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(54) HEAT EXCHANGER AND REFRIGERANT CYCLE DEVICE

(57) In a heat exchanger (100), a refrigerant flows in a longitudinal direction (DL) between a second flow hole (120b) on an upper side and a second flow hole (120b) on a lower side. The heat exchanger (100) includes a first heat transfer plate (110) and a second heat transfer plate (120) forming N flow path regions (F1 to F5) arranged adjacent to each other along the longitudinal direction (DL). A first flow path region (F1) and an N-th flow path region (F5) are different from each other in number and cross-sectional area of the flow paths. The first flow path region (F1) is one of the N flow path regions located to be closest to the second flow hole (120b) on the upper side in the longitudinal direction (DL). The N-th flow path region (F5) is one of the N flow path regions located to be N-th closest to the second flow hole (120b) on the upper side in the longitudinal direction (DL).

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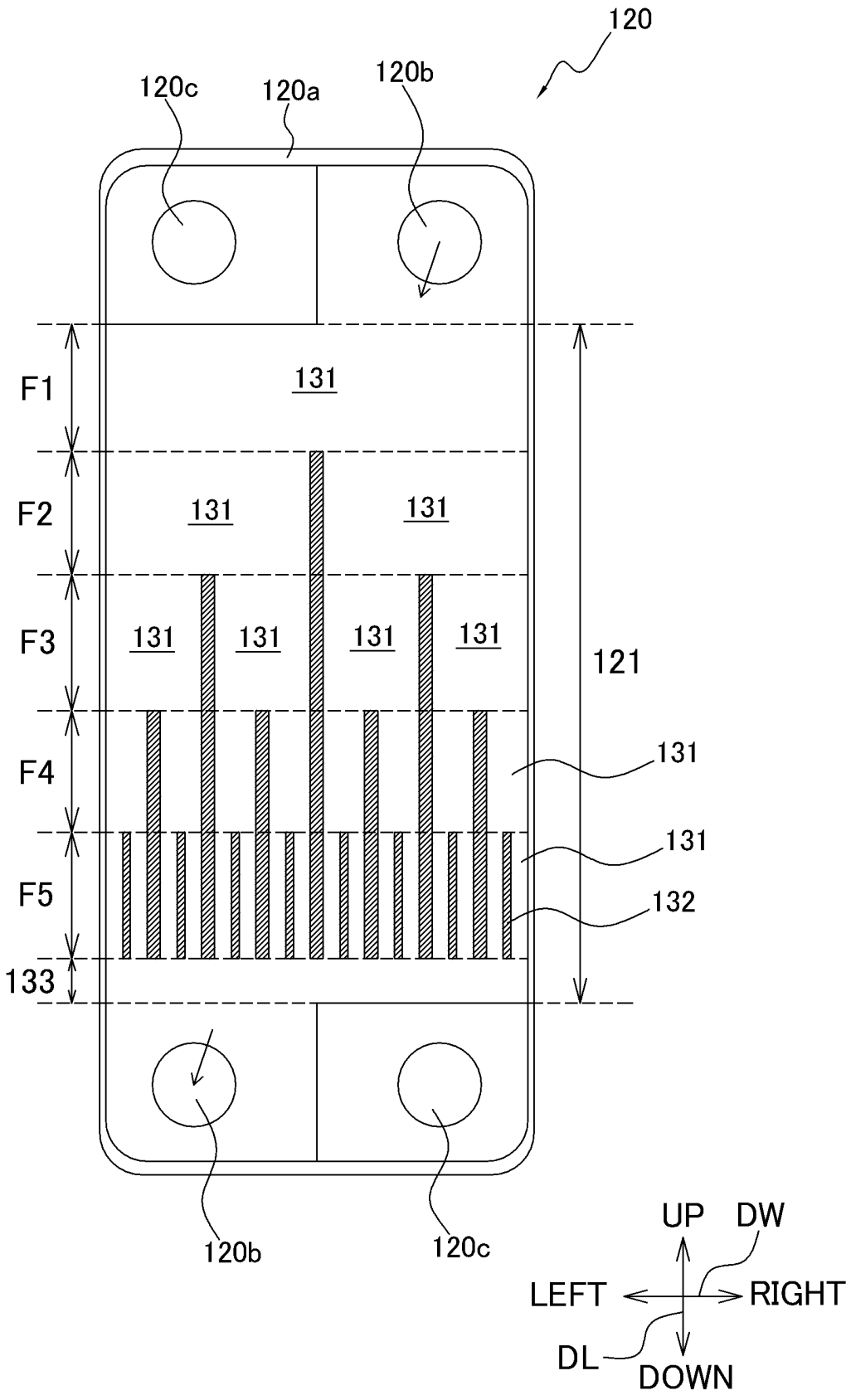

120
120c
120a
120b
F1
131
F2
131
131
F3
131
131
131
131
121
F4
131
F5
131
132
133
120b
120c
UP
DW
LEFT
RIGHT
DL
DOWN

FIG. 6

Description

Technical Field

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

Background Art

[0002] Conventionally, a heat exchanger has been used that includes a heat transfer member in which a plurality of heat exchange flow paths for exchanging heat with a fluid and branch flow paths for distributing the fluid to the heat exchange flow paths are formed.

Summary of Invention

Technical Problem

[0003] PTL 1 (Japanese Unexamined Patent Application Publication No. 2016-90157) discloses a plate fin type heat exchanger including a metal plate in which a plurality of heat exchange flow paths and a pair of branch flow paths connected to both ends of the heat exchange flow paths are formed. In such a conventional heat exchanger, the fluid introduced into the heat exchanger is divided into all the heat exchange flow paths by the branch flow paths in the vicinity of the inlet of the heat exchanger, and is merged by the branch flow paths in the vicinity of the outlet of the heat exchanger. Therefore, in many cases, the number and the cross-sectional area of the heat exchange flow paths are constant from the vicinity of the inlet to the vicinity of the outlet of the heat exchanger. In this case, the performance of the heat exchanger may deteriorate due to a large pressure loss in the heat exchange flow paths in the vicinity of the inlet through which the gaseous fluid flows. In addition, the heat transfer efficiency may deteriorate due to a low flow velocity of the fluid in the heat exchange flow path in the vicinity of the outlet through which the liquid fluid flows.

Solution to Problem

[0004] A heat exchanger of a first aspect is a heat exchanger in which a fluid flows in a first direction between a first opening and a second opening. The heat exchanger includes a member forming N flow path regions arranged adjacent to each other along the first direction between the first opening and the second opening, N being an integer of 2 or more. Each of the N flow path regions includes a flow path through which the fluid flows. A first flow path region and an N-th flow path region are different from each other in number and cross-sectional area of the flow paths. The first flow path region is one of the N flow path regions located to be closest to the first opening in the first direction. The N-th flow path region is one of the N flow path regions located to be N-th closest to the first opening in the first direction.

[0005] In the heat exchanger of the first aspect, the flow path through which the fluid flows is formed such that a suitable flow velocity of the fluid flowing inside the heat exchanger is achieved in accordance with the phase change (density change) of the fluid. Therefore, deterioration in the performance of the heat exchanger due to a large pressure loss in the flow path in the vicinity of the inlet through which the gaseous fluid flows is suppressed. Furthermore, deterioration in the heat transfer efficiency due to a low flow velocity of the fluid in the flow path in the vicinity of the outlet through which the liquid fluid flows is suppressed.

[0006] A heat exchanger of a second aspect is the heat exchanger of the first aspect, wherein the number of the flow paths in an i-th flow path region is smaller than the number of the flow paths in a j-th flow path region, and the cross-sectional area of the flow paths in the i-th flow path region is larger than the cross-sectional area of the flow path in the j-th flow path region. The i-th flow path region is one of the N flow path regions located to be i-th closest to the first opening in the first direction. The j-th flow path region is one of the N flow path regions located to be j-th closest to the first opening in the first direction, and i and j are integers satisfying $1 \leq i < j \leq N$.

[0007] In the heat exchanger of the second aspect, since the flow path cross-sectional area gradually decreases from the gas side (inlet side) toward the liquid side (outlet side), the pressure loss on the gas side is reduced, and the flow velocity of the fluid on the liquid side is ensured. In addition, since the number of flow paths gradually increases from the gas side toward the liquid side, even when the flow path cross-sectional area decreases from the gas side toward the liquid side, a decrease in the heat transfer area of the fluid is suppressed.

[0008] A heat exchanger of a third aspect is the heat exchanger of the first aspect or the second aspect, wherein the number of the flow paths in the first flow path region is one.

[0009] A heat exchanger of a fourth aspect is the heat exchanger of the third aspect, wherein a distance L1 and a distance L0 satisfy a relational expression $0.2 \times L0 \leq L1 \leq 0.8 \times L0$. The distance L1 is a distance in the first direction between the first opening and a boundary between a second flow path region and the first flow path region. The distance L0 is a distance in the first direction between the first opening and the second opening. The second flow path region is one of the N flow path regions located to be second closest to the first opening in the first direction.

[0010] A heat exchanger of a fifth aspect is the heat exchanger of the fourth aspect, wherein a distance L2 and the distance L0 satisfy a relational expression $0.2 \times L0 \leq L2 \leq 0.8 \times L0$. The distance L2 is a distance in the first direction between the first opening and a boundary between two flow path regions adjacent to each other in the first direction among the N flow path regions. The distance L0 is a distance in the first direction between the

first opening and the second opening.

[0011] A heat exchanger of a sixth aspect is the heat exchanger of any one of the first to fifth aspects, wherein the flow paths branch at a boundary between a k-th flow path region and a (k+1)-th flow path region, and the number of the flow paths in the (k+1)-th flow path region is doubled to quadrupled the number of the flow paths in the k-th flow path region. The k-th flow path region is one of the N flow path regions located to be k-th closest to the first opening in the first direction, and k is an integer satisfying $1 \leq k \leq N-1$. The (k+1)-th flow path region is one of the N flow path regions located to be (k+1)-th closest to the first opening in the first direction.

[0012] A heat exchanger of a seventh aspect is the heat exchanger of any one of the first to sixth aspects, wherein a length in the first direction of each of the N flow path regions is 10% to 50% of a distance in the first direction between the first opening and the second opening.

[0013] A heat exchanger of an eighth aspect is the heat exchanger of any one of the first to seventh aspects, including a plurality of the members stacked in a second direction intersecting the first direction. The N flow path regions are formed between the members adjacent to each other in the second direction.

[0014] A heat exchanger of a ninth aspect is the heat exchanger of the eighth aspect, wherein the N flow path regions with the flow paths through which a first medium as the fluid flows and the N flow path regions with the flow paths through which a second medium as the fluid flows are alternately stacked in the second direction. The first medium flows through the flow paths from the first opening toward the second opening. The second medium flows through the flow paths from the second opening toward the first opening.

[0015] A refrigerant cycle apparatus of a tenth aspect includes the heat exchanger of any one of the first to ninth aspects.

Brief Description of Drawings

[0016]

[Fig. 1] Fig. 1 is a schematic configuration diagram of a refrigerant cycle apparatus 1 including a heat exchanger 100.

[Fig. 2] Fig. 2 is an exploded perspective view of the heat exchanger 100.

[Fig. 3] Fig. 3 is a cross-sectional view of the heat exchanger 100.

[Fig. 4] Fig. 4 is a plan view of a first heat transfer plate 110.

[Fig. 5] Fig. 5 is a plan view of a second heat transfer plate 120.

[Fig. 6] Fig. 6 is a plan view of the second heat transfer plate 120.

[Fig. 7] Fig. 7 is a plan view of the second heat transfer plate 120 according to Modification A.

[Fig. 8] Fig. 8 is a plan view of the second heat transfer plate 120 according to Modification B.

Description of Embodiments

(1) Refrigerant cycle apparatus 1

[0017] A refrigerant cycle apparatus 1 including a heat exchanger 100 according to an embodiment of the present disclosure will be described. The refrigerant cycle apparatus 1 is a cascade refrigeration apparatus that cools an air conditioning target space (not illustrated) such as an interior of a building by executing a vapor compression cycle.

[0018] As illustrated in Fig. 1, the refrigerant cycle apparatus 1 includes a heat source side cycle 10 and a utilization side cycle 20. The heat source side cycle 10 is a vapor compression cycle in which a refrigerant circulates. The refrigerant is, for example, R1234ze. The utilization side cycle 20 is a vapor compression cycle in which a heating medium, which is a fluid having a lower boiling point than the refrigerant, circulates. The heating medium is, for example, carbon dioxide. Heat exchange between the refrigerant and the heating medium occurs in the heat exchanger 100.

(1-1) Heat exchanger 100

[0019] The heat exchanger 100 is a cascade condenser causing the heat exchange between the refrigerant and the heating medium. The heat exchanger 100 functions as an evaporator for the refrigerant and a condenser for the heating medium. The heat exchanger 100 includes a first introduction pipe 150a, a first lead-out pipe 150b, a second introduction pipe 160a, a second lead-out pipe 160b, a first flow path 111, and a second flow path 121.

[0020] The first flow path 111 is a flow path through which the refrigerant flows. The first flow path 111 is formed between the first introduction pipe 150a and the first lead-out pipe 150b. The second flow path 121 is a flow path through which the heating medium flows. The second flow path 121 is formed between the second introduction pipe 160a and the second lead-out pipe 160b. A detailed structure of the heat exchanger 100 will be described below.

(1-2) Heat source side cycle 10

[0021] The heat source side cycle 10 is formed by a heat source side compressor 11, a heat source side heat exchanger 12, and a heat source side expansion valve 13, as well as the first introduction pipe 150a, the first lead-out pipe 150b, and the first flow path 111 of the heat exchanger 100. The heat source side cycle 10 is installed outside the air conditioning target space.

[0022] The heat source side compressor 11 takes in a low-pressure gas-phase refrigerant in the heat source

side cycle 10 from a first intake portion 11a, compresses the refrigerant, and discharges the refrigerant as a high-pressure gas-phase refrigerant from a first discharge portion 11b. The heat source side heat exchanger 12 functions as a condenser, and causes heat exchange between the refrigerant and outside air (air outside the air conditioning target space). The heat source side expansion valve 13 adjusts the flow rate of the refrigerant circulating through the heat source side cycle 10. The heat source side expansion valve 13 functions as a pressure reducing device that reduces the pressure of the refrigerant.

[0023] The first discharge portion 11b of the heat source side compressor 11 is connected to one end of the heat source side heat exchanger 12. The other end of the heat source side heat exchanger 12 is connected to one end of the heat source side expansion valve 13. The other end of the heat source side expansion valve 13 is connected to the first introduction pipe 150a of the heat exchanger 100. The first lead-out pipe 150b of the heat exchanger 100 is connected to the first intake portion 11a of the heat source side compressor 11.

(1-3) Utilization side cycle 20

[0024] The utilization side cycle 20 is formed by a utilization side compressor 21, a utilization side heat exchanger 22, and a utilization side expansion valve 23, as well as the second introduction pipe 160a, the second lead-out pipe 160b, and the second flow path 121 of the heat exchanger 100. The utilization side cycle 20 is installed in the air conditioning target space.

[0025] The utilization side compressor 21 takes in a low-pressure gas-phase heating medium in the utilization side cycle 20 from a second intake portion 21a, compresses the heating medium, and discharges the heating medium as a high-pressure gas-phase heating medium from a second discharge portion 21b. The utilization side heat exchanger 22 functions as an evaporator, and causes heat exchange between the heating medium and the air in the air conditioning target space. The utilization side expansion valve 23 adjusts the flow rate of the heating medium circulating in the utilization side cycle 20. The utilization side expansion valve 23 functions as a pressure reducing device that reduces the pressure of the heating medium.

[0026] The second discharge portion 21b of the utilization side compressor 21 is connected to the second introduction pipe 160a of the heat exchanger 100. The second lead-out pipe 160b of the heat exchanger 100 is connected to one end of the utilization side expansion valve 23. The other end of the utilization side expansion valve 23 is connected to one end of the utilization side heat exchanger 22. The other end of the utilization side heat exchanger 22 is connected to the first intake portion 11a of the utilization side compressor 21.

(1-4) Operations

[0027] Operations of the heat source side cycle 10 and the utilization side cycle 20 during the operation of the refrigerant cycle apparatus 1 will be described. When the operation of the refrigerant cycle apparatus 1 starts, a control unit (not illustrated) drives the heat source side compressor 11 and the utilization side compressor 21, and sets the opening degrees of the heat source side expansion valve 13 and the utilization side expansion valve 23 to appropriate opening degrees corresponding to the air conditioning load.

(1-4-1) Operation of heat source side cycle 10

[0028] The heat source side compressor 11 takes in a low-pressure gas-phase refrigerant in the heat source side cycle 10 from the first intake portion 11a, and discharges the refrigerant as a high-pressure gas-phase refrigerant from the first discharge portion 11b. The high-pressure gas-phase refrigerant reaches the heat source side heat exchanger 12. The heat source side heat exchanger 12 condenses the high-pressure gas-phase refrigerant into a high-pressure liquid-phase refrigerant. At this time, the refrigerant releases heat to the outside air. The high-pressure liquid-phase refrigerant reaches the heat source side expansion valve 13. The heat source side expansion valve 13 set to an appropriate opening degree decompresses the high-pressure liquid-phase refrigerant into a low-pressure gas-liquid two phase refrigerant. The low-pressure gas-liquid two phase refrigerant passes through the first introduction pipe 150a of the heat exchanger 100 and enters the first flow path 111. The heat exchanger 100 evaporates the low-pressure gas-liquid two phase refrigerant into a low-pressure gas-phase refrigerant. At this time, the refrigerant absorbs heat from the heating medium passing through the second flow path 121 of the heat exchanger 100. The low-pressure gas-phase refrigerant passes through the first lead-out pipe 150b, exits the first first flow path 111, and is taken into the heat source side compressor 11 from the first intake portion 11a.

(1-4-2) Operation of utilization side cycle 20

[0029] The utilization side compressor 21 takes in a low-pressure gas-phase heating medium in the utilization side cycle 20 from the second intake portion 21a, and discharges the medium as a high-pressure gas-phase heating medium from the second discharge portion 21b. The high-pressure gas-phase heating medium passes through the second introduction pipe 160a of the heat exchanger 100 and enters the second flow path 121. The heat exchanger 100 condenses the high-pressure gas-phase heating medium into a high-pressure liquid-phase heating medium. At this time, the heating medium releases heat to the refrigerant passing through the first flow path 111 of the heat exchanger 100. The high-pres-

sure liquid-phase heating medium passes through the second lead-out pipe 160b, exits the second flow path 121, and reaches the utilization side expansion valve 23. The utilization side expansion valve 23 set to an appropriate opening degree decompresses the high-pressure liquid-phase heating medium into a low-pressure gas-liquid two phase heating medium. The low-pressure gas-liquid two phase heating medium reaches the utilization side heat exchanger 22. The utilization side heat exchanger 22 evaporates the low-pressure gas-liquid two phase heating medium into a low-pressure gas-phase heating medium. At this time, the heating medium absorbs heat from the air in the air conditioning target space. The low-pressure gas-phase heating medium exits the utilization side heat exchanger 22 and is taken into the utilization side compressor 21 through the second intake portion 21a.

(2) Heat exchanger 100

(2-1) Overall configuration

[0030] As illustrated in Fig. 2, the heat exchanger 100 is a plate-type heat exchanger including a plurality of first heat transfer plates 110, a plurality of second heat transfer plates 120, a first frame 130, and a second frame 140. The heat exchanger 100 has the first flow path 111 and the second flow path 121 formed therein.

[0031] The first heat transfer plates 110 and the second heat transfer plates 120 are plate-shaped members made of metal and having the same rectangular outer shape. In the present embodiment, as illustrated in Fig. 2, the first heat transfer plates 110, the second heat transfer plates 120, the first frame 130, and the second frame 140 are formed in a rectangular shape extending along a longitudinal direction DL.

[0032] The plurality of first heat transfer plates 110 and the plurality of second heat transfer plates 120 are alternately stacked between the first frame 130 and the second frame 140. 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 according to the required performance. The materials and sizes of the first frame 130, the first heat transfer plates 110, the second heat transfer plates 120, and the second frame 140 are not limited, and are appropriately set according to the required performance. The first frame 130, the first heat transfer plates 110, the second heat transfer plates 120, and the second frame 140 are integrally joined by, for example, brazing.

[0033] In the following description, a direction in which the first heat transfer plates 110 and the second heat transfer plates 120 are stacked is referred to as a stacking direction DS, and a direction orthogonal to the longitudinal direction DL and the stacking direction DS is referred to as a width direction DW. Further, as illustrated in Fig. 2, directions of "up", "down", "left", "right", "front", and "rear" are defined. The longitudinal direction DL is the up-down direction. The width direction DW is the left-right direction. The stacking direction DS is the front-rear direction.

(2-2) Detailed configuration

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

[0034] The first heat transfer plate 110 is a corrugated fin having a corrugated cross section. In the present embodiment, as illustrated in Fig. 2 and Fig. 3, the corrugated shape of the first heat transfer plate 110 is formed such that the top portion draws a herring bone pattern that is convex upward in plan view.

[0035] The first heat transfer plate 110 forms the first flow path 111 and the second flow path 121 together with the second heat transfer plate 120 stacked adjacent thereto. The first heat transfer plate 110 includes a first joining region 110a, two first flow holes 110b, two first through holes 110c, a first front surface 110sa, and a first rear surface 110sb.

[0036] The first joining region 110a is a region for joining the first heat transfer plate 110 and the second heat transfer plate 120 to each other. The first joining region 110a is a strip-shaped region with an end edge of a predetermined width bent toward the front side.

[0037] The first flow holes 110b are circular holes through which the refrigerant is introduced into or led out from the first flow path 111. The first flow holes 110b are formed on the upper left side and the lower right side of the first heat transfer plate 110.

[0038] The first through holes 110c are circular holes through which the heating medium passes in the stacking direction DS. The first through holes 110c are formed on the upper right side and the lower left side of the first heat transfer plate 110.

[0039] The first front surface 110sa is a surface on the front side of the first heat transfer plate 110. The first front surface 110sa is a surface that faces a second rear surface 120sb of the second heat transfer plate 120, which will be described below, when the first heat transfer plate 110 and the second heat transfer plate 120 are stacked.

[0040] The first rear surface 110sb is a surface on the rear side of the first heat transfer plate 110. The first rear surface 110sb is a surface that faces a second front surface 120sa of the second heat transfer plate 120, which will be described below, when the first heat transfer plate 110 and the second heat transfer plate 120 are stacked.

[0041] The first heat transfer plate 110 is formed by, for example, pressing, but the manufacturing method is not limited thereto.

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

[0042] The second heat transfer plate 120 forms the first flow path 111 and the second flow path 121 together

with the first heat transfer plate 110 stacked adjacent thereto. The second heat transfer plate 120 includes a second joining region 120a, two second flow holes 120b, two second through holes 120c, the second front surface 120sa, and the second rear surface 120sb.

[0043] The second joining region 120a is a region for joining the first heat transfer plate 110 and the second heat transfer plate 120 to each other. The second joining region 120a is a strip-shaped region with an end edge of a predetermined width bent toward the front side.

[0044] The second flow holes 120b are circular holes through which the heating medium is introduced into or led out from the second flow path 121. The second flow holes 120b are formed on the upper right side and the lower left side of the second heat transfer plate 120. The second flow holes 120b are formed at positions overlapping and communicating with the first through holes 110c when the first heat transfer plate 110 and the second heat transfer plate 120 are stacked. The size and shape of the second flow holes 120b are the same as those of the first through holes 110c.

[0045] The second through holes 120c are circular holes through which the refrigerant passes in the stacking direction DS. The second through holes 120c are formed on the upper left side and the lower right side of the second heat transfer plate 120. The second through holes 120c are formed at positions overlapping and communicating with the first flow holes 110b when the first heat transfer plate 110 and the second heat transfer plate 120 are stacked. The size and shape of the second through holes 120c are the same as those of the first flow holes 110b.

[0046] The second front surface 120sa is a surface on the front side of the second heat transfer plate 120. The second front surface 120sa is a surface that faces the first rear surface 110sb of the first heat transfer plate 110 when the first heat transfer plate 110 and the second heat transfer plate 120 are stacked.

[0047] The second rear surface 120sb is a surface on the rear side of the second heat transfer plate 120. The second rear surface 120sb is a surface that faces the first front surface 110sa of the first heat transfer plate 110 when the first heat transfer plate 110 and the second heat transfer plate 120 are stacked.

[0048] The second heat transfer plate 120 is formed by, for example, pressing, but the manufacturing method is not limited thereto. The shape of the second heat transfer plate 120 will be described in detail below.

(2-2-3) First frame 130 and second frame 140

[0049] The first frame 130 and the second frame 140 are metal plate-shaped members that sandwich the plurality of first heat transfer plates 110 and the plurality of second heat transfer plates 120, which are alternately stacked, at both ends in the stacking direction DS.

(2-2-4) First introduction pipe 150a and first lead-out pipe 150b

[0050] The first introduction pipe 150a is a pipe for introducing the refrigerant into the first flow path 111. The first introduction pipe 150a is formed through the upper left side of the first frame 130 and communicates with the first flow path 111. More specifically, the first introduction pipe 150a is formed so as to communicate with the first flow hole 110b and the second through hole 120c formed on the upper left side, which communicate with each other when the first heat transfer plate 110, the second heat transfer plate 120, and the first frame 130 are stacked.

[0051] The first lead-out pipe 150b is a pipe through which the refrigerant is led out from the first flow path 111. The first lead-out pipe 150b is formed through the lower right side of the first frame 130 and communicates with the first flow path 111. More specifically, the first lead-out pipe 150b is formed so as to communicate with the first flow hole 110b and the second through hole 120c formed on the lower right side, which communicate with each other when the first heat transfer plate 110, the second heat transfer plate 120, and the first frame 130 are stacked.

(2-2-5) Second introduction pipe 160a and second lead-out pipe 160b

[0052] The second introduction pipe 160a is a pipe for introducing the heating medium into the second flow path 121. The second introduction pipe 160a is formed through the upper right side of the first frame 130 and communicates with the second flow path 121. More specifically, the second introduction pipe 160a is formed to communicate with the second flow hole 120b and the first through hole 110c formed on the upper right side, which communicate with each other when the first heat transfer plate 110, the second heat transfer plate 120, and the first frame 130 are stacked.

[0053] The second lead-out pipe 160b is a pipe through which the heating medium is led out from the second flow path 121. The second lead-out pipe 160b is formed through the lower left side of the first frame 130 and communicates with the second flow path 121. More specifically, the second introduction pipe 160a is formed so as to communicate with the second flow hole 120b and the first through hole 110c formed on the lower left side, which communicate with each other when the first heat transfer plate 110, the second heat transfer plate 120, and the first frame 130 are stacked.

(2-2-6) First flow path 111 and second flow path 121

[0054] As illustrated in Fig. 3, the first flow path 111 and the second flow path 121 are alternately formed in the stacking direction DS by alternately stacking the first heat transfer plates 110 and the second heat transfer plates

120. More specifically, by alternately stacking the first heat transfer plates 110 and the second heat transfer plates 120, a space in which the first front surface 110sa of the first heat transfer plate 110 and the second rear surface 120sb of the second heat transfer plate 120 face each other is formed as the first flow path 111. By alternately stacking the first heat transfer plates 110 and the second heat transfer plates 120, a space in which the first rear surface 110sb of the first heat transfer plate 110 and the second front surface 120sa of the second heat transfer plate 120 face each other is formed as the second flow path 121.

[0055] The first heat transfer plate 110 and the second heat transfer plate 120 are joined by brazing. More specifically, the first heat transfer plate 110 and the second heat transfer plate 120 are joined to each other by brazing in the first joining region 110a and the second joining region 120a.

[0056] In the following description, the first flow path 111 is located between the first flow hole 110b on the upper side and the first flow hole 110b on the lower side, and is a rectangular region whose size in the width direction DW is constant over the longitudinal direction DL. Similarly, the second flow path 121 is located between the second flow hole 120b on the upper side and the second flow hole 120b on the lower side, and is a rectangular region whose size in the width direction DW is constant over the longitudinal direction DL. Fig. 4 and Fig. 5 illustrate ranges of the first flow path 111 and the second flow path 121, respectively, in the longitudinal direction DL and the width direction DW.

(2-3) Flow of refrigerant and heating medium

[0057] The refrigerant introduced from the first introduction pipe 150a of the heat exchanger 100 passes through the second through hole 120c and the first flow hole 110b on the upper side and flows into the first flow path 111. The refrigerant that has flowed into the first flow path 111 flows through the first flow path 111 toward the first flow hole 110b on the lower side. The refrigerant that has reached the first flow hole 110b on the lower side passes through the second through hole 120c on the lower side and is led out from the first lead-out pipe 150b. In this process, the liquid refrigerant flowing through the first flow path 111 exchanges heat with the heating medium in the adjacent second flow path 121 via the first heat transfer plate 110 or the second heat transfer plate 120 and evaporates to become a gaseous refrigerant. In other words, the heat exchanger 100 functions as an evaporator for the refrigerant.

[0058] On the other hand, the heating medium introduced from the second introduction pipe 160a of the heat exchanger 100 passes through the second flow hole 120b and the first through hole 110c on the upper side and flows into the second flow path 121. The heating medium that has flowed into the second flow path 121 flows through the second flow path 121 toward the second flow hole 120b on the lower side. The heating medium that has reached the second flow hole 120b on the lower side passes through the first through hole 110c on the lower side and is led out from the second lead-out pipe 160b. In this process, the gaseous heating medium flowing through the second flow path 121 exchanges heat with the refrigerant in the adjacent first flow path 111 via the first heat transfer plate 110 or the second heat transfer plate 120, and is condensed into a liquid heating medium. In other words, the heat exchanger 100 functions as a condenser for the heating medium.

(2-4) Detailed configuration of second flow path 121

[0059] In the heat exchanger 100, the heating medium flowing through the second flow path 121 flows along the longitudinal direction DL between the second flow hole 120b on the upper side and the second flow hole 120b on the lower side. In the present embodiment, the heating medium flows in from the second flow hole 120b on the upper side, passes through the second flow path 121, and then flows out from the second flow hole 120b on the lower side. The second flow hole 120b on the upper side communicates with the second introduction pipe 160a via the first through hole 110c on the upper side. The second flow hole 120b on the lower side communicates with the second lead-out pipe 160b via the first through hole 110c on the lower side. The gaseous heating medium before the heat exchange in the heat exchanger 100 flows from the second introduction pipe 160a into the second flow path 121 through the second flow hole 120b on the upper side. While passing through the second flow path 121, the gaseous heating medium exchanges heat to be liquid. After flowing out of the second flow path 121, the liquid heating medium is supplied to the second lead-out pipe 160b through the second flow hole 120b on the lower side.

[0060] The first heat transfer plate 110 and the second heat transfer plate 120 form N flow path regions. The value N is an integer not less than 2. In the present embodiment, as illustrated in Fig. 6, the value N is 5, and the first heat transfer plate 110 and the second heat transfer plate 120 form five flow path regions F1 to F5. Each of the flow path regions F1 to F5 has a part of the second flow path 121. The flow path regions F1 to F5 are rectangular regions arranged adjacent to each other along the longitudinal direction DL between the second flow hole 120b on the upper side and the second flow hole 120b on the lower side. The size of each of the flow path regions F1 to F5 in the width direction DW is equal to the size of the second flow path 121 in the width direction DW.

[0061] In the following description, among the N flow path regions, the flow path region located to be x-th closest to the second flow hole 120b on the upper side in the longitudinal direction DL is referred to as an x-th flow path region. The value x is an integer satisfying $1 \leq x \leq N$. For example, in Fig. 6, the first flow path region F1 is located below the second flow hole 120b on the upper

side, and the second flow path region F2 is located below the first flow path region F1. The fifth flow path region F5 (N-th flow path region) is located below the fourth flow path region F4 and above the second flow hole 120b on the lower side. Thus, the first to the N-th flow path regions are arranged adjacent to each other in a row along the longitudinal direction DL from the second flow hole 120b on the upper side toward the second flow hole 120b on the lower side.

[0062] Each of the flow path regions F1 to F5 includes one or a plurality of flow path elements 131. The flow path element 131 is a space in which the heating medium flows along the longitudinal direction DL. When the flow path region includes a plurality of flow path elements 131, the plurality of flow path elements 131 are arranged along the width direction DW. Two flow path elements 131 adjacent to each other in the width direction DW are partitioned by a partition element 132 extending along the longitudinal direction DL. In Figs. 5 to 8, the partition element 132 is illustrated as a hatched region.

[0063] As illustrated in Fig. 3, the flow path element 131 corresponds to a space in which the first rear surface 110sb of the first heat transfer plate 110 and the second front surface 120sa of the second heat transfer plate 120 face each other. The partition element 132 corresponds to a portion where the first rear surface 110sb of the first heat transfer plate 110 and the second front surface 120sa of the second heat transfer plate 120 are joined. When the flow path region includes a plurality of flow path elements 131, the plurality of flow path elements 131 have the same size in the width direction DW and the same cross-sectional area.

[0064] Two flow path regions adjacent to each other in the longitudinal direction DL are different from each other in the number and the cross-sectional area of the flow path elements 131. Further, in the flow path regions F1 to F5, the number and the cross-sectional area of the flow path elements 131 are constant. Therefore, when the N flow path regions are formed, the first flow path region is different from the N-th flow path region in the number and the cross-sectional area of the flow path elements 131.

[0065] Specifically, when the values i and j are integers satisfying $1 \leq i < j \leq N$, the number of flow path elements 131 in the i-th flow path region is smaller than the number of flow path elements 131 in the j-th flow path region, and the cross-sectional area of the flow path elements 131 in the i-th flow path region is larger than the cross-sectional area of the flow path elements 131 in the j-th flow path region. For example, as illustrated in Fig. 6, the second flow path region F2 includes two flow path elements 131, and the third flow path region F3 includes four flow path elements 131. In this case, the size of the flow path elements 131 in the second flow path region F2 in the width direction DW is larger than the size of the flow path elements 131 in the third flow path region F3 in the width direction DW. Therefore, the cross-sectional area of the flow path elements 131 in the second flow path region F2 is larger than the cross-sectional area of the flow path elements 131 in the third flow path region F3.

[0066] In the present embodiment, as illustrated in Fig. 6, the number of flow path elements 131 in the first flow path region F1 is one. In other words, the first flow path region F1 does not include the partition element 132.

[0067] Further, in the present embodiment, as illustrated in Fig. 6, a merging region 133 is formed between the fifth flow path region F5 (N-th flow path region) and the second flow hole 120b on the lower side. The merging region 133 communicates with all the flow path elements 131 in the fifth flow path region F5. The size of the merging region 133 in the longitudinal direction DL is preferably not larger than 20% of the size of the second flow path 121 in the longitudinal direction DL.

[0068] Therefore, the number of flow path elements 131 in the flow path regions F1 to F5 gradually increases and the cross-sectional area of the flow path elements 131 in the flow path regions F1 to F5 gradually decreases from the second flow hole 120b on the upper side toward the second flow hole 120b on the lower side. In other words, while the gaseous heating medium flows through the second flow path 121 to be the liquid heating medium, the number of flow path elements 131 through which the heating medium flows gradually increases, and the cross-sectional area of the flow path elements 131 gradually decreases.

[0069] In the second flow path 121, a boundary between two flow path regions adjacent to each other in the longitudinal direction DL is a position where the number and the cross-sectional area of the flow path elements 131 change. Therefore, in the second flow path 121, the flow of the heating medium is gradually branched while the heating medium flows from the first flow path region F1 toward the fifth flow path region F5. The heating medium that has passed through the flow path elements 131 in the fifth flow path region F5 merges in the merging region 133 and supplied to the second flow hole 120b on the lower side.

[0070] In Fig. 6, the numbers of the flow path elements 131 in the first to fifth flow path regions F1 to F5 are 1, 2, 4, 8, and 16, respectively. In other words, the number of flow path elements 131 is doubled every time the flow of the heating medium is branched while the heating medium flows from the first flow path region F1 toward the second flow hole 120b on the lower side.

[0071] The number of the flow path regions F1 to F5, the size thereof in the longitudinal direction DL, and the like are not limited, and are appropriately set according to the required performance. Further, the number of flow path elements 131 in each of the flow path regions F1 to F5 is not limited, and is appropriately set according to the required performance. For example, the first flow path region F1 may include one flow path element 131, and the second flow path region F2 may include ten flow path elements 131. In this case, the number of flow path elements 131 may be doubled every time the flow of the heating medium is branched while the heating medium flows from the second flow path region F2 toward the

second flow hole 120b on the lower side.

(3) Features

(3-1)

[0072] Conventionally, a plate fin type heat exchanger including a metal plate in which a plurality of heat exchange flow paths for exchanging heat with a fluid and a pair of branch flow paths connected to both ends of the heat exchange flow paths are formed has been used. In such a heat exchanger, the fluid flowing into the heat exchanger is divided into all the heat exchange flow paths by the branch flow paths in the vicinity of the inlet of the heat exchanger, and is merged by the branch flow paths in the vicinity of the outlet of the heat exchanger. Therefore, the number and the cross-sectional area of the heat exchange flow paths are constant from the vicinity of the inlet to the vicinity of the outlet of the heat exchanger. When phase change from the gaseous fluid into the liquid fluid occurs through the heat exchange in the heat exchange flow path, the performance of the heat exchanger may deteriorate due to a large pressure loss in the heat exchange flow path in the vicinity of the inlet through which the gaseous fluid flows. In addition, the heat transfer efficiency may deteriorate due to a low flow velocity of the fluid in the heat exchange flow path in the vicinity of the outlet through which the liquid fluid flows.

[0073] The heat exchanger 100 of the present embodiment includes the first heat transfer plates 110 and the second heat transfer plates 120 that are alternately stacked. The first heat transfer plates 110 and the second heat transfer plates 120 form the second flow path 121 in which a gaseous heating medium is condensed by heat exchange to become a liquid heating medium. In the second flow path 121, while the heating medium flows from the inlet side into which the gaseous heating medium flows toward the outlet side from which the liquid heating medium flows out, the flow of the heating medium gradually branches, and the cross-sectional area of the flow path elements 131 through which the heating medium flows gradually decreases. A larger cross-sectional area of the flow path in the vicinity of the inlet through which the gaseous heating medium flows facilitates reduction of pressure loss. A smaller cross-sectional area of the flow path in the vicinity of the outlet through which the liquid heating medium flows facilitates suppression of a decrease in the flow velocity of the heating medium. Therefore, in the heat exchanger 100, the second flow path 121 in which the cross-sectional area of the flow path elements 131 through which the heating medium flows gradually decreases is formed such that a suitable flow velocity of the heating medium flowing through the second flow path 121 is achieved in accordance with the phase change (density change) of the heating medium.

[0074] Therefore, in the heat exchanger 100 of the present embodiment, an increase in pressure loss in the flow path in the vicinity of the inlet through which the gaseous fluid flows is suppressed, whereby deterioration in the performance of the heat exchanger is suppressed. In addition, in the heat exchanger 100 of the present embodiment, a decrease in the flow velocity of the fluid is suppressed in the flow path in the vicinity of the outlet through which the liquid fluid flows, whereby deterioration in the heat transfer efficiency is suppressed.

[0075] (3-2)

In the heat exchanger 100 of the present embodiment, while the heating medium flows from the inlet side into which the gaseous heating medium flows toward the outlet side from which the liquid heating medium flows out in the second flow path 121, the flow of the heating medium gradually branches, and the number of flow path elements 131 through which the heating medium flows gradually increases.

[0076] Therefore, in the heat exchanger 100 of the present embodiment, even when the cross-sectional area of the flow path through which the fluid flows from the inlet side toward the outlet side gradually decreases, a decrease in the flow rate of the fluid and a decrease in the area (heat transfer area) of a portion that contributes to heat exchange of the fluid are suppressed, whereby deterioration in the heat transfer efficiency is suppressed.

(4) Modifications

(4-1) Modification A

[0077] Next, in Modifications A to D, specific examples of the second flow path 121 of the above embodiment will be described. Fig. 7 and Fig. 8 are plan views of the second heat transfer plate 120 similar to Fig. 6.

[0078] In Fig. 7, the distance L0 is a distance in the longitudinal direction DL between the second flow hole 120b on the upper side and the second flow hole 120b on the lower side. The center of the circular shape of the second flow hole 120b is defined as the position of the second flow hole 120b. In the space between the first heat transfer plate 110 and the second heat transfer plate 120, the distance L0 is a distance, in the longitudinal direction DL, of the movement of the heating medium that flows in from the second flow hole 120b on the upper side and flows out from the second flow hole 120b on the lower side. The distance L1 is a distance in the longitudinal direction DL between a boundary B1 between the first flow path region F1 and the second flow path region F2 and the second flow hole 120b on the upper side.

[0079] In the above embodiment, the distance L0 and the distance L1 preferably satisfy the relational expression $0.2 \times L0 \leq L1 \leq 0.8 \times L0$. In this case, in the longitudinal direction DL, the position at which the flow of the heating medium first branches is located at a position corresponding to 20% to 80% of the distance L0, which corresponds to the length of the flow paths for the heating medium. The position at which the flow of the heating medium first branches corresponds to the position of the boundary B1 in the longitudinal direction DL.

(4-2) Modification B

[0080] In Fig. 8, the distance L0 is a distance in the longitudinal direction DL between the second flow hole 120b on the upper side and the second flow hole 120b on the lower side. The center of the circular shape of the second flow hole 120b is defined as the position of the second flow hole 120b. In the space between the first heat transfer plate 110 and the second heat transfer plate 120, the distance L0 is a distance, in the longitudinal direction DL, of the movement of the heating medium that flows in from the second flow hole 120b on the upper side and flows out from the second flow hole 120b on the lower side. The distance L2 is a distance in the longitudinal direction DL between a boundary between two flow path regions adjacent to each other in the longitudinal direction DL and the second flow hole 120b on the upper side.

[0081] Fig. 8 illustrates boundaries B1 to B4 between two flow path regions adjacent to each other in the longitudinal direction DL from the second flow hole 120b on the upper side toward the second flow hole 120b on the lower side. The number of boundaries is a value smaller by one than the number of flow path regions. Fig. 8 illustrates the five flow path regions F1 to F5 and the four boundaries B1 to B4. In the longitudinal direction DL, the boundaries B1 to B4 are located at positions where the flow of the heating medium is branched. In Fig. 8, the distance L2 is illustrated as a distance in the longitudinal direction DL between the boundary B2 and the second flow hole 120b on the upper side.

[0082] In the above embodiment, the distance L0 and the distance L2 preferably satisfy the relational expression $0.2 \times L0 \leq L2 \leq 0.8 \times L0$. In this case, in the longitudinal direction DL, all the positions where the flow of the heating medium is branched are located at positions corresponding to 20% to 80% of the distance L0, which corresponds to the length of the flow paths for the heating medium. The positions where the flow of the heating medium branches correspond to the positions of the boundaries B1 to B4 in the longitudinal direction DL.

(4-3) Modification C

[0083] In the above embodiment, the lengths of the respective flow path regions F1 to F5 in the longitudinal direction DL are preferably 10% to 50% of the distance L0. The distance L0 is a distance in the longitudinal direction DL between the second flow hole 120b on the upper side and the second flow hole 120b on the lower side. The center of the circular shape of the second flow hole 120b is defined as the position of the second flow hole 120b. In the space between the first heat transfer plate 110 and the second heat transfer plate 120, the distance L0 is a distance, in the longitudinal direction DL, of the movement of the heating medium that flows in from the second flow hole 120b on the upper side and flows out from the second flow hole 120b on the lower side.

[0084] In this case, in the longitudinal direction DL, the distance from a branch position to an adjacent branch position is preferably 10% to 50% of the distance L0, which corresponds to the length of the flow paths for the heating medium. The branch position is a position in the longitudinal direction DL where the flow of the heating medium branches.

[0085] In Modifications A to C, the distance L0 may be the size of the first heat transfer plate 110 and the second heat transfer plate 120 in the longitudinal direction DL. Further, the distance L0 may be the size of the second flow path 121 in the longitudinal direction DL.

(4-4) Modification D

[0086] In the above embodiment, when the value k is an integer satisfying $1 \leq k \leq N-1$, the number of flow paths in the (k+1)-th flow path region is preferably doubled to quadrupled the number of flow paths in the k-th flow path region. In other words, every time the flow of the heating medium is branched at the boundary between two flow path regions adjacent to each other in the longitudinal direction DL, the number of flow paths for the heating medium increases to be doubled to quadrupled.

(4-5) Modification E

[0087] In the above embodiment, the flow path regions F1 to F5 of the second flow path 121 include one or a plurality of flow path elements 131. The flow path element 131 corresponds to a space in which the first rear surface 110sb of the first heat transfer plate 110 and the second front surface 120sa of the second heat transfer plate 120 face each other. In other words, in the flow path element 131, the first heat transfer plate 110 is not in contact with the second heat transfer plate 120. However, a reinforcing element for bringing the first heat transfer plate 110 and the second heat transfer plate 120 into contact with each other in the flow path element 131 may be provided in at least one of the first heat transfer plate 110 and the second heat transfer plate 120. The reinforcing element is a component for guaranteeing the strength of the first heat transfer plate 110 and the second heat transfer plate 120 in the flow path element 131. By providing the reinforcing element, the first rear surface 110sb of the first heat transfer plate 110 and the second front surface 120sa of the second heat transfer plate 120 are prevented from coming into contact with each other in the flow path element 131, and the flow path cross-sectional area of the second flow path 121 is prevented from being reduced.

[0088] The reinforcing element is, for example, a protrusion in a dot form formed on at least one of the first heat transfer plate 110 and the second heat transfer plate 120. The reinforcing element has such a size that the flow velocity of the heating medium in the flow path element 131 is not reduced, and has such a shape that the flow path is not substantially branched in the flow path ele-

ment 131. In other words, the reinforcing element preferably has a size and a shape that does not affect the number and the cross-sectional area of the flow path elements 131 in the flow path region.

(4-6) Modification F

[0089] In the above embodiment, the heat exchanger 100 is formed such that the refrigerant flowing through the first flow path 111 and the heating medium flowing through the second flow path 121 form a parallel flow. However, the heat exchanger 100 may be formed such that the refrigerant flowing through the first flow path 111 and the refrigerant flowing through the second flow path 121 form a counterflow. For example, in the first flow path 111, the refrigerant may flow from the first flow hole 110b on the lower side toward the first flow hole 110b on the upper side, and in the second flow path 121, the heating medium may flow from the second flow hole 120b on the upper side toward the second flow hole 120b on the lower side.

(4-7) Modification G

[0090] In the above embodiment, the heat exchanger 100 has a branched structure in which the flow of the heating medium gradually branches in the second flow path 121, and the number of flow path elements 131 through which the heating medium flows gradually increases. However, the heat exchanger 100 may have a branched structure similar to that of the second flow path 121, in the first flow path 111. Specifically, the first flow path 111 may have a branched structure in which the flow of the refrigerant gradually branches and the number of spaces (corresponding to the flow path elements 131) through which the refrigerant flows gradually increases.

[0091] In the heat source side heat exchanger 12 of the heat source side cycle 10, the flow path through which the refrigerant flows may have a branched structure similar to that of the second flow path 121. Further, in the utilization side heat exchanger 22 of the utilization side cycle 20, the flow path through which the heating medium flows may have a branched structure similar to that of the second flow path 121.

(4-8) Modification H

[0092] In the above embodiment, R1234ze is described as an example of the refrigerant, and carbon dioxide is described as an example of the heating medium, but the refrigerant and the heating medium are not limited thereto.

[0093] As the refrigerant, R32, a HFO-based refrigerant, a mixed refrigerant of R32 and a HFO-based refrigerant, carbon dioxide, ammonia, propane, or the like may be used. As the heating medium, a refrigerant such as R-32, a HFO-based refrigerant, a mixed refrigerant of HFC-32 and a HFO-based refrigerant, carbon dioxide, ammonia, or propane, water, an antifreeze solution, or the like may be used.

(4-9) Modification I

[0094] In the above embodiment, all of the first introduction pipe 150a, the first lead-out pipe 150b, the second introduction pipe 160a, and the second lead-out pipe 160b are formed in the first frame 130. However, at least a part of the first introduction pipe 150a, the first lead-out pipe 150b, the second introduction pipe 160a, and the second lead-out pipe 160b may be formed in the second frame 140.

(4-10) Modification J

[0095] In the above embodiment, the refrigerant cycle apparatus 1 is a cascade refrigeration apparatus having the heat source side cycle 10 and the utilization side cycle 20. However, the refrigerant cycle apparatus 1 may be a refrigeration apparatus having only one vapor compression cycle in which the refrigerant circulates. For example, the refrigerant cycle apparatus 1 may have a refrigerant cycle including elements corresponding to the heat source side compressor 11, the heat source side heat exchanger 12, the heat source side expansion valve 13, and the utilization side heat exchanger 22. In this case, the heat source side heat exchanger 12 functioning as a condenser for the refrigerant may have a branched structure similar to that of the second flow path 121 of the above embodiment.

[0096] While embodiments of the present disclosure have been described above, it should be understood that various changes in mode and detail may be made without departing from the spirit and scope of the present disclosure as set forth in the claims.

Reference Signs List

[0097]

1	Refrigerant cycle apparatus
100	Heat exchanger
110	First heat transfer plate (member)
120	Second heat transfer plate (member)
120b	Second flow hole on upper side (first opening)
120b	Second flow hole on lower side (second opening)
131	Flow path element (flow path)
DL	Longitudinal direction (first direction)
DS	Stacking direction (second direction)
F1	First flow path region
F2	Second flow path region
F5	Fifth flow path region (N-th flow path region)

Citation List

Patent Literature

[0098] PTL 1: Japanese Unexamined Patent Application Publication No. 2016-90157

Claims

1. A heat exchanger (100) in which a fluid flows in a first direction (DL) between a first opening (120b) and a second opening (120b), the heat exchanger comprising

   a member (110, 120) forming N flow path regions arranged adjacent to each other along the first direction between the first opening and the second opening, N being an integer of 2 or more, wherein
   each of the N flow path regions includes a flow path (131) through which the fluid flows, and
   a first flow path region (F1) and an N-th flow path region (F5) are different from each other in number and cross-sectional area of the flow paths, the first flow path region being one of the N flow path regions located to be closest to the first opening in the first direction, the N-th flow path region being one of the N flow path regions located to be N-th closest to the first opening in the first direction.

2. The heat exchanger according to claim 1, wherein the number of the flow paths in an i-th flow path region is smaller than the number of the flow paths in a j-th flow path region, and the cross-sectional area of the flow paths in the i-th flow path region is larger than the cross-sectional area of the flow path in the j-th flow path region, the i-th flow path region being one of the N flow path regions located to be i-th closest to the first opening in the first direction, the j-th flow path region being one of the N flow path regions located to be j-th closest to the first opening in the first direction, i and j being integers satisfying $1 \leq i < j \leq N$.

3. The heat exchanger according to claim 1 or 2, wherein the number of the flow paths in the first flow path region is one.

4. The heat exchanger according to claim 3, wherein a distance L1 and a distance L0 satisfy a relational expression $0.2 \times L0 \leq L1 \leq 0.8 \times L0$, the distance L1 being a distance in the first direction between the first opening and a boundary between a second flow path region (F2) and the first flow path region, the distance L0 being a distance in the first direction between the first opening and the second opening, the second flow path region being one of the N flow path regions located to be second closest to the first opening in the first direction.

5. The heat exchanger according to claim 4, wherein a distance L2 and the distance L0 satisfy a relational expression $0.2 \times L0 \leq L2 \leq 0.8 \times L0$, the distance L2 being a distance in the first direction between the first opening and a boundary between two flow path regions adjacent to each other in the first direction among the N flow path regions, the distance L0 being a distance in the first direction between the first opening and the second opening.

6. The heat exchanger according to any one of claims 1 to 5, wherein the flow paths branch at a boundary between a k-th flow path region and a (k+1)-th flow path region, and the number of the flow paths in the (k+1)-th flow path region is doubled to quadrupled the number of the flow paths in the k-th flow path region, the k-th flow path region being one of the N flow path regions located to be k-th closest to the first opening in the first direction, k being an integer satisfying $1 \leq k \leq N-1$, the (k+1)-th flow path region being one of the N flow path regions located to be (k+1)-th closest to the first opening in the first direction.

7. The heat exchanger according to any one of claims 1 to 6, wherein a length in the first direction of each of the N flow path regions is 10% to 50% of a distance in the first direction between the first opening and the second opening.

8. The heat exchanger according to any one of claims 1 to 7, comprising a plurality of the members stacked in a second direction (DS) intersecting the first direction, wherein
   the N flow path regions are formed between the members adjacent to each other in the second direction.

9. The heat exchanger according to claim 8, wherein

   the N flow path regions with the flow paths through which a first medium as the fluid flows and the N flow path regions with the flow paths through which a second medium as the fluid flows are alternately stacked in the second direction,
   the first medium flows through the flow paths from the first opening toward the second opening, and
   the second medium flows through the flow paths from the second opening toward the first opening.

10. A refrigerant cycle apparatus (1) comprising the heat exchanger according to any one of claims 1 to 9.

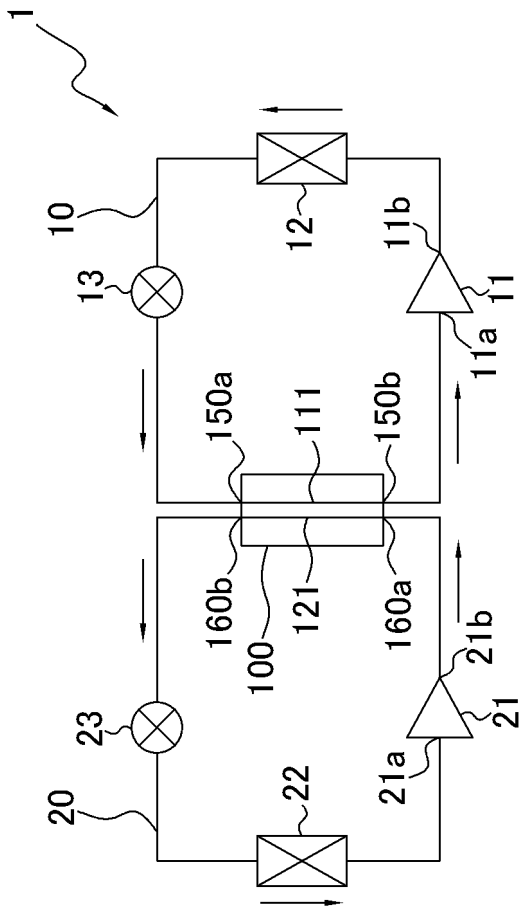

1
10
12
11b
13
11
11a
150a
111
150b
160b
100
121
160a
21b
23
21
21a
20
22

FIG. 1

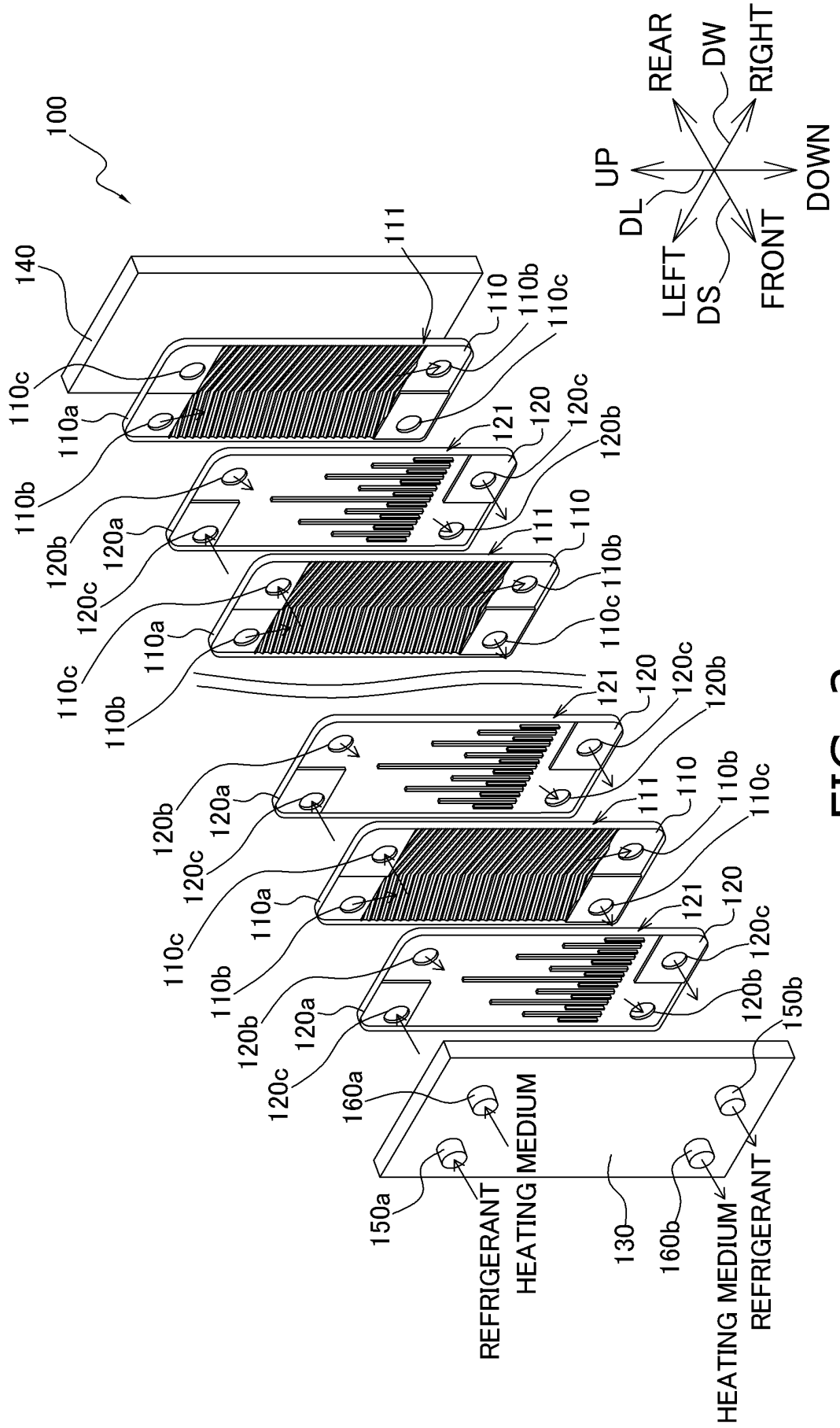

100
140
111
110
110b
110c
110a
120
120c
120b
121
120a
REAR
DW
RIGHT
UP
DL
DOWN
LEFT
DS
FRONT
150b
150a
160a
160b
130
REFRIGERANT
HEATING MEDIUM
HEATING MEDIUM
REFRIGERANT

FIG. 2

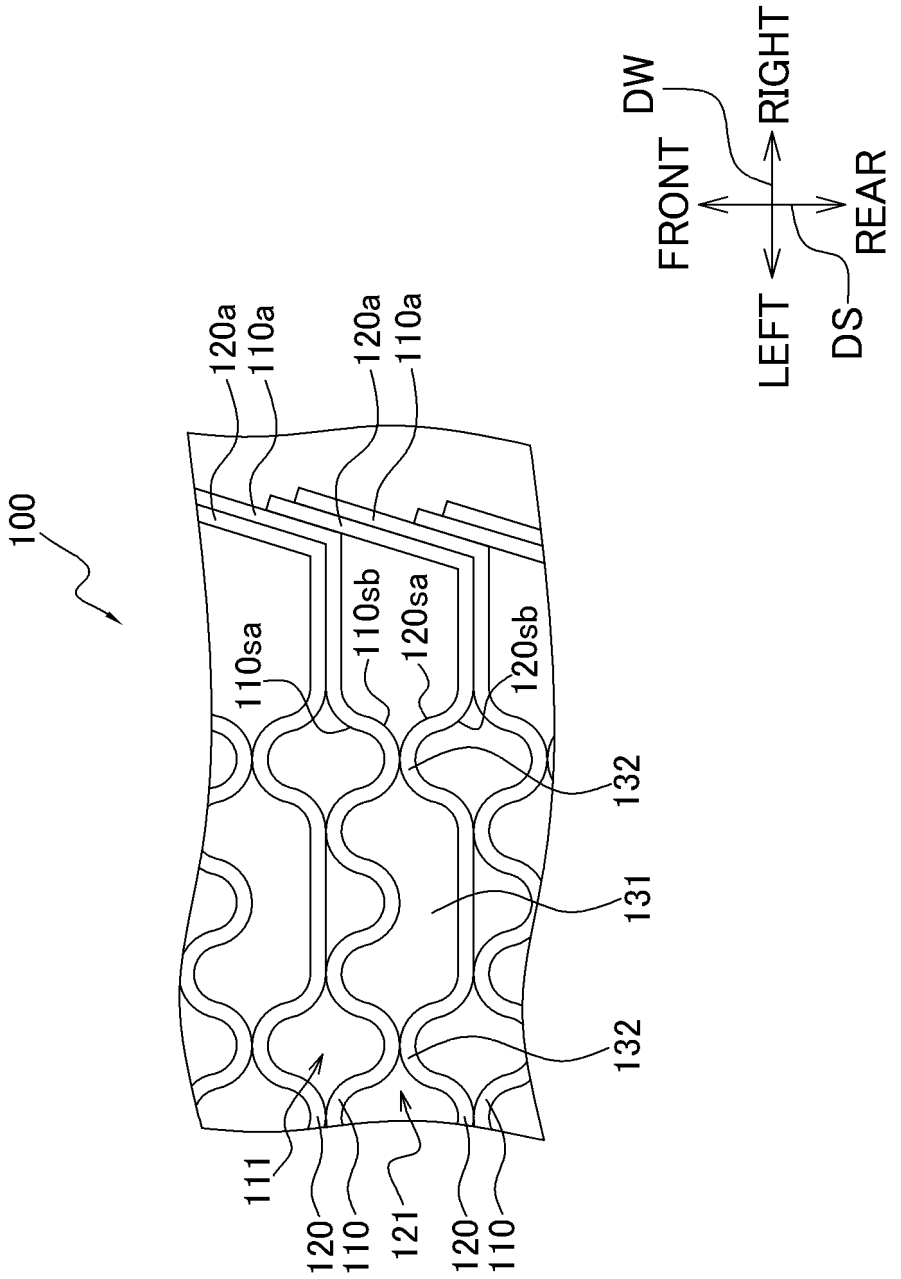

100
120a
110a
120a
110a
110sa
110sb
120sa
120sb
132
131
132
111
120
110
121
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110
DW
RIGHT
FRONT
REAR
LEFT
DS

FIG. 3

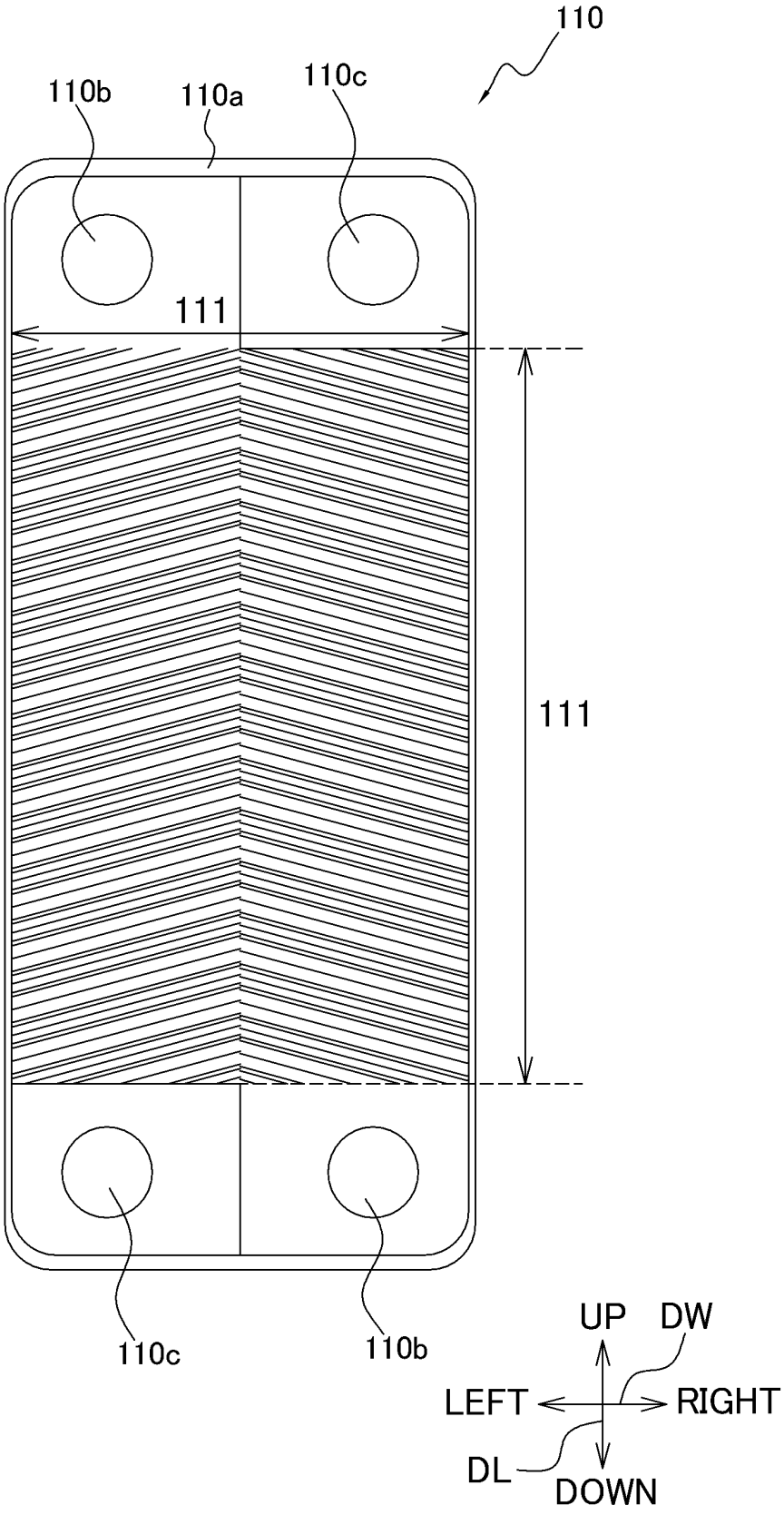


FIG. 4

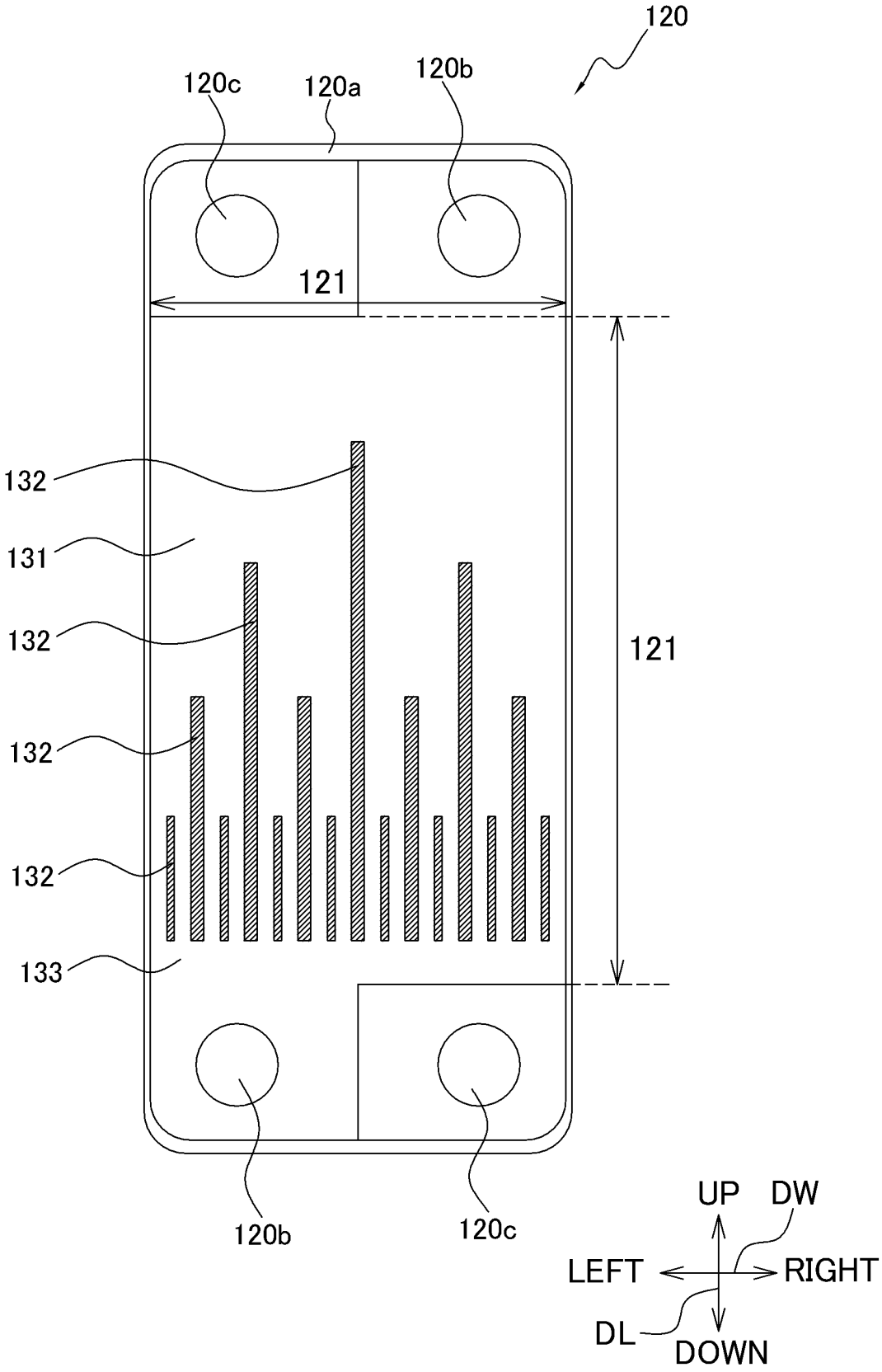

120
120c
120a
120b
121
132
131
132
132
132
133
121
120b
120c
UP
DW
LEFT
RIGHT
DL
DOWN

FIG. 5

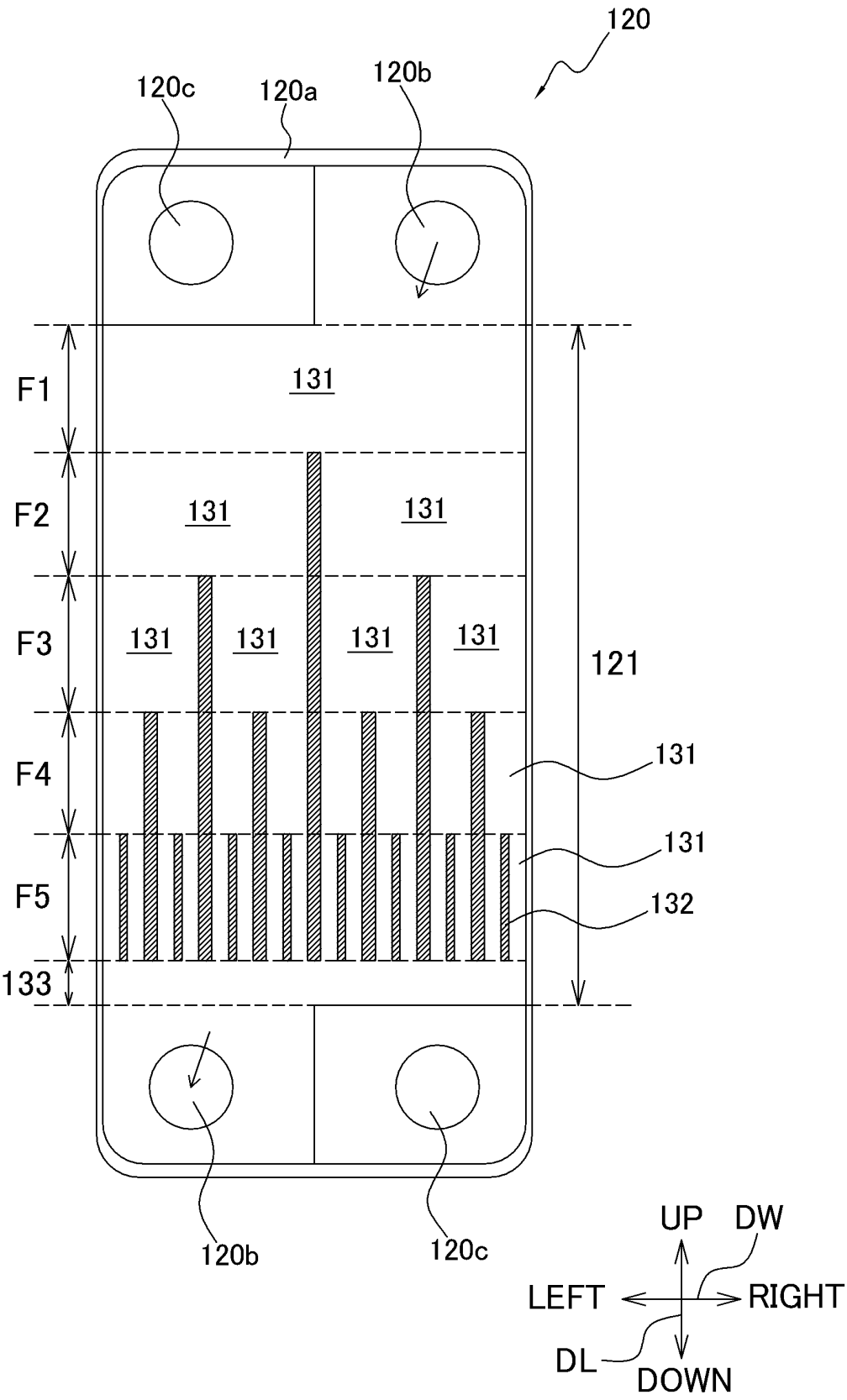

120
120c
120a
120b
F1
131
F2
131
131
F3
131
131
131
131
121
F4
131
131
F5
132
133
120b
120c
UP
DW
LEFT
RIGHT
DL
DOWN

FIG. 6

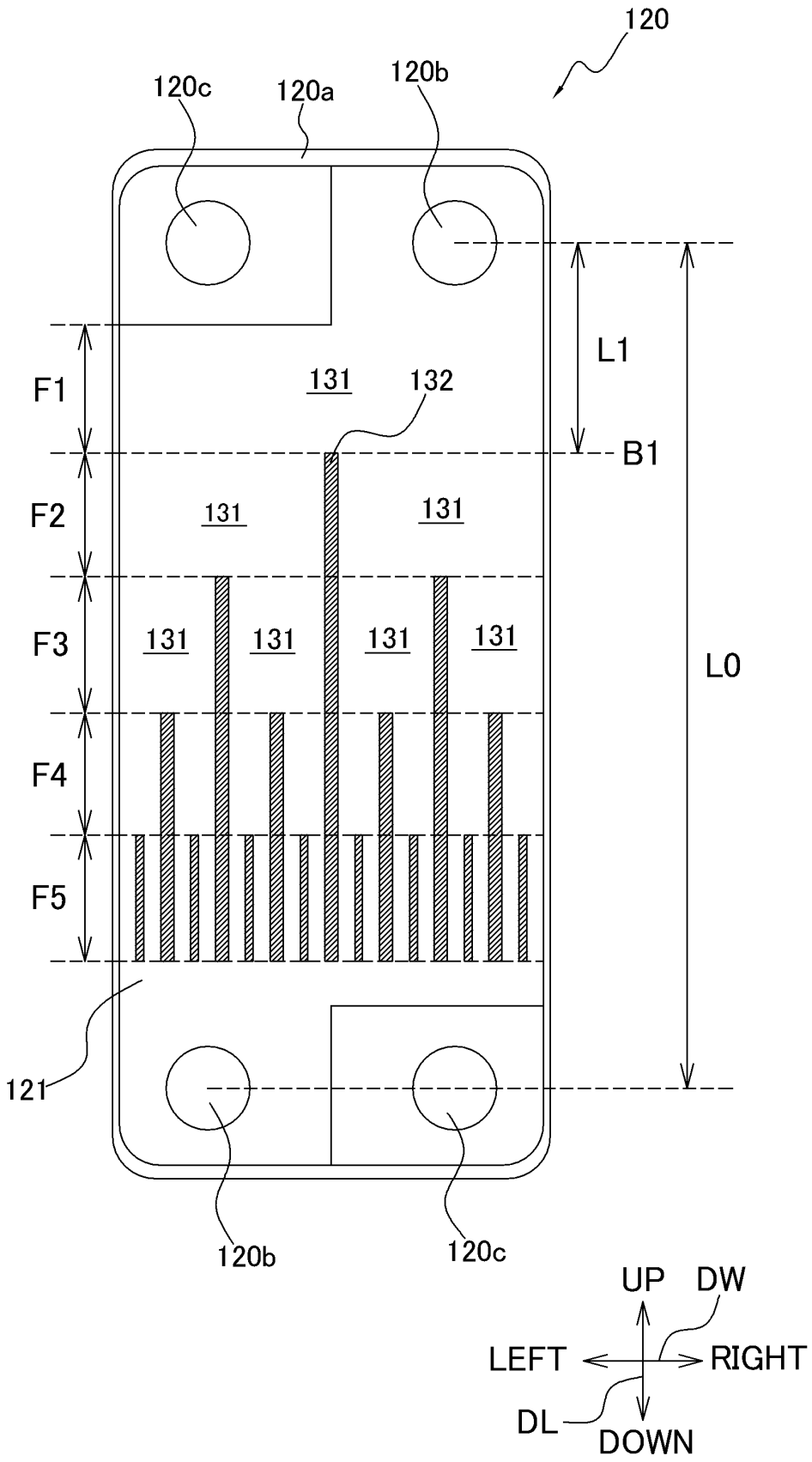

120
120c
120a
120b
L1
F1
131
132
B1
F2
131
131
F3
131
131
131
131
L0
F4
F5
121
120b
120c
UP
DW
LEFT
RIGHT
DL
DOWN

FIG. 7

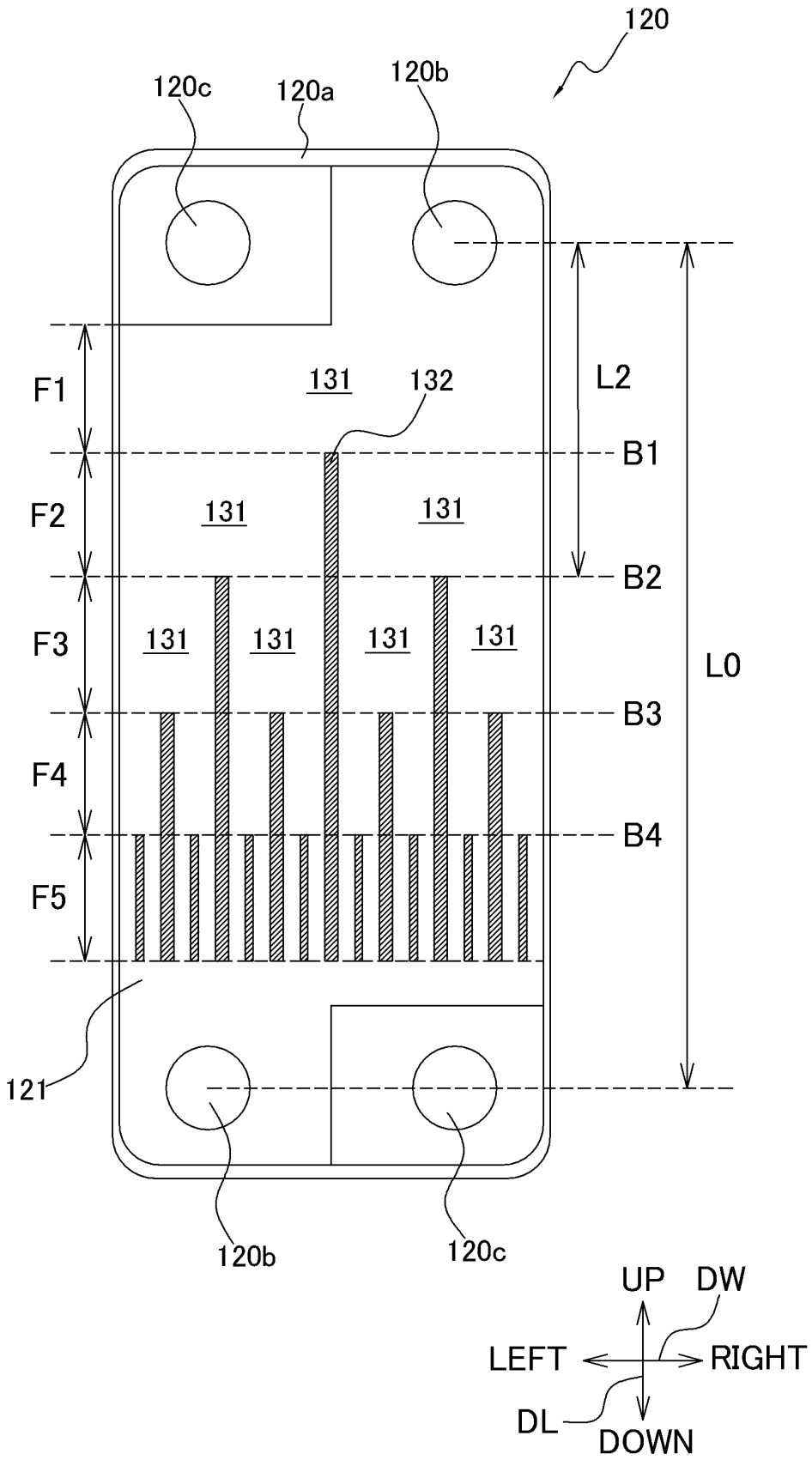

120
120c
120a
120b
F1
F2
F3
F4
F5
131
132
L2
L0
B1
B2
B3
B4
121
UP
DW
LEFT
RIGHT
DL
DOWN

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/025812

A. CLASSIFICATION OF SUBJECT MATTER

F28D 9/02(2006.01)i; ***F28F 3/00***(2006.01)i; ***F28F 3/04***(2006.01)i; ***F28F 3/08***(2006.01)i; ***F28F 9/22***(2006.01)i
FI: F28F3/08 301Z; F28D9/02; F28F3/00 301Z; F28F3/04 B; F28F9/22

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)

F28D9/02; F28F3/00; F28F3/04; F28F3/08; F28F9/22

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 5847913 B1 (SUMITOMO PRECISION PROD CO) 27 January 2016 (2016-01-27) paragraphs [0018]-[0041], [0044], [0082], [0087], fig. 1-4, 15	1-10
A	CN 102564205 A (HANGZHOU SHENSHI HEAT EXCHANGER CO., LTD.) 11 July 2012 (2012-07-11) paragraphs [0001]-[0032], fig. 1-3	1-10
A	JP 2004-504584 A (ROBERT BOSCH GMBH) 12 February 2004 (2004-02-12) fig. 3-5	1-10

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

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"E" earlier application or patent but published on or after the international filing date
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"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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 September 2023	**19 September 2023**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/025812

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 5847913 B1	27 January 2016	US 2017/0328644 A1 paragraphs [0033]-[0056], [0059], [0097], [0102], fig. 1-4, 15 WO 2016/072100 A1 EP 3217119 A1	
CN 102564205 A	11 July 2012	(Family: none)	
JP 2004-504584 A	12 February 2004	US 2003/0094271 A1 fig. 3-5 WO 2002/008680 A1 EP 1305561 A1 DE 10035939 A1 BR 106982 A KR 10-2002-0032602 A	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2016090157 A **[0003] [0098]**