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(54) **CENTRIFUGAL IMPELLER AND CENTRIFUGAL COMPRESSOR**

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(57) **ABSTRACT**

The impeller provides that when an angle made by a projection line **33** that is obtained by projecting a camber line **32** of the blade **22** onto a predetermined meridional cross section and the camber line **32** is defined as an inclination angle γθ and an inclination in a direction opposite to a rotating direction of the rotary shaft is defined to be positive, the blade **22** is formed in such a manner that the inclination angle γθ of a leading edge **22**A is zero or positive on the hub **20** side and gradually increasing toward the shroud **21** and the inclination angle is gradually decreasing from the leading edge toward a trailing edge in a flow direction of the fluid.

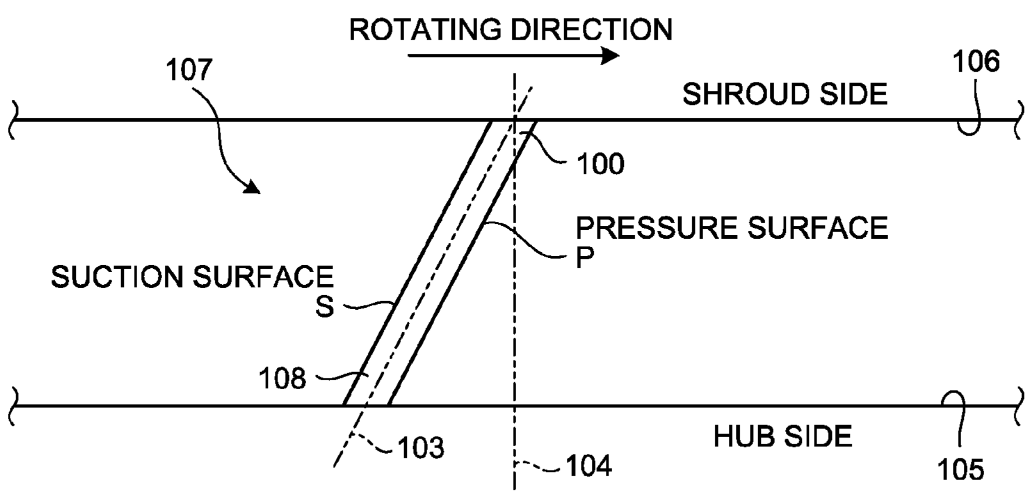


FIG.1

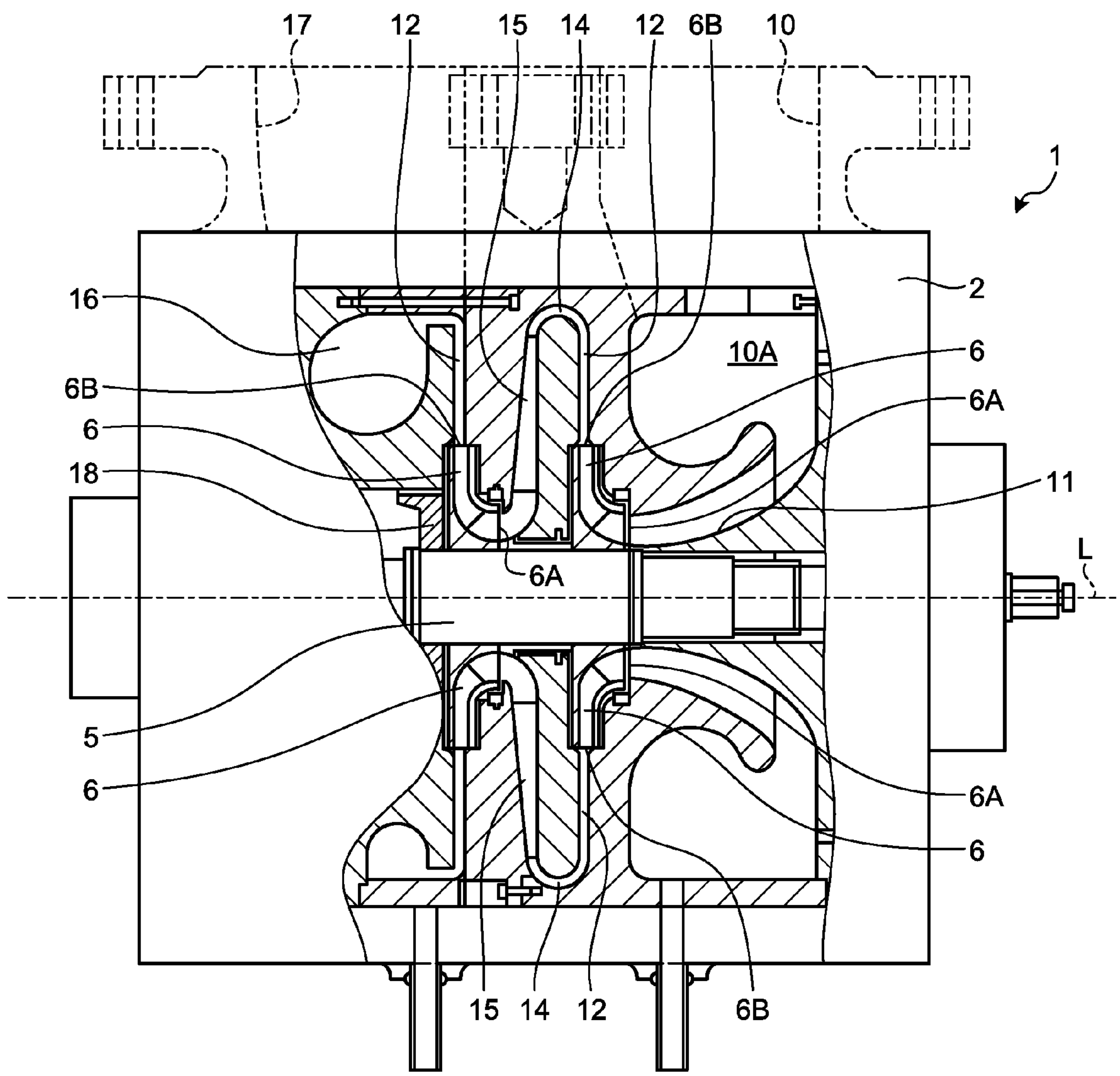


FIG.2

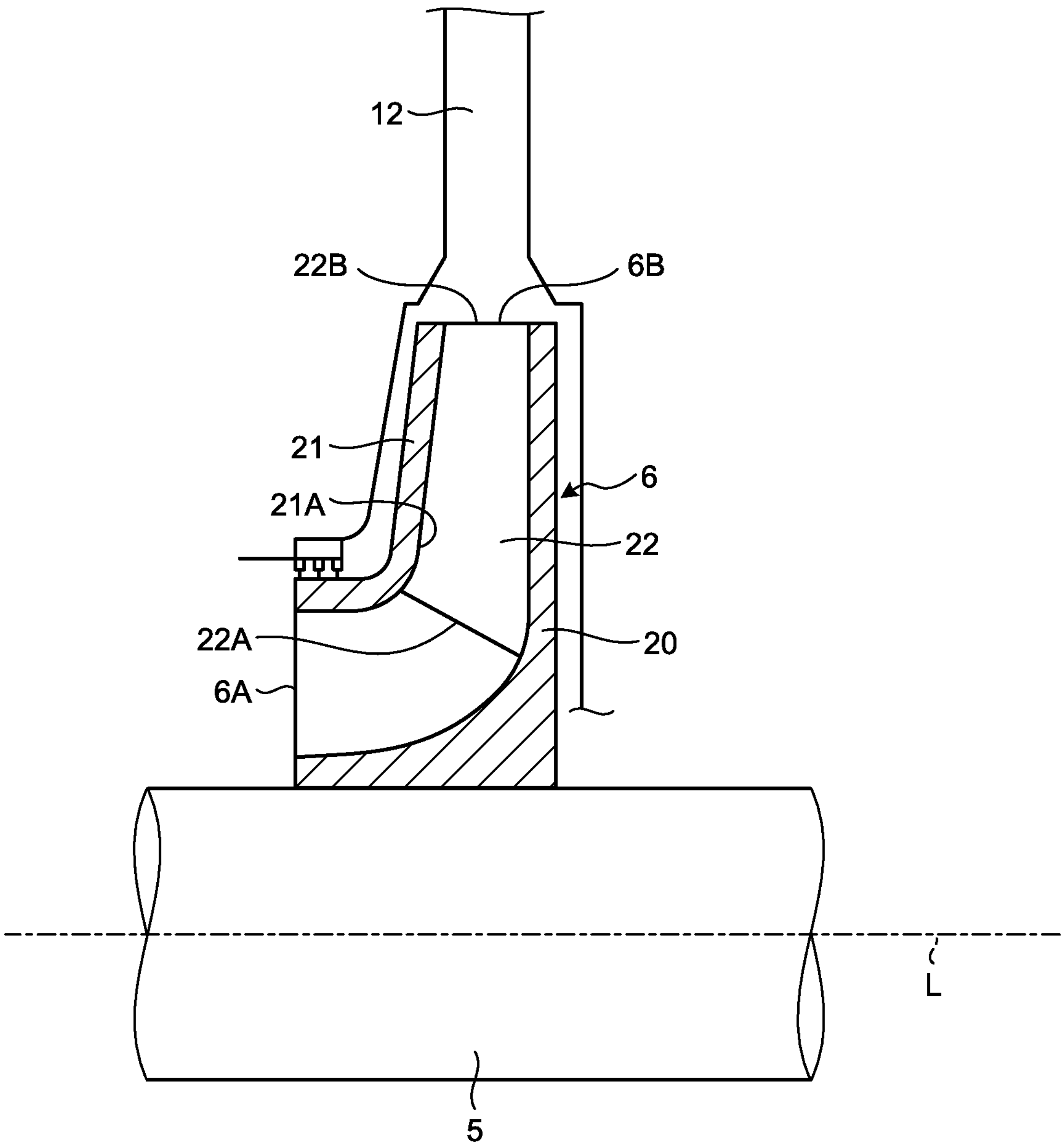


FIG.3

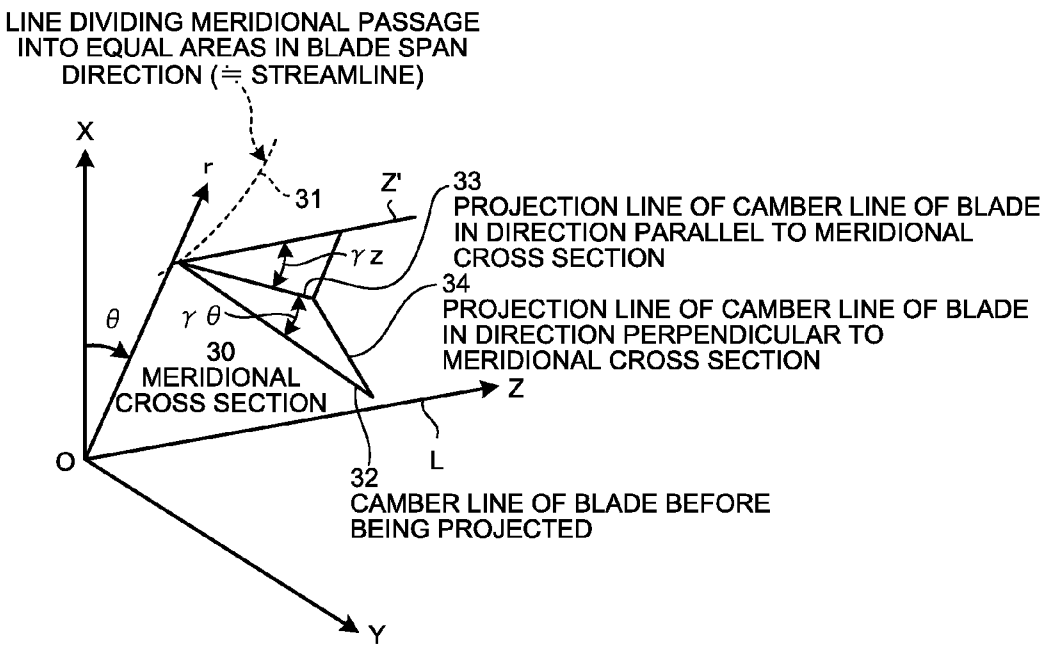

LINE DIVIDING MERIDIONAL PASSAGE
INTO EQUAL AREAS IN BLADE SPAN
DIRECTION (≒ STREAMLINE)
X
r
31
Z'
33
PROJECTION LINE OF CAMBER LINE OF BLADE
IN DIRECTION PARALLEL TO MERIDIONAL
CROSS SECTION
γz
34
PROJECTION LINE OF CAMBER LINE OF BLADE
IN DIRECTION PERPENDICULAR TO
MERIDIONAL CROSS SECTION
γθ
θ
30
MERIDIONAL
CROSS SECTION
Z
O
L
32
CAMBER LINE OF BLADE BEFORE
BEING PROJECTED
Y

FIG.4

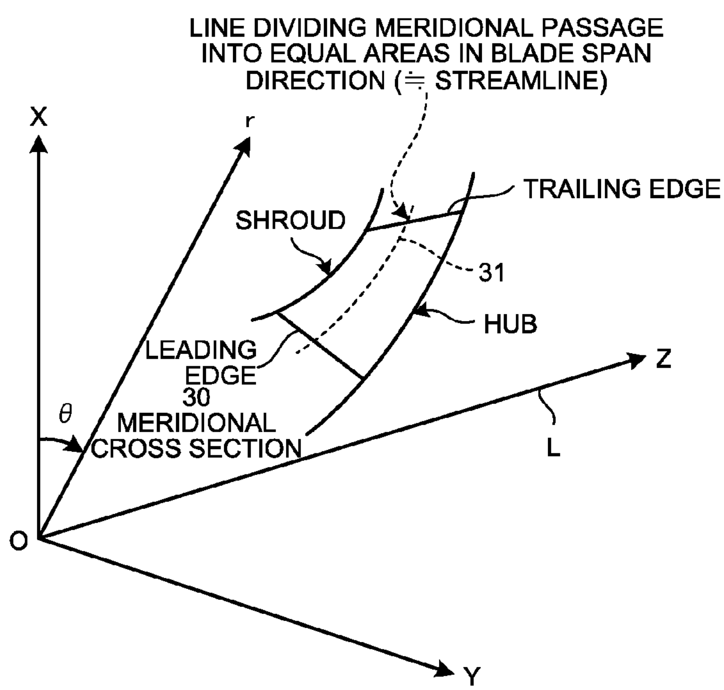

LINE DIVIDING MERIDIONAL PASSAGE
INTO EQUAL AREAS IN BLADE SPAN
DIRECTION (≒ STREAMLINE)
X
r
TRAILING EDGE
SHROUD
31
HUB
LEADING
EDGE
Z
30
θ
MERIDIONAL
CROSS SECTION
L
O
Y

FIG.5

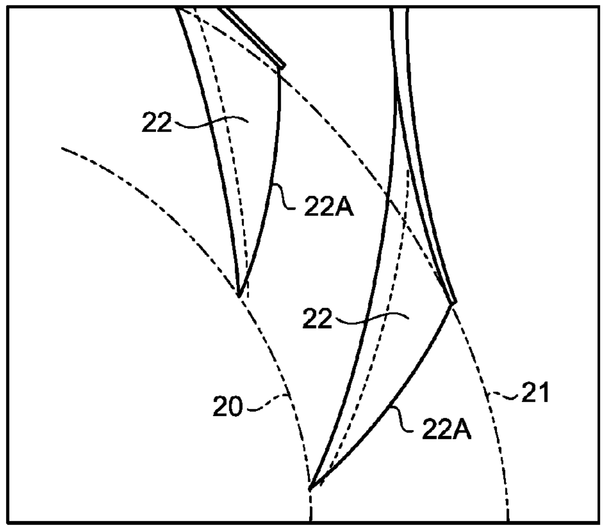

22
22A
22
20
21
22A

FIG.6

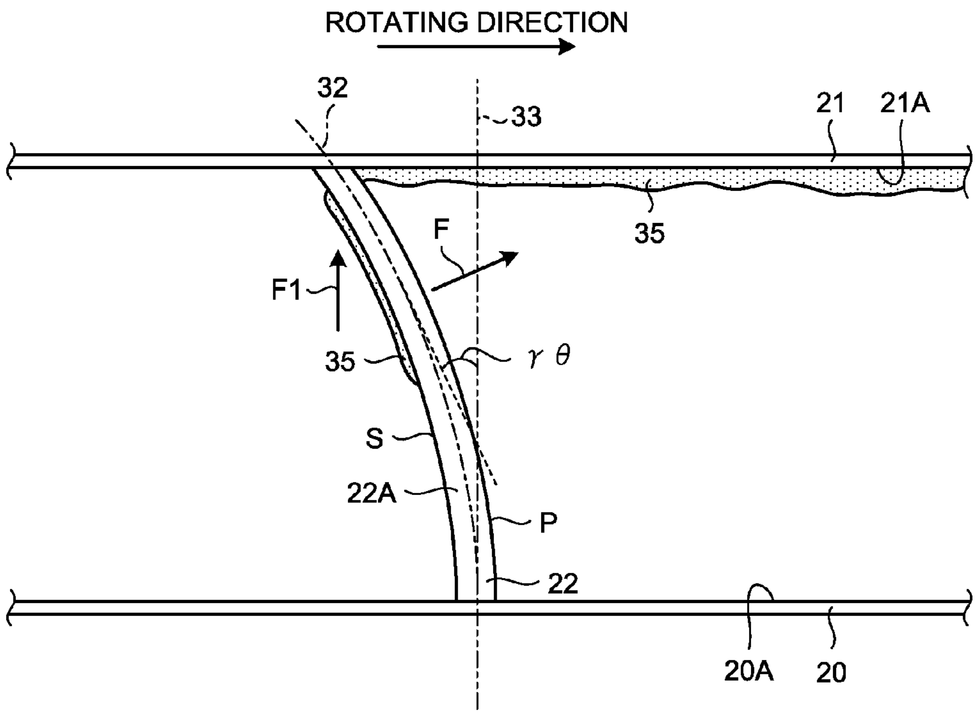

ROTATING DIRECTION
32
33
21
21A
35
F
F1
35
γ θ
S
22A
P
22
20A
20

FIG.7

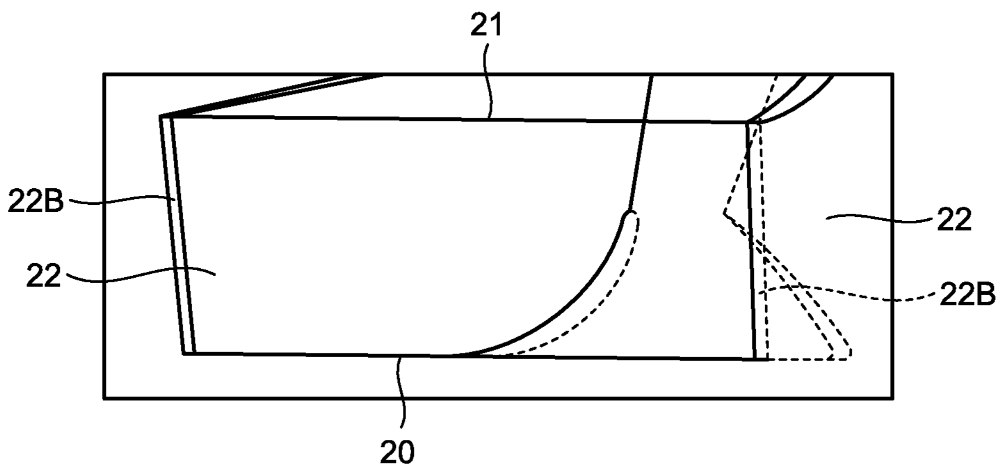


FIG.8

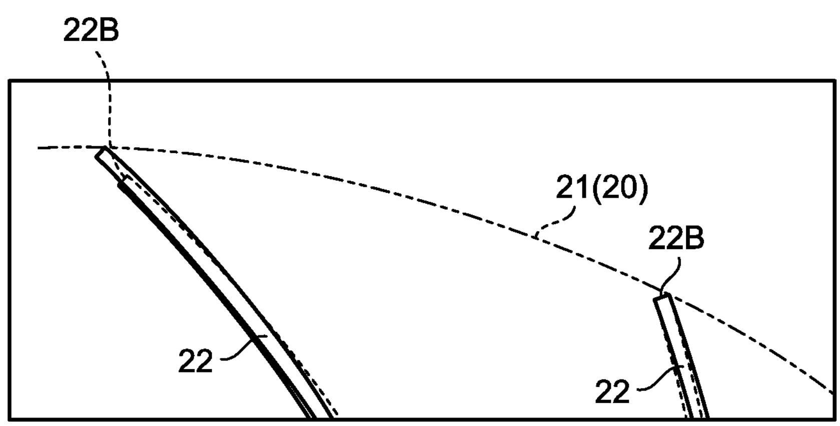


FIG.9

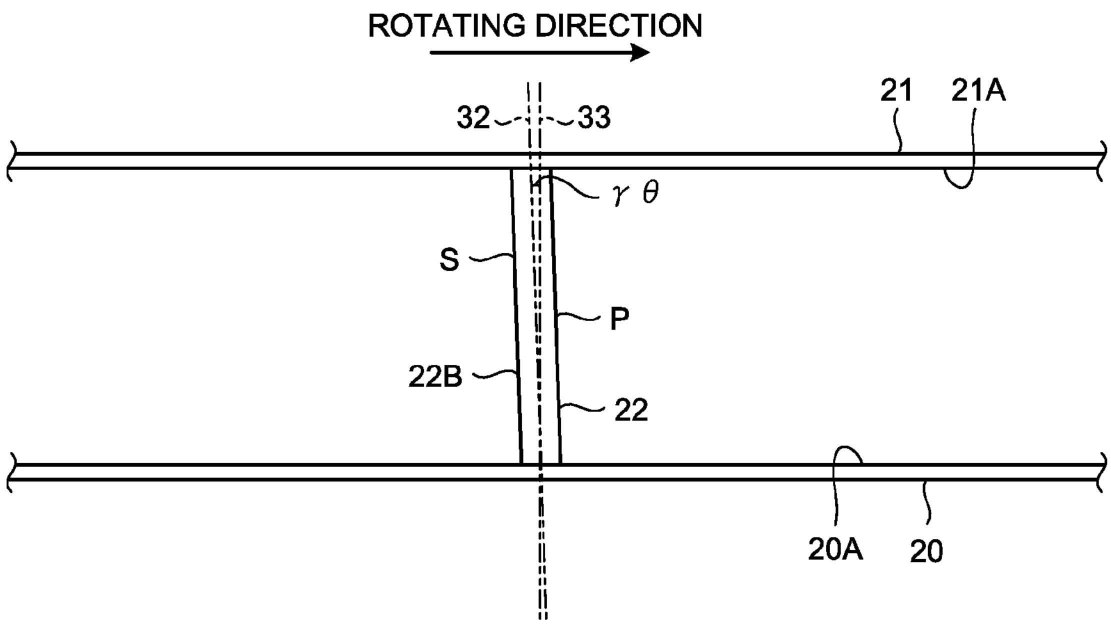


FIG.10

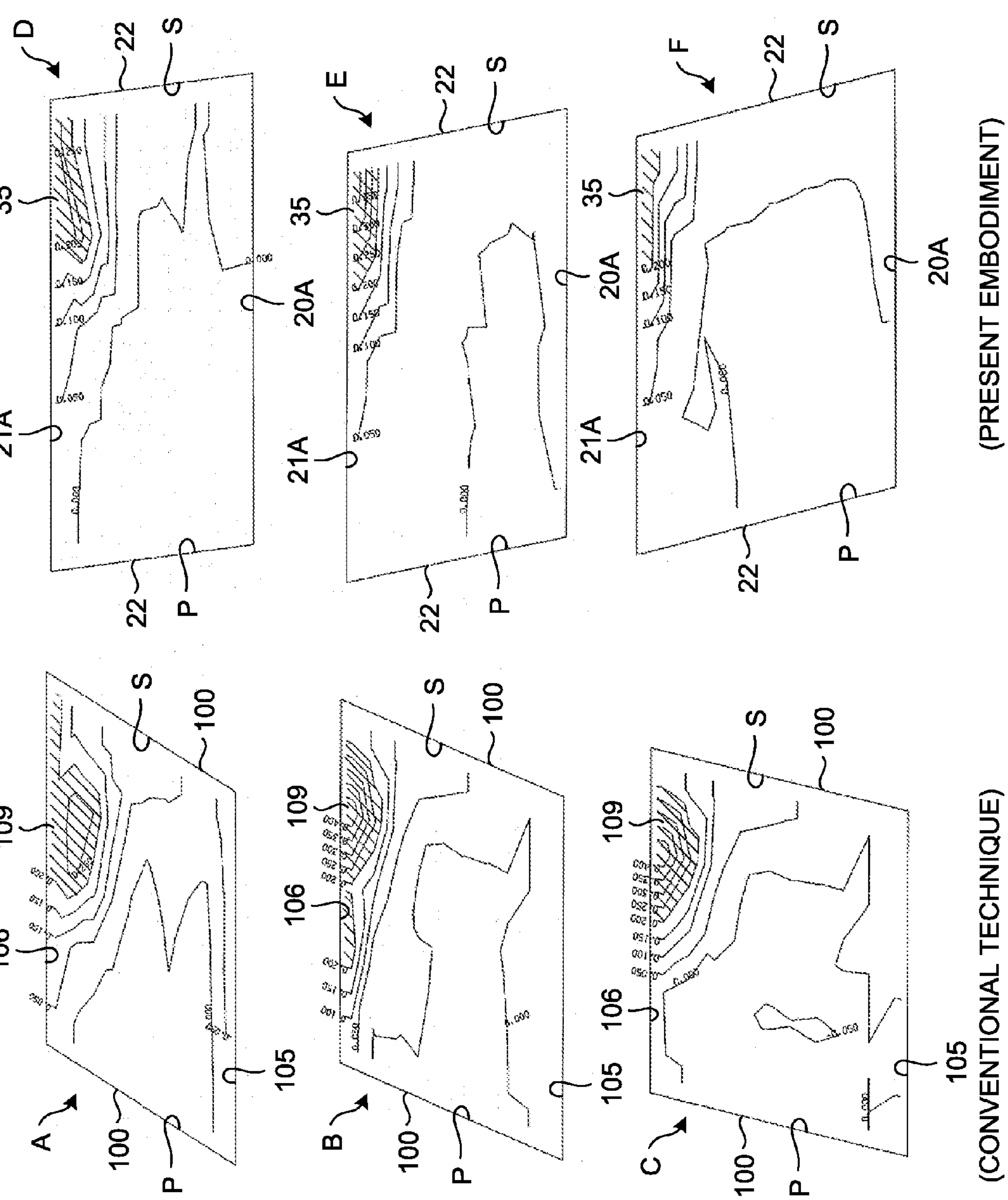

A
B
C
D
E
F
100
105
106
109
P
S
22
35
21A
20A
(CONVENTIONAL TECHNIQUE)
(PRESENT EMBODIMENT)

FIG.11

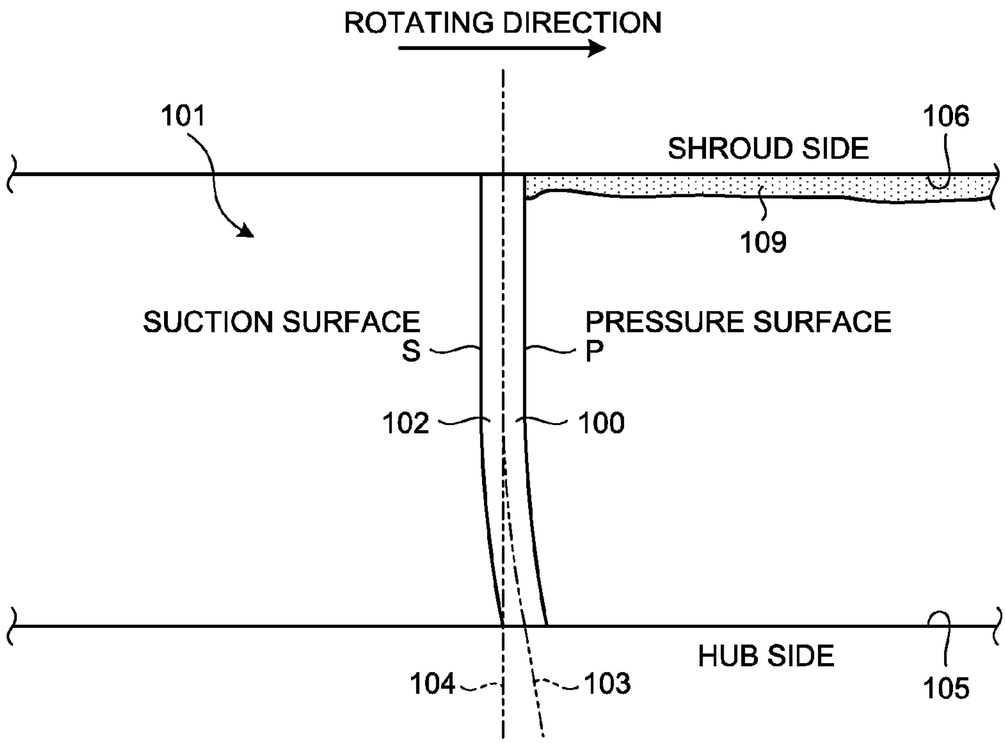
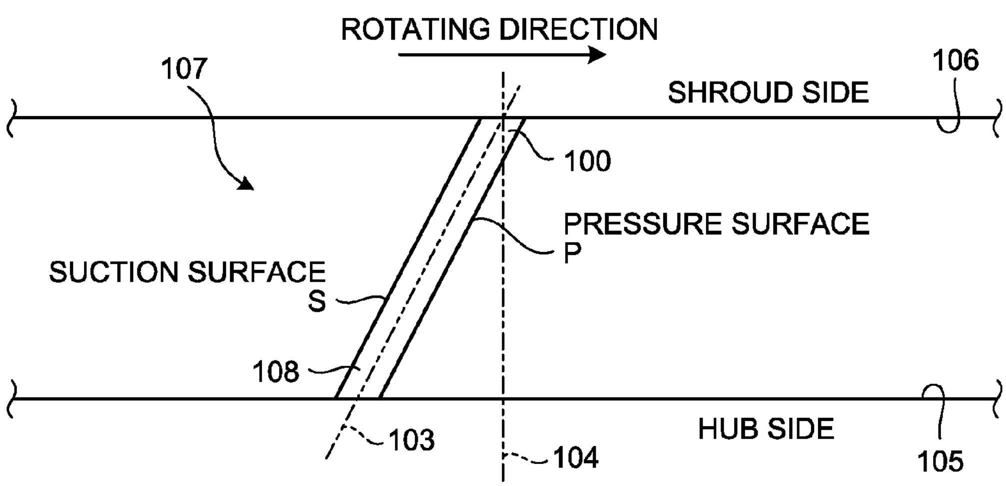

ROTATING DIRECTION
101
106
SHROUD SIDE
109
SUCTION SURFACE
S
PRESSURE SURFACE
P
102
100
HUB SIDE
104
103
105

FIG.12


ROTATING DIRECTION
107
106
SHROUD SIDE
100
PRESSURE SURFACE
P
SUCTION SURFACE
S
108
HUB SIDE
103
104
105

CENTRIFUGAL IMPELLER AND CENTRIFUGAL COMPRESSOR

FIELD

[0001] The present invention relates to a centrifugal impeller and a centrifugal compressor including the centrifugal impeller.

BACKGROUND

[0002] Centrifugal compressors for industrial use are generally used in petrochemical plants or natural gas plants, for example. A centrifugal compressor of this type employs a centrifugal impeller for blowing out fluid in a radial direction by the rotation of a rotary shaft, including a hub fixed to the rotary shaft and a plurality of blades disposed in the hub (see Patent Literature 1, for example).

CITATION LIST

Patent Literature

[0003] Patent Literature 1: Japanese Patent Application Laid-Open No. 2004-044473

SUMMARY

Technical Problem

[0004] According to a conventional configuration, when a blade **100** of a centrifugal impeller is viewed from an intake port **101** side, the blade **100** is formed in such a manner that an angle made by a camber line **103** of a leading edge **102** and a straight line **104** extending in a radial direction from the center of rotation is approximately 0° over a region from a wall surface **105** on a hub side to a wall surface **106** on a shroud side as shown in FIG. **11**. When the blade **100** is viewed from a blowoff port **107** side, the blade latter half of the blade **100** including a trailing edge **108** inclines obliquely in such a manner that a suction surface S of the blade **100** faces the wall surface **106** on the shroud side as shown in FIG. **12**.

[0005] By the way, in the centrifugal impeller of this type, a boundary layer **109** is generated on the wall surface **106** on the shroud side, which constitutes a passage for fluid. The boundary layer **109** develops in a deceleration zone of the wall surface **106** on the shroud side in the first half of the blade. Also on a surface of the blade **100**, a boundary layer develops, starting from the leading edge **102**, on the suction surface S having larger deceleration than a pressure surface P to which a positive pressure is applied by the rotation. This boundary layer is attracted to a radially upper part by centrifugal force, thereby flowing into and merging with the boundary layer **109** generated on the wall surface **106** on the shroud side. Thus, the boundary layer **109** on the wall surface **106** on the shroud side develops further. The thus developed boundary layer develops further also in the latter half of the blade, thereby creating a large energy deficit portion on a blade outlet side. Thus, it is expected to deteriorate the performance of the centrifugal impeller. The conventional configuration, however, has made no contraption for suppressing the boundary layer **109** developed on the wall surface **106** on the shroud side in the first half of the blade, in particular.

[0006] The present invention has been made in view of such circumstances, and it is an object of the present invention to provide a centrifugal impeller capable of suppressing the development of a boundary layer and thus fulfilling its performance sufficiently, and a centrifugal compressor.

Solution to Problem

[0007] According to an aspect of the present invention, a centrifugal impeller comprises: a hub; a shroud; and a plurality of blades disposed between the hub and the shroud, the centrifugal impeller blowing out fluid in a radial direction by rotation of a rotary shaft fixed to the hub. When an angle made by a projection line that is obtained by projecting a camber line of the blade onto a predetermined meridional cross section and the camber line is defined as an inclination angle and an inclination in a direction opposite to a rotating direction of the rotary shaft is defined to be positive, the blade is formed in such a manner that the inclination angle of a leading edge is zero or positive on the hub side and gradually increasing toward the shroud and the inclination angle is gradually decreasing from the leading edge toward a trailing edge in a flow direction.

[0008] According to this configuration, the inclination angle of the leading edge in the blade is zero or positive on the hub side and gradually increasing toward the shroud. Thus, a pressure surface of the blade faces the shroud in a portion of the blade from the leading edge to the first half thereof. Consequently, a boundary layer is pressed against the shroud by force of the pressure surface of the blade, thereby suppressing the development of the boundary layer. On a suction surface of the blade, a boundary layer is pressed against the suction surface by centrifugal force, thereby preventing its movement toward the shroud and thus suppressing the development of the boundary layer. Furthermore, in the flow direction, the blade is formed in such a manner that the inclination angle is gradually decreasing from the leading edge toward the trailing edge. Consequently, the surface area of the blade in the latter half of the blade is reduced, and thus the amount of the boundary layer developed over the blade surface in the latter half of the blade can be reduced. This can suppress the generation of an energy deficit portion on a blade outlet side, thereby allowing the performance of the centrifugal impeller to be fulfilled sufficiently.

[0009] In this configuration, the inclination angle of the trailing edge in the blade is preferably zero or positive on the hub side and gradually increasing toward the shroud. According to such a configuration, the pressure surface of the blade faces the shroud also in the latter half of the blade. Consequently, the boundary layer is pressed against the shroud by the force of the pressure surface of the blade, thereby suppressing the development of the boundary layer.

[0010] Alternatively, the inclination angle of the trailing edge in the blade is preferably zero or positive over a region from the hub side to the shroud side. Moreover, such a positive value is preferably closer to zero. According to such a configuration, the length of the trailing edge of the blade can be made the shortest distance, thereby minimizing an amount of wake flow due to the thickness of the trailing edge of the blade. Furthermore, the reduced surface area of the blade in the latter half of the blade can reduce the amount of the boundary layer developed over the blade surface in the latter half of the blade as compared to the conventional technique.

[0011] The leading edge of the blade, when projected onto the meridional cross section, preferably has a linear shape from the hub side to the shroud side or a shape protruded toward an upstream side of the flow direction between the hub side and the shroud side. According to such a configuration, the area of a portion of the leading edge of the blade facing the shroud can be increased, thereby more effectively suppressing the development of the boundary layer accordingly.

[0012] The provision of the above-described centrifugal impeller in a centrifugal compressor can suppress the generation of the energy deficit portion on the blade outlet side, thus improving the compression efficiency of the centrifugal compressor.

Advantageous Effects of Invention

[0013] According to the centrifugal impeller of the present invention, the blade is formed in such a manner that the inclination angle of the leading edge is zero or positive on the hub side and gradually increasing toward the shroud and the inclination angle is gradually decreasing from the leading edge toward the trailing edge in the flow direction. Thus, the pressure surface of the blade faces the shroud in the portion of the blade from the leading edge to the first half thereof. This can suppress the development of the boundary layer and thus suppress the generation of the energy deficit portion on the blade outlet side, thereby allowing the performance of the centrifugal impeller to be fulfilled sufficiently.

BRIEF DESCRIPTION OF DRAWINGS

[0014] FIG. **1** is a longitudinal cross-sectional view of a centrifugal compressor according to the present embodiment.

[0015] FIG. **2** is a partial enlarged view illustrating an impeller.

[0016] FIG. **3** is a diagram for explaining an inclination angle of a blade shown on a meridional cross section.

[0017] FIG. **4** is a diagram illustrating the blade projected on the meridional cross section.

[0018] FIG. **5** is a diagram illustrating an intake port of the impeller as seen from an axial direction.

[0019] FIG. **6** is a schematic view illustrating the shape of a leading edge of the blade of the impeller.

[0020] FIG. **7** is a diagram illustrating a blowoff port of the impeller as seen from a radial direction.

[0021] FIG. **8** is a diagram illustrating the blowoff port of the impeller as seen from the axial direction.

[0022] FIG. **9** is a schematic view illustrating the shape of a trailing edge of the blade of the impeller.

[0023] FIG. **10** is an experimental measurement diagram showing changes in the development of boundary layers due to the shapes of blades in a conventional technique and the present embodiment.

[0024] FIG. **11** is a schematic view illustrating the shape of a leading edge of a blade in a conventional impeller.

[0025] FIG. **12** is a schematic view illustrating the shape of a trailing edge of the blade in the conventional impeller.

DESCRIPTION OF EMBODIMENTS

[0026] An embodiment of the present invention will be described below with reference to the drawings. Note that this invention is not limited by the following embodiment. Note also that elements in the following embodiment encompass those substitutable by and obvious to a person skilled in the art, or substantially the same elements.

[0027] FIG. **1** is a longitudinal cross-sectional view of a centrifugal compressor according to the present embodiment. A centrifugal compressor **1** includes: a casing **2** formed by a combination of a plurality of parts; a rotary shaft **5** supported so as to be rotatable about an axis line L via bearings (not shown) in the casing **2**; and closed type impellers **6** fixed to the rotary shaft **5** so as to rotate integrally with the rotary shaft **5**. In other words, the centrifugal compressor **1** of the present embodiment is a two-stage centrifugal compressor.

[0028] In the centrifugal compressor **1**, the rotary shaft **5** is driven by a driving mechanism (not shown) to rotate the impellers **6**. Consequently, fluid, such as gas or air, to be compressed is sucked into the centrifugal compressor **1** via a suction port **10** provided in the casing **2**. An intake passage **11** is connected to the suction port **10** via a suction space **10**A formed in the casing **2**. The intake passage **11** bends along the direction of the axis line L of the rotary shaft **5** (axial direction) and has an opening facing an intake port **6**A of the first-stage impeller **6**.

[0029] Centrifugal force is imparted to the fluid sucked from the suction port **10** by the rotation of the first-stage impeller **6**. The kinetic energy of such fluid is converted to pressure energy by a first-stage vaneless diffuser **12** provided at a blowoff port **6**B of the impeller **6**. This fluid is further guided to an intake port **6**A of the second-stage impeller **6**, which is the next compression stage, via a return bend **14** and a return vane **15**.

[0030] Similarly, centrifugal force is imparted to such compressed fluid by the second-stage impeller **6**. The kinetic energy of such fluid is converted to pressure energy by a second-stage vaneless diffuser **12** and discharged to a scroll **16** as compressed fluid with a higher pressure. Thereafter, the fluid is sent out from the scroll **16** to a discharge pipe (not shown) via a discharge port **17** provided in the casing **2**. Note that the reference numeral **18** in FIG. **1** denotes a balance piston provided for adjusting thrust of the impeller **6**. The impeller **6** will be described next.

[0031] FIG. **2** is a partial enlarged view illustrating the impeller. As shown in FIG. **2**, the impeller **6** includes: a hub **20** fixed to the rotary shaft **5**; a shroud **21** disposed with a space from the hub **20** in a radial direction and the axial direction; and a plurality of blades **22** disposed between the hub **20** and the shroud **21**. The blades **22** are disposed radially with a space around the axis line L, although their graphic representation is omitted. A leading edge **22**A of the blade **22** is positioned on the intake port **6**A side of the impeller **6**, and a trailing edge **22**B extends to the blowoff port **6**B of the impeller **6**.

[0032] By the way, a boundary layer is generated on an inner wall surface **21**A of the shroud **21**, which constitutes a fluid passage together with the hub **20**, on the intake port **6**A side of the impeller **6**. This boundary layer grows (develops) on the inner wall surface **21**A of the shroud **21** when the fluid flows from the leading edge **22**A of the blade **22** toward the trailing edge **22**B. Consequently, a large energy deficit is generated at the blowoff port (blade outlet side) **6**B. Thus, it is expected to deteriorate the performance of the impeller. In the present embodiment, the shape of the blade **22** has the following configuration in order to suppress the growth of the boundary layer.

[0033] An inclination angle required to define the shape of the blade **22** of the impeller **6** will be described first. FIG. **3** is a diagram for explaining the inclination angle of the blade shown on a meridional cross section. FIG. **4** is a diagram illustrating the blade projected on the meridional cross section. Since the blade **22** of the impeller **6** has a three-dimensional shape, the inclination angle is expressed with a cylindrical coordinate system shown in FIGS. **3** and **4**.

[0034] In FIGS. **3** and **4**, the Z-axis represents the axis line L of the rotary shaft **5**. An r-Z plane formed by the Z-axis and a straight line r extending from an origin point O at an angle made by a predetermined angle θ from the X-axis represents a predetermined meridional cross section **30**. When the blade **22** is projected on the meridional cross section **30**, a broken line denoted by the reference numeral **31** is a line (streamline) dividing a meridional passage into equal areas in a blade span direction.

[0035] In FIG. **3**, the reference numeral **32** denotes a camber line of the blade (for example, the leading edge) before being projected. When the camber line **32** is projected on the meridional cross section **30**, a projection line (projection line of the camber line of the blade parallel to the meridional cross section **30**) **33** is formed. An angle made by the projection line **33** and the camber line **32** is defined as the inclination angle of the blade **22** (inclination angle in a circumferential direction of the blade) γθ in the present embodiment. Note that the positive or negative sign of the inclination angle γθ is defined in accordance with the rotating direction of the rotary shaft **5**. In the present embodiment, a direction opposite to the rotating direction (counter-rotating direction) is defined to be positive.

[0036] Note that the reference numeral **34** denotes a projection line of a camber line of the blade perpendicular to the meridional cross section **30**. An angle γZ made by the above-described projection line **33** and the Z-axis (parallel line Z' translated onto the meridional cross section **30**) is defined as an axial tilt angle of the blade projected onto the meridional cross section **30**.

[0037] The shape of the blade **22** will be described next. FIG. **5** is a diagram illustrating the intake port of the impeller as seen from the axial direction. FIG. **6** is a schematic view illustrating the shape of the leading edge of the blade of the impeller. As shown in FIG. **6**, the leading edge **22**A is formed in a curved manner so as to project more on the inner wall surface **21**A side of the shroud **21** than on a inner wall surface **20**A side of the hub **20**. Specifically, the camber line **32** of the leading edge **22**A curves in such a manner that the inclination angle γθ with respect to the projection line **33** formed on the above-described meridional cross section **30** (FIG. **3**) is approximately zero or positive on the hub **20** side and gradually increasing toward the shroud **21**. In such a configuration, the shroud **21** side of the leading edge **22**A of the blade **22** inclines in the counter-rotating direction. Thus, a pressure surface P of the blade **22** is disposed so as to face the inner wall surface **21**A of the shroud **21**. Furthermore, since the inclination angle γθ gradually increases toward the shroud **21**, the leading edge **22**A inclines more on the shroud **21** side, thus facing the inner wall surface **21**A of the shroud **21** in a larger degree. Consequently, gradually toward the shroud **21**, force F generated by the pressure surface P of the blade **22** is headed to the inner wall surface **21**A of the shroud **21**. Note that the curve of the leading edge **22**A may be a curve along a single arc or a curve made by a combination of arcs.

[0038] According to this configuration, the inclination angle γθ of the leading edge **22**A in the blade **22** is zero or positive on the hub **20** side and gradually increasing toward the shroud **21**. Thus, the pressure surface P of the blade **22** faces the inner wall surface **21**A of the shroud **21** in a portion of the blade **22** from the leading edge **22**A to the first half thereof in a flow direction. Consequently, a boundary layer **35** is pressed against the inner wall surface **21**A of the shroud **21** by the force F of the pressure surface P of the blade **22**, thereby suppressing the development of the boundary layer **35**. On a suction surface S side of the blade **22**, a boundary layer **35** generated on the suction surface S is pressed against the suction surface S by centrifugal force F**1**, thereby preventing its movement toward the shroud **21** and thus suppressing the development of the boundary layer **35**.

[0039] The trailing edge **22**B side of the blade **22** will be described next. FIG. **7** is a diagram illustrating the blowoff port of the impeller as seen from the radial direction. FIG. **8** is a diagram illustrating the blowoff port as seen from the axial direction. FIG. **9** is a schematic view illustrating the shape of the trailing edge of the blade of the impeller. Unlike the leading edge **22**A side, the trailing edge **22**B side of the blade **22** is formed in such a manner that the inclination angle γθ of the camber line **32** with respect to the projection line **33** is approximately zero or positive. Such a positive value is preferably closer to zero. A region between the leading edge **22**A and the trailing edge **22**B in the blade **22** is formed in such a manner that the inclination angle γθ gradually decreases (becomes closer to zero) along the flow direction of the fluid. In this configuration, the trailing edge **22**B of the blade **22** erects generally perpendicular to the inner wall surface **20**A of the hub **20** and the inner wall surface **21**A of the shroud **21**, thereby making its height (length) in the direction of the axis line L the shortest distance. Thus, an amount of wake flow due to the thickness of the trailing edge **22**B of the blade **22** can be minimized.

[0040] Effects of the present embodiment will be described next. FIG. **10** is an experimental measurement diagram showing changes in the development of the boundary layers due to the shapes of the blades in the conventional technique and the present embodiment. In FIG. **10**, A to C show changes in the boundary layer in the configuration using the conventional blade **100** (FIGS. **11** and **12**). D to F show changes in the boundary layer in the configuration using the blade **22** of the present embodiment. Specifically, A and D each illustrate an amount of the boundary layer at a position before the outflow port of the impeller. Moreover, B and E each illustrate an amount of the boundary layer in midstream to the outflow port of the impeller. Furthermore, C and F each illustrate an amount of the boundary layer in a middle portion of the length of the blade in the flow direction.

[0041] In the conventional configuration, an amount of the boundary layer **109** (a portion with a particularly large pressure loss in an accumulated development portion of the boundary layer) increases along the flow direction of the fluid (C→B→A). In the present embodiment, on the other hand, while an amount of the boundary layer **35** (a portion with a particularly large pressure loss in an accumulated development portion of the boundary layer) slightly increases along the flow direction of the fluid (F→E→D), the amount of the boundary layer is reduced significantly as compared to the conventional configuration. Thus, it can be understood that the growth of the boundary layer (the portion with a particularly large pressure loss in the accumulated development portion of the boundary layer) can be suppressed.

[0042] As described above, the impeller **6** according to the present embodiment is configured to include the hub **20**, the shroud **21**, and the plurality of blades **22** disposed between the hub **20** and the shroud **21** and blow out the fluid in the radial direction by the rotation of the rotary shaft **5** fixed to the hub **20**. When the angle made by the projection line **33** that is obtained by projecting the camber line **32** of the blade **22** onto the predetermined meridional cross section **30** and the camber line **32** is defined as the inclination angle $\gamma\theta$ and an inclination in the direction opposite to the rotating direction of the rotary shaft **5** is defined to be positive, the inclination angle $\gamma\theta$ of the leading edge **22**A in the blade **22** is zero or positive on the hub **20** side and gradually increasing toward the shroud **21**. Thus, the pressure surface P of the blade **22** faces the inner wall surface **21**A of the shroud **21** in the portion of the blade **22** from the leading edge **22**A to the first half thereof. Consequently, the boundary layer **35** is pressed against the inner wall surface **21**A of the shroud **21** by the force F of the pressure surface P of the blade **22**, thereby suppressing the development of the boundary layer **35**. On the suction surface S of the blade **22**, the boundary layer **35** is pressed against the suction surface S by the centrifugal force F**1**, thereby preventing its movement toward the shroud **21** and thus suppressing the development of the boundary layer **35**.

[0043] Furthermore, in the flow direction of the fluid, the blade **22** is formed in such a manner that the inclination angle $\gamma\theta$ is gradually decreasing from the leading edge **22**A toward the trailing edge **22**B. Consequently, the surface area of the blade **22** in the latter half of the blade **22** is reduced, and thus the amount of the boundary layer developed over the blade surface in the latter half of the blade **22** can be reduced. This can suppress the generation of the energy deficit portion on the blade outlet side, thereby allowing the performance of the impeller **6** to be fulfilled sufficiently.

[0044] Moreover, the inclination angle $\gamma\theta$ of the trailing edge **22**B in the blade **22** is zero or positive over the region from the hub **20** side to the shroud **21** side according to the present embodiment. Thus, the height (length) of the trailing edge **22**B of the blade **22** in the direction of the axis line L can be made the shortest distance. Consequently, the amount of the wake flow due to the thickness of the trailing edge **22**B of the blade **22** can be minimized. Furthermore, the reduced surface area of the blade **22** in the latter half of the blade **22** can significantly reduce the amount of the boundary layer developed over the blade surface in the latter half of the blade **22** as compared to the conventional technique.

[0045] Moreover, the provision of the above-described impeller **6** in the centrifugal compressor **1** of the present embodiment can suppress the generation of the energy deficit portion on the outlet side of the blade **22**, thus improving the compression efficiency of the centrifugal compressor **1**.

[0046] While the embodiment of the present invention has been described above, the present invention is not limited by the above details. For example, the above-described embodiment has described the configuration in which the inclination angle $\gamma\theta$ of the trailing edge **22**B in the blade **22** is zero or positive over a region from the hub **20** side to the shroud **21** side. However, the inclination angle $\gamma\theta$ of the trailing edge in the blade **22** may be zero or positive on the hub **20** side and may be gradually increasing toward the shroud **21**. According to such a configuration, the pressure surface P of the blade **22** faces the inner wall surface **21**A of the shroud **21** also in the latter half of the blade **22**. Consequently, the boundary layer **35** is pressed against the shroud **21** by the force of the pressure surface P of the blade **22**, thereby suppressing the development of the boundary layer **35** more effectively.

[0047] Moreover, the leading edge **22**A of the blade **22**, when projected onto the meridional cross section, has the shape in which the hub **20** and the shroud **21** are generally straight lines in the above-described embodiment. However, the present invention is not limited thereto. The leading edge **22**A may have a protruding shape protruded toward the upstream side in the flow direction of the fluid between the hub **20** and the shroud **21**. According to such a configuration, the area of a portion of the leading edge **22**A of the blade **22** facing the shroud **21** can be increased, thereby more effectively suppressing the development of the boundary layer **35** accordingly.

[0048] Moreover, while the leading edge of the blade **22** in the present embodiment is configured such that the inclination angle $\gamma\theta$ curves with a gradually larger degree from the hub **20** side toward the shroud **21**, the present invention is not limited thereto. The inclination may be configured to increase (bend) sharply so as to turn outwardly (configuration provided with a discontinuous portion somewhere in the span direction). In this case, not a single but a plurality of bent portions (discontinuous portions) may be provided.

[0049] Moreover, while the impeller **6** in the present embodiment is provided in the two-stage centrifugal compressor **1**, the impeller **6** can be applied to a single-stage centrifugal compressor or a multistage centrifugal compressor including three or more stages as long as the compressor includes an impeller.

REFERENCE SIGNS LIST

[0050] **1** centrifugal compressor
[0051] **2** casing
[0052] **5** rotary shaft
[0053] **6** impeller (rotary impeller)
[0054] **6**A intake port
[0055] **6**B blowoff port
[0056] **10** suction port
[0057] **10**A suction space
[0058] **11** intake passage
[0059] **12** vaneless diffuser
[0060] **14** return bend
[0061] **15** return vane
[0062] **16** scroll
[0063] **17** discharge port
[0064] **18** balance piston
[0065] **20** hub
[0066] **20**A inner wall surface
[0067] **21** shroud
[0068] **21**A inner wall surface
[0069] **22** blade
[0070] **22**A leading edge
[0071] **22**B trailing edge
[0072] **30** meridional cross section
[0073] **32** camber line
[0074] **33** projection line

[0075] **35** boundary layer (a portion with a particularly large pressure loss in an accumulated development portion of the boundary layer)

[0076] **100** blade

[0077] **101** intake port

[0078] **102** leading edge

[0079] **103** camber line

[0080] **104** straight line

[0081] **105** wall surface

[0082] **106** wall surface

[0083] **107** blowoff port

[0084] **108** trailing edge

[0085] **109** boundary layer (a portion with a particularly large pressure loss in an accumulated development portion of the boundary layer)

[0086] L axis line

[0087] O origin point

[0088] P pressure surface

[0089] S suction surface

[0090] Z' parallel line

[0091] r straight line

[0092] γθ inclination angle

1. A centrifugal impeller comprising: a hub; a shroud; and a plurality of blades disposed between the hub and the shroud, the centrifugal impeller blowing out fluid in a radial direction by rotation of a rotary shaft fixed to the hub, wherein

when an angle made by a projection line that is obtained by projecting a camber line of the blade onto a predetermined meridional cross section and the camber line is defined as an inclination angle and an inclination in a direction opposite to a rotating direction of the rotary shaft is defined to be positive,

the blade is formed in such a manner that the inclination angle of a leading edge is zero or positive on a hub side and gradually increasing toward the shroud and the inclination angle is gradually decreasing from the leading edge toward a trailing edge in a flow direction, and

the inclination angle of the trailing edge in the blade is zero or positive on the hub side and gradually increasing toward the shroud.

2. (canceled)

3. The centrifugal impeller according to claim **1**, wherein the inclination angle of the trailing edge in the blade is zero or positive over a region from the hub side to the shroud side.

4. The centrifugal impeller according to claim **1**, wherein the leading edge of the blade, when projected onto the meridional cross section, has a linear shape from the hub side to the shroud side or a shape protruded toward an upstream side of the flow direction between the hub side and the shroud side.

5. A centrifugal compressor comprising the centrifugal impeller according to claim **1**.

6. The centrifugal impeller according to claim **3**, wherein the leading edge of the blade, when projected onto the meridional cross section, has a linear shape from the hub side to the shroud side or a shape protruded toward an upstream side of the flow direction between the hub side and the shroud side.

7. A centrifugal compressor comprising the centrifugal impeller according to claim **3**.

8. A centrifugal compressor comprising the centrifugal impeller according to claim **4**.

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