



(11) **EP 4 462 064 A1**

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

(43) Date of publication:
13.11.2024 Bulletin 2024/46

(21) Application number: **24733060.8**

(22) Date of filing: **08.03.2024**

(51) International Patent Classification (IPC):
F28F 9/26 ^(2006.01) **F25B 39/02** ^(2006.01)
F28D 1/047 ^(2006.01) **F28F 9/02** ^(2006.01)
F28F 27/02 ^(2006.01)

(52) Cooperative Patent Classification (CPC):
F28D 1/0471; F28D 1/05391; F28F 9/0275;
F28F 1/022; F28F 1/32; F28F 2210/08

(86) International application number:
PCT/JP2024/009040

(87) International publication number:
WO 2024/203167 (03.10.2024 Gazette 2024/40)

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **31.03.2023 JP 2023059201**

(71) Applicant: **Daikin Industries, Ltd.**
Osaka-shi, Osaka 5300001 (JP)

(72) Inventors:
• **YAMADA, Kouju**
Osaka-shi, Osaka 530-0001 (JP)
• **ZHENG, Chen**
Osaka-shi, Osaka 530-0001 (JP)
• **UDA, Masafumi**
Osaka-shi, Osaka 530-0001 (JP)
• **MATSUMOTO, Yoshiyuki**
Osaka-shi, Osaka 530-0001 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

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

(57) Providing a heat exchanger capable of suppressing frosting on a multi-channeled flat tube at the lowermost stage, and a refrigeration cycle apparatus including the heat exchanger. A first heat exchanger (11) includes a plurality of multi-channeled flat tubes (110) arranged in a vertical direction, and a flow divider (170) as a pressure loss part. The plurality of multi-channeled flat tubes include multi-channeled flat tubes of a first tube group (114) and multi-channeled flat tubes of a second tube group (116) other than the multi-channeled flat tubes of the first tube group. The first tube group forms a first path (P1). The first path is a flow path of a refrigerant including a multi-channeled flat tube (110L) disposed at the lowermost stage in the first heat exchanger. The second tube group forms a second path (P2) that is a flow path of the refrigerant. When the first heat exchanger functions as an evaporator, at least a portion of the refrigerant supplied to the first heat exchanger flows into the pressure loss part after flowing through the first path, and flows into the second path after flowing out the pressure loss part.

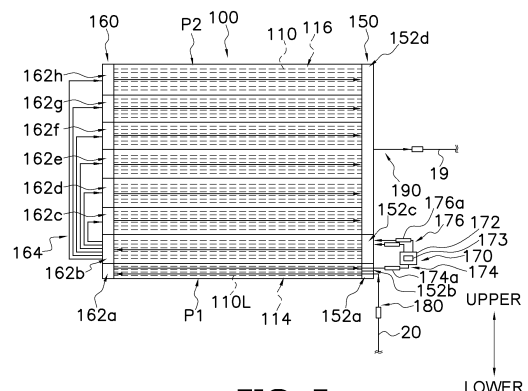


FIG. 5

EP 4 462 064 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger using a multi-channeled flat tube and a refrigeration cycle apparatus including the heat exchanger.

BACKGROUND ART

[0002] When heat is exchanged between low-temperature air and a refrigerant in a heat exchanger using multi-channeled flat tubes used as an evaporator, frosting on the multi-channeled flat tube at the lowermost stage in the heat exchanger is likely to be a problem.

[0003] In order to suppress the frosting on the multi-channeled flat tube at the lowermost stage in the heat exchanger, in PTL 1 (Japanese Unexamined Patent Application Publication No. 2019-60596), the path length of a refrigerant path including the multi-channeled flat tube at the lowermost stage is set to be longer than the path lengths of other refrigerant paths, thereby suppressing frosting of the refrigerant on the multi-channeled flat tube at the lowermost stage.

SUMMARY

<Technical Problem>

[0004] However, in the heat exchanger of PTL 1 (Japanese Unexamined Patent Application Publication No. 2019-60596), the frosting on the multi-channeled flat tube at the lowermost stage may fail to be sufficiently suppressed, and there is room for improvement in terms of suppression of the frosting on the multi-channeled flat tube at the lowermost stage.

<Solution to Problem>

[0005] A heat exchanger of a first aspect includes a plurality of multi-channeled flat tubes and a pressure loss part through which a refrigerant flows. The plurality of multi-channeled flat tubes are arranged side by side in a vertical direction. The plurality of multi-channeled flat tubes include the multi-channeled flat tubes of a first tube group including the multi-channeled flat tube disposed at a lowermost stage in the heat exchanger, and the multi-channeled flat tubes of a second tube group other than the multi-channeled flat tubes of the first tube group. The multi-channeled flat tubes of the first tube group form a first path that is a flow path of the refrigerant. The second tube group forms a second path that is a flow path of the refrigerant. When the heat exchanger functions as an evaporator, at least a portion of the refrigerant supplied to the heat exchanger flows into the pressure loss part after flowing through the first path, and flows into the second path after flowing out the pressure loss part.

[0006] In the heat exchanger of the first aspect, the

pressure loss part is provided on downstream of the first path in a flow direction of the refrigerant when the heat exchanger is used as an evaporator. Therefore, in the heat exchanger of the first aspect, it is possible to ensure a large pressure difference between the entry into the first path and the entry into the second path, in other words, a large temperature difference between the entry into the first path and the entry into the second path. Therefore, in the heat exchanger of the first aspect, the heat radiation amount from the first path when the heat exchanger functions as an evaporator can be ensured, and frosting on the first path can be suppressed.

[0007] A heat exchanger of a second aspect is the heat exchanger of the first aspect, wherein, when the heat exchanger functions as an evaporator, an entire amount of the refrigerant supplied to the heat exchanger flows into the pressure loss part after flowing through the first path, and flows into the second path after flowing through the pressure loss part.

[0008] In the heat exchanger of the second aspect, when the heat exchanger functions as an evaporator, the entire amount of the refrigerant that flows into the heat exchanger flows through the first path, and therefore a large heat radiation amount from the first path can be achieved when the heat exchanger functions as an evaporator.

[0009] A heat exchanger of a third aspect is the heat exchanger of the first aspect or the second aspect, wherein the first tube group includes a plurality of multi-channeled flat tubes disposed in parallel.

[0010] In the heat exchanger of the third aspect, excessive pressure loss in the first path can be suppressed.

[0011] A heat exchanger of a fourth aspect is the heat exchanger of the first aspect or the second aspect, wherein a flow path area of each of the multi-channeled flat tubes of the first tube group is larger than a flow path area of each of the multi-channeled flat tubes of the second tube group.

[0012] In the heat exchanger of the fourth aspect, excessive pressure loss in the first path can be suppressed.

[0013] A heat exchanger of a fifth aspect is the heat exchanger of any of the first aspect to the fourth aspect, wherein number of the multi-channeled flat tubes included in the first tube group is smaller than number of the multi-channeled flat tubes included in the second tube group.

[0014] In the heat exchanger of the fifth aspect, a large volume of refrigerant can flow through each of the multi-channeled flat tubes of the first path, and a large heat radiation amount from each of the multi-channeled flat tubes of the first path can be achieved when the heat exchanger functions as an evaporator.

[0015] A heat exchanger of a sixth aspect is the heat exchanger of any of the first aspect to the fifth aspect, wherein the pressure loss part is an orifice disposed in a flow path of the refrigerant between the first path and the second path.

[0016] In the heat exchanger of the sixth aspect, by

providing the orifice at the subsequent stage of the first path, it is possible to ensure a large pressure difference between the entry into the first path and the entry into the second path, in other words, a large temperature difference between the entry into the first path and the entry into the second path. Therefore, in the heat exchanger of the sixth aspect, when the heat exchanger functions as an evaporator, a large heat radiation amount from the first path can be achieved and frosting on the first path can be suppressed.

[0017] A heat exchanger of a seventh aspect is the heat exchanger of any of the first aspect to the fifth aspect, wherein the pressure loss part is a flow divider disposed in the flow path of the refrigerant between the first path and the second path.

[0018] In the heat exchanger of the seventh aspect, a large pressure difference between the entry into the first path and the entry into the second path, in other words, a large temperature difference between the entry into the first path and the entry into the second path can be ensured, by using the flow divider with which the refrigerant after passing through the first path is divided to flow into the multi-channeled flat tubes of the second tube group. Therefore, in the heat exchanger of the first aspect, when the heat exchanger functions as an evaporator, a large heat radiation amount from the first path can be achieved and frosting on the first path can be suppressed.

[0019] A heat exchanger of an eighth aspect is the heat exchanger of any of the first aspect to the fifth aspect, further comprising a header disposed in a flow path of the refrigerant between the first path and the second path. The pressure loss part is a nozzle disposed inside the header.

[0020] In the heat exchanger of the eighth aspect, using the nozzle disposed inside the header ensures a large pressure difference between the entry into the first path and the entry into the second path, in other words, a large temperature difference between the entry into the first path and the entry into the second path. Therefore, in the heat exchanger of the first aspect, when the heat exchanger functions as an evaporator, a large heat radiation amount from the first path can be achieved and frosting on the first path can be suppressed.

[0021] A heat exchanger of a ninth aspect is the heat exchanger of the first aspect, further comprising a bypass path through which the refrigerant is guided to the second path without flowing through the first path.

[0022] In the heat exchanger of the ninth aspect, it is possible to suppress the occurrence of a problem in that efficiency of the refrigeration cycle apparatus using the heat exchanger is deteriorated due to the pressure loss being too large as a result of the entire amount of refrigerant flowing through the first path when an extremely large amount of refrigerant is supplied to the heat exchanger.

[0023] A heat exchanger of a tenth aspect is the heat exchanger of any of the first aspect to the ninth aspect, wherein the multi-channeled flat tubes are disposed in a

plurality of rows in a direction of air flow generated by a fan that sends air to the heat exchanger. The first path is disposed only on the windward side in the direction of the air flow.

[0024] In the heat exchanger of the tenth aspect, it is easy to suppress frosting on the multi-channeled flat tubes on the windward and lower sides of the heat exchanger where adhesion of frost or ice tends to become a problem.

[0025] A refrigeration cycle apparatus according to an eleventh aspect includes a refrigerant circuit and a fan. The refrigerant circuit includes the heat exchanger according to any one of the first aspect to the tenth aspect as a heat source heat exchanger, and a compressor that compresses the refrigerant. The fan sends air to the heat exchanger.

[0026] In the refrigeration cycle apparatus of the eleventh aspect, frosting on the multi-channeled flat tubes of the first tube group of the heat exchanger can be suppressed, and therefore the interruption time of the operation during which the heat exchanger functions as an evaporator can be shortened.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

[Fig. 1] Fig. 1 is a schematic configuration diagram of an air conditioning apparatus according to an embodiment of a refrigeration cycle apparatus of the present disclosure.

[Fig. 2] Fig. 2 is a schematic plan view of the interior of the heat source unit illustrating the arrangement of a first heat exchanger in a heat source unit of the air conditioning apparatus in Fig. 1.

[Fig. 3] Fig. 3 is a schematic perspective view of a heat exchanger according to a first embodiment of the present disclosure used in the air conditioning apparatus in Fig. 2.

[Fig. 4] Fig. 4 is a partially enlarged perspective view of the first heat exchanger in Fig. 3.

[Fig. 5] Fig. 5 is a diagram schematically illustrating a structure of the first heat exchanger in Fig. 3 and schematically illustrating a flow of a refrigerant in the first heat exchanger when the first heat exchanger functions as an evaporator.

[Fig. 6] Fig. 6 is a diagram schematically illustrating a flow of the refrigerant in a first path of the first heat exchanger when the first heat exchanger in Fig. 3 functions as an evaporator.

[Fig. 7] Fig. 7 is a diagram schematically illustrating a structure of a first heat exchanger according to another example, and schematically illustrating a flow of the refrigerant in the first heat exchanger when the first heat exchanger functions as an evaporator.

[Fig. 8A] Fig. 8A is a diagram illustrating a difference between the flow of the refrigerant in the heat ex-

changer of the present disclosure and a flow of the refrigerant in a conventional heat exchanger, and is a diagram conceptually illustrating the flow of the refrigerant in the heat exchanger of the present disclosure.

[Fig. 8B] Fig. 8B is a diagram illustrating a difference between the flow of the refrigerant in the heat exchanger of the present disclosure and the flow of the refrigerant in the conventional heat exchanger, and is a diagram conceptually illustrating the flow of the refrigerant in the conventional heat exchanger.

[Fig. 9] Fig. 9 is a diagram schematically illustrating a Mollier diagram in a case where a heating operation is performed by the air conditioning apparatus according to an embodiment of the refrigeration cycle apparatus of the present disclosure.

[Fig. 10] Fig. 10 is a diagram conceptually illustrating a flow of a refrigerant in a first path of a heat exchanging part of a first heat exchanger according to Modification A.

[Fig. 11] Fig. 11 is a schematic cross-sectional view of a first heat exchanger according to Modification C taken along a virtual plane orthogonal to the direction in which the multi-channeled flat tube extends.

[Fig. 12] Fig. 12 is a diagram depicting an internal structure of part of a first header of a first heat exchanger according to Modification D.

[Fig. 13] Fig. 13 is a diagram conceptually illustrating a flow of the refrigerant in a heat exchanger according to Modification E.

DESCRIPTION OF EMBODIMENTS

[0028] Embodiments of a heat exchanger of the present disclosure and a refrigeration cycle apparatus including the heat exchanger will be described with reference to the drawings.

(1) Overall configuration

[0029] An overview of the refrigeration cycle apparatus of the present disclosure will be described with reference to Fig. 1. Fig. 1 is a schematic configuration diagram of an air conditioning apparatus 1 according to an embodiment of a refrigeration cycle apparatus of the present disclosure.

[0030] The air conditioning apparatus 1 is an apparatus capable of cooling and heating an air conditioning target space by implementing a vapor compression refrigeration cycle. Note that the type of the refrigeration cycle apparatus of the present disclosure is not limited to the air conditioning apparatus, and may be, for example, a hot water supply apparatus or the like.

[0031] As illustrated in Fig. 1, the air conditioning apparatus 1 mainly includes a heat source unit 2, utilization units 3a and 3b, a liquid-refrigerant connection pipe 4, a gas-refrigerant connection pipe 5, and a control unit 23. The control unit 23 controls the operation of the devices

constituting the heat source unit 2 and the utilization units 3a and 3b.

[0032] The liquid-refrigerant connection pipe 4 and the gas-refrigerant connection pipe 5 connect the heat source unit 2 and the utilization units 3a and 3b. In the air conditioning apparatus 1, the heat source unit 2 and the utilization units 3a and 3b are connected with each other via the refrigerant connection pipes 4 and 5, thereby configuring a refrigerant circuit 6 (see Fig. 1). In the refrigerant circuit 6, a compressor 8, a flow direction switching mechanism 10, a first heat exchanger 11, a first expansion mechanism 12, a first stop valve 13, a second stop valve 14, second expansion mechanisms 31a and 31b, and second heat exchangers 32a and 32a, which will be described below, are connected with each other by refrigerant pipes as illustrated in Fig. 1.

[0033] In the refrigerant circuit 6, for example, R32 that is an HFC refrigerant is sealed as a refrigerant. However, the type of the refrigerant is not limited to R32, and the refrigerant may be, for example, R410A, R1234yf, R1234ze(E) R290, CO₂, or the like.

[0034] In Fig. 1, the air conditioning apparatus 1 includes one heat source unit 2 and two utilization units 3a and 3b, but the number of these units is merely an example. The air conditioning apparatus 1 may include a plurality of heat source units, or may include one or three or more utilization units.

(2) Detailed configuration

[0035] The heat source unit 2, the utilization units 3a and 3b, the liquid-refrigerant connection pipe 4, the gas-refrigerant connection pipe 5, and the control unit 23 of the air conditioning apparatus 1 will be described below.

(2-1) Heat source unit

[0036] The heat source unit 2 is installed outdoors, for example, on the roof of a building where the air conditioning apparatus 1 is installed, around the outer wall of the building, or the like, but is not limited to this.

[0037] The heat source unit 2 of the present embodiment is a side-blowing type unit (see Fig. 2) that takes in air for heat exchange with the refrigerant from sides (rear and left sides) of a housing 2a (see Fig. 2) that houses various devices of the heat source unit 2, and blows out the air after the heat exchange with the refrigerant from a side (front) of the housing 2a. However, the type of the heat source unit 2 is not limited to the side-blowing type, and a top-blowing type unit may be employed that takes in the air for heat exchange with the refrigerant from a side of the housing 2a and blows the air after the heat exchange with the refrigerant upward from the upper portion of the housing 2a.

[0038] The heat source unit 2 mainly includes an accumulator 7, the compressor 8, the flow direction switching mechanism 10, the first heat exchanger 11, the first expansion mechanism 12, the first stop valve 13, the sec-

ond stop valve 14, and a first fan 15 (see Fig. 1).

[0039] The heat source unit 2 includes a suction pipe 17, a discharge pipe 18, a first gas refrigerant pipe 19, a liquid refrigerant pipe 20, and a second gas refrigerant pipe 21 (see Fig. 1). The suction pipe 17 connects the flow direction switching mechanism 10 and the suction side of the compressor 8. The suction pipe 17 is provided with the accumulator 7. The discharge pipe 18 connects the discharge side of the compressor 8 and the flow direction switching mechanism 10. The first gas refrigerant pipe 19 connects the flow direction switching mechanism 10 and a gas end of the first heat exchanger 11. The liquid refrigerant pipe 20 connects a liquid end of the first heat exchanger 11 and the first stop valve 13. The first expansion mechanism 12 is provided in the liquid refrigerant pipe 20. The second gas refrigerant pipe 21 connects the flow direction switching mechanism 10 and the second stop valve 14.

(2-1-1) Compressor

[0040] The compressor 8 is a device that intakes a low-pressure refrigerant in the refrigeration cycle flowing in from the suction pipe 17, compresses the refrigerant to raise the pressure to a high pressure in the refrigeration cycle, and discharges the high-pressure refrigerant in the refrigeration cycle to the discharge pipe 18. In the compressor 8, a motor (not illustrated) is inverter-controlled. The number of rotations of the motor of the compressor 8 is adjusted by the control unit 23 in accordance with the operating conditions. The compressor 8 may be a compressor in which the number of rotations of the motor is constant.

(2-1-2) Flow direction switching mechanism

[0041] The flow direction switching mechanism 10 is a mechanism that switches the flow direction of the refrigerant in the refrigerant circuit 6 in accordance with an instructed operating mode or at a timing at which defrosting is performed during the heating operation. In the present embodiment, the flow direction switching mechanism 10 is a four-way switching valve.

[0042] During the cooling operation (including the dehumidifying operation) and the defrosting operation, the flow direction switching mechanism 10 switches the flow direction of the refrigerant in the refrigerant circuit 6 to send the refrigerant discharged from the compressor 8 to the first heat exchanger 11 (see the solid line in Fig. 1) by connecting the suction pipe 17 with the second gas refrigerant pipe 21 and connecting the discharge pipe 18 with the first gas refrigerant pipe 19 (such a pipe connection state by the flow direction switching mechanism 10 is referred to as a first state).

[0043] During the heating operation, the flow direction switching mechanism 10 switches the flow direction of the refrigerant in the refrigerant circuit 6 to send the refrigerant discharged from the compressor 8 to the second

heat exchangers 32a and 32b (see the broken line in Fig. 1), by connecting the suction pipe 17 with the first gas refrigerant pipe 19 and connecting the discharge pipe 18 with the second gas refrigerant pipe 21 (such a connection state of the pipes by the flow direction switching mechanism 10 is referred to as a second state).

[0044] Note that the flow direction switching mechanism 10 is not limited to a four-way switching valve, and may be configured as a combination of a plurality of electromagnetic valves and refrigerant pipes capable of switching the flow direction of the refrigerant as described above.

(2-1-3) First heat exchanger

[0045] The first heat exchanger 11 is a heat exchanger that functions as a radiator (condenser) during the cooling operation/defrosting operation and functions as an evaporator (heat absorber) during the heating operation. The first heat exchanger 11 is an example of a heat exchanger in the claims.

[0046] The structure of the first heat exchanger 11 and the flow of the refrigerant in the first heat exchanger 11 will be described later.

(2-1-4) First expansion mechanism

[0047] The first expansion mechanism 12 is a mechanism that expands the refrigerant flowing between the first heat exchanger 11 and the second heat exchangers 32a and 32b of the utilization units 3a and 3b in the refrigerant circuit 6. The first expansion mechanism 12 is, for example, an electronic expansion valve whose opening degree is adjustable. The opening degree of the first expansion mechanism 12 is adjusted by the control unit 23 in accordance with the operating conditions.

(2-1-5) First fan

[0048] The first fan 15 generates an air flow and supplies air to the first heat exchanger 11. The first fan 15 generates a flow of air that flows into the heat source unit 2 from the outside of the housing 2a, passes through the first heat exchanger 11, and flows out to the outside of the housing 2a. The first fan 15 is, for example, a propeller fan. However, the type of the first fan 15 is not limited to a propeller fan, and may be another type of fan.

(2-2) Utilization unit

[0049] The utilization units 3a and 3b are installed in the air conditioning target space or in the vicinity of the air conditioning target space (such as, for example, in the attic space of the air conditioning target space).

[0050] The utilization unit 3a mainly includes a second expansion mechanism 31a, a second heat exchanger 32a, and a second fan 33a (see Fig. 1). The utilization unit 3b mainly includes a second expansion mechanism

31b, a second heat exchanger 32b, and a second fan 33b (see Fig. 1).

(2-2-1) Second expansion mechanism

[0051] The second expansion mechanisms 31a and 31b are mechanisms that expand the refrigerant flowing between the second heat exchangers 32a and 32b of the utilization units 3a and 3b and the first heat exchanger 11 in the refrigerant circuit 6. The second expansion mechanisms 31a and 31b are, for example, electronic expansion valves whose opening degree is adjustable. The opening degree of the second expansion mechanisms 31a and 31b is adjusted by the control unit 23 in accordance with the operating conditions.

(2-2-2) Second heat exchanger

[0052] The second heat exchangers 32a and 32b are heat exchangers that function as a heat absorber (evaporator) during the cooling operation to cool the indoor air, and function as a refrigerant radiator (condenser) during the heating operation to heat the indoor air.

[0053] The liquid side of the second heat exchangers 32a and 32b is connected with the liquid-refrigerant connection pipe 4 via a refrigerant pipe, and the gas side of the second heat exchangers 32a and 32b is connected with the gas-refrigerant connection pipe 5 via a refrigerant pipe. The second heat exchangers 32a and 32b are, for example, a cross-fin type fin- and-tube heat exchanger including a plurality of heat transfer tubes (not illustrated) and a plurality of fins (not illustrated).

(2-2-3) Second fan

[0054] The second fans 33a and 33b generate a flow of air that flows into the utilization units 3a and 3b from the outside (air conditioning target space) of a housing (not illustrated) that houses various devices of the utilization units 3a and 3b therein, passes through the second heat exchangers 32a and 32b, and flows out to the outside of the housing (air conditioning target space). The second fans 33a and 33b are, for example, a centrifugal fan.

(2-3) Refrigerant connection pipe

[0055] The refrigerant connection pipes 4 and 5 are refrigerant pipes constructed on site when the air conditioning apparatus 1 is installed. One end of the liquid-refrigerant connection pipe 4 is connected with the first stop valve 13 of the heat source unit 2, and the other end of the liquid-refrigerant connection pipe 4 is connected with the refrigerant pipe connected with the liquid side of the second heat exchangers 32a and 32b of the utilization units 3a and 3b (see Fig. 1). One end of the gas-refrigerant connection pipe 5 is connected with the second stop valve 14 of the heat source unit 2, and the other end

of the gas-refrigerant connection pipe 5 is connected with the refrigerant pipes connected with the gas sides of the second heat exchangers 32a and 32b of the utilization units 3a and 3b (see Fig. 1).

5

(2-4) Control unit

[0056] The control unit 23 is configured by communicably connecting control boards (not illustrated) including CPU, ROM, RAM, and the like, which are provided in the heat source unit 2 and the utilization units 3a and 3b. In Fig. 1, for the sake of simplicity, the control unit 23 is illustrated at a position away from the heat source unit 2 and the utilization units 3a and 3b.

10

[0057] As indicated by the broken line in Fig. 1, the control unit 23 is electrically connected with devices constituting the air conditioning apparatus 1. Specifically, the control unit 23 is electrically connected with, for example, the compressor 8, the flow direction switching mechanism 10, the first expansion mechanism 12, the first fan 15, the second expansion mechanisms 31a and 31b, and the second fans 33a and 33b. The control unit 23 is also electrically connected with various sensors (not illustrated) provided to the heat source unit 2 and the utilization units 3a and 3b.

15

[0058] By executing a program for controlling the air conditioning apparatus 1 (by the CPU executing a program stored in the ROM), the control unit 23 controls the devices forming the air conditioning apparatus 1 based on operations from a remote controller (not illustrated), measured values from various sensors (not illustrated), and the like.

20

[0059] The control unit 23 causes the air conditioning apparatus 1 to execute the cooling operation (including a dehumidifying operation) or the heating operation by controlling the devices forming the air conditioning apparatus 1. When a predetermined condition is satisfied during the heating operation of the air conditioning apparatus 1, the control unit 23 switches the operation of the air conditioning apparatus 1 to the defrosting operation. The operation of the air conditioning apparatus 1 during each operation will be described below.

25

30

(3) Operation of air conditioning apparatus

35

[0060] The cooling operation (including the dehumidifying operation), the heating operation, and the defrosting operation of the air conditioning apparatus 1 will be described. The defrosting operation is an operation for melting frost or ice adhered to the first heat exchanger 11, and is performed while the heating operation being performed is temporarily interrupted.

40

[0061] During the cooling operation, the refrigerant circulates through the refrigerant circuit 6 in the order of the compressor 8, the first heat exchanger 11, the first expansion mechanism 12, the second expansion mechanisms 31a and 31b, the second heat exchangers 32a and 32b, and the accumulator 7.

45

[0062] During the heating operation, the refrigerant circulates through the refrigerant circuit 6 in the order of the compressor 8, the second heat exchangers 32a and 32b, the second expansion mechanisms 31a and 31b, the first expansion mechanism 12, the first heat exchanger 11, and the accumulator 7.

[0063] During the defrosting operation, as in the cooling operation, the refrigerant circulates through the refrigerant circuit 6 in the order of the compressor 8, the first heat exchanger 11, the first expansion mechanism 12, the second expansion mechanisms 31a and 31b, the second heat exchangers 32a and 32b, and the accumulator 7. In other words, in the air conditioning apparatus 1 of the present embodiment, the refrigerant flows through the refrigerant circuit 6 in a direction opposite to that during the heating operation, to melt frost and ice adhered to the first heat exchanger 11.

[0064] An operation of the air conditioning apparatus 1 during the cooling operation will be described.

[0065] During the cooling operation, the connection state of the pipes achieved by the flow direction switching mechanism 10 is switched to the first state described above. The gas refrigerant at a low pressure in the refrigeration cycle (hereinafter, simply referred to as a low pressure) sucked into the compressor 8 from the suction pipe 17 is compressed by the compressor 8 to have a high pressure in the refrigeration cycle (hereinafter, simply referred to as a high pressure), and is then discharged to the discharge pipe 18. The high-pressure gas refrigerant discharged to the discharge pipe 18 is sent to the first heat exchanger 11 through the flow direction switching mechanism 10. The high-pressure gas refrigerant sent to the first heat exchanger 11 radiates heat through heat exchange with the air supplied by the first fan 15 in the first heat exchanger 11 functioning as a radiator for the refrigerant, and thus turns into a high-pressure liquid refrigerant. The high-pressure liquid refrigerant as a result of the heat radiation in the first heat exchanger 11 is sent to the second expansion mechanisms 31a and 31b through the first expansion mechanism 12, the first stop valve 13, and the liquid-refrigerant connection pipe 4. The refrigerant sent to the second expansion mechanisms 31a and 31b is decompressed to a low pressure by the second expansion mechanisms 31a and 31b, to be a low-pressure gas-liquid two-phase refrigerant. The low-pressure gas-liquid two-phase refrigerant as a result of the decompression by the second expansion mechanisms 31a and 31b is sent to the second heat exchangers 32a and 32b. The low-pressure gas-liquid two-phase refrigerant sent to the second heat exchangers 32a and 32b is heat-exchanged with the air supplied by the second fans 33a and 33b to evaporate in the second heat exchangers 32a and 32b. The air cooled in the second heat exchangers 32a and 32b is blown out to the air conditioning target space. The low-pressure gas refrigerant after the evaporation in the second heat exchangers 32a and 32b passes through the gas-refrigerant connection pipe 5, the second stop valve 14, the flow direction switch-

ing mechanism 10, and the accumulator 7, and is again sucked into the compressor 8.

[0066] During the cooling operation, the control unit 23 performs, for example, the following control. Note that the control by the control unit 23 described here is an example, and the control is not limited to this.

[0067] The control unit 23 controls the opening degree of the electronic expansion valve as an example of each of the second expansion mechanisms 31a and 31b so that the degree of superheating of the refrigerant at the outlet of each of the second heat exchangers 32a and 32b reaches a target degree of superheating based on a measured value from a sensor (not illustrated). Further, the control unit 23 controls the operating capacity of the compressor 8 so that the evaporation temperature approaches the target evaporation temperature.

[0068] The operation of the air conditioning apparatus 1 during the heating operation will be described.

[0069] During the heating operation, the connection state of the pipes achieved by the flow direction switching mechanism 10 is switched to the above-described second state. The low-pressure gas refrigerant sucked into the compressor 8 from the suction pipe 17 is compressed to a high pressure by the compressor 8, and then discharged to the discharge pipe 18. The high-pressure gas refrigerant discharged to the discharge pipe 18 is sent to the second heat exchangers 32a and 32b through the flow direction switching mechanism 10, the second stop valve 14, and the gas-refrigerant connection pipe 5. The high-pressure gas refrigerant sent to the second heat exchangers 32a and 32b is heat-exchanged with the air supplied from the second fans 33a and 33b in the second heat exchangers 32a and 32b to radiate heat, and thus turns into a high-pressure liquid refrigerant or gas-liquid two phase refrigerant. The air heated through heat exchange with the refrigerant in the second heat exchangers 32a and 32b is blown out to the air conditioning target space. The high-pressure refrigerant after the heat radiation in the second heat exchangers 32a and 32b is sent to the first expansion mechanism 12 through the second expansion mechanisms 31a and 31b, the liquid-refrigerant connection pipe 4, and the first stop valve 13. The refrigerant sent to the first expansion mechanism 12 is decompressed by the first expansion mechanism 12 to be a low-pressure gas-liquid two-phase refrigerant. The low-pressure gas-liquid two-phase refrigerant after the decompression by the first expansion mechanism 12 is sent to the first heat exchanger 11. The low-pressure gas-liquid two-phase refrigerant sent to the first heat exchanger 11 is evaporated through heat exchange with the air supplied from the first fan 15 in the first heat exchanger 11 functioning as an evaporator for the refrigerant, and turns into a low-pressure gas refrigerant. The low-pressure refrigerant after the evaporation in the first heat exchanger 11 passes through the flow direction switching mechanism 10 and the accumulator 7 and is sucked into the compressor 8 again.

[0070] During the heating operation, the control unit 23

performs, for example, the following control. Note that the control by the control unit 23 described here is an example, and the control is not limited to this.

[0071] The control unit 23 controls the opening degree of the electronic expansion valve as an example of the first expansion mechanism 12 based on a measured value from a sensor (not illustrated) so that the degree of superheating of the refrigerant at the outlet of the first heat exchanger 11 reaches a target degree of superheating. Further, the control unit 23 controls the operating capacity of the compressor 8 so that the evaporation temperature approaches the target evaporation temperature.

[0072] When a start condition for the defrosting operation is satisfied during the heating operation, the control unit 23 switches the operation of the air conditioning apparatus 1 from the heating operation to the defrosting operation. Although not limited, the start condition of the defrosting operation is, for example, a condition that the temperature of the refrigerant flowing through the first heat exchanger 11 is lower than a predetermined temperature, or a condition that the continuous time of the heating operation exceeds a predetermined time.

[0073] As in the cooling operation, the defrosting operation is an operation in which the connection state of the pipes is switched to the first state by the flow direction switching mechanism 10 and the first heat exchanger 11 is caused to function as a radiator for the refrigerant. Description of how the refrigerant flows through the air conditioning apparatus 1 during the defrosting operation will be omitted.

[0074] The control unit 23 executes the defrosting operation until a defrosting operation end condition is satisfied (until a predetermined defrosting time elapses, or until it is determined that defrosting of the first heat exchanger 11 has been completed based on measured values from various sensors provided to the air conditioning apparatus 1). Specifically, for example, the control unit 23 determines that the defrosting for the first heat exchanger 11 has been completed when a measured value from a temperature sensor (not illustrated) provided to the first gas refrigerant pipe 19 continues to be higher than a predetermined temperature for a predetermined time. When the defrosting operation end condition is satisfied, the control unit 23 ends the defrosting operation and restarts the heating operation of the air conditioning apparatus 1.

(4) First heat exchanger

[0075] The shape, structure, and the like of the first heat exchanger 11 will be described with further referring to Figs. 2 to 6.

[0076] Fig. 2 is a schematic plan view of the interior of the heat source unit 2 for explaining the arrangement of the first heat exchanger 11 in the heat source unit 2. Fig. 3 is a schematic perspective view of the first heat exchanger 11. Fig. 4 is a partially enlarged perspective view

of the first heat exchanger 11. Fig. 5 is a view illustrating the structure of the first heat exchanger 11 and schematically illustrating the flow of the refrigerant in the first heat exchanger 11 when the first heat exchanger 11 functions as an evaporator. Fig. 6 is a diagram schematically illustrating the flow of the refrigerant in a first path P1 of the first heat exchanger 11 when the first heat exchanger 11 functions as an evaporator. Fig. 6 is a diagram illustrating end surfaces on the side of a first header 150, which will be described below, of multi-channeled flat tubes 110 of a first tube group 114 of the first heat exchanger 11, which will be described below.

[0077] Fig. 5 is a diagram schematically illustrating the structure of the first heat exchanger 11. Therefore, for example, the first heat exchanger 11 has an L-shape as illustrated in Fig. 3, but is illustrated to have a linear shape (I-shape) in Fig. 5. In addition, for example, the number of the multi-channeled flat tubes 110 (indicated by the broken lines) illustrated in the first heat exchanger 11 is not the actual number of the multi-channeled flat tubes 110 included in the first heat exchanger 11.

[0078] In the following description, in order to describe directions and positional relationships, expressions such as "left", "right", "front", "rear", "front surface", and "rear surface" may be used for convenience. The directions indicated by these expressions follow the directions of the arrows illustrated in the drawings unless otherwise specified.

[0079] The heat source unit 2 includes the housing 2a as described above. The accumulator 7, the compressor 8, the flow direction switching mechanism 10, the first heat exchanger 11, the first expansion mechanism 12, the first stop valve 13, the second stop valve 14, and the first fan 15 are housed in the housing 2a. The inside of the housing 2a is partitioned into a machine chamber R1 in which the compressor 8, the accumulator 7, the flow direction switching mechanism 10, the first expansion mechanism 12, the first stop valve 13, and the second stop valve 14 are mainly disposed, and a fan chamber R2 in which the first heat exchanger 11 and the first fan 15 are mainly disposed (see Fig. 2). In Fig. 2, devices arranged in the machine chamber R1 are not illustrated.

[0080] In the present embodiment, the first heat exchanger 11 has a substantially L shape as illustrated in Figs. 2 and 3. As illustrated in Fig. 2, in plan view, the first heat exchanger 11 extends from the rear right side of the housing 2a (near the machine chamber R1) to the vicinity of the rear left end portion of the housing 2a along the back surface of the housing 2a, changes direction near the rear left end portion of the housing 2a, and extends to the vicinity of the front left end portion.

[0081] The first fan 15 is disposed in front of the first heat exchanger 11. When the first fan 15 is operated, air is sucked in from the back surface and the left side surface of the housing 2a and passes through the first heat exchanger 11 (see the arrows in Fig. 2). The air that has passed through the first heat exchanger 11 is finally blown out forward from the front surface of the housing

2a (see the arrow in Fig. 2).

[0082] As illustrated in Figs. 3 and 5, the first heat exchanger 11 mainly includes a heat exchanging part 100, the first header 150, a second header 160, a flow divider 170, a first pipe 180, and a second pipe 190.

[0083] Although not limited, the heat exchanging part 100, the first header 150, the second header 160, the flow divider 170, the first pipe 180, and the second pipe 190 of the first heat exchanger 11 are made of aluminum or an aluminum alloy. The heat exchanging part 100, the first header 150, the second header 160, the flow divider 170, the first pipe 180, and the second pipe 190 are joined to each other by brazing or the like.

(4-1) Configuration of first heat exchanger

[0084] Various configurations of the first heat exchanger 11 will be described.

(4-1-1) Heat exchanging part

[0085] The heat exchanging part 100 is a main part of the first heat exchanger 11. The heat exchange between the refrigerant and the air mainly takes place in the heat exchanging part 100. The heat exchanging part 100 includes a plurality of the multi-channeled flat tubes 110 arranged side by side in the vertical direction, and a plurality of fins 120 attached to the multi-channeled flat tubes 110. In the present embodiment, 73 multi-channeled flat tubes 110 are arranged side by side in the vertical direction in the heat exchanging part 100. Note that, the number of multi-channeled flat tubes 110 of the heat exchanging part 100 is merely an example, and may be changed as appropriate.

[0086] In the present embodiment, as illustrated in Fig. 4, in the first heat exchanger 11, two rows of the heat exchanging parts 100 are arranged in the direction of the air flow generated by the first fan 15 (air flow direction A). In other words, in the first heat exchanger 11 of the present embodiment, a plurality of rows of the multi-channeled flat tubes 110 are arranged in the air flow direction A.

[0087] Hereinafter, among the two rows of the heat exchanging parts 100, the heat exchanging part 100 disposed on the upstream side may be referred to as a heat exchanging part 100u, and the heat exchanging part 100 disposed on the downstream side may be referred to as a heat exchanging part 100d (see Fig. 4). Note that when there is no particular needs to distinguish between the heat exchanging parts 100u and 100d, such as when describing contents common to the two, the heat exchanging parts may be simply referred to as the heat exchanging parts 100.

[0088] The air flow direction A here means the direction of the air flow passing through the heat exchanging part 100 when the heat exchanging parts 100 are viewed along the vertical direction in which the multi-channeled flat tubes 110 of the heat exchanging parts 100 are ar-

ranged. In other words, here, the air flow direction A means the flow direction of the air passing through the heat exchanging parts 100 when the heat exchanging parts 100 are viewed from the upper side (in plan view).

[0089] In the first heat exchanger 11 of the present embodiment, the heat exchanging parts 100 are arranged in two rows in the air flow direction A. However, the first heat exchanger 11 may have only one row of the heat exchanging part 100. Further, the first heat exchanger 11 may include three or more rows of heat exchanging parts 100 in the air flow direction A.

[0090] As illustrated in Fig. 6, the multi-channeled flat tube 110 is a flat-shaped heat transfer tube (in the cross section of the heat transfer tube, the thickness (height in the vertical direction) is smaller than the width). As illustrated in Figs. 4 and 6, each of the multi-channeled flat tubes 110 has a plurality of holes 112 formed to extend in parallel to each other along the direction in which the multi-channeled flat tube 110 extends. The holes 112 of each multi-channeled flat tube 110 function as flow paths for the refrigerant.

[0091] Each of the multi-channeled flat tubes 110 of each heat exchanging part 100 has a substantially L-shape corresponding to the shape of the first heat exchanger 11. One end of each of the multi-channeled flat tubes 110 is connected with the first header 150, and the other end of each of the multi-channeled flat tubes 110 is connected with the second header 160. Specifically, in plan view, each of the multi-channeled flat tubes 110 extends from the first header 150 disposed in the vicinity of the machine chamber R1 on the rear right side of the housing 2a to the vicinity of the rear left end portion along the back surface of the housing 2a, changes direction in the vicinity of the rear left end portion of the housing 2a, and extends to the second header 160 disposed in the vicinity of the front left end portion of the housing 2a.

[0092] Note that the shape of the multi-channeled flat tubes 110 (in other words, the shape of the first heat exchanger 11) is not limited to the L-shape. Depending on the type of the heat source unit 2, the required performance, and the like, a shape other than the L-shape, such as a linear shape (I-shape), a U-shape, or a quadrangular shape, may be adopted as the shape of the multi-channeled flat tube 110.

[0093] The multi-channeled flat tubes 110 of each heat exchanging part 100 are divided into two groups (the first tube group 114 and a second tube group 116). In other words, the plurality of multi-channeled flat tubes 110 include the multi-channeled flat tubes 110 of the first tube group 114 and the flat multi-channeled flat tubes 110 of the second tube group 116. In the heat exchanging part 100, the multi-channeled flat tubes 110 of the second tube group 116 mainly contribute to heat exchange between the refrigerant and the air.

[0094] The first tube group 114 includes one or more multi-channeled flat tubes 110. The multi-channeled flat tubes 110 of the first tube group 114 include the multi-channeled flat tube 110 disposed at the lowermost stage

in the first heat exchanger 11 (disposed at the lowermost stage in each heat exchanging part 100). Here, the multi-channeled flat tubes 110 disposed at the lowermost stage in the first heat exchanger 11 are denoted by the symbol "110L" (see Fig. 5 and Fig. 6).

[0095] In the present embodiment, the first tube group 114 includes the multi-channeled flat tube 110L disposed at the lowermost stage and the multi-channeled flat tube 110 disposed at the second stage from the bottom in each of the heat exchanging parts 100u and 100d. However, depending on the design, the first tube group 114 may include only the multi-channeled flat tube 110L disposed at the lowermost stage in each of the heat exchanging parts 100u and 100d, or may include the multi-channeled flat tube 110 disposed at the third lowest stage from the bottom or higher, in addition to those at the lowermost stage and the second stage from the bottom in each of the heat exchanging parts 100u and 100d.

[0096] The second tube group 116 includes the multi-channeled flat tubes 110 other than the multi-channeled flat tubes 110 of the first tube group 114. In particular, in the present embodiment, all of the multi-channeled flat tubes 110 except for the multi-channeled flat tubes 110 of the first tube group 114, belong to the second tube group 116. The number of the multi-channeled flat tubes 110 included in the first tube group 114 is preferably smaller than the number of the multi-channeled flat tubes 110 included in the second tube group 116. For example, in the present embodiment, the number of multi-channeled flat tubes 110 included in the first tube group 114 is 4 (2 tubes $\times$ 2 rows), and the number of multi-channeled flat tubes 110 included in the second tube group 116 is 142 (71 tubes $\times$ 2 rows). Preferably, the number of the multi-channeled flat tubes 110 included in the first tube group 114 is within 10%, more preferably within 5%, of the total number of the multi-channeled flat tubes 110 included in the first heat exchanger 11.

[0097] The multi-channeled flat tubes 110 of the first tube group 114 form the first path P1 that is a flow path of the refrigerant.

[0098] The multi-channeled flat tubes 110 of the second tube group 116 form a second path P2 that is a flow path of the refrigerant.

[0099] The refrigerant flows in the following manners respectively when the first heat exchanger 11 functions as a radiator and as an evaporator.

[0100] When the first heat exchanger 11 functions as an evaporator, the refrigerant flows into the flow divider 170 as an example of a pressure loss part after through the first path P1, and then flows into the second path P2 after flowing through the flow divider 170. In particular, in the present embodiment, when the first heat exchanger 11 functions as an evaporator, the entire amount of the refrigerant supplied to the first heat exchanger 11 flows into the flow divider 170 after flowing through the first path P1, and flows into the second path P2 after flowing through the flow divider 170. Details of how the refrigerant flows through the first heat exchanger 11 when the first

heat exchanger 11 functions as an evaporator will be described below.

[0101] When the first heat exchanger 11 functions as a radiator, the refrigerant flows through the first heat exchanger 11 in a direction opposite to that when the first heat exchanger 11 functions as an evaporator. In short, when the first heat exchanger 11 functions as a radiator, the refrigerant flows into the flow divider 170 after flowing through the second path P2, and flows into the first path P1 after flowing through the flow divider 170. In particular, in the present embodiment, when the first heat exchanger 11 functions as a radiator, the entire amount of refrigerant supplied to the first heat exchanger 11 flows into the flow divider 170 after flowing through the second path P2, and flows into the first path P1 after flowing through the flow divider 170. Details of how the refrigerant flows through the first heat exchanger 11 when the first heat exchanger 11 functions as a radiator will be described below.

[0102] The fin 120 partitions the space between the multi-channeled flat tubes 110 adjacent to each other in the vertical direction (the direction in which the multi-channeled flat tubes 110 are arranged) into a plurality of ventilation channels through which air flows. The fins 120 have a plurality of horizontally elongated notches 122 formed into which the plurality of multi-channeled flat tubes 110 can be inserted (see Fig. 4). The direction in which the notches 122 extend substantially coincides with the air flow direction A generated by the first fan 15. The notches 122 are open on the leeward side so that the multi-channeled flat tubes 110 are inserted from the leeward side toward the windward side in the air flow direction. The notches 122 of the fins 120 are formed at a predetermined interval in the vertical direction.

(4-1-2) First header

[0103] The first header 150 is a vertically long hollow tubular member whose upper end and lower end are closed. One first header 150 is provided for each of the two rows of heat exchanging parts 100. However, the first header 150 may be a single tubular member shared by the two rows of heat exchanging parts 100, and the inside of the first header 150 may be partitioned into spaces corresponding to the two rows of heat exchanging parts 100.

[0104] Two first headers 150 are installed in an upright state in the vicinity of the machine chamber R1 on the rear right side of the housing 2a (see Fig. 2). One end of each of the plurality of multi-channeled flat tubes 110 of the corresponding heat exchanging part 100 is connected with each first header 150.

[0105] Although the internal structure is not limited, in the first heat exchanger 11 of the present embodiment, the inside of each of the first headers 150 is partitioned into four independent spaces 152a to 152d in the vertical direction. Inside the first header 150, the spaces 152a, 152b, 152c, and 152d are arranged in this order from the bottom.

[0106] As illustrated in Fig. 5, the space 152a at the lowermost stage is connected with one end of the first pipe 180 and communicates with the first pipe 180. As illustrated in Fig. 5, the liquid refrigerant pipe 20 is connected with the other end of the first pipe 180 (the end portion opposite to the side connected with the space 152a of the first header 150). Further, as illustrated in Fig. 5, the space 152a of each first header 150 is connected with one end of the multi-channeled flat tube 110L at the lowermost stage in the heat exchanging part 100 corresponding to the first header 150. Thus, the space 152a and the multi-channeled flat tube 110L at the lowermost stage in the heat exchanging part 100 communicate with each other.

[0107] As illustrated in Fig. 5, the space 152b communicates with a pipe (main pipe) 174 of the flow divider 170, and communicates with a main body 172 of the flow divider 170 via the pipe 174. The space 152b of each first header 150 is connected with one end of the multi-channeled flat tube 110 at the second stage from the bottom (the multi-channeled flat tube 110 of the first tube group 114) in the heat exchanging part 100 corresponding to that first header 150. Thus, the space 152b and the multi-channeled flat tube 110 at the second stage from the bottom in the heat exchanging part 100 communicate with each other.

[0108] As illustrated in Fig. 5, the space 152c communicates with a pipe (capillary) 176 of the flow divider 170, and communicates with the main body 172 of the flow divider 170 via the pipe 176. In addition, for example, one end of each of the multi-channeled flat tube 110 at the 3rd to 14th stages from the bottom in the heat exchanging part 100 corresponding to the first header 150 is connected with the space 152c of each first header 150. Thus, the space 152c and each of the multi-channeled flat tubes 110 at the 3rd to 14th stages from the bottom in the heat exchanging part 100 communicate with each other.

[0109] As illustrated in Fig. 5, the space 152d at the uppermost stage is connected with the one end of the second pipe 190 and communicates with the second pipe 190. As illustrated in Fig. 5, the first gas refrigerant pipe 19 is connected with the other end of the second pipe 190 (the end portion opposite to the side connected with the space 152d of the first header 150). The space 152d of each first header 150 is connected, for example, with one end of the multi-channeled flat tubes 110 at the 15th to 73rd stages from the bottom in the heat exchanging part 100 corresponding to the first header 150. Thus, the space 152d and the multi-channeled flat tubes 110 at the 15th to 73rd stages from the bottom in the heat exchanging part 100 communicate with each other.

(4-1-3) Second header

[0110] The second header 160 is a vertically long hollow tubular member whose upper end and lower end are closed. One second header 160 is provided for each of

the two rows of heat exchanging parts 100. However, the second header 160 may be a single tubular member shared by the two rows of heat exchanging parts 100, and the inside of the second header 160 may be partitioned into spaces corresponding to the two rows of heat exchanging parts 100.

[0111] Two second headers 160 are installed in an upright state at the front left end of the housing 2a of the heat source unit 2 (see Fig. 2). One end (the end portion on the side not connected with the first header 150) of each of the plurality of multi-channeled flat tubes 110 of the corresponding heat exchanging part 100 is connected with each second header 160.

[0112] Although the internal structure is not limited, in the first heat exchanger 11 of the present embodiment, the inside of each of the second headers 160 is partitioned into eight independent spaces 162a to 162h. Inside the first header 150, the spaces 162a, 162b, 162c, 162d, 162e, 162f, 162g, and 162h are arranged in this order from the bottom.

[0113] The space 162a is connected with one ends of the multi-channeled flat tubes 110 at the lowermost stage and the second stage from the bottom in the heat exchanging part 100 corresponding to the first header 150 (in other words, the multi-channeled flat tubes 110 of the first tube group 114). Thus, the space 162a communicates with the multi-channeled flat tubes 110 of the first tube group 114.

[0114] The space 162b is connected with each of the spaces 162c to 162h through a plurality of pipes 164, and the space 162b communicates with all of the plurality of spaces 162c to 162h. The space 162b is connected with one ends of the multi-channeled flat tubes 110 at the 3rd to 14th stages from the bottom in the heat exchanging part 100 corresponding to the first header 150. Thus, the space 162b communicates with the multi-channeled flat tubes 110 at the 3rd to 14th stages from the bottom in the heat exchanging part 100.

[0115] The spaces 162c to 162h are similar, and thus will be described in a simplified manner.

[0116] The space 162c is connected with the space 162b through the pipe 164, and is connected with one end of each of the multi-channeled flat tubes 110 at the 15th to 24th stages from the bottom in the heat exchanging part 100 corresponding to the first header 150.

[0117] The space 162d is connected with the space 162b through the pipe 164, and is connected with one end of each of the multi-channeled flat tubes 110 at the 25th to 34th stages from the bottom in the heat exchanging part 100 corresponding to the first header 150.

[0118] The space 162e is connected with the space 162b through the pipe 164, and is connected with one end of each of the multi-channeled flat tubes 110 at the 35th to 44th stages from the bottom in the heat exchanging part 100 corresponding to the first header 150.

[0119] The space 162f is connected with the space 162b through the pipe 164, and is connected with one end of each of the multi-channeled flat tubes 110 at the

45th to 54th stages from the bottom in the heat exchanging part 100 corresponding to the first header 150.

[0120] The space 162f is connected with the space 162b through the pipe 164, and is connected with one end of each of the multi-channeled flat tubes 110 at the 55th to 64th stages from the bottom in the heat exchanging part 100 corresponding to the first header 150.

[0121] The space 162h is connected with the space 162b through the pipe 164, and is connected with one end of each of the multi-channeled flat tubes 110 at the 65th to 73rd stages from the bottom in the heat exchanging part 100 corresponding to the first header 150.

(4-1-4) Flow divider

[0122] The flow divider 170 is a device with which the refrigerant flowing from the first path P1 is divided to flow into the spaces 152c of the two respective first headers 150 when the first heat exchanger 11 functions as an evaporator.

[0123] The flow divider 170 includes the flow divider main body 172, the pipe (main pipe) 174, and the plurality of pipes (capillaries) 176. The pipe 174 communicates the flow divider main body 172 with the space 152b of each of the two first headers 150. The pipe 176 communicates the flow divider main body 172 with the space 152c of each of the two first headers 150.

[0124] The flow divider main body 172 is a mechanism with which the refrigerant flowing in from the pipe 174 is divided to flow into the plurality of pipes 176. While with the flow divider 170 here, the refrigerant that has flowed into the flow divider main body 172 is divided to flow into the two pipes 176, the number of flow paths into which the refrigerant divided by the flow divider 170 flows may be appropriately determined in accordance with how the paths are designed in the first heat exchanger 11 or the like.

[0125] Here, the flow divider 170 is an example of the pressure loss part of the present disclosure.

[0126] When the first heat exchanger 11 is used as an evaporator, if a predetermined amount of refrigerant (for example, at a specified maximum flow rate in a normal operation) flows through the flow divider 170 functioning as a pressure loss part and the second path P2 in this order, the total pressure loss in the pressure loss part becomes larger than the total pressure loss in the second path P2. In other words, the pressure loss part here is defined as a part where the total pressure loss is larger than that in the second path P2 when a predetermined amount of refrigerant (for example, at a specified maximum flow rate in a normal operation) flows, when the first heat exchanger 11 is used as an evaporator.

[0127] Preferably, the minimum cross-sectional area of the flow path of the flow divider 170 or another form of pressure loss part is set to be smaller than the sum of the cross-sectional areas of the flow paths of the multi-channeled flat tube 110 at the lowermost stage included in the first path P1. As in Modification A described below,

when there are other multi-channeled flat tubes 110 that are different from those at the lowermost stage and are connected in parallel with the multi-channeled flat tube 110 at the lowermost stage in the first path P1, for example, the minimum cross-sectional area of the flow path of the pressure loss part is set to be smaller than the sum of the flow path cross-sectional areas of the multi-channeled flat tube 110 at the lowermost stage included in the first path P1 and the multi-channeled flat tubes 110 connected in parallel with this multi-channeled flat tube 110 at the lowermost stage.

[0128] With such a configuration, decrease in the liquid pressure, which is insufficient when the liquid simply flows through the first path P1, can be easily promoted by the pressure loss part.

[0129] Specifically, for example, in the present embodiment, since the first path P1 includes the multi-channeled flat tubes 110 of the two rows of heat exchanging parts 100 connected in parallel, the sum of the flow path cross-sectional areas of the multi-channeled flat tubes 110 at the lowermost stage included in the first path P1 means the sum of the flow path cross-sectional areas of the holes 112 of the two multi-channeled flat tubes 110. The minimum cross-sectional area of the flow path of the flow divider 170 or another type of pressure loss part is preferably set to be smaller than the sum of the cross-sectional areas of the flow paths of the holes 112 of the two multi-channeled flat tubes 110.

[0130] As a way of increasing the pressure loss of the flow divider 170, the pressure loss in the flow divider 170 may be set to a desired magnitude by providing an orifice 173 in the refrigerant flow path in the flow divider main body 172.

[0131] Further, as another way of increasing the pressure loss in the flow divider 170, in addition to the provision of the orifice 173 in the flow divider main body 172, or instead of the provision of the orifice 173 in the flow divider main body 172, the pipe diameters of the pipe 174 and the pipe 176 may be appropriately selected with respect to the predetermined amount of the refrigerant flowing into the first heat exchanger 11.

[0132] Furthermore, as another way of increasing the pressure loss in the flow divider 170, an orifice 174a may be provided in the pipe 174 or an orifice 176a may be provided in the pipe 176 in addition to or instead of any of the above-described ways.

[0133] While all of the orifice 173, the orifice 174a, and the orifice 176a are illustrated in Fig. 5, this does not mean that all of the orifice 173, the orifice 174a, and the orifice 176a need to be provided.

[0134] Here, an example in which the flow divider 170 functions as the pressure loss part is described, but something other than the pressure loss part may be used as the pressure loss part. For example, in a case where the flow does not need to be divided after the flow out from the first path P1, the flow divider 170 may be omitted as illustrated in Fig. 7, and an orifice 171a may be provided in a pipe 171 connecting the space 152b and the

space 152c of the first header 150.

(5) Flow of refrigerant in first heat exchanger

(5-1) Feature of and effect obtained by heat exchanger of the present disclosure

[0135] First, features of the heat exchanger of the present disclosure and effects obtained by the heat exchanger of the present disclosure will be described with reference to Figs. 8 and 9.

[0136] Fig. 8A is a diagram illustrating a difference between the flow of the refrigerant in the heat exchanger of the present disclosure and a flow of the refrigerant in a conventional heat exchanger, and is a diagram conceptually illustrating the flow of the refrigerant in a heat exchanger HEX of the present disclosure functioning as an evaporator.

[0137] Fig. 8B is a diagram illustrating a difference between the flow of the refrigerant in the heat exchanger of the present disclosure and a flow of the refrigerant in the conventional heat exchanger, and is a diagram conceptually illustrating the flow of the refrigerant in a conventional heat exchanger HEX1 functioning as an evaporator.

[0138] It should be noted that the heat exchanger HEX illustrated in Fig. 8A used in the description here is a simplified heat exchanger of the present disclosure for facilitating understanding of the description, and has a structure different from the first heat exchanger 11 described above. For example, the heat exchanger HEX illustrated in Fig. 8A is not illustrated in a mode in which the refrigerant flows through the multi-channeled flat tubes 110 in a turning back manner in the first path P1. For example, the heat exchanger HEX illustrated in Fig. 8A is not illustrated in a mode in which the refrigerant flows through the multi-channeled flat tubes 110 in a turning back manner in the second path P2.

[0139] While a detailed description of the heat exchanger HEX1 in Fig. 8B is omitted, the heat exchanger HEX1 is the same as the heat exchanger HEX of the present disclosure except for the way in which the refrigerant flows and the fact that a flow divider DIV is not intended to achieve the pressure loss. Similarly to heat exchanger HEX, the heat exchanger HEX1 is a heat exchanger in which the plurality of multi-channeled flat tubes 110 are arranged in the vertical direction.

[0140] Fig. 9 is a diagram schematically illustrating a Mollier diagram in a case where a heating operation is performed by the air conditioning apparatus according to an embodiment of the refrigeration cycle apparatus including the heat exchanger HEX, for explaining the effect obtained by the heat exchanger HEX of the present disclosure. Note that Fig. 9 is a diagram for explanation and does not illustrate an actual Mollier diagram of the air conditioning apparatus of the present disclosure.

[0141] In the conventional heat exchanger HEX1 illustrated in Fig. 8B, when the heat exchanger HEX1 is used

as an evaporator, the entire amount of the refrigerant flows into the flow divider DIV, is divided by the flow divider DIV to flow into each path of the heat exchanging part of the heat exchanger HEX1, and then flows out of the heat exchanger HEX1. The heat exchanger HEX1 has a structure in which a path length of a path (referred to as a lowermost stage path) including the flat heat transfer tube at the lowermost stage in the heat exchanging part is longer than path lengths of other paths. For example, in the example of Fig. 8B, the refrigerant flows out from the paths other than the path at the lowermost stage in the heat exchanging part without turning back (the path length is equivalent to one multi-channeled flat tube), whereas in the path at the lowermost stage in the heat exchanging part, the refrigerant turns back twice and thus flows out after flowing for a length corresponding to three flat tubes. In the heat exchanger HEX1 in Fig. 8B, since the pressure loss of the lowermost stage path of the heat exchanging part is larger than those of the other paths, the amount of the refrigerant flowing through the lowermost stage path of the heat exchanging part is small, and the refrigerant hardly exchanges heat. Thus, the flat heat transfer tube at the lowermost stage in the heat exchanging part is less likely to be frosted.

[0142] On the other hand, in the conventional heat exchanger HEX1, the pressure loss in the lowermost stage path of the heat exchanging part is not large as in the heat exchanger HEX of the present disclosure and the refrigerant hardly flows in the lowermost stage path of the heat exchanging part. Therefore, when the outside air temperature becomes low, the multi-channeled flat tube in the lowermost stage path in the heat exchanging part is likely to be frosted.

[0143] The pressure loss in the lowermost stage path in the heat exchanging part is larger than those in other paths in the heat exchanger HEX1. Therefore, also when the heat exchanger HEX1 is used as a condenser during the defrosting operation, the amount of refrigerant flowing through the lowermost stage path in the heat exchanging part is likely to be small. Therefore, once frost or ice adheres to the lowermost stage path in the heat exchanger HEX1, it takes time to remove the frost or ice (until the defrosting operation is completed).

[0144] On the other hand, in the heat exchanger HEX of the present disclosure illustrated in Fig. 8A, when the heat exchanger HEX is used as an evaporator, the refrigerant passes through the first path P1 (path including the multi-channeled flat tube 110L at the lowermost stage) in the heat exchanging part, flows into the flow divider 170 as the pressure loss part, and then flows into the second path P2 formed by the multi-channeled flat tubes 110 (of the second tube group 116) other than the first tube group 114 forming the first path P1. In particular, in the first heat exchanger 11 described in the first embodiment, when the first heat exchanger 11 is used as an evaporator, the entire amount of refrigerant flowing into the first heat exchanger 11 passes through the first path P1 of the heat exchanging part, flows into the flow

divider 170 as the pressure loss part, and then flows into the second path P2 of the heat exchanging part formed by the multi-channeled flat tubes 110 of the second tube group 116.

[0145] Therefore, a large pressure loss can be achieved with the flow divider 170 as an example of the pressure loss part in the heat exchanger HEX of the present disclosure. Thus, the Mollier diagram as illustrated in Fig. 9 is obtained when the air conditioning apparatus according to the embodiment of the refrigeration cycle apparatus of the present disclosure is caused to perform the heating operation, and a large temperature difference ($T_a - T_b$) between the inlet and the outlet of the first path P1 can be achieved. Further, as in the first heat exchanger 11 of the first embodiment, when the entire amount of the refrigerant flowing into the heat exchanger HEX flows through the first path P1, a large amount of the refrigerant can flow through the first path P1 as compared with the lowermost stage path of the conventional heat exchanger HEX1. As a result, heat radiation proportional to the product of the amount of refrigerant flowing and the temperature difference ($T_a - T_b$) is obtained in the first path P1 of the heat exchanger HEX, and suppression of frosting is facilitated even when the temperature of the air for heat exchange is low in the first path P1 of the heat exchanger HEX.

[0146] Further, in the heat exchanger HEX, when the heat exchanger HEX is used as a condenser in the defrosting operation, all the refrigerant flowing into the heat exchanger HEX flows into the first path P1 after passing through the second path P2 and the flow divider 170. Therefore, in the heat exchanger HEX, even if frost adheres to the first path P1 or ice adheres to the multi-channeled flat tube 110L of the first path P1 or the like, the time required for removing them (defrosting operation time) can be shortened.

[0147] The flow direction of the refrigerant when the heat exchangers HEX and HEX1 function as a radiator is simply opposite to the flow direction of the refrigerant when the heat exchangers function as an evaporator, and thus a detailed description thereof will be omitted herein.

(5-2) Flow of refrigerant in first heat exchanger

[0148] Next, the flow of the refrigerant in the first heat exchanger 11 when the first heat exchanger 11 described in the above embodiment functions as an evaporator will be described with reference to Figs. 5 and 6. The direction of the flow of the refrigerant when the first heat exchanger 11 functions as a radiator is simply opposite to that when the first heat exchanger 11 functions as an evaporator, and thus a detailed description thereof will be omitted herein.

[0149] When the first heat exchanger 11 functions as an evaporator, the refrigerant flows into the first pipe 180 from the liquid refrigerant pipe 20, and then the refrigerant flows into the spaces 152a in the two first headers 150.

As illustrated in Figs. 5 and 6, the refrigerant that has flowed into the space 152a flows through the multi-channeled flat tube 110L (first path P1) of the heat exchanging part 100 communicating with the space 152, turns back in the space 162a of the second header 160 communicating with the multi-channeled flat tube 110L, and flows through the multi-channeled flat tube 110 (first path P1) at the second stage from the bottom in the heat exchanging part 100 communicating with the space 162a, to the space 152b of the first header 150 communicating with the multi-channeled flat tube 110. The refrigerant that has flowed into the space 152b passes through the flow divider 170 while flowing through the pipe 174, the flow divider main body 172, and the pipe 176 in this order to be divided to flow into the spaces 152c of the two first headers 150. The refrigerant that has flowed into the space 152c of each first header 150 flows to the space 162b of the second header 160 through the multi-channeled flat tube 110 (second path P2) of the heat exchanging part 100 communicating with the space 152c. The refrigerant that has flowed into the space 162b of each second header 160 is divided to flow into the plurality of pipes 164, flows into the spaces 162c to 162h of the second header 160, and flows through the multi-channeled flat tubes 110 (second path P2) communicating with the spaces 162c to 162h of the second header 160 to the space 152d of the first header 150. The refrigerant that has flowed into the spaces 152d of the two first headers 150 passes through the second pipe 190 and flows into the first gas refrigerant pipe 19.

[0150] In the present embodiment, the first tube group 114 includes the two heat exchanging parts 100, and includes the plurality of multi-channeled flat tubes 110 arranged in parallel (connected in parallel). With the plurality of multi-channeled flat tubes 110 arranged in parallel thus included, even when the entire amount of refrigerant flowing into the first heat exchanger 11 flows through the first path P1, it is possible to suppress the occurrence of excessive pressure loss in the multi-channeled flat tubes 110 of the first path P1. In other words, all of the refrigerant supplied to the first heat exchanger 11 flowing through a single multi-channeled flat tube 110, may lead to excessive pressure loss. In view of this, the first heat exchanger 11 of the present embodiment includes the plurality of multi-channeled flat tubes 110 arranged in parallel (connected in parallel), whereby the occurrence of such an excessive pressure loss can be suppressed.

[0151] In the present embodiment, in the first path P1, the refrigerant flows through the multi-channeled flat tube 110L, and then flows through the multi-channeled flat tube 110 at the second stage from the bottom, but this configuration is merely an example. For example, the first path P1 may include only the multi-channeled flat tubes 110L, and the refrigerant that has flowed through the multi-channeled flat tubes 110L of the two rows of the heat exchanging parts 100 may immediately flow into the flow divider 170. However, when such a configuration

is adopted, it may be necessary to connect the first pipe 180 with the second header 160 side of the first heat exchanger 11. However, for the sake of easier manufacturing of the first heat exchanger 11, the first pipe 180 and the second pipe 190 are preferably connected with the same header (in particular, the first header 150 in the present embodiment).

(6) Features

[0152] (6-1)

The first heat exchanger 11 includes the plurality of multi-channeled flat tubes 110 and the pressure loss part through which the refrigerant flows.

[0153] The pressure loss part is, for example, the flow divider 170. The pressure loss part is, for example, the orifice 173, 174a, or 176a provided in the flow divider 170. Alternatively, the pressure loss part may be the orifice 171a provided in the pipe 171.

[0154] The plurality of multi-channeled flat tubes 110 are arranged side by side in the vertical direction. The plurality of multi-channeled flat tubes 110 include the multi-channeled flat tubes 110 of the first tube group 114 including the multi-channeled flat tube 110 (110L) disposed at the lowermost stage in the first heat exchanger 11, and the multi-channeled flat tubes 110 of the second tube group 116 other than the multi-channeled flat tubes 110 of the first tube group 114. The multi-channeled flat tubes 110 of the first tube group 114 form the first path P1 that is a flow path of the refrigerant. The multi-channeled flat tubes 110 of the second tube group 116 form the second path P2 that is a flow path of the refrigerant. When the first heat exchanger 11 functions as an evaporator, at least a portion of the refrigerant supplied to the first heat exchanger 11 flows into the pressure loss part after flowing through the first path P1, and flows into the second path P2 after flowing out the pressure loss part.

[0155] The pressure loss part is provided downstream of the first path P1 in the flow direction of the refrigerant when the first heat exchanger 11 is used as an evaporator. Therefore, in the first heat exchanger 11, it is possible to ensure a large pressure difference between the entry into the first path P1 and the entry into the second path P2, in other words, a large temperature difference between the entry into the first path P1 and the entry into the second path P2. Therefore, in the first heat exchanger 11, the heat radiation amount from the first path P1 when the first heat exchanger 11 functions as an evaporator can be ensured, and frosting on the first path P1 can be suppressed.

[0156] (6-2)

In the first heat exchanger 11, when the first heat exchanger 11 functions as an evaporator, the entire amount of refrigerant supplied to the first heat exchanger 11 flows into the pressure loss part after flowing through the first path P1, and flows into the second path P2 after flowing through the pressure loss part.

[0157] In the first heat exchanger 11 of the second as-

pect, when the first heat exchanger 11 functions as an evaporator, the entire amount of the refrigerant flowing into the first heat exchanger 11 flows through the first path P1, and therefore a large heat radiation amount from the first path P1 can be achieved when the first heat exchanger 11 functions as an evaporator. Therefore, in the first heat exchanger 11, frosting on the multi-channeled flat tube 110 (110L) at the lowermost stage is less likely to occur.

[0158] Further, when the first heat exchanger 11 functions as a radiator, in the first heat exchanger 11, the entire amount of the inflowing refrigerant flows into the first path P1 after passing through the second path P2. With all the refrigerant flowing through the first path P1, it is possible to melt and remove frost and ice adhered to the multi-channeled flat tubes 110 of the first tube group 114 in a relatively short period of time during reverse cycle defrosting in which the first heat exchanger 11 is used as a radiator.

[0159] For example, even if moisture generated during defrosting freezes around the multi-channeled flat tube 110L at the lowermost stage in the first heat exchanger 11, the reverse cycle defrosting operation can melt the ice that has attached to the multi-channeled flat tube 110L and remove the ice in a relatively short period of time.

[0160] (6-3)

In the first heat exchanger 11, the first tube group 114 includes a plurality of multi-channeled flat tubes 110 arranged in parallel.

[0161] Specifically, in the above embodiment, when the first heat exchanger 11 functions as an evaporator, in the first path P1, the refrigerant flows in parallel through the multi-channeled flat tubes 110L at the lowermost stage in the two heat exchanging parts 100, and then flows in parallel through the multi-channeled flat tubes 110 at the second stage from the bottom in the two heat exchanging parts 100. In the above embodiment, when the first heat exchanger 11 functions as a radiator, in the first path P1, the refrigerant flows in parallel through the multi-channeled flat tubes 110 at the second stage from the bottom in the two heat exchanging parts 100, and then flows in parallel through the multi-channeled flat tubes 110L at the lowermost stage in the two heat exchanging parts 100.

[0162] In the first heat exchanger 11, the occurrence of an excessive pressure loss in the first path P1 can be suppressed.

[0163] (6-4)

In the first heat exchanger 11, the number of the multi-channeled flat tubes 110 included in the first tube group 114 is smaller than the number of the multi-channeled flat tubes 110 included in the second tube group 116.

[0164] In the first heat exchanger 11, a high flow rate of the refrigerant in each of the multi-channeled flat tubes 110 of the first path P1 can be achieved, and a large heat radiation amount from each of the multi-channeled flat tubes 110 of the first path P1 can be achieved when the first heat exchanger 11 functions as an evaporator/radi-

ator.

[0165] (6-5)

The air conditioning apparatus 1 includes the refrigerant circuit 6 and the first fan 15 as an example of a fan. The refrigerant circuit 6 includes the first heat exchanger 11 as a heat source heat exchanger, and the compressor 8 that compresses the refrigerant. The first fan 15 sends air to the first heat exchanger 11.

[0166] In the air conditioning apparatus 1, frosting on the multi-channeled flat tubes 110 of the first tube group 114 of the first heat exchanger 11 can be suppressed, and therefore, the interruption time of the operation in which the first heat exchanger 11 functions as an evaporator can be shortened.

[0167] In addition, in the air conditioning apparatus 1, as described above, defrosting of the multi-channeled flat tubes 110 of the first tube group 114 of the first heat exchanger 11 can be completed in a short period of time, and thus, the defrosting operation performed while the operation in which the first heat exchanger 11 functions as an evaporator is interrupted can be completed.

(7) Modifications

[0168] The above-described embodiment can be appropriately modified, for example, as illustrated in the following modifications. It should be noted that each of the modifications may be applied in combination with another modification as appropriate as long as they do not contradict each other.

(7-1) Modification A

[0169] In the above embodiment, in the first path P1, the refrigerant flows through the multi-channeled flat tubes 110L at the lowermost stage arranged in parallel in the two heat exchanging parts 100, and then flows through the multi-channeled flat tubes 110 at the second stage from the bottom arranged in parallel in the two heat exchanging parts 100.

[0170] However, the configuration in which the refrigerant flows through the plurality of multi-channeled flat tubes 110 arranged in parallel (connected in parallel) in the first path P1 is not limited to the configuration described above. For example, in the first path P1, as illustrated in Fig. 10, the refrigerant may flow through the multi-channeled flat tubes 110 at the lowermost stage and the second stage from the bottom arranged in parallel in a heat exchanging part 100, and then flow through the multi-channeled flat tubes 110 at the third stage and the fourth stage from the bottom arranged in parallel in that heat exchanging part 100.

[0171] The configuration of Modification A can be applied not only to the case where a plurality of rows of the heat exchanging parts 100 exist, but also to the case where only one row of the heat exchanging part 100 exists, for example.

(7-2) Modification B

[0172] The first path P1 described in the above embodiment may be disposed only on the windward side in the air flow direction A where frost or ice is particularly likely to be a problem. For example, in the embodiment described above, the first path P1 may be disposed only in the heat exchanging part 100u.

[0173] When the first path P1 is disposed only in the heat exchanging part 100u as described above, for example, the configuration of the heat exchanging part 100 described in Modification A can be applied.

[0174] When the first path P1 is disposed only in the heat exchanging part 100u, the first heat exchanger 11 may be designed so that the refrigerant flows through the first path P1, then flows through the flow divider 170, and then flows through the second path P2 including all the multi-channeled flat tubes 110 of the heat exchanging part 100d and the multi-channeled flat tubes 110 other than those in the first tube group 114 of the heat exchanging part 100u.

(7-3) Modification C

[0175] In the above embodiment, the refrigerant flows through the plurality of multi-channeled flat tubes 110 arranged in parallel in the first path P1 for suppressing occurrence of excessive pressure loss.

[0176] However, the configuration of the first path P1 for excessive pressure loss is not limited to such a configuration. For example, in the first path P1, the flow path area of each of the multi-channeled flat tubes 110 of the first tube group 114 may be made larger than the flow path area of each of the multi-channeled flat tubes 110 of the second tube group 116, in order to suppress excessive pressure loss in the first path P1. Specifically, as the multi-channeled flat tubes forming the first path P1, like the multi-channeled flat tube 110a of the heat exchanging part 100u in Fig. 11, a multi-channeled flat tube in which the size of the holes 112 and the number of the holes 112 are larger than those of the other multi-channeled flat tubes 110 may be used. Alternatively, only one of a configuration in which the size of the holes 112 is larger than that of the other multi-channeled flat tubes 110 in the multi-channeled flat tube 110a and a configuration in which the number of holes 112 is larger than that of the other multi-channeled flat tubes 110 may be adopted.

[0177] In Fig. 10, an example where the first path P1 is disposed only in the heat exchanging part 100u is illustrated as an example.

(7-4) Modification D

[0178] In the above-described embodiment, the pressure loss part is the flow divider 170 or the orifice 171a disposed in the pipe 171. However, the pressure loss part may be a nozzle disposed inside the header. Spe-

cifically, the pressure loss part may be a nozzle 154 disposed in the space 152c of the first header 150.

[0179] To be more specific, as illustrated in Fig. 12, the space 152c of the first header 150 may be provided with a structure in which when the first heat exchanger 11 functions as an evaporator, the refrigerant flowing in from the pipe 176 is blown upward by the nozzle 154, and the refrigerant is distributed to the multi-channeled flat tube 110 communicating with the space 152c while being circulated in the upper space as indicated by arrows. The first heat exchanger 11 may be designed such that a desired pressure loss is achieved by the nozzle 154.

(7-5) Modification E

[0180] In the above-described embodiment, the entire amount of refrigerant flowing into the first heat exchanger 11 flows through the first path P1.

[0181] However, in the case where the refrigeration cycle apparatus in which the heat exchanger is used is large, the amount of refrigerant flowing into the heat exchanger becomes extremely large, and when all the refrigerant flows through the first path P1, excessive pressure loss may occur in the first path P1. If the number of the multi-channeled flat tubes 110 of the first tube group 114 is increased and the refrigerant flows through the large number of the multi-channeled flat tubes 110 connected in parallel, the pressure loss occurring in the first path P1 can be suppressed. However, in such a configuration, the number of the multi-channeled flat tubes 110 belonging to the second path P2 mainly contributing to heat exchange may be reduced, and thus the efficiency of the refrigeration cycle apparatus may be compromised.

[0182] Therefore, as illustrated in Fig. 13, the heat exchanger HEX of the present disclosure may include a bypass path through which the refrigerant is guided to the second path P2 without flowing through the first path P1. In Fig. 13, a path through which the refrigerant flows to the second path P2 through the flow divider 170 after flowing through the first path P1 is referred to as a main path M, and a path through which the refrigerant flows to the second path P2 through the flow divider 170 without flowing through the first path P1 is referred to as a bypass path B.

[0183] While it is preferable to reduce the amount of the refrigerant flowing through the first path P1 in order to suppress the pressure loss in the first path P1, it is preferable to increase the amount of the refrigerant flowing through the first path P1 for the sake of suppression of frosting and the like. Therefore, at least 50% of the amount of the refrigerant supplied to the heat exchanger HEX preferably flows through first path P1. More preferably, at least 70% of the refrigerant supplied to the heat exchanger HEX flows through first path P1.

[0184] This heat exchanger HEX can suppress the occurrence of a problem in that the efficiency of the air conditioning apparatus 1 using the heat exchanger HEX is

compromised due to excessive pressure loss as a result of the entire amount of refrigerant flowing in the first path P1 when an extremely large amount of the refrigerant is supplied to the heat exchanger HEX.

<Additional note>

[0185] While embodiments and modifications 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

[0186]

1	Air conditioning apparatus (refrigeration cycle apparatus)
6	Refrigerant circuit
8	Compressor
11	First heat exchanger (heat exchanger)
15	First fan (fan)
110	Multi-channeled flat tube
110A	Multi-channeled flat tube (multi-channeled flat tube of first tube group)
110L	Multi-channeled flat tube disposed at lowermost stage
114	First tube group
116	Second tube group
150	First header (header)
154	Nozzle (pressure loss part)
170	Flow divider (pressure loss part)
171a	Orifice (pressure loss part)
173	Orifice (pressure loss part)
174a	Orifice (pressure loss part)
176a	Orifice (pressure loss part)
A	Air flow direction
B	Bypass path
P1	First path
P2	Second path

CITATION LIST

PATENT LITERATURE

[0187] PTL 1: Japanese Unexamined Patent Application Publication No. 2019-60596

Claims

1. A heat exchanger (11) comprising:
 - a plurality of multi-channeled flat tubes (110) arranged side by side in a vertical direction; and
 - a pressure loss part (154, 170, 171a, 173, 174a, 176a) through which a refrigerant flows, wherein

- the plurality of multi-channeled flat tubes include the multi-channeled flat tubes of a first tube group (114) including the multi-channeled flat tube disposed at a lowermost stage in the heat exchanger, and the multi-channeled flat tubes of a second tube group (116) other than the multi-channeled flat tubes of the first tube group, the multi-channeled flat tubes of the first tube group form a first path (P 1) that is a flow path of the refrigerant, the multi-channeled flat tubes of the second tube group form a second path (P2) that is a flow path of the refrigerant, and when the heat exchanger functions as an evaporator, at least a portion of the refrigerant supplied to the heat exchanger flows into the pressure loss part after flowing through the first path, and flows into the second path after flowing through the pressure loss part.
2. The heat exchanger according to claim 1, wherein when the heat exchanger functions as an evaporator, an entire amount of the refrigerant supplied to the heat exchanger flows into the pressure loss part after flowing through the first path, and flows into the second path after flowing through the pressure loss part.
 3. The heat exchanger according to claim 1 or 2, wherein the first tube group includes a plurality of the multi-channeled flat tubes arranged in parallel.
 4. The heat exchanger according to claim 1 or 2, wherein a flow path area of each of the multi-channeled flat tubes (110a) of the first tube group is larger than a flow path area of each of the multi-channeled flat tubes (110) of the second tube group.
 5. The heat exchanger according to any one of claims 1 to 4, wherein number of the multi-channeled flat tubes included in the first tube group is smaller than number of the multi-channeled flat tubes included in the second tube group.
 6. The heat exchanger according to any one of claims 1 to 5, wherein the pressure loss part is an orifice (171a, 173, 174a, 176a) disposed in a flow path of the refrigerant between the first path and the second path.
 7. The heat exchanger according to any one of claims 1 to 5, wherein the pressure loss part is a flow divider (170) disposed in a flow path of the refrigerant between the first path and the second path.
 8. The heat exchanger according to any one of claims 1 to 5, further comprising a header (150) disposed in a flow path of the refrigerant between the first path and the second path, wherein the pressure loss part is a nozzle (154) disposed inside the header.
 9. The heat exchanger according to claim 1, further comprising a bypass path (B) through which the refrigerant is guided to the second path without flowing through the first path.
 10. The heat exchanger according to any one of claims 1 to 9, wherein the multi-channeled flat tubes are arranged in a plurality of rows in a direction (A) of an air flow generated by a fan that sends air to the heat exchanger, and the first path is arranged only on a windward side in the direction of the air flow.
 11. A refrigeration cycle apparatus (1) comprising:
 - a refrigerant circuit (6) including the heat exchanger according to any one of claims 1 to 10 as a heat source heat exchanger and a compressor (8) that compresses the refrigerant; and
 - a fan (15) that sends air to the heat exchanger.

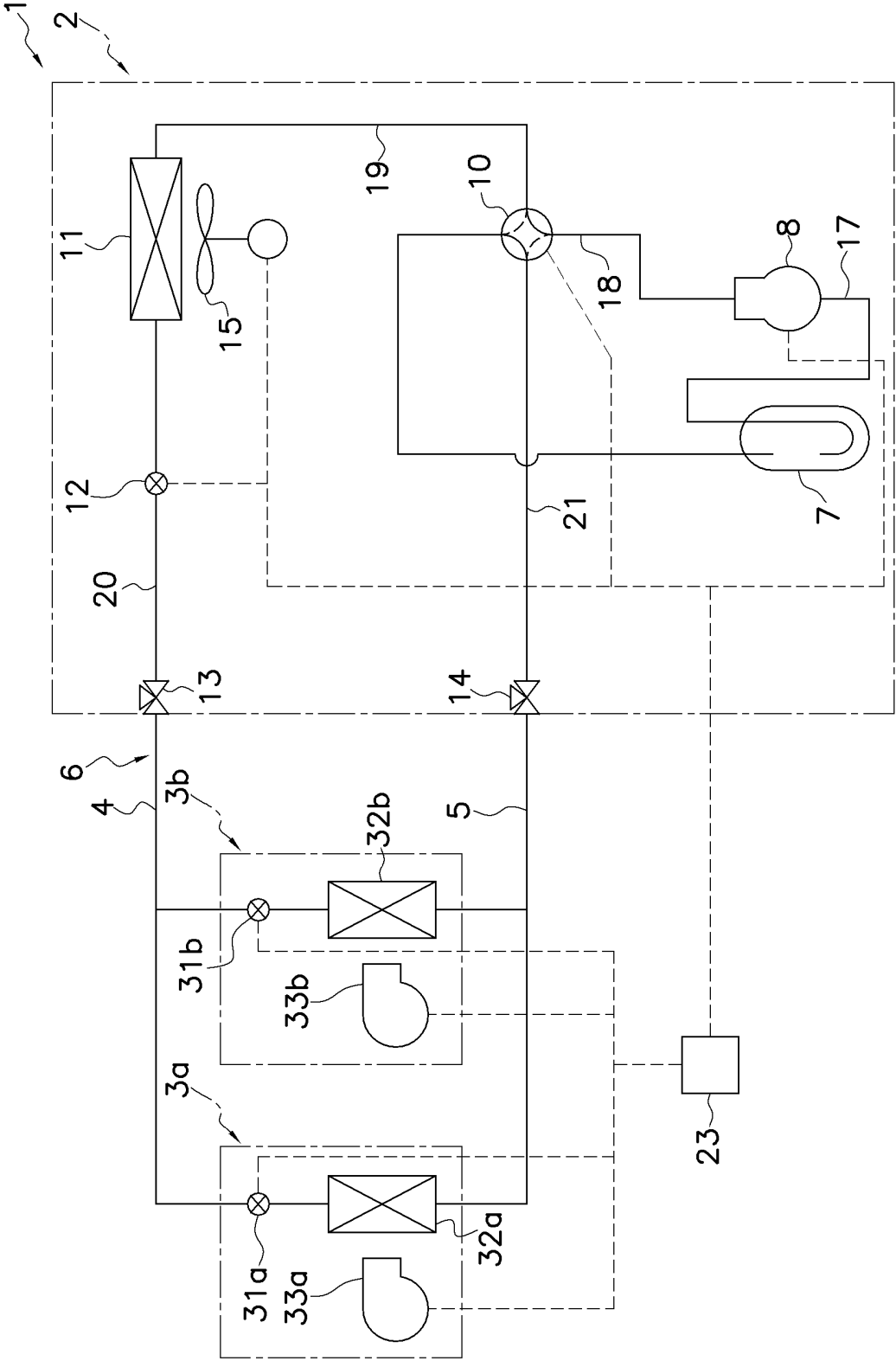


FIG. 1

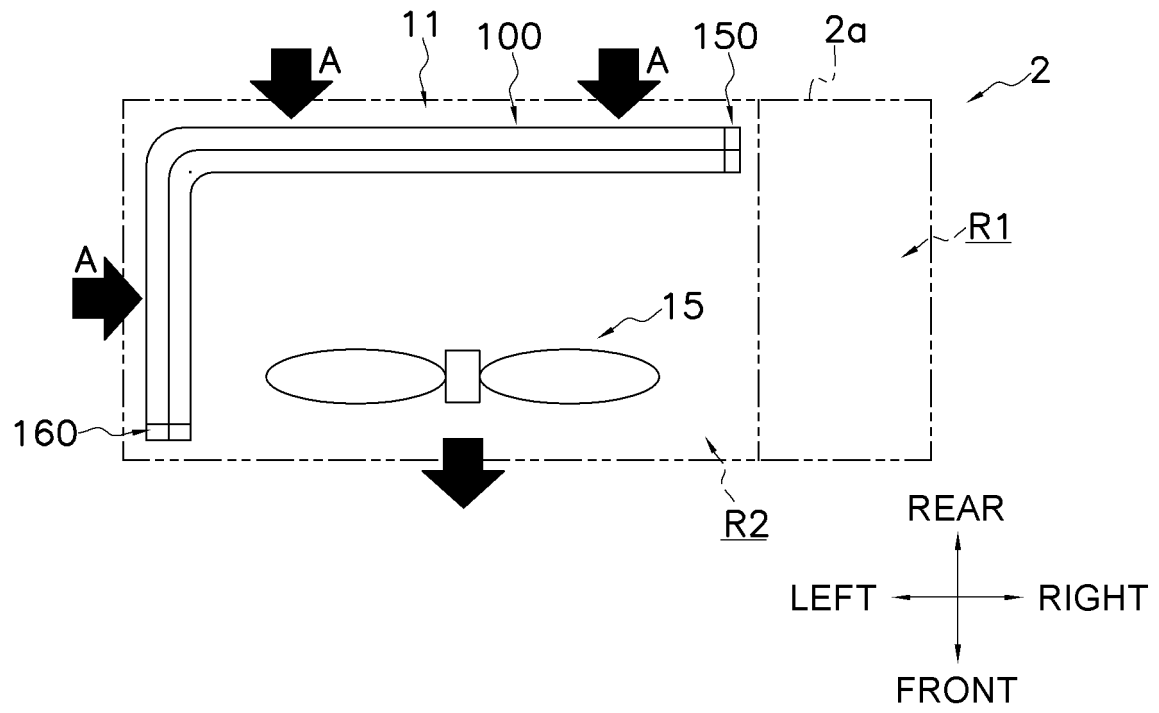


FIG. 2

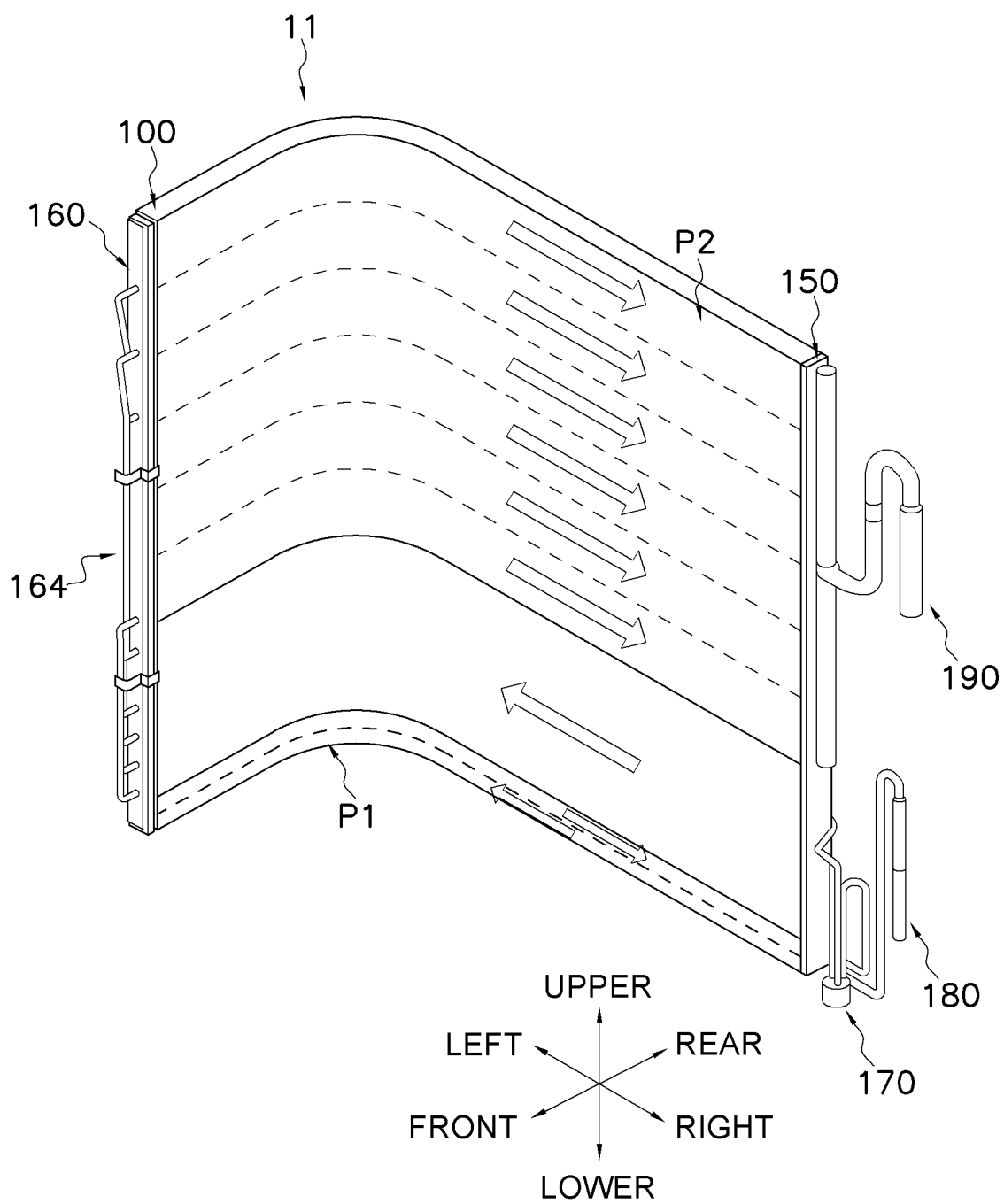


FIG.3

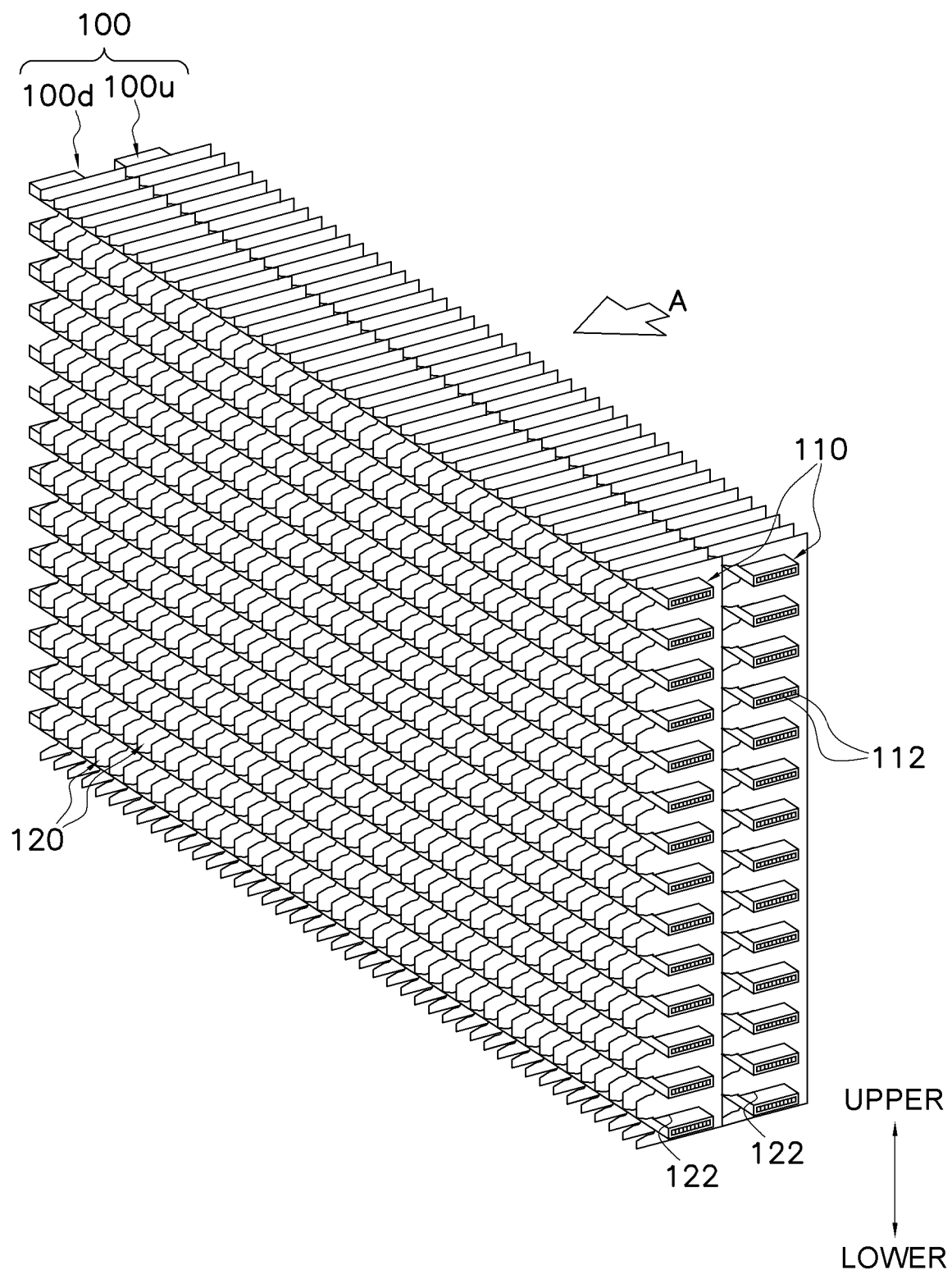


FIG. 4

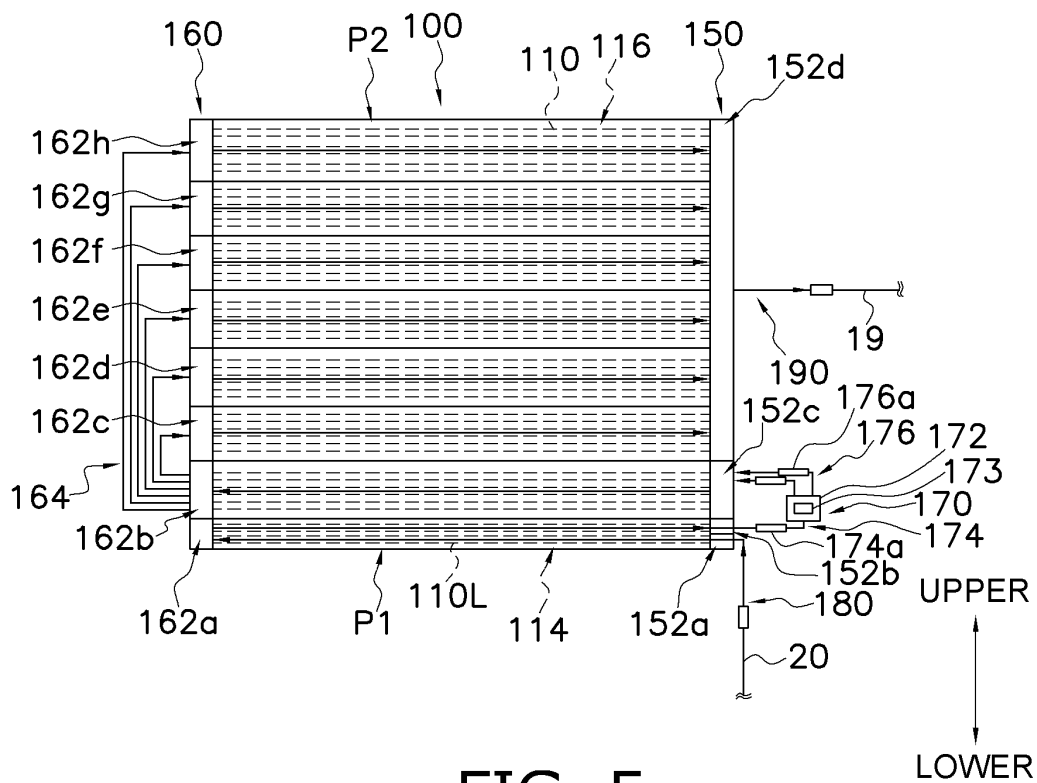


FIG. 5

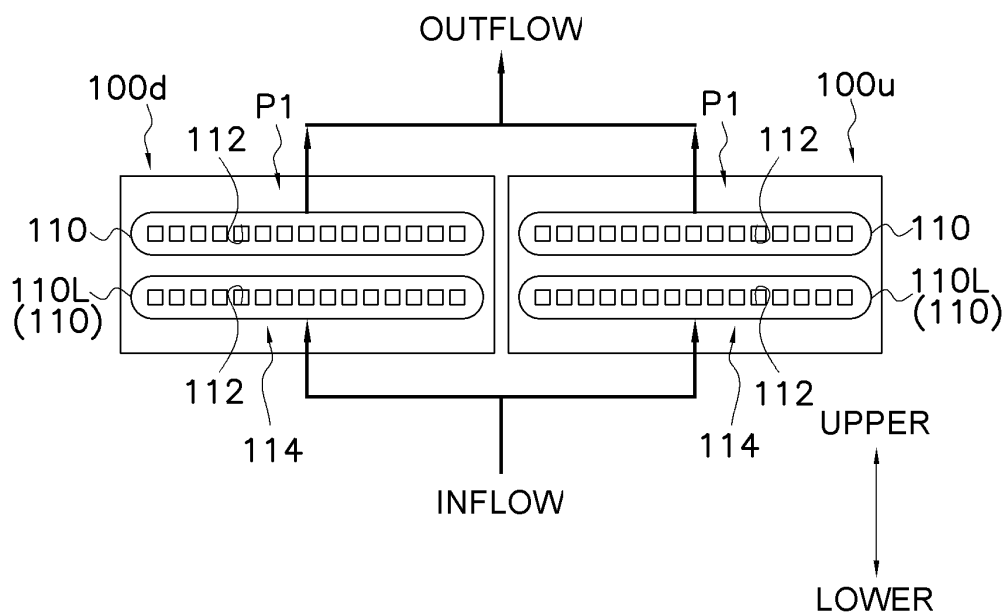


FIG. 6

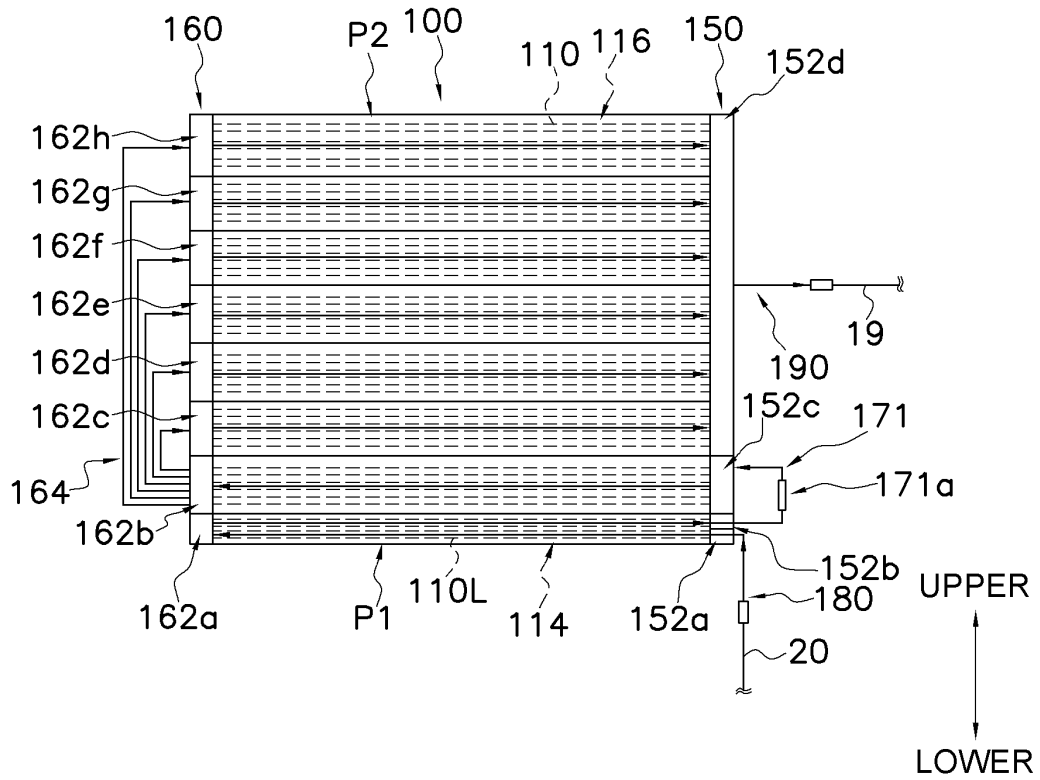


FIG. 7

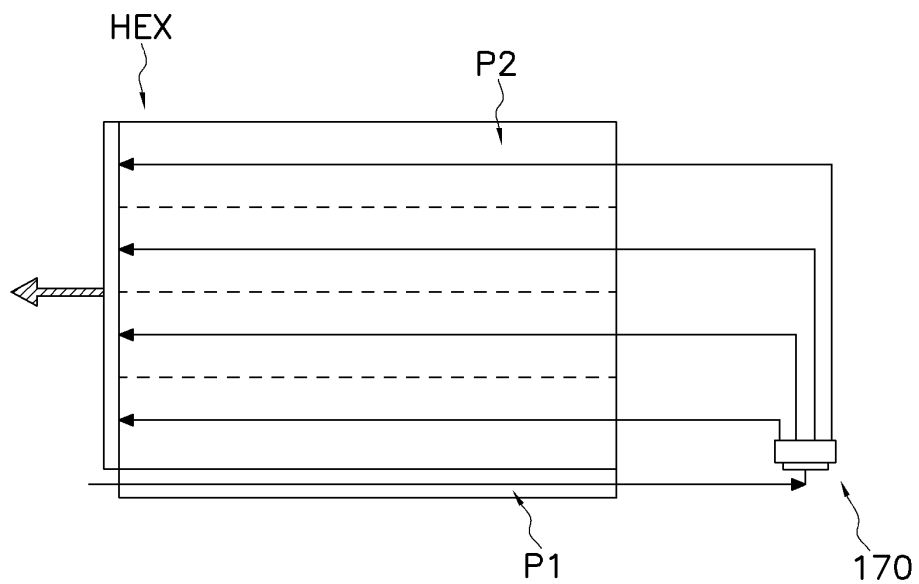


FIG. 8A

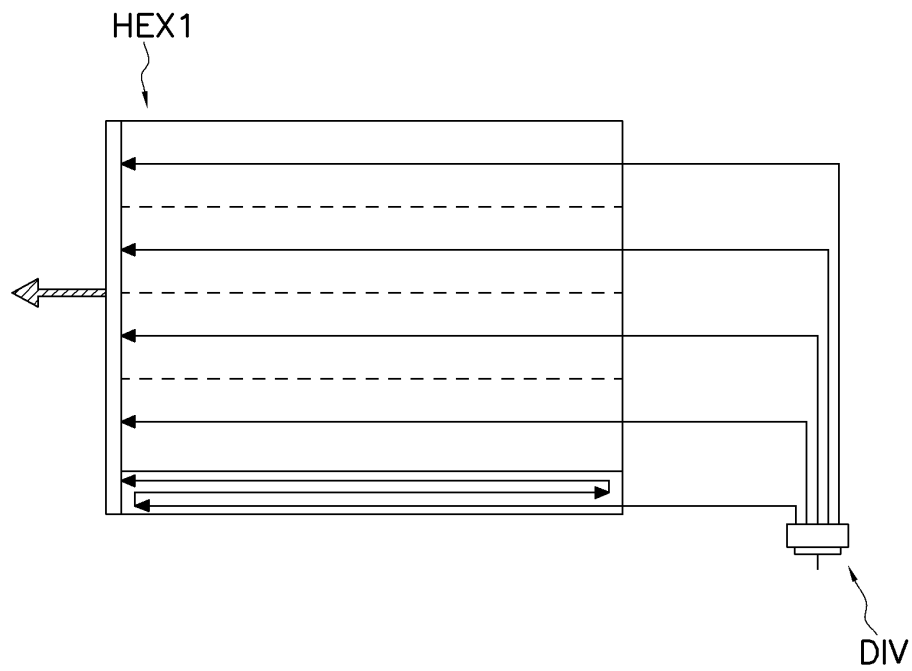


FIG. 8B

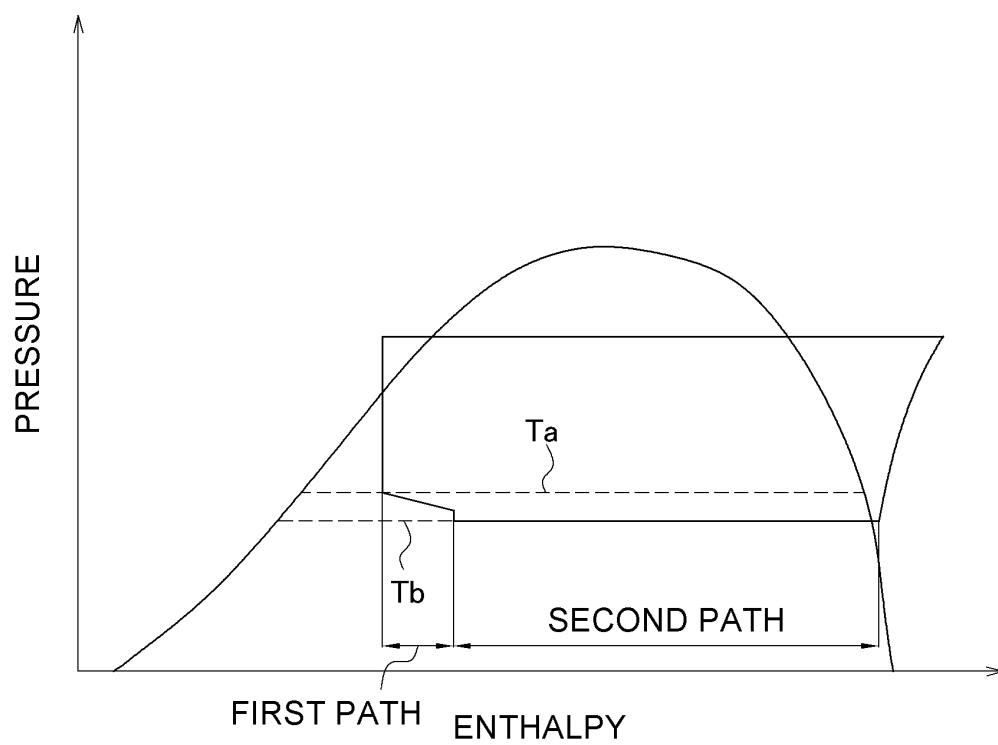


FIG. 9

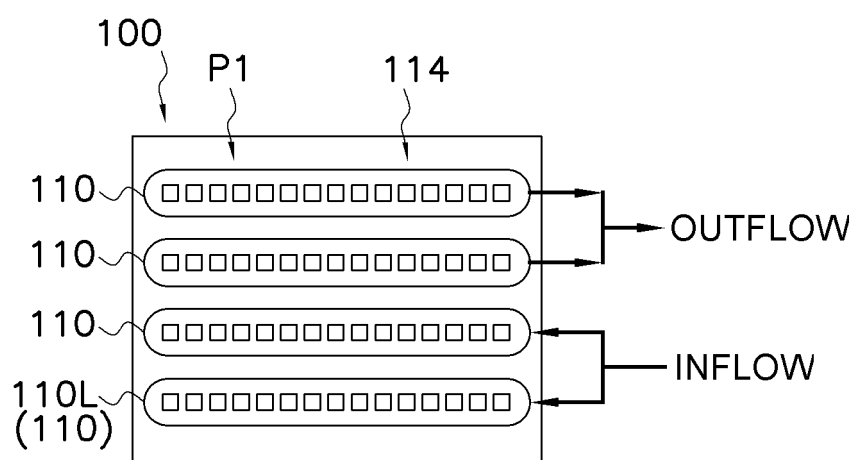


FIG. 10

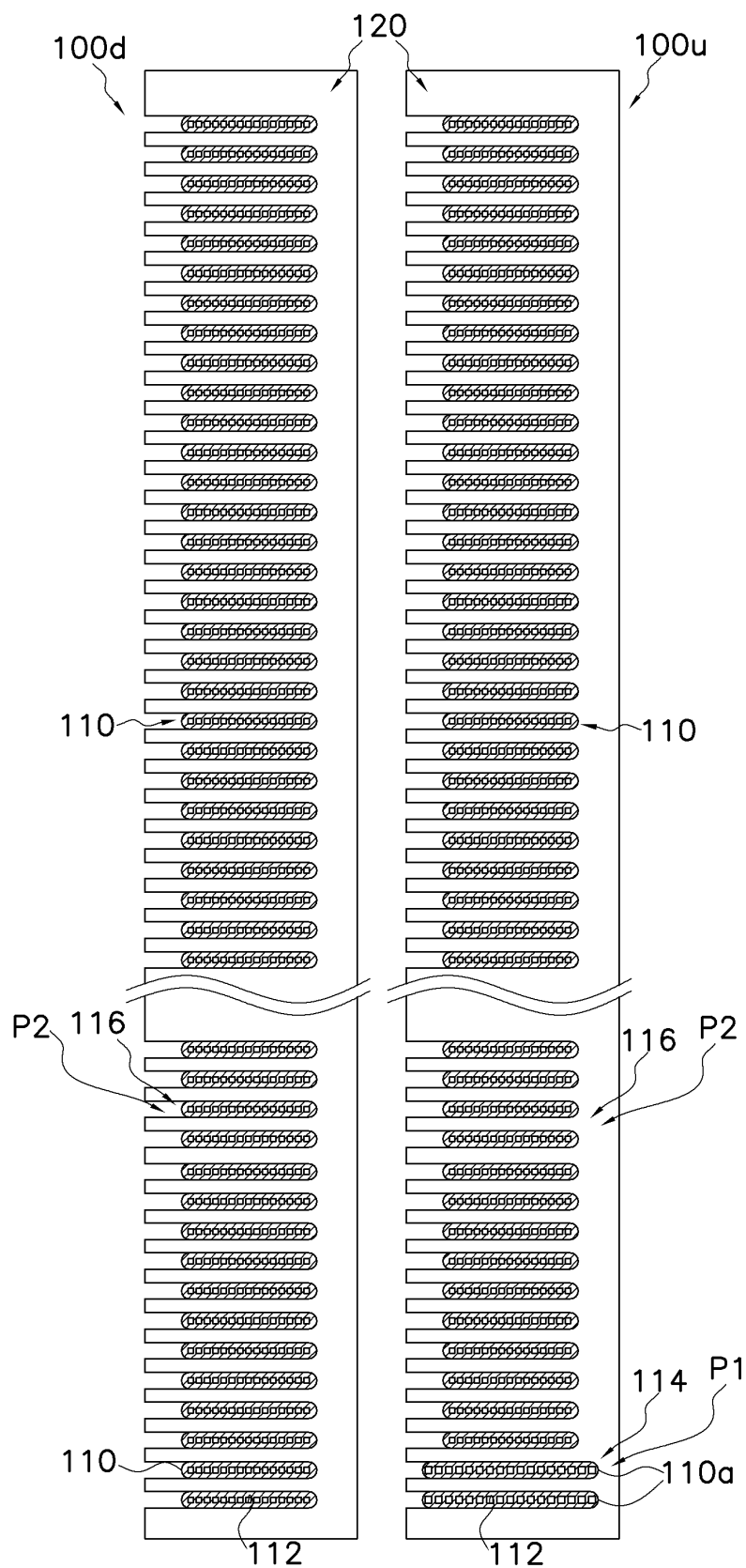


FIG. 11

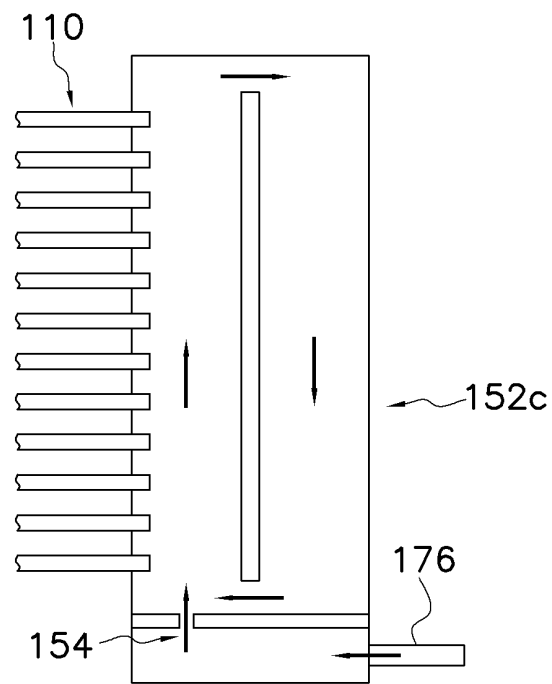


FIG. 12

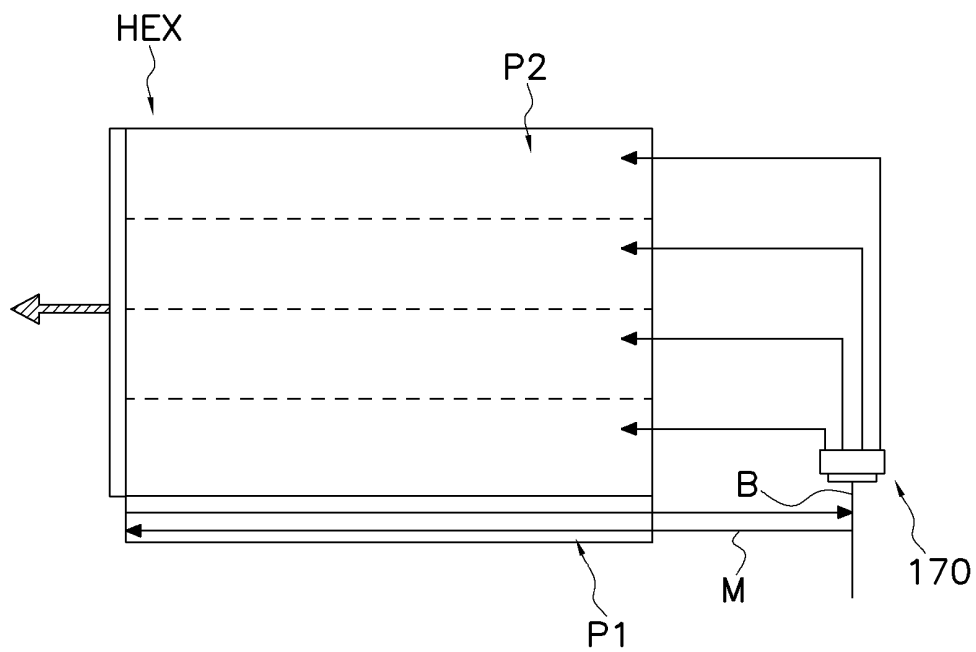


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/009040

A. CLASSIFICATION OF SUBJECT MATTER <i>F28F 9/26</i> (2006.01)i; <i>F25B 39/02</i> (2006.01)i; <i>F28D 1/047</i> (2006.01)i; <i>F28F 9/02</i> (2006.01)i; <i>F28F 27/02</i> (2006.01)i FI: F28F9/26; F25B39/02 F; F28D1/047 Z; F28F9/02 301E; F28F27/02 B 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) F28F9/26; F25B39/02; F28D1/047; F28F9/02; F28F27/02		
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 1971-2024 Registered utility model specifications of Japan 1996-2024 Published registered utility model applications of Japan 1994-2024		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2012-163319 A (DAIKIN INDUSTRIES, LTD.) 30 August 2012 (2012-08-30) paragraphs [0033]-[0034], [0079]-[0095], fig. 7-8	1-3, 5, 7, 11 9 4, 10
X Y A	JP 2020-165644 A (DAIKIN INDUSTRIES, LTD.) 08 October 2020 (2020-10-08) paragraphs [0033]-[0037], [0062]-[0095], fig. 1, 5-6	1-3, 5-6, 8, 11 9 4, 10
Y	WO 2017/073096 A1 (MITSUBISHI ELECTRIC CORPORATION) 04 May 2017 (2017-05-04) paragraphs [0016]-[0019], fig. 2	9
☐ Further documents are listed in the continuation of Box C.		☒ See patent family annex.
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search 13 May 2024	Date of mailing of the international search report 28 May 2024	
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.	

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2024/009040

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2012-163319 A	30 August 2012	US 2013/0306285 A1 paragraphs [0053]-[0055], [0108]-[0124], fig. 7-8	
		WO 2012/098917 A1	
		EP 2660550 A1	
		AU 2012208123 A1	
		CN 103348212 A	
		KR 10-2013-0114249 A	
		CN 104677170 A	
JP 2020-165644 A	08 October 2020	WO 2020/203589 A1	
WO 2017/073096 A1	04 May 2017	US 2018/0292096 A1 paragraphs [0040]-[0043], fig. 2	
		EP 3370000 A1	
		CN 108139089 A	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2019060596 A [0003] [0004] [0187]