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(54) **HEAT EXCHANGER, AND REFRIGERATION CYCLE DEVICE**

(57) Provided is a heat exchanger and a refrigeration cycle apparatus capable of easily ensuring a gap between partition walls. A plate heat exchanger (30) that exchanges heat between a refrigerant and water includes a first plate-shaped member (50), a second plate-shaped member (60), a second refrigerant partition wall (72), and a first water partition wall (81). The second refrigerant partition wall (72) is located between the first plate-shaped member (50) and the second plate-shaped member (60). The first water partition wall (81) is located between the second refrigerant partition wall (72) and the second plate-shaped member (60). The first plate-shaped member (50) includes a first flow path (51). The refrigerant flows through the first flow path (51) in a direction intersecting a first plate thickness direction that is a plate thickness direction of the first plate-shaped member (50). The second plate-shaped member (60) includes a second flow path (61). The water flows through the second flow path (61) in a direction intersecting a second plate thickness direction that is a plate thickness direction of the second plate-shaped member (60). In the plate heat exchanger (30), the first water partition wall (81) includes a flat portion (82a) and a plurality of protrusions (81y) protruding in the second plate thickness direction, and distal ends of the protrusions (81y) are in

contact with the second refrigerant partition wall (72).

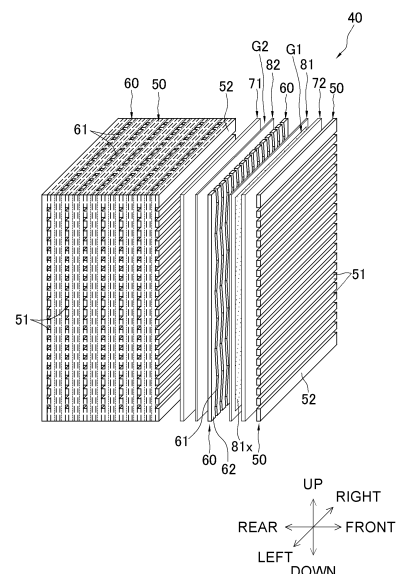


FIG. 5

Description

Technical Field

[0001] The present disclosure relates to a heat exchanger and a refrigeration cycle apparatus.

Background Art

[0002] Conventionally, there has been known a plate-type heat exchanger formed by stacking and bonding a plurality of heat transfer plates to each other. This heat exchanger exchanges heat between a first fluid and a second fluid by alternately stacking a space that is sandwiched between heat transfer plates and through which the first fluid flows and a space that is sandwiched between heat transfer plates and through which the second fluid flows.

[0003] In such a plate-type heat exchanger, for example, some adopt double-wall type heat transfer plates, each of which includes two partition walls, as described in PTL 1 (Japanese Unexamined Patent Application Publication No. 2002-107089). The double-wall type heat transfer plate has a structure in which a gap is interposed between two partition walls that overlap each other. According to this heat exchanger, even in a case where either of the partition walls of the heat transfer plate is cracked due to a factor, such as corrosion, since the heat transfer plate has a double-wall structure, a fluid leaked from the crack can be guided to the gap, and the fluids to be heat-exchanged are prevented from mixing.

Disclosure of Invention

Technical Problem

[0004] The heat exchanger that adopts the double-wall type heat transfer plates described in the above PTL 1 has a structure that ensures a gap for guiding a fluid in a case where a partition wall is cracked. Therefore, when attempting to pressurize and bond a plurality of heat transfer plates in a plate thickness direction in manufacturing the heat exchanger, there is a possibility that the gap included in the double-wall structure may collapse.

Solution to Problem

[0005] A heat exchanger according to a first aspect is a heat exchanger that exchanges heat between a first fluid and a second fluid, including a first flow path, a second flow path, a first wall portion, and a second wall portion. The first fluid flows through the first flow path. The second fluid flows through the second flow path. The first wall portion is located between the first flow path and the second flow path. The second wall portion is located between the first wall portion and the second flow path. The first fluid flows through the first flow path in a direction intersecting a stacking direction that is a direction in which

the first wall portion and the second wall portion are stacked. The second fluid flows through the second flow path in a direction intersecting the stacking direction. In the heat exchanger, at least either the first wall portion including a first flat portion and a plurality of first protrusions protruding in the stacking direction, and distal ends of the first protrusions being in contact with the second wall portion, or the second wall portion including a second flat portion and a plurality of second protrusions protruding in the stacking direction, and distal ends of the second protrusions being in contact with the first wall portion.

[0006] In this heat exchanger, the first wall portion and the second wall portion are interposed between the first flow path through which the first fluid flows and the second flow path through which the second fluid flows. Accordingly, a double-wall structure can be formed. Here, the distal ends of the plurality of first protrusions of the first wall portion are in contact with the second wall portion, or the distal ends of the plurality of second protrusions of the second wall portion are in contact with the first wall portion. Therefore, a gap between the first wall portion and the second wall portion can be supported by a plurality of contact portions while ensuring the gap between the first wall portion and the second wall portion. Accordingly, even when the heat exchanger including the first wall portion and the second wall portion is pressurized in the stacking direction, the length of the gap between the first wall portion and the second wall portion in the stacking direction is kept from decreasing.

[0007] A heat exchanger according to a second aspect is the heat exchanger of the first aspect, including a first plate-shaped member and a second plate-shaped member. The first plate-shaped member includes the first flow path. The second plate-shaped member includes the second flow path and the second wall portion. The second flow path and the second wall portion are provided so as to be arranged in a second plate thickness direction that is a plate thickness direction of the second plate-shaped member.

[0008] In this heat exchanger, the second flow path and the second wall portion are provided in the second plate-shaped member as a single member. Therefore, the number of components can be reduced while maintaining the double-wall structure.

[0009] Note that, in this heat exchanger, the first wall portion and the second wall portion of the second plate-shaped member are interposed between the first flow path of the first plate-shaped member and the second flow path through which the second fluid flows in the second plate-shaped member. In addition, the distal ends of the plurality of first protrusions of the first wall portion are in contact with the second plate-shaped member, or the distal ends of the plurality of second protrusions of the second plate-shaped member are in contact with the first wall portion. Therefore, a gap between the first wall portion and the second plate-shaped member can be supported by a plurality of contact portions while ensuring the gap between the first wall portion and the second

plate-shaped member. Accordingly, even when the heat exchanger including the first wall portion and the second plate-shaped member is pressurized in the stacking direction, the length of the gap between the first wall portion and the second plate-shaped member in the stacking direction is kept from decreasing.

[0010] A heat exchanger according to a third aspect is the heat exchanger of the second aspect, further including a first partition wall. The first partition wall includes the first wall portion. The first partition wall is located between the first plate-shaped member and the second plate-shaped member. At least either the first partition wall including the first flat portion and the plurality of first protrusions, and the distal ends of the first protrusions being in contact with the second wall portion, or the second wall portion including the second flat portion and the plurality of second protrusions, and the distal ends of the second protrusions being in contact with the first partition wall.

[0011] In this heat exchanger, the first partition wall and the second wall portion of the second plate-shaped member are interposed between the first flow path of the first plate-shaped member and the second flow path through which the second fluid flows in the second plate-shaped member. In addition, the distal ends of the plurality of first protrusions of the first partition wall are in contact with the second plate-shaped member, or the distal ends of the plurality of second protrusions of the second plate-shaped member are in contact with the first partition wall. Therefore, a gap between the first partition wall and the second plate-shaped member can be supported by a plurality of contact portions while ensuring the gap between the first partition wall and the second plate-shaped member. Accordingly, even when the heat exchanger including the first partition wall and the second plate-shaped member is pressurized in the stacking direction, the length of the gap between the first partition wall and the second plate-shaped member in the stacking direction is kept from decreasing.

[0012] A heat exchanger according to a fourth aspect is the heat exchanger of the third aspect, including a liquid between the first partition wall and the second wall portion.

[0013] This heat exchanger can improve heat exchange efficiency between the first fluid and the second fluid as compared with a case where air is filled between the first partition wall and the second wall portion.

[0014] A heat exchanger according to a fifth aspect is the heat exchanger of the fourth aspect, further including a sealing portion. The sealing portion covers between the first partition wall and the second wall portion from a periphery in the stacking direction.

[0015] This heat exchanger can prevent the liquid located between the first partition wall and the second wall portion from flowing out from the heat exchanger to the outside.

[0016] A heat exchanger according to a sixth aspect is the heat exchanger according to any one of the third

to fifth aspects, in which at least either the first partition wall including a first concave portion recessed in the stacking direction with respect to the first flat portion, and the distal ends of the first protrusions being located closer than the first concave portion to a side of the second wall portion in the stacking direction, or the second wall portion including a second concave portion recessed in the stacking direction with respect to the second flat portion, and the distal ends of the second protrusions being located closer than the second concave portion to a side of the first partition wall in the stacking direction.

[0017] This heat exchanger easily ensures the gap between the first partition wall and the second wall portion.

[0018] A heat exchanger according to a seventh aspect is the heat exchanger according to any one of the third to sixth aspects, in which the second wall portion includes a second region including the plurality of second protrusions. The first partition wall includes a first region facing the second region when viewed along the stacking direction. The second region has a larger surface area than the first region.

[0019] This heat exchanger easily prevents breakage of the first partition wall including the first region having a smaller surface area than the second region. Accordingly, an outflow of the first fluid due to the breakage of the first partition wall is prevented.

[0020] A heat exchanger according to an eighth aspect is the heat exchanger according to any one of the third to seventh aspects, in which the first partition wall includes a first opening. The second wall portion includes a second opening provided at a position overlapping the first opening in the stacking direction. The first opening and the second opening allow the first fluid or the second fluid to pass in the stacking direction. The first partition wall and the second wall portion include a portion where the first flat portion around the first opening and the second flat portion around the second opening are in surface contact with each other.

[0021] In this heat exchanger, the first partition wall and the second wall portion can be bonded via the surface contact portion between the first flat portion and the second flat portion.

[0022] A heat exchanger according to a ninth aspect is the heat exchanger of the second aspect, in which the first plate-shaped member further includes the first wall portion. The first flow path and the first wall portion are provided so as to be arranged in a first plate thickness direction that is a plate thickness direction of the first plate-shaped member.

[0023] In this heat exchanger, the first flow path and the first wall portion are provided in the first plate-shaped member as a single member. Therefore, the number of components can be reduced while maintaining the double-wall structure.

[0024] Note that, in this heat exchanger, the first wall portion of the first plate-shaped member and the second wall portion of the second plate-shaped member are interposed between the first flow path through which the

first fluid flows in the first plate-shaped member and the second flow path through which the second fluid flows in the second plate-shaped member. In addition, the distal ends of the plurality of first protrusions of the first wall portion are in contact with the second wall portion, or the distal ends of the plurality of second protrusions of the second wall portion are in contact with the first wall portion. Therefore, a gap between the first plate-shaped member and the second plate-shaped member can be supported by a plurality of contact portions while ensuring the gap between the first plate-shaped member and the second plate-shaped member. Accordingly, even when the heat exchanger including the first plate-shaped member and the second plate-shaped member is pressurized in the stacking direction, the length of the gap between the first plate-shaped member and the second plate-shaped member in the stacking direction is kept from decreasing.

[0025] A heat exchanger according to a tenth aspect is the heat exchanger of the first aspect, including a first plate-shaped member, a second plate-shaped member, a first partition wall, and a second partition wall. The first plate-shaped member includes the first flow path. The second plate-shaped member includes the second flow path. The first partition wall is the first wall portion located between the first plate-shaped member and the second plate-shaped member. The second partition wall is the second wall portion located between the first partition wall and the second plate-shaped member. In the heat exchanger, at least either the first partition wall including the first flat portion and the plurality of first protrusions, and the distal ends of the first protrusions being in contact with the second partition wall, or the second partition wall including the second flat portion and the plurality of second protrusions, and the distal ends of the second protrusions being in contact with the first partition wall.

[0026] Note that the first flow path may be a path that allows the first fluid to flow in a direction intersecting the first plate thickness direction that is the plate thickness direction of the first plate-shaped member. The second flow path may be a path that allows the second fluid to flow in a direction intersecting the second plate thickness direction that is the plate thickness direction of the second plate-shaped member.

[0027] In this heat exchanger, the first partition wall and the second partition wall are interposed between the first plate-shaped member including the first flow path through which the first fluid flows and the second plate-shaped member including the second flow path through which the second fluid flows. Here, the distal ends of the plurality of first protrusions of the first partition wall are in contact with the second partition wall, or the distal ends of the plurality of second protrusions of the second partition wall are in contact with the first partition wall. Therefore, a gap between the first partition wall and the second partition wall can be supported by a plurality of contact portions while ensuring the gap between the first partition wall and the second partition wall. Accordingly, even

when the heat exchanger including the first partition wall and the second partition wall is pressurized in the stacking direction, the length of the gap between the first partition wall and the second partition wall in the stacking direction is kept from decreasing.

[0028] A heat exchanger according to an eleventh aspect is the heat exchanger of the tenth aspect, including a liquid between the first partition wall and the second partition wall.

[0029] This heat exchanger can improve heat exchange efficiency between the first fluid and the second fluid as compared with a case where air is filled between the first partition wall and the second partition wall.

[0030] A heat exchanger according to a twelfth aspect is the heat exchanger of the eleventh aspect, further including a sealing portion. The sealing portion covers between the first partition wall and the second partition wall from a periphery in the stacking direction.

[0031] Note that the sealing portion may cover between the first partition wall and the second partition wall from a periphery in the first plate thickness direction that is the plate thickness direction of the first plate-shaped member.

[0032] This heat exchanger can prevent the liquid located between the first partition wall and the second partition wall from flowing out from the heat exchanger to the outside.

[0033] A heat exchanger according to a thirteenth aspect is the heat exchanger according to any one of the tenth to twelfth aspects, in which at least either the first partition wall including a first concave portion recessed in the stacking direction with respect to the first flat portion, and the distal ends of the first protrusions being located closer than the first concave portion to a side of the second partition wall in the stacking direction, or the second partition wall including a second concave portion recessed in the stacking direction with respect to the second flat portion, and the distal ends of the second protrusions being located closer than the second concave portion to a side of the first partition wall in the stacking direction.

[0034] Note that the first partition wall may include the first concave portion recessed in the first plate thickness direction that is the plate thickness direction of the first plate-shaped member with respect to the first flat portion. The distal ends of the first protrusions may be located closer than the first concave portion to a side of the second partition wall in the first plate thickness direction. Furthermore, the second partition wall may include the second concave portion recessed in the second plate thickness direction that is the plate thickness direction of the second plate-shaped member with respect to the second flat portion. Furthermore, the distal ends of the second protrusions may be located closer than the second concave portion to a side of the first partition wall in the second plate thickness direction.

[0035] This heat exchanger easily ensures the gap between the first partition wall and the second partition wall.

[0036] A heat exchanger according to a fourteenth aspect is the heat exchanger according to any one of the tenth to thirteenth aspects, in which the second partition wall includes a second region. The second region includes the plurality of second protrusions. The first partition wall includes a first region. The first region faces the second region when viewed along the stacking direction. A surface area of the second region is larger than a surface area of the first region.

[0037] Note that the first region may face the second region when viewed along the first plate thickness direction that is the plate thickness direction of the first plate-shaped member.

[0038] This heat exchanger easily prevents breakage of the first partition wall including the first region having a smaller surface area than the second region. Accordingly, the outflow of the first fluid due to the breakage of the first partition wall is prevented.

[0039] A heat exchanger according to a fifteenth aspect is the heat exchanger according to any one of the tenth to fourteenth aspects, in which the first partition wall includes a first opening. The second partition wall includes a second opening provided at a position overlapping the first opening in the stacking direction. The first opening and the second opening allow the first fluid or the second fluid to pass in the stacking direction. The first partition wall and the second partition wall include a portion where the first flat portion around the first opening and the second flat portion around the second opening are in surface contact with each other.

[0040] Note that the second partition wall may include the second opening provided at a position overlapping the first opening in the first plate thickness direction that is the plate thickness direction of the first plate-shaped member. The first opening and the second opening may allow the first fluid or the second fluid to pass in the first plate thickness direction.

[0041] In this heat exchanger, the first partition wall and the second partition wall can be bonded via the surface contact portion between the first flat portion and the second flat portion.

[0042] A heat exchanger according to a sixteenth aspect is the heat exchanger according to any one of the first to fifteenth aspects, in which the second fluid is water.

[0043] In this heat exchanger, even when the second partition wall is broken due to the freezing of the second fluid, the first fluid and the second fluid are prevented from mixing.

[0044] A heat exchanger according to a seventeenth aspect is the heat exchanger according to any one of the first to sixteenth aspects, in which the first fluid is a refrigerant with flammability.

[0045] This heat exchanger is provided with the first partition wall, so that the outflow of the refrigerant with flammability is prevented.

[0046] A refrigeration cycle apparatus according to an eighteenth aspect includes a refrigerant circuit. A first refrigerant flows through the refrigerant circuit. The re-

frigerant circuit includes the heat exchanger according to any one of the first to seventeenth aspects.

[0047] This refrigeration cycle apparatus can perform a refrigeration cycle using the heat exchanger in which the gap between the first partition wall and the second partition wall is ensured.

Brief Description of Drawings

[0048]

[Fig. 1] Fig. 1 is a schematic configuration diagram of a plate heat exchanger according to an embodiment of the present disclosure and a heat pump system including the plate heat exchanger.

[Fig. 2] Fig. 2 is a schematic perspective view of an external appearance of the plate heat exchanger.

[Fig. 3] Fig. 3 is an explanatory view illustrating an arrangement of first flow paths in a case where the plate heat exchanger is viewed from the front.

[Fig. 4] Fig. 4 is an explanatory view illustrating an arrangement of second flow paths in a case where the plate heat exchanger is viewed from the front.

[Fig. 5] Fig. 5 is a partially exploded perspective view illustrating a main part of a heat exchange unit of the plate heat exchanger.

[Fig. 6] Fig. 6 is an explanatory view illustrating an arrangement in the vicinity of inlets and outlets of the first flow paths in a case where the plate heat exchanger is viewed from the left.

[Fig. 7] Fig. 7 is an explanatory view illustrating an arrangement in the vicinity of inlets of the second flow paths in a case where the plate heat exchanger is viewed from below.

[Fig. 8] Fig. 8 is a schematic configuration diagram of a first refrigerant partition wall as viewed from the front.

[Fig. 9] Fig. 9 is a schematic configuration diagram of a first plate-shaped member as viewed from the front.

[Fig. 10] Fig. 10 is a schematic configuration diagram of a second refrigerant partition wall as viewed from the front.

[Fig. 11] Fig. 11 is a schematic configuration diagram of a first water partition wall as viewed from the front.

[Fig. 12] Fig. 12 is a schematic configuration diagram of a second plate-shaped member as viewed from the front.

[Fig. 13] Fig. 13 is a schematic configuration diagram of a second water partition wall as viewed from the front.

[Fig. 14] Fig. 14 is a schematic configuration diagram of the second water partition wall as viewed from the rear.

[Fig. 15] Fig. 15 is an explanatory view illustrating an arrangement in the vicinity of inlets and outlets of the first flow paths in a case where a plate heat exchanger according to another embodiment A is viewed

from the left.

[Fig. 16] Fig. 16 is a schematic perspective view of an external appearance of a first water partition wall according to another embodiment B.

[Fig. 17] Fig. 17 is a cross-sectional view illustrating an example of a cross-sectional shape of the first water partition wall according to the other embodiment B.

[Fig. 18] Fig. 18 is a cross-sectional view of another example of the cross-sectional shape of the first water partition wall according to the other embodiment B.

[Fig. 19] Fig. 19 is an explanatory view illustrating an arrangement in the vicinity of inlets and outlets of the first flow paths in a case where a plate heat exchanger according to another embodiment C is viewed from the left.

[Fig. 20] Fig. 20 is a partially exploded perspective view illustrating a main part of a heat exchange unit of a plate heat exchanger according to another embodiment F.

[Fig. 21] Fig. 21 is a partially exploded perspective view illustrating a main part of a heat exchange unit of a plate heat exchanger according to another embodiment G.

[Fig. 22] Fig. 22 is a partially exploded perspective view illustrating a main part of a heat exchange unit of a plate heat exchanger according to another embodiment H.

[Fig. 23] Fig. 23 is a partially exploded perspective view illustrating a main part of a heat exchange unit of a plate heat exchanger according to another embodiment I.

Description of Embodiments

[0049] Hereinafter, a heat exchanger and a heat pump system as a refrigeration cycle apparatus including the heat exchanger will be described with reference to the drawings.

(1) Heat pump system

[0050] Fig. 1 is a schematic configuration diagram of a plate heat exchanger 30 as a heat exchanger according to an embodiment of the present disclosure and a heat pump system 1 as a refrigeration cycle apparatus including the plate heat exchanger 30.

[0051] The heat pump system 1 mainly includes a first circuit 10 and a second circuit 20. The first circuit 10 is a refrigerant circuit through which a refrigerant as a first fluid serving as a heat exchange medium circulates. The second circuit 20 is a water circuit through which water as a second fluid serving as a heating target fluid circulates. The heat pump system 1 is an apparatus that heats water by utilizing a refrigerant compression-type heat pump cycle in the first circuit 10, and processes a use-side load such as heating an inside of a room with the

heated water.

[0052] Note that the refrigerant that circulates through the first circuit 10 is not limited, and for example, a refrigerant with flammability can be used. Note that, as the refrigerant with flammability, highly flammable refrigerants of classes A3 and B3, flammable refrigerants of classes A2 and B2, low-flammable refrigerants of classes A2L and B2L, and the like in ASHRAE Safety Group can be named. For example, especially, the refrigerant with flammability may be one or two or more kinds selected from the group consisting of R290, R600, and R600a. Note that the first circuit 10 is filled with refrigerating machine oil together with the above-described refrigerant.

(1-1) First circuit

[0053] The first circuit 10 mainly includes a compressor 11, the plate heat exchanger 30, an expansion mechanism 13, and a first heat exchanger 14. In addition, the first circuit 10 is filled with a refrigerant. The refrigerant is not limited, and for example, an HFC-based refrigerant, an HFO-based refrigerant, a natural refrigerant, or the like can be used.

[0054] The compressor 11 is a device that compresses a refrigerant. The compressor 11 is, for example, a compressor in which a refrigerant compression element of a rotary type, a scroll type, or the like is driven by a drive mechanism such as a motor.

[0055] The plate heat exchanger 30 is a device that exchanges heat between the refrigerant circulating through the first circuit and water circulating through the second circuit 20. In the present embodiment, the plate heat exchanger 30 cools the refrigerant compressed in the compressor 11 with the water circulating through the second circuit 20. Note that details of the plate heat exchanger 30 will be described later. Furthermore, a discharge port of the compressor 11 and a refrigerant inlet 35, which is an inlet on the refrigerant side of the plate heat exchanger 30, are connected by a first refrigerant pipe 15.

[0056] The expansion mechanism 13 is a device that decompresses the refrigerant cooled in the plate heat exchanger 30. The expansion mechanism 13 is, for example, an expansion valve or a capillary tube. Furthermore, a refrigerant outlet 36, which is an outlet on the refrigerant side of the plate heat exchanger 30, and the expansion mechanism 13 are connected by a second refrigerant pipe 16.

[0057] The first heat exchanger 14 is a device that exchanges heat between the refrigerant flowing inside the first heat exchanger 14 and a fluid, such as air, passing around the first heat exchanger 14. In the present embodiment, the first heat exchanger 14 evaporates the refrigerant decompressed in the expansion mechanism 13 by exchanging heat with the air supplied by a blower fan 19. The blower fan 19 generates a flow of air that serves as a heating source for the refrigerant. As such a first heat exchanger 14, for example, a fin-and-tube heat ex-

changer that heats the refrigerant with air can be used. The blower fan 19 is a fan that drives a blower element of a propeller type or the like by a drive mechanism such as a motor. Furthermore, the expansion mechanism 13 and a refrigerant inlet of the first heat exchanger 14 are connected by a third refrigerant pipe 17. A refrigerant outlet of the first heat exchanger 14 and a suction port of the compressor 11 are connected by a fourth refrigerant pipe 18.

(1-2) Second circuit

[0058] The second circuit 20 mainly includes the plate heat exchanger 30, a pump 21, and a second heat exchanger 22. In addition, the second circuit 20 is filled with water.

[0059] As described above, the plate heat exchanger 30 is a device that cools the refrigerant compressed in the compressor 11 with water circulating through the second circuit 20. Furthermore, the plate heat exchanger 30 is a device that heats water with the refrigerant circulating through the first circuit 10. Note that details of the plate heat exchanger 30 will be described later.

[0060] The pump 21 is a device that generates a flow of water in the second circuit 20, and boosts water in the present embodiment. The pump 21 is, for example, a pump that drives a centrifugal or positive displacement pump element by a drive mechanism such as a motor. Here, a water outlet 34, which is an outlet on the water side of the plate heat exchanger 30, and a suction port of the pump 21 are connected by a second water pipe 24.

[0061] The second heat exchanger 22 is a device that heats, or the like, an inside of a room with the water heated by the plate heat exchanger 30. The second heat exchanger 22 is, for example, a radiator or a floor heater. Furthermore, a discharge port of the pump 21 and a water inlet of the second heat exchanger 22 are connected by a third water pipe 25. A water outlet of the second heat exchanger 22 and a water inlet 33, which is an inlet on the water side of the plate heat exchanger 30, are connected by a first water pipe 23.

[0062] The devices forming the heat pump system 1 are controlled by a control apparatus 2. The control apparatus 2 includes a control board, or the like, on which a processor such as a central processing unit (CPU), memories such as a ROM and a RAM, and the like are mounted.

(2) Driving operation

[0063] Next, an example of the operation of the heat pump system 1 will be described with reference to Fig. 1.

[0064] As described above, the heat pump system 1 can perform a heating operation, or the like, in which water is heated by utilizing the refrigerant compression-type heat pump cycle in the first circuit 10, and an inside of a room is heated with the heated water. Note that the heating operation is controlled by the control apparatus 2.

[0065] In the first circuit 10, the refrigerant compressed in the compressor 11 and discharged is sent to the plate heat exchanger 30. The refrigerant sent to the plate heat exchanger 30 is cooled and condensed through heat exchange with the water circulating through the second circuit 20. The refrigerant, the heat of which has been radiated in the plate heat exchanger 30, is decompressed by the expansion mechanism 13 and then sent to the first heat exchanger 14. The refrigerant sent to the first heat exchanger 14 is evaporated by being heated through heat exchange with the air passing through the first heat exchanger 14 by the blower fan 19. The refrigerant evaporated in the first heat exchanger 14 is sucked into the compressor 11, compressed again in the compressor 11, and discharged.

[0066] On the other hand, in the second circuit 20, water is heated by the heat radiated from the refrigerant in the plate heat exchanger 30. The water heated in the plate heat exchanger 30 is boosted and discharged by the pump 21. The water discharged from the pump 21 is sent to the second heat exchanger 22. The water sent to the second heat exchanger 22 is cooled by heating the inside of the room. The water cooled in the second heat exchanger 22 is sent to the plate heat exchanger 30, and heated again in the plate heat exchanger 30.

(3) Details of plate heat exchanger

[0067] Next, details of the plate heat exchanger 30 as a water heat exchanger will be described with reference to Figs. 2 to 7.

[0068] Here, Fig. 2 is a schematic perspective view of an external appearance of the plate heat exchanger 30. Fig. 3 is an explanatory view illustrating an arrangement of first flow paths 51 in a case where the plate heat exchanger 30 is viewed from the front direction. Fig. 4 is an explanatory view illustrating an arrangement of second flow paths 61 in a case where the plate heat exchanger 30 is viewed from the front direction. Fig. 5 is a partially exploded perspective view illustrating a main part of a heat exchange unit 40. Fig. 6 is an explanatory view illustrating an arrangement in the vicinity of inlets and outlets of the first flow paths 51 in a case where the main part of the heat exchange unit 40 is viewed from the left. Fig. 7 is an explanatory view illustrating an arrangement in the vicinity of inlets of the second flow paths 61 in a case where the main part of the heat exchange unit 40 is viewed from below.

[0069] Furthermore, in the following description, in order to describe directions and positional relationships, expressions such as "up", "down", "left", "right", "front", and "rear" are used in some cases. The directions indicated by these expressions follow the directions of arrows illustrated in the drawings unless otherwise specified. Note that, in the present embodiment, an example of a posture of the plate heat exchanger 30 is illustrated. The plate heat exchanger 30 may be used by changing each direction of up and down, left and right, and front

and rear.

[0070] The plate heat exchanger 30 mainly includes a casing 31 and the heat exchange unit 40 that is disposed inside the casing 31 and exchanges heat between water and a refrigerant as a heat exchange medium.

(3-1) Casing

[0071] The casing 31 accommodates the heat exchange unit 40 therein.

[0072] In the present embodiment, the casing 31 has a substantially rectangular parallelepiped shape.

[0073] Each surface portion of the casing 31 of the present embodiment is preferably made of, for example, metal, and for example, stainless steel, an aluminum alloy, a copper alloy, or the like can be used. Note that the casing 31 and the heat exchange unit 40, described later, are preferably made of the same material.

[0074] The water inlet 33 serving as an inlet of water is formed in a lower surface portion of the casing 31, and communicates with a water inlet header 43 included in the heat exchange unit 40 described later. The first water pipe 23 is connected to the water inlet 33.

[0075] The water outlet 34 serving as an outlet of water is formed in an upper surface portion of the casing 31, and communicates with a water outlet header 44 included in the heat exchange unit 40 described later. The second water pipe 24 is connected to the water outlet 34.

[0076] The refrigerant inlet 35 serving as an inlet of refrigerant is formed in an upper portion of a left side surface portion of the casing 31, and communicates with a refrigerant inlet header 45 included in the heat exchange unit 40 described later. The first refrigerant pipe 15 is connected to the refrigerant inlet 35.

[0077] The refrigerant outlet 36 serving as an outlet of refrigerant is formed in a lower portion of the left side surface portion of the casing 31, and communicates with a refrigerant outlet header 46 included in the heat exchange unit 40 described later. The second refrigerant pipe 16 is connected to the refrigerant outlet 36.

[0078] Each surface portion of the casing 31 is disposed so as to cover each surface of the heat exchange unit 40, and is bonded to the heat exchange unit 40. The heat exchange unit 40 and the casing 31 are bonded in a state where an object obtained by repeatedly stacking a predetermined number of a first water partition wall 81, a second plate-shaped member 60, a second water partition wall 82, a first refrigerant partition wall 71, a first plate-shaped member 50, and a second refrigerant partition wall 72, described later, is covered with each surface portion of the casing 31. This bonding method is not limited, and diffusion bonding and the like can be named, for example. Note that, from the viewpoint of obtaining a favorable bonded state, the heat exchange unit 40 and the casing 31 are preferably bonded in a state of being pressurized in a plate thickness direction that is a stacking direction of the plate-shaped members and the partition walls forming the heat exchange unit 40. Note that,

after the heat exchange unit 40 is formed by bonding the plate-shaped members and the partition walls of the heat exchange unit 40 to each other, the casing 31 may be further bonded to the heat exchange unit 40.

[0079] In the plate heat exchanger 30, when the heat pump system 1 is in operation, water flows from the water inlet 33 into the water inlet header 43 of the heat exchange unit 40 described later. The water that has flowed into the water inlet header 43 is branched into inlet portions of the plurality of second flow paths 61, and flows upward from below in each of the second flow paths 61. The water is heated through heat exchange with the refrigerant as the water flows through the plurality of second flow paths 61, and merges in the water outlet header 44 of the heat exchange unit 40, described later, via outlet portions of the plurality of second flow paths 61. The water that has merged in the water outlet header 44 flows out from the water outlet 34.

[0080] In the plate heat exchanger 30, when the heat pump system 1 is in operation, a refrigerant flows from the refrigerant inlet 35 into the refrigerant inlet header 45 of the heat exchange unit 40 described later. The refrigerant that has flowed into the refrigerant inlet header 45 is branched into inlet portions of the plurality of first flow paths 51, and flows downward from above while alternately flowing between left and right in the first flow paths 51. The refrigerant radiates heat through heat exchange with water as the water flows through the plurality of first flow paths 51, and merges in the refrigerant outlet header 46 of the heat exchange unit 40, described later, via outlet portions of the plurality of first flow paths 51. The refrigerant that has merged in the refrigerant outlet header 46 flows out from the refrigerant outlet 36.

(3-2) Heat exchange unit

[0081] The heat exchange unit 40 is formed by stacking the plurality of first plate-shaped members 50, the plurality of second plate-shaped members 60, the plurality of first refrigerant partition walls 71, the plurality of second refrigerant partition walls 72, the plurality of first water partition walls 81, and the plurality of second water partition walls 82 on each other in the plate thickness direction. Members forming the heat exchange unit 40 are preferably made of, for example, metal, and for example, stainless steel, an aluminum alloy, a copper alloy, or the like can be used.

[0082] Note that the direction in which the first plate-shaped members 50, the second plate-shaped members 60, the first refrigerant partition walls 71, the second refrigerant partition walls 72, the first water partition walls 81, and the second water partition walls 82 are stacked is defined as the stacking direction, and corresponds to the front-rear direction in the present embodiment.

[0083] In the heat exchange unit 40, the front side of one first plate-shaped member 50 and the rear side of one first refrigerant partition wall 71 are partially in surface contact with each other. The rear side of one first plate-

shaped member 50 and the front side of one second refrigerant partition wall 72 are partially in surface contact with each other. The front side of one second plate-shaped member 60 and the rear side of one first water partition wall 81 are partially in surface contact with each other. The rear side of one second plate-shaped member 60 and the front side of one second water partition wall 82 are partially in surface contact with each other. The front side of one first refrigerant partition wall 71 and the rear side of one second water partition wall 82 are partially in surface contact with each other. The rear side of one second refrigerant partition wall 72 and the front side of one first water partition wall 81 are partially in surface contact with each other. In this manner, from the front side toward the rear side, plate-shaped members and partition walls are stacked in the plate thickness direction so as to be repeatedly arranged in order of the first refrigerant partition wall 71, the first plate-shaped member 50, the second refrigerant partition wall 72, the first water partition wall 81, the second plate-shaped member 60, the second water partition wall 82, the first refrigerant partition wall 71, the first plate-shaped member 50, and so on.

[0084] In the heat exchange unit 40, these pluralities of first plate-shaped members 50, second plate-shaped members 60, first refrigerant partition walls 71, second refrigerant partition walls 72, first water partition walls 81, and second water partition walls 82 are bonded to each other in a state of being stacked in the plate thickness direction. Here, the bonding method is not limited, and vacuum brazing, diffusion bonding, and the like can be named, for example. Note that, from the viewpoint of obtaining a favorable bonded state, the plate-shaped members and the partition walls are preferably bonded in a state of being pressurized in the plate thickness direction.

[0085] One first plate-shaped member 50 includes a plurality of first flow paths 51 that allow the refrigerant to flow within a range of the plate thickness. The first flow path 51 is a flow path provided so as to penetrate the first plate-shaped member 50 in the plate thickness direction and formed by being sandwiched between the first refrigerant partition wall 71 and the second refrigerant partition wall 72, which are adjacent to the first plate-shaped member 50, in the front-rear direction. In the present embodiment, the plurality of first flow paths 51 are arranged in the vertical direction in one first plate-shaped member 50. The direction in which the plurality of first flow paths 51 are arranged is defined as an arrangement direction of the first flow paths 51. Furthermore, each first flow path 51 extends in the left-right direction. In this manner, when the first plate-shaped member 50 is viewed along the front-rear direction that is the stacking direction of the second plate-shaped member 60 and the first plate-shaped member 50, the first flow paths 51 extend in the left-right direction in the first plate-shaped member 50 along a direction intersecting the arrangement direction in which the plurality of first flow paths 51 are arranged.

[0086] Note that, in the present embodiment, the plurality of first flow paths 51 are divided into a plurality of flow path groups arranged in the vertical direction, and are configured to allow the refrigerant to flow as described below. Specifically, the refrigerant that has flowed into the refrigerant inlet header 45 flows toward the right in a flow path group including a plurality of first flow paths 51, and flows toward a first return header 47. The refrigerant that has reached the first return header 47 flows so as to return toward the left in a flow path group that is located one stage below the above flow path group and includes a plurality of first flow paths 51, and flows toward a second return header 48. The refrigerant that has reached the second return header 48 flows so as to return toward the right in a flow path group that is located one stage further below the above flow path group and includes a plurality of first flow paths 51, and flows toward a third return header 49. The refrigerant that has reached the third return header 49 flows so as to return toward the left in a flow path group that is located one stage further below the above flow path group and includes a plurality of first flow paths 51, and flows toward the refrigerant outlet header 46.

[0087] One second plate-shaped member 60 includes a plurality of second flow paths 61 that allow water to flow within a range of the plate thickness. The second flow path 61 is a flow path provided so as to penetrate the second plate-shaped member 60 in the plate thickness direction and formed by being sandwiched between the first water partition wall 81 and the second water partition wall 82, which are adjacent to the second plate-shaped member 60, in the front-rear direction. In the present embodiment, the plurality of second flow paths 61 are arranged in the left-right direction in one second plate-shaped member 60. The direction in which the plurality of second flow paths 61 are arranged is defined as an arrangement direction of the second flow paths 61. Furthermore, each second flow path 61 extends in the vertical direction. In this manner, when the second plate-shaped member 60 is viewed along the front-rear direction that is the stacking direction of the second plate-shaped member 60 and the first plate-shaped member 50, the second flow paths 61 extend in the vertical direction in the second plate-shaped member 60 along a direction intersecting the arrangement direction in which the plurality of second flow paths 61 are arranged. Note that, in the present embodiment, when the second plate-shaped member 60 is viewed along the stacking direction, the second flow path 61 has a shape that meanders in the arrangement direction of the second flow paths 61 as the second flow path 61 extends in the direction in which the second flow path 61 extends. The meandering shape can enhance heat transfer performance.

[0088] The first flow path 51 and the second flow path 61 are, for example, micro flow paths having very small flow path cross-sectional areas, and are formed of flow paths having equivalent diameters of, for example, 1.5 mm or less. The plate heat exchanger 30 is referred to

as a micro flow path heat exchanger in some cases.

[0089] Furthermore, the plate heat exchanger 30 of the present embodiment is configured such that the refrigerant flowing through the first flow path 51 and the water flowing through the second flow path 61 are in counter flow from each other. Furthermore, the plate heat exchanger 30 of the present embodiment is configured such that the refrigerant flowing through the first flow path 51 and the water flowing through the second flow path 61 flow orthogonally to each other. This flow relationship can enhance heat transfer efficiency.

(4) Details of each plate-shaped member and partition wall

[0090] Hereinafter, the first refrigerant partition wall 71, the first plate-shaped member 50, the second refrigerant partition wall 72, the first water partition wall 81, the second plate-shaped member 60, and the second water partition wall 82, which form the heat exchange unit 40, will be described one by one in order.

(4-1) First refrigerant partition wall

[0091] Fig. 8 is a schematic configuration diagram of the first refrigerant partition wall 71 as viewed from the front.

[0092] The first refrigerant partition wall 71 is a plate-shaped member including a flat portion 71a, a water inlet communication port 71b, a water outlet communication port 71c, a refrigerant inlet communication port 71d, and a refrigerant outlet communication port 71e.

[0093] The flat portion 71a is formed to have a substantially rectangular shape in a front view. Both surfaces on the front side and the rear side of the flat portion 71a are formed of flat surfaces. The water inlet communication port 71b is an opening formed in the vicinity of a lower end portion of the first refrigerant partition wall 71 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The water outlet communication port 71c is an opening formed in the vicinity of an upper end portion of the first refrigerant partition wall 71 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The refrigerant inlet communication port 71d is an opening formed in the vicinity of the upper left of the first refrigerant partition wall 71 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. The refrigerant outlet communication port 71e is an opening formed in the vicinity of the lower left of the first refrigerant partition wall 71 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction.

(4-2) First plate-shaped member

[0094] Fig. 9 is a schematic configuration diagram of the first plate-shaped member 50 as viewed from the

front.

[0095] The first plate-shaped member 50 is a plate-shaped member including a plurality of first flow paths 51, a flat portion 52, a water inlet communication port 53, a water outlet communication port 54, a refrigerant inlet communication port 55, a refrigerant outlet communication port 56, a first return communication port 57, a second return communication port 58, and a third return communication port 59.

[0096] The flat portion 52 is formed to have a substantially rectangular shape in a front view. Both surfaces on the front side and the rear side of the flat portion 52 are formed of flat surfaces. The water inlet communication port 53 is an opening formed in the vicinity of a lower end portion of the first plate-shaped member 50 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The water outlet communication port 54 is an opening formed in the vicinity of an upper end portion of the first plate-shaped member 50 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The refrigerant inlet communication port 55 is an opening formed in the vicinity of the upper left of the first plate-shaped member 50 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. The refrigerant outlet communication port 56 is an opening formed in the vicinity of the lower left of the first plate-shaped member 50 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction.

[0097] The first return communication port 57 is an opening formed in the vicinity of the upper right of the first plate-shaped member 50 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. An upper half of the first return communication port 57 spreads vertically at a position corresponding to the refrigerant inlet communication port 55. The third return communication port 59 is an opening formed in the vicinity of the lower right of the first plate-shaped member 50 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. A lower half of the third return communication port 59 spreads vertically at a position corresponding to the refrigerant outlet communication port 56. The second return communication port 58 is an opening formed in the vicinity of the center on the left side of the first plate-shaped member 50 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. An upper half of the second return communication port 58 spreads vertically at a position corresponding to a lower half of the first return communication port 57. A lower half of the second return communication port 58 spreads vertically at a position corresponding to an upper half of the third return communication port 59.

[0098] The plurality of first flow paths 51 are provided such that the plurality of first flow paths 51 extending in the left-right direction are arranged in the vertical direction. The plurality of first flow paths 51 are formed to be divided into a plurality of flow path groups. A first flow

path group of the plurality of first flow paths 51 extends so as to connect the refrigerant inlet communication port 55 and the first return communication port 57. A second flow path group of the plurality of first flow paths 51 extends so as to connect the first return communication port 57 and the second return communication port 58. A third flow path group of the plurality of first flow paths 51 extends so as to connect the second return communication port 58 and the third return communication port 59. A fourth flow path group of the plurality of first flow paths 51 extends so as to connect the third return communication port 59 and the refrigerant outlet communication port 56.

(4-3) Second refrigerant partition wall

[0099] Fig. 10 is a schematic configuration diagram of the second refrigerant partition wall 72 as viewed from the front.

[0100] The second refrigerant partition wall 72 is a plate-shaped member including a flat portion 72a, a water inlet communication port 72b, a water outlet communication port 72c, a refrigerant inlet communication port 72d, and a refrigerant outlet communication port 72e.

[0101] The flat portion 72a is formed to have a substantially rectangular shape in a front view. Both surfaces on the front side and the rear side of the flat portion 72a are formed of flat surfaces. The water inlet communication port 72b is an opening formed in the vicinity of a lower end portion of the second refrigerant partition wall 72 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The water outlet communication port 72c is an opening formed in the vicinity of an upper end portion of the second refrigerant partition wall 72 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The refrigerant inlet communication port 72d is an opening formed in the vicinity of the upper left of the second refrigerant partition wall 72 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. The refrigerant outlet communication port 72e is an opening formed in the vicinity of the lower left of the second refrigerant partition wall 72 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction.

(4-4) First water partition wall

[0102] Fig. 11 is a schematic configuration diagram of the first water partition wall 81 as viewed from the front.

[0103] The first water partition wall 81 is a plate-shaped member including a flat portion 81a, a rough surface portion 81x, a water inlet communication port 81b, a water outlet communication port 81c, a refrigerant inlet communication port 81d, and a refrigerant outlet communication port 81e.

[0104] The first water partition wall 81 is formed to have a substantially rectangular shape in a front view.

[0105] A surface on the rear side of the flat portion 81a is formed of a flat surface. Furthermore, on the front side of the flat portion 81a, a portion other than the rough surface portion 81x is formed of a flat surface.

[0106] The rough surface portion 81x has an uneven shape in the plate thickness direction of the first water partition wall 81. The rough surface portion 81x spreads in a surface on the front side of the first water partition wall 81 from the right side of the refrigerant inlet communication port 81d and the refrigerant outlet communication port 81e to a right side end portion between the water inlet communication port 81b and the water outlet communication port 81c in the vertical direction.

[0107] The water inlet communication port 81b is an opening formed in the vicinity of a lower end portion of the first water partition wall 81 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The water outlet communication port 81c is an opening formed in the vicinity of an upper end portion of the first water partition wall 81 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The refrigerant inlet communication port 81d is an opening formed in the vicinity of the upper left of the first water partition wall 81 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. The refrigerant outlet communication port 81e is an opening formed in the vicinity of the lower left of the first water partition wall 81 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction.

[0108] The rough surface portion 81x has a shape obtained by cutting the flat surface on the front side of the flat portion 81a so as to be partially recessed toward the rear side. The rough surface portion 81x is provided with a plurality of protrusions 81y, which are portions protruding so as to have the same position in the front-rear direction as the flat surface on the front side of the flat portion 81a. Note that the plurality of protrusions 81y are provided in a dispersed manner in the rough surface portion 81x when viewed along the front-rear direction. In addition, distal ends of the plurality of protrusions 81y are in contact with a surface on the rear side of the flat portion 72a of the second refrigerant partition wall 72. Note that, when viewed along the stacking direction of the first water partition wall 81 and the second refrigerant partition wall 72, the sum of the areas of the portions where the distal ends of the plurality of protrusions 81y are in contact with the surface on the rear side of the flat portion 72a of the second refrigerant partition wall 72 with respect to the entire area of the rough surface portion 81x is not limited, and may be 50 or more, preferably 10% or more, and preferably 25% or more, from the viewpoint of obtaining a favorable heat transmission, for example.

[0109] Note that the surface on the rear side of the flat portion 72a of the second refrigerant partition wall 72 is a flat surface. Therefore, when viewed in the stacking direction of the first water partition wall 81 and the second refrigerant partition wall 72, the surface area of the rough

surface portion 81x per unit area is larger than the surface area of the surface on the rear side of the flat portion 72a of the second refrigerant partition wall 72 per unit area.

(4-5) Second plate-shaped member

[0110] Fig. 12 is a schematic configuration diagram of the second plate-shaped member 60 as viewed from the front.

[0111] The second plate-shaped member 60 is a plate-shaped member including a plurality of second flow paths 61, a flat portion 62, a water inlet communication port 63, a water outlet communication port 64, a refrigerant inlet communication port 65, and a refrigerant outlet communication port 66.

[0112] The flat portion 62 is formed to have a substantially rectangular shape in a front view. Both surfaces on the front side and the rear side of the flat portion 62 are formed of flat surfaces. The water inlet communication port 63 is an opening formed in the vicinity of a lower end portion of the second plate-shaped member 60 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The water outlet communication port 64 is an opening formed in the vicinity of an upper end portion of the second plate-shaped member 60 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The refrigerant inlet communication port 65 is an opening formed in the vicinity of the upper left of the second plate-shaped member 60 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. The refrigerant outlet communication port 66 is an opening formed in the vicinity of the lower left of the second plate-shaped member 60 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction.

[0113] The plurality of second flow paths 61 are provided such that the plurality of second flow paths 61 extending substantially in the vertical direction are arranged in the left-right direction. The plurality of second flow paths 61 extend so as to connect the water inlet communication port 63 and the water outlet communication port 64. Here, in the present embodiment, the second flow paths 61 extend in the vertical direction while meandering to the left and right in order to enhance the heat transfer performance.

(4-6) Second water partition wall

[0114] Fig. 13 is a schematic configuration diagram of the second water partition wall 82 as viewed from the front.

[0115] The second water partition wall 82 is a plate-shaped member including a flat portion 82a, a rough surface portion 82x, a water inlet communication port 82b, a water outlet communication port 82c, a refrigerant inlet communication port 82d, and a refrigerant outlet communication port 82e.

[0116] The second water partition wall 82 is formed to

have a substantially rectangular shape in a front view.

[0117] A surface on the front side of the flat portion 82a is formed of a flat surface. Furthermore, on the rear side of the flat portion 82a, a portion other than the rough surface portion 82x is formed of a flat surface.

[0118] The rough surface portion 82x has an uneven shape in the plate thickness direction of the second water partition wall 82. The rough surface portion 82x spreads in a surface on the rear side of the second water partition wall 82 from the right side of the refrigerant inlet communication port 82d and the refrigerant outlet communication port 82e to a right side end portion between the water inlet communication port 82b and the water outlet communication port 82c in the vertical direction.

[0119] The water inlet communication port 82b is an opening formed in the vicinity of a lower end portion of the second water partition wall 82 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The water outlet communication port 82c is an opening formed in the vicinity of an upper end portion of the second water partition wall 82 so as to spread entirely in the left-right direction, and penetrates in the plate thickness direction. The refrigerant inlet communication port 82d is an opening formed in the vicinity of the upper left of the second water partition wall 82 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction. The refrigerant outlet communication port 82e is an opening formed in the vicinity of the lower left of the second water partition wall 82 so as to spread partially in the vertical direction, and penetrates in the plate thickness direction.

[0120] The rough surface portion 82x has a shape obtained by cutting the flat surface on the rear side of the flat portion 82a so as to be partially recessed toward the front side. The rough surface portion 82x is provided with a plurality of protrusions 82y, which are portions protruding so as to have the same position in the front-rear direction as the flat surface on the rear side of the flat portion 82a. Note that the plurality of protrusions 82y are provided in a dispersed manner in the rough surface portion 82x when viewed along the front-rear direction. In addition, distal ends of the protrusions 82y are in contact with a surface on the front side of the flat portion 71a of the first refrigerant partition wall 71. Note that, when viewed along the stacking direction of the second water partition wall 82 and the first refrigerant partition wall 71, the sum of the areas of the portions where the distal ends of the plurality of protrusions 82y are in contact with the surface on the front side of the flat portion 71a of the first refrigerant partition wall 71 with respect to the entire area of the rough surface portion 82x is not limited, and may be 50 or more, preferably 10% or more, and preferably 25% or more, from the viewpoint of obtaining a favorable heat transmission, for example.

[0121] Note that the surface on the front side of the flat portion 71a of the first refrigerant partition wall 71 is a flat surface. Therefore, when viewed in the stacking direction of the second water partition wall 82 and the first refrig-

erant partition wall 71, the surface area of the rough surface portion 82x per unit area is larger than the surface area of the surface on the front side of the flat portion 71a of the first refrigerant partition wall 71 per unit area.

(4-7) In re headers formed by each penetration portion

[0122] As described above, in a state where the first refrigerant partition wall 71, the first plate-shaped member 50, the second refrigerant partition wall 72, the first water partition wall 81, the second plate-shaped member 60, and the second water partition wall 82 are stacked to be arranged in the plate thickness direction, the water inlet header 43, the water outlet header 44, the refrigerant inlet header 45, and the refrigerant outlet header 46, which are spaces located inside the heat exchange unit 40, are formed.

[0123] The water inlet header 43 is an internal space formed by overlapping the water inlet communication port 71b of the first refrigerant partition wall 71, the water inlet communication port 53 of the first plate-shaped member 50, the water inlet communication port 72b of the second refrigerant partition wall 72, the water inlet communication port 81b of the first water partition wall 81, the water inlet communication port 63 of the second plate-shaped member 60, and the water inlet communication port 82b of the second water partition wall 82 with each other in the front-rear direction.

[0124] The water outlet header 44 is an internal space formed by overlapping the water outlet communication port 71c of the first refrigerant partition wall 71, the water outlet communication port 54 of the first plate-shaped member 50, the water outlet communication port 72c of the second refrigerant partition wall 72, the water outlet communication port 81c of the first water partition wall 81, the water outlet communication port 64 of the second plate-shaped member 60, and the water outlet communication port 82c of the second water partition wall 82 with each other in the front-rear direction.

[0125] The refrigerant inlet header 45 is an internal space formed by overlapping the refrigerant inlet communication port 71d of the first refrigerant partition wall 71, the refrigerant inlet communication port 55 of the first plate-shaped member 50, the refrigerant inlet communication port 72d of the second refrigerant partition wall 72, the refrigerant inlet communication port 81d of the first water partition wall 81, the refrigerant inlet communication port 65 of the second plate-shaped member 60, and the refrigerant inlet communication port 82d of the second water partition wall 82 with each other in the front-rear direction.

[0126] The refrigerant outlet header 46 is an internal space formed by overlapping the refrigerant outlet communication port 71e of the first refrigerant partition wall 71, the refrigerant outlet communication port 56 of the first plate-shaped member 50, the refrigerant outlet communication port 72e of the second refrigerant partition wall 72, the refrigerant outlet communication port 81e of

the first water partition wall 81, the refrigerant outlet communication port 66 of the second plate-shaped member 60, and the refrigerant outlet communication port 82e of the second water partition wall 82 with each other in the front-rear direction.

[0127] Note that the first return communication port 57, the second return communication port 58, and the third return communication port 59 included in the first plate-shaped member 50 are partitioned by the flat portion 71a of the first refrigerant partition wall 71 and the flat portion 72a of the second refrigerant partition wall 72, which are adjacent to the first plate-shaped member 50.

[0128] Furthermore, flat surface regions that are in surface contact with each other in the stacking direction are provided around the water inlet communication port 71b of the first refrigerant partition wall 71, around the water inlet communication port 53 of the first plate-shaped member 50, around the water inlet communication port 72b of the second refrigerant partition wall 72, around the water inlet communication port 81b of the first water partition wall 81, around the water inlet communication port 63 of the second plate-shaped member 60, and around the water inlet communication port 82b of the second water partition wall 82, which are around a plurality of openings forming the water inlet header 43. Therefore, favorable bonding strength can be obtained between the members forming the water inlet header 43.

[0129] Furthermore, flat surface regions that are in surface contact with each other in the stacking direction are provided around the water outlet communication port 71c of the first refrigerant partition wall 71, around the water outlet communication port 54 of the first plate-shaped member 50, around the water outlet communication port 72c of the second refrigerant partition wall 72, around the water outlet communication port 81c of the first water partition wall 81, around the water outlet communication port 64 of the second plate-shaped member 60, and around the water outlet communication port 82c of the second water partition wall 82, which are around a plurality of openings forming the water outlet header 44. Therefore, favorable bonding strength can be obtained between the members forming the water outlet header 44.

[0130] Furthermore, flat surface regions that are in surface contact with each other in the stacking direction are provided around the refrigerant inlet communication port 71d of the first refrigerant partition wall 71, around the refrigerant inlet communication port 55 of the first plate-shaped member 50, around the refrigerant inlet communication port 72d of the second refrigerant partition wall 72, around the refrigerant inlet communication port 81d of the first water partition wall 81, around the refrigerant inlet communication port 65 of the second plate-shaped member 60, and around the refrigerant inlet communication port 82d of the second water partition wall 82, which are around a plurality of openings forming the refrigerant inlet header 45. Therefore, favorable bonding strength can be obtained between the members forming

the refrigerant inlet header 45.

[0131] Furthermore, flat surface regions that are in surface contact with each other in the stacking direction are provided around the refrigerant outlet communication port 71e of the first refrigerant partition wall 71, around the refrigerant outlet communication port 56 of the first plate-shaped member 50, around the refrigerant outlet communication port 72e of the second refrigerant partition wall 72, around the refrigerant outlet communication port 81e of the first water partition wall 81, around the refrigerant outlet communication port 66 of the second plate-shaped member 60, and around the refrigerant outlet communication port 82e of the second water partition wall 82, which are a plurality of openings forming the refrigerant outlet header 46. Therefore, favorable bonding strength can be obtained between the members forming the refrigerant outlet header 46.

(5) Gap between water partition wall and refrigerant partition wall

[0132] As described above, the first water partition wall 81 is provided with the rough surface portion 81x, so that there exists a portion recessed toward the rear side compared to the flat surface on the front side of the flat portion 81a. Therefore, a first gap G1, the thickness direction of which is the front-rear direction, is formed between the portion that is within the rough surface portion 81x of the first water partition wall 81 and is recessed toward the rear side and the flat surface on the rear side of the flat portion 72a of the second refrigerant partition wall 72. The first gap G1 spreads in the vertical and left-right directions.

[0133] Furthermore, the second water partition wall 82 is provided with the rough surface portion 82x, so that there exists a portion recessed toward the front side compared to the flat surface on the rear side of the flat portion 82a. Therefore, a second gap G2, the thickness direction of which is the front-rear direction, is formed between the portion that is within the rough surface portion 82x of the second water partition wall 82 and is recessed toward the front side and the flat surface on the front side of the flat portion 71a of the first refrigerant partition wall 71. The second gap G2 spreads in the vertical and left-right directions.

(6) Feature of embodiment

[0134] In the plate heat exchanger 30 of the present embodiment, the first refrigerant partition wall 71 and the second water partition wall 82 or the second refrigerant partition wall 72 and the first water partition wall 81 are provided between the first flow paths 51 of the first plate-shaped member 50 through which the refrigerant flows and the second flow paths 61 of the second plate-shaped member 60 through which the water flows. Therefore, the first flow paths 51 through which the refrigerant flows and the second flow paths 61 through which the water

flows are partitioned by two partition walls. As a result, even when either of the two partition walls is damaged, the refrigerant and the water are prevented from mixing. For example, in a case where damage has occurred to the second water partition wall 82 out of the first refrigerant partition wall 71 and the second water partition wall 82, some of the water flowing through the second flow path 61 flows into the second gap G2 between the first refrigerant partition wall 71 and the second water partition wall 82 through the damaged portion of the second water partition wall 82. Nevertheless, even in such a case, the refrigerant and the water are prevented from mixing. Furthermore, in a case where damage has occurred to the first water partition wall 81 out of the second refrigerant partition wall 72 and the first water partition wall 81, some of the water flowing through the second flow path 61 flows into the first gap G1 between the second refrigerant partition wall 72 and the first water partition wall 81 through the damaged portion of the first water partition wall 81. Nevertheless, even in such a case, the refrigerant and the water are prevented from mixing. Note that the cause of damage to the first water partition wall 81 and the second water partition wall 82 here is not limited. For example, deformation due to thermal expansion or thermal contraction, aging deterioration, expansion of the second flow path 61 due to the freezing of the water flowing through the second flow path 61, and the like are considered. Note that even in a case where damage has occurred to the first refrigerant partition wall 71 or the second refrigerant partition wall 72, the refrigerant and the water are prevented from mixing.

[0135] In the plate heat exchanger 30 of the present embodiment, the second gap G2 is provided between the first refrigerant partition wall 71 and the second water partition wall 82, and the first gap G1 is provided between the second refrigerant partition wall 72 and the first water partition wall 81. Therefore, even when breakage has occurred to any one of the first refrigerant partition wall 71, the second water partition wall 82, the second refrigerant partition wall 72, and the first water partition wall 81, the refrigerant flowing through the first flow path 51 or the water flowing through the second flow path 61 can be guided to the first gap G1 or the second gap G2.

[0136] Here, the plate heat exchanger 30 of the present embodiment is provided with the second gap G2 between the first refrigerant partition wall 71 and the second water partition wall 82 and the first gap G1 between the second refrigerant partition wall 72 and the first water partition wall 81, which are provided for guiding the leaking water and refrigerant. In addition, the first water partition wall 81 is provided with the rough surface portion 81x and the second water partition wall 82 is provided with the rough surface portion 82x. The rough surface portion 81x of the first water partition wall 81 does not have a shape in which the entire rough surface portion 81x is separated from the second refrigerant partition wall 72. Instead, the rough surface portion 81x is provided with the plurality of protrusions 81y that protrude, in a dispersed manner,

toward the side of the second refrigerant partition wall 72 so as to be in contact with the second refrigerant partition wall 72. Similarly, the rough surface portion 82x of the second water partition wall 82 does not have a shape in which the entire rough surface portion 82x is separated from the first refrigerant partition wall 71. Instead, the rough surface portion 82x is provided with a plurality of protrusions 82y that protrude, in a dispersed manner, toward the side of the first refrigerant partition wall 71 so as to be in contact with the first refrigerant partition wall 71. Therefore, in manufacturing the plate heat exchanger 30, the first gap G1 and the second gap G2 are less likely to collapse even in a case where the plate-shaped members and the partition walls are bonded by a method such as diffusion bonding by pressurizing and pressing the plate-shaped members and the partition walls in the stacking direction at a high temperature. Furthermore, since the first gap G1 and the second gap G2 have shapes that prevent the first gap G1 and the second gap G2 from collapsing. Therefore, it is possible to increase the pressure when the plate-shaped members and the partition walls are pressurized in the stacking direction and are bonded, so that a favorable bonding state at the bonded portion can be obtained. Note that, as a method of bonding the plate-shaped members and the partition walls, a bonding method other than the bonding method by brazing is preferably used from the viewpoint of preventing a melted brazing material from being filled in the first gap G1 or the second gap G2. By providing the rough surface portion 81x and the rough surface portion 82x, the first gap G1 and the second gap G2 are easily ensured. Therefore, even when the plate-shaped members and the partition walls are diffusion-bonded by being pressurized and pressed in the stacking direction at a high temperature, it is possible to prevent the second refrigerant partition wall 72 and the first water partition wall 81 from becoming one plate member due to the collapse of the first gap G1, and to prevent the first refrigerant partition wall 71 and the second water partition wall 82 from becoming one plate member due to the collapse of the second gap G2. Accordingly, a state where two partition walls are interposed between the refrigerant and the water can be ensured, improving the reliability of the heat exchanger in that the refrigerant and the water are not mixed. Moreover, by providing the rough surface portion 81x, the distal ends of the plurality of protrusions 81y of the rough surface portion 81x are in contact with the second refrigerant partition wall 72 while the first gap G1 is ensured between the second refrigerant partition wall 72 and the first water partition wall 81. Therefore, it is possible to obtain a favorable heat transmission between the second refrigerant partition wall 72 and the first water partition wall 81. Furthermore, by providing the rough surface portion 82x, the distal ends of the plurality of protrusions 82y of the rough surface portion 82x are in contact with the first refrigerant partition wall 71 while the first refrigerant partition wall 71 and the second water partition wall 82 ensures the second gap G2 between the first

refrigerant partition wall 71 and the second water partition wall 82. Therefore, it is possible to obtain a favorable heat transmission between the first refrigerant partition wall 71 and the second water partition wall 82.

[0137] In the plate heat exchanger 30 of the present embodiment, the first water partition wall 81 includes the rough surface portion 81x, the second water partition wall 82 includes the rough surface portion 82x, and the first refrigerant partition wall 71 and the second refrigerant partition wall 72 are not provided with corresponding rough surface portions. Specifically, in the region of the first refrigerant partition wall 71, a region facing the rough surface portion 82x of the second water partition wall 82 is not provided with a rough surface portion, and is a flat surface. Furthermore, in the region of the second refrigerant partition wall 72, a region facing the rough surface portion 81x of the first water partition wall 81 is not provided with a rough surface portion, and is a flat surface. Therefore, in a case where some load is applied to the plate heat exchanger 30, the first water partition wall 81 or the second water partition wall 82 is damaged in preference to the first refrigerant partition wall 71 and the second refrigerant partition wall 72 among the first refrigerant partition wall 71, the second refrigerant partition wall 72, the first water partition wall 81, and the second water partition wall 82. In addition, the first refrigerant partition wall 71 and the second refrigerant partition wall 72 are less likely to be damaged. Therefore, in a case where a refrigerant with flammability is used as the refrigerant flowing through the first circuit 10, the leakage of the refrigerant with flammability is prevented.

(7) Other embodiments

(7-1) Another embodiment A

[0138] In the heat pump system 1 of the above-described embodiment, the heat exchange unit 40 has been described as an example in which the first water partition wall 81 is provided with the rough surface portion 81x, the second water partition wall 82 is provided with the rough surface portion 82x, and the first refrigerant partition wall 71 and the second refrigerant partition wall 72 are not provided with rough surface portions and have flat shapes.

[0139] Alternatively, for example, as illustrated in Fig. 15, the heat exchange unit 40 may be provided with a first water partition wall 181, a second water partition wall 182, a first refrigerant partition wall 171, and a second refrigerant partition wall 172 in place of the first water partition wall 81, the second water partition wall 82, the first refrigerant partition wall 71, and the second refrigerant partition wall 72, of the above-described embodiment, respectively.

[0140] The first water partition wall 181 is provided with openings similarly to the first water partition wall 81 of the above-described embodiment, but is not provided with the rough surface portion 81x unlike the above-de-

scribed embodiment, and includes flat surfaces on both sides in the plate thickness direction as the flat portion 181a.

[0141] The second water partition wall 182 is provided with openings similarly to the second water partition wall 82 of the above-described embodiment, but is not provided with the rough surface portion 82x unlike the above-described embodiment, and includes flat surfaces on both sides in the plate thickness direction as the flat portion 182a.

[0142] The first refrigerant partition wall 171 includes a flat portion 171a, a rough surface portion 171x, and the water inlet communication port 71b, the water outlet communication port 71c, the refrigerant inlet communication port 71d, and the refrigerant outlet communication port 71e similarly to those in the above-described embodiment. A surface on the rear side of the flat portion 171a is formed of a flat surface. Furthermore, on the front side of the flat portion 171a, a portion other than the rough surface portion 171x is formed of a flat surface. The first refrigerant partition wall 171 includes the rough surface portion 171x in a surface on the side of the second water partition wall 182, which is the front side of the first refrigerant partition wall 171. The rough surface portion 171x spreads from the right side of the refrigerant inlet communication port 71d and the refrigerant outlet communication port 71e to a right side end portion between the water inlet communication port 71b and the water outlet communication port 71c in the vertical direction. Note that, in the surface on the front side of the flat portion 171a of the first refrigerant partition wall 171, a portion other than the rough surface portion 171x is formed of a flat surface. The rough surface portion 171x has a shape obtained by cutting the flat surface on the front side of the flat portion 171a so as to be partially recessed toward the rear side. The rough surface portion 171x is provided with a plurality of protrusions 171y, which are portions protruding so as to have the same position in the front-rear direction as the flat surface on the front side of the flat portion 171a. Note that the plurality of protrusions 171y are provided in a dispersed manner in the rough surface portion 171x when viewed along the front-rear direction. In addition, distal ends of the plurality of protrusions 171y are in contact with a surface on the rear side of the flat portion 182a of the second water partition wall 182.

[0143] The second refrigerant partition wall 172 includes a flat portion 172a, a rough surface portion 172x, and the water inlet communication port 72b, the water outlet communication port 72c, the refrigerant inlet communication port 72d, and the refrigerant outlet communication port 72e similarly to those in the above-described embodiment. A surface on the front side of the flat portion 172a is formed of a flat surface. Furthermore, on the rear side of the flat portion 172a, a portion other than the rough surface portion 172x is formed of a flat surface. The second refrigerant partition wall 172 includes the rough surface portion 172x in a surface on the side of the first water

partition wall 181, which is the rear side of the second refrigerant partition wall 172. The rough surface portion 172x spreads from the right side of the refrigerant inlet communication port 72d and the refrigerant outlet communication port 72e to a right side end portion between the water inlet communication port 72b and the water outlet communication port 72c in the vertical direction. Note that, in the surface on the rear side of the flat portion 172a of the second refrigerant partition wall 172, a portion other than the rough surface portion 172x is formed of a flat surface. The rough surface portion 172x has a shape obtained by cutting the flat surface on the rear side of the flat portion 172a so as to be partially recessed toward the front side. The rough surface portion 172x is provided with a plurality of protrusions 172y, which are portions protruding so as to have the same position in the front-rear direction as the flat surface on the rear side of the flat portion 172a. Note that the plurality of protrusions 172y are provided in a dispersed manner in the rough surface portion 172x when viewed along the front-rear direction. In addition, distal ends of the plurality of protrusions 172y are in contact with a surface on the rear side of the flat portion 181a of the first water partition wall 181.

[0144] Note that, out of the partition wall on the refrigerant side and the partition wall on the water side, the partition wall including the rough surface portion is more likely to be damaged. From such a viewpoint, if the rough surface portion is provided, the rough surface portion is preferably provided on the partition wall on the water side, which is the partition wall other than the partition wall on the refrigerant side.

(7-2) Another embodiment B

[0145] In the above-described embodiment, a case has been described as an example in which the first water partition wall 81 includes the rough surface portion 81x formed to be partially recessed toward the rear side with respect to the flat surface on the front side of the flat portion 81a of the first water partition wall 81.

[0146] Alternatively, for example, as illustrated in Fig. 16, the first water partition wall 181 including an uneven portion 181x including a recessed flat surface 181z and a plurality of protrusions 181y may be used in place of the first water partition wall 81 of the above-described embodiment. The recessed flat surface 181z spreads vertically and horizontally between the flat surface on the front side and the flat surface on the rear side of the flat portion 81a of the first water partition wall 181. The protrusions 181y are provided so as to protrude from the recessed flat surface 181z toward the front side. The protrusions 181y have shapes tapered toward the front side, and distal ends thereof are in contact with the surface on the rear side of the flat portion 72a of the second refrigerant partition wall 72. According to the above configuration, the same effect as that of the above-described embodiment can also be obtained.

[0147] Note that the first water partition wall 181 may include concave portions 181q on the back surface side opposite to the protruding direction of the protrusion 181y as illustrated in Fig. 17. The concave portions 181q are recessed so as to correspond to the respective protrusions 181y. Furthermore, the first water partition wall 181 may include a flat surface 181p on the back surface side opposite to the protruding direction of the protrusion 181y as illustrated in Fig. 18.

(7-3) Another embodiment C

[0148] In the plate heat exchanger 30 of the above-described embodiment, a case has been described as an example in which the first gap G1, which is an area in which air exists, is provided between the second refrigerant partition wall 72 and the first water partition wall 81, and the second gap G2, which is an area in which air exists, is provided between the first refrigerant partition wall 71 and the second water partition wall 82.

[0149] Alternatively, for example, the first gap G1 and the second gap G2 may be filled with a liquid L with higher thermal conductivity than air as illustrated in Fig. 19.

[0150] Here, as the liquid L, for example, silicone oil, fluoroether oil, mineral oil, animal and vegetable natural oil, paraffin, synthetic oil, or the like can be used.

[0151] In this manner, the first gap G1 and the second gap G2 are filled with the liquid L with high thermal conductivity, so that a favorable heat transmission is obtained between the second refrigerant partition wall 72 and the first water partition wall 81 and between the first refrigerant partition wall 71 and the second water partition wall 82. Therefore, it is possible to obtain a favorable heat exchange efficiency between the refrigerant flowing through the first flow paths 51 and the water flowing through the second flow paths 61.

[0152] Note that, even in a case where the first gap G1 and the second gap G2 are filled with the liquid L with high thermal conductivity, leakage of the liquid L is prevented because an end portion of the bonded portion between the second refrigerant partition wall 72 and the first water partition wall 81 and an end portion of the bonded portion between the first refrigerant partition wall 71 and the second water partition wall 82 are covered with the casing 31. Note that, in the above-described embodiment, the end portion of the bonded portion between the second refrigerant partition wall 72 and the first water partition wall 81 and the end portion of the bonded portion between the first refrigerant partition wall 71 and the second water partition wall 82 are covered with the casing 31 made of metal, but instead, the end portion of the bonded portion between the second refrigerant partition wall 72 and the first water partition wall 81 and the end portion of the bonded portion between the first refrigerant partition wall 71 and the second water partition wall 82 may be covered with a sealing material such as a coating film obtained by applying a resin coating material. Note that, in the plate heat exchanger 30 of the above-de-

scribed embodiment, the rough surface portion 81x of the first water partition wall 81 and the rough surface portion 82x of the second water partition wall 82 spread to a right side surface of the heat exchange unit 40. Therefore, the right side surface of the heat exchange unit 40 is preferably covered with the sealing material, the casing 31, or both the sealing material and the casing 31.

(7-4) Another embodiment D

[0153] In the second circuit 20 of the above-described embodiment, a case has been described as an example in which water is used as the circulating fluid.

[0154] Nevertheless, the fluid flowing through the second circuit 20 is not limited to water, and may be, for example, a heating medium, such as antifreeze or brine.

(7-5) Another embodiment E

[0155] In the plate heat exchanger 30 of the above-described embodiment, a case has been described as an example in which the plurality of first flow paths 51 are formed as a plurality of through holes included in the first plate-shaped member 50. Furthermore, a case has been described as an example in which the plurality of second flow paths 61 is formed as a plurality of through holes included in the second plate-shaped member 60.

[0156] Nevertheless, the first flow paths 51 or the second flow paths 61 are not limited thereto. For example, the entire portion in which the plurality of first flow paths 51 are provided in the above-described embodiment is formed to be a through hole, and a corrugated fin for forming a plurality of flow paths may be provided in the through hole portion. The corrugated fin includes a plurality of mountain fold portions and a plurality of valley fold portions extending along the longitudinal direction of the first flow path 51, and has a shape in which the mountain fold portions and the valley fold portions are alternately provided in a direction intersecting the longitudinal direction of the first flow path 51. Similarly, as for the second flow path 61, the entire portion in which the plurality of second flow paths 61 are provided in the above-described embodiment is formed to be a through hole, and a corrugated fin for forming a plurality of flow paths may be provided in the through hole portion. The corrugated fin includes a plurality of mountain fold portions and a plurality of valley fold portions extending along the longitudinal direction of the second flow path 61, and has a shape in which the mountain fold portions and the valley fold portions are alternately provided in a direction intersecting the longitudinal direction of the second flow path 61.

[0157] The above configuration allows the refrigerant and water to flow, similarly to the above-described embodiment.

(7-6) Another embodiment F

[0158] In the heat pump system 1 of the above-described embodiment, the heat exchange unit 40 has been described as an example in which the first water partition wall 81 is provided with the rough surface portion 81x, the second water partition wall 82 is provided with the rough surface portion 82x, and the first refrigerant partition wall 71 and the second refrigerant partition wall 72 are not provided with rough surface portions and have flat shapes.

[0159] Alternatively, for example, the plate heat exchanger 30 including a heat exchange unit 40a as illustrated in Fig. 20 may be employed. Note that the orientation of the heat exchange unit 40a is not limited.

[0160] The heat exchange unit 40a is formed by stacking a plurality of plate-shaped members in the stacking direction. As illustrated in Fig. 20, in the heat exchange unit 40a, from a first side toward a second side in the stacking direction, plate-shaped members and partition walls are stacked in the plate thickness direction so as to be repeatedly arranged in order of a first plate-shaped member 250, a first refrigerant water partition wall 270, a second plate-shaped member 260, a second refrigerant water partition wall 280, the first plate-shaped member 250, the first refrigerant water partition wall 270, the second plate-shaped member 260, the second refrigerant water partition wall 280, and so on.

[0161] The first plate-shaped member 250 includes a plurality of first flow paths 251, a plurality of first flow path partitions 252, a first wall portion 257, and a first plane 258. The first plate-shaped member 250 is a plate-shaped member whose plate thickness direction is the stacking direction. The first plane 258 is a plane that spreads on the second side of the first plate-shaped member 250 such that the stacking direction is the normal direction. The plurality of first flow paths 251 are provided on the first side of the first plate-shaped member 250 so as to extend in a direction intersecting the stacking direction and be arranged in parallel with each other. The first flow path partition 252 is provided between two first flow paths 251 adjacent to each other so as to partition the first flow paths 251. The plurality of first flow paths 251 are provided by, for example, partially etching a surface on the first side of the first plate-shaped member 250, and non-etched portions become the first flow path partitions 252. The plurality of first flow paths 251 have shapes recessed in the plate thickness direction from the surface on the first side of the first plate-shaped member 250 toward the second side. The plurality of first flow paths 251 are flow paths that do not reach the first plane 258, which is a surface on the second side of the first plate-shaped member 250, and do not penetrate the first plate-shaped member 250 in the plate thickness direction. The first flow paths 251 of the first plate-shaped member 250 are open on the first side. Another member is provided so as to be in surface contact with the first flow path partitions 252 on the first side of the first plate-

shaped member 250. As a result, the first side of the first flow paths 251 is closed, and flow paths are completed. Specifically, here, a partition wall plane 282 of the second refrigerant water partition wall 280 is in surface contact with the first flow path partitions 252 of the first plate-shaped member 250. The first wall portion 257 is a plate-shaped portion that spreads in the plate thickness direction of the first plate-shaped member 250 between second side end portions of the plurality of first flow paths 251 and the first plane 258 such that the stacking direction is the thickness direction. The first wall portion 257 functions as one wall that prevents a fluid, such as a refrigerant, flowing through the first flow paths 251 from reaching second flow paths 261 described later.

[0162] The first refrigerant water partition wall 270 includes a rough surface portion 271 provided on the first side and a partition wall plane 272 provided on the second side. The first refrigerant water partition wall 270 is a plate-shaped member whose plate thickness direction is the stacking direction. The rough surface portion 271 is provided on the first side of the first refrigerant water partition wall 270, and is provided with a plurality of protrusions 271y that are portions protruding in the plate thickness direction of the first refrigerant water partition wall 270. Distal ends on the first side of the plurality of protrusions 271y are provided so as to be in contact with the first plane 258 of the first plate-shaped member 250. Accordingly, a gap is formed between the first refrigerant water partition wall 270 and the first plate-shaped member 250. The partition wall plane 272 is a plane that spreads on the second side of the first refrigerant water partition wall 270 such that the stacking direction is the normal direction.

[0163] The second plate-shaped member 260 includes a plurality of second flow paths 261, a plurality of second flow path partitions 262, a second wall portion 267, and a second plane 268. The second plate-shaped member 260 is a plate-shaped member whose plate thickness direction is the stacking direction. The second plane 268 is a plane that spreads on the second side of the second plate-shaped member 260 such that the stacking direction is the normal direction. The plurality of second flow paths 261 are provided on the first side of the second plate-shaped member 260 so as to extend in a direction intersecting the stacking direction and be arranged in parallel with each other. Note that the direction in which the second flow path 261 extends and the direction in which the first flow path 251 extends preferably intersect with each other when viewed in the stacking direction. The second flow path partition 262 is provided between two second flow paths 261 adjacent to each other so as to partition the second flow paths 261. The plurality of second flow paths 261 are provided by, for example, partially etching a surface on the first side of the second plate-shaped member 260, and non-etched portions become the second flow path partitions 262. The plurality of second flow paths 261 have shapes recessed in the plate thickness direction from the surface on the first side of

the second plate-shaped member 260 toward the second side. The plurality of second flow paths 261 are flow paths that do not reach the second plane 268, which is a surface on the second side of the second plate-shaped member 260, and do not penetrate the second plate-shaped member 260 in the plate thickness direction. The second flow paths 261 of the second plate-shaped member 260 are open on the first side. Another member is provided so as to be in surface contact with the second flow path partitions 262 on the first side of the second plate-shaped member 260. As a result, the first side of the second flow paths 261 is closed, and flow paths are completed. Specifically, here, the partition wall plane 272 of the first refrigerant water partition wall 270 is in surface contact with the second flow path partitions 262 of the second plate-shaped member 260. The second wall portion 267 is a plate-shaped portion that spreads in the plate thickness direction of the second plate-shaped member 260 between second side end portions of the plurality of second flow paths 261 and the second plane 268 such that the stacking direction is the thickness direction. The second wall portion 267 functions as one wall that prevents a fluid, such as water, flowing through the second flow paths 261 from reaching the first flow paths 251.

[0164] The second refrigerant water partition wall 280 includes a rough surface portion 281 provided on the first side and the partition wall plane 282 provided on the second side. The second refrigerant water partition wall 280 is a plate-shaped member whose plate thickness direction is the stacking direction. The rough surface portion 281 is provided on the first side of the second refrigerant water partition wall 280, and is provided with a plurality of protrusions 281y that are portions protruding in the plate thickness direction of the second refrigerant water partition wall 280. Distal ends on the first side of the plurality of protrusions 281y are provided so as to be in contact with the second plane 268 of the second plate-shaped member 260. Accordingly, a gap is formed between the second refrigerant water partition wall 280 and the second plate-shaped member 260. The partition wall plane 282 is a plane that spreads on the second side of the second refrigerant water partition wall 280 such that the stacking direction is the normal direction.

[0165] Also in the above heat exchange unit 40a, the first flow paths 251 through which the first fluid such as a refrigerant flows and the second flow paths 261 through which the second fluid such as water flows are partitioned by two partition walls, the first wall portion 257 of the first plate-shaped member 250 and the first refrigerant water partition wall 270, so that a double-wall structure can be formed. Therefore, even when either of the two is damaged, the first fluid such as a refrigerant and the second fluid such as water are prevented from mixing. In addition, the leaked fluid can be discharged through the gap between the first refrigerant water partition wall 270 and the first plate-shaped member 250 or the gap between the second refrigerant water partition wall 280 and the second plate-shaped member 260. Furthermore, in manu-

facturing the plate heat exchanger 30, these gaps are less likely to collapse even in a case where the plate-shaped members and the partition walls are bonded by a method such as diffusion bonding by pressurizing and pressing the plate-shaped members and the partition walls in the stacking direction at a high temperature. In addition, it is possible to increase the pressure when the plate-shaped members and the partition walls are pressurized in the stacking direction and are bonded, so that a favorable bonding state at the bonded portion can be obtained.

[0166] Furthermore, according to the above heat exchange unit 40a, even if there is only one plate-shaped member between the first plate-shaped member 250, which is a member in which the first flow paths 251 are formed, and the second plate-shaped member 260, which is a member in which the second flow paths 261 are formed, a double-wall structure can be formed. Therefore, the number of components can be reduced.

[0167] Note that, also in the heat exchange unit 40a, as in another embodiment B, an uneven portion including a recessed flat surface and a plurality of protrusions may be provided in place of providing the rough surface portions 271 and 281 formed to be partially recessed with respect to the flat surfaces.

[0168] Note that, also in the heat exchange unit 40a, as in another embodiment C, the gap may be filled with the liquid L with higher thermal conductivity than air. In addition, in order to prevent the leakage of the liquid L, a structure in which the periphery is covered with the casing 31 may be employed, or the periphery may be covered with a sealing material, such as a coating film, obtained by applying a resin coating material.

(7-7) Another embodiment G

[0169] In the heat pump system 1 of the above-described embodiment, for example, the plate heat exchanger 30 including a heat exchange unit 40b as illustrated in Fig. 21 may be employed in place of the heat exchange unit 40a of another embodiment F. Note that the orientation of the heat exchange unit 40b is not limited.

[0170] The heat exchange unit 40b is formed by stacking a plurality of plate-shaped members in the stacking direction. As illustrated in Fig. 21, in the heat exchange unit 40b, from the first side toward the second side in the stacking direction, plate-shaped members and partition walls are stacked in the plate thickness direction so as to be repeatedly arranged in order of the first plate-shaped member 250, the first refrigerant water partition wall 270, a second plate-shaped member 260a, a second refrigerant water partition wall 280a, the first plate-shaped member 250, the first refrigerant water partition wall 270, the second plate-shaped member 260a, the second refrigerant water partition wall 280a, and so on.

[0171] The first plate-shaped member 250 and the first refrigerant water partition wall 270 are similar to those in

the other embodiment F. Note that the partition wall plane 282 of the second refrigerant water partition wall 280a is in surface contact with the first flow path partitions 252 of the first plate-shaped member 250.

[0172] The second plate-shaped member 260a includes the plurality of second flow paths 261, the plurality of second flow path partitions 262, the second wall portion 267, and a rough surface portion 269. The second plate-shaped member 260a is a plate-shaped member whose plate thickness direction is the stacking direction. The rough surface portion 269 is an uneven surface that spreads on the second side of the second plate-shaped member 260a such that the stacking direction is the normal direction. The rough surface portion 269 is provided with a plurality of protrusions 269y that are portions protruding in the plate thickness direction of the second plate-shaped member 260a. Distal ends on the second side of the plurality of protrusions 269y are provided so as to be in contact with a partition wall plane 281a of the second refrigerant water partition wall 280a. Accordingly, a gap is formed between the second plate-shaped member 260a and the second refrigerant water partition wall 280a. The plurality of second flow paths 261 and the second flow path partitions 262 are similar to those in the other embodiment F. The partition wall plane 272 of the first refrigerant water partition wall 270 is in surface contact with the second flow path partitions 262 of the second plate-shaped member 260a.

[0173] The second refrigerant water partition wall 280a includes the partition wall plane 281a provided on the first side and the partition wall plane 282 provided on the second side. The second refrigerant water partition wall 280a is a plate-shaped member whose plate thickness direction is the stacking direction. The partition wall plane 281a is a plane provided so as to spread on the first side of the second refrigerant water partition wall 280a such that the stacking direction is the normal direction. The partition wall plane 282 is a plane that spreads on the second side of the second refrigerant water partition wall 280a such that the stacking direction is the normal direction.

[0174] The above heat exchange unit 40b can also achieve operational effects similar to those in the heat exchange unit 40a of the other embodiment F. Furthermore, in the heat exchange unit 40b, both the rough surface portion 271 of the first refrigerant water partition wall 270 and the rough surface portion 269 of the second plate-shaped member 260a are provided on a side closer to the second flow paths 261 that allow the second fluid such as water to flow than the first flow paths 251 that allow the first fluid such as a refrigerant to flow. In addition, in the second refrigerant water partition wall 280a provided on the first side of the first flow paths 251, the partition wall plane 281a, which is a surface on the first side, is a flat surface. Therefore, a crack or the like is less likely to be formed. Moreover, the first plane 258, which is the surface on the second side of the first plate-shaped member 250 and is located on the second side of the first flow

paths 251, is also a flat surface. Therefore, a crack or the like is less likely to be formed. As a result, leakage of the first fluid, such as a refrigerant, is less likely to occur.

[0175] Note that, also in the heat exchange unit 40b, as in the other embodiment B, an uneven portion including a recessed flat surface and a plurality of protrusions may be provided in place of providing the rough surface portions 271 and 269 formed to be partially recessed with respect to the flat surfaces.

[0176] Note that, also in the heat exchange unit 40b, as in the other embodiment C, the gap may be filled with the liquid L with higher thermal conductivity than air. In addition, in order to prevent the leakage of the liquid L, a structure in which the periphery is covered with the casing 31 may be employed, or the periphery may be covered with a sealing material, such as a coating film, obtained by applying a resin coating material.

(7-8) Another embodiment H

[0177] In the heat pump system 1 of the above-described embodiment, for example, the plate heat exchanger 30 including a heat exchange unit 40c as illustrated in Fig. 22 may be employed in place of the heat exchange unit 40a of the other embodiment F. Note that the orientation of the heat exchange unit 40c is not limited.

[0178] The heat exchange unit 40c is formed by stacking a plurality of plate-shaped members in the stacking direction. As illustrated in Fig. 22, in the heat exchange unit 40c, from the first side toward the second side in the stacking direction, plate-shaped members and partition walls are stacked in the plate thickness direction so as to be repeatedly arranged in order of the first plate-shaped member 250, a second plate-shaped member 260b, a second partition wall 370, a first partition wall 380, the first plate-shaped member 250, the second plate-shaped member 260b, the second partition wall 370, the first partition wall 380, and so on.

[0179] The first plate-shaped member 250 is similar to that in the other embodiment F. Note that, here, a partition wall plane 382 of the first partition wall 380 is in surface contact with the first flow path partitions 252 of the first plate-shaped member 250. A partition wall plane 371 of the second partition wall 370 is in surface contact with second flow path partitions 262a of the second plate-shaped member 260b.

[0180] The second plate-shaped member 260b includes a plurality of second flow paths 261a, a plurality of second flow path partitions 262a, a second wall portion 267a, and a rough surface portion 269a. The second plate-shaped member 260b is a plate-shaped member whose plate thickness direction is the stacking direction. The rough surface portion 269a is provided on the first side of the second plate-shaped member 260b, and is provided with the plurality of protrusions 269y that are portions protruding in the plate thickness direction of the

second plate-shaped member 260b. Distal ends on the first side of the plurality of protrusions 269y are provided so as to be in contact with the first plane 258 of the first plate-shaped member 250. Accordingly, a gap is formed between the first plate-shaped member 250 and the second plate-shaped member 260b. The plurality of second flow paths 261a are provided on the second side of the second plate-shaped member 260b so as to extend in a direction intersecting the stacking direction and be arranged in parallel with each other. Note that the direction in which the second flow path 261a extends and the direction in which the first flow path 251 extends preferably intersect with each other when viewed in the stacking direction. The second flow path partition 262a is provided between two second flow paths 261a adjacent to each other so as to partition the second flow paths 261a. The plurality of second flow paths 261a are provided by, for example, partially etching a surface on the second side of the second plate-shaped member 260b, and the non-etched portions become the second flow path partitions 262a. The plurality of second flow paths 261a have shapes recessed in the plate thickness direction from the surface on the second side of the second plate-shaped member 260b toward the first side. The plurality of second flow paths 261a are flow paths that do not reach the rough surface portion 269a, which is a surface on the first side of the second plate-shaped member 260b, and do not penetrate the second plate-shaped member 260b in the plate thickness direction. The second flow paths 261a of the second plate-shaped member 260b are open on the second side. Another member is provided so as to be in surface contact with the second flow path partitions 262a on the second side of the second plate-shaped member 260b. As a result, the second side of the second flow paths 261a is closed, and flow paths are completed. Specifically, here, the partition wall plane 371 of the second partition wall 370 is in surface contact with the second flow path partitions 262a of the second plate-shaped member 260b. The second wall portion 267a is a plate-shaped portion that spreads in the plate thickness direction of the second plate-shaped member 260b between first side end portions of the plurality of second flow paths 261a and the rough surface portion 269a such that the stacking direction is the thickness direction. The second wall portion 267a functions as one wall that prevents a fluid, such as water, flowing through the second flow paths 261a from reaching the first flow paths 251.

[0181] The second partition wall 370 includes the partition wall plane 371 provided on the first side and a partition wall plane 372 provided on the second side. The second partition wall 370 is a plate-shaped member whose plate thickness direction is the stacking direction. The partition wall plane 371 is a plane that spreads on the first side of the second partition wall 370 such that the stacking direction is the normal direction. The partition wall plane 372 is a plane that spreads on the second side of the second partition wall 370 such that the stacking direction is the normal direction.

[0182] The first partition wall 380 includes a rough surface portion 381 provided on the first side and the partition wall plane 382 provided on the second side. The first partition wall 380 is a plate-shaped member whose plate thickness direction is the stacking direction. The rough surface portion 381 is provided on the first side of the first partition wall 380, and is provided with a plurality of protrusions 381y that are portions protruding in the plate thickness direction of the first partition wall 380. Distal ends on the first side of the plurality of protrusions 381y are provided so as to be in contact with the partition wall plane 372 of the second partition wall 370. Accordingly, a gap is formed between the first partition wall 380 and the second partition wall 370. The partition wall plane 382 is a plane that spreads on the second side of the first partition wall 380 such that the stacking direction is the normal direction.

[0183] The above heat exchange unit 40c can also achieve operational effects similar to those in the heat exchange unit 40a of the other embodiment F. Furthermore, the heat exchange unit 40c includes a portion in which another plate-shaped member is not provided between the first plate-shaped member 250, which is a member in which the first flow paths 251 are formed, and the second plate-shaped member 260b, which is a member in which the second flow paths 261a are formed. Therefore, heat exchange efficiency between the first fluid flowing through the first flow paths 251 and the second fluid flowing through the second flow paths 261a can be enhanced.

[0184] Note that, also in the heat exchange unit 40c, as in the other embodiment B, an uneven portion including a recessed flat surface and a plurality of protrusions may be provided in place of providing the rough surface portions 381 and 269a formed to be partially recessed with respect to the flat surfaces.

[0185] Note that, also in the heat exchange unit 40c, as in the other embodiment C, the gap may be filled with the liquid L with higher thermal conductivity than air. In addition, in order to prevent the leakage of the liquid L, a structure in which the periphery is covered with the casing 31 may be employed, or the periphery may be covered with a sealing material, such as a coating film, obtained by applying a resin coating material.

(7-9) Another embodiment I

[0186] In the heat pump system 1 of the above-described embodiment, for example, the plate heat exchanger 30 including a heat exchange unit 40d as illustrated in Fig. 23 may be employed in place of the heat exchange unit 40a of the other embodiment F. Note that the orientation of the heat exchange unit 40d is not limited.

[0187] The heat exchange unit 40d is formed by stacking a plurality of plate-shaped members in the stacking direction. As illustrated in Fig. 23, in the heat exchange unit 40d, from the first side toward the second side in the

stacking direction, plate-shaped members and partition walls are stacked in the plate thickness direction so as to be repeatedly arranged in order of the first plate-shaped member 250, the second plate-shaped member 260b, a second partition wall 370a, a first partition wall 380a, the first plate-shaped member 250, the second plate-shaped member 260b, the second partition wall 370a, the first partition wall 380a, and so on.

[0188] The first plate-shaped member 250 and the second plate-shaped member 260b are similar to those in the other embodiment H. Note that, here, the partition wall plane 382 of the first partition wall 380a is in surface contact with the first flow path partitions 252 of the first plate-shaped member 250. The partition wall plane 371 of the second partition wall 370a is in surface contact with the second flow path partitions 262a of the second plate-shaped member 260b.

[0189] The second partition wall 370a includes the partition wall plane 371 provided on the first side and a rough surface portion 372a provided on the second side. The second partition wall 370a is a plate-shaped member whose plate thickness direction is the stacking direction. The partition wall plane 371 is a plane that spreads on the first side of the second partition wall 370a such that the stacking direction is the normal direction. The rough surface portion 372a is provided on the second side of the second partition wall 370a, and is provided with a plurality of protrusions 372y that are portions protruding in the plate thickness direction of the second partition wall 370a. Distal ends on the second side of the plurality of protrusions 372y are provided so as to be in contact with a partition wall plane 381a of the first partition wall 380a. Accordingly, a gap is formed between the second partition wall 370a and the first partition wall 380a. The partition wall plane 371 is a plane that spreads on the first side of the second partition wall 370a such that the stacking direction is the normal direction.

[0190] The first partition wall 380a includes the partition wall plane 381a provided on the first side and the partition wall plane 382 provided on the second side. The first partition wall 380a is a plate-shaped member whose plate thickness direction is the stacking direction. The partition wall plane 381a is a plane that spreads on the first side of the first partition wall 380a such that the stacking direction is the normal direction. The partition wall plane 382 is a plane that spreads on the second side of the first partition wall 380a such that the stacking direction is the normal direction.

[0191] The above heat exchange unit 40d can also achieve operational effects similar to those in the heat exchange unit 40a of the other embodiment F. Furthermore, the heat exchange unit 40d includes a portion in which another plate-shaped member is not provided between the first plate-shaped member 250, which is a member in which the first flow paths 251 are formed, and the second plate-shaped member 260b, which is a member in which the second flow paths 261a are formed. Therefore, heat exchange efficiency between the first flu-

id flowing through the first flow paths 251 and the second fluid flowing through the second flow paths 261a can be enhanced. Furthermore, in the heat exchange unit 40d, both the rough surface portion 372a of the second partition wall 370a and the rough surface portion 269a of the second plate-shaped member 260b are provided on a side closer to the second flow paths 261a that allow the second fluid such as water to flow than the first flow paths 251 that allow the first fluid such as a refrigerant to flow. In addition, in the first partition wall 380a provided on the first side of the first flow paths 251, the partition wall plane 381a, which is a surface on the first side, is a flat surface. Therefore, a crack or the like is less likely to be formed. Moreover, the first plane 258, which is the surface on the second side of the first plate-shaped member 250 and is located on the second side of the first flow paths 251, is also a flat surface. Therefore, a crack or the like is less likely to be formed. As a result, leakage of the first fluid, such as a refrigerant, is less likely to occur.

[0192] Note that, also in the heat exchange unit 40d, as in the other embodiment B, an uneven portion including a recessed flat surface and a plurality of protrusions may be provided in place of providing the rough surface portions 372a and 269a formed to be partially recessed with respect to the flat surfaces.

[0193] Note that, also in the heat exchange unit 40d, as in the other embodiment C, the gap may be filled with the liquid L with higher thermal conductivity than air. In addition, in order to prevent the leakage of the liquid L, a structure in which the periphery is covered with the casing 31 may be employed, or the periphery may be covered with a sealing material, such as a coating film, obtained by applying a resin coating material.

(7-10) Another embodiment J

[0194] In the above-described other embodiments F, G, H, and I, cases have been described as examples in which flow paths that do not penetrate the first plate-shaped member 250, the second plate-shaped member 260, and 260a in the thickness direction are used as the first flow path 251, the second flow path 261, and 261a. Alternatively, for example, the heat exchange unit may be one including both a flow path that is provided so as to penetrate in the thickness direction of the plate-shaped member as described in the above-described embodiment and a flow path that is provided so as not to penetrate in the thickness direction of the plate-shaped member as in the other embodiments F, G, H, and I as the first flow path and the second flow path.

(Supplementary)

[0195] The embodiments of the present disclosure have been described heretofore, and it will be understood that a variety of modifications in mode and detail may be made without departing from the gist and scope of the present disclosure as set forth in claims.

Reference Signs List

[0196]

1 HEAT PUMP SYSTEM (REFRIGERATION CY- CLE APPARATUS)	5
2 CONTROL APPARATUS	
10 FIRST CIRCUIT (REFRIGERANT CIRCUIT)	10
11 COMPRESSOR	
13 EXPANSION MECHANISM	
14 FIRST HEAT EXCHANGER	15
20 SECOND CIRCUIT	
21 PUMP	20
22 SECOND HEAT EXCHANGER	
23 FIRST WATER PIPE	
24 SECOND WATER PIPE	25
25 THIRD WATER PIPE	
30 PLATE HEAT EXCHANGER (HEAT EXCHANG- ER)	30
31 CASING (SEALING PORTION)	
40 HEAT EXCHANGE UNIT	35
43 WATER INLET HEADER	
44 WATER OUTLET HEADER	40
45 REFRIGERANT INLET HEADER	
46 REFRIGERANT OUTLET HEADER	
47 FIRST RETURN HEADER	45
48 SECOND RETURN HEADER	
49 THIRD RETURN HEADER	
50 FIRST PLATE-SHAPED MEMBER	50
51 FIRST FLOW PATH	
52 FLAT PORTION	55
53 WATER INLET COMMUNICATION PORT	

54 WATER OUTLET COMMUNICATION PORT
55 REFRIGERANT INLET COMMUNICATION PORT
56 REFRIGERANT OUTLET COMMUNICATION PORT
57 FIRST RETURN COMMUNICATION PORT
58 SECOND RETURN COMMUNICATION PORT
59 THIRD RETURN COMMUNICATION PORT
60 SECOND PLATE-SHAPED MEMBER
61 SECOND FLOW PATH
62 FLAT PORTION
63 WATER INLET COMMUNICATION PORT
64 WATER OUTLET COMMUNICATION PORT
65 REFRIGERANT INLET COMMUNICATION PORT
66 REFRIGERANT OUTLET COMMUNICATION PORT
71 FIRST REFRIGERANT PARTITION WALL (FIRST PARTITION WALL, FIRST WALL POR- TION)
71a FLAT PORTION (PORTION IN SURFACE CONTACT)
71b WATER INLET COMMUNICATION PORT (FIRST OPENING)
71c WATER OUTLET COMMUNICATION PORT (FIRST OPENING)
71d REFRIGERANT INLET COMMUNICATION PORT
71e REFRIGERANT OUTLET COMMUNICATION PORT
72 SECOND REFRIGERANT PARTITION WALL (FIRST PARTITION WALL, FIRST WALL POR- TION)
72a FLAT PORTION (PORTION IN SURFACE CONTACT)
72b WATER INLET COMMUNICATION PORT (FIRST OPENING)

72c WATER OUTLET COMMUNICATION PORT (FIRST OPENING)		171a FLAT PORTION (FIRST FLAT PORTION)
72d REFRIGERANT INLET COMMUNICATION PORT	5	171x ROUGH SURFACE PORTION
72e REFRIGERANT OUTLET COMMUNICATION PORT		171y PROTRUSION (FIRST PROTRUSION)
81 FIRST WATER PARTITION WALL (SECOND PARTITION WALL, SECOND WALL PORTION)	10	172 SECOND REFRIGERANT PARTITION WALL (FIRST PARTITION WALL, FIRST WALL POR- TION)
81a FLAT PORTION (SECOND FLAT PORTION, PORTION IN SURFACE CONTACT)	15	172a FLAT PORTION (FIRST FLAT PORTION)
81b WATER INLET COMMUNICATION PORT (SECOND OPENING)		172x ROUGH SURFACE PORTION
81c WATER OUTLET COMMUNICATION PORT (SECOND OPENING)	20	172y PROTRUSION (FIRST PROTRUSION)
81d REFRIGERANT INLET COMMUNICATION PORT		181 FIRST WATER PARTITION WALL (SECOND PARTITION WALL, SECOND WALL PORTION)
81e REFRIGERANT OUTLET COMMUNICATION PORT	25	181a FLAT PORTION
81x ROUGH SURFACE PORTION (SECOND RE- GION)	30	181p SURFACE
81y PROTRUSION (SECOND PROTRUSION)		181q CONCAVE PORTION
82 SECOND WATER PARTITION WALL (SECOND PARTITION WALL, SECOND WALL PORTION)	35	181x UNEVEN PORTION
82a FLAT PORTION (SECOND FLAT PORTION, PORTION IN SURFACE CONTACT)		181y PROTRUSION (SECOND PROTRUSION)
82b WATER INLET COMMUNICATION PORT (SECOND OPENING)	40	181z RECESSED FLAT SURFACE (SECOND CONCAVE PORTION)
82c WATER OUTLET COMMUNICATION PORT (SECOND OPENING)		182 SECOND WATER PARTITION WALL (SEC- OND PARTITION WALL, SECOND WALL POR- TION)
82d REFRIGERANT INLET COMMUNICATION PORT	45	182a FLAT PORTION
82e REFRIGERANT OUTLET COMMUNICATION PORT	50	250 FIRST PLATE-SHAPED MEMBER
82x ROUGH SURFACE PORTION (SECOND RE- GION)		251 FIRST FLOW PATH
82y PROTRUSION (SECOND PROTRUSION)	55	257 FIRST WALL PORTION
171 FIRST REFRIGERANT PARTITION WALL (FIRST PARTITION WALL, FIRST WALL POR- TION)		258 FIRST PLANE (FIRST WALL PORTION)
		260 SECOND PLATE-SHAPED MEMBER
		260a SECOND PLATE-SHAPED MEMBER
		260b SECOND PLATE-SHAPED MEMBER
		261 SECOND FLOW PATH
		261a SECOND FLOW PATH
		267 SECOND WALL PORTION

267a SECOND WALL PORTION			
268 SECOND PLANE (SECOND WALL PORTION)			
269y PROTRUSION (SECOND PROTRUSION)	5		first protrusions (171y, 172y, 281y) protruding in the stacking direction, and distal ends of the first protrusions being in contact with the second wall portion (181, 182, 267, 268), or the second wall portion including a second flat portion (81a, 82a) and a plurality of second protrusions (81y, 82y, 181y, 269y, 271y) protruding in the stacking direction, and distal ends of the second protrusions being in contact with the first wall portion (71, 72, 257, 258, 280a, 281a).
271y PROTRUSION (SECOND PROTRUSION)			
280 FIRST PARTITION WALL	10		
280a SECOND REFRIGERANT WATER PARTITION WALL (FIRST WALL PORTION, FIRST PARTITION WALL)		2.	The heat exchanger according to claim 1, comprising:
281a PARTITION WALL PLANE (FIRST WALL PORTION, FIRST PARTITION WALL)	15		a first plate-shaped member (250) including the first flow path; and
281y PROTRUSION (FIRST PROTRUSION)			a second plate-shaped member (260, 260a, 260b) including the second flow path and the second wall portion, wherein
G1 FIRST GAP	20		the second flow path and the second wall portion are provided so as to be arranged in a second plate thickness direction that is a plate thickness direction of the second plate-shaped member.
G2 SECOND GAP			
L LIQUID			
Citation List	25	3.	The heat exchanger according to claim 2, further comprising a first partition wall (280) including the first wall portion, wherein
Patent Literature			
[0197] PTL 1: Japanese Unexamined Patent Application Publication No. 2002-107089	30		the first partition wall is located between the first plate-shaped member and the second plate-shaped member, and
Claims			at least either the first partition wall including the first flat portion and the plurality of first protrusions (281y), and the distal ends of the first protrusions being in contact with the second wall portion (267, 267a, 268), or
1. A heat exchanger (30) that exchanges heat between a first fluid and a second fluid, the heat exchanger (30), comprising:	35		the second wall portion including the second flat portion and the plurality of second protrusions (269y), and the distal ends of the second protrusions being in contact with the first partition wall (280a, 281a).
a first flow path (51, 251) through which the first fluid flows;	40		
a second flow path (61, 261, 261a) through which the second fluid flows;		4.	The heat exchanger according to claim 3, comprising a liquid (L) between the first partition wall and the second wall portion.
a first wall portion (71, 72, 171, 172, 257) located between the first flow path and the second flow path; and	45		
a second wall portion (81, 82, 181, 182, 267, 267a) located between the first wall portion and the second flow path, wherein		5.	The heat exchanger according to claim 4, further comprising a sealing portion (31) that covers between the first partition wall and the second wall portion from a periphery in the stacking direction.
the first fluid flows through the first flow path in a direction intersecting a stacking direction that is a direction in which the first wall portion and the second wall are stacked,	50		
the second fluid flows through the second flow path in a direction intersecting the stacking direction, and		6.	The heat exchanger according to any one of claims 3 to 5, wherein
at least either the first wall portion including a first flat portion (171a, 172a) and a plurality of	55		at least either the first partition wall including a first concave portion recessed in the stacking direction with respect to the first flat portion, and the distal ends of the first protrusions being lo-

- cated closer than the first concave portion to a side of the second wall portion in the stacking direction, or
the second wall portion including a second concave portion recessed in the stacking direction with respect to the second flat portion, and the distal ends of the second protrusions being located closer than the second concave portion to a side of the first partition wall in the stacking direction.
7. The heat exchanger according to any one of claims 3 to 6, wherein
- the second wall portion includes a second region including the plurality of second protrusions, the first partition wall includes a first region facing the second region when viewed along the stacking direction, and the second region has a larger surface area than the first region.
8. The heat exchanger according to any one of claims 3 to 7, wherein
- the first partition wall includes a first opening (71b, 71c, 72b, 72c),
the second wall portion includes a second opening (81b, 81c, 82b, 82c) provided at a position overlapping the first opening in the stacking direction,
the first opening and the second opening allow the first fluid or the second fluid to pass in the stacking direction, and
the first partition wall and the second wall portion include a portion (71a, 72a, 81a, 82a) where the first flat portion around the first opening and the second flat portion around the second opening are in surface contact with each other.
9. The heat exchanger according to claim 2, wherein
- the first plate-shaped member (250) further includes the first wall portion (257), and the first flow path and the first wall portion are provided so as to be arranged in a first plate thickness direction that is a plate thickness direction of the first plate-shaped member.
10. The heat exchanger (30) according to claim 1, comprising:
- a first plate-shaped member (50) including the first flow path;
a second plate-shaped member (60) including the second flow path;
a first partition wall (71, 72, 171, 172) that is the first wall portion located between the first plate-shaped member and the second plate-shaped member; and
a second partition wall (81, 82, 181, 182) that is the second wall portion located between the first partition wall and the second plate-shaped member, wherein
at least either the first partition wall including the first flat portion (171a, 172a) and the plurality of first protrusions (171y, 172y), and the distal ends of the first protrusions being in contact with the second partition wall (181, 182), or
the second partition wall including the second flat portion (81a, 82a) and the plurality of second protrusions (81y, 82y, 181y), and the distal ends of the second protrusions being in contact with the first partition wall (71, 72).
11. The heat exchanger according to claim 10, comprising a liquid (L) between the first partition wall and the second partition wall.
12. The heat exchanger according to claim 11, further comprising a sealing portion (31) that covers between the first partition wall and the second partition wall from a periphery in the stacking direction.
13. The heat exchanger according to any one of claims 10 to 12, wherein
- at least either the first partition wall including a first concave portion recessed in the stacking direction with respect to the first flat portion, and the distal ends of the first protrusions being located closer than the first concave portion to a side of the second partition wall in the stacking direction, or
the second partition wall including a second concave portion (181z) recessed in the stacking direction with respect to the second flat portion, and the distal ends of the second protrusions being located closer than the second concave portion to a side of the first partition wall in the stacking direction.
14. The heat exchanger according to any one of claims 10 to 13, wherein
- the second partition wall includes a second region (81x, 82x) including the plurality of second protrusions,
the first partition wall includes a first region facing the second region when viewed along the stacking direction, and
the second region has a larger surface area than the first region.
15. The heat exchanger according to any one of claims 10 to 14, wherein

the first partition wall includes a first opening (71b, 71c, 72b, 72c),
the second partition wall includes a second opening (81b, 81c, 82b, 82c) provided at a position overlapping the first opening in the stacking direction, 5
the first opening and the second opening allow the first fluid or the second fluid to pass in the stacking direction, and
the first partition wall and the second partition wall include a portion (71a, 72a, 81a, 82a) where the first flat portion around the first opening and the second flat portion around the second opening are in surface contact with each other. 10

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16. The heat exchanger according to any one of claims 1 to 15, wherein the second fluid is water.
17. The heat exchanger according to any one of claims 1 to 16, wherein the first fluid is a refrigerant with flammability. 20
18. A refrigeration cycle apparatus (1), comprising:
a refrigerant circuit (10) which includes the heat exchanger (30) according to any one of claims 1 to 17 25
and through which the first fluid flows.

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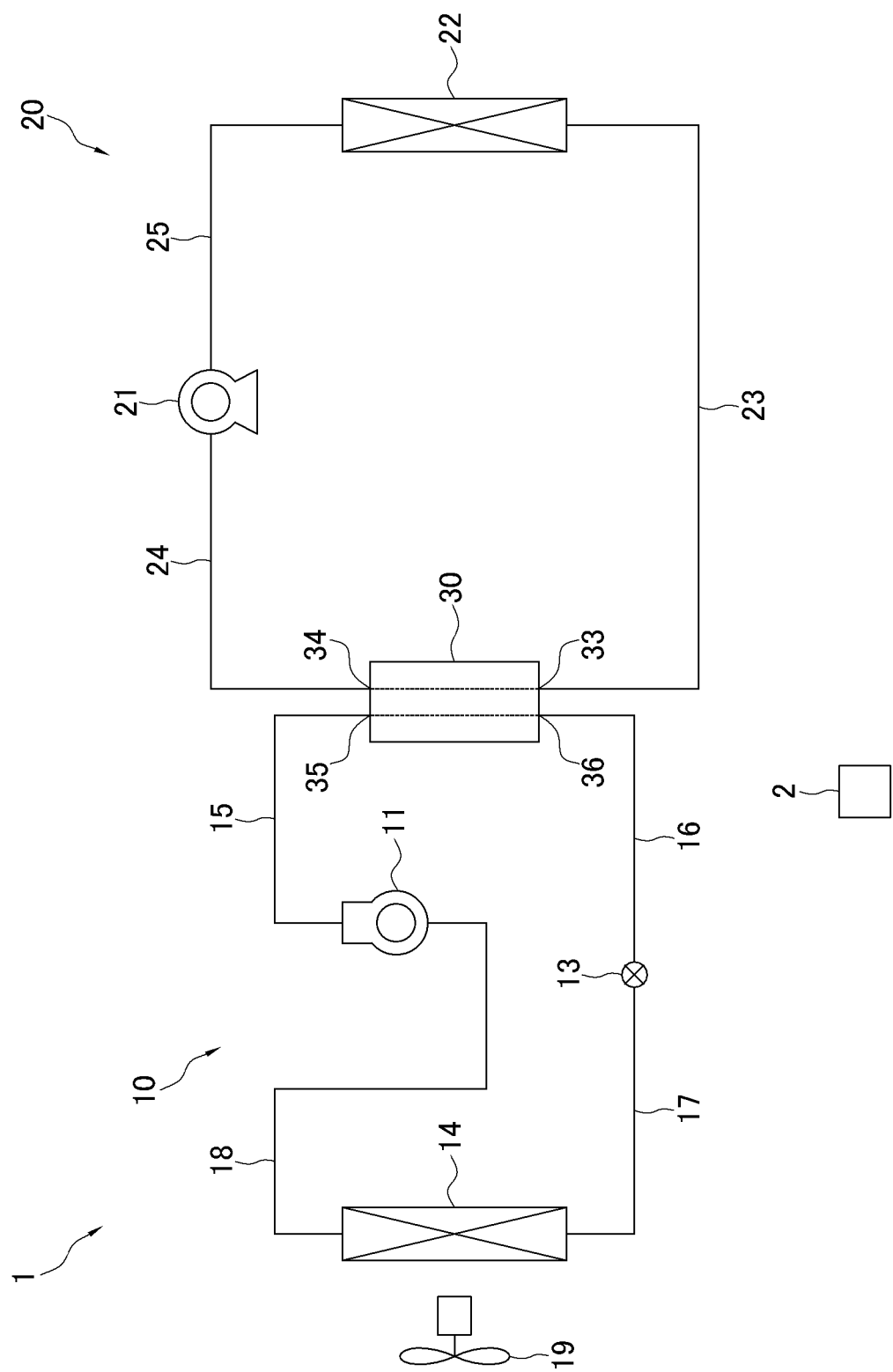


FIG. 1

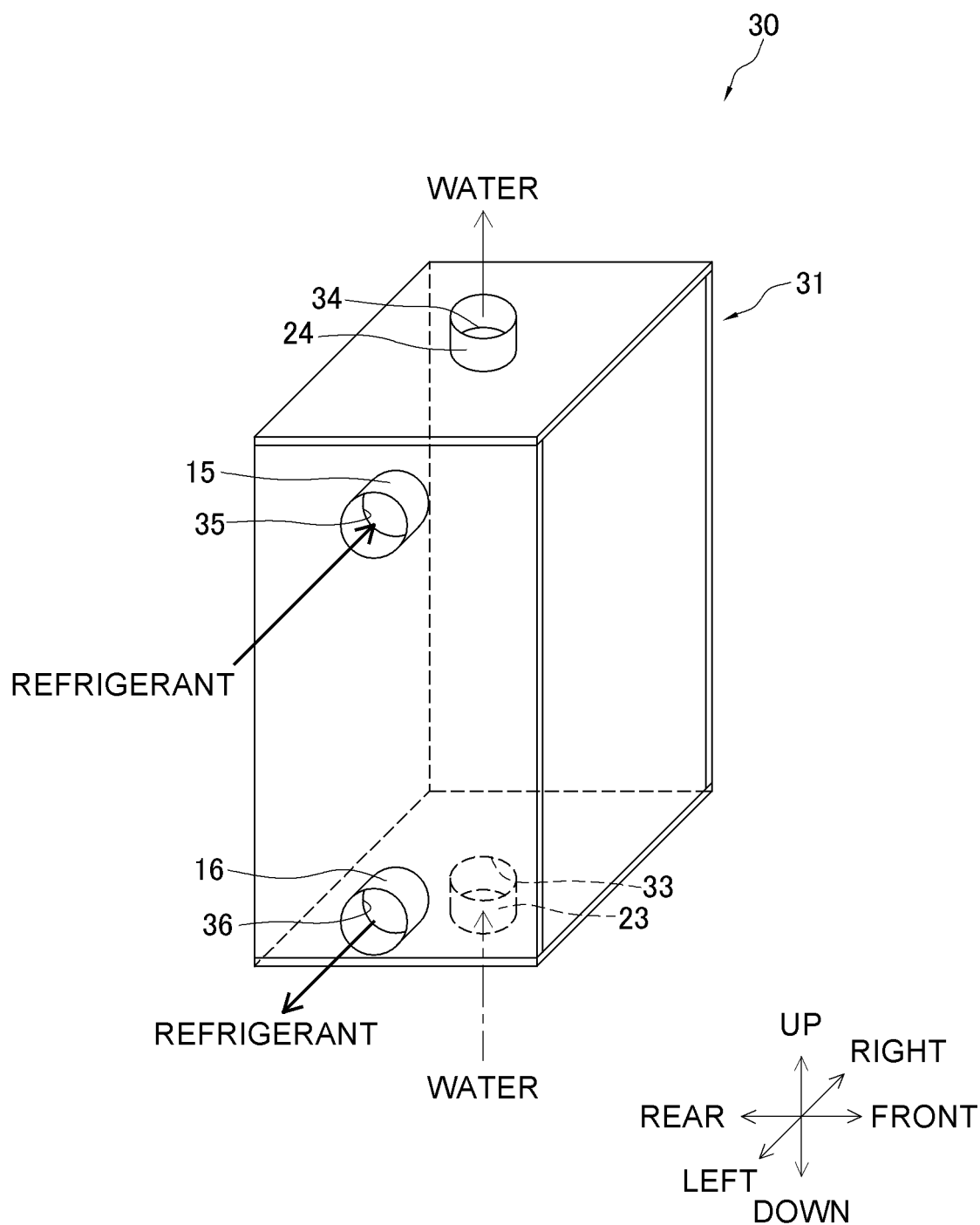


FIG. 2

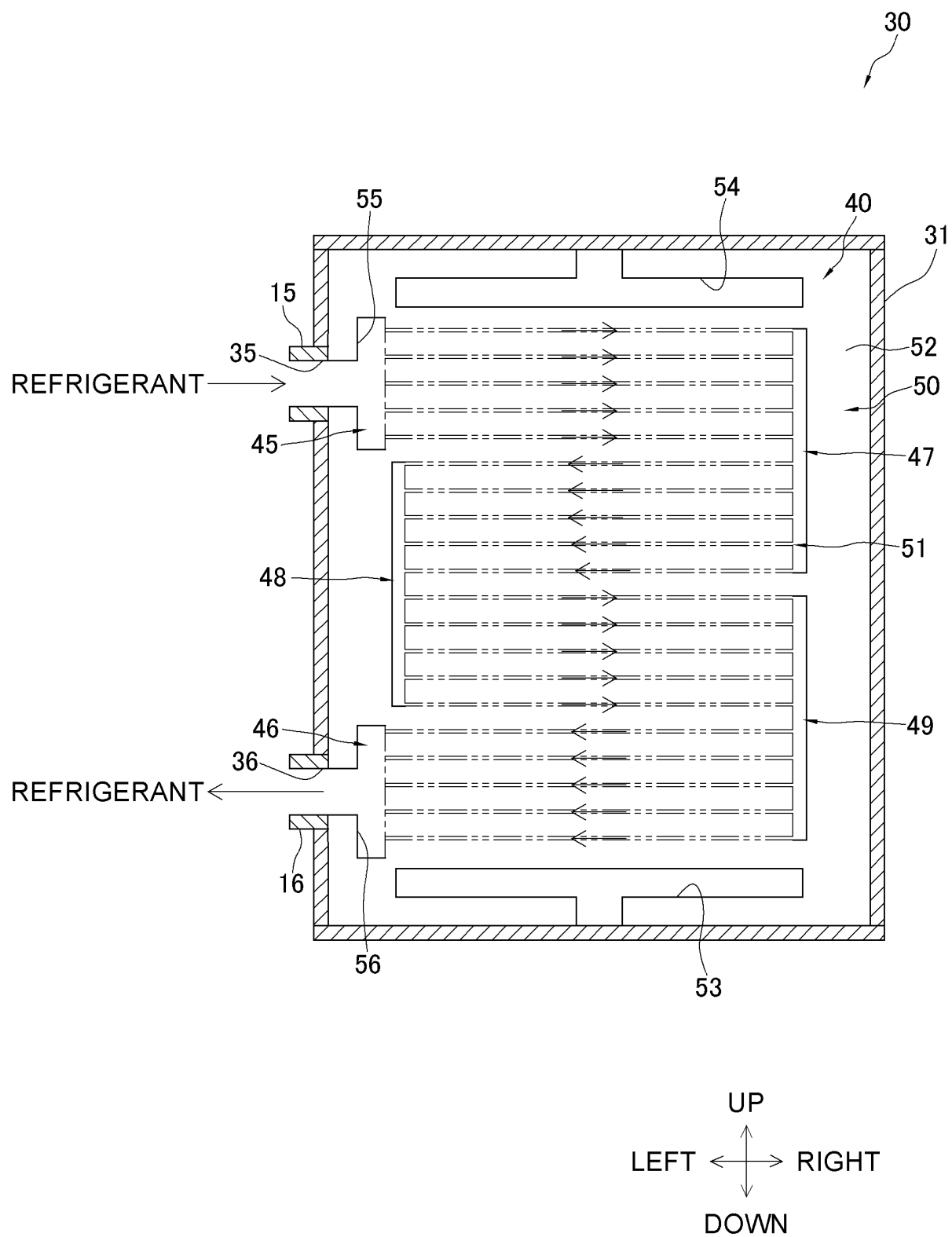


FIG. 3

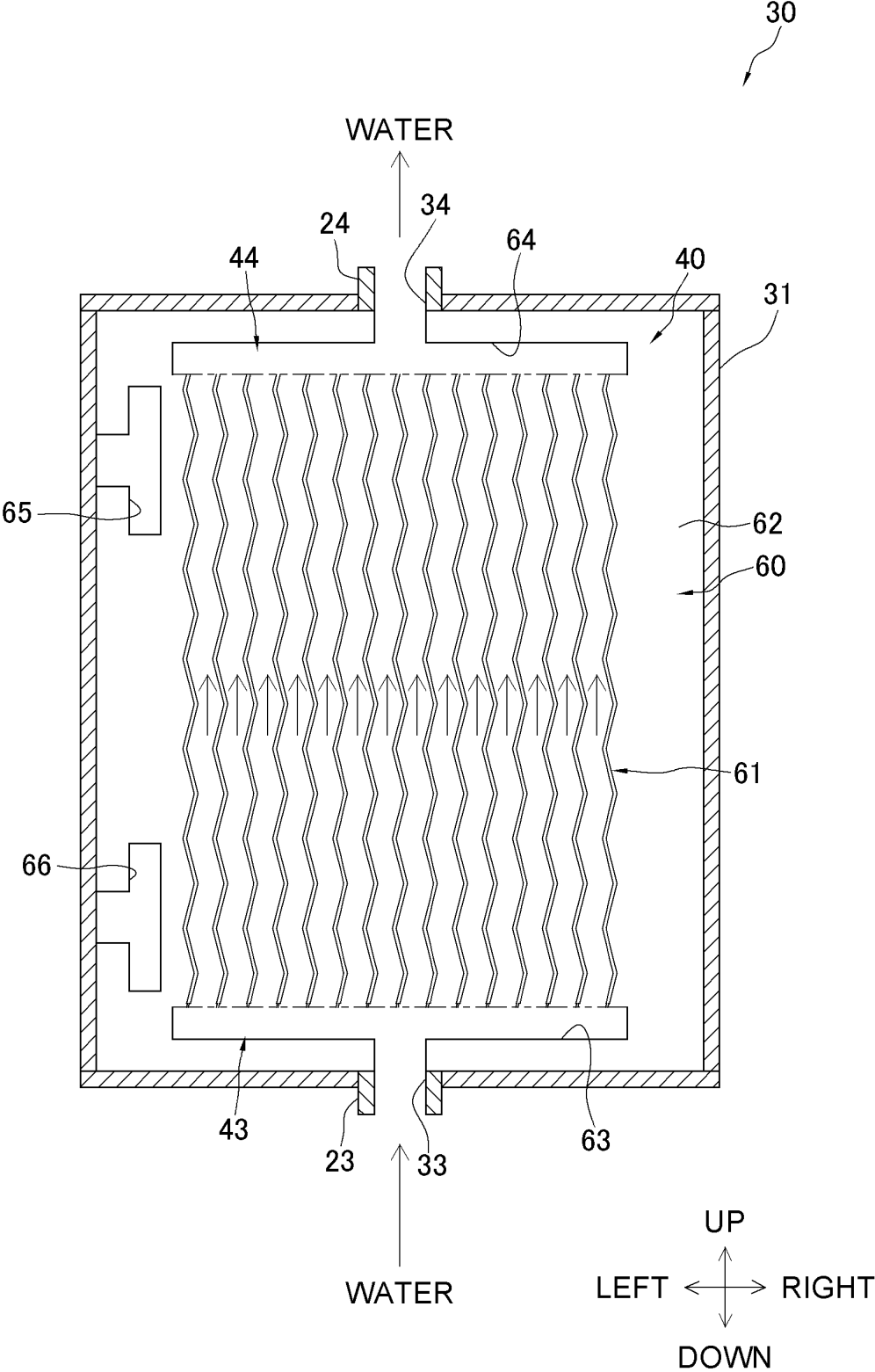


FIG. 4

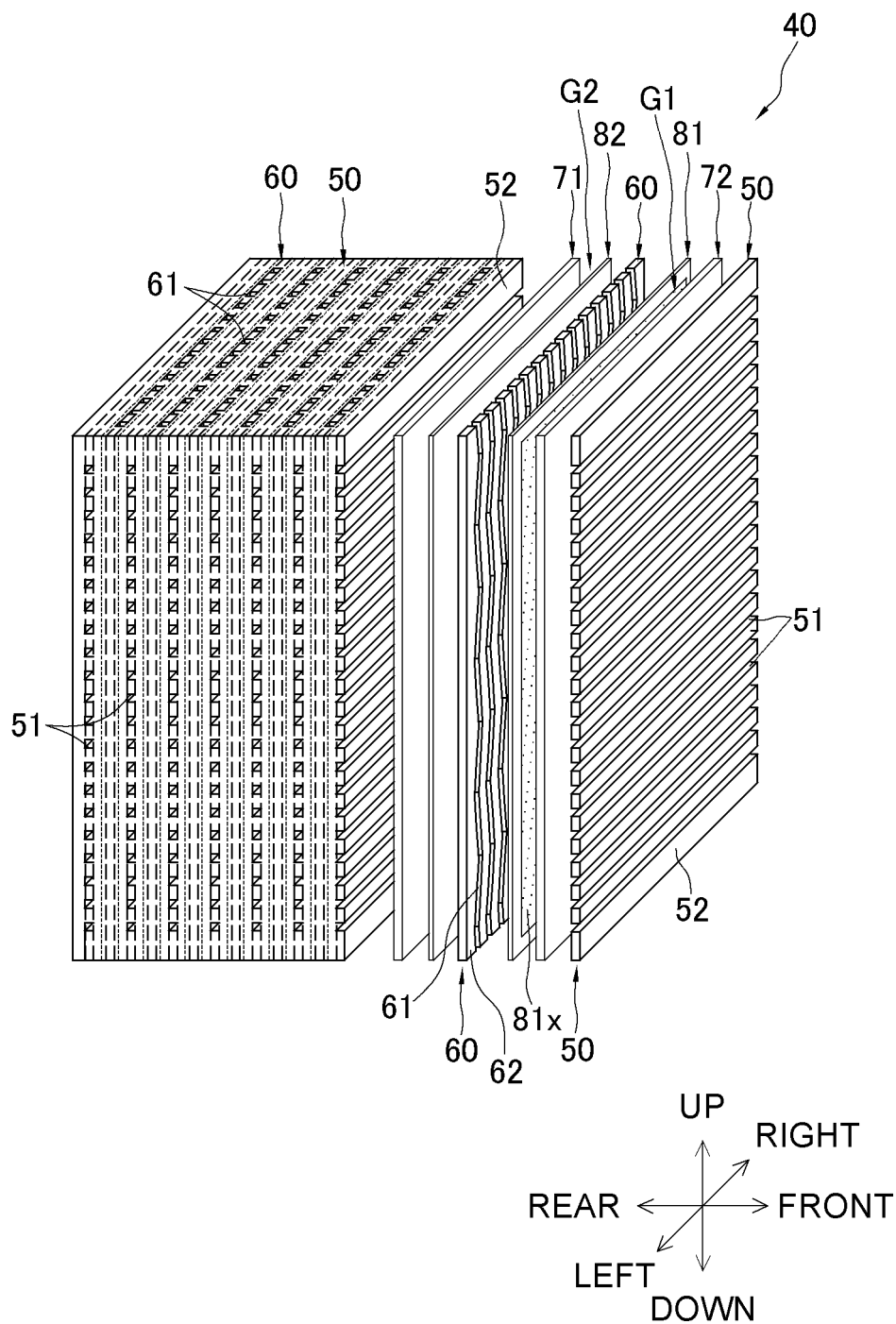


FIG. 5

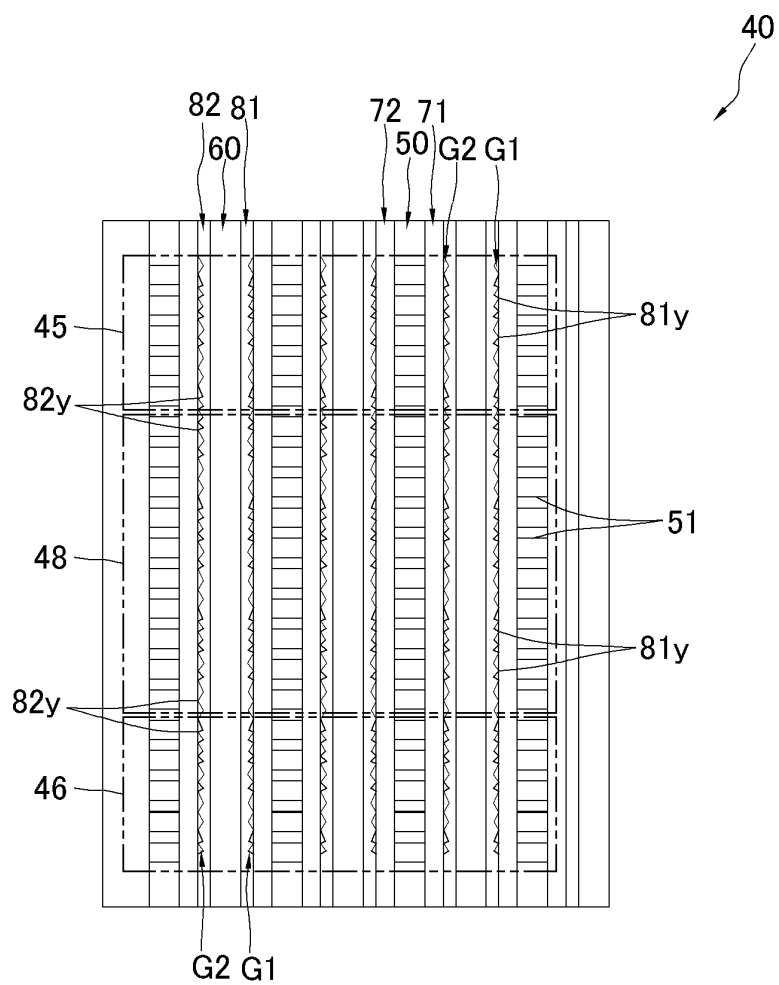


FIG. 6

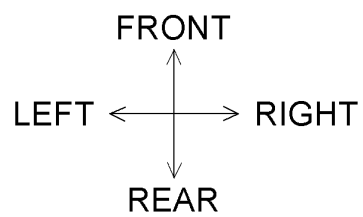
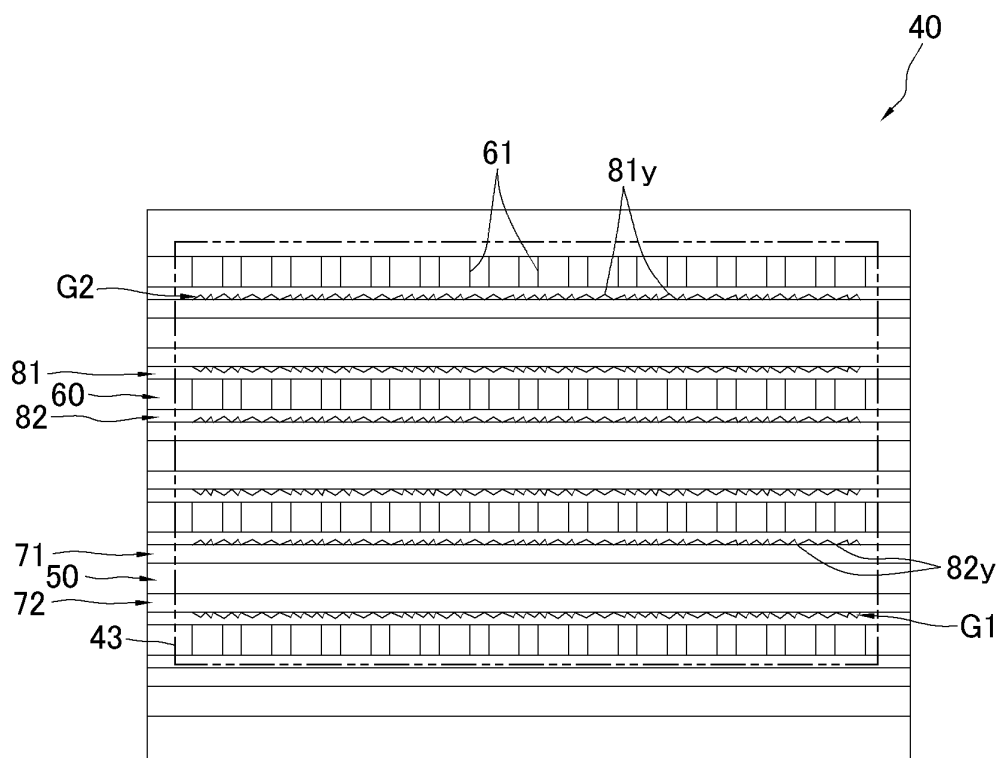


FIG. 7

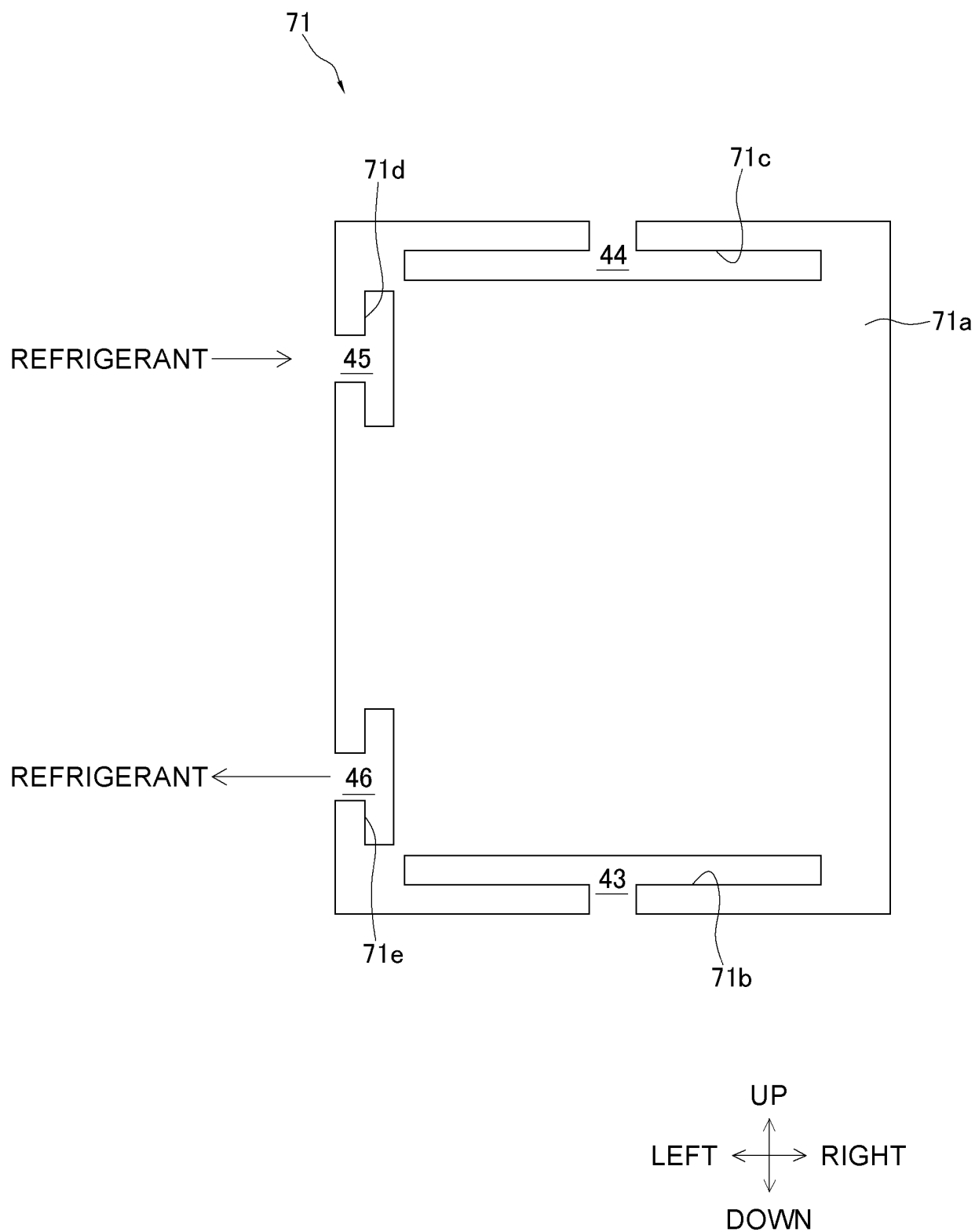


FIG. 8

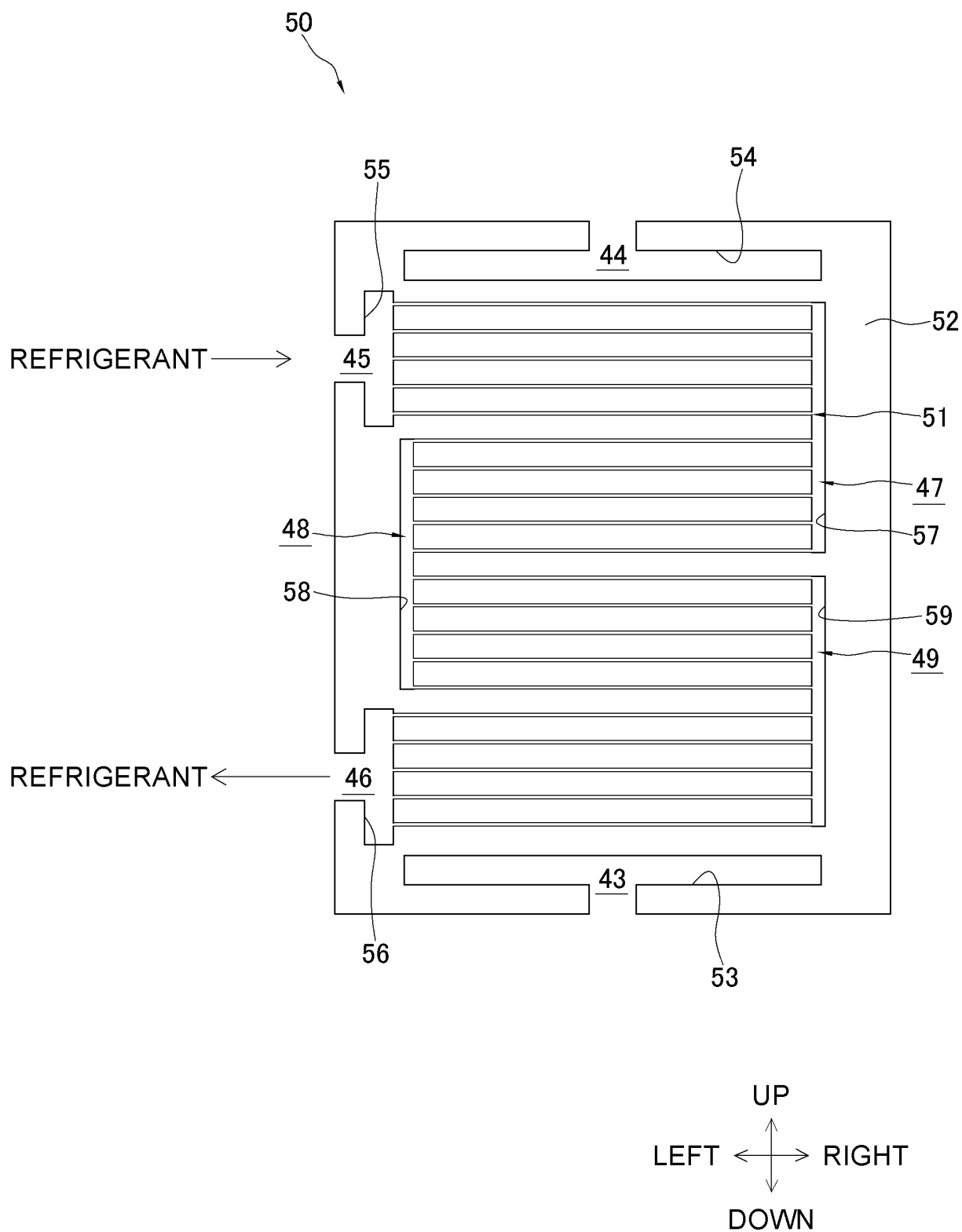


FIG. 9

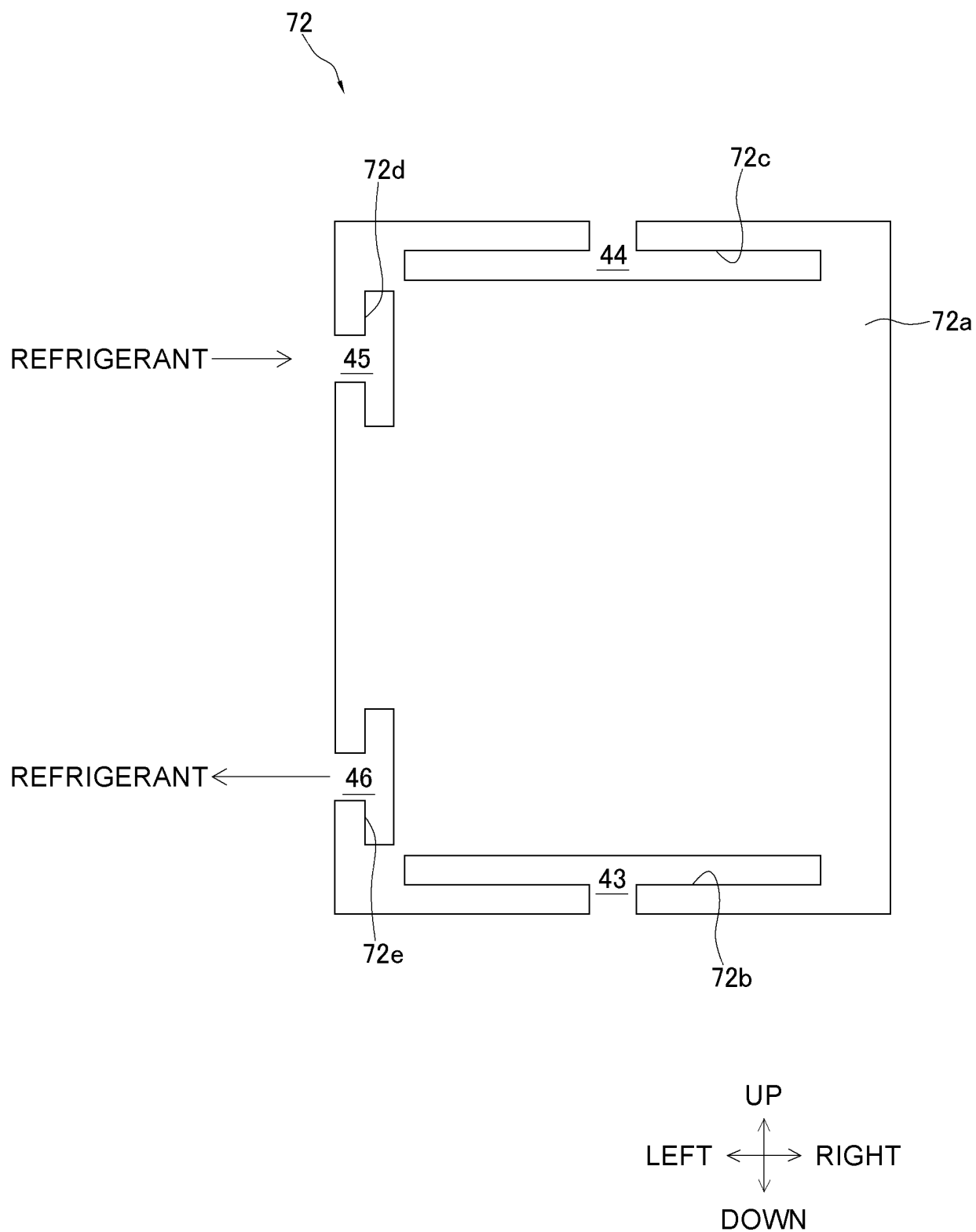


FIG. 10

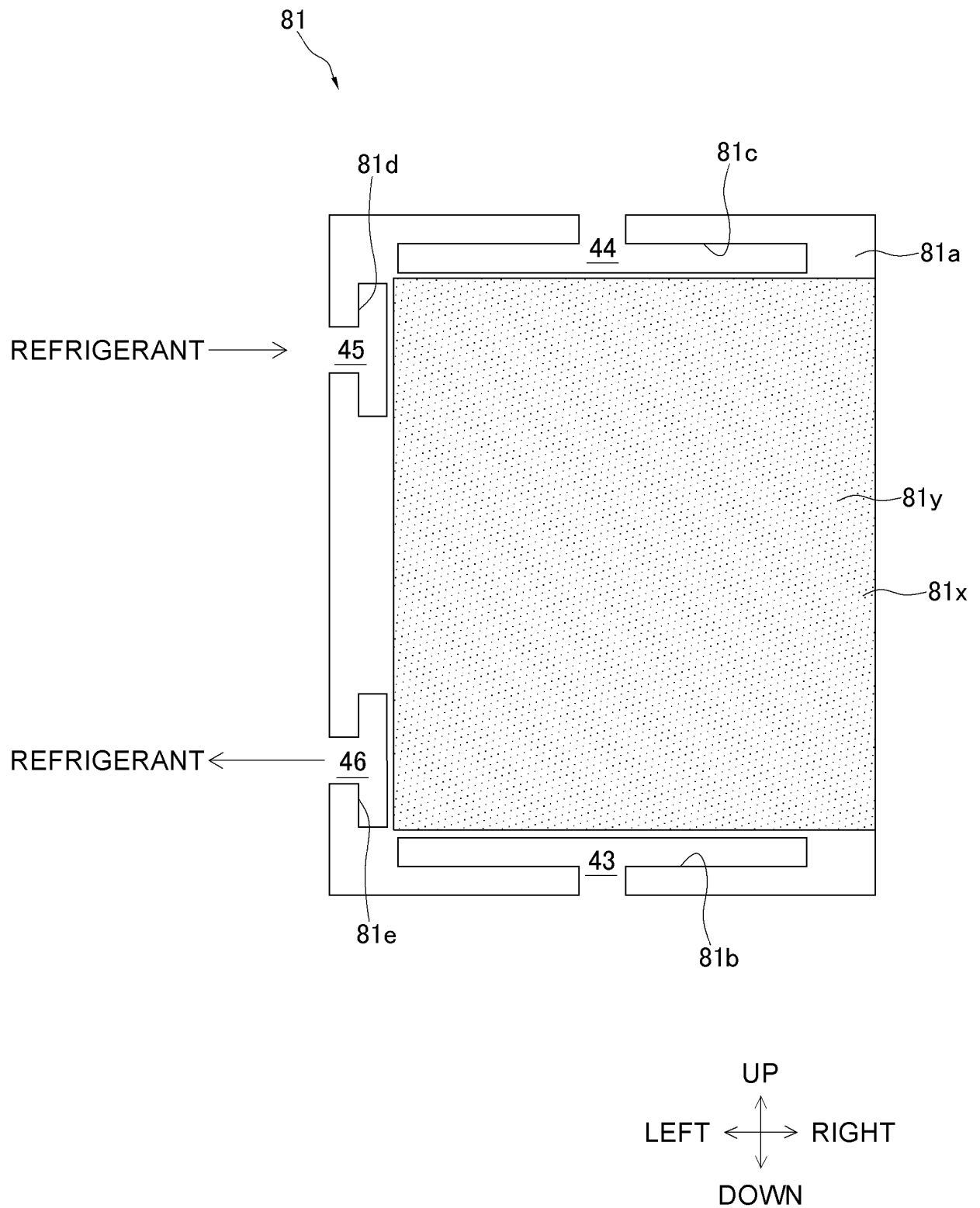


FIG. 11

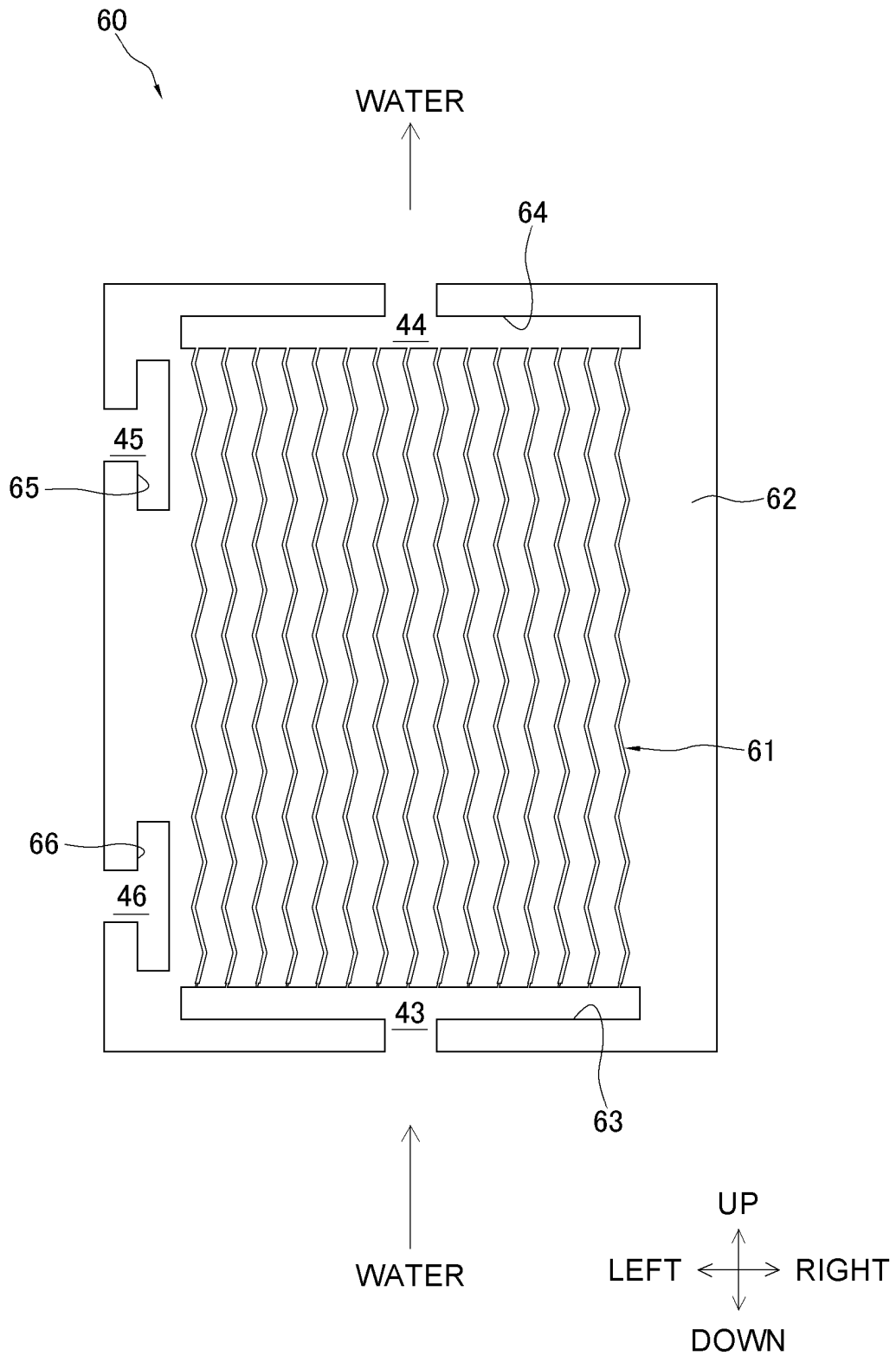


FIG. 12

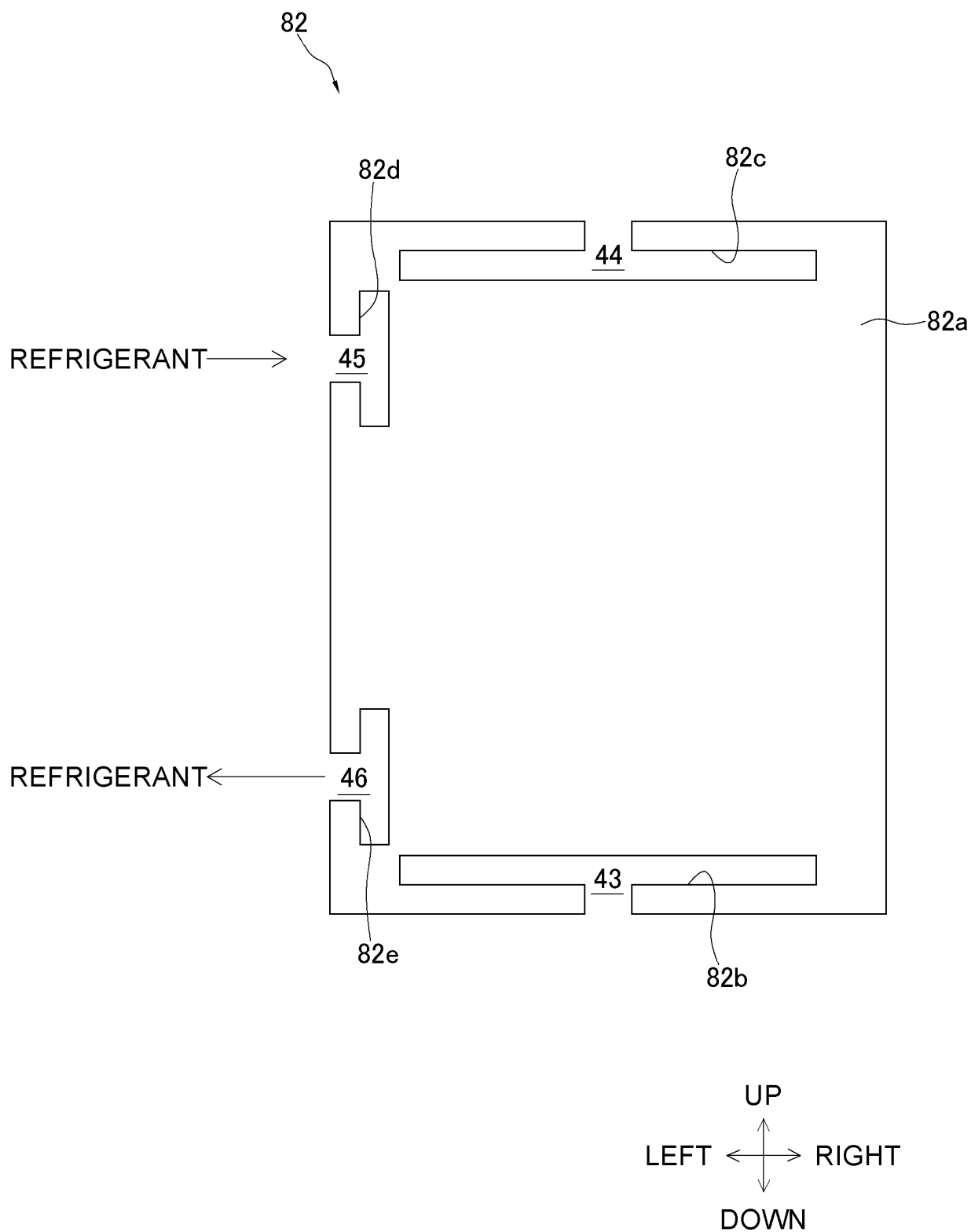


FIG. 13

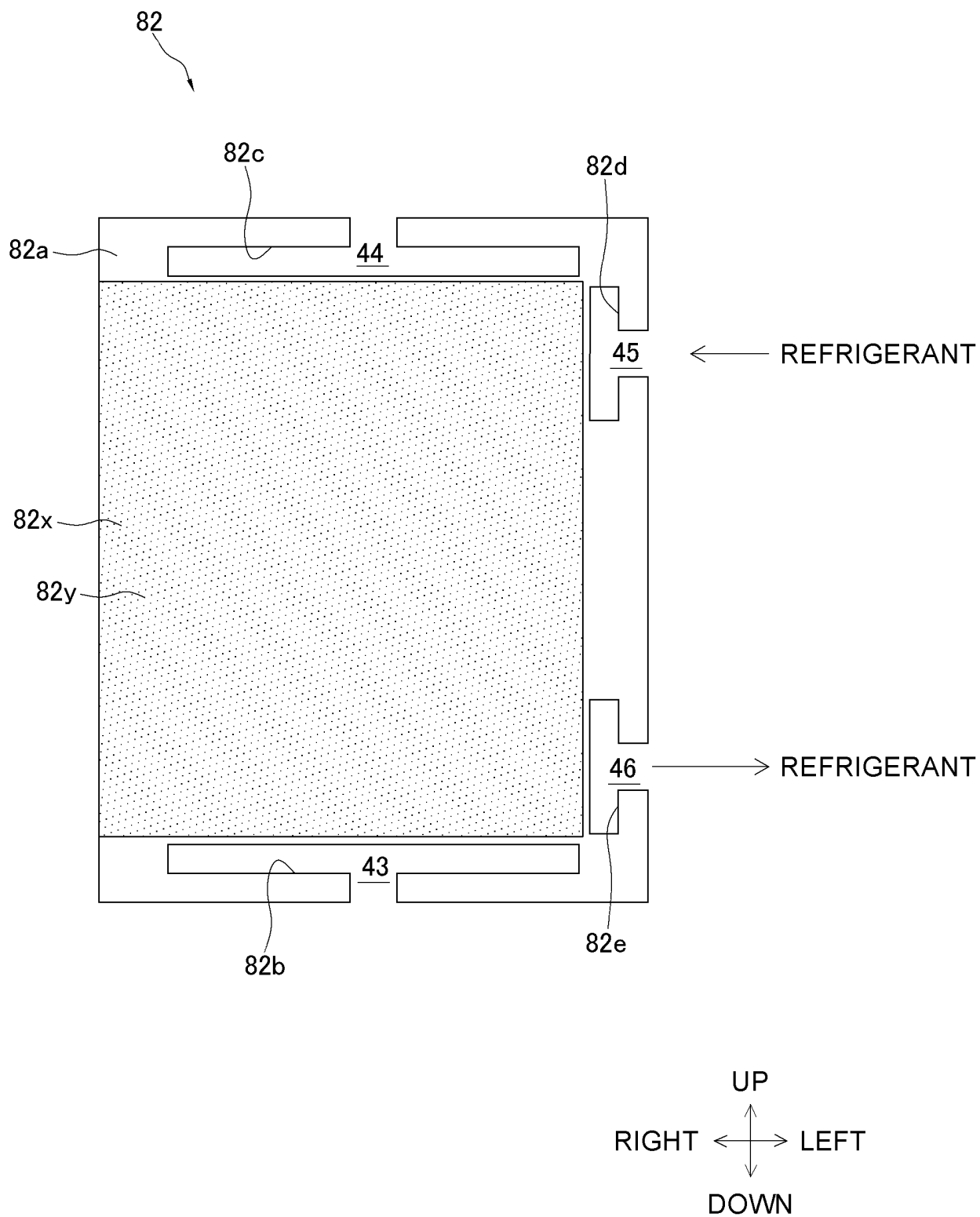


FIG. 14

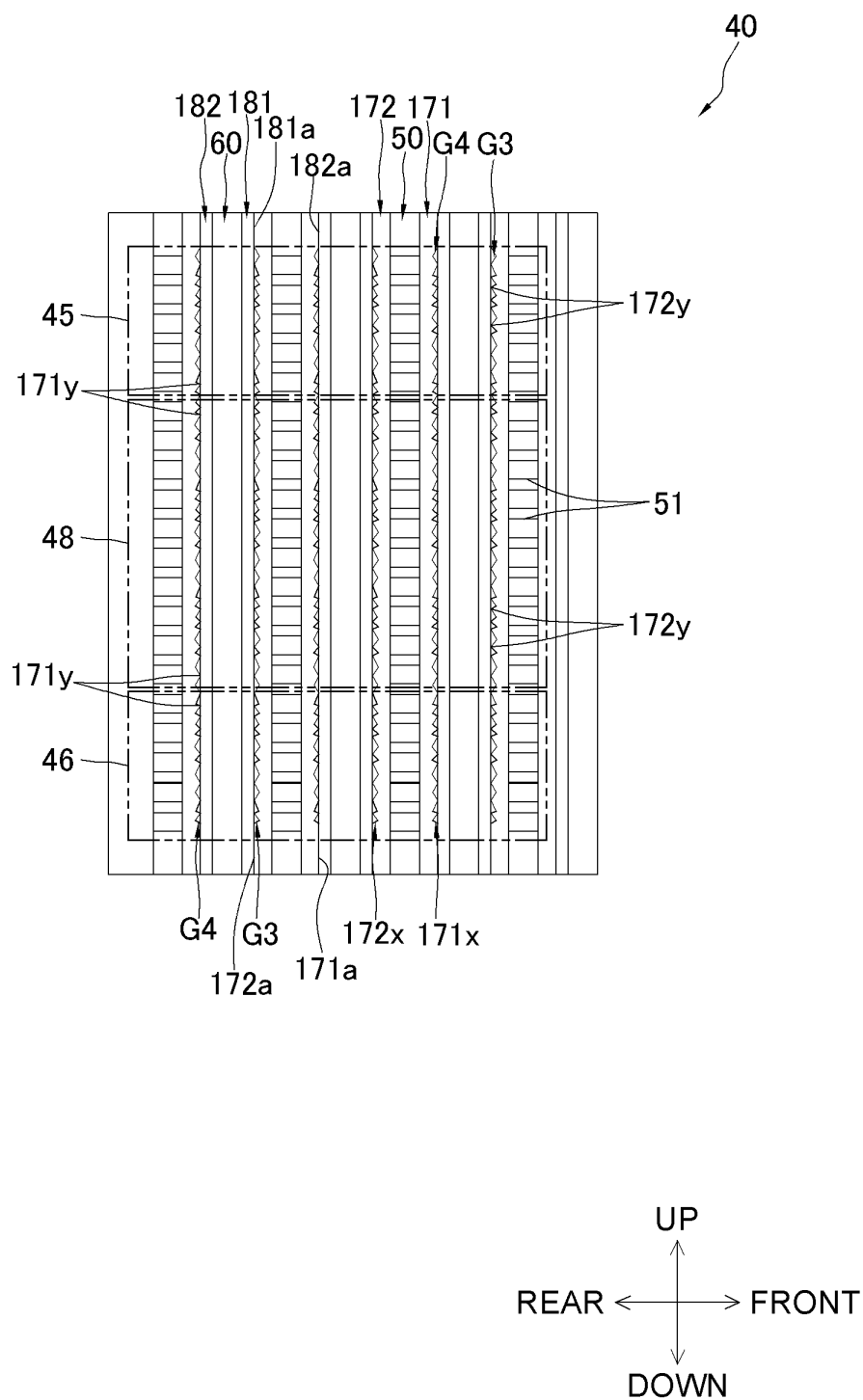


FIG. 15

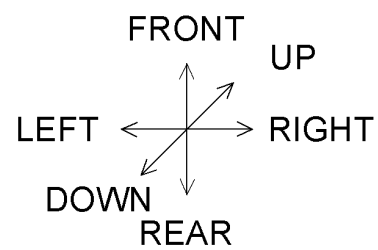
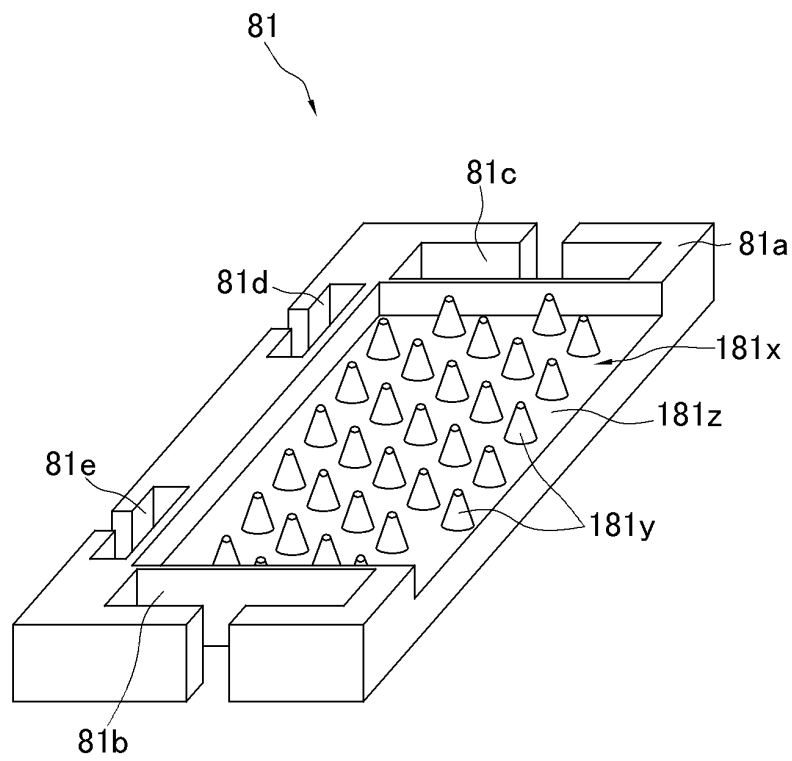


FIG. 16

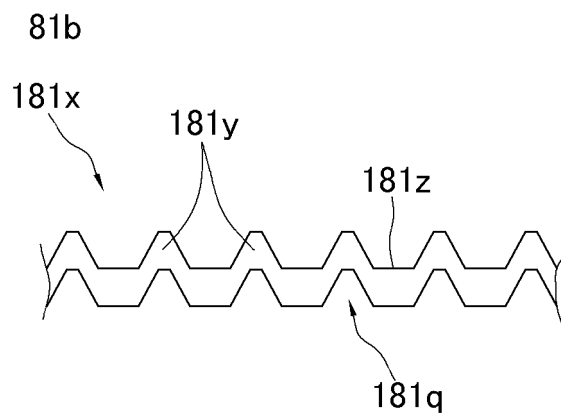


FIG. 17

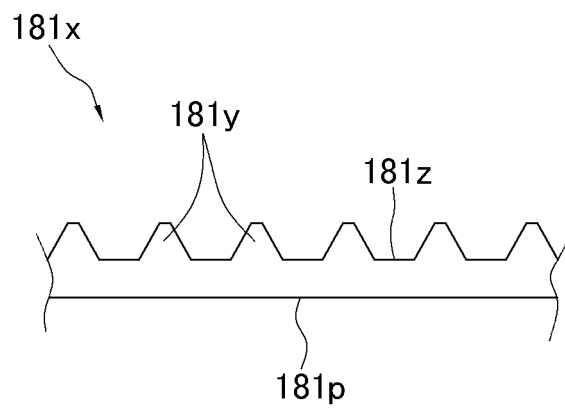


FIG. 18

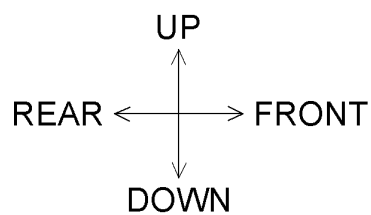
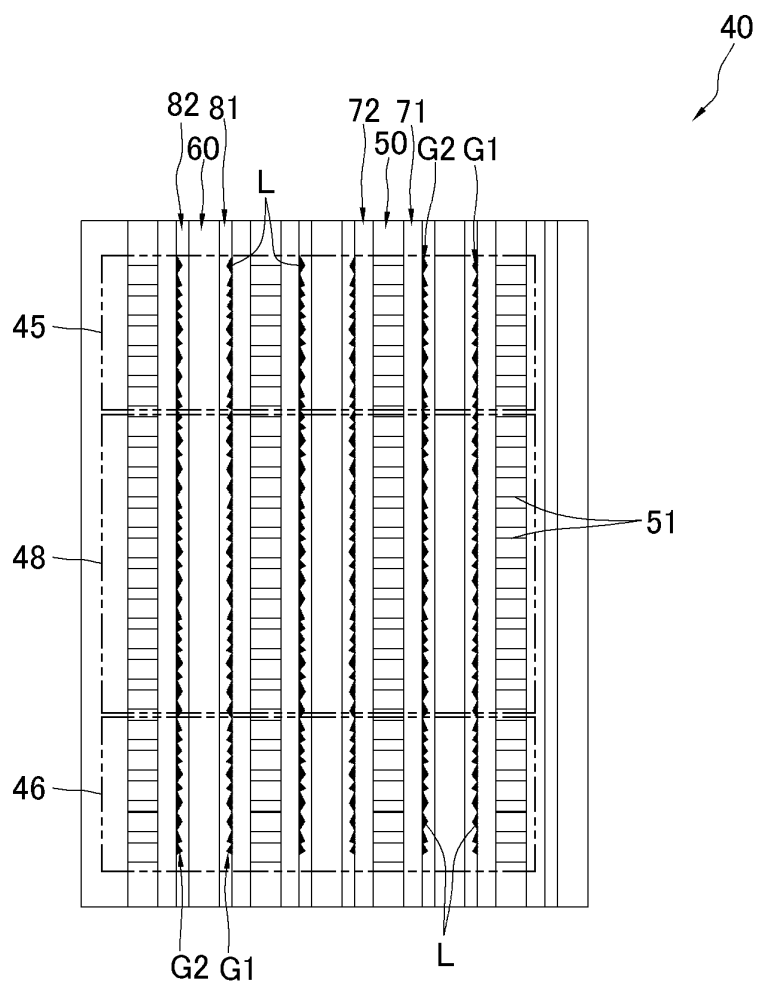


FIG. 19

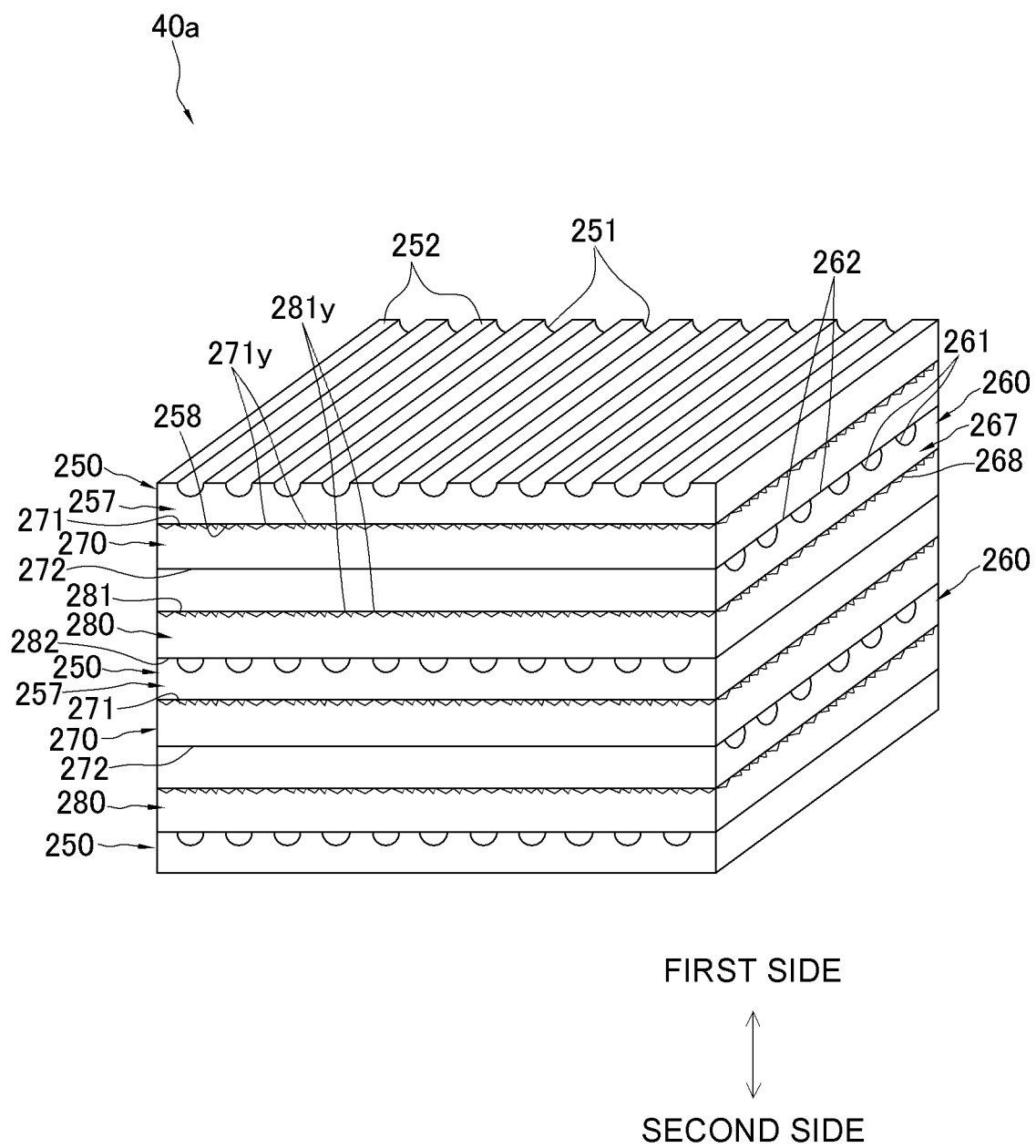


FIG. 20

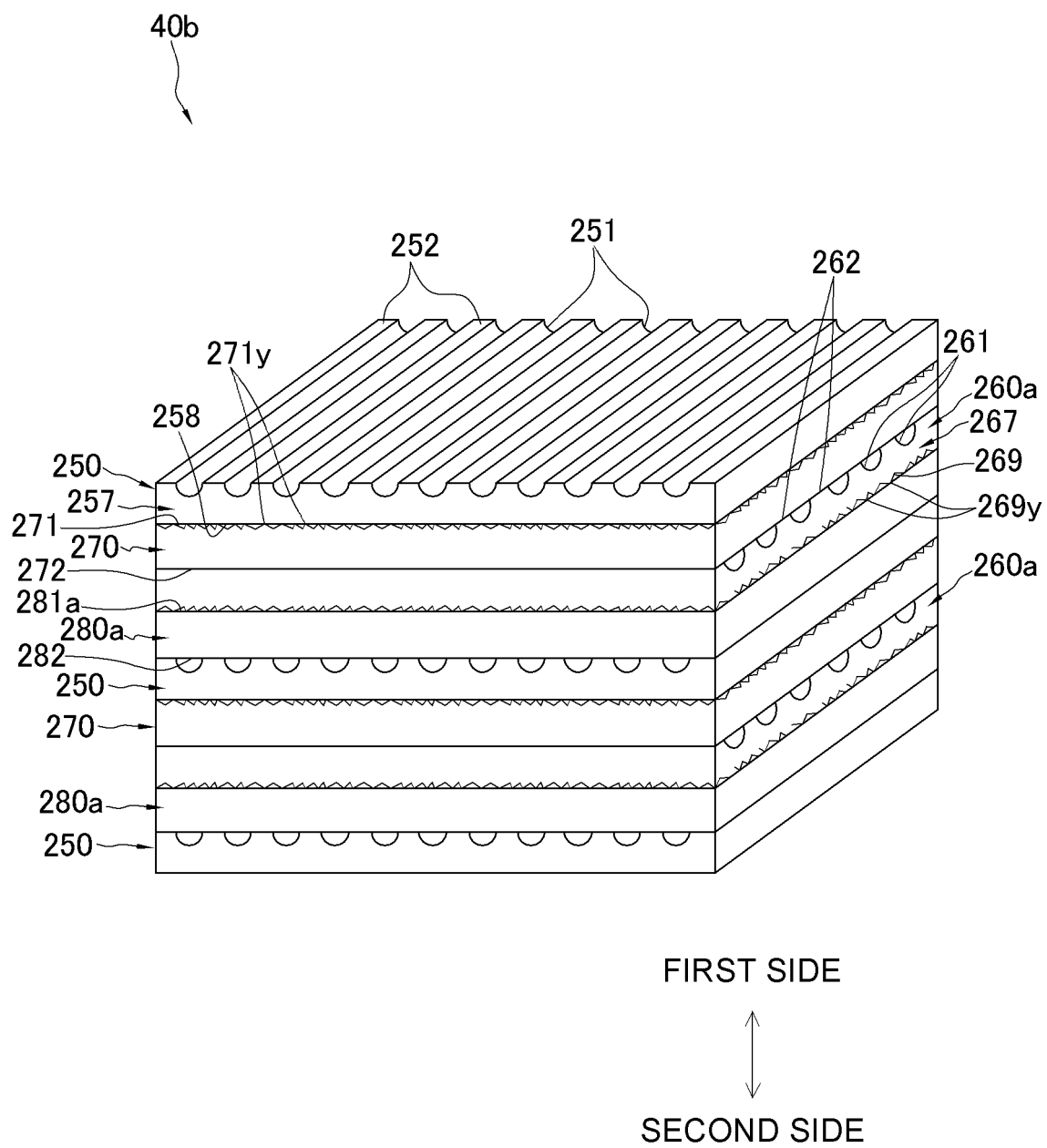


FIG. 21

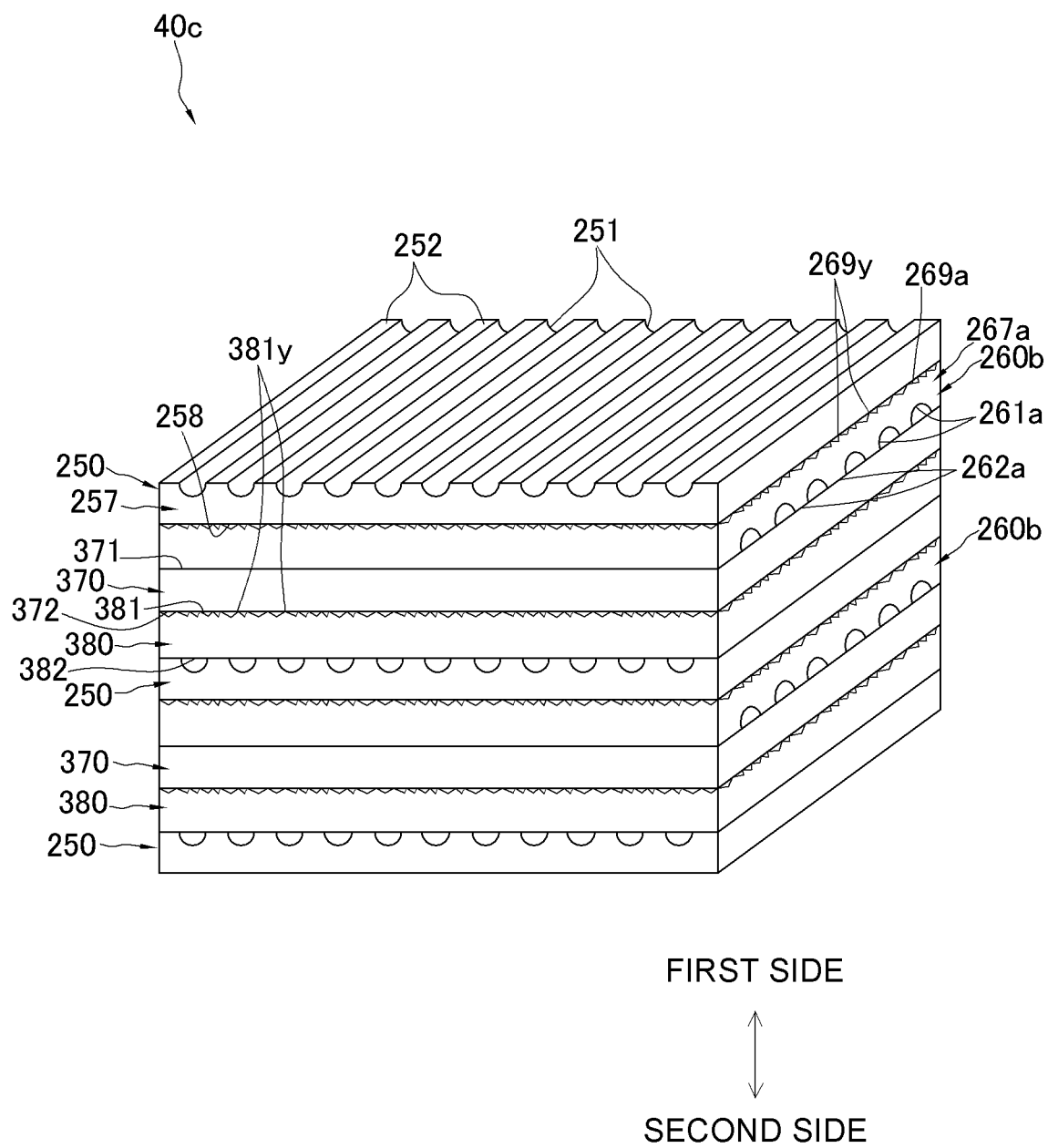


FIG. 22

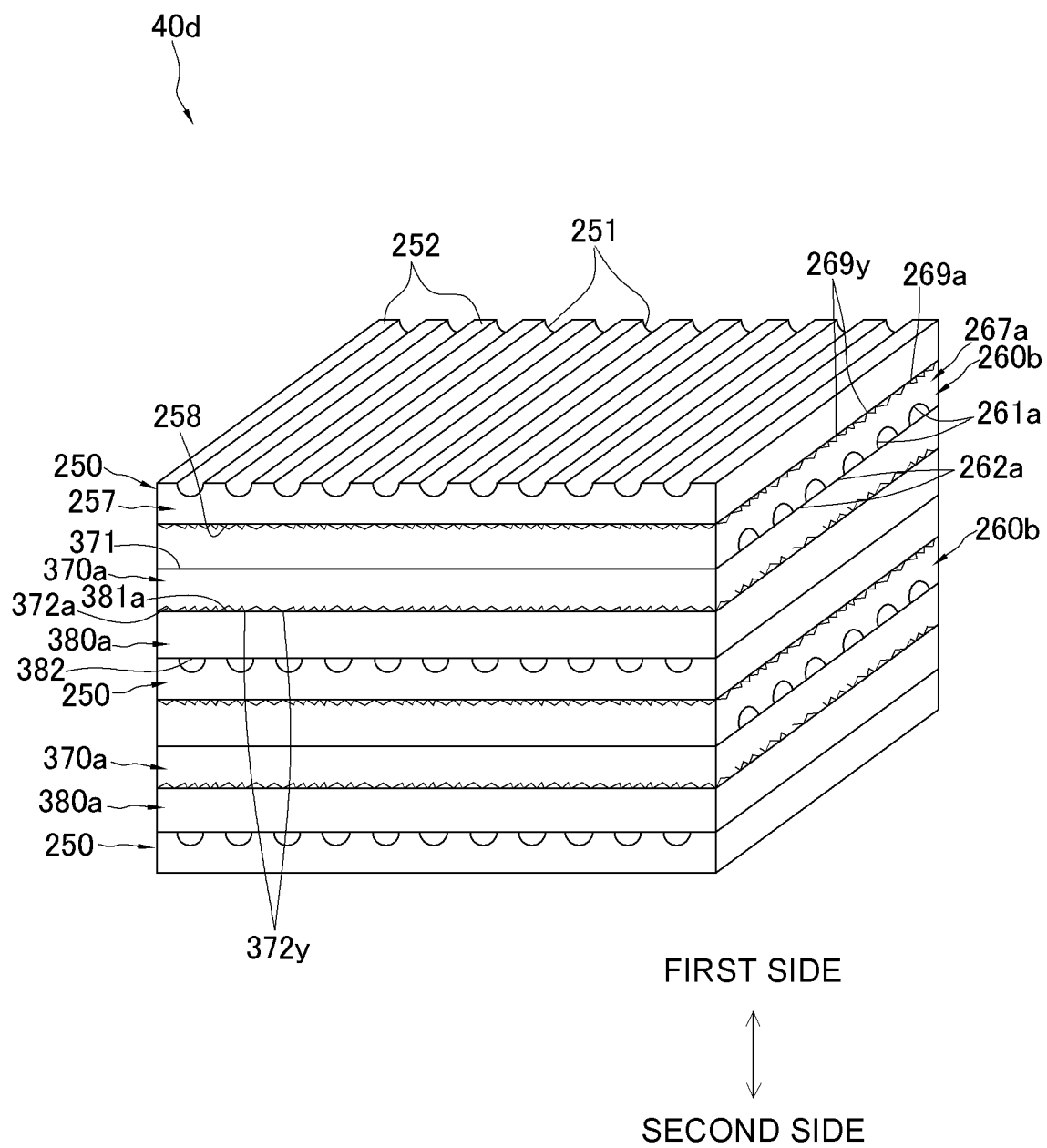


FIG. 23

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/035444

A. CLASSIFICATION OF SUBJECT MATTER F28F 3/08 (2006.01)i; F28D 9/00 (2006.01)i FI: F28F3/08 301Z; F28D9/00 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) F28F3/00 - 99/00; F28D9/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2023 Registered utility model specifications of Japan 1996-2023 Published registered utility model applications of Japan 1994-2023		
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 Y	JP 2020-176754 A (MITSUBISHI ELECTRIC CORPORATION) 29 October 2020 (2020-10-29) paragraphs [0010]-[0046], fig. 1-9	1-3, 9-10 4-8, 11-18
Y	US 2018/0073811 A1 (CLIMATE MASTER, INC.) 15 March 2018 (2018-03-15) paragraphs [0011]-[0017], fig. 1	4-8, 11-18
A	WO 2019/176567 A1 (MITSUBISHI ELECTRIC CORPORATION) 19 September 2019 (2019-09-19) entire text, all drawings	1-18
A	JP 2007-529707 A (SPEC CO., LTD.) 25 October 2007 (2007-10-25) entire text, all drawings	1-18
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family	
Date of the actual completion of the international search 06 December 2023	Date of mailing of the international search report 19 December 2023	
Name and mailing address of the ISA/IP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.	

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/035444

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP	2020-176754	A	29 October 2020	(Family: none)	
US	2018/0073811	A1	15 March 2018	(Family: none)	
WO	2019/176567	A1	19 September 2019	US 2020/0408465	A1
				entire text, all drawings	
				CN 111819414	A
JP	2007-529707	A	25 October 2007	WO 2005/080901	A1
				entire text, all drawings	

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2002107089 A [0003] [0197]