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(54) HEAT EXCHANGER, REFRIGERANT CYCLE DEVICE, AND HOT WATER SUPPLY APPARATUS

(57) To provide a heat exchanger capable of securing the heat exchange performance even in a case where two fluids have different pressures at the time of inflow, and a refrigerant cycle apparatus and a water heater using the heat exchanger. A first heat exchanger (100) includes a first heat transfer plate (110) and a second heat transfer plate (120). The second heat transfer plate includes a second flow port (121a, 121b), a second through hole (122a, 122b), a second heat transfer region (123), and a second connection portion (125a, 125b). The second flow port introduces or discharges a second fluid having a lower boiling point than the first fluid. The first fluid passes through the second through hole in the thickness direction. The second fluid exchanges heat with the first fluid while passing through the second heat transfer region. One end of the second connection portion is connected to the second flow port, and the other end thereof is connected to the second heat transfer region. The second flow port is formed at a position opposite to the second heat transfer region with the second through hole interposed therebetween. The second connection portion is formed so as to go around an outer side of the second through hole, and includes a second protrusion portion (127a, 127b).

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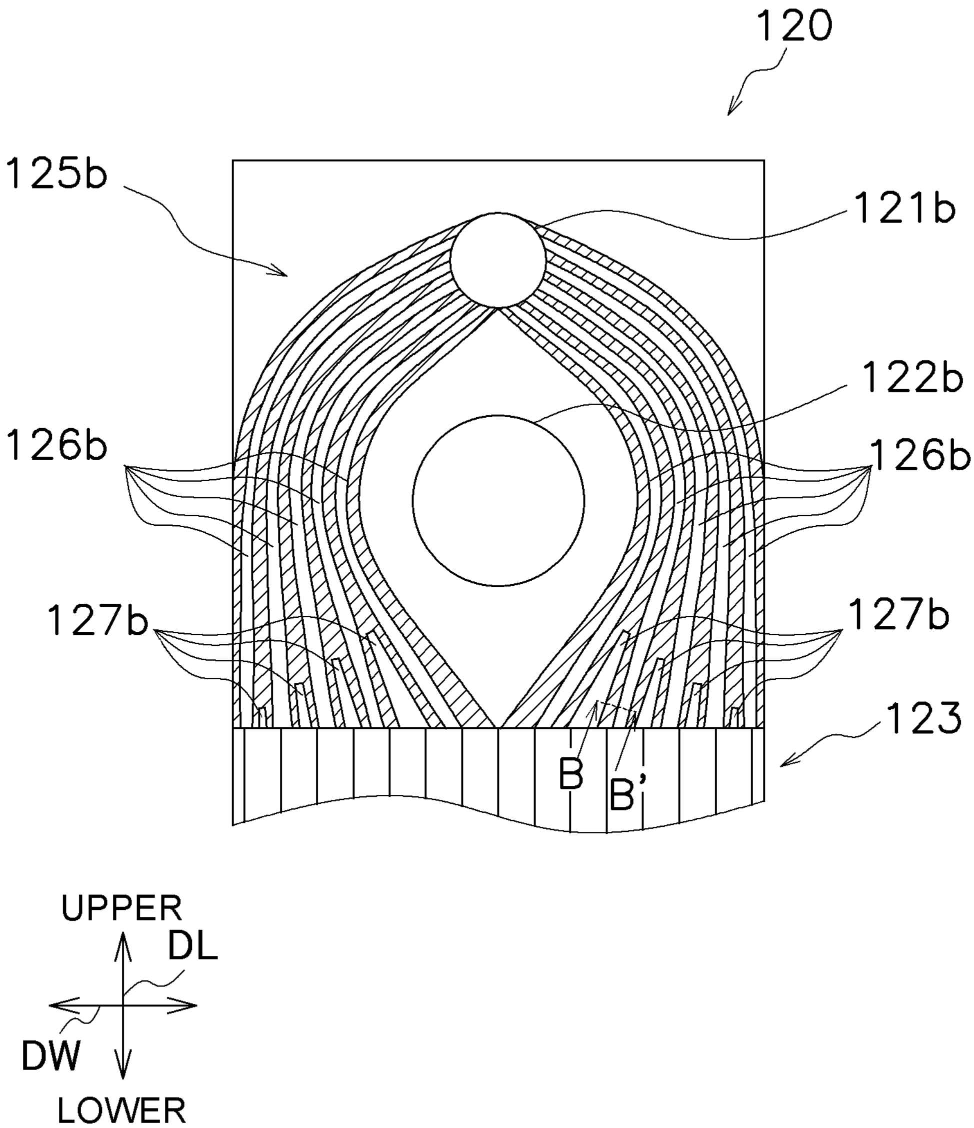

120
125b
121b
122b
126b
126b
127b
127b
123
B
B'
UPPER
DL
DW
LOWER

FIG. 7

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger, a refrigerant cycle apparatus, and a water heater.

BACKGROUND ART

[0002] There is known a plate-shaped heat exchanger in which a plurality of heat transfer plates are laminated at predetermined intervals in a laminating direction to alternately form a flow path through which a first fluid flows and a flow path through which a second fluid flows and which causes heat exchange between the two fluids.

[0003] PTL 1 (Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2012-512382) discloses a heat transfer plate (heat exchange plate) and a heat exchanger using the same, the heat transfer plate mainly including two flow ports through which one fluid flows in or out, a heat transfer region in which a plurality of grooves are formed for heat exchange of the inflowing fluid, a connection portion (distribution region) in which a groove for connecting one of the flow ports and the heat transfer region is formed, and a pair of through holes through which the other fluid passes.

SUMMARY OF THE INVENTION

<Technical Problem>

[0004] In the heat exchanger of PTL 1, the length of the flow path through which the first fluid flows is the same as the length of the flow path through which the second fluid flows. Therefore, the same degree of pressure loss occurs in the two fluids inside the heat exchanger. In comparison of the rates of pressure reduction due to the pressure loss occurred in this way, the pressure of one of the two fluids that has a lower pressure at the time of inflow is reduced at a relatively larger rate. As a result, there is a problem that the heat exchanger cannot sufficiently exert the heat exchange performance.

[0005] The present disclosure provides a heat exchanger capable of securing the heat exchange performance even in a case where two fluids have different pressures at the time of inflow, and a refrigerant cycle apparatus and a water heater using the same.

<Solution to Problem>

[0006] A first heat exchanger of a first aspect includes a first heat transfer plate and a second heat transfer plate that are laminated on each other.

[0007] The first heat transfer plate includes a first flow port, a first through hole, a first heat transfer region, and a first connection portion.

[0008] The first flow port introduces or discharges a first fluid. A second fluid having a lower boiling point than the first fluid passes through the first through hole in a thickness direction. The first heat transfer region is a region in which the first fluid having flowed in from the first flow port exchanges heat with the second fluid while passing therethrough. One end of the first connection portion is connected to the first flow port, and the other end thereof is connected to the first heat transfer region.

[0009] The second heat transfer plate includes a second flow port, a second through hole, a second heat transfer region, and a second connection portion.

[0010] The second flow port communicates with the first through hole and introduces or discharges the second fluid. The first fluid passes through the second through hole in the thickness direction. The second heat transfer region is a region in which the second fluid having flowed in from the second flow port exchanges heat with the first fluid while passing therethrough. The second connection portion has one end connected to the second flow port and the other end connected to the second heat transfer region.

[0011] The second flow port is formed at a position opposite to the second heat transfer region with the second through hole interposed therebetween. The second connection portion is formed so as to go around an outer side of the second through hole, and includes a second protrusion portion.

[0012] In the present heat exchanger, the second connection portion is formed so as to go around the outer side of the second through hole. In other words, the length of the flow path of the first connection portion through which the first fluid passes is formed to be shorter than the length of the flow path of the second connection portion through which the second fluid having a lower boiling point than the first fluid passes. Therefore, it is possible to make the pressure loss occurred in the first fluid when passing through the first connection portion smaller than the pressure loss occurred in the second fluid when passing through the second connection portion. This suppresses the reduction of the pressure of the first fluid at a large rate. Therefore, in the present heat exchanger, it is possible to secure the heat exchange performance even in a case where two fluids have different pressures at the time of inflow.

[0013] A heat exchanger of a second aspect is the heat exchanger of the first aspect, in which the second protrusion portion has a linear shape in plan view.

[0014] A heat exchanger of a third aspect is the heat exchanger of the first aspect or the second aspect, in which the second connection portion has a linear shape in plan view.

[0015] A heat exchanger of a fourth aspect is the heat exchanger of the first aspect, in which the second protrusion portion has a circular shape in plan view.

[0016] A heat exchanger of a fifth aspect is the heat exchanger of the first aspect, in which the second protrusion portion has a triangular shape in plan view.

[0017] A heat exchanger of a sixth aspect is the heat exchanger of the first aspect, in which the second protrusion portion has a quadrangular shape in plan view.

[0018] **A heat exchanger** of a seventh aspect is the heat exchanger of the first aspect, in which the second protrusion portion has a teardrop shape in plan view.

[0019] A heat exchanger of an eighth aspect is the heat exchanger of the first aspect, in which the first connection portion is formed such that a flow path cross sectional area increases from the first flow port toward the first heat transfer region.

[0020] The present heat exchanger further reduces a pressure loss occurred in the first fluid passing through the first connection portion, and thus further suppresses the reduction of the pressure of the first fluid at a large rate and secures the heat exchange performance more effectively.

[0021] A heat exchanger of a ninth aspect is the heat exchanger of the eighth aspect, in which the first connection portion includes a first protrusion portion, and the first protrusion portion has a linear shape in plan view.

[0022] A heat exchanger of a tenth aspect is the heat exchanger of the eighth aspect, in which the first connection portion includes a first protrusion portion, and the first protrusion portion has a circular shape in plan view.

[0023] A heat exchanger of an eleventh aspect is the heat exchanger of the eighth aspect, in which the first connection portion includes a first protrusion portion, and the first protrusion portion has a triangular shape in plan view.

[0024] A heat exchanger of a twelfth aspect is the heat exchanger of the eighth aspect, in which the first connection portion includes a first protrusion portion, and the first protrusion portion has a quadrangular shape in plan view.

[0025] A heat exchanger of a thirteenth aspect is the heat exchanger of the eighth aspect, in which the first connection portion includes a first protrusion portion, and the first protrusion portion has a teardrop shape in plan view.

[0026] A heat exchanger of a fourteenth aspect is the heat exchanger of any one of the first aspect to the thirteenth aspect, including a partition wall. The partition wall is a plate-shaped member laminated between the first heat transfer plate and the second heat transfer plate. When in a cross section orthogonal to a flow direction of the first fluid, a length along which a first separation portion separating adjacent first connection portions from each other is in contact with the partition wall is La1, and an interval between adjacent first separation portions is **P1,** the first connection portion is formed so as to satisfy a relation:

$$0.005 < La1/P1 < 0.15$$

[0027] With the first connection portion formed so as to satisfy the above-described relation, the force that the partition wall receives from the first fluid passing through the first connection portion is suppressed from exceeding the pressure resistance strength.

[0028] A heat exchanger of a fifteenth aspect is the heat exchanger of the fourteenth aspect in which the first connection portion is formed so as to satisfy a relation:

$$0.005 < La1/P1 < 0.05$$

[0029] In the present heat exchanger, with the first connection portion formed so as to satisfy the above-described relation, the force that the partition wall receives from the first fluid passing through the first connection portion is more effectively suppressed from exceeding the pressure resistance strength.

[0030] A heat exchanger of a sixteenth aspect is the heat exchanger of any one of the first aspect to the fifteenth aspect, including a partition wall. When in a cross section orthogonal to a flow direction of the second fluid, a length along which a second separation portion or the protrusion portion separating adjacent second connection portions from each other is in contact with the partition wall is La2, and an interval between adjacent second separation portions or second protrusion portions is P2, the second connection portion is formed so as to satisfy a relation:

$$0.005 < L2/P2 < 0.15$$

[0031] In the present heat exchanger, with the second connection portion formed so as to satisfy the above-described relation, the force that the partition wall receives from the second fluid passing through the second connection portion is suppressed from exceeding the pressure resistance strength.

[0032] A heat exchanger according to a seventeenth aspect is the heat exchanger according to the sixteenth aspect in which the second connection portion is formed so as to satisfy a relation:

$$0.02 < L2/P2 < 0.15$$

[0033] In the present heat exchanger, with the second connection portion formed so as to satisfy the above-described relation, the force that the partition wall receives from the second fluid passing through the second connection portion is more effectively suppressed from exceeding the pressure resistance strength.

[0034] A refrigerant cycle apparatus of an eighteenth aspect includes the heat exchanger of any one of the first aspect to the seventeenth aspects, a first fluid circuit in which the first fluid circulates, and a second fluid circuit in which the second fluid circulates.

[0035] A water heater of a nineteenth aspect includes the heat exchanger of any one of the first aspect to the seventeenth aspects, a first fluid circuit in which the first fluid circulates, and a second fluid circuit in which the second fluid circulates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

Fig. 1 is a schematic configuration diagram showing a refrigerant cycle apparatus 1 including a first heat exchanger 100.
Fig. 2 is an exploded perspective view of the first heat exchanger 100.
Fig. 3 is a plan view of a first heat transfer plate 110.
Fig. 4 is an enlarged view of the vicinity of the upper end portion of the first heat transfer plate 110.
Fig. 5 is a sectional view of a part taken along line A-A' of Fig. 4.
Fig. 6 is a plan view of a second heat transfer plate 120.
Fig. 7 is an enlarged view of the vicinity of the upper end portion of the second heat transfer plate 120.
Fig. 8 is a sectional view of a part taken along line B-B' of Fig. 7.
Fig. 9 is an enlarged view of the vicinity of the upper end portion of the second heat transfer plate 120 of the first heat exchanger 100 according to a modification A.
Fig. 10 is an enlarged view of the vicinity of the upper end portion of the second heat transfer plate 120 of the first heat exchanger 100 according to another example of the modification A.
Fig. 11 is an enlarged view of the vicinity of the upper end portion of the second heat transfer plate 120 of the first heat exchanger 100 according to another example of the modification A.
Fig. 12 is an enlarged view of the vicinity of the upper end portion of the second heat transfer plate 120 of the first heat exchanger 100 according to another example of the modification A.
Fig. 13 is an enlarged view of the vicinity of the upper end portion of the first heat transfer plate 110 of the first heat exchanger 100 according to a modification B.
Fig. 14 is an enlarged view of the vicinity of the upper end portion of the first heat transfer plate 110 of the first heat exchanger 100 according to a modification F.
Fig. 15 is an enlarged view of the vicinity of the upper end portion of the first heat transfer plate 110 of the first heat exchanger 100 according to a modification G.
Fig. 16 is an enlarged view of the vicinity of the upper end portion of the first heat transfer plate 110 of the first heat exchanger 100 according to another example of the modification G.
Fig. 17 is a schematic configuration diagram showing a water heater 2 including the first heat exchanger 100.

DESCRIPTION OF EMBODIMENTS

<First embodiment>

(1) Refrigerant cycle apparatus 1

[0037] First, the refrigerant cycle apparatus 1 including the first heat exchanger 100 according to the first embodiment of the present disclosure will be described. The refrigerant cycle apparatus 1 is a binary refrigerant cycle apparatus that executes a vapor compression cycle to perform cooling and heating operations of an air-conditioning target space (not shown) such as the interior of a building.

[0038] The refrigerant cycle apparatus 1 heats or cools water, and performs a heating operation and a cooling operation of a target space (not shown) using the water. The refrigerant cycle apparatus 1 includes the first heat exchanger 100, a second heat exchanger 300, a first fluid circuit 10, a second fluid circuit 20, a water circuit 30, and a control unit 40. As will be described in detail later, a first fluid circulates in the first fluid circuit 10, a second fluid having a lower boiling point than the first fluid circulates in the second fluid circuit 20, and water circulates in the water circuit 30. In the present embodiment, the water circuit 30 is installed indoors, and the second fluid circuit 20 is installed outdoors, although not limited thereto. The first fluid circuit 10 may be installed indoors or outdoors, and a part of the first fluid circuit 10 may be installed indoors or outdoors.

(1-1) First heat exchanger 100

[0039] The first heat exchanger 100 causes heat exchange between the first fluid circulating in the first fluid circuit 10 and the second fluid circulating in the second fluid circuit 20. The first heat exchanger 100 includes first flow pipes 141a, 141b, second flow pipes 142a, 142b, a first flow path 220, and a second flow path 230.

[0040] The first flow path 220 is a flow path through which the first fluid flows. The first flow path 220 is provided between the first flow pipe 1410a and the first flow pipe 141b. The second flow path 230 is a flow path through which the second fluid flows. The second flow path 230 is formed between the second flow pipe 142a and the second flow pipe 142b. The first fluid flowing through the first flow path 220 exchanges heat with the second fluid passing through the second flow path 230. A detailed structure of the first heat exchanger 100 will be described later.

(1-2) Second heat exchanger 300

[0041] The second heat exchanger 300 causes heat exchange between the first fluid circulating in the first fluid circuit 10 and the water circulating in the water circuit 30.

The second heat exchanger 300 includes first flow pipes 341a, 341b, second flow pipes 342a, 342b, a first flow path 420, and a second flow path 430.

[0042] The first flow path 420 is a flow path through which the first fluid flows. The first flow path 420 is provided between the first flow pipe 341a and the first flow pipe 341b. The second flow path 430 is a flow path through which the water flows. The second flow path 430 is formed between the second flow pipe 342a and the second flow pipe 342b. The first fluid flowing through the first flow path 420 exchanges heat with the water passing through the second flow path 430.

(1-3) First fluid circuit 10

[0043] In the first fluid circuit 10, the first fluid is heated or cooled. The first fluid circuit 10 includes a compressor 11, a four-way switching valve 12, an expansion valve 13, the first flow path 220 of the first heat exchanger 100, and the first flow path 420 of the second heat exchanger 300. The compressor 11, the four-way switching valve 12, the expansion valve 13, the first flow path 220 of the first heat exchanger 100, and the first flow path 420 of the second heat exchanger 300 are connected by pipes, and the first fluid circulates therein. In the present embodiment, the first fluid is R1234ze.

[0044] The compressor 11 sucks the low-pressure first fluid in the first fluid circuit 10 from a suction portion 11a, compresses it, and discharges the compressed first fluid as the high-pressure first fluid from a discharge portion 11b.

[0045] The four-way switching valve 12 includes a first port 12a, a second port 12b, a third port 12c, and a fourth port 12d. The four-way switching valve 12 is switched between a first state and a second state that have different communication states of the first port 12a, the second port 12b, the third port 12c, and the fourth port 12d, on the basis of an instruction from the control unit 40. In the first state, the first port 12a and the second port 12b communicate with each other, and the third port 12c and the fourth port 12d communicate with each other. In the second state, the first port 12a and the fourth port 12d communicate with each other, and the second port 12b and the third port 12c communicate with each other.

[0046] The first port 12a is connected to the discharge portion 11b of the compressor 11. The second port 12b is connected to the first flow pipe 341b of the second heat exchanger 300. The third port 12c is connected to the suction portion 11a of the compressor 11. The fourth port 12d is connected to the first flow pipe 141a of the first heat exchanger 100.

[0047] The expansion valve 13 functions as a decompression apparatus that adjusts a flow rate of the first fluid circulating in the first fluid circuit 10 and reduces the pressure of the first fluid.

[0048] One end of the expansion valve 13 is connected to the first flow pipe 141b of the first heat exchanger 100. The other end of the expansion valve 13 is connected to the first flow pipe 341a of the second heat exchanger 300.

(1-4) Second fluid circuit 20

[0049] In the second fluid circuit 20, the second fluid is heated or cooled. The second fluid circuit 20 includes a compressor 21, a four-way switching valve 22, an expansion valve 23, a heat source heat exchanger 24, and the second flow path 230 of the first heat exchanger 100. The compressor 21, the four-way switching valve 22, the expansion valve 23, the heat source heat exchanger 24, and the second flow path 230 of the first heat exchanger 100 are connected by pipes, and the second fluid circulates therein. In the present embodiment, the second fluid is carbon dioxide.

[0050] The compressor 21 sucks the low-pressure second fluid in the second fluid circuit 20 from a suction portion 21a, compresses it, and discharges the compressed second fluid as the high-pressure second fluid from a discharge portion 21b.

[0051] The four-way switching valve 22 includes a first port 22a, a second port 22b, a third port 22c, and a fourth port 22d. The four-way switching valve 22 is switched between a first state and a second state that have different communication states of the first port 22a, the second port 22b, the third port 22c, and the fourth port 22d, on the basis of an instruction from the control unit 40. In the first state, the first port 22a and the second port 22b communicate with each other, and the third port 22c and the fourth port 22d communicate with each other. In the second state, the first port 22a and the fourth port 22d communicate with each other, and the second port 22b and the third port 22c communicate with each other.

[0052] The first port 22a is connected to the discharge portion 21b of the compressor 21. The second port 22b is connected to the second flow pipe 142b of the first heat exchanger 100. The third port 22c is connected to the suction portion 21a of the compressor 21. The fourth port 22d is connected to one end of the heat source heat exchanger 24.

[0053] The expansion valve 23 functions as a decompression apparatus that adjusts a flow rate of the second fluid circulating in the second fluid circuit 20 and reduces the pressure of the second fluid.

[0054] One end of the expansion valve 23 is connected to the second flow pipe 142a of the first heat exchanger 100. The other end of the expansion valve 23 is connected to the other end of the heat source heat exchanger 24.

[0055] The heat source heat exchanger 24 causes heat exchange between the second fluid circulating in the second fluid circuit 20 and a heat source (for example, outdoor air).

(1-5) Water circuit 30

[0056] The water having subjected to heat exchange with the first fluid circulates in the water circuit 30. The water circuit 30 includes a water circulation pump 31, a water storage tank 32, and the second flow path 430 of the second heat exchanger 300. The water circulation pump 31, the water storage tank 32, and the second flow path 430 of the second heat exchanger 300 are connected by pipes, and water circulates therein.

[0057] The water circulation pump 31 circulates water inside the water circuit 30. The water circulation pump 31 sucks water inside the water circuit 30 from a suction portion 31a and discharges the water from a discharge portion 31b.

[0058] The suction portion 31a is connected to the second flow pipe 342b of the second heat exchanger 300.

[0059] The water storage tank 32 stores water heated or cooled by the second heat exchanger 300 to heat or cool (in other words, perform heating or cooling) indoor air. The water storage tank 32 includes a water intake portion 32a for taking in water circulating in the water circuit 30 and a drain portion 32b for discharging stored water.

[0060] The water intake portion 32a is connected to the discharge portion 31b of the water circulation pump 31. The drain portion 32b is connected to the second flow pipe 342b of the second heat exchanger 300.

(1-6) Control unit 40

[0061] The control unit 40 controls the compressors 11, 21, the four-way switching valves 12, 22, the expansion valves 13, 23, and the water circulation pump 31. Although not shown, the control unit 40 is electrically connected to the compressors 11, 21, the four-way switching valves 12, 22, the expansion valves 13, 23, and the water circulation pump 31 so as to enable the transmission and reception of control signals.

(1-7) Operation of refrigerant cycle apparatus 1

[0062] The refrigerant cycle apparatus 1 performs a heating operation and a cooling operation.

(1-7-1) Heating operation

[0063] The heating operation is an operation by the refrigerant cycle apparatus 1 to heat water in the water circuit 30. In the heating operation, the control unit 40 sets the four-way switching valves 12, 22 to the first state, drives the compressors 11, 21 and the water circulation pump 31, and controls the opening degrees of the expansion valves 13, 23.

(1-7-1-1) Second fluid circuit 20

[0064] The compressor 21 sucks the low-pressure gas-phase second fluid in the second fluid circuit 20 from the suction portion 21a, and discharges it as the high-pressure gas-phase second fluid from the discharge portion 21b. The high-pressure gas-phase second fluid passes through the four-way switching valve 22 in the order of the first port 22a and the second port 22b, and reaches the second flow path 230 from the second flow pipe 142a of the first heat exchanger 100. In the second flow path 230 of the first heat exchanger 100, the high-pressure gas-phase second fluid is condensed into a high-pressure liquid-phase second fluid. At this time, the second fluid releases heat to the first fluid passing through the first flow path 220. The high-pressure liquid-phase second fluid reaches the expansion valve 23. The expansion valve 23 set to an appropriate opening degree reduces the pressure of the high-pressure liquid-phase second fluid to form a low-pressure gas-liquid two-phase second fluid. The low-pressure gas-liquid two-phase second fluid evaporates in the heat source heat exchanger 24 to become a low-pressure gas-phase second fluid. At this time, the second fluid absorbs heat from the heat source. The low-pressure gas-phase second fluid passes through the four-way switching valve 22 in the order of the fourth port 22d and the third port 22c, and then is sucked into the compressor 21 from the suction portion 21a.

(1-7-1-2) First fluid circuit 10

[0065] The compressor 11 sucks the low-pressure gas-phase first fluid in the first fluid circuit 10 from the suction portion 11a, and discharges it as the high-pressure gas-phase first fluid from the discharge portion 11b. The high-pressure gas-phase first fluid passes through the four-way switching valve 12 in the order of the first port 12a and the second port 12b, and reaches the first flow path 420 from the first flow pipe 341a of the second heat exchanger 300. In the first flow path 420 of the second heat exchanger 300, the high-pressure gas-phase first fluid is condensed into a high-pressure liquid-phase first fluid. At this time, the first fluid releases heat to the water passing through the second flow path 430. The high-pressure liquid-phase first fluid reaches the expansion valve 13. The expansion valve 13 set to an appropriate opening degree reduces the pressure of the high-pressure liquid-phase first fluid to form a low-pressure gas-liquid two-phase first fluid. The low-pressure gas-liquid two-phase first fluid passes through the first flow pipe 141a of the first heat exchanger 100, and then evaporates in the first flow path 220 to become a low-pressure gas-phase first fluid. At this time, the first fluid absorbs heat from the second fluid passing through the second flow path 230. The low-pressure gas-phase first fluid passes through the four-way switching valve 12 in the order of the fourth port 12d and the third port 12c, and then is sucked into the compressor 11 from the suction portion 11a.

(1-7-1-3) Water circuit 30

[0066] The water circulation pump 31 sucks water circulating in the water circuit 30 from the suction portion

31a and discharges it from the discharge portion 31b. The discharged water is stored in the water storage tank 32 through the water intake portion 32a. The water stored in the water storage tank 32 releases heat to indoor air. In other words, the water stored in the water storage tank 32 heats the indoor air. The water stored in the water storage tank 32 passes through the drain portion 32b, and then passes through the second flow pipe 342a of the second heat exchanger 300 to reach the second flow path 430. The water having reached the second flow path 430 of the second heat exchanger 300 absorbs heat from the first fluid passing through the first flow path 420. The water having absorbed heat is sucked into the water circulation pump 31 from the suction portion 31a.

(1-7-2) Cooling operation

[0067] The cooling operation is an operation by the refrigerant cycle apparatus 1 to cool water in the water circuit 30. In the cooling operation, the control unit 40 sets the four-way switching valves 12, 22 to the second state, drives the compressors 11, 21 and the water circulation pump 31, and controls the opening degrees of the expansion valves 13, 23.

(1-7-2-1) Second fluid circuit 20

[0068] The compressor 21 sucks the low-pressure gas-phase second fluid in the second fluid circuit 20 from the suction portion 21a, and discharges it as the high-pressure gas-phase second fluid from the discharge portion 21b. The high-pressure gas-phase second fluid passes through the four-way switching valve 22 in the order of the first port 22a and the fourth port 22d, and reaches the heat source heat exchanger 24. In the heat source heat exchanger 24, the high-pressure gas-phase second fluid is condensed into a high-pressure liquid-phase second fluid. At this time, the second fluid releases heat to the heat source. The high-pressure liquid-phase second fluid reaches the expansion valve 23. The expansion valve 23 set to an appropriate opening degree reduces the pressure of the high-pressure liquid-phase second fluid to form a low-pressure gas-liquid two-phase second fluid. The low-pressure gas-liquid two-phase second fluid passes through the second flow pipe 142b of the first heat exchanger 100, and then evaporates in the second flow path 230 to become a low-pressure gas-phase second fluid. At this time, the second fluid absorbs heat from the first fluid passing through the second flow path 230. The low-pressure gas-phase second fluid passes through the four-way switching valve 22 in the order of the second port 22b and the third port 22c, and then is sucked into the compressor 21 from the suction portion 21a.

(1-7-2-2) First fluid circuit 10

[0069] The compressor 11 sucks the low-pressure gas-phase first fluid in the first fluid circuit 10 from the suction portion 11a, and discharges it as the high-pressure gas-phase first fluid from the discharge portion 11b. The high-pressure gas-phase first fluid passes through the four-way switching valve 12 in the order of the first port 12a and the fourth port 12d, and reaches the first flow path 220 from the first flow pipe 141b of the first heat exchanger 100. In the first flow path 220 of the first heat exchanger 100, the high-pressure gas-phase first fluid is condensed into a high-pressure liquid-phase first fluid. At this time, the first fluid releases heat to the second fluid passing through the second flow path 230. The high-pressure liquid-phase first fluid reaches the expansion valve 13. The expansion valve 13 set to an appropriate opening degree reduces the pressure of the high-pressure liquid-phase first fluid to form a low-pressure gas-liquid two-phase first fluid. The low-pressure gas-liquid two-phase first fluid passes through the first flow pipe 341b of the second heat exchanger 300, and then evaporates in the first flow path 420 to become a low-pressure gas-phase first fluid. At this time, the first fluid absorbs heat from the second fluid passing through the second flow path 430. The low-pressure gas-phase first fluid passes through the four-way switching valve 12 in the order of the second port 12b and the third port 12c, and then is sucked into the compressor 11 from the suction portion 11a.

(1-7-2-3) Water circuit 30

[0070] The water circulation pump 31 sucks water circulating in the water circuit 30 from the suction portion 31a and discharges it from the discharge portion 31b. The discharged water is stored in the water storage tank 32 through the water intake portion 32a. The water stored in the water storage tank 32 absorbs heat from indoor air. In other words, the water stored in the water storage tank 32 cools the indoor air. The water stored in the water storage tank 32 passes through the drain portion 32b, and then passes through the second flow pipe 342a of the second heat exchanger 300 to reach the second flow path 430. The water having reached the second flow path 430 of the second heat exchanger 300 releases heat to the first fluid passing through the first flow path 420. The water having released heat is sucked into the water circulation pump 31 from the suction portion 31a.

(2) Heat exchanger

(2-1) Overall configuration

[0071] The first heat exchanger 100 is a plate-shaped heat exchanger including a plurality of first heat transfer plates 110, a plurality of second heat transfer plates 120, a plurality of partition walls 130, a first frame 140, and a second frame 150. The first flow path 220 and the second flow path 230 are provided inside the first heat exchanger 100.

[0072] The first heat transfer plate 110, the second heat transfer plate 120, and the partition wall 130 are plate-shaped metal members having the same rectangular outer shape. In the present embodiment, as shown in Fig. 2, the outer shapes of the first heat transfer plate 110, the second heat transfer plate 120, the partition wall 130, the first frame 140, and the second frame 150 are formed in a band shape elongated in a first direction.

[0073] The plurality of first heat transfer plates 110 and the plurality of second heat transfer plates 120 are alternately laminated with the partition wall 130 interposed therebetween between the first frame 140 and the second frame 150. The number of each of the plurality of first heat transfer plates 110 and the plurality of second heat transfer plates 120 is not limited, and is appropriately set in accordance with the required performance. The first frame 140, the first heat transfer plate 110, the partition wall 130, the second heat transfer plate 120, and the second frame 150 are integrally joined by, for example, brazing although not limited thereto.

[0074] In the following description, the first direction may be referred to as a longitudinal direction DL for convenience. Moreover, the width directions of the first heat transfer plate 110, the partition wall 130, and the second heat transfer plate 120 may be referred to as a width direction DW. Further, the thickness directions (in other words, the laminating direction) of the first heat transfer plate 110, the partition wall 130, and the second heat transfer plate 120 may be referred to as a thickness direction DT (for all of these, see arrows shown in some of the drawings). Moreover, the upper and lower directions referred to in the following description respectively correspond to "upper" and "lower" shown in some of the drawings.

(2-2) Detailed configuration

(2-2-1) First heat transfer plate 110

[0075] The first heat transfer plate 110 forms the first flow path 220 together with the partition wall 130 laminated adjacent thereto. The first heat transfer plate 110 includes first flow ports 111a, 111b, first through holes 112a, 112b, a first heat transfer region 113, and pluralities of first connection portions 115a, 115b.

[0076] The first flow ports 111a, 111b are holes for introducing or discharging the first fluid into or from the first flow path 220. The first flow ports 111a, 111b are formed so as to penetrate the first heat transfer plate 110 along the thickness direction DT. In the present embodiment, the first flow ports 111a, 111b are formed in a circular shape in plan view of the first heat transfer plate 110. The first flow ports 111a, 111b are formed at positions spaced from both ends in the longitudinal direction DL of the first heat transfer region 113 by a predetermined distance along the longitudinal direction DL such that the centers of the first flow ports 111a, 111b are located at the center in the width direction DW. The first flow port 111a is formed on the upper side than the first heat transfer region 113, and the first flow port 111b is formed on the lower side than the first heat transfer region 113.

[0077] The first through holes 112a, 112b are holes through which the second fluid passes along the thickness direction DT. The first through holes 112a, 112b are formed so as to penetrate the first heat transfer plate 110 along the thickness direction DT. In the present embodiment, the first through holes 112a, 112b are formed in a circular shape in plan view of the first heat transfer plate 110. The first through holes 112a, 112b are formed at positions spaced from the first flow ports 111a, 111b toward the ends in the longitudinal direction DL of the first heat transfer plate 110 with a predetermined distance along the longitudinal direction DL such that the centers of the first flow through holes 112a, 112b are located at the center in the width direction DW. In other words, the first through holes 112a, 112b are formed at positions opposite to the first heat transfer region 113 with the first flow ports 111a, 111b interposed therebetween in the longitudinal direction DL. The first through hole 112a is formed on the upper side than the first flow port 111a, and the first through hole 112b is formed on the lower side than the first flow port 111b.

[0078] The first heat transfer region 113 is a region in which the first fluid having flowed in from the first flow ports 111a, 111b exchanges heat with the second fluid while passing therethrough. The first heat transfer region 113 is a rectangular region having substantially the same width as the first heat transfer plate 110. The first heat transfer region 113 is formed from the center of the first heat transfer plate 110 toward both ends in the longitudinal direction DL to the end portions on the first heat transfer region 113 side of the first connection portions 115a, 115b.

[0079] In the first heat transfer region 113, a plurality of first heat transfer flow paths 114, which are groove-shaped flow paths through which the first fluid having flowed in from the first flow ports 111a, 111b passes, are formed. The first heat transfer flow paths 114 are each a groove formed along the longitudinal direction DL. The plurality of first heat transfer flow paths 114 are formed at predetermined intervals along the width direction DW of the first heat transfer plate 110.

[0080] The first connection portions 115a are each a groove-shaped flow path having one end connected to the first flow port 111a and the other end connected to an upper end portion of the first heat transfer region 113 in the longitudinal direction DL. The first connection portion 115b are each a groove-shaped flow path having one end connected to the first flow port 111b and the other end connected to a lower end portion of the first heat transfer region 113 in the longitudinal direction DL. The adjacent first connection portions 115a are separated from each other by a first separation portion 116a. The adjacent first connection portions 115b are separated from each other by a first separation portion 116b.

[0081] The first flow path 220 includes the first heat transfer region 113 (first heat transfer flow path 114) and the first connection portions 115a, 115b connected to both ends of the first heat transfer region 113. Therefore, the first heat exchanger 100 includes the same number of first flow paths 220 as the number of the first heat transfer plates 110.

[0082] In the present embodiment, the first connection portions 115a, 115b are formed linearly as shown in Fig. 4. The first connection portions 115a, 115b are formed such that the flow path cross sectional area increases from the first flow ports 111a, 111b toward the first heat transfer region 113. Although not limited, in the present embodiment, 18 first connection portions 115a, 115b are connected to one first flow port 111a, 111b.

[0083] The first connection portions 115a, 115b may be formed such that, in a cross section orthogonal to the flow direction of the first fluid, the first separation portions 116a, 116b separating the adjacent first connection portions 115a, 115b from each other satisfy the following relation of (Expression 1), preferably of (Expression 2).

$$0.005 < La1/P1 < 0.15 \cdots \text{(Expression 1)}$$

$$0.005 < La1/P1 < 0.05 \cdots \text{(Expression 2)}$$

[0084] As shown in Fig. 5, La1 is a length along which the first separation portion 116a, 116b is in contact with the partition wall 130. P1 is an interval between the adjacent first separation portions 116a, 116b. The P1 is obtained by adding La1 to Lb1 that is a length along which the partition wall 130 is in contact with the first connection portion 115a, 115b (P1 = Lb1 + La1).

[0085] The first heat transfer region 113 (first heat transfer flow path 114) and the first connection portions 115a, 115b are formed on one surface of the first heat transfer plate 110. The first flow ports 111a, 111b, the first through holes 112a, 112b, the first heat transfer region 113, and the first connection portions 115a, 115b are formed by, for example, press working although not limited thereto.

(2-2-2) Second heat transfer plate 120

[0086] The second heat transfer plate 120 forms the second flow path 230 together with the partition wall 130 laminated adjacent thereto. The second heat transfer plate 120 includes second flow ports 121a, 121b, second through holes 122a, 122b, a second heat transfer region 123, pluralities of second connection portions 125a, 125b, and second protrusion portions 127a, 127b.

[0087] The second flow ports 121a, 121b are holes for introducing or discharging the second fluid into or from the second flow path 111. The second flow ports 121a, 121b are formed so as to penetrate the second heat transfer plate 120 along the thickness direction DT. In the present embodiment, the second flow ports 121a, 121b are formed in a circular shape in plan view of the second heat transfer plate 120. The second flow ports 121a, 121b are formed at positions spaced from the second through holes 122a, 122b toward the ends in the longitudinal direction DL of the second heat transfer plate 120 with a predetermined distance along the longitudinal direction DL such that the centers of the second flow ports 121a, 121b are located at the center in the width direction DW. In other words, the second flow ports 121a, 121b are formed at positions opposite to the second heat transfer region 123 with the second through holes 122a, 122b interposed therebetween. The second flow port 121a is formed on the lower side than the second heat transfer region 123, and the second flow port 121b is formed on the upper side than the second heat transfer region 123.

[0088] The second flow port 121a and the first through hole 112a have the same shape, and are formed at positions overlapping each other in plan view in a state where the first heat transfer plate 110 and the second heat transfer plate 120 are laminated. The second flow port 121b and the first through hole 112b have the same shape, and are formed at positions overlapping each other in plan view in a state where the first heat transfer plate 110 and the second heat transfer plate 120 are laminated.

[0089] The second through holes 122a, 122b are holes through which the second fluid passes along the thickness direction. The second through holes 122a, 122b are formed so as to penetrate the second heat transfer plate 120 in the thickness direction. In the present embodiment, the second through holes 122a, 122b are formed in a circular shape in plan view of the second heat transfer plate 120. The second through holes 122a, 122b are formed at positions spaced with a predetermined distance along the longitudinal direction DL from both ends of the second heat transfer region 123 in the longitudinal direction DL such that the centers of the second through holes 122a, 122b are located at the center in the width direction DW. The second through hole 122a is formed on the lower side than the second flow port 121a, and the second through hole 122b is formed on the upper side than the second flow port 121b.

[0090] The second through hole 122a and the first flow port 111a have the same shape, and are formed at positions overlapping each other in plan view in a state where the first heat transfer plate 110 and the second heat transfer plate 120 are laminated. The second through hole 122b and the first flow port 111b have the same shape, and are formed at positions overlapping each other in plan view in a state where the first heat transfer plate 110 and the second heat transfer plate 120 are laminated.

[0091] The second heat transfer region 123 is a region in which the second fluid having flowed in from the second flow ports 121a, 121b exchanges heat with the first fluid while passing therethrough. The second heat transfer region 123 is a rectangular region having substantially the same width as the second heat transfer plate 120. The second heat transfer region 123 is formed from the center of the second heat transfer plate 120 toward both ends in the longitudinal direction DL to the end portions on the second heat transfer region 123 side of the second connection portions 125a, 125b.

[0092] In the second heat transfer region 123, a plurality of second heat transfer flow paths 124, which are groove-shaped flow paths through which the second fluid having flowed in from the second flow ports 121a, 121b passes, are formed. The second heat transfer flow paths 124 are each a groove formed along the longitudinal direction DL. The plurality of second heat transfer flow paths 124 are formed at predetermined intervals along the width direction DW of the second heat transfer plate 120.

[0093] The second heat transfer region 123 and the first heat transfer region 113 have the same shape, and are formed at positions overlapping each other in plan view in a state where the first heat transfer plate 110 and the second heat transfer plate 120 are laminated. The plurality of second heat transfer flow paths 124 and the plurality of first heat transfer flow paths 114 have the same shape, and are formed at positions overlapping each other in plan view in a state where the first heat transfer plate 110 and the second heat transfer plate 120 are laminated.

[0094] The second connection portions 125a are each a groove-shaped flow path having one end connected to the second flow port 121a and the other end connected to a lower end portion of the second heat transfer region 123 in the longitudinal direction DL. The second connection portion 125bs are each a groove-shaped flow path having one end connected to the second flow port 121b and the other end connected to an upper end portion of the second heat transfer region 123 in the longitudinal direction DL. The second connection portions 125a, 125b are formed **so as to** go around the outer side of the second through holes 122a, 122b from the second flow ports 121a, 121b toward the second heat transfer region 123. The adjacent second connection portions 125a are separated from each other by a second separation portion 126a. The adjacent second connection portions 125b are separated from each other by the second separation portion 126b.

[0095] The second flow path 230 includes the second heat transfer region 123 (second heat transfer flow path 124) and the second connection portions 125a, 125b connected to both ends of the second heat transfer region 123. Therefore, the first heat exchanger 100 includes the same number of second flow paths 230 as the number of the second heat transfer plates 120.

[0096] In the present embodiment, the second connection portions 125a, 125b are formed in a curved shape as shown in Fig. 7. The second connection portions 125a, 125b are formed such that the flow path cross sectional area increases from the second flow ports 121a, 121b toward the second heat transfer region 123. Although not limited, in the present embodiment, 12 second connection portions 125a, 125b are connected to one first flow port 111a, 111b. More specifically, as shown in Fig. 6 and Fig. 7, the second connection portions 125a, 125b connected to one first flow port 111a, 111b are divided into two in the width direction DW in a unit of six, and are formed so as to go around the outer side of the second through holes 122a, 122b.

[0097] The second protrusion portions 127a, 127b are provided in the second connection portions 125a, 125b. The second protrusion portions 127a, 127b define the second connection portions 125a, 125b, and limit force (pressure) that the partition wall 130 receives from the second fluid. The second protrusion portions 127a are each formed in a linear shape projecting with a predetermined length from the second heat transfer region 123 toward the second connection portion 125a in plan view. The second protrusion portions 127b are each formed in a linear shape projecting with a predetermined length from the second heat transfer region 123 toward the second connection portion 125b in plan view. In the present embodiment, the second protrusion portions 127a, 127b are formed at four inner connection portions among the second connection portions 125a, 125b divided into two in a unit of six, although not limited thereto.

[0098] The pluralities of second connection portions 125a, 125b may be formed such that, in a cross section orthogonal to the flow direction of the second fluid, the second separation portions 126a, 126b or the second protrusion portions 127a, 127b separating the adjacent second connection portions 125a, 125b from each other satisfy the following relation of (Expression 3), preferably of (Expression 4).

$$0.005 < La2/P2 < 0.15 \cdots \text{(Expression 3)}$$

$$0.02 < La2/P2 < 0.05 \cdots \text{(Expression 4)}$$

[0099] As shown in Fig. 8, La2 is a length along which the second separation portion 126a, 126b or the second protrusion portion 127a, 127b is jointed to the partition wall 130. The P2 is an interval between the adjacent second separation portions 126a, 126b or second protrusion portions 127a, 127b. The P2 is obtained by adding La2 to Lb2 that is a length along which the partition wall 130 is in contact with the first connection portion 115a, 115b (P2 = Lb1 + Lb2).

[0100] The second heat transfer region 123 (second heat transfer flow path 124) and the second connection portions 125a, 125b are formed on one surface of the second heat transfer plate 120. The second flow ports 121a, 121b, the second through holes 122a, 122b, the second heat transfer region 123, the second connection portions 125a, 125b, and the second protrusion portions 127a, 127b are formed by, for example, press working although not limited thereto.

(2-2-3) Partition wall 130

[0101] The partition wall 130 is a flat plate that separates the first heat transfer plate 110 and the second heat transfer plate 120 from each other in the thickness direction DT. The partition wall 130 includes two first flow holes 131a, 131b and two second flow holes 132a, 132b.

[0102] The first flow holes 131a, 131b are holes through which the first fluid passes along the thickness direction DT. The first flow holes 131a, 131b are formed so as to penetrate the partition wall 130 along the thickness direction DT. In the present embodiment, the first flow holes 131a, 131b are formed in a circular shape in plan view of the partition wall 130.

[0103] The first flow hole 131a, the first flow port 111a, and the second through hole 122b have the same shape, and are formed at positions overlapping each other in plan view in a state where the partition wall 130, the first heat transfer plate 110, and the second heat transfer plate 120 are laminated. The first flow hole 131b, the first flow port 111b, and the second through hole 122a have the same shape, and are formed at positions overlapping each other in plan view in a state where the partition wall 130, the first heat transfer plate 110, and the second heat transfer plate 120 are laminated.

[0104] The second flow holes 132a, 132b are holes through which the second fluid passes along the thickness direction. The second flow holes 132a, 132b are formed so as to penetrate the partition wall 130 along the thickness direction. In the present embodiment, the second flow holes 132a, 132b are formed in a circular shape in plan view of the partition wall 130.

[0105] The second flow hole 132a, the second flow port 121b, and the first through hole 112a have the same shape, and are formed at positions overlapping each other in plan view in a state where the partition wall 130, the first heat transfer plate 110, and the second heat transfer plate 120 are laminated. The second flow hole 132b, the second flow port 121a, and the first through hole 112b have the same shape, and are formed at positions overlapping each other in plan view in a state where the partition wall 130, the first heat transfer plate 110, and the second heat transfer plate 120 are laminated.

(2-2-4) First communication paths 211a, 211b and second communication paths 212a, 212b

[0106] The plurality of first heat transfer plates 110, the plurality of second heat transfer plates 120, and the plurality of partition walls 130 are laminated, whereby the first flow holes 131a, the first flow ports 111a, and the second through holes 122b communicate with each other. The first flow holes 131a, the first flow ports 111a, and the second through holes 122b that communicate with each other form a first communication path 211a extending along the thickness direction DT. The first communication path 211a communicates with the first flow path 220 through the first flow port 111a.

[0107] The plurality of first heat transfer plates 110, the plurality of second heat transfer plates 120, and the plurality of partition walls 130 are laminated, whereby the first flow holes 131b, the first flow ports 111b, and the second through holes 122a communicate with each other. The first flow holes 131b, the first flow ports 111b, and the second through holes 122a that communicate with each other, form a first communication path 211b extending along the thickness direction DT. The first communication path 211b communicates with the first flow path 220 through the first flow port 111b.

[0108] The plurality of first heat transfer plates 110, the plurality of second heat transfer plates 120, and the plurality of partition walls 130 are laminated, whereby the second flow holes 132b, the second flow ports 121a, and the first through holes 112b communicate with each other. The second flow holes 132b, the second flow ports 121a, and the first through holes 112b that communicate with each other, form a second communication path 212a extending along the thickness direction DT. The second communication path 212a communicates with the second flow path 230 through the second flow port 121a.

[0109] The plurality of first heat transfer plates 110, the plurality of second heat transfer plates 120, and the plurality of partition walls 130 are laminated, whereby the second flow holes 132a, the second flow ports 121b, and the first through holes 112a communicate with each other. The second flow holes 132a, the second flow ports 121b, and the first through holes 112a that communicate with each other, form a second communication path 212b extending along the thickness direction DT. The second communication path 212b communicates with the second flow path 230 through the second flow port 121b.

(2-2-5) First frame 140 and second frame 150

[0110] The first frame 140 and the second frame 150 are plate-shaped metal members that sandwich, at both ends in the thickness direction DT, the plurality of first heat transfer plates 110 and the plurality of second heat transfer plates 120 alternately laminated with the partition wall 130 interposed therebetween.

[0111] The first frame 140 includes the first flow pipe 141a, the first flow pipe 141b, the second flow pipe 142a, and the second flow pipe 142b.

[0112] The first flow pipe 141a penetrates the first frame 140 and communicates with the first communication path 211a.

[0113] The first flow pipe 141b penetrates the first frame 140 and communicates with the first communication path 211b.

[0114] The second flow pipe 142a penetrates the first frame 140 and communicates with the second communication path 212a.

[0115] The second flow pipe 142b penetrates the first frame 140 and communicates with the second communication path 212b.

(2-3) Flows of first fluid and second fluid

(2-3-1) Heating operation

[0116] The low-pressure gas-liquid two-phase first fluid introduced from the first flow pipe 141a of the first heat exchanger 100 passes through the first communication path 211a and flows into the first flow path 220 from the first flow port 111a. The gas-liquid two-phase first fluid having flowed into the first flow path 220 passes through the first connection portion 115a, the first heat transfer region 113 (first heat transfer flow path 114), and the first connection portion 115b in this order. The first fluid flowing through the first heat transfer region 113 exchanges heat with the second fluid in the second flow path 230 adjacent thereto through the partition wall 130, evaporates, and absorbs heat from the second fluid. In other words, the first heat exchanger 100 functions as an evaporator for the first fluid. The evaporated first fluid becomes a low-pressure gas-phase first fluid, passes through the first flow port 111b and the first communication path 211b, and is discharged from the first flow pipe 141b.

[0117] Meanwhile, the high-pressure gas-phase second fluid introduced from the second flow pipe 142a of the first heat exchanger 100 passes through the second communication path 212a and flows into the second flow path 230 from the second flow port 121a. The high-pressure gas-phase second fluid having flowed into the second flow path 230 passes through the second connection portion 125a, the second heat transfer region 123 (second heat transfer flow path 124), and the second connection portion 125b in this order. The second fluid flowing through the second heat transfer region 123 exchanges heat with the first fluid in the first flow path 220 adjacent thereto through the partition wall 130, is condensed, and releases heat. In other words, the first heat exchanger 100 functions as a condenser for the second fluid. The condensed second fluid becomes a high-pressure liquid-phase second fluid, passes through the second flow port 121b and the second communication path 212b, and is discharged from the second flow pipe 142b.

(2-3-2) Cooling operation

[0118] The high-pressure gas-phase first fluid introduced from the first flow pipe 141b of the first heat exchanger 100 passes through the first communication path 211b and flows into the first flow path 220 from the first flow port 111b. The high-pressure gas-phase first fluid having flowed into the first flow path 220 passes through the first connection portion 115b, the first heat transfer region 113 (first heat transfer flow path 114), and the first connection portion 115a in this order. The first fluid flowing through the first heat transfer region 113 exchanges heat with the second fluid in the second flow path 230 adjacent thereto through the partition wall 130, is condensed, and releases heat to the second fluid. In other words, the first heat exchanger 100 functions as a radiator for the first fluid. The condensed first fluid becomes a high-pressure liquid-phase first fluid, passes through the first flow port 111a and the first communication path 211a, and is discharged from the first flow pipe 141a.

[0119] Meanwhile, the low-pressure gas-liquid two-phase second fluid introduced from the second flow pipe 142b of the first heat exchanger 100 passes through the second communication path 212b, and flows into the second flow path 230 from the second flow port 121b. The low-pressure gas-liquid two-phase second fluid having flowed into the second flow path 230 passes through the second connection portion 125b, the second heat transfer region 123 (second heat transfer flow path 124), and the second connection portion 125a in this order. The second fluid flowing through the second heat transfer region 123 exchanges heat with the first fluid in the first flow path 220 adjacent thereto through the partition wall 130, evaporates, and absorbs heat from the first fluid. In other words, the first heat exchanger 100 functions as an evaporator for the second fluid. The evaporated second fluid becomes a low-pressure gas-phase second fluid, passes through the second flow port 121a and the second communication path 212a, and is discharged from the second flow pipe 142a.

(3) Characteristics

[0120] (3-1)
The first heat exchanger 100 includes the first heat transfer plate 110 and the second heat transfer plate 120 that are laminated on each other.

[0121] The first heat transfer plate 110 includes the first flow ports 111a, 111b, the first through holes 112a, 112b, the first heat transfer region 113, and the first connection portions 115a, 115b.

[0122] The first flow ports 111a, 111b introduce or discharge the first fluid. The second fluid having a lower boiling point than the first fluid passes through the first through holes 112a, 112b in the thickness direction. The first heat transfer region 113 is a region in which the first fluid having flowed in from the first flow ports 111a, 111b exchanges heat with the second fluid while passing therethrough. One ends of the first connection portions 115a, 115b are connected to the first flow ports 111a, 111b, and the other ends thereof are connected to the first heat transfer region 113.

[0123] The second heat transfer plate 120 includes the second flow ports 121a, 121b, the second through holes 122a, 122b, the second heat transfer region 123, and the second connection portions 125a, 125b.

[0124] The second flow ports 121a, 121b communicate with the first through holes 112a, 112b, and introduce or discharge the second fluid. The first fluid passes through the second through holes 122a, 122b in the thickness direction. The second heat transfer region 123 is a region in which the second fluid having flowed in from the second flow ports 121a, 121b exchanges heat with the first fluid while passing therethrough. One ends of the second connection portions 125a, 125b are connected to the second flow ports 121a, 121b, and the other ends thereof are connected to the second heat transfer region 123.

[0125] The second flow ports 121a, 121b are formed at positions opposite to the second heat transfer region 123 with the second through holes 122a, 122b interposed therebetween. The second connection portions 125a, 125b are formed so as to go around the outer side of the second through holes 122a, 122b, and include the second protrusion portions 127a, 127b.

[0126] In the heat exchanger including two heat transfer plates, if the length of the flow path through which the first fluid flows is the same as the length of the flow path through which the second fluid flows, the same degree of pressure loss occurs in the two fluids. In comparison of the rates of pressure reduction caused by the pressure loss occurred in this way, the pressure of one of the two fluids that has a lower pressure at the time of inflow is reduced at a larger rate. As a result, there is a problem that the heat exchanger cannot sufficiently exert the heat exchange performance.

[0127] In the first heat exchanger 100, the second connection portions 125a, 125b are formed so as to go around the outer side of the second through holes 122a, 122b. In other words, the lengths of the flow paths of the first connection portions 115a, 115b through which the first fluid passes are formed to be shorter than the lengths of the flow paths of the second connection portions 125a, 125b through which the second fluid having a lower boiling point than the first fluid passes. Therefore, it is possible to make the pressure loss occurred in the first fluid when passing through the first connection portions 115a, 115b smaller than the pressure loss occurred in the second fluid when passing through the second connection portions 125a, 125b. This suppresses the reduction of the pressure of the first fluid at a large rate. Therefore, in the first heat exchanger 100, it is possible to secure the heat exchange performance even in a case where two fluids have different pressures at the time of inflow.

(3-2)
The second protrusion portions 127a, 127b have a linear shape in plan view.
(3-3)
The second connection portions 125a, 125b have a linear shape in plan view.
(3-4)
The first connection portions 115a, 115b are formed such that the flow path cross sectional area increases from the first flow ports 111a, 111b toward the first heat transfer region 113.

[0128] This further reduces a pressure loss occurred in the first fluid passing through the first connection portions 115a, 115b, and thus further suppresses the reduction of the pressure of the first fluid at a large rate. Therefore, with the first heat exchanger 100, it is possible to secure the heat exchange performance more effectively.

[0129] (3-5)
The first heat exchanger 100 includes the partition wall 130. The partition wall 130 is a plate-shaped member laminated between the first heat transfer plate 110 and the second heat transfer plate 120. When in a cross section orthogonal to the flow direction of the first fluid, the length along which the first separation portion 116a, 116b separating the adjacent first connection portions 115a, 115b from each other is in contact with the partition wall 130 is La1 and the interval between the adjacent first separation portions is P1, the first connection portions 115a, 115b are formed so as to satisfy the relation:

$$0.005 < La1/P1 < 0.15$$

[0130] With the first connection portions 115a, 115b formed so as to satisfy the above-described relation, the force (pressure) that the partition wall 130 receives from the first fluid passing through the first connection portions 115a, 115b is limited, thereby suppressing the excess over the pressure resistance strength.

[0131] (3-6)
Further, the first connection portions 115a, 115b are formed so as to satisfy the relation:

$$0.005 < La1/P1 < 0.05$$

[0132] With the first connection portions 115a, 115b formed so as to satisfy the above-described relation, the force (pressure) that the partition wall 130 receives from the first fluid passing through the first connection portions 115a, 115b is limited, thereby suppressing the excess over the pressure resistance strength.

[0133] (3-7)
When in a cross section orthogonal to the flow direction of the second fluid, the length along which the second separation portion 126a, 126b or the second protrusion portion 127a, 127b separating the adjacent second connection portions 125a, 125b from each other is in contact with the partition wall 130 is La2 and the interval between the adjacent second separation portions 126a, 126b or second protrusion portions 127a, 127b is P2, the second connection portions 125a, 125b are formed so as to satisfy the relation:

$$0.005 < L2/P2 < 0.15$$

[0134] With the second connection portions 125a, 125b formed so as to satisfy the above-described relation, the force (pressure) that the partition wall 130 receives from the second fluid passing through the second connection portions 125a, 125b is limited, thereby suppressing the excess over the pressure resistance strength.

[0135] (3-8)

Further, the second connection portions 125a, 125b are formed so as to satisfy the relation:

$$0.02 < L2/P2 < 0.15$$

[0136] With the second connection portions 125a, 125b formed so as to satisfy the above-described relation, the force (pressure) that the partition wall 130 receives from the second fluid passing through the second connection portions 125a, 125b is limited, thereby suppressing the excess over the pressure resistance strength.

(4) Modification

(4-1) Modification A

[0137] The second connection portions 125a, 125b are not limited to the above-described aspect as long as they are formed so as to go around the outer side of the second through holes 122a, 122b and are partitioned by the protrusion portions.

[0138] As shown in Fig. 9, the second connection portion 125b of the first heat exchanger 100 according to Modification A is a planar region (a hatched region in Fig. 9) provided on the outer side of the second through hole 122b, and includes a plurality of second protrusion portions 128b formed in a circular shape in plan view. For example, the second protrusion portions 128b each have a radius of 1 mm in plan view and a height of 0.5 mm in the thickness direction DT, and are arranged in the longitudinal direction DL and the width direction DW at intervals of 1 mm. The second protrusion portions 128b are formed by, for example, press working or etching although not limited thereto. Although not shown, the second connection portion 125a provided on the lower side of the second heat transfer plate 120 also has the same shape, and includes a plurality of second protrusion portions 128a.

[0139] The shape of the second protrusion portions 128a, 128b is not limited to a circular shape. The shape of the second protrusion portions 128a, 128b may be any one of a triangular shape (see Fig. 10), a quadrangular shape (see Fig. 11), and a teardrop shape (see Fig. 12) in plan view. Moreover, the pluralities of second protrusion portions 128a, 128b of the second connection portion 125b may have mutually different shapes.

(4-2) Modification B

[0140] The first connection portions 115a, 115b may be formed in a curved shape.

[0141] The first connection portion 115a of the first heat exchanger 100 according to Modification B is formed in a curved shape, as shown in Fig. 13. Although not shown, the first connection portion 115b provided on the lower side of the first heat transfer plate 110 also has the same shape.

(4-3) Modification C

[0142] In the above-described embodiment, R1234ze is exemplified as the first fluid, and carbon dioxide is exemplified as the second fluid, but the invention is not limited thereto. As the first fluid, there may be used, for example, R32, an HFO-based refrigerant, a mixed refrigerant of R32 and an HFO-based first fluid, carbon dioxide, ammonia, propane, or the like. The second fluid only needs to be a fluid having a lower boiling point than the first fluid, and there may be used, for example, R-32, an HFO-based refrigerant, a mixed refrigerant of HFC-32 and an HFO-based refrigerant, a refrigerant of carbon dioxide, ammonia, propane, or the like, water, antifreeze, or the like.

(4-4) Modification D

[0143] In the above-described embodiment, the first heat exchanger 100 is formed such that the first fluid flowing through the first flow path 220 and the second fluid flowing through the second flow path 230 form counter flows. However, the first heat exchanger 100 may be formed such that the first fluid flowing through the first flow path 220 and the second fluid flowing through the second flow path 230 form parallel flows.

(4-5) Modification E

[0144] In the above-described embodiment, all of the first flow pipe 141a, the first flow pipe 141b, the second flow pipe 142a, and the second flow pipe 142b are formed in the first frame 140. However, at least a part of the first flow pipe 141a, the first flow pipe 141b, the second flow pipe 142a, and the second flow pipe 142b may be formed in the second frame 150.

(4-6) Modification F

[0145] The first connection portion 115a, 115b is not limited to the above-described aspect as long as one end is connected to the first flow port 111a, and the other end is connected to the first heat transfer region 113. The first connection portion 115a may further include a first protrusion portion 117a. In addition, the first connection portion 115b may further include a first protrusion portion 117b.

[0146] As shown in Fig. 14, the first protrusion portion 117a defines the first connection portion 115a and limits the force (pressure) that the partition wall 130 receives from the first fluid. The first protrusion portion 117a is formed in a linear shape projecting with a predetermined length from the first heat transfer region 113 toward the first connection portion 115a in plan view. Although not shown, the first connection portion 115b provided on the lower side of the first heat transfer plate 110 also has the same shape, and includes a plurality of first protrusion portions 117b.

(4-7) Modification G

[0147] As shown in Fig. 15, the first connection portion 115a of the first heat exchanger 100 according to Modification G is a planar region provided on the outer side of the first flow port 111a, and includes a plurality of first protrusion portions 117a formed in a circular shape in plan view.

[0148] In the first heat exchanger 100 according to Modification G, the first heat transfer plate 110 includes a clearance 119a, which is a band-like region where the first connection portion 115a is not provided over a predetermined width, between the upper end portion and the first connection portion 115a in plan view. With the clearance 119a, it is possible to suppress a case where the length of the flow path of the first connection portion 115a through which the first fluid passes is longer than that of the second connection portion 125a through which the second fluid passes.

[0149] For example, the first protrusion portions 117a each has a radius of 1 mm in plan view and a height of 0.5 mm in the thickness direction DT, and are arranged in the longitudinal direction DL and the width direction DW at intervals of 1 mm. The first protrusion portions 117a are formed by, for example, press working or etching although not limited thereto. Although not shown, the first connection portion 115b provided on the lower side of the first heat transfer plate 110 also has the same shape, and includes a plurality of first protrusion portions 117b.

[0150] The shape of the first protrusion portions 117a, 117b is not limited to a circular shape. The shape of the first protrusion portions 117a, 117b may be any one of a triangular shape, a quadrangular shape, and a teardrop shape, which are shown in Fig. 10 to Fig. 13 as the examples of the second protrusion portions 128b, in plan view. Moreover, the pluralities of first protrusion portions 117a, 117b of the first connection portions 115a, 115b may have mutually different shapes.

[0151] The shape of the planar first connection portion 115a may be trapezoid with the width expanding from the first flow port 111a toward the first heat transfer region 113, as shown in Fig. 16. Although not shown, the first connection portion 115b provided on the lower side of the first heat transfer plate 110 is formed in the same manner.

<Second embodiment>

(1) Water heater 2

[0152] The water heater 2 including the first heat exchanger 100 according to a second embodiment of the present disclosure will be described with reference to Fig. 12. The water heater 2 heats water supplied from the outside. Note that in the following description, the same or corresponding characteristics as those of the first embodiment are denoted by the same reference numerals, and the description thereof will be omitted.

[0153] The water heater 2 includes the first heat exchanger 100, a water circuit 50, a heat source side circuit 60, and a hot water supply tank 70. The water circuit 50 is a circuit for circulating water. The heat source side circuit 60 is a circuit for circulating carbon dioxide, which is a fluid having a lower boiling point than water. The heat exchange between water and carbon dioxide is performed in the first heat exchanger 100. In the present embodiment, the water circuit 50 is installed indoors, and the heat source side circuit 60 is installed outdoors.

[0154] Water is an example of the first fluid. Carbon dioxide is an example of the second fluid. The water circuit 50 is an example of the first fluid circuit. The heat source side circuit 60 is an example of the second fluid circuit.

(1-1) Water circuit 50

[0155] The water circuit 50 includes a water circulation pump 51, a use side heat exchanger 52, and the first flow path 220 of the first heat exchanger 100.

[0156] The water circulation pump 51 circulates water inside the water circuit 50. The water circulation pump 51 sucks water inside the water circuit 50 from a suction portion 51a and discharges the water from a discharge portion 51b.

[0157] The suction portion 51a is connected to the first flow pipe 141b of the first heat exchanger 100.

[0158] The use side heat exchanger 52 causes heat exchange between water circulating in the water circuit 50 and water stored in the hot water supply tank 70. The use side heat exchanger 52 is disposed inside the hot water supply tank 70 so as to enable the heat exchange between the water passing in the use side heat exchanger 52 and the water stored in the hot water supply tank 70.

[0159] One end of the use side heat exchanger 52 is connected to the discharge portion 51b of the water circulation pump 51. The other end of the use side heat exchanger 52 is connected to the first flow pipe 141a of the first heat exchanger 100.

(1-2) Heat source side circuit 60

[0160] The heat source side circuit 60 includes a heat source side compressor 61, a heat source side expansion valve 62, a heat source side heat exchanger 63, and the second flow path 230 of the first heat exchanger 100.

[0161] The heat source side compressor 61 sucks the low-pressure gas-phase carbon dioxide in the heat source side circuit 60 from a suction portion 61a, compresses it, and discharges it as the high-pressure gas-phase carbon dioxide from a discharge portion 61b.

[0162] The discharge portion 61b is connected to the second flow pipe 142a of the first heat exchanger 100.

[0163] The heat source side expansion valve 62 functions as a decompression apparatus that adjusts a flow rate of the carbon dioxide circulating through the heat source side circuit 60 and reduces the pressure of the carbon dioxide.

[0164] One end of the heat source side expansion valve 62 is connected to the second flow pipe 142b of the first heat exchanger 100. The other end of the heat source side expansion valve 62 is connected to one end of the heat source side heat exchanger 63.

[0165] The heat source side heat exchanger 63 functions as an evaporator, and causes heat exchange between carbon dioxide and a heat source (for example, outside air).

[0166] The other end of the heat source side heat exchanger 63 is connected to the suction portion 61a of the heat source side compressor 61.

(1-3) Hot water supply tank 70

[0167] The hot water supply tank 70 stores water supplied from the outside. The stored water exchanges heat with the water passing through the use side heat exchanger 42. The hot water supply tank 70 takes in water supplied from the outside from a water inlet part 70b and stores it. The stored water is discharged from a water outlet part 70a.

(1-4) Operation

[0168] The operation of each part during the operation of the water heater 2 will be described. When the water heater 2 starts operation, a control unit (not shown) drives the water circulation pump 51 and the heat source side compressor 61, and sets the opening degree of the heat source side expansion valve 62 to an appropriate opening degree corresponding to a target temperature of the water discharged from the hot water supply tank 70.

(1-4-1) Operation of water circuit 30

[0169] When the water circulation pump 51 is driven, the water sucked from the suction portion 51a is discharged from the discharge portion 51b. The discharged water exchanges heat with the water stored in the hot water supply tank 70 in the use side heat exchanger 52. The water subjected to heat exchange and circulating in the water circuit 30 passes through the first flow pipe 141a of the first heat exchanger 100 and flows into the first flow path 220. The water passing through the first flow path 220 absorbs heat from the carbon dioxide passing through the second flow path 230 (in other words, is heated by the carbon dioxide). The water having absorbed heat and circulating in the liquid water circuit 30 passes through the first flow pipe 141b and flows out of the first flow path 220. The water circulation pump 51 sucks the water having flowed out of the first flow path 220 from the suction portion 51a and discharges it from the discharge portion 51b.

(1-4-2) Operation of heat source side circuit 60

[0170] The heat source side compressor 61 sucks the low-pressure gas-phase carbon dioxide in the heat source side circuit 60 from the suction portion 61a, and discharges it as the high-pressure gas-phase carbon dioxide from the discharge portion 61b. The high-pressure gas-phase carbon dioxide passes through the second flow pipe 142a of the first heat exchanger 100 and flows into the second flow path 230. The first heat exchanger 100 condenses the high-pressure gas-phase carbon dioxide into high-pressure liquid-phase carbon dioxide by releasing heat. At this time, the carbon dioxide releases heat to the water passing through the first flow path 220 of the first heat exchanger 100 (in other words, heats the water). The high-pressure liquid-phase carbon dioxide passes through the second flow pipe 142b, flows out of the second flow path 230, and reaches the heat source side expansion valve 62. The heat source side expansion valve 62 with an appropriate opening degree set decompresses the high-pressure liquid-phase carbon dioxide into low-pressure gas-liquid two-phase carbon dioxide. The low-pressure gas-liquid two-phase carbon dioxide reaches the heat source side heat exchanger 63. The heat source side heat exchanger 63 evaporates low-pressure gas-liquid two-phase carbon dioxide into low-pressure gas-phase carbon dioxide. At this time, the carbon dioxide absorbs heat from the heat source (outside air). The low-pressure gas-phase carbon dioxide flows out of the heat source side heat exchanger 63 and is sucked into the heat source side compressor 61 from the suction portion 61a.

(2) Characteristics

[0171] Also in the water heater 2, the first heat exchanger 100 exerts the same effect as in the case where it is used in the refrigerant cycle apparatus 1. Specifically, it is possible to make the pressure loss occurred in water when passing through the first connection portions 115a, 115b smaller than the pressure loss occurred in carbon dioxide when passing through the second connection portions 125a, 125b. This suppresses the reduction of the pressure of water at a large rate. Therefore, in the first heat exchanger 100, it is possible to secure the heat exchange performance even in a case where two fluids have different pressures at the time of inflow.

[0172] While embodiments of the present disclosure have been described above, it will be understood that various changes in forms and details may be made therein without departing from the spirit and scope of the present disclosure as set forth in the appended claims.

REFERENCE SIGNS LIST

[0173]

1 refrigerant cycle apparatus
2 water heater
10 first fluid circuit
20 second fluid circuit
30 water circuit (refrigerant cycle apparatus)
40 control unit
50 water circuit (water heater)
60 heat source side circuit
100 first heat exchanger
110 first heat transfer plate
111a, 111b first flow port
112a, 112b first through hole
113 first heat transfer region
115a, 115b first connection portion
116a, 116b first separation portion
117a, 117b first protrusion portion
120 second heat transfer plate
121a, 121b second flow port
122a, 122b second through hole
123 second heat transfer region
125a, 125b second connection portion
126a, 126b second separation portion
127a, 127b second protrusion portion
128b second protrusion portion (circular shape)
130 partition wall
DL longitudinal direction
DT thickness direction
DW width direction

CITATION LIST

PATENT LITERATURE

[0174] PTL 1: Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2012-512382

Claims

1. A heat exchanger, comprising:

a first heat transfer plate (110); and
a second heat transfer plate (120), the first heat transfer plate (110) and the second heat transfer plate (120) being laminated on each other, wherein
the first heat transfer plate includes
two first flow ports (111a, 111b) that introduce or discharge a first fluid,
two first through holes (112a, 112b) through which a second fluid having a lower boiling point than the first fluid passes in a thickness direction ,
a first heat transfer region (113) in which the first fluid having flowed in from one of the first flow ports exchanges heat with the second fluid while passing through the first heat transfer region (113), and
a first connection portion (115a, 115b) having one end connected to one of the first flow ports and the other end connected to the first heat transfer region,
the second heat transfer plate (120) includes
a second flow port (121a, 121b) that communicates with one of the first through holes and introduces or discharges the second fluid,
two second through holes (122a, 122b) through which the first fluid passes in the thickness direction,
a second heat transfer region (123) in which the second fluid having flowed in from the second flow port exchanges heat with the first fluid while passing through the second heat transfer region (123), and
a second connection portion (125a, 125b) having one end connected to the second flow port and the other end connected to the second heat transfer region,
the second flow port
is formed at a position opposite to the second heat transfer region with one of the second through holes interposed, and
the second connection portion
is formed so as to go around an outer side of the second through hole, and
includes a second protrusion portion (127a, 127b, 128a, 128b).

2. The heat exchanger according to claim 1, wherein the second protrusion portion has a linear shape in plan view.

3. The heat exchanger according to claim 1 or 2, wherein
the second connection portion has a linear shape in plan view.

4. The heat exchanger according to claim 1, wherein the second protrusion portion has a circular shape (128b) in plan view.

5. The heat exchanger according to claim 1, wherein the second protrusion portion has a triangular shape in plan view.

6. The heat exchanger according to claim 1, wherein the second protrusion portion has a quadrangular shape in plan view.

7. The heat exchanger according to claim 1, wherein the second protrusion portion has a teardrop shape in plan view.

8. The heat exchanger according to claim 1, wherein the first connection portion is formed such that a flow path cross sectional area increases from the first flow port toward the first heat transfer region.

9. The heat exchanger according to claim 8, wherein

the first connection portion includes a first protrusion portion (117a, 117b), and
the first protrusion portion has a linear shape in plan view.

10. The heat exchanger according to claim 8, wherein

the first connection portion includes a first protrusion portion, and
the first protrusion portion has a circular shape in plan view.

11. The heat exchanger according to claim 8, wherein

the first connection portion includes a first protrusion portion, and
the first protrusion portion has a triangular shape in plan view.

12. The heat exchanger according to claim 8, wherein

the first connection portion includes a first protrusion portion, and
the first protrusion portion has a quadrangular shape in plan view.

13. The heat exchanger according to claim 8, wherein

the first connection portion includes a first protrusion portion, and
the first protrusion portion has a teardrop shape in plan view.

14. The heat exchanger according to any one of claims 1 to 13 comprising:

a partition wall (130) that is a plate-shaped member laminated between the first heat transfer plate and the second heat transfer plate, wherein
when in a cross section orthogonal to a flow direction of the first fluid,
a length along which a first separation portion (116a, 116b) separating adjacent first connection portions from each other is in contact with the partition wall is La1, and
an interval between adjacent first separation portions is P1,
the first connection portion is formed so as to satisfy a relation:

$$0.005 < La1/P1 < 0.15.$$

15. The heat exchanger according to claim 14, wherein the first connection portion is formed so as to satisfy a relation:

$$0.005 < La1/P1 < 0.05.$$

16. The heat exchanger according to any one of claims 1 to 15 comprising:

a partition wall that is a plate-shaped member laminated between the first heat transfer plate and the second heat transfer plate, wherein
when in a cross section orthogonal to a flow direction of the second fluid,
a length along which a second separation portion (126a, 126b) or the second protrusion portion separating adjacent second connection portions from each other is in contact with the partition wall is La2, and
an interval between adjacent second separation portions or second protrusion portions is P2,
the second connection portion is formed so as to satisfy a relation:

$$0.005 < L2/P2 < 0.15.$$

17. The heat exchanger according to claim 16, wherein the second connection portions are formed so as to satisfy a relation:

$$0.02 < L2/P2 < 0.15.$$

18. A refrigerant cycle apparatus, comprising:

the heat exchanger according to any one of claims 1 to 17;
a first fluid circuit (10) in which the first fluid circulates; and
a second fluid circuit (20) in which the second fluid circulates.

19. A water heater, comprising:

the heat exchanger according to any one of claims 1 to 17;
a first fluid circuit (50) in which the first fluid circulates; and
a second fluid circuit (60) in which the second fluid circulates.

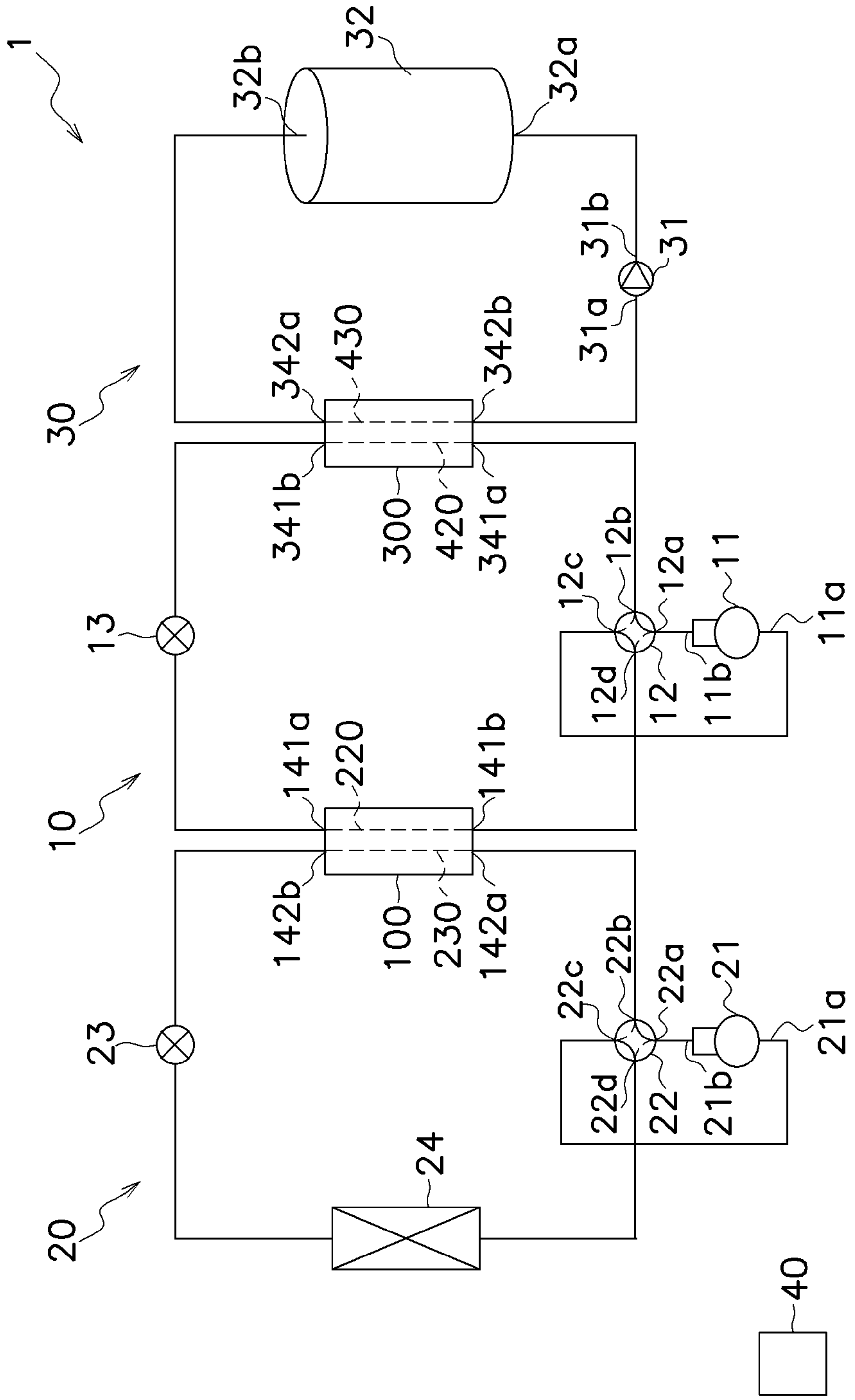
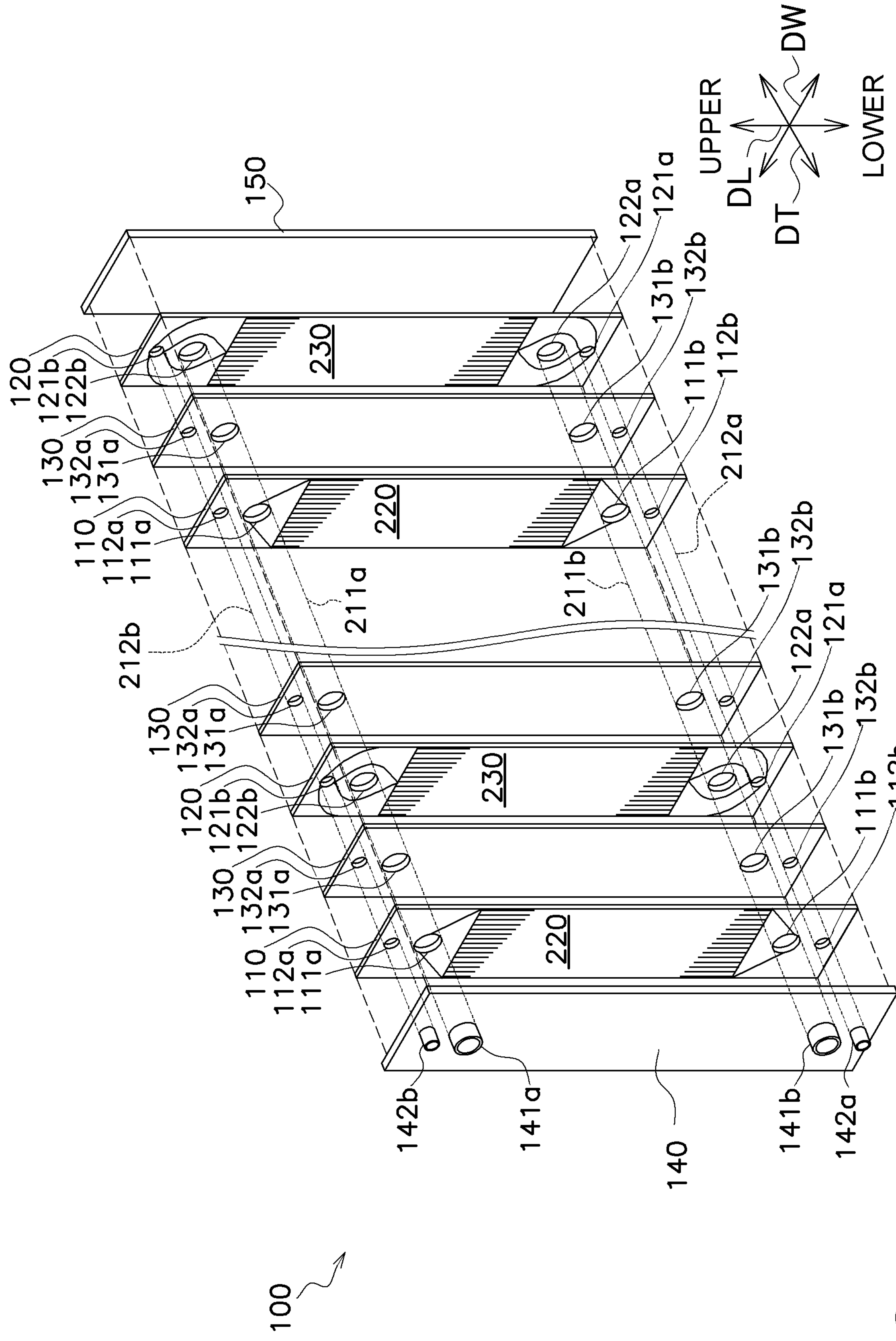

1
32
32b
32a
31b
31
31a
30
342a
430
342b
341b
300
420
341a
13
12c
12b
12a
11
11a
12d
12
11b
10
141a
220
141b
142b
100
230
142a
23
22c
22b
22a
21
21a
22d
22
21b
20
24
40

FIG. 1



150
120
121b
122b
230
122a
121a
131b
132b
130
132a
131a
110
112a
111a
220
111b
112b
212a
211a
211b
212b
131b
132b
122a
121a
130
132a
131a
120
121b
122b
230
131b
132b
130
132a
131a
110
112a
111a
220
111b
112b
142b
141a
140
141b
142a
100
UPPER
LOWER
DW
DL
DT

FIG. 2

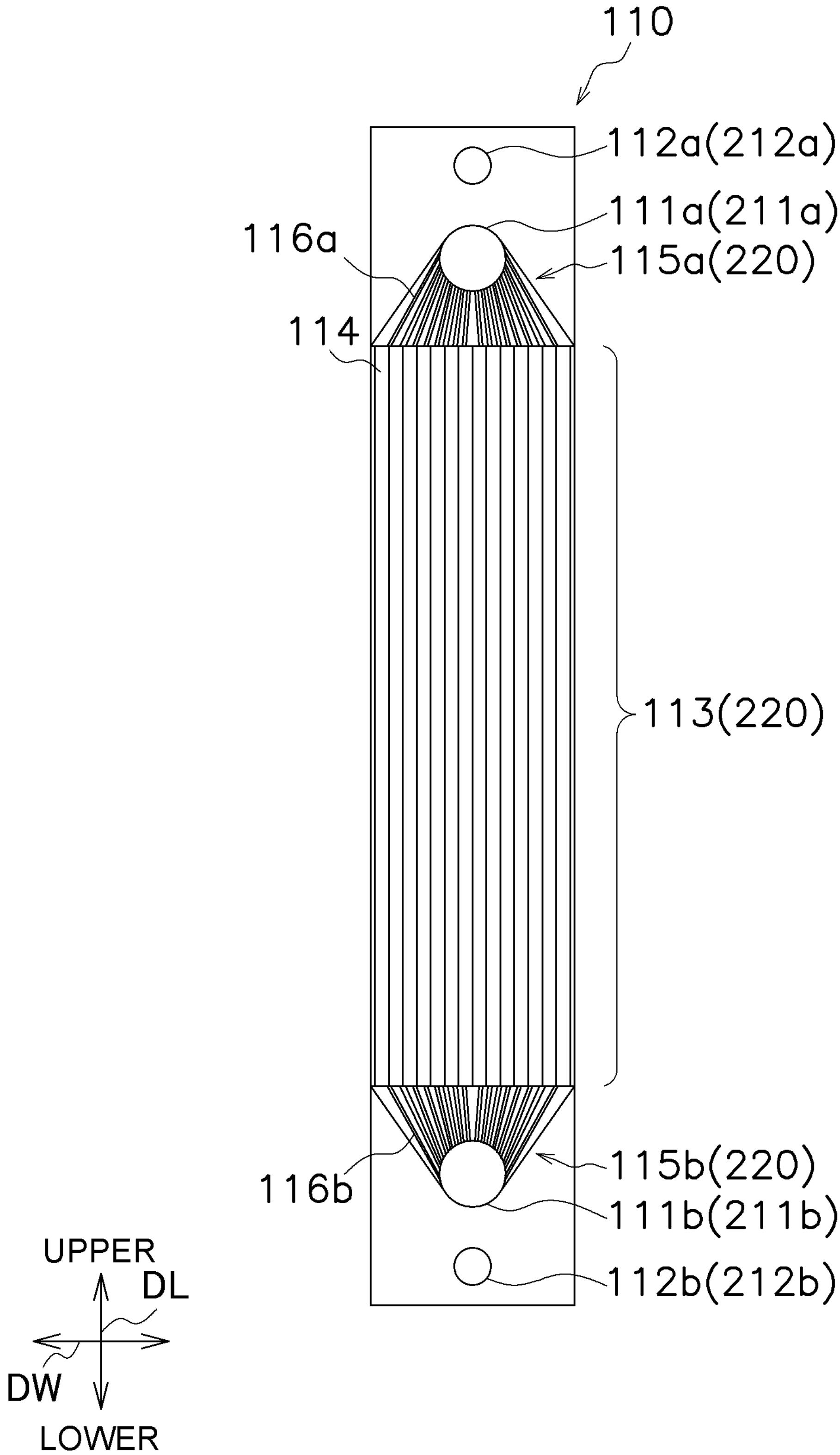

110
112a(212a)
111a(211a)
116a
115a(220)
114
113(220)
115b(220)
116b
111b(211b)
112b(212b)
UPPER
DL
DW
LOWER

FIG. 3

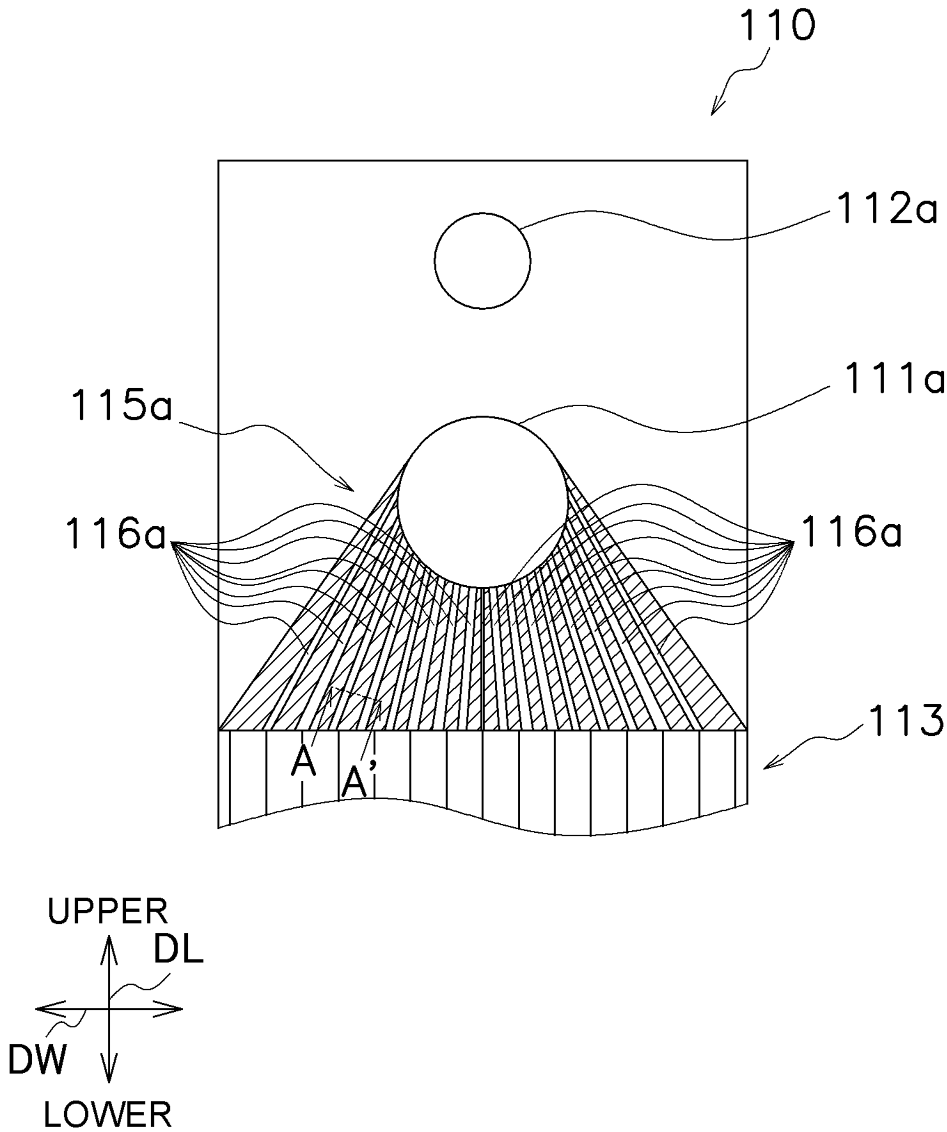


FIG. 4

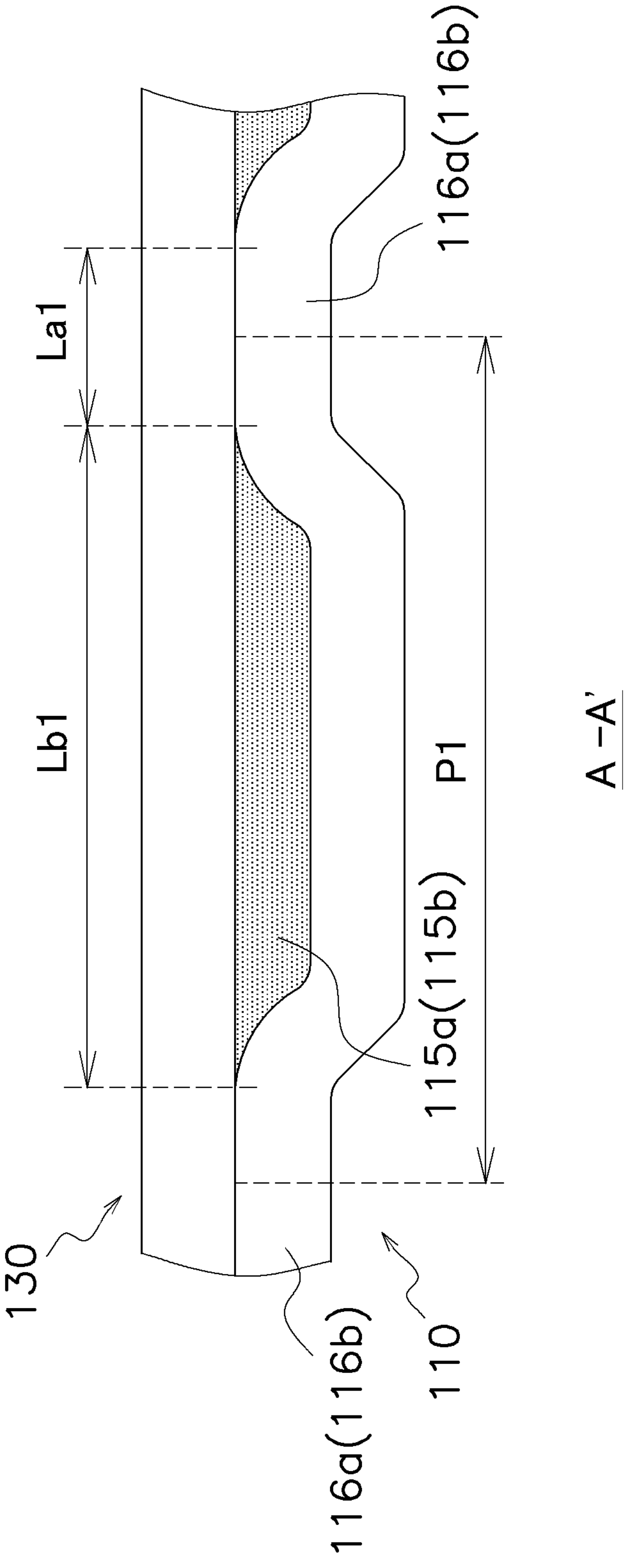


FIG. 5

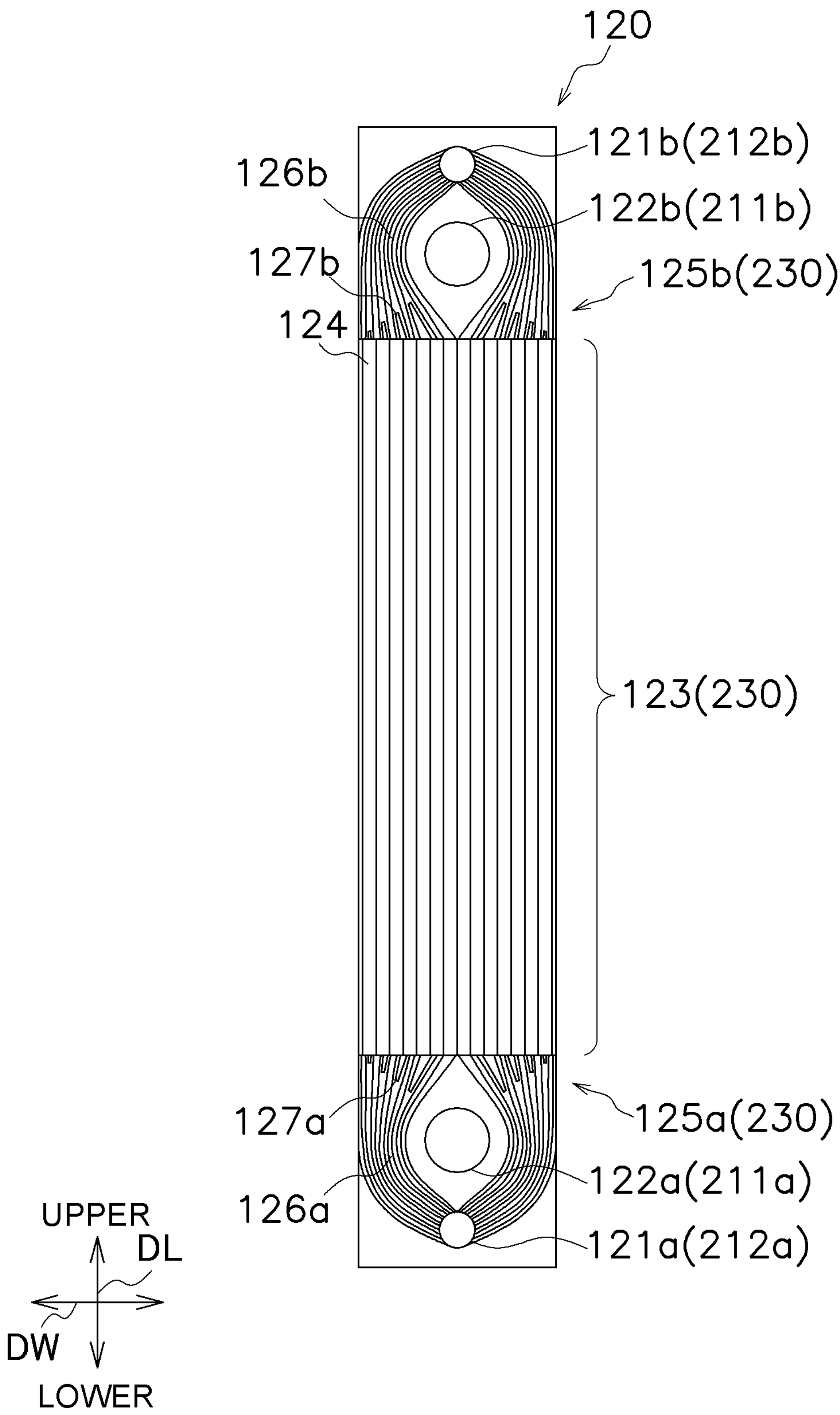

120
121b(212b)
126b
122b(211b)
127b
125b(230)
124
123(230)
127a
125a(230)
122a(211a)
126a
121a(212a)
UPPER
DL
DW
LOWER

FIG. 6

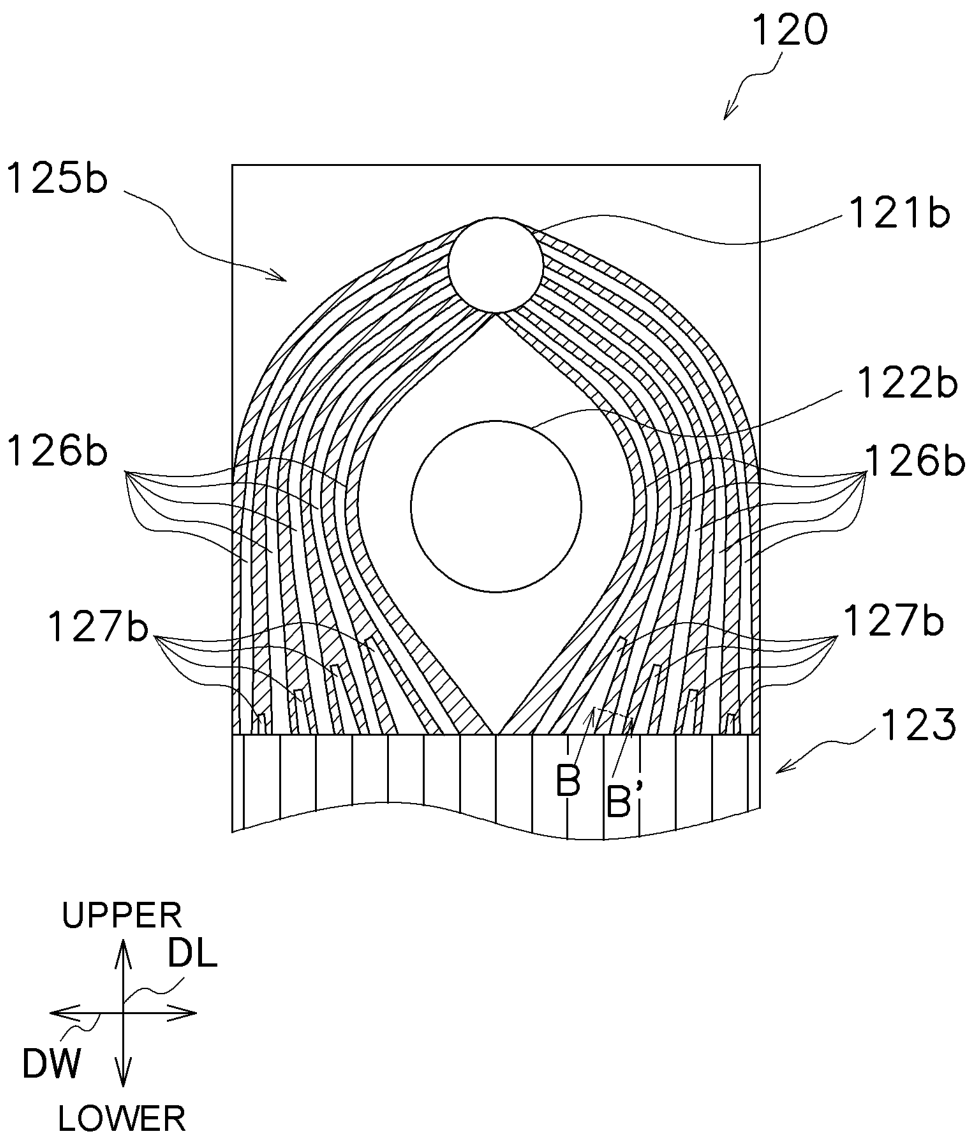
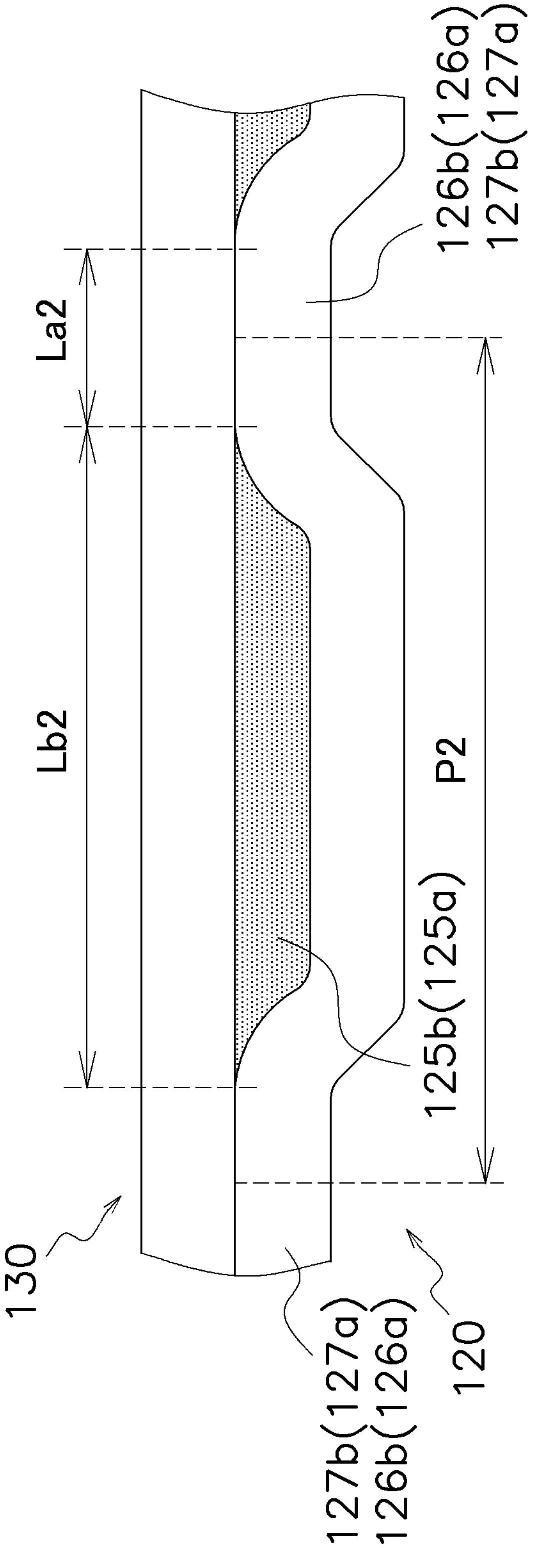

120
125b
121b
122b
126b
126b
127b
127b
123
B
B'
UPPER
DL
DW
LOWER

FIG. 7


126b(126a)
127b(127a)
La2
Lb2
P2
125b(125a)
130
127b(127a)
126b(126a)
120

B-B'

FIG. 8

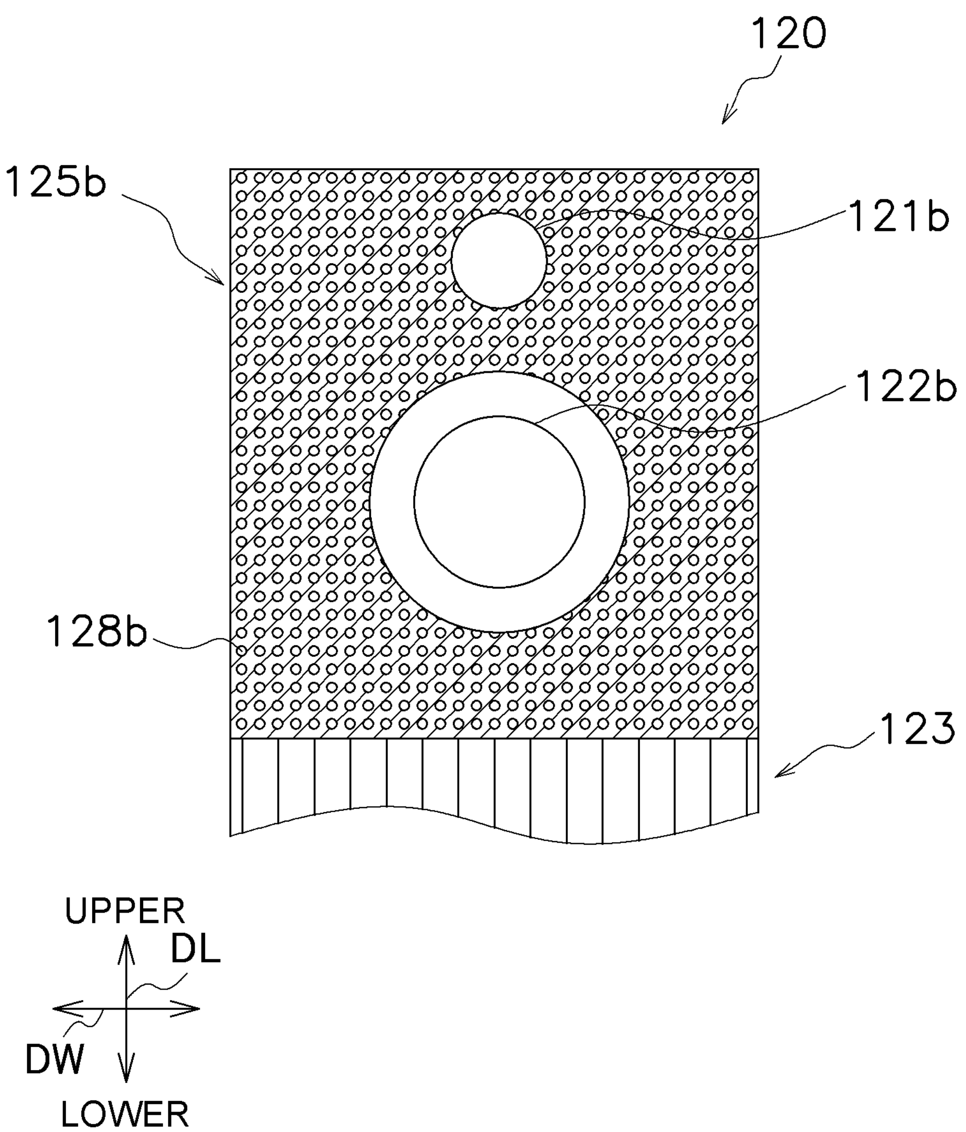


FIG. 9

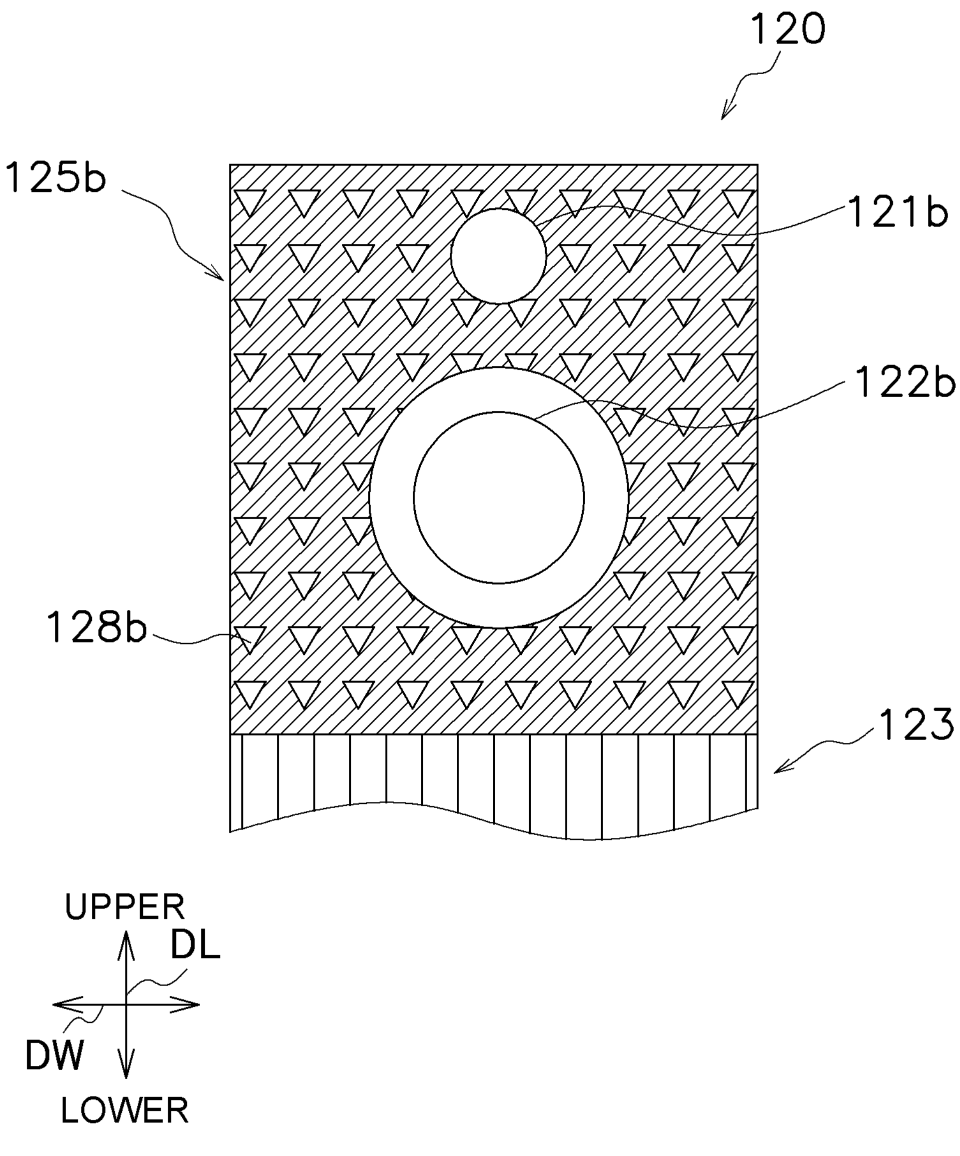


FIG. 10

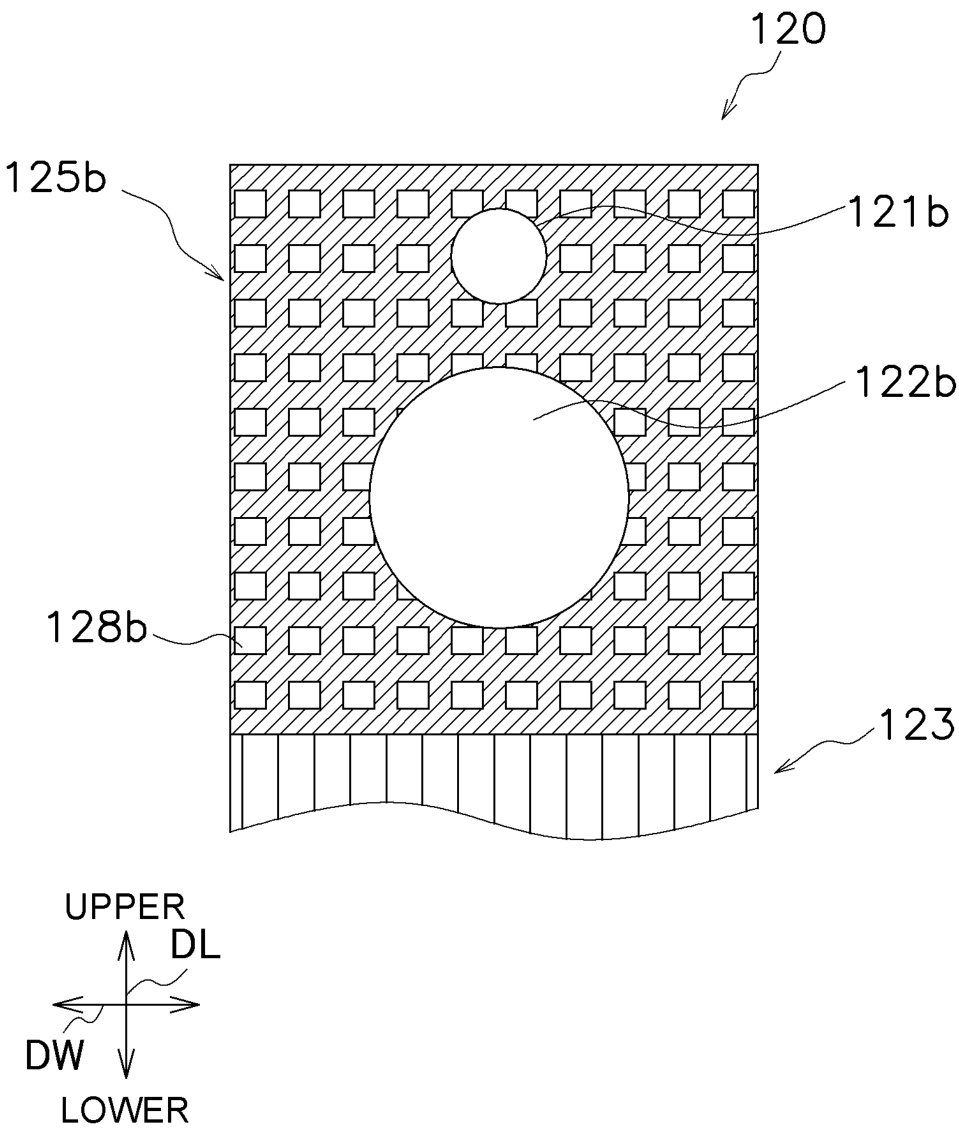


FIG. 11

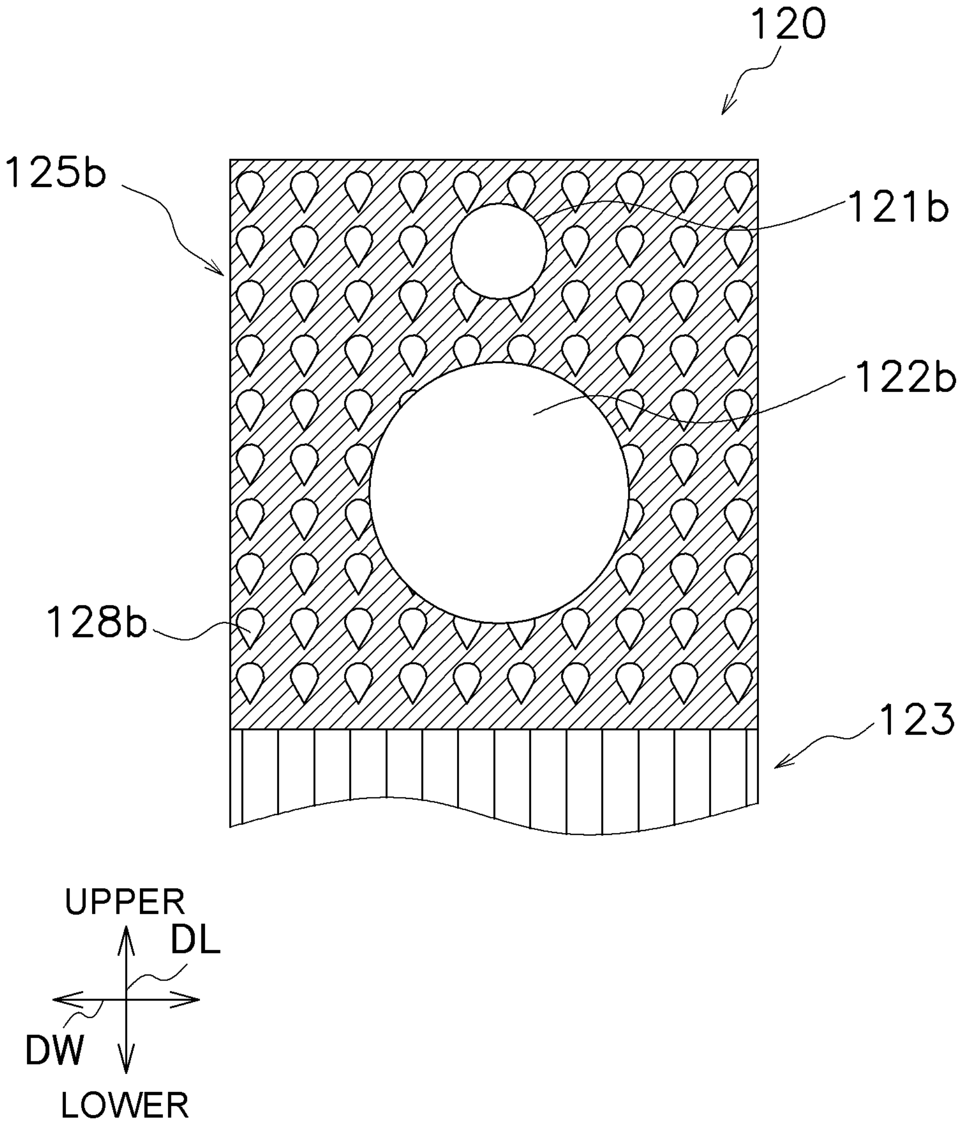


FIG. 12

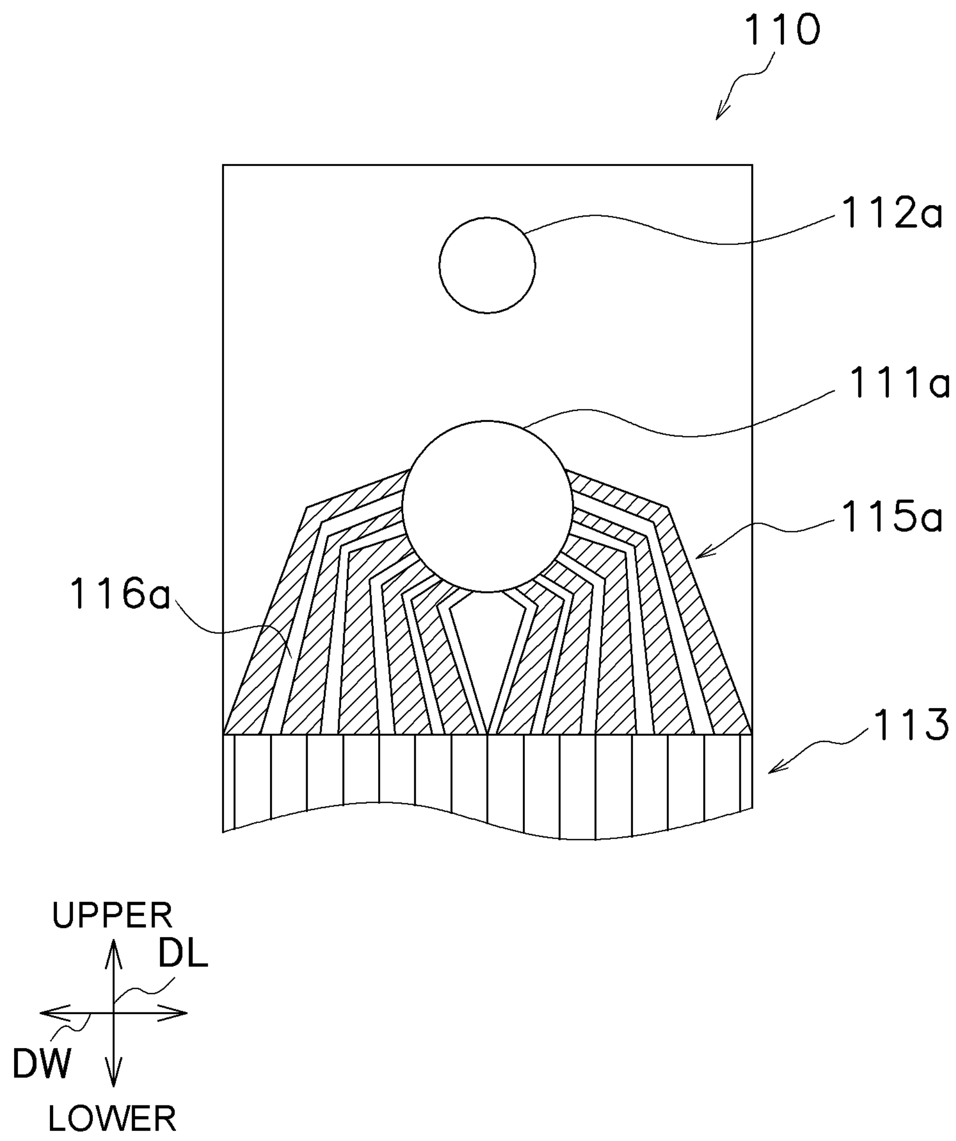


FIG. 13

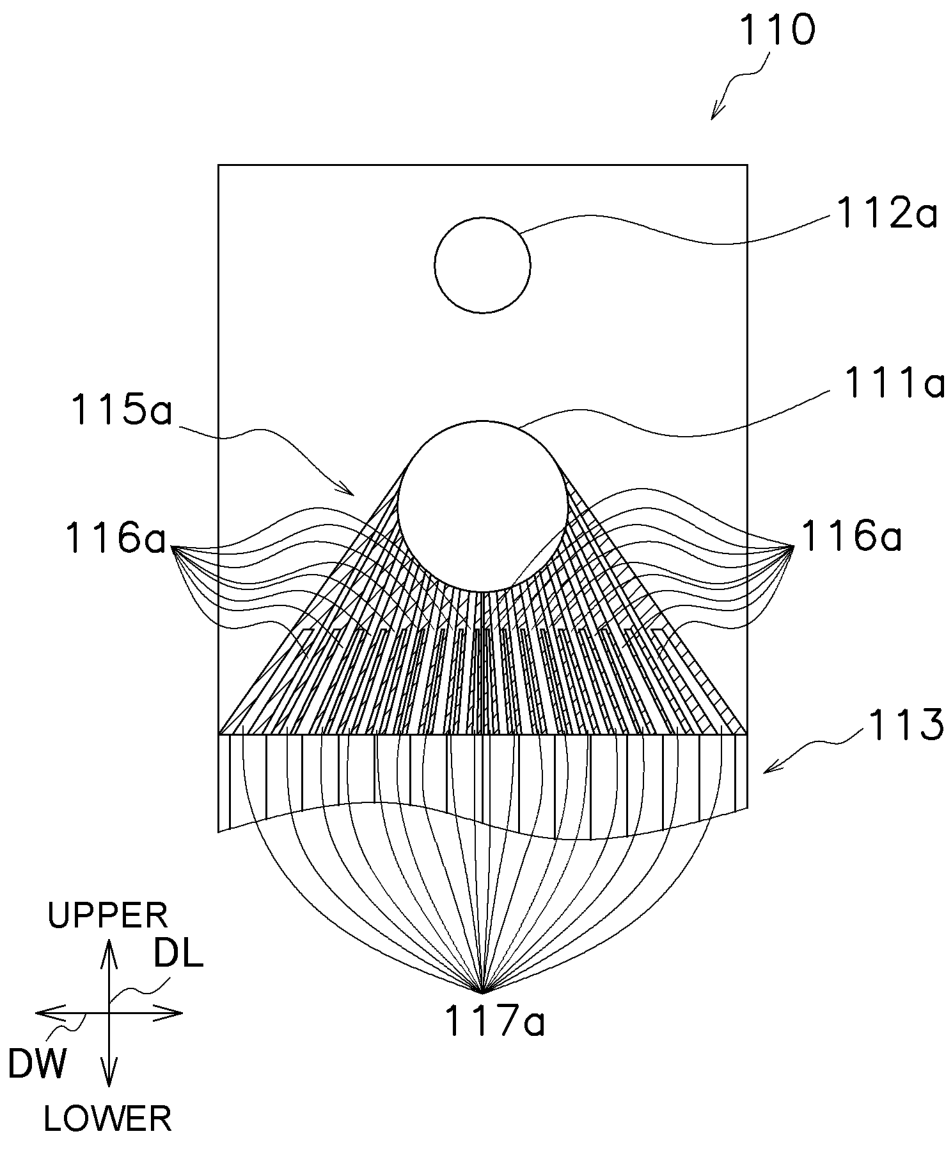


FIG. 14

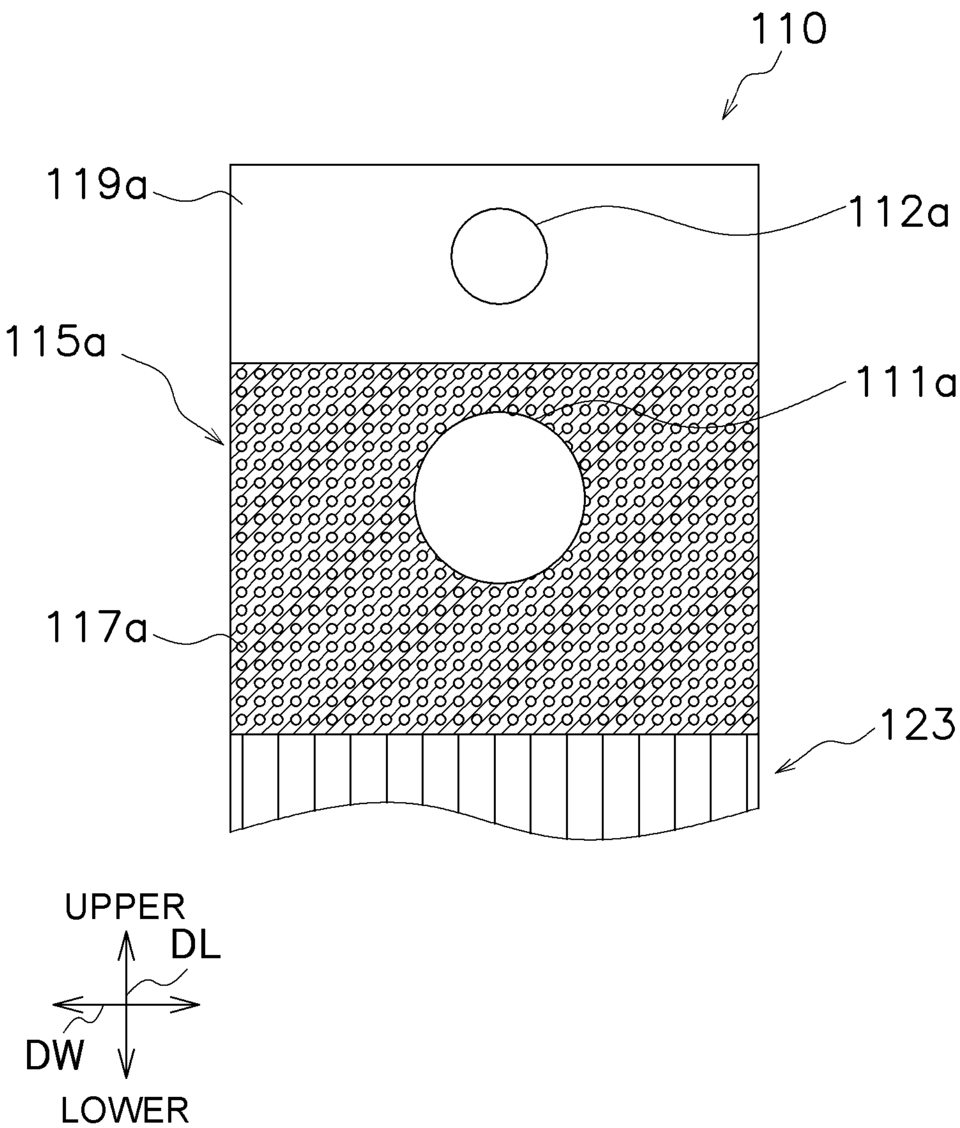


FIG. 15

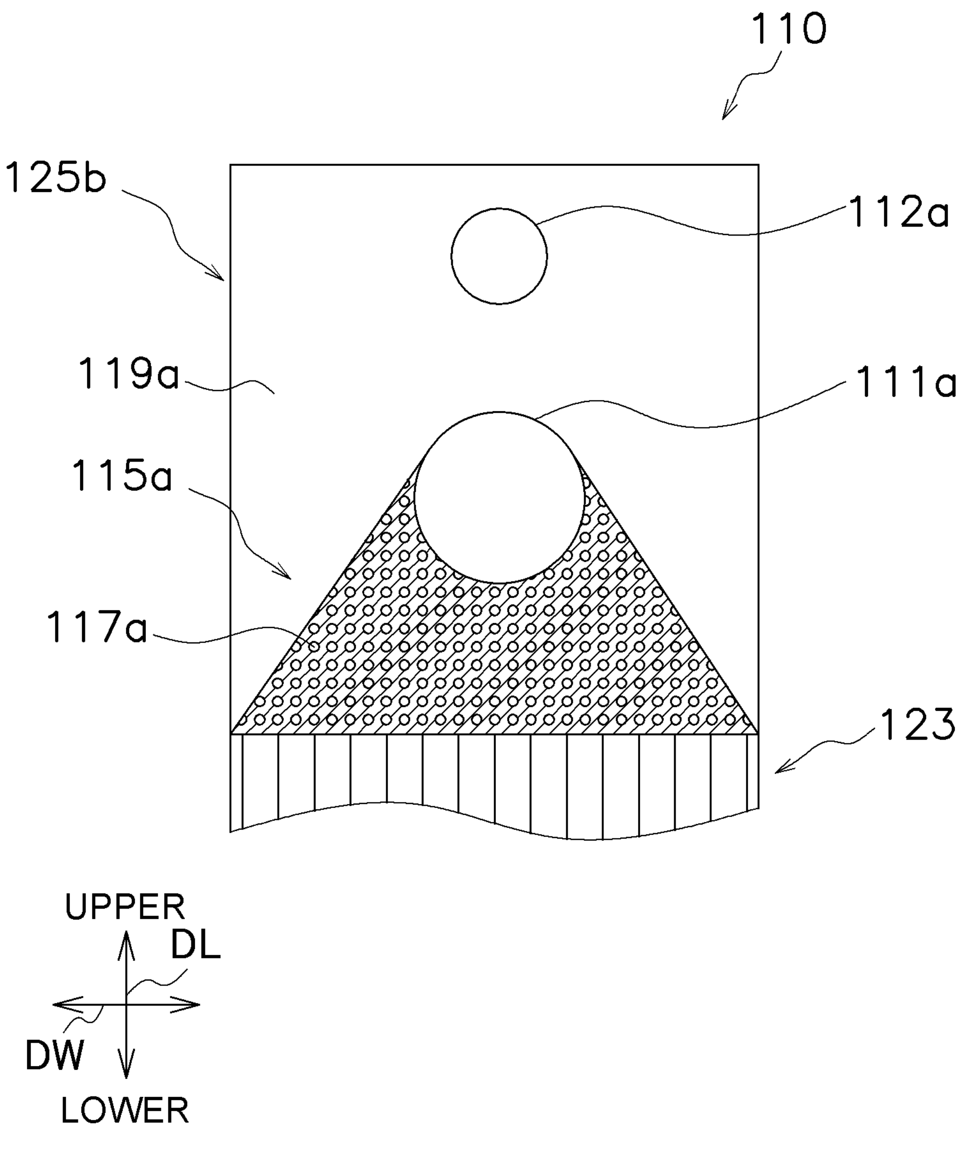


FIG. 16

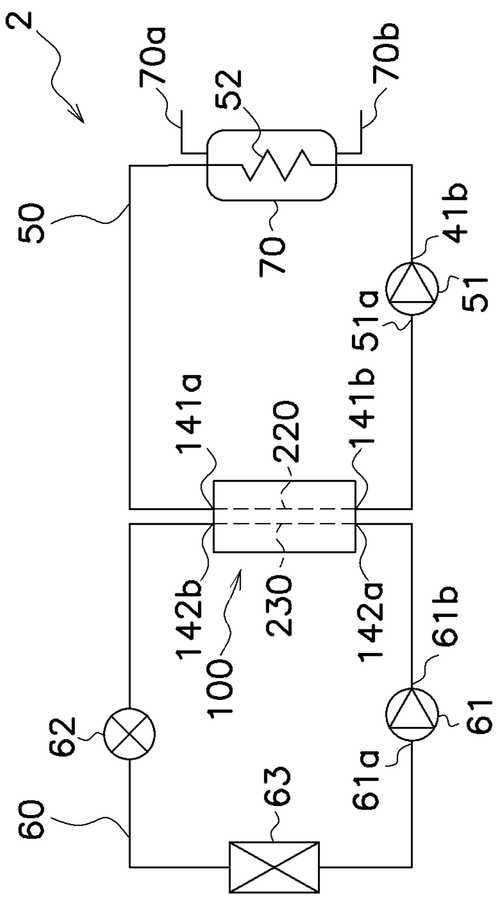

2
70a
52
70b
50
70
41b
51
51a
141a
220
141b
142b
230
142a
100
62
61b
61
61a
63
60

FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/025800

A. CLASSIFICATION OF SUBJECT MATTER

F25B 39/00(2006.01)i; ***F28D 9/02***(2006.01)i; ***F28F 3/04***(2006.01)i; ***F28F 9/02***(2006.01)i; ***F24H 9/00***(2022.01)i
FI: F28F9/02 301J; F28F3/04 B; F28D9/02; F25B39/00 G; F24H9/00 A

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)

F25B39/00; F28D9/02; F28F3/04; F28F9/02; F24H9/00

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.
Y A	JP 10-339590 A (DAIKIN INDUSTRIES, LTD.) 22 December 1998 (1998-12-22) paragraphs [0027]-[0075], fig. 1-8	1-13, 18-19 14-17
Y	JP 9-280764 A (HITACHI LTD., HITACHI TSUCHIURA ENGINEERING CO., LTD.) 31 October 1997 (1997-10-31) paragraph [0014], fig. 1	1-13, 18-19
Y	JP 2004-504584 A (ROBERT BOSCH GMBH) 12 February 2004 (2004-02-12) paragraphs [0039]-[0042], fig. 4	1-13, 18-19
Y	WO 2017/138322 A1 (MITSUBISHI ELECTRIC CORP.) 17 August 2017 (2017-08-17) paragraphs [0012]-[0043], [0087]-[0107], fig. 1, 2, 11-14	1-13, 18-19
Y	WO 2021/157514 A1 (HISAKA WORKS LTD.) 12 August 2021 (2021-08-12) paragraphs [0033]-[0048], [0072]-[0075], fig. 1-6	1-13, 18-19

☐ 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	Date of mailing of the international search report
06 September 2023	**19 September 2023**

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Information on patent family members

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