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(54) **CENTRIFUGAL COMPRESSOR**

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(57) **ABSTRACT**

Provided is a centrifugal compressor in which a malfunction such as shaft vibration due to rotating stall is suppressed, and degradation of performance due to friction losses or the like is suppressed. In a centrifugal compressor (**10**) including a diffuser section (**15**) for circulating fluid discharged from an impeller (**13**), a flow path width W**2** of the diffuser section (**15**) at an inflow position where the fluid flows in the diffuser section (**15**) is narrower than a flow path width W**1** of the impeller (**13**) at a discharge position where the fluid is discharged from the impeller (**13**), and a flow path width enlarged section (**15**c) wider than the flow path width W**1** of diffuser section (**15**) at the inflow position is provided on a downstream side with respect to the inflow position of the diffuser section (**15**).

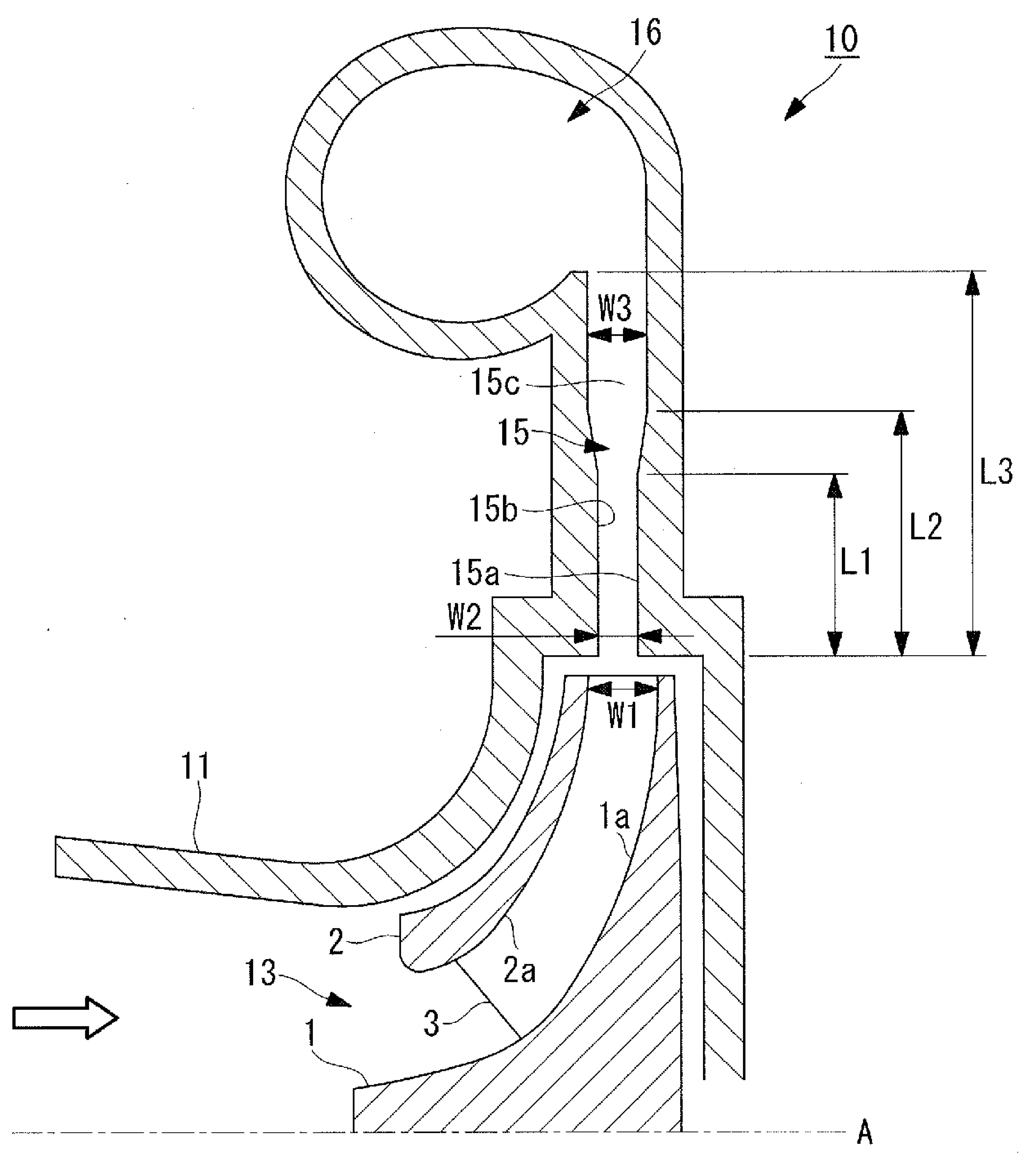


FIG. 1

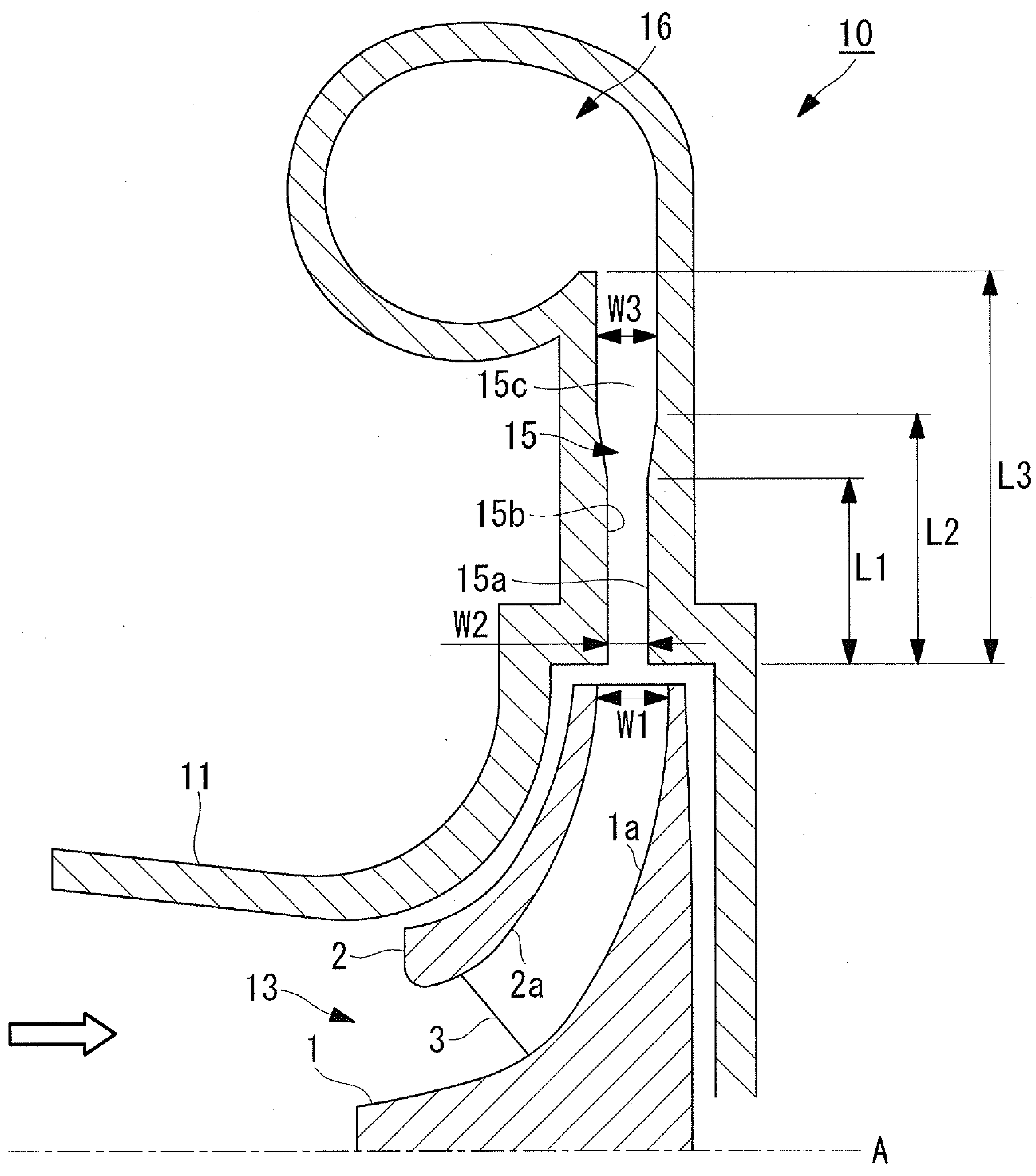


FIG. 2

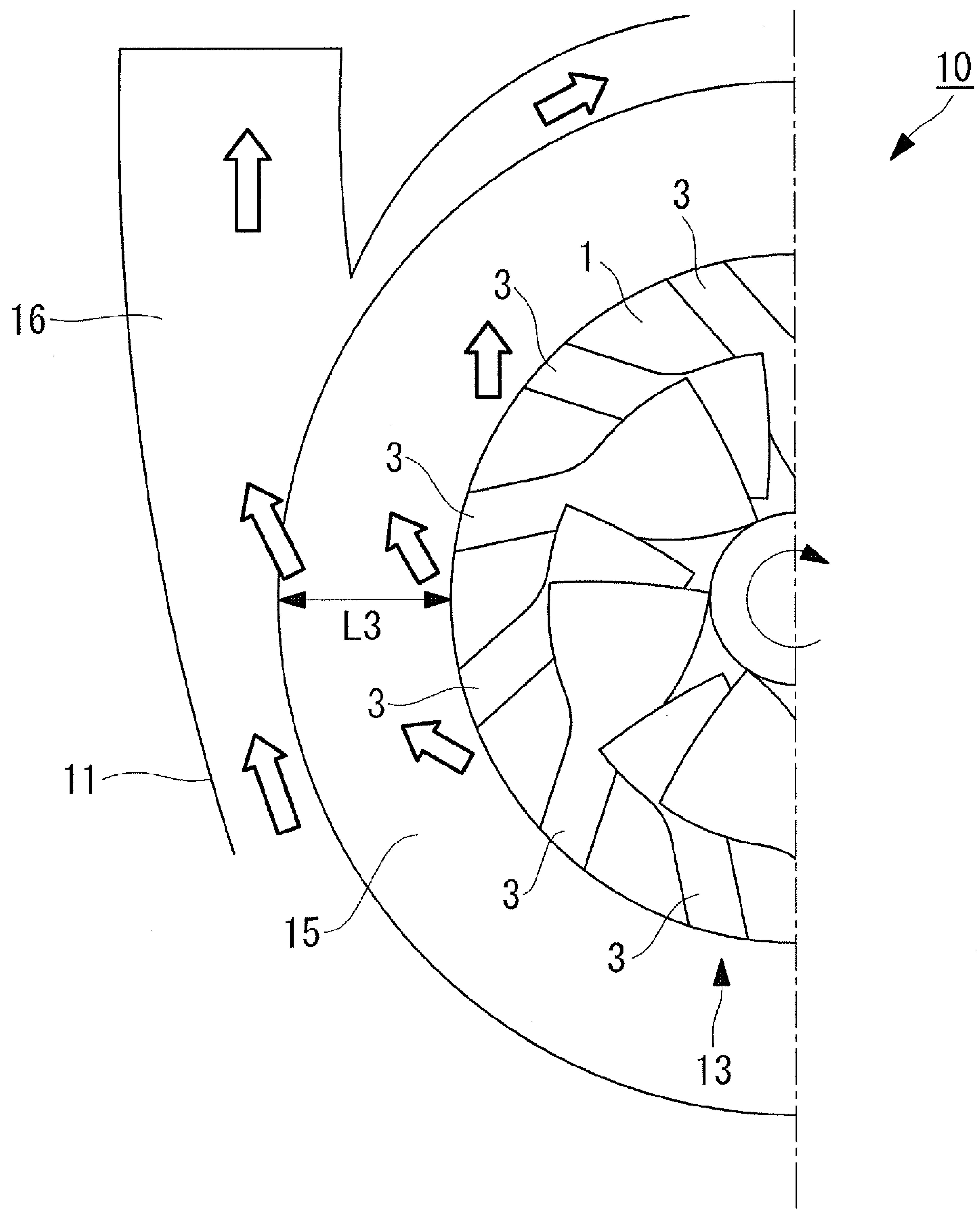


FIG. 3

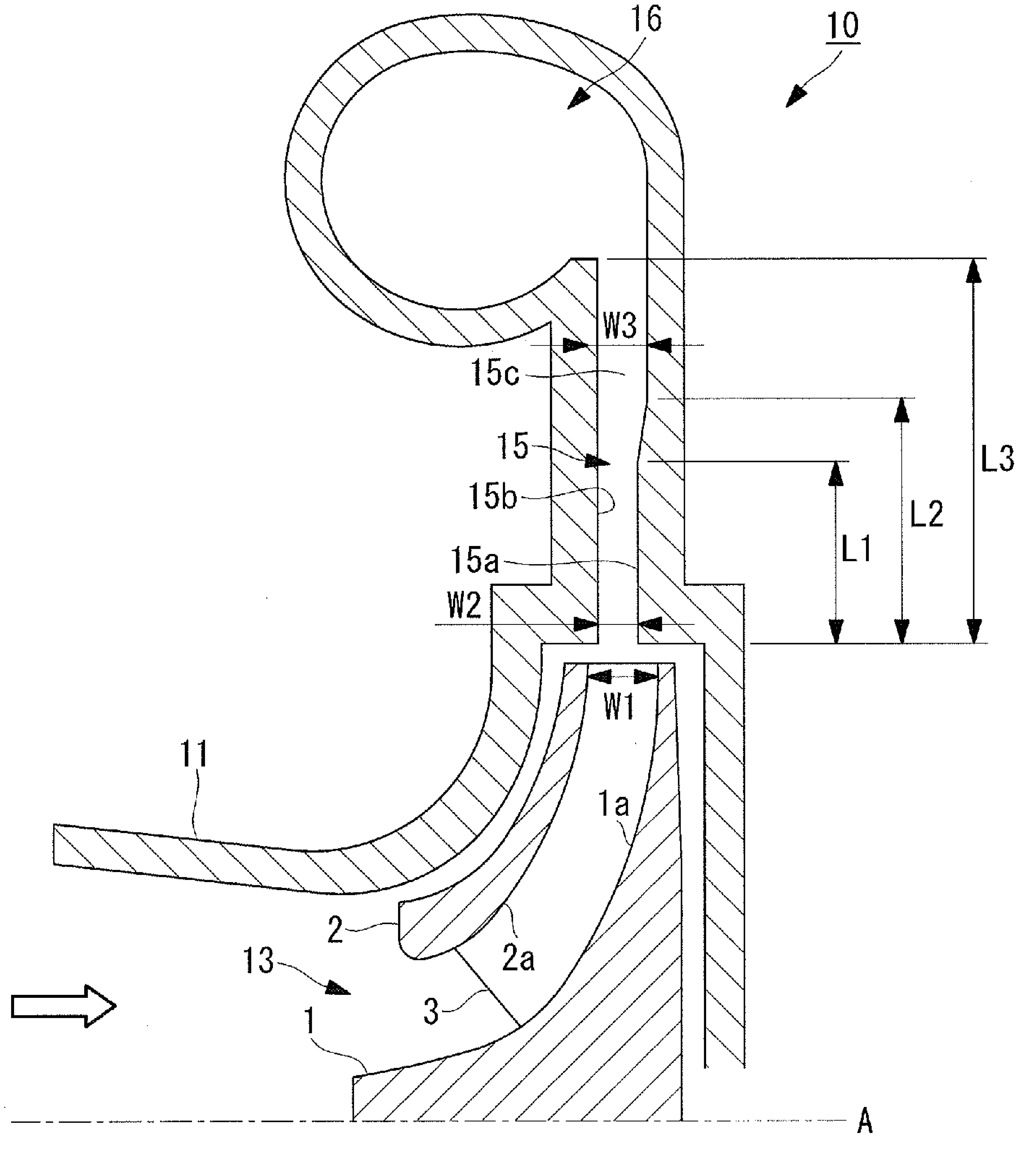


FIG. 4

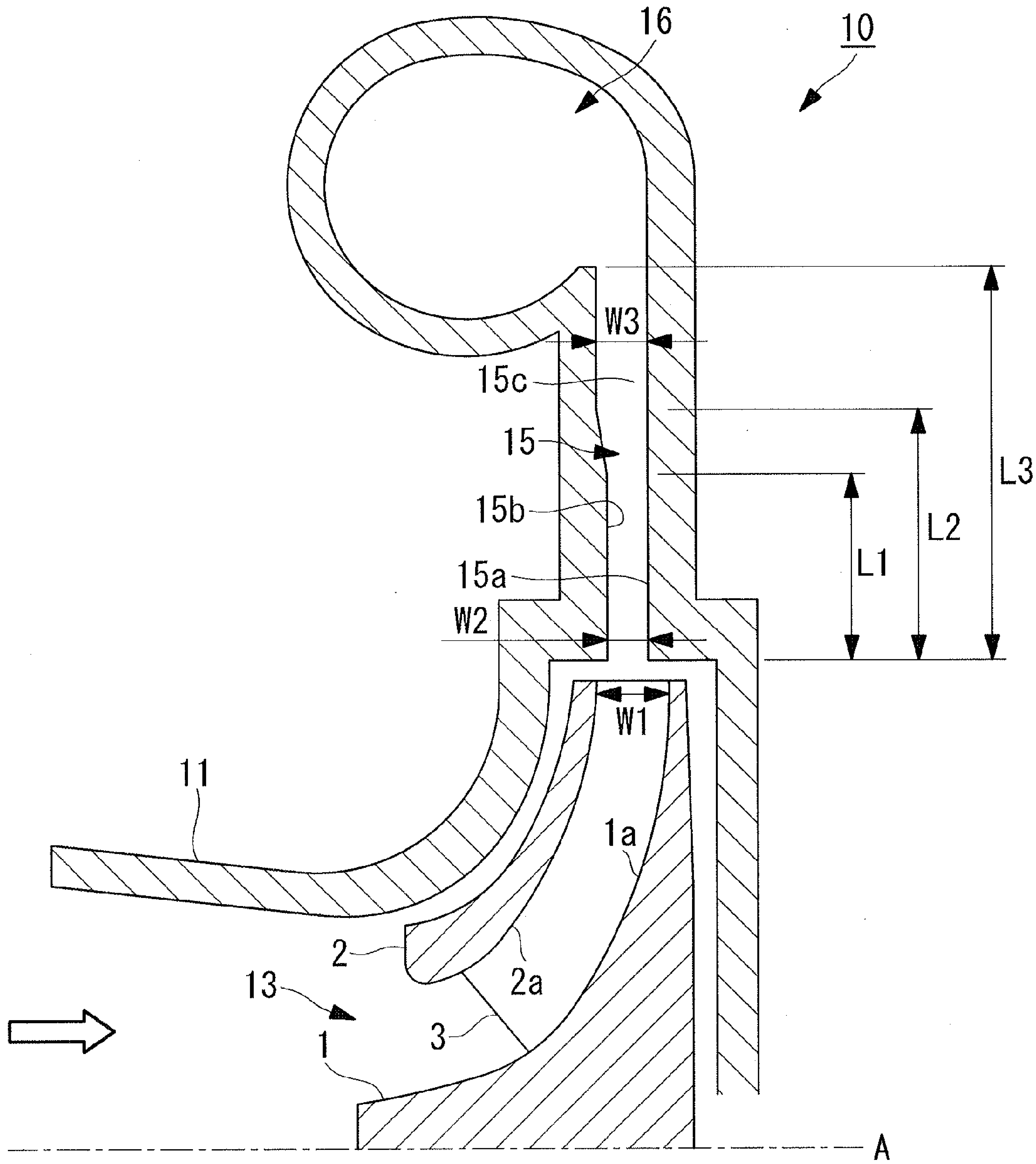


FIG. 5

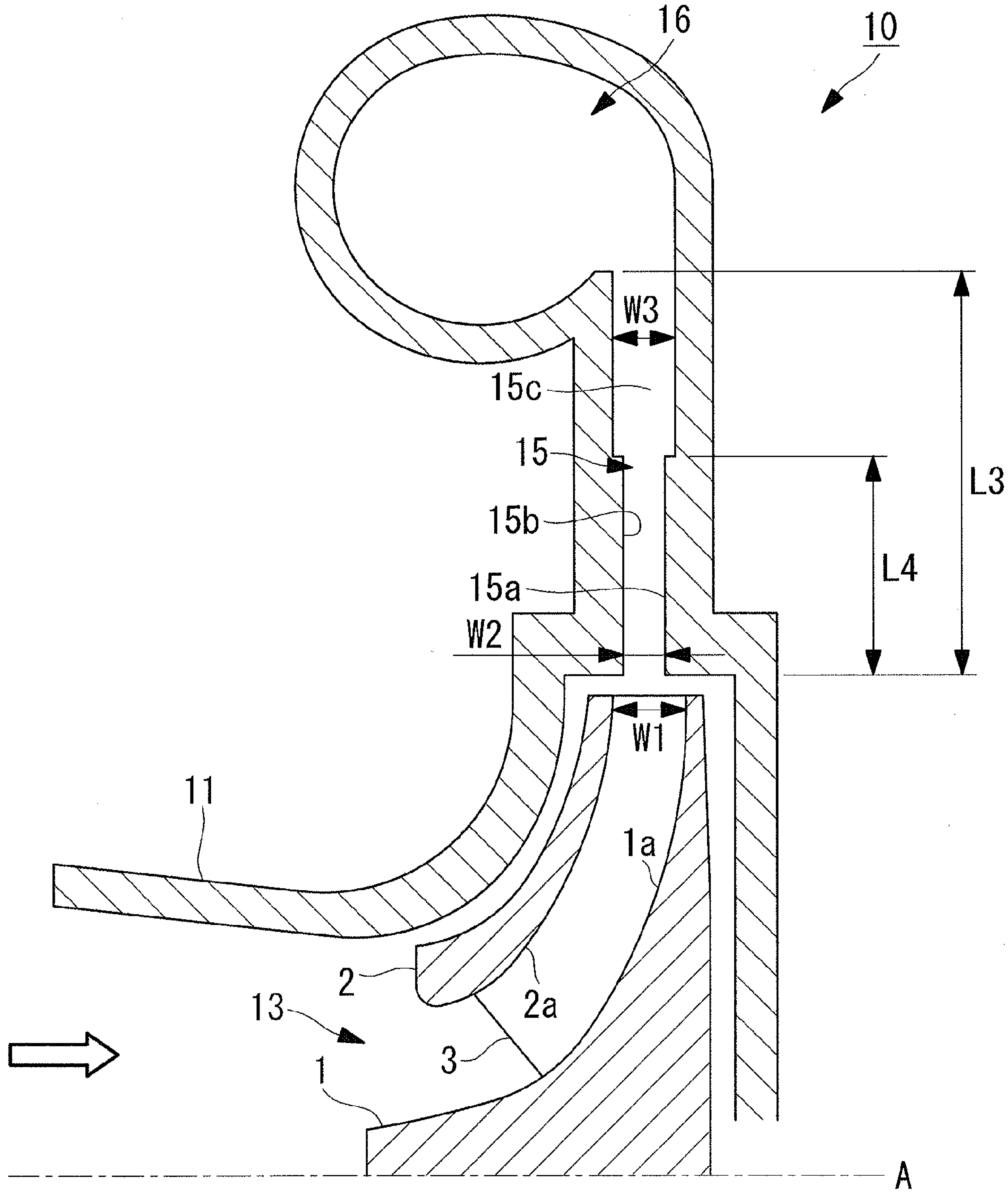
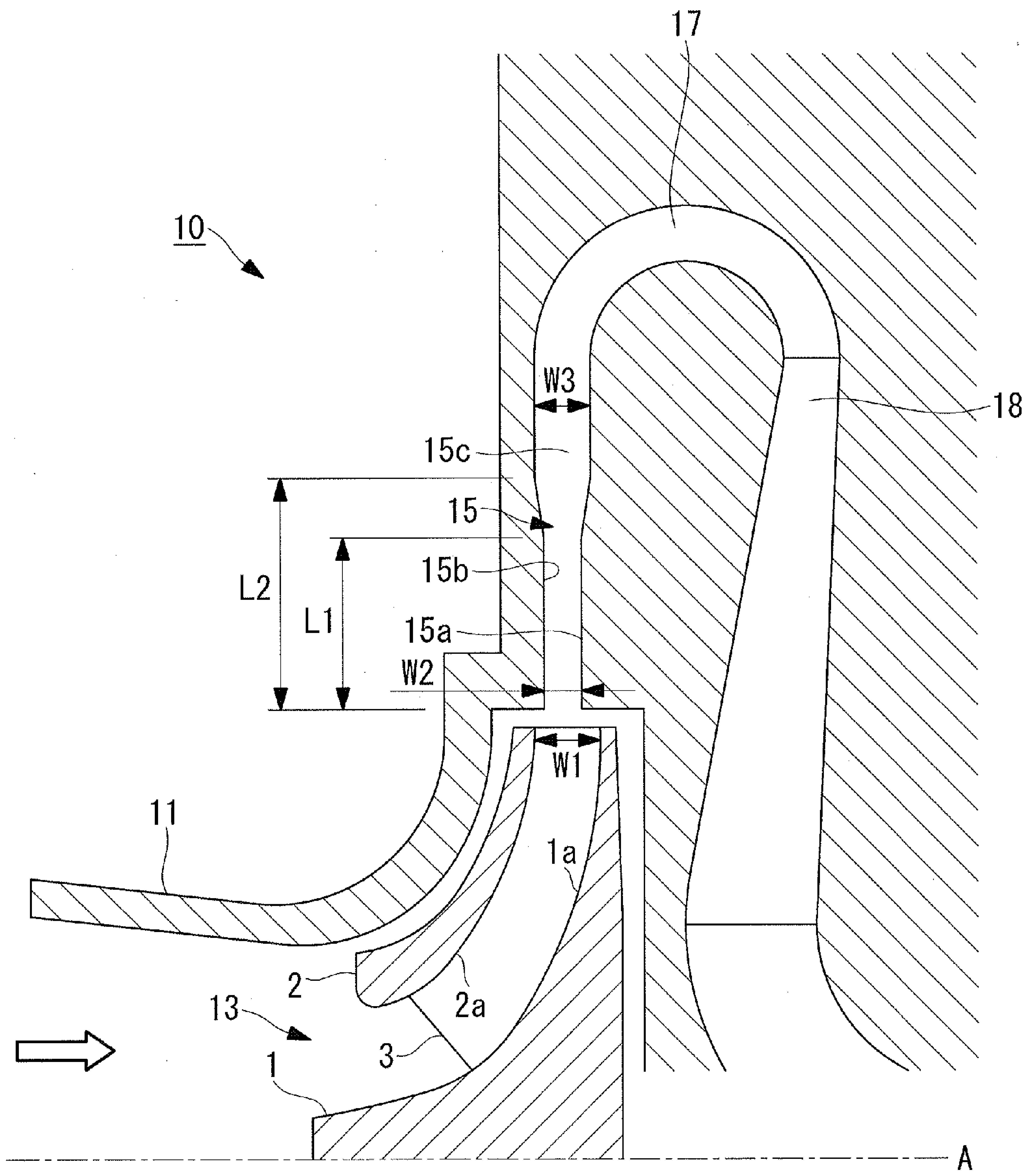


FIG. 6



CENTRIFUGAL COMPRESSOR

TECHNICAL FIELD

[0001] The present invention relates to a centrifugal compressor.

BACKGROUND ART

[0002] Conventionally, as a compressor used in a plant or the like, a centrifugal compressor is known. Several improvements are proposed in order to enable miniaturization of the centrifugal compressor, or operation at a small flow rate.

[0003] For example, Patent Literature 1 discloses a centrifugal compressor in which a flow path width of one part of a diffuser is narrowed by use of a variable diaphragm mechanism in order to enable operation at a small flow rate.

[0004] Additionally, Patent Literature 2 discloses a centrifugal compressor in which a flow path height of a diffuser flow path is gradually increases and a flow path width is enlarged in order to attain miniaturization and enlarge an operating range to a large flow rate side.

CITATION LIST

Patent Literature

{PTL 1} Japanese Unexamined Patent Application, Publication No. 2003-120594

{PTL 2} Japanese Unexamined Patent Application, Publication No. 2010-144698

SUMMARY OF INVENTION

Technical Problem

[0005] In the centrifugal compressor, it is generally known that, when a flow angle (angle formed by the discharge direction of fluid from the impeller and the radial direction of the impeller) increases, a loss becomes large, and rotating stall causing an uneven circumferential flow occurs, thereby resulting in generation of a malfunction such as shaft vibration. In order to prevent the malfunction such as the shaft vibration, the flow angle is reduced. That is, it is effective to bring the discharge direction of the fluid from the impeller close to the radial direction of the impeller. Then, for example, as described in Patent Citation 1 and Patent Citation 2, the flow path width of the diffuser is narrowed, so that the flow velocity of the fluid can be increased, and the flow angle can be reduced.

[0006] However, in the diffuser of the centrifugal compressor described in each of Patent Citation 1 and Patent Citation 2, while the flow path width of the one part of the flow path is narrowed, a flow path width of the diffuser section at an inflow position, in which the fluid discharged from the impeller flows, is not narrowed. Accordingly, in the diffuser described in each of Patent Citation 1 and Patent Citation 2, the flow velocity of the fluid at the inflow position of the fluid to the diffuser is not sufficiently increased, which sometimes causes rotating stall.

[0007] The present invention has been made in view of the above circumstances, and an object of the invention is to provide a centrifugal compressor in which a malfunction such as shaft vibration due to rotating stall and degradation of performance due to friction losses or the like are suppressed.

Solution to Problem

[0008] A centrifugal compressor according to the present invention includes: an impeller that is rotatable around an axis, and discharges fluid, which flows in an axial direction along the axis, in a direction inclined from the axial direction; a casing section that houses the impeller; and a diffuser section that circulates the fluid discharged from the impeller, wherein the impeller includes a hub and a shroud that are arranged along the axial direction side by side, and a plurality of blades that are arranged between the hub and the shroud, wherein a flow path width of the diffuser section at an inflow position where the fluid flows in the diffuser section is narrower than a flow path width of the impeller at a discharge position where the fluid discharges from the impeller, and wherein a flow path width enlarged section wider than the flow path width of the diffuser section at the inflow position is provided on a downstream side with respect to the inflow position of the diffuser section.

[0009] The centrifugal compressor according to the present invention includes: the impeller that discharges the fluid, which flows along the axial direction, in the direction inclined from the axial direction; the casing section that houses the impeller; and the diffuser section that circulates the fluid discharged from the impeller, wherein the impeller has the hub and the shroud that are arranged along the axial direction side by side, and the plurality of blades that are arranged between the hub and the shroud.

[0010] Then, according to the centrifugal compressor according to the present invention, the flow path width of the diffuser section at the inflow position where the fluid flows in the diffuser section is narrower than the flow path width of the impeller at the discharge position where the fluid discharges from the impeller. Thus, the flow velocity of the fluid at the inflow position where the fluid flows in the diffuser section is sufficiently increased, and occurrence of rotating stall is suppressed, so that it is possible to suppress a malfunction such as shaft vibration due to rotating stall.

[0011] Additionally, according to the centrifugal compressor according to the present invention, the flow path width enlarged section wider than the flow path width of the diffuser section at the inflow position is provided on a downstream side with respect to the inflow position of the diffuser section. Thus, it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid circulating in the diffuser section, compared to a case where the flow path width from the inflow position of the diffuser section to the downstream side is the same.

[0012] In a centrifugal compressor of a first aspect of the present invention, the diffuser section is defined by a hub side wall provided on a side of the hub, and a shroud side wall provided on a side of the shroud, the hub side wall at the flow path width enlarged section is disposed in a direction in which the flow path width of the diffuser section enlarges with respect to the hub side wall at the inflow position, and the shroud side wall at the flow path width enlarged section is disposed in a direction in which the flow path width of the diffuser section enlarges with respect to the shroud side wall at the inflow position.

[0013] Thus, the both side walls at the flow path width enlarged section of the diffuser section are disposed in the direction in which the flow path width of the diffuser section enlarges, and it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid, compared to a case where the flow path width from the inflow position of the diffuser section to the downstream side is the same.

[0014] In a centrifugal compressor of a second aspect of the present invention, the diffuser section is defined by a hub side wall provided on a side of the hub, and a shroud side wall provided on a side of the shroud, and the hub side wall at the flow path width enlarged section is disposed in a direction in which the flow path width of the diffuser section enlarges with respect to the hub side wall at the inflow position.

[0015] Thus, the hub side wall of the diffuser section at the flow path width enlarged section is disposed in the direction in which the flow path width of the diffuser section enlarges, so that it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid, compared to a case where the flow path width from the inflow position of the diffuser section to the downstream side is the same. Additionally, the hub side wall is disposed in the direction in which the flow path width of the diffuser section enlarges, and therefore it is possible to form the flow path in which the fluid is stably circulated, in a case where the discharge direction in which fluid discharges from the impeller is directed to a direction of the hub side wall with respect to a direction orthogonal to the axial direction.

[0016] In a centrifugal compressor of a third aspect of the present invention, the diffuser section is defined by a hub side wall provided on a side of the hub, and a shroud side wall provided on a side of the shroud, and the shroud side wall at the flow path width enlarged section is disposed in a direction in which the flow path width of the diffuser section enlarges with respect to the shroud side wall at the inflow position.

[0017] Thus, the shroud side wall of the diffuser section at the flow path width enlarged section is disposed in the direction in which the flow path width of the diffuser section enlarges, so that it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid, compared to a case where the flow path width from the inflow position of the diffuser section to the downstream side is the same.

[0018] In the above centrifugal compressor of the first aspect of the present invention, a shape of the hub side wall may be a tapered shape in which the flow path width gradually enlarges along a circulating direction of the fluid at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section, and a shape of the shroud side wall may be a tapered shape in which the flow path width gradually enlarges along the circulating direction of the fluid at the intermediate position of the diffuser section.

[0019] Thus, it is possible to form the flow path that allows the fluid to stably circulate in the flow path at the intermediate position of the diffuser section.

[0020] In the above centrifugal compressor of the second aspect of the present invention, a shape of the hub side wall may be a tapered shape in which the flow path width gradually enlarges along a circulating direction of the fluid at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section. Thus, it is possible to form the flow path that allows the fluid to stably circulate in the flow path at the intermediate position of the diffuser section.

[0021] In the above centrifugal compressor of the third aspect of the present invention, a shape of the shroud side wall may be a tapered shape in which the flow path width gradually enlarges along a circulating direction of the fluid at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section.

[0022] Thus, it is possible to form the flow path that allows the fluid to stably circulate in the flow path at the intermediate position of the diffuser section.

[0023] In the above centrifugal compressor of the first aspect of the present invention, a shape of the hub side wall may be a stepped shape in which the flow path width enlarges along a circulating direction of the fluid stepwise at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section, and a shape of the shroud side wall may be a stepped shape in which the flow path width enlarges along the circulating direction of the fluid stepwise at the intermediate position of the diffuser section.

[0024] Thus, the flow path connecting the inflow position and the downstream side can be formed at the intermediate position of the diffuser section by a relatively easy machining process.

[0025] In the above centrifugal compressor of the second aspect of the present invention, a shape of the hub side wall may be a stepped shape in which the flow path width enlarges along a circulating direction of the fluid stepwise at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section.

[0026] Thus, the flow path connecting the inflow position and the downstream side can be formed at the intermediate position of the diffuser section by a relatively easy machining process.

[0027] In the above centrifugal compressor of the third aspect of the present invention, a shape of the shroud side wall may be a stepped shape in which the flow path width enlarges along a circulating direction of the fluid stepwise at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section.

[0028] Thus, the flow path connecting the inflow position and the downstream side can be formed at the intermediate position of the diffuser section by a relatively easy machining process.

[0029] In a centrifugal compressor of a fourth aspect of the present invention, a ratio of the flow path width of the diffuser section at the inflow position to the flow path width of the impeller at the discharge position is not less than 0.5 and less than 0.8.

[0030] Thus, the flow path width of the diffuser section at the inflow position is made to be a sufficiently narrow width, and the flow velocity of the fluid at the inflow position where the fluid flows in the diffuser section is sufficiently increased, and occurrence of rotating stall is suppressed, so that it is possible to suppress a malfunction such as shaft vibration due to rotating stall.

[0031] In a centrifugal compressor of a fifth aspect of the present invention, a ratio of a flow path width of the diffuser section at the flow path width enlarged section to the flow path width of the impeller at the discharge position is not less than 0.8 and not more than 1.0.

[0032] Thus, the flow path width of the diffuser section at the flow path width enlarged section is made to be a sufficiently wide width, so that it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid, compared to a case where the flow path width from the inflow position of the diffuser section to the downstream side is the same.

[0033] In a centrifugal compressor of a sixth aspect of the present invention, the impeller discharges the fluid, which flows along the axial direction, in a direction orthogonal to the axial direction.

[0034] Thus, in the centrifugal compressor that discharges the fluid, which flows along the axial direction, in the direction orthogonal to the axial direction, it is possible to suppress a malfunction such as shaft vibration due to rotating stall, and to suppress degradation of performance due to friction losses or the like.

[0035] In a centrifugal compressor of a seventh aspect of the present invention, a flow rate coefficient is not less than 0.01 and not more than 0.05.

[0036] Thus, in the centrifugal compressor having a relatively small flow rate coefficient, it is possible to suppress a malfunction such as shaft vibration due to rotating stall, and to suppress degradation of performance due to friction losses or the like.

Advantageous Effects of Invention

[0037] According to the present invention, it is possible to provide a centrifugal compressor in which a malfunction such as shaft vibration due to rotating stall is suppressed, and degradation of performance due to friction losses or the like is suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0038] FIG. **1** is a longitudinal sectional view of a centrifugal compressor of a first embodiment.

[0039] FIG. **2** is a front view of the centrifugal compressor of the first embodiment.

[0040] FIG. **3** is a longitudinal sectional view of a centrifugal compressor of a second embodiment.

[0041] FIG. **4** is a longitudinal sectional view of a centrifugal compressor of a third embodiment.

[0042] FIG. **5** is a longitudinal sectional view of a centrifugal compressor of a fourth embodiment.

[0043] FIG. **6** is a longitudinal sectional view of a centrifugal compressor of a fifth embodiment.

BRIEF DESCRIPTION OF DRAWINGS

First Embodiment

[0044] Hereinafter, a centrifugal compressor **10** of a first embodiment will be described with reference to FIG. **1** and FIG. **2**. FIG. **1** is a longitudinal sectional view of the centrifugal compressor **10** of the first embodiment. FIG. **2** is a front view of the centrifugal compressor **10** of the first embodiment.

[0045] The centrifugal compressor **10** illustrated in FIG. **1** includes an impeller **13** rotatable around an axis A, a casing section **11** housing the impeller **13**, a diffuser section **15** for circulating fluid discharged from the impeller **13**, and a volute section **16** provided downstream of the diffuser section **15**.

[0046] FIG. **2** is a front view when viewing a position where fluid flows in the impeller **13** along the axial direction of axis A. In order to facilitate the description, the impeller **13**, the diffuser section **15**, the casing section **11**, and the volute section **16** are partially omitted.

[0047] The centrifugal compressor **10** of the first embodiment is a centrifugal compressor whose flow rate coefficient is a relatively small flow rate coefficient, namely not less than 0.01 and not more than 0.05.

[0048] The impeller **13** is connected to a driving device such as a motor and a turbine (not illustrated) through a rotary shaft (not illustrated) along the axis A, and is rotatable around the axis A. The impeller **13** has a hub **1** and a shroud **2** arranged along the axial direction of axis A, and a plurality of blades **3** arranged between the hub **1** and the shroud **2**. Although only one blade **3** is illustrated in FIG. **1**, a plurality of the blades **3** are arranged at equal intervals in a circumferential direction with the axis A as the center, between the hub **1** and the shroud **2** (FIG. **2**).

[0049] The impeller **13** is provided with a space defined by an inner wall la of the hub **1** and an inner wall **2*a*** of the shroud **2**, and the space is partitioned into a plurality of spaces by the plurality of blades **3**. Then, the impeller **13** applies radial centrifugal force to fluid flowing along the axial direction (direction illustrated by the arrow in FIG. **1**), discharges the fluid in a direction orthogonal to the axial direction (inclined direction; radial direction of the impeller **13**), and allows the fluid to flow in the diffuser section **15**.

[0050] The diffuser section **15** is a fluid flow path defined by a hub side wall **15*a*** provided on the hub **1** side and a shroud side wall **15*b*** provided on the shroud **2** side. As illustrated in FIG. **2**, the diffuser section **15** is provided so as to surround a discharge position provided on a whole circumference of the impeller **13**. In the diffuser section **15**, the flow velocity of the fluid discharged from the discharge position of the impeller **13** is reduced, so that kinetic energy (dynamic pressure) applied to the fluid is converted into pressure energy (static pressure).

[0051] The fluid, the flow velocity of which is reduced when passing through the diffuser section **15**, is compressed, and flows in a volute section (volute chamber) **16** communicated with diffuser section **15**. The compressed fluid that flows in the volute section **16** is discharged to a discharge pipe (not illustrated) through a discharge port (not illustrated).

[0052] Herein, operation of the centrifugal compressor **10** will be described.

[0053] In the centrifugal compressor **10**, the driving device such as the motor and the turbine (not illustrated) rotates the impeller **13** around the axis A. The impeller **13** rotates, so that fluid taken from a suction port (not illustrated) is introduced into the casing section **11**. To the fluid introduced into the casing section **11**, centrifugal force in the direction orthogonal to the axis A (radial direction) is applied through the blades **3** by the rotation of the impeller **13**. The fluid, to which the centrifugal force is applied, is discharged from the impeller **13**, and flows in the diffuser section **15**. The flow velocity of the fluid that flows in the diffuser section **15** reduces, and the fluid becomes compressed fluid to be discharged to the volute section **16**. The compressed fluid that flows in the volute section **16** is discharged to the discharge pipe (not illustrated) through the discharge port (not illustrated).

[0054] Now, flow path widths of the impeller **13** and the diffuser section **15** will be described.

[0055] As illustrated in FIG. **1**, a flow path width W2 of the diffuser section **15** at an inflow position where fluid flows in the diffuser section **15** is narrower than a flow path width W1 of the impeller **13** at a discharge position where the fluid is discharged from the impeller **13**. By such a narrowing configuration, a flow velocity of the fluid at the inflow position where the fluid flows in the diffuser section **15** is sufficiently increased, and occurrence of rotating stall is suppressed, so that it is possible to suppress a malfunction such as shaft vibration due to rotating stall.

[0056] Thus, the flow velocity of the fluid at the inflow position where the fluid flows in the diffuser section **15** is sufficiently increased, so that occurrence of rotating stall is suppressed. On the other hand, when the flow velocity of the fluid is increased, losses due to friction between the fluid and the hub side wall **15***a* and friction between the fluid and the shroud side wall **15***b* increase. Therefore, in the first embodiment, a flow path width enlarged section **15***c* in which the flow path width of the diffuser section **15** is enlarged is provided on the downstream side of the inflow position where the fluid flows in the diffuser section **15**, in order to suppress the losses due to the friction.

[0057] As illustrated in FIG. **1**, the flow path width W**1** expresses a length in a direction along the axis A (axial direction). The flow path width W**1** is equal to a distance in the axial direction between the inner wall **1***a* of the hub **1** and the inner wall **2***a* of the shroud **2** at the discharge position where the fluid is discharged from the impeller **13**.

[0058] As illustrated in FIG. **1**, the flow path width W**2** expresses a length in the direction along the axis A. The flow path width W**2** is equal to a distance in the axial direction between the hub side wall **15***a* and the shroud side wall **15***b* at the inflow position where the fluid flows in the diffuser section **15**.

[0059] The flow path width of the diffuser section **15** (distance in the axial direction between the hub side wall **15***a* and the shroud side wall **15***b*) in a range in a circulating direction of the fluid (direction orthogonal to the axial direction) from the inflow position where the fluid flows in the diffuser section **15** to L**1** is constant, namely the flow path width W**2**. Then, at a position (intermediate position) where the distance from the inflow position is between L**1** and L**2**, the hub side wall **15***a* that defines the diffuser section **15** has a tapered shape in which the flow path width gradually enlarges along the circulating direction of the fluid. Additionally, at the position (intermediate position) where the distance from the inflow position is between L**1** and L**2**, the shroud side wall **15***b* that defines the diffuser section **15** also has a tapered shape in which the flow path width gradually enlarges along the circulating direction of the fluid.

[0060] The hub side wall **15***a* at a position where the distance from the inflow position where the fluid flows in the diffuser section **15** is between L**2** and L**3** is disposed in a direction in which the flow path width of the diffuser section **15** enlarges with respect to the hub side wall **15***a* at the inflow position where the fluid flows in the diffuser section **15**. Similarly, the shroud side wall **15***b* is disposed in a direction in which the flow path width of the diffuser section **15** enlarges with respect to the shroud side wall **15***b* at the inflow position where the fluid flows in the diffuser section **15**. At the position where the distance from the inflow position is between L**2** and L**3**, the flow path width of the diffuser section **15** is constant, namely a flow path width W**3**.

[0061] As described above, the flow path width enlarged section **15***c* that is wider than the flow path width of the diffuser section **15** at the inflow position of the diffuser section **15** is provided on the downstream side in the circulating direction of the fluid with respect to the inflow position where the fluid flows in the diffuser section **15**.

[0062] In the flow path width enlarged section **15***c*, the shape of the hub side wall **15***a* and the shape of the shroud side wall **15***b* are desirably horizontally symmetrical with respect to the center axis of the flow path.

[0063] In the first embodiment, a ratio of the flow path width W**2** of the diffuser section **15** at the inflow position to the flow path width W**1** of the impeller **13** at the discharge position is not less than 0.5 and less than 0.8. Additionally, a ratio of the flow path width W**3** of the diffuser section **15** at the flow path width enlarged section **15***c* to the flow path width W**1** of the impeller **13** at the discharge position is not less than 0.8 and not more than 1.0. However, as described above, the respective ratios are selected such that the flow path width W**3** of the diffuser section **15** at the flow path width enlarged section **15***c* is wider than the flow path width W**2** of the diffuser section **15** at the inflow position.

[0064] As described above, the centrifugal compressor **10** of the first embodiment includes the impeller **13** that discharges fluid, which flows along the axial direction, in the inclined direction from the axial direction (radial direction orthogonal to the axial direction), the casing section **11** that houses the impeller **13**, and the diffuser section **15** that circulates the fluid discharged from the impeller **13**, wherein the impeller **13** has the hub **1** and the shroud **2** arranged along the axial direction side by side, and the plurality of blades **3** arranged between the hub **1** and the shroud **2**.

[0065] According to the centrifugal compressor **10** of the first embodiment, the flow path width W**2** of the diffuser section **15** at the inflow position where the fluid flows in the diffuser section **15** is narrower than the flow path width W**1** of the impeller **13** at the discharge position where the fluid is discharged from the impeller **13**. Thus, the flow velocity of the fluid at the inflow position where the fluid flows in the diffuser section **15** is sufficiently increased, and occurrence of rotating stall is suppressed, so that it is possible to suppress a malfunction such as shaft vibration due to rotating stall.

[0066] According to the centrifugal compressor **10** of the first embodiment, the flow path width enlarged section **15***c* having the flow path width W**3** wider than the flow path width of the diffuser section **15** at the inflow position of the diffuser section **15** is provided downstream with respect to the inflow position of the diffuser section **15**. Thus, it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid circulating in the diffuser section **15**, compared to a case where the flow path width from the inflow position of the diffuser section **15** to the downstream side is the same flow path width, namely the flow path width W**2**.

[0067] In the first embodiment, the diffuser section **15** is defined by the hub side wall **15***a* provided on the hub **1** side, and the shroud side wall **15***b* provided on the shroud **2** side. Then, the hub side wall **15***a* at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges with respect to the hub side wall **15***a* at the inflow position. Additionally, the shroud side wall **15***b* at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges with respect to the shroud side wall **15***b* at the inflow position.

[0068] Thus, the both side walls at the flow path width enlarged section **15***c* of the diffuser section **15** are disposed in the direction in which the flow path width of the diffuser section **15** enlarges, so that it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid, compared to the case where the flow path width from the inflow position of the diffuser section **15** to the downstream side is the same flow path width, namely the flow path width W**2**.

[0069] In the first embodiment, the shape of the hub side wall **15***a* is the tapered shape in which the flow path width gradually enlarges along the circulating direction of the fluid at the intermediate position between the inflow position of the diffuser section **15** and the flow path width enlarged section **15***c*, and the shape of the shroud side wall **15***b* is the tapered shape in which the flow path width gradually enlarges along the circulating direction of the fluid at the intermediate position of the diffuser section **15**. Thus, it is possible to form the flow path that allows the fluid to stably circulate in the flow path at the intermediate position of the diffuser section **15**.

[0070] In the first embodiment, the ratio of the flow path width W**2** of the diffuser section **15** at the inflow position to the flow path width W**1** of the impeller **13** at the discharge position is not less than 0.5 and less than 0.8. Thus, the flow path width W**2** relative to the flow path width W**1** is made to be a sufficiently narrow width, and the flow velocity of the fluid at the inflow position where the fluid flows in the diffuser section **15** is sufficiently increased, and occurrence of rotating stall is suppressed, so that it is possible to suppress a malfunction such as shaft vibration due to rotating stall.

[0071] In the first embodiment, the ratio of the flow path width W**3** of the diffuser section **15** at the flow path width enlarged section **15***c* to the flow path width W**1** of the impeller **13** at the discharge position is not less than 0.8 and not more than 1.0. Thus, the flow path width W**3** relative to the flow path width W**1** is made to be a sufficiently wide width, and it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid, compared to the case where the flow path width from the inflow position of the diffuser section **15** to the downstream side is the same flow path width, namely the flow path width W**2**.

Second Embodiment

[0072] Now, a centrifugal compressor **10** of a second embodiment will be described with reference to FIG. **3**. FIG. **3** is a longitudinal sectional view of the centrifugal compressor **10** of the second embodiment.

[0073] In the first embodiment, the both side walls (the hub side wall **15***a* and the shroud side wall **15***b*) of the diffuser section **15** at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges. On the contrary, in the second embodiment, one side wall (hub side wall **15***a*) of a diffuser section **15** at a flow path width enlarged section **15***c* is disposed in a direction in which a flow path width of the diffuser section **15** enlarges.

[0074] The second embodiment is a modification of the first embodiment. Configurations other than the shape of the hub side wall **15***a* which defines the diffuser section **15** are similar to those of the first embodiment, and therefore the description of the configurations will be omitted.

[0075] In the second embodiment, as illustrated in FIG. **3**, the hub side wall **15***a* at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges with respect to the hub side wall **15***a* at an inflow position. On the other hand, the shroud side wall **15***b* at the flow path width enlarged section **15***c* and the shroud side wall **15***b* at the inflow position are disposed such that the positions in the axial direction are the same.

[0076] Although the centrifugal compressor **10** illustrated in FIG. **3** discharges fluid, which flows in an impeller **13**, in a direction orthogonal to the axial direction, a modification in which the centrifugal compressor discharges fluid in a direction inclined to the hub side wall **15***a* with respect to the direction orthogonal to the axial direction is applicable. In this case, the fluid that flows in the diffuser section **15** includes a velocity component in a direction in which the fluid vertically abuts on the hub side wall **15***a*. Accordingly, a loss due to friction is more easily generated at the hub side wall **15***a* than the shroud side wall **15***b*, and therefore suppression of a friction loss generated at the hub side wall **15***a* is desirable.

[0077] In the modification of the second embodiment, the hub side wall **15***a* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges, and therefore it is possible to form the flow path in which the fluid is stably circulated, and a friction loss caused by the hub side wall **15***a* is suppressed, in a case where a discharge direction in which fluid discharged from the impeller **13** is directed (inclined) to the direction of the hub side wall **15***a* with respect to the direction orthogonal to the axial direction.

[0078] Like the modification of the second embodiment, a compressor of a type of discharge in a direction inclined to the hub side wall **15***a* with respect to the direction orthogonal to the axial direction of the impeller **13** is called a mixed flow compressor. In the second embodiment, the compressor is not called the mixed flow compressor, but called a centrifugal compressor which means a compressor that converts fluid flowing in the axial direction into fluid including a velocity component in a direction orthogonal to an axis A (centrifugal direction).

[0079] As described above, according to the centrifugal compressor **10** of the second embodiment, a flow path width W**2** of the diffuser section **15** at the inflow position where the fluid flows in the diffuser section **15** is narrower than a flow path width W**1** of the impeller **13** at a discharge position where the fluid is discharged from the impeller **13**. Thus, a flow velocity of fluid at the inflow position where the fluid flows in the diffuser section **15** is sufficiently increased, and occurrence of rotating stall is suppressed, so that it is possible to suppress a malfunction such as shaft vibration due to rotating stall.

[0080] In the second embodiment, the hub side wall **15***a* at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges with respect to the hub side wall **15***a* at the inflow position. Thus, the hub side wall **15***a* of the diffuser section **15** at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges, so that it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid, compared to a case where the flow path width from the inflow position of the diffuser section **15** to the downstream side is the same flow path width, namely the flow path width W**2**.

[0081] In the second embodiment, the shape of the hub side wall **15***a* is a tapered shape in which the flow path width gradually enlarges along a circulating direction of the fluid at an intermediate position between the inflow position of the diffuser section **15** and the flow path width enlarged section **15***c*. Thus, it is possible to form the flow path that allows the fluid to stably circulate in the flow path at the intermediate position of the diffuser section **15**.

Third Embodiment

[0082] Now, a centrifugal compressor **10** of the third embodiment will be described with reference to FIG. **4**. FIG. **4** is a longitudinal sectional view of the centrifugal compressor **10** of the third embodiment.

[0083] In the first embodiment, the both side walls (the hub side wall **15***a* and the shroud side wall **15***b*) of the diffuser section **15** at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges. On the contrary, in the third embodiment, one side wall (shroud side wall **15***b*) of a diffuser section **15** at a flow path width enlarged section **15***c* is disposed in a direction in which a flow path width of the diffuser section **15** enlarges.

[0084] The third embodiment is a modification of the first embodiment. Configurations other than the shape of the shroud side wall **15***b* which defines the diffuser section **15** are similar to those of the first embodiment, and therefore the description of the configurations will be omitted.

[0085] In the third embodiment, as illustrated in FIG. **4**, the shroud side wall **15***b* at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges with respect to the shroud side wall **15***b* at an inflow position. On the other hand, the hub side wall **15***a* at the flow path width enlarged section **15***c* and the hub side wall **15***a* at the inflow position are disposed such that the positions in the axial direction are the same.

[0086] As described above, according to the centrifugal compressor **10** of the third embodiment, a flow path width W**2** of the diffuser section **15** at the inflow position where the fluid flows in the diffuser section **15** is narrower than a flow path width W**1** of the impeller **13** at a discharge position where the fluid is discharged from the impeller **13**. Thus, a flow velocity of fluid at the inflow position where the fluid flows in the diffuser section **15** is sufficiently increased, and occurrence of rotating stall is suppressed, so that it is possible to suppress a malfunction such as shaft vibration due to rotating stall.

[0087] In the third embodiment, the shroud side wall **15***b* at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges with respect to the shroud side wall **15***b* at the inflow position. Thus, the shroud side wall **15***b* of the diffuser section **15** at the flow path width enlarged section **15***c* is disposed in the direction in which the flow path width of the diffuser section **15** enlarges, so that it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of the fluid, compared to a case where the flow path width from the inflow position of the diffuser section **15** to the downstream side is the same flow path width, namely the flow path width W**2**.

[0088] In the third embodiment, the shape of the shroud side wall **15***b* is the tapered shape in which the flow path width gradually enlarges along a circulating direction of the fluid at the intermediate position of the diffuser section **15**. Thus, it is possible to form the flow path that allows the fluid to stably circulate in the flow path at the intermediate position of the diffuser section **15**.

Fourth Embodiment

[0089] Now, a centrifugal compressor **10** of the fourth embodiment will be described with reference to FIG. **5**. FIG. **5** is a longitudinal sectional view of the centrifugal compressor **10** of the fourth embodiment.

[0090] In the first embodiment, between the flow path having the flow path width W**2**, provided at the inflow position of the diffuser section **15**, and the flow path width enlarged section **15***c* having the flow path width W**3**, provided downstream of the diffuser section **15** (at the intermediate position), both the hub side wall **15***a* and the shroud side wall **15***b* have tapered shapes in which the flow path width gradually enlarges along the circulating direction of fluid.

[0091] On the contrary, in the fourth embodiment, in place of the tapered shape, a stepped shape in which the flow path width enlarges along the circulating direction of the fluid stepwise.

[0092] A flow path width of a diffuser section **15** (distance in the axial direction between a hub side wall **15***a* and a shroud side wall **15***b*) in a range in the circulating direction of the fluid (direction orthogonal to the axial direction) from an inflow position where the fluid flows in the diffuser section **15** to L**4** is constant, namely a flow path width W**2**. Then, at a position where the distance from the inflow position is between L**4** and L**3**, the flow path width of the diffuser section **15** is constant, namely a flow path width W**3**.

[0093] In the fourth embodiment illustrated in FIG. **5**, only one step is provided in the diffuser section **15**. However, not only one step but also a plurality of steps may be provided. For example, in place of the tapered part (intermediate position of the diffuser section **15**) illustrated in FIG. **1** of the first embodiment, the diffuser section **15** may be formed in a stepped shape of two steps, three steps, or more steps, and the flow path width of the diffuser section may be gradually enlarge.

[0094] In the fourth embodiment illustrated in FIG. **5**, both the hub side wall **15***a* and the shroud side wall **15***b* are provided with stepped shapes. However, the stepped shape may be provided in any one of the hub side wall **15***a* and the shroud side wall **15***b*, and the stepped shape may not be provided in the other wall. For example, in a case where the stepped shape is not provided in the hub side wall **15***a*, the hub side wall **15***a* at the flow path width enlarged section **15***c*, and the hub side wall **15***a* at the inflow position are disposed such that the positions in the axial direction are the same. Additionally, for example, in a case where the stepped shape is not provided in the shroud side wall **15***b*, the shroud side wall **15***b* at the flow path width enlarged section **15***c*, and the shroud side wall **15***b* at the inflow position are disposed such that the positions in the axial direction are the same.

[0095] As described above, according to the centrifugal compressor **10** of the fourth embodiment, a flow path width W**2** of the diffuser section **15** at the inflow position where the fluid flows in the diffuser section **15** is narrower than a flow path width W**1** of an impeller **13** at a discharge position where the fluid is discharged from the impeller **13**. Thus, a flow velocity of fluid at the inflow position where the fluid flows in the diffuser section **15** is sufficiently increased, and occurrence of rotating stall is suppressed, so that it is possible to suppress a malfunction such as shaft vibration due to rotating stall.

[0096] According to the centrifugal compressor **10** of the fourth embodiment, the flow path width enlarged section **15***c* having the flow path width W**3**, which is wider than the flow path width W**2** of the diffuser section **15** at the inflow position of the diffuser section **15**, is provided on the downstream side with respect to the inflow position of the diffuser section **15**. Thus, it is possible to suppress degradation of performance due to, for example, friction losses caused by increase in the flow velocity of fluid circulating in the diffuser section **15**, compared to a case where the flow path width from the inflow position of the diffuser section **15** to the downstream side is the same flow path width, namely the flow path width W**2**.

[0097] In the fourth embodiment, the shape of the hub side wall **15***a* is the stepped shape in which the flow path width enlarges along the circulating direction of the fluid stepwise at the intermediate position between the inflow position of the diffuser section **15** and the flow path width enlarged section **15***c*, and the shape of the shroud side wall **15***b* is the stepped shape in which the flow path width gradually enlarges along the circulating direction of the fluid at the intermediate position of the diffuser section **15**. Thus, the flow path connecting the inflow position and the downstream side can be formed at the intermediate position of the diffuser section **15** by a relatively easy machining process.

Fifth Embodiment

[0098] Now, a centrifugal compressor **10** of the fifth embodiment will be described with reference to FIG. **6**. FIG. **6** is a longitudinal sectional view of the centrifugal compressor **10** of the fifth embodiment.

[0099] In the first embodiment to the fourth embodiment, a single-stage centrifugal compressor provided with the volute section **16** downstream of the diffuser section **15** is described. However, the centrifugal compressor **10** of the fifth embodiment is a multistage centrifugal compressor in which fluid compressed by an impeller **13** and a diffuser section **15** at the first stage flows in an impeller **13** and a diffuser section **15** at a next stage.

[0100] The fifth embodiment is a modification of the first embodiment. Configurations are similar to those of the first embodiment except that a return bend **17** and a return vane **18** are provided in place of the volute section **16**, and therefore the description of the configurations will be omitted.

[0101] In the first embodiment, compressed fluid that flows in the flow path width enlarged section **15***c* of the diffuser section **15** flows in the volute section **16** provided downstream of the flow path width enlarged section **15***c*. On the contrary, in the fifth embodiment, compressed fluid that flows in a flow path width enlarged section **15***c* of the diffuser section **15** flows in the return bend **17** provided downstream of the flow path width enlarged section **15***c*. The compressed fluid that flows in the return bend **17** is guided to the impeller **13** at the next stage (second stage) via the return vane **18**.

[0102] In a case where a two-stage centrifugal compressor is employed as the centrifugal compressor **10** of the fifth embodiment, the fluid guided to the impeller **13** at the second stage is discharged to the diffuser section **15** at the second stage. The fluid further compressed in the diffuser section **15** at the second stage is guided to a volute section **16** similar to the volute section illustrated in FIG. **1** of the first embodiment.

[0103] In a case where a three-stage centrifugal compressor is employed as the centrifugal compressor **10** of the fifth embodiment, fluid guided to an impeller **13** at a second stage is discharged to a diffuser section **15** at a second stage. The fluid further compressed in the diffuser section **15** at the second stage flows in a return bend **17** at the second stage. The compressed fluid that flows in the return bend **17** at the second stage is guided to an impeller **13** at a next state (third stage) via the return vane **18**. The fluid guided to the impeller **13** at the third stage is discharged to a diffuser section **15** at the third stage. The fluid further compressed in the diffuser section **15** at the third stage is guided to a volute section **16** similar to the volute section illustrated in FIG. **1** of the first embodiment.

[0104] As described above, the two-stage or the three-stage centrifugal compressor **10** is employed as the centrifugal compressor **10**, so that it is possible to further increase a compression ratio of fluid. Additionally, an effect similar to the effect of the first embodiment can be exerted by the shapes of the impeller **13** and the diffuser section **15** at each stage.

[0105] As the shape of the diffuser section **15** at each stage, not only the shape described in the first embodiment, but also any shape described in the second embodiment to the fourth embodiment can be employed.

[0106] Additionally, in the fifth embodiment, the two-stage and the three-stage centrifugal compressor **10** are described. However, a modification of a four or more stage centrifugal compressor **10** may be employed.

REFERENCE SIGNS LIST

[0107] **1**: Hub
[0108] **2**: Shroud
[0109] **3**: Blade
[0110] **10**: Centrifugal compressor
[0111] **11**: Casing section
[0112] **13**: Impeller
[0113] **15**: Diffuser section
[0114] **15***a*: Hub side wall
[0115] **15***b*: Shroud side wall
[0116] **15***c*: Flow path width enlarged section
[0117] **16**: Volute section
[0118] A: Axis
[0119] W**1**: Flow path width of impeller at discharge position
[0120] W**2**: Flow path width of diffuser section at inflow position
[0121] W**3**: Flow path width of diffuser section at flow path width enlarged section

1. A centrifugal compressor comprising:

an impeller that is rotatable around an axis, and discharges fluid, which flows in an axial direction along the axis, in a direction inclined from the axial direction;

a casing section that houses the impeller; and

a diffuser section that circulates forms a diffuser flow path for allowing the fluid discharged from the impeller to circulate, wherein

the impeller includes a hub and a shroud that are arranged along the axial direction side by side, and a plurality of blades that are arranged between the hub and the shroud, the plurality of blades partitioning a space defined by an inner wall of the hub and an inner wall of the shroud to form a plurality of discharge flow paths,

a flow path width of the diffuser section at an inflow position where the fluid flows in the diffuser section is narrower than a flow path width of the impeller at a discharge position where the fluid discharges from the impeller,

a hub side wall of the diffuser section at the inflow position is disposed on a side closer to a center of the diffuser flow path than an extension line of the inner wall of the hub at the discharge position toward the diffuser section,

a shroud side wall of the diffuser section at the inflow position is disposed on a side closer to a center of the diffuser flow path than an extension line of the inner wall of the shroud at the discharge position toward the diffuser section, and a flow path width enlarged section wider than the flow path width of the diffuser section at the inflow position is provided on a downstream side with respect to the inflow position of the diffuser section.

2. The centrifugal compressor according to claim **1**, wherein

the diffuser section is defined by a hub side wall provided on a side of the hub, and a shroud side wall provided on a side of the shroud,

the hub side wall at the flow path width enlarged section is disposed in a direction in which the flow path width of the diffuser section enlarges with respect to the hub side wall at the inflow position, and

the shroud side wall at the flow path width enlarged section is disposed in a direction in which the flow path width of the diffuser section enlarges with respect to the shroud side wall at the inflow position.

3. The centrifugal compressor according to claim **1**, wherein

the diffuser section is defined by a hub side wall provided on a side of the hub, and a shroud side wall provided on a side of the shroud, and

the hub side wall at the flow path width enlarged section is disposed in a direction in which the flow path width of the diffuser section enlarges with respect to the hub side wall at the inflow position.

4. The centrifugal compressor according to claim **1**, wherein

the diffuser section is defined by a hub side wall provided on a side of the hub, and a shroud side wall provided on a side of the shroud, and

the shroud side wall at the flow path width enlarged section is disposed in a direction in which the flow path width of the diffuser section enlarges with respect to the shroud side wall at the inflow position.

5. The centrifugal compressor according to claim **2**, wherein

a shape of the hub side wall is a tapered shape in which the flow path width gradually enlarges along a circulating direction of the fluid at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section, and

a shape of the shroud side wall is a tapered shape in which the flow path width gradually enlarges along the circulating direction of the fluid at the intermediate position of the diffuser section.

6. The centrifugal compressor according to claim **3**, wherein

a shape of the hub side wall is a tapered shape in which the flow path width gradually enlarges along a circulating direction of the fluid at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section.

7. The centrifugal compressor according to claim **4**, wherein

a shape of the shroud side wall is a tapered shape in which the flow path width gradually enlarges along a circulating direction of the fluid at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section.

8. The centrifugal compressor according to claim **2**, wherein

a shape of the hub side wall is a stepped shape in which the flow path width enlarges along a circulating direction of the fluid stepwise at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section, and

a shape of the shroud side wall is a stepped shape in which the flow path width enlarges along the circulating direction of the fluid stepwise at the intermediate position of the diffuser section.

9. The centrifugal compressor according to claim **3**, wherein

a shape of the hub side wall is a stepped shape in which the flow path width enlarges along a circulating direction of the fluid stepwise at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section.

10. The centrifugal compressor according to claim **4**, wherein

a shape of the shroud side wall is a stepped shape in which the flow path width enlarges along a circulating direction of the fluid stepwise at an intermediate position between the inflow position of the diffuser section and the flow path width enlarged section.

11. The centrifugal compressor according to claim **1**, wherein

a ratio of the flow path width of the diffuser section at the inflow position to the flow path width of the impeller at the discharge position is not less than 0.5 and less than 0.8.

12. The centrifugal compressor according to claim **1**, wherein

a ratio of a flow path width of the diffuser section at the flow path width enlarged section to the flow path width of the impeller at the discharge position is not less than 0.8 and not more than 1.0.

13. The centrifugal compressor according to claim **1**, wherein

the impeller discharges the fluid, which flows along the axial direction, in a direction orthogonal to the axial direction.

14. The centrifugal compressor according to claim **1**, wherein

a flow rate coefficient is not less than 0.01 and not more than 0.05.

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