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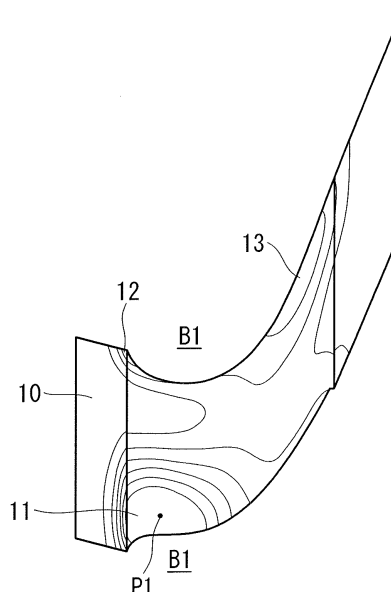
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(54) **TURBINE BLADE-CASCADE END WALL**

(57) Provided is a turbine blade cascade endwall that is capable of reducing crossflow and is capable of reducing secondary-flow loss that occurs in association with the crossflow, therefore being capable of achieving enhanced turbine performance. A convex portion (11) that is gently swollen as a whole, that has an apex (P1) at a position of 0 to 20 % pitch in a position of 5 to 25 % Cax, that gently slopes from this apex (P1) toward a downstream side and a suction side surface of an adjacently disposed turbine stationary blade (B1) or turbine moving blade, and that slopes slightly steeply from the apex (P1) toward an upstream side is provided between one turbine stationary blade (B1) or turbine moving blade and another turbine stationary blade (B1) or turbine moving blade disposed adjacent to one turbine stationary blade (B1) or turbine moving blade.

FIG. 1



Description

Technical Field

[0001] The present invention relates to a turbine blade cascade endwall.

Background Art

[0002] On a turbine blade cascade endwall in a turbine serving as a motive power generator that obtains motive power by converting kinetic energy of a fluid to rotational motion, a so-called "crossflow (secondary flow)" occurs from the pressure side of one turbine blade to the suction side of an adjacent turbine blade.

In order to enhance the turbine performance, it is necessary to reduce this crossflow and to reduce secondary-flow loss that occurs in association with the crossflow.

[0003] Therefore, as a turbine blade cascade endwall that reduces such secondary-flow loss associated with crossflow to improve turbine performance, one having non-axisymmetric irregularities formed thereon has been known (for example, see Patent Citation 1).

Patent Citation 1: U.S. Patent No. 6,283,713, Specification.

Disclosure of Invention

[0004] In a turbine blade cascade endwall disclosed in the above-described Patent Citation, a concave portion is formed on a suction-side trailing edge of one turbine blade and a convex portion is formed on a pressure-side trailing edge of an adjacent turbine blade.

However, in the convex portion formed on the pressure-side trailing edge, static pressure declines thereat, and a discharge angle of a blade outlet ends up increasing, which deteriorates the performance of a blade cascade located downstream of a blade cascade having irregularities, thereby posing the risk of decreasing the overall performance of a turbine having a plurality of blade cascades.

[0005] The present invention has been conceived in light of above-described circumstances, and an object thereof is to provide a turbine blade cascade endwall that is capable of reducing a crossflow and that is also capable of reducing secondary-flow loss that occurs in association with the crossflow, thus being capable of achieving enhanced turbine performance.

[0006] In order to solve the above-described problems, the present invention employs the following solutions. defining 0% Cax as a leading edge position of the turbine stationary blades or the turbine moving blades in an axial direction and 100% Cax as a trailing edge position of the turbine stationary blades or the turbine moving blades in the axial direction, and defining 0% pitch as a position on a pressure side surface of the turbine stationary blades or the turbine moving blades, and 100% pitch as

a position on a suction side surface of a turbine stationary blade or a turbine moving blade facing the pressure side surface of the turbine stationary blade or the turbine moving blade, a convex portion, which is gently swollen as a whole, which has an apex at a position of 0 to 20 % pitch at a position of 5 to 25 % Cax, which gently slopes from this apex toward a downstream side and the suction side surface of the adjacently disposed turbine stationary blade or turbine moving blade, and which slopes slightly steeply from the apex toward an upstream side, is provided between one turbine stationary blade or turbine moving blade and another turbine stationary blade or turbine moving blade disposed adjacent to one turbine stationary blade or turbine moving blade.

[0007] With the turbine blade cascade endwall according to the first aspect of the present invention, because the static pressure near the convex portion can be reduced and the flow of working fluid in the axial direction can be increased, it is possible to reduce the crossflow and to reduce secondary-flow loss that occurs in association with the crossflow; therefore, enhanced turbine performance can be achieved.

[0008] A turbine blade cascade endwall according to a first aspect of the present invention is a turbine blade cascade endwall that is positioned on a tip side or a hub side of a plurality of turbine stationary blades or turbine moving blades arranged in the form of a ring, wherein, defining 0% Cax as a leading edge position of the turbine stationary blades or the turbine moving blades in an axial direction and 100% Cax as a trailing edge position of the turbine stationary blades or the turbine moving blades in the axial direction, and defining 0% pitch as a position on a pressure side surface of the turbine stationary blades or the turbine moving blades and 100% pitch as a position on a suction side surface of a turbine stationary blade or a turbine moving blade facing the pressure side surface of the turbine stationary blade or the turbine moving blade, a concave portion, which is gently depressed as a whole, which has a bottom point at a position of 70 to 90 % pitch in a position of 5 to 25 % Cax, which gently slopes from this bottom point toward a downstream side and the pressure side surface of the adjacently disposed turbine stationary blade or turbine moving blade, and which slopes slightly steeply from the bottom point toward an upstream side, is provided between one turbine stationary blade or turbine moving blade and another turbine stationary blade or turbine moving blade disposed adjacent to one turbine stationary blade or turbine moving blade.

[0009] With the turbine blade cascade endwall according to the second aspect of the present invention, because the static pressure near the concave portion can be increased and the flow of working fluid in the axial direction can be increased, it is possible to reduce the crossflow and to reduce secondary-flow loss that occurs in association with the crossflow; therefore, enhanced turbine performance can be achieved.

[0010] It is further preferable that a second convex por-

tion that is gently swollen as a whole or a convex portion be provided near a throat of the turbine blade cascade endwall according to the first aspect or the second aspect described above.

[0011] According to the turbine blade cascade endwall as described above, because the flow rate of the working fluid passing near the throat increases, thereby reducing the static pressure thereof and alleviating a pressure gradient generated at the suction side surface of the turbine stationary blade or the turbine moving blade in a blade-height direction, vortices generated at the suction side surface of the turbine stationary blade or the turbine moving blade can be suppressed, and therefore, it is possible to reduce secondary-flow loss associated with these vortices.

[0012] A turbine according to a third aspect of the present invention is provided with the turbine blade cascade endwall according to the first aspect or the second aspect described above.

With the turbine according to the third aspect of the present invention, because it is equipped with a turbine blade cascade endwall that is capable of reducing the crossflow and is capable of reducing secondary-flow loss that occurs in association with the crossflow, it is possible to achieve enhanced overall turbine performance.

[0013] With the present invention, an advantage is afforded in that it is possible to reduce the crossflow and to reduce secondary-flow loss that occurs in association with the crossflow, and therefore, enhanced turbine performance can be achieved.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is a plan view of relevant portions of a turbine blade cascade endwall according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a plan view of relevant portions of a turbine blade cascade endwall according to a second embodiment of the present invention.

[Fig. 3] Fig. 3 is a plan view of relevant portions of a turbine blade cascade endwall according to a third embodiment of the present invention.

[Fig. 4] Fig. 4 is a plan view of relevant portions of a turbine blade cascade endwall according to a fourth embodiment of the present invention.

[Fig. 5] Fig. 5 is a plan view of relevant portions of a turbine blade cascade endwall according to another embodiment of the present invention.

[Fig. 6] Fig. 6 is a diagram showing isobaric lines at a suction side surface of a turbine stationary blade shown in Fig. 5.

Best Mode for Carrying Out the Invention

[0015] A first embodiment of a turbine blade cascade endwall according to the present invention will be de-

scribed below, with reference to Fig. 1.

As shown in Fig. 1, each turbine blade cascade endwall (hereinafter, referred to as "third-stage stationary-blade tip endwall") 10 according to this embodiment has a first convex portion 11 between one turbine third-stage stationary blade (hereinafter, referred to as "third-stage stationary blade") B1 and another third-stage stationary blade B1 disposed adjacent to this third-stage stationary blade B1.

Note that, solid lines drawn on the third-stage stationary-blade tip endwall 10 in Fig. 1 indicate contour lines of the first convex portion 11, contour lines of a second convex portion 12, to be described later, and contour lines of a third convex portion 13, to be described later.

[0016] The first convex portion 11 has an apex (peak) P1 at a position of 0 to 20 % pitch (substantially 7 % pitch in this embodiment) at a position of 5 to 25 % Cax (substantially 14 % Cax in this embodiment) and is, as a whole, a gently (smoothly) swollen portion which moderately slopes, from the apex P1, toward the downstream side and the suction side surface of the adjacently disposed third-stage stationary blade B1, and which slopes slightly steeply (slopes at a sloping angle that is larger (steeper) than a sloping angle toward the downstream side and the suction side surface of the adjacently disposed third-stage stationary blade B1 from the apex P1) toward the upstream side from the apex P1.

Here, 0 % Cax indicates a leading edge position of the third-stage stationary blade B1 in the axial direction, and 100 % Cax indicates a trailing edge position of the third-stage stationary blade B1 in the axial direction. - (minus) indicates a position on the upstream side going up from the leading edge position of the third-stage stationary blade B1 in the axial direction, and + (plus) indicates a position on the downstream side going down from the leading edge position of the third-stage stationary blade B1 in the axial direction. Furthermore, 0 % pitch indicates a position on the pressure side surface of the third-stage stationary blade B1, and 100 % pitch indicates a position on the suction side surface of the third-stage stationary blade B1.

The height (degree of convexity) of the apex P1 of this first convex portion 11 is set at 5 % to 20 % (about 13 % in this embodiment) of the axial chord length of the third-stage stationary blade B1 (length of the third-stage stationary blade B1 in the axial direction).

[0017] Note that, as shown in Fig. 1, the third-stage stationary-blade tip endwall 10 according to this embodiment has, in addition to the first convex portion 11, a second convex portion 12 that moderately slopes toward a base of the first convex portion 11 from a position of substantially 100 % pitch at a position of substantially 0 % Cax, and a third convex portion 13 that moderately slopes toward the base of the first convex portion 11 from a position of substantially 100 % pitch at a position of substantially 90 % Cax.

[0018] With the third-stage stationary-blade tip endwall 10 according to this embodiment, because the static

pressure near the first convex portion 11 can be reduced and the flow of working fluid in the axial direction can be increased, it is possible to reduce cross flow and to reduce secondary-flow loss that occurs in association with the crossflow; therefore, enhanced turbine performance can be achieved.

[0019] A second embodiment of a turbine blade cascade endwall according to the present invention will be described with reference to Fig. 2.

As shown in Fig. 2, each turbine blade cascade endwall (hereinafter, referred to as "third-stage stationary-blade hub endwall) 20 according to this embodiment has a fourth convex portion 21 between one turbine third-stage stationary blade (hereinafter, referred to as "third-stage stationary blade") B1 and another third-stage stationary blade B1 disposed adjacent to this third-stage stationary blade B1. Note that, solid lines drawn on the third-stage stationary-blade hub endwall 20 in Fig. 2 indicate contour lines of the fourth convex portion 21 and contour lines of a fifth convex portion 22, to be described later.

[0020] The fourth convex portion 21 has an apex (peak) P2 at a position of 0 to 20 % pitch (substantially 3 % pitch in this embodiment) at a position of 5 to 25 % Cax (substantially 14 % Cax in this embodiment) and is, as a whole, a gently (smoothly) swollen portion which moderately slopes from the apex P2 toward the downstream side and the suction side surface of the adjacently disposed third-stage stationary blade B1, and which slopes slightly steeply (slopes at a sloping angle that is larger (steeper) than a sloping angle toward the downstream side and the suction side surface of the adjacently disposed third-stage stationary blade B1 from the apex P2) toward the upstream side from the apex P2.

The height (degree of convexity) of the apex P2 of this fourth convex portion 21 is set at 5 % to 20 % (about 12.5 % in this embodiment) of the axial chord length of the third-stage stationary blade B1 (length of the third-stage stationary blade B1 in the axial direction).

[0021] Note that, as shown in Fig. 2, the third-stage stationary-blade hub endwall 20 according to this embodiment has the fifth convex portion 22 that moderately slopes toward a base of the fourth convex portion 21 from a suction side surface located between substantially -10 % Cax and substantially 85 % Cax of the adjacently disposed third-stage stationary blade B1.

[0022] With the third-stage stationary-blade hub endwall 20 according to this embodiment, because the static pressure near the fourth convex portion 21 can be reduced and the flow of working fluid in the axial direction can be increased, it is possible to reduce crossflow and to reduce secondary-flow loss that occurs in association with the crossflow; therefore, enhanced turbine performance can be achieved.

[0023] A third embodiment of a turbine blade cascade endwall according to the present invention will be described with reference to Fig. 3.

As shown in Fig. 3, each turbine blade cascade endwall (hereinafter, referred to as "fourth-stage stationary-blade

tip endwall) 30 according to this embodiment has a first concave portion 31 between one turbine fourth-stage turbine stationary blade (hereinafter, referred to as "fourth-stage stationary blade") B2 and another fourth-stage stationary blade B2 disposed adjacent to this fourth-stage stationary blade B2. Note that, solid lines drawn on the fourth-stage stationary-blade tip endwall 30 in Fig. 3 indicate isobathic lines of the first concave portion 31 and isobathic lines of a sixth convex portion 32, to be described later.

[0024] The first concave portion 31 has a bottom point (depression peak) P3 at a position of 70 to 90 % pitch (substantially 83 % pitch in this embodiment) at a position of 5 to 25 % Cax (substantially 17 % Cax in this embodiment) and is, as a whole, a gently (smoothly) depressed portion which moderately slopes from the bottom point P3 toward the downstream side and the pressure side surface of the adjacently disposed fourth-stage stationary blade B2, and which slopes slightly steeply (slopes at a sloping angle that is larger (steeper) than a sloping angle toward the downstream side and the pressure side surface of the adjacently disposed fourth-stage stationary blade B2 from the bottom point P3) toward the upstream side from the bottom point P3.

The depth (degree of concavity) of the bottom point P3 of this first concave portion 31 is set at 5 % to 15 % (about 6 % in this embodiment) of the axial chord length of the fourth-stage stationary blade B2 (length of the fourth-stage stationary blade B2 in the axial direction).

[0025] Note that, as shown in Fig. 3, the fourth-stage stationary-blade tip endwall 30 according to this embodiment has a sixth convex portion 32 that has an apex (peak) P4 at a position of substantially 90 % pitch at a position of substantially 90 % Cax and that moderately slopes toward the bottom point P3 and a pressure side surface of the adjacently disposed fourth-stage stationary blade B2.

[0026] With the fourth-stage stationary-blade tip endwall 30 according to this embodiment, because the static pressure near the first concave portion 31 can be increased and the flow of working fluid in the axial direction can be increased, it is possible to reduce crossflow and to reduce secondary-flow loss that occurs in association with the crossflow; therefore, enhanced turbine performance can be achieved.

[0027] A fourth embodiment of a turbine blade cascade endwall according to the present invention will be described with reference to Fig. 4.

As shown in Fig. 4, each turbine blade cascade endwall (hereinafter, referred to as "fourth-stage stationary-blade hub endwall) 40 according to this embodiment has a second concave portion 41 between one turbine fourth-stage stationary blade (hereinafter, referred to as "fourth-stage stationary blade") B2 and another fourth-stage stationary blade B2 disposed adjacent to this fourth-stage stationary blade B2. Note that, solid lines drawn on the fourth-stage stationary-blade hub endwall 40 in Fig. 4 indicate isobathic lines of the second concave portion 41.

[0028] The second concave portion 41 has a bottom point (depression peak) P5 at a position of 70 to 90 % pitch (substantially 81 % pitch in this embodiment) at a position of 5 to 25 % Cax (substantially 18 % Cax in this embodiment) and is, as a whole, a gently (smoothly) depressed portion which moderately slopes from the bottom point P5 toward the downstream side and the pressure side surface of the adjacently disposed fourth-stage stationary blade B2, and which slopes slightly steeply (slopes at a sloping angle that is larger (steeper) than a sloping angle toward the downstream side and the pressure side surface of the adjacently disposed fourth-stage stationary blade B2 from the bottom point P5) toward the upstream side from the bottom point P5.

The depth (degree of concavity) of the bottom point P5 of this second concave portion 41 is set at 5 % to 15 % (about 9.4 % in this embodiment) of the axial chord length of the fourth-stage stationary blade B2 (length of the fourth-stage stationary blade B2 in the axial direction).

[0029] With the fourth-stage stationary-blade hub endwall 40 according to this embodiment, because the static pressure near the second concave portion 41 can be increased and the flow of working fluid in the axial direction can be increased, it is possible to reduce crossflow and to reduce secondary-flow loss that occurs in association with the crossflow; therefore, enhanced turbine performance can be achieved.

[0030] With a turbine equipped with the turbine blade cascade endwall 10, 20, 30, or 40 according to the embodiments described above, because it is equipped with the turbine blade cascade endwall 10, 20, 30, or 40 that is capable of reducing crossflow and is capable of reducing secondary-flow loss that occurs in association with the crossflow, it is possible to achieve enhanced overall turbine performance.

[0031] As shown in Fig. 5, in the above-described embodiments, it is further preferable that a seventh convex portion 51 (not shown) be provided (formed) on the turbine blade cascade endwall 10, 20, 30, or 40 near a throat thereof.

By providing such a seventh convex portion 51 on the turbine blade cascade endwall 10, 20, 30, or 40 near the throat thereof, because the flow rate of working fluid passing near the throat increases, thereby reducing the static pressure thereof and alleviating a pressure gradient generated at the suction side surfaces of the third-stage stationary blade B1 and the fourth-stage stationary blade B2 in a blade-height direction (up-down direction in Fig. 6), as in the contour lines shown by the solid lines in the blade surface in Fig. 6, vortices generated at the suction side surfaces of the third-stage stationary blade B1 and the fourth-stage stationary blade B2 can be suppressed, and therefore, it is possible to reduce secondary-flow loss associated with these vortices.

[0032] The present invention is not limited to the above-described embodiments, and appropriate modifications, alterations, and combinations thereof that do not depart from the gist of the present invention are possible.

[0033] In the above-described embodiments, a turbine blade cascade endwall has been described as exemplified in the third-stage stationary-blade tip endwall, the third-stage stationary-blade hub endwall, the fourth-stage stationary-blade tip endwall, and the fourth-stage stationary-blade hub endwall; however, the present invention is not limited thereto, and it can be applied to a hub endwall of turbine moving blades, a tip endwall of turbine moving blades, a stationary-blade tip endwall of other stages, or a stationary-blade tip endwall of other stages.

[0034] Furthermore, the turbine blade cascade endwall according to the present invention can be applied to both a gas turbine and a steam turbine.

Claims

1. A turbine blade cascade endwall that is positioned on a tip side or a hub side of a plurality of turbine stationary blades or turbine moving blades arranged in the form of a ring, wherein, defining 0% Cax as a leading edge position of the turbine stationary blades or the turbine moving blades in an axial direction and 100% Cax as a trailing edge position of the turbine stationary blades or the turbine moving blades in the axial direction, and defining 0% pitch as a position on a pressure side surface of the turbine stationary blades or the turbine moving blades and 100% pitch as a position on a suction side surface of a turbine stationary blade or a turbine moving blade facing the pressure side surface of the turbine stationary blade or the turbine moving blade, a convex portion that is gently swollen as a whole, that has an apex at a position of 0 to 20 % pitch at a position of 5 to 25 % Cax, that gently slopes from this apex toward a downstream side and the suction side surface of the adjacently disposed turbine stationary blade or turbine moving blade, and that slopes slightly steeply from the apex toward an upstream side is provided between one turbine stationary blade or turbine moving blade and another turbine stationary blade or turbine moving blade disposed adjacent to one turbine stationary blade or turbine moving blade.
2. A turbine blade cascade endwall that is positioned on a tip side or a hub side of a plurality of turbine stationary blades or turbine moving blades arranged in the form of a ring, wherein, defining 0% Cax as a leading edge position of the turbine stationary blades or the turbine moving blades in an axial direction and 100% Cax as a trailing edge position of the turbine stationary blades or the turbine moving blades in the axial direction, and defining 0% pitch as a position on a pressure side surface of the turbine stationary blades or the turbine

moving blades and 100% pitch as a position on a suction side surface of a turbine stationary blade or a turbine moving blade facing the pressure side surface of the turbine stationary blade or the turbine moving blade,

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a concave portion that is gently depressed as a whole, that has a bottom point at a position of 70 to 90 % pitch in a position of 5 to 25 % Cax, that gently slopes from this bottom point toward a downstream side and the pressure side surface of the adjacently disposed turbine stationary blade or turbine moving blade, and that slopes slightly steeply from the bottom point toward an upstream side is provided between one turbine stationary blade or turbine moving blade and another turbine stationary blade or turbine moving blade disposed adjacent to one turbine stationary blade or turbine moving blade.

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3. A turbine blade cascade endwall according to Claim 1 or 2, wherein a second convex portion that is gently swollen as a whole or a convex portion is provided near a throat.

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4. A turbine provided with a turbine blade cascade endwall according to any one of Claims 1 to 3.

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FIG. 1

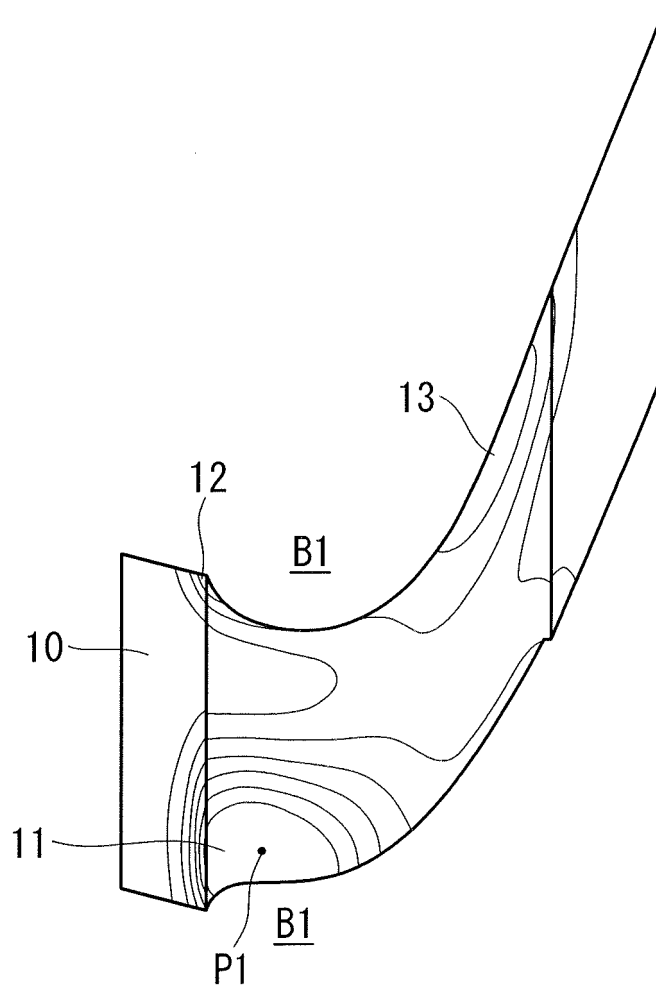


FIG. 2

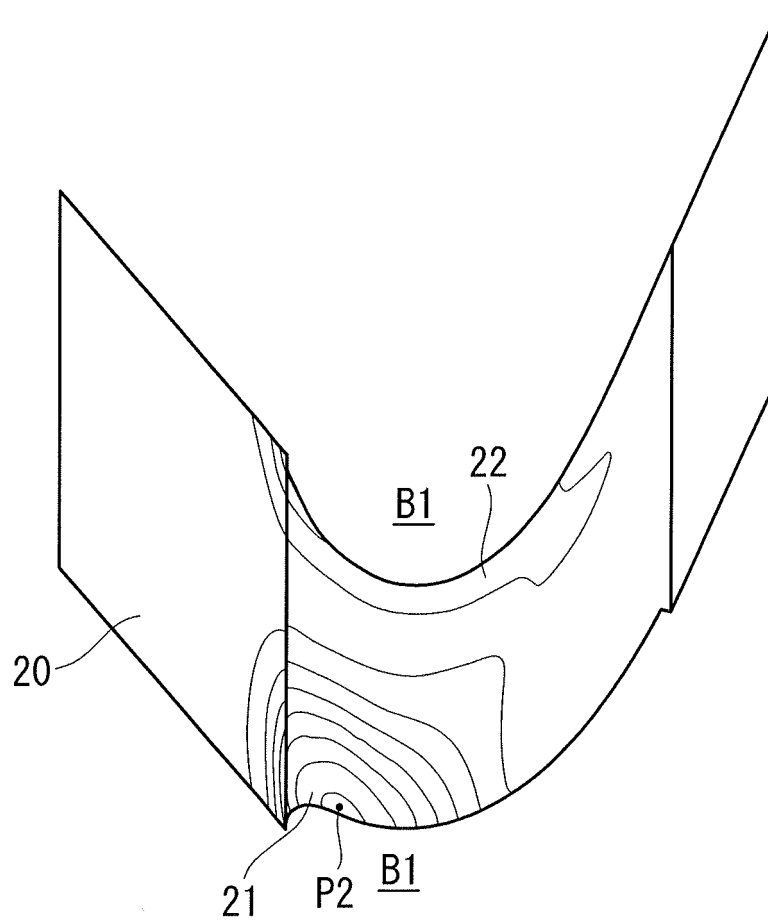


FIG. 3

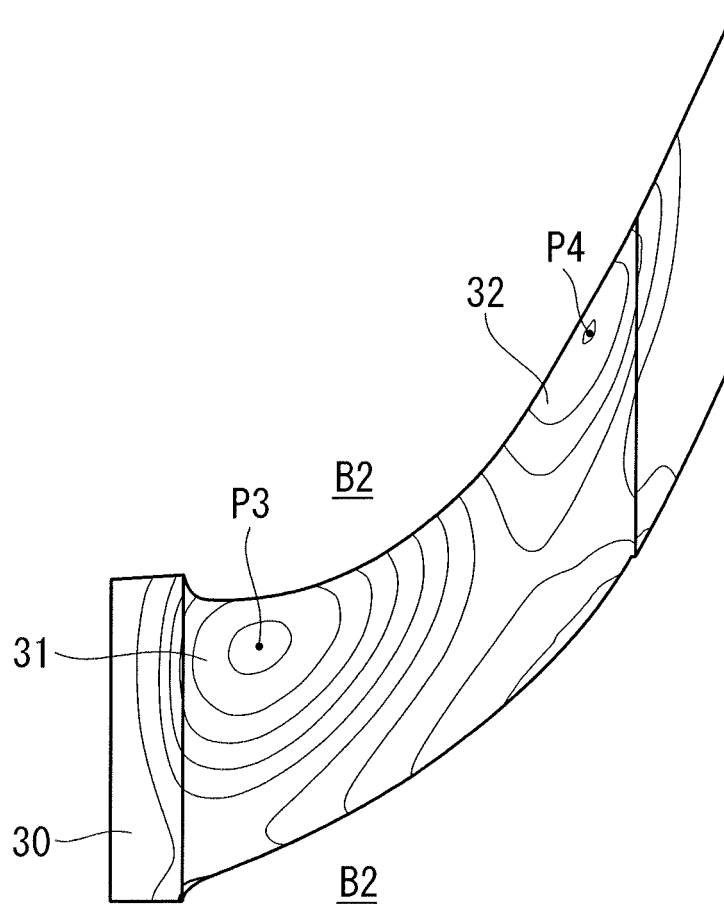


FIG. 4

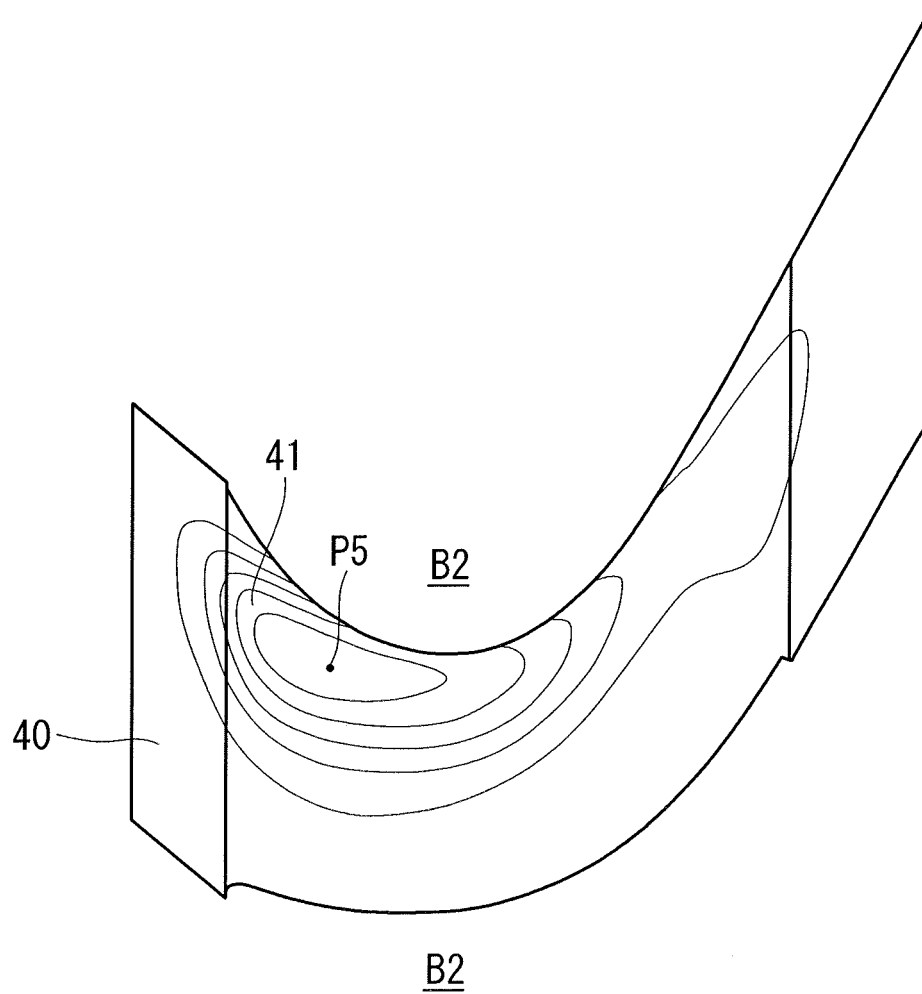


FIG. 5

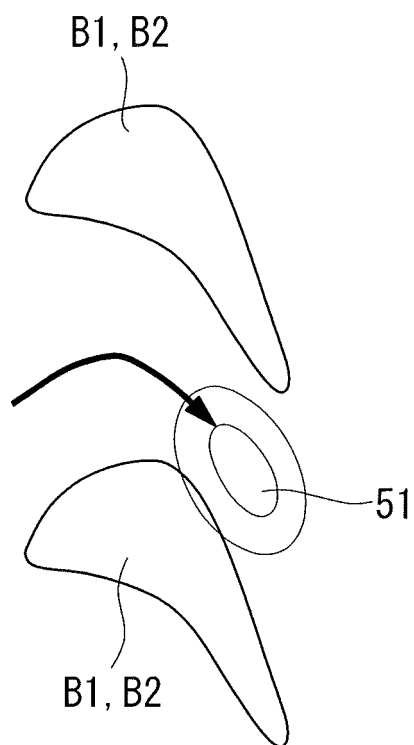
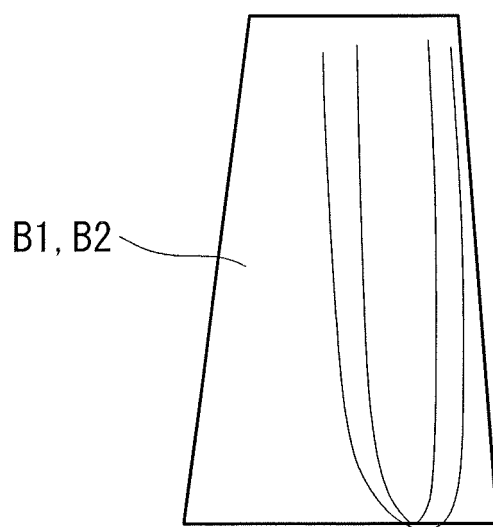


FIG. 6



EP 2 241 723 A1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/067231

A. CLASSIFICATION OF SUBJECT MATTER

F01D9/02(2006.01) i, F01D5/14(2006.01) i, F01D9/04(2006.01) i

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)

F01D9/02, F01D5/14, F01D9/04

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2007-247542 A (Mitsubishi Heavy Industries, Ltd.), 27 September, 2007 (27.09.07), Par. Nos. [0016], [0028]; Figs. 3, 5, 6 & WO 2007/108232 A1	1, 4
X	ROSE et al., 'THE EFFECT OF END-WALL PROFILING ON SECONDARY FLOW AND LOSS DEVELOPMENT IN A TURBINE CASCADE', In: Proceedings of ASME Turbo Expo 2002, GT-2002-30339, ASME, 2002, p.2 (Figure 1)	2-4

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search
30 October, 2008 (30.10.08)

Date of mailing of the international search report
11 November, 2008 (11.11.08)

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Patent documents cited in the description

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