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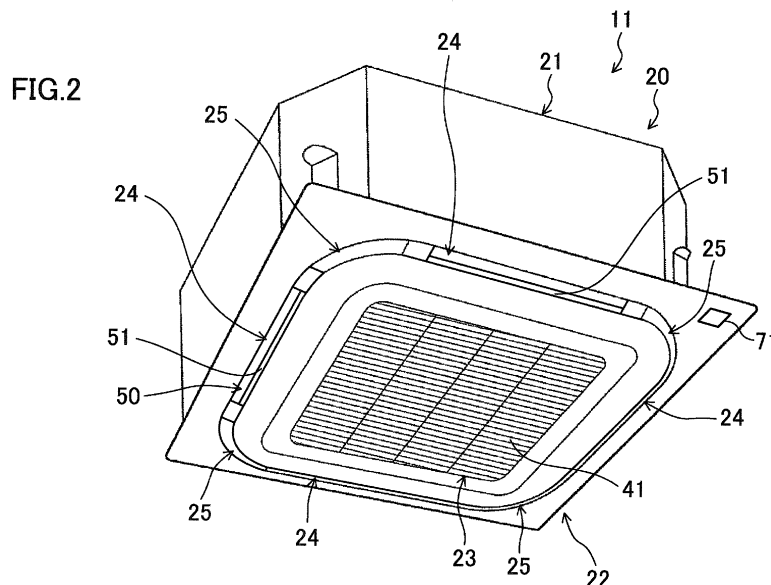
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(54) **AIR-CONDITIONING-DEVICE INDOOR UNIT**

(57) Disclosed herein is an indoor unit including: a load detector (71) for detecting a heavy-load area to bear a relatively heavy air-conditioning load during a heating mode of operation and a light-load area to bear a lighter air-conditioning load than the heavy-load area from a perimeter zone of a space to be air-conditioned (R); and an air volume adjuster (50) for setting the volume of air blown

toward the light-load area to be lower than that of air blown toward the heavy-load area in a horizontal blowing mode. This allows the entire room, including the perimeter zone, to be air-conditioned efficiently during the heating mode of operation with temperature non-uniformity reduced in the room.



Description

TECHNICAL FIELD

[0001] The present invention relates to an indoor unit for an air conditioner, and more particularly relates to a technique for controlling an airflow while an indoor unit mounted on a ceiling is performing a heating mode of operation.

BACKGROUND ART

[0002] Some known air conditioners adopt a so-called "zoned air conditioning" technique, in which the target space is divided into a perimeter zone and an interior zone to be air-conditioned separately, and change their mode of operation according to a given air-conditioning load in the perimeter zone (see, for example, Patent Document 1).

[0003] The air conditioner disclosed in Patent Document 1 uses a floor indoor unit. This air conditioner is configured to blow air through an upper air outlet of the indoor unit when a heavy air-conditioning load is imposed in the perimeter zone while the target space to be air-conditioned is being heated and to start blowing the air through a lower air outlet to heat the air at the user's feet when the air-conditioning load in the perimeter zone decreases.

CITATION LIST

PATENT DOCUMENT

[0004] PATENT DOCUMENT 1: Japanese Unexamined Patent Publication No. H04-028946

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] The air conditioner disclosed in Patent Document 1 is designed to blow the air through the upper air outlet by detecting the load in the perimeter zone. Even so, the air conditioner still blows the air-conditioning air toward the entire perimeter zone. That is why any significant non-uniformity in the air-conditioning load in the perimeter zone hampers the air conditioner from conditioning the air efficiently enough.

[0006] Meanwhile, a ceiling-mounted air conditioner indoor unit is generally designed to perform a heating mode of operation by blowing air-conditioning air downward in order to heat the interior zone and supply that heated air to the perimeter zone. This type of airflow control, however, could form a non-uniform temperature distribution inside the room, because part of the heated air downwardly blown by the indoor unit would rise, instead of falling and reaching out for the perimeter, to decrease the volume of the air reaching the perimeter.

[0007] In view of the foregoing background, it is therefore an object of the present invention to provide a technique for air-conditioning the entire target space, including the perimeter zone, efficiently with the temperature non-uniformity reduced while performing a heating mode of operation.

SOLUTION TO THE PROBLEM

[0008] A first aspect of the present disclosure is directed to an air conditioner indoor unit including a casing (20) mounted on a ceiling (U) of a space to be air-conditioned (R). The casing (20) has a plurality of air outlets (24, 25) configured to blow air in multiple blowing directions in a horizontal blowing mode.

[0009] This indoor unit further includes: a load detector (71) configured to detect a heavy-load area to bear a relatively heavy air-conditioning load during a heating mode of operation and a light-load area to bear a lighter air-conditioning load than the heavy-load area from a perimeter zone of the space to be air-conditioned (R); an air volume adjuster (50) configured to perform an air volume adjustment operation such that a smaller volume of air is blown toward the light-load area than toward the heavy-load area in the horizontal blowing mode; and an operation controller (70) including an air volume controller (72) configured to control the air volume adjustment operation by the air volume adjuster (50). As used herein, the "horizontal blowing mode" refers to a mode in which the air is blown substantially horizontally (or may be slightly obliquely downward) such that the air can reach a location distant from the indoor unit (11) in the room.

[0010] According to this first aspect, performing the air volume adjustment operation in the horizontal blowing mode during a heating mode of operation results in a smaller volume of the air blown toward the light-load area than the air blown toward the heavy-load area. Stated otherwise, this results in a larger volume of the air blown toward the heavy-load area than the air blown toward the light-load area. As can be seen, a greater volume of air is blown toward the heavy-load area that is at a lower temperature than in the light-load area while air is being blown in the horizontal blowing mode. Thus, according to the present invention, the heavy-load area of the perimeter zone is supplied with heated air first to have its temperature raised, resulting in a less significant temperature difference between the light-load area and the heavy-load area.

[0011] A second aspect of the present disclosure is an embodiment of the first aspect of the present disclosure. In the second aspect, the air volume controller (72) performs control that allows a greater volume of air to be blown toward the heavy-load area during the air volume adjustment operation in the horizontal blowing mode than during an operation in which air is blown uniformly in all directions.

[0012] According to this second aspect, a greater volume of air is blown toward the heavy-load area during

the air volume adjustment operation than during an operation in which air is blown uniformly in all directions, and therefore, heated air blown by the indoor unit is reliably supplied to the heavy-load area. This reduces the temperature difference between the light- and heavy-load areas with reliability.

[0013] A third aspect of the present disclosure is an embodiment of the first or second aspect of the present disclosure. In the third aspect, the air volume adjuster (50) is configured as airflow direction adjusting vanes (51) provided for the air outlets (24, 25). The air volume controller (72) sets the area of a gap between respective opening edges of the air outlets (24, 25) through which air is blown toward the light-load area and respective peripheral edges of the airflow direction adjusting vanes (51) to be smaller than the area of a gap between the respective opening edges of the air outlets (24, 25) through which the air is blown toward the heavy-load area and the respective peripheral edges of the airflow direction adjusting vanes (51) by adjusting an angle of the airflow direction adjusting vanes (51) during the air volume adjustment operation.

[0014] According to this third aspect, adjusting the angle of the airflow direction adjusting vanes (51) using the air volume controller (72) during the air volume adjustment operation sets the area of a gap between respective opening edges of the air outlets (24, 25) through which air is blown toward the light-load area and respective peripheral edges of the airflow direction adjusting vanes (51) to be smaller than the area of a gap at the air outlets through which the air is blown toward the heavy-load area, thus resulting in greater ventilation resistance. This decreases the volume of the air blown toward the light-load area and relatively increases the volume of the air blown toward the heavy-load area. In addition, the volume of the air blown toward the heavy-load area becomes greater than that of the air during the operation in which the air is blown uniformly in all directions. Consequently, this decreases the temperature difference between the light- and heavy-load areas with reliability.

[0015] A fourth aspect of the present disclosure is an embodiment of any one of the first to third aspects of the present disclosure. In the fourth aspect, the operation controller (70) is configured to select the horizontal blowing mode from a plurality of blowing modes (e.g., the horizontal blowing mode and a downward blowing mode).

[0016] According to this fourth aspect, the horizontal blowing mode may be selected from a plurality of blowing modes and the air volume adjustment operation may be performed in the horizontal blowing mode. Thus, if the load in the heavy-load area has increased to beyond a predetermined value in the perimeter zone while operation is being performed in another mode, the air volume adjustment operation may be performed as needed in the horizontal blowing mode so as to reduce the temperature difference between the light- and heavy-load areas.

[0017] A fifth aspect of the present disclosure is an

embodiment of any one of the first to fourth aspects of the present disclosure. In the fifth aspect, the air conditioner indoor unit further includes an input device (73) allowing a user to indicate whether or not there is any wall surface (W) in the space to be air-conditioned (R). The air volume controller (72) performs control that restricts the air blowing direction to a direction leading to the wall surface (W) during the air volume adjustment operation in the horizontal blowing mode.

[0018] According to this fifth aspect, the input device (73) allows the user to indicate whether or not there is any wall surface (W), thus enabling the air conditioner to perform the air volume adjustment operation with the air blowing direction restricted to a direction leading to the wall surface. Blowing air in a direction leading to no wall surfaces would produce no circulating airflow in the space to be air-conditioned (R). However, blowing the air in such a direction leading to a wall surface would produce a circulating airflow there, thus making the temperature in the space to be air-conditioned (R) uniform.

ADVANTAGES OF THE INVENTION

[0019] According to the first aspect of the present disclosure, the load detector (71) may detect a heavy-load area to bear a relatively heavy air-conditioning load during a heating mode of operation and a light-load area to bear a lighter air-conditioning load than the heavy-load area from a perimeter zone of the space to be air-conditioned (R). Then, the air volume controller (72) of the operation controller (70) controls the air volume adjuster (50) in the horizontal blowing mode to perform an air volume adjustment operation such that a smaller volume of air is blown toward the light-load area than toward the heavy-load area, which results in a less significant temperature difference between the heavy- and light-load areas. This reduces temperature non-uniformity in the space to be air-conditioned, thus enabling highly efficient heating mode of operation.

[0020] According to the second aspect of the present disclosure, a greater volume of air is blown toward the heavy-load area during the air volume adjustment operation than during an operation in which air is blown uniformly in all directions, thus reducing the temperature difference between the light- and heavy-load areas with reliability. This allows for further reducing the temperature non-uniformity in the space to be air-conditioned and performing the heating mode of operation even more efficiently.

[0021] The third aspect of the present disclosure easily provides a configuration for allowing a greater volume of air to be blown toward the heavy-load area during the air volume adjustment operation than during an operation in which the air is blown uniformly in all directions just by adjusting the angle of the airflow direction adjusting vanes (51). This allows for further reducing the temperature non-uniformity in the space to be air-conditioned and performing the heating mode of operation even more

efficiently.

[0022] According to the fourth aspect of the present disclosure, the horizontal blowing mode may be selected from a plurality of blowing modes. In addition, selecting the horizontal blowing mode allows the air volume adjustment operation to be performed if the load in the heavy-load area has increased to beyond a predetermined value in the perimeter zone while operation is being performed in another mode. This reduces the temperature difference between the light- and heavy-load areas. After that, the operation may be performed with another mode (e.g., downward blowing mode) selected instead of the horizontal blowing mode.

[0023] According to the fifth aspect of the present disclosure, the input device (73) allows the user to indicate whether or not there is any wall surface (W), thus enabling the air to be blown in only a direction in which a circulating airflow is produced in the space to be air-conditioned during the air volume adjustment operation. This reduces the temperature non-uniformity in the room and improves the efficiency of operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

[FIG. 1] FIG. 1 is a refrigerant circuit diagram for an air conditioner according to an embodiment of the present invention.

[FIG. 2] FIG. 2 is a perspective view illustrating an indoor unit for the air conditioner shown in FIG. 1.

[FIG. 3] FIG. 3 is a schematic plan view of an indoor unit as viewed from over the unit with its top panel removed.

[FIG. 4] FIG. 4 is a schematic cross-sectional view of the indoor unit (11) taken along the plane IV-IV shown in FIG. 3.

[FIG. 5] FIG. 5 is a schematic bottom view of the indoor unit.

[FIG. 6] FIGS. 6A, 6B, and 6C are partial cross-sectional views of the indoor unit in three different states where an airflow direction adjusting vane is set at a horizontal blowing position, a downward blowing position, and a blowing regulated position, respectively.

[FIG. 7] FIG. 7 is a perspective view illustrating an exemplary arrangement of an indoor unit in a room.

[FIG. 8] FIG. 8A is a diagram showing how the indoor unit shown in FIG. 1 blows the air in four directions in the horizontal blowing mode, and FIG. 8B is a diagram showing how the indoor unit shown in FIG. 1 blows the air in two directions in the horizontal blowing mode.

[FIG. 9] FIG. 9 shows the flow of heated air and a temperature distribution in a vertical cross section of a room subjected to an airflow control of this embodiment.

[FIG. 10] FIG. 10 shows the flow of heated air and a temperature distribution in a vertical cross section of

a room subjected to a conventional downward blowing operation.

[FIG. 11] FIG. 11A shows a temperature distribution in a transverse cross section of a room subjected to the airflow control of this embodiment at a constant blowing temperature, and FIG. 11B shows a temperature distribution in a transverse cross section of a room subjected to the conventional airflow control at a constant blowing temperature.

[FIG. 12] FIG. 12A shows a temperature distribution in a transverse cross section of a room subjected to the airflow control of this embodiment at a constant feed capacity, and FIG. 12B shows a temperature distribution in a transverse cross section of a room subjected to the conventional airflow control at a constant feed capacity.

DESCRIPTION OF EMBODIMENTS

[0025] Embodiments of the present invention will now be described with reference to the accompanying drawings.

[0026] An embodiment of the present invention is an air conditioner (1) for cooling and heating indoor air. As illustrated in FIG. 1, the air conditioner (1) includes an outdoor unit (10) installed outdoors and an indoor unit (11) installed indoors. The outdoor and indoor units (10, 11) are connected to each other via two communication pipes (2, 3), thus forming a refrigerant circuit C in this air conditioner (1). The refrigerant circuit C circulates a refrigerant injected therein to perform a vapor compression refrigeration cycle.

<Configuration for Refrigerant Circuit>

[0027] In the outdoor unit (10), connected together are a compressor (12), an outdoor heat exchanger (13), an outdoor expansion valve (14), and a four-way switching valve (15). The compressor (12) compresses a low-pressure refrigerant, and discharges a high-pressure refrigerant thus compressed. In the compressor (12), a compression mechanism such as a scroll or rotary compression mechanism is driven by a compressor motor (12a). The compressor motor (12a) is configured so that the number of revolutions (i.e., the operation frequency) thereof can be changed by an inverter.

[0028] The outdoor heat exchanger (13) is a fin-and-tube heat exchanger. An outdoor fan (16) is installed near the outdoor heat exchanger (13). In the outdoor heat exchanger (13), the air transported by the outdoor fan (16) exchanges heat with the refrigerant. The outdoor fan (16) is configured as a propeller fan driven by an outdoor fan motor (16a). The outdoor fan motor (16a) is configured so that the number of revolutions thereof can be changed by an inverter.

[0029] The outdoor expansion valve (14) is configured as an electronic expansion valve, of which the degree of opening is variable. The four-way switching valve (15)

includes first to fourth ports. In the four-way switching valve (15), the first port is connected to a discharge side of the compressor (12), the second port is connected to a suction side of the compressor (12), the third port is connected to a gas-side end portion of the outdoor heat exchanger (13), and the fourth port is connected to a gas-side shutoff valve (5). The four-way switching valve (15) is switchable between a first state (a state indicated by the solid curves in FIG. 1) and a second state (a state indicated by the broken curves in FIG. 1). In the four-way switching valve (15) in the first state, the first port communicates with the third port, and the second port communicates with the fourth port. In the four-way switching valve (15) in the second state, the first port communicates with the fourth port, and the second port communicates with the third port.

[0030] The two communication pipes are comprised of a liquid communication pipe (2) and a gas communication pipe (3). The liquid communication pipe (2) has one end connected to the liquid-side shutoff valve (4) and the other end connected to a liquid-side end portion of the indoor heat exchanger (32). The gas communication pipe (3) has one end connected to the gas-side shutoff valve (5) and the other end connected to a gas-side end portion of the indoor heat exchanger (32).

[0031] The indoor unit (11) includes an indoor heat exchanger (32) and an indoor expansion valve (39). The indoor heat exchanger (32) is a fin-and-tube heat exchanger. An indoor fan (31) is installed near the indoor heat exchanger (32). The indoor fan (31) is a centrifugal blower driven by an indoor fan motor (31 a) as will be described later. The indoor fan motor (31 a) is configured so that the number of revolutions thereof can be changed by an inverter. The indoor expansion valve (39) is connected to the liquid-side end portion of the indoor heat exchanger (32) in the refrigerant circuit C. The indoor expansion valve (39) is configured as an electronic expansion valve, of which the degree of opening is variable.

<Indoor Unit>

[0032] FIGS. 2-5 illustrate an exemplary configuration for the indoor unit (11). The indoor unit (11) is connected to the outdoor unit (10) installed outside of an indoor space (R), which is the space to be air-conditioned, through the communication pipes (2, 3), thereby forming, along with the outdoor unit (10), the air conditioner (1). The air conditioner (1) performs a cooling mode of operation and a heating mode of operation in the indoor space (R). In this example, the indoor unit (11) is configured as a ceiling-mounted type, and includes an indoor casing (20), an indoor fan (31), the indoor heat exchanger (32), a drain pan (33), and a bell mouth (34). The indoor casing (20) is mounted on the ceiling (U) of the indoor space (R), and is comprised of a casing body (21) and a decorative panel (22).

[0033] FIG. 2 is a schematic perspective view illustrating the indoor unit (11) as viewed from obliquely below

it. FIG. 3 is a schematic plan view of the indoor unit (11) as viewed from over the unit with its top panel (21 a) removed. FIG. 4 is a schematic cross-sectional view of the indoor unit (11) taken along the plane IV-IV shown in FIG. 3. FIG. 5 is a schematic bottom view of the indoor unit (11).

<Casing Body>

[0034] The casing body (21) is arranged so as to be inserted into an opening cut through the ceiling (U) of the indoor space (R). The casing body (21) is formed in a generally rectangular parallelepiped box shape with a bottom opening, and includes a generally square top panel (21a), and four generally rectangular side panels (21b) extending downward from the peripheral edges of the top panel (21a). The casing body (21) houses the indoor fan (31), the indoor heat exchanger (32), the drain pan (33), and the bell mouth (34). One (21b) of the four side panels (21b) has a through hole (H) into which an indoor refrigerant pipe (P) may be inserted to connect the indoor heat exchanger (32) and the communication pipes (2, 3) together.

<Indoor Fan>

[0035] The indoor fan (31) is arranged at the center inside the casing body (21), and laterally blows the air sucked from under the casing body (21). In this example, the indoor fan (31) is configured as a centrifugal blower, and is driven by an indoor fan motor (31 a) arranged at the center of the top panel (21a) of the casing body (21).

<Indoor Heat Exchanger>

[0036] The indoor heat exchanger (32) is formed by bending a refrigerant pipe (a heat transfer tube) so as to surround the indoor fan (31), and exchanges heat between the refrigerant flowing through the heat transfer tube (not shown and) provided inside and the air sucked into the casing body (21). The indoor heat exchanger (32) may be configured as a fin-and-tube heat exchanger, for example. Also, the indoor heat exchanger (32) serves as a refrigerant evaporator to cool the air during the cooling mode of operation, and serves as a refrigerant condenser (radiator) to heat the air during the heating mode of operation.

<Drain Pan>

[0037] The drain pan (33) is formed in a vertically thin, generally rectangular parallelepiped shape, and is arranged under the indoor heat exchanger (22). A suction passage (33a) is formed in a center area of the drain pan (33). The upper surface of the drain pan (33) has a water-receiving groove (33b). Four first blowing passages (33c) and four second blowing passages (33d) are further arranged along the outer periphery of the drain pan (33).

The suction passage (33a) vertically penetrates the drain pan (33). The water-receiving groove (33b) forms an annular ring surrounding the suction passage (33a) in a plan view. The four first blowing passages (33c) respectively extend along the four sides of the drain pan (33) so as to surround the water-receiving groove (33b) in a plan view, and vertically penetrate the drain pan (33). The four second blowing passages (33d) are respectively located at the four corners of the drain pan (33) in a plan view, and also vertically penetrate the drain pan (33).

<Bell mouth>

[0038] The bell mouth (34) has a cylindrical shape with an opening area that expands downward from its top toward its bottom. The bell mouth (34) has its top opening inserted into a suction hole (i.e., bottom opening) of the indoor fan (31) and housed in the suction passage (33a) of the drain pan (33). This configuration guides the air sucked through the bottom opening of the bell mouth (34) to the suction hole of the indoor fan (31).

<Decorative Panel>

[0039] The decorative panel (22) is formed in a vertically thin, generally rectangular parallelepiped shape. The decorative panel (22) has a suction port (23) in its center area, and also has a plurality of air outlets (24, 25) around its outer periphery. Specifically, the plurality of air outlets (24, 25) includes four first air outlets (24) and four second air outlets (25). These air outlets (24, 25) allow the air to be blown in multiple blowing directions in the horizontal blowing mode.

[0040] The horizontal blowing mode is a mode of operation in which the air is blown almost horizontally (i.e., at an angle of almost 0 degrees with respect to the horizontal plane) to reach a location distant from the indoor unit (11) in the room. Note, however, that in this horizontal blowing mode, the air does not always have to be blown horizontally but may also be blown slightly obliquely downward as well.

«Suction Port»

[0041] The suction port (23) vertically penetrates the decorative panel (22) and communicates with the inner space of the bell mouth (34). In this example, the suction port (23) is formed in a generally square shape in a plan view. The suction port (23) is provided with a suction grille (41) and a suction filter (42). The suction grille (41) is formed in a generally square shape and has a lot of through holes in its center area. The suction grille (41) is mounted onto the suction port (23) of the decorative panel (22) to cover the suction port (23). The suction filter (42) catches dust and dirt in the air sucked through the suction grille (41).

«Air Outlets»

[0042] The four first air outlets (24) are straight air outlets respectively extending linearly along the four sides of the decorative panel (22) so as to surround the suction port (23) in a plan view, and vertically penetrate the decorative panel (22) to communicate with the four first blowing passages (33c) of the drain pan (33). In this example, the first air outlets (24) are formed in a generally rectangular shape in a plan view. The four second air outlets (25) are curved air outlets respectively located at the four corners of the decorative panel (22) in a plan view, and vertically penetrate the decorative panel (22) to communicate with the four second blowing passages (33d) of the drain pan (33).

<Airflow in Indoor Unit>

[0043] Next, it will be described with reference to FIG. 4 how the air flows in the indoor unit (11). First, when the indoor fan (31) starts running, indoor air is sucked from the indoor space (R) into the indoor fan (31) via the suction grille (41) and suction filter (42) provided for the suction port (23) of the decorative panel (22) and the inner space of the bell mouth (34) in this order. The air sucked into the indoor fan (31) is laterally blown to beside the indoor fan (31) and exchanges heat with the refrigerant flowing through the indoor heat exchanger (32) while passing through the indoor heat exchanger (32). As a result, the air passing through the indoor heat exchanger (32) is cooled while the indoor heat exchanger (32) is serving as an evaporator (i.e., during the cooling mode of operation) and is heated while the indoor heat exchanger (32) is serving as a condenser (i.e., during the heating mode of operation). Thereafter, the air that has passed through the indoor heat exchanger (32) diverges into the four first blowing passages (33c) and four second blowing passages (33d) of the drain pan (33) and then is blown into the indoor space (R) through the four first air outlets (24) and four second air outlets (25) of the decorative panel (22).

<Airflow Direction Adjusting Vanes>

[0044] The first air outlets (24) are each provided with an airflow direction adjusting vane (51) for adjusting the airflow direction of the air flowing through an associated one of the first blowing passages (33c) (i.e., the airflow direction of the blowing air). Each airflow direction adjusting vane (51) is formed in the shape of a flat plate extending from one longitudinal end of an associated first air outlet (24) of the decorative panel (22) through the other end thereof. The airflow direction adjusting vane (51) is supported by a supporting member (52) on a pivotal axis (53) extending in the length direction, and is configured to rotate freely on the pivotal axis (53). The airflow direction adjusting vane (51) has an arced transverse cross section (i.e., a cross section taken perpen-

dicularly to the length direction) which projects outward from the pivotal axis (53) of its rocking movement. None of the second air outlets (25) are provided with any airflow direction adjusting vane. However, the second air outlets (25) may also be provided with such airflow direction adjusting vanes.

[0045] The airflow direction adjusting vane (51) is a movable vane, and is configured to change its position from one of the horizontal blowing position shown in FIG. 6A, the downward blowing position shown in FIG. 6B, and the blowing regulated position shown in FIG. 6C into another in accordance with settings entered. The horizontal blowing position is selected in the horizontal blowing mode in which the air is blown horizontally through the first air outlets (24). The downward blowing position is selected in a downward blowing mode in which the air is blown downward through the first air outlets (24). The blowing regulated position is selected when blowing the air through the first air outlets (24) is regulated. Note that airflow direction adjusting vanes optionally provided for the second air outlets (25) may have substantially the same configuration, and may operate in almost the same way, as their counterparts (51) for the first air outlets (24).

[0046] In this embodiment, the horizontal blowing mode is carried out with the first air outlets (24) selectively used. If airflow direction adjusting vanes are also provided for the second air outlets (25), however, the horizontal blowing mode may also be carried out with both of the first and second air outlets (24, 25) used.

[0047] In this embodiment, an air volume controller (72) is included in the operation controller (70) implemented as a control board as shown in FIG. 1, and controlling the positions of the airflow direction adjusting vanes (51) via this air volume controller (72) allows for selecting the horizontal blowing mode from a plurality of blowing modes. Specifically, the operation controller (70) allows for selecting either the horizontal blowing mode to be carried out with the airflow direction adjusting vanes (51) set at the horizontal blowing position or the downward blowing mode in which the air is blown toward the floor (F) of the space to be air-conditioned with the airflow direction adjusting vanes (51) set at the downward blowing position.

[0048] The airflow direction adjusting vanes (51) provided for the four first air outlets (24) are controllable by the air volume controller (72) of the operation controller (70) independently of each other. If the airflow direction adjusting vane (51) is set at the blowing regulated position in at least one of the four first air outlets (24), then the area of the gap between opening edge of that particular first air outlet (24) and the peripheral edge of the airflow direction adjusting vane (51) is restricted to be smaller than the area of a gap at any other first air outlet (24), thus resulting in greater ventilation resistance. The greater the ventilation resistance, the less easily the air can be blown through the first air outlet (24). As a result, the air blown through the other first air outlets (24) comes to have an increased airflow velocity and an increased

air volume. In addition, the air blown through the first air outlet (24) where the airflow direction adjusting vane (51) is set at the blowing regulated position has so small a volume and so low a velocity that the air is sucked into the suction port (23) as it is without flowing out into the indoor space, thus causing a short-circuit there. Note that the blowing regulated position at which the gap between the opening edge of the first air outlet (24) and the peripheral edge of the airflow direction adjusting vane (51) is restricted to a small area is not limited to the position shown in FIG. 6C but may also be a position where some ventilation resistance is produced with the angle of the airflow direction adjusting vane (51) set to be even closer to 0 degrees with respect to the horizontal plane as indicated by the phantom arrows in FIG. 6A.

[0049] As can be seen, according to this embodiment, the airflow direction adjusting vanes (51) are used as the air volume adjuster (50) of the present invention, which is controlled by the air volume controller (72) of the operation controller (70). In this embodiment, the airflow direction adjusting vanes (51) are provided for only the first air outlets (24), not for any of the second air outlets (25), and therefore, the air volume adjuster (50) is also provided for only the first air outlets (24). If the airflow direction adjusting vanes are provided for the second air outlets (25), the air volume adjuster (50) is provided for the second air outlets (24) as well.

[0050] In the indoor unit (11) of this embodiment, only a single casing (20) may be arranged at the center of a room with a square ceiling (U) or square floor (F) as shown in FIG. 7, for example. The casing (20) of this indoor unit (11) has four first air outlets (24) as described above. The casing (20) may allow the air to be blown uniformly in four directions in the horizontal blowing mode as shown in FIG. 8A or may allow the air to be blown in only two mutually opposite directions in the horizontal blowing mode as shown in FIG. 8B. Although not shown, the air may also be blown in any two directions other than the ones shown in FIG. 8B or in any three directions as well. As will be described later, FIG. 8B illustrates a state of the air volume adjustment operation of the present invention in which the volume of the air blown toward the light-load area is set to be smaller than that of the air blown toward the heavy-load area.

[0051] The indoor unit (11) of this embodiment includes a load detector (sensor) (71) for detecting a heavy-load area to bear a relatively heavy air-conditioning load during a heating mode of operation and a light-load area to bear a lighter air-conditioning load than the heavy-load area from a perimeter zone in the perimeter of the indoor space (R) that is the space to be air-conditioned. The load detector (71) may be provided at a single point on the lower surface of the decorative panel (22) as shown in FIG. 2.

[0052] Furthermore, according to this embodiment, the air volume controller (72) of the operation controller (70) shown in FIG. 1 controls, based on the result of sensing obtained by the load detector (71), the angle of the airflow

direction adjusting vanes (51) in the horizontal blowing mode, thereby performing an air volume adjustment operation such that a smaller volume of the air is blown toward the light-load area than toward the heavy-load area. In particular, the air volume controller (72) of the operation controller (70) performs control that allows a greater volume of the air to be blown toward the heavy-load area during the air volume adjustment operation in the horizontal blowing mode than during an operation in which the air is blown uniformly in all directions.

-Modes of Operation-

[0053] Next, the modes of operation of the air conditioner (1) according to this embodiment will be described. The air conditioner (1) selectively performs either a cooling mode of operation or a heating mode of operation while switching its modes from one to the other.

<Cooling Mode of Operation>

[0054] During the cooling mode of operation, the four-way switching valve (15) shown in FIG. 1 is switched to the state indicated by the solid curves to activate the compressor (12), the indoor fan (31), and the outdoor fan (16). Thus, the refrigerant circuit C performs a refrigeration cycle in which the outdoor heat exchanger (13) serves as a condenser and the indoor heat exchanger (32) serves as an evaporator.

[0055] Specifically, a high-pressure refrigerant compressed by the compressor (12) flows through the outdoor heat exchanger (13) to exchange heat with the outdoor air. In the outdoor heat exchanger (13), the high-pressure refrigerant dissipates its heat into the outdoor air and condenses. The refrigerant condensed in the outdoor heat exchanger (13) is then sent to the indoor unit (11), in which the refrigerant has its pressure reduced by the indoor expansion valve (39) and then flows through the indoor heat exchanger (32).

[0056] In the indoor unit (11), the indoor air flows upward through the suction hole (23) and the inner space of the bell mouth (34) in this order, and then is sucked into the indoor fan (31). The air is then blown radially outward from the indoor fan (31). This air passes through the indoor heat exchanger (32) and exchanges heat with the refrigerant. In the indoor heat exchanger (32), the refrigerant absorbs heat from the indoor air and evaporates, thereby cooling the air.

[0057] The air that has been cooled by the indoor heat exchanger (32) diverges into the first and second blowing passages (33c, 33d), flows downward, and then is supplied to the indoor space (R) through the air outlets (24, 25). The refrigerant evaporated in the indoor heat exchanger (32) is sucked into the compressor (12) and compressed there again.

<Heating Mode of Operation>

[0058] During the heating mode of operation, the four-way switching valve (15) shown in FIG. 1 is switched to the state indicated by the broken curves to activate the compressor (12), the indoor fan (31), and the outdoor fan (16). Thus, the refrigerant circuit C performs a refrigeration cycle in which the indoor heat exchanger (32) serves as a condenser and the outdoor heat exchanger (13) serves as an evaporator.

[0059] Specifically, a high-pressure refrigerant compressed by the compressor (12) flows through the indoor heat exchanger (32) of the indoor unit (11). In the indoor unit (11), the indoor air flows upward through the suction hole (23) and the inner space of the bell mouth (34) in this order, and then is sucked into the indoor fan (31). The air is then blown radially outward from the indoor fan (31). This air passes through the indoor heat exchanger (32) and exchanges heat with the refrigerant. In the indoor heat exchanger (32), the refrigerant dissipates heat into the indoor air and condenses, thereby heating the air.

[0060] The air that has been heated by the indoor heat exchanger (32) diverges into the first and second blowing passages (33c, 33d), flows downward, and then is supplied to the indoor space (R) through the air outlets (24, 25). The refrigerant condensed in the indoor heat exchanger (32) has its pressure reduced by the outdoor expansion valve (14), and then flows through the outdoor heat exchanger (13), in which the refrigerant absorbs heat from the outdoor air and evaporates. The refrigerant evaporated from the outdoor heat exchanger (13) is sucked into the compressor (12) and compressed there again.

<Airflow Control during Heating Mode of Operation>

[0061] According to this embodiment, the air volume controller (72) of the operation controller (70) may perform an air volume adjustment operation such that a smaller volume of air is blown toward the light-load area than toward the heavy-load area in the horizontal blowing mode (see FIG. 8B) during the heating mode of operation. More particularly, in FIG. 8B, the airflow direction adjusting vane (51) for the first air outlets (24) through which the air is blown toward the light-load area is set at the blowing regulated position, thereby either preventing the air from being blown toward the light-load area or reducing the volume of the air blown toward that direction. This allows the heated air to be supplied preferentially to the heavy-load area in the perimeter zone.

[0062] In this state, the air will reach the heavy-load area in the perimeter zone as shown in FIG. 9. Then, the air flows downward through that heavy-load area, travels toward the center area of the room, and then rises upward to be sucked into the indoor unit (11). That is to say, a circulating airflow is produced. In a conventional general indoor unit, on the other hand, the heated air is blown downward from the indoor unit (11), and then travels to-

ward the perimeter zone. However, part of the air starts rising upward before reaching the perimeter zone as shown in FIG. 10. Consequently, only a decreased volume of air can reach the perimeter zone and a circulating airflow is less likely produced.

[0063] With this regard, performing the airflow control of this embodiment at a constant blowing temperature allows the indoor space to be air-conditioned efficiently with the indoor temperature non-uniformity reduced as shown in FIG. 11A. The conventional airflow control, on the other hand, tends to result in a larger degree of indoor temperature non-uniformity and a smaller degree of air-conditioning efficiency as shown in FIG. 11B compared with the airflow control of this embodiment. More specifically, according to FIG. 11A showing the temperature distribution obtained in two-direction blowing according to this embodiment, the suction temperature was 22.6°C, the blowing temperature was 40.0°C, and the feed capability was 3.53 kW. On the other hand, according to FIG. 11B showing the temperature distribution obtained in four-direction blowing, the suction temperature was 23.3°C, the blowing temperature was 40.0°C, and the feed capability was 4.49 kW. In FIG. 11A, the indoor space (R) had an average temperature of 21.8°C with a standard deviation of 0.26 K. In FIG. 11B, on the other hand, the indoor space (R) had an average temperature of 22.5°C with a standard deviation of 0.38 K. Note that FIGS. 11A and 11B each show the temperature distribution measured at 0.6 m over the floor (F).

[0064] Also, performing the airflow control of this embodiment at a constant feed capacity allows the indoor space to be air-conditioned efficiently with the indoor temperature non-uniformity reduced as shown in FIG. 12A. The conventional airflow control, on the other hand, tends to result in a larger degree of indoor temperature non-uniformity and a smaller degree of air-conditioning efficiency as shown in FIG. 12B compared with the airflow control of this embodiment. More specifically, according to FIG. 12A showing the temperature distribution obtained in the two-direction blowing according to this embodiment, the suction temperature was 22.6°C, the blowing temperature was 40.0°C, and the feed capability was 3.53 kW. On the other hand, according to FIG. 12B showing the temperature distribution obtained in the four-direction blowing, the suction temperature was 21.7°C, the blowing temperature was 34.7°C, and the feed capability was 3.53 kW. In FIG. 12A, the indoor space (R) had an average temperature of 21.8°C with a standard deviation of 0.26 K. In FIG. 12B, on the other hand, the indoor space (R) had an average temperature of 21.1°C with a standard deviation of 0.31 K. Note that FIGS. 12A and 12B, as well as FIGS. 11A and 11B, each show the temperature distribution measured at 0.6 m over the floor (F).

-Advantages of this Embodiment-

[0065] As can be seen from the foregoing description, according to this embodiment, the load detector (71) de-

fects a heavy-load area to bear a relatively heavy air-conditioning load during a heating mode of operation and a light-load area to bear a lighter air-conditioning load than the heavy-load area from a perimeter zone of the indoor space (R). Then, the air volume controller (72) of the operation controller (70) controls the airflow direction adjusting vanes (51) in the horizontal blowing mode to perform an air volume adjustment operation such that a smaller volume of air is blown toward the light-load area than toward the heavy-load area. In particular, setting the airflow direction adjusting vanes (51) at a blowing regulated position during the air volume adjustment operation makes the volume of the air blown toward the heavy-load area greater than that of the air blown during the operation in which the air is blown uniformly in all directions, thus reducing the difference in temperature between the heavy- and light-load areas with reliability. This reduces temperature non-uniformity in the indoor space (R), thus enabling more efficient heating mode of operation than the conventional one.

[0066] In addition, according to this embodiment, the horizontal blowing mode or the downward blowing mode may be selected by the operation controller (70). Thus, when the load in the heavy-load area has increased to beyond a predetermined value in the perimeter zone while operation is normally being performed in the downward blowing mode, the air volume adjustment operation may be performed in the horizontal blowing mode. This may reduce the temperature difference between the light- and heavy-load areas. After that, the operation may be performed in the downward blowing mode again.

-Variation of the Embodiment

[0067] In the embodiment described above, the indoor unit (11) includes the load detector (71) for detecting the perimeter load. Optionally, the air conditioner may also be configured to include a means for allowing the user to indicate whether or not there is any wall surface in perimeter zone, in addition to the load detector (71). For that purpose, an input device (73) allowing the user to indicate whether or not there is any wall surface (W) in the perimeter zone that is the space to be air-conditioned during the air volume adjustment operation in the horizontal blowing mode may be provided as shown in FIG. 1. In that case, the air conditioner may be configured to use a remote controller as the input device to be connected to the operation controller (70).

[0068] Even with such an alternative configuration adopted, making the user indicate, through the input device (73), whether or not there is any wall surface (W) in the heavy-load area also allows the heated air to be supplied first to the heavy-load area in the perimeter zone. This allows the air to be blown only in a direction leading to the wall surface to produce circulating airflow there, thus reducing the temperature non-uniformity in the indoor space (R) and efficiently air-conditioning the indoor space (R).

«Other Embodiments»

[0069] The embodiments described above may be modified as follows.

[0070] For example, in the embodiments described above, the indoor unit (11) of the air conditioner (1) is configured as a ceiling-mounted type to be fitted into the opening (O) of the ceiling (U). However, the indoor unit (11) may also be a suspended-type indoor unit to be arranged in the indoor space (R) by having its casing (20) suspended from the ceiling. Also, the blowing directions of the indoor unit (11) include at least two directions toward the heavy- and light-load areas in the perimeter zone, and therefore, do not have to be four directions or eight directions exemplified above.

[0071] Furthermore, the embodiment described above is an indoor unit which may operate in the horizontal blowing mode and the downward blowing mode. However, these blowing modes are not the only blowing modes of the indoor unit according to the present invention. For instance, the present invention is also applicable to an indoor unit including a blowing mode in which the airflow direction adjusting vanes (51) swing, as long as that indoor unit can also operate in the horizontal blowing mode. As the case may be, the present invention is also applicable to even an indoor unit configured to operate only in the horizontal blowing mode.

[0072] Furthermore, in the embodiment described above, the airflow direction adjusting vanes (51) are used as the air volume adjuster (50). However, as long as air may be supplied in mutually different volumes toward the heavy- and light-load areas in the horizontal blowing mode, any members other than the airflow direction adjusting vanes (51) may also be used as the air volume adjuster (50).

[0073] Note that the embodiments described above are mere typical examples in nature, and are not intended to limit the scope, application, or uses of the present invention.

INDUSTRIAL APPLICABILITY

[0074] As can be seen from the foregoing description, the present invention is effectively applicable as a technique for controlling the airflow of a ceiling-mounted air conditioner indoor unit during its heating mode of operation.

DESCRIPTION OF REFERENCE CHARACTERS

[0075]

- 1 Air Conditioner
- 11 Indoor Unit
- 20 Casing
- 24 First Air Outlet
- 25 Second Air Outlet
- 50 Air Volume Adjuster

- 51 Airflow Direction Adjusting Vane
- 70 Operation Controller
- 71 Load Detector
- 72 Air Volume Controller
- 5 73 Input Device
- R Indoor Space (Space to Be Air-Conditioned)
- U Ceiling
- W Wall Surface

Claims

1. An air conditioner indoor unit comprising a casing (20) mounted on a ceiling (U) of a space to be air-conditioned (R), the casing (20) having a plurality of air outlets (24, 25) configured to blow air in multiple blowing directions in a horizontal blowing mode, wherein the indoor unit further comprises:

a load detector (71) configured to detect a heavy-load area to bear a relatively heavy air-conditioning load during a heating mode of operation and a light-load area to bear a lighter air-conditioning load than the heavy-load area from a perimeter zone of the space to be air-conditioned (R);

an air volume adjuster (50) configured to perform an air volume adjustment operation such that a smaller volume of air is blown toward the light-load area than toward the heavy-load area in the horizontal blowing mode; and

an operation controller (70) including an air volume controller (72) configured to control the air volume adjustment operation by the air volume adjuster (50).

2. The air conditioner indoor unit of claim 1, wherein the air volume controller (72) performs control that allows a greater volume of air to be blown toward the heavy-load area during the air volume adjustment operation in the horizontal blowing mode than during an operation in which air is blown uniformly in all directions.

3. The air conditioner indoor unit of claim 1 or 2, wherein the air volume adjuster (50) is configured as airflow direction adjusting vanes (51) provided for the air outlets (24, 25), and the air volume controller (72) sets the area of a gap between respective opening edges of the air outlets (24, 25) through which air is blown toward the light-load area and respective peripheral edges of the airflow direction adjusting vanes (51) to be smaller than the area of a gap between the respective opening edges of the air outlets (24, 25) through which the air is blown toward the heavy-load area and the respective peripheral edges of the airflow direction ad-

justing vanes (51) by adjusting an angle of the airflow direction adjusting vanes (51) during the air volume adjustment operation.

4. The air conditioner indoor unit of any one of claims 1-3, wherein the operation controller (70) is configured to select the horizontal blowing mode from a plurality of blowing modes. 5
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5. The air conditioner indoor unit of any one of claims 1-4, comprising an input device (73) allowing a user to indicate whether or not there is any wall surface (W) in the space to be air-conditioned (R), wherein the air volume controller (72) performs control that restricts the air blowing direction to a direction leading to the wall surface (W) during the air volume adjustment operation in the horizontal blowing mode. 15
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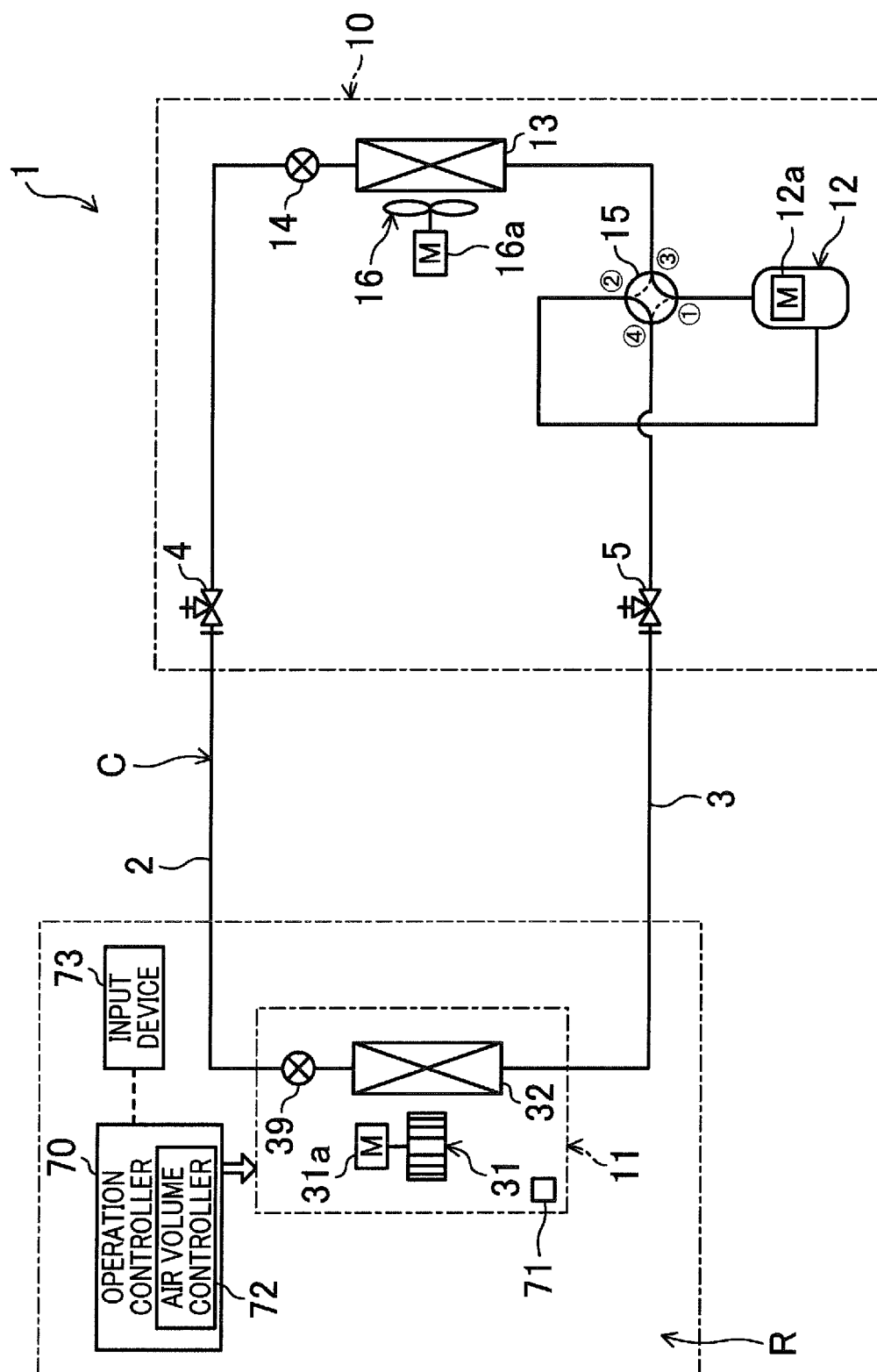
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FIG. 1

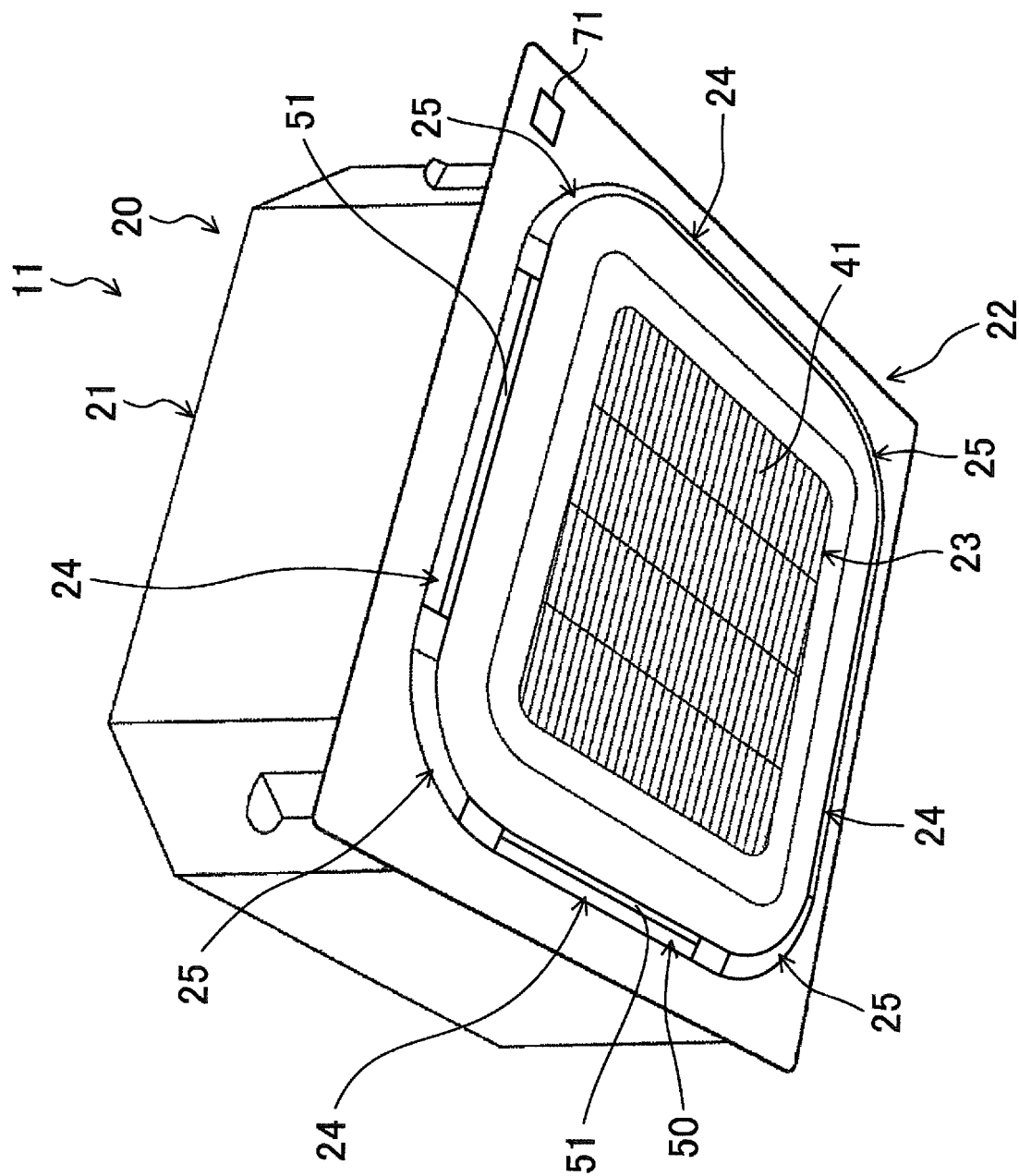
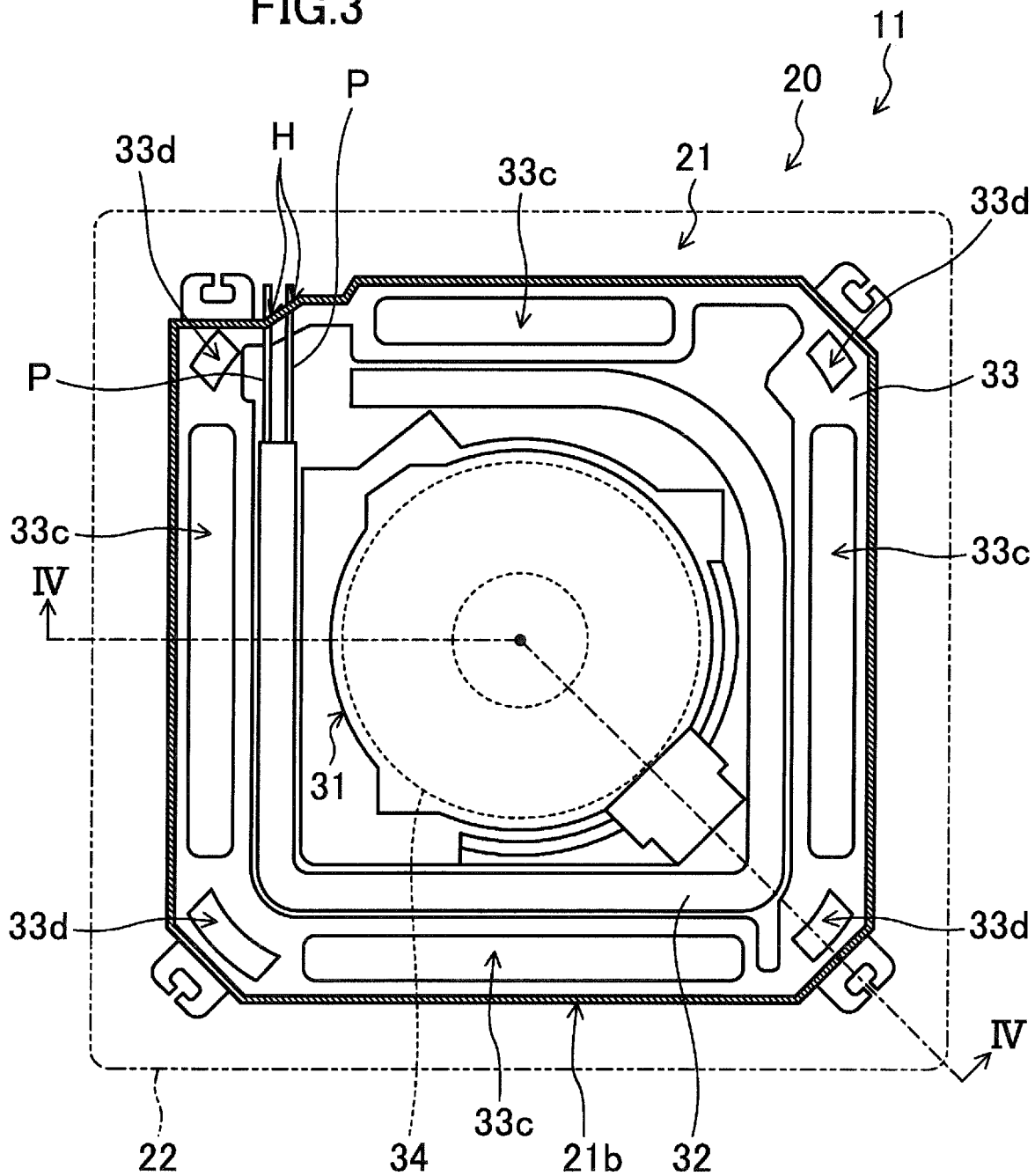


FIG. 2

FIG.3



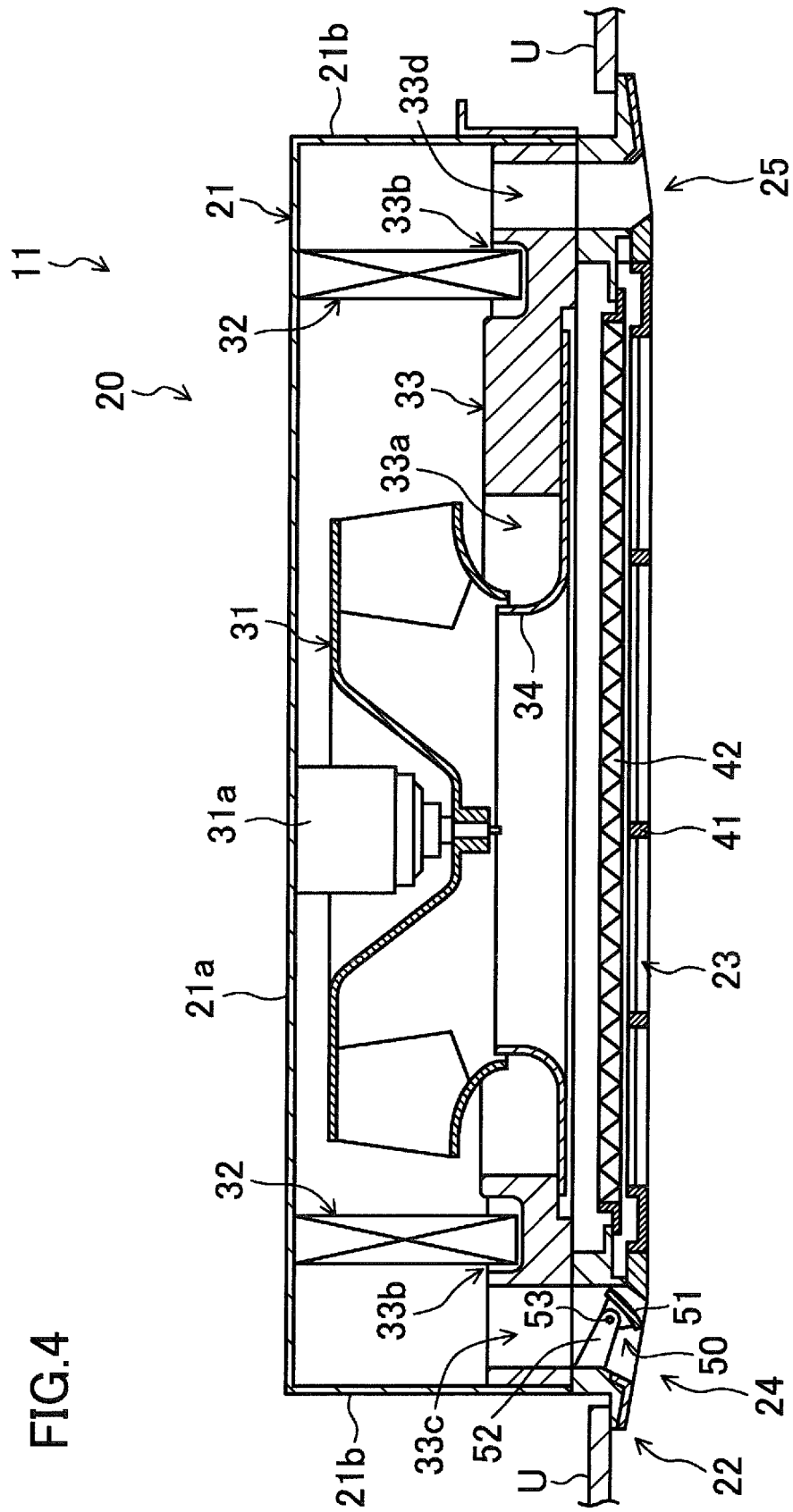


FIG.5

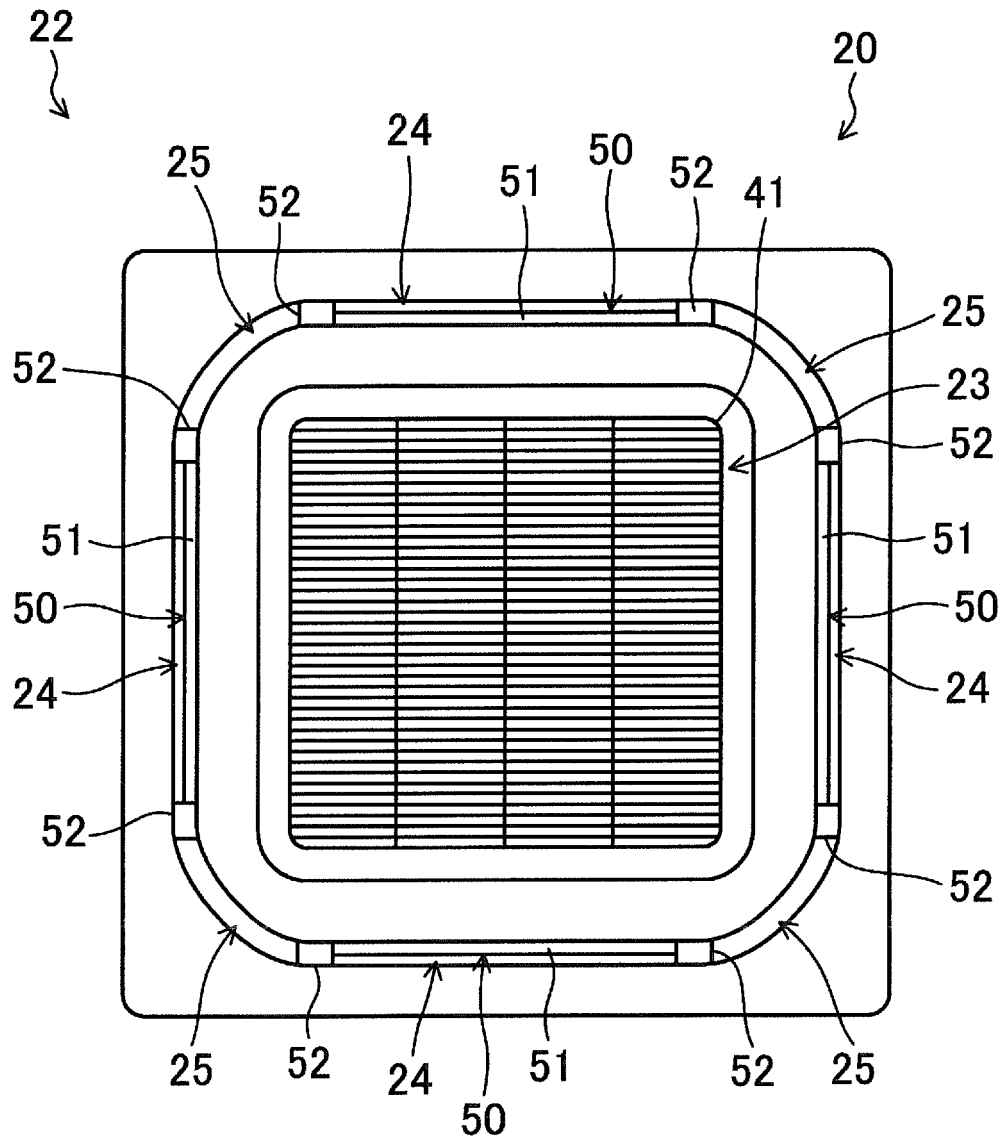


FIG.6A

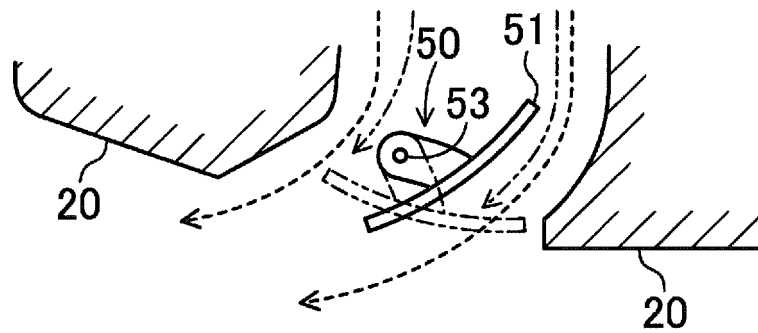


FIG.6B

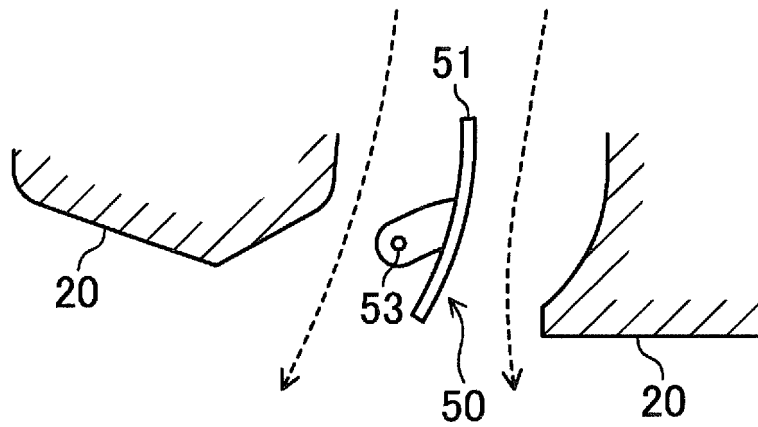


FIG.6C

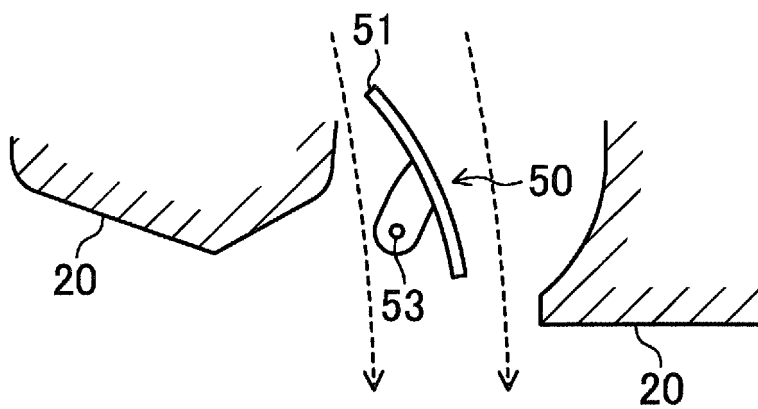


FIG.7

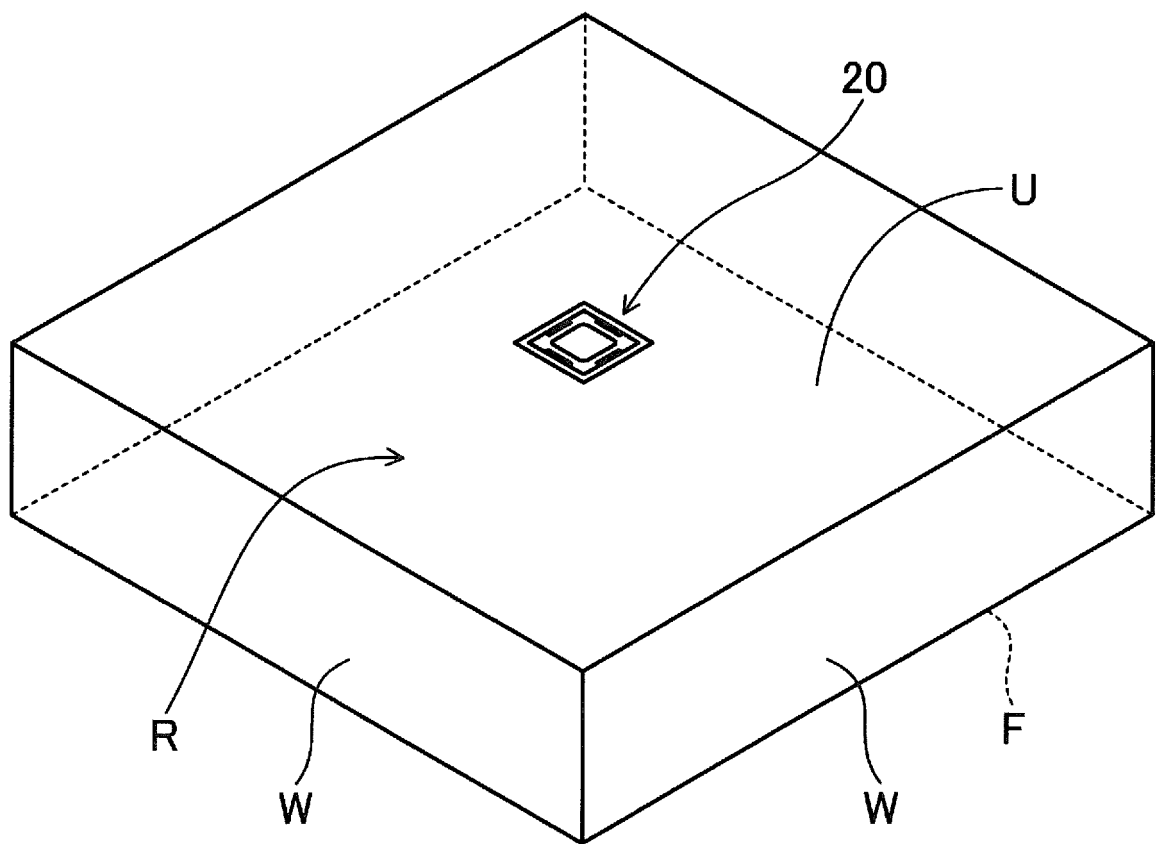


FIG.8A

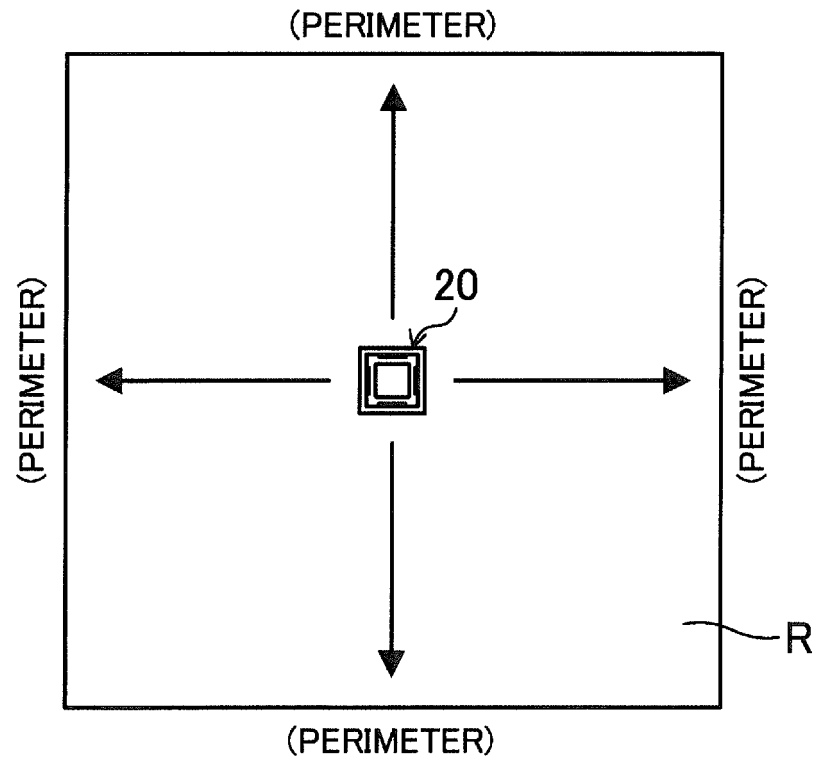


FIG.8B

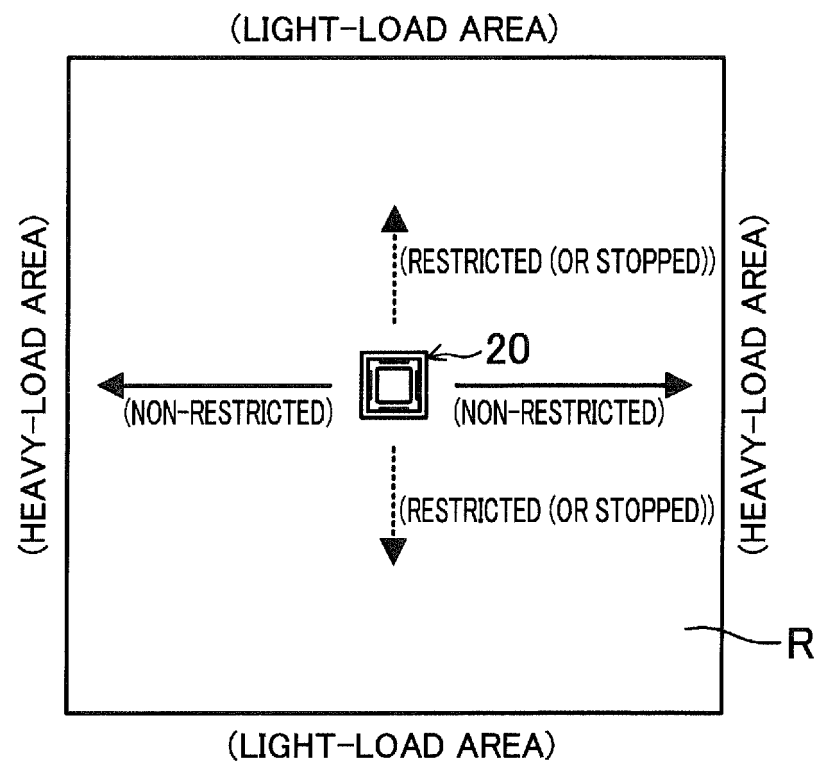


FIG.9

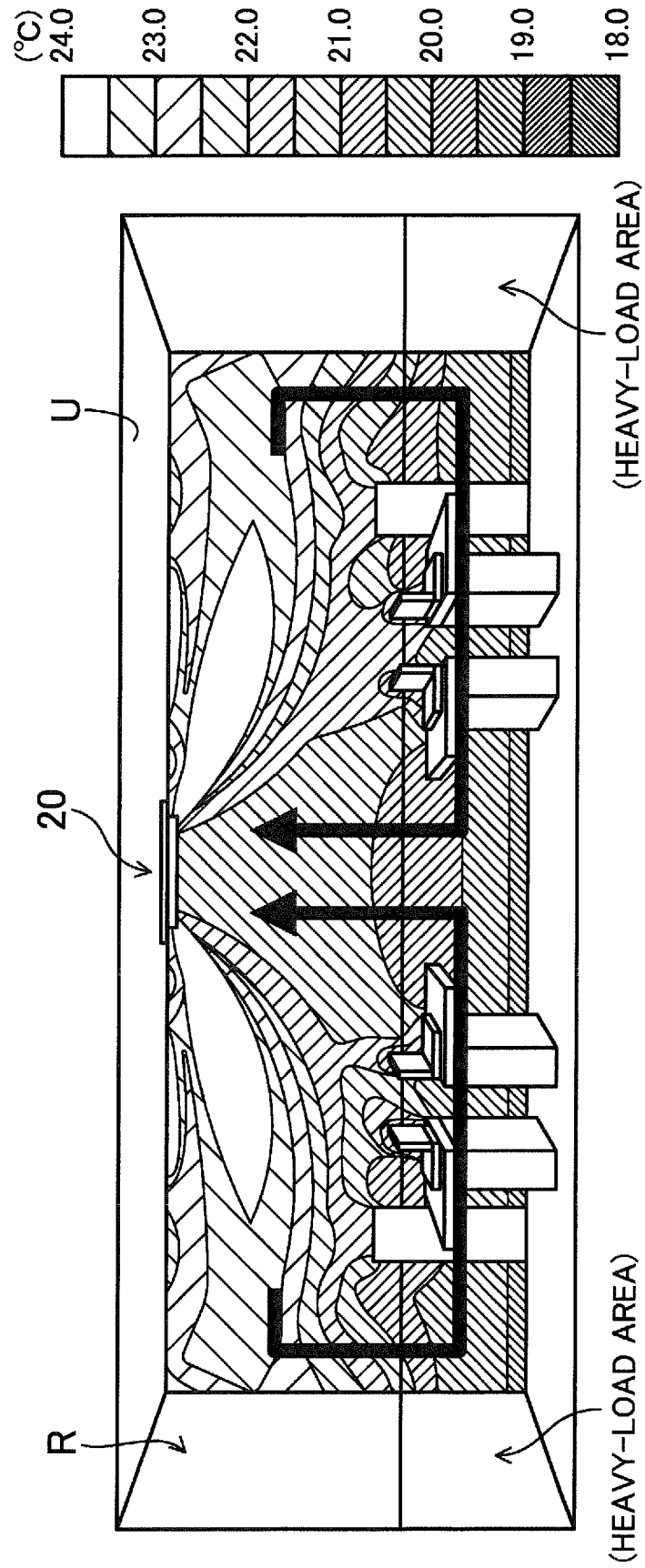


FIG.10

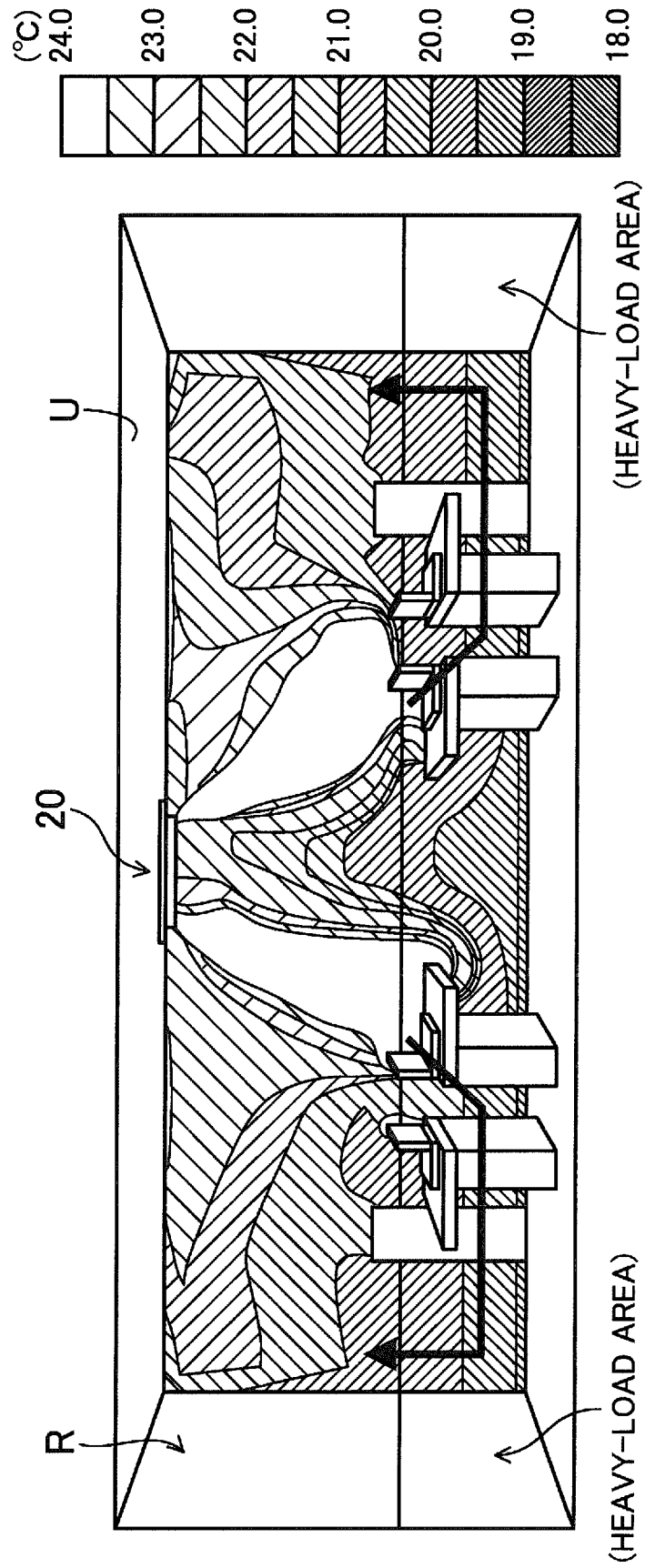


FIG.11A

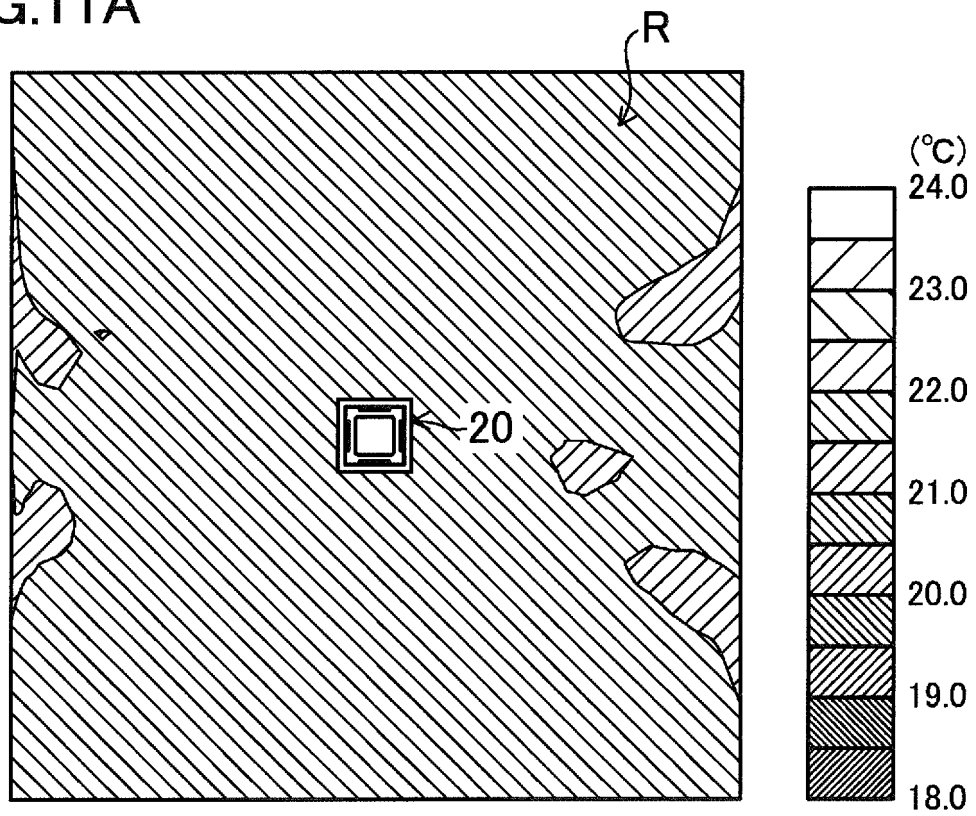


FIG.11B

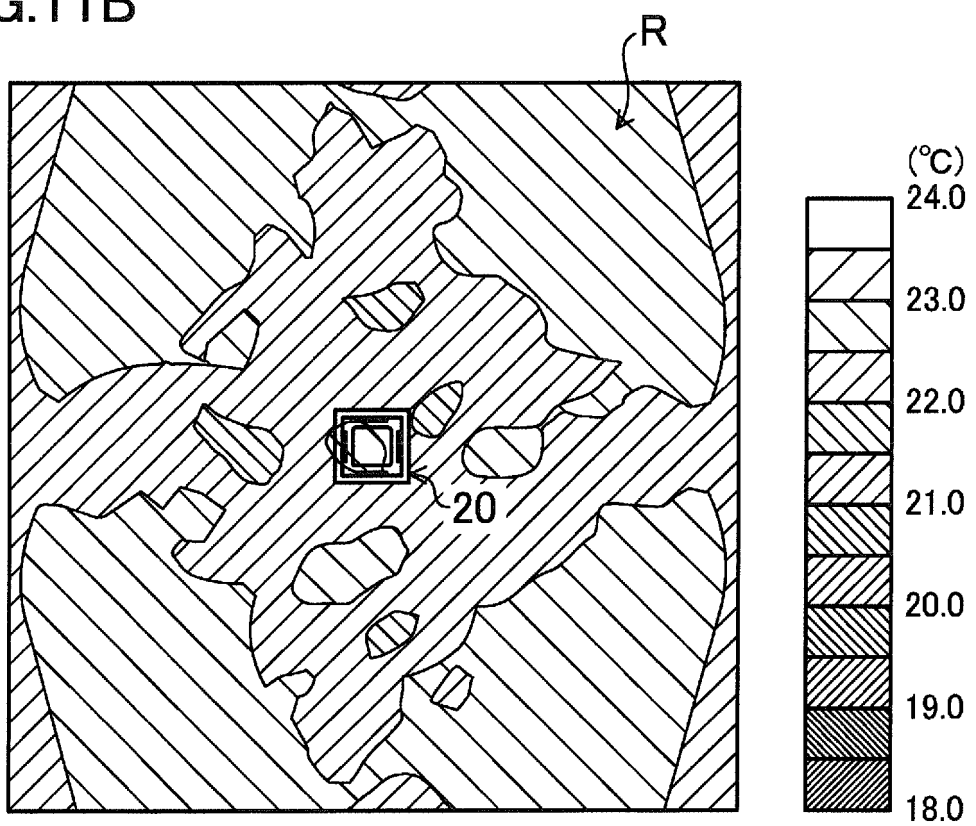


FIG.12A

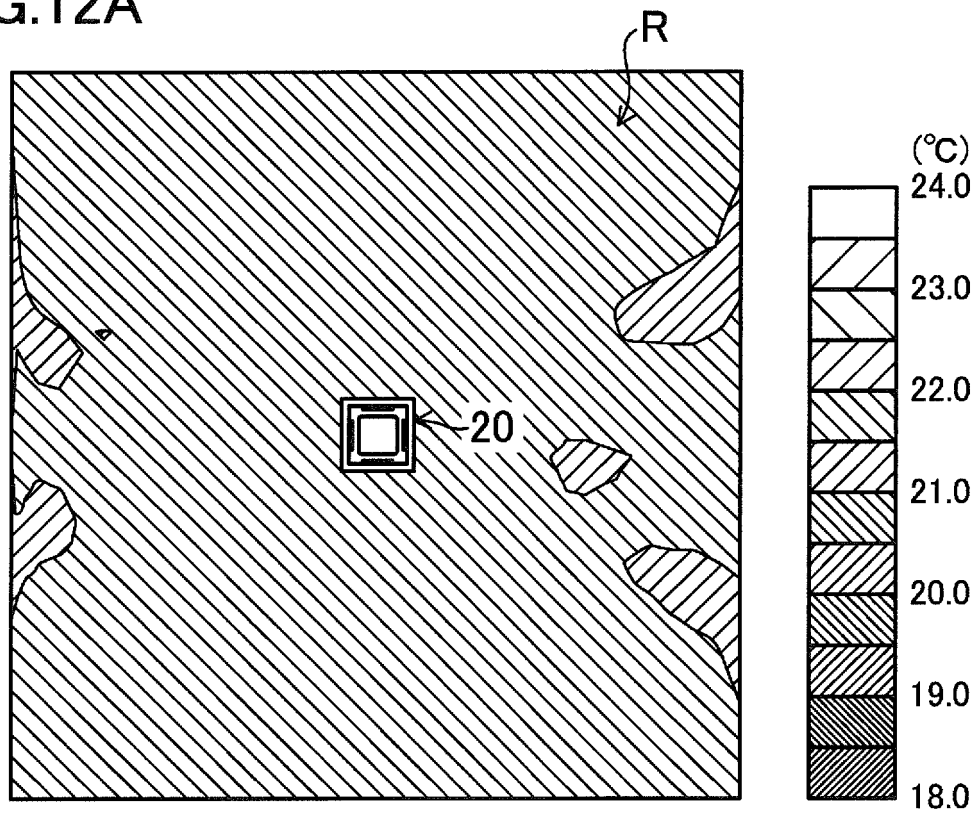
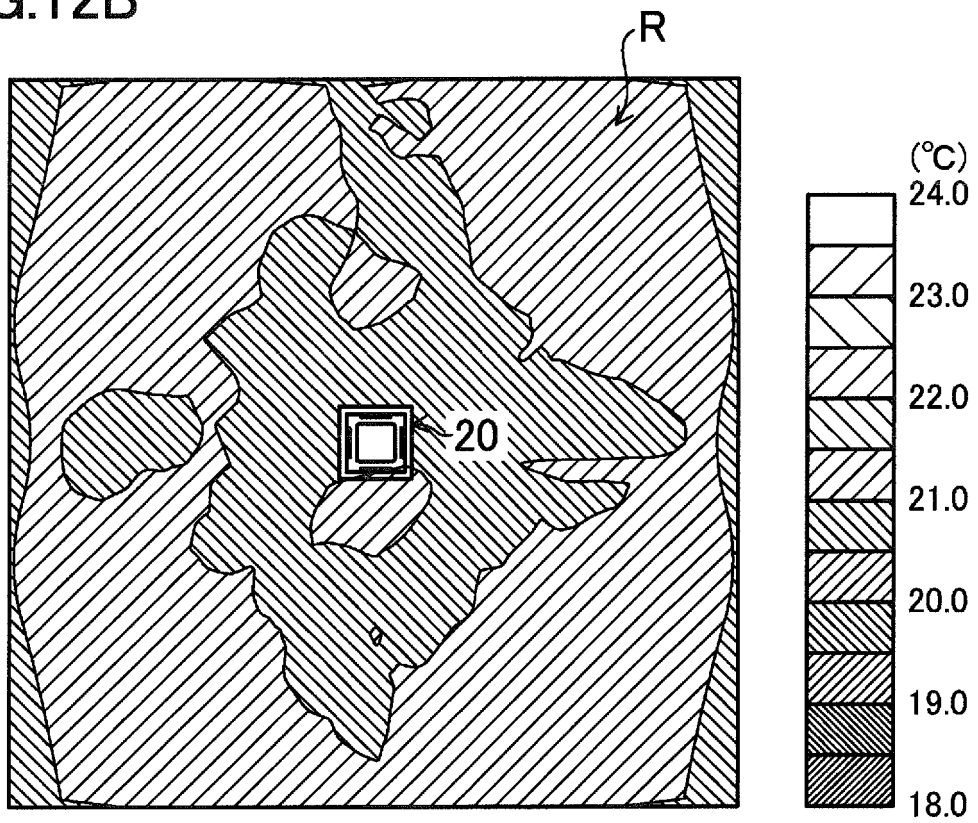


FIG.12B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/003774

A. CLASSIFICATION OF SUBJECT MATTER

F24F11/053(2006.01)i, F24F11/02(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F11/053, F24F11/02

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 3105119 U (LG Electronics Inc.),	1, 3
Y	21 October 2004 (21.10.2004),	2, 4
A	paragraphs [0008] to [0019]; fig. 1 to 5	5
	& JP 2003-185227 A & EP 1319900 A1	
	paragraphs [0012] to [0038]; fig. 2 to 6	
	& KR 10-2003-0048919 A & CN 1425882 A	
Y	JP 2002-98397 A (Daikin Industries, Ltd.),	2, 4
	05 April 2002 (05.04.2002),	
	paragraphs [0018], [0019]; fig. 7	
	(Family: none)	
Y	JP 2010-8004 A (Mitsubishi Electric Corp.),	4
	14 January 2010 (14.01.2010),	
	claim 1; paragraph [0023]	
	(Family: none)	

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
15 October 2015 (15.10.15)Date of mailing of the international search report
27 October 2015 (27.10.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/003774

5	C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	A	JP 2002-61941 A (Matsushita Electric Industrial Co., Ltd.), 28 February 2002 (28.02.2002), paragraphs [0023] to [0039]; fig. 1 to 12 (Family: none)	5
10			
	A	JP 11-132540 A (Sekisui Chemical Co., Ltd.), 21 May 1999 (21.05.1999), paragraphs [0011] to [0016]; fig. 1 (Family: none)	5
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Form PCT/ISA/210 (continuation of second sheet) (July 2009)

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Patent documents cited in the description

- JP H04028946 A [0004]