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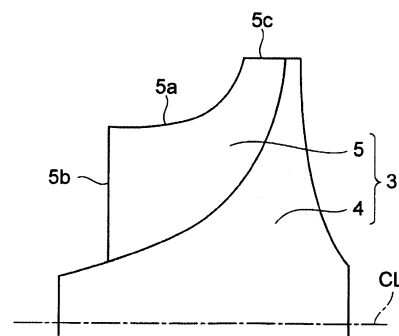
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(54) **COMPRESSOR**

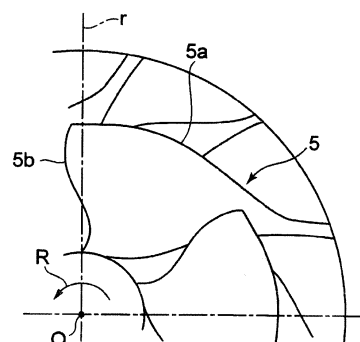
(57) A compressor (1) that compresses a gas that flows in from the axial direction and discharges the gas in the radial direction or in a direction that is diagonal with respect to the axial direction includes: a rotating shaft (2); an impeller (3) that rotates together with the rotating shaft; and a compressor housing (6) that rotatably accommodates the impeller. The impeller includes: a hub (4) that is fixed to the rotating shaft and a plurality of main blades (5) that are provided so as to protrude from the hub. A leading edge (5b) of each of the main blades, when the impeller is viewed from the axial direction, at a position that is at least 50% of the length (L) of the blades that extend outward in the radial direction, is inclined to a rotation direction side with respect to the radial direction outward in the radial direction.

FIG.3

(a)



(b)



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to compressors such as centrifugal compressors and mixed flow compressors.

BACKGROUND

[0002] Conventionally, as compressors of turbochargers used for engines of automobiles and ships, centrifugal compressors each of which compresses a gas that flows in from an axial direction and discharges the gas in a radial direction and mixed flow compressors each of which compresses a gas that flows in from an axial direction and discharges the gas in a direction that is diagonal with respect to the axial direction have been known.

[0003] For instance, in Patent Document 1, a centrifugal compressor including a main blade that is curved in an arch form in a direction reverse to a rotation direction in an axial view of an impeller for enabling performance improvement of the compressor is disclosed by the present inventor.

Citation List

Patent Literature

[0004] Patent Document 1: JPA2004-44473

SUMMARY

Technical Problem

[0005] The present inventor found out that the centrifugal compressor described in Patent Document 1 has a problem in which, as described later, a shock wave is developed during high-speed operation of an impeller caused by a leading edge shape of a main blade, and performance may be degraded in a high-speed rotation region.

[0006] The present invention was made in view of the above-described conventional problem, and aims at providing a compressor capable of improving performance in a high-speed rotation region by devising a leading edge shape of a main blade to suppress the development of a shock wave generated during high-speed operation

Solution to Problem

[0007] At least one embodiment of the present invention is

a compressor that is configured to compress a gas that flows in from an axial direction and discharge the gas in a radial direction or in a direction that is diagonal with respect to the axial direction comprising:

a rotary shaft;

an impeller that is configured to rotate with the rotary shaft; and

a compressor housing that is configured to rotatably accommodate the impeller, wherein

the impeller includes a hub that is fixed to the rotary shaft and a plurality of main blades that are provided by being protruded from the hub, and

a leading edge of each of the main blades, when the impeller is viewed from the axial direction, at a position that is at least 50% of a blade length extending outward in a radial direction, is inclined to a rotation direction side with respect to the radial direction outward in the radial direction.

[0008] In the compressor, a leading edge of each of the main blades, when the impeller is viewed from the axial direction, at a position that is at least 50% of the blade length, is inclined to a rotation direction side with respect to the radial direction outward in the radial direction. Therefore, as described later, a shock wave generated during high-speed operation of the impeller may be suppressed and performance of the compressor in a high-speed rotation region may be improved.

[0009] In some embodiments, a leading edge of each of the main blades, in a range of at least 40% to 80% of the blade length, is inclined to a rotation direction side with respect to the radial direction outward in the radial direction.

[0010] In the embodiments, a maximum inclination angle in a range of 40% to 80% of the blade length is in a range of 3 to 20 degrees with respect to the radial direction.

[0011] According to such a configuration, a shock wave generated during high-speed operation of the impeller may be effectively suppressed and performance of the compressor in a high-speed rotation region may be improved.

[0012] In some embodiments, a leading edge of each of the main blades, when the impeller is viewed from the axial direction, at an end part inside in the radial direction, is inclined to a rotation direction side with respect to the radial direction inward in the radial direction.

[0013] According to such a configuration, while performance of the compressor is improved in a high-speed rotation region, a connection length between a main blade and a hub may be secured long, and stress concentration at a root part of the main blade may be relaxed.

[0014] In some embodiments, a leading edge of each of the main blades, when the impeller is viewed from the axial direction, at an end part outside in the radial direction, is inclined to a direction opposite to a rotation direction with respect to the radial direction outward in the radial direction.

[0015] According to such a configuration, since, while performance of the compressor is improved in a high-speed rotation region, sharpness at a tip part of the main blade may be eased and rigidity at the tip part of the main

blade may be enhanced, vibration generated at the tip part of the main blade may be suppressed.

[0016] In some embodiments, a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at a position that is at least 50% of a blade height extending to a shroud side of the compressor housing, is inclined to an upstream side with respect to an axis perpendicular direction toward the shroud side.

[0017] According to such a configuration, as described later, development of a shock wave generated during high-speed operation of the impeller may be suppressed, and performance of the compressor in a high-speed rotation region may be improved.

[0018] In some embodiments, a leading edge of each of the main blades, in a range of 40% to 80% of the blade height, is continuously inclined to an upstream side with respect to an axis perpendicular direction toward the shroud side.

[0019] A maximum inclination angle in the range of 40% to 80% of the blade height is in a range of 10 to 30 degrees with respect to an axis perpendicular direction.

[0020] According to such a configuration, development of a shock wave generated during high-speed operation of the impeller may be effectively suppressed, and performance of the compressor in a high-speed rotation region may be improved.

[0021] In some embodiments, a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at an end part of a hub side, is inclined to an upstream side with respect to an axis perpendicular direction toward the hub side.

[0022] According to such a configuration, while performance of the compressor is improved in a high-speed rotation region, a connection length between a main blade and a hub may be secured long, and stress concentration at a root part of the main blade may be relaxed.

[0023] In some embodiments, a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at an end part on the shroud side, is inclined to a lower stream side with respect to an axis perpendicular direction toward the shroud side.

[0024] According to such a configuration, since, while performance of the compressor is improved in a high-speed rotation region, sharpness at a tip part of the main blade may be eased and rigidity at the tip part of the main blade may be enhanced, vibration generated at the tip part of the main blade may be suppressed.

Advantageous Effects

[0025] According to at least one embodiment of the present invention, a leading edge of each of the main blades, when the impeller is viewed from the axial direction, at a position that is at least 50% of the blade length, is inclined to a rotation direction side with respect to the radial direction outward in the radial direction. Therefore, a compressor capable of suppressing development of a

shock wave generated during high-speed operation and improving performance in a high-speed rotation region may be provided.

BRIEF DESCRIPTION OF DRAWINGS

[0026]

Fig. 1 is a view illustrating a compressor associated with one embodiment.

Fig. 2 is a perspective view illustrating an impeller of a compressor associated with one embodiment.

Fig. 3 is a partially enlarged view illustrating an impeller of a compressor associated with one embodiment, (a) is a meridional plane view viewed from a meridional plane direction, and (b) is a plan view viewed from an axial direction.

Fig. 4 is an explanatory drawing illustrating a planar shape of a leading edge of a main blade.

Fig. 5 is an explanatory drawing for explaining an effect when a leading edge of a main blade is made to be inclined to a rotation direction side with respect to the radial direction outward in the radial direction.

Fig. 6 is a perspective view illustrating an impeller of a compressor associated with one embodiment.

Fig. 7 is a partially enlarged view illustrating an impeller of a compressor associated with one embodiment, (a) is a meridional plane view viewed from a meridional plane direction, and (b) is a plan view viewed from an axial direction.

Fig. 8 is an explanatory drawing illustrating a meridional shape of a leading edge of a main blade.

Fig. 9 is an explanatory drawing for explaining an effect when a leading edge of a main blade is made to be inclined to an upstream side with respect to the axial perpendicular direction toward the shroud side.

DETAILED DESCRIPTION

[0027] Below, embodiments of the present invention will be described according to the attached drawings. However, dimensions of components, materials, shapes, relative placements, and such described in the embodiments are no more than simple examples and the scope of the invention is not intended to be limited to those. The same reference numerals are assigned to the same configuration and detailed descriptions may be omitted.

[0028] Fig. 1 is a view illustrating a compressor associated with one embodiment. Fig. 2 is a perspective view illustrating an impeller of a compressor associated with one embodiment.

[0029] As illustrated in Fig. 1, a compressor 1 is configured as a centrifugal compressor 1 that compresses a gas that flows in an axial direction of the compressor and discharge the gas in a radial direction. The centrifugal compressor 1 includes: a rotary shaft 2; an impeller 3 provided at a one end part of the rotary shaft 2; and a compressor housing 6 that rotatably accommodates the

impeller 3.

[0030] The rotary shaft is rotatably supported by an unillustrated bearing and is rotatably configured about a center line CL as a center.

[0031] The impeller 3 includes: a conical hub fixed at one end part of the rotary shaft 2; and a plurality of main blades 5 provided by being protruded from a surface of the hub 4. The impeller 3, as illustrated in Fig. 2, may include splitter blades 7 that are formed between the neighboring main blades 5, 5 and are shorter than the main blades 5 in the axial direction. Between the main blades 5 and the splitter blades 7 (when there are no splitter blades 7, between the neighboring main blades 5, 5), flow path 11 through which a gas flows are formed.

[0032] The compressor housing 6, as illustrated in Fig. 1, includes: an inlet flow path 12 that introduces a gas in the axial direction; a diffuser flow path 14 through which a compressed gas is discharged by the impeller 3; and a scroll flow path 16 through which the compressed gas is guided to an outside of the housing. The impeller 3 is so formed that a blade tip 5a of each of the main blades 5 follows an inner circumferential shape of a shroud part 18, and is rotatably accommodated in the compressor housing 6. By the impeller 3 being rotated in high speed, a gas flowing in from leading edges 5b flows through the flow path 11 and is accelerated, and flows out from trailing edges 5c to the diffuser flow path 14.

[0033] Fig. 3 is a partially enlarged view illustrating an impeller of a compressor associated with one embodiment, (a) is a meridional plane view viewed from a meridional plane direction, and (b) is a plan view viewed from an axial direction.

[0034] A leading edge 5b of each of the main blades 5, as illustrated in Fig. 3 (a), is extended in a direction orthogonal to a center line CL in a meridional plane view. On the other hand, as illustrated in Fig. 3 (b), a leading edge 5b of each of the main blades 5, in a plan view, is inclined to a rotation direction R side with respect to a radial direction r outward in the radial direction in a neighborhood of a center part of the leading edge 5b. A planar shape, when a leading edge 5b of each of the main blades 5 is viewed from the axial direction, is described in detail with reference to Fig. 4.

[0035] Fig. 4 is an explanatory drawing illustrating a planar shape of a leading edge of a main blade.

[0036] As illustrated in Fig. 4, a planar shape of the leading edge 5b, when a blade length of the leading edge 5b extending to an outside in the radial direction is denoted as L, is such that a most backward point P1 is formed at a position of 0.2 L outward in the radial direction. A most forward point P2 is formed at a position of 0.8 L outward in the radial direction. In a range of 20 to 80% (0.2 to 0.8 L) of the blade length L, the leading edge 5b is inclined at a maximum inclination angle $\theta 1$ to the rotation direction R side with respect to the radial direction r outward in the radial direction.

[0037] In this way, when a certain range of a center part of the leading edge 5b is inclined to the rotation di-

rection R side with respect to the radial direction r outward in the radial direction, as described below, development of a shock wave generated during high-speed operation of the impeller 3 may be suppressed, and performance of the compressor 1 in a high-speed rotation region may be improved.

[0038] Fig. 5 is an explanatory drawing for explaining an effect when a leading edge of a main blade is made to be inclined to a rotation direction side with respect to the radial direction outward in the radial direction, (a) illustrates a case where the leading edge is parallel to the radial direction (reference example), and (b) illustrates a case where the leading edge is inclined with respect to the radial direction (embodiment example).

[0039] An arrow V in the figure represents a gas flow direction, and a length of the arrow V means a magnitude of flow velocity. With high-speed rotation of the impeller 3, relative flow velocity between the main blades 5 and a gas becomes larger toward an outside in the radial direction. Therefore, the arrow V becomes longer toward the outside in the radial direction.

[0040] When the gas is accelerated in the flow path 11 of the impeller 3, the pressure is lowered by an amount caused by the flow velocity being increased, and a negative pressure region N is generated on a rear side of each of the main blades 5. When each leading edge 5b is extended in parallel to a radial direction, as illustrated in Fig. 5, the gas simultaneously collides with the entire leading edges 5b and flows through the flow path 11 almost in parallel. When the gas is accelerated in each of the flow path 11 and the flow velocity reaches a supersonic region, the negative pressure region N is expanded in an outside in the radial direction where the flow velocity is large and a shock wave M is generated. When such a shock wave M is generated, a shock wave loss is increased and compression efficiency is reduced.

[0041] On the other hand, when each leading edge 5b is inclined to the rotation direction R side with respect to the radial direction outward in the radial direction, as illustrated in Fig. 5 (b), the gas collides first with part of the leading edge 5b in an outside in the radial direction, where a negative pressure region N is generated. Then, a gas colliding with the leading edge 5b and flowing the flow path 11 later changes the flow direction so as to be absorbed by the negative pressure region N generated earlier. As a result, compared to a case illustrated in Fig. 5 (a), the expansion of the negative pressure region N is suppressed and reduction of the compression efficiency caused by the shock wave is avoided.

[0042] Concerning the reduction in the compression efficiency due to the shock wave, since a leading edge 5b of each of the main blades 5, when the impeller 3 is viewed from the axial direction, at a position that is at least 50% of the blade length L extending to an outside in the radial direction, is inclined to the rotation direction side R with respect to the radial direction outward in the radial direction, its effect may be expected.

[0043] It is preferable that a leading edge 5b of each

of the main blades 5 is inclined to the rotation direction R side with respect to the radial direction outward in the radial direction in a range of at least 40% to 80% of the blade length L. When the maximum inclination angle θ_1 in a range of 40% to 80% of the blade length L is in a range of 3 to 20 degrees with respect to the radial direction, the shock wave generated during high-speed operation of the impeller 3 may be effectively suppressed.

[0044] As illustrated in Fig. 4, a leading edge 5b of each of the main blades 5, when the impeller 3 is viewed from the axial direction, at an end part inside in the radial direction (for instance, as illustrated in Fig. 4, in a range of 0.0 to 0.2 L), is inclined to the rotation direction R side with respect to the radial direction inward in the radial direction.

[0045] According to such a configuration, while performance of the compressor 1 in a high-speed rotation region is improved, a connection length between the main blades 5 and the hub 4 may be secured long. Thus, overhung may be relaxed and stress concentration at a root part of the main blades 5 may be relaxed.

[0046] As illustrated in Fig. 4, a leading edge 5b of each of the main blades 5, when the impeller 3 is viewed from the axial direction, at an end part outside in the radial direction (0.8 L to 1.0 L), is inclined to a reverse side of the rotation direction with respect to the radial direction outward in the radial direction.

[0047] According to such a configuration, while performance of the compressor 1 in a high-speed rotation region is improved, sharpness at a tip part of each of the main blades 5 may be eased and the rigidity at the tip part of each of the main blades 5 may be enhanced. Thus a vibration generated at the tip part of each of the main blades 5 may be suppressed.

[0048] Next, an impeller associated with another one embodiment is described with reference to Fig. 6 to Fig. 9.

[0049] Fig. 6 is a perspective view illustrating an impeller of a compressor associated with one embodiment. Fig. 7 is a partially enlarged view illustrating an impeller of a compressor associated with one embodiment, (a) is a meridional plane view viewed from a meridional plane direction, and (b) is a plan view viewed from an axial direction. Fig. 8 is an explanatory drawing illustrating a meridional shape of a leading edge of a main blade.

[0050] The impeller 3 associated with the present embodiment is basically similar to the above-described embodiment, and the same reference numerals are assigned to the same configuration and detailed descriptions may be omitted.

[0051] Concerning the impeller 3 of the present embodiment, as illustrated in Fig. 7 (b), a planar shape of a leading edge 5b of each of the main blades 5 has a shape similar to the above-described embodiment and, as illustrated in Fig. 7 (a), the leading edge 5b in a meridional plane view at a neighborhood of the center part is inclined to an upstream side with respect to an axial perpendicular direction p toward the shroud side.

[0052] As is illustrated in detail in Fig. 8, concerning a

meridional plane shape of the leading edge 5b, when a blade height of the leading edge 5b extending to the shroud side is denoted as H, a most backward point P1 is formed at a position of 0.2 H toward the shroud side.

5 The most forward point P2 is formed at a position of 0.8 H toward the shroud side. A range of the blade height H of 20 to 80% (0.2 to 0.8 H) is inclined at a maximum inclination angle θ_2 to the upstream side with respect to the axial perpendicular direction p toward the shroud side.

10 **[0053]** Next, an effect of inclining a leading edge 5b of each of the main blades 5 to the upstream side with respect to the axial orthogonal direction p toward the shroud side is described with reference to Fig. 9.

15 Fig. 9 is an explanatory drawing for explaining an effect when a leading edge of a main blade is made to be inclined to an upstream side with respect to the axial orthogonal direction toward the shroud side, and is corresponding to Fig. 5 of the above-described embodiment.

20 Fig. 9 (a) illustrates a case where the leading edge is parallel to the axial orthogonal direction, and (b) illustrates a case where the leading edge is inclined with respect to the axial orthogonal direction. With high-speed rotation of the impeller 3, relative flow velocity between the main blades 5 and a gas becomes larger toward the shroud side from the hub side. Therefore, the arrow V becomes longer toward the shroud side from the hub side.

25 **[0054]** When the gas is accelerated in the flow path 11 of the impeller 3, the pressure is lowered by an amount caused by the flow velocity being increased, and a negative pressure region N is generated on a rear side of each of the main blades 5. When each leading edge 5b is extended in parallel to the axial orthogonal direction, as illustrated in Fig. 9, the gas simultaneously collides with the entire leading edges 5b and flows through the flow path 11 almost in parallel. When the gas is accelerated in each of the flow path 11 and the flow velocity reaches a supersonic region, the negative pressure region N is expanded in an outside in the radial direction where the flow velocity is large and a shock wave M is generated. When such a shock wave M is generated, a shock wave loss is increased and compression efficiency is reduced.

30 **[0055]** On the other hand, when each leading edge 5b is inclined to the shroud side with respect to the axial orthogonal direction outward in the radial direction, as illustrated in Fig. 9 (b), the gas collides first with part of the leading edge 5b on the shroud side, where a negative pressure region N is generated. Then, a gas colliding with the leading edge 5b and flowing the flow path 11 later changes the flow direction so as to be absorbed by the negative pressure region N generated earlier. As a result, compared to a case illustrated in Fig. 9 (a), the expansion of the negative pressure region N is suppressed and reduction of the compression efficiency caused by the shock wave is avoided.

35 **[0056]** Thus, by inclining a leading edge 5b of each of

the main blades 5 to the upstream side with respect to the axial orthogonal direction p toward the shroud side, in addition to an effect of devising a planar shape of the leading edge 5b of the above-described embodiment, expansion of the negative pressure region N may be further suppressed.

[0057] Concerning the reduction in the compression efficiency due to the shock wave, since a leading edge 5b of each of the main blades 5, when the impeller 3 is viewed from the meridional plane direction, at a position that is at least 50% of the blade height H extending to the shroud side, is inclined to the upstream side with respect to the axial orthogonal direction toward the shroud side, its effect may be expected.

[0058] It is preferable that a leading edge 5b of each of the main blades 5 is inclined to the upstream side with respect to the axial orthogonal direction toward the shroud side in a range of at least 40% to 80% of the blade height H. When the maximum inclination angle θ_2 in a range of 40% to 80% of the blade height H is in a range of 10 to 30 degrees with respect to the radial direction, the shock wave generated during high-speed operation of the impeller 3 may be effectively suppressed.

[0059] As illustrated in Fig. 8, a leading edge 5b of each of the main blades 5, when the impeller 3 is viewed from the meridional plane direction, at an end part of the hub side (for instance, as illustrated in Fig. 8, in a range of 0.0 to 0.2 H), is inclined to the upstream side with respect to the axial orthogonal direction to the hub side.

[0060] According to such a configuration, while performance of the compressor 1 in a high-speed rotation region is improved, a connection length between the main blades 5 and the hub 4 may be secured long. Thus, overhung may be relaxed and stress concentration at a root part of the main blades 5 may be relaxed.

[0061] As illustrated in Fig. 8, a leading edge 5b of each of the main blades 5, when the impeller 3 is viewed from the meridional plane direction, at an end part on the shroud side (0.8 H to 1.0 H), is inclined to a lower stream side with respect to the axial orthogonal direction toward the shroud side.

[0062] According to such a configuration, while performance of the compressor 1 in a high-speed rotation region is improved, sharpness at a tip part of each of the main blades 5 may be eased and the rigidity at the tip part of each of the main blades 5 may be enhanced. Thus a vibration generated at the tip part of each of the main blades 5 may be suppressed.

[0063] Although the embodiments of the present invention are described in detail, the present invention is not limited to the embodiments, and it goes without saying that various improvements and deformations may be performed within a range not deviating from the gist of the present invention. For instance, in the above-described embodiments, although examples of a case where the compressor 1 is a centrifugal compressor are described, the present invention is not limited to the embodiments, and the compressor 1 may be configured as a mixed flow

compressor that compresses a gas flowing in the axial direction and discharges the gas in a direction that is diagonal with respect to the axial direction.

5 Industrial Applicability

[0064] A compressor of at least one embodiment of the present invention is suitably used as a compressor of a turbocharger used for an engine of an automobile or a ship, for instance.

Reference Signs List

[0065]

- | | |
|-----|---------------------|
| 1: | compressor |
| 2: | rotary shaft |
| 3: | impeller |
| 4: | hub |
| 5: | main blade |
| 5a: | blade tip |
| 5b: | leading edge |
| 5c: | trailing edge |
| 6: | compressor housing |
| 7: | splitter blade |
| 11: | flow path |
| 12: | inlet flow path |
| 14: | diffuser flow path |
| 16: | scroll flow path |
| 18: | shroud part |
| P1: | most backward point |
| P2: | most forward point |
| L: | blade length |
| H: | blade height |

Claims

1. A compressor that is configured to compress a gas that flows in from an axial direction and discharge the gas in a radial direction or in a direction that is diagonal with respect to the axial direction comprising:
 - a rotary shaft;
 - an impeller that is configured to rotate with the rotary shaft; and
 - a compressor housing that is configured to rotatably accommodate the impeller, wherein the impeller includes a hub that is fixed to the rotary shaft and a plurality of main blades that are provided by being protruded from the hub, and
 - a leading edge of each of the main blades, when the impeller is viewed from the axial direction, at a position that is at least 50% of a blade length extending outward in a radial direction passing through a rotation center and the leading edge,

is inclined to a rotation direction side with respect to the radial direction outward in the radial direction.

2. A compressor according to Claim 1, wherein a leading edge of each of the main blades, in a range of at least 40% to 80% of the blade length, is inclined to a rotation direction side with respect to the radial direction outward in the radial direction. 5
3. A compressor according to Claim 2, wherein a maximum inclination angle in a range of 40% to 80% of the blade length is in a range of 3 to 20 degrees with respect to the radial direction. 10
4. A compressor according to any one of Claims 1 to 3, wherein a leading edge of each of the main blades, when the impeller is viewed from an axial direction, at an end part inside in the radial direction, is inclined to a rotation direction side with respect to the radial direction inward in the radial direction. 15 20
5. A compressor according to any one of Claims 1 to 4, wherein a leading edge of each of the main blades, when the impeller is viewed from an axial direction, at an end part outside in the radial direction, is inclined to a direction opposite to a rotation direction with respect to the radial direction outward in the radial direction. 25 30
6. A compressor according to any one of Claims 1 to 5, wherein a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at a position that is at least 50% of a blade height extending to a shroud side of the compressor housing, is inclined to an upstream side with respect to an axis perpendicular direction toward the shroud side. 35
7. A compressor according to Claim 6, wherein a leading edge of each of the main blades, in a range of 40% to 80% of the blade height, is continuously inclined to an upstream side with respect to an axis perpendicular direction toward the shroud side. 40 45
8. A compressor according to Claim 7, wherein a maximum inclination angle in the range of 40% to 80% of the blade height is in a range of 10 to 30 degrees with respect to an axis perpendicular direction. 50
9. A compressor according to any one of Claims 6 to 8, wherein a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at an end part of a hub side, is inclined to an upstream side with respect to an axis perpendicular direction toward the hub side. 55
10. A compressor according to any one of Claims 6 to

9, wherein a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at an end part on the shroud side, is inclined to a lower stream side with respect to an axis perpendicular direction toward the shroud side.

Amended claims under Art. 19.1 PCT

1. A compressor that is configured to compress a gas that flows in from an axial direction and discharge the gas in a radial direction or in a direction that is diagonal with respect to the axial direction comprising:

a rotary shaft;
 an impeller that is configured to rotate with the rotary shaft; and
 a compressor housing that is configured to rotatably accommodate the impeller, wherein the impeller includes a hub that is fixed to the rotary shaft and a plurality of main blades that are provided by being protruded from the hub, and
 a leading edge of each of the main blades, when the impeller is viewed from the axial direction, at a position that is at least 50% of a blade length extending outward in a radial direction passing through a rotation center and the leading edge, is inclined to a rotation direction side with respect to the radial direction outward in the radial direction.

2. A compressor according to Claim 1, wherein a leading edge of each of the main blades, in a range of at least 40% to 80% of the blade length, is inclined to a rotation direction side with respect to the radial direction outward in the radial direction.

3. A compressor according to Claim 2, wherein a maximum inclination angle in a range of 40% to 80% of the blade length is in a range of 3 to 20 degrees with respect to the radial direction.

4. A compressor according to any one of Claims 1 to 3, wherein a leading edge of each of the main blades, when the impeller is viewed from an axial direction, at an end part inside in the radial direction, is inclined to a rotation direction side with respect to the radial direction inward in the radial direction.

5. A compressor according to any one of Claims 1 to 4, wherein a leading edge of each of the main blades, when the impeller is viewed from an axial direction, at an end part outside in the radial direction, is inclined to a direction opposite to a rotation direction with respect

6. A compressor according to any one of Claims 1 to 5, wherein a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at a position that is at least 50% of a blade height extending to a shroud side of the compressor housing, is inclined to an upstream side with respect to an axis perpendicular direction toward the shroud side.

7. A compressor according to Claim 6, wherein a leading edge of each of the main blades, in a range of 40% to 80% of the blade height, is continuously inclined to an upstream side with respect to an axis perpendicular direction toward the shroud side.

8. A compressor according to Claim 7, wherein a maximum inclination angle in the range of 40% to 80% of the blade height is in a range of 10 to 30 degrees with respect to an axis perpendicular direction.

9. A compressor according to any one of Claims 6 to 8, wherein a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at an end part of a hub side, is inclined to an upstream side with respect to an axis perpendicular direction toward the hub side.

10. A compressor according to any one of Claims 6 to 9, wherein a leading edge of each of the main blades, when the impeller is viewed from a meridional plane direction, at an end part on the shroud side, is inclined to a lower stream side with respect to an axis perpendicular direction toward the shroud side.

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FIG.1

1

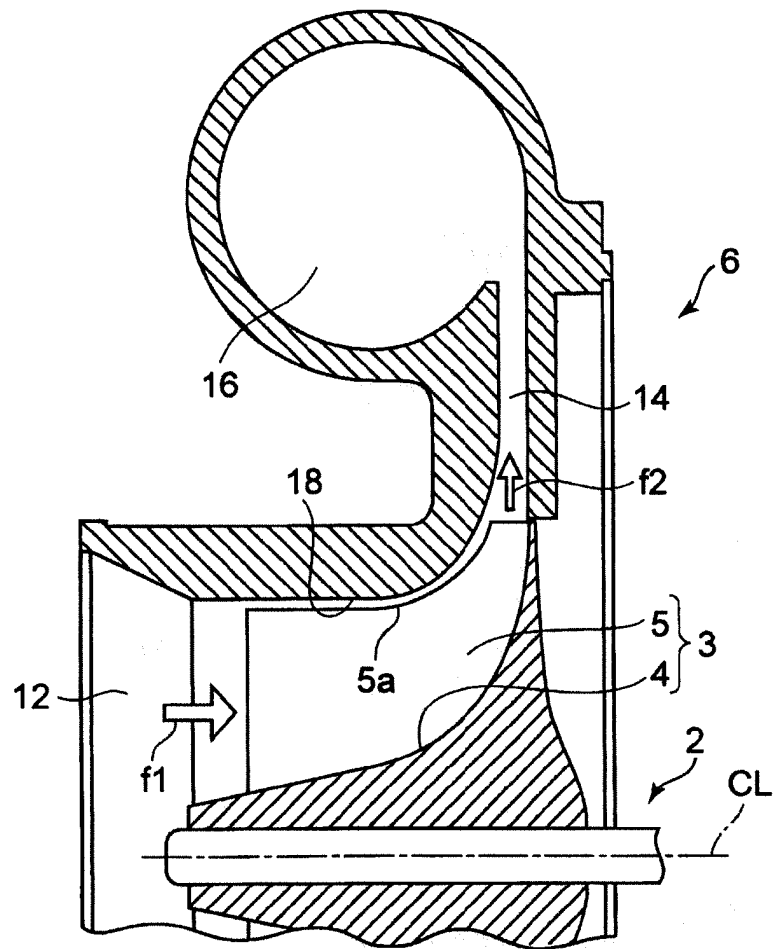


FIG.2

3

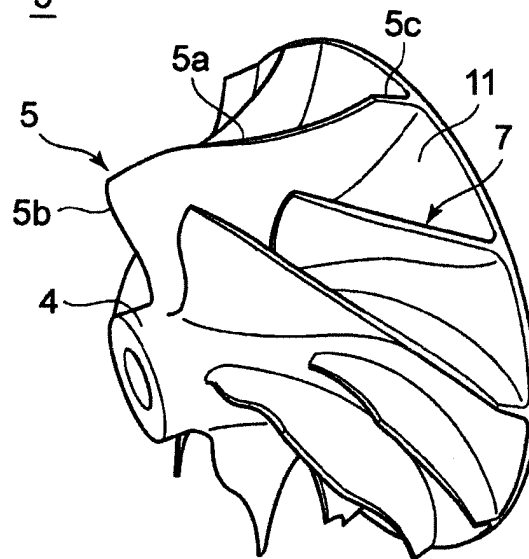
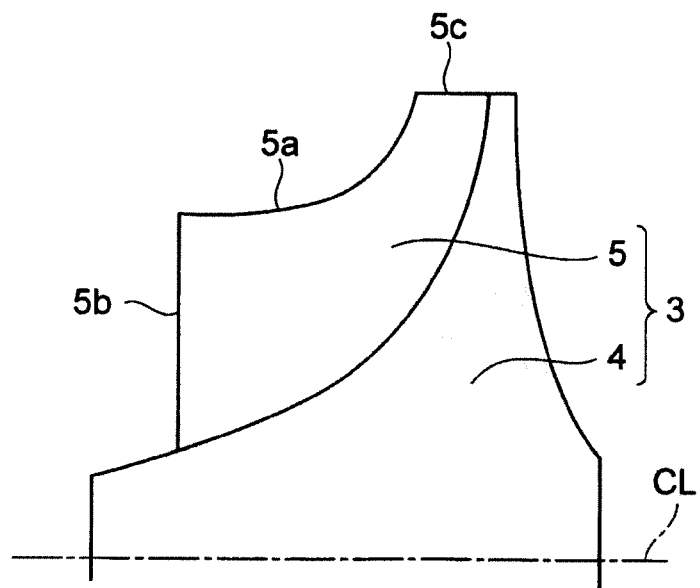


FIG.3

(a)



(b)

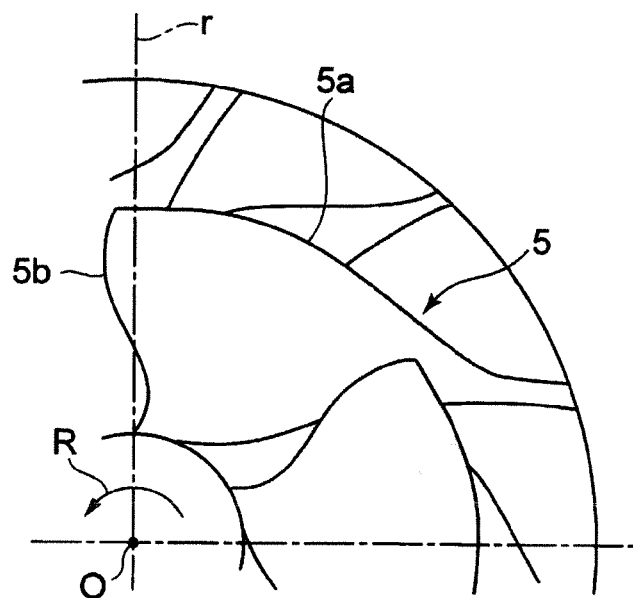


FIG.4

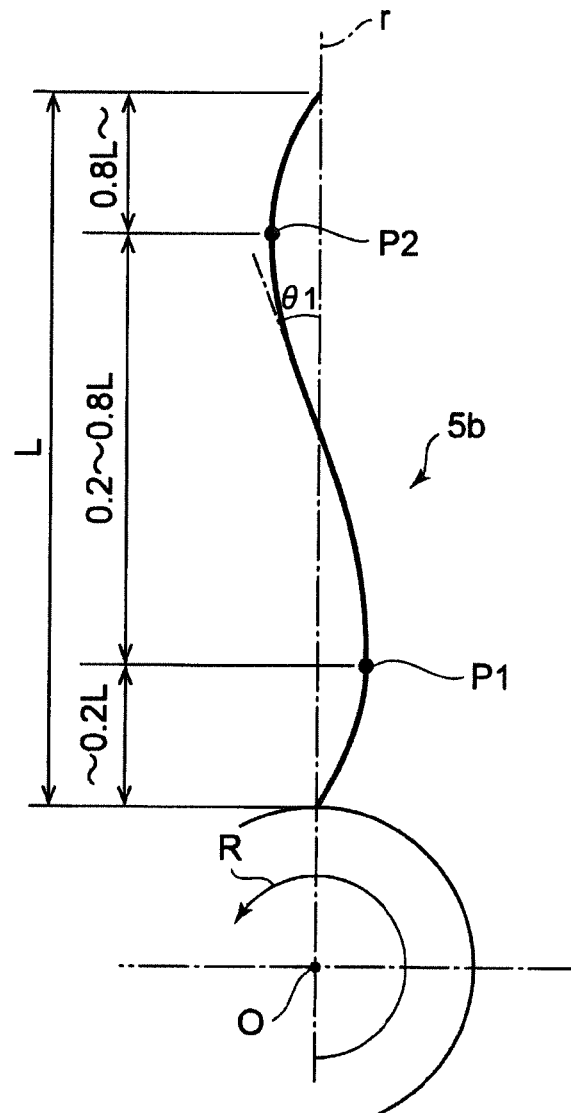


FIG.5

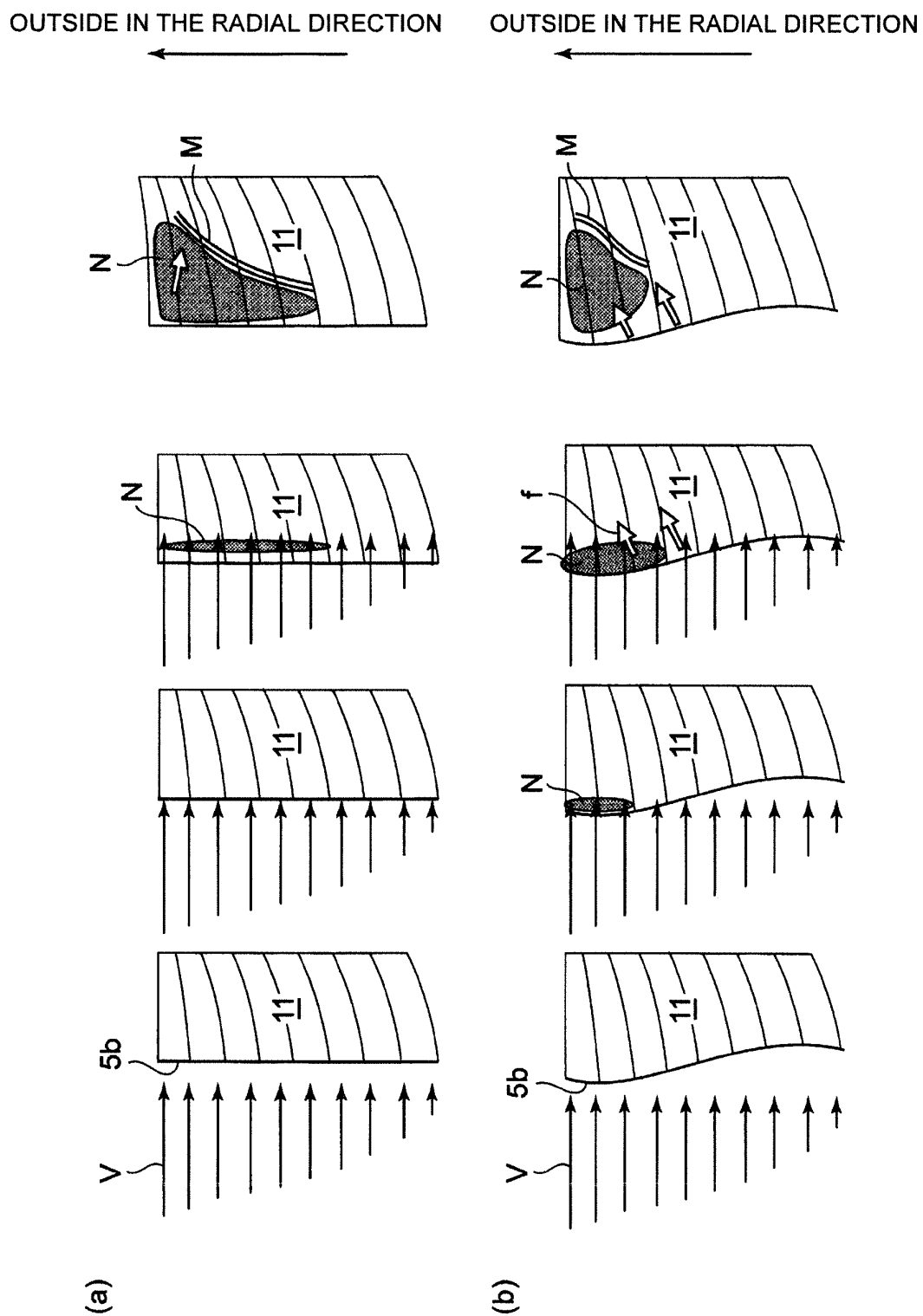


FIG.6

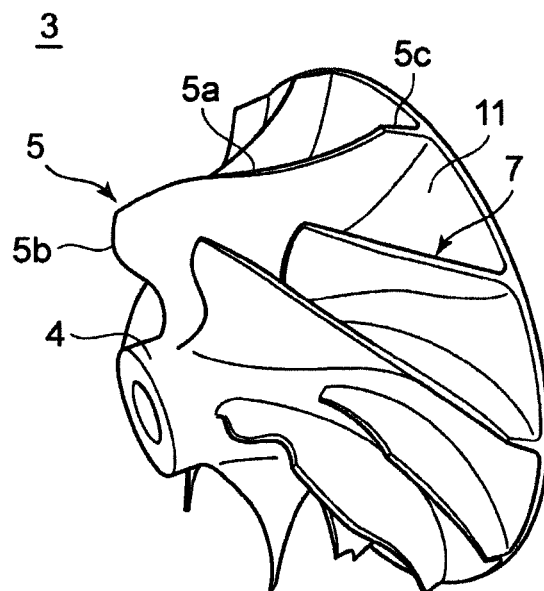
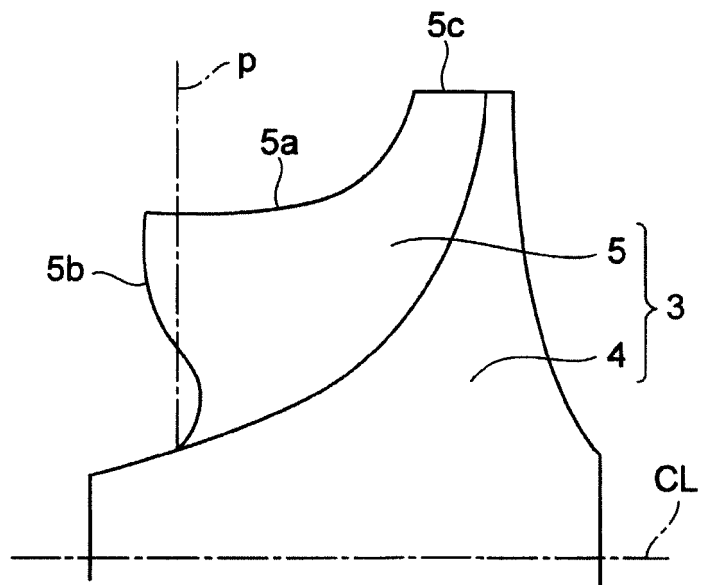


FIG.7

(a)



(b)

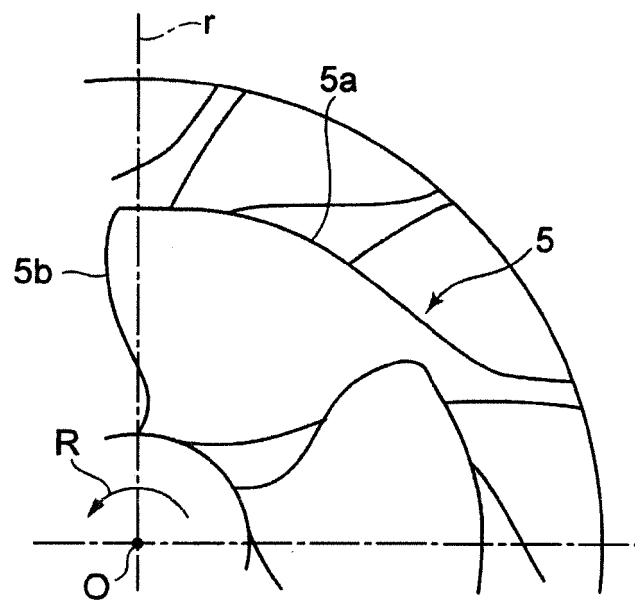


FIG.8

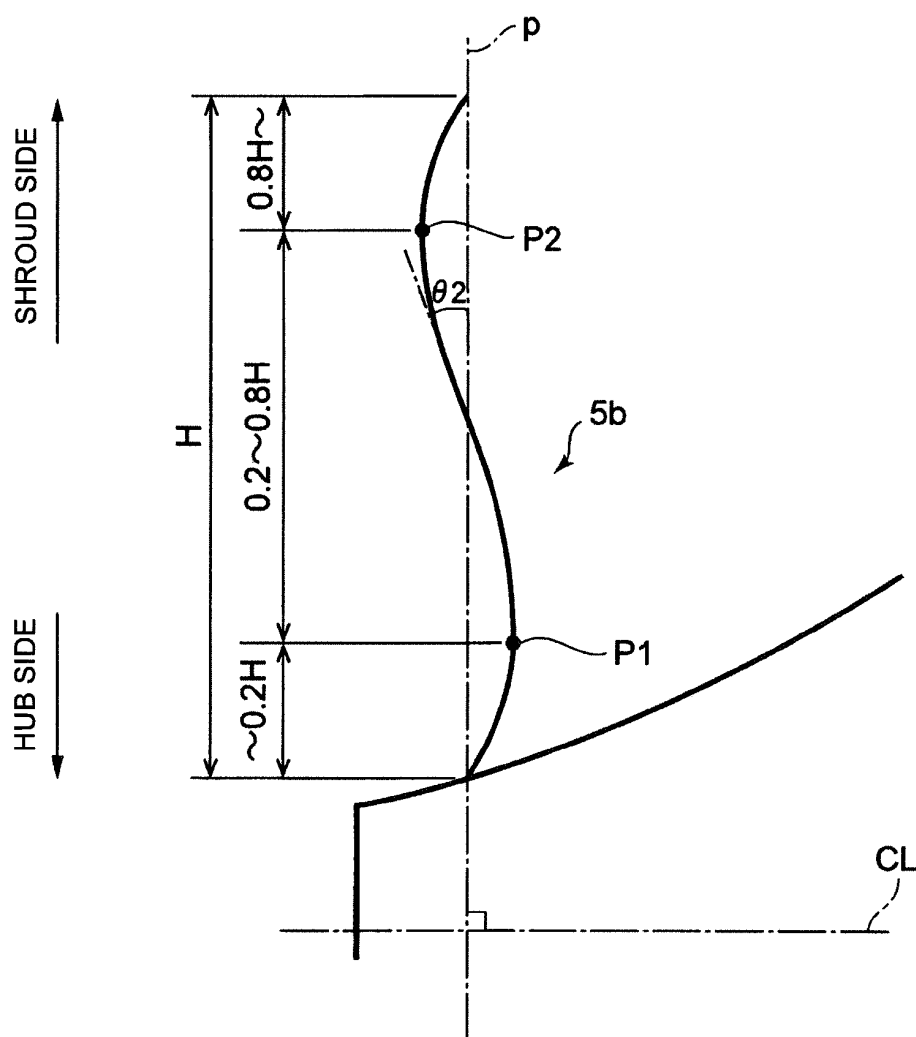
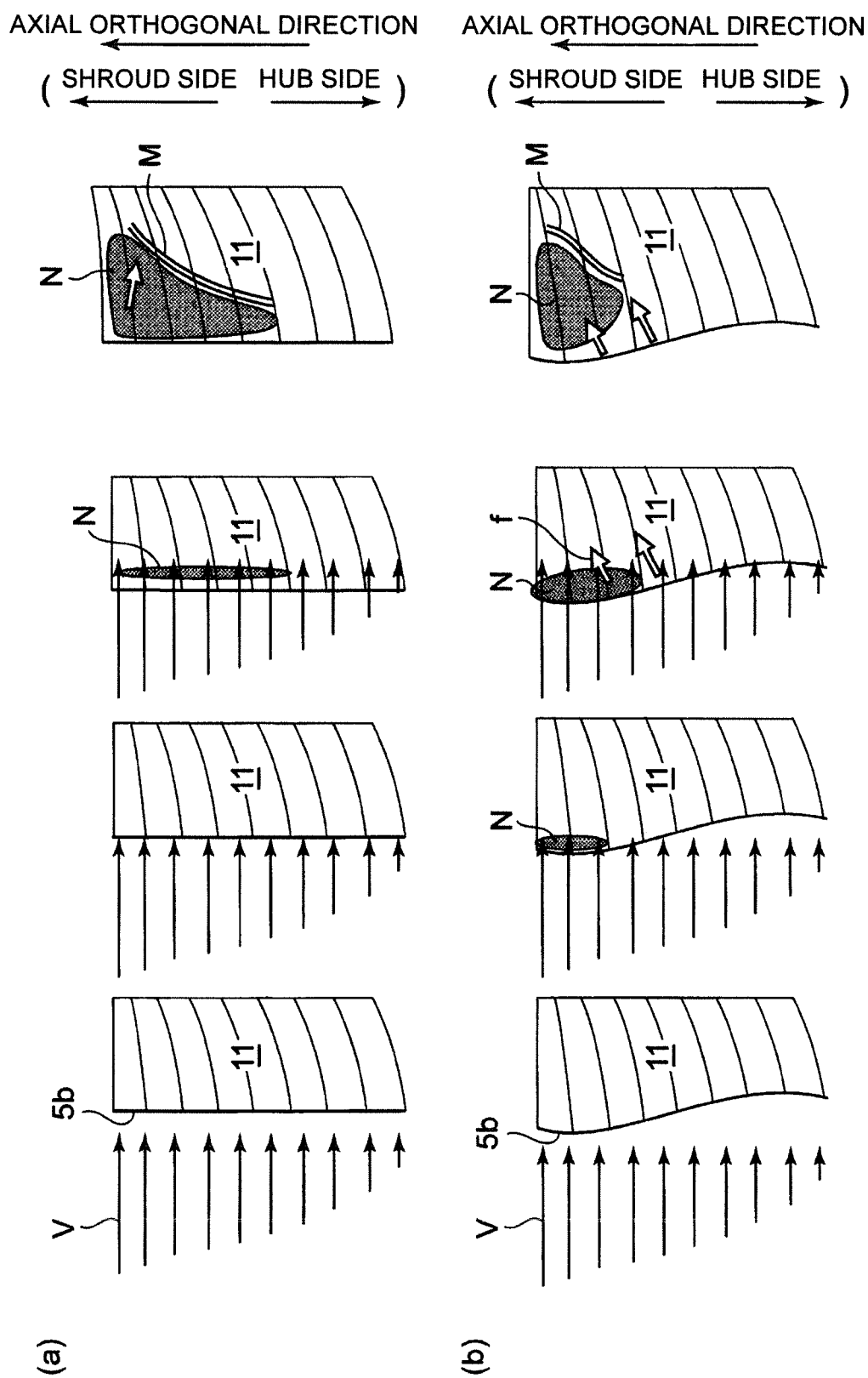


FIG.9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/074030

A. CLASSIFICATION OF SUBJECT MATTER

F04D29/30(2006.01)i, F04D21/00(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)

F04D29/30, F04D21/00

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 1996-2013

Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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 2004-52754 A (BorgWarner Inc.), 19 February 2004 (19.02.2004), fig. 1 & EP 1361008 A1 & US 6588485 B	1-10
X A	GB 2486019 A (DYSON TECHNOLOGY LTD.), 06 June 2012 (06.06.2012), fig. 7, 8 & WO 2012/072996 A1 & CN 102562652 A	1-5 6-10
A	JP 2012-52534 A (General Electric Co.), 15 March 2012 (15.03.2012), fig. 2 & US 2012/0051933 A1 & EP 2423511 A2 & CN 102410249 A	1-10

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 ☐ See patent family annex.

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Date of the actual completion of the international search
25 September, 2013 (25.09.13)Date of mailing of the international search report
08 October, 2013 (08.10.13)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/074030

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 152541/1986(Laid-open No. 60097/1988) (Mitsubishi Heavy Industries, Ltd.), 21 April 1988 (21.04.1988), fig. 2 (Family: none)	1-10
A	JP 2013-508618 A (General Electric Co.), 07 March 2013 (07.03.2013), fig. 4 & US 2013/0195608 A1 & WO 2011/053278 A1	1-10
A	JP 2009-228549 A (IHI Corp.), 08 October 2009 (08.10.2009), fig. 2 (Family: none)	1-10

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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