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(19) **United States**(12) **Patent Application Publication**
Okazawa(10) **Pub. No.: US 2013/0125579 A1**(43) **Pub. Date: May 23, 2013**(54) **AIR-SENDING DEVICE OF OUTDOOR UNIT,
OUTDOOR UNIT, AND REFRIGERATION
CYCLE APPARATUS**(52) **U.S. Cl.**CPC *F04D 29/522* (2013.01); *F25D 17/06*
(2013.01)USPC **62/507; 415/220**(75) Inventor: **Hiroki Okazawa**, Tokyo (JP)(73) Assignee: **MITSUBISHI ELECTRIC
CORPORATION**, Tokyo (JP)

(57)

ABSTRACT(21) Appl. No.: **13/814,537**(22) PCT Filed: **Sep. 14, 2010**(86) PCT No.: **PCT/JP2010/005596**

§ 371 (c)(1),

(2), (4) Date: **Feb. 6, 2013****Publication Classification**(51) **Int. Cl.****F04D 29/52** (2006.01)**F25D 17/06** (2006.01)

A propeller fan rotates about a vertical axis. A bellmouth has a wall extending such that an air passage on an outlet side spreads outward. The bellmouth has a shape satisfying: $H/D \geq 0.04$ between a length H of the sloping surface in a direction of the rotation axis from an end on an inlet; side to an end on the outlet side and a fan diameter D of the propeller fan $0 < \theta \leq 60^\circ$ for an angle θ formed between a line connecting the ends of the sloping surface and the rotation axis; and $L/L_0 \geq 0.5$ between a length L in the direction of the rotation axis from an opening on the inlet side to the end of the sloping surface on the inlet side and a length L_0 of the blades of the propeller fan in the direction of the rotational axis.

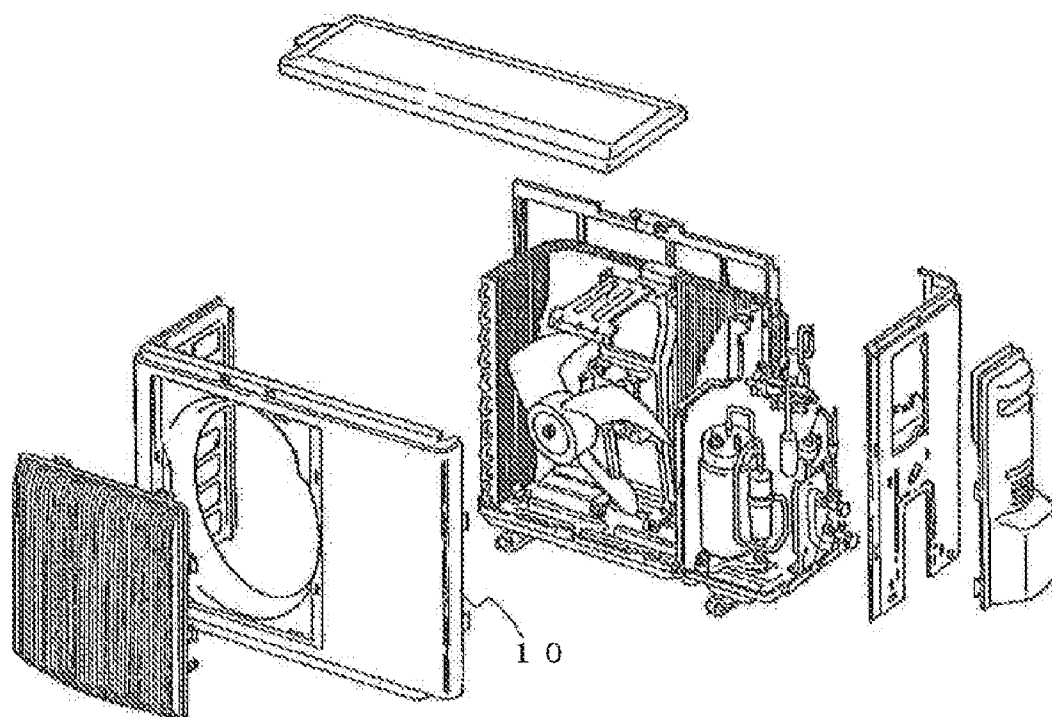


FIG. 1

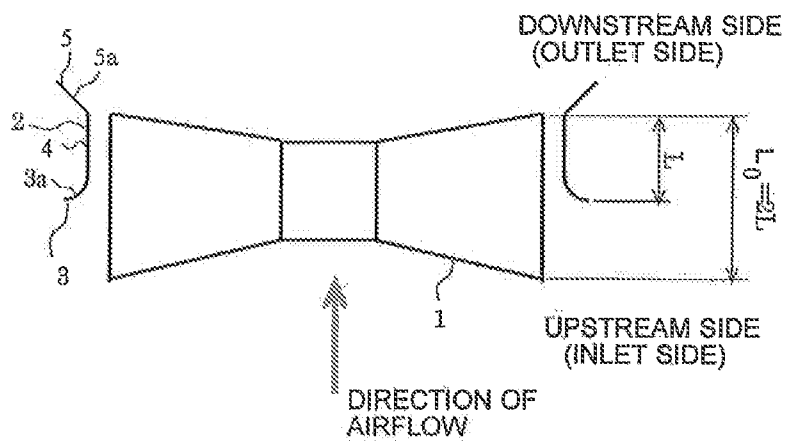


FIG. 2

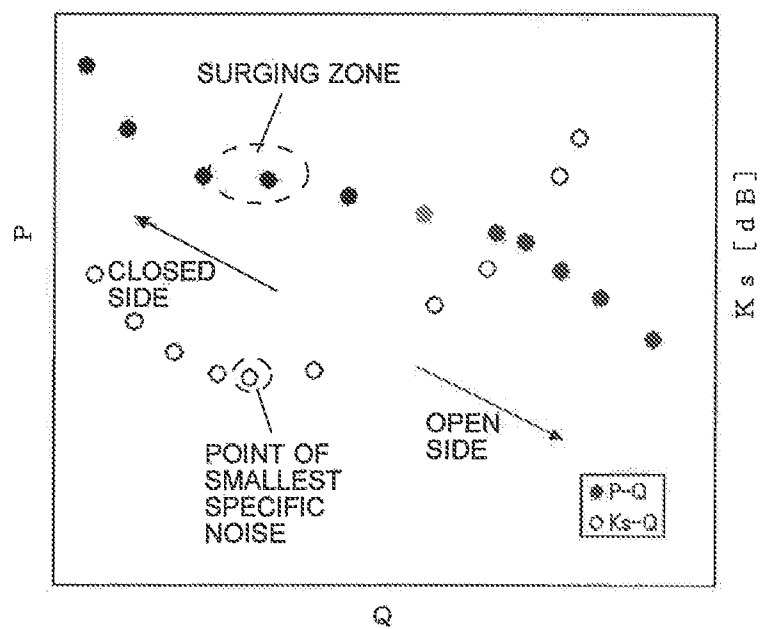


FIG. 3

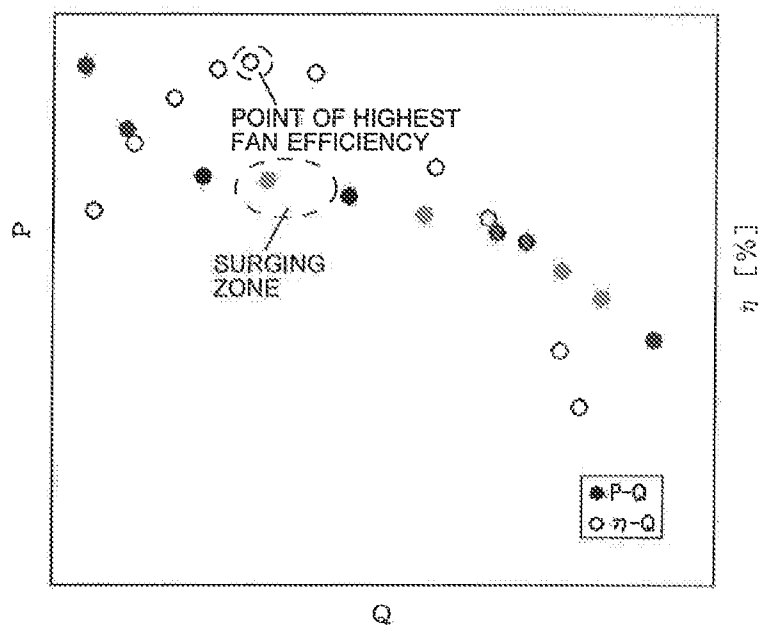


FIG. 4

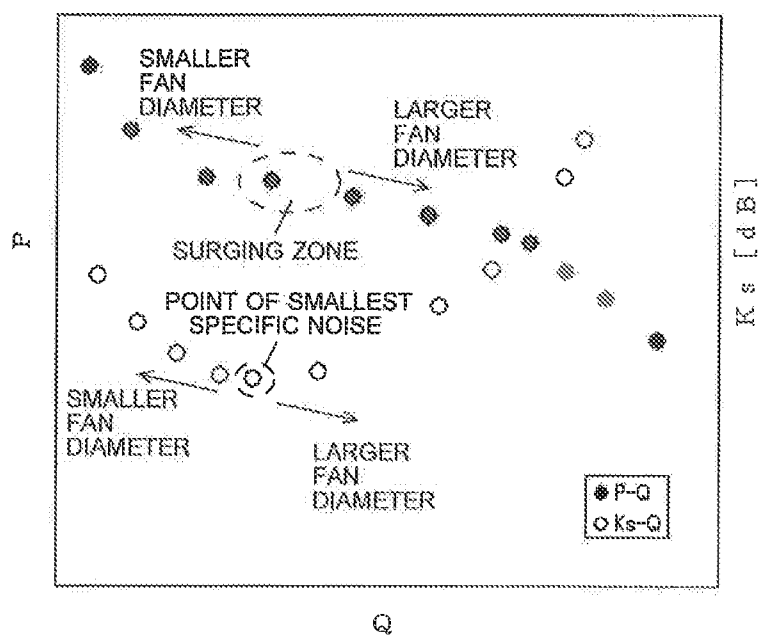


FIG. 5

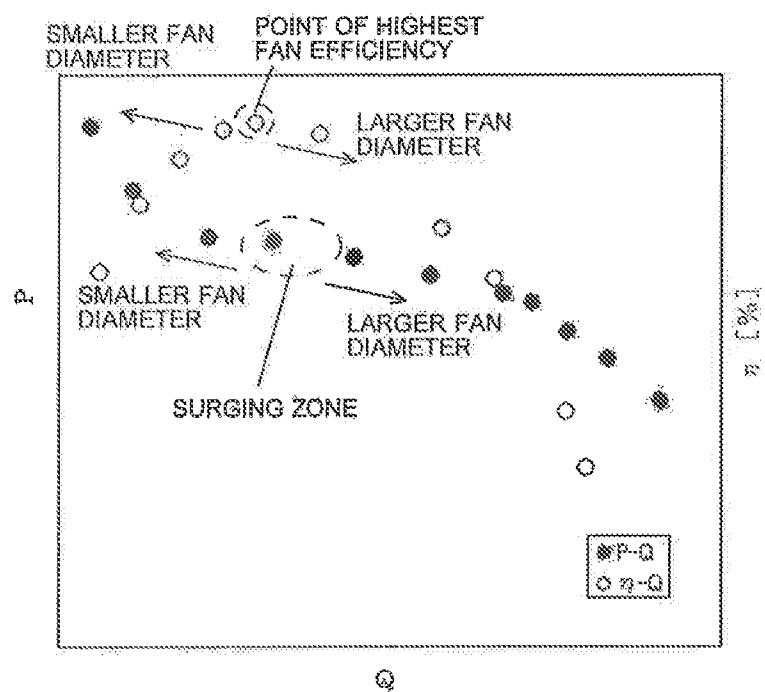


FIG. 6

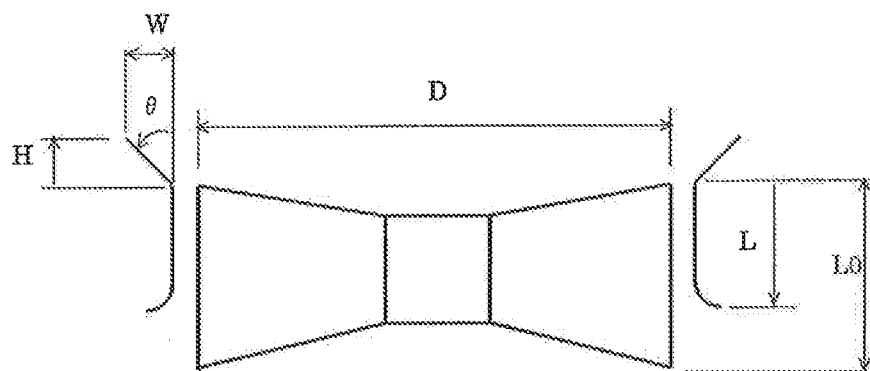


FIG. 7

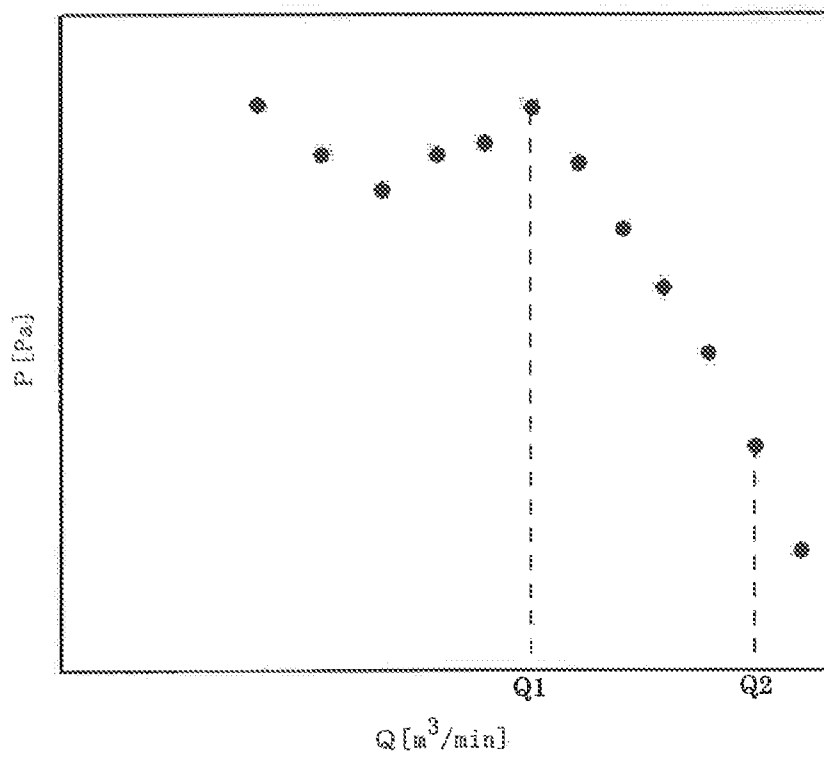


FIG. 8

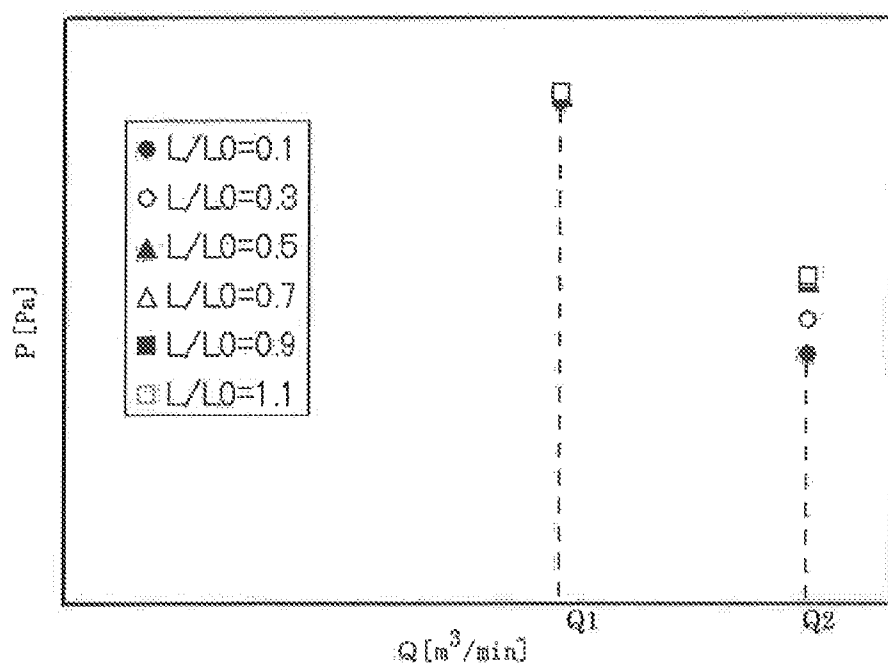


FIG. 9

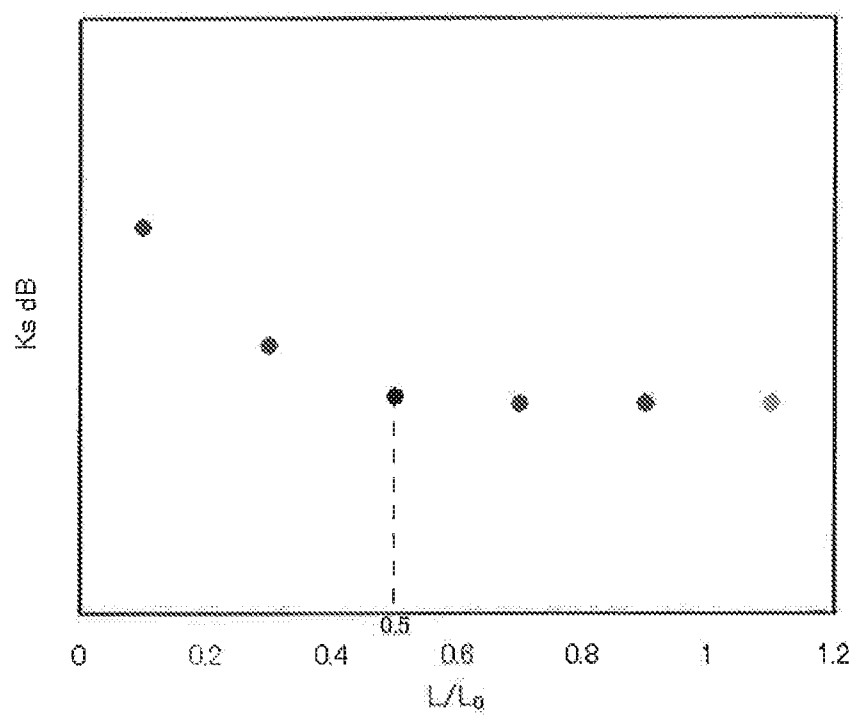


FIG. 10

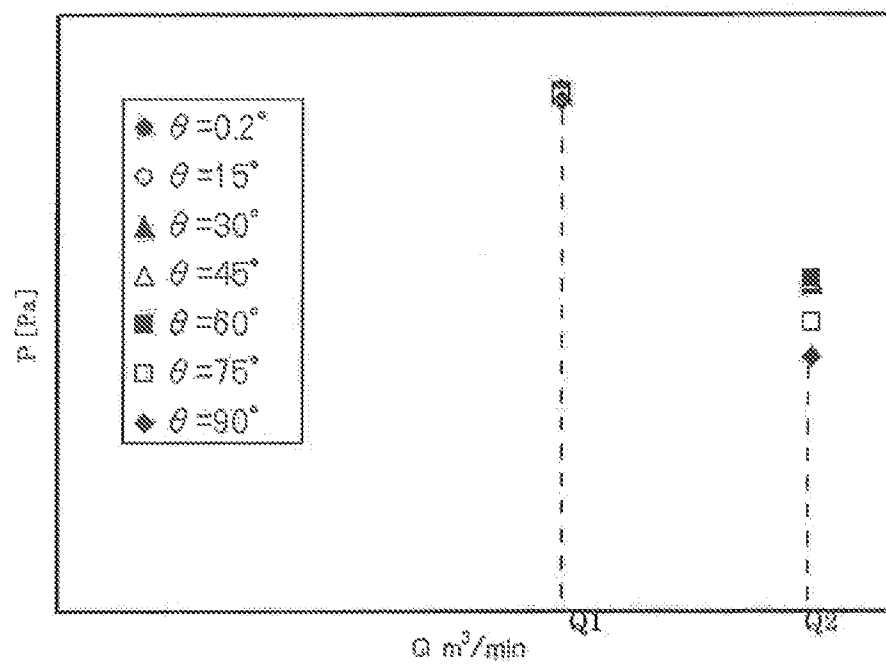


FIG. 11

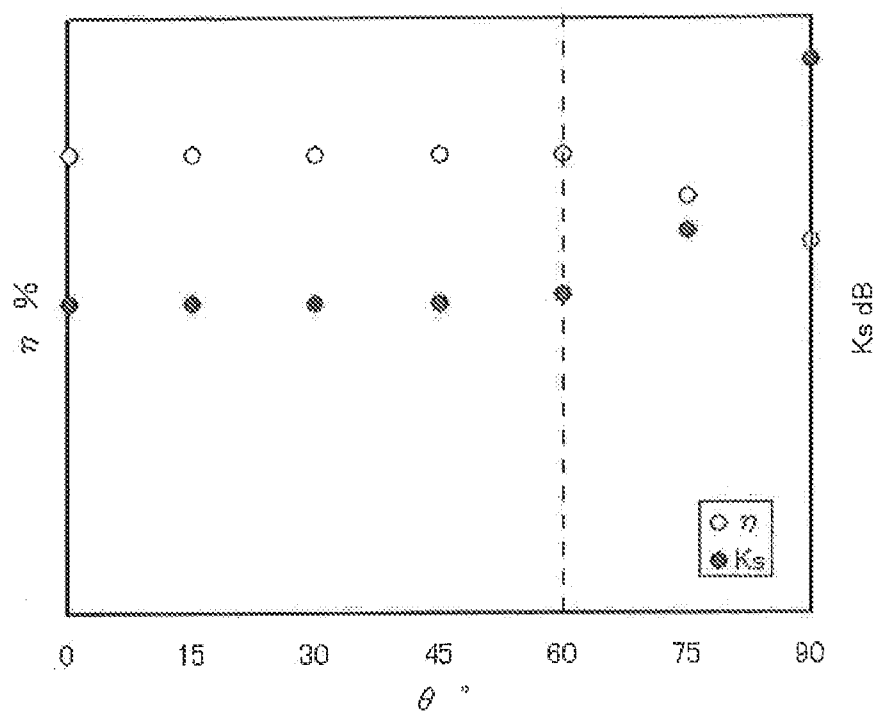


FIG. 12

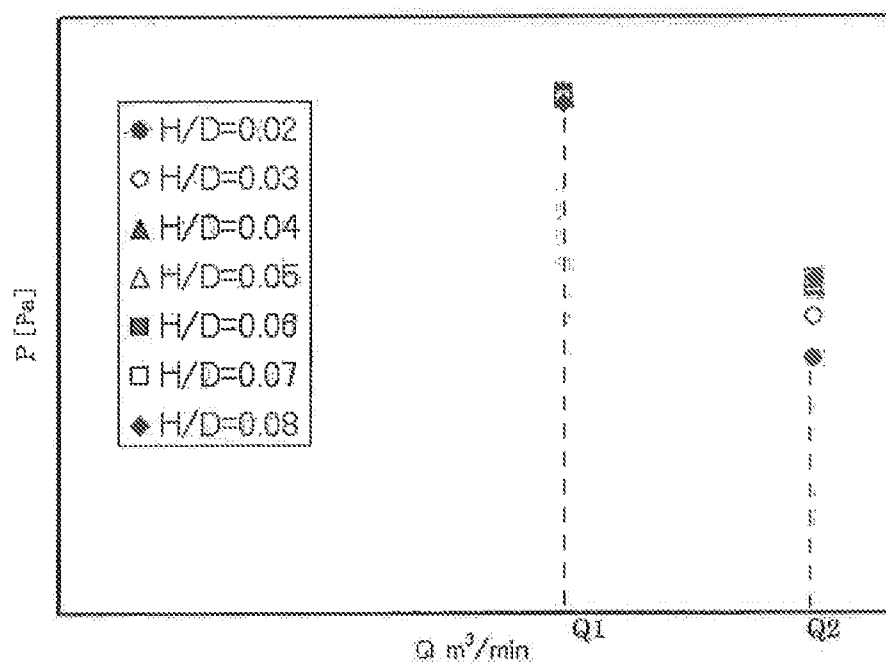


FIG. 13

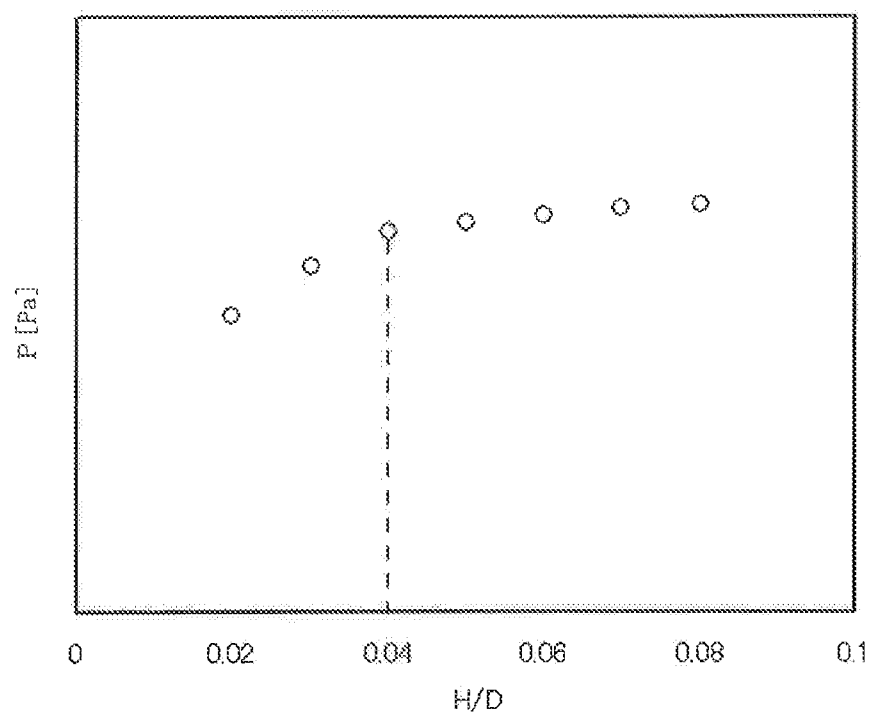


FIG. 14

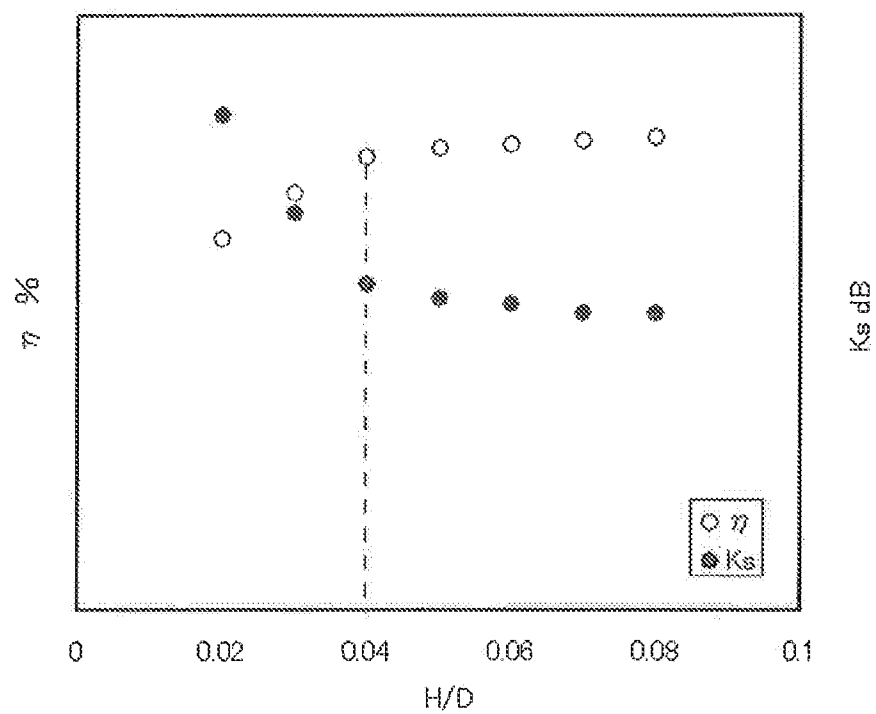


FIG. 15

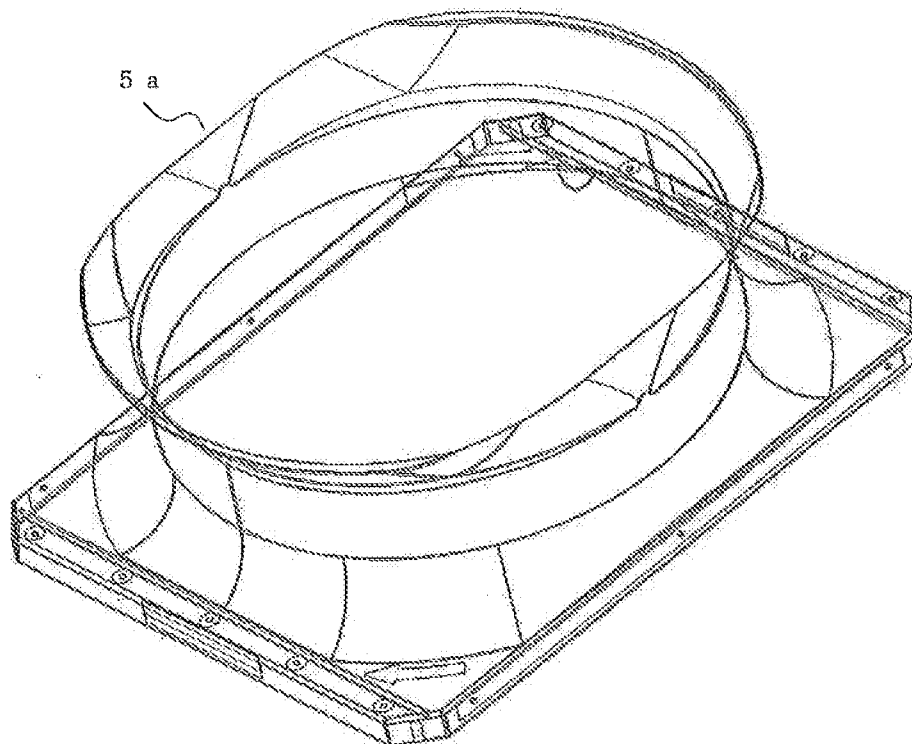


FIG. 16

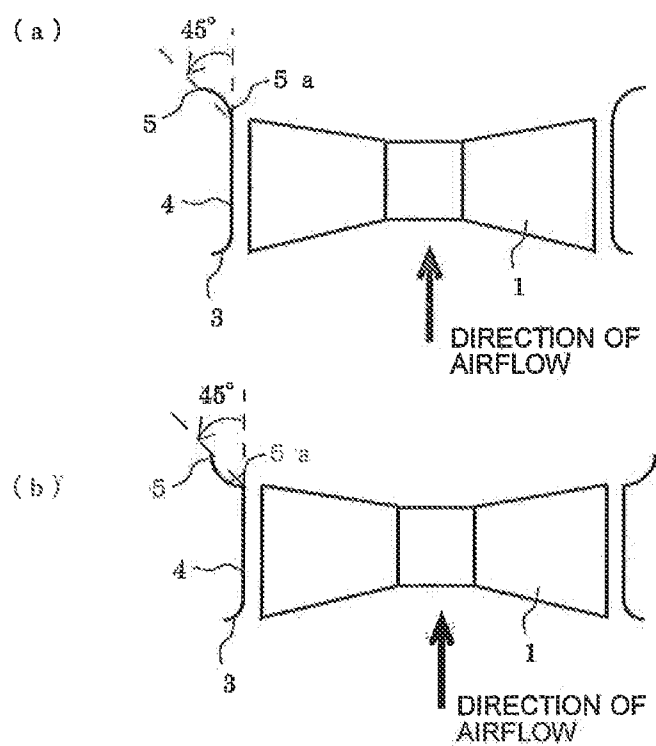
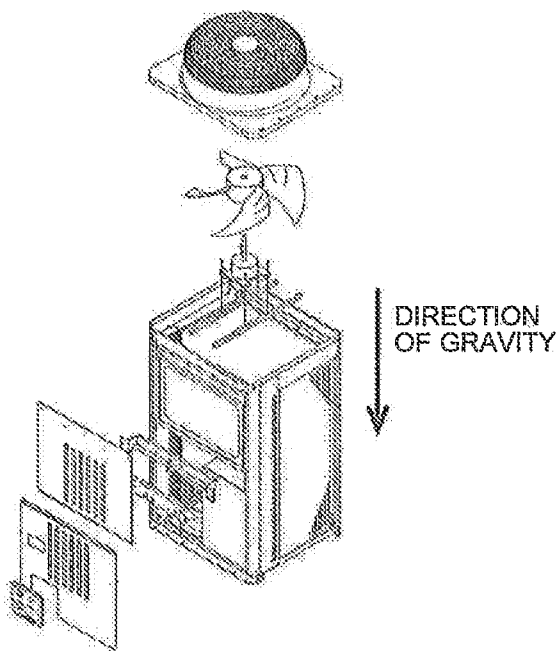


FIG. 17

(a)



(b)

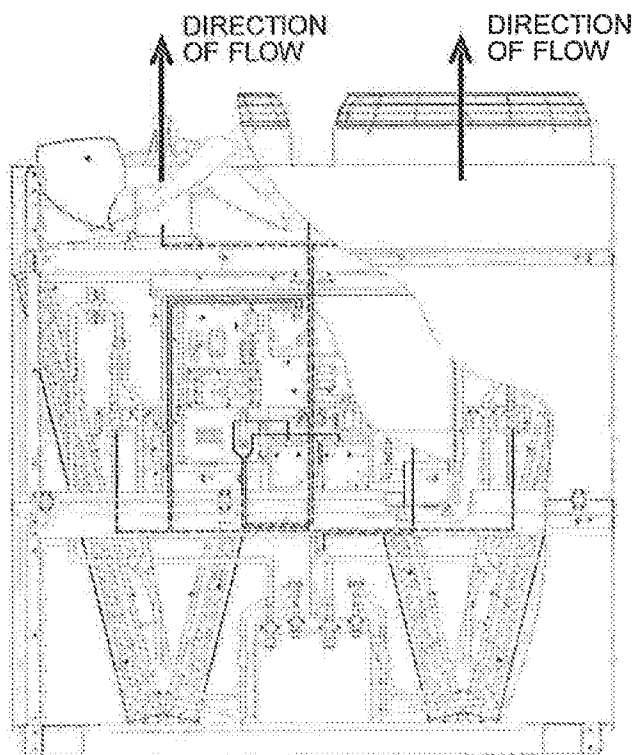


FIG. 18

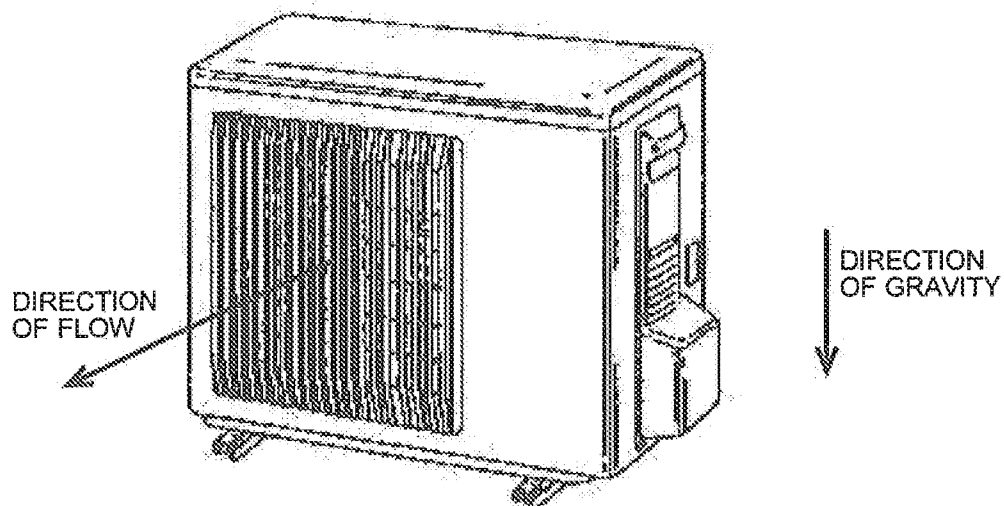


FIG. 19

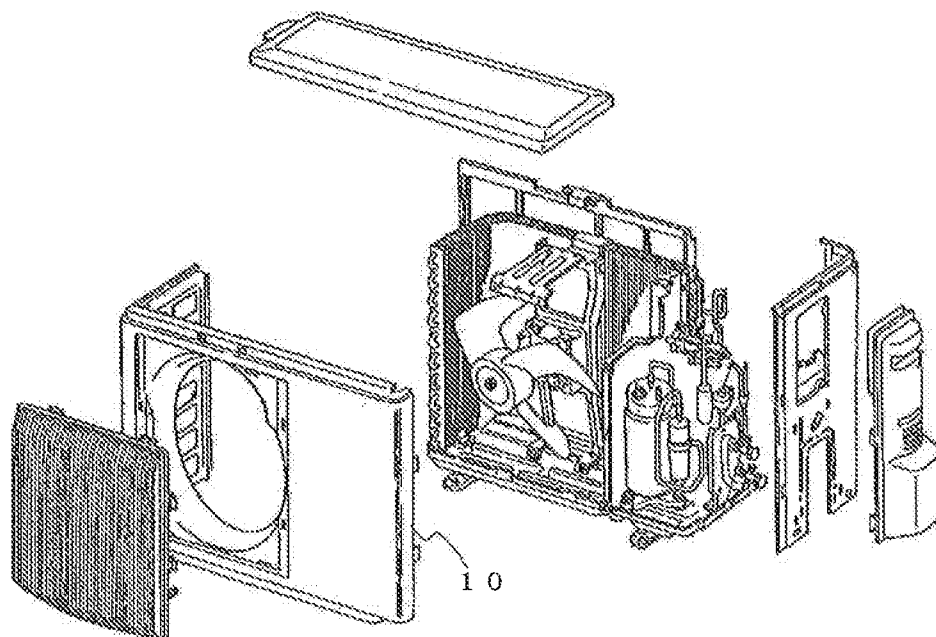


FIG. 20

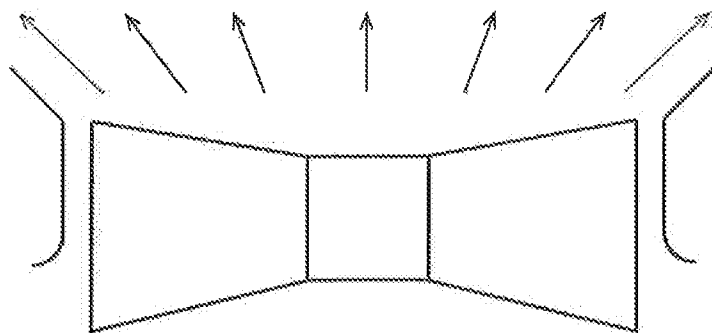


FIG. 21

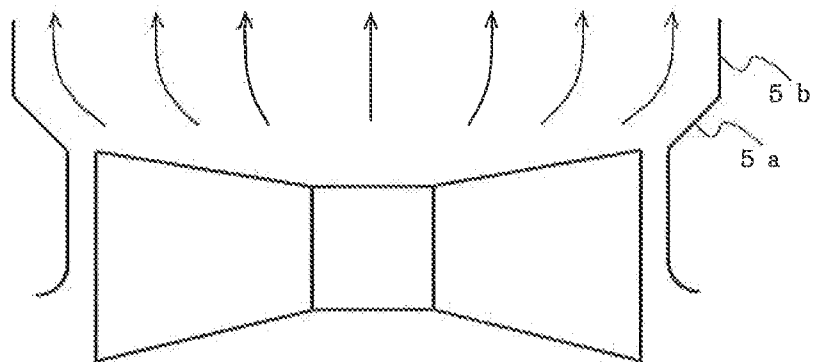


FIG. 22

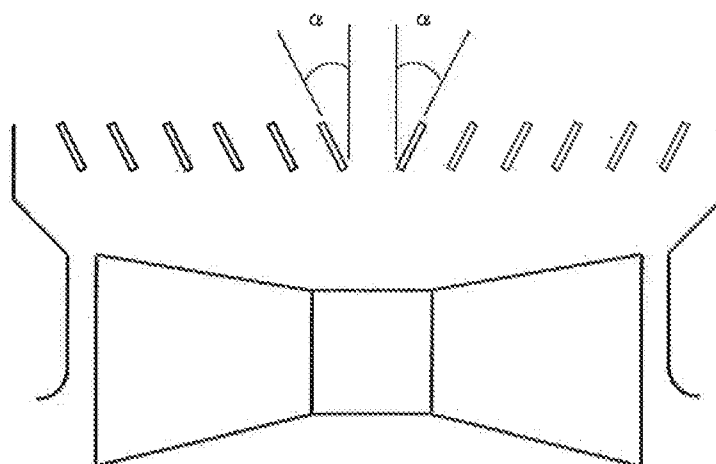


FIG. 23

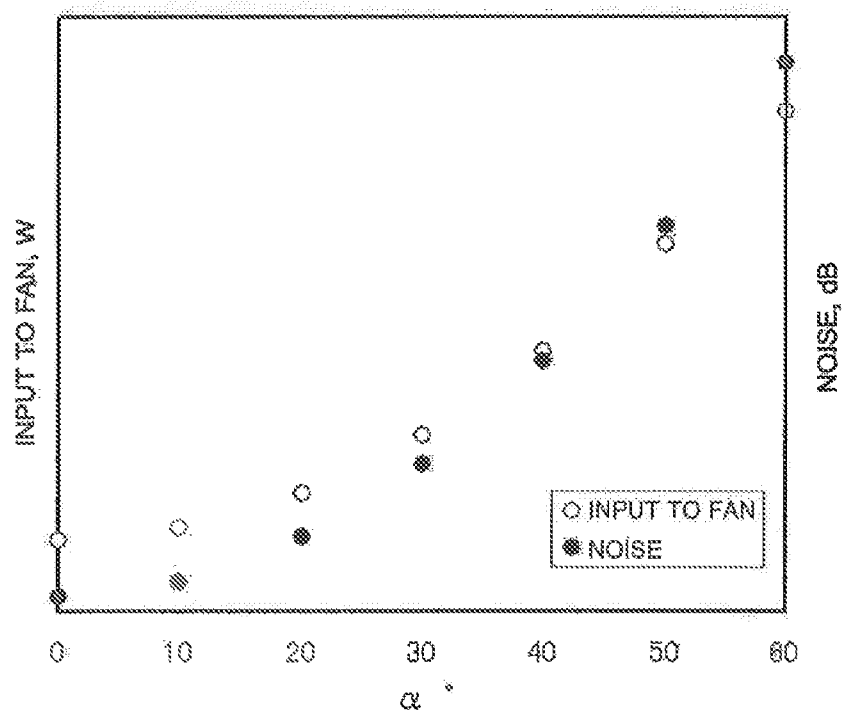


FIG. 24

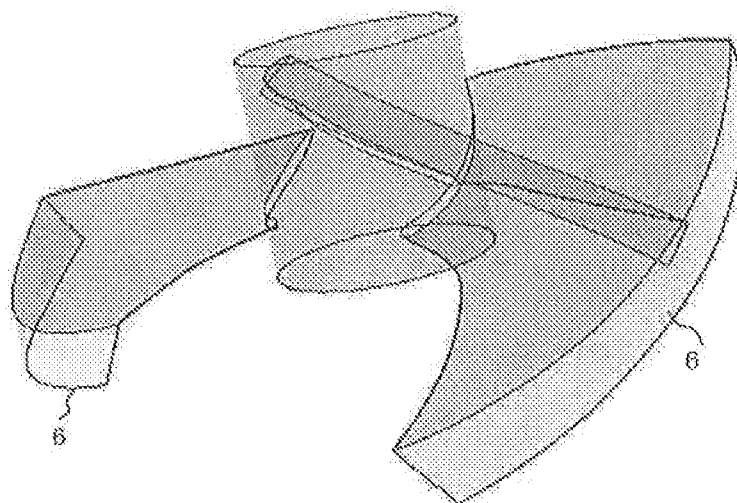


FIG. 25

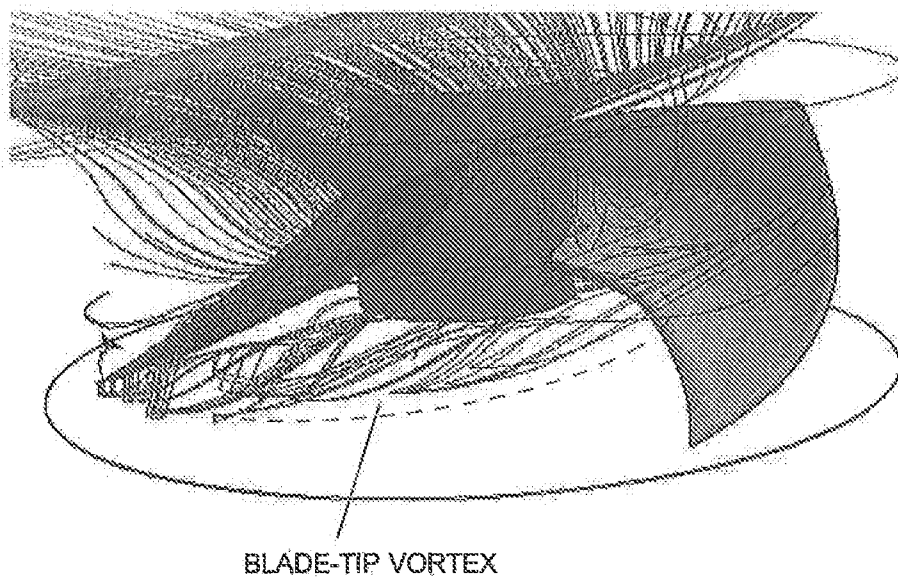


FIG. 26

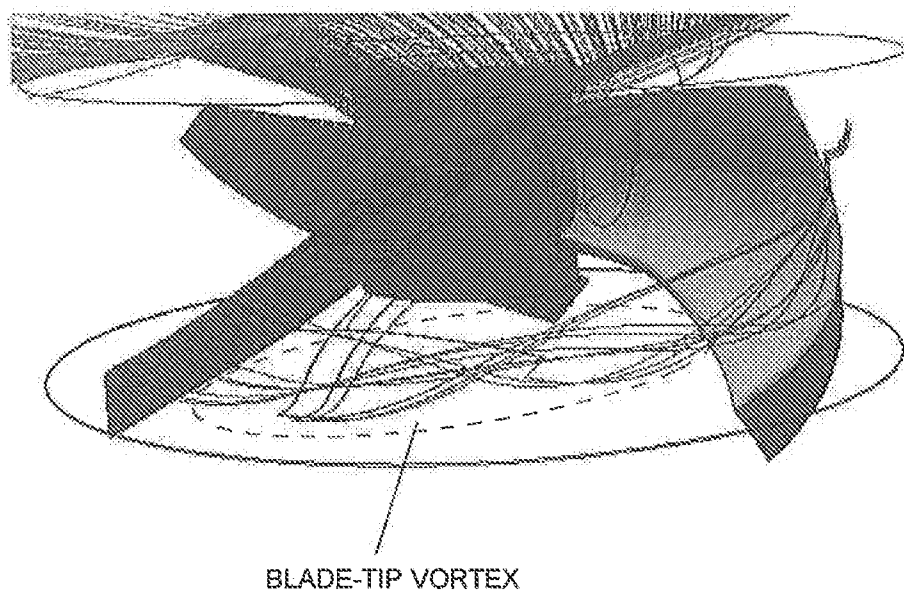


FIG. 27

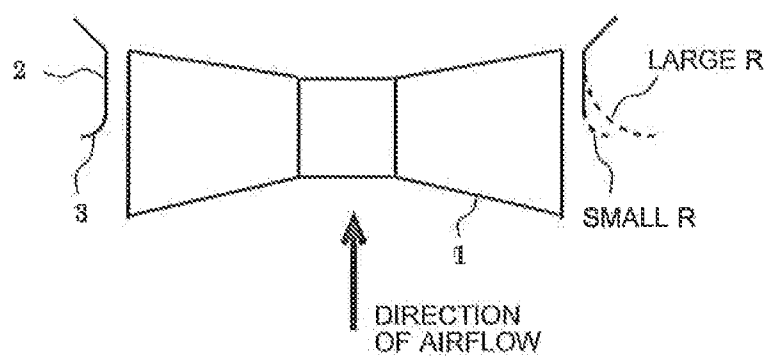


FIG. 28

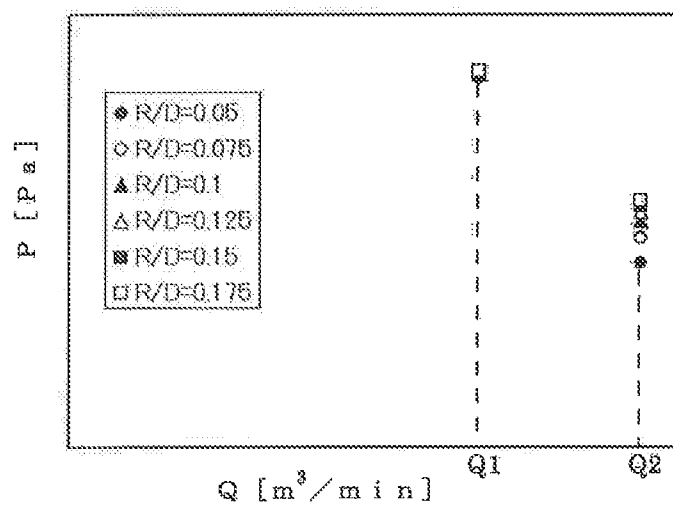


FIG. 29

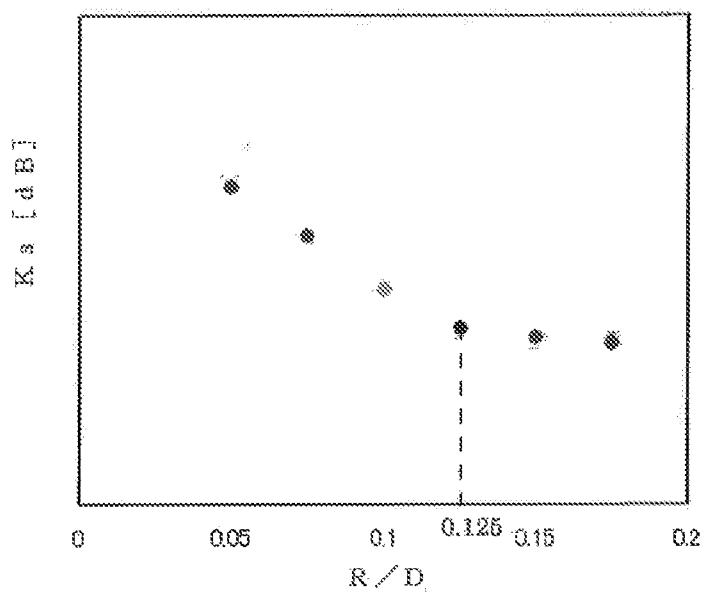


FIG. 30

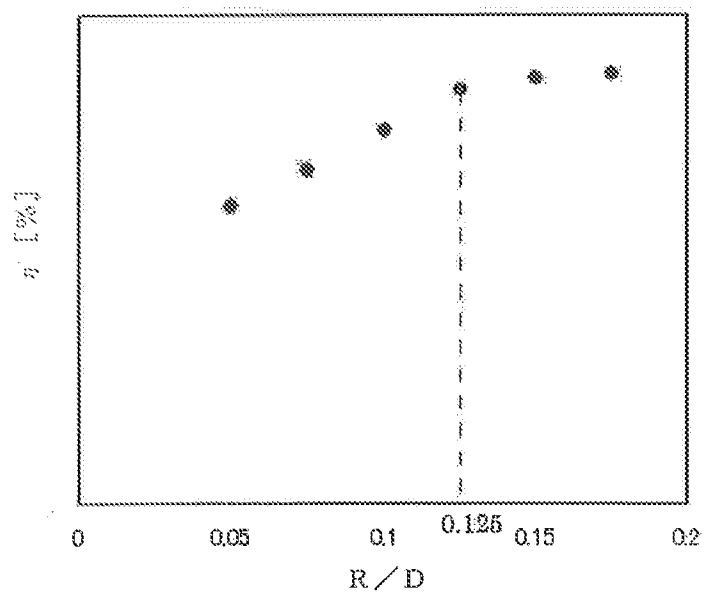
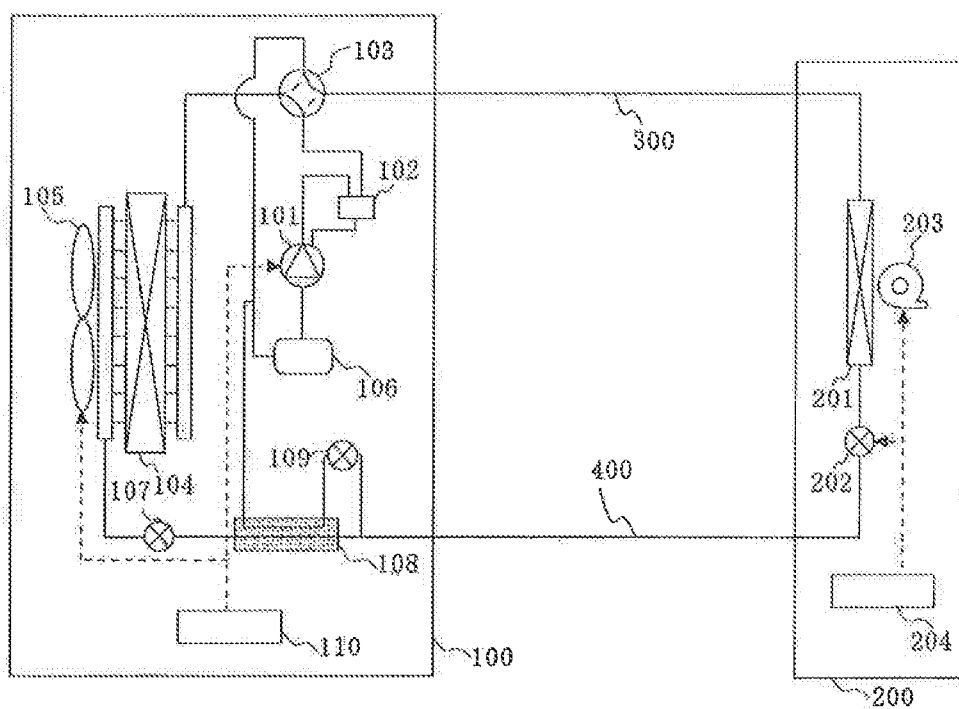


FIG. 31



AIR-SENDING DEVICE OF OUTDOOR UNIT, OUTDOOR UNIT, AND REFRIGERATION CYCLE APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a U.S. national stage application of PCT/JP2010/005596 filed on Sep. 14, 2010, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to an outdoor unit and the like that each include an air-sending device including a propeller fan and a bellmouth.

BACKGROUND

[0003] There is an air-sending device (fan unit) that sends air (that performs cooling, heat exhaust, and so forth) while producing a flow of air by rotating a propeller fan having blades (a propeller). Such an air-sending device including a propeller fan is applied to a wide variety of fields such as outdoor devices (outdoor units) for refrigeration and air-conditioning apparatuses, refrigerators, electric fans, and cooling devices for computers and the like.

[0004] Some of such air-sending devices each include, for example, a bellmouth with a wall extending in the direction of rotation of the propeller fan. Such a bellmouth generally has an opening spreading outward so that air is blown out smoothly (see Patent Literatures 1 and 2, for example).

CITATION LIST

Patent Literature

[0005] Patent Literature 1: Japanese Patent No. 3087876

[0006] Patent Literature 2: Japanese Patent No. 3199931

SUMMARY

[0007] For example, in the air-sending device described above in which the opening simply spreads outward, sound regarded as noise increases and the fan efficiency is reduced. For example, in a case where the above air-sending device is provided in an outdoor unit of an air-conditioning apparatus, noise from the outdoor unit generated with the rotation of the propeller fan may annoy neighborhood residents. Therefore, there is a need to reduce noise of outdoor unit. Meanwhile, in recent years, there have been a need for air-conditioning apparatuses having high energy efficiency for prevention of global warming. To achieve high energy efficiency, measures such as increasing the air flow rate of the outdoor unit is effective. Basically, however, noise increases with the air flow rate. Moreover, air-conditioning apparatuses or the like are typically operated without any stoppage or for a long time. Therefore, it is also important to reduce power consumed by the air-sending device itself.

[0008] In view of the above, it is an object of the present invention to provide an outdoor unit of a refrigeration cycle apparatus and the like, the outdoor unit and the like each including an air-sending device in which the generation of noise and the increase in power consumption are further suppressed.

Solution to Problem

[0009] An air-sending device of an outdoor unit according to the present invention includes a propeller fan that rotates about a rotation axis extending in a direction of gravity and includes a plurality of blades that produce a flow of gas in a direction opposite to the direction of gravity, and a bellmouth for rectifying the gas, the bellmouth having an annular wall extending in a direction of rotation of the blades of the propeller fan on an outer side with respect to outer peripheral edges of the blades. The bellmouth has a wall forming a sloping surface extending such that an air passage on an outlet side spreads outward. The bellmouth has a shape satisfying conditions represented as a relationship of $H/D \geq 0.04$ between a length H of the sloping surface in a direction of the rotation axis from an end on an inlet side to an end on the outlet side and a fan diameter D of the propeller fan, a relationship of $0 < \theta \leq 60^\circ$ for an angle θ formed between a line connecting the ends of the sloping surface and the rotation axis, and a relationship of $L/L_0 \geq 0.5$ between a length L in the direction of the rotation axis from an opening on the inlet side to the end of the sloping surface on the inlet side and a length L_0 of the blades of the propeller fan in the direction of the rotational axis.

[0010] In the air-sending device of an outdoor unit according to the present invention, the bellmouth has the sloping surface extending such that the air passage on the outlet side spreads outward. Furthermore, with respect to the propeller fan, the bellmouth has a shape satisfying the relationships of $L/L_0 \geq 0.5$, $0 < \theta \leq 60^\circ$, and $H/D \geq 0.04$. Therefore, the relationship between the static pressure and the air flow rate on an open side can be made closer to the relationship between the static pressure and the air flow rate in a surging zone without increasing the fan diameter. This, for example, reduces the differences between the specific noise level and the fan efficiency at an operating point in an operation at the highest air flow rate and the smallest specific noise level and the highest fan efficiency, respectively. Thus, input to the fan and noise can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0011] FIG. 1 is a diagram illustrating an outline of an air-sending device according to Embodiment 1 of the present invention.

[0012] FIG. 2 is a graph illustrating a P-Q characteristic and a Ks-Q characteristic of a propeller fan 1 alone.

[0013] FIG. 3 is a graph illustrating the P-Q characteristic and an η -Q characteristic of the propeller fan 1 alone.

[0014] FIG. 4 is a graph illustrating relationships of the P-Q characteristic and the Ks-Q characteristic with respect to the diameter.

[0015] FIG. 5 is a graph illustrating relationships of the P-Q characteristic and the η -Q characteristic with respect to the diameter.

[0016] FIG. 6 is a diagram illustrating exemplary dimensional parameters related to a bellmouth 2.

[0017] FIG. 7 is a graph illustrating the P-Q characteristic based on the dimensional parameters.

[0018] FIG. 8 is a graph illustrating the P-Q characteristic observed when L/L_0 is varied.

[0019] FIG. 9 is a graph illustrating a relationship between specific noise level Ks and the value of L/L_0 at an air flow rate Q2.

[0020] FIG. 10 is a graph illustrating the P-Q characteristic observed when a sloping-portion angle θ is varied.

[0021] FIG. 11 is a graph illustrating relationships of fan efficiency η and the specific noise level Ks with respect to the angle θ at the air flow rate Q2.

[0022] FIG. 12 is a graph illustrating the P-Q characteristic observed when the value of H/D is varied.

[0023] FIG. 13 is a graph illustrating a relationship between static pressure P and the value of H/D at the air flow rate Q2.

[0024] FIG. 14 is a graph illustrating relationships of the fan efficiency η and the specific noise level Ks with respect to the H/D at the air flow rate Q2.

[0025] FIG. 15 is a perspective view of a bellmouth 2 having another shape.

[0026] FIG. 16 includes diagrams illustrating sloping portions 5a having other exemplary shapes.

[0027] FIG. 17 includes diagrams illustrating configurations of top-blowing outdoor units.

[0028] FIG. 18 is a diagram illustrating a configuration of a side-blowing outdoor unit.

[0029] FIG. 19 is an exploded perspective view of a side-blowing bellmouth.

[0030] FIG. 20 is a diagram illustrating a relationship between the shape of the bellmouth 2 and the flow of air.

[0031] FIG. 21 is a diagram illustrating a shape of the bellmouth 2 according to Embodiment 2 and the flow of air.

[0032] FIG. 22 is a diagram illustrating a relationship between the bellmouth 2 and a fan guard.

[0033] FIG. 23 is a graph illustrating relationships of input to the fan and noise with respect to an angle α .

[0034] FIG. 24 is a diagram illustrating a propeller fan 1 according to Embodiment 4.

[0035] FIG. 25 is a diagram illustrating path lines representing a blade-tip vortex produced in a case where ribs 6 are not provided.

[0036] FIG. 26 is a diagram illustrating path lines representing a blade-tip vortex produced in a case where the ribs 6 are provided.

[0037] FIG. 27 is a diagram illustrating an inlet opening 3 of the bellmouth 2.

[0038] FIG. 28 is a graph illustrating a relationship between the P-Q characteristic and the R/D value.

[0039] FIG. 29 is a graph illustrating a relationship between the specific noise level Ks and the R/D value at the air flow rate Q2.

[0040] FIG. 30 is a graph illustrating a relationship between the fan efficiency η and the R/D value at the air flow rate Q2.

[0041] FIG. 31 is a block diagram of a refrigeration and air-conditioning apparatus according to Embodiment 6 of the present invention.

DETAILED DESCRIPTION

Embodiment 1

[0042] FIG. 1 is a diagram illustrating an outline of an air-sending device according to Embodiment 1 of the present invention. FIG. 1 illustrates a propeller fan 1 and a bellmouth 2 in sectional view. The air-sending device according to Embodiment 1 is to be provided in, for example, an outdoor unit of a refrigeration cycle apparatus such as an air-conditioning apparatus.

[0043] The propeller fan 1 is an axial fan that produces a flow of air (fluid) by causing a plurality of blades (a propeller, or wings) to rotate about a rotation axis when a motor or the

like (not illustrated) is driven with power supplied thereto. The propeller fan 1 described herein is not especially limited to but is a fan having a forward-swept shape. Furthermore, the propeller fan 1 (air-sending device) is disposed as a top-blowing air-sending device in the outdoor unit such that the rotation axis thereof substantially corresponds to the direction of gravity (vertical direction, hereinafter also referred to as height direction of the air-sending device) and air is thus blown in a direction opposite to the direction of gravity.

[0044] The bellmouth 2 covers the propeller fan 1 in such a manner as to extend in the circumferential direction (direction of rotation) of the propeller fan 1 (the bellmouth 2 surrounds the propeller fan 1) and is configured to rectify the flow of air produced by the rotation of the propeller fan 1. That is, a tubular wall is provided around the propeller fan 1. As illustrated in FIG. 1, the bellmouth 2 according to Embodiment 1 covers about 50% of the propeller fan 1 in the direction of the rotation axis (height direction) of the propeller fan 1.

[0045] An inlet opening 3 is open on the upstream side (inlet side) of the bellmouth 2 so that air is taken in therefrom. In the bellmouth 2 according to Embodiment 1, the distance between the rotation axis of the propeller fan 1 and the end of the inlet opening 3 (the radius of the opening) is larger than the distance between the rotation axis and the surface of a straight tubular portion 4 (the radius of the straight tubular portion 4) (the end of the inlet opening 3 spreads outward). Furthermore, an inner wall (a surface facing the propeller fan 1) extending from the inlet-side end of the straight tubular portion 4 to the end of the inlet opening 3 forms a curved surface (with an arc sectional shape). The curved surface has a radius of curvature R. A portion of the inlet opening 3 having the curved surface is referred to as radius corner 3a.

[0046] The straight tubular portion 4 is a portion of the bellmouth 2 where the inner wall of the bellmouth 2 extends parallel to the rotation axis of the propeller fan 1. The position of the outlet-side end of the straight tubular portion 4 and the outlet-side position of the blades of the propeller fan 1 are not especially limited to but substantially coincide with each other in the height direction of the air-sending device.

[0047] An outlet opening 5 is open on the downstream side (outlet side) of the bellmouth 2 so that air is blown therefrom. Regarding the outlet opening 5 also, the distance between the rotation axis of the propeller fan 1 and the end of the outlet opening 5 (the radius of the opening) is larger than the distance between the rotation axis and the surface of the straight tubular portion 4 (the radius of the straight tubular portion 4). Furthermore, an inner wall extending from the outlet-side end of the straight tubular portion 4 (the inlet-side end of the outlet opening 5) to the outlet-side end of the outlet opening 5 forms a sloping surface that spreads outward with a tapered (flared) sectional shape. The tapered portion is referred to as a sloping portion 5a. Although the inner wall of the bellmouth 2 according to Embodiment 1 may be formed merely with the sloping portion 5a and the radius corner 3a.

[0048] FIG. 2 is a graph illustrating a P-Q characteristic and a Ks-Q characteristic of the propeller fan 1 alone. FIG. 3 is a graph illustrating the P-Q characteristic and an η -Q characteristic of the propeller fan 1 alone. Here, P denotes static pressure, Q denotes air flow rate, Ks denotes specific noise level [dB], and η denotes fan efficiency (static-pressure efficiency) [%]. Given the static pressure P and the air flow rate Q, the specific noise level Ks and the fan efficiency η satisfy the below Equations (1) and (2), respectively, where SPL denotes noise [dB] at a position away from the propeller fan

1 by a predetermined distance, T denotes torque [Nm], and ω denotes angular velocity [rad/s]. In Equation (1), the unit of static pressure $P1$ is [mmAq], and the unit of air flow rate $Q1$ is [m³/min]. In Equation (2), the unit of static pressure $P2$ is [Pa], and the unit of air flow rate $Q2$ is [m³/s].

$$Ks = SPL - 10 \log 10(P1 \cdot Q1^{2.5}) \quad (1)$$

$$\eta = 100 \times P2 \cdot Q2 / T\omega \quad (2)$$

[0049] Referring to FIGS. 2 and 3, relationships among the static pressure P , the air flow rate Q , the specific noise level Ks , and the fan efficiency η will be described. The P - Q characteristic represents a relationship between the static pressure P , which is airflow resistance, and the air flow rate Q , supposing that the fan rotation speed of the propeller fan 1 is constant. Hereinafter, a side having low air flow rate and high static pressure is referred to as closed side, and a side having high air flow rate and low static pressure is referred to as open side. In general, air flows more easily as the airflow resistance becomes smaller (the air flow rate Q becomes higher as the static pressure P becomes lower), whereas air flows more difficulty as the airflow resistance becomes larger (the air flow rate Q becomes lower as the static pressure P becomes higher).

[0050] However, the air flow rate Q and the static pressure P do not always have such a relationship. There is a zone in which the variation in static pressure P with respect to the air flow rate Q is small. This zone is referred to as a surging zone. During rotation of any propeller fan 1, the specific noise level Ks becomes smallest and the fan efficiency η becomes highest around the surging zone.

[0051] FIG. 4 is a graph illustrating relationships of the P - Q characteristic and the Ks - Q characteristic with respect to the fan diameter (fan rotation diameter) of the propeller fan 1. FIG. 5 is a graph illustrating relationships of the P - Q characteristic and the η - Q characteristic with respect to the diameter of the propeller fan 1. As illustrated in FIGS. 4 and 5, when the fan diameter is increased, the surging zone shifts toward the open side. Furthermore, when the fan diameter is increased, the gradient of the P - Q characteristic becomes gentler in a zone on the open side with respect to the surging zone. In contrast, when the fan diameter is reduced, the gradient of the P - Q characteristic becomes steeper in the zone on the open side with respect to the surging zone.

[0052] Now, an operating point will be described. In an outdoor unit of an air-conditioning apparatus including the propeller fan 1 (air-sending device), let the fan rotation speed of the propeller fan 1 at a predetermined air flow rate $Q0$ be $N0$ while a static pressure $P0$ at the air flow rate $Q0$ is calculated from the P - Q characteristic of the propeller fan 1 alone obtained at the fan rotation speed $N0$, then, $(P0, Q0)$ is defined as the operating point.

[0053] In a case in which the operating point of the air-sending device is on the open side with respect to the surging zone, the specific noise level Ks at the operating point is larger than the specific noise level at a point where specific noise level is smallest and the fan efficiency η at the operating point is lower than the fan efficiency at a point where fan efficiency is highest. In this case, when the fan diameter is increased, the surging zone shifts toward the open side, as described above, and closer to the operating point. Therefore, the specific noise level Ks and the fan efficiency η at the operating point become closer to the specific noise level at the point where specific noise level is smallest and to the fan efficiency at the point

where fan efficiency is highest, respectively. Hence, noise and input (power supply) to the fan can be reduced.

[0054] However, if the fan diameter is increased, the size of the air-sending device increases and hence the size of an apparatus in which the air-sending device is to be provided needs to be increased. The increase in size leads to problems such as increase in cost, deterioration in design, increase in installation space, and so forth.

[0055] To make the specific noise level Ks and the fan efficiency η at the operating point become closer to the smallest specific noise level and the highest fan efficiency in a case where the fan diameter cannot be increased and the operating point is on the open side with respect to the surging zone, the gradient of the P - Q characteristic may be made gentler in a zone on the open side with respect to the surging zone so that the static pressure on the open side becomes higher. In such a case, the gradients of the Ks - Q characteristic and the η - Q characteristic also become gentler, and the deviations of the specific noise level Ks and the fan efficiency η at the operating point from the specific noise level at the point where specific noise level is smallest and the fan efficiency at the point where fan efficiency is highest become smaller than those in a case where the foregoing gradients are steep. Therefore, noise and input to the fan can be reduced. In the case where the gradients of the Ks - Q characteristic and the η - Q characteristic are gentle, even if the operating point is shifted by, for example, changing the setting of the air flow rate in the air-sending device, the variations in the specific noise level Ks and in the fan efficiency η can be suppressed to be small. Therefore, an efficient operation is achieved. In such a case, the smallest specific noise level and the highest fan efficiency are determined dominantly by the fan diameter. The larger the fan diameter, the smaller the smallest specific noise level and the higher the highest fan efficiency. The smaller the fan diameter, the larger the smallest specific noise level and the lower the highest fan efficiency. Furthermore, the larger the fan diameter, the gentler the gradient of the P - Q characteristic. The smaller the fan diameter, the steeper the gradient of the P - Q characteristic.

[0056] For example, in an air-conditioning apparatus including a propeller fan 1, there are ones in which the setting of the air flow rate is changed among a plurality of levels. In the case where the fan diameter cannot be increased, during an operation at the highest air flow rate, the operating points for the Ks - Q characteristic and for the η - Q characteristic deviate from the point where specific noise level is smallest and the point where fan efficiency is highest, respectively. Consequently, noise and input to the fan tend to increase. This is because of the following reason. As described above, in the case where the fan diameter cannot be increased sufficiently, the surging zone is on the closed side while the operating point in the operation at the highest air flow rate is on the open side.

[0057] FIG. 6 is a diagram illustrating exemplary dimensional parameters related to the bellmouth 2. As illustrated in FIG. 6, the diameter of the propeller fan 1 (fan diameter) is denoted by D , the length of the bellmouth 2 in the direction of the rotation axis from the end of the inlet opening 3 to the outlet-side end of the straight tubular portion 4 (bellmouth height) is denoted by L , the length of the blades in the direction of the rotation axis of the propeller fan 1 (fan height) is denoted by $L0$, the lengths of the sloping portion 5a at the outlet opening 5 in the direction of the rotation axis of the propeller fan 1 (height, hereinafter referred to as sloping-

portion height) and in the direction of the fan diameter D (hereinafter referred to as sloping-portion length) are denoted by H and W , respectively, and the angle between a direction in which the sloping portion **5a** is tapered and the direction of the rotation axis of the propeller fan **1** is denoted as sloping-portion angle θ .

[0058] FIG. 7 is a graph illustrating the P-Q characteristic based on the dimensional parameters illustrated in FIG. 6, specifically, the P-Q characteristic observed when the parameters related to the air-sending device illustrated in FIG. 6 are set so as to satisfy $D=700$ mm, $L/L_0=0.1$, $H/D=0.01$, and $\theta=45^\circ$, with the fan rotation speed set to NA. In FIG. 7, the air flow rate Q_1 corresponds to the air flow rate around the surging zone, and the air flow rate Q_2 corresponds to the air flow rate at the operating point that is on the open side with respect to the surging zone.

[0059] Now, there will be described an air-sending device in which the static pressure P at the operating point that is on the open side with respect to the surging zone is high and the gradient of the P-Q characteristic on the open side with respect to the surging zone is gentle. Hereinafter, the term open side refers to an operating point that is on the open side with respect to the surging zone.

[0060] FIG. 8 is a graph illustrating the P-Q characteristic observed when L/L_0 is varied. In this case, L/L_0 is varied by varying the bellmouth height L with the fan height L_0 being constant. As illustrated in FIG. 8, the static pressure P is substantially constant around the surging zone where the air flow rate is Q_1 , regardless of the value of L/L_0 . At the operating point where the air flow rate is Q_2 that is on the open side with respect to the air flow rate Q_1 , as L/L_0 becomes larger, the static pressure P becomes higher in a range of $L/L_0<0.5$ but is substantially constant in a range of $L/L_0\geq 0.5$.

[0061] FIG. 9 is a graph illustrating a relationship between the specific noise level K_s [dB] and the value of L/L_0 in the air-sending device with the fan rotation speed being NA and the air flow rate being Q_2 . As illustrated in FIG. 9, in the range of $L/L_0<0.5$, the specific noise level K_s on the open side can be reduced more as the value of L/L_0 becomes larger. Meanwhile, in the range of $L/L_0\geq 0.5$, the specific noise level K_s on the open side does not substantially change.

[0062] The reason for this is as follows. In a case where the bellmouth height L is small, a blade-tip vortex tends to occur from portions of the blades of the propeller fan **1** that are not covered by the bellmouth **2**, generating noise. In contrast, in a case where the bellmouth height L is large, the flow path for the blade-tip vortex is narrowed. Therefore, noise due to the blade-tip vortex is reduced, whereas variations in the static pressure on the wall of the bellmouth **2** facing the fan increase. Hence, in the range of $L/L_0<0.5$, noise due to the blade-tip vortex is reduced more as the bellmouth height L becomes larger. In the range of $L/L_0\geq 0.5$, the influences of the two are of substantially the same level and do not substantially vary. Accordingly, the specific noise level K_s does not vary. Considering the above, the propeller fan **1** and the bellmouth **2** desirably satisfy a relationship of $L/L_0\geq 0.5$ in the height direction.

[0063] Now, there will be described a case where the sloping-portion angle θ is varied while the parameters illustrated in FIG. 6 are set so as to satisfy $L/L_0=0.5$ and $W/D=0.15$. In this case, $H=W/\tan \theta$. To distinguish this case from a case where $W=0$ and the fan diameter D is large, the sloping-portion length W is set so as to be constant.

[0064] FIG. 10 is a graph illustrating the P-Q characteristic observed when the sloping-portion angle θ is varied with the fan rotation speed being NA. The static pressure P is substantially constant around the surging zone, regardless of the sloping-portion angle θ . In contrast, in a range of $\theta\geq 60^\circ$, the static pressure P on the open side with respect to the surging zone becomes smaller as the sloping-portion angle θ becomes larger. In a range of $0<\theta\leq 60^\circ$, the static pressure P on the open side is substantially constant.

[0065] FIG. 11 is a graph illustrating relationships of the fan efficiency η and the specific noise level K_s with respect to the angle θ with the fan rotation speed being NA and the air flow rate being Q_2 . In FIG. 11, the fan efficiency η and the specific noise level K_s around the surging zone are substantially constant regardless of θ . In the range of $\theta\geq 60^\circ$, the fan efficiency η becomes lower and the specific noise level K_s becomes higher as θ becomes larger. In the range of $0<\theta\leq 60^\circ$, the fan efficiency η and the specific noise level K_s on the open side are considered to be substantially constant with small rates of increase (note that $0<\theta\leq 45^\circ$ is considered to be more preferable because the fan efficiency η and the specific noise level K_s slightly increase in a range between 45° and 60°).

[0066] The reason why the fan efficiency η and the specific noise level K_s on the open side are improved in the range of $0<\theta\leq 60^\circ$ compared with those observed in the range of $\theta\geq 60^\circ$ is as follows. Since the area of an outlet air passage provided at the outlet opening **5** is increased, the velocity at which air is blown is reduced and the static pressure P is increased. Furthermore, since the outlet opening **5** spreads outward, the outlet air passage functions as a diffuser. In such a situation, in the range of $0<\theta\leq 60^\circ$, air flowing near the sloping portion **5a** is blown along the sloping portion **5a**. Thus, the function as a diffuser is exerted.

[0067] FIG. 12 is a graph illustrating the P-Q characteristic observed when the value of H/D is varied with the fan rotation speed being NA. FIG. 13 is a graph illustrating a relationship between the static pressure P and the value of H/D with the fan rotation speed being NA and the air flow rate being Q_2 . In this case, the parameters related to the air-sending device illustrated in FIG. 6 are set so as to satisfy $L/L_0=0.5$ and $\theta=60^\circ$.

[0068] Referring to FIG. 12, the static pressure P is substantially constant around the surging zone, regardless of the value of H/D . In contrast, in a range of $H/D<0.04$, the static pressure P on the open side with respect to the surging zone becomes larger as the value of H/D becomes larger. In a range of $H/D\geq 0.04$, the static pressure P on the open side is substantially constant.

[0069] As illustrated in FIG. 13, as the value of H/D becomes larger, the static pressure P on the open side becomes larger but the increase in the static pressure P with respect to the value of H/D is smaller than that in the range of $H/D<0.04$.

[0070] FIG. 14 is a graph illustrating relationships of the fan efficiency η and the specific noise level K_s with respect to H/D with the fan rotation speed being NA and the air flow rate being Q_2 . In FIG. 14, the fan efficiency η and the specific noise level K_s around the surging zone are substantially constant regardless of the value of H/D . In contrast, in the range of $H/D<0.04$, the fan efficiency η becomes lower and the specific noise level K_s becomes larger as the value of H/D becomes smaller. In the range of $H/D\geq 0.04$, the improve-

ments in the fan efficiency η and in the specific noise level Ks on the open side become smaller relative to the increase in the value of H/D.

[0071] The reason why the fan efficiency and the specific noise level on the open side are more improved in the range of $H/D \geq 0.04$ than in the range of $H/D < 0.04$ is as follows. Since the area of the outlet air passage is increased, the velocity at which air is blown is reduced and the static pressure P is increased. Furthermore, since the outlet opening 5 spreads outward, the outlet air passage functions as a diffuser. In such a situation, in the range of $H/D \geq 0.04$, the function as a diffuser is exerted efficiently.

[0072] As described above, when the fan diameter D is small, the surging zone is shifted toward the closed side. Therefore, a certain size of the fan diameter D needs to be provided (for example, in an outdoor unit, the fan diameter D is desired to be 600 mm or larger). Hence, when it is attempted to increase the value of H/D, the sloping-portion height H is to be increased. This accompanies an increase in the size of a downstream portion of the bellmouth 2.

[0073] As illustrated in FIG. 14, for example, in the range of $H/D \geq 0.04$, the improvements in the fan efficiency η and in the specific noise level Ks on the open side are relatively small even if the value of H/D is increased. Therefore, in the range of $H/D \geq 0.04$, H/D is set to a large value if, for example, there is any allowance for the range of possible size of the bellmouth 2 in relation to the casing of a heat source unit. If there is no such allowance, at least $H/D = 0.04$ is to be satisfied. Thus, the fan efficiency η and the specific noise level Ks on the open side can be improved.

[0074] In the air-sending device according to Embodiment 1 that is to be provided in an outdoor unit, the propeller fan 1 and the bellmouth 2 are configured such that conditions (parameters) are set so as to satisfy the relationships of $H/D \geq 0.04$, $0 < \theta \leq 60^\circ$, and $L/L_0 \geq 0.5$ as described above. In addition, as demonstrated by the above results, if the air-sending device is configured on the basis of the conditions satisfying the above relationships, the conditions each provide an effect of suppressing the increase in noise and power consumption (input to the fan). For example, one of the conditions for suppressing the increase in noise and power consumption that provides the most significant effect is the condition satisfying $H/D \geq 0.04$, followed by the condition satisfying $0 < \theta \leq 60^\circ$ and the condition satisfying $L/L_0 \geq 0.5$, sequentially. Therefore, even if not all of the conditions are satisfied, one of or a combination of any of the conditions only needs to be satisfied, whereby the effects according to the present invention are provided.

[0075] FIG. 15 is a perspective view of a bellmouth 2 having another shape. For example, if the diameter of the bellmouth 2 (particularly, the outlet opening 5) is larger than at least one of the width and the depth of the casing of an outdoor unit, the bellmouth 2 extends beyond the casing and comes into contact with another bellmouth provided in another outdoor unit. This may make it difficult to arrange a plurality of outdoor units close to one another. Hence, the shape of the bellmouth 2 may be partially altered such that the diameter thereof becomes smaller than the width and the depth of the casing of the outdoor unit. For example, in the bellmouth 2 illustrated in FIG. 16, the sloping-portion angle θ is not constant over the entire circumference of the bellmouth 2 and is changed in some portions. Thus, the bellmouth 2 is prevented from extending beyond the casing while the above-described conditions are satisfied.

[0076] FIG. 16 includes diagrams illustrating sloping portions 5a having other exemplary shapes, respectively. For example, in FIG. 1 and others, the sloping portion 5a extends linearly in sectional view. In some cases, however, the sloping portion 5a may not be able to extend linearly because of restrictions on the manufacturing process, design, dimensions, and so forth. Even in such a case, an effect similar to that provided by the sloping portion 5a that extends linearly can be provided, as long as the angle of a straight line connecting the two ends of the sloping portion 5a falls within a range of about $0 < \theta \leq 60^\circ$. For example, the sloping portion 5a may have a concave, substantially arc shape as illustrated in FIG. 16(a), a convex, substantially arc shape as illustrated in FIG. 16(b), or the like.

[0077] FIG. 17 includes diagrams illustrating configurations of top-blowing outdoor units, respectively. FIG. 17(a) illustrates an outdoor unit in which an outdoor-side heat exchanger that exchanges heat between a refrigerant and air has a rectangular U shape in a casing. FIG. 17(b) illustrates an outdoor unit in which an outdoor-side heat exchanger has a V shape, or a W shape. As illustrated in FIG. 17, in a top-blowing outdoor unit, the heat exchanger has a rectangular U, V, or W shape with a plurality of bends, and the air-sending device blows air in the direction opposite to the direction of gravity (in a top-blowing direction).

[0078] FIG. 18 is a diagram illustrating a configuration of a side-blowing outdoor unit. As illustrated in FIG. 18, an air-sending device provided in the side-blowing outdoor unit blows air in a direction perpendicular to the direction of gravity. The side-blowing outdoor unit includes an outdoor-side heat exchanger having an L shape.

[0079] Comparing the rectangular-U-shaped heat exchanger for the top-blowing type illustrated in FIG. 17(a) and an L-shaped heat exchanger for the side-blowing type, the rectangular-U-shaped heat exchanger takes in air from three sides, whereas the L-shaped heat exchanger takes in air from two sides. Therefore, the rectangular-U-shaped heat exchanger can have a certain level of capacity more easily than the L-shaped heat exchanger.

[0080] In the top-blowing type with a plurality of bends illustrated in FIG. 17(b), a portion of the heat exchanger allocated to one propeller fan (air-sending device) has a V shape. In this case, air is taken in from two sides, as with the L-shaped heat exchanger. Furthermore, the two heat exchangers have the same length. In contrast, in the L-shaped heat exchanger for the side-blowing outdoor unit, one side of the heat exchanger as the inlet side is short. Therefore, the V-shaped heat exchanger provided in the top-blowing outdoor unit can have a certain level of capacity more easily than the L-shaped heat exchanger. Hence, the area of the front surface of the heat exchanger increases, and the front velocity through the heat exchanger is reduced. Accordingly, the airflow resistance of the heat exchanger is reduced. Thus, the airflow resistance of the outdoor unit as a whole can be reduced.

[0081] Hereinafter, a loss factor ξ is used as an index that indicates on which of the closed side and the open side the operating point is. Letting the static pressure and the air flow rate at the operating point be P and Q, respectively, the loss factor ξ is expressed as $\xi = P/Q^2$. As ξ becomes smaller, the operating point is shifted more toward the open side. As ξ becomes larger, the operating point is shifted more toward the closed side.

[0082] The heat exchanger of the top-blowing outdoor unit, which in general has smaller airflow resistance than that of the side-blowing outdoor unit as described above, has a smaller loss factor ξ with the operating point being on the open side. Therefore, to bring the surging zone closer to the operating point, the top-blowing type needs to have a larger fan diameter D than the side-blowing type. If the fan diameter D cannot be increased because of any design restrictions, such as installation area, on the size of the outdoor unit, the operating point is defined on the open side with respect to the surging zone. Consequently, the specific noise level K_s is increased and the fan efficiency η is reduced.

[0083] In view of the above, the configuration according to the present invention defined so as to bring the operating point closer to the surging zone without increasing the fan diameter D is more necessary for the top-blowing outdoor unit than for the side-blowing outdoor unit and can exert its effects more in the top-blowing outdoor unit.

[0084] Now, differences between a bellmouth for the top-blowing type and a bellmouth for the side-blowing type will be described. As an exemplary bellmouth for the top-blowing type, the bellmouth **2** shaped as illustrated in FIG. 15 is made of resin and can be formed by solid casting, regardless of L/L_0 illustrated in FIG. 1.

[0085] FIG. 19 is an exploded perspective view of the side-blowing bellmouth. In general, a bellmouth sheet metal **10** illustrated in FIG. 19 is formed into a bellmouth for a side-blowing outdoor unit by solid casting. In such a case, L/L_0 of the bellmouth **2** cannot be made large ($L/L_0=1$, for example). To do so, other parts need to be prepared.

[0086] Hence, to apply the bellmouth shape according to the present invention to a side-blowing outdoor unit is relatively more difficult than to apply it to a top-blowing outdoor unit and is not practical.

[0087] As described above, according to Embodiment 1, the air-sending device of the outdoor unit is configured under the conditions of $L/L_0 \geq 0.5$, $0 < \theta \leq 60^\circ$, and $H/D \geq 0.04$. Therefore, the relationship between the static pressure P and the air flow rate Q on the open side can be made closer to the relationship between the static pressure P and the air flow rate Q in the surging zone without increasing the fan diameter D , and hence the fan efficiency η and the specific noise level K_s can be improved. Thus, input to the fan and noise can be reduced.

Embodiment 2

[0088] FIG. 20 is a diagram illustrating a relationship between the shape of the bellmouth **2** and the flow of air. In FIG. 20, individual airflows are represented by streamlines. On the downstream side of the bellmouth, air blown from the outlet opening **5** flows more obliquely along the sloping portion **5a** as the distance to the wall of the sloping portion **5a** becomes smaller. For example, in a case where an air-conditioning apparatus includes a plurality of outdoor units that are provided on the rooftop of a building, short cycles may occur in which air that have been blown obliquely is taken into adjacent outdoor units because of the suction force of propeller fans **1** of the adjacent outdoor units and ambient wind. For example, in an outdoor unit that has taken in high-temperature air blown from another outdoor unit including an outdoor-side heat exchanger functioning as a condenser in a casing, the temperature difference between the refrigerant and air is reduced. This may reduce the efficiency of heat exchange and hence COP.

[0089] FIG. 21 is a diagram illustrating a shape of the bellmouth **2** according to Embodiment 2 and the flow of air. The bellmouth **2** according to Embodiment 2 illustrated in FIG. 21 includes a straight tubular portion **5b** provided at the downstream exit (end) of the outlet opening **5**. Suppose that the sloping portion **5a** satisfies the conditions (parameters) that are set as described in Embodiment 1.

[0090] Under such circumstances, air around the outer circumference of a downstream portion of the bellmouth **2** flows along the sloping portion **5a** and the straight tubular portion **5b** and is blown upward (the direction opposite to the direction of gravity). Therefore, the occurrence of short cycles into adjacent outdoor units can be suppressed.

[0091] Furthermore, for example, to protect the propeller fan **1** and other members from foreign matter that may be taken into the outlet opening **5**, a fan guard in the form of a grating that covers the outlet opening **5** may be provided. In such a case, the fan guard can be easily fixed by providing a straight tubular portion **5b** at the downstream end of the bellmouth.

[0092] As described above, in the outdoor unit including the air-sending device according to Embodiment 2, the straight tubular portion **5b** is provided at the downstream exit (end) of the outlet opening **5** and allows air to be blown upward so that adjacent outdoor units are not affected. Thus, the occurrence of short cycles can be suppressed. Furthermore, the fan guard in the form of a grating can be easily fixed.

Embodiment 3

[0093] FIG. 22 is a diagram illustrating a relationship between the bellmouth **2** of an air-sending device and a fan guard **10** provided to the air-sending device. In FIG. 22, the fan guard is a grating-like net and covers the outlet opening **5**, thereby protecting the propeller fan **1** and other devices provided in the casing of the outdoor unit. The grating has a certain length in the height direction. Therefore, some air collides on side surfaces depending on the angle of airflow. In this case, the angle between the grating of the fan guard and the rotation axis of the fan is denoted by α .

[0094] FIG. 23 is a graph illustrating relationships of the input to the fan and the noise with respect to the angle α in a case where, for example, air is blown from the outdoor unit at a predetermined rate. As illustrated in FIG. 23, when $\alpha=0^\circ$, the input to the fan and the noise are both smallest. This is because the airflow resistance at the grating of the fan guard becomes smallest when $\alpha=0^\circ$. Considering such circumstances, the grating of the fan guard is preferably configured such that the angle thereof with respect to the rotation axis of the fan becomes as close to 0° as possible.

[0095] As described above, in the outdoor unit including the air-sending device according to Embodiment 3, air resistance can be minimized by setting the angle between the grating of the fan guard and the rotation axis of the fan to 0° . Therefore, input to the fan required and noise generated when air is blown from the outdoor unit at a predetermined air flow rate can be minimized, and the outdoor unit can have high operation and energy efficiency.

Embodiment 4

[0096] FIG. 24 is a diagram illustrating a propeller fan **1** according to Embodiment 4. In Embodiment 4, a shape of the propeller fan **1** will be described. The propeller fan **1** according to Embodiment 4 has ribs **6** extending from the outer

peripheral edge of a suction surface of the propeller fan 1 toward the upstream side in the axial direction.

[0097] Table 1 summarizes values of the input to the fan and the noise at a predetermined air flow rate for an air-sending device including the propeller fan 1 having the ribs 6 and an air-sending device including the propeller fan 1 not having the ribs 6.

TABLE 1

	Input to fan [W]	Noise [dB]
Without ribs 6	632	62.1
With ribs 6	630	60.8

[0098] Table 1 shows that the values of the input to the fan are substantially the same, whereas the noise for the case where the ribs 6 are provided is smaller. The reason for this is as follows. First, the rms of variations in the static pressure on the wall of the straight tubular portion 4 of the bellmouth 2 is defined on the basis of a static pressure $P_s(t)$ in accordance with Equations (3) and (4) given below. The larger the rms of variations in the static pressure, the larger the noise generated from the wall.

[Math. 1]

$$p_s(t) = \bar{p}_s + p_s'(t) \quad (3)$$

[0099] ($\bar{p}_s$: average, $p_s'(t)$: variation)

$$\text{rms of variations in static pressure} = \{(P_s(t)^2/N)^{0.5} \quad (4)$$

[0100] ($i=1, 2, \dots, N$)

[0101] With the increase in the vorticity of the blade-tip vortex, which is a leakage flow occurring because of a difference in static pressure near the outer peripheral edge of the propeller fan 1 and from the pressure surface to the suction surface, the rms of variations in the static pressure increases, generating noise. The ribs 6 act as airflow resistances for the leakage flow in the form of a blade-tip vortex occurring from the pressure surface to the suction surface and hence narrow the flow path for the leakage flow. Therefore, the occurrence of a blade-tip vortex can be suppressed.

[0102] FIG. 25 is a diagram illustrating path lines representing a blade-tip vortex produced by the rotation of the propeller fan 1 not having the ribs 6. FIG. 26 is a diagram illustrating path lines representing a blade-tip vortex produced in the case where the ribs 6 are provided. Table 2 summarizes values of the rms of variations in the static pressure in the cases where the ribs 6 are provided and not provided.

TABLE 2

	rms [Pa]
Without ribs 6	118.0
With ribs 6	94.4

[0103] As illustrated in FIG. 26, in the case where the ribs 6 are provided, the vorticity of the blade-tip vortex is smaller than that in the case where the ribs 6 are not provided. Therefore, in the air-sending device of the outdoor unit according to Embodiment 4, the rms of variations in the static pressure on the wall of the bellmouth 2 is reduced as shown in Table 2. Accordingly, noise can be reduced.

Embodiment 5

[0104] FIG. 27 is a diagram illustrating the radius of curvature R at the radius corner 3a of the inlet opening 3 of the bellmouth 2 according to Embodiment 5. In FIG. 27, two shapes of the inlet opening 3 having different radii of curvature R are illustrated.

[0105] FIG. 28 is a graph illustrating a relationship between the P-Q characteristic and R/D. The graph is based on values of R/D (hereinafter referred to as R/D) obtained when the radius of curvature R at the radius corner 3a is varied while the fan diameter D and the rotation speed N0 are set so as to be constant and the position of the end of the inlet opening 3 of the bellmouth 2 is fixed. In FIG. 28, the P-Q characteristic is represented as R/D at each of the air flow rates Q1 and Q2.

[0106] As illustrated in FIG. 28, the static pressure P does not significantly vary at the air flow rate Q1 regardless of R/D. Although not especially illustrated, the specific noise level Ks and the fan efficiency η at Q1 do not significantly vary, either, despite the variations in R/D.

[0107] FIG. 29 is a graph illustrating a relationship between the specific noise level Ks and R/D at the air flow rate Q2. FIG. 30 is a graph illustrating a relationship between the fan efficiency η and R/D at the air flow rate Q2. As illustrated in FIGS. 28 to 30, at the air flow rate Q2, as R/D is increased, the static pressure P and the fan efficiency η become higher and the specific noise level Ks becomes smaller. Furthermore, the gradients of the P-Q characteristic, the Ks-Q characteristic, and the η -Q characteristic on the open side become gentler. That is, in the bellmouth 2, the more the radius of curvature R at the radius corner 3a is increased, the more the static pressure P and the fan efficiency η at the operating point that is on the open side are improved and the more the specific noise level Ks at the operating point that is on the open side is reduced. Thus, rotation speed, input to the fan, and noise can be reduced.

[0108] As described above, the larger the radius of curvature R at the radius corner 3a of the inlet opening 3, the higher the fan efficiency η and the smaller the specific noise level Ks. However, for example, if the radius of curvature R at the radius corner 3a are to be made uniform over the entire circumference in a case where the casing has a width and a depth (longitudinal side and lateral side) that are of different lengths (sizes) because of restrictions on the dimensions of the outdoor unit and so forth, the radius of curvature R generally becomes small.

[0109] Hence, if the ratios of the longitudinal length and the lateral length of the casing of the outdoor unit are different, any part of the radius corner 3a that can be widened may be widened such that there are variations in the position of the end of the inlet opening 3 so that the integrated value of radii of curvature R at the radius corner 3a obtained over the entire circumference of the inlet opening 3 becomes largest.

Embodiment 6

[0110] FIG. 31 is a block diagram of a refrigeration and air-conditioning apparatus according to Embodiment 6 of the present invention. Embodiment 6 concerns a refrigeration and air-conditioning apparatus as an exemplary refrigeration cycle apparatus including the above-described air-sending device. The refrigeration and air-conditioning apparatus illustrated in FIG. 31 includes an outdoor unit (outdoor device) 100, which is the one described above, and a load unit (indoor device) 200 that are connected by refrigerant pipes,

thereby forming a refrigerant circuit as a main part (hereinafter referred to as main refrigerant circuit) through which a refrigerant is made to circulate. One of the refrigerant pipes through which a refrigerant in a gas state (gas refrigerant) flows is referred to as gas pipe 300. Another of the refrigerant pipes through which a refrigerant in a liquid state (liquid refrigerant or, occasionally, two-phase gas-liquid refrigerant) flows is referred to as liquid pipe 400.

[0111] The outdoor unit 100 according to Embodiment 6 includes the following devices (means): a compressor 101, an oil extractor 102, a four-way valve 103, an outdoor-side heat exchanger 104, an outdoor-side air-sending device 105, an accumulator (gas-liquid separator) 106, an outdoor-side throttle device (expansion valve) 107, a heat exchanger 108 related to a refrigerant, a bypass throttle device 109, and an outdoor-side controller 110.

[0112] The compressor 101 compresses a refrigerant sucked thereto and discharges the refrigerant. The compressor 101 includes an inverter device or the like and is capable of finely changing the capacity of the compressor 101 (the amount of the refrigerant to be discharged per unit time) by arbitrarily changing the operating frequency.

[0113] The oil extractor 102 extracts lubricant contained in the refrigerant that has been discharged from the compressor 101. The lubricant thus extracted is returned to the compressor 101. The four-way valve 103 switches the flow of the refrigerant between that for a cooling operation and that for a heating operation on the basis of instructions issued by the outdoor-side controller 110. The outdoor-side heat exchanger 104 exchanges heat between a refrigerant and air (outdoor air). For example, in the heating operation, the outdoor-side heat exchanger 104 functions as an evaporator and exchanges heat between the refrigerant having flowed thereto via the outdoor-side throttle device 107 and thus having a low pressure and air, thereby evaporating and gasifying the refrigerant. In the cooling operation, the outdoor-side heat exchanger 104 functions as a condenser and exchanges heat between the refrigerant having been compressed by the compressor 101 and having flowed thereto from the side of the four-way valve 103 and air, thereby condensing and liquefying the refrigerant. The outdoor-side heat exchanger 104 includes the outdoor-side air-sending device 105, which is the air-sending device according to any of Embodiments 1 to 4 described above, so that heat is efficiently exchanged between the refrigerant and air. The outdoor-side air-sending device 105 may also include an inverter device so as to finely change the rotation speed of the propeller fan 1 by arbitrarily changing the operating frequency of the fan motor.

[0114] The heat exchanger 108 related to a refrigerant exchanges heat between the refrigerant flowing through a main flow path in the refrigerant circuit and the refrigerant having branched off from the flow path into the bypass throttle device 109 (expansion valve) and whose flow rate has been thus controlled. Particularly, in a case where the refrigerant needs to be supercooled in the cooling operation, the heat exchanger 108 related to the refrigerant supercools the refrigerant and supplies the refrigerant to the load unit 200. The liquid flowing therethrough via the bypass throttle device 109 is returned to the accumulator 106 via a bypass pipe. The accumulator 106 is means that stores, for example, an excessive refrigerant that is in a liquid state. The outdoor-side controller 110 includes, for example, a microcomputer or the like. The outdoor-side controller 110 is capable of wired or radio communication with a load-side controller 204 and

controls operations concerning the entirety of the refrigeration and air-conditioning apparatus by controlling various means included in the refrigeration and air-conditioning apparatus by, for example, controlling the operating frequency of the compressor 101 while controlling the inverter circuit on the basis of data concerning detection performed by various detecting means (sensors) provided in the refrigeration and air-conditioning apparatus.

[0115] The load unit 200 includes a load-side heat exchanger 201, a load-side throttle device (expansion valve) 202, a load-side air-sending device 203, and the load-side controller 204. The load-side heat exchanger 201 exchanges heat between a refrigerant and air. For example, in the heating operation, the load-side heat exchanger 201 functions as a condenser and exchanges heat between the refrigerant having flowed thereto from the gas pipe 300 and air, thereby condensing and liquefying the refrigerant (or turning the refrigerant into two-phase gas-liquid) before discharging the refrigerant toward the side of the liquid pipe 400. In the cooling operation, the load-side heat exchanger 201 functions as an evaporator and exchanges heat between the refrigerant whose pressure has been reduced by the load-side throttle device 202 and air, thereby evaporating and gasifying the refrigerant, while letting the refrigerant take away the heat from the air, before discharging the refrigerant toward the side of the gas pipe 300. The load unit 200 includes the load-side air-sending device 203 for adjusting the flow of air used for heat exchange. The speed of operation of the load-side air-sending device 203 is determined on the basis of, for example, settings made by the user. The load-side throttle device 202 is provided for adjusting the pressure of the refrigerant in the load-side heat exchanger 201 by changing its opening degree.

[0116] The load-side controller 204 also includes a microcomputer or the like and is capable of wired or radio communication with, for example, the outdoor-side controller 110. The load-side controller 204 controls various devices (means) included in the load unit 200 so that, for example, indoor air comes to have a predetermined temperature on the basis of instructions issued by the outdoor-side controller 110, the residents, or the like. Furthermore, the load-side controller 204 transmits signals containing data concerning detection performed by detecting means provided in the load unit 200.

[0117] As described above, in the refrigeration and air-conditioning apparatus according to Embodiment 5, the outdoor-side air-sending device 105, which is the air-sending device described in any of Embodiments 1 to 4, is applied to the outdoor unit 100 so that air is blown in the direction opposite to the direction of gravity, whereby noise reduction is realized while air flow rate is increased. Thus, the energy efficiency of the refrigeration and air-conditioning apparatus (refrigeration cycle apparatus) can be improved.

1. An air-sending device of an outdoor unit comprising:

a propeller fan that rotates about a rotation axis extending in a direction of gravity and includes a plurality of blades that produce a flow of gas in a direction opposite to the direction of gravity; and

a bellmouth rectifying the gas, the bellmouth having an annular wall extending in a direction of rotation of the blades of the propeller fan on an outer side with respect to outer peripheral edges of the blades,

wherein, the bellmouth has a wall forming a sloping surface extending such that an air passage on an outlet side

spreads outward in a case where an operating point of the propeller fan is on an open side with respect to a surging zone, and

the bellmouth has a shape satisfying conditions represented as a relationship of $H/D \geq 0.04$ between a length H of the sloping surface in a direction of the rotation axis from an end on an inlet side to an end on the outlet side and a fan diameter D of the propeller fan,

a relationship of $0 < \theta \leq 60^\circ$ for an angle θ formed between a line connecting the ends of the sloping surface and the rotation axis, and

a relationship of $L/L_0 \geq 0.5$ between a length L in the direction of the rotation axis from an opening on the inlet side to the end of the sloping surface on the inlet side and a length L_0 of the blades of the propeller fan in the direction of the rotation axis.

2. The air-sending device of the outdoor unit of claim 1, wherein the bellmouth includes a wall extending in the direction of the rotation axis from the end of the sloping surface on the outlet side, the wall being provided at an opening on the outlet side.

3. The air-sending device of the outdoor unit of claim 1, further comprising a fan guard having a grating that covers the opening on the outlet side,

wherein an orientation of the grating in the direction of the rotation axis is parallel to the rotation axis.

4. The air-sending device of the outdoor unit of claim 1, wherein the propeller fan has a rib provided on each of the blades over an entirety of an outer peripheral edge or a part of

the outer peripheral edge excluding two ends thereof and extending substantially parallel to the rotation axis toward the inlet side.

5. The air-sending device of the outdoor unit of claim 1, wherein a part of the opening of the bellmouth on the outlet side is deformed according to an area defined by dimensions of a casing of the outdoor unit.

6. The air-sending device of the outdoor unit of claim 1, wherein the bellmouth has a curved surface provided at the opening on the inlet side and configured such that an integrated value of radii of curvature of the curved surface over an entire circumference becomes largest under conditions for provision or installation.

7. An outdoor unit comprising:

a compressor that compresses a refrigerant;
an outdoor-side heat exchanger that exchanges heat between the refrigerant and air; and
the air-sending device of claim 1 that allows the air to pass through the outdoor-side heat exchanger.

8. A refrigeration cycle apparatus comprising:

a load unit having a plurality of load-side heat exchangers that each exchange heat between a subject of heat exchange and a refrigerant, and flow control means that adjusts a flow rate of the refrigerant made to flow into the load-side heat exchangers; and

the outdoor unit of claim 7,

wherein the load unit and the outdoor unit are connected by pipes to constitute a refrigerant circuit.

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