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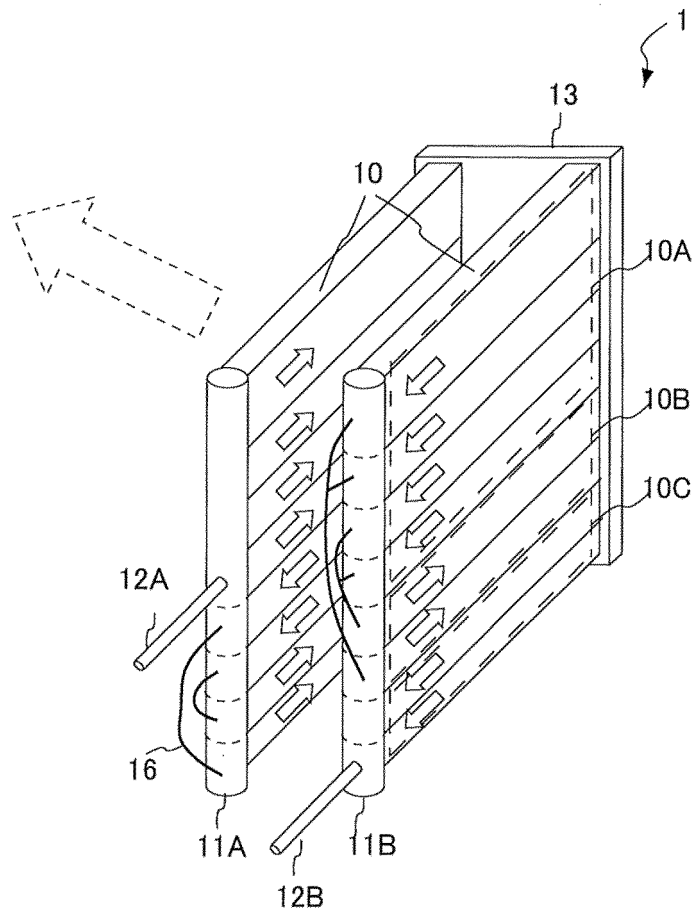
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(54) **HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE**

(57) A heat exchanger according to 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, the 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.

FIG. 2



## Description

### Technical Field

**[0001]** 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 Art

**[0002]** 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).

### Citation List

#### Patent Literature

**[0003]** Patent Literature 1: Japanese Patent Publication No. 5679084

### Summary of Invention

#### Technical Problem

**[0004]** 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.

**[0005]** 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.

#### Solution to Problem

**[0006]** 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.

**[0007]** 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.

#### Advantageous Effects of Invention

**[0008]** 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 ex-

change 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

#### [0009]

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

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

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

[Fig. 4] 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.

[Fig. 5] 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.

[Fig. 6] 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.

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

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

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

#### Description of Embodiments

[0010] 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>

[0011] 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.

[0012] 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.

[0013] 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.

**[0014]** 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.

**[0015]** 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.

**[0016]** 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>

**[0017]** 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.

**[0018]** 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>

**[0019]** 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 11A and a distribution header 11B) 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.

**[0020]** 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.

**[0021]** 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.

**[0022]** 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 12A and a refrigerant inlet/outlet pipe 12B) 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 12A, and flows out through the refrigerant inlet/outlet pipe 12B. In contrast, when the heat exchanger 1 serves as an evaporator, refrigerant flows into the heat exchanger 1 through the refrigerant inlet/outlet pipe 12B, and flows out through the refrigerant inlet/outlet pipe 12A. 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.

**[0023]** 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 10A of the airflow upstream side row and the main heat exchange portion 10A 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 10A 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.

**[0024]** 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.

**[0025]** 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 sur-

face 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.

**[0026]** 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.

**[0027]** 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 10A, a first auxiliary heat exchange portion 10B, and a second auxiliary heat exchange portion 10C. The uppermost region is defined as the main heat exchange portion 10A. The region lower than the main heat exchange portion 10A is defined as the first auxiliary heat exchange portion 10B. The region lower than the first auxiliary heat exchange portion 10B is defined as the second auxiliary heat exchange portion 10C. 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 10A>the first auxiliary heat exchange portion 10B≥the second auxiliary heat exchange portion 10C."

**[0028]** 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 12A into the distribution header 11A. The refrigerant having flowed into the distribution header 11A passes through the flat heat transfer tubes 14 belonging to the main heat exchange portion 10A 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.

**[0029]** 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 10A 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 11B. The refrigerant having flowed into the distribution header 11B passes through the connection pipes 16 and flows into other spaces in the distribution header 11B. Then, the refrigerant passes through the flat heat transfer tubes 14 belonging to the first auxiliary heat exchange portion 10B of the airflow upstream side row, is turned back in the turn-back header 13, passes through the first auxiliary heat exchange portion 10B of the airflow downstream side row, and then flows into the distribution header 11A.

**[0030]** The refrigerant having flowed into the distribution header 11A passes through the connection pipes 16 and flows into other spaces in the distribution header 11A. Then, the refrigerant passes through the flat heat transfer tubes 14 belonging to the second auxiliary heat exchange portion 10C of the airflow downstream side row, is turned back in the turn-back header 13, passes through the second auxiliary heat exchange portion 10C of the airflow upstream side row, and then flows into the distribution header 11B. The refrigerant, having flowed in the order described and condensed, flows out through the refrigerant inlet/outlet pipe 12B. Therefore, when the heat exchanger 1 in Embodiment 1 serves as a condenser, refrigerant that flows in the main heat exchange portions 10A 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.

**[0031]** 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.

**[0032]** 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 12B into the distribution header 11B. The refrigerant having flowed into the distribution header 11B passes through the flat heat transfer tubes 14 belonging to the second auxiliary heat exchange portion 10C 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.

**[0033]** 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 10C 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 11A. The refrigerant having flowed into the distribution header 11A passes through the connection pipes 16 and flows into other spaces in the distribution header 11A. Then, the refrigerant passes through the flat heat transfer tubes 14 belonging to the first auxiliary heat exchange portion 10B of the airflow downstream side row, is turned back in the turn-back header 13, passes through the first auxiliary heat exchange portion 10B of the airflow upstream side row, and then flows into the distribution header 11B.

**[0034]** The refrigerant having flowed into the distribution header 11B passes through the connection pipes 16 and flows into other spaces in the distribution header 11B. Then, the refrigerant passes through the flat heat transfer tubes 14 belonging to the main heat exchange portion 10A of the airflow upstream side row, is turned back in the turn-back header 13, passes through the main heat exchange portion 10A of the airflow downstream side row, and then flows into the distribution header 11A. The refrigerant, having flowed in the order described and condensed, flows out through the refrigerant inlet/outlet pipe 12A. Therefore, when the heat exchanger 1 in Embodiment 1 serves as an evaporator, refrigerant that flows in the main heat exchange portions 10A 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.

**[0035]** 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 10A. However, refrigerant initially passes through the second auxiliary heat exchange portion 10C 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 10A, and eventually the refrigerant flows into the main heat exchange portion 10A. 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 10A. Therefore, the refrigerant passing through the main heat exchange portion 10A 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.

**[0036]** 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 10A, 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.

**[0037]** In contrast, when the heat exchanger 1 serves as an evaporator, a flow of refrigerant in the main heat exchange portion 10A, 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 10C, and refrigerant whose temperature has decreased flows into the main heat exchange portion 10A. Due to this configuration, the refrigerant passing through the main heat exchange portion 10A 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.

**[0038]** 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

**[0039]** 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 10A>the first auxiliary heat exchange portion 10B>the second auxiliary heat exchange portion 10C."

**[0040]** When the heat exchanger 1 serves as an evaporator, refrigerant flows through the refrigerant inlet/outlet pipe 12B into the distribution header 11B, and then passes through the flat heat transfer tubes 14 belonging to the second auxiliary heat exchange portion 10C 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 10C 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 10C 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

**[0041]** 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 10A 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.

**[0042]** 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 allo-

cated 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

**[0043]** 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 10A of the airflow upstream side row are connected to each other by using a layered distributor 17, instead of using the distribution header 11B. 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 10B of the airflow upstream side row, the distribution header 11B, and the connection pipes 16. When the heat exchanger 1 serves as an evaporator, the layered distributor 17 merges refrigerant flows having passed through the main heat exchange portion 10A.

**[0044]** 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 17A on one another, that are a plurality of plate-like parts including through holes or through grooves serving as a flow passage. The plates 17A include flow passage grooves 17B and flow passage holes 17C. The flow passage grooves 17B allow refrigerant to pass therethrough. The flow passage holes 17C are through holes communicating with the adjacent plates 17A to allow the refrigerant to pass therethrough. The layered distributor 17 is not limited to having the configuration illustrated in Fig. 9.

**[0045]** The large region of main heat exchange portion 10A 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

**[0046]** 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.

**[0047]** 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.

**[0048]** 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.

#### Reference Signs List

**[0049]** 1: heat exchanger, 10: heat exchange portion, 10A: main heat exchange portion, 10B: first auxiliary heat exchange portion, 10C: second auxiliary heat exchange portion, 11, 11A, 11B: distribution header, 12, 12A, 12B: refrigerant inlet/outlet pipe, 13: turn-back header, 14: flat heat transfer tube, 15: corrugated fin, 16: connection pipe, 17: layered distributor, 17A: plate, 17B: flow passage groove, 17C: flow passage hole, 100: indoor unit, 110: indoor heat exchanger, 120: expansion valve, 130: indoor air-sending device, 200: outdoor unit, 210: compressor, 220: four-way valve, 230: outdoor heat exchanger, 240: accumulator, 250: outdoor air-sending device, 300: refrigerant pipe

#### Claims

##### 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 hav-  
 ing fewer number of the heat transfer tubes  
 than those of the main heat exchange por-  
 tion, 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 ex-  
 changer serves as a condenser, allow the refrig-  
 erant to flow through the heat exchanger in order  
 of

the main heat exchange portion of the air-  
 flow downstream side row,  
 the main heat exchange portion of the air-  
 flow 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

and allow the refrigerant to flow out of the heat  
 exchanger.

2. The heat exchanger of claim 1, wherein the heat ex-  
 change 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. The heat exchanger of claim 1 or 2, 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 distribu-  
 tion merge portions.
4. The heat exchanger of claim 3, 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 sub-  
 groups.
5. The heat exchanger of any one of claims 1 to 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.

6. The heat exchanger of any one of claims 1 to 5,  
 wherein the distribution merge portions include a lay-  
 ered distributor of a plurality of plate-like parts  
 stacked on one another.

7. The heat exchanger of any one of claims 1 to 6,  
 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 ex-  
 changer of any one of claims 1 to 7 to serve at least  
 as a condenser.

9. The refrigeration cycle device of claim 8, wherein

the heat transfer tubes of the heat exchange por-  
 tion 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 por-  
 tion, and  
 when the heat exchanger serves as an evapo-  
 rator, 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 8 or 9, com-  
 prising an air-sending device including a fan and ori-  
 ented 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.

FIG. 1

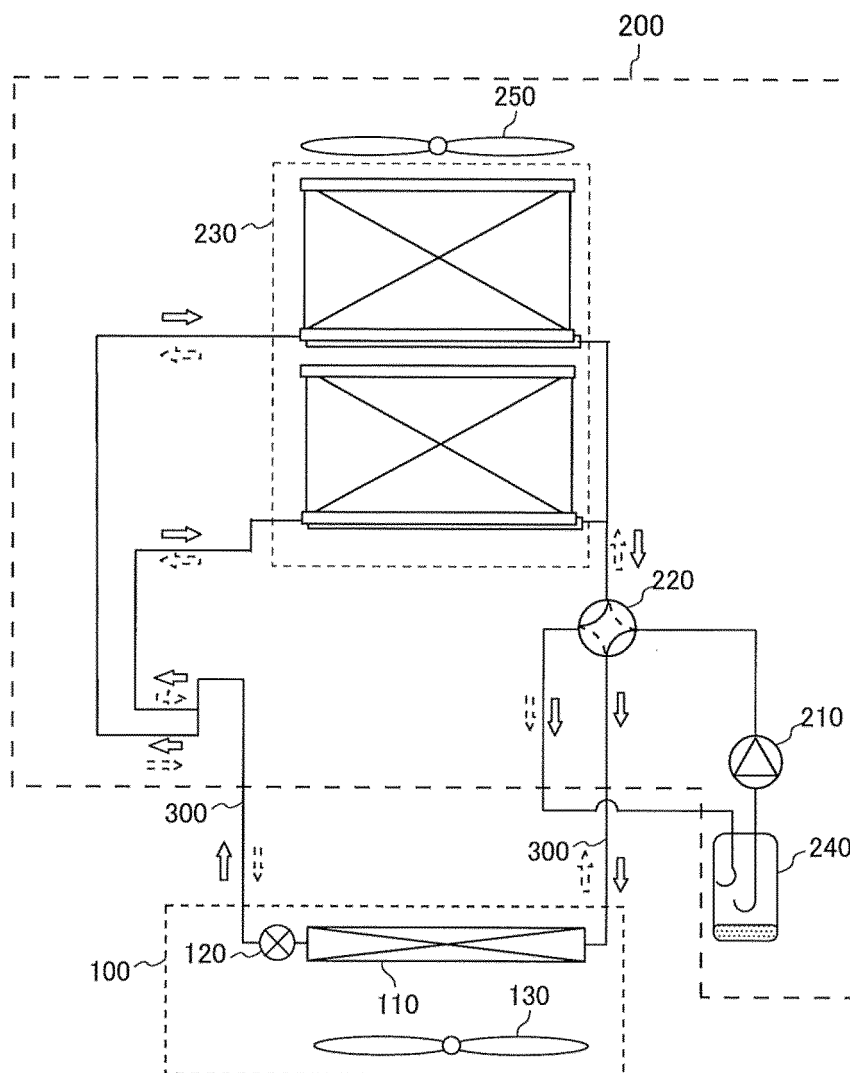


FIG. 2

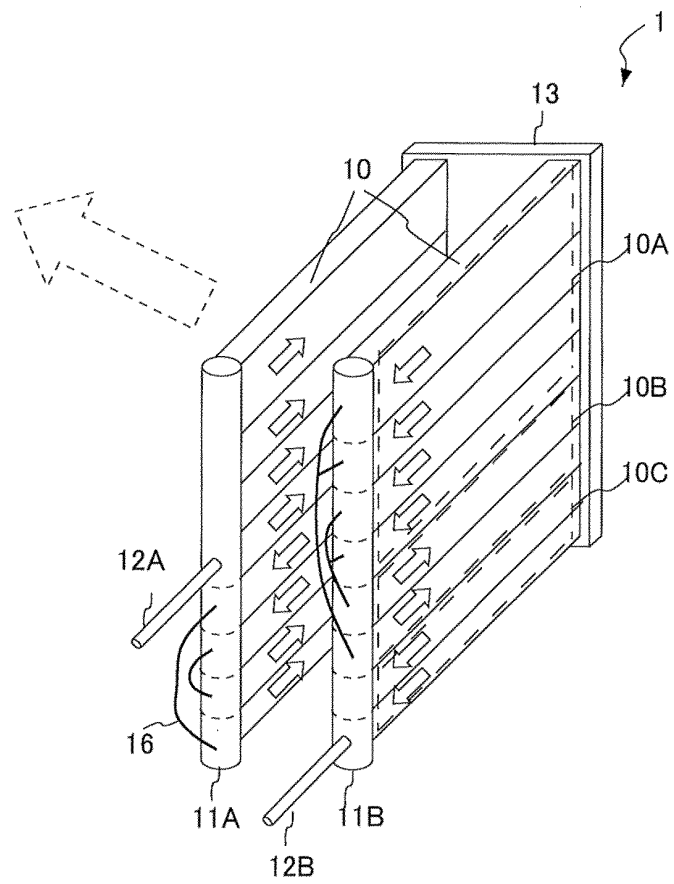


FIG. 3

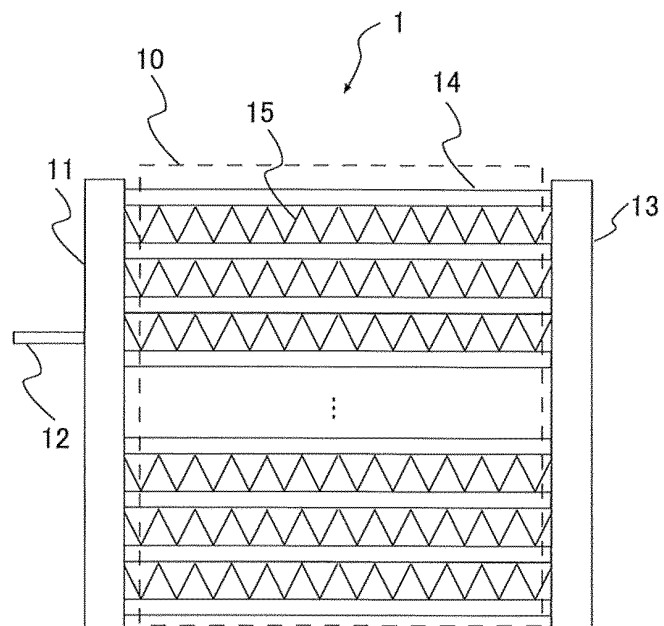


FIG. 4

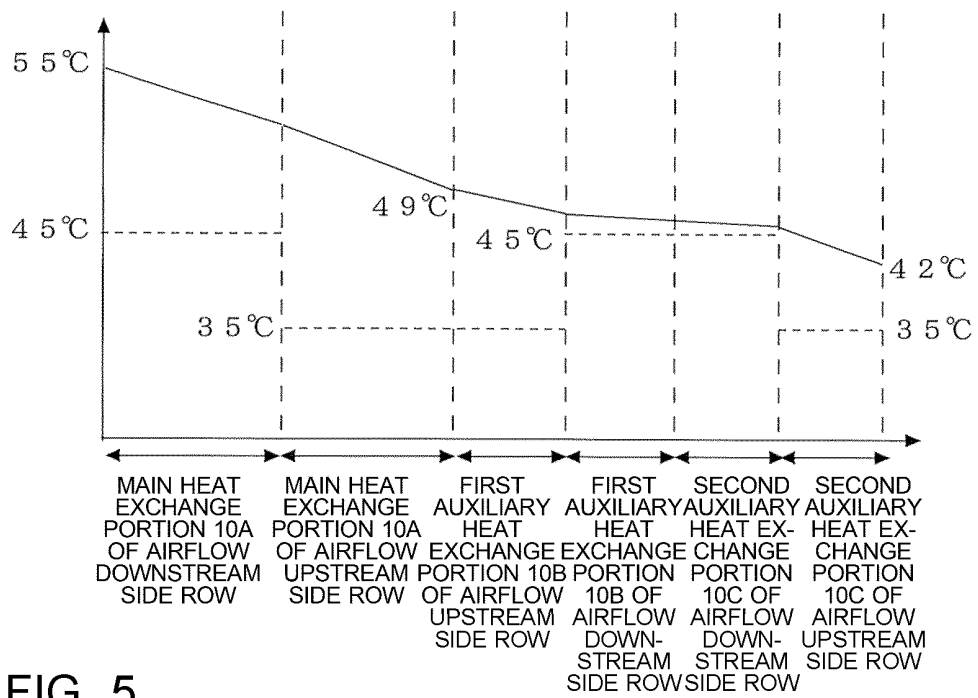


FIG. 5

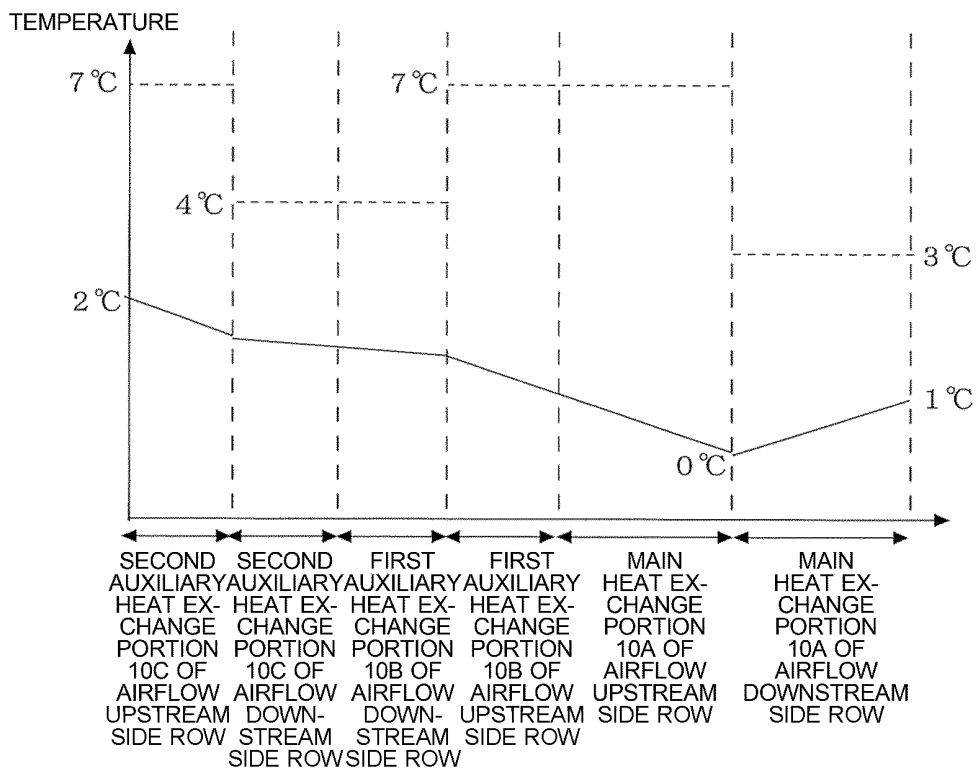


FIG. 6

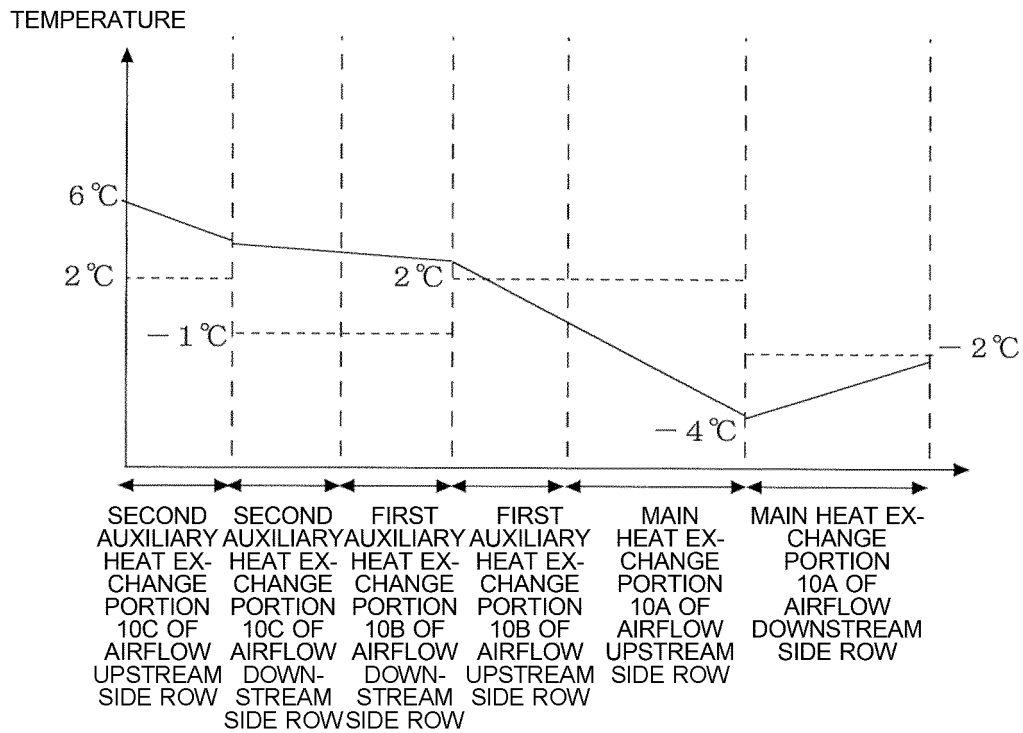


FIG. 7

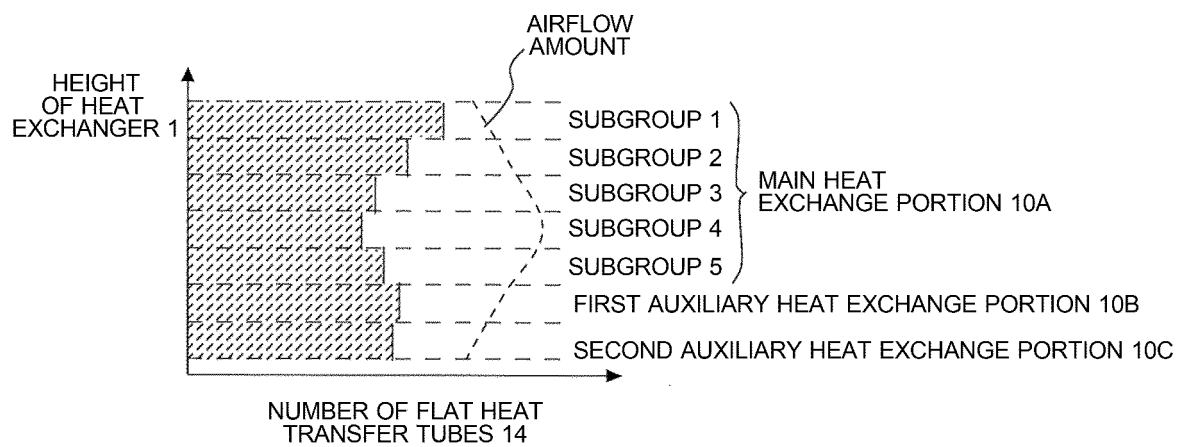


FIG. 8

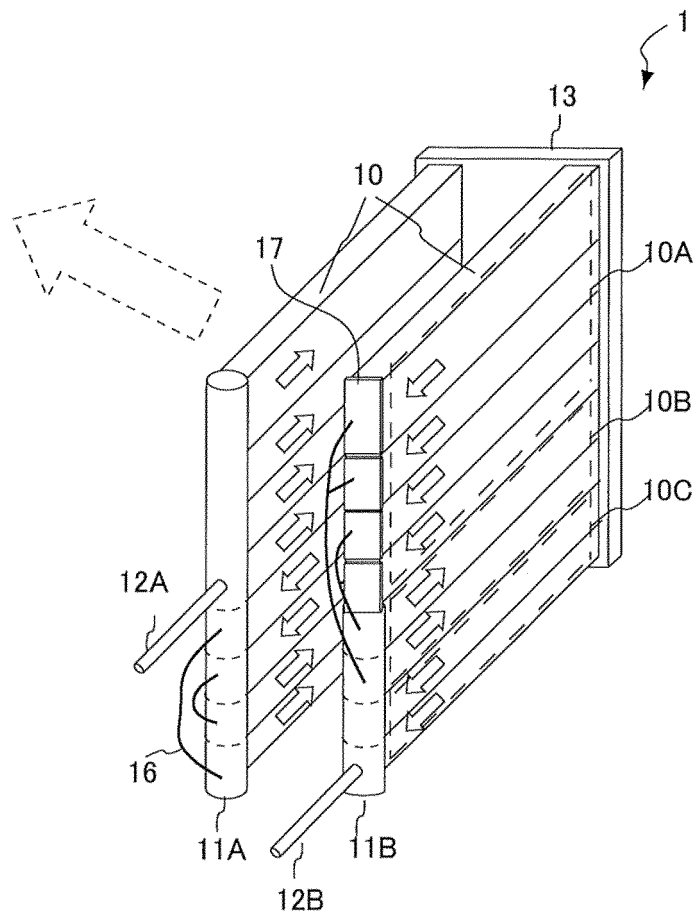
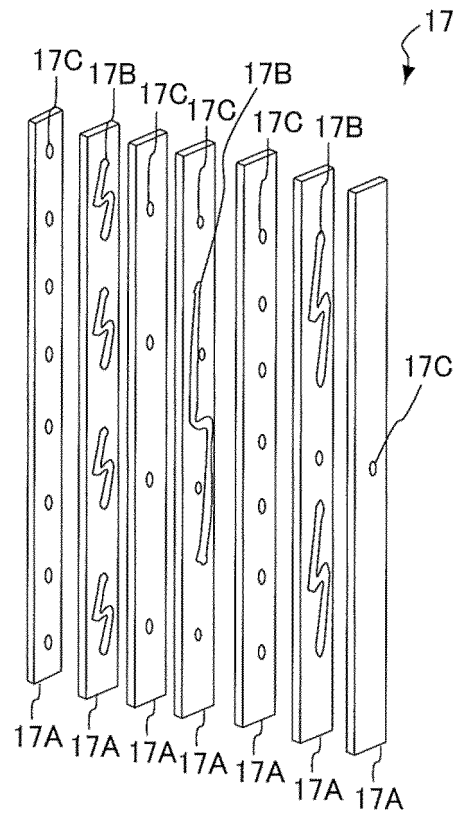


FIG. 9



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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/022105

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## A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F28F9/02 (2006.01) i

FI: F28F9/02 301D, F28F9/02 301C

According to International Patent Classification (IPC) or to both national classification and IPC

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## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl. F28F9/02

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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 1971-2020

Registered utility model specifications of Japan 1996-2020

Published registered utility model applications of Japan 1994-2020

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                 | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y         | JP 2003-121092 A (HALLA CLIMATE CONTROL CORPORATION) 23 April 2003, paragraphs [0028]-[0083], fig. 1-31                                                                                                            | 1-10                  |
| Y         | CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 42596/1992 (Laid-open No. 96773/1993) (ZEXEL CORP.) 27 December 1993, paragraphs [0008]-[0030], fig. 1-5 | 1-10                  |
| Y         | JP 2002-372340 A (CALSONIC KANSEI CORP.) 26 December 2002, paragraphs [0012]-[0038], fig. 1-9                                                                                                                      | 1-10                  |

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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search  
30.07.2020Date of mailing of the international search report  
11.08.2020

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Name and mailing address of the ISA/  
Japan Patent Office  
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Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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## INTERNATIONAL SEARCH REPORT

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| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                    |                       |
|-------------------------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------|
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| Y                                                     | WO 2017/175346 A1 (MITSUBISHI ELECTRIC CORP.) 12 October 2017, paragraphs [0011]-[0056], fig. 1-11 | 6-10                  |
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**REFERENCES CITED IN THE DESCRIPTION**

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