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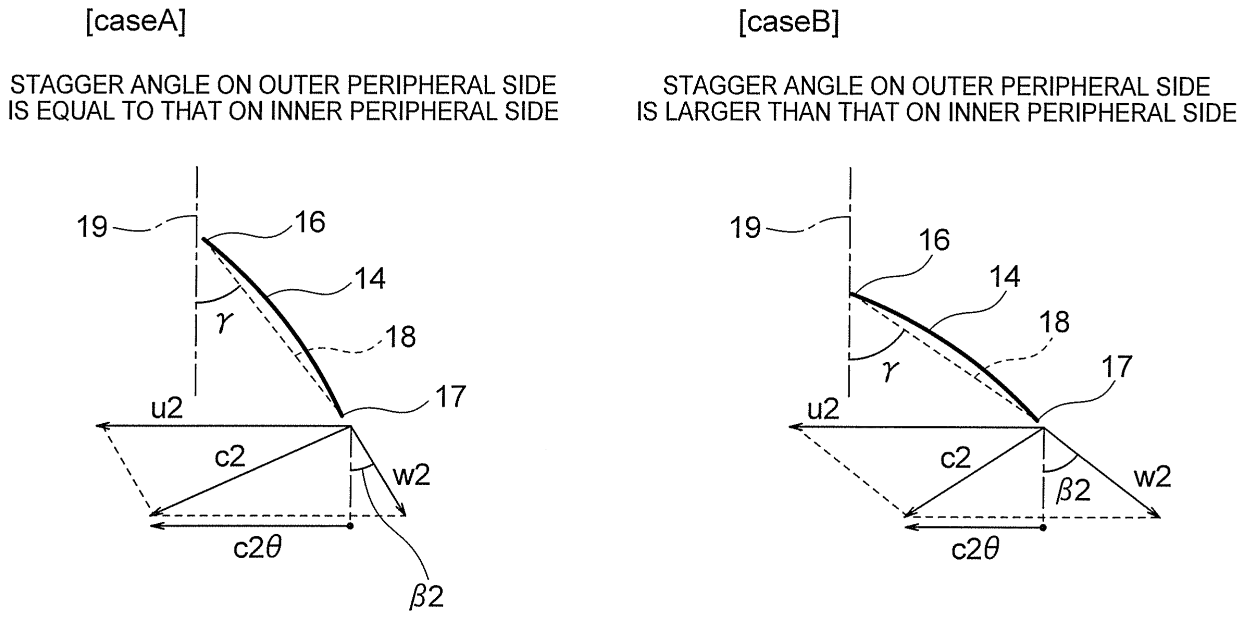
(54) MULTI-BLADE FAN

(57) A multiblade blower (1) includes: a first impeller (3a) arranged in a casing (2) having an air inlet (6) ; and a second impeller (3b) arranged in an internal space of the first impeller. The first impeller is a centrifugal fan including a plurality of first-impeller blades (11). The second impeller is an axial-flow fan including a plurality of second-impeller blades (14) extending radially from a rotation axis (5). In the second-impeller blades, a swirling-direction component of a wake in a region on an outer peripheral side in the internal space of the first impeller is smaller than a swirling-direction component of a wake in a region on an inner peripheral side in the internal space.

FIG. 3



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Description

Technical Field

[0001] The present invention relates to a multiblade blower.

Background Art

[0002] Multiblade blowers are air blowers devised to attain a large flow rate based on a centrifugal blower. An inner-outer diameter ratio of each blade is set relatively large in order to increase a diameter of an air inlet. The large inner-outer diameter ratio causes reduction in length of the blade in cross section horizontal to a rotation axis. Thus, the number of the blades is increased so as to prevent separation. Further, in general, in order to increase an effective head at a constant peripheral speed, forward curved vanes are employed so as to increase an outlet absolute speed, and a scroll casing is provided so as to change high dynamic pressure into static pressure. The multiblade blowers have simple configuration and are manufactured at low cost, and hence are widely used for general industrial applications, air conditioning applications, and the like.

[0003] An impeller arranged in the multiblade blower has a plurality of elongated blades arrayed in a circumferential direction, and entirely has a columnar shape when viewed in a rotation locus. An air inlet is formed on one side of the column or each of end surface regions having a circular shape on both sides of the column, and an air stream flowing through the air inlet passes between the blades, and flows out from a side surface region of a cylindrical shape in the columnar shape.

[0004] In order to attain the larger flow rate at a predetermined impeller diameter and a predetermined number of rotations, it is necessary to increase a dimension of the multiblade blower in a rotation axis direction. When the dimension in the rotation axis direction is increased, there is a problem in that sufficient volume of flow is not supplied to a region of each blade, which is far from the air inlet. Therefore, according to the technical document of Non Patent Literature 1, a ratio of the dimension in the rotation axis direction to an outer diameter of the impeller is appropriately set to about 0.5.

[0005] Further, there are known related-art multiblade blowers having a shape in which a motor is inserted into the impeller, which are devised to cope with a problem in that the motor hinders the flow. In Patent Literature 1, as an effort to supply the flow to the region of each blade, which is far from the air inlet in the rotation axis direction, an axial-flow fan is arranged inside the impeller of the multiblade blower.

Citation List

Patent Literature

[0006] [PTL 1] JP 2007-231863 A (Page 2 and FIG. 3)

Non Patent Literature

[0007] [NPL1] "Turbo Blower and Compressor" written by Takefumi Ikui, published by CORONA PUBLISHING CO., LTD. in August 25, 1988, page 295

Summary of Invention

Technical Problem

[0008] It is possible to increase the volume of the flow supplied to the region of each blade, which is far from the air inlet, by applying the related art, specifically, providing the axial-flow fan inside the multiblade blower having the large dimension in the rotation axis direction.

[0009] However, the flow passing through the axial-flow fan is applied with a swirling component from the axial-flow fan, and hence a vector of the flow varies between the front and back of the axial-flow fan. Therefore, even when the flow into the blades and the blade shape are appropriate on an upstream side of the axial-flow fan, the flow into the blades and the blade shape are inappropriate on a downstream side of the axial-flow fan. Thus, there is a problem in that the flow rate in accordance with the dimension of the multiblade blower in the rotation axis direction cannot be attained. Further, inappropriate flow into the blades and inappropriate blade shape cause a problem in that the separation at an inlet portion of the blade is significant to increase noise.

[0010] The present invention has been made to solve the problems as described above, and it is an object of the present invention to provide a multiblade blower capable of attaining the large flow rate while suppressing noise.

Solution to Problem

[0011] In order to achieve the above-mentioned object, according to one embodiment of the present invention, there is provided a multiblade blower, including: a casing having an air inlet; a first impeller arranged in the casing so as to be rotatable; and a second impeller arranged in an internal space of the first impeller so as to be rotatable, the first impeller being a centrifugal fan including a plurality of first-impeller blades positioned so as to forma cylindrical shape, the second impeller being an axial-flow fan including a plurality of second-impeller blades extending radially from a rotation axis, the plurality of second-impeller blades each being constructed such that a swirling-direction component of a wake in a region on an outer peripheral side in the internal space of the first impeller is smaller than a swirling-direction component of a wake in a region on an inner peripheral side in the internal space.

[0012] Further, a stagger angle in a region of each of the second-impeller blades on the outer peripheral side may be larger than a stagger angle in a region of each of the second-impeller blades on the inner peripheral side.

[0013] Further, a chord line in the region of each of the second-impeller blades on the outer peripheral side may be smaller than a chord line in the region of each of the second-impeller blades on the inner peripheral side.

[0014] Further, a number of the second-impeller blades arranged in the region on the outer peripheral side in the internal space of the first impeller may be smaller than a number of the second-impeller blades arranged in the region on the inner peripheral side in the internal space.

[0015] Further, it is preferred that the first impeller include a main plate fixed to a drive shaft, that the plurality of first-impeller blades be arranged along a periphery of the main plate, that the plurality of second-impeller blades connect together the drive shaft and the first-impeller blades, and that the plurality of first-impeller blades be held by the main plate and be also held by the second-impeller blades.

[0016] Further, it is preferred that a distance in the first impeller from an end portion on the air inlet side to a position connected to the second impeller be from 0.5 time to 1.0 time as large as an outer diameter of the first impeller.

[0017] Further, it is preferred that a dimension of the first impeller in a rotation axis direction be from 1.0 time to 1.5 times as large as the outer diameter of the first impeller.

Advantageous Effects of Invention

[0018] The multiblade blower according to the one embodiment of the present invention is capable of attaining the large flow rate while suppressing noise.

Brief Description of Drawings

[0019]

FIG. 1 is an external view of a multiblade blower according to a first embodiment of the present invention.

FIG. 2 is a view for illustrating a cross section taken along the line II-II of FIG. 1.

FIG. 3 is a sectional view for illustrating a shape of a part of a second-impeller blade on an outer peripheral side.

FIG. 4 is a view for illustrating a flow along a meridian plane inside an impeller.

FIG. 5 is a view for illustrating a dimension of the impeller.

FIG. 6 is an external view of a multiblade blower according to a second embodiment of the present invention.

FIG. 7 is a sectional view for illustrating a shape of a part of a second-impeller blade on an outer peripheral side.

FIG. 8 is an external view of a multiblade blower according to a third embodiment of the present invention.

FIG. 9 is a view for illustrating a cross section of first-impeller blades taken along the line IX-IX of FIG. 2 according to a fourth embodiment of the present invention.

FIG. 10 is a view for illustrating a cross section of the first-impeller blades taken along the line X-X of FIG. 2 according to the fourth embodiment.

Description of Embodiments

[0020] Now, a multiblade blower according to embodiments of the present invention is described with reference to the accompanying drawings. Note that, in the drawings, the same reference symbols represent the same or corresponding parts.

First Embodiment

[0021] FIG. 1 is an external view of a multiblade blower according to a first embodiment of the present invention, for illustrating a state in which an air inlet described later corresponds to a front side of the drawing sheet and the multiblade blower is viewed toward the air inlet. FIG. 2 is a view for illustrating a cross section of the multiblade blower taken along the line II-II of FIG. 1.

[0022] A multiblade blower 1 is an air blower to be used in, for example, an air conditioner or a ventilation fan, and includes a casing 2, an impeller 3, and a drive motor 4 serving as a drive source. The drive motor 4 and the impeller 3 share a rotation axis 5. In the description, a direction parallel to the rotation axis 5 is referred to as a rotation axis direction. A radiation direction of a straight line starting from the rotation axis 5 as the end point in a plane perpendicular to the rotation axis 5 is referred to as a radial direction. A side of the radial direction, which is closer to the rotation axis 5, is referred to as an inner peripheral side. A side of the radial direction, which is far from the rotation axis 5, is referred to as an outer peripheral side.

[0023] The casing 2 is, for example, a scroll casing, and includes an air inlet 6, a scroll wall 7, and an air outlet 8. The scroll wall 7 forms a scroll shape as an enlarging air duct in a cross section perpendicular to the rotation axis 5. The air inlet 6 is an opening formed by an annular portion having a bellmouth shape. The air inlet 6 is formed on one side surface of the casing 2, and the rotation axis 5 extends to pass through the center of the opening. The air outlet 8 is formed in a plane of the casing 2 in a swirling direction of the scroll shape.

[0024] The drive motor 4 is arranged on an outside of a side surface of the casing 2 on a side opposite to the air inlet 6. A motor shaft 9 of the drive motor 4 passes through the casing 2 to extend along the rotation axis 5 inside the casing 2. Further, the motor shaft 9 serving as a drive shaft protrudes toward the air inlet 6.

[0025] The impeller 3 includes a first impeller 3a serving as a centrifugal fan such as a sirocco fan, and a second impeller 3b serving as an axial-flow fan, and is received in the casing 2. The first impeller 3a includes a main plate 10 having a substantially disc-like shape, and a plurality of first-impeller blades 11. The main plate 10 is fixed to the motor shaft 9 in the vicinity of an inner wall surface of the casing 2 on the side opposite to the air inlet 6.

[0026] The plurality of first-impeller blades 11 extend to be elongated along a direction of the rotation axis 5, and are positioned so as to form a cylindrical shape. Further, the plurality of first-impeller blades 11 are arranged along a periphery of the main plate 10, and are arrayed to be equiangularly separated from each other so as to form an annular shape. An annular member 12 for reinforcement is fitted to end portions of the plurality of first-impeller blades 11 on the air inlet 6 side. An outer peripheral ring 15 has a shape covering outer peripheral sides of the first-impeller blades 11, and hence an outer diameter of the outer peripheral ring 15 is larger than an outer diameter of the first-impeller blades 11.

[0027] The second impeller 3b is arranged in an internal space (radially inner space) of the first impeller 3a having a cylindrical shape so as to be positioned between the main plate 10 of the first impeller 3a and the air inlet 6. Further, the second impeller 3b is supported by the motor shaft 9. The second impeller 3b includes an annular hub 13, a plurality of second-impeller blades 14, and the outer peripheral ring 15. The hub 13 is fixed in the vicinity of a distal end of the motor shaft 9. The plurality of second-impeller blades 14 extend radially from the rotation axis 5, more specifically, are arranged radially on an outer periphery of the hub 13. The outer peripheral ring 15 is arranged so as to connect together radially outer sides of the plurality of second-impeller blades 14.

[0028] A shape of each second-impeller blade 14 is changed from an inner peripheral side to an outer peripheral side. With the blade shape varying between the inner peripheral side and the outer peripheral side, a swirling-direction component $c2\theta$ of an outlet absolute flow, which is generated in a wake of the second-impeller blade 14 on the outer peripheral side (see FIG. 3 described later), is reduced.

[0029] Description is given of a mode that is one feature of the first embodiment, in which a stagger angle γ in a region of the second-impeller blade 14 on the outer peripheral side is set larger than a stagger angle in a region thereof on the inner peripheral side.

[0030] FIG. 3 is a sectional view for illustrating a shape of a part of the second-impeller blade 14 on the outer peripheral side, specifically, for illustrating an arc cross section having the rotation axis 5 as the center, which is developed into a plane. Further, FIG. 3 corresponds to a cross section of FIG. 1 at the position indicated by the reference symbol III. The left side [case A] of FIG. 3 corresponds to a case where the stagger angle γ on the outer peripheral side is set to be equal to that on the inner peripheral side, and the right side [case B] of FIG. 3 corresponds to a case where the stagger angle γ on the outer peripheral side is set larger than that on the inner peripheral side. That is, the first embodiment corresponds to the [case B].

[0031] An upper side in the drawing sheet of FIG. 3 corresponds to the air inlet 6 side, and a lower side in the drawing sheet of FIG. 3 corresponds to the main plate 10 side. A direction from the right side to the left side in the drawing sheet corresponds to a rotation direction of the impeller 3.

[0032] In the cross section of the second-impeller blade 14, an end portion in the rotation direction is referred to as a leading edge 16, and an end portion in a counter-rotation direction is referred to as a trailing edge 17. A straight line connecting the leading edge 16 and the trailing edge 17 is referred to as a chord line 18. An angle formed by a straight line 19 parallel to the rotation axis 5 and the chord line 18 is referred to as the stagger angle γ. Note that, the arrows illustrated on the lower side with respect to the trailing edge 17 in the drawing sheet form speed triangles for schematically illustrating a speed component of the flow on the downstream of the blade for the axial-flow fan.

[0033] An outlet peripheral speed u2 is proportional to a distance from the rotation axis 5. Thus, the peripheral speed is higher on the outer peripheral side than the inner peripheral side, and the swirling-direction component $c2\theta$ of an outlet absolute speed c2 is larger on the outer peripheral side. As understood from comparison between the [case A] and the [case B], when the stagger angle γ is increased, an outflow angle $\beta 2$ formed by an outlet relative speed w2 is increased, thereby being capable of reducing the swirling-direction component of the absolute speed.

[0034] Next, an actuation of the multiblade blower 1 is described.

[0035] In the multiblade blower 1, when the drive motor 4 is operated, the first-impeller blades 11 and the second-impeller blades 14 are rotated through intermediation of the motor shaft 9, the main plate 10, and the hub 13. With this, outside air is sucked into the impeller 3 through the air inlet 6, and is blown into the casing 2 due to an effect of pressure rise by the impeller 3. Then, the outside air is reduced in speed by the enlarging air duct formed by the scroll wall 7 of the casing 2, and is recovered to be moved only by static pressure, to thereby be blown out to the outside through the air outlet 8. In this manner, the air is blown.

[0036] The multiblade blower 1 of the first embodiment includes the second impeller 3b of the axial-flow type inside the first impeller 3a, and hence performance of sending the outside air from the air inlet 6 to the main plate 10 side is high. Thus, even when a dimension of the impeller 3 in the rotation axis direction is large, the air can be supplied to a region of each first-impeller blade 11 in the vicinity of the main plate 10.

[0037] The broken-line arrows of FIG. 4 schematically indicate a flow along a meridian plane from the air inlet 6 to the first-impeller blades 11. The air passing through the outer peripheral sides of the second-impeller blades 14 flows into portions of the first-impeller blades 11 in regions closer to the second-impeller blades 14.

[0038] The multiblade blower 1 of the first embodiment is constructed such that the stagger angle γ in the region of each second-impeller blade 14 on the outer peripheral side is set larger than the stagger angle in the region thereof on the inner peripheral side so as to reduce the swirling-direction component $c2\theta$ of the wake. Thus, as compared to an upstream side with respect to the second impeller 3b, change in angle of the flow into the first-impeller blade 11 is suppressed to be small. Therefore, reduction of air-sending performance, which may be caused when the flow enters the first-impeller blade 11 at an improper angle, is reduced. As a result, the large flow rate is secured, thereby being capable of providing the multiblade blower 1 reduced in noise.

[0039] Referring to FIG. 5, supplementary description is given of the dimensions and the positions of the impellers. An outer diameter of the first impeller 3a is represented by D1, a dimension of the impeller 3 in the rotation axis 5 direction is represented by L1, a distance in the first impeller 3a from an end portion on the air inlet 6 side to a position connected to the second impeller 3b is represented by L2, and a distance in the first impeller 3a from the position connected to the second impeller 3b to a position connected to the main plate 10 is represented by L3.

[0040] As described in the technical document above, the dimension in the rotation axis direction of the related-art general multiblade blower without the second impeller 3b is appropriately set up to about 0.5 time as large as D1. In the multiblade blower 1 of the first embodiment, the pressure increasing performance by the second impeller 3b is exerted. Thus, the distance L2 in the first impeller 3a from the end portion on the air inlet 6 side to the position connected to the second impeller 3b is appropriately set up to about 0.5 time to about 1.0 time as large as D1. Further, the distance in the first impeller 3a from the position connected to the second impeller 3b to the position connected to the main plate 10 is appropriately set up to about 0.5 time as large as D1. Thus, the dimension L1 of the impeller in the rotation axis direction is appropriately set to about 1.0 time to about 1.5 times as large as D1.

[0041] Further, as described above, due to the function of the second impeller 3b, the dimension of the impeller 3 in the rotation axis 5 direction in the multiblade blower 1 can be increased. On the other hand, in general, when the dimension in the rotation axis direction is increased, there is a problem in that runout of the impeller during the rotation is liable to be significant due to centrifugal forces generated in the blades during the rotation, displacement between the center of gravity of the impeller and the rotation axis, and the like. However, in the multiblade blower 1 of the first embodiment, at least a plurality of (as one preferred example, in the first embodiment, all of) the second-impeller blades 14 connect together the motor shaft 9 and the first-impeller blades 11. That is, the first-impeller blades 11 can be held not only by the main plate 10 but also by the second impeller 3b at a distance from the main plate 10. Thus, the second impeller 3b contributing to the increase in the flow rate and the reduction of noise also contributes to the support of the first impeller 3a, thereby being capable of obtaining an advantage against the above-mentioned problem in that the runout during the rotation can be suppressed to be small.

Second Embodiment

[0042] Next, a second embodiment of the present invention is described referring to FIG. 6 and FIG. 7. FIG. 6 and FIG. 7 are views similar to FIG. 1 and FIG. 3, for illustrating the second embodiment. That is, FIG. 6 is an external view of a multiblade blower of the second embodiment when viewed from the same direction as FIG. 1, and FIG. 7 corresponds to a cross section of FIG. 6 at the position indicated by the reference symbol VII. Further, the second embodiment is different from the first embodiment in the shape of each second-impeller blade, and except for the parts described below, the second embodiment is similar to the first embodiment.

[0043] Alsoina multiblade blower 101 of the second embodiment, a shape of each second-impeller blade 114 is changed, that is, a chord line LB in a region of each second-impeller blade 114 on the outer peripheral side is set smaller than a chord line in a region thereof on the inner peripheral side.

[0044] FIG. 7 is an illustration of a [case C] where the chord line LB on the outer peripheral side is set equal to that on the inner peripheral side, and a [case D] where the chord line LB on the outer peripheral side is set smaller than that on the inner peripheral side. The [case D] corresponds to the second embodiment.

[0045] The arrows illustrated on the lower side with respect to the trailing edge 17 in the drawing sheet form speed triangles for schematically illustrating a speed component of a flow on the downstream of the blade for the axial-flow fan, and also illustrate an inlet relative speed w1 in an overlapping manner. Change in angle from the inlet relative speed w1 to the outlet relative speed w2 corresponds to a deflection angle $\Delta\beta$. When energy applied by the blade to the air stream is increased, the deflection angle $\Delta\beta$ is increased. When the deflection angle $\Delta\beta$ is increased, the swirling-direction component $c2\theta$ of the outlet absolute flow is also increased.

[0046] As understood from the comparison between the [case C] and the [case D], when the chord line LB is reduced, the energy applied by the blade to the air is reduced, and the deflection angle $\Delta\beta$ is reduced. When the deflection angle $\Delta\beta$ is reduced, the swirling-direction component $c2\theta$ of the outlet absolute flow can also be reduced.

[0047] The air passing through the region of each second-impeller blade 114 on the outer peripheral side flows into a region of each first-impeller blade 11 in the vicinity of the second-impeller blade 114. The multiblade blower 101 of the second embodiment is constructed such that the swirling-direction component of the wake of the region of each second-impeller blade 114 on the outer peripheral side is reduced. As a result, as compared to the upstream side with respect to the second impeller 3b, the change in angle of the flow into the first-impeller blade 11 is suppressed to be small. Therefore, the reduction of the air-sending performance, which may be caused when the flow enters the first-impeller blade 11 at an improper angle, is reduced. As a result, the large flow rate is secured, thereby being capable of providing the multiblade blower 101 reduced in noise.

Third Embodiment

[0048] Next, a third embodiment of the present invention is described referring to FIG. 8. FIG. 8 is a view similar to FIG. 1, for illustrating the third embodiment. FIG. 8 is an external view of a multiblade blower of the third embodiment when viewed from the same direction as FIG. 1. Further, except for the parts described below, the third embodiment is similar to the first embodiment or the second embodiment.

[0049] In a multiblade blower 201 according to the third embodiment, in the internal space of the first impeller 3a, the number of the second-impeller blades present therein varies between a region on the outer peripheral side and a region on the inner peripheral side. That is, as an example, as illustrated in FIG. 8, five second-impeller blades 214a are arranged in total in the region on the outer peripheral side (region in a substantially annular shape in FIG. 8), and ten second-impeller blades 214a and 214b are arranged in total in the region on the inner peripheral side (region in a substantially circular shape in FIG. 8). That is, in the third embodiment, in the internal space of the first impeller 3a, the number of the second-impeller blades arranged in the region on the outer peripheral side is set smaller than the number of the second-impeller blades arranged in the region on the inner peripheral side. Note that, the number in each of the regions is merely an example, and the present invention is not limited thereto.

[0050] The specific configuration of the example in FIG. 8 is described. As blades constructing the second impeller 3b, the second-impeller blades 214a and the second-impeller blades 214b are prepared. Each second-impeller blade 214a has a relatively large dimension in the radial direction, and an end portion of each second-impeller blade 214a on the radially outer side reaches the first impeller 3a. On the other hand, each second-impeller blade 214b has a relatively small dimension in the radial direction, and an end portion of each second-impeller blade 214b on the radially outer side is away from the first impeller 3a as a free end. Further, those two types of the second-impeller blades 214a and the second-impeller blades 214b are arrayed equiangularly and alternately.

[0051] Through the reduction of the number of the blades of the second impeller 3b in the region on the outer peripheral side in the internal space of the first impeller 3a, the energy applied by the blades of the second impeller 3b to the air is reduced. When the energy applied to the air is reduced, the deflection angle $\Delta\beta$ of the flow is reduced, and the swirling-direction component $c2\theta$ to be applied is also reduced.

[0052] The air passing through the region of each second-impeller blade 214a on the outer peripheral side flows into a region of each first-impeller blade 11 in the vicinity of the second-impeller blade 214a. The multiblade blower 201 of the third embodiment is constructed such that the swirling-direction component of the wake of the region of each second-impeller blade 214a on the outer peripheral side is reduced. As a result, as compared to the upstream side of the second impeller 3b, the change in angle of the flow into the first-impeller blade 11 is suppressed to be small. Therefore, the reduction of the air-sending performance, which may be caused when the flow enters the blade at an improper angle, is reduced. As a result, the large flow rate is secured, thereby being capable of providing the multiblade blower 1 reduced in noise.

Fourth Embodiment

[0053] Next, a fourth embodiment of the present invention is described referring to FIG. 9 and FIG. 10. FIG. 9 and FIG. 10 are views for illustrating a blade shape of each first-impeller blade according to the fourth embodiment. More specifically, FIG. 9 and FIG. 10 are cross sections of the first-impeller blade respectively taken along the arrow IX and the arrow X of FIG. 2. Further, except for the parts described below, the fourth embodiment is similar to any one of the first to third embodiments.

[0054] In the multiblade blower according to the fourth embodiment, the shape of each first-impeller blade 11 of the first impeller 3a varies between a region on the upstream side with respect to the second impeller 3b (illustrated in FIG. 9) and a region on the downstream side with respect to the second impeller 3b (illustrated in FIG. 10).

[0055] The end point of each first-impeller blade 311 on an inlet side (inner peripheral side) is referred to as a leading edge 320. Assuming that reference symbol 321 represents a straight line passing through the rotation axis 5 and the leading edge 320 and reference symbol 322 represents a straight line crossing the straight line

321 at a right angle at the leading edge 320 and extending toward a rearward side in a rotation direction 317, an angle formed by a tangent line 323 of the leading edge 320 and the above-mentioned straight line 322 is referred to as a blade inlet angle βb1.

[0056] In the multiblade blower according to the third embodiment, an inlet angle βb1 in a region of the first-impeller blade 311 on the downstream side with respect to the second impeller 3b (illustrated in FIG. 10) is set larger than an inlet angle βb1 in a region of the first-impeller blade 311 on the upstream side with respect to the second impeller 3b (illustrated in FIG. 9).

[0057] The arrows of FIG. 9 and FIG. 10, which are illustrated on the lower side (rotation axis side) with respect to the leading edges 320 in the blade cross section, form speed triangles for illustrating a state of the flow on the inlet side. In the region of the first-impeller blade 311 on the downstream side with respect to the second impeller 3b, due to the swirling-direction component c2θ applied by the second-impeller blade, a swirling-direction component c1θ of an absolute flow c1 flowing into the first-impeller blade 311, which is parallel to an inlet peripheral speed u1, is larger than a swirling-direction component c2θ of an absolute flow c1 flowing into the first-impeller blade 311 in the region of the first-impeller blade 311 on the upstream side with respect to the second impeller 3b. Therefore, a relative flow w1 flowing into the first-impeller blade 311 also varies between the region on the upstream side and the region on the downstream side. In the region on the downstream side with respect to the second impeller 3b, the flow enters the first-impeller blade 311 at a small inflow angle β1.

[0058] As described above, in the fourth embodiment, the inlet angle βb1 in the region of the first-impeller blade 311 on the downstream side with respect to the second impeller 3b is set larger than the inlet angle βb1 in the region of the first-impeller blade 311 on the upstream side with respect to the second impeller 3b. Thus, both on the upstream side and the downstream side with respect to the second impeller 3b, the flow enters the first-impeller blade 11 at an appropriate angle. Also with this, the effect of increasing the flow rate and reducing noise can be obtained.

[0059] Although the details of the present invention are specifically described above with reference to the preferred embodiments, it is apparent that persons skilled in the art may adopt various modifications based on the basic technical concepts and teachings of the present invention.

Reference Signs List

[0060]

1, 101, 201 multiblade blower, 2 casing, 3a first impeller, 3b second impeller, 5 rotation axis, 6 air inlet, 9 motor shaft (drive shaft), 10 main plate, 11, 311 first-impeller blade, 14, 114, 214a, 214b second-impeller blade

Claims

1. A multiblade blower, comprising:

    a casing having an air inlet;
    a first impeller arranged in the casing so as to be rotatable; and
    a second impeller arranged in an internal space of the first impeller so as to be rotatable,
    the first impeller comprising a centrifugal fan comprising a plurality of first-impeller blades positioned so as to form a cylindrical shape,
    the second impeller comprising an axial-flow fan comprising a plurality of second-impeller blades extending radially from a rotation axis,
    the plurality of second-impeller blades each being constructed such that a swirling-direction component of a wake in a region on an outer peripheral side in the internal space of the first impeller is smaller than a swirling-direction component of a wake in a region on an inner peripheral side in the internal space.

2. A multiblade blower according to claim 1, wherein a stagger angle in a region of each of the second-impeller blades on the outer peripheral side is larger than a stagger angle in a region of each of the second-impeller blades on the inner peripheral side.

3. A multiblade blower according to claim 1 or 2, wherein a chord line in the region of each of the second-impeller blades on the outer peripheral side is smaller than a chord line in the region of each of the second-impeller blades on the inner peripheral side.

4. A multiblade blower according to any one of claims 1 to 3, wherein a number of the second-impeller blades arranged in the region on the outer peripheral side in the internal space of the first impeller is smaller than a number of the second-impeller blades arranged in the region on the inner peripheral side in the internal space.

5. A multiblade blower according to any one of claims 1 to 4,
    wherein the first impeller comprises a main plate fixed to a drive shaft,
    wherein the plurality of first-impeller blades are arranged along a periphery of the main plate,
    wherein the plurality of second-impeller blades connect together the drive shaft and the first-impeller blades, and
    wherein the plurality of first-impeller blades are held by the main plate and are also held by the second-impeller blades.

6. A multiblade blower according to any one of claims 1 to 5, wherein a distance in the first impeller from an end portion on the air inlet side to a position connected to the second impeller is from 0.5 time to 1.0 time as large as an outer diameter of the first impeller.

7. A multiblade blower according to claim 6, wherein a dimension of the first impeller in a rotation axis direction is from 1.0 time to 1.5 times as large as the outer diameter of the first impeller.

FIG. 1

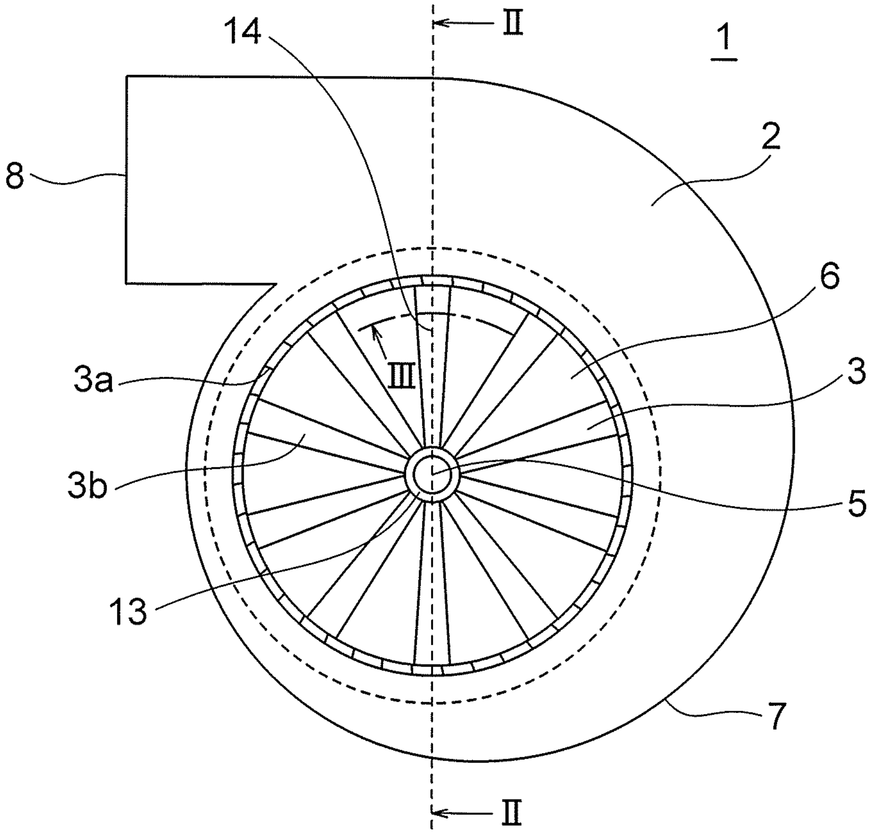


FIG. 2

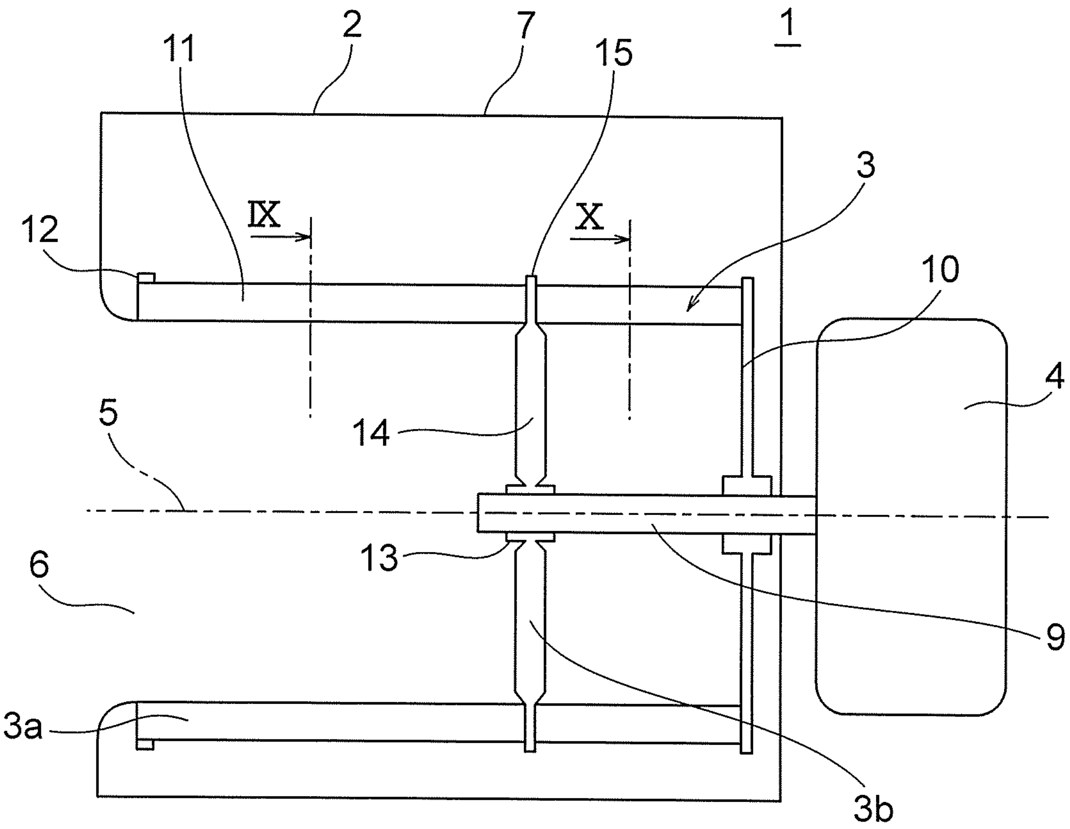


FIG. 3

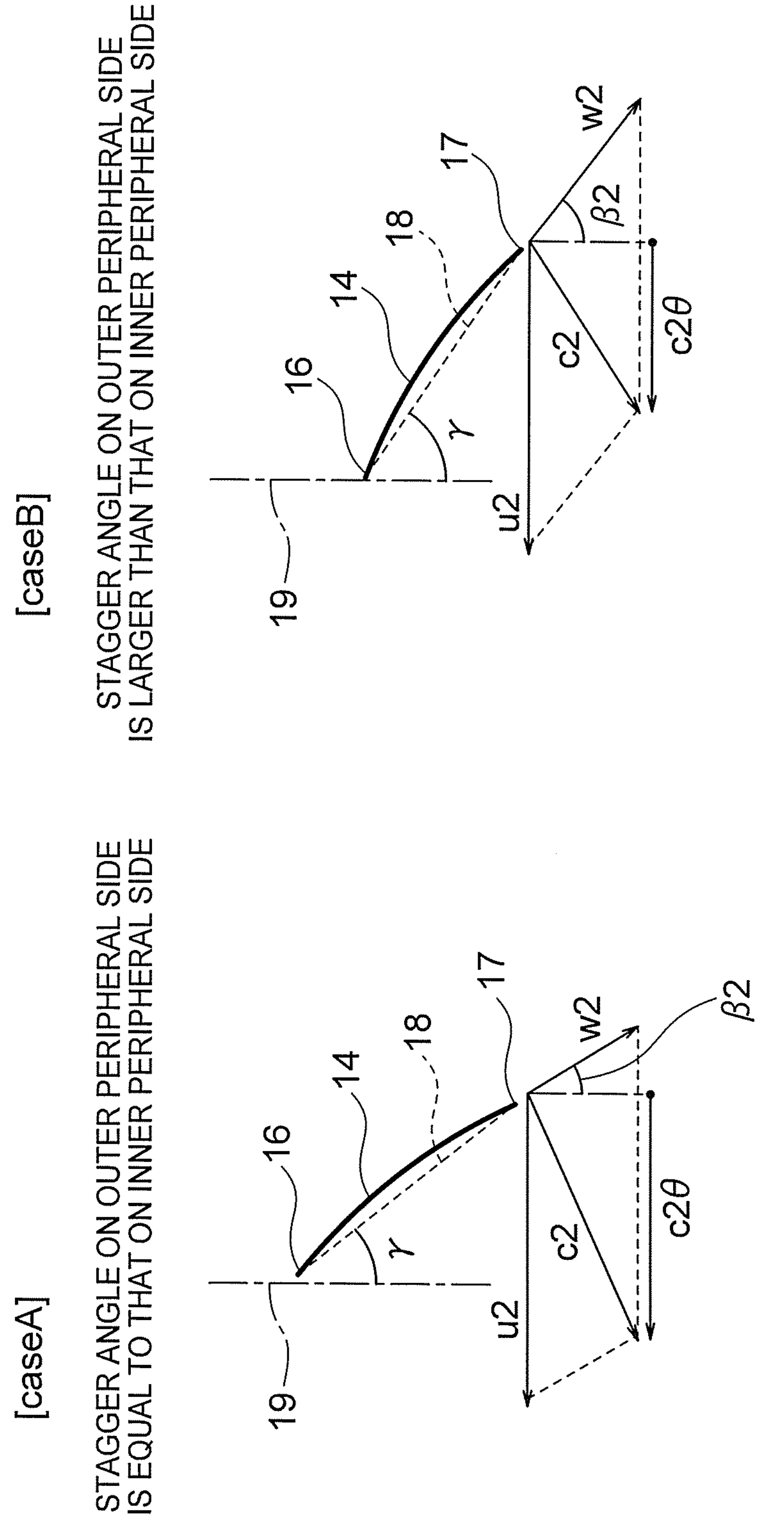

[caseA]
STAGGER ANGLE ON OUTER PERIPHERAL SIDE IS EQUAL TO THAT ON INNER PERIPHERAL SIDE
19
16
14
18
17
γ
w2
β2
u2
c2
c2θ
[caseB]
STAGGER ANGLE ON OUTER PERIPHERAL SIDE IS LARGER THAN THAT ON INNER PERIPHERAL SIDE
19
16
14
18
17
γ
w2
β2
u2
c2
c2θ

FIG. 4

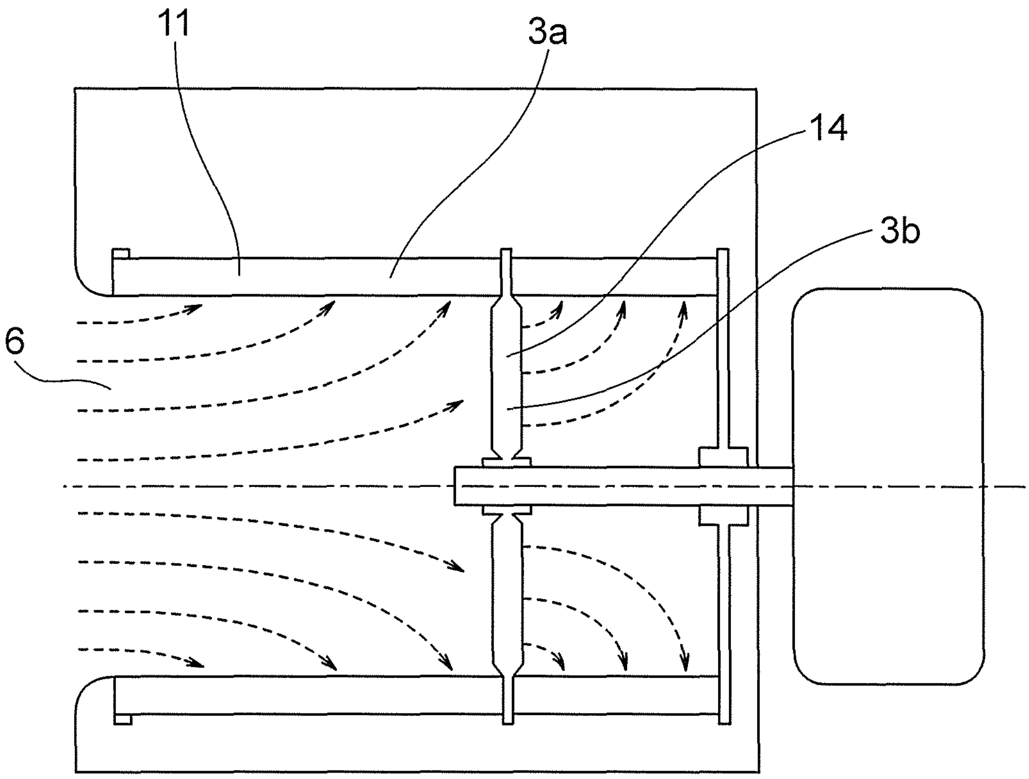


FIG. 5

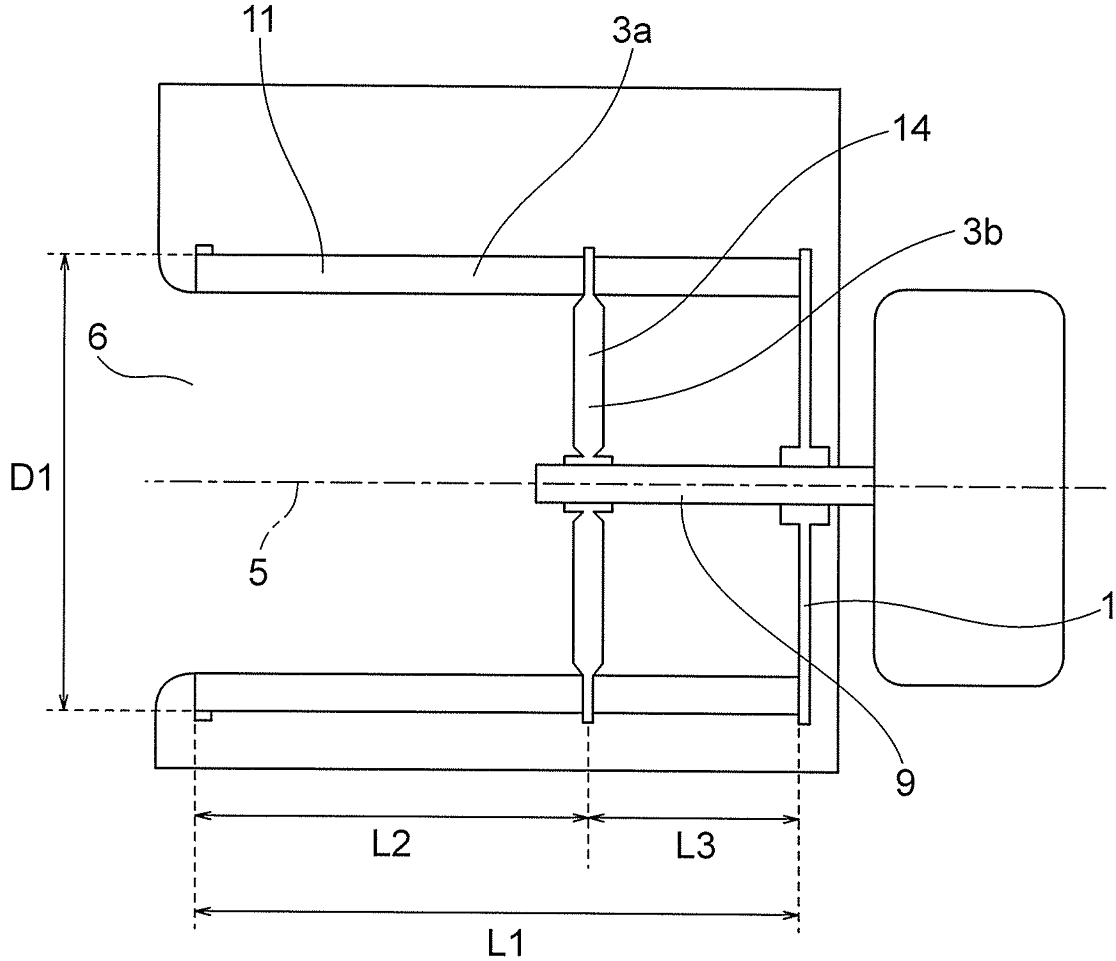


FIG. 6

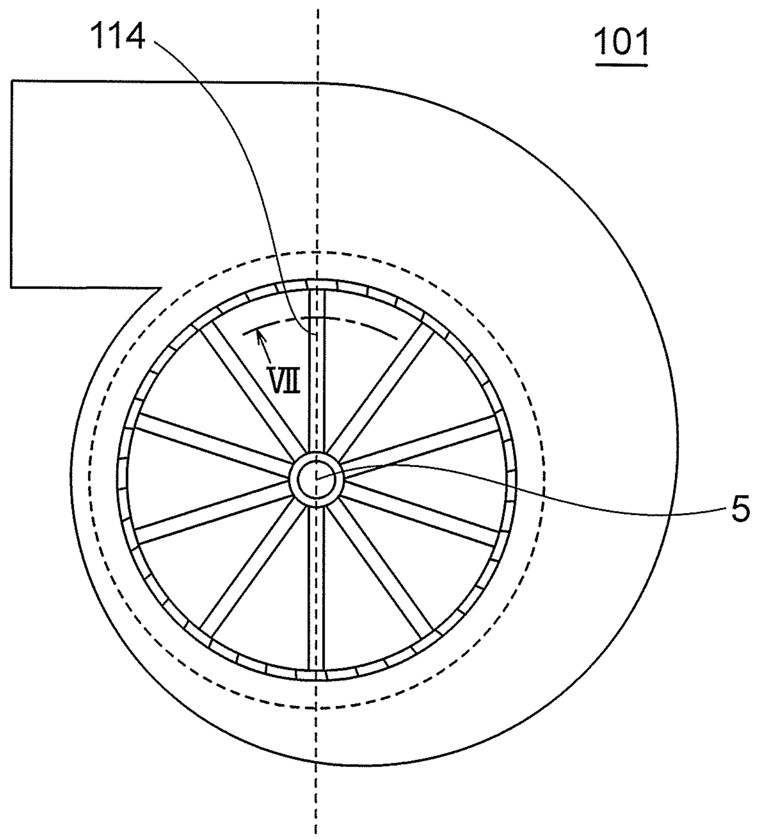


FIG. 7

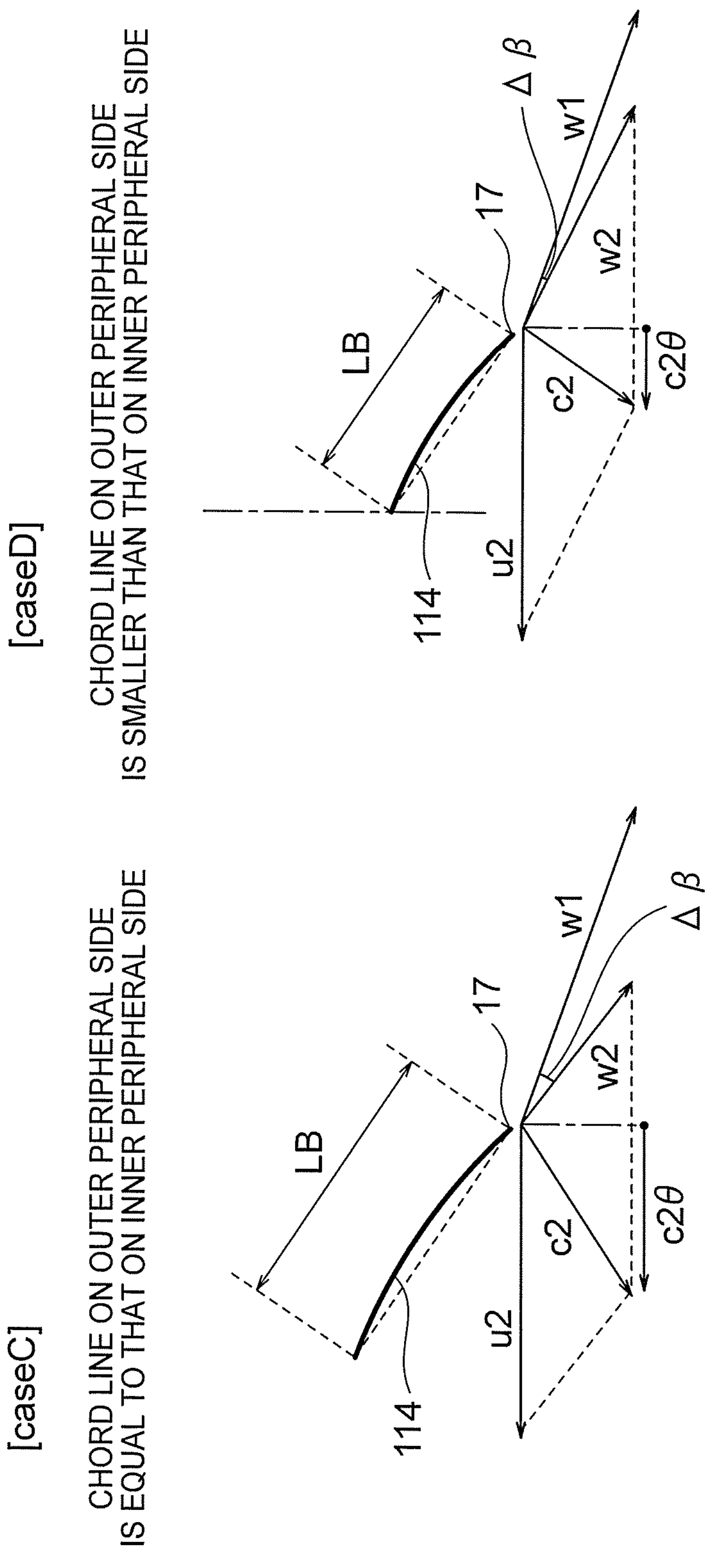

[caseC]
CHORD LINE ON OUTER PERIPHERAL SIDE
IS EQUAL TO THAT ON INNER PERIPHERAL SIDE
LB
114
17
u2
c2
c2θ
w2
w1
Δβ
[caseD]
CHORD LINE ON OUTER PERIPHERAL SIDE
IS SMALLER THAN THAT ON INNER PERIPHERAL SIDE
LB
114
17
u2
c2
c2θ
w2
w1
Δβ

FIG. 8

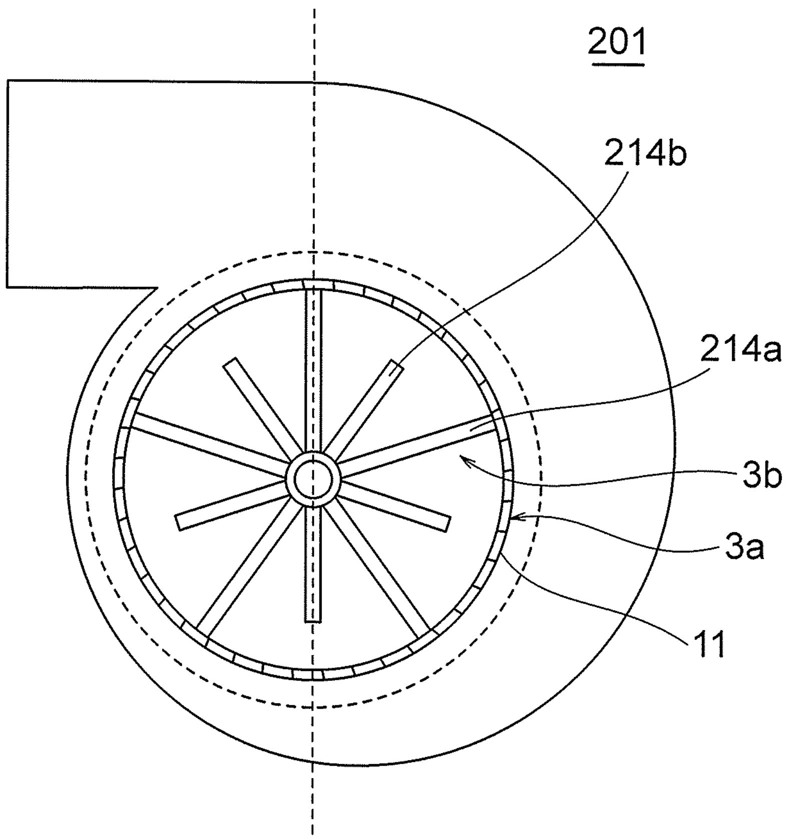


FIG. 9

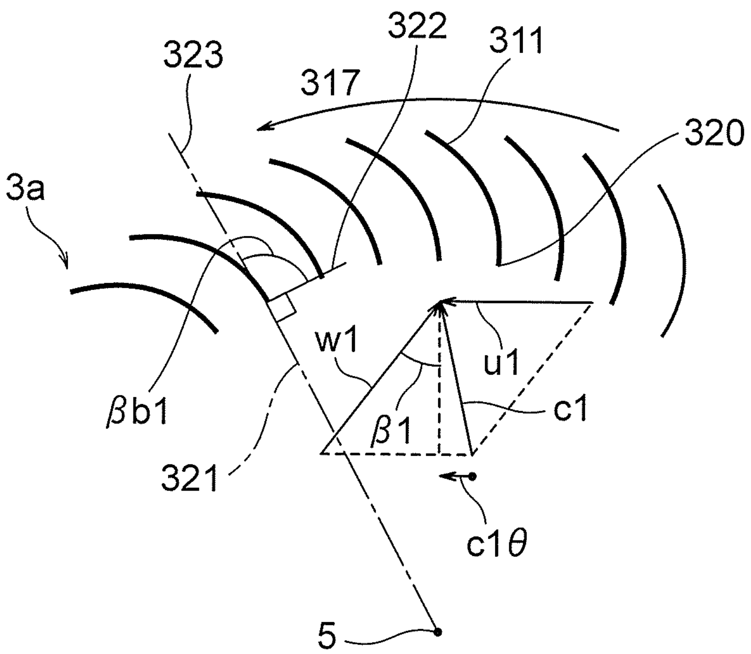
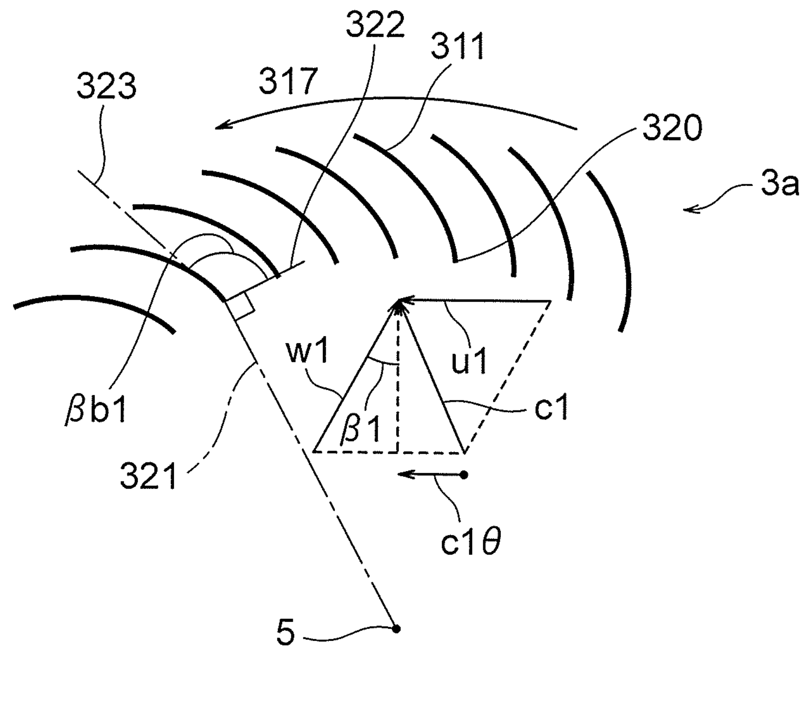

322
311
323
317
320
3a
w1
u1
βb1
β1
c1
321
c1θ
5

FIG. 10


322
311
323
317
320
3a
w1
u1
βb1
β1
c1
321
c1θ
5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/068871

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/30(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

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.
A	JP 2001-271791 A (Matsushita Seiko Co., Ltd.), 05 October 2001 (05.10.2001), paragraphs [0006], [0042] to [0048]; fig. 1 to 6 (Family: none)	1-7
A	JP 10-141296 A (Kubota Corp.), 26 May 1998 (26.05.1998), paragraphs [0014] to [0023]; fig. 3, 4 (Family: none)	1-7
A	JP 06-129388 A (Matsushita Seiko Co., Ltd.), 10 May 1994 (10.05.1994), paragraphs [0011] to [0013]; fig. 1 to 3 (Family: none)	1-7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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- "E" earlier application or patent but published on or after the international filing date
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 October, 2013 (02.10.13)	15 October, 2013 (15.10.13)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/068871

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 62-206291 A (Sanyo Electric Co., Ltd.), 10 September 1987 (10.09.1987), page 2, upper right column, line 20 to page 3, upper left column, line 12; fig. 1 to 4 (Family: none)	4-7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007231863 A **[0006]**

Non-patent literature cited in the description

- **TAKEFUMI IKUI.** Turbo Blower and Compressor. CORONA PUBLISHING CO., LTD, 25 August 1988, 295 **[0007]**