



(11) **EP 4 336 045 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.03.2024 Bulletin 2024/11

(51) International Patent Classification (IPC):
F04D 17/04^(2006.01)

(21) Application number: **21939823.7**

(52) Cooperative Patent Classification (CPC):
F04D 17/04

(22) Date of filing: **07.05.2021**

(86) International application number:
PCT/JP2021/017432

(87) International publication number:
WO 2022/234630 (10.11.2022 Gazette 2022/45)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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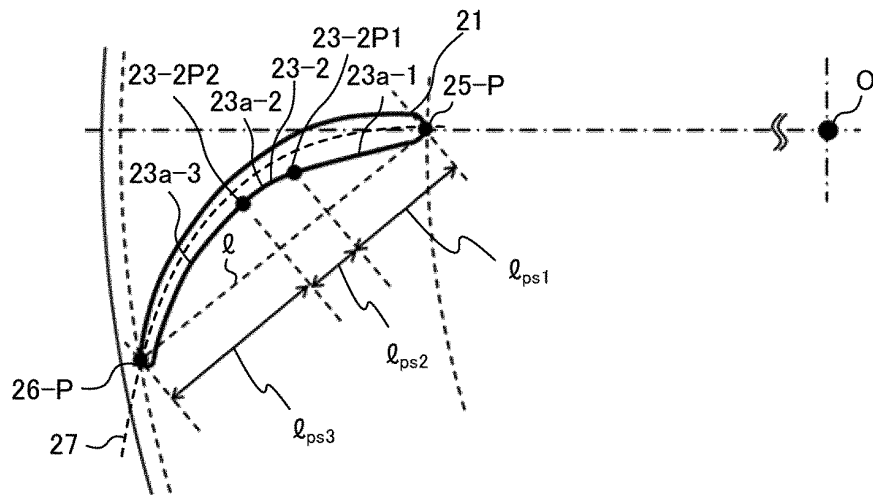
(54) **BLOWER, AIR CONDITIONER, AND REFRIGERATION CYCLE DEVICE**

(57) An air sending device is provided with a cross flow fan including an impeller in which a plurality of blades is arranged annularly. Each of the blades includes a pressure surface, a suction surface, an inner peripheral end face, and an outer peripheral end face, and in a section perpendicular to a rotation shaft of the cross flow fan, the pressure surface is concave in a rotation direction of the cross flow fan, the suction surface is convex in the opposite direction to the rotation direction, the inner peripheral end face is arcuately formed on an inner peripheral side of the blade and connecting the pressure surface and the suction surface, and the outer peripheral end face is arcuately formed on an outer peripheral side of the blade and connecting the pressure surface and the suction surface. The outer peripheral end face is located more forwardly than the inner peripheral end face in the rotation direction. The pressure surface of the blade sat-

isfies the following relationship: a curvature of a second pressure-surface side curved surface > a curvature of a third pressure-surface side curved surface > a curvature of a first pressure-surface side curved surface. When a first pressure-surface side area, a second pressure-surface side area, and a third pressure-surface side area of a surface of part of the blade that is located on a pressure surface side of the blade are projected on a chord line connecting the inner peripheral end and the outer peripheral end of the blade, a length of the first pressure-surface side area, a length of the second pressure-surface side area, and a length of the third pressure-surface side area satisfy the following relationship: the length of the third pressure-surface side area > the length of the first pressure-surface side area > the length of the second pressure-surface side area.

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FIG. 5



Description

Technical Field

[0001] The present disclosure relates to an air sending device provided with a cross flow fan, and also relates to an air-conditioning apparatus and a refrigeration cycle device.

Background Art

[0002] An air sending device located in a housing of an air-conditioning apparatus includes a fan casing and a cross flow fan accommodated in the fan casing. The cross flow fan has a configuration in which impellers are stacked on one another in a direction of a rotation shaft, and each of the impellers includes a plurality of blades arranged annually about the rotation shaft, and a support plate formed in a circular shape on which the plurality of blades are installed, the support plate supporting the plurality of blades integrally (see, for example, Patent Literature 1). The impeller has a suction region and a blowing region in the circumferential direction, and generates air current to suction air from the radially outer side toward the radially inner side in the suction region, and blow out the air from the radially inner side toward the radially outer side in the blowing region. In Patent Literature 1, the blades extending in the radial direction of the impeller have a uniform blade thickness, and the curvature on the outer peripheral side of the blades is smaller than the curvature on the inner peripheral side thereof, thereby to reduce the volume of air current that separates from the blades in the blowing region.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2001-280288

Summary of Invention

Technical Problem

[0004] In Patent Literature 1, separation of air current from the blades in the blowing region of the impeller is restrained, however, separation of air current in a boundary region between the suction region and the blowing region of the impeller is not considered.

[0005] The present disclosure has been made in view of the above problems, and it is an object of the present disclosure to provide an air sending device in which it is possible to restrain separation of air current in a boundary region between a suction region and a blowing region of an impeller, and to provide an air-conditioning apparatus and a refrigeration cycle device.

Solution to Problem

[0006] An air sending device according to one embodiment of the present disclosure is an air sending device provided with a cross flow fan including an impeller in which a plurality of blades are arranged annularly, wherein each of the blades includes a pressure surface, a suction surface, an inner peripheral end face, and an outer peripheral end face, and in a section perpendicular to a rotation shaft of the cross flow fan, the pressure surface is concave in a rotation direction of the cross flow fan, the suction surface is convex in the opposite direction to the rotation direction, the inner peripheral end face is arcuately formed on an inner peripheral side of the blade and connecting the pressure surface and the suction surface, and the outer peripheral end face is arcuately formed on an outer peripheral side of the blade and connecting the pressure surface and the suction surface, the outer peripheral end face is located more forwardly than the inner peripheral end face in the rotation direction, the pressure surface of the blade includes a first pressure-surface side curved surface, a second pressure-surface side curved surface, and a third pressure-surface side curved surface that are arranged in this order from the inner peripheral side of the impeller, and the first pressure-surface side curved surface, the second pressure-surface side curved surface, and the third pressure-surface side curved surface have different curvatures that satisfy the following relationship: the curvature of the second pressure-surface side curved surface > the curvature of the third pressure-surface side curved surface > the curvature of the first pressure-surface side curved surface, and where of two parts of the blade into which the blade is divided with respect to an imaginary center plane extending through a center portion of the blade that is located at the center of the blade in a thickness direction of the blade, a surface of part of the blade that is located on a pressure surface side of the blade is divided into three areas at an inner peripheral end and an outer peripheral end of the second pressure-surface side curved surface, the three areas being provided as a first pressure-surface side area, a second pressure-surface side area, and a third pressure-surface side area that are arranged in this order from the inner peripheral side, when the first pressure-surface side area, the second pressure-surface side area, and the third pressure-surface side area are projected on a chord line connecting the inner peripheral end and the outer peripheral end of the blade, a length of the first pressure-surface side area, a length of the second pressure-surface side area, and a length of the third pressure-surface side area satisfy the following relationship: the length of the third pressure-surface side area > the length of the first pressure-surface side area > the length of the second pressure-surface side area.

[0007] An air-conditioning apparatus according to another embodiment of the present disclosure includes the above air sending device, a housing configured to ac-

commodate the air sending device therein, and a heat exchanger.

[0008] A refrigeration cycle device according to still another embodiment of the present disclosure includes the above air sending device.

Advantageous Effects of Invention

[0009] According to one embodiment of the present disclosure, the curvature of the first pressure-surface side curved surface of the blade is the smallest among the three curved surfaces that make up the pressure surface, and the length of the first pressure-surface side area is greater than the length of the second pressure-surface side area, so that the air sending device can restrain separation of air current in a boundary region between a suction region and a blowing region of the impeller.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a schematic perspective view illustrating the configuration of an air-conditioning apparatus including an air sending device according to Embodiment 1.

[Fig. 2] Fig. 2 is a schematic vertical sectional view of the air-conditioning apparatus including the air sending device according to Embodiment 1.

[Fig. 3] Fig. 3 is a schematic front view of a cross flow fan of the air sending device according to Embodiment 1.

[Fig. 4] Fig. 4 is a sectional view of a portion of an impeller of the air sending device according to Embodiment 1, taken along the direction perpendicular to a rotation shaft.

[Fig. 5] Fig. 5 is an explanatory view illustrating first to third pressure-surface side areas of the impeller of the air sending device according to Embodiment 1.

[Fig. 6] Fig. 6 is an explanatory view illustrating an inflow angle of air current relative to the impeller of the air sending device according to Embodiment 1.

[Fig. 7] Fig. 7 illustrates a fan-blowing airflow velocity distribution in the cross flow fan of the air sending device according to Embodiment 1.

[Fig. 8] Fig. 8 is a sectional view of a portion of the impeller of the air sending device according to Embodiment 2, taken along the direction perpendicular to the rotation shaft.

[Fig. 9] Fig. 9 is an explanatory view illustrating first to third suction-surface side areas of the impeller of the air sending device according to Embodiment 2.

[Fig. 10] Fig. 10 is a sectional view of a portion of the impeller of the air sending device according to Embodiment 3, taken along the direction perpendicular to the rotation shaft.

[Fig. 11] Fig. 11 is a sectional view of a portion of the

impeller of the air sending device according to Embodiment 4, taken along the direction perpendicular to the rotation shaft.

[Fig. 12] Fig. 12 is a sectional view of a portion of the impeller according to Embodiment 5, taken along the direction perpendicular to the rotation shaft.

[Fig. 13] Fig. 13 illustrates the configuration of a refrigeration cycle device according to Embodiment 6.

10 Description of Embodiments

[0011] Embodiments of an air-conditioning apparatus according to the present disclosure will be described below. Note that the forms illustrated in the drawings are merely examples, and are not intended to limit the present disclosure. In the drawings below, the same reference signs denote the same or equivalent components, which are common throughout the entire specification. Further, the relationship of sizes of the components in the drawings described below may differ from that of actual ones.

Embodiment 1

[0012] Fig. 1 is a schematic perspective view illustrating the configuration of an air-conditioning apparatus 1 including an air sending device 7 according to Embodiment 1. Fig. 2 is a schematic vertical sectional view of the air-conditioning apparatus 1 including the air sending device 7 according to Embodiment 1. Fig. 3 is a schematic front view of a cross flow fan 11 of the air sending device 7 according to Embodiment 1.

Overall configuration of air-conditioning apparatus

[0013] The air-conditioning apparatus 1 uses a refrigeration cycle that allows refrigerant to circulate, to thereby supply conditioned air to an air-conditioning target space such as a room. A housing 2 of the air-conditioning apparatus 1 includes a main body 3 mounted in a ceiling of a room, and a cosmetic panel 4 provided on the lower side of the main body 3. In the housing 2, a heat exchanger 6 and the air sending device 7 are accommodated. In the housing 2, a drain pan 8 is further provided below the heat exchanger 6 to collect condensed water generated in the heat exchanger 6.

[0014] On the cosmetic panel 4, an air inlet 4a and an air outlet 4b are formed. The air inlet 4a serves as an entrance to the air-conditioning apparatus 1 for air current generated by rotation of the air sending device 7. The air outlet 4b serves as an exit for the air current. At the air inlet 4a, a filter 5 is located to remove dust and dirt in the air to be suctioned into the housing 2. At the air outlet 4b, an up-down airflow direction adjustment plate 9 and a left-right airflow direction adjustment plate 10 are located to control the direction of airflow to be blown. The heat exchanger 6 is located on an upstream side of an airflow path extending from the air inlet 4a to the air outlet

4b. The air sending device 7 is provided on a downstream side of the airflow path.

[0015] The air-conditioning apparatus 1 suctions air generated by driving of the air sending device 7 from the air inlet 4a into the housing 2, then exchanges heat between the suctioned air and refrigerant in the heat exchanger 6, and thereafter blows the air from the air outlet 4b to a room, thereby adjusting the room temperature. In the descriptions below, the term "upstream" refers to upstream of a certain target in air current, while the term "downstream" refers to downstream of a certain target in air current. Note that Figs. 1 and 2 illustrate an example in which the air-conditioning apparatus 1 is a ceiling-mounted air-conditioning indoor unit, however, the air-conditioning apparatus 1 is not limited thereto, but may be, for example, an indoor wall-mounted air-conditioning indoor unit.

Air sending device 7

[0016] The air sending device 7 includes the cross flow fan 11 configured to generate air current, a motor 12 (see Fig. 3) configured to cause the cross flow fan 11 to rotate, and a fan casing 13 configured to guide air blown out from the cross flow fan 11 to the air outlet 4b. As illustrated in Fig. 3, the cross flow fan 11 has a configuration in which impellers 20 are stacked on one another in a direction of a rotation shaft O of the motor 12, and each of the impellers 20 includes a plurality of blades 21 arranged annularly about the rotation axis of the rotation shaft O, and a support plate 22 on which the plurality of blades 21 are installed, the support plate 22 supporting the plurality of blades 21 integrally. The cross flow fan 11 is installed horizontally with the rotation shaft O extending in the left-right direction of the housing 2. In the descriptions below, the direction in which the rotation shaft O extends is referred to as "axial direction," the direction perpendicular to the axial direction is referred to as "radial direction," and the direction about the rotation shaft O is referred to as "circumferential direction."

[0017] The impeller 20 rotates in the solid-arrow direction in Fig. 2, suctions air current from a suction region E1, and blows out the air current from a blowing region E2. In the suction region E1, air current passes through gaps between the blades 21 (hereinafter, referred to as "blade-to-blade gap") from the radially outer side to the radially inner side. In the blowing region E2, air current flows through the blade-to-blade gap from the radially inner side to the radially outer side.

[0018] As illustrated in Fig. 2, the fan casing 13 includes a rear guide 14 and a stabilizer 15. The rear guide 14 is a guide portion to guide air blown out from the impeller 20 to the air outlet 4b. The rear guide 14 forms a scroll surface from an upstream end 14a of the rear guide 14 to a downstream end 14b thereof. The stabilizer 15 is a wall portion opposite to the rear guide 14 with respect to the impeller 20. The stabilizer 15 is formed along the outer peripheral surface of the impeller 20.

[0019] The suction region E1 and the blowing region E2 of the impeller 20 are divided by the rear guide 14 and the stabilizer 15. Specifically, the entire circumference of the impeller 20 is divided into two regions with respect to a boundary line connecting the stabilizer 15 and the rear guide 14 that are opposite to each other. The upstream-side region of the two regions is defined as the suction region E1, while the downstream-side region of the two regions is defined as the blowing region E2. A boundary region between the suction region E1 and the blowing region E2 in the circumferential direction of the impeller 20 serves as a switching region switching between suctioning a flow of air and blowing a flow of air. There are two boundary regions, one of which is located near the upstream end 14a of the rear guide 14, and the other of which is located near the stabilizer 15. Hereinafter, the boundary region located near the upstream end 14a of the rear guide 14 is referred to as "first boundary region E3," while the boundary region located near the stabilizer 15 is referred to as "second boundary region E4."

[0020] Next, the blades 21 of the impeller 20 are described in detail.

[0021] Fig. 4 is a sectional view of a portion of the impeller 20 of the air sending device 7 according to Embodiment 1, taken along the direction perpendicular to the rotation shaft O. Fig. 5 is an explanatory view illustrating first to third pressure-surface side areas of the impeller 20 of the air sending device 7 according to Embodiment 1.

[0022] Each of the blades 21 is made up of a pressure surface 23, a suction surface 24, an inner peripheral end face 25, and an outer peripheral end face 26. In a section perpendicular to the rotation shaft O, the pressure surface 23 is concave in a rotation direction illustrated by the arrow in Fig. 4, and the suction surface 24 is convex in the opposite direction to the rotation direction. The inner peripheral end face 25 is arcuately formed on an inner peripheral side of the blade 21 and connects the pressure surface 23 and the suction surface 24. The outer peripheral end face 26 is arcuately formed on an outer peripheral side of the blade 21 and connects the pressure surface 23 and the suction surface 24. The outer peripheral end face 26 is located more forwardly than the inner peripheral end face 25 in the rotation direction. The blade 21 includes an inner peripheral end 25-P that is an end of the blade 21 on its inner peripheral side, and an outer peripheral end 26-P that is an end of the blade 21 on its outer peripheral side. The inner peripheral end 25-P is included in the inner peripheral end face 25. The outer peripheral end 26-P is included in the outer peripheral end face 26. In Fig. 4, a reference numeral 23-P1 denotes an inner peripheral end of the pressure surface 23, while a reference numeral 23-P2 denotes an outer peripheral end of the pressure surface 23. A reference numeral 24-P1 denotes an inner peripheral end of the suction surface 24, while a reference numeral 24-P2 denotes an outer peripheral end of the suction surface 24.

[0023] The pressure surface 23 is made up of a plurality of curved surfaces. The plurality of curved surfaces is provided as a first pressure-surface side curved surface 23-1, a second pressure-surface side curved surface 23-2, and a third pressure-surface side curved surface 23-3 that are arranged in this order from the inner peripheral side. The pressure surface 23 is formed satisfying the following relationship: the curvature of the second pressure-surface side curved surface 23-2 > the curvature of the third pressure-surface side curved surface 23-3 > the curvature of the first pressure-surface side curved surface 23-1. The first pressure-surface side curved surface 23-1 may be a flat surface with a curvature of 0.

[0024] As illustrated in Fig. 5, the blade 21 includes two parts into which the blade 21 is divided with respect to an imaginary center plane 27 extending through a center portion of the blade 21 that is located at the center of the blade 21 in its thickness direction. The two parts include a surface of part of the blade that is located on its pressure surface side, and a surface of part of the blade that is located on its suction surface side. The imaginary center plane 27 passes through the inner peripheral end 25-P and the outer peripheral end 26-P. The surface of part of the blade that is located on its pressure surface side is divided into three areas at an inner peripheral end 23-2P1 and an outer peripheral end 23-2P2 of the second pressure-surface side curved surface 23-2. The three areas are provided as a first pressure-surface side area 23a-1, a second pressure-surface side area 23a-2, and a third pressure-surface side area 23a-3 that are arranged in this order from the inner peripheral side. The first pressure-surface side area 23a-1 extends from the inner peripheral end 25-P of the blade 21 to the inner peripheral end 23-2P1 of the second pressure-surface side curved surface 23-2. The second pressure-surface side area 23a-2 is equivalent to the area of the second pressure-surface side curved surface 23-2. The third pressure-surface side area 23a-3 extends from the outer peripheral end 23-2P2 of the second pressure-surface side curved surface 23-2 to the outer peripheral end 26-P of the blade 21.

[0025] As illustrated in Fig. 5, when the first pressure-surface side area 23a-1, the second pressure-surface side area 23a-2, and the third pressure-surface side area 23a-3 are projected on a chord line l , their respective lengths in this order are defined as a length l_{ps1} of the first pressure-surface side area, a length l_{ps2} of the second pressure-surface side area, and a length l_{ps3} of the third pressure-surface side area. Based on this definition, the blade 21 is formed satisfying the following relationship: the length l_{ps3} of the third pressure-surface side area > the length l_{ps1} of the first pressure-surface side area > the length l_{ps2} of the second pressure-surface side area. Note that the chord line l is a straight line connecting the inner peripheral end 25-P and the outer peripheral end 26-P of the blade 21.

[0026] Operational effects due to the above configura-

tion are described below.

[0027] Fig. 6 is an explanatory view illustrating an inflow angle of air current relative to the impeller 20 of the air sending device 7 according to Embodiment 1. In the impeller 20, when focus is on only a single blade 21, the inflow angle of air current relative to the blade 21 varies depending on the position of the blade 21 in the rotation direction. The inflow angle refers to an angle formed by an air-current direction and a tangent line L to the imaginary center plane 27 extending through the center portion of the blade 21 in its thickness direction at the inner peripheral end 25-P. Specifically, Fig. 6 illustrates air current 30 when the blade 21 is located in the blowing region E2, and an inflow angle θ of the air current 30 is represented as $\theta 1$. Fig. 6 also illustrates air current 31 when the blade 21 is located in the first boundary region E3, and the inflow angle θ of the air current 31 is represented as $\theta 2$.

[0028] When the inflow angle θ to the blade 21 is relatively small as illustrated as $\theta 1$, air current flows along the pressure surface 23. However, when the inflow angle θ is relatively large as illustrated as $\theta 2$, air current is more likely to separate from the pressure surface 23 on its inner peripheral side. That is, in the first boundary region E3, the inflow angle θ of air current to the blade 21 is relatively increased, so that the air current is more likely to separate from the pressure surface 23 on its inner peripheral side. In the conventional technique, an inflow angle of air current to a blade in a region equivalent to the first boundary region E3 is relatively increased as described above, so that the air current is more likely to separate from the pressure surface on its inner peripheral side. This issue has not been considered in the conventional technique, and consequently noise is generated due to separation of the air current.

[0029] In contrast to this, in Embodiment 1, in the blade 21, the first pressure-surface side curved surface 23-1 (see Fig. 4), located on the inner peripheral side of the blade 21 from which air current enters, has the smallest curvature among the three curved surfaces that make up the pressure surface 23. Accordingly, even if the air current separates from the blade 21 at the inner peripheral end 25-P, the smallest curvature helps the air current to flow easily in contact with the pressure surface 23 again. That is, separation of the air current from the pressure surface 23 of the blade 21 in the first boundary region E3 is restrained. This stabilizes the direction of air current in the blade-to-blade gap in the first boundary region E3 such that the air current flows from the radially inner side toward the radially outer side. This is substantially equivalent to categorizing the blade 21 in the first boundary region E3, that is one of the two boundary regions and located near the upstream end 14a of the rear guide 14, as a blade 21 in the blowing region E2. That is, the impeller 20 can enlarge the blowing region E2 toward the upstream end 14a of the rear guide 14.

[0030] Meanwhile, on the blowing side of the impeller 20, an uneven distribution of airflow velocity is likely to

occur in the blade-to-blade gap between the pressure surface 23 of the blade 21 and the suction surface 24 of the adjacent blade 21. In the uneven distribution, the air-flow velocity is low on the pressure surface 23, while being high on the suction surface 24.

[0031] In Embodiment 1, the length l_{ps1} of the first pressure-surface side area, including the first pressure-surface side curved surface 23-1 having the smallest curvature and located on the air-current entrance side of the pressure surface 23, is greater than the length l_{ps2} of the second pressure-surface side area. This allows air current having entered the blade-to-blade gap to flow easily in contact with the pressure surface 23, so that separation of the air current from the pressure surface 23 is restrained. In addition, the air current having entered the blade-to-blade gap flows easily in contact with the pressure surface 23, so that the airflow velocity of the air current on the pressure surface 23 is increased. As the airflow velocity of the air current on the pressure surface 23 is increased, the uneven distribution of airflow velocity in the blade-to-blade gap is reduced. Accordingly, an even distribution of airflow velocity in the blade-to-blade gap is achieved. As the uneven distribution of airflow velocity in the blade-to-blade gap is reduced, an air movement resistance in the blade-to-blade gap is decreased, so that effects of reducing the fan input and the noise level can be obtained.

[0032] Fig. 7 illustrates a fan-blowing airflow velocity distribution in the cross flow fan 11 of the air sending device 7 according to Embodiment 1. In Fig. 7, the horizontal axis represents a particular area of the impeller 20 in its circumferential direction, and the vertical axis represents a fan-blowing airflow velocity [m/s]. The particular area of the impeller 20 in its circumferential direction refers to a circumferential area extending from the circumferential position of the impeller 20 opposite to the upstream-side end portion of the stabilizer 15, to the circumferential position of the impeller opposite to the upstream end 14a of the rear guide 14, and including the blowing region E2.

[0033] In Fig. 7, a curve (a) shows the fan-blowing airflow velocity in Embodiment 1, while a curve (b) shows the fan-blowing airflow velocity in the conventional technique. It is apparent from Fig. 7 that in Embodiment 1, the blowing region is enlarged toward the upstream end of the rear guide, compared to the conventional technique. As the blowing region is enlarged, the maximum flow rate is decreased accordingly. As a result, the air movement resistance is decreased, so that the effects of reducing the fan input and the noise level can be obtained.

[0034] As explained above, the air sending device 7 in Embodiment 1 is an air sending device provided with the cross flow fan 11 including the impeller 20 in which a plurality of the blades 21 are arranged annularly. The pressure surface 23 of the blade 21 satisfies the following relationship: the curvature of the second pressure-surface side curved surface 23-2 > the curvature of the third

pressure-surface side curved surface 23-3 > the curvature of the first pressure-surface side curved surface 23-1. In addition, the pressure surface 23 of the blade 21 satisfies the following relationship: the length l_{ps3} of the third pressure-surface side area > the length l_{ps1} of the first pressure-surface side area > the length l_{ps2} of the second pressure-surface side area.

[0035] As described above, on the pressure surface 23 of the blade 21, the curvature of the first pressure-surface side curved surface 23-1 is the smallest among the three curved surfaces that make up the pressure surface 23. The length l_{ps1} of the first pressure-surface side area is greater than the length l_{ps2} of the second pressure-surface side area. With this configuration, the air sending device 7 can restrain separation of air current in the first boundary region E3, specifically, separation of air current from the pressure surface 23 of the blade 21 in the first boundary region E3. In addition, the length l_{ps1} of the first pressure-surface side area is greater than the length l_{ps2} of the second pressure-surface side area, so that the air sending device 7 can increase the airflow velocity of air current on the pressure surface 23. The airflow velocity of air current on the pressure surface 23 can be increased, and accordingly the air sending device 7 can reduce the uneven distribution of airflow velocity in the blade-to-blade gap, thus can decrease the air movement resistance in the blade-to-blade gap, and consequently can reduce the fan input and the noise level.

Embodiment 2

[0036] Fig. 8 is a sectional view of a portion of the impeller 20 of the air sending device 7 according to Embodiment 2, taken along the direction perpendicular to the rotation shaft O. Fig. 9 is an explanatory view illustrating the first to third suction-surface side areas of the impeller 20 of the air sending device 7 according to Embodiment 2. Hereinafter, constituent elements in Embodiment 2 which are different from Embodiment 1 are mainly explained, and descriptions of the same constituent elements as those in Embodiment 1 are omitted in Embodiment 2.

[0037] The suction surface 24 of the blade 21 in Embodiment 2 is made up of a plurality of curved surfaces. As illustrated in Fig. 8, the plurality of curved surfaces include a first suction-surface side curved surface 24-1, a second suction-surface side curved surface 24-2, and a third suction-surface side curved surface 24-3 that are arranged in this order from the inner peripheral side. The first suction-surface side curved surface 24-1 is formed to have the smallest curvature among the plurality of curved surfaces. The first suction-surface side curved surface 24-1 may be a flat surface with a curvature of 0.

[0038] The blade 21 includes two parts into which the blade 21 is divided with respect to the imaginary center plane 27 extending through a center portion of the blade 21 that is located at the center of the blade 21 in its thickness direction. The two parts include a surface of part of

the blade that is located on its pressure surface side, and a surface of part of the blade that is located on its suction surface side. As illustrated in Fig. 9, the surface of part of the blade that is located on its suction surface side is divided into three areas at an inner peripheral end 24-2P1 and an outer peripheral end 24-2P2 of the second suction-surface side curved surface 24-2. The three areas are provided as a first suction-surface side area 24a-1, a second suction-surface side area 24a-2, and a third suction-surface side area 24a-3. The first suction-surface side area 24a-1 extends from the inner peripheral end 25-P of the blade 21 to the inner peripheral end 24-2P1 of the second suction-surface side curved surface 24-2. The second suction-surface side area 24a-2 is equivalent to the area of the second suction-surface side curved surface 24-2. The third suction-surface side area 24a-3 extends from the outer peripheral end 24-2P2 of the second suction-surface side curved surface 24-2 to the outer peripheral end 26-P of the blade 21.

[0039] When the first suction-surface side area 24a-1, the second suction-surface side area 24a-2, and the third suction-surface side area 24a-3 of the blade 21 are projected on the chord line l , their respective lengths in this order are defined as a length l_{ss1} of the first suction-surface side area, a length l_{ss2} of the second suction-surface side area, and a length l_{ss3} of the third suction-surface side area. Note that in Fig. 9, for the convenience of illustrations, the length l_{ss1} of the first suction-surface side area, the length l_{ss2} of the second suction-surface side area, and the length l_{ss3} of the third suction-surface side area are not illustrated on the chord line l , but are illustrated on a line parallel to the chord line l . The length l_{ps1} of the first pressure-surface side area is greater than the length l_{ss1} of the first suction-surface side area.

[0040] A position P_{23-1P2} , at which the outer peripheral end 23-1 P2 of the first pressure-surface side curved surface 23-1 is projected on the chord line l , is located on the inner peripheral side relative to a center P_c of the chord line l . The outer peripheral end 23-1P2 of the first pressure-surface side curved surface 23-1 is equivalent to the inner peripheral end 23-2P1 of the second pressure-surface side curved surface 23-2.

[0041] Operational effects due to the above configuration are described below.

[0042] As described above, in the blade 21, the first pressure-surface side curved surface 23-1 has the smallest curvature among the three curved surfaces that make up the pressure surface 23, while the first suction-surface side curved surface 24-1 has the smallest curvature among the three curved surfaces that make up the suction surface 24. The length l_{ps1} of the first pressure-surface side area is greater than the length l_{ss1} of the first suction-surface side area.

[0043] With the above configuration, air current having entered the blade-to-blade gap flows easily along the pressure surface 23, and the airflow velocity on the pressure surface 23 increases accordingly. In the blowing region E2 of the impeller 20, the airflow velocity of air

current in the blade-to-blade gap is lower on the pressure-surface side of the blade 21 than on the suction-surface side of the blade 21. In view of that, an even distribution of airflow velocity in the blade-to-blade gap can be achieved by increasing the airflow velocity on the pressure surface 23.

[0044] In the blade 21, the position P_{23-1P2} , at which the outer peripheral end 23-1 P2 of the first pressure-surface side curved surface 23-1 is projected on the chord line l , is located on the inner peripheral side relative to the center P_c of the chord line l . Assuming that the position P_{23-1P2} , at which the outer peripheral end of the first pressure-surface side curved surface 23-1 is projected on the chord line l , is located on the outer peripheral side relative to the center P_c of the chord line l , then air current having flowed from the inner peripheral side to the outer peripheral side along the pressure surface 23 is more likely to be directed toward the radial direction on the outer peripheral side of the pressure surface 23, instead of being directed toward the circumferential direction.

[0045] When air current having flowed from the inner peripheral side to the outer peripheral side along the pressure surface 23 is directed toward the circumferential direction on the outer peripheral side of the pressure surface 23, the following operational effect can be obtained due to this air current directed toward the circumferential direction. That is, the air current directed toward the circumferential direction flows toward the suction surface 24 of the adjacent blade 21, and thus presses air current in the blade-to-blade gap between the pressure surface 23 and the suction surface 24 of the adjacent blade 21 in the circumferential direction toward the suction surface 24. Consequently, the air current having entered from the inner peripheral side and flowing toward the suction surface 24 can be restrained from separating from the suction surface 24 on its outer peripheral side. On the other hand, when air current having flowed from the inner peripheral side to the outer peripheral side along the pressure surface 23 is directed toward the radial direction on the outer peripheral side of the pressure surface 23, the above operational effect cannot be obtained. Consequently, the air current is more likely to separate from the suction surface 24 on its outer peripheral side.

[0046] In contrast to this, in Embodiment 2, the position P_{23-1P2} , at which the outer peripheral end 23-1 P2 of the first pressure-surface side curved surface 23-1 is projected on the chord line l , is located on the inner peripheral side relative to the center P_c of the chord line l . With this configuration, the air current flowing from the inner peripheral side toward the outer peripheral side along the first pressure-surface side curved surface 23-1 of the blade 21 is directed more toward the circumferential direction as the air current flows toward the outer peripheral side. With this configuration, the above operational effect can be obtained, so that separation of the air current from the suction surface 24 on its outer peripheral side is restrained.

[0047] As explained above, in Embodiment 2, the same effects as those achieved by Embodiment 1 can be obtained. Additionally, with the above configuration, an even distribution of airflow velocity in the blade-to-blade gap can be achieved and separation of the air current from the suction surface 24 of the blade 21 on its outer peripheral side can be restrained.

Embodiment 3

[0048] Fig. 10 is a sectional view of a portion of the impeller 20 of the air sending device 7 according to Embodiment 3, taken along the direction perpendicular to the rotation shaft O. Hereinafter, constituent elements in Embodiment 3 which are different from Embodiments 1 and 2 are mainly explained, and descriptions of the same constituent elements as those in Embodiments 1 and 2 are omitted in Embodiment 3.

[0049] The suction surface 24 of the blade 21 in Embodiment 3 is formed satisfying the following relationship: the curvature of the second suction-surface side curved surface 24-2 > the curvature of the third suction-surface side curved surface 24-3 > the curvature of the first suction-surface side curved surface 24-1. The blade 21 is also formed satisfying the following relationship: the length l_{SS3} of the third suction-surface side area > the length l_{SS2} of the second suction-surface side area > the length l_{SS1} of the first suction-surface side area.

[0050] In the blowing region E2 of the impeller 20, since the airflow velocity is higher on the suction-surface side than on the pressure-surface side, air current is more likely to separate from the suction surface 24. Particularly, air current is more likely to separate from the suction surface 24 on its outer peripheral side. In view of that, the length l_{SS3} of the third suction-surface side area located on the outermost circumferential side of the suction surface 24 is secured in such a manner that the length l_{SS3} is the greatest in the suction surface 24. As the curvature is larger, separation of air current is more likely to occur. Therefore, from the viewpoint of reducing the largest curvature of the second suction-surface side curved surface 24-2 as minimum as possible, the length l_{SS2} of the second suction-surface side area is secured in such a manner that the length l_{SS2} is greater than the length l_{SS1} of the first suction-surface side area.

[0051] With the above configuration, the impeller 20 further restrains separation of air current from the suction surface 24 of the blade 21 in the blowing region E2.

[0052] According to Embodiment 3, the same effects as those achieved by Embodiments 1 and 2 can be obtained. Additionally, with the above configuration, the impeller 20 can further restrain separation of air current from the suction surface 24 of the blade 21 in the blowing region E2.

Embodiment 4

[0053] Fig. 11 is a sectional view of a portion of the

impeller 20 of the air sending device 7 according to Embodiment 4, taken along the direction perpendicular to the rotation shaft O. Hereinafter, constituent elements in Embodiment 4 which are different from Embodiments 1 to 3 are mainly explained, and descriptions of the same constituent elements as those in Embodiments 1 to 3 are omitted in Embodiment 4.

[0054] In Fig. 11, at a position A_{ps} on the pressure surface 23, a perpendicular distance L_{ps} from the pressure surface 23 to the chord line I is maximized when the blade 21 is viewed in a section perpendicular to the rotation shaft O. In the blade 21, at a position A_{ss} on the suction surface 24, a perpendicular distance L_{ss} from the suction surface 24 to the chord line I is maximized when the blade 21 is viewed in a section perpendicular to the rotation shaft O. In the blade 21 in Embodiment 4, a position P_{ps} , at which the position A_{ps} on the pressure surface 23 is projected on the chord line I is located on the outer peripheral side relative to a position P_{ss} , at which the position A_{ss} on the suction surface 24 is projected on the chord line I.

[0055] With the above configuration, in the blowing region E2, a sufficient airflow path width of the blade-to-blade gap is secured on the outer peripheral side. Consequently, an increase in the airflow velocity in the blade-to-blade gap is suppressed. Since an increase in the airflow velocity in the blade-to-blade gap is suppressed, the impeller 20 can obtain the effects of reducing the fan input and the noise level.

[0056] According to Embodiment 4, the same effects as those achieved by Embodiments 1 to 3 can be obtained. Additionally, with the above configuration, the effects of reducing the fan input and the noise level can be obtained.

Embodiment 5

[0057] In the above Embodiments 1 to 4, improvement of air current on the blowing side has been described. In Embodiment 5, improvement of air current on the suction side will be described.

[0058] Fig. 12 is a sectional view of a portion of the impeller 20 according to Embodiment 5, taken along the direction perpendicular to the rotation shaft O. Hereinafter, constituent elements in Embodiment 5 which are different from Embodiments 1 to 4 are mainly explained, and descriptions of the same constituent elements as those in Embodiments 1 to 4 are omitted in Embodiment 5.

[0059] On the suction side of the impeller 20, air current flows in a direction illustrated by the arrow. The outer peripheral side of the blade 21 serves as an entrance for air current, while the inner peripheral side of the blade 21 serves as an exit for air current. In Embodiment 5, a position at which the thickness of the blade 21 is maximized is identified. In the blade 21 in Embodiment 5, a position P_{28a} , at which a center 28a of a maximum blade thickness 28 is projected on the chord line I (hereinafter,

referred to as "maximum blade-thickness projected position P_{28a} "), is located within an area 23-1a in which the first pressure-surface side curved surface 23-1 is projected on the chord line I. In the blade 21, the maximum blade-thickness projected position P_{28a} is located within an area between a position equivalent to 10% of the chord line I and a position equivalent to 15% of the chord line I from the inner peripheral end 25-P of the blade 21.

[0060] Assuming that the maximum blade-thickness projected position P_{28a} is located on the inner peripheral side relative to the position equivalent to 10% of the chord line I from the inner peripheral end 25-P of the blade 21, the thickness of the blade 21 increases on the downstream side in the air current direction on the suction side. This causes an increase in the air movement resistance and an increase in the level of airflow noise.

[0061] In contrast to this, in Embodiment 5, the maximum blade-thickness projected position P_{28a} is located on the outer peripheral side relative to the position equivalent to 10% of the chord line I from the inner peripheral end 25-P of the chord line I, in other words, on the upstream side in the air current direction on the suction side. With this configuration, the blade 21 has a decreased thickness on the downstream side in the air current direction on the suction side. When only a single blade 21 is considered, this configuration allows air current having flowed on the pressure surface 23 of this blade 21, and air current having flowed on the suction surface 24 of this blade 21 to easily merge together downstream of the blade 21. Accordingly, the blade 21 with the above configuration can prevent a water dead region from being generated downstream of the blade 21, so that the air movement resistance is decreased and the level of airflow noise is reduced.

[0062] Assuming that the maximum blade-thickness projected position P_{28a} is located on the outer peripheral side relative to the position equivalent to 15% of the chord line I from the inner peripheral end 25-P of the blade 21, this reduces the effect of restraining separation of air current from the pressure surface and the suction surface. In view of that, the maximum blade-thickness projected position P_{28a} is located within the area at the position equivalent to 15% or smaller of the chord line I from the inner peripheral end 25-P of the blade 21.

[0063] According to Embodiment 5, the same effects as those achieved by Embodiments 1 to 4 can be obtained. Additionally, the maximum blade-thickness projected position P_{28a} is located within the area between the position equivalent to 10% of the chord line I and the position equivalent to 15% of the chord line I from the inner peripheral end 25-P of the blade 21, so that the following effects can also be obtained. That is, the impeller 20 can decrease the air movement resistance on the suction side, and thus can reduce the level of airflow noise.

[0064] Note that in the above Embodiments 1 to 5, the air sending device 7 including the impeller 20 has been described as being installed in an indoor unit. However,

the air sending device 7 may be installed in an outdoor unit. Also in this case, the same effects can be obtained.

Embodiment 6

[0065] Fig. 13 illustrates the configuration of a refrigeration cycle device 50 according to Embodiment 6. Note that the air sending device 7 in any of Embodiments 1 to 5 is used as an indoor air sending device 202 in the refrigeration cycle device 50 according to Embodiment 6. In the descriptions below, the refrigeration cycle device 50 that is used for the purpose of air-conditioning is explained. However, the refrigeration cycle device 50 is not limited to being used for the purpose of air-conditioning. The refrigeration cycle device 50 is used for the purpose of refrigeration or air-conditioning in, for example, a refrigerator or a freezer, or an automatic dispenser, an air-conditioning apparatus, a refrigeration device, a water heater, or other devices.

[0066] The refrigeration cycle device 50 according to Embodiment 6 transfers heat between outside air and room air through refrigerant to condition the air in the room by heating or cooling the air. The refrigeration cycle device 50 according to Embodiment 6 includes an outdoor unit 100 and an indoor unit 200. The refrigeration cycle device 50 has a refrigerant circuit in which the outdoor unit 100 and the indoor unit 200 are connected by a refrigerant pipe 300 and a refrigerant pipe 400 to allow refrigerant to circulate in the refrigerant circuit. The refrigerant pipe 300 is a gas pipe through which gas-phase refrigerant flows. The refrigerant pipe 400 is a liquid pipe through which liquid-phase refrigerant flows. Note that two-phase gas-liquid refrigerant may flow through the refrigerant pipe 400. In the refrigerant circuit of the refrigeration cycle device 50, a compressor 101, a flow switching device 102, an outdoor heat exchanger 103, an expansion valve 105, and an indoor heat exchanger 201 are connected to each other through the refrigerant pipes.

Outdoor unit 100

[0067] The outdoor unit 100 includes the compressor 101, the flow switching device 102, the outdoor heat exchanger 103, and the expansion valve 105. The compressor 101 compresses suctioned refrigerant and discharges the compressed refrigerant. The flow switching device 102 is, for example, a four-way valve and is configured to change the flow direction in a refrigerant flow passage. The refrigeration cycle device 50 uses the flow switching device 102 to change the flow direction of refrigerant based on an instruction from a controller (not illustrated), and thus can perform heating operation or cooling operation.

[0068] The outdoor heat exchanger 103 exchanges heat between refrigerant and outside air. The outdoor heat exchanger 103 serves as an evaporator during the heating operation, and exchanges heat between the out-

side air and low-pressure refrigerant having entered from the refrigerant pipe 400 to evaporate and gasify the refrigerant. The outdoor heat exchanger 103 serves as a condenser during the cooling operation, and exchanges heat between the outside air and refrigerant having entered the compressor 101 from the flow switching device 102 and been compressed by the compressor 101 to condense and liquefy the refrigerant. The outdoor heat exchanger 103 is provided with an outdoor air sending device 104 to improve the efficiency in heat exchange between refrigerant and outside air. The outdoor air sending device 104 may have an inverter device installed therein to change the operational frequency of a fan motor and thus change the rotation speed of a fan. The expansion valve 105 is an expansion device, and functions as an expansion valve by adjusting the flow rate of refrigerant that flows through the expansion valve 105. The expansion valve 105 changes its opening degree to adjust the pressure of refrigerant. For example, in a case where the expansion valve 105 is constituted by an electronic expansion valve or the like, the opening degree of the expansion valve 105 is adjusted based on an instruction from the controller.

Indoor unit 200

[0069] The indoor unit 200 includes an indoor heat exchanger 201 configured to exchange heat between refrigerant and room air, and the indoor air sending device 202 configured to adjust a flow of air with which the indoor heat exchanger 201 exchanges heat. The indoor heat exchanger 201 serves as a condenser during the heating operation, and exchanges heat between the room air and refrigerant having entered from the refrigerant pipe 300 to condense and liquefy the refrigerant to cause this refrigerant to flow out toward the refrigerant pipe 400. The indoor heat exchanger 201 serves as an evaporator during the cooling operation, and exchanges heat between the room air and refrigerant having been brought into a low-pressure state by the expansion valve 105 to cause heat of the air to be transferred to the refrigerant to evaporate and gasify the refrigerant, and then cause this refrigerant to flow out toward the refrigerant pipe 300. The indoor air sending device 202 is provided to face the indoor heat exchanger 201. The air sending device 7 according to Embodiments 1 to 5 is applied to the indoor air sending device 202. The operational speed of the indoor air sending device 202 is determined by a user setting. The indoor air sending device 202 may have an inverter device installed therein to change the operational frequency of a fan motor (not illustrated) and thus change the rotation speed of a cross flow fan.

Operation example of refrigeration cycle device 50

[0070] Next, cooling-mode operation is described as an example of operation of the refrigeration cycle device 50. High-temperature high-pressure gas refrigerant com-

pressed by and discharged from the compressor 101 enters the outdoor heat exchanger 103 via the flow switching device 102. The gas refrigerant having entered the outdoor heat exchanger 103 exchanges heat with outside air delivered by the outdoor air sending device 104, then condenses into low-temperature refrigerant, and flows out from the outdoor heat exchanger 103. The refrigerant having flowed out from the outdoor heat exchanger 103 is expanded and reduced in pressure by the expansion valve 105 into low-temperature low-pressure two-phase gas-liquid refrigerant. This two-phase gas-liquid refrigerant enters the indoor heat exchanger 201 in the indoor unit 200, evaporates into low-temperature low-pressure gas refrigerant by exchanging heat with room air delivered by the indoor air sending device 202. Then, this low-temperature low-pressure gas refrigerant flows out from the indoor heat exchanger 201. At this time, room air having been cooled by refrigerant removing heat from the room air becomes conditioned air to be blown out from a discharge port of the indoor unit 200 to an air-conditioning target space. The gas refrigerant having flowed out from the indoor heat exchanger 201 is suctioned into the compressor 101 via the flow switching device 102 and is compressed again. The operation described above is repeated.

[0071] Next, heating-mode operation is described as an example of operation of the refrigeration cycle device 50. High-temperature high-pressure gas refrigerant compressed by and discharged from the compressor 101 enters the indoor heat exchanger 201 in the indoor unit 200 via the flow switching device 102. The gas refrigerant having entered the indoor heat exchanger 201 condenses into low-temperature refrigerant by exchanging heat with room air delivered by the indoor air sending device 202. Then, this low-temperature refrigerant flows out from the indoor heat exchanger 201. At this time, room air having been heated by receiving heat from the gas refrigerant becomes conditioned air to be blown out from the discharge port of the indoor unit 200 to an air-conditioning target space. The refrigerant having flowed out from the indoor heat exchanger 201 is expanded and reduced in pressure by the expansion valve 105 into low-temperature low-pressure two-phase gas-liquid refrigerant. This two-phase gas-liquid refrigerant enters the outdoor heat exchanger 103 in the outdoor unit 100, evaporates into low-temperature low-pressure gas refrigerant by exchanging heat with outside air delivered by the outdoor air sending device 104. Then, this low-temperature low-pressure gas refrigerant flows out from the outdoor heat exchanger 103. The gas refrigerant having flowed out from the outdoor heat exchanger 103 is suctioned into the compressor 101 via the flow switching device 102 and is compressed again. The operation described above is repeated.

[0072] The refrigeration cycle device 50 according to Embodiment 6 includes the air sending device 7 according to Embodiments 1 to 5, and can therefore obtain the same effects as those achieved by the above Embodi-

ments 1 to 5.

[0073] The configurations described in the foregoing embodiments are merely examples, and can thus be combined with another publicly known technique, or partially omitted and modified without departing from the scope of the present disclosure.

Reference Signs List

[0074] 1: air-conditioning apparatus, 2: housing, 3: main body, 4: cosmetic panel, 4a: air inlet, 4b: air outlet, 5: filter, 6: heat exchanger, 7: air sending device, 8: drain pan, 9: up-down airflow direction adjustment plate, 10: left-right airflow direction adjustment plate, 11: cross flow fan, 12: motor, 13: fan casing, 14: rear guide, 14a: up-stream end, 14b: downstream end, 15: stabilizer, 20: impeller, 21: blade, 22: support plate, 23: pressure surface, 23-1: first pressure-surface side curved surface, 23-1 P2: outer peripheral end, 23-1a: area, 23-2: second pressure-surface side curved surface, 23-2P1: inner peripheral end, 23-2P2: outer peripheral end, 23-3: third pressure-surface side curved surface, 23a-1: first pressure-surface side area, 23a-2: second pressure-surface side area, 23a-3: third pressure-surface side area, 24: suction surface, 24-1: first suction-surface side curved surface, 24-2: second suction-surface side curved surface, 24-2P1: inner peripheral end, 24-2P2: outer peripheral end, 24-3: third suction-surface side curved surface, 24a-1: first suction-surface side area, 24a-2: second suction-surface side area, 24a-3: third suction-surface side area, 25: inner peripheral end face, 25-P: inner peripheral end, 26: outer peripheral end face, 26-P: outer peripheral end, 27: imaginary center plane, 27-P: inner peripheral end, 28: maximum blade thickness, 28a: center, 30: air current, 31: air current, 50: refrigeration cycle device, 100: outdoor unit, 101: compressor, 102: flow switching device, 103: outdoor heat exchanger, 104: outdoor air sending device, 105: expansion valve, 200: indoor unit, 201: indoor heat exchanger, 202: indoor air sending device, 300: refrigerant pipe, 400: refrigerant pipe, E1: suction region, E2: blowing region, E3: first boundary region, E4: second boundary region, L: tangent line, L_{ps} : perpendicular distance, L_{ss} : perpendicular distance, O: rotation shaft, P_{28a} : maximum blade-thickness projected position, P_c : center, l: chord line, l_{ps1} : length of first pressure-surface side area, l_{ps2} : length of second pressure-surface side area, l_{ps3} : length of third pressure-surface side area, l_{ss1} : length of first suction-surface side area, l_{ss2} : length of second suction-surface side area, l_{ss3} : length of third suction-surface side area, θ : inflow angle

Claims

1. An air sending device provided with a cross flow fan including an impeller in which a plurality of blades are arranged annularly,

wherein each of the blades includes a pressure surface, a suction surface, an inner peripheral end face, and an outer peripheral end face, and in a section perpendicular to a rotation shaft of the cross flow fan, the pressure surface is concave in a rotation direction of the cross flow fan, the suction surface is convex in the opposite direction to the rotation direction, the inner peripheral end face is arcuately formed on an inner peripheral side of the blade and connecting the pressure surface and the suction surface, and the outer peripheral end face is arcuately formed on an outer peripheral side of the blade and connecting the pressure surface and the suction surface,

the outer peripheral end face is located more forwardly than the inner peripheral end face in the rotation direction,

the pressure surface of the blade includes a first pressure-surface side curved surface, a second pressure-surface side curved surface, and a third pressure-surface side curved surface that are arranged in this order from the inner peripheral side of the impeller, and the first pressure-surface side curved surface, the second pressure-surface side curved surface, and the third pressure-surface side curved surface have different curvatures that satisfy the following relationship: the curvature of the second pressure-surface side curved surface > the curvature of the third pressure-surface side curved surface > the curvature of the first pressure-surface side curved surface, and

where of two parts of the blade into which the blade is divided with respect to an imaginary center plane extending through a center portion of the blade that is located at the center of the blade in a thickness direction of the blade, a surface of part of the blade that is located on a pressure surface side of the blade is divided into three areas at an inner peripheral end and an outer peripheral end of the second pressure-surface side curved surface, the three areas being provided as a first pressure-surface side area, a second pressure-surface side area, and a third pressure-surface side area that are arranged in this order from the inner peripheral side, when the first pressure-surface side area, the second pressure-surface side area, and the third pressure-surface side area are projected on a chord line connecting the inner peripheral end and the outer peripheral end of the blade, a length of the first pressure-surface side area, a length of the second pressure-surface side area, and a length of the third pressure-surface side area satisfy the following relationship: the length of the third pressure-surface side area > the length of the first pressure-surface side area

> the length of the second pressure-surface side area.

2. The air sending device of claim 1, wherein

the suction surface of the blade includes a first suction-surface side curved surface, a second suction-surface side curved surface, and a third suction-surface side curved surface that are arranged in this order from the inner peripheral side of the impeller, and the first suction-surface side curved surface, the second suction-surface side curved surface, and the third suction-surface side curved surface have different curvatures in which the curvature of the first suction-surface side curved surface is smaller than the curvatures of the second suction-surface side curved surface and the third suction-surface side curved surface, and

where of two parts of the blade into which the blade is divided with respect to the imaginary center plane, a surface of part of the blade that is located on a suction surface side of the blade is divided into three areas at an inner peripheral end and an outer peripheral end of the second suction-surface side curved surface, an innermost circumferential area of the three areas being provided as a first suction-surface side area, when a length of the first suction-surface side area that is projected on the chord line is defined as a length of the first suction-surface side area, the length of the first pressure-surface side area is greater than the length of the first suction-surface side area, and a position at which an outer peripheral end of the first pressure-surface side curved surface is projected on the chord line is located on the inner peripheral side relative to a center of the chord line.

3. The air sending device of claim 2, wherein

the suction surface of the blade is formed satisfying the following relationship: the curvature of the second suction-surface side curved surface > the curvature of the third suction-surface side curved surface > the curvature of the first suction-surface side curved surface, and where the surface of part of the blade that is located on the suction surface side of the blade is divided into three areas at an inner peripheral end and an outer peripheral end of the second suction-surface side curved surface, the three areas being provided as the first suction-surface side area, a second suction-surface side area, and a third suction-surface side area that are arranged in this order from the inner peripheral side, when the first suction-surface side area, the second suction-surface side area, and the

third suction-surface side area are projected on the chord line, a length of the first suction-surface side area, a length of the second suction-surface side area, and a length of the third suction-surface side area satisfy the following relationship: the length of the third suction-surface side area > the length of the second suction-surface side area > the length of the first suction-surface side area.

4. The air sending device of any one of claims 1 to 3, wherein when a position on the pressure surface, at which a perpendicular distance from the pressure surface to the chord line is maximized, is projected on the chord line, while an other position on the suction surface, at which a perpendicular distance from the suction surface to the chord line is maximized, is projected on the chord line, the position projected on the chord line is located on an outer peripheral side relative to the other position projected on the chord line.

5. The air sending device of any one of claims 1 to 4, wherein at a position at which the blade has a maximum blade thickness, when a center of the maximum blade thickness is projected on the chord line, a position of the center projected on the chord line is located within an area in which the first pressure-surface side curved surface is projected on the chord line, while being located within an area between a position equivalent to 10% of the chord line and a position equivalent to 15% of the chord line from the inner peripheral end of the blade.

6. An air-conditioning apparatus comprising: the air sending device of any one of claims 1 to 5; a housing configured to accommodate the air sending device therein; and a heat exchanger.

7. A refrigeration cycle device comprising the air sending device of any one of claims 1 to 5.

FIG. 1

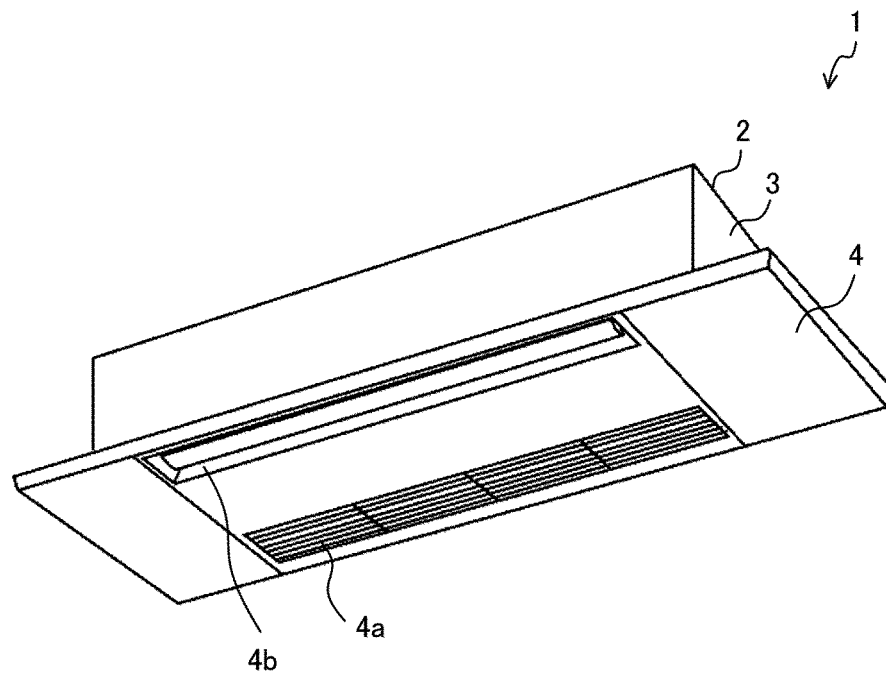


FIG. 2

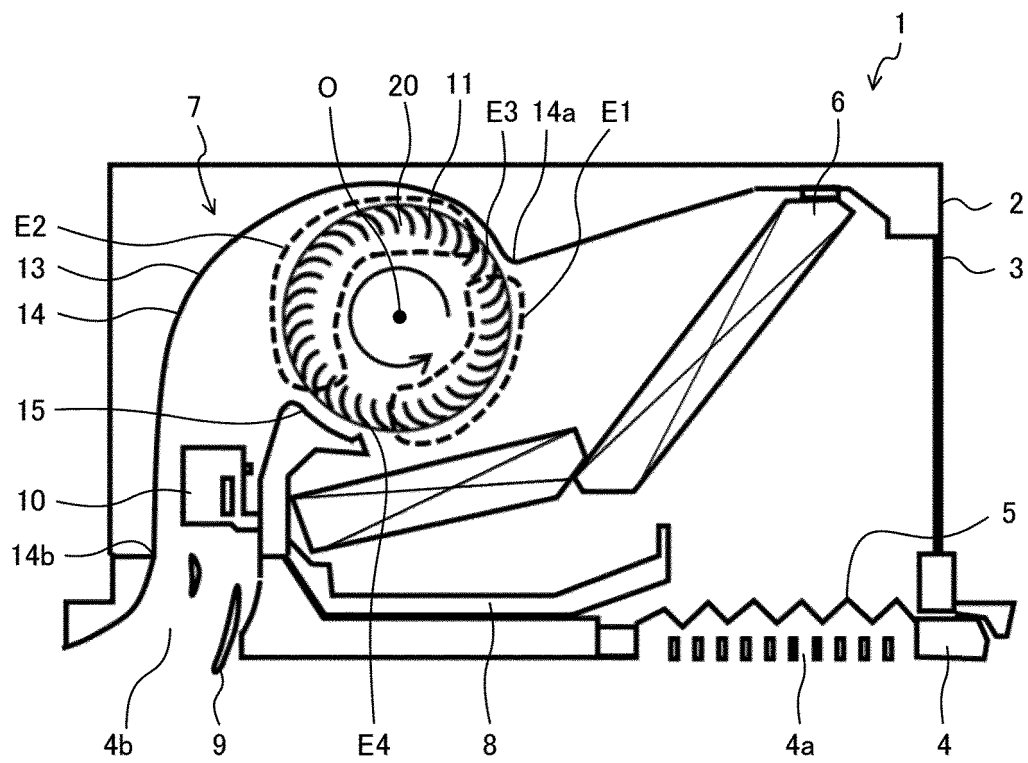


FIG. 3

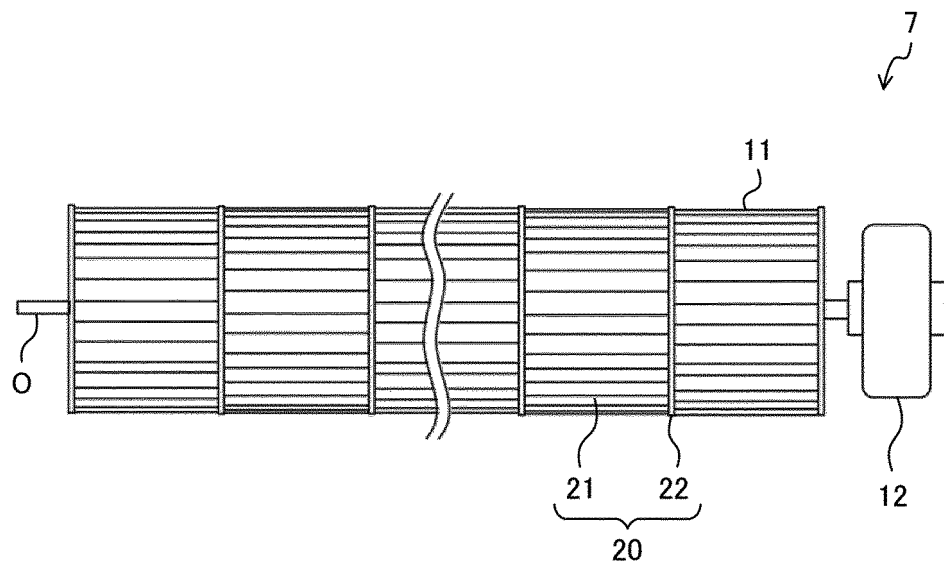


FIG. 4

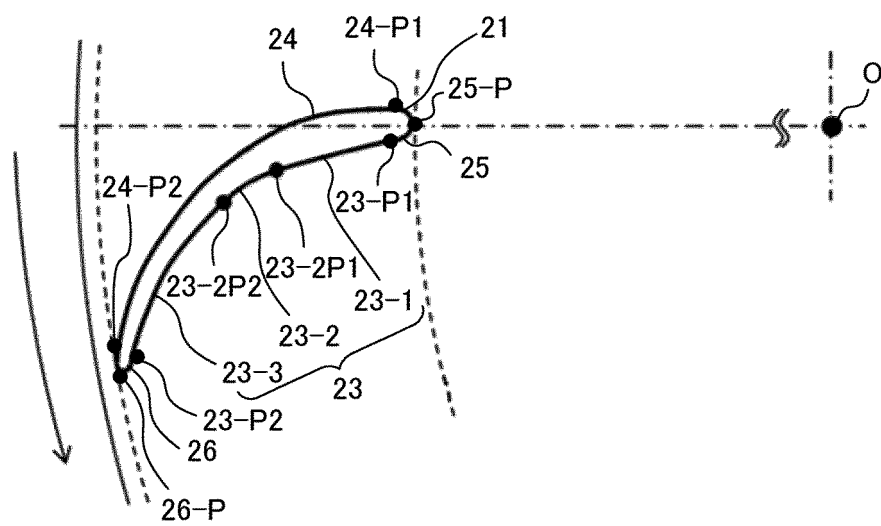


FIG. 5

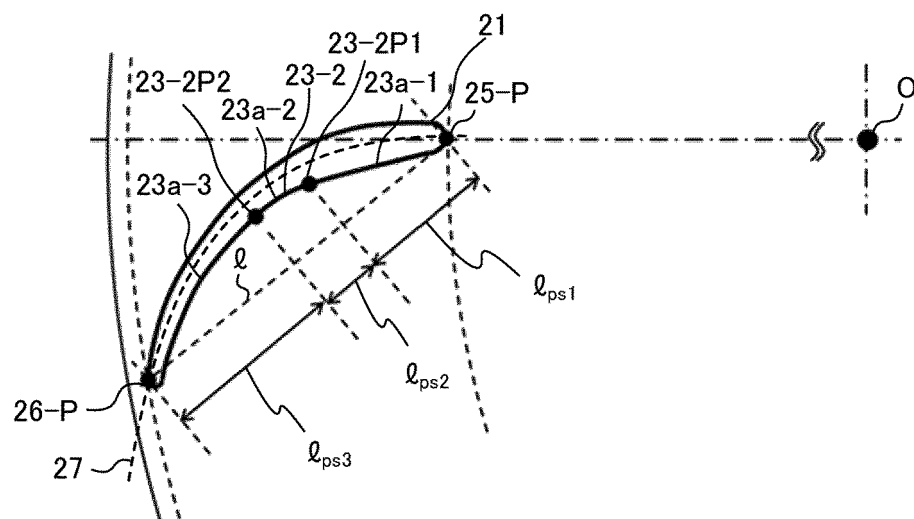


FIG. 6

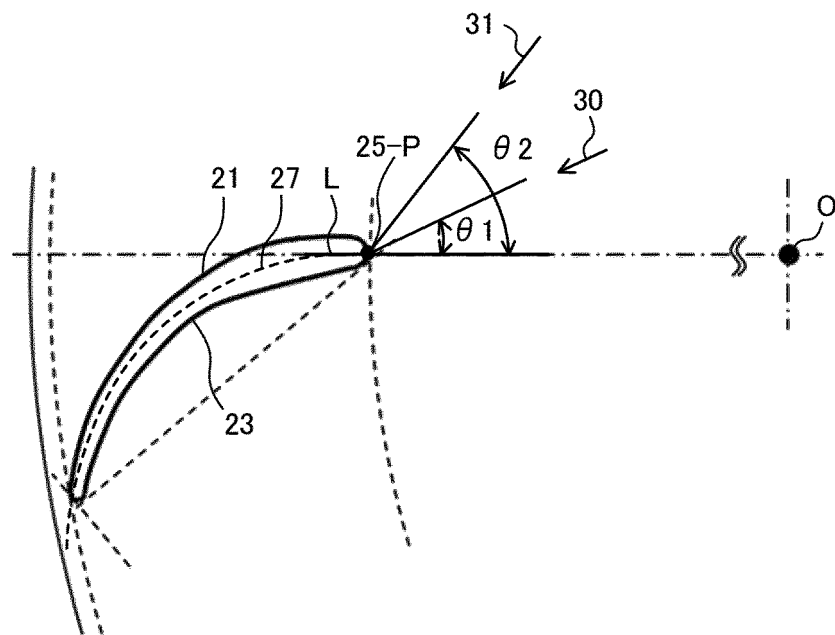


FIG. 7

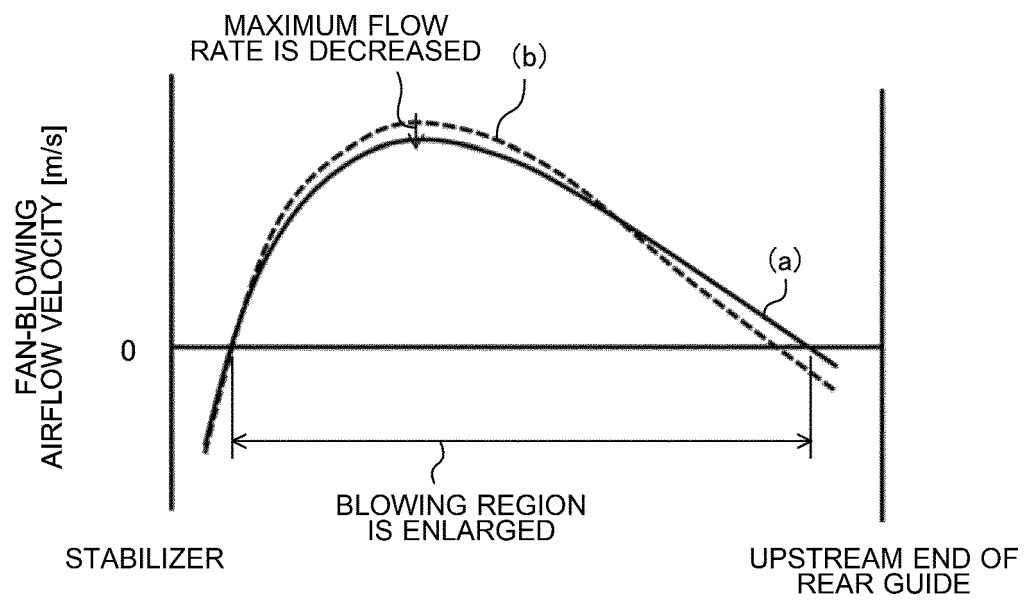


FIG. 8

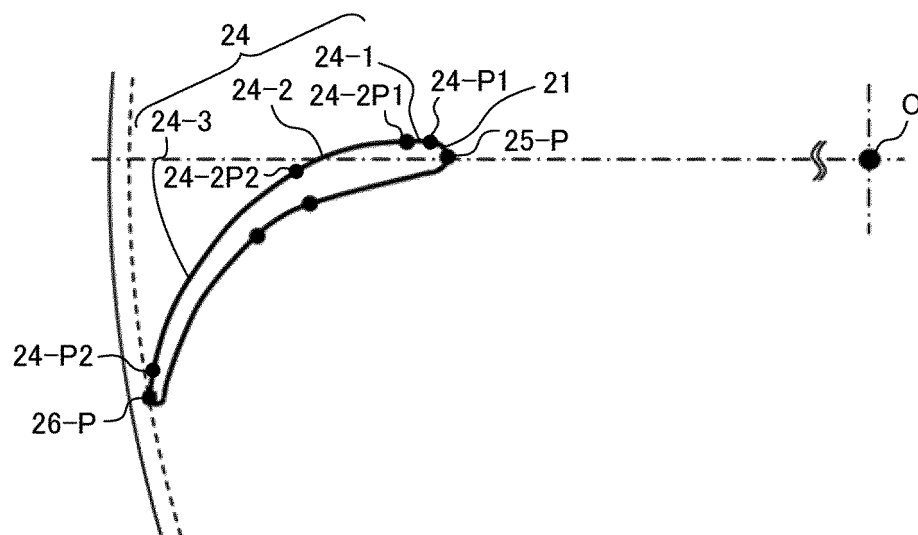


FIG. 9

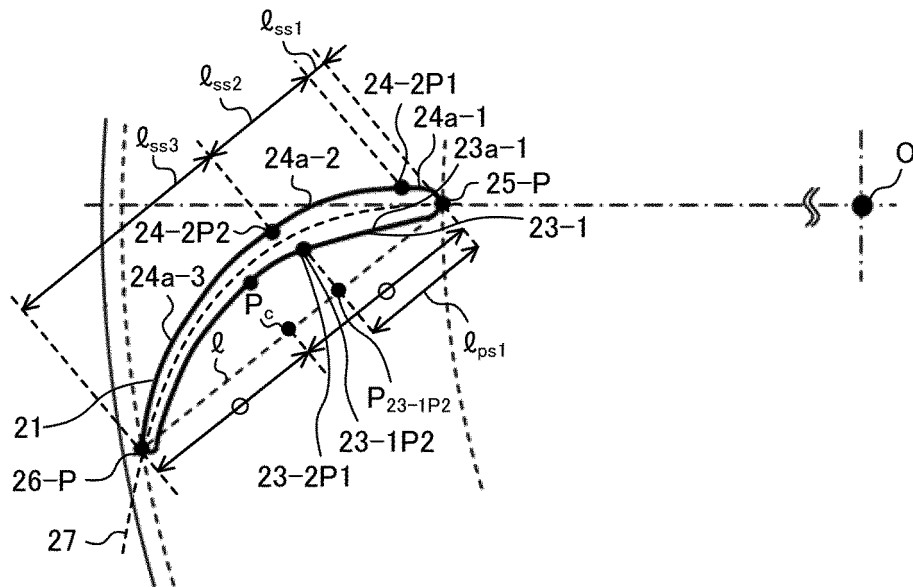


FIG. 10

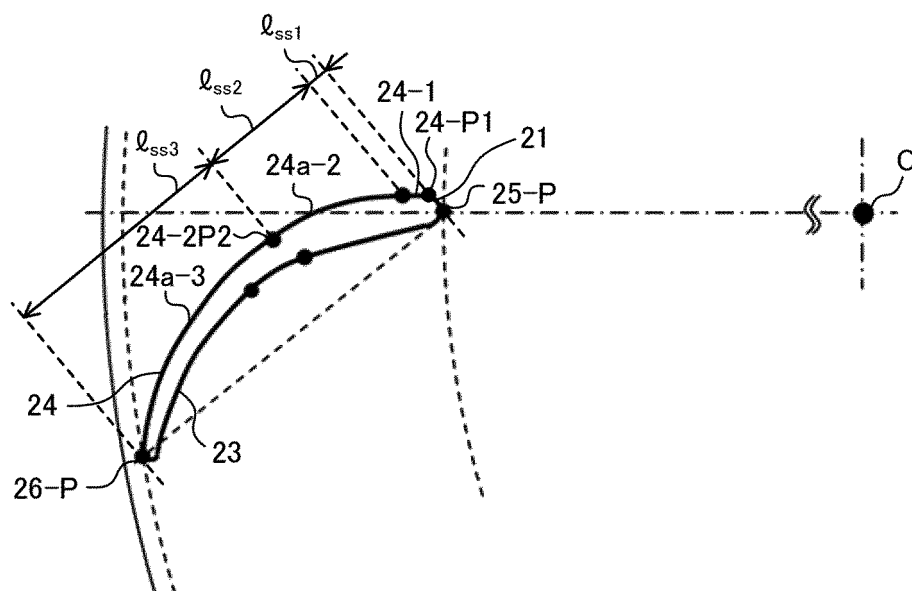


FIG. 11

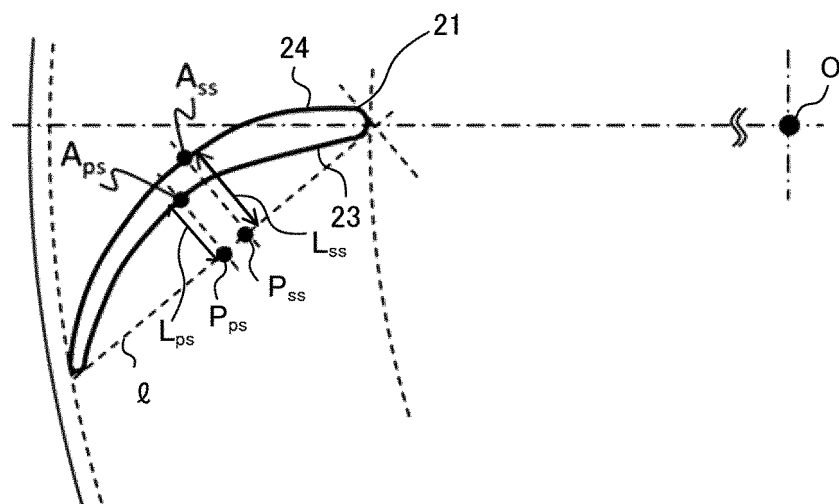


FIG. 12

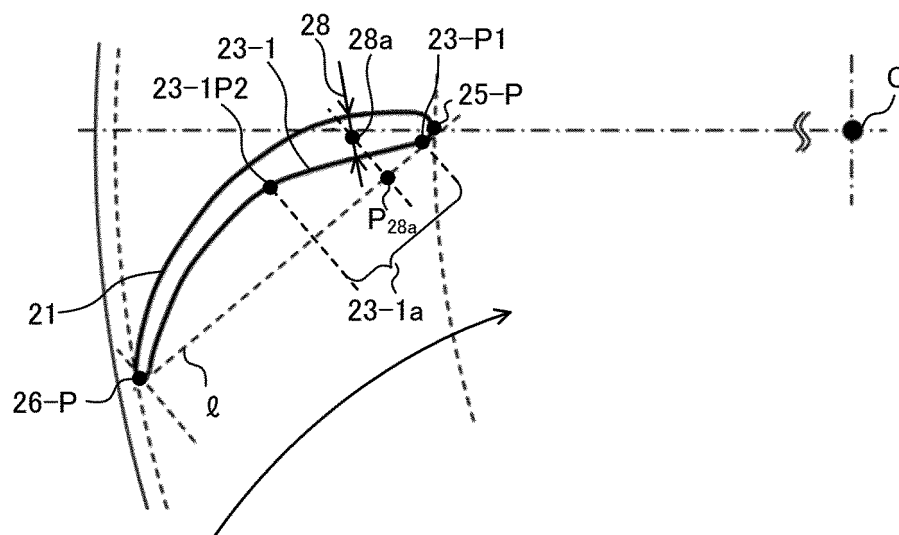
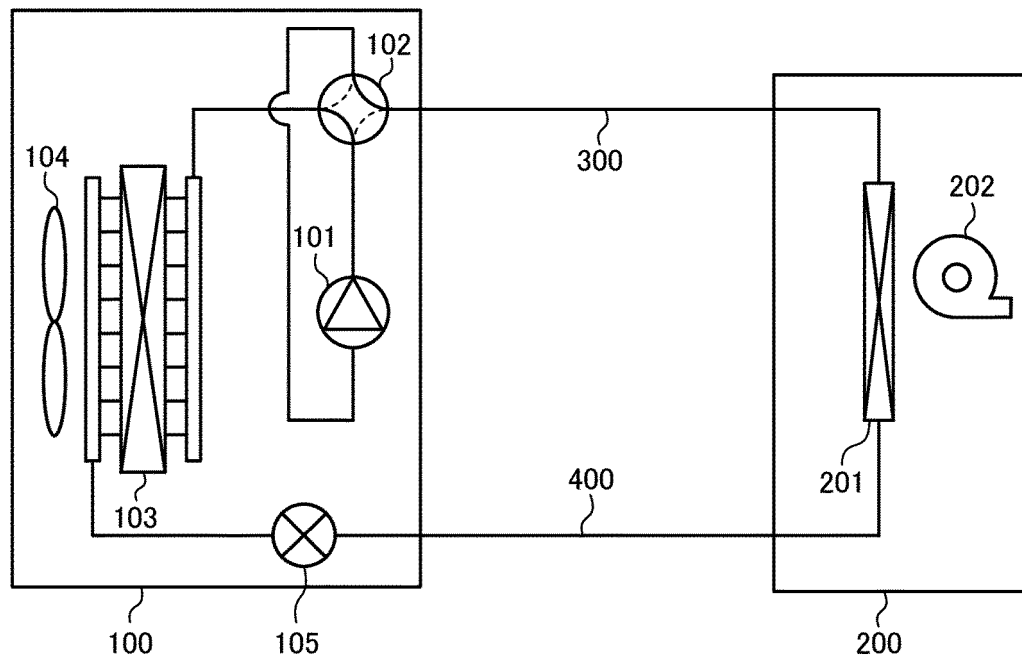


FIG. 13



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/017432

A. CLASSIFICATION OF SUBJECT MATTER

F04D 17/04(2006.01)i

FI: F04D17/04 B

According to International Patent Classification (IPC) or to both national classification and IPC

10

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04D17/04

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2021

Registered utility model specifications of Japan 1996-2021

Published registered utility model applications of Japan 1994-2021

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

20

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2001-263285 A (MITSUBISHI ELECTRIC CORP) 26 September 2001 (2001-09-26) paragraphs [0038], [0089]-[0091], fig. 2-3, 32	1-7
A	JP 56-52599 A (SEIBU GIKEN KK) 11 May 1981 (1981-05-11) fig. 3, 12	1-7
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Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2001-263285 A	26 Sep. 2001	(Family: none)	
JP 56-52599 A	11 May 1981	(Family: none)	
JP 49-11990 U1	31 Jan. 1974	(Family: none)	

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