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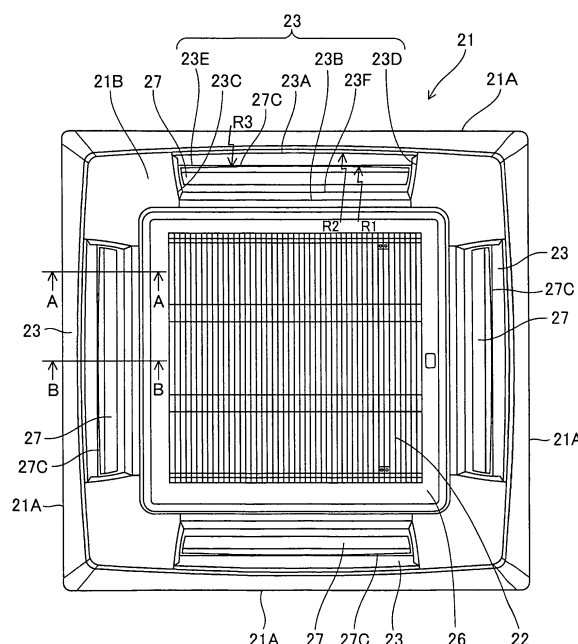
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(54) **In-ceiling embedded type air conditioner**

(57) In an in-ceiling embedded type air conditioner including an air conditioner main body (1) having a heat exchanger (11) and an air blower (9) mounted therein and a face panel (21) that is mounted on a ceiling plane while assembled with the air conditioner main body and has air blow-out ports (23) for blowing air in four directions, each of the air blow-out ports has a trapezoidal shape which gradually expands in width toward the outer edge of the face panel.

FIG.2



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an in-ceiling embedded type air conditioner having a flap at an air blow-out port thereof.

2. Description of Related Art

[0002] There is generally known an in-ceiling embedded type air conditioner which includes an air conditioner main body having a heat exchanger and an air blower mounted therein and a face panel which is disposed on the ceiling plane while assembled with the air conditioner main body and has an air blow-out port for blowing air in four directions. This type of air conditioner has a problem that a flap is shifted to a horizontally air-blowing position under cooling operation, for example, and thus smudge (stain of the ceiling in the neighborhood of the air blow-out port) occurs. This is because the relative humidity of blown-out air is frequently equal to about 90% or more under cooling operation and thus smudge inside the air conditioner more easily adheres to the ceiling plane.

[0003] With respect to the relationship between the shape of the air blow-out port and the flap, the air flowing speed increases in the neighborhood of the short sides at both the sides in the longitudinal direction of the air blow-out port, and thus the stain of the ceiling plane due to smudging does not occur in the neighborhood of the center of the flap, but frequently occurs at both the sides of the flap. Accordingly, it has been hitherto general that both the sides of the flap are greatly cut out so that blow-out air flows downwardly so as to be far away from the ceiling plane, thereby preventing smudging (see JP-A-2001-194000).

[0004] According to the construction described above, smudging can be prevented, however, there is a problem that cold air drops and thus a user feels draft.

SUMMARY OF THE INVENTION

[0005] Therefore, an object of the present invention is to provide an air conditioner that can prevent smudging with making a user feel no draft.

[0006] In order to attain the above object, an in-ceiling embedded type air conditioner including an air conditioner main body (1) having a heat exchanger (11) and an air blower (9) mounted therein and a face panel (21) that is mounted on a ceiling plane while assembled with the air conditioner main body and has air blow-out ports (23) for blowing air in four directions is **characterized in that** each of the air blow-out ports has a trapezoidal shape which gradually expands in width toward the outer edge of the face panel.

[0007] In the above in-ceiling embedded type air con-

ditioner a flap (27) is provided at each of the air blow-out ports, and a front edge (27C) of the flap is curved to be convex outwardly.

[0008] In the above in-ceiling embedded type air conditioner, an outer long side (23A, 23B) of the air blow-out port (23) has a curved face (23G) that is curved toward a back end (23E) of the air blow-out port, and the curved face is common to the center and both the sides of the air blow-out port in the longitudinal direction thereof from the back-end position till a predetermined position of the air blow-out port and is more greatly curved at the center of the air blow-out port than at both the sides of the air blow-out port from the predetermined position till the surface position of the long side so that the curvature at the center in the longitudinal direction of the air blow-out port is larger than the curvature at both the sides in the longitudinal direction of the air blow-out port.

[0009] In the above in-ceiling embedded type air conditioner, when the flap is shifted to a horizontally air blowing position, the interval between the front edge of the flap and the back end of the air blow-out port increases as the position of the air blow-out port is shifted to both the sides in the longitudinal direction thereof.

[0010] In the above in-ceiling embedded type air conditioner, when the flap is shifted to a downwardly air blowing position, an opening area of the air blowing port is maximum.

[0011] In the above in-ceiling embedded type air conditioner, all the air blow-out ports in the four directions expand current flow in a horizontal direction, thereby implementing circle flow.

[0012] According to the present invention, uniform air flow velocity can be obtained over the air blow-out port without increasing the air flow velocity in the neighborhood of the short sides at both the sides of the air blow-out port in the longitudinal direction. Therefore, stain of a ceiling plane by smudging can be suppressed without making a user feel any draft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a side cross-sectional view showing an in-ceiling embedded type air conditioner according to an embodiment of the present invention;

Fig. 2 is a plan view showing a face panel secured to the in-ceiling embedded type air conditioner;

Fig. 3 is a cross-sectional view taken along A-A of Fig. 2;

Fig. 4 is a cross-sectional view taken along B-B of Fig. 2;

Fig. 5 is a diagram showing a state that a flap is shifted to a horizontally air-blowing position; and

Fig. 6 is a diagram showing a state that the flap is shifted to a downward air-blowing position.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0014] A preferred embodiment according to the present invention will be described hereunder with reference to the accompanying drawings.

[0015] Fig. 1 is a side cross-sectional view showing an in-ceiling embedded type air conditioner according to an embodiment of the present invention, and Fig. 2 is a plan view showing a face panel of the in-ceiling embedded type air conditioner when viewed from a room side to be air-conditioned.

[0016] As shown in Fig. 1, the in-ceiling embedded type air conditioner has an air conditioner main body 1 formed of a steel plate, and mounted while suspended from the ceiling by suspending bolts 2.

[0017] The air conditioner main body 1 is designed in a substantially rectangular box-shape having an opened lower surface. In Fig. 1, the lower side of the air conditioner main body 1 corresponds to a room to be air-conditioned. A heat insulating member 3 of foamed polystyrene is disposed substantially in contact with the inner surface of the side plate 1A of the air conditioner main body 1 to thereby prevent dew condensation at the side plate 1A.

[0018] A motor 5 is fixed to the top plate 1B of the air conditioner main body 1. A vane wheel 7 is secured to the shaft of the motor 5, and the motor 5 and the vane wheel 7 constitutes an air blower 9. A heat exchanger 11 which is bent (crooked) in a substantially rectangular shape so as to surround the side of the air blower 9. A drain pan 13 formed of foamed polystyrene is disposed at the lower side of the heat exchanger 11 so as to cover the lower surface 11A of the heat exchanger 11. The drain pan 13 receives drain water occurring in the heat exchanger 11, and various kinds of parts such as a nozzle 17 of the air blower 9, an electrical component box (not shown), etc. are fixed to the drain pan 13 by screws.

[0019] As shown in Figs. 1 and 2, the face panel 21 having the substantially rectangular shape is secured to the lower surface of the air conditioner main body 1 so as to cover a lower-side opening of the air conditioner main body 1. Air blow-out ports 24 through which air-conditioned air is supplied into the room to be air-conditioned are formed along four sides of the face panel 21. As shown in Fig. 2, each of the air blow-out ports in the four directions is provided with a flap 27 for changing the air blow-out direction. Furthermore, an air suction grill 26 is detachably mounted on the face panel 21 to be located at the center portion surrounded by the air blow-out ports 23 and at the lower side of the air blower 9. An air suction port 22 is formed in the air suction grill 26 so as to face the room to be air-conditioned. The air suction grill 26 is secured to the face panel 21 through a filter 25.

[0020] Accordingly, the air in the room to be air-conditioned is sucked from the air suction port 22 by the air blower 9, passed through the filter 25 and further the heat exchanger to be heat-exchanged, and then fed out from

the air blow-out port 23 into the room to be air-conditioned.

[0021] In this embodiment, each of the air blow-out ports in the four directions is compartmented by a pair of long sides 23A and 23B and a pair of short sides 23C and 23D at the position of the surface 21B of the face panel 21, and when viewed from the surface 21B, the air blow-out port is designed to have a trapezoidal shape which gradually expands in width toward the outer edge 21A side of the face panel 21 (i.e., spatulate form).

[0022] Fig. 3 is a cross-sectional view taken along B-B of Fig. 2, and Fig. 5 is a diagram showing a state that the flap 27 is shifted to a horizontally blow-out position under cooling operation, for example.

[0023] As shown in Figs. 3 and 4, the long side 23A at the outer edge side is designed so that a curved surface 23G is curved toward and terminates at the back side of the air blow-out port 23. The curved surface 23G serves as a common curved surface both at the position of Fig. 3 (both the sides of the air blow-out port) and the position of Fig. 4 (the center of the air blow-out port) in the area from the back side of the air blow-out port 23 till A point. In the area from the position of the point till the long side 23A, the curved surface 23G at the center of the air blow-out port (Fig. 4) is more greatly curved than the curved surface 23G at both the sides of the air blow-out port (Fig. 3). That is, with respect to the curvature of the curved surface 23G from the A point till the long side 23A, the curvature ($1/R_4$, see Fig. 4) at the center portion of the air blow-out port in the longitudinal direction of the air blow-out port 23 is larger than the curvature ($1/R_5$, see Fig. 3) at both the side portions of the air blow-out port in the longitudinal direction. Here, as shown in Fig. 3, the A point is located at the substantially half height of the whole height H of the air blow-out port in the depth (backward) direction thereof.

[0024] In this embodiment, as shown in Fig. 5, a line L2 at the back end 23E is substantially linear, and a line L3 of the long side 23 is outwardly curved in a convex shape so as to greatly protrude at the center in the longitudinal direction. As shown in Figs. 3 and 4, the long side 23B at the inner edge side is gently sloped to the back side of the air blow-out port 23, and terminates at the back end 23F. The positions of the long side 23B and the back end 23F are not varied in the longitudinal direction of the air blow-out port 23, and thus as shown in Fig. 3, both a line L4 at the long side 23B and a line L5 at the back end 23F are linear.

[0025] The substantially rectangular flap 27 for changing the air flowing direction is disposed at each air blow-out port 23. The flap 27 has a front face 27A and a back face 27B, and is pivotally mounted on a pair of short sides 23C and 23D through a hinge portion (shaft) 28 provided at the center in the width direction of the back face 27B. The shaft 28 is joined to a driving motor (not shown). As shown in Fig. 5, the line L1 of the front edge 27F of the flap 27 is curved to be convex outwardly, and the line L6 of the rear edge 27D of the flap 27 is substantially linear.

That is, the front edge 27C of the flap 27 and the outer edge 23A of the air blow-out port 23 which corresponds to the front edge 27C are curved to be convex outwardly.

[0026] As shown in Figs. 3 to 5, the width from the long side 23A at the outer edge side till the back end 23E is set to W1 at the position of Fig. 3 (at both the sides of the air blow-out port) and W2 at the position of Fig. 4 (the center of the air blow-out port) ($W2 > W1$) in plan view. As shown in Fig. 5, the interval between the front edge 27C of the flap 27 and the back end 23E of the air blow-out port 23 is set to t1 at both the sides of the air blow-out port and t2 (=0) at the center of the air blow-out port.

[0027] Furthermore, the curvature (1/R1) of the line L1 of the front edge 27C of the flap is substantially equal to the curvature (1/R2) of the line L3 of the outer edge 23A of the air blow-out port, or slightly larger than the curvature (1/R2) of the line L3.

[0028] In this embodiment, as shown in Fig. 5, when the flap 27 is shifted to the horizontally air blow-out position, the interval between the front edge 27C of the flap 27 and the back end 23E of the air blow-out port 23 increases as the position is shifted to both the sides of the air blow-out port 23 in the longitudinal direction. Accordingly, when the cross-section of the air blow-out port 23 is viewed, the air blow-out opening having substantially the same area between the position of Fig. 3 and the position of Fig. 4 can be secured, and thus substantially the same air flow amount can be secured at the center and both the sides of the air blow-out port 23.

[0029] Furthermore, as shown in Fig. 5, the pair of short sides 23C and 23D are sloped sideward, and the air blow-out port 23 is designed in such a trapezoidal shape as to gradually expand in width toward the outer edge 21A of the face panel 21. Therefore, at both the sides of the air blow-out port 23 in the longitudinal direction, the air does not suffer flow path resistance of the short sides 23C and 23D and thus it can smoothly flow.

[0030] Accordingly, the phenomenon that the air flow velocity increases more greatly at both the pair of short sides 23C and 23D than that at the center portion can be prevented, and substantially uniform air flow amount and air flow velocity can be attained in the longitudinal direction from the air blow-out port 23. Therefore, occurrence of so-called smudging which is caused by the increase of the air flow velocity at the short sides 23C and 23D can be prevented.

[0031] The shape of the long side 23A of the air blow-out port 23 is set to have a constant curvature (1/R2), (1/R4) or (1/R5). Therefore, as indicated by an arrow of Fig. 5, air flow along the shape of the long side 23A of the air blow-out port 23 occurs, and the air flow expands in the horizontal direction with Coanda effect. In this construction, the same Coanda effect is obtained for all the four air blow-out ports 23, and the air flow from each of the air blow-out port expands horizontally. By totalizing these air flows, a circle flow (circle air flow) phenomenon that air flow expands substantially over 360° is obtained.

[0032] In this construction, the circle air flow can be

implemented and gentle air flow expanding in all the directions can be obtained. Therefore, air flow which has little temperature variation, can suppress undesirable draft feeling and also is comfortable and gentle can be uniformly delivered to the overall room.

[0033] Furthermore, it was found in a past experimental result that when the air flow velocity from the air blow-out port 23 was equal to 1m/sec or more, the ceiling plane is more easily splashed.

[0034] In this construction, the air blow-out port 23 from the center to both the sides of the air blow-out port 23 in the longitudinal direction is designed so that the air flow velocity from the air blow-out port to the ceiling plane is equal to 1m/sec or less. That is, the air flow velocity at both the sides when the flap 27 is set to the horizontally air blowing position is set to 1m/sec or less.

[0035] According to this embodiment, as shown in Fig. 6, when the flap 27 is shifted to the downward air blow-out position under heating operation or the like, the opening area of the air blow-out port 23 is substantially constant in the longitudinal direction. In addition, in this case, the area of the opening is maximum.

[0036] As described above, in the above construction, the positional relationship between the flap 27 and the air blow-out port 23 is not uniform. The flap 27 is shifted to the horizontal position, the downward blowing position or the intermediate position therebetween, whereby the opening area of the air blow-out port 23 is varied as described above.

[0037] The present invention is not limited to the above embodiment, and various modifications may be made without departing from the subject matter of the present invention.

Claims

1. An in-ceiling embedded type air conditioner including an air conditioner main body (1) having a heat exchanger (11) and an air blower (9) mounted therein and a face panel (21) that is mounted on a ceiling plane while assembled with the air conditioner main body and has air blow-out ports (23) for blowing air in four directions, **characterized in that** each of the air blow-out ports has a trapezoidal shape which gradually expands in width toward the outer edge of the face panel.
2. The in-ceiling embedded type air conditioner according to claim 1, wherein a flap (27) is provided at each of the air blow-out ports, and a front edge (27C) of the flap is curved to be convex outwardly.
3. The in-ceiling embedded type air conditioner according to claim 1 or 2, wherein an outer long side (23A, 23B) of the air blow-out port (23) has a curved face (23G) that is curved toward a back end (23E) of the air blow-out port, and the curved face is common to

the center and both the sides of the air blow-out port in the longitudinal direction thereof from the back-end position till a predetermined position of the air blow-out port and is more greatly curved at the center of the air blow-out port than at both the sides of the air blow-out port from the predetermined position till the surface position of the long side so that the curvature at the center in the longitudinal direction of the air blow-out port is larger than the curvature at both the sides in the longitudinal direction of the air blow-out port.

4. The in-ceiling embedded type air conditioner according to claim 2 or 3, wherein when the flap is shifted to a horizontally air blowing position, the interval between the front edge of the flap and the back end of the air blow-out port increases as the position of the air blow-out port is shifted to both the sides in the longitudinal direction thereof.
5. The in-ceiling embedded type air conditioner according to any one of claims 2 to 4, wherein when the flap is shifted to a downwardly air blowing position, an opening area of the air blowing port is maximum.
6. The in-ceiling embedded type air conditioner according to any one of claims 1 to 5, wherein all the air blow-out ports in the four directions expand current flow in a horizontal direction, thereby implementing circle flow.

FIG.1

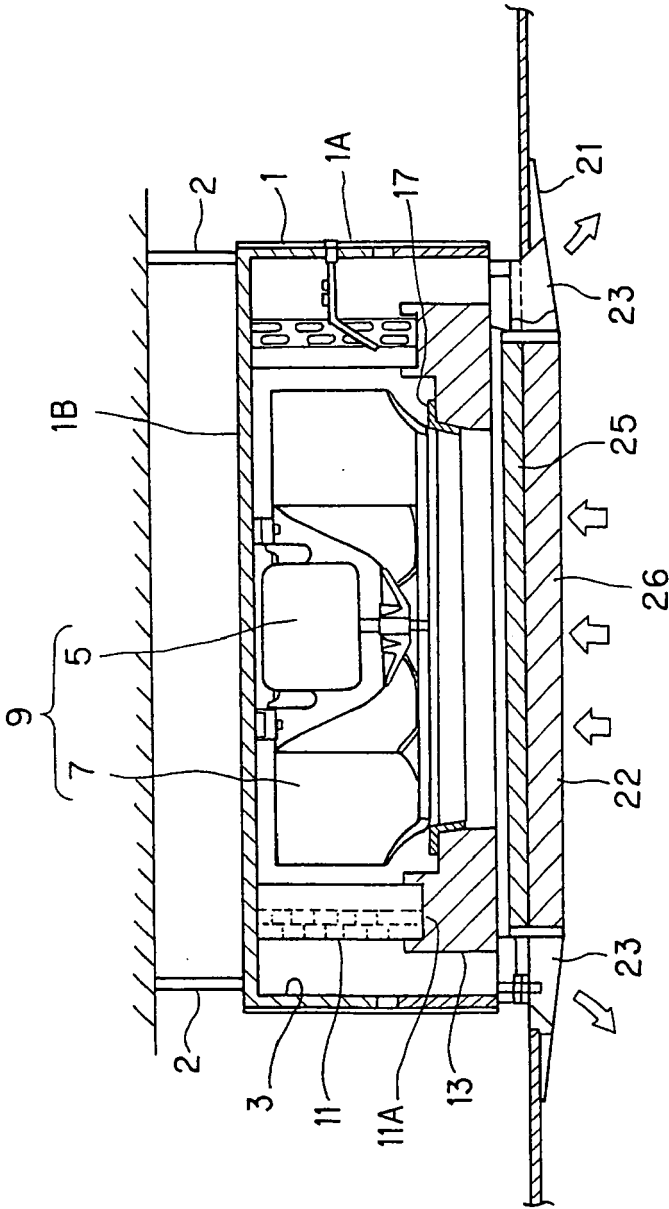


FIG.2

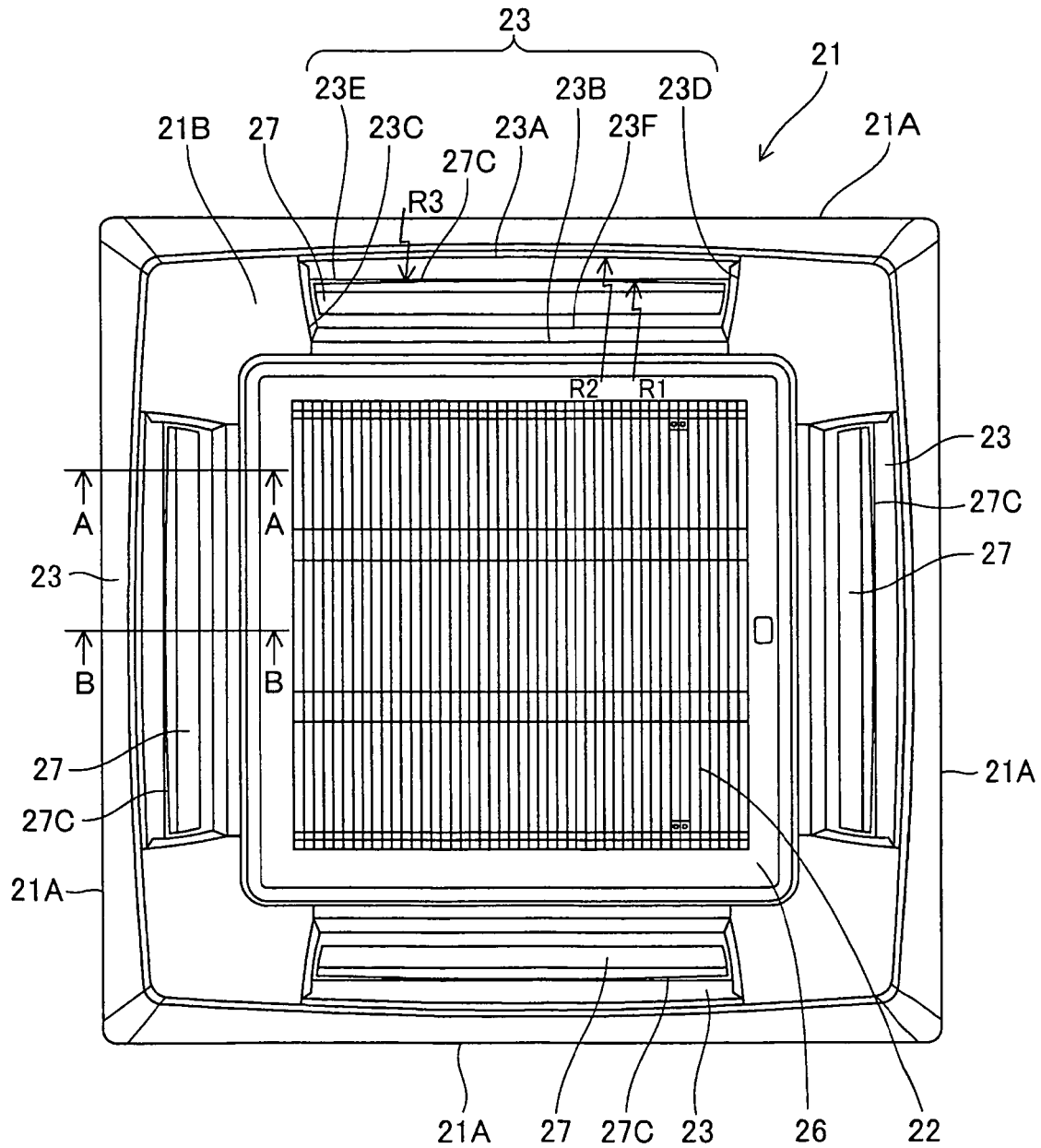


FIG.3

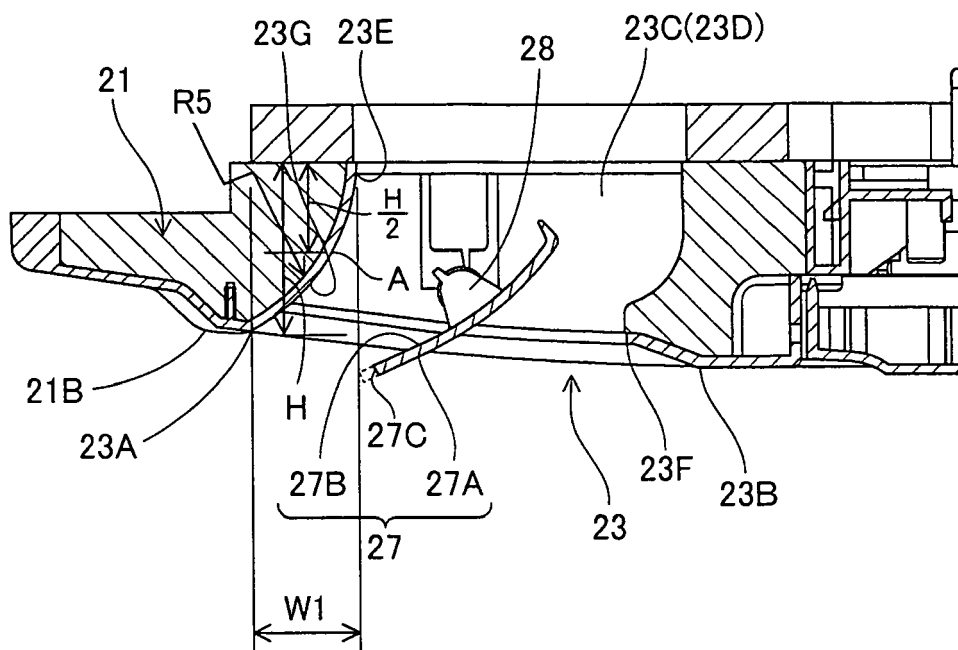


FIG.4

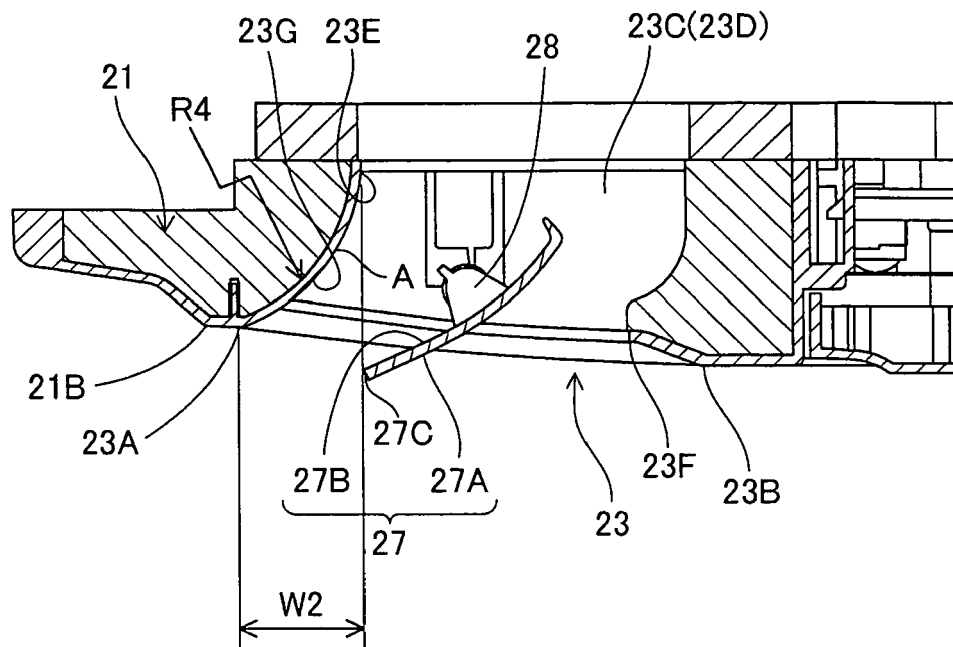


FIG.5

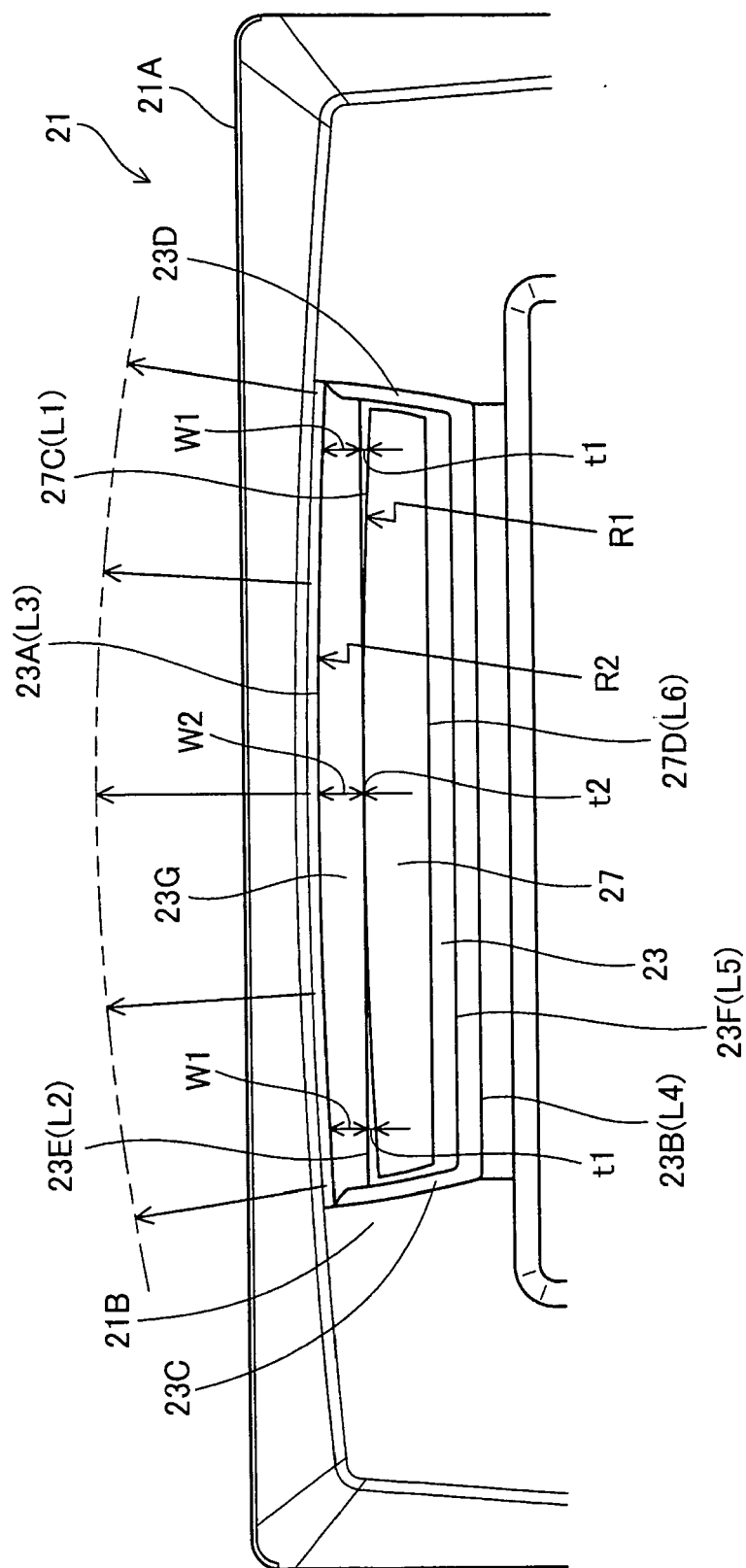
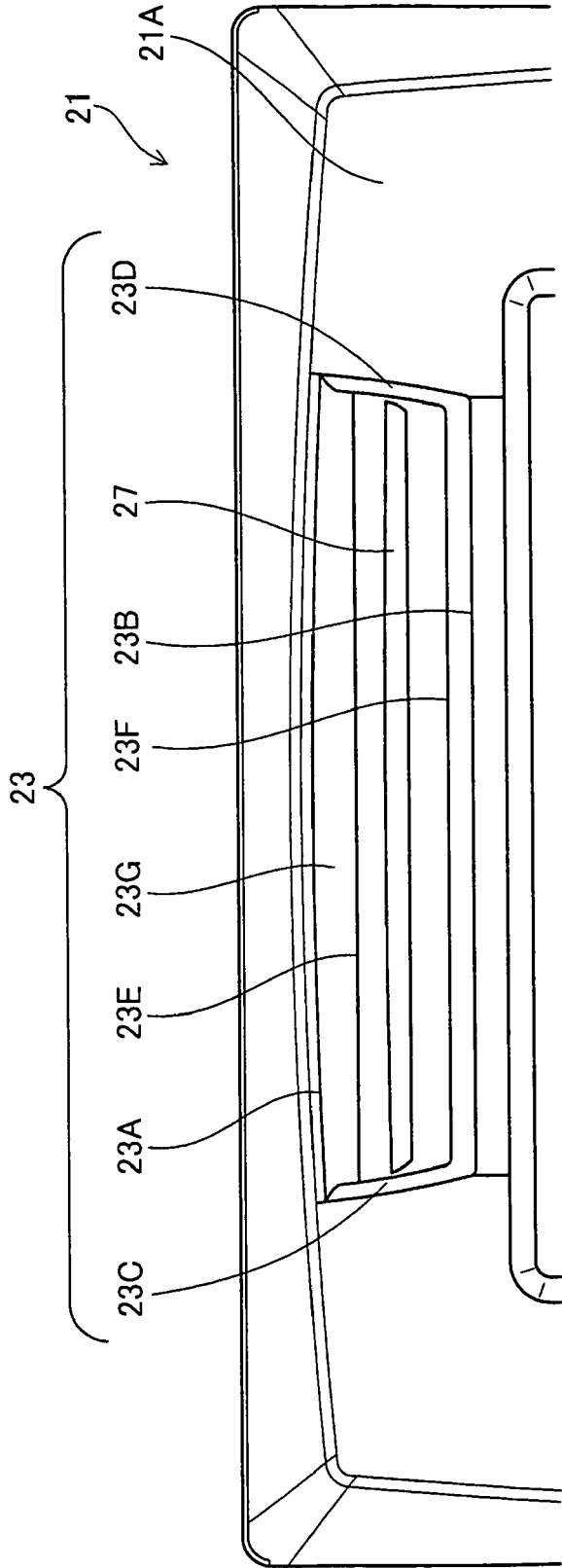


FIG.6



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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