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Remarks:
This application was filed on 16-05-2013 as a divisional application to the application mentioned under INID code 62.

(54) **Air conditioner**

(57) Provided is an air conditioner capable of securing the necessary static pressure even when the arrangement of air inlets is such that the suction resistance tends to increase. The air conditioner includes an indoor heat exchanger (4), a bellmouth (13) disposed behind the indoor heat exchanger (4) such that its opening (14) through which air passes faces the indoor heat exchanger (4), and a front panel (22) that covers the front side of the indoor heat exchanger (4). The air conditioner is provided with a casing (2) having air inlets (8 - 11) and air outlets (6, 7), and a turbofan (5) that generates an air flow in which air is sucked in from the air inlets (8 -11), passes through the indoor heat exchanger (4) and the opening (14) of the bellmouth (13), and is blown out from the air outlets (6, 7).; The air inlets (8 -11) are provided in the front panel (22) and/or around thereof, and are located substantially outside the opening of the bellmouth (13) as seen from the front. The total suction area of the air inlets (8 -11) is equal to or greater than 15% of the projected area of the indoor heat exchanger (4) as seen from the front.

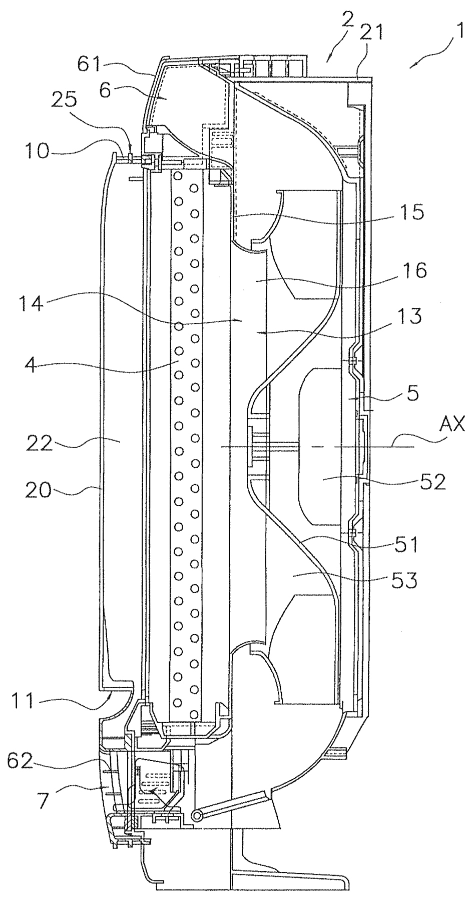

FIG. 3

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Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioner.

BACKGROUND ART

[0002] Conventionally, there is known an air conditioner in which a front panel of a casing, a heat exchanger, and a bellmouth are arranged in this order from front to back of the casing, and air inlets are provided around the front panel. Such an air conditioner is provided with a once-through fan, which generates an air flow in which air is sucked in from the air inlets, passes through the heat exchanger and an opening of the bellmouth, and is blown out from air outlets (see patent document 1).

[0003] The second patent document discloses an air conditioner mountable to a ceiling with a suction opening in a central part of a front panel and with air outlets disposed to all four sides of the suction opening and additional air outlet disposed at side walls located adjacent and above of the front panel.

<Patent document 1> JP-A Publication No. 64-58965 (Figures 1 and 2)
<Patent document 2> JP-A Publication No. 2002-005500

DISCLOSURE OF THE INVENTION

<TECHNICAL PROBLEM>

[0004] In the above described type of air conditioner, the air inlets are provided around the front panel, and thus it is possible to improve the design of the front panel. However, the air suction resistance is increased compared to the case where the air inlets are provided in the center of the front panel. This causes the output of the once-through fan to be insufficient, making it difficult to secure the necessary static pressure.

[0005] An object of the present invention is to provide an air conditioner capable of securing the necessary static pressure even when the arrangement of air inlets is such that the suction resistance tends to increase.

<SOLUTION TO THE PROBLEM>

[0006] An air conditioner according to claim 1 includes a heat exchanger, a bellmouth, a casing, and a turbofan. The bellmouth is disposed behind the heat exchanger such that an opening thereof through which air passes faces the heat exchanger. The casing has a front panel that covers the front side of the heat exchanger, and is provided with air inlets and air outlets. The turbofan is disposed behind the bellmouth, and generates an air flow in which air is sucked in from the air inlets, passes through the heat exchanger and the opening of the bellmouth, and is blown out from the air outlets. Additionally, the air inlets are provided in the front panel and/or around thereof, and are located substantially outside the opening of the bellmouth as seen from the front. Further, the distance between the heat exchanger and the bellmouth is equal to or greater than 10% of the diameter of the opening of the bellmouth.

[0007] In this air conditioner, an air flow is generated by the turbofan, so that it is possible to secure the necessary static pressure even when the arrangement of the air inlets is such that the suction resistance tends to increase. In addition, when an air flow is generated by the turbofan disposed behind the heat exchanger, air tends to unevenly flow mainly through the center of the heat exchanger, which may reduce the heat exchange efficiency; however, the present invention can improve the air conditioning efficiency because the distance between the heat exchanger and the bellmouth is equal to or greater than 10% of the diameter of the opening of the bellmouth, allowing air to easily flow over a larger area of the heat exchanger.

<EFFECTS OF THE INVENTION>

[0008] In the air conditioner according to the present invention, an air flow is generated by the turbo fan, so that it is possible to secure the necessary static pressure even when the arrangement of the air inlets is such that the suction resistance tends to increase. In addition, it is possible to improve the air conditioning efficiency because the distance between the heat exchanger and the bellmouth is equal to or greater than 10% of the diameter of the opening of the bellmouth, which allows air to easily flow over a larger area of the heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Figure 1 is a front view of an air conditioner.
Figure 2 is a side view of the air conditioner.
Figure 3 is a side cross sectional view of the air conditioner.
Figure 4 is a schematic view showing the projected area of an indoor heat exchanger as seen from the front.
Figure 5 is a schematic view showing the distance between the indoor heat exchanger and a bellmouth, and the diameter of an opening of the bellmouth.
Figure 6 is a graph showing the relationship between the ratio of the total suction area to the heat exchange area and the suction noise.
Figure 7 is a graph showing the relationship between the air conditioning efficiency and the distance between the indoor heat exchanger and the bellmouth with respect to the diameter of the opening of the bellmouth.

EXPLATION OF THE REFERENCE SYMBOLS

[0010]

1	Air conditioner
2	Casing
4	Indoor heat exchanger (heat exchanger)
5	Air blowing device (turbofan)
6	First air outlet (air outlet)
7	Second air outlet (air outlet)
8	First air inlet (air inlet)
9	Second air inlet (air inlet)
10	Third air inlet (air inlet)
11	Fourth air inlet (air inlet)
13	Bellmouth
14	Opening
22	Front panel

BEST MODE FOR CARRYING OUT THE INVENTION

<STRUCTURE>

[0011] An air conditioner 1 according to an embodiment of the present invention is shown in Figure 1 through Figure 3. Figure 1 is a front view of the air conditioner 1, and Figure 2 is a side view of the air conditioner 1. In addition, Figure 3 is a side cross sectional view of the air conditioner 1. The air conditioner 1 is a floor standing indoor unit, and is provided with a casing 2, an indoor heat exchanger 4, a bellmouth 13, and an air blowing device 5. Note that the terms "up", "down", "left", and "right" used in the description below refer to the up, down, left, and right sides of the air conditioner 1 as seen from the front.

<CASING 2>

[0012] The casing 2 comprises a hollow body made of synthetic resin, and houses the indoor heat exchanger 4, the bellmouth 13, and the air blowing device 5 therein. The casing 2 includes a casing main body 21 and a front panel 22 attached to a front surface of the casing main body 21.

[0013] The front surface of the casing main body 21 has a large opening formed therein. The casing main body 21 has the indoor heat exchanger 4, the bellmouth 13, and the air blowing device 5 arranged in this order from front to back inside thereof.

[0014] The front surface of the casing 2 has a first air outlet 6 and a second air outlet 7 provided thereto. The first air outlet 6 is an opening having a horizontally long shape that is disposed along the upper end of the front surface of the casing 2, and air that is blown out into the room passes therethrough. The second air outlet 7 is an opening having a horizontally long shape that is disposed along the lower end of the front surface of the casing 2, and air that is blown out into the room passes therethrough. Note that the first air outlet 6 is provided with a first flap 61 that guides air blown out from the first air outlet 6 such that the first flap 61 can freely pivot, and the first air outlet 6 can be opened and closed by the first flap 61. In addition, the second air outlet 7 is provided with a second flap 62 that guides air blown out from the second air outlet 7 such that the second flap 62 can freely pivot.

[0015] The front panel 22 is mounted to the front surface of the casing main body 21, and has an outer shape that is smaller than the front surface of the casing main body 21. The front panel 22 covers the front side of the indoor heat exchanger 4, and is disposed below the first air outlet 6 as seen from the front. In addition, a front surface of the front panel 22 is disposed at a slight distance forward from the front surface of the casing main body 21. Side surfaces 23 and 24 of the front panel 22 which connect the side end portions of the front surface of the front panel 22 to the front surface of the casing main body 21 are provided with a first air inlet 8 and a second air inlet 9, respectively. The first air inlet 8 is an opening having a longitudinally long shape that is disposed in the right side surface 23 of the front panel 22, and air sucked into the casing 2 from the room passes therethrough. The second air inlet 9 is an opening having a longitudinally long shape that is disposed in the left side surface 24 of the front panel 22, and air sucked into the casing 2 from the room passes therethrough.

[0016] In addition, a top surface 25 of the front panel 22 which connects the upper end portion of the front surface of the front panel 22 to the front surface of the casing main body 21 is provided with a third air inlet 10. The third air inlet 10 is an opening having a horizontally long shape that is disposed below the first air outlet 6, and air sucked into the casing 2 from the room passes therethrough. In addition, a bottom portion of the front surface of the front panel 22 is provided with a fourth air inlet 11. The fourth air inlet 11 is an opening having a horizontally long shape that is disposed above the second air outlet 7, and air sucked into the casing 2 from the room passes therethrough. Note that a bottom surface of the front panel 22 which connects the front lower end of the front panel 22 to the front surface of the casing main body 21 is closed. In addition, a portion between the third air inlet 10 and the fourth air inlet 11 of the front surface of the casing 2 is a flat panel portion 20 in which an opening is not provided.

[0017] As described above, the casing 2 has the four air inlets from the first air inlet 8 through the fourth air inlet 11 provided in the front panel 22, one at each of the four sides (up, down, left, and right) around the flat panel portion 20, and air is sucked in from the four sides (up, down, left, and right) of the flat panel portion 20. In addition, as shown in Figure 1, these air inlets 8 through 11 are located outside the opening 14 of the bellmouth 13 as seen from the front.

<INDOOR HEAT EXCHANGER 4>

[0018] The indoor heat exchanger 4 shown in Figure 3 constitutes a refrigerant circuit together with an outdoor heat exchanger disposed in the outdoor unit (not shown) and performs heat exchange with air that passes through the indoor heat exchanger 4. The indoor heat exchanger 4 is disposed behind the front panel 22. The indoor heat exchanger 4 has a thin plate-like outer shape and is disposed parallel to the flat panel portion 20. In addition, the indoor heat exchanger 4 has the same size as the front panel 22 as seen from the front, and the following expression is obtained: $S/B \geq 0.15$, where B is the projected area of the indoor heat exchanger 4 as seen from the front, and S (not shown) is the total suction area of the above described air inlets 8 through 11, as shown in Figure 4. In other words, the total suction area S of the air inlets 8 through 11 is equal to or greater than 15% of the projected area B of the indoor heat exchanger 4 as seen from the front.

<BELLMOUTH 13>

[0019] The bellmouth 13 is disposed behind the indoor heat exchanger 4, and the bellmouth 13 includes a flat portion 15 and a circular tube portion 16. The flat portion 15 has an outer shape that is about the same size as that of the indoor heat exchanger 4 as seen from the front, and is disposed parallel to the indoor heat exchanger 4 so as to face the rear surface of the indoor heat exchanger 4. The flat portion 15 is connected to the edge on the entrance side of an opening 14 of the circular tube portion 16. Note that the circular tube portion 16 curves such that the diameter of its front end side expands, and the circular tube portion 16 is loosely connected to the peripheral edge of the opening 14. Here, the following expression is obtained: $a/d \geq 0.1$, where "a" is the distance between the indoor heat exchanger 4 and the bellmouth 13, i.e., the distance between the indoor heat exchanger 4 and the entrance of the opening 14 of the bellmouth 13, and "d" is the diameter of the opening 14 of the bellmouth 13. In other words, the distance "a" between the indoor heat exchanger 4 and the bellmouth 13 is equal to or greater than the diameter "d" of the opening 14 of the bellmouth 13. Note that the rear end of the circular tube portion 16 enters inside a fan cover 53 (described later) through an opening on a front surface of the fan cover 53. In addition, the opening 14 of the bellmouth 13 has an outer shape that is smaller than that of the indoor heat exchanger 4 as seen from the front.

<AIR BLOWING DEVICE 5>

[0020] The air blowing device 5 is disposed behind the bellmouth 13, and generates an air flow in which air is sucked in from each of the air inlets 8 through 11, passes through the indoor heat exchanger 4 and the opening 14 of the bellmouth 13, and is blown out from each of the air outlets 6 and 7. The air blowing device 5 is a turbofan that sucks in air from the front and causes the wind to blow out in a centrifugal direction. The air blowing device 5 includes a fan rotor 51, a fan motor 52, and the fan cover 53.

[0021] The fan rotor 51 is disposed such that a rotation axis AX thereof is horizontal. The fan rotor 51 includes a plurality of blades disposed so as to spiral away from the rotation axis AX.

[0022] The fan motor 52 is a driving source for rotatingly driving the fan rotor 51, and is disposed behind the fan rotor 51.

[0023] The fan cover 53 is a member that is disposed in front of the fan rotor 51. An opening through which air that is taken into the fan cover 53 passes is disposed in the front surface of the fan cover 53. Air that passes through the opening in the front surface of the fan cover 53 branches up and down as a result of being blown out in a centrifugal direction by the fan rotor 51 and is blown out into the room from the first air outlet 6 and the second air outlet 7.

<CHARACTERISTICS>

(1)

[0024] In the air conditioner 1, the front panel 22 is provided with the air inlets 8 through 11 in the top surface 25, the right side surface 23, the left side surface 24, and the bottom portion of the front surface, respectively, and has the flat panel portion 20 in a smooth shape at the center. Accordingly, it is possible to refine the external appearance of the air conditioner 1 as seen from the front, thus allowing enhancement of the aesthetic appearance.

[0025] In addition, the air inlets 8 through 11 are disposed outside the opening 14 of the bellmouth 13 as seen from the front. Accordingly, it is possible to allow air that is sucked in from the air inlets 8 through 11 to pass over a larger area of the indoor heat exchanger 4, thus allowing improvement of the air conditioning efficiency.

[0026] In addition, because the fourth air inlet 11 is provided in the bottom portion of the front surface of the front panel 22, it is possible to increase the suction area while suppressing an increase in the size of other air inlets 8 through 10. Accordingly, it is possible to suppress an increase in the thickness of the front panel 22 caused by an increase in the size of other air inlets 8 through 10, thus allowing the external shape of the air conditioner 1 to be thinner.

(2)

[0027] Although the arrangement of the air inlets 8 through 11 as described above increases the suction resistance, it is possible in this air conditioner 1 to sufficiently secure the necessary static pressure because an air flow is generated by the air blowing device 5 that is a turbofan.

[0028] In addition, in the air conditioner 1 according to the present invention, a necessary air flow can be generated by one turbofan, unlike the case where a once-through fan is provided to each of the upper and lower air outlets as in the conventional air conditioner. Accordingly, it is possible to reduce the manufacturing cost.

(3)

[0029] Although the use of the turbofan when the arrangement of the air inlets 8 through 11 is as described above may augment the suction noise, the air conditioner 1 can reduce the suction noise because the total suction area S of the air inlets 8 through 11 is equal to or greater than 15% of the projected area B of the indoor heat exchanger 4 as seen from the front. In other words, as shown in Figure 6, a sufficient effect of the suction noise reduction can be obtained in the range where $S/B \geq 15\%$. Note that, because an increase in the value of S/B entails an increase in the total suction area, it is better if the value of S/B is smaller in terms of the size reduction of the air conditioner 1. Considering this, it is more preferable that $0.15 \leq S/B \leq 0.35$, for example, $S/B = 0.2$.

[0030] In addition, when an air flow is generated by one turbofan disposed behind the indoor heat exchanger 4, air tends to unevenly flow mainly through the center of the indoor heat exchanger 4, which may reduce the heat exchange efficiency; however, the air conditioner 1 can further improve the air conditioning efficiency because the distance "a" between the indoor heat exchanger 4 and the bellmouth 13 is equal to or greater than 10% of the diameter "d" of the opening 14 of the bellmouth 13, allowing air to easily flow over a larger area of the indoor heat exchanger 4. In other words, as shown in Figure 7, a sufficient effect of an increase in the air conditioning efficiency can be obtained in the range where $a/d \geq 10\%$. In addition, because an increase in the value of a/d entails an increase in the distance between the indoor heat exchanger 4 and the bellmouth 13, it is better if the value of a/d is smaller in terms of the thickness reduction of the air conditioner 1. Considering this, it is more preferable that $0.1 \leq a/d \leq 0.25$, for example, $a/d = 0.15$.

<OTHER EMBODIMENT>

(1)

[0031] In the above described embodiment, all of the air inlets 8 through 11 are disposed in the front panel 22. However, one, some, or all of the air inlets 8 through 11 may be disposed in the casing main body 21, specifically at a portion or portions located around the front panel 22.

(2)

[0032] In the above described embodiment, the air conditioner 1 is the floor-standing air conditioner. However, the present invention is applicable to a wall-mounted air conditioner and a ceiling-embedded air conditioner.

(3)

[0033] In the above described embodiment, the air inlets 8 through 11 are located outside the opening 14 of the bellmouth 13 as seen from the front. However, they may be located somewhat inside the opening 14 of the bellmouth 13. For example, the air inlets 8 through 11 may be located inside the opening 14 of the bellmouth 13 as long as the air inlets 8 through 11 are not located within a peripheral boundary that is concentric with and 80% of the inside diameter of the opening 14 of the bellmouth 13. In other words, any such modification may be made as long as the air inlets 8 through 11 are located outside a peripheral boundary that is concentric with and 80% of the inside diameter of the opening 14 of the bellmouth 13 as seen from the front.

INDUSTRIAL APPLICABILITY

[0034] The present invention has an effect of securing the necessary static pressure even when the arrangement of air inlets is such that the suction resistance tends to increase, and the present invention is useful as an air conditioner.

FURTHER EMBODIMENTS

[0035]

1. An air conditioner (1), comprising:

   a heat exchanger (4);
   a bellmouth (13) disposed behind the heat exchanger (4) such that an opening (14) thereof through which air passes faces the heat exchanger (4);
   a casing (2) having a front panel (22) that covers the front side of the heat exchanger (4) and provided with air inlets (8-11) and air outlets (6, 7); and
   a turbofan (5) disposed behind the bellmouth (13) and configured to generate an air flow in which air is sucked in from the air inlets (8-11), passes through the heat exchanger (4) and the opening (14) of the bellmouth (13), and is blown out from the air outlets (6, 7),wherein
   the air inlets(8 -11) are provided in the front panel (22) and/or around thereof, and are located substantially outside the opening (14) of the bellmouth (13) as seen from the front, and
   the total suction area of the air inlets (8 -11) is equal to or greater than 15% of the projected area of the heat exchanger (4) as seen from the

front.

2. An air conditioner (1), comprising:

a heat exchanger (4);
a bellmouth (13) disposed behind the heat exchanger (4) such that an opening (14) thereof through which air passes faces the heat exchanger (4);
a casing (2) having a front panel (22) that covers the front side of the heat exchanger (4) and provided with air inlets (8 -11) and air outlets (6, 7); and
a turbofan (5) disposed behind the bellmouth (13) and configured to generate an air flow in which air is sucked in from the air inlets (8-11), passes through the heat exchanger (4) and the opening (14) of the bellmouth (13), and is blown out from the air outlets (6, 7),wherein
the air inlets(8 -11) are provided in the front panel (22) and/or around thereof, and are located substantially outside the opening (14) of the bellmouth (13) as seen from the front, and
the distance between the heat exchanger (4) and the bellmouth (13) is equal to or greater than 10% of the diameter of the opening (14) of the bellmouth (13).

Claims

1. An air conditioner (1), comprising:

a heat exchanger (4);
a bellmouth (13) disposed behind the heat exchanger (4) such that an opening (14) thereof through which air passes faces the heat exchanger (4);
a casing (2) having a front panel (22) that covers the front side of the heat exchanger (4) and provided with air inlets (8-11) and air outlets (6, 7); and
a turbofan (5) disposed behind the bellmouth (13) and configured to generate an air flow in which air is sucked in from the air inlets (8-11), passes through the heat exchanger (4) and the opening (14) of the bellmouth (13), and is blown out from the air outlets (6, 7), **characterized in that**
the air inlets (8-11) are provided in the front panel (22) and/or around thereof, and are located substantially outside the opening (14) of the bellmouth (13) as seen from the front, and
the distance between the heat exchanger (4) and the bellmouth (13) is equal to or greater than 10% of the diameter of the opening (14) of the bellmouth (13).

2. An air conditioner (1), according to claim 1, **characterized in that**:

the front panel (22) has a flat panel portion (20) that is disposed so as to overlap with the opening (14) of the bellmouth (13) as seen from the front and is located in front of the heat exchanger (4), and
the air inlets (8-11) are provided around the flat panel portion (20).

FIG. 1

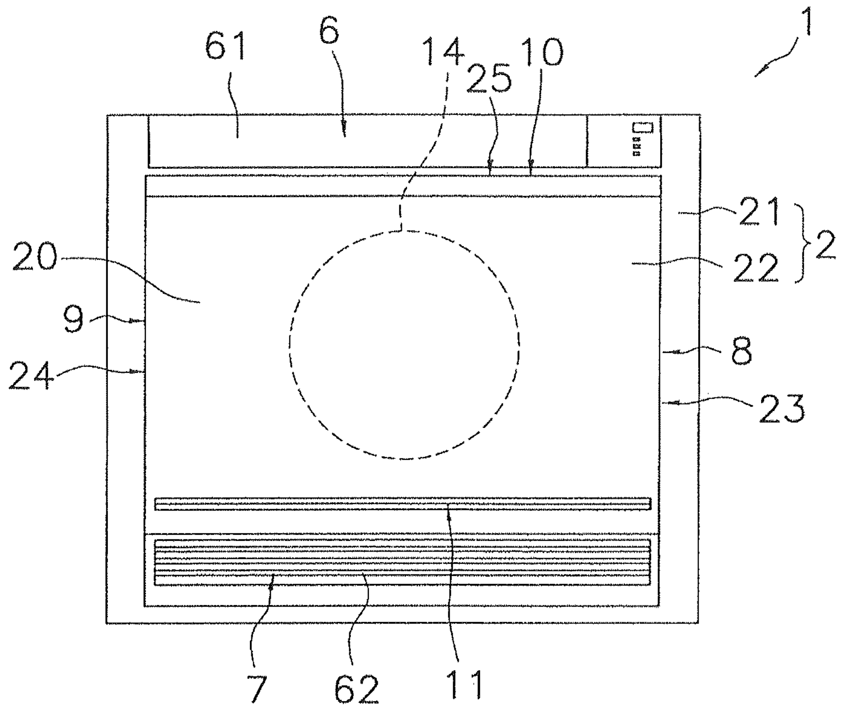
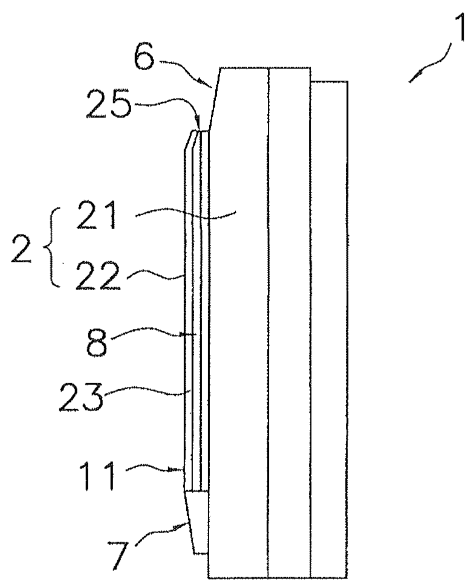


FIG. 2



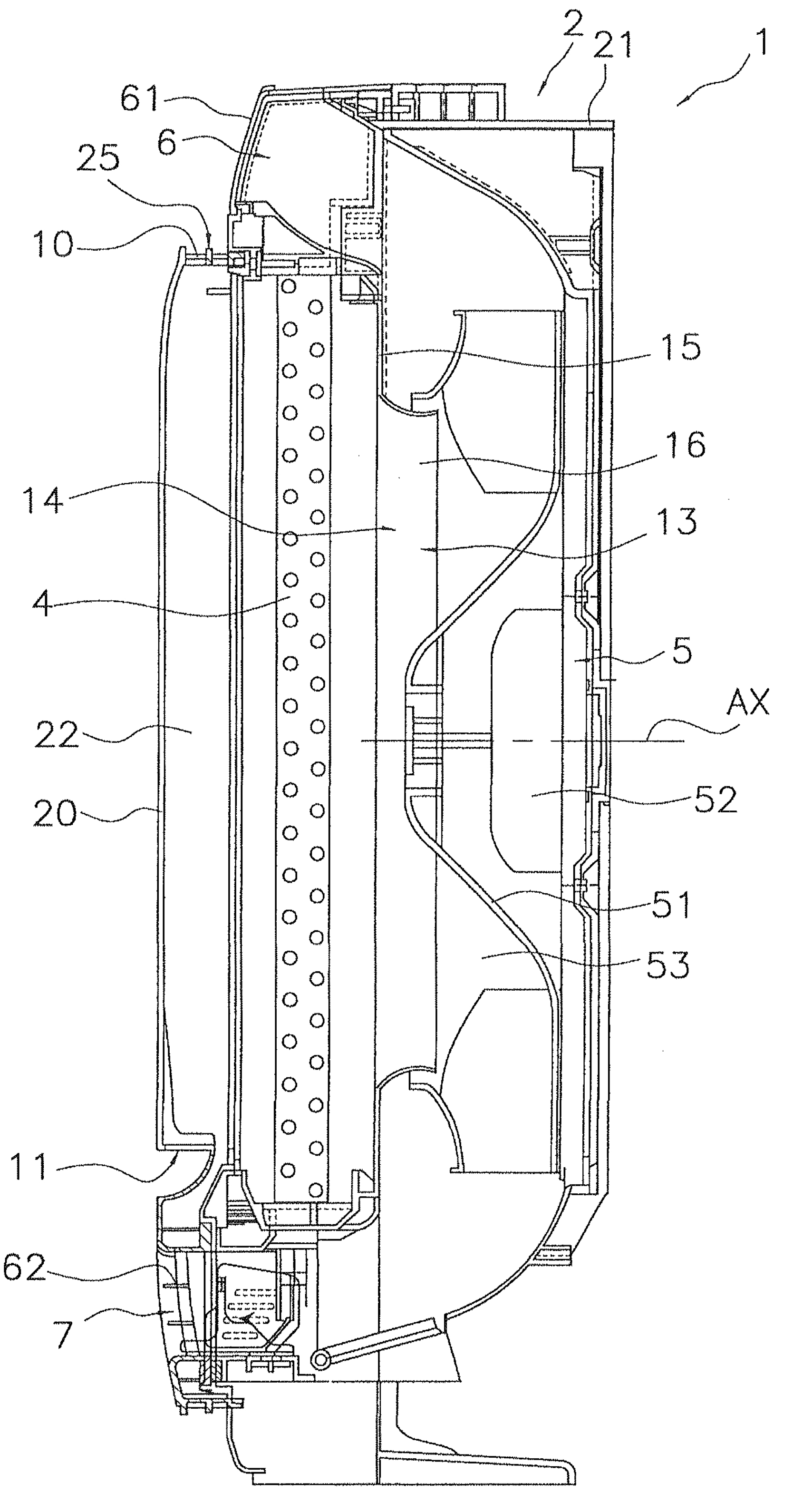


FIG. 3

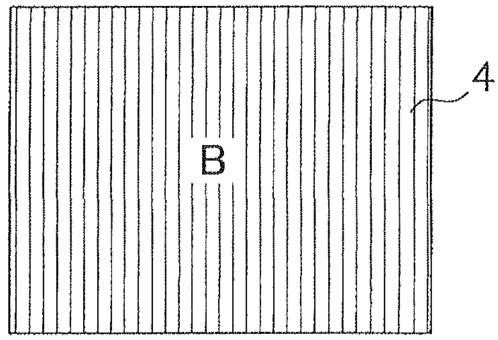


FIG. 4

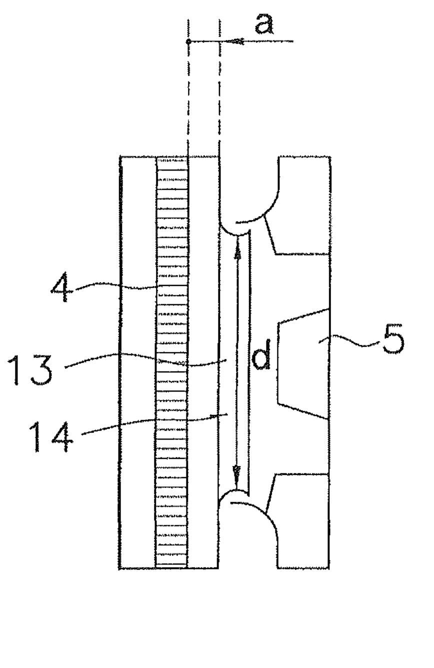


FIG. 5

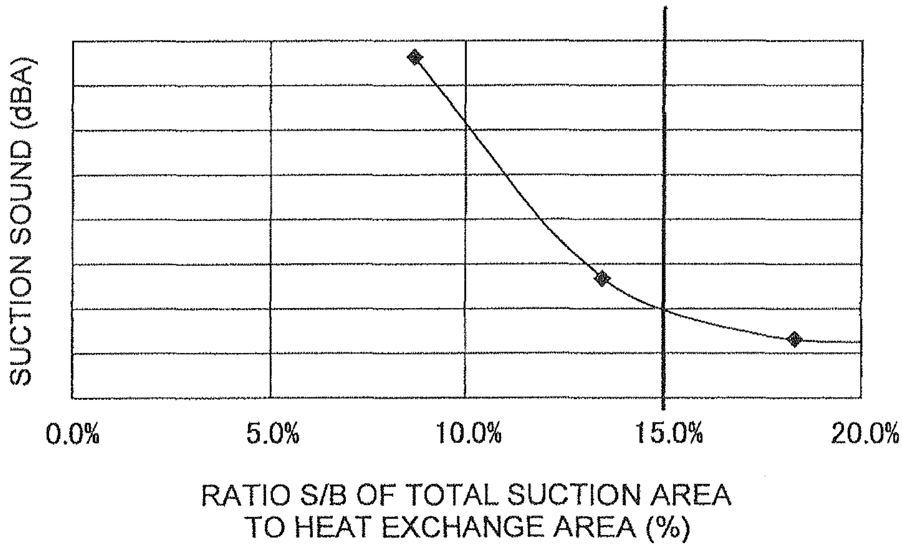

SUCTION SOUND (dBA)
0.0%
5.0%
10.0%
15.0%
20.0%
RATIO S/B OF TOTAL SUCTION AREA
TO HEAT EXCHANGE AREA (%)

FIG. 6

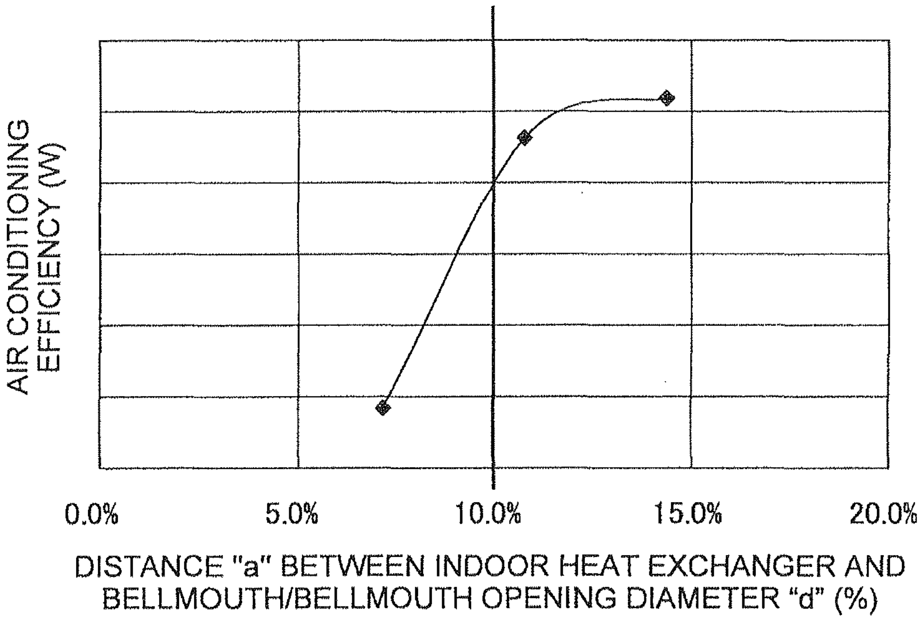

AIR CONDITIONING
EFFICIENCY (W)
0.0%
5.0%
10.0%
15.0%
20.0%
DISTANCE "a" BETWEEN INDOOR HEAT EXCHANGER AND
BELLMOUTH/BELLMOUTH OPENING DIAMETER "d" (%)

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 13 16 8014

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 512 919 A2 (LG ELECTRONICS INC [KR]) 9 March 2005 (2005-03-09) * figures 5-7 * -----	1	INV. F24F1/00 F24F13/20
X	US 5 787 717 A (BANG YONG-WOONG [KR]) 4 August 1998 (1998-08-04) * figure 5 * -----	1	
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TECHNICAL FIELDS SEARCHED (IPC)
F24F
F04D

1

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	31 October 2013	Vuc, Arianda

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 13 16 8014

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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