



(11)

EP 4 006 474 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
01.06.2022 Bulletin 2022/22

(21) Application number: **19940038.3**

(22) Date of filing: **29.07.2019**

(51) International Patent Classification (IPC):
F28D 1/053 ^(2006.01)

(52) Cooperative Patent Classification (CPC):
F28D 1/0477; F28D 1/053; F28F 9/0275;
F28F 2210/08

(86) International application number:
PCT/JP2019/029678

(87) International publication number:
WO 2021/019647 (04.02.2021 Gazette 2021/05)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

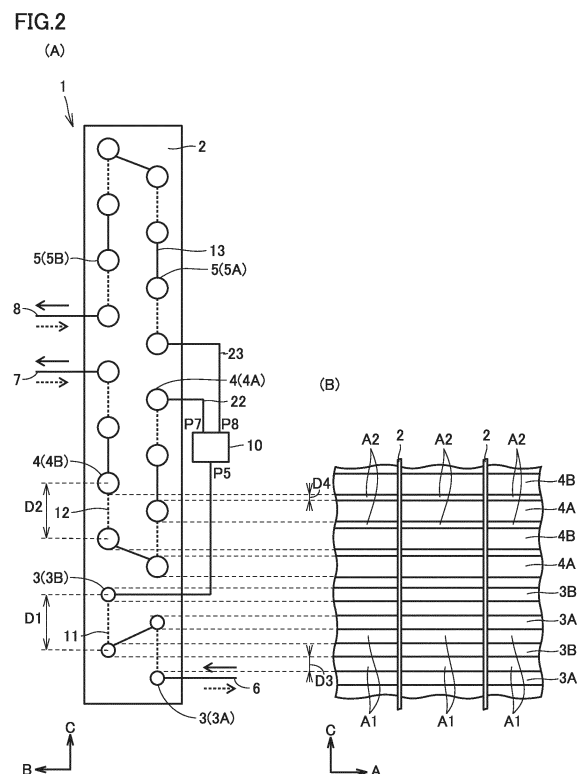
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(54) **HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE**

(57) A heat exchanger (1) is provided with a plurality of heat transfer tubes. The plurality of heat transfer tubes include a first heat transfer tube (3) configured to extend in a first direction intersecting a vertical direction (C), and a second heat transfer tube (4) which is located above the first heat transfer tube and configured to extend in the first direction. A first air passage is formed in a region adjacent to the first heat transfer tube in the vertical direction and is configured to extend in a second direction (B) intersecting both the vertical direction and the first direction. A second air passage is formed in a region adjacent to the second heat transfer tube in the vertical direction and is configured to extend in the second direction. The first heat transfer tube is connected in series to the second heat transfer tube. The flow path cross-sectional area of the first heat transfer tube is smaller than the flow path cross-sectional area of the second heat transfer tube. When viewed from the second direction, the projected area of the first air passage is greater than the projection area of the second air passage.



Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] During the heating operation, refrigerant flowing in a heat transfer tube and air flowing around the heat transfer tube exchange heat with each other in an outdoor heat exchanger, and thereby, moisture in the air may be condensed into condensation water on the surface of the outdoor heat exchanger. When the temperature of the outdoor unit heat exchanger is low, the condensation water is frozen on the surface of the outdoor unit heat exchanger and becomes frost. Since the condensation water accumulates in a lower part of the heat exchanger, the lower part of the heat exchanger is particularly affected by the frost.

[0003] According to the outdoor unit disclosed in Japanese Patent Laying-Open No. 2004-347135, in order to prevent frost from being formed in the lower part of the outdoor heat exchanger, an overcooling heat exchange member configured to excessively cool the liquid refrigerant condensed in the indoor heat exchanger during the heating operation is located on the windward side of the lower part of the outdoor heat exchanger. A part of the heat exchange member which operates as an evaporator in the outdoor heat exchanger during the heating operation is located on the leeward side of the overcooling heat exchange member.

CITATION LIST

PATENT LITERATURE

[0004] PTL 1: Japanese Patent Laying-Open No. 2004-347135

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] In the outdoor heat exchanger described above, since heat is exchanged between the overcooling heat exchange member and another heat exchange member located on the leeward side of the overcooling heat exchange member, the amount of heat exchanged between each heat exchange member and air is reduced, which deteriorates the performance of the outdoor heat exchanger.

[0006] A main object of the present invention is to provide a heat exchanger capable of preventing the formation of frost while preventing the performance thereof from being deteriorated by frost as compared with a conventional outdoor heat exchanger.

SOLUTION TO PROBLEM

[0007] The heat exchanger according to the present invention includes a plurality of heat transfer tubes. The plurality of heat transfer tubes include at least one first heat transfer tube configured to extend in a first direction intersecting a vertical direction, and at least one second heat transfer tube which is located above the at least one first heat transfer tube and configured to extend in the first direction. A first air passage is formed in a region adjacent to the at least one first heat transfer tube in the vertical direction and is configured to extend in a second direction intersecting both the vertical direction and the first direction. A second air passage is formed in a region adjacent to the at least one second heat transfer tube in the vertical direction and is configured to extend in the second direction. The at least one first heat transfer tube is connected in series to the at least one second heat transfer tube. The flow path cross-sectional area of the at least one first heat transfer tube is smaller than the flow path cross-sectional area of the at least one second heat transfer tube. When viewed from the second direction, the projected area of the first air passage is greater than the projected area of the second air passage.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] According to the present invention, it is possible to provide a heat exchanger capable of preventing the formation of frost while preventing the performance thereof from being deteriorated by the frost as compared with a conventional outdoor heat exchanger.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a view illustrating a refrigeration cycle apparatus according to a first embodiment;

Fig. 2(A) is a view illustrating a heat exchanger according to the first embodiment;

Fig. 2(B) is a view explaining the projected area of a first air passage and a second air passage of the heat exchanger illustrated in Fig. 2(A) when viewed from a second direction;

Fig. 3 is a cross-sectional view illustrating a first heat transfer tube of the heat exchanger according to the first embodiment;

Fig. 4 is a cross-sectional view illustrating a second heat transfer tube of the heat exchanger according to the first embodiment;

Fig. 5 is a view illustrating a heat exchanger according to a second embodiment;

Fig. 6 is a view illustrating a heat exchanger according to a third embodiment; and

Fig. 7 is a view illustrating a heat exchanger according to a fourth embodiment.

DESCRIPTION OF EMBODIMENTS

[0010] Hereinafter, embodiments of the present invention will be described with reference to the drawings. In the drawings, the same or corresponding portions are denoted by the same reference numerals, and the description thereof will not be repeated in principle.

First Embodiment

<Configuration of Refrigeration Cycle Apparatus>

[0011] As illustrated in Fig. 1, a refrigeration cycle apparatus 100 according to a first embodiment includes a refrigerant circuit in which refrigerant is circulated. The refrigerant circuit includes a compressor 101, a four-way valve 102 which serves as a flow path switching unit, a decompressor 103, a first heat exchanger 1, and a second heat exchanger 104. The refrigeration cycle apparatus 100 further includes a first fan 105 configured to blow air to the first heat exchanger 1 and a second fan 106 configured to blow air to the second heat exchanger 104.

[0012] The compressor 101 is provided with a discharge port configured to discharge refrigerant and a suction port configured to suck refrigerant. The decompressor 103 may be, for example, an expansion valve. The decompressor 103 is connected to a first inlet/outlet 6 of the first heat exchanger 1. The first fan 105 creates an airflow in a second direction B which will be described later.

[0013] The four-way valve 102 is provided with a first port P1 connected to the discharge port of the compressor 101 via a discharge pipe, a second port P2 connected to the suction port of the compressor 101 via a suction pipe, a third opening P3 connected to a second inlet/outlet 7 and a third inlet/outlet 8 of the first heat exchanger 1, and a fourth opening P4 connected to the second heat exchanger 104. The four-way valve 102 is configured to switch between a first state in which the first heat exchanger 1 operates as a condenser while the second heat exchanger 104 operates as an evaporator, and a second state in which the second heat exchanger 104 operates as a condenser while the first heat exchanger 1 operates as an evaporator. The arrows in solid line as illustrated in Fig. 1 indicate a flow direction of refrigerant circulated in the refrigerant circuit when the refrigeration cycle apparatus 100 is operating in the second state, and the arrows in dotted line as illustrated in Fig. 1 indicate a flow direction of refrigerant circulated in the refrigerant circuit when the refrigeration cycle apparatus 100 is operating in the first state.

<Configuration of First Heat Exchanger>

[0014] As illustrated in Figs. 2(A) and 2(B), the first heat exchanger 1 mainly includes, for example, a plurality of fins 2, a plurality of heat transfer tubes 3, 4 and 5, and

a distributor 10. The first heat exchanger 1 is configured to exchange heat between refrigerant flowing in each of the plurality of first heat transfer tubes 3, 4 and 5 in a first direction A and air flowing through the plurality of fins 2 in a second direction B. The first direction A intersects the second direction B, and may be, for example, orthogonal to the second direction B. The first direction A and the second direction B both intersect a vertical direction C, and each may be, for example, a horizontal direction.

[0015] As illustrated in Figs. 2(A) and 2(B), each of the plurality of fins 2 extends in the vertical direction C and the second direction B, and the plurality of fins 2 are spaced from each other in the first direction A.

[0016] The plurality of heat transfer tubes 3, 4 and 5 are composed of a plurality of first heat transfer tubes 3, a plurality of second heat transfer tubes 4, and a plurality of third heat transfer tubes 5. The plurality of first heat transfer tubes 3, the plurality of second heat transfer tubes 4, and the plurality of third heat transfer tubes 5 are configured to extend in the first direction A and are spaced from each other in the vertical direction C.

[0017] As illustrated in Fig. 2(A), the plurality of first heat transfer tubes 3 are arranged below the plurality of second heat transfer tubes 4 and the plurality of third heat transfer tubes 5. Among the plurality of heat transfer tubes provided in the first heat exchanger 1, at least one first heat transfer tube 3 is arranged at the lowest position. The plurality of first heat transfer tubes 3 are not aligned with the plurality of second heat transfer tubes 4 in the second direction B. The plurality of third heat transfer tubes 5 are located above the plurality of second heat transfer tubes 4.

[0018] As illustrated in Fig. 2(A), the plurality of first heat transfer tubes 3 are connected in series to each other via a first connection member 11. The plurality of second heat transfer tubes 4 are connected in series to each other via a second connection member 12. The plurality of third heat transfer tubes 5 are connected in series to each other via a third connection member 13.

[0019] As illustrated in Fig. 2(A), the plurality of first heat transfer tubes 3 are connected in series to the distributor 10 via a fourth connection member 21. The plurality of second heat transfer tubes 4 are connected in series to the distributor 10 via a fifth connection member 22. The plurality of third heat transfer tubes 5 are connected in series to the distributor 10 via a sixth connection member 23. Each of the first connection member 11, the second connection member 12, the third connection member 13, the fourth connection member 21, the fifth connection member 22, and the sixth connection member 23 is formed as a connection tube that connects two inlets/outlets in series to each other. In Fig. 2, each first connection member 11 indicated by a solid line is connected to one end of each first heat transfer tube 3, each second connection member 12 indicated by a solid line is connected to one end of each second heat transfer tube 4, and each third connection member 13 indicated by a solid line is connected to one end of each third heat

transfer tube 5; and each first connection member 11 indicated by a dotted line is connected to the other end of each first heat transfer tube 3, each second connection member 12 indicated by a dotted line is connected to the other end of each second heat transfer tube 4, and each third connection member 13 indicated by a dotted line is connected to the other end of each third heat transfer tube 5.

[0020] As illustrated in Fig. 2(A), the distributor 10 includes a first port P5 connected to the first heat transfer tube 3 via the fourth connection member 21, a second port P6 connected to the second heat transfer tube 4 via the fifth connection member 22, and a third port P7 connected to the third heat transfer tube 5 via the sixth connection member 23. The first port P5 is arranged below both the second port P6 and the third port P7. The distributor 10 further includes a refrigerant flow path which connects the first port P5 to the second port P6, and a refrigerant flow path which connects the first port P5 to the third port P7.

[0021] The plurality of first heat transfer tubes 3 connected in series to each other via the first connection member 11 constitute a first refrigerant flow path. The plurality of second heat transfer tubes 4 connected in series to each other via the second connection member 12 constitute a second refrigerant flow path. The plurality of third heat transfer tubes 5 connected in series to each other via the third connection member 13 constitute a third refrigerant flow path. The first refrigerant flow path is arranged below the second refrigerant flow path. The third refrigerant flow path is located above the second refrigerant flow path, for example.

[0022] The first refrigerant flow path is connected in series to both the second refrigerant flow path and the third refrigerant flow path via the distributor 10. The first heat transfer tubes 3 are connected in series to both the second heat transfer tubes 4 and the third heat transfer tubes 5 via the distributor 10. The second refrigerant flow path and the third refrigerant flow path are branched from the first refrigerant flow path. The second heat transfer tubes 4 and the third heat transfer tubes 5 are connected to the distributor 10 in parallel with each other.

[0023] One end of the first refrigerant flow path is connected to the first port P5 of the distributor 10. The other end of the first refrigerant flow path is connected to the first inlet/outlet 6. One end of the second refrigerant flow path is connected to the second port P6 of the distributor 10. The other end of the second refrigerant flow path is connected to the second inlet/outlet 7. One end of the third refrigerant flow path is connected to the third port P7 of the distributor 10. The other end of the third refrigerant flow path is connected to the third inlet/outlet 8.

[0024] In the first state, the refrigerant flows from the second inlet/outlet 7 and the third inlet/outlet 8 into the first heat exchanger 1, after the refrigerant flows through the second refrigerant flow path and the third refrigerant flow path, the refrigerant flows through the first refrigerant flow path, and then flows out of the first heat exchanger

1 from the first inlet/outlet 6. In the second state, the refrigerant flows from the first inlet/outlet 6 into the first heat exchanger 1, after the refrigerant flows through the first refrigerant flow path, the refrigerant flows through the second refrigerant flow path and the third refrigerant flow path, and then flows out of the first heat exchanger 1 from the second inlet/outlet 7 and the third inlet/outlet 8.

[0025] As illustrated in Fig. 2(A), each of the plurality of first heat transfer tubes 3 has the same configuration. The plurality of first heat transfer tubes 3 include a first group of first heat transfer tubes 3A spaced from each other in the vertical direction C, and a second group of first heat transfer tubes 3B spaced from each other in the vertical direction C and spaced from the first group of first heat transfer tubes 3A in the second direction B. In other words, the column number of the first heat transfer tubes 3 arranged in the second direction B is 2 or more. In the first embodiment, the column number of the first heat transfer tubes 3 arranged in the second direction B is equal to the column number of the second heat transfer tubes 4 arranged in the second direction B.

[0026] The first group of first heat transfer tubes 3A and the second group of first heat transfer tubes 3B are adjacent to each other in the second direction B. When viewed from the second direction B, at least a part of each first heat transfer tube 3B is located between two of the first heat transfer tubes 3A adjacent to each other in the vertical direction. For example, the entire part of each first heat transfer tube 3B is located between two of the first heat transfer tubes 3A adjacent to each other in the vertical direction. The first group of first heat transfer tubes 3A are connected in series to each other, for example. The second group of first heat transfer tubes 3B are connected in series to each other, for example. The first group of first heat transfer tubes 3A are connected in series to the second group of first heat transfer tubes 3B, for example.

[0027] The lowest first heat transfer tube 3 of the plurality of first heat transfer tubes 3 is the lowest first heat transfer tubes 3A in the first group of first heat transfer tubes 3A. The lowest first heat transfer tubes 3A in the first group of first heat transfer tubes 3A is connected to the first inlet/outlet 6. The uppermost first heat transfer tube 3 of the plurality of first heat transfer tubes 3 is the uppermost first heat transfer tube 3B in the second group of first heat transfer tubes 3B. The uppermost first heat transfer tube 3B in the second group of first heat transfer tubes 3B is connected to the distributor 10 via the fourth connection member 21. The first group of first heat transfer tubes 3A are located on the windward side of the second group of first heat transfer tubes 3B.

[0028] As illustrated in Fig. 2(A), each of the plurality of second heat transfer tubes 4 has the same configuration. The plurality of second heat transfer tubes 4 include a first group of second heat transfer tubes 4A spaced from each other in the vertical direction C, and a second group of second heat transfer tubes 4B spaced from each other in the vertical direction C and spaced from the first

group of second heat transfer tubes 4A in the second direction B. In other words, the column number of the plurality of second heat transfer tubes 4 arranged in the second direction B is 2 or more.

[0029] The first group of second heat transfer tubes 4A and the second group of second heat transfer tubes 4B are adjacent to each other in the second direction B. When viewed from the second direction B, at least a part of each second heat transfer tube 4B is located between two of the second heat transfer tubes 4A adjacent to each other in the vertical direction. For example, the entire part of each second heat transfer tube 4B is located between two of the second heat transfer tubes 4A adjacent to each other in the vertical direction. The first group of second heat transfer tubes 4A are connected in series to each other, for example. The second group of second heat transfer tubes 4B are connected in series to each other, for example. The first group of second heat transfer tubes 4A are connected in series to the second group of second heat transfer tubes 4B, for example. The first group of second heat transfer tubes 4A are located on the windward side of the second group of second heat transfer tubes 4B.

[0030] The lowest second heat transfer tubes 4 of the plurality of second heat transfer tubes 4 is the lowest second heat transfer tubes 4A in the first group of second heat transfer tubes 4A. The lowest second heat transfer tube 4A in the first group of second heat transfer tubes 4A is connected to the lowest second heat transfer tube 4B in the second group of second heat transfer tubes 4B via the second connection member 12.

[0031] As illustrated in Fig. 2(A), each of the plurality of third heat transfer tubes 5 has the same configuration. The plurality of third heat transfer tubes 5 include a first group of third heat transfer tubes 5A spaced from each other in the vertical direction C, and a second group of third heat transfer tubes 5B spaced from each other in the vertical direction C and spaced from the first group of third heat transfer tubes 5A in the second direction B. In other words, the column number of the third heat transfer tubes 5 arranged in the second direction B is 2 or more.

[0032] The first group of third heat transfer tubes 5A and the second group of third heat transfer tubes 5B are adjacent to each other in the second direction B. The first group of third heat transfer tubes 5A are located on the windward side of the second group of third heat transfer tubes 5B. When viewed from the second direction B, at least a part of each third heat transfer tube 5B is located between two of the third heat transfer tubes 5A adjacent to each other in the vertical direction. For example, the entire part of each third heat transfer tube 5B is located between two of the third heat transfer tubes 5A adjacent to each other in the vertical direction. The first group of third heat transfer tubes 5A are connected in series to each other, for example. The second group of third heat transfer tubes 5B are connected in series to each other, for example. The first group of third heat transfer tubes 5A are connected in series to the second group of third

heat transfer tubes 5B, for example.

[0033] As illustrated in Fig. 2(B), a plurality of first air passages A1 are formed in a region adjacent to each first heat transfer tube 3 in the vertical direction C and configured to extend in the second direction B. Each first air passage A1 is a minimum unit of the entire air passage formed in a region adjacent to each first heat transfer tube 3 in the vertical direction C. The plurality of first air passages A1 are arranged side by side in the first direction A. Two of the first air passages A1 adjacent to each other in the first direction are partitioned by a fin 2. When viewed from the second direction B, each first air passage A1 is located between the first heat transfer tubes 3A and 3B adjacent to each other in the vertical direction C. A width D3 of each first air passage A1 in the vertical direction C is equal to a gap between the first heat transfer tubes 3A and 3B adjacent to each other in the vertical direction C when viewed from the second direction B, but is smaller than a gap D1 (see Fig. 2(A)) between two of the first heat transfer tubes 3 arranged side by side in the vertical direction C.

[0034] Among the plurality of air passages formed in a region adjacent to each of the plurality of heat transfer tubes 3, 4 and 5 in the vertical direction C and configured to extend in the second direction B, an air passage located at the lowest position constitutes the first air passage A1.

[0035] As illustrated in Fig. 2(B), a plurality of second air passages A2 are formed in a region adjacent to each second heat transfer tube 4 in the vertical direction C and configured to extend in the second direction B. Each second air passage A2 is a minimum unit of the entire air passage formed in a region adjacent to each second heat transfer tube 4 in the vertical direction C. The second air passages A2 are arranged side by side in the first direction A. Two of the second air passages A2 adjacent to each other in the first direction are partitioned by a fin 2. Each second air passage A2 is located above each first air passage A1. When viewed from the second direction B, each second air passage A2 is located between the second heat transfer tubes 4A and 4B adjacent to each other in the vertical direction C. A width D4 of the second air passage A2 in the vertical direction C is equal to a gap between the second heat transfer tubes 4A and 4B adjacent to each other in the vertical direction C when viewed from the second direction B, but is smaller than a gap D2 (see Fig. 2(A)) between two of the second heat transfer tubes 4 arranged side by side in the vertical direction C.

[0036] As illustrated in Fig. 2(B), when viewed from the second direction B, the projected area of each first air passage A1 is greater than the projected area of each second air passage A2. In other words, the width of each first air passage A1 in the vertical direction C is greater than the width of each second air passage A2 in the vertical direction C.

[0037] As illustrated in Fig. 2(A), the gap D1 between two of the first heat transfer tubes 3 arranged side by

side in the vertical direction C is equal to the gap D2 between two of the second heat transfer tubes 4 arranged side by side in the vertical direction C. As illustrated in Figs. 2(A), 3 and 4, a width W1 of each first heat transfer tube 3 in the vertical direction is smaller than a width W2 of each second heat transfer tube 4 in the vertical direction. Therefore, the gap D3 between the first heat transfer tubes 3A and 3B in the vertical direction C when viewed from the second direction B is greater than the gap D4 between the second heat transfer tubes 4A and 4B in the vertical direction C when viewed from the second direction B. The gap D3 between the first heat transfer tubes 3A and 3B in the vertical direction C when viewed from the second direction B is equal to the width of the first air passage A1 in the vertical direction C. The gap D4 between the second heat transfer tubes 4A and 4B in the vertical direction C when viewed from the second direction B is equal to the width of each second air passage A2 in the vertical direction C. Therefore, the width of each first air passage A1 in the vertical direction C is greater than the width of each second air passage A2 in the vertical direction C.

[0038] The projected area of each first air passage A1 is obtained by subtracting, from the projected area of a space between two of the first heat transfer tubes 3 located on the most windward side and arranged adjacent to each other in the vertical direction C, the projected area of a first heat transfer tube 3 located between the two first heat transfer tubes 3. The projected area of each second air passage A2 is obtained by subtracting, from the projected area of a space between two of the second heat transfer tubes 4 located on the most windward side and arranged adjacent to each other in the vertical direction C, the projected area of a second heat transfer tube 4 located between the two second heat transfer tubes 4.

[0039] As illustrated in Figs. 3 and 4, the flow path cross-sectional area of the refrigerant in each of the plurality of first heat transfer tubes 3 is smaller than the flow path cross-sectional area of the refrigerant in each of the plurality of second heat transfer tubes 4.

[0040] As illustrated in Figs. 2(A), 3 and 4, each of the plurality of first heat transfer tubes 3 and the plurality of second heat transfer tubes 4 is formed as a circular tube, for example. As illustrated in Figs. 2(A), 3 and 4, the outer diameter W1 of each of the plurality of first heat transfer tubes 3 is smaller than the outer diameter W2 of each of the plurality of second heat transfer tubes 4. The inner diameter of each of the plurality of first heat transfer tubes 3 is smaller than the inner diameter of each of the plurality of second heat transfer tubes 4.

[0041] A plurality of third air passages (not shown) are formed in a region adjacent to each third heat transfer tube 5 in the vertical direction C and configured to extend in the second direction B. The third air passages are arranged side by side in the first direction A. Two of the third air passages adjacent to each other in the first direction are partitioned by a fin 2. Each third air passage is a minimum unit of the entire air passage formed in a

region adjacent to each third heat transfer tube 5 in the vertical direction C. When viewed from the second direction B, each third air passage is located between the third heat transfer tubes 5A and 5B adjacent to each other in the vertical direction C. The width of the third air passage in the vertical direction C is equal to the gap between the third heat transfer tubes 5A and 5B adjacent to each other in the vertical direction C when viewed from the second direction B, but is smaller than the gap between two of the third heat transfer tubes 5 arranged side by side in the vertical direction C.

[0042] When viewed from the second direction B, the projected area of each first air passage A1 is greater than the projected area of each third air passage. The gap between two of the plurality of first heat transfer tubes 3 adjacent to each other in the vertical direction is equal to the gap between two of the plurality of third heat transfer tubes 5 adjacent to each other in the vertical direction. The vertical width W1 of each first heat transfer tube 3 in the vertical direction is smaller than the vertical width of each third heat transfer tube 5 in the vertical direction. The flow path cross-sectional area of the refrigerant in each of the plurality of first heat transfer tubes 3 is smaller than the flow path cross-sectional area of the refrigerant in each of the plurality of third heat transfer tubes 5.

[0043] The projected area of each third air passage is equal to the projected area of each second air passage. The gap between two of the plurality of third heat transfer tubes 5 adjacent to each other in the vertical direction is equal to the gap between two of the plurality of second heat transfer tubes 4 adjacent to each other in the vertical direction. The width of each third heat transfer tube 5 in the vertical direction is equal to the width W2 of each second heat transfer tube 4 in the vertical direction. The flow path cross-sectional area of the refrigerant in each of the plurality of third heat transfer tubes 5 is equal to the flow path cross-sectional area of the refrigerant in each of the plurality of second heat transfer tubes 4.

<Effects>

[0044] In the first heat exchanger 1, the flow path cross-sectional area of the refrigerant in the first heat transfer tube 3 is smaller than the flow path cross-sectional area of the refrigerant in the second heat transfer tube 4. In other words, the pressure loss of the refrigerant flowing in the first heat transfer tube 3 is greater than the pressure loss of the refrigerant flowing in the second heat transfer tube 4. Therefore, when the refrigerant flows from the first heat transfer tube 3 into the second heat transfer tube 4 in the second state, the pressure of the refrigerant flowing in the first heat transfer tube 3 is higher than the pressure of the refrigerant flowing in the second heat transfer tube 4. In the second state, the refrigerant flowing through the first heat transfer tube 3 and the second heat transfer tube 4 is in a gas-liquid two-phase state, and the pressure of the refrigerant is positively correlated to the temperature of the refrigerant. Therefore, in the second

state, the temperature of the refrigerant flowing in the first heat transfer tube 3 is higher than the temperature of the refrigerant flowing in the second heat transfer tube 4.

[0045] Further, in the first heat exchanger 1, when viewed from the second direction B, the projected area of the first air passage A1 is greater than the projected area of the second air passage A2. Therefore, the air volume in the first air passage A1 is greater than the air volume in the second air passage A2, which makes it easier to drain the condensation water in the first air passage A1 to the outside.

[0046] Specifically, in the first heat exchanger 1, the air flowing around the first heat transfer tube 3 and the refrigerant flowing in the first heat transfer tube 3 prevent frost from being formed on the first heat transfer tube 3. Therefore, even if the temperature difference between the temperature of the refrigerant flowing in the first heat transfer tube 3 and the temperature of the refrigerant flowing in the second heat transfer tube 4 is smaller than the temperature difference between the temperature of the overcooling heat exchange member and the temperature of the other heat exchange members in the conventional heat exchanger mentioned above, it is possible to prevent frost from being formed on the first heat transfer tube 3 at a capacity equal to or greater than that of the conventional heat exchanger mentioned above. In other words, according to the first heat exchanger 1, it is possible to prevent the formation of frost while preventing the performance thereof from being deteriorated by the frost as compared with a conventional outdoor heat exchanger.

[0047] Further, in the first heat exchanger 1, an air passage which is located at the lowest position among the plurality of air passages formed in a region adjacent to each of the plurality of heat transfer tubes 3, 4 and 5 in the vertical direction C and configured to extend in the second direction B constitutes the first air passage A1. Frost is more likely to be formed in the lowest air passage than an upper air passage thereof. Therefore, according to the first heat exchanger 1 in which the first air passage A1 is constituted by the lowest air passage, it is possible to effectively prevent the performance thereof from being deteriorated by the frost.

[0048] Moreover, the first heat exchanger 1 further includes a plurality of third heat transfer tubes 5 connected to the plurality of first heat transfer tubes 3 in parallel with the plurality of second heat transfer tubes 4. Therefore, the flow rate of the refrigerant flowing through each of the first heat transfer tubes 3 is greater than the flow rate of the refrigerant flowing through each of the second heat transfer tubes 4, which makes the flow velocity of the refrigerant flowing through each of the first heat transfer tubes 3 faster than the flow velocity of the refrigerant flowing through each of the second heat transfer tubes 4. As a result, the pressure loss of the refrigerant flowing through the first heat transfer tube 3 becomes greater than the pressure loss of the refrigerant flowing through

the second heat transfer tube 4 due to the difference in the flow path cross-sectional area and the difference in the flow velocity, whereby the temperature of the refrigerant flowing through the first heat transfer tube 3 becomes higher than the temperature of the refrigerant flowing through the second heat transfer tube 4 in the second state.

[0049] In the refrigeration cycle apparatus 100, the first heat exchanger 1 is configured in such a manner that the refrigerant flows from the first heat transfer tube 3 into the second heat transfer tube 4 in the second state. Thus, it is possible for the first heat exchanger 1 to prevent the formation of frost while preventing the performance thereof from being deteriorated by the frost as compared with a conventional outdoor heat exchanger. As a result, the operation efficiency of the refrigeration cycle apparatus 100 in the second state is improved than that of a refrigeration cycle apparatus equipped with the conventional outdoor heat exchanger.

Second Embodiment

[0050] As illustrated in Fig. 5, a first heat exchanger 1A according to a second embodiment has basically the same configuration as the first heat exchanger 1 according to the first embodiment, but differs from the first heat exchanger 1 according to the first embodiment in that the gap D1 between two of the first heat transfer tubes 3 adjacent to each other in the vertical direction C is greater than the gap D2 between two of the second heat transfer tubes 4 adjacent to each other in the vertical direction C.

[0051] In this case, the projected area of the first air passage A1 in the first heat exchanger 1A is greater than the projected area of the second air passage A2 in the first heat exchanger 1A. Further, when the first heat exchanger 1A having the gap D2 is compared with the first heat exchanger 1 having the same gap D2 according to the first embodiment, the gap D1 in the first heat exchanger 1A is greater than the gap D1 in the first heat exchanger 1, whereby the projected area of the first air passage A1 in the first heat exchanger 1A is greater than the projected area of the first air passage A1 in the first heat exchanger 1. As a result, it is possible for the first heat exchanger 1A according to the second embodiment to further prevent frost from being formed on the first heat transfer tube 3 as compared with the first heat exchanger 1 according to the first embodiment.

Third Embodiment

[0052] As illustrated in Fig. 6, a first heat exchanger 1B according to a third embodiment has basically the same configuration as the first heat exchanger 1 according to the first embodiment, but differs from the first heat exchanger 1 according to the first embodiment in that the column number of the plurality of first heat transfer tubes 3 arranged in the second direction B is smaller than the column number of the plurality of second heat transfer

tubes 4 arranged in the second direction B.

[0053] The column number of the first heat transfer tubes 3 arranged in the second direction B is 1 or more. The column number of the plurality of second heat transfer tubes 4 arranged in the second direction B is greater than the column number of the plurality of first heat transfer tubes 3 arranged in the second direction B, and is 2 or more.

[0054] With reference to Fig. 6, a configuration example in which the column number of the first heat transfer tubes 3 arranged in the second direction B is 1 will be described. In this configuration, each first air passage A1 is located between two adjacent first heat transfer tubes 3 arranged side by side in the vertical direction C. Therefore, the width of the first air passage A1 in the vertical direction C is equal to the gap D1 between the two adjacent first heat transfer tubes 3 arranged side by side in the vertical direction C.

[0055] On the other hand, each second air passage A2 is located between the second heat transfer tubes 4A and 4B adjacent to each other in the vertical direction C when viewed from the second direction B. The width of the second air passage A2 in the vertical direction C is equal to the gap between the second heat transfer tubes 4A and 4B adjacent to each other in the vertical direction C when viewed from the second direction B, but is smaller than the gap D2 (see Fig. 2(A)) between two of the second heat transfer tubes 4 arranged side by side in the vertical direction C.

[0056] Thus, even when the gap D1 is equal to the gap D2, the width of the first air passage A1 in the vertical direction C is twice as great as the width of the second air passage A2 in the vertical direction C. As a result, the projected area of the first air passage A1 is twice as great as the projected area of the second air passage A2, whereby the drainage efficiency of the first air passage A1 is considerably higher than the drainage efficiency of the second air passage A2.

[0057] When the first heat exchanger 1B according to the third embodiment is compared with the first heat exchanger 1 according to the first embodiment in which the gap D1 and the gap D2 are equal to those in the first heat exchanger 1B, the projected area of the first air passage A1 in the first heat exchanger 1B is greater than the projected area of the first air passage A1 in the first heat exchanger 1. Thus, the drainage efficiency of the first air passage A1 in the first heat exchanger 1B becomes higher than the drainage efficiency of the first air passage A1 in the first heat exchanger 1.

[0058] Moreover, in the first heat exchanger 1 according to the third embodiment, the column number of the first heat transfer tubes 3 arranged in the second direction B may be two or more as long as the column number of the first heat transfer tubes 3 arranged in the second direction B is smaller than the column number of the first heat transfer tubes 3 arranged in the second direction B. Even in this case, the column number of the first heat transfer tubes 3 which are located on the most windward

side and arranged between two of the first heat transfer tubes 3 adjacent to each other in the vertical direction C when viewed from the second direction B is smaller than the column number of the second heat transfer tubes 4 which are located on the most windward side and arranged between two of the second heat transfer tubes 4 adjacent to each other in the vertical direction C.

[0059] As described above, the projected area of each first air passage A1 is obtained by subtracting, from the projected area of a space between the projected area of two of the first heat transfer tubes 3 located on the most windward side and arranged adjacent to each other in the vertical direction C, the projected area of a first heat transfer tube 3 arranged between the two first heat transfer tubes 3. The projected area of each second air passage A2 is obtained by subtracting, from the projected area of a space between two of the second heat transfer tubes 4 located on the most windward side and arranged adjacent to each other in the vertical direction C, the projected area of a second heat transfer tube 4 arranged between the two second heat transfer tubes 4.

[0060] In the first heat exchanger 1B, even if the column number of the first heat transfer tubes 3 is two or more, since the column number of the first heat transfer tubes 3 is smaller than the column number of the second heat transfer tubes 4, the number of the first heat transfer tubes 3 arranged between two of the first heat transfer tubes 3 is smaller than the number of the second heat transfer tubes 4 arranged between two of the second heat transfer tubes 4. As a result, the projected area of the first air passage A1 is greater than the projected area of the second air passage A2, and thereby, the drainage efficiency of the first air passage A1 is higher than the drainage efficiency of the second air passage A2.

Fourth Embodiment

[0061] As illustrated in Fig. 7, the first heat exchanger 1C according to a fourth embodiment has basically the same configuration as the first heat exchanger 1A according to the second embodiment, but differs from the first heat exchanger 1A according to the second embodiment in that the column number of the plurality of first heat transfer tubes 3 arranged in the second direction B is smaller than the column number of the plurality of second heat transfer tubes 4 arranged in the second direction B. From another point of view, the first heat exchanger 1C has basically the same configuration as the first heat exchanger 1B according to the third embodiment, but differs from the first heat exchanger 1B according to the third embodiment in that the gap D1 between two of the first heat transfer tubes 3 adjacent to each other in the vertical direction C is greater than the gap D2 between two of the second heat transfer tubes 4 adjacent to each other in the vertical direction C.

[0062] Since the first heat exchanger 1C includes both the configuration of the first heat exchanger 1A and the configuration of the first heat exchanger 1B, the projected

area of the first air passage A1 of the first heat exchanger 1C is greater than the projected area of the second air passage A2 of the first heat exchanger 1C, and is greater than the projected area of the first air passage A1 of the first heat exchanger 1, the projected area of the first air passage A1 of the first heat exchanger 1A, and the projected area of the first air passage A1 of the first heat exchanger 1B. As a result, it is possible for the first heat exchanger 1C to more efficiently prevent frost from being formed on the first heat transfer tube 3 than the first heat exchanger 1, the first heat exchanger 1A, and the first heat exchanger 1B.

<Modifications>

[0063] In the first heat exchangers 1, 1A, 1B and 1C, each of the plurality of heat transfer tubes 3, 4 and 5 is formed as a circular tube, but it is not limited thereto. Each of the plurality of heat transfer tubes 3, 4 and 5 may be formed as a flat tube.

[0064] Each of the first heat exchangers 1, 1A, 1B and 1C is configured to include a plurality of first heat transfer tubes 3 and a plurality of second heat transfer tubes 4, but it is not limited thereto. Each of the first heat exchangers 1, 1A, 1B and 1C may include one first heat transfer tube 3 and one second heat transfer tube 4.

[0065] Although the embodiments of the present invention have been described above, the embodiments described above may be modified in various ways. The scope of the present invention is not limited to the embodiments described above. The scope of the present invention is defined by the terms of the claims, and is intended to include all modifications within the meaning and scope equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0066] 1, 1A, 1B, 1C: first heat exchanger; 2: fin; 3, 3A, 3B: first heat transfer tube; 4, 4A, 4B: second heat transfer tube; 5, 5A, 5B: third heat transfer tube; 6: first inlet/outlet; 7: second inlet/outlet; 8: third inlet/outlet; 10: distributor; 11: first connection member; 12: second connection member; 13: third connection member; 21: fourth connection member; 22: fifth connection member; 23: sixth connection member; 100: refrigeration cycle apparatus; 101: compressor; 102: four-way valve; 103: decompressor; 104: second heat exchanger; 105: first fan; 106: second fan

Claims

1. A heat exchanger comprising:

a plurality of heat transfer tubes;
the plurality of heat transfer tubes including:
at least one first heat transfer tube config-

ured to extend in a first direction intersecting a vertical direction; and
at least one second heat transfer tube located above the at least one first heat transfer tube and configured to extend in the first direction,

a first air passage being formed in a region adjacent to the at least one first heat transfer tube in the vertical direction and being configured to extend in a second direction intersecting both the vertical direction and the first direction, a second air passage being formed in a region adjacent to the at least one second heat transfer tube in the vertical direction and being configured to extend in the second direction, the at least one first heat transfer tube being connected in series to the at least one second heat transfer tube,
a flow path cross-sectional area of the at least one first heat transfer tube being smaller than a flow path cross-sectional area of the at least one second heat transfer tube, and
when viewed from the second direction, a projected area of the first air passage being greater than a projected area of the second air passage.

2. The heat exchanger according to claim 1, wherein

the at least one first heat transfer tube includes a plurality of the first heat transfer tubes, the at least one second heat transfer tube includes a plurality of the second heat transfer tubes,
the plurality of first heat transfer tubes are spaced from each other in the vertical direction and connected in series to each other, the plurality of second heat transfer tubes are spaced from each other in the vertical direction and connected in series to each other, the first air passage is located between two of the plurality of first heat transfer tubes adjacent to each other in the vertical direction, and the second air passage is located between two of the plurality of second heat transfer tubes adjacent to each other in the vertical direction.

3. The heat exchanger according to claim 2, wherein a gap between two of the plurality of first heat transfer tubes adjacent to each other in the vertical direction is greater than a gap between two of the plurality of second heat transfer tubes adjacent to each other in the vertical direction.

4. The heat exchanger according to claim 2 or 3, wherein the column number of the plurality of first heat transfer tubes arranged in the second direction is smaller

than the column number of the plurality of second heat transfer tubes arranged in the second direction.

5. The heat exchanger according to any one of claims 2 to 4 further comprising: 5
a plurality of third heat transfer tubes connected to the plurality of first heat transfer tubes in parallel with the plurality of second heat transfer tubes.
6. The heat exchanger according to any one of claims 1 to 5, wherein among a plurality of air passages, 10
each of which is formed in a region adjacent to each of the plurality of heat transfer tubes in the vertical direction and is configured to extend in the second direction, an air passage located at the lowest position constitutes the first air passage. 15
7. A refrigeration cycle apparatus comprising:
 - a compressor; 20
 - a flow path switching unit;
 - a decompressor;
 - a first heat exchanger; and
 - a second heat exchanger, 25
 - the flow path switching unit being configured to switch between a first state and a second state, 25
 - in the first state, refrigerant flowing through the compressor, the first heat exchanger, the decompressor, and the second heat exchanger in this order, and in the second state, the refrigerant 30
 - flowing through the compressor, the second heat exchanger, the decompressor, and the first heat exchanger in this order, 30
 - the first heat exchanger being the heat exchanger according to any one of claims 1 to 6, 35
 - the refrigerant flowing from the at least one second heat transfer tube to the at least one first heat transfer tube in the first state, and flowing 40
 - from the at least one first heat transfer tube to the at least one second heat transfer tube in the second state. 40

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FIG.1

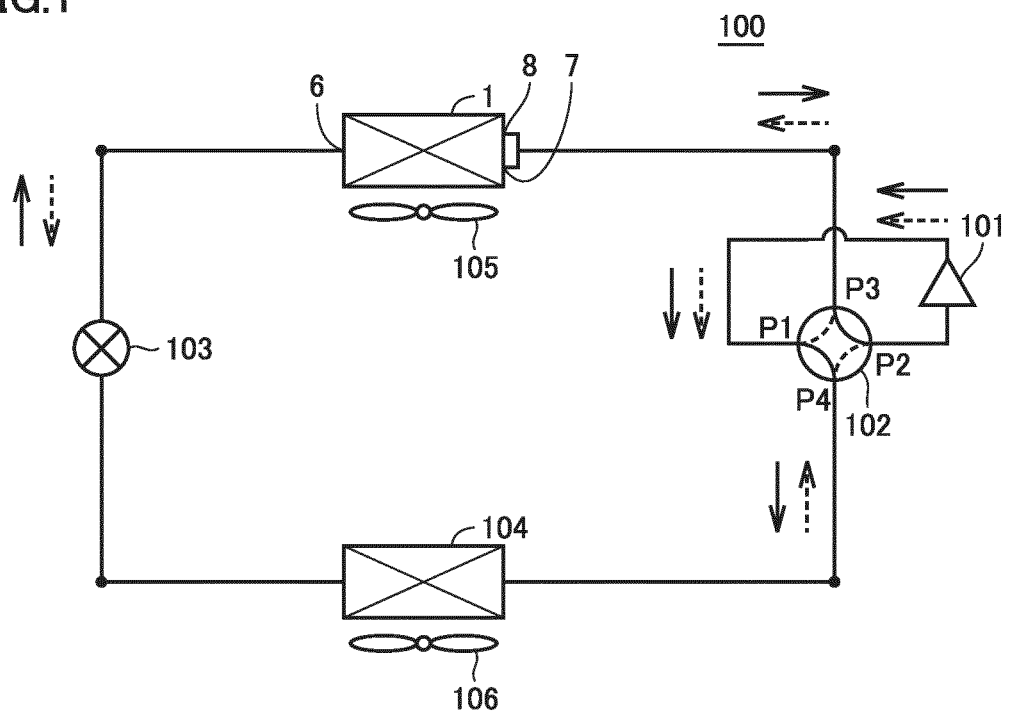


FIG.2

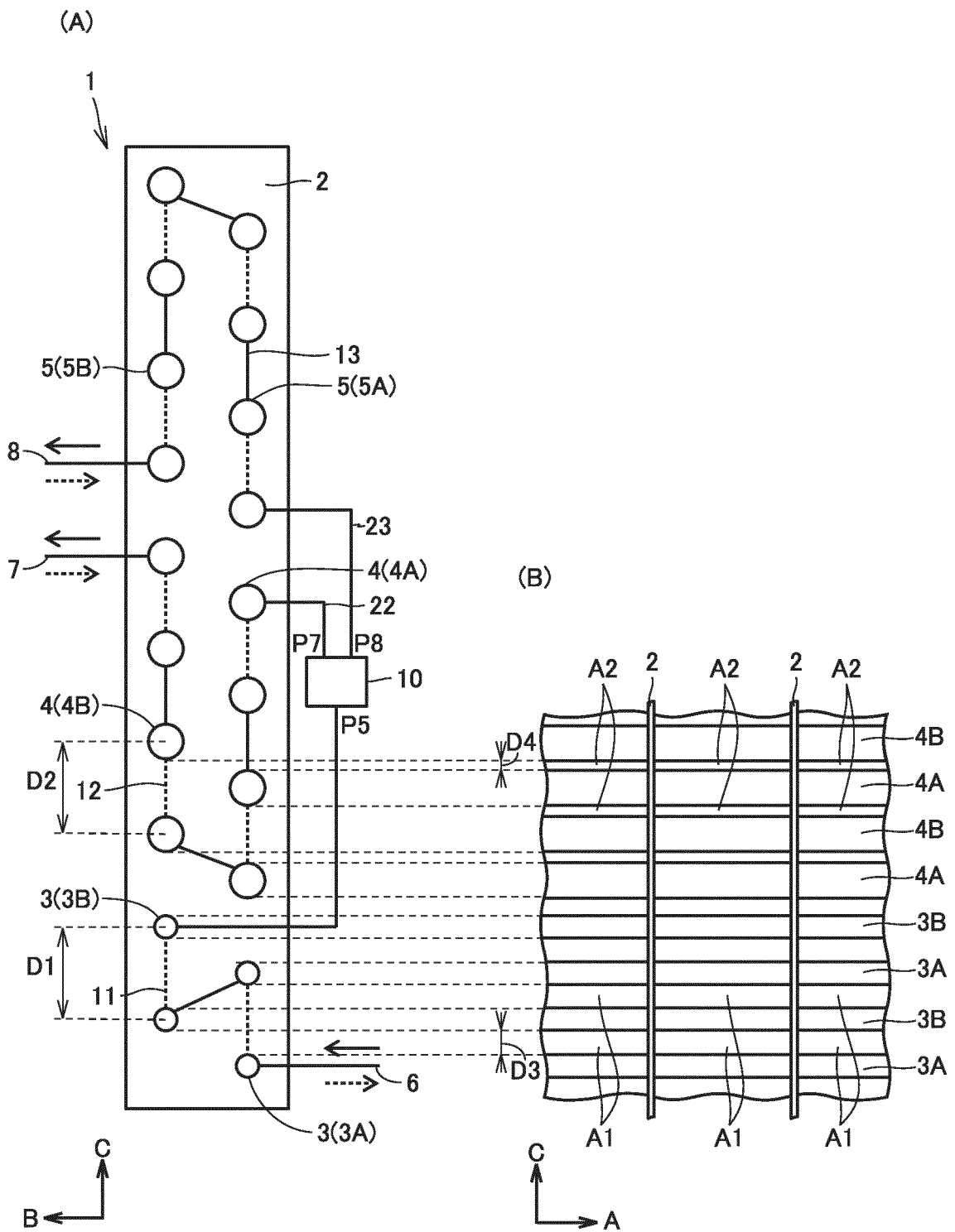


FIG.3

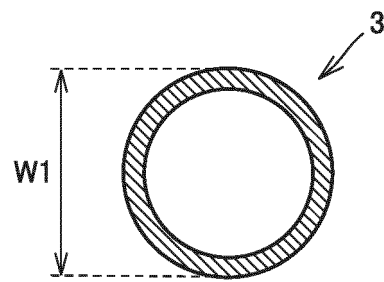


FIG.4

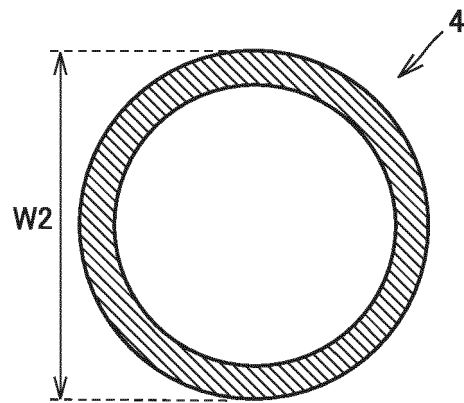


FIG.5

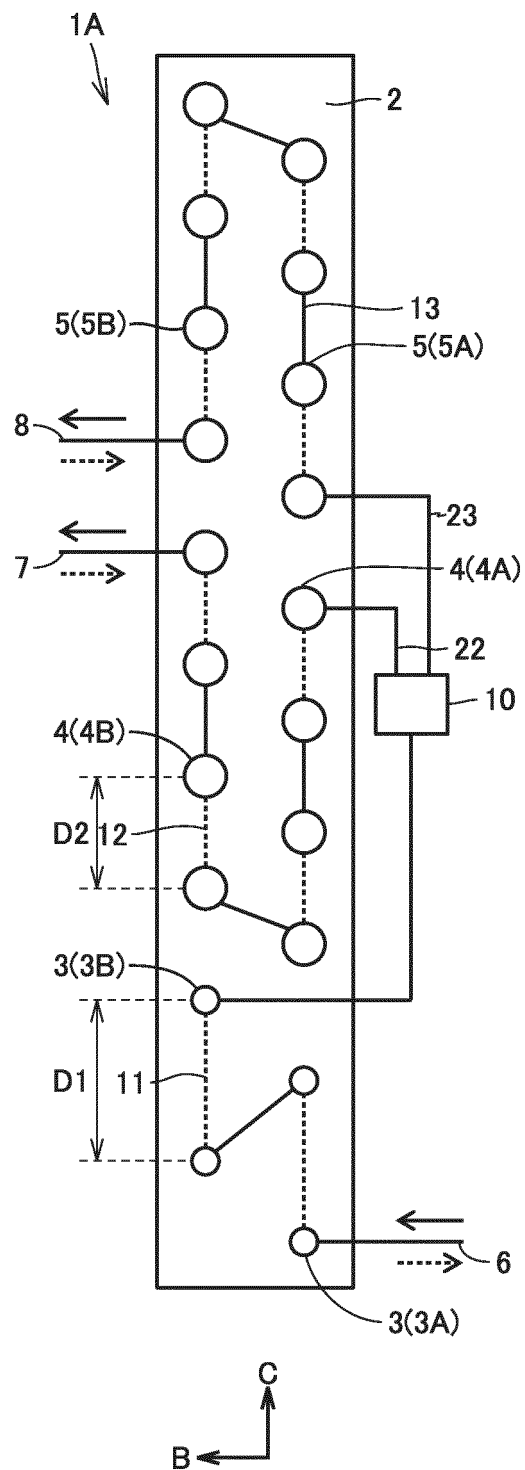


FIG.6

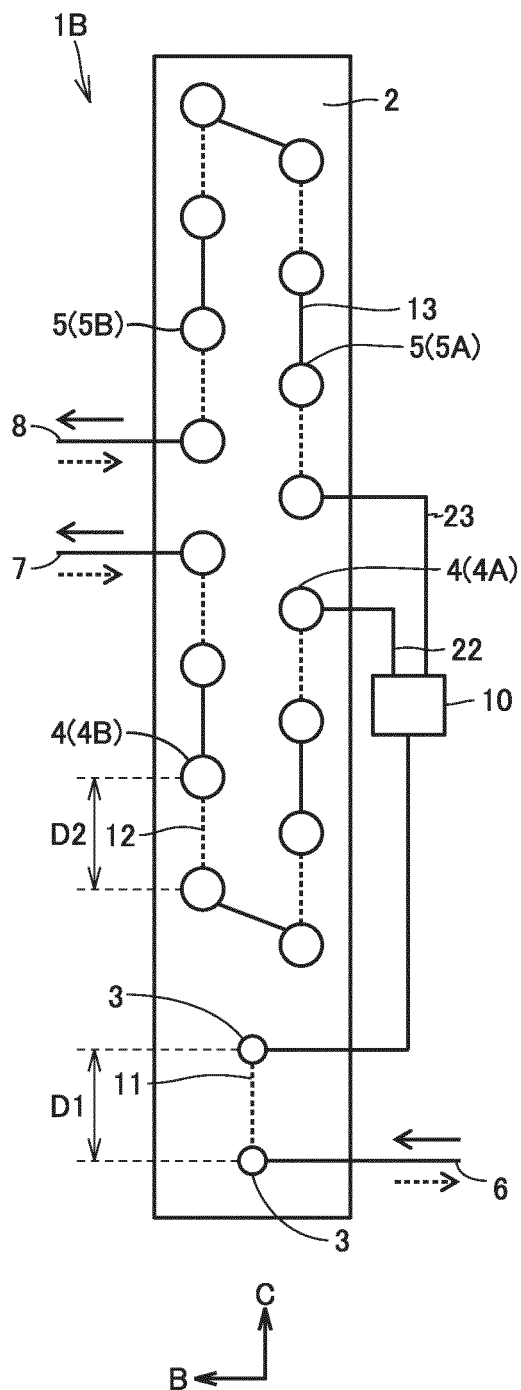
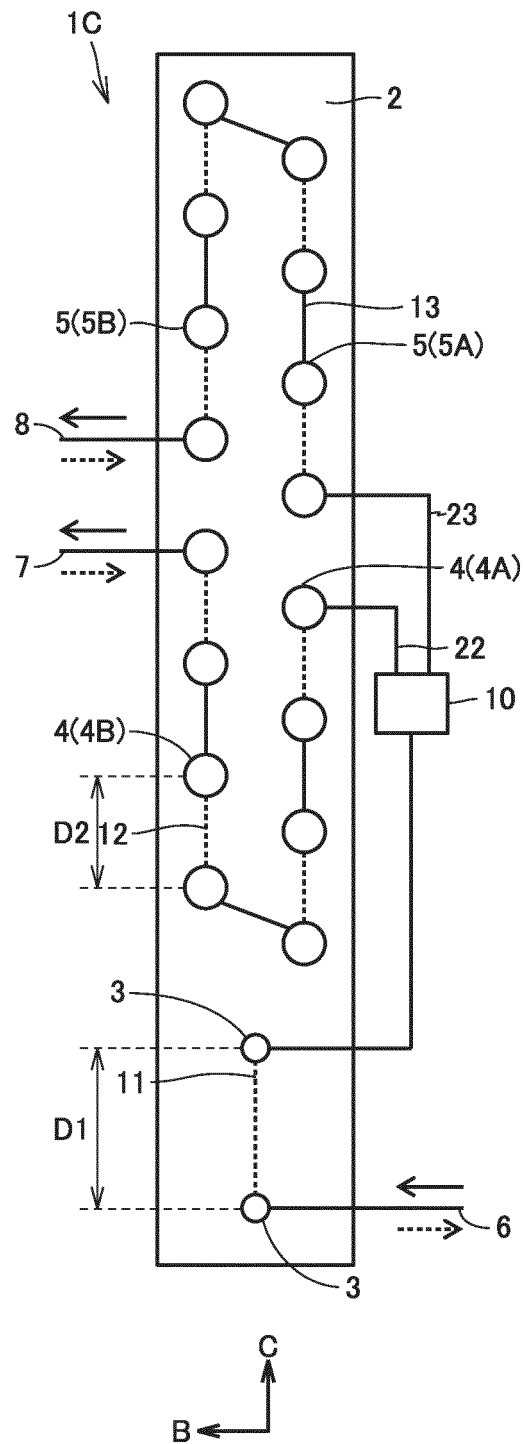


FIG.7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/029678

5	A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. F28D1/053 (2006.01) i		
	According to International Patent Classification (IPC) or to both national classification and IPC		
10	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl. F28D1/053		
15	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 1971-2019 Registered utility model specifications of Japan 1996-2019 Published registered utility model applications of Japan 1994-2019		
20	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.
25	X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 89960/1984 (Laid-open No. 8775/1986) (MITSUBISHI ELECTRIC CORPORATION) 20 January 1986, specification, page 2, line 2 to page 5, line 14, fig. 1, 2	1
30	Y	(Family: none)	2-7
35	Y	CN 206787114 U (GUANGDONG MIDEA HVAC EQUIPMENT CO., LTD.) 22 December 2017, paragraphs [0041]-[0047], fig. 1-3	2-7
		(Family: none)	
40	☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
45	* 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		
50	Date of the actual completion of the international search 24.09.2019		Date of mailing of the international search report 01.10.2019
55	Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan		Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/029678

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-347135 A (TOSHIBA CARRIER CORPORATION) 09 December 2004, paragraphs [0009]-[0018], fig. 1-3 & WO 2004/097306 A1	4-7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004347135 A [0003] [0004]