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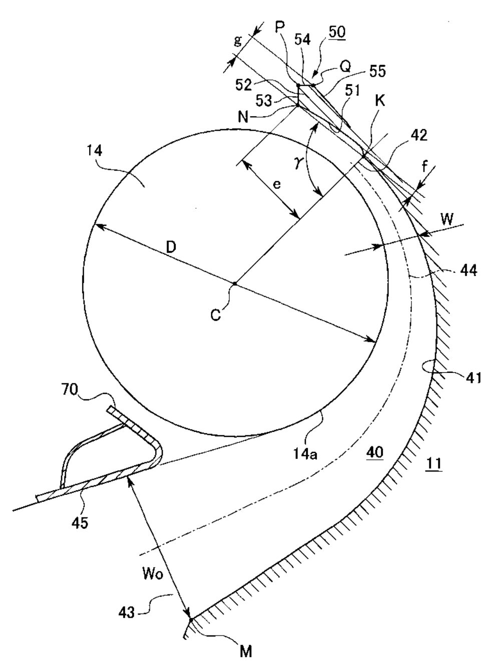
(54) **Indoor unit and air-conditioner**

(57) In an indoor unit, when the fan diameter of a tangential fan (14) is taken to be D, and the width of the intake diaphragm provided on the upstream side of the inlet of an air duct (40) inside the casing is taken to be f, f/D is within the range of 0.002 to 0.003 ($0.002 \leqq f/D \leqq 0.003$). In addition, when the width of the outlet of an air duct (40) formed between the outer peripheral surface (14a) of a tangential fan (14) and the air duct wall surface (41) of the casing is taken to be Wo, Wo/D is 0.55 or less ($Wo/D \leqq 0.55$). In addition, when a line extending in the direction of flow along the upper surface that forms the discharge port serving as the air duct outlet in the casing is taken to be a, the stabilizer tongue end angle α, which is formed between the surface of the stabilizer opposing tangential fan (14) and the extended line a, is within the range of 50 degrees to 60 degrees (50 degrees $\leqq\alpha\leqq$60 degrees). In addition, when the distance between the extended line a and a tangent b of the fan diameter D parallel to said extended line a is taken to be d, d/D is within the range of -0.2 to 0.2 ($-0.2 \leqq d/D \leqq 0.2$).

FIG. 2



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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to an indoor unit and an air-conditioner that provides a comfortable indoor environment by heating or cooling, and more particularly, to a technology that is suitable for use in an indoor unit and air-conditioner that is capable of reducing the operating noise generated in the air blowing system of an indoor unit that uses a tangential fan.

DESCRIPTION OF THE RELATED ART

[0002] Air-conditioners are composed of two large constituent elements in the form of an indoor unit and outdoor unit. Each of these units is equipped with an indoor heat exchanger and outdoor heat exchanger that perform heat exchange between a refrigerant and the indoor air and between refrigerant and the outside air.

[0003] These indoor and outdoor heat exchangers are elements that compose a refrigerant circuit in addition to elements such as a compressor and expansion valve. As a result of refrigerant physically circulating through the circuit, indoor cooling and heating are realized by following a circulation process of thermal changes in state consisting of high-temperature, high-pressure gas, low-temperature, low-pressure gas, high-temperature, high-pressure liquid and low-temperature, low-pressure liquid. Furthermore, this indoor cooling and heating is realized directly by heat exchange between refrigerant within the indoor heat exchanger and indoor air.

[0004] Incidentally, during heating operation, gaseous refrigerant transformed into a high-temperature, high-pressure gas with a compressor is sent to an indoor heat exchanger, and as a result of heat exchange between this refrigerant and indoor air, the refrigerant condenses, realizing a transformation to a high-temperature, high-pressure liquid refrigerant. In addition, during cooling operation, a high-temperature, high-pressure gaseous refrigerant is sent to an outdoor heat exchanger, where a high-temperature, high-pressure liquid refrigerant is formed as a result of heat exchange with the outside air. Subsequently, as a result of the high-temperature, high-pressure liquid refrigerant passing through an expansion valve, its pressure decreases resulting in the formation of a low-temperature, low-pressure liquid refrigerant, which is then sent to an indoor heat exchanger where heat exchange occurs between this refrigerant and the indoor air, causing the refrigerant to evaporate and realizing the formation of a low-temperature, low-pressure gas.

[0005] However, in the case of the above-mentioned air-conditioner, the shape of the casing of the indoor unit has conventionally been determined empirically. Among such air-conditioners, for example, among those widely popular for home use, a tangential fan (cross flow fan) has conventionally been employed as a typical fan provided in the indoor unit.

[0006] In this case, after air in a room (indoor air) that has been taken in by the tangential fan (to be simply referred to as the "fan") has been air-conditioned by passing through an indoor heat exchanger, it is blown into the room after passing through an air duct formed between the outer peripheral surface of the fan and the air duct wall surface of the casing. In this type of indoor unit, it is desirable to further improve the product performance of the air-conditioner by making additional improvements in terms of aerodynamic performance in the form of air quantity and noise level with respect to the fan air blowing system inside the casing, including the shape of the air duct and the shape of the stabilizer provided on the upstream side of the fan.

[0007] On the basis of this background, it is necessary to find basic rules for optimizing the shape of the air duct, shape of the stabilizer, the forms of inflow and discharge of air in the fan air blowing system, and so forth. Furthermore, it is desirable to be able to easily realize lower noise levels and higher efficiency of the air blowing system and casing shape by employing a design that complies with these rules.

BRIEF SUMMARY OF THE INVENTION

[0008] In view of the above problems, an object of the present invention is to provide indices that facilitate design for improving aerodynamic performance by optimizing the shape of the air blowing system formed in the indoor unit of an air-conditioner, and particularly the shape of the air inflow back wall provided above the inlet of the air duct, and forms of the inflow and discharge of air in the fan air blowing system and the shape of the stabilizer.

[0009] The present invention provides an indoor unit comprising a tangential fan that suctions in indoor air from an intake port and blows out that air from a blower outlet, an indoor heat exchanger that performs heat exchange between the above indoor air and refrigerant supplied from an outdoor unit, an indoor unit controller composed of various electrical circuit elements, and a casing that houses each of these devices, and provides the following constitution for solving the above problems.

[0010] A first aspect of the present invention is characterized by f/D being within the range of 0.002 to 0.003 ($0.002 \leqq f/D \leqq 0.003$) when the fan diameter of the above tangential fan is taken to be D, and the width of the intake diaphragm provided on the upstream side of the air duct inlet inside the above casing is taken to be f.

[0011] According to this type of indoor unit, by designing such that f/D is $0.002 \leqq f/D \leqq 0.003$, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0012] A second aspect of the present invention is characterized by g/D being 0.06 or more ($0.06 \leqq g/D$) when the fan diameter of the above tangential fan is taken to be D, and the width of the inverted portion of incoming air flow provided on the upstream side of the air duct inlet inside the above casing is taken to be g.

[0013] According to this type of indoor unit, by designing such that g/D is $0.06 \leqq g/D$, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0014] A third aspect of the present invention is characterized by e/D being within the range of 0.25 to 0.3 ($0.25 \leqq e/D \leqq 0.3$), and γ being within the range of 80 degrees to 90 degrees (80 degrees$\leqq \gamma \leqq$90 degrees) when the fan diameter of the above tangential fan is taken to be D, the length of the auxiliary intake path provided on the upstream side of the air duct inlet inside the above casing is taken to be e, and the intake diaphragm angle is taken to be γ.

[0015] According to this type of indoor unit, by designing such that e/D is $0.25 \leqq e/D \leqq 0.3$ and γ is 80 degrees$\leqq \gamma \leqq$90 degrees, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0016] In addition, the above first through third aspects may be designed in combination in a single indoor unit.

[0017] According to this type of indoor unit, an even greater reduction in the noise level of the fan air blowing system can be achieved for the same air quantity due to mutual synergistic effects.

[0018] In addition, in the second aspect, a concave portion may be formed in the surface that forms width g of the above inverted portion.

[0019] According to this type of indoor unit, even if the value of the width g of the inverted portion is increased (increased in thickness) so as to be advantageous for lowering noise levels, the generation of strain caused by thermal stress during forming can be prevented.

[0020] A fourth aspect of the present invention is characterized by designing such that Wo/D is 0.55 or less ($Wo/D \leqq 0.55$) when the fan diameter D of the above tangential fan is taken to be D, and the width of the outlet of the air duct formed between the outer peripheral surface of the above tangential fan and the air duct wall surface of the above casing is taken to be Wo.

[0021] According to this type of indoor unit, by designing such that the ratio of outlet width Wo to fan diameter D is $Wo/D \leqq 0.55$, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0022] A fifth aspect of the present invention is characterized by being designed such that the upstream opening angle $\theta 2$, which becomes the negative pressure region on the air upstream side of the above tangential fan, is 180 degrees or more ($\theta 2 \geqq 180$ degrees).

[0023] According to this type of indoor unit, by designing so that the upstream opening angle $\theta 2$, which becomes the negative pressure region on the air upstream side of the tangential fan, is $\theta 2 \geqq 180$ degrees, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0024] In addition, the above fourth and fifth aspects may be designed in combination in a single indoor unit.

[0025] According to this type of indoor unit, an even greater reduction in the noise level of the fan air blowing unit can be achieved for the same air quantity due to mutual synergistic effects.

[0026] A sixth aspect of the present invention is characterized by the stabilizer tongue end angle α, which is formed between the surface of the stabilizer opposing the above tangential fan and an extended line a, being within the range of 50 degrees to 60 degrees (50 degrees$\leqq \alpha \leqq$60 degrees) when the fan diameter of the above tangential fan is taken to be D, and a line extending in the direction of flow along the upper surface that forms the discharge port serving as the air duct outlet in the above casing is taken to be a.

[0027] According to this type of indoor unit, by designing such that the stabilizer tongue end angle a is 50 degrees$\leqq \alpha \leqq$60 degrees, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0028] A seventh aspect of the present invention is characterized by being designed so that the ratio of stabilizer actual height h to fan diameter D is 25% or less ($h/D \leqq 25\%$) when the fan diameter of the above tangential fan is taken to be D, and the actual height of the stabilizer provided on the upstream side of the above tangential fan is taken to be h.

[0029] According to this type of indoor unit, by designing such that the ratio of actual height h of the stabilizer to fan diameter D is $h/D \leqq 25\%$, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0030] An eighth aspect of the present invention is characterized by providing a guide in the indoor air inflow portion of the stabilizer provided on the upstream side of the above tangential fan that leads the flow of the above indoor air in the direction of roughly the center of the above tangential fan.

[0031] According to this type of indoor unit, by providing a guide in the indoor air inflow portion of the stabilizer that leads the flow of indoor air in the direction of roughly the center of the tangential fan, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0032] In addition, the above sixth through eighth aspects may also be designed in combination in a single indoor unit.

[0033] According to this type of indoor unit, an even greater reduction in the noise level of the fan air blowing system can be achieved for the same air quantity due to mutual synergistic effects.

[0034] A ninth aspect of the present invention is characterized by d/D being within the range of -0.2 to 0.2 (-

0.2≦d/D≦0.2) when the fan diameter of the above tangential fan is taken to be D, and the distance between extended line a in the direction of flow along the upper surface that forms the discharge port serving as the air duct outlet inside the above casing, and the tangent b of the above fan diameter D parallel to said extended line a, is taken to be d.

[0035] In this case, extended line a and tangent b most preferably coincide with the same straight line (d/D = 0).

[0036] According to this type of indoor unit, as a result of designing such that fan diameter D and distance d between extended line a and tangent b are such that -0.2≦d/D ≦0.2, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0037] A tenth aspect of the present invention is characterized by the angle θ1 opening towards the downstream side formed by the line that passes through fan center C perpendicular to the above tangent b, and the line that passes through origin K of the casing coil and fan center C, being within the range of 115 degrees to 125 degrees (115 degrees≦θ1≦125 degrees) when the fan diameter of the above tangential fan is taken to be D, and the tangent of the above fan diameter D that is parallel to or coincides with extended line a in the direction of flow along the upper surface that forms the discharge port serving as the air duct outlet inside the above casing is taken to be b.

[0038] According to this type of indoor unit, by designing such that angle θ1 opening towards the downstream side is 115 degrees≦θ1≦125 degrees, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0039] An eleventh aspect of the present invention is characterized by air duct width W formed between the outer peripheral surface of the above tangential fan and the air duct wall surface of the above casing having an enlarged linear portion, which increases from the origin to outlet width Wo in proportion to the extended length of the casing air duct center line, and a curved portion on the inlet side that gradually increases from inlet width Wi serving as the above origin and leads to the above enlarged linear portion, and said air duct width W changing.

[0040] According to this type of indoor unit, by designing such that air duct width W has an enlarged linear portion on the outlet side that increases from the origin to outlet width Wo in proportion to the extended length of the casing air duct center line, and a curved portion on the inlet side that gradually increases from inlet width Wi serving as the above origin and leads to the above enlarged linear portion, and allowing said air duct width W to change, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0041] A twelfth aspect of the present invention is characterized by air duct width W formed between the outer peripheral surface of the above tangential fan and the air duct wall surface of the above casing being such that inlet width Wi serving as the origin is within the range of 0.7% to 0.8% of fan diameter D (0.7%≦Wi/D≦0.8%) when the fan diameter of the above tangential fan is taken to be D.

[0042] According to this type of indoor unit, by designing such that the ratio of inlet width Wi to fan diameter D is 0.7%≦Wi/D≦0.8%, a reduction in the noise level of the fan air blowing system can be achieved for the same air quantity.

[0043] In addition, the above ninth through twelfth aspects may be designed in combination in a single indoor unit.

[0044] According to this type of indoor unit, an even greater reduction in the noise level of the fan air blowing system can be achieved due to mutual synergistic effects.

[0045] In addition, the present invention provides an air-conditioner comprising an outdoor heat exchanger, a compressor that feeds a high-temperature, high-pressure gaseous refrigerant to the heat exchanger, an outdoor unit provided with an outdoor unit controller comprised of various electrical circuit elements, and the above indoor unit.

[0046] According to this type of air-conditioner, as a result of comprising an indoor unit capable of easily achieving a reduction in the noise level for the same air quantity, an air-conditioner can be provided having superior aerodynamic performance and a high degree of product appeal.

[0047] The indoor unit and air-conditioner of the present invention described above demonstrate the remarkable effect of improving product appeal by being able to significantly and easily reduce the operating noise of the fan air blowing system in the indoor unit to a greater extent than the prior art, thereby lowering the noise levels of the indoor unit and an air-conditioner that has said indoor unit as a constituent feature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048]

Fig. 1 is a partial, cross-sectional perspective view showing one embodiment of the indoor unit and air-conditioner as claimed in the present invention.

Fig. 2 is a cross-sectional view taken along arrows A-A of Fig. 1 showing one embodiment of the tangential fan and its air blowing system of the indoor unit as claimed in the present invention.

Fig. 3 is a graph showing the results of measuring noise level based on the same air quantity for the ratio of intake diaphragm width (f) to fan diameter (D) in a first embodiment of the present invention.

Fig. 4 is a graph showing the results of measuring noise level based on the same air quantity for the ratio of inverted portion width (g) to fan diameter (D) in a second embodiment of the present invention.

Fig. 5 is a graph showing the results of measuring noise level based on the same air quantity for the ratio of the length of auxiliary intake path (e) to fan diameter (D) in a third embodiment of the present invention.

Fig. 6 is a graph showing the results of measuring noise level based on the same air quantity for intake diaphragm angle (γ) in a third embodiment of the present invention.

Fig. 7 is an essential portion cross-sectional view showing a variation of the shape of the inverted portion in the present invention.

Fig. 8 is a cross-sectional view taken along arrows A-A of Fig. 1 showing a fourth embodiment of the tangential fan and its air blowing system of the indoor unit as claimed in the present invention.

Fig. 9 is a graph showing the results of measuring noise level based on the same air quantity for the ratio of outlet width (Wo) to fan diameter (D) in a fourth embodiment of the present invention.

Fig. 10 is a graph showing the results of measuring noise level based on the same air quantity for upstream opening angle (θ2) in a fifth embodiment of the present invention.

Fig. 11A is a drawing as viewed from the fan side of a corrugated stabilizer showing one example of the shape of the end portion of the stabilizer.

Fig. 11B is a drawing as viewed from the fan side of a linear stabilizer showing one example of the shape of the end portion of the stabilizer.

Fig. 12 is a cross-sectional view taken along arrows A-A of Fig. 1 showing a sixth embodiment of the tangential fan and its air blowing system of the indoor unit as claimed in the present invention.

Fig. 13 is a graph showing the results of measuring noise level based on the same air quantity for the stabilizer tongue end angle (α) in a sixth embodiment of the present invention.

Fig. 14 is a graph showing the results of measuring noise level based on the same air quantity for the ratio of stabilizer actual height (h) to fan diameter (D) in a seventh embodiment of the present invention.

Fig. 15A is a drawing as viewed from the fan side of a corrugated stabilizer showing one example of the shape of the end portion of the stabilizer.

Fig. 15B is a drawing as viewed from the fan side of a linear stabilizer showing one example of the shape of the end portion of the stabilizer.

Fig. 16 is a graph showing the results of comparing noise level based on the same air quantity as measured in the presence and absence of a guide in an eighth embodiment of the present invention.

Fig. 17 is a cross-sectional view taken along arrows A-A showing a ninth embodiment of the tangential fan and its air blowing system in the indoor unit as claimed in the present invention.

Fig. 18 is a drawing for explaining the action as claimed in a ninth embodiment of the present invention, and is a graph showing the results of measuring noise level based on the same air quantity for the ratio of the distance (d) between extended line (a) and tangent (b) to fan diameter (D).

Fig. 19 is a graph showing the results of measuring noise level based on the same air quantity for downstream side opening angle (θ1) in a tenth embodiment of the present invention.

Fig. 20 is a drawing showing changes (three kinds) in air duct width W relative to the extended length L of the casing air duct center line in an eleventh embodiment of the present invention.

Fig. 21 is a graph showing the results of measuring noise level based on the same air quantity for the changes in air duct width shown in Fig. 20.

Fig. 22 is a drawing for explaining the shape of air duct width W defined in the eleventh embodiment, and shows the relationship between extended length (L) of the casing air duct center line and air duct width W.

Fig. 23 is a drawing for explaining the action as claimed in a twelfth embodiment of the present invention, and is a graph showing the results of measuring noise level based on the same air quantity for inlet width (Wi) of the air duct.

DETAILED DESCRIPTION OF THE INVENTION

[0049] The following provides an explanation of the aspects for carrying out the indoor unit and air-conditioner according to the present invention with reference to the drawings.

[0050] Fig. 1 is an explanatory drawing showing the overall constitution of the air-conditioner. The air-conditioner is composed of indoor unit 10 and outdoor unit 20. This indoor unit 10 and outdoor unit 20 are connected by refrigerant lines 21, through which refrigerant passes, and electrical wiring and so forth not shown. There are two refrigerant lines 21 provided, and refrigerant flows from indoor unit 10 to outdoor unit 20 through one of the lines, and from outdoor unit 20 to indoor unit 10 through the other.

[0051] Indoor unit 10 is integrally composed of base 11 serving as a casing and front panel 12. Base 11 is equipped with various equipment including a plate fin tube type of indoor heat exchanger 13 and a roughly cylindrical tangential fan (to be simply referred to as a "fan") 14. Base 11 is also equipped with indoor unit controller 15 composed of various electrical circuit elements and so forth for performing various operational controls relating to indoor unit 10. Indoor unit controller 15 is equipped with a suitable indicator 15a for displaying the operating status and error modes. This indicator 15a can be confirmed visually from the outside through window 12a provided on front panel 12. Furthermore, installation plate 16 is provided on the back of base 11, and this enables indoor unit 10 to be installed on the wall and so forth of a room.

[0052] Intake grilles (intake ports) 12b are respectively formed in the front and top surfaces of front panel 12. Air inside a room (indoor air) is suctioned into indoor unit 10 from multiple directions by these intake grilles 12b. Incidentally, air filters 17 are equipped behind intake grilles 12b, and act to remove dust in the air and so forth that is suctioned in. In addition, blower outlet 12c is formed below front panel 12, and is designed so that warmed air or cooled air (namely, air-conditioned air) is blown out therefrom. Furthermore, this suctioning of air and blowing of air is performed due to the operation of fan 14.

[0053] The above-mentioned indoor unit 10 is equipped with a remote controller serving as a controller that performs control of various operations. Various switches, a liquid crystal display and so forth are provided on this remote controller 30, and various operation control signals, temperature settings and so forth of the air-conditioner can be transmitted in the form of, for example, infrared signals, towards the receiving unit (not shown) of indoor unit controller 15. Furthermore, partial operational control of the air-conditioner can also be performed by switches not shown provided at appropriate locations on the indoor unit.

[0054] Outdoor unit 20 is equipped with outdoor heat exchanger 20b, propeller fan 20c, compressor 20f and outdoor unit controller 20g in housing 20a. Outdoor heat exchanger 20b is composed of a refrigeration line equipped with a large number of blade-shaped fins around its periphery, and is for realizing heat exchange between the refrigerant and outside air. Propeller fan 20c continuously brings in fresh air to housing 20a by generating an air flow that escapes from the back to the front inside housing 20a, and is provided to improve the heat exchange efficiency in outdoor heat exchanger 20b.

[0055] Furthermore, fin guard 20d and fin guard 20e are respectively provided on the sides of housing 20a on which the above outdoor heat exchanger 20b and propeller fan 20c are facing the outside. Fan guard 20d is provided so as to prevent the above blade-shaped fins from being damaged by unexpected impacts from the outside. Fin guard 20e is also similarly provided for the purpose of protecting propeller fan 20c from external impacts.

[0056] Compressor 20f discharges low-temperature, low-pressure gaseous refrigerant by converting to a high-temperature, high-pressure gaseous refrigerant, and plays the most important role among the components that compose the refrigerant circuit. Incidentally, the refrigerant circuit refers to that which is roughly composed of this compressor 20f as well as the above-mentioned indoor heat exchanger 13, outdoor heat exchanger 20b, refrigerant lines 21, an expansion valve, a four-way valve that determines the direction of refrigerant flow (both the expansion valve and four-way valve are not shown) and so forth, and allows refrigerant to circulate between indoor unit 10 and outdoor unit 20.

[0057] Outdoor unit controller 20g performs operational control relating to the above-mentioned propeller fan 20c, compressor 20f and various other equipment provided in outdoor unit 20, and is composed of various electrical circuit elements.

[0058] In addition to that indicated above, outdoor unit 20 is also equipped with a base plate 20h to avoid the effects of external vibrations and so forth while also supporting housing 20a. In addition, a removable panel 20i for performing maintenance and so forth on the above compressor 20f is provided in the wall of case 20 near the above compressor 20f.

[0059] The following provides an explanation of the action of the air-conditioner composed of these components, dividing into an explanation of that during heating operation and that during cooling operation.

[0060] To begin with, during heating operation, refrigerant that has been transformed into a high-temperature, high-pressure gas in compressor 20f is sent through refrigerant line 21 to indoor heat exchanger 13 of indoor unit 10. Inside indoor unit 10, heat from the high-temperature, high-pressure gaseous refrigerant that passes through indoor heat exchanger 13 is imparted to indoor air taken in from intake grilles 12 by fan 14. As a result, warm air is blown out from blower outlet 12c below front panel 12. At the same time, high-temperature, high-pressure gaseous refrigerant condenses and liquefies in the above indoor heat exchanger 13 and becomes a high-temperature, high-pressure liquid refrigerant.

[0061] This high-temperature, high-pressure liquid refrigerant is sent again through refrigerant line 21 to outdoor heat exchanger 20b in outdoor unit 20. In outdoor unit 20, it passes through an expansion valve not shown where its pressure is reduced and it becomes a low-temperature, low-pressure liquid refrigerant. This low-temperature, low-pressure liquid refrigerant that passes through outdoor heat exchanger 20b then takes the heat from fresh outside air that has been taken into housing 20a by propeller fan 20c. This low-temperature, low-pressure liquid refrigerant evaporates to a gas as a result of this, becoming a low-temperature, low-pressure gaseous refrigerant. This is then again sent to compressor 20f where the above process is repeated.

[0062] Next, during cooling operation, the refrigerant flows through the refrigerant circuit in the opposite direction from that described above. Namely, after being transformed into a high-temperature, high-pressure gas in compressor 20f, the refrigerant is sent to outdoor heat exchanger 20b through refrigerant line 21 where it imparts heat to the outside air and condenses and liquefies to become a high-temperature, high-pressure liquid refrigerant. This high-temperature, high-pressure liquid refrigerant passes through an expansion valve not shown and becomes a low-temperature, low-pressure liquid refrigerant, after which it is sent to indoor heat exchanger 13 again through refrigerant line 21. The low-temperature, low-pressure liquid refrigerant takes the heat from the indoor air and together with cooling said indoor air, the refrigerant itself evaporates and vaporizes resulting in the formation of a low-temperature, low-pressure gaseous refrigerant. This is again sent out to compressor 20f where the above process is then repeated.

[0063] These operations are controlled by indoor unit controller 15 housed in indoor unit 10 and by outdoor unit controller 20g housed in outdoor unit 20.

[0064] The following provides an explanation of the characteristic portion of the present invention with reference to Fig. 2. Furthermore, Fig. 2 used in this explanation is a cross-section taken along arrows A-A of Fig. 1 that shows fan 14 and its air blowing system.

[0065] A fan air blowing system is provided inside the above-mentioned indoor unit 10 for suctioning in indoor air through intake grilles 12b by operating fan 14, passing that air through indoor heat exchanger 13, and blowing out the air-conditioned air that has undergone heat exchange from blower outlet 12c. Air duct 40 that guides air-conditioned air to blower outlet 12c is provided in this fan air blowing system.

[0066] Air duct 40 is a space formed between outer peripheral surface 14a of cylindrical fan 14 and air duct wall surface 41 provided in base 11 serving as a constituent member of the casing.

[0067] Inlet 42 of air duct 40 is on a line that connects fan center C that serves as the axial center during rotation of fan 14 and point K on air duct wall surface 41, and the width of this inlet is represented with Wi. Point K serves as the origin of the casing coil (concave curved surface in the direction of flow of air duct wall surface 41), and when viewed from the side of front panel 12 of indoor unit 10, is roughly positioned behind the upper portion of fan 14 (wall side).

[0068] Air duct 40 is formed to outlet 43 in the direction of rotation of fan 14 (clockwise direction in the example shown in the drawing) with inlet 42 serving as the origin. The width of air duct 40, namely air duct width W, gradually increases from inlet width Wi of inlet 42 to outlet width Wo of outlet 43. Outlet width Wo is the distance covered by a line perpendicular to air duct center line 44 extending from end point M of the casing coil on casing wall surface 41 to outlet upper surface 45.

[0069] Front panel 12 is arranged to the front of the direction of flow of outlet 43 (front side of indoor unit 10), and blower outlet 12c of said panel 12 is open facing into the room. In addition, in a typical configuration, louvers (not shown) are arranged near outlet 43 that adjust the blowing direction to the left and right, and flaps (not shown) are arranged in blower outlet 12c that adjust the blowing direction upward and downward.

[0070] Furthermore, as shown in Fig. 2, fan 14 is also provided with stabilizer 70, and air inflow back wall 50 located in the upper portion of air duct 40.

[0071] Air inflow back wall 50 is a portion that is located above inlet 42 of air duct 40 and provided in continuation from air duct wall surface 41, and inverted portion 52 is provided on the end (upper end) of auxiliary intake path 51. Auxiliary intake path 51 is a wall surface that forms a concave portion continuing from origin K of air duct wall surface 41 to wall surface starting point N, and the depth of the concave portion serving as auxiliary intake path 51 (depth from the line connecting origin K and wall surface starting point N to the deepest part of the concave portion) is hereinafter to be referred to as intake diaphragm width f.

[0072] On the other hand, inverted portion 52 is a portion that is arranged behind air duct wall surface 41 and air inflow back wall 50 that inverts the flow of air-conditioned air so as to guide air-conditioned air that has passed through indoor heat exchanger 13 to air duct 40, and its end shape is composed by providing a first flat portion 53, which forms a roughly vertical surface extending upward from wall surface starting point N to peak P, and a second flat portion 54, which forms a roughly horizontal surface extending backward (back side) from peak P to inverted portion starting point Q. Furthermore, back portion 55 is provided on the back side of auxiliary intake path 51 that forms an inclined surface facing downward on an angle from inverted portion starting point Q.

[0073] The width of the above-mentioned inverted portion 52, namely distance NQ from wall surface starting point N to inverted portion starting point Q is to hereinafter be referred to as inverted portion width (inverted thickness) g, distance KN from origin K to wall surface starting point N is to hereinafter be referred to as auxiliary intake path length e, and the angle from the line connecting fan center C and origin K to line KN that defines auxiliary intake path length e is hereinafter to be referred to as intake diaphragm angle γ.

[0074] In the fan air blowing system described above, intake diaphragm width f of the shape of air inflow back wall 50 is defined in the manner explained below in a first embodiment.

[0075] Intake diaphragm width f is a value indicating the concave depth of the concave wall surface provided in continuation facing upward from inlet 42 (origin K) of air duct wall surface 41 that forms air duct 40, namely auxiliary intake path 51, and indicates the vertical distance from line KN to the deepest part. Here, if the fan diameter of fan 14 is taken to be D, then intake diaphragm width f provided on the upstream side of the air duct inlet inside the casing is set so that the ratio to fan diameter D (f/D) is within the range of 0.002 to 0.003 ($0.002 \leqq f/D \leqq 0.003$).

[0076] Fig. 3 shows the results of respectively measuring noise level based on the same air quantity by suitably changing the above-mentioned f/D.

[0077] On the basis of these measurement results, the noise level was the lowest when f/D was roughly 0.025, and when intake diaphragm width f was increased or decreased from the value corresponding to this minimum noise level, the noise level was found to increase in both cases. Therefore, the range over which ΔdB increases 1 dB (A) from f/D at which the noise level is the lowest based on the same air quantity was determined to be the proper design range of intake diaphragm width f, and according to the results shown in Fig. 3, the range of f/D was defined as $0.002 \leqq f/D \leqq 0.003$.

[0078] Furthermore, the reason for assuming ΔdB = 1 dB (A) is based on the reason that the value of 1 dB (A) is the level at which the effect of noise reduction can be clearly recognized in consideration of measurement error, variation and so forth.

[0079] Next, inverted portion width g of the shape of air inflow back wall 50 in the above-mentioned fan air blowing system is defined as explained below.

[0080] Inverted portion width (inverted thickness) g is the distance NQ from wall surface starting point N to inverted portion starting point Q that indicates the width of inverted portion 52. Here, if the fan diameter of fan 14 is taken to be D, inverted portion width g of intake air flow provided on the upstream side of the air duct inlet inside the casing is set so that the ratio to fan diameter D (g/D) is $0.06 \leqq g/D$.

[0081] Fig. 4 shows the results of respectively measuring noise levels based on the same air quantity by suitably changing the above-mentioned g/D.

[0082] On the basis of these measurement results, it was found that the noise level was the lowest in the case g/D was 0.06, the noise level increased when g/D was smaller than 0.06, and there was hardly any change in the noise level, namely the noise level remained roughly constant, even if g/D was increased beyond 0.06. Therefore, a value of g/D = 0.06, at which the noise level for the same air quantity hardly decreases further, was determined to be the borderline value of inverted portion width g, and according to the results of Fig. 4, the proper design range was defined as $0.06 \leqq g/D$.

[0083] However, although it is preferable with respect to inverted portion width g to make the ratio to fan diameter D as described above greater than or equal to 0.06, increasing g/D means that the inverted portion width g becomes thicker. However, if the wall thickness of inverted portion 52, which is a plastic molded part integrally formed with base 11, becomes thicker, there is greater susceptibility to strain caused by thermal deformation as a result of being greatly subjected to the effects of thermal contraction during molding. Consequently, the upper limit of inverted portion width g is subject to restriction due to problems in terms of production engineering in the form of the occurrence of thermal deformation.

[0084] Therefore, a shape is desired for inverted portion 52 that ensures an inverted portion width g capable of reducing noise levels while also increasing resistance to the occurrence of thermal deformation during molding.

[0085] Fig. 7 shows a variation of inverted portion 52 in which concave portion 56 having a rectangular cross-section is provided on first flat portion 53. In the case of this variation, the formation of thick walled portion in inverted portion 52 can be prevented while maintaining inverted portion width g. Thus, since the occurrence of strain caused by thermal deformation due to plastic molding can be prevented, restrictions in terms of production engineering can be minimized, thereby making it possible to increase the degree of freedom of inverted portion width g. Furthermore, in the example shown in the drawing, although concave portion 56 has a rectangular cross-section, the shape of concave portion 56 is not limited to this, but rather other variations are also effective, including the forming of surface 56a into a concave curved surface.

[0086] Next, auxiliary intake path length e and intake diaphragm angle γ of air inflow back wall 50 are defined in the manner explained below in a third embodiment in the fan air blowing system described above.

[0087] Auxiliary intake path length e is the distance KN from origin K to wall surface starting point N, while intake diaphragm angle γ is the angle from line CK that connects fan center C and origin K to line KN that defines auxiliary intake path length e. Here, if the fan diameter of fan 14 is taken to be D, then the ratio of auxiliary intake path length e provided on the upstream side of the air duct inlet inside the casing to fan diameter D (e/D) is set so as to be within the range of $0.25 \leqq e/D \leqq 0.3$. Moreover, intake diaphragm angle γ is set so as to be within the range of 80 degrees $\leqq \gamma \leqq$ 90 degrees.

[0088] Fig. 5 shows the results of respectively measuring noise levels for the same air quantity by suitably changing the above-mentioned angle γ.

[0089] Based on these measurement results, the noise level is the lowest when e/D is roughly 0.275, and when auxiliary intake path length e is increased or decreased from the value corresponding to this minimum noise level, the noise level was determined to increase in both cases. Therefore, similar to the intake diaphragm width f described above, the range over which ΔdB increases 1 dB (A) from e/D for which the noise level is the lowest based on the same air quantity was judged to be the proper design range of intake diaphragm width f, and according to the results shown in Fig. 5, the range of e/D was defined as $0.25 \leqq e/D \leqq 0.3$.

[0090] Fig. 6 shows the results of respectively measuring noise levels based on the same air quantity by suitably changing the above-mentioned γ.

[0091] According to these measurement results, the case of setting intake diaphragm angle γ to roughly 85 degrees resulted in the lowest noise levels, and noise levels were determined to demonstrate an increasing trend when the angle γ was increased or decreased from this value. Therefore, in the same manner as the above-mentioned intake diaphragm width f, the range over which ΔdB increases 1 dB (A) from the intake diaphragm angle γ at which noise level was the lowest for the same air quantity was judged to be the proper design range for intake diaphragm angle γ, and according to the results shown in Fig. 6, the range of γ is defined to be 80 degrees≦γ≦90 degrees.

[0092] In this manner, if the shape of air inflow back wall 50 in the fan air blowing system is designed using as indices the stipulations explained in the above-mentioned first through third embodiments, aerodynamic performance in terms of air quantity and noise level can be easily improved. In addition, since the values stipulated in each embodiment are determined so as to be contained within the range over which the noise level based on the same air quantity is 1 dB (A) higher than the minimum noise level, the shape of an air duct having a low noise level can be easily set by using a shape for the air duct that is within the above defined values.

[0093] In addition, although each of the above embodiments allows the obtaining of the action and effect of improving aerodynamic performance even if each is used alone, if each embodiment is suitably used in combination, namely by using a suitable combination of at least two of the above embodiments, reduction in noise levels of air inflow back wall 50 and the fan air blowing system for the same air quantity can be further promoted due to mutual synergistic effects.

[0094] Namely, indoor unit 10, which is equipped with air inflow back wall 50 having a shape designed using the above-mentioned stipulations, has superior aerodynamic performance with respect to low noise levels of the fan air blowing system and so forth, and is able to improve the product appeal of an air-conditioner having this for its constituent element.

[0095] Next, outlet width Wo of air duct 40 of the fan air blowing system equipped with air duct 40 described above is defined as explained below in a fourth embodiment. Furthermore, outlet width Wo relates to the discharge form of air-conditioned air flowing out of the fan air blowing system.

[0096] Here, when the fan diameter of fan 14 is taken to be D, and the extended line in the direction of flow along outlet upper surface 45 that forms a discharge port in the form of outlet 43 of air duct 40 inside the casing is taken to be a, the ratio of outlet width Wo to fan diameter D is set to be 0.55 or less (Wo/D≦0.55).

[0097] Fig. 9 shows the results of respectively measuring noise levels based on the same air quantity by suitably changing the above Wo/D.

[0098] According to these measurement results, although noise level is constant in the region where Wo/D is less than 0.55, if Wo/D exceeds 0.55, the noise level was found to increase. Therefore, it was determined that there is a borderline at W/o = 0.55 at which noise level for the same air quantity begins to increase, and the proper range of outlet width Wo was defined as Wo/D≦0.55.

[0099] Next, upstream opening angle θ2 of the fan air blowing system equipped with the above air duct 40 is defined in the manner explained below in a fifth embodiment. Furthermore, upstream opening angle θ2 relates to air inflow of air-conditioned air that is introduced into fan 14 in the fan air blowing system.

[0100] Here, upstream opening angle θ2 is defined. This upstream opening angle 02 refers to the angle of the negative pressure region on the air inflow side of fan 14, and this upstream opening angle θ2 is set to be θ2≧180 degrees.

[0101] Furthermore, as a more concrete explanation of upstream opening angle θ, it refers to the angle from the line connecting the peak of effective end height h in stabilizer 70 and fan center C to the line connecting origin K of the casing coil and fan center C.

[0102] However, stabilizer 70 may have a corrugated shape in which there are peaks and valleys in the end portion of stabilizer 70 as shown in Fig. 11A, or it may have a linear shape in which the end portion has a constant or roughly constant height as shown in Fig. 11B. The effective end height h of stabilizer 70 is defined as the effective stabilizer height from extended line a, and thus, in the case of a corrugated shape, is the height from extended line a to valley 70a, and in the case of a linear shape, the height from extended line a to end portion 70c becomes the actual height h. Furthermore, reference symbol 70b in Fig. 11A indicates a peak of the corrugated shape.

[0103] Fig. 10 shows the results of respectively measuring noise levels for the same air quantity by suitably changing the above upstream opening angle θ2.

[0104] According to these measurement results, although noise level decreases at a comparatively high rate (steep slope) until upstream opening angle θ2 increases to 180 degrees, the noise level was found to become constant as upstream opening angle θ2 increased beyond 180 degrees. Therefore, based on the results shown in Fig. 10, setting θ2 to 180 degrees or more was judged to be the proper design range, and was defined as θ2 ≧180 degrees.

[0105] In addition, although the above fourth and fifth embodiments allow the obtaining of the action and effect of improving aerodynamic performance even if each is used alone, if the two embodiments are suitably used in combination, reduction in noise levels of the fan air blowing system for the same air quantity can be further promoted due to mutual synergistic effects.

[0106] Namely, an indoor unit 10 equipped with outlet width Wo and upstream opening angle θ2 having a shape designed using the above stipulations has superior aerodynamic performance with respect to low noise levels of the fan air blowing system and so forth, and is able to improve the product appeal of an air-conditioner having this for its constituent element.

[0107] Next, the shape of stabilizer 70, and particularly stabilizer tongue end angle α, in the above fan air blowing system equipped with air duct 40 is defined in the manner explained below in a sixth embodiment.

[0108] Here, when the fan diameter of fan 14 is taken to be D, and the extended line in the direction of flow along outlet upper surface 45 that forms the discharge port in the form of outlet 43 of air duct 40 inside the casing is taken to be a, the angle α formed by stabilizer surface 71 opposing fan 14 and extended line a is referred to as the stabilizer tongue end angle, and this tongue end angle is set to be within the range of 50 degrees to 60 degrees (50 degrees$\leqq\alpha\leqq$60 degrees).

[0109] Fig. 13 shows the results of respectively measuring noise levels based on the same air quantity by suitably changing the above stabilizer tongue end angle α.

[0110] According to these measurement results, the noise levels were the lowest when stabilizer tongue end angle α was set to the vicinity of 57 degrees, and even if this angle was changed in the decreasing direction or increasing direction from this value, the noise level was found to increase. Therefore, the angle over the range in which ΔdB increases 1 dB (A) from a reference value based on the noise level corresponding to the stabilizer tongue end angle α at which noise level is the lowest based on the same air quantity was judged to be the proper design range of stabilizer tongue end angle α, and according to the results of Fig. 13, the range of stabilizer tongue end angle α was defined as 50 degrees$\leqq\alpha\leqq$60 degrees.

[0111] Furthermore, the reason for assuming ΔdB = 1 dB (A) is based on the reason that the value of 1 dB (A) is the level at which the effect of noise reduction can be clearly recognized in consideration of measurement error, variation and so forth.

[0112] Next, the shape of stabilizer 70, and particularly the actual height h of stabilizer 70, in the above fan air blowing system equipped with air duct 40 is defined in the manner explained below in a seventh embodiment.

[0113] Here, an explanation is provided of actual height h of stabilizer 70. Stabilizer 70 may have a corrugated shape in which there are peaks and valleys in the end of stabilizer 70 as shown in Fig. 15A, or a linear shape in which the end has a constant or roughly constant height as shown in Fig. 15B. The actual height h of stabilizer 70 is defined as the effective stabilizer height from extended line a, and thus, the height from extended line a to valley 71a becomes actual height h in the case of the corrugated shape, while the height from extended line a to end 71c becomes actual height h in the case of the linear shape.

[0114] The above actual height h of stabilizer 70 is set so that h/D is 25% or less (h/D$\leqq$ 25%) in the case the ratio to fan diameter D of fan 14 is represented as a percentage.

[0115] Fig. 14 shows the results of respectively measuring noise levels based on the same air quantity by suitably changing the above actual height h.

[0116] According to these measurement results, noise level is the lowest in the case h is set to lower than roughly 15%, and when h is increased or decreased from the value of h corresponding to this minimum value, noise level was found to increase in both cases. Therefore, the region within the range over which ΔdB increases 1 dB (A) based on this minimum value was judged to be the proper design range, and according to the results shown in Fig. 14, the range of h/D is defined as h/D $\leq$ 25%. On the other hand, the lower limit of the actual height h of stabilizer 70 is determined according to the required water receiving height H that is a value higher (larger) than h corresponding to h/D ≒ 15% at which noise level is the lowest. Furthermore, the required water receiving height H is the value required to prevent outflow of condensed water that has formed in indoor heat exchanger 14.

[0117] Next, the providing of guide 60 on stabilizer 70 in the above fan air blowing system equipped with air duct 40 is explained in an eighth embodiment.

[0118] Guide 60 is provided on the indoor air inflow portion of the stabilizer provided on the upstream side of fan 14 so as to introduce the flow of indoor air in the direction of roughly the center of fan 14. This guide 60 is located on the upstream side of stabilizer 70, namely on the side of front panel 12 from stabilizer 70, and is provided in the axial direction of fan 14 and lengthwise direction of stabilizer 70 so as to form air guiding surface 61 that is continuous with the above actual height h of stabilizer 70.

[0119] As a result of providing this guide 60, since indoor air that has been introduced by operation of fan 14 smoothly flows in the direction of the center of fan 14 along air guiding surface 61, the providing of guide 60 results in lower noise levels as compared with noise levels based on the same air quantity in the manner of the noise level measurement results shown in Fig. 16.

[0120] In this manner, by designing the shape of stabilizer 70 using as indices the stipulations explained in the above sixth and seventh embodiments, or by providing guide 60 explained in the eighth embodiment, aerodynamic performance in terms of air quantity and noise level in the fan air blowing system of indoor unit 10 can be easily improved. In addition, since the values defined in each embodiment are determined so as to be contained with the range over which the noise level based on the same air quantity is 1 dB (A) higher than the minimum noise level value, the use of a stabilizer shape within the above defined values makes it possible to easily set a stabilizer shape that is advantageous for low noise levels.

[0121] In addition, although each of the above embodiments allows the obtaining of the action and effect of improving aerodynamic performance even if each is used alone, if each embodiment is suitably used in combination, namely by using a suitable combination of at least two of the above embodiments, reduction in noise levels of stabilizer 70 and the fan air blowing system for the same air quantity can be further promoted due to mutual synergistic effects.

[0122] Namely, indoor unit 10, which is equipped with stabilizer 70 having a shape designed using the above-mentioned stipulations, has superior aerodynamic performance with respect to low noise levels of the fan air blowing system and so forth, and is able to improve the product appeal of an air-conditioner having this for its constituent element.

[0123] Next, the positional relationship of fan 14 and outlet 43 in the shape of the above air duct 40 are defined in the manner explained below in a ninth embodiment.

[0124] Here, when the fan diameter of fan 14 is taken to be D, the extended line in the direction of flow along outlet upper surface 45 that forms a discharge port in the form of outlet 43 of air duct 40 inside the casing is taken to be a, and the distance between tangent b of fan diameter D parallel to extended line a and extended line a is taken to be d, the ratio of distance d to fan diameter D (d/D) is set to be within the range of -0.2 to 0.2 ($-0.2 \leqq d/D \leqq 0.2$).

[0125] In the example shown in the drawing, b = 0 since tangent b of fan 14 and extended line a coincide. Thus, b/D becomes 0. In addition, in the case of 14' or 14" indicated with imaginary lines in the drawing, the distance between tangents b' or b" and extended line a are -d and d, respectively. Namely, distance d here is negative in the direction of air duct wall surface 41 moving away from center C of fan 14, and positive in the direction approaching center C of fan 14 based on tangent b (d = 0).

[0126] Fig. 18 shows the results of respectively measuring noise levels based on the same air quantity by suitably changing the above d/D.

[0127] According to these measurement results, the case of d/D = 0, namely the case in which tangent b and extended line a coincide, resulted in the lowest noise level, and noise level was found to increase when tangent b was shifted in either the negative or positive direction. Therefore, the range over which ΔdB increases 1 dB (A) from the case of d/D = 0 for which noise level is the lowest based on the same air quantity was judged to be the proper design range of distance d, and according to the results shown in Fig. 18, the range of d/D was defined as $-0.2 \leqq d/D \leqq 0.2$.

[0128] Furthermore, the reason for assuming ΔdB = 1 dB (A) is based on the reason that the value of 1 dB (A) is the level at which the effect of noise reduction can be clearly recognized in consideration of measurement error, variation and so forth.

[0129] Next, downstream downward angle θ1 of the shape of the above air duct 40 is defined in the manner explained below in a tenth embodiment.

[0130] Here, downstream downward angle θ1 is defined. When the fan diameter of fan 14 is taken to be D, the extended line in the direction of flow along outlet upper surface 45 that forms a discharge port in the form of outlet 43 of air duct 40 inside the casing is taken to be a, and the tangent of fan diameter D that is parallel or coincides with extended line a is taken to be b, the angle on the side of air duct wall surface 41 formed by line 81 that is perpendicular to this tangent b and passes through fan center C, and by line 82 that passes through origin K of the casing coil that forms air duct wall surface 41 and fan center C, is downstream opening angle θ1, and this downstream downward angle θ1 is set to be within the range of 115 degrees to 125 degrees (115 degrees$\leqq \theta 1 \leqq$125 degrees).

[0131] Fig. 19 shows the results of respectively measuring noise levels based on the same air quantity by suitably changing the above θ1.

[0132] According to these measurement results, the case of setting downstream opening angle θ1 to 120 degrees resulted in the lowest noise level, and the noise level was determined to increase if this angle θ1 was increased or decreased from 120 degrees. Therefore, similar to distance d described above, the range over which ΔdB increases 1 dB (A) from the case of θ1 = 120 degrees for which the noise level is the lowest based on the same air quantity was judged to be the proper design range of downstream opening angle 1, and according to the results shown in Fig. 19, the range of θ1 was defined as 115 degrees $\leqq \theta 1 \leqq$125 degrees.

[0133] Next, air duct width W that is formed between outer peripheral surface of fan 14 and air duct wall surface 41 of the shape of the above air duct 40 is defined in the manner explained below in an eleventh embodiment.

[0134] Air duct width W gradually increases in the direction of flow corresponding to extended length L of casing air duct center line 44 from inlet 42 to outlet 43, and the following provides a discussion of the optimum shape of this increase in width.

[0135] With this in mind, when considering the change in air duct width W, this change is classified into three kinds as shown in Fig. 20. Namely, the change in air duct width W that increases from inlet 42 to outlet 43 consists of (1) a convex shape in which the change on the inlet side is large, (2) a straight line in which the change increases from the inlet to the outlet at a constant rate, and (3) a concave shape in which the change on the outlet side is large. Measurement of noise level based on the same air quantity for each of these three kinds of air duct shapes yielded the results shown in Fig. 21. Based on these results, it is preferable that the change in air duct width W be of a shape in which it increases linearly having inlet 43 as the origin (W = 0), or in other words, the shape in which it increases from the origin of 0 to outlet 43 in proportion to the extended length L of air duct center line 44.

[0136] However, since inlet 42 is required to have inlet width Wi ($Wi \neq 0$), as shown in Fig. 22, it is necessary that air duct width W have a curved portion that increases gradually and smoothly from the origin of inlet width Wi, preferably increasing in the form of the concave curved line shown in (3) of Fig. 20, and is connected to the above-mentioned straight line portion (proportionally increasing portion). Namely, the optimum shape of air duct width W should be formed so that air duct width W changes having an expanding linear portion 61 on the side of outlet 43, in which it increases from inlet 42 as the origin to outlet width Wo in proportion to extended length L of air duct center line 44, and curved portion 62 on the side of inlet 42 that is connected to expanding linear portion 61, in which it increases gradually from inlet width Wi as the origin.

[0137] Finally, the optimum value of inlet width Wi of the shape of the above air duct 40 is defined in the manner explained below in a twelfth embodiment.

[0138] Here, if the fan diameter of fan 14 is assumed to be D, the ratio of inlet width Wi to fan diameter D (Wi/D) in terms of a percentage is set to be within the range of 0.7% to 0.8% (0.7%≦Wi/D≦0.8%).

[0139] Fig. 23 shows the results of respectively measuring noise levels based on the same air quantity by suitably changing the above Wi/D.

[0140] According to these measurement results, the case of setting Wi/D to about 0.75% results in the lowest noise level, and it was found that noise level tends to increase when this ratio is either increased or decreased. Therefore, similar to distance d previously described, the range over which ΔdB increases 1 dB (A) from inlet width Wi for which the noise level is the lowest based on the same air quantity was judged to be the proper design range of inlet width Wi, and according to the results shown in Fig. 23, the range of Wi/D was defined as 0.7%≦Wi/D≦0.8%.

[0141] In this manner, if the shape of air duct 40 is designed using as indices the stipulations explained in the above ninth to twelfth embodiments, aerodynamic performance in terms of air quantity and noise level can be easily improved. In addition, since the value defined in each embodiment are determined so as to be contained within the range over which the noise level based on the same air quantity is 1 dB (A) higher than the minimum noise level, the shape of an air duct having a low noise level can be easily set by using a shape for the air duct that is within the above defined values.

[0142] In addition, although each of the above embodiments allows the obtaining of the action and effect of improving aerodynamic performance even if each is used alone, if each embodiment is suitably used in combination, namely by using a suitable combination of at least two of the above embodiments, reduction in noise levels of air duct 40 and the fan air blowing system for the same air quantity can be further promoted due to mutual synergistic effects.

[0143] Namely, indoor unit 10, which is equipped with air duct 40 having a shape designed using the above-mentioned stipulations, has superior aerodynamic performance with respect to low noise levels of the fan air blowing system and so forth, and is able to improve the product appeal of an air-conditioner having this for its constituent element.

[0144] Furthermore, the constitution of the present invention is not limited to the above-mentioned embodiments, but rather may be suitably changed within a range that does not deviate from the gist of the present invention.

Claims

1. An indoor unit for an air conditioner, comprising:

a tangential fan for suctioning in indoor air from an intake port and blowing out that air from a blower outlet, said tangential fan having a fan diameter "D";
an indoor heat exchanger that is adapted to perform heat exchange between the indoor air and a refrigerant supplied from an outdoor unit;
an indoor unit controller composed of various electrical circuit elements; and
a casing that houses each of these devices,
said indoor unit being designed such that one or more of the following conditions a) to 1) are met:

a) 0.002 ≤ f/D ≤ 0.003, wherein "f" is the width of an intake diaphragm provided on an upstream side of an air duct inlet inside the casing;
b) 0.06 ≤ g/D, wherein "g" is the width of an inverted portion of incoming air flow provided on an upstream side of an air duct inlet inside the casing;
c) 0.25 ≤ e/D ≤ 0.3 and 80 degrees ≤ γ ≤ 90 degrees, wherein "e" is the length of an auxiliary intake path provided on an upstream side of an air duct inlet inside the casing and "γ" is an intake diaphragm angle;
d) Wo/D ≤ 0.55, wherein "Wo" is the width of an outlet of an air duct formed between an outer peripheral surface of the tangential fan and an air duct wall surface of the casing;
e) Θ2 ≥ 180 degrees, wherein "Θ2" is an upstream opening angle which becomes the negative pressure region on an air upstream side of the tangential tan;
f) 50 degrees ≤ α ≤ 60 degrees, wherein "α" is a stabilizer tongue end angle which is formed between a surface of a stabilizer opposing the tangential fan and a line extending in the direction of flow along an upper surface that forms the discharge port serving as an air duct outlet in the casing;
g) h/D ≤ 25%, wherein "h" is the actual height of a stabilizer provided on an upstream side of the tangential fan;
h) a guide is provided in an indoor air inflow portion of a stabilizer provided on an upstream side of the tangential fan that leads the flow of the indoor air in the direction of roughly the center of the tangential fan;
i) -0.2 ≤ d/D ≤ 0.2, wherein "d" is the distance between an extended line a in the di-

rection of flow along an upper surface that forms a discharge port serving as an air duct outlet inside the casing and a tangent b of the fan diameter "D" parallel to said extended line a;

j) 115 degrees ≤ Θ1 ≤ 125 degrees, wherein "Θ1" is a downstream opening angle formed by a line that passes through fan center C perpendicular to a tangent b of the fan diameter D that is parallel to or coincides with an extended line a in the direction of flow along an upper surface that forms a discharge port serving as an air duct outlet inside the casing, and line that passes through origin K of a casing coil and fan center C;

k) an air duct width W formed between an outer peripheral surface of the tangential fan and an air duct wall surface of the casing has an enlarged linear portion which increases from an origin to an outlet width Wo in proportion to an extended length of an casing air duct center line, and a curved portion on the inlet side that gradually increases from an inlet width Wi serves as the origin and leads to said enlarged linear portion, and said air duct width W changes;

1) 0.7% ≤ Wi/D ≤ 0.8%, wherein "Wi" is an inlet width serving as an origin of an air duct width W formed between an outer peripheral surface of the tangential fan and an air duct wall surface of the casing.

2. The indoor unit according to claim 1, wherein a concave portion is formed in the surface that forms the inverted portion width "g".

3. An air-conditioner comprising:

an outdoor unit provided with an outdoor heat exchanger;

a compressor that is adapted to feed a high-temperature, high-pressure gaseous refrigerant to the heat exchanger;

a controller comprised of various electrical circuit elements, and

an indoor unit according to claim 1 or 2.

FIG. 1

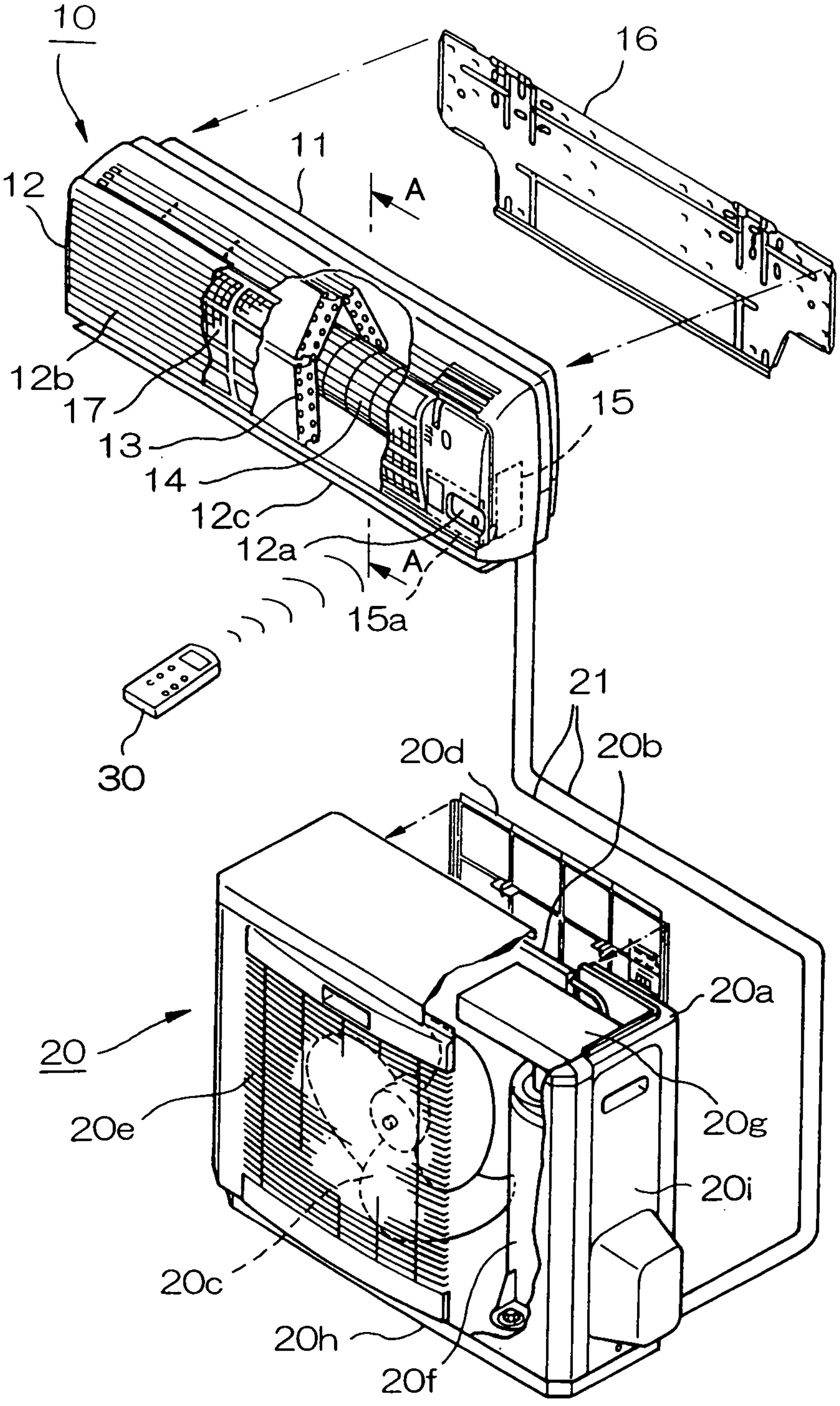

10
16
11
A
12
12b
17
13
14
12c
15
12a
A
15a
21
30
20d
20b
20a
20
20g
20e
20i
20c
20h
20f

FIG. 2

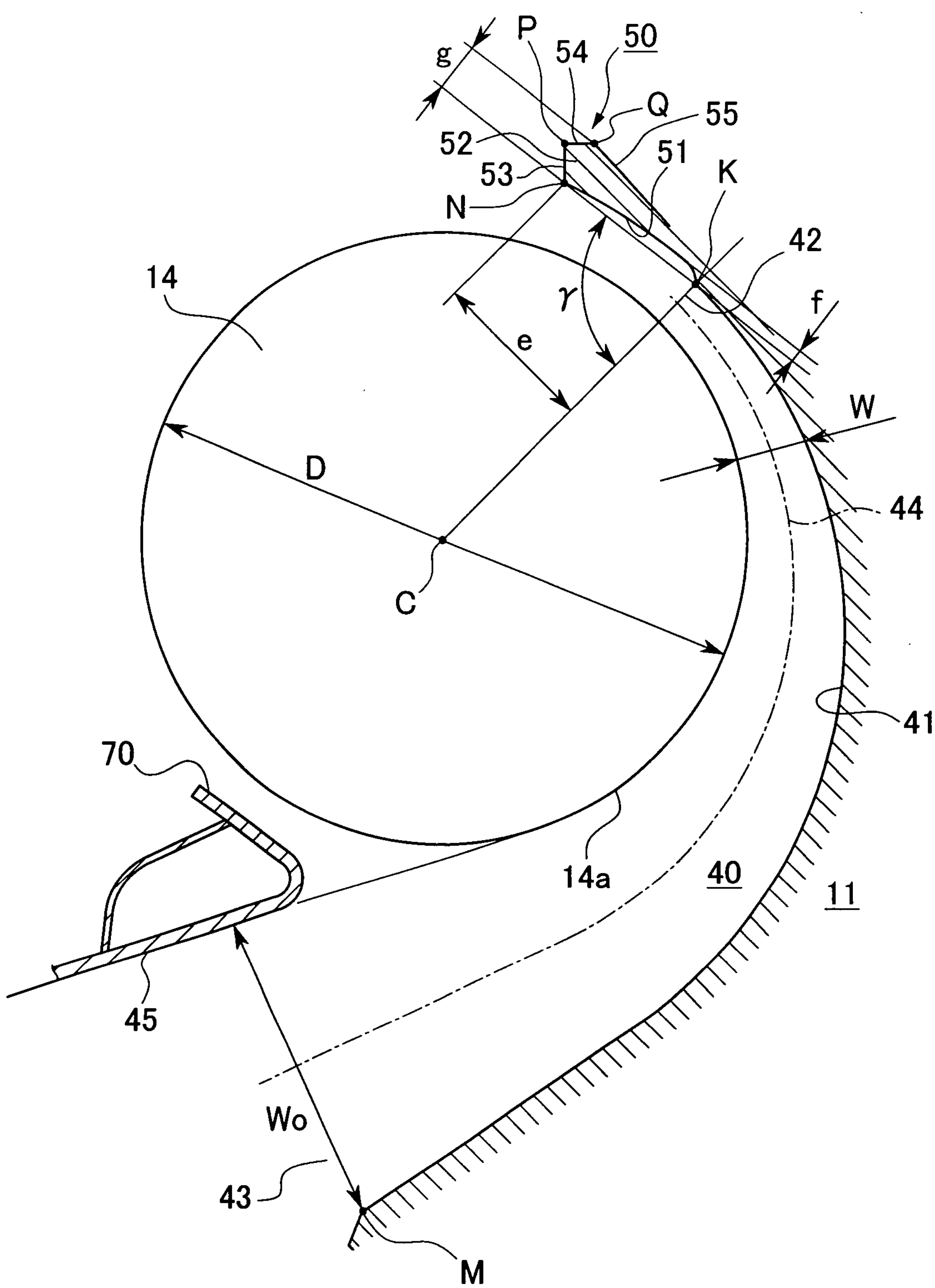


FIG. 3

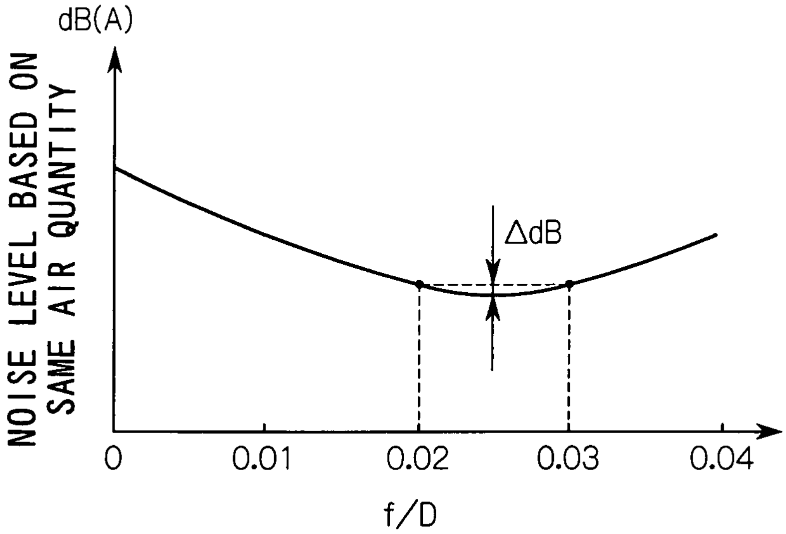

dB(A)
NOISE LEVEL BASED ON
SAME AIR QUANTITY
ΔdB
0
0.01
0.02
0.03
0.04
f/D

FIG. 4

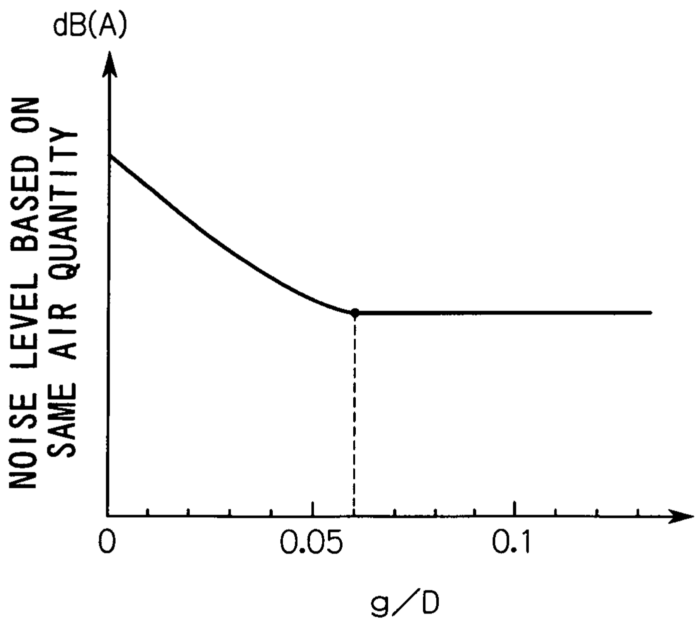

dB(A)
NOISE LEVEL BASED ON
SAME AIR QUANTITY
0
0.05
0.1
g/D

FIG. 5

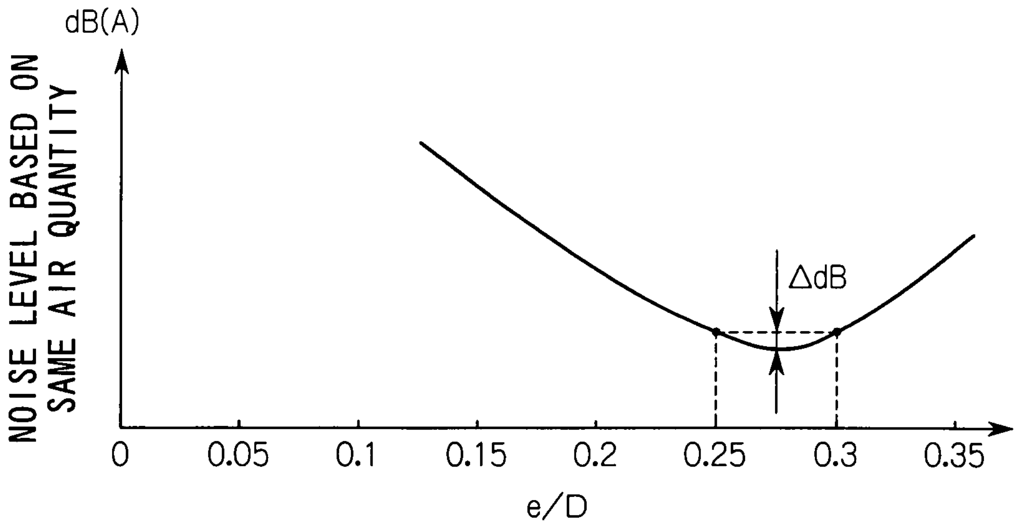

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
ΔdB
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
e/D

FIG. 6

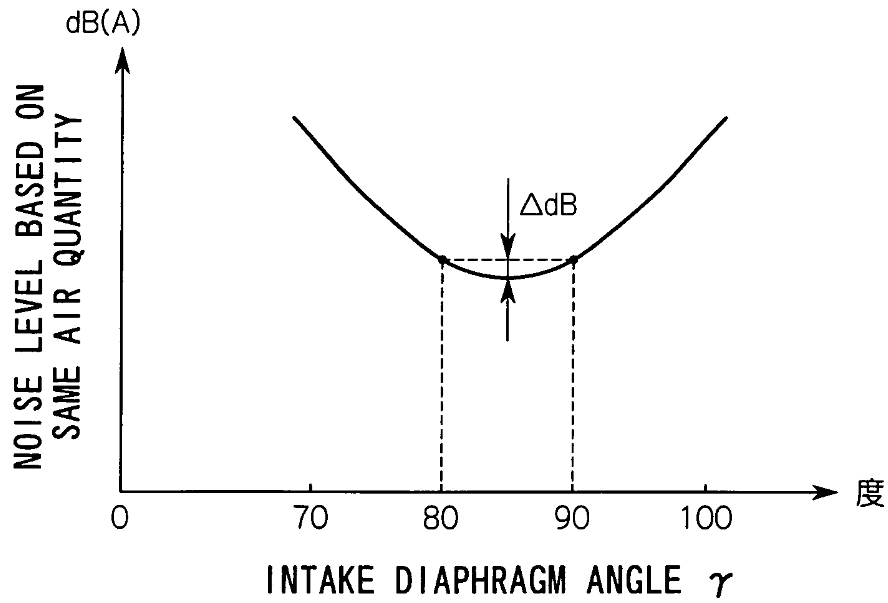

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
ΔdB
0
70
80
90
100
度
INTAKE DIAPHRAGM ANGLE γ

FIG. 7

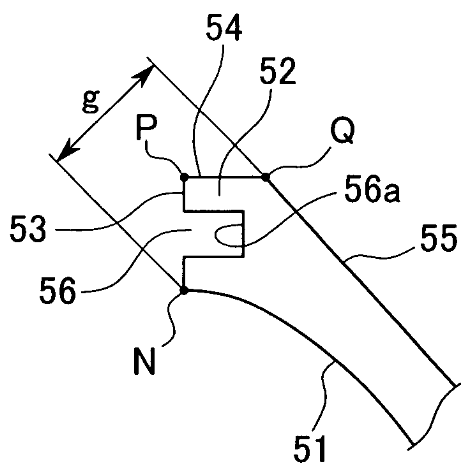


FIG. 8

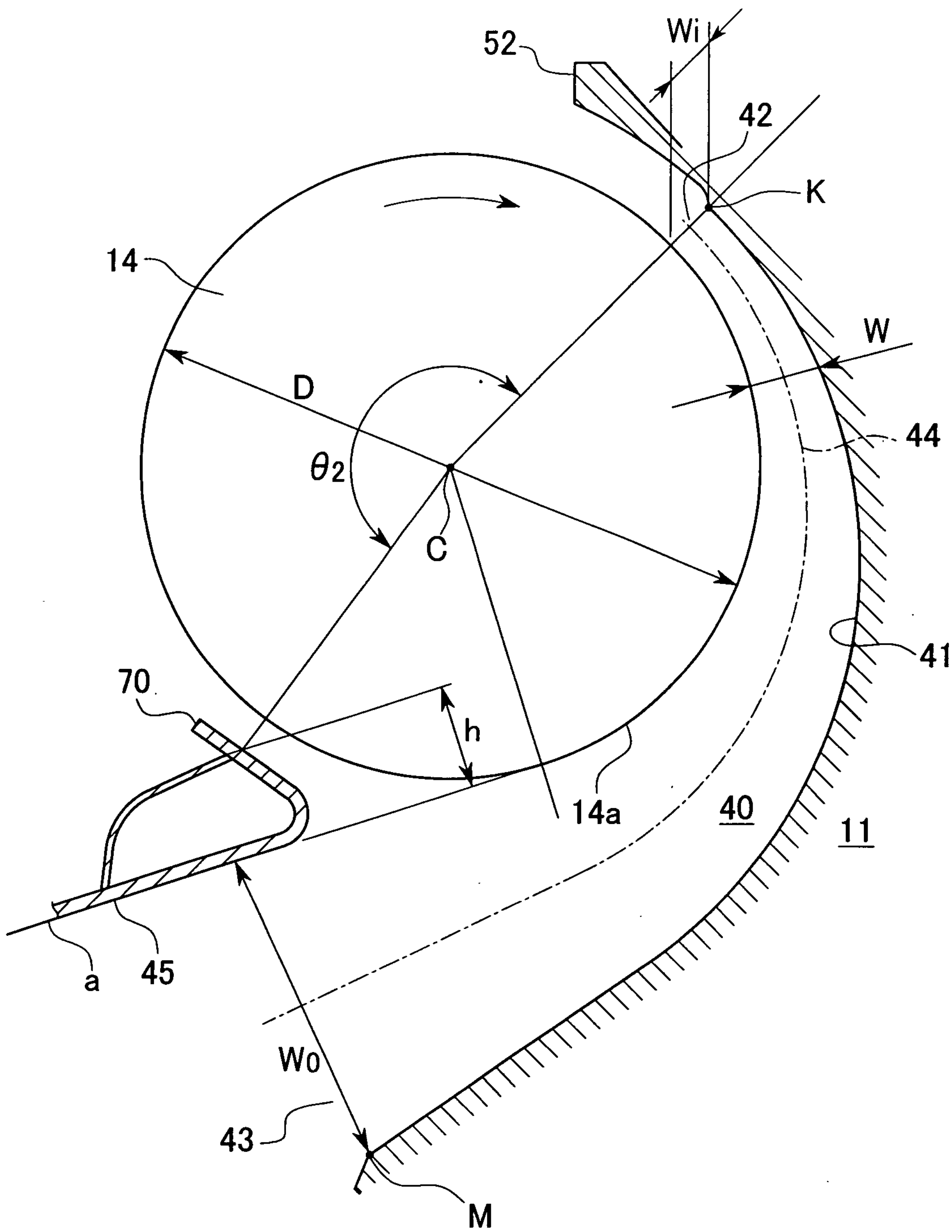


FIG. 9

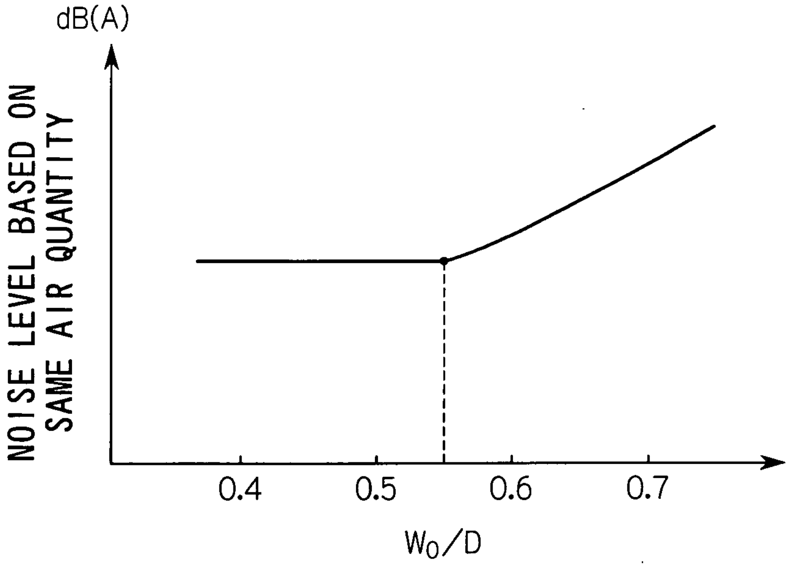

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
0.4
0.5
0.6
0.7
W0/D

FIG. 10

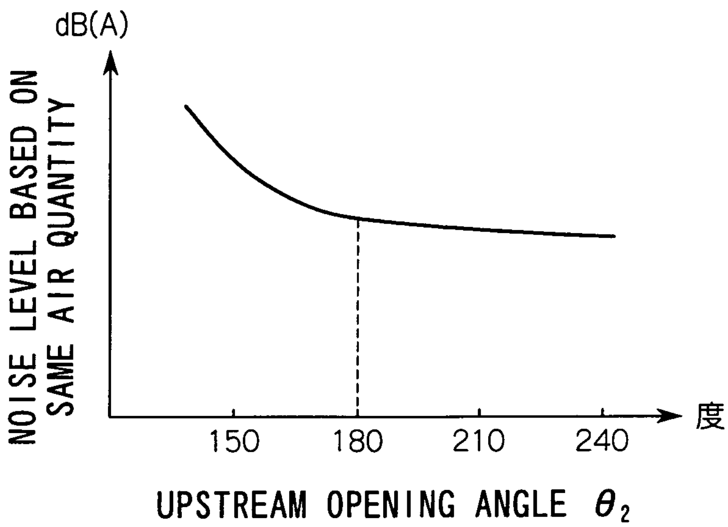

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
150
180
210
240
度
UPSTREAM OPENING ANGLE θ2

FIG. 11A

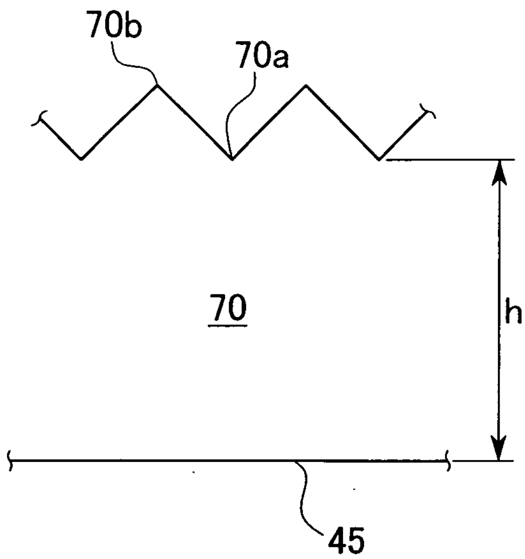


FIG. 11B

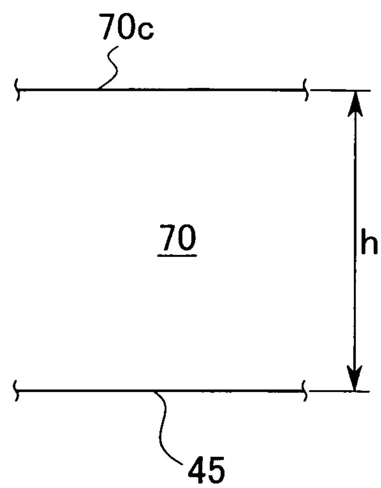


FIG. 12

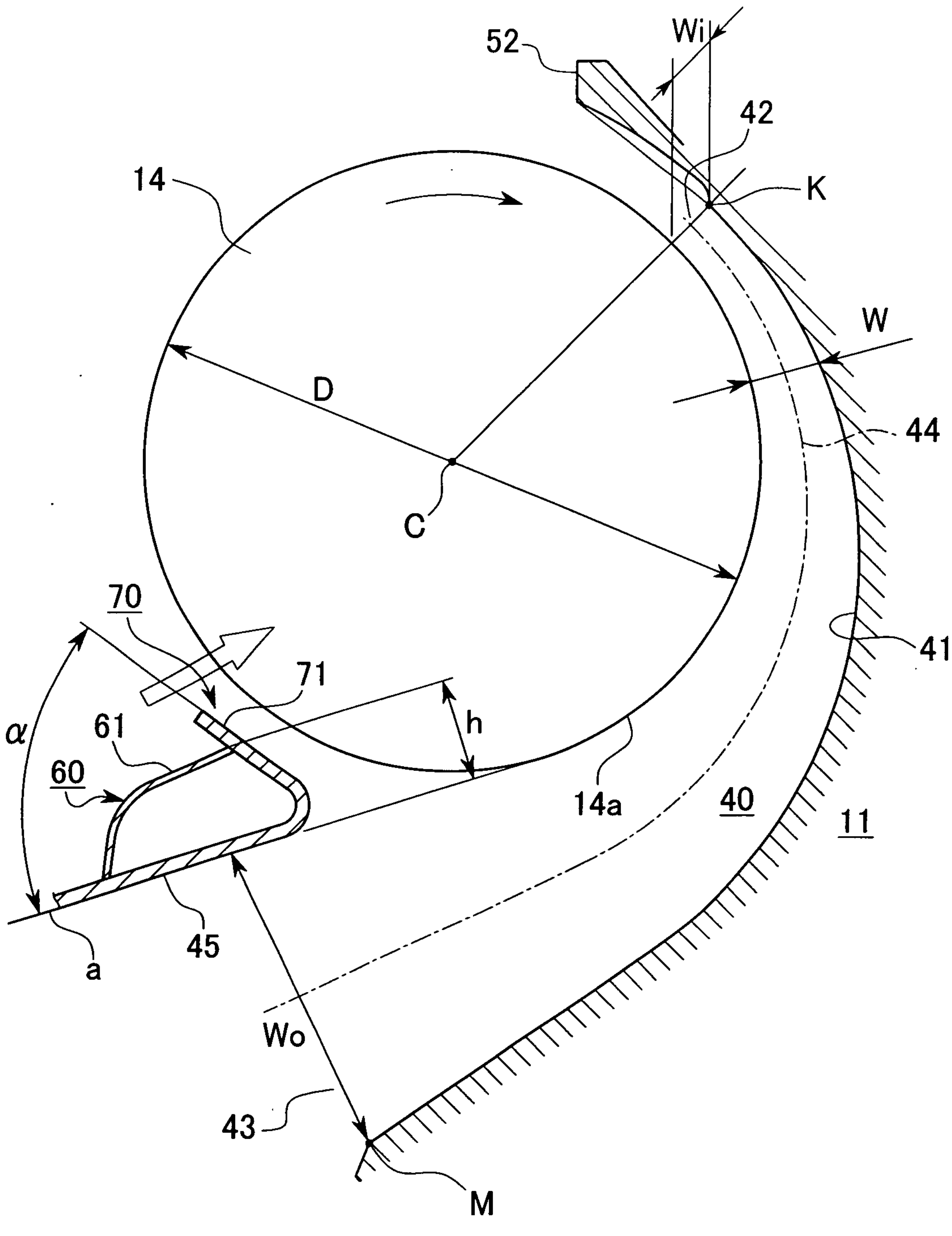


FIG. 13

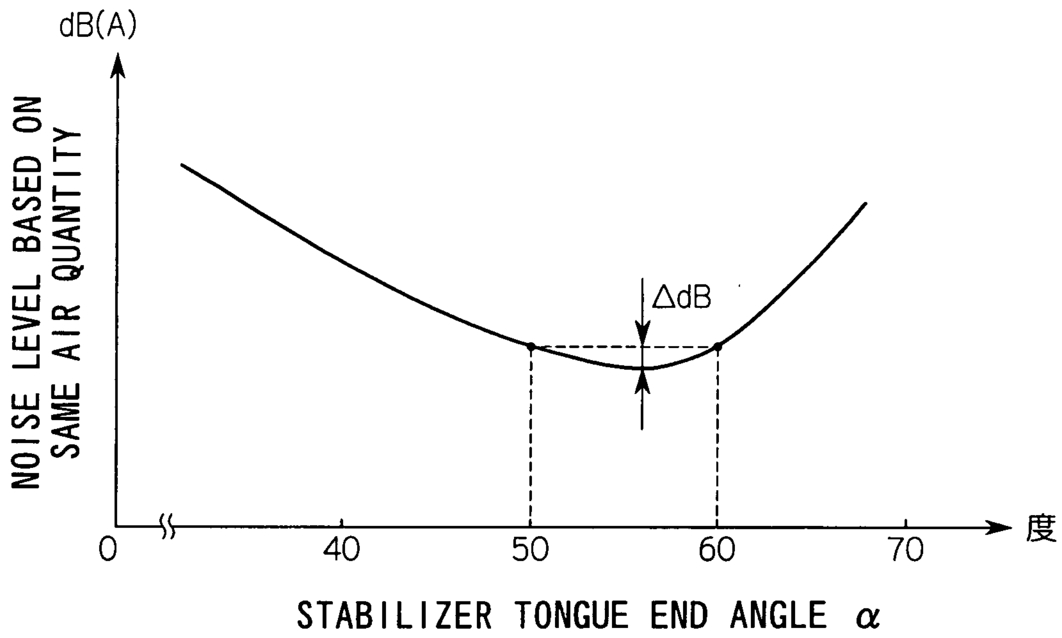

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
ΔdB
0
40
50
60
70
度
STABILIZER TONGUE END ANGLE α

FIG. 14

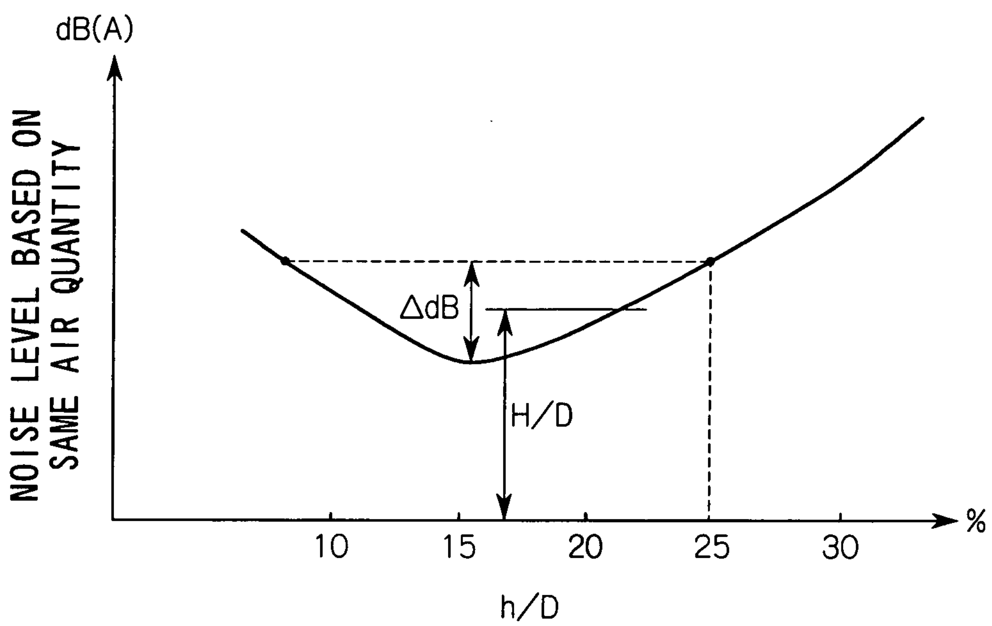

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
ΔdB
H/D
10
15
20
25
30
%
h/D

FIG. 15A

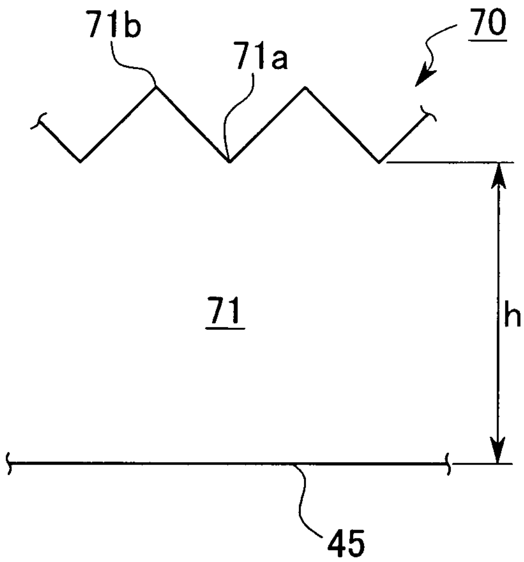


FIG. 15B

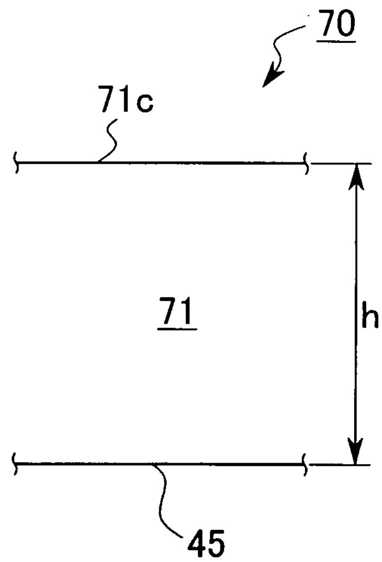


FIG. 16

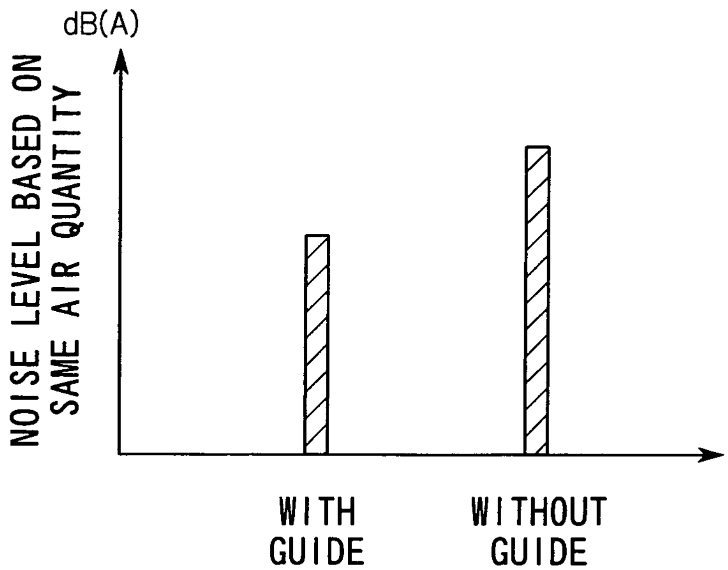


FIG. 17

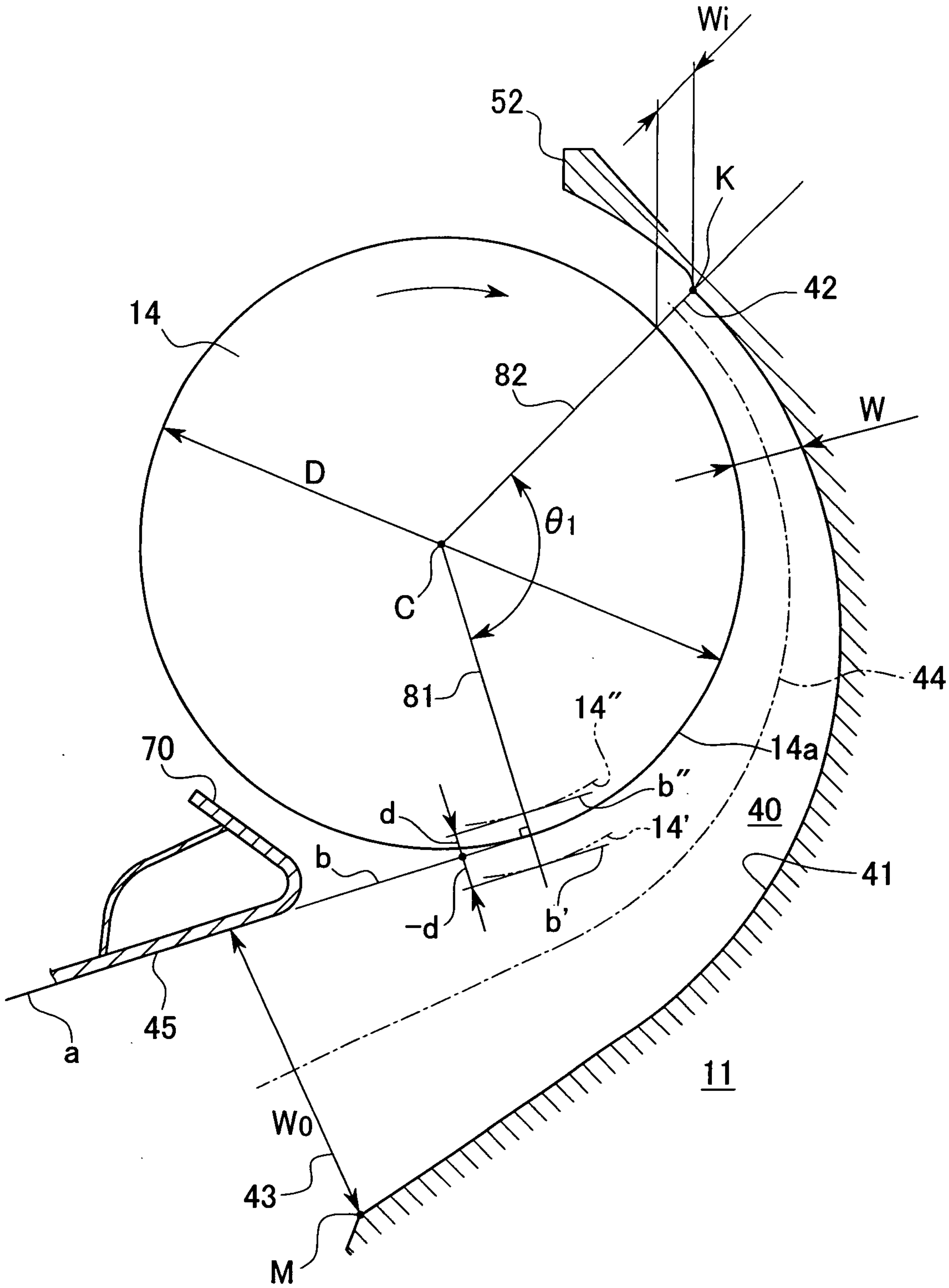

Wi
52
K
42
14
82
W
D
θ_1
C
44
81
14″
14a
70
b″
40
d
14'
b
41
-d
b'
a
45
11
W0
43
M

FIG. 18

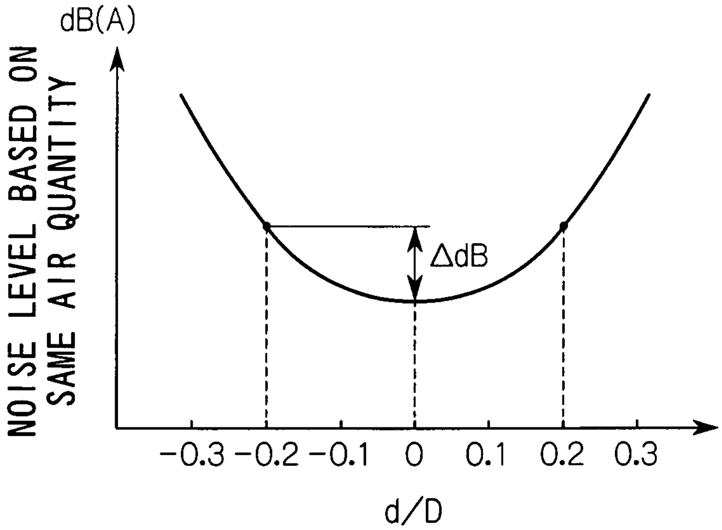

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
ΔdB
-0.3 -0.2 -0.1 0 0.1 0.2 0.3
d/D

FIG. 19

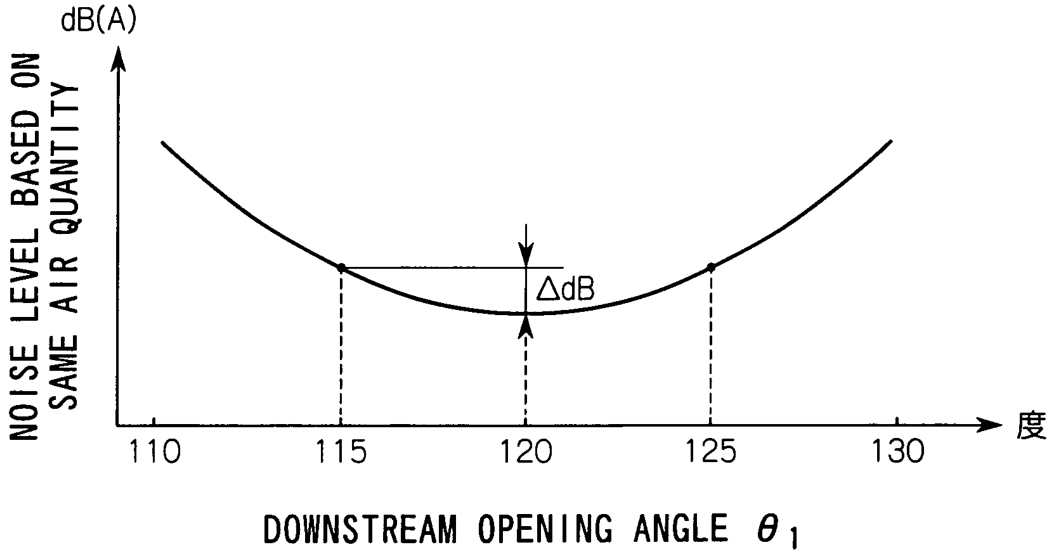

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
ΔdB
110 115 120 125 130
度
DOWNSTREAM OPENING ANGLE θ1

FIG. 20

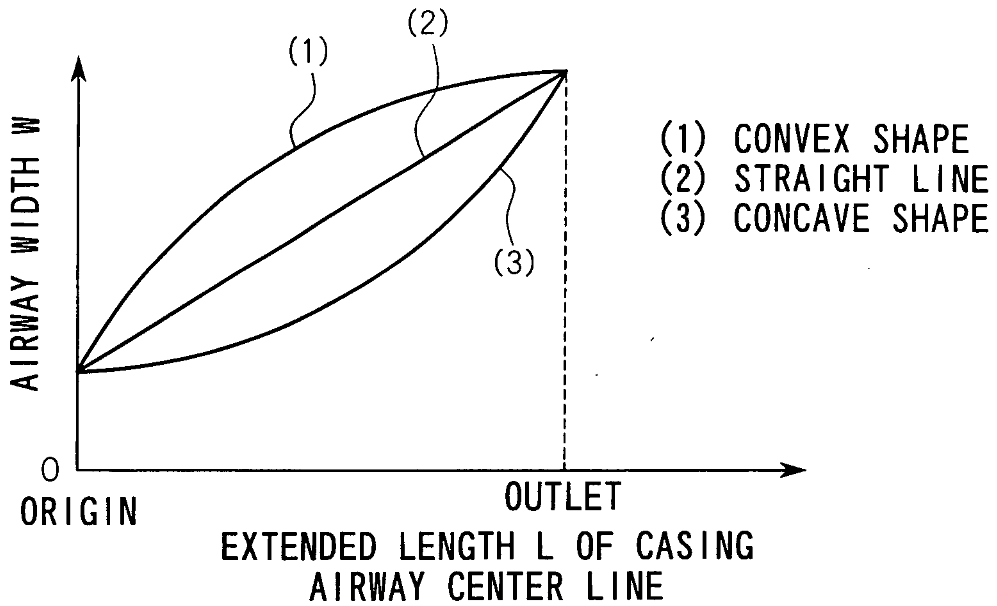

(1)
(2)
(3)
AIRWAY WIDTH W
0
ORIGIN
OUTLET
EXTENDED LENGTH L OF CASING AIRWAY CENTER LINE
(1) CONVEX SHAPE
(2) STRAIGHT LINE
(3) CONCAVE SHAPE

FIG. 21

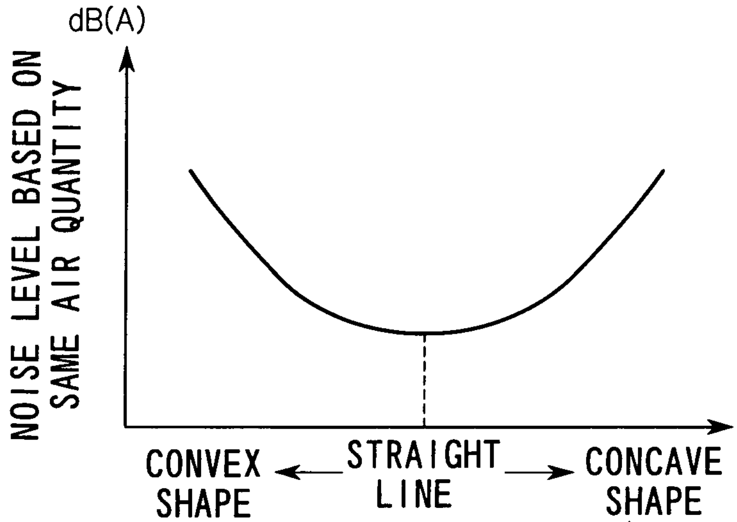

dB(A)
NOISE LEVEL BASED ON SAME AIR QUANTITY
CONVEX SHAPE
STRAIGHT LINE
CONCAVE SHAPE

FIG. 22

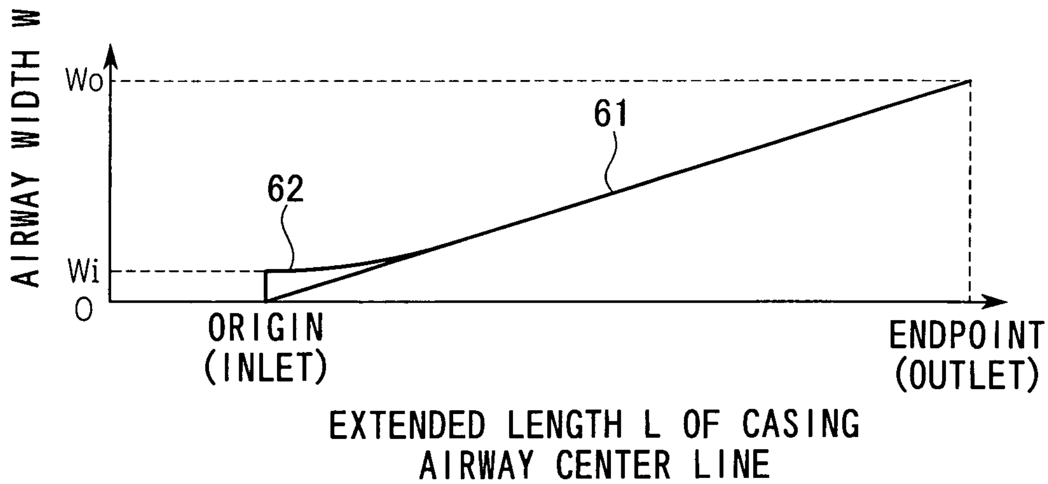
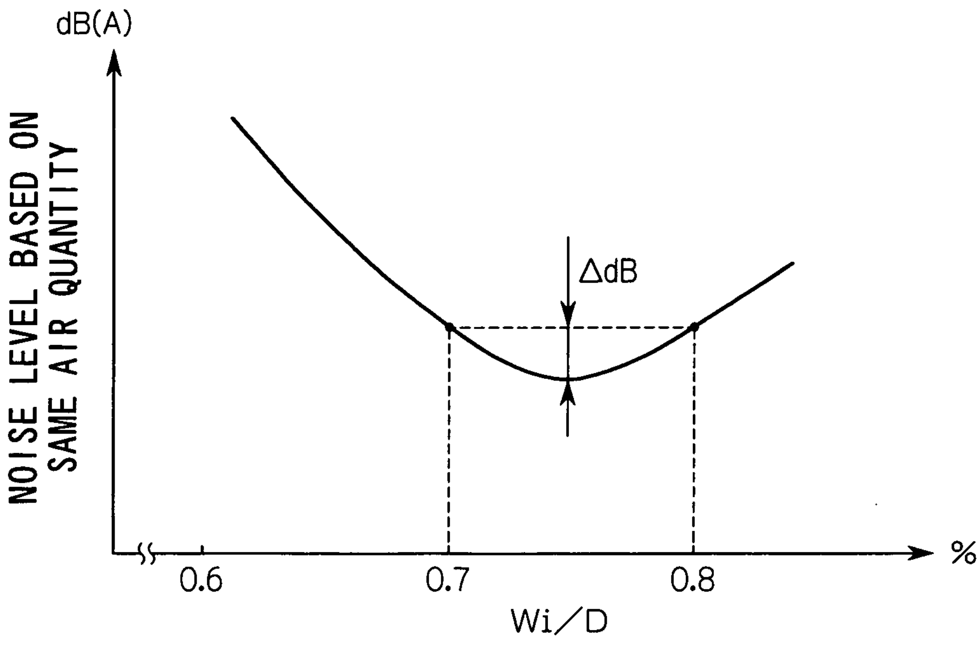

AIRWAY WIDTH W
Wo
Wi
O
61
62
ORIGIN
(INLET)
ENDPOINT
(OUTLET)
EXTENDED LENGTH L OF CASING
AIRWAY CENTER LINE

FIG. 23


dB(A)
NOISE LEVEL BASED ON
SAME AIR QUANTITY
ΔdB
0.6
0.7
0.8
%
Wi/D