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

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(52) **U.S. Cl.**

CPC ***F28D 7/1607*** (2013.01); ***F25B 39/04*** (2013.01); ***F28F 9/26*** (2013.01); ***F28F 9/02*** (2013.01)

(57) **ABSTRACT**

A heat exchanger includes: a heat exchange portion in which a plurality of heat transfer tubes, in which refrigerant flows, are arranged in a height direction and grouped into, in order from an upper side in the height direction, a main, first auxiliary and second auxiliary heat exchange portion and configured to, when the heat exchanger serves as a condenser, allow the refrigerant to flow through the heat exchanger in order of the main heat exchange portion of the airflow downstream side row, the main heat exchange portion of the airflow upstream side row, the first auxiliary heat exchange portion of the airflow upstream side row, the first auxiliary heat exchange portion of the airflow downstream side row, the second auxiliary heat exchange portion of the airflow downstream side row, and the second auxiliary heat exchange portion of the airflow upstream side row, and flow out of the heat exchanger.

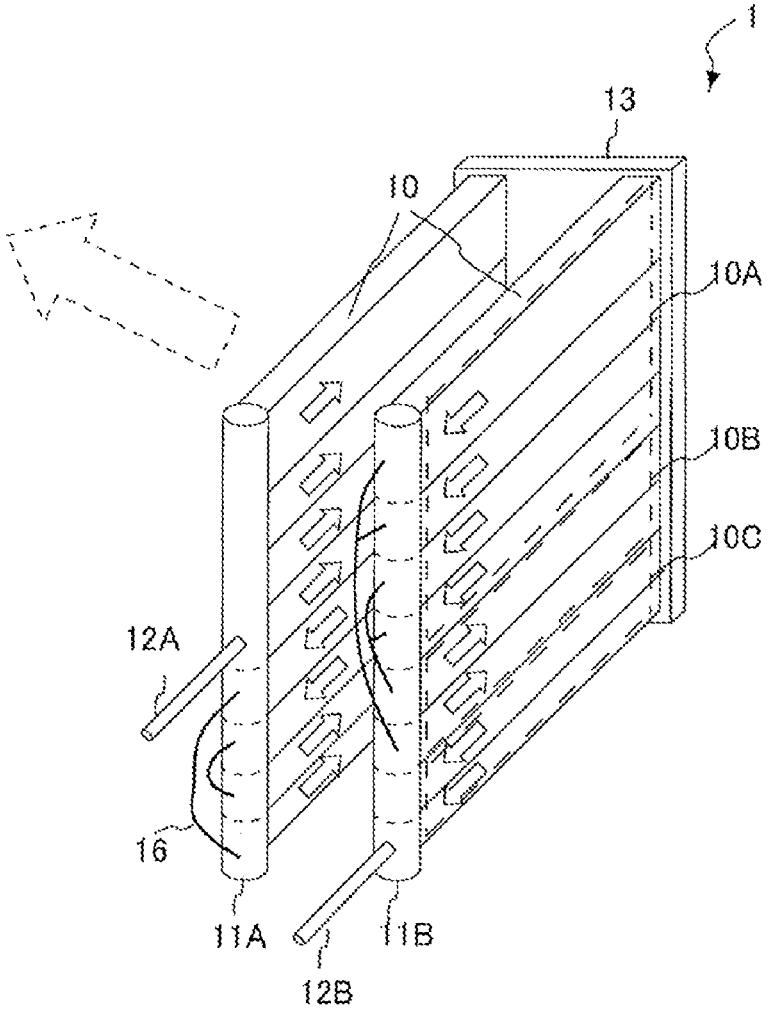


FIG. 1

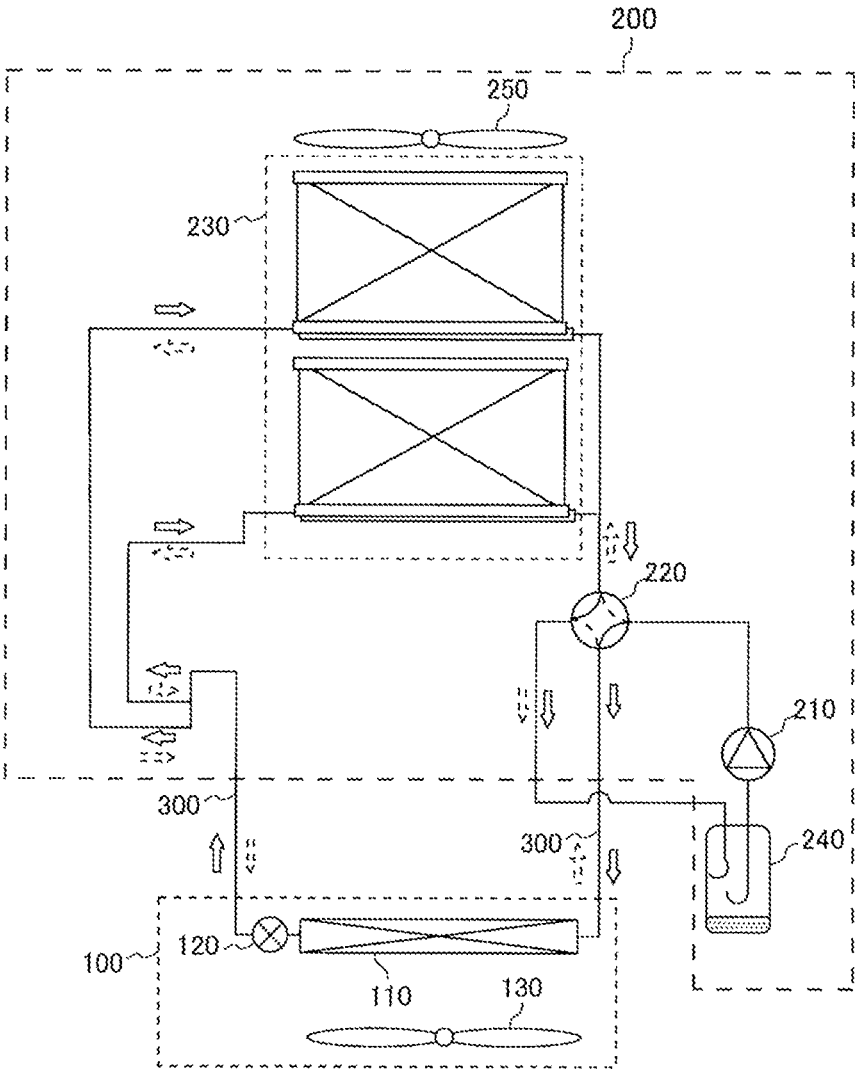


FIG. 2

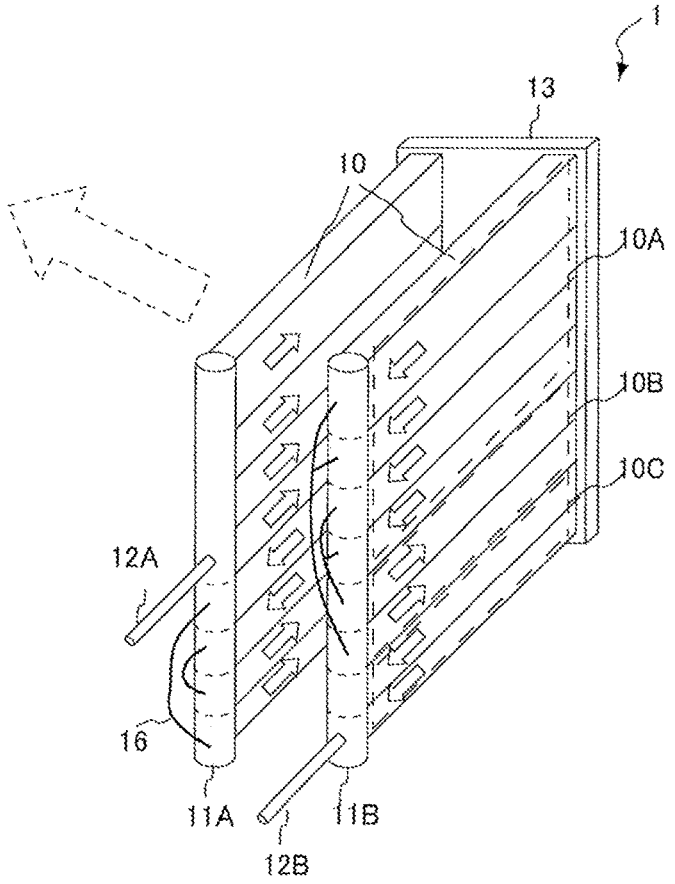


FIG. 3

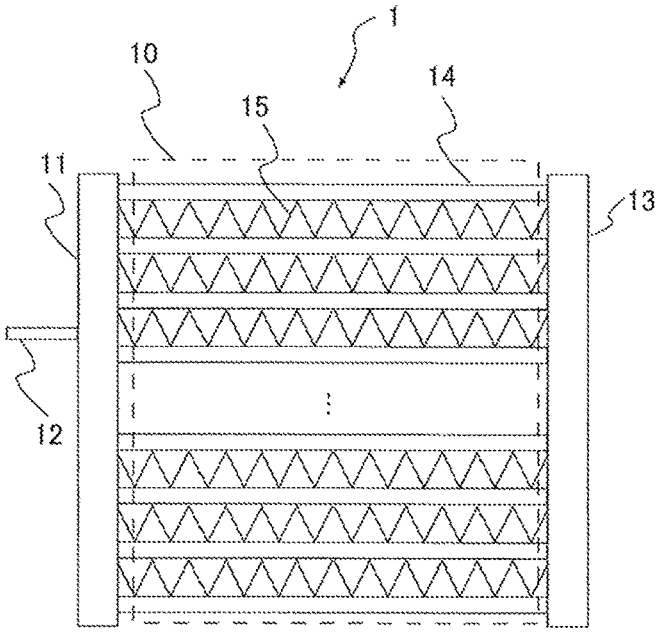


FIG. 4

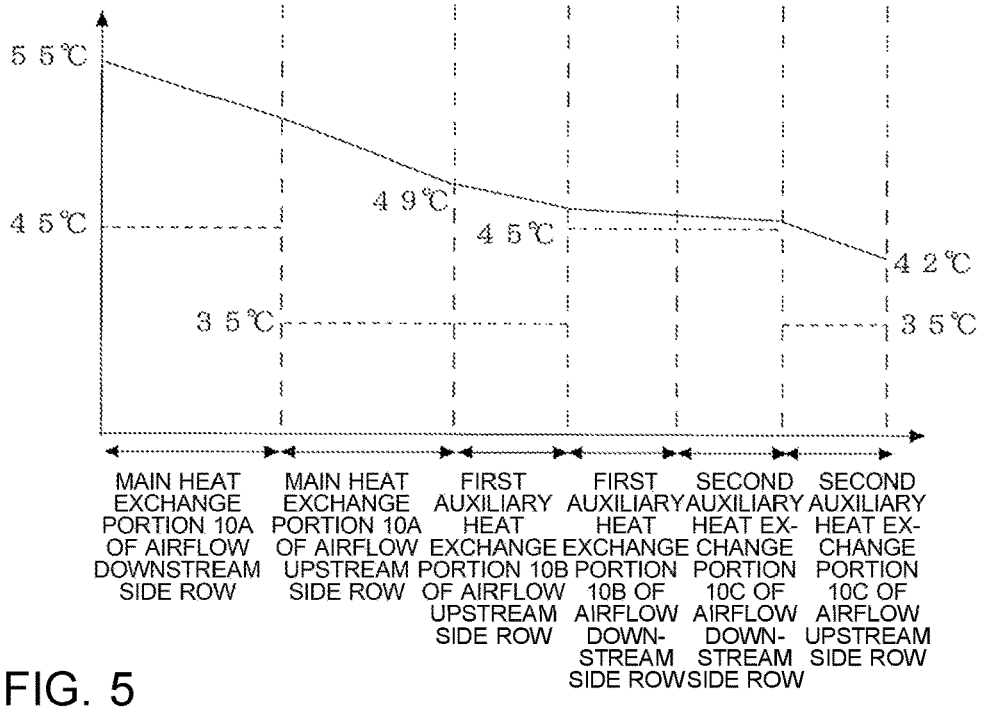

5 5℃
4 5℃
4 9℃
4 5℃
4 2℃
3 5℃
3 5℃
MAIN HEAT EXCHANGE PORTION 10A OF AIRFLOW DOWNSTREAM SIDE ROW
MAIN HEAT EXCHANGE PORTION 10A OF AIRFLOW UPSTREAM SIDE ROW
FIRST AUXILIARY HEAT EXCHANGE PORTION 10B OF AIRFLOW UPSTREAM SIDE ROW
FIRST AUXILIARY HEAT EXCHANGE PORTION 10B OF AIRFLOW DOWN-STREAM SIDE ROW
SECOND AUXILIARY HEAT EX-CHANGE PORTION 10C OF AIRFLOW DOWN-STREAM SIDE ROW
SECOND AUXILIARY HEAT EX-CHANGE PORTION 10C OF AIRFLOW UPSTREAM SIDE ROW

FIG. 5

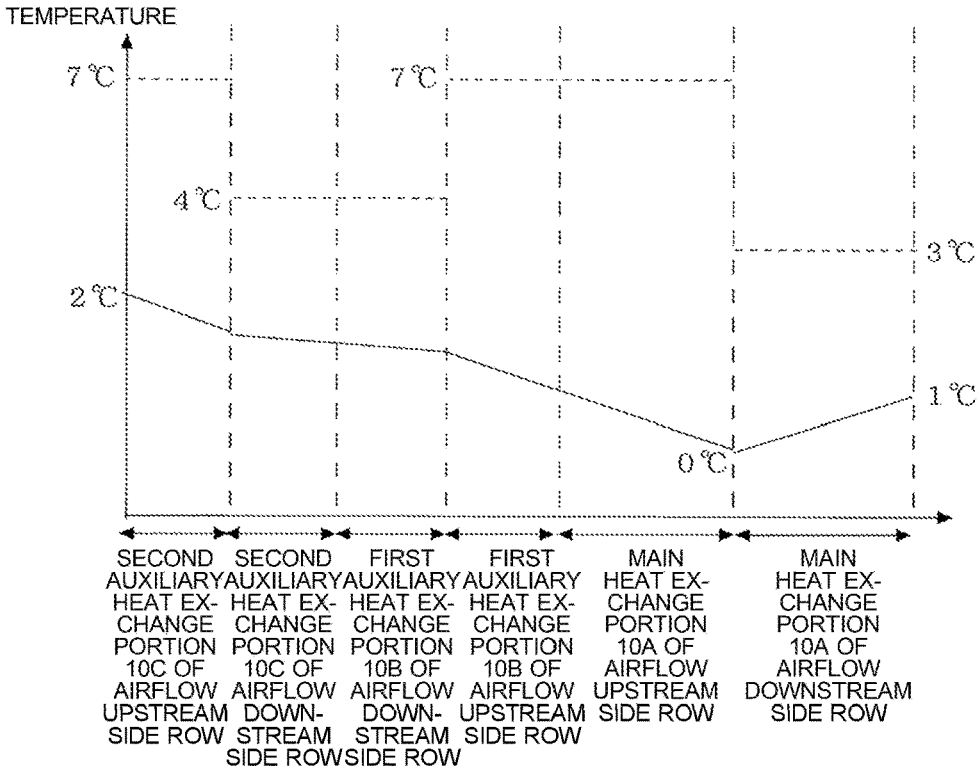

TEMPERATURE
7℃
7℃
4℃
3℃
2℃
1℃
0℃
SECOND AUXILIARY HEAT EX-CHANGE PORTION 10C OF AIRFLOW UPSTREAM SIDE ROW
SECOND AUXILIARY HEAT EX-CHANGE PORTION 10C OF AIRFLOW DOWN-STREAM SIDE ROW
FIRST AUXILIARY HEAT EX-CHANGE PORTION 10B OF AIRFLOW DOWN-STREAM SIDE ROW
FIRST AUXILIARY HEAT EX-CHANGE PORTION 10B OF AIRFLOW UPSTREAM SIDE ROW
MAIN HEAT EX-CHANGE PORTION 10A OF AIRFLOW UPSTREAM SIDE ROW
MAIN HEAT EX-CHANGE PORTION 10A OF AIRFLOW DOWNSTREAM SIDE ROW

FIG. 6

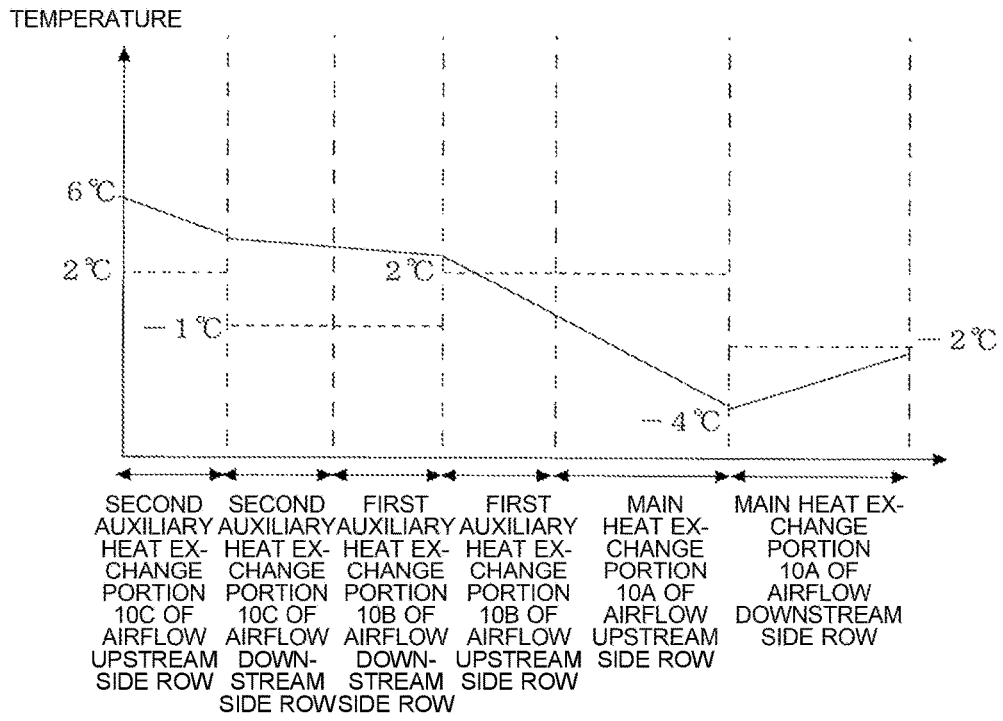

TEMPERATURE
6℃
2℃
2℃
−1℃
−4℃
2℃
SECOND AUXILIARY HEAT EXCHANGE PORTION 10C OF AIRFLOW UPSTREAM SIDE ROW
SECOND AUXILIARY HEAT EXCHANGE PORTION 10C OF AIRFLOW DOWNSTREAM SIDE ROW
FIRST AUXILIARY HEAT EXCHANGE PORTION 10B OF AIRFLOW DOWNSTREAM SIDE ROW
FIRST AUXILIARY HEAT EXCHANGE PORTION 10B OF AIRFLOW UPSTREAM SIDE ROW
MAIN HEAT EXCHANGE PORTION 10A OF AIRFLOW UPSTREAM SIDE ROW
MAIN HEAT EXCHANGE PORTION 10A OF AIRFLOW DOWNSTREAM SIDE ROW

FIG. 7

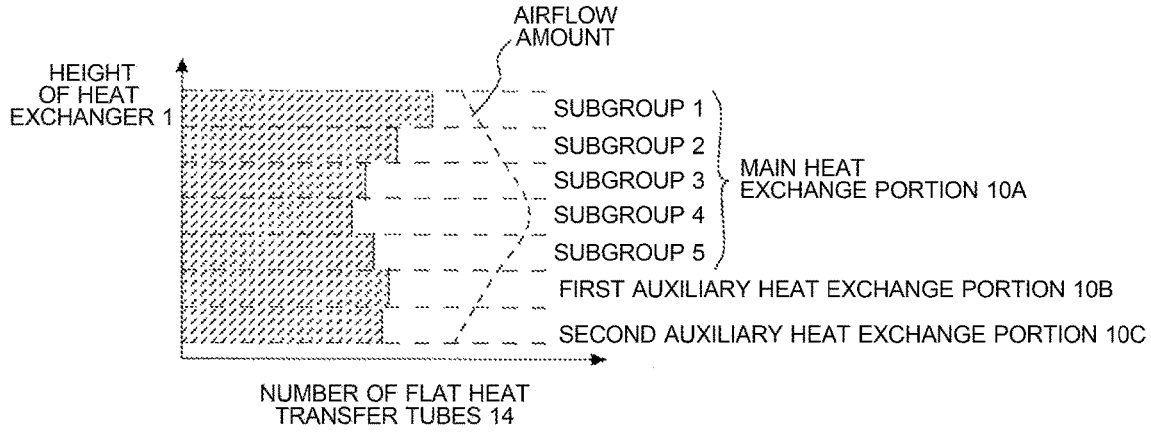

AIRFLOW AMOUNT
HEIGHT OF HEAT EXCHANGER 1
SUBGROUP 1
SUBGROUP 2
SUBGROUP 3
SUBGROUP 4
SUBGROUP 5
MAIN HEAT EXCHANGE PORTION 10A
FIRST AUXILIARY HEAT EXCHANGE PORTION 10B
SECOND AUXILIARY HEAT EXCHANGE PORTION 10C
NUMBER OF FLAT HEAT TRANSFER TUBES 14

FIG. 8

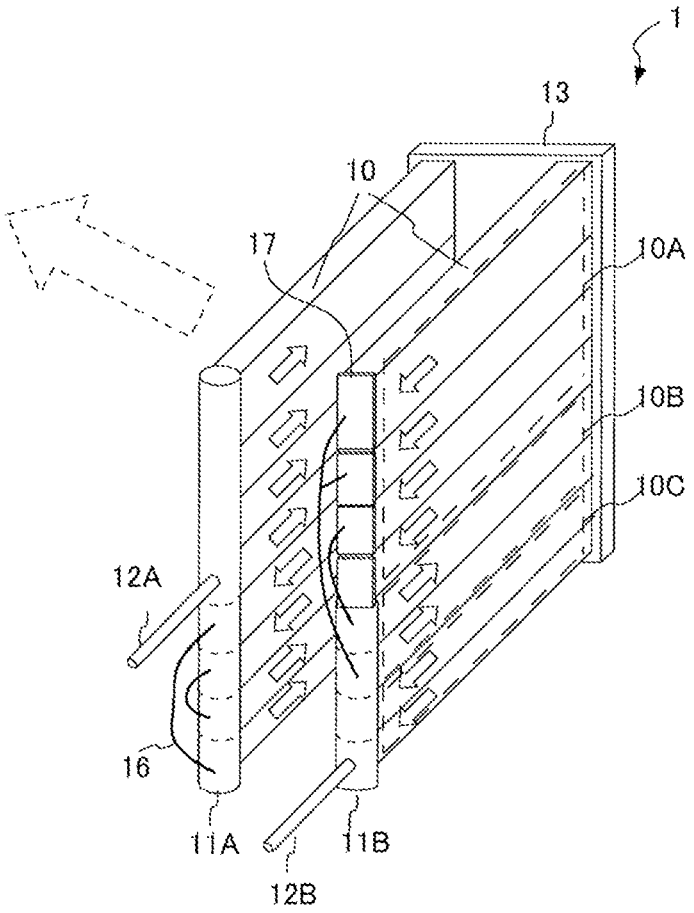
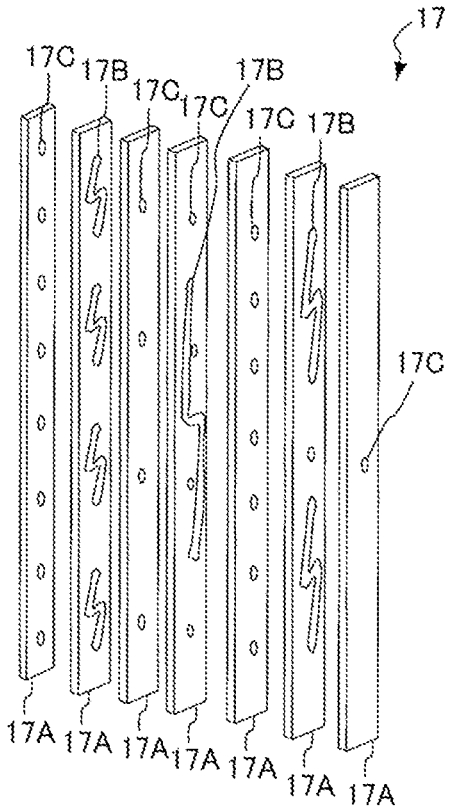


FIG. 9



HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a U.S. national stage application of International Patent Application No. PCT/JP2020/022105 filed on Jun. 4, 2020, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present technology relates to a heat exchanger and a refrigeration cycle device. Particularly, the present technology relates to a heat exchanger that exchanges heat while distributing refrigerant.

BACKGROUND

[0003] In recent years, a heat exchanger for an air-conditioning device uses heat transfer tubes that have become increasingly thinner to reduce the amount of refrigerant and improve performance of the heat exchanger. While using the heat transfer tubes that have become increasingly thinner, the heat exchanger has an increased number of passes (the number of branches) to minimize the increase in pressure loss of refrigerant. Heat exchangers using a header refrigerant distributor have been developed to cope with this multi-branch distribution (see, for example, Patent Literature 1).

PATENT LITERATURE

[0004] Patent Literature 1: Japanese Patent Publication No. 5679084

[0005] The header refrigerant distributor unevenly distributes gas refrigerant with a larger amount on the upper side due to an inertial force. Due to this uneven distribution, when operating as an evaporator, the heat exchanger tends to exhibit degraded evaporator performance. To prevent the evaporator performance from being degraded, when the heat exchanger operates as an evaporator, a counter flow is formed such that refrigerant flows in a direction opposite to the airflow direction in a section of the heat exchanger with a greater number of tube layers than in the other sections. In contrast, when the heat exchanger operates as a condenser, refrigerant flows in the heat exchanger in a direction reverse to the refrigerant flow direction when the heat exchanger operates as an evaporator. Thus, when the heat exchanger operates as a condenser, a parallel flow is formed such that refrigerant flows in a direction parallel to the airflow direction. Compared to the counter flow, the parallel flow cannot ensure a sufficient temperature difference between refrigerant and air, and this results in degradation in condensation performance of the heat exchanger.

SUMMARY

[0006] The present disclosure has been achieved to solve the above problems, and it is an object of the present disclosure to provide a heat exchanger that can improve its heat exchange performance, and a refrigeration cycle device.

[0007] A heat exchanger according to one embodiment of the present disclosure includes: a heat exchange portion in which a plurality of heat transfer tubes, in which refrigerant flows, are arranged in a height direction, the plurality of heat transfer tubes being configured to exchange heat between the refrigerant and air; a turn-back portion to which one end of each of the plurality of heat transfer tube is connected and which is configured to allow the refrigerant to flow between two rows of heat exchange portions arranged in an airflow direction, one of the two rows of heat exchange portions being the heat exchange portion and arranged on an airflow upstream side, an other of the two rows of heat exchange portions being the heat exchange portion and arranged on an airflow downstream side; and a plurality of distribution merge portions to each of which the other end of the heat transfer tube of the heat exchange portion of each row is connected, and which is configured to distribute the refrigerant to the heat transfer tube or merge refrigerant flows from the heat exchange portions, the plurality of heat transfer tubes of the heat exchange portion being grouped into, in order from an upper side in the height direction, a main heat exchange portion, a first auxiliary heat exchange portion having fewer number of the heat transfer tubes than those of the main heat exchange portion, and a second auxiliary heat exchange portion having fewer number of the heat transfer tubes than those of the first auxiliary heat exchange portion, and being configured to, when the heat exchanger serves as a condenser, allow the refrigerant to flow through the heat exchanger in order of the main heat exchange portion of the airflow downstream side row, the main heat exchange portion of the airflow upstream side row, the first auxiliary heat exchange portion of the airflow upstream side row, the first auxiliary heat exchange portion of the airflow downstream side row, the second auxiliary heat exchange portion of the airflow downstream side row, and the second auxiliary heat exchange portion of the airflow upstream side row, and allow the refrigerant to flow out of the heat exchanger.

[0008] A refrigeration cycle device according to another embodiment of the present disclosure includes the heat exchanger described above to serve at least as a condenser.

[0009] According to one embodiment of the present disclosure, when the heat exchanger serves as a condenser, a flow of refrigerant in the main heat exchange portion and a flow of air passing through the heat exchanger form a counter flow to exchange heat between the upstream side of the refrigerant in the main heat exchange portion and the downstream side of the air, and exchange heat between the downstream side of the refrigerant in the main heat exchange portion and the upstream side of the air. Due to this configuration, the heat exchanger can maintain a sufficient temperature difference between refrigerant and air to effectively exchange heat between them throughout the entire refrigerant flow passage, and can consequently improve the heat transfer performance of the heat exchanger.

BRIEF DESCRIPTION OF DRAWINGS

[0010] FIG. **1** illustrates the configuration of an air-conditioning device according to Embodiment 1.

[0011] FIG. **2** schematically illustrates the configuration of a heat exchanger **1** according to Embodiment 1.

[0012] FIG. **3** is an explanatory view illustrating each part of a heat exchange portion **10** in the heat exchanger **1** according to Embodiment 1.

[0013] FIG. **4** schematically illustrates variations in the temperatures of air and refrigerant in the heat exchanger **1** according to Embodiment 1 when the heat exchanger **1** serves as a condenser.

[0014] FIG. **5** schematically illustrates variations in the temperatures of air and refrigerant in the heat exchanger **1** according to Embodiment 1 when the heat exchanger **1** serves as an evaporator.

[0015] FIG. **6** schematically illustrates variations in the temperatures of air and refrigerant in the heat exchanger **1** according to Embodiment 2 when the heat exchanger **1** serves as an evaporator.

[0016] FIG. **7** is an explanatory view illustrating allocation of flat heat transfer tubes **14** in the heat exchanger **1** according to Embodiment 3.

[0017] FIG. **8** schematically illustrates the configuration of the heat exchanger **1** according to Embodiment 4.

[0018] FIG. **9** illustrates an example of the configuration of a layered distributor **17** according to Embodiment 4.

DETAILED DESCRIPTION

[0019] Hereinafter, a heat exchanger and a refrigeration cycle device according to the embodiments will be described with reference to the drawings and the like. In the drawings below, like reference signs denote the like or corresponding components, and are common throughout the entire descriptions of the embodiments described below. In addition, the relationship of sizes of the constituent parts in the drawings may differ from that of actual ones. Furthermore, in the cross-sectional view, hatching is omitted in some of the drawings and devices in view of visibility. The forms of the constituent elements represented throughout the entire specification are merely examples, and do not intend to limit the constituent elements to the forms described in the specification. In particular, the combination of constituent elements is not limited to only the combination in each embodiment, and the constituent elements described in one embodiment can be applied to another embodiment. The upper side in the drawings is described as "up," while the lower side in the drawings is described as "down." Furthermore, the level of the pressure and temperature is not particularly determined in relation to an absolute value, but is determined relative to the conditions or operation of a device or the like. When it is not necessary to distinguish or specify a plurality of devices of the same type that are distinguished from each other by subscripts, the subscripts may be omitted.

Embodiment 1

<Configuration of Air-Conditioning Device>

[0020] FIG. **1** illustrates the configuration of an air-conditioning device according to Embodiment 1. The air-conditioning device is now explained as an example of the refrigeration cycle device including a heat exchanger in Embodiment 1.

[0021] As illustrated in FIG. **1**, the air-conditioning device in Embodiment 1 includes an outdoor unit **200**, an indoor unit **100**, and two refrigerant pipes **300**. The outdoor unit **200** includes a compressor **210**, a four-way valve **220**, and an outdoor heat exchanger **230**. The indoor unit **100** includes an indoor heat exchanger **110** and an expansion valve **120**. The compressor **210**, the four-way valve **220**, the outdoor heat exchanger **230**, the indoor heat exchanger **110**, and the expansion valve **120** are connected by the refrigerant pipes **300** to form a refrigerant circuit. In the air-conditioning device in Embodiment 1, one outdoor unit **200** and one indoor unit **100** are connected by pipes. However, the number of outdoor units **200** and the number of indoor units **100** to be connected to each other are not limited to this example.

[0022] The indoor unit **100** includes an indoor air-sending device **130** in addition to the indoor heat exchanger **110** and the expansion valve **120**. The expansion valve **120** that is an expansion device or other device reduces the pressure of refrigerant and expands the refrigerant. When the expansion valve **120** is made up of, for example, an electronic expansion valve, the expansion valve **120** adjusts its opening degree based on an instruction provided by a controller (not illustrated) or other device. The indoor heat exchanger **110** exchanges heat between refrigerant and air in a room that is an air-conditioned space. For example, during heating operation, the indoor heat exchanger **110** functions as a condenser, and condenses and liquefies the refrigerant. During cooling operation, the indoor heat exchanger **110** functions as an evaporator, and evaporates and vaporizes the refrigerant. The indoor air-sending device **130** allows the air in the room to pass through the indoor heat exchanger **110**, and supplies the air having passed through the indoor heat exchanger **110** to the room.

[0023] The outdoor unit **200** in Embodiment 1 includes devices forming the refrigerant circuit, such as the compressor **210**, the four-way valve **220**, the outdoor heat exchanger **230**, and an accumulator **240**. The outdoor unit **200** includes an outdoor air-sending device **250**. The compressor **210** compresses suctioned refrigerant and discharges the compressed refrigerant. The compressor **210** is, for example, a scroll compressor, a reciprocating compressor, or a vane compressor. For example, the compressor **210** may allow an inverter circuit to optionally change the operational frequency to change the capacity of the compressor **210**, although the configuration of the compressor **210** is not particularly limited.

[0024] For example, the four-way valve **220** that serves as a flow switching device is a valve to change the flow direction of refrigerant depending on cooling operation or heating operation. When heating operation is performed, the four-way valve **220** connects the discharge side of the compressor **210** to the indoor heat exchanger **110**, while connecting the suction side of the compressor **210** to the outdoor heat exchanger **230**. When cooling operation is performed, the four-way valve **220** connects the discharge side of the compressor **210** to the outdoor heat exchanger **230**, while connecting the suction side of the compressor **210** to the indoor heat exchanger **110**. A case where the four-way valve **220** is used is described as an example, however, the flow switching device is not limited to this case. For example, a plurality of two-way valves or other valves may be combined to form the flow switching device. The accumulator **240** is installed on the suction side of the compressor **210**. The accumulator **240** allows refrigerant in gas form (hereinafter, referred to as "gas refrigerant") to pass through the accumulator **240**, while accumulating refrigerant in liquid form (hereinafter, referred to as "liquid refrigerant") in the accumulator **240**.

[0025] The outdoor heat exchanger **230** exchanges heat between refrigerant and outdoor air. Refrigerant is fluid to serve as a heat exchange medium for the outdoor heat exchanger **230**. The outdoor heat exchanger **230** in Embodiment 1 functions as an evaporator during heating operation, and evaporates and vaporizes the refrigerant. In contrast,

during cooling operation, the outdoor heat exchanger **230** functions as a condenser and a subcooling device, and condenses and liquefies the refrigerant to be subcooled. The outdoor heat exchanger **230** in Embodiment 1 includes heat exchangers **1**, each of which includes a heat exchange portion **10** as will be described later. The heat exchanger **1** will be described later in detail. The outdoor air-sending device **250** is driven to allow air from the outside of the outdoor unit **200** to pass through the outdoor heat exchanger **230** to form a flow of air that flows out of the outdoor unit **200**.

<Operation of Air-Conditioning Device>

[0026] Next, operation of each device in the air-conditioning device is described based on the flow of refrigerant. First, operation of each device in the refrigerant circuit during heating operation is described based on the flow of refrigerant. The solid arrows in FIG. **1** show the flow of refrigerant during heating operation. High-temperature high-pressure gas refrigerant, compressed by and discharged from the compressor **210**, passes through the four-way valve **220**, and then flows into the indoor heat exchanger **110**. While passing through the indoor heat exchanger **110**, the gas refrigerant exchanges heat with air in, for example, an air-conditioned space, and thereby condenses into liquid. The refrigerant having condensed into liquid passes through the expansion valve **120**. When the refrigerant passes through the expansion valve **120**, the pressure of the refrigerant is reduced. The refrigerant, reduced in pressure by the expansion valve **120** and brought into a two-phase gas-liquid state, passes through the outdoor heat exchanger **230**. In the outdoor heat exchanger **230**, the refrigerant exchanges heat with outdoor air delivered from the outdoor air-sending device **250**, and thereby evaporates into gas. The gas refrigerant passes through the four-way valve **220** and the accumulator **240**, and then is suctioned into the compressor **210** again. In the manner as described above, refrigerant of the air-conditioning device circulates, and thus the air-conditioning device performs heating-related air conditioning.

[0027] Next, cooling operation is described. The dotted arrows in FIG. **1** show the flow of refrigerant during cooling operation. High-temperature high-pressure gas refrigerant, compressed by and discharged from the compressor **210**, passes through the four-way valve **220**, and then flows into the outdoor heat exchanger **230**. The refrigerant passes through the outdoor heat exchanger **230**, exchanges heat with outdoor air supplied by the outdoor air-sending device **250**, and thereby condenses into liquid. The heat exchanger **1** will be described later. The liquid refrigerant passes through the expansion valve **120**. When passing through the expansion valve **120**, the subcooled refrigerant is reduced in pressure and brought into a two-phase gas-liquid state. This refrigerant, reduced in pressure by the expansion valve **120** and brought into a two-phase gas-liquid state, then passes through the indoor heat exchanger **110**. In the indoor heat exchanger **110**, the refrigerant, having exchanged heat with air in, for example, the air-conditioned space and thereby evaporated into gas, passes through the four-way valve **220**, and is suctioned into the compressor **210** again. In the manner as described above, refrigerant of the air-conditioning device circulates, and thus the air-conditioning device performs cooling-related air conditioning.

<Configuration of Heat Exchanger **1**>

[0028] FIG. **2** schematically illustrates the configuration of the heat exchanger **1** according to Embodiment 1. FIG. **3** is an explanatory view illustrating each part of the heat exchange portion **10** in the heat exchanger **1** according to Embodiment 1. The heat exchanger **1** according to Embodiment 1 is included in the outdoor heat exchanger **230**. However, the heat exchanger **1** is not limited to being included in the outdoor heat exchanger **230**, but may be included in the indoor heat exchanger **110**. The heat exchanger **1** is a corrugated-fin and tube heat exchanger that is a parallel pipe heat exchanger. The heat exchanger **1** includes two distribution headers **11** (a distribution header **11**A and a distribution header **11**B) serving as a distribution merge portion, a turn-back header **13** serving as a turn-back portion, and the heat exchange portion **10** including a plurality of flat heat transfer tubes **14** and a plurality of corrugated fins **15**.

[0029] In the heat exchanger **1** in Embodiment 1, the two distribution headers **11** are located separately from the turn-back header **13** on either the left or right side. In FIG. **3**, the turn-back header **13** is positioned on the right side, while the two distribution headers **11** are positioned on the left side relative to the turn-back header **13**. However, the distribution headers **11** may be positioned on the right side, while the turn-back header **13** may be positioned on the left side. In the explanations below, the up-down direction in FIGS. **2** and **3** is defined as a height direction. The right-left direction in which the distribution headers **11** and the turn-back header **13** are located is defined as a horizontal direction. The direction in which the outdoor air-sending device **250** allows air to flow, shown by the dotted arrow in FIG. **2**, is defined as a depth direction.

[0030] As illustrated in FIG. **3**, between the two distribution headers **11** and the turn-back header **13**, the plurality of flat heat transfer tubes **14** are arranged in the height direction to be perpendicular to the distribution headers **11** and the turn-back header **13** with the flat surfaces of the flat heat transfer tubes **14** facing parallel to each other. In the heat exchanger **1** in Embodiment 1, groups of the plurality of flat heat transfer tubes **14** are arranged in two rows in the depth direction that is the front-rear direction. One row of a group of the flat heat transfer tubes **14** is connected to a single distribution header **11**. Each of the flat heat transfer tubes **14** serves as a flow passage of refrigerant. In the heat exchanger in Embodiment 1, the number of the flat heat transfer tubes **14** is equal in each row group. The number of the flat heat transfer tubes **14** is equal as described above, so that the flat heat transfer tubes **14** are equally spaced from each other, thereby not to interfere with the passage of air. In addition, the heat exchanger **1** can be easily manufactured. One of the two rows of the flat heat transfer tubes **14**, arranged on the airflow upstream side relative to the direction in which air passes through the heat exchanger **1**, is defined as "airflow upstream side row," while the other row arranged on the airflow downstream side is defined as "airflow downstream side row." An example in which the flat heat transfer tubes **14** are arranged in two rows is described below.

[0031] The distribution headers **11** that are devices serving as a distribution merge portion are connected by pipes to other devices that make up the refrigeration cycle device. Each of the distribution headers **11** is a pipe serving as a refrigerant distributor to allow refrigerant to flow into and out of the heat exchanger **1**, and divide and distribute the

refrigerant or merge refrigerant flows. The refrigerant is fluid serving as a heat exchange medium. While the distribution headers **11** have a circular cylindrical shape, the distribution headers **11** are not limited to having a particular shape. The distribution headers **11** respectively include refrigerant inlet/outlet pipes **12** (a refrigerant inlet/outlet pipe **12**A and a refrigerant inlet/outlet pipe **12**B) through which refrigerant flows in from and out to the outside. When the heat exchanger **1** serves as a condenser, refrigerant flows into the heat exchanger **1** through the refrigerant inlet/outlet pipe **12**A, and flows out through the refrigerant inlet/outlet pipe **12**B. In contrast, when the heat exchanger **1** serves as an evaporator, refrigerant flows into the heat exchanger **1** through the refrigerant inlet/outlet pipe **12**B, and flows out through the refrigerant inlet/outlet pipe **12**A. The interior of the distribution header **11** is partitioned by a plurality of baffles (not illustrated) into a plurality of spaces. The interior of the distribution header **11** is divided into a plurality of spaces, and thus the heat exchanger **1** can be divided into a plurality of regions. The region refers to a group of the flat heat transfer tubes **14**, in each of which refrigerant flows in the same direction. The baffles partition the interior of the distribution header **11**, so that a plurality of the flat heat transfer tubes **14** can be grouped into a single region. The regions in Embodiment 1 will be described later. Connection pipes **16** connect the spaces, separated from each other inside the distribution header **11**, from the outside. Each of the connection pipes **16** not only connects the spaces inside the distribution header **11** on a one-to-one basis, but can also branch off on one side to connect one of the spaces inside the distribution header **11** to a plurality of the spaces.

[0032] The turn-back header **13** serves as a bridge configured to merge refrigerant flows from one row of a group of the flat heat transfer tubes **14**, and then divide the refrigerant into the other row of a group of the flat heat transfer tubes **14** to allow the refrigerant to flow out. In the turn-back header **13**, baffles (not illustrated) are also installed at least at positions corresponding to the positions of the baffles in the distribution headers **11** to divide the interior of the turn-back header **13** into a plurality of spaces. For example, baffles may be installed inside the turn-back header **13** corresponding to the respective flat heat transfer tubes **14**. Particularly, between the main heat exchange portion **10**A of the airflow upstream side row and the main heat exchange portion **10**A of the airflow downstream side row, the interior of the turn-back header **13** may be divided into spaces in a one-to-one correspondence with their respective flat heat transfer tubes **14**. The main heat exchange portions **10**A of the airflow upstream side row and the airflow downstream side row will be described later. In this case, in the turn-back header **13**, refrigerant flows are not merged, or the refrigerant is not divided into flows. There is a case where the flat heat transfer tubes **14** in the heat exchange portion **10** of the airflow upstream side row are brought into one-to-one correspondence with the flat heat transfer tubes **14** in the heat exchange portion **10** of the airflow downstream side row. In that case, individual connection pipes or the like can be used to connect the flat heat transfer tubes **14** corresponding to each other.

[0033] Each of the flat heat transfer tubes **14** has an elongated shape in cross-section in which the outer surface on the longitudinal side of the elongated shape along the depth direction that is an air flow direction is flat, while the outer surface on the relatively short side of the elongated shape perpendicular to the longitudinal direction is curved. Each of the flat heat transfer tubes **14** in Embodiment 1 is a multi-hole flat heat transfer tube having a plurality of holes serving as a flow passage of refrigerant inside the tube. In Embodiment 1, since the holes of the flat heat transfer tubes **14** serve as a flow passage extending between the distribution headers **11** and the turn-back header **13**, these holes are formed in the horizontal direction. As described above, the flat heat transfer tubes **14** are aligned with equal spacing in the height direction with their outer surfaces on the longitudinal side facing each other. In the process of manufacturing the heat exchange portion **10** in Embodiment 1, each of the flat heat transfer tubes **14** is inserted into an insertion hole (not illustrated) formed on the distribution header **11** and an insertion hole (not illustrated) formed on the turn-back header **13** to be brazed and joined to the distribution header **11** and the turn-back header **13**. Examples of the brazing material to be used include an aluminum-containing brazing material. With this brazing, the inside of each of the flat heat transfer tubes **14** communicates with the distribution header **11** and the turn-back header **13**.

[0034] The corrugated fins **15** are located between the opposite flat surfaces of the flat heat transfer tubes **14** aligned in a row. The corrugated fins **15** are located to increase the heat transfer area between refrigerant and outside air. Each of the corrugated fins **15** is formed by corrugating a plate material into a wavy shape in which the plate material is folded in a zigzag pattern with a series of alternate crest folds and valley folds. The folded portions of protrusions and recesses formed into a wavy shape are the peaks of the wavy shape. In Embodiment 1, the peaks of the corrugated fins **15** are arranged along the height direction. Each of the corrugated fins **15** is in surface contact at the peaks of the wavy shape with the flat surfaces of the flat heat transfer tubes **14**. The contact portions are brazed and joined to each other by using a brazing material. The plate material for the corrugated fins **15** is made of, for example, aluminum alloy. The surface of the plate material is coated with a layer of brazing material. The coating layer of brazing material is, for example, based on a brazing material containing aluminum silicon-based aluminum.

[0035] In the heat exchange portion **10** of the heat exchanger **1** in Embodiment 1, when the heat exchange portion **10** is used as a condenser, high-temperature high-pressure refrigerant flows through the refrigerant flow passages inside the flat heat transfer tubes **14**. When the heat exchange portion **10** is used as an evaporator, low-temperature low-pressure refrigerant flows through the refrigerant flow passages inside the flat heat transfer tubes **14**.

[0036] The regions mentioned above are now described. In Embodiment 1, the baffles installed inside the distribution headers **11** and the turn-back header **13** divide the flat heat transfer tubes **14** of the airflow upstream side row into regions, and divide the flat heat transfer tubes **14** of the airflow downstream side row into regions. The regions are the main heat exchange portion **10**A, a first auxiliary heat exchange portion **10**B, and a second auxiliary heat exchange portion **10**C. The uppermost region is defined as the main heat exchange portion **10**A. The region lower than the main heat exchange portion **10**A is defined as the first auxiliary heat exchange portion **10**B. The region lower than the first auxiliary heat exchange portion **10**B is defined as the second auxiliary heat exchange portion **10**C. The number of the flat heat transfer tubes **14** grouped together in each region of the

heat exchanger **1** in Embodiment 1 has the relationship expressed as "the main heat exchange portion **10**A>the first auxiliary heat exchange portion **10**B≥the second auxiliary heat exchange portion **10**C."

[0037] FIG. **4** schematically illustrates variations in the temperatures of air and refrigerant in the heat exchanger **1** according to Embodiment 1 when the heat exchanger **1** serves as a condenser. The solid line shows the temperature of refrigerant, while the dotted line shows the temperature of air (the same applies in FIGS. **5** and **6**). In FIG. **2** described above, the arrows illustrated in the heat exchange portion **10** show the flow of refrigerant in the heat exchange portion **10** when the heat exchanger **1** serves as a condenser. When the heat exchanger **1** serves as a condenser, refrigerant flows through the refrigerant inlet/outlet pipe **12**A into the distribution header **11**A. The refrigerant having flowed into the distribution header **11**A passes through the flat heat transfer tubes **14** belonging to the main heat exchange portion **10**A of the airflow downstream side row. The flat heat transfer tubes **14** exchange heat between refrigerant passing through the inside of the tubes and outside air passing outside the tubes. At this time, while passing through the flat heat transfer tubes **14**, the refrigerant transfers heat to the outside air. Hereinafter, when the heat exchanger **1** serves as a condenser, refrigerant transfers heat to the outside air while passing through the flat heat transfer tubes **14**, in all the regions in the same manner.

[0038] The refrigerant is turned back in the turn-back header **13**, and passes through the flat heat transfer tubes **14** belonging to the main heat exchange portion **10**A of the airflow upstream side row. The refrigerant, having passed through the flat heat transfer tubes **14** of the airflow upstream side row and having exchanged heat with air, flows into the distribution header **11**B. The refrigerant having flowed into the distribution header **11**B passes through the connection pipes **16** and flows into other spaces in the distribution header **11**B. Then, the refrigerant passes through the flat heat transfer tubes **14** belonging to the first auxiliary heat exchange portion **10**B of the airflow upstream side row, is turned back in the turn-back header **13**, passes through the first auxiliary heat exchange portion **10**B of the airflow downstream side row, and then flows into the distribution header **11**A.

[0039] The refrigerant having flowed into the distribution header **11**A passes through the connection pipes **16** and flows into other spaces in the distribution header **11**A. Then, the refrigerant passes through the flat heat transfer tubes **14** belonging to the second auxiliary heat exchange portion **10**C of the airflow downstream side row, is turned back in the turn-back header **13**, passes through the second auxiliary heat exchange portion **10**C of the airflow upstream side row, and then flows into the distribution header **11**B. The refrigerant, having flowed in the order described and condensed, flows out through the refrigerant inlet/outlet pipe **12**B. Therefore, when the heat exchanger **1** in Embodiment 1 serves as a condenser, refrigerant that flows in the main heat exchange portions **10**A forms a counter flow to the flow of air. The counter flow refers to a flow in which refrigerant on the downstream side of the refrigerant flow and air on the upstream side of the air flow exchange heat between them, and also refrigerant on the upstream side of the refrigerant flow and air on the downstream side of the air flow exchange heat between them.

[0040] As illustrated in FIG. **4**, in the flat heat transfer tubes **14** of the airflow downstream side row relative to the air flow, heat is exchanged between refrigerant, not having yet exchanged heat with air, and air having already exchanged heat with refrigerant in the flat heat transfer tubes **14** of the airflow upstream side row. In contrast, in the flat heat transfer tubes **14** of the airflow upstream side row relative to the air flow, heat is exchanged between refrigerant, having already exchanged heat with air in the flat heat transfer tubes **14** of the airflow downstream side row, and air not having yet exchanged heat with refrigerant. Therefore, in both the flat heat transfer tubes **14** of the airflow upstream side row, and the flat heat transfer tubes **14** of the airflow downstream side row, a sufficient temperature difference between refrigerant and air can be maintained to effectively exchange heat between them.

[0041] FIG. **5** schematically illustrates variations in the temperatures of air and refrigerant in the heat exchanger **1** according to Embodiment 1 when the heat exchanger **1** serves as an evaporator. When the heat exchanger **1** serves as an evaporator, refrigerant flows through the refrigerant inlet/outlet pipe **12**B into the distribution header **11**B. The refrigerant having flowed into the distribution header **11**B passes through the flat heat transfer tubes **14** belonging to the second auxiliary heat exchange portion **10**C of the airflow upstream side row. The flat heat transfer tubes **14** exchange heat between refrigerant passing through the inside of the tubes and outside air passing outside the tubes. At this time, while passing through the flat heat transfer tubes **14**, the refrigerant receives heat from the outside air. Hereinafter, when the heat exchanger **1** serves as an evaporator, refrigerant receives heat from the outside air while passing through the flat heat transfer tubes **14**, in all the regions in the same manner.

[0042] The refrigerant is turned back in the turn-back header **13**, and passes through the flat heat transfer tubes **14** belonging to the second auxiliary heat exchange portion **10**C of the airflow downstream side row. The refrigerant, having passed through the flat heat transfer tubes **14** of the airflow downstream side row and having exchanged heat with air, flows into the distribution header **11**A. The refrigerant having flowed into the distribution header **11**A passes through the connection pipes **16** and flows into other spaces in the distribution header **11**A. Then, the refrigerant passes through the flat heat transfer tubes **14** belonging to the first auxiliary heat exchange portion **10**B of the airflow downstream side row, is turned back in the turn-back header **13**, passes through the first auxiliary heat exchange portion **10**B of the airflow upstream side row, and then flows into the distribution header **11**B.

[0043] The refrigerant having flowed into the distribution header **11**B passes through the connection pipes **16** and flows into other spaces in the distribution header **11**B. Then, the refrigerant passes through the flat heat transfer tubes **14** belonging to the main heat exchange portion **10**A of the airflow upstream side row, is turned back in the turn-back header **13**, passes through the main heat exchange portion **10**A of the airflow downstream side row, and then flows into the distribution header **11**A. The refrigerant, having flowed in the order described and condensed, flows out through the refrigerant inlet/outlet pipe **12**A. Therefore, when the heat exchanger **1** in Embodiment 1 serves as an evaporator, refrigerant that flows in the main heat exchange portions **10**A forms a parallel flow to the flow of air. The parallel flow

refers to a flow in which refrigerant on the upstream side of the refrigerant flow and air on the upstream side of the air flow exchange heat between them, and also refrigerant on the downstream side of the refrigerant flow and air on the downstream side of the air flow exchange heat between them.

[0044] When the heat exchanger **1** serves as an evaporator, there is a relationship of parallel flow between the air flow and the refrigerant flow in the main heat exchange portions **10**A. However, refrigerant initially passes through the second auxiliary heat exchange portion **10**C having a fewer number of the flat heat transfer tubes **14** and a smaller flow passage area than those of the main heat exchange portion **10**A, and eventually the refrigerant flows into the main heat exchange portion **10**A. This causes pressure loss of refrigerant and other problems, and results in a decrease in the temperature of the refrigerant at the time when the refrigerant passes through the main heat exchange portion **10**A. Therefore, the refrigerant passing through the main heat exchange portion **10**A has a sufficient temperature difference from the air passing through the heat exchanger **1** to effectively exchange heat between them. This prevents the heat exchanger **1** from degrading its heat exchange performance when the heat exchanger **1** serves as an evaporator. Thus, the heat exchanger **1** can maintain its evaporator performance.

[0045] As described above, in the heat exchanger **1** to be used as the outdoor heat exchanger **230** of the air-conditioning device in Embodiment 1, when the heat exchanger **1** serves as a condenser, refrigerant flows in such a manner that a flow of refrigerant in the main heat exchange portion **10**A, and a flow of air passing through the heat exchanger **1** form a counter flow. Due to this configuration, the heat exchanger **1** can maintain a sufficient temperature difference between refrigerant and air to effectively exchange heat between them throughout the entire refrigerant flow passage, and can consequently improve the heat transfer performance of the heat exchanger **1**.

[0046] In contrast, when the heat exchanger **1** serves as an evaporator, a flow of refrigerant in the main heat exchange portion **10**A, and a flow of air passing through the heat exchanger **1** form a parallel flow. However, this causes pressure loss of refrigerant in the second auxiliary heat exchange portion **10**C, and refrigerant whose temperature has decreased flows into the main heat exchange portion **10**A. Due to this configuration, the refrigerant passing through the main heat exchange portion **10**A has a sufficient temperature difference from the air passing through the heat exchanger **1** to effectively exchange heat between them. Thus, the heat exchanger **1** can maintain its evaporator performance.

[0047] In the heat exchanger **1** in Embodiment 1, the number of the flat heat transfer tubes **14** is equal in both two rows, and consequently air can pass through the flat heat transfer tubes **14** that are equally spaced from each other. In the turn-back header **13**, refrigerant flows are not merged, or the refrigerant is not divided into flows, and one row of the flat heat transfer tubes **14** are brought into one-to-one correspondence with another row of the flat heat transfer tubes **14**. This can prevent an uneven flow of refrigerant in the turn-back header **13**.

Embodiment 2

[0048] FIG. **6** schematically illustrates variations in the temperatures of air and refrigerant in the heat exchanger **1** according to Embodiment 2 when the heat exchanger **1** serves as an evaporator. The air-conditioning device and the heat exchanger **1** in Embodiment 2 have identical configurations to the air-conditioning device and the heat exchanger **1** described in Embodiment 1. However, the number of the flat heat transfer tubes **14** grouped into each region of the heat exchanger **1** in Embodiment 2 particularly has a relationship expressed as "the main heat exchange portion **10**A>the first auxiliary heat exchange portion **10**B>the second auxiliary heat exchange portion **10**C."

[0049] When the heat exchanger **1** serves as an evaporator, refrigerant flows through the refrigerant inlet/outlet pipe **12**B into the distribution header **11**B, and then passes through the flat heat transfer tubes **14** belonging to the second auxiliary heat exchange portion **10**C of the airflow upstream side row, that is the region at the lowermost position of the heat exchanger **1**. At this time, as illustrated in FIG. **6**, the air-conditioning device allows refrigerant to circulate in the refrigerant circuit such that the refrigerant flows into the second auxiliary heat exchange portion **10**C of the airflow upstream side row with a temperature of the refrigerant higher than the temperature of air that passes through the heat exchange portion **10** of the airflow upstream side row. In the heat exchanger **1** included in the air-conditioning device in Embodiment 2, the refrigerant passing through the second auxiliary heat exchange portion **10**C of the airflow upstream side row at the lowermost position has a temperature higher than the temperature of air. This prevents drain water accumulating at the bottom of the heat exchanger **1** to be used as the outdoor heat exchanger **230** in the outdoor unit **200** from freezing. With this configuration, the passage of air through the heat exchanger **1** is prevented from being interfered with by root ice or the like, and the heat exchange efficiency can be maintained.

Embodiment 3

[0050] FIG. **7** is an explanatory view illustrating allocation of flat heat transfer tubes **14** in the heat exchanger **1** according to Embodiment 3. In the heat exchanger **1** in Embodiment 3, the flat heat transfer tubes **14** belonging to the main heat exchange portion **10**A are further divided into a plurality of subgroups with different distribution paths by baffles in the distribution headers **11** and the turn-back header **13**. The number of the flat heat transfer tubes **14** may not be equal in each of the subgroups, but may differ between the subgroups.

[0051] For example, there is a case where an air-sending device includes a side flow fan with its rotational shaft extending in the same direction as the direction in which air passes through the heat exchanger **1**. In that case, the subgroups are arranged at least in such a manner that the number of the flat heat transfer tubes **14** in the nearest subgroup from the rotation center of the air-sending device is fewer than those in the other subgroups. Basically, air flows at a relatively high speed at the rotation center of the air-sending device. In view of this, a fewer number of the flat heat transfer tubes **14** are allocated near the rotation center, while a larger amount of refrigerant flows in the flat heat transfer tubes **14** with a higher thermal load, so that the heat exchanger **1** can improve its heat exchange performance.

Embodiment 4

[0052] FIG. **8** schematically illustrates the configuration of the heat exchanger **1** according to Embodiment 4. In FIG. **8**,

the same components as those described in Embodiment 1 are denoted by the same reference numerals as those illustrated in FIG. **2**. In the heat exchanger **1** in Embodiment 4, the subgroups of the flat heat transfer tubes **14** belonging to the main heat exchange portion **10**A of the airflow upstream side row are connected to each other by using a layered distributor **17**, instead of using the distribution header **11**B. When the heat exchanger **1** serves as an evaporator, the layered distributor **17** distributes refrigerant flowing therein after the refrigerant has passed through the first auxiliary heat exchange portion **10**B of the airflow upstream side row, the distribution header **11**B, and the connection pipes **16**. When the heat exchanger **1** serves as a condenser, the layered distributor **17** merges refrigerant flows having passed through the main heat exchange portion **10**A.

[0053] FIG. **9** illustrates an example of the configuration of the layered distributor **17** according to Embodiment 4. The layered distributor **17** is manufactured by stacking a plurality of plates **17**A on one another, that are a plurality of plate-like parts including through holes or through grooves serving as a flow passage. The plates **17**A include flow passage grooves **17**B and flow passage holes **17**C. The flow passage grooves **17**B allow refrigerant to pass therethrough. The flow passage holes **17**C are through holes communicating with the adjacent plates **17**A to allow the refrigerant to pass therethrough. The layered distributor **17** is not limited to having the configuration illustrated in FIG. **9**.

[0054] The large region of main heat exchange portion **10**A uses the layered distributor **17** to distribute refrigerant, and can thereby minimize uneven refrigerant distribution, such as gas-phase refrigerant of the two-phase gas-liquid refrigerant passing excessively through the flat heat transfer tubes **14** arranged on the upper side. This can improve the efficiency in heat exchange.

INDUSTRIAL APPLICABILITY

[0055] In Embodiment 1 described above, the heat exchangers **1** are used as the outdoor heat exchanger **230** of the outdoor unit **200**, however, use of the heat exchangers **1** is not limited to this example. The heat exchangers **1** may be used as the indoor heat exchanger **110** of the indoor unit **100**, or may be used as both the outdoor heat exchanger **230** and the indoor heat exchanger **110**.

[0056] In Embodiment 1 described above, the air-conditioning device has been explained. However, the heat exchanger **1** is also applicable to other refrigeration cycle devices, such as a refrigerator, a freezer, or a water heater.

[0057] In Embodiments 1 to 4 described above, the heat exchanger **1** is described as a corrugated-fin and tube heat exchanger including the heat exchange portion **10** using the flat heat transfer tubes **14**. However, the heat exchanger **1** may include the heat exchange portion **10** configured to exchange heat by using, for example, circular heat transfer tubes.

1. A heat exchanger comprising:

a heat exchange portion in which a plurality of heat transfer tubes, in which refrigerant flows, are arranged in a height direction, the plurality of heat transfer tubes being configured to exchange heat between the refrigerant and air;

a turn-back portion to which one end of each of the plurality of heat transfer tube is connected and which is configured to allow the refrigerant to flow between two rows of heat exchange portions arranged in an airflow direction,

one of the two rows of heat exchange portions being the heat exchange portion and arranged on an airflow upstream side,

an other of the two rows of heat exchange portions being the heat exchange portion and arranged on an airflow downstream side; and

a plurality of distribution merge portions to each of which the other end of the heat transfer tube of the heat exchange portion of each row is connected, and which is configured to distribute the refrigerant to the heat transfer tube or merge refrigerant flows from the heat exchange portions,

the plurality of heat transfer tubes of the heat exchange portion being grouped into, in order from an upper side in the height direction,

a main heat exchange portion,

a first auxiliary heat exchange portion having fewer number of the heat transfer tubes than those of the main heat exchange portion, and

a second auxiliary heat exchange portion having fewer number of the heat transfer tubes than those of the first auxiliary heat exchange portion,

and being configured to, when the heat exchanger serves as a condenser, allow the refrigerant to flow through the heat exchanger in order of the main heat exchange portion of the airflow downstream side row,

the main heat exchange portion of the airflow upstream side row,

the first auxiliary heat exchange portion of the airflow upstream side row,

the first auxiliary heat exchange portion of the airflow downstream side row,

the second auxiliary heat exchange portion of the airflow downstream side row, and

the second auxiliary heat exchange portion of the airflow upstream side row, and allow the refrigerant to flow out of the heat exchanger,

wherein in the main heat exchange portion, the heat transfer tubes are further divided into a plurality of subgroups by distribution paths of the refrigerant from the distribution merge portions.

2. The heat exchanger of claim **1**, wherein the heat exchange portion of the airflow upstream side row, and the heat exchange portion of the airflow downstream side row have equal number of the heat transfer tubes.

3. (canceled)

4. The heat exchanger of claim **1**, wherein the main heat exchange portion has fewer number of the heat transfer tubes in the subgroups through which a large amount of the air passes than those in other subgroups.

5. The heat exchanger of claim **1**, wherein the turn-back portion connects the heat transfer tubes of the main heat exchange portion in the heat exchange portion of the airflow upstream side row, and the heat transfer tubes of the main heat exchange portion in the heat exchange portion of the airflow downstream side row to each other on a one-to-one basis.

6. The heat exchanger of claim **1**, wherein the distribution merge portions include a layered distributor of a plurality of plate-like parts stacked on one another.

7. The heat exchanger of claim 1, wherein each of the heat transfer tubes is a flat heat transfer tube having a flat shape in cross-section, and having flow passages therein through which the refrigerant flows.

8. A refrigeration cycle device comprising the heat exchanger of claim 1 to serve at least as a condenser.

9. The refrigeration cycle device of claim 8, wherein

the heat transfer tubes of the heat exchange portion in the heat exchanger have a relationship expressed as

number of the heat transfer tubes of the main heat exchange portion>number of the heat transfer tubes of the first auxiliary heat exchange portion>number of the heat transfer tubes of the second auxiliary heat exchange portion, and

when the heat exchanger serves as an evaporator, a temperature of refrigerant flowing into the heat exchanger from the second auxiliary heat exchange portion of the airflow upstream side row is higher than a temperature of the air flowing into the heat exchange portion.

10. The refrigeration cycle device of claim 7, comprising an air-sending device including a fan and oriented with a rotational shaft of the fan extending in a same direction as a direction in which air passes through the heat exchange portion, the air-sending device being configured to allow the air to pass through the heat exchange portion, wherein

number of the heat transfer tubes in the subgroup nearest in distance from a rotation center of the fan is fewer than those in the other subgroups.

11. The heat exchanger of claim 2, wherein the main heat exchange portion has fewer number of the heat transfer tubes in the subgroups through which a large amount of the air passes than those in other subgroups.

12. The heat exchanger of claim 2, wherein the turn-back portion connects the heat transfer tubes of the main heat exchange portion in the heat exchange portion of the airflow upstream side row, and the heat transfer tubes of the main heat exchange portion in the heat exchange portion of the airflow downstream side row to each other on a one-to-one basis.

13. The heat exchanger of claim 4, wherein the turn-back portion connects the heat transfer tubes of the main heat exchange portion in the heat exchange portion of the airflow upstream side row, and the heat transfer tubes of the main heat exchange portion in the heat exchange portion of the airflow downstream side row to each other on a one-to-one basis.

14. The heat exchanger of claim 2, wherein the distribution merge portions include a layered distributor of a plurality of plate-like parts stacked on one another.

15. The heat exchanger of claim 4, wherein the distribution merge portions include a layered distributor of a plurality of plate-like parts stacked on one another.

16. The heat exchanger of claim 5, wherein the distribution merge portions include a layered distributor of a plurality of plate-like parts stacked on one another.

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