, 102 enters on the blade trailing edge side to flow through the serpentine cooling passage comprising the cooling passages 6a, 6b, 6c, 6d, 6e, becoming turbulent by the turbulators 8 provided obliquely therein, to cool those portions of the blade, hence the entire blade can be cooled with the enhanced cooling effect.

[0031] Moreover, the sealing air 103, 104 flows through the serpentine routes formed by the knife edges 13, 14 and the upper surface and lower surface sloping portions 10, 11 to flow out obliquely upwardly through the passages 17, 18, thereby the sealing performance is enhanced and also the front end portion 2a of the platform 2 of the moving blade 1 and the inner shroud front

end portion of the adjacent rear stage stationary blade can be cooled as well.

[0032] It is understood that the invention is not limited to the particular construction and arrangement herein illustrated and described but embraces such modified forms thereof as come within the scope of the appended claims.

10 Claims

1. A gas turbine cooled moving blade comprising a cooling air passage provided in the moving blade for leading therethrough cooling air supplied from below a platform for cooling of the moving blade and a seal portion formed between an inner shroud end each of a front stage stationary blade and a rear stage stationary blade both adjacent to the moving blade and each end of said platform and constructed such that sealing air having passed through said seal portion flows out into a combustion gas path, characterized in that said cooling air passage comprises a first passage (3, 3a) constructed such that the cooling air (100) flows on a leading edge side of the moving blade (1) to flow out of a tip portion of the moving blade (1) and a second passage (6, 6a, 6b, 6c, 6d, 6e) constructed such that a portion of the cooling air (101, 102) supplied to a trailing edge (7) side of the moving blade (1) flows out of a multiplicity of slots (15) provided in a trailing edge (7) of the moving blade (1) and a remainder thereof flows in a serpentine form toward the leading edge side to flow out of the tip portion of the moving blade (1).
2. A gas turbine cooled moving blade as claimed in Claim 1, characterized in that said seal portion comprises a seal structure formed by a knife edge (13, 14) provided on each said end (2b, 2d) of the platform (2) and said inner shroud end each of the front stage stationary blade and the rear stage stationary blade and the sealing air (103, 104) having passed through said seal portion flows in a serpentine form to flow out into the combustion gas path obliquely upwardly so as to go along a flow direction of combustion gas therein.

Fig. 1

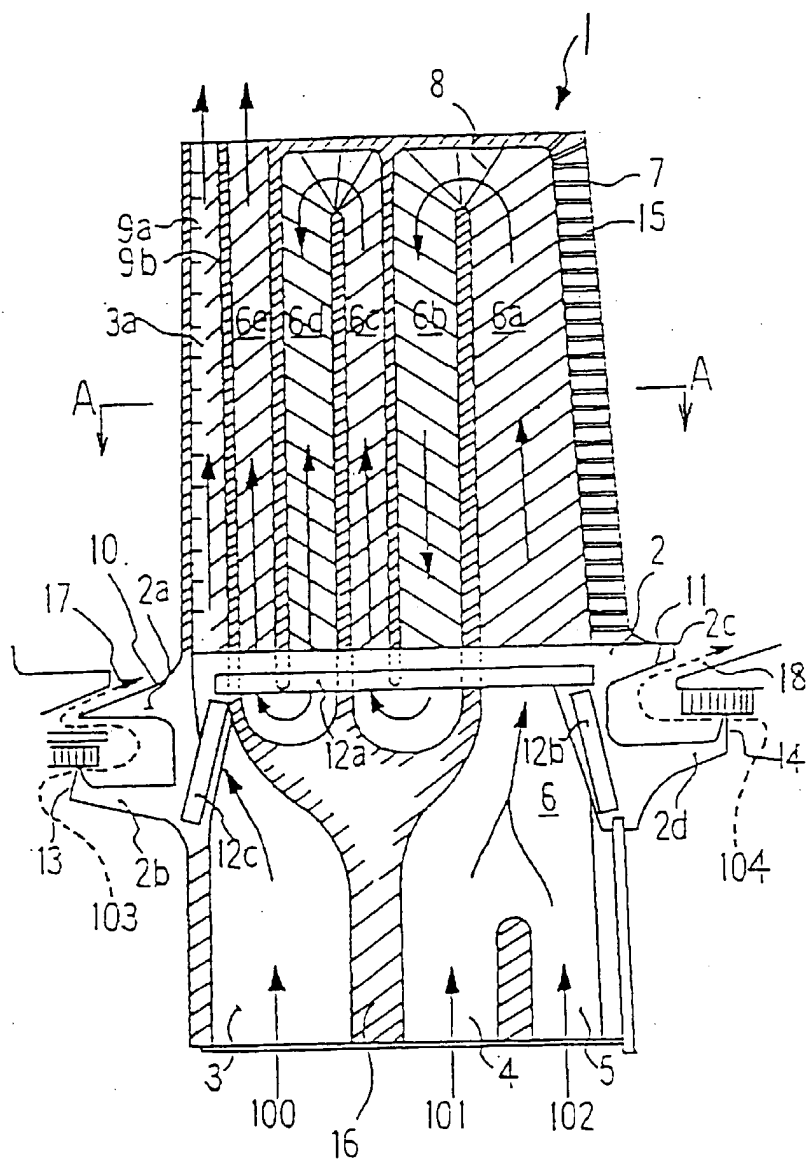


Fig. 2

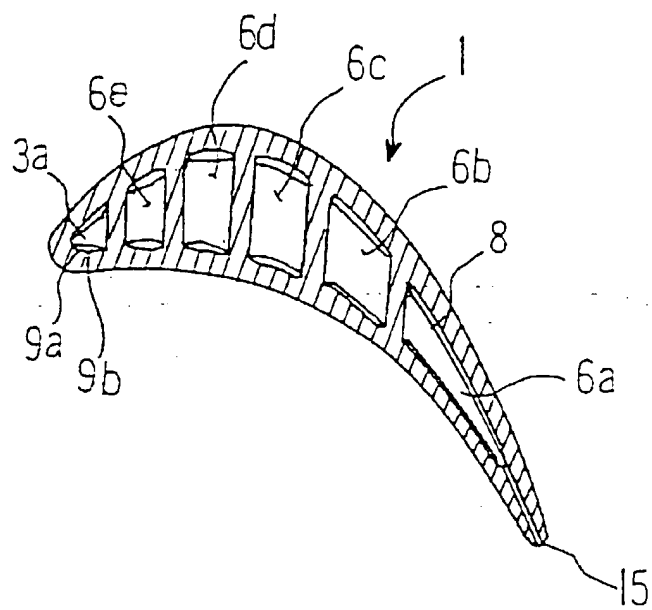


Fig. 3

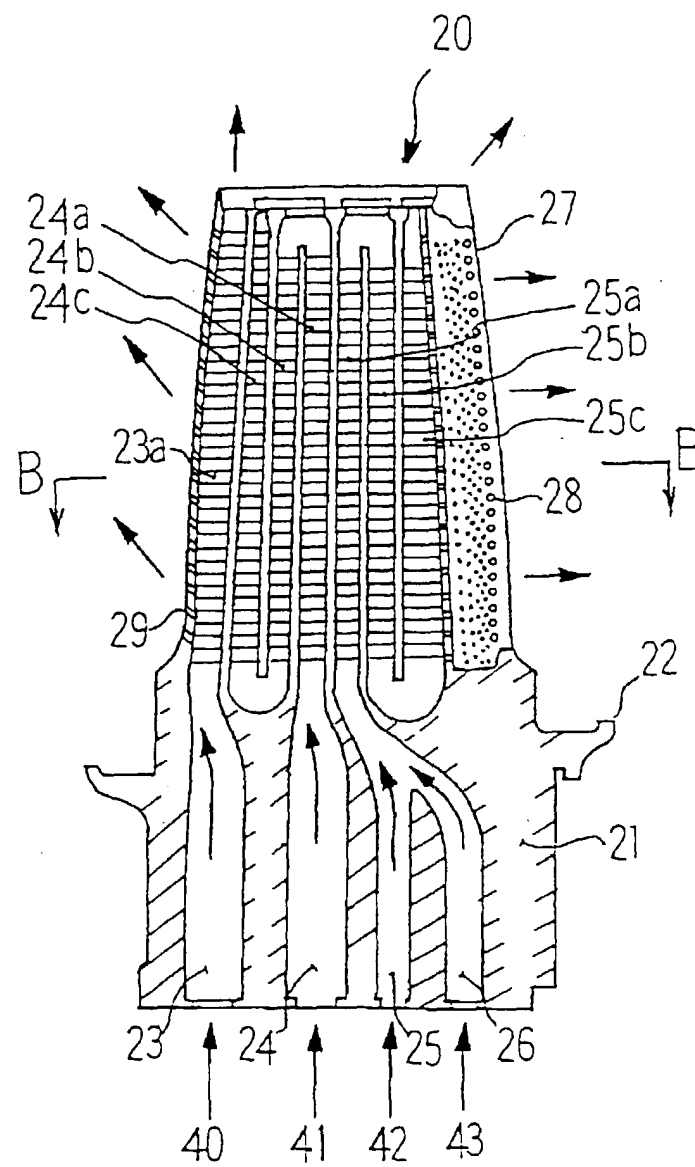


Fig. 4

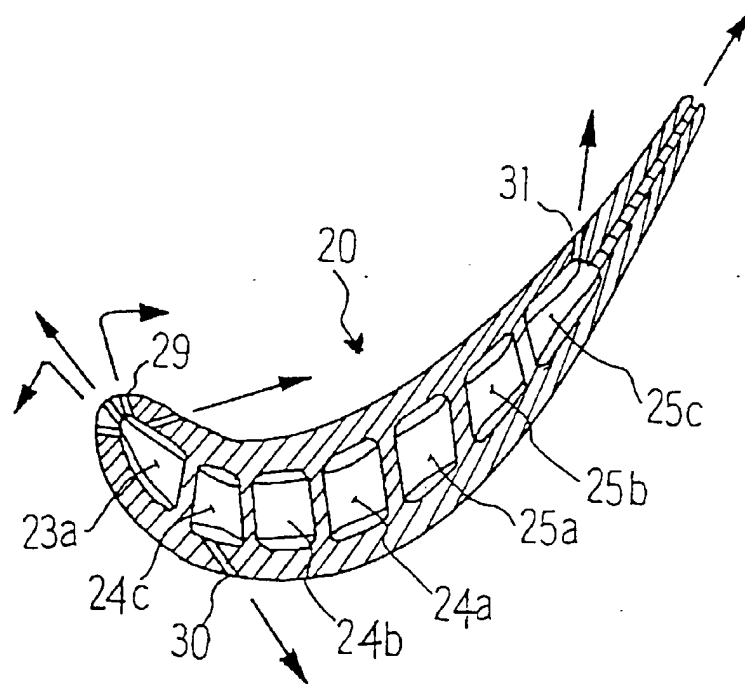
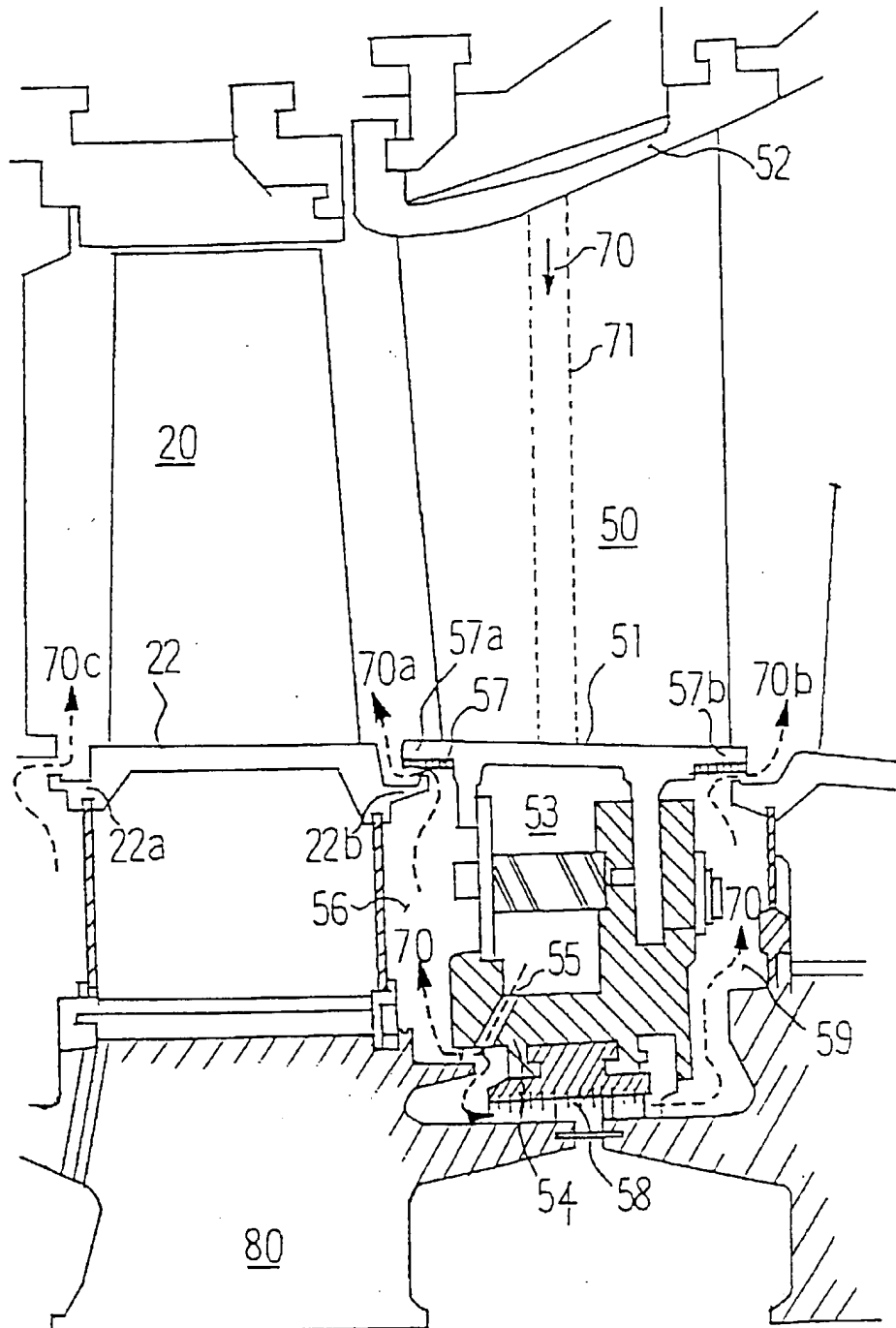


Fig. 5





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 12 0722

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Place of search THE HAGUE		Date of completion of the search 16 March 2000	Examiner Raspo, F
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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