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

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CPC ***F25B 29/003*** (2013.01); ***F25B 41/40*** (2021.01); ***F28F 9/0275*** (2013.01)

(57) **ABSTRACT**

A heat exchanger includes: a first heat transfer portion having a plurality of first heat transfer tubes; and a zeotropic refrigerant flowing through the plurality of first heat transfer tubes of the first heat transfer portion. The plurality of first heat transfer tubes are arranged in a line. The first heat transfer portion has the plurality of first heat transfer tubes arranged to allow flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes to be orthogonal to flow of air flowing across the first heat transfer portion.

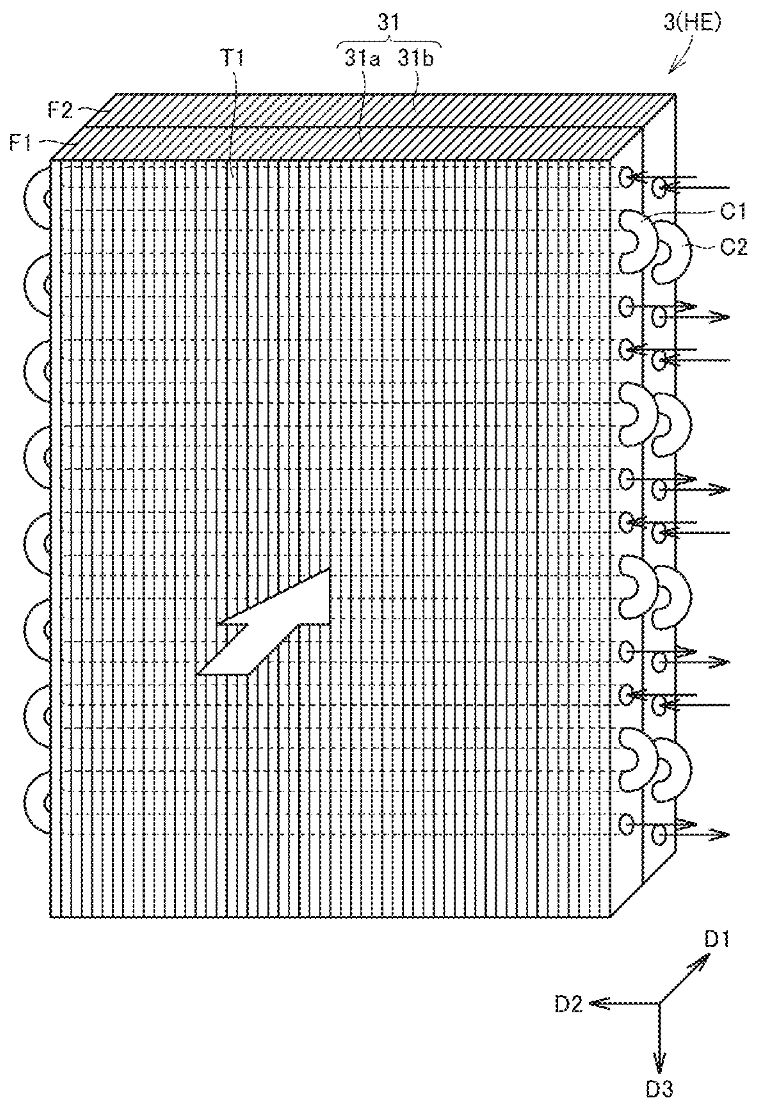


FIG.1

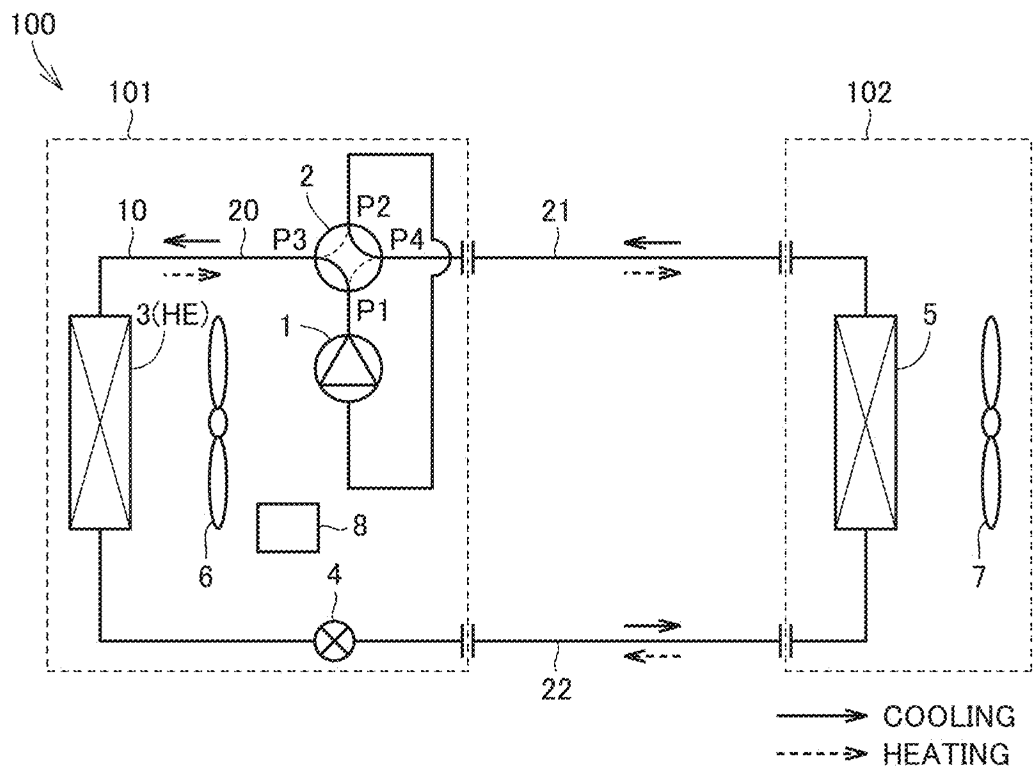


FIG.2

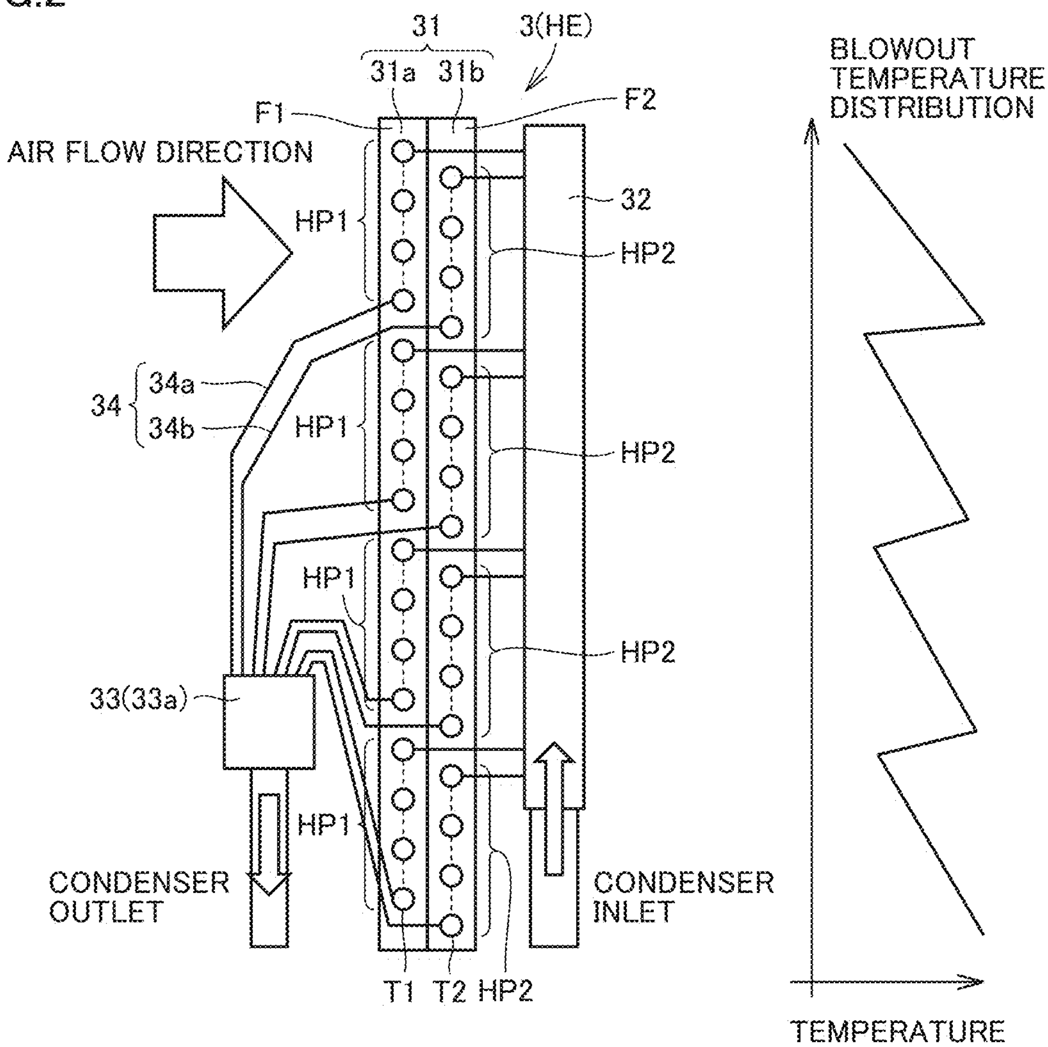

31
3(HE)
31a
31b
F1
F2
AIR FLOW DIRECTION
HP1
HP2
32
34a
34
34b
HP1
HP2
HP1
HP2
33(33a)
HP1
CONDENSER
OUTLET
CONDENSER
INLET
T1
T2
HP2
BLOWOUT
TEMPERATURE
DISTRIBUTION
TEMPERATURE

FIG.3

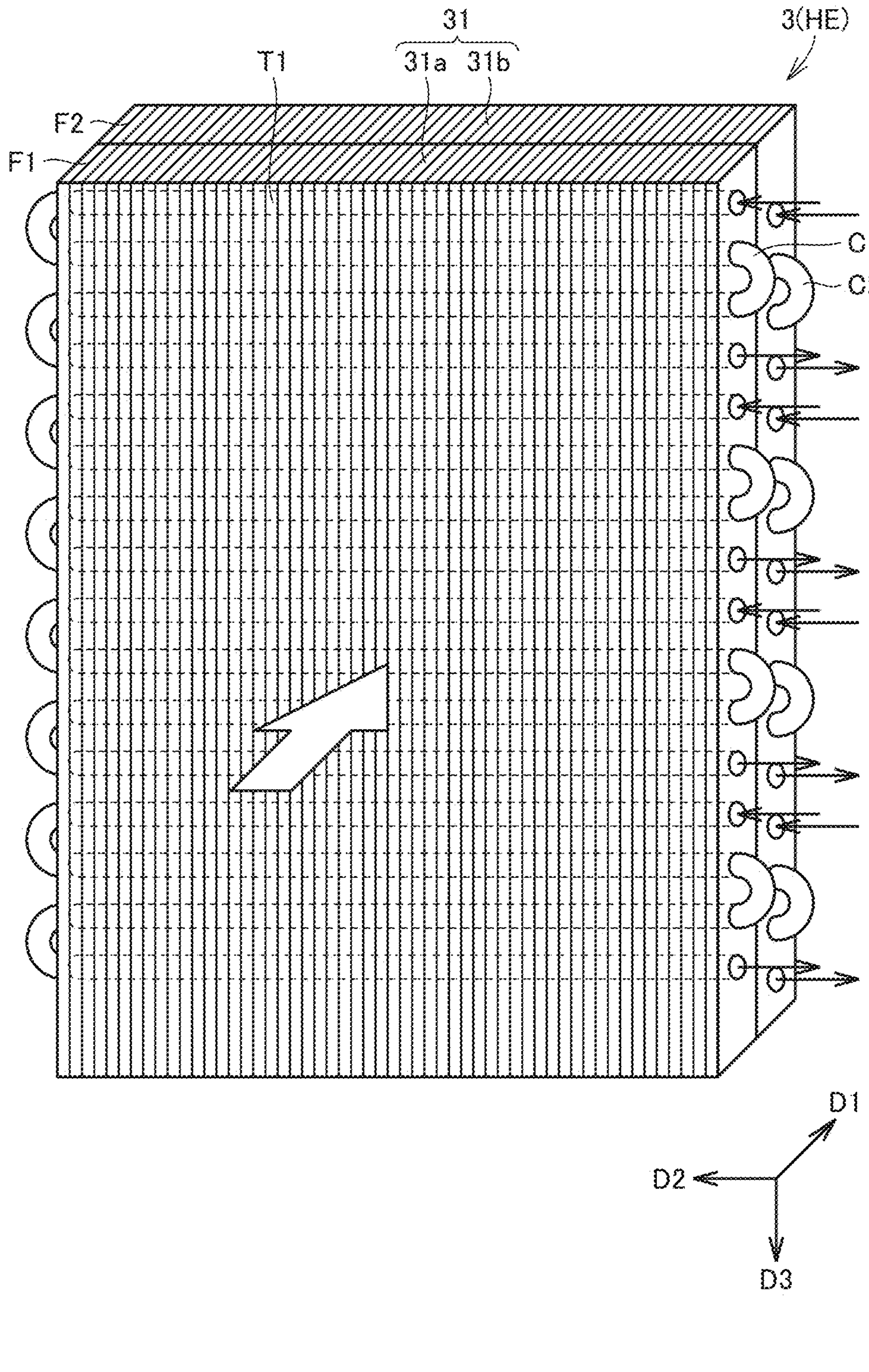


FIG.4

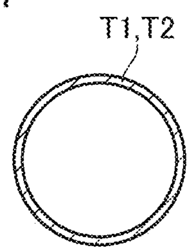


FIG.5

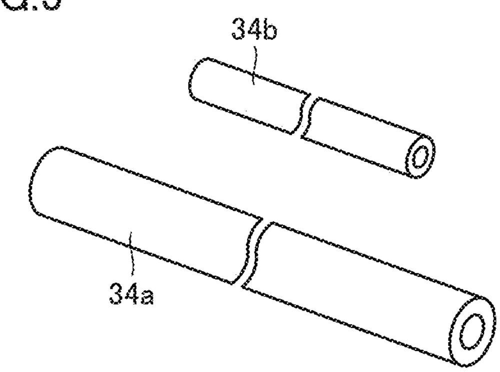


FIG.6

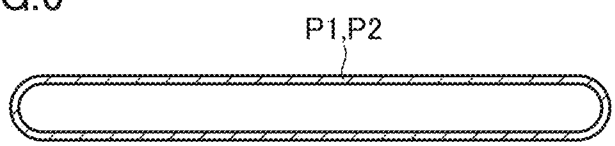


FIG.7

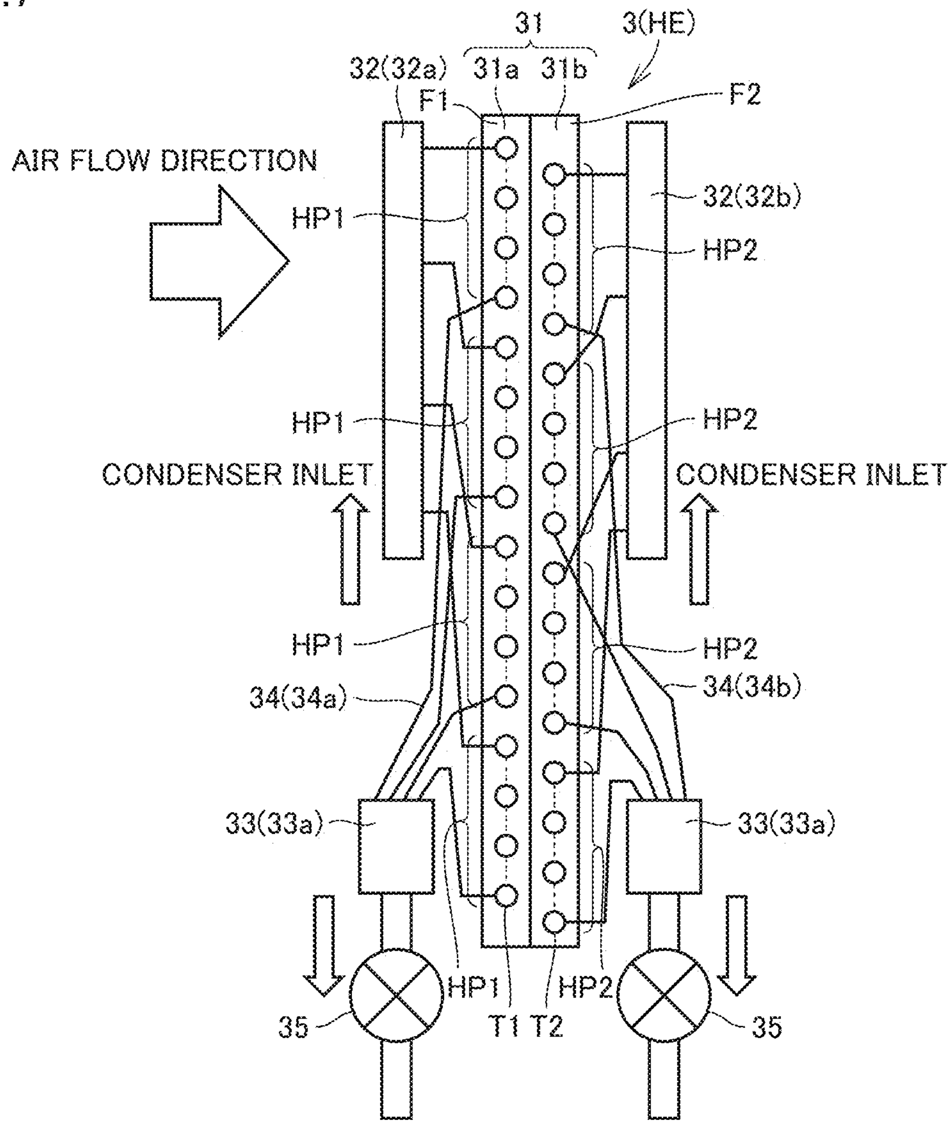

31
3(HE)
32(32a)
31a
31b
F1
F2
AIR FLOW DIRECTION
32(32b)
HP1
HP2
HP1
HP2
CONDENSER INLET
CONDENSER INLET
HP1
HP2
34(34a)
34(34b)
33(33a)
33(33a)
HP1
HP2
35
T1 T2
35

FIG.8

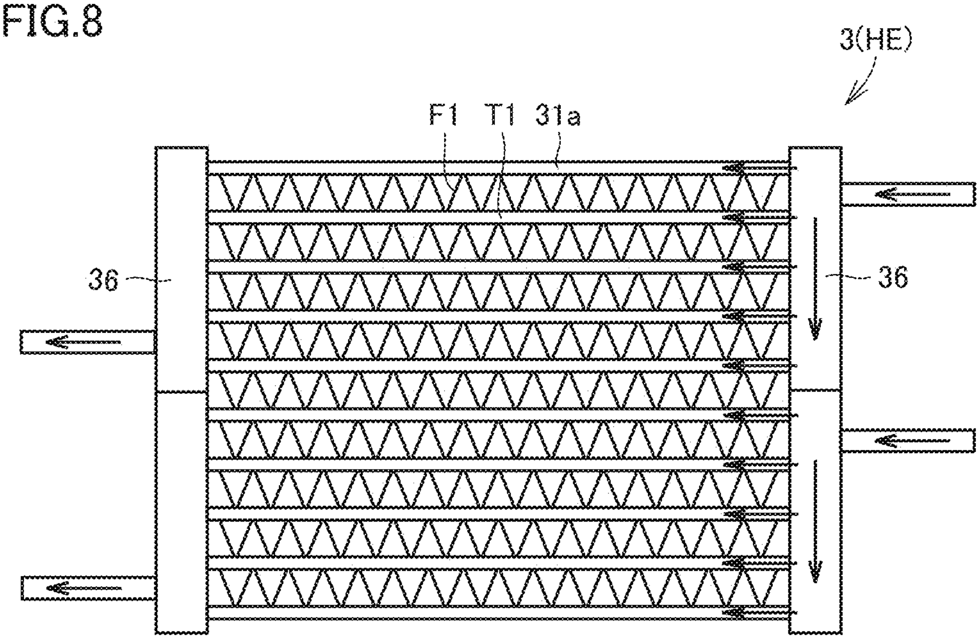


FIG.9

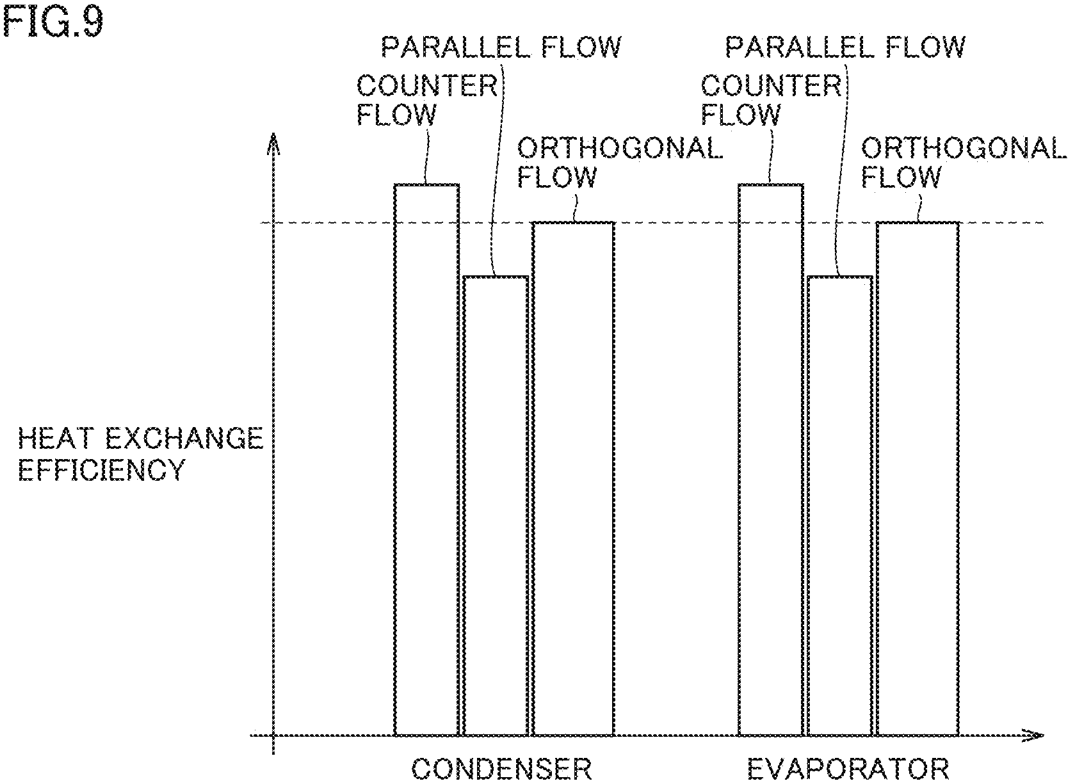

PARALLEL FLOW
COUNTER FLOW
ORTHOGONAL FLOW
PARALLEL FLOW
COUNTER FLOW
ORTHOGONAL FLOW
HEAT EXCHANGE EFFICIENCY
CONDENSER
EVAPORATOR

FIG.10

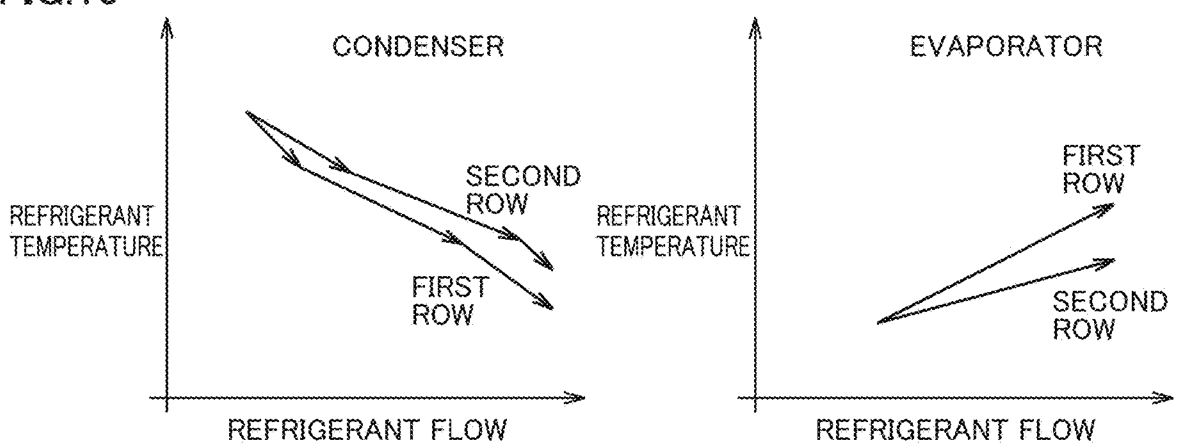

CONDENSER
SECOND ROW
REFRIGERANT TEMPERATURE
FIRST ROW
REFRIGERANT FLOW
EVAPORATOR
FIRST ROW
REFRIGERANT TEMPERATURE
SECOND ROW
REFRIGERANT FLOW

FIG.11

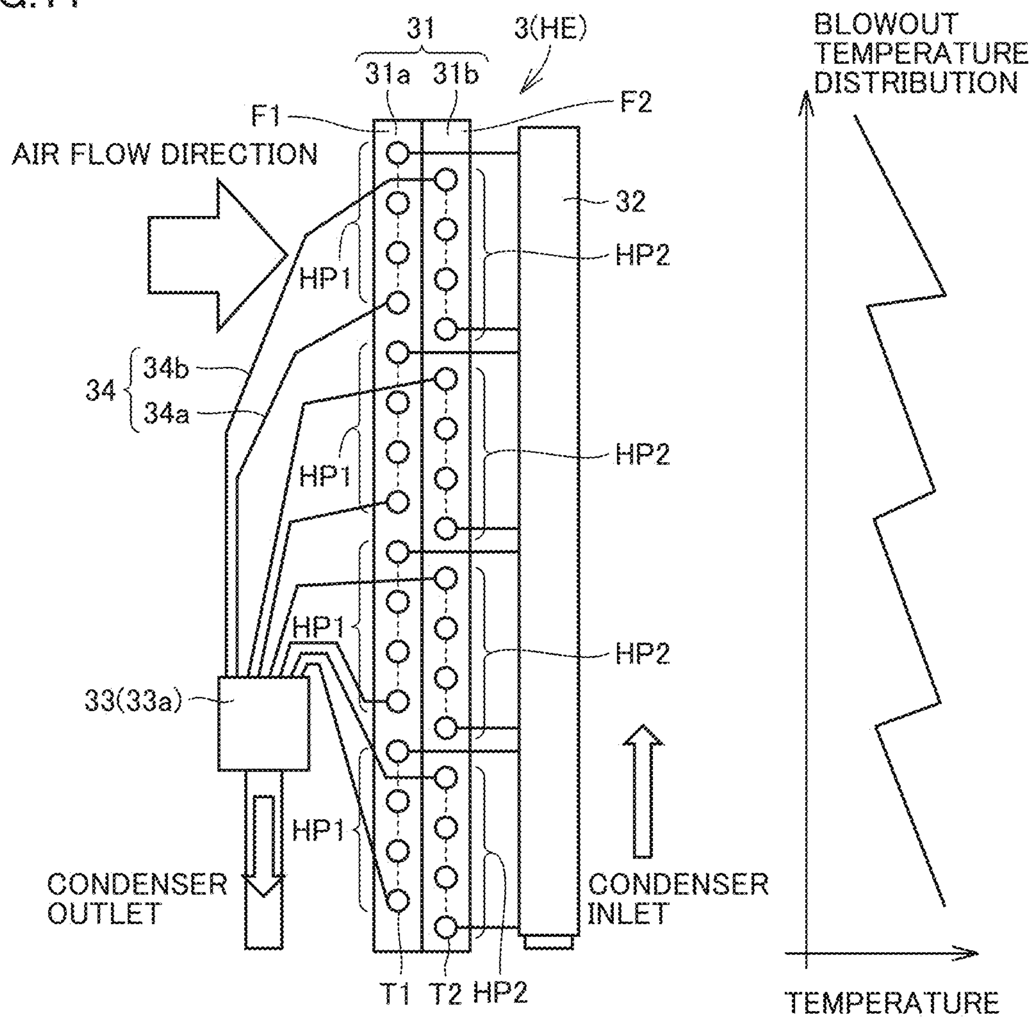
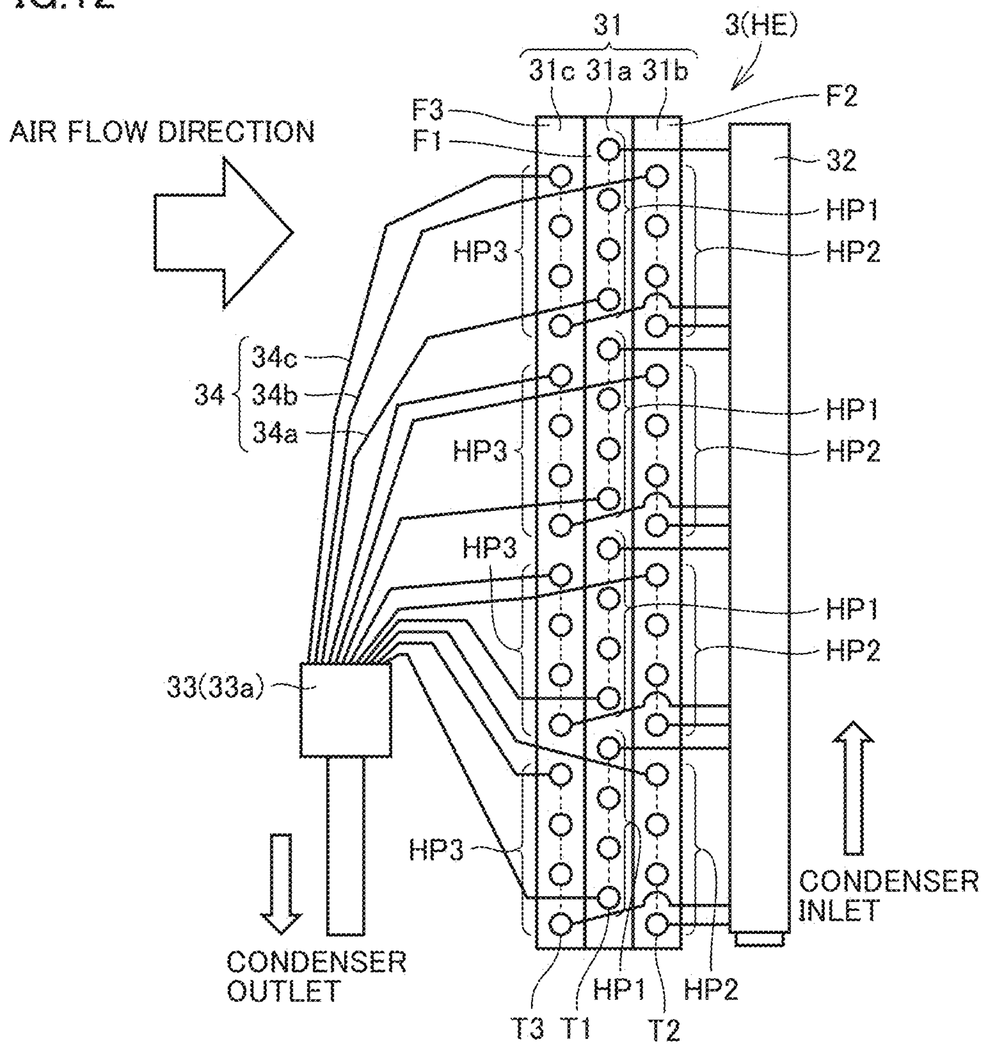

31
3(HE)
31a 31b
F1
F2
AIR FLOW DIRECTION
32
HP1
HP2
34
34b
34a
HP1
HP2
HP1
HP2
33(33a)
HP1
CONDENSER OUTLET
CONDENSER INLET
T1 T2 HP2
BLOWOUT TEMPERATURE DISTRIBUTION
TEMPERATURE

FIG.12



31
3(HE)
31c 31a 31b
F3
F2
F1
AIR FLOW DIRECTION
32
HP1
HP3
HP2
34c
34
34b
34a
HP1
HP3
HP2
HP3
HP1
HP2
33(33a)
HP3
CONDENSER INLET
CONDENSER OUTLET
T3 T1
HP1
T2
HP2

FIG.13

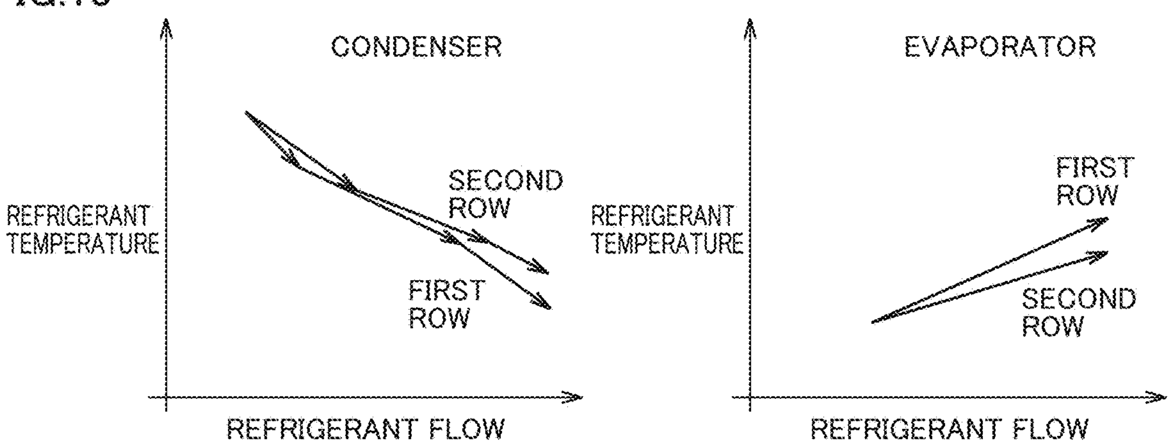

CONDENSER
REFRIGERANT TEMPERATURE
SECOND ROW
FIRST ROW
REFRIGERANT FLOW
EVAPORATOR
REFRIGERANT TEMPERATURE
FIRST ROW
SECOND ROW
REFRIGERANT FLOW

FIG.14

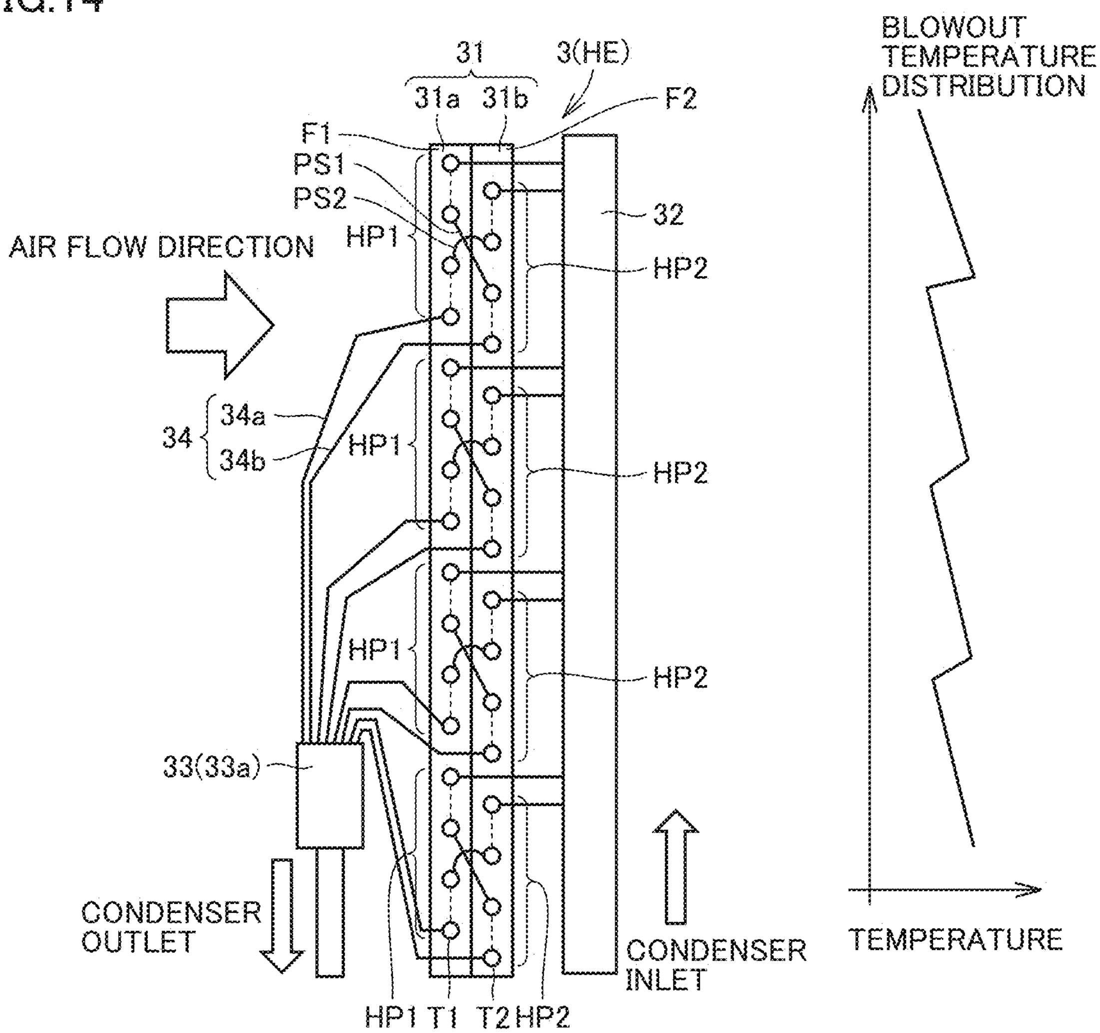

31
3(HE)
31a 31b
F1
F2
PS1
PS2
HP1
32
AIR FLOW DIRECTION
HP2
34
34a
34b
33(33a)
CONDENSER OUTLET
CONDENSER INLET
HP1 T1 T2 HP2
BLOWOUT TEMPERATURE DISTRIBUTION
TEMPERATURE

FIG.15

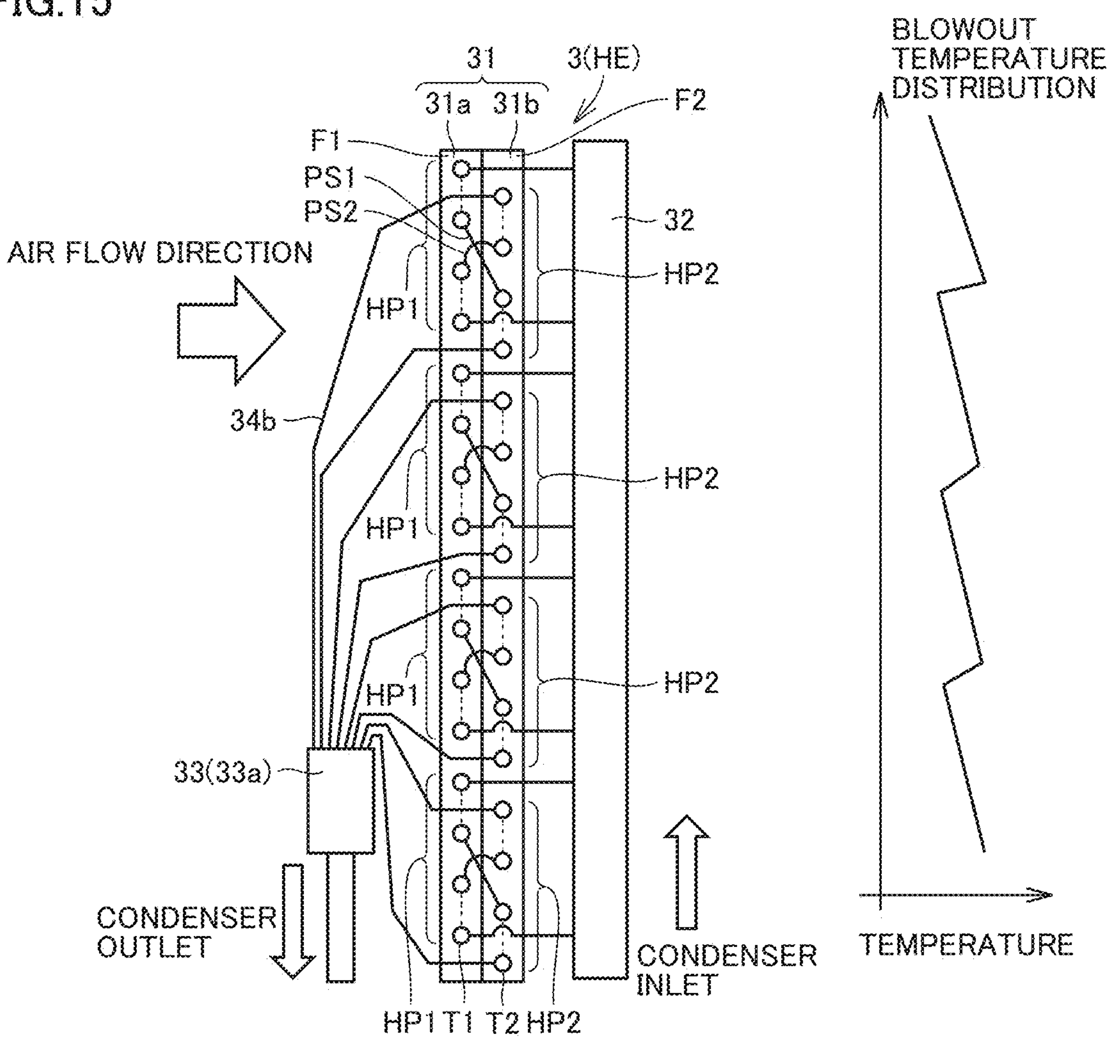

31
3(HE)
31a 31b
F2
F1
PS1
PS2
32
AIR FLOW DIRECTION
HP1
HP2
34b
HP1
HP2
HP1
HP2
33(33a)
CONDENSER OUTLET
CONDENSER INLET
HP1 T1 T2 HP2
BLOWOUT TEMPERATURE DISTRIBUTION
TEMPERATURE

FIG.16

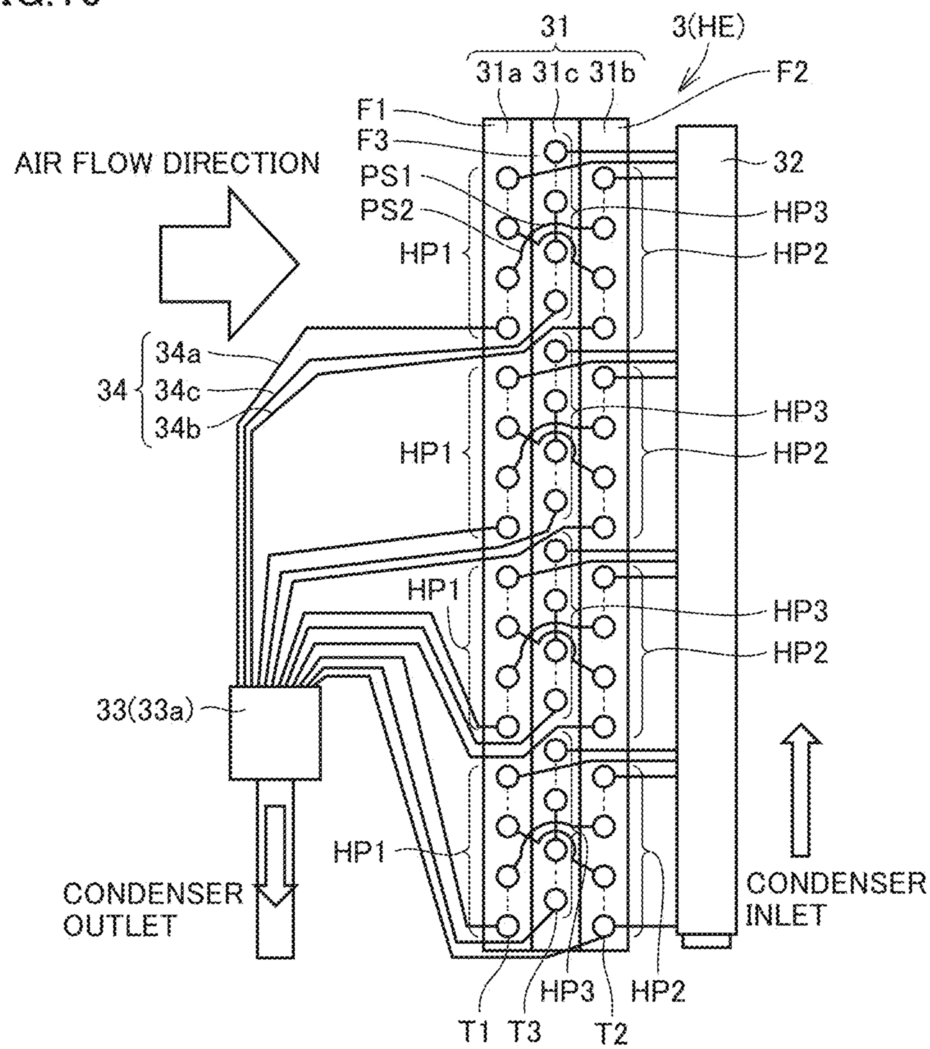
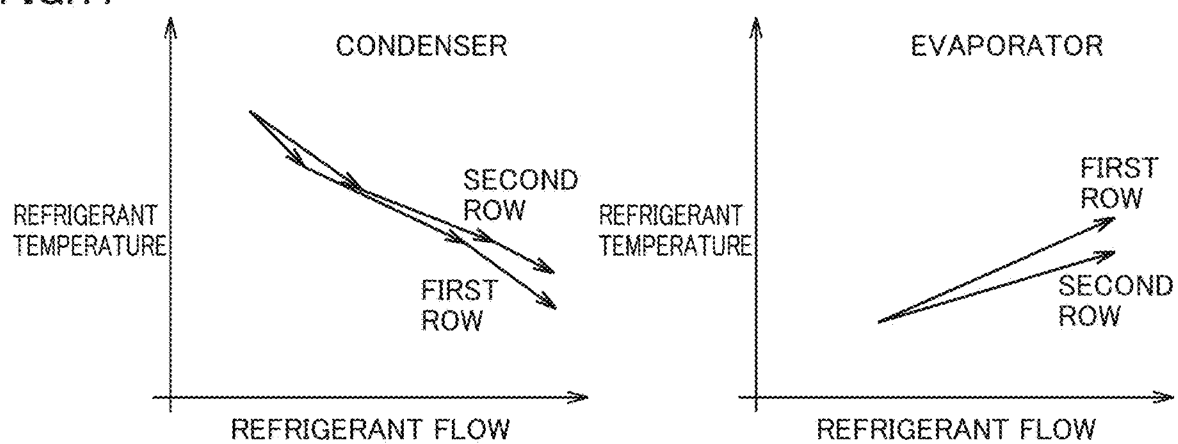

31
3(HE)
31a 31c 31b
F2
F1
F3
32
AIR FLOW DIRECTION
PS1
PS2
HP3
HP2
HP1
34a
34
34c
34b
HP1
HP3
HP2
HP1
HP3
HP2
33(33a)
HP1
CONDENSER
OUTLET
CONDENSER
INLET
HP3
HP2
T1 T3
T2

FIG.17


CONDENSER
REFRIGERANT TEMPERATURE
SECOND ROW
FIRST ROW
REFRIGERANT FLOW
EVAPORATOR
REFRIGERANT TEMPERATURE
FIRST ROW
SECOND ROW
REFRIGERANT FLOW

HEAT EXCHANGER AND REFRIGERATION CYCLE APPARATUS

TECHNICAL FIELD

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

BACKGROUND ART

[0002] Arranging heat transfer tubes in multiple lines has been proposed in order to enhance the performance of a heat exchanger of a refrigeration cycle apparatus. Since a heat exchanger is mounted in a limited space, arranging heat transfer tubes in multiple lines can lead to an increase in mounting density of the heat transfer tubes and an increase in heat transfer area. For example, a heat exchanger of an indoor unit of an air conditioning apparatus described in Japanese Patent Laying-Open No. 2014-40983 (PTL 1) has heat transfer tubes arranged in multiple lines.

CITATION LIST

Patent Literature

[0003] PTL 1: Japanese Patent Laying-Open No. 2014-40983

SUMMARY OF INVENTION

Technical Problem

[0004] In the case where a zeotropic refrigerant is used in a heat exchanger having heat transfer tubes arranged in multiple lines, temperature distribution occurs in the zeotropic refrigerant, and due to this, a heat exchange loss occurs when the refrigerant flows parallel to an air flow. A direction of the refrigerant flowing through the heat exchanger when the heat exchanger functions as a condenser is opposite to a direction of the refrigerant flowing through the heat exchanger when the heat exchanger functions as an evaporator. Therefore, the refrigerant flows parallel to the air flow in either the condenser or the evaporator. Thus, the heat exchange efficiency decreases in either the condenser or the evaporator.

[0005] The present disclosure has been made in light of the above-described problem, and an object thereof is to provide a heat exchanger and a refrigeration cycle apparatus that make it possible to averagely ensure the heat exchange efficiency in a condenser and an evaporator, while using a zeotropic refrigerant.

Solution to Problem

[0006] A heat exchanger of the present disclosure includes: a first heat transfer portion having a plurality of first heat transfer tubes; and a zeotropic refrigerant flowing through the plurality of first heat transfer tubes of the first heat transfer portion. The plurality of first heat transfer tubes are arranged in a line. The first heat transfer portion has the plurality of first heat transfer tubes arranged to allow flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes to be orthogonal to flow of air flowing across the first heat transfer portion.

Advantageous Effects of Invention

[0007] According to the heat exchanger of the present disclosure, it is possible to averagely ensure the heat exchange efficiency in a condenser and an evaporator, while using a zeotropic refrigerant.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** is a refrigerant circuit diagram of a refrigeration cycle apparatus according to a first embodiment.
[0009] FIG. **2** shows a heat exchanger according to the first embodiment and a blowout temperature distribution.
[0010] FIG. **3** is a perspective view schematically showing the heat exchanger according to the first embodiment.
[0011] FIG. **4** is a cross-sectional view schematically showing a first heat transfer tube and a second heat transfer tube of the heat exchanger according to the first embodiment.
[0012] FIG. **5** is a perspective view schematically showing a capillary tube of the heat exchanger according to the first embodiment.
[0013] FIG. **6** is a cross-sectional view schematically showing a modification of the first heat transfer tube and the second heat transfer tube of the heat exchanger according to the first embodiment.
[0014] FIG. **7** is a cross-sectional view schematically showing a first modification of the heat exchanger according to the first embodiment.
[0015] FIG. **8** is a front view schematically showing a second modification of the heat exchanger according to the first embodiment.
[0016] FIG. **9** shows the heat exchange efficiency of a counter flow, a parallel flow and an orthogonal flow in each of a condenser and an evaporator.
[0017] FIG. **10** shows a relationship between a refrigerant flow and a refrigerant temperature in each of the condenser and the evaporator of the heat exchanger according to the first embodiment.
[0018] FIG. **11** shows a heat exchanger according to a second embodiment and a blowout temperature distribution.
[0019] FIG. **12** is a cross-sectional view schematically showing a modification of the heat exchanger according to the second embodiment.
[0020] FIG. **13** shows a relationship between a refrigerant flow and a refrigerant temperature in each of a condenser and an evaporator of the heat exchanger according to the second embodiment.
[0021] FIG. **14** shows a heat exchanger according to a third embodiment and a blowout temperature distribution.
[0022] FIG. **15** is a cross-sectional view schematically showing a first modification of the heat exchanger according to the third embodiment.
[0023] FIG. **16** is a cross-sectional view schematically showing a second modification of the heat exchanger according to the third embodiment.
[0024] FIG. **17** shows a relationship between a refrigerant flow and a refrigerant temperature in each of a condenser and an evaporator of the heat exchanger according to the third embodiment.

DESCRIPTION OF EMBODIMENTS

[0025] Embodiments will be described hereinafter with reference to the drawings, in which the same or corresponding portions are denoted by the same reference characters and description thereof will not be repeated.

First Embodiment

[0026] A configuration of a refrigeration cycle apparatus **100** according to a first embodiment will be described with reference to FIG. **1**. In the first embodiment, an air conditioner is described as an example of refrigeration cycle apparatus **100**. A solid arrow in FIG. **1** indicates a flow of refrigerant during cooling operation. A dashed arrow in FIG. **1** indicates a flow of refrigerant during heating operation.

[0027] As shown in FIG. **1**, refrigeration cycle apparatus **100** includes a compressor **1**, a four-way valve **2**, an outdoor heat exchanger **3**, an expansion valve **4**, an indoor heat exchanger **5**, an outdoor blower **6**, an indoor blower **7**, and a controller **8**. A heat exchanger HE according to the first embodiment is applied to outdoor heat exchanger **3**. Refrigeration cycle apparatus **100** includes an outdoor unit **101**, and an indoor unit **102** connected to outdoor unit **101**.

[0028] A refrigerant circuit **10** includes compressor **1**, four-way valve **2**, outdoor heat exchanger **3**, expansion valve **4**, and indoor heat exchanger **5**. Compressor **1**, four-way valve **2**, outdoor heat exchanger **3**, expansion valve **4**, and indoor heat exchanger **5** are connected by a pipe **20**. Refrigerant circuit **10** is configured to circulate the refrigerant.

[0029] The refrigerant is a zeotropic refrigerant. The zeotropic refrigerant includes R32, and may include R1234yf as another refrigerant. The zeotropic refrigerant may include R1123 or R1234ze as another refrigerant. Alternatively, the zeotropic refrigerant may be a mixture of three or more types of refrigerant.

[0030] Compressor **1**, four-way valve **2**, outdoor heat exchanger **3**, expansion valve **4**, outdoor blower **6**, and controller **8** are housed in outdoor unit **101**. Indoor heat exchanger **5** and indoor blower **7** are housed in indoor unit **102**. Outdoor unit **101** and indoor unit **102** are connected by a gas pipe **21** and a liquid pipe **22**. A part of pipe **20** forms gas pipe **21** and liquid pipe **22**.

[0031] Refrigerant circuit **10** is configured such that the refrigerant circulates in the order of compressor **1**, four-way valve **2**, outdoor heat exchanger **3**, expansion valve **4**, indoor heat exchanger **5**, and four-way valve **2** during the cooling operation. In addition, refrigerant circuit **10** is configured such that the refrigerant circulates in the order of compressor **1**, four-way valve **2**, indoor heat exchanger **5**, expansion valve **4**, outdoor heat exchanger **3**, and four-way valve **2** during the heating operation.

[0032] Compressor **1** is configured to compress the refrigerant. Compressor **1** is for compressing the zeotropic refrigerant flowing into heat exchanger HE. Compressor **1** is configured to compress and discharge the suctioned refrigerant. Compressor **1** may be configured to be capacity-variable. Compressor **1** may be configured such that a capacity thereof varies through the adjustment of the rotation speed of compressor **1** based on an instruction from controller **8**.

[0033] Four-way valve **2** is configured to switch the flow of the refrigerant to allow the refrigerant compressed by compressor **1** to flow to outdoor heat exchanger **3** or indoor heat exchanger **5**. Four-way valve **2** has a first port P**1** to a fourth port P**4**. First port P**1** is connected to the discharge side of compressor **1**. Second port P**2** is connected to the suction side of compressor **1**. Third port P**3** is connected to outdoor heat exchanger **3**. Fourth port P**4** is connected to indoor heat exchanger **5**. Four-way valve **2** is configured to allow the refrigerant discharged from compressor **1** to flow to outdoor heat exchanger **3** during the cooling operation. During the cooling operation, third port P**3** is connected to first port P**1** and fourth port P**4** is connected to second port P**2** in four-way valve **2**. In addition, four-way valve **2** is configured to allow the refrigerant discharged from compressor **1** to flow to indoor heat exchanger **5** during the heating operation. During the heating operation, fourth port P**4** is connected to first port P**1** and third port P**3** is connected to second port P**2** in four-way valve **2**.

[0034] Outdoor heat exchanger **3** is configured to perform heat exchange between the refrigerant flowing inside outdoor heat exchanger **3** and the air flowing outside outdoor heat exchanger **3**. Outdoor heat exchanger **3** is configured to function as a condenser that condenses the refrigerant during the cooling operation, and to function as an evaporator that evaporates the refrigerant during the heating operation.

[0035] Expansion valve **4** is configured to expand the refrigerant condensed by the condenser to decompress the refrigerant. Expansion valve **4** is configured to decompress the refrigerant condensed by outdoor heat exchanger **3** during the cooling operation, and to decompress the refrigerant condensed by indoor heat exchanger **5** during the heating operation. Expansion valve **4** is, for example, a solenoid expansion valve.

[0036] Indoor heat exchanger **5** is configured to perform heat exchange between the refrigerant flowing inside indoor heat exchanger **5** and the air flowing outside indoor heat exchanger **5**. Indoor heat exchanger **5** is configured to function as an evaporator that evaporates the refrigerant during the cooling operation, and to function as a condenser that condenses the refrigerant during the heating operation.

[0037] Outdoor blower **6** is configured to blow the outdoor air to outdoor heat exchanger **3**. That is, outdoor blower **6** is configured to supply the air to outdoor heat exchanger **3**.

[0038] Indoor blower **7** is configured to blow the indoor air to indoor heat exchanger **5**. That is, indoor blower **7** is configured to supply the air to indoor heat exchanger **5**.

[0039] Controller **8** is configured to control the devices of refrigeration cycle apparatus **100** by, for example, performing calculations or providing instructions. Controller **8** is electrically connected to compressor **1**, four-way valve **2**, expansion valve **4**, outdoor blower **6**, indoor blower **7** and the like to control the operation of these components.

[0040] A configuration of outdoor heat exchanger **3** to which heat exchanger HE according to the first embodiment is applied will be described in detail with reference to FIGS. **2** to **5**. It is to be noted that heat exchanger HE according to the first embodiment may be applied to indoor heat exchanger **5**. FIG. **2** shows a relationship between a structure of heat exchanger HE and a blowout temperature distribution of the air. A solid arrow in FIG. **3** indicates a refrigerant flow, and a hollow arrow in FIG. **3** indicates an air flow.

[0041] As shown in FIGS. **2** and **3**, in the present embodiment, outdoor heat exchanger **3** has a heat exchange portion **31**, a header distributor **32**, a gas-liquid two-phase distributor **33**, and the zeotropic refrigerant.

[0042] Heat exchange portion **31** includes a first heat exchange portion **31***a* and a second heat exchange portion **31***b*. First heat exchange portion **31***a* is arranged on the windward side in an air flow direction D1. First heat exchange portion **31***a* is arranged in a first row in air flow direction D1. Second heat exchange portion 31*b* is arranged on the leeward side in air flow direction D1. Second heat exchange portion 31*b* is arranged in a second row in air flow direction D1.

[0043] First heat exchange portion 31*a* includes a first heat transfer portion HP1. In the present embodiment, first heat exchange portion 31*a* includes a plurality of first heat transfer portions HP1. Second heat exchange portion 31*b* includes a second heat transfer portion HP2. In the present embodiment, second heat exchange portion 31*b* includes a plurality of second heat transfer portions HP2.

[0044] First heat exchange portion 31*a* has a plurality of first fins F1, a plurality of first heat transfer tubes T1, and a plurality of first connection portions C1. Each of the plurality of first fins F1 is formed like a plate. The plurality of first fins F1 are arranged to overlap with each other. The plurality of first fins F1 are made of, for example, aluminum.

[0045] The plurality of first heat transfer tubes T1 pass through the plurality of first fins F1. The plurality of first heat transfer tubes T1 are configured to extend linearly in an orthogonal direction D2 that is orthogonal to air flow direction D1. The plurality of first connection portions C1 are portions that connect first heat transfer tubes T1 outside the plurality of first fins F1. Each of the plurality of first heat transfer tubes T1 is connected by each of the plurality of first connection portions C1, such that the plurality of first heat transfer tubes T1 and the plurality of first connection portions C1 are configured to meander as a whole. The plurality of first heat transfer tubes T1 and the plurality of first connection portions C1 are made of, for example, copper or aluminum.

[0046] First heat transfer portion HP1 has the plurality of first heat transfer tubes T1. The plurality of first heat transfer tubes T1 are arranged in a line. The plurality of first heat transfer tubes T1 are aligned in a column direction D3 that intersects with air flow direction D1 and orthogonal direction D2.

[0047] First heat transfer portion HP1 has the plurality of first heat transfer tubes T1 arranged to allow a flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes T1 to be orthogonal to a flow of air flowing across first heat transfer portion HP1.

[0048] Second heat exchange portion 31*b* has a plurality of second fins F2, a plurality of second heat transfer tubes T2, and a plurality of second connection portions C2. Each of the plurality of second fins F2 is formed like a plate. The plurality of second fins F2 are arranged to overlap with each other. The plurality of second fins F2 are made of, for example, aluminum.

[0049] The plurality of second heat transfer tubes T2 pass through the plurality of second fins F2. The plurality of second heat transfer tubes T2 are configured to extend linearly in orthogonal direction D2 that is orthogonal to air flow direction D1. The plurality of second connection portions C2 are portions that connect second heat transfer tubes T2 outside the plurality of second fins F2. Each of the plurality of second heat transfer tubes T2 is connected by each of the plurality of second connection portions C2, such that the plurality of second heat transfer tubes T2 and the plurality of second connection portions C2 are configured to meander as a whole. The plurality of second heat transfer tubes T2 and the plurality of second connection portions C2 are made of, for example, copper or aluminum.

[0050] Second heat transfer portion HP2 has the plurality of second heat transfer tubes T2. Second heat transfer portion HP2 is arranged adjacent to first heat transfer portion HP1. The plurality of second heat transfer tubes T2 are arranged in a line. The plurality of second heat transfer tubes T2 are aligned along the direction in which the plurality of first heat transfer tubes T1 are arranged. The plurality of second heat transfer tubes T2 are aligned in column direction D3 that intersects with air flow direction D1 and orthogonal direction D2.

[0051] The zeotropic refrigerant flows through the plurality of first heat transfer tubes T1 of first heat transfer portion HP1. The zeotropic refrigerant continuously flows through the plurality of first heat transfer tubes T1 and the plurality of first connection portions C1. The zeotropic refrigerant flows through the plurality of second heat transfer tubes T2 of second heat transfer portion HP2. The zeotropic refrigerant continuously flows through the plurality of second heat transfer tubes T2 and the plurality of second connection portions C2.

[0052] When outdoor heat exchanger 3 functions as a condenser, header distributor 32 is provided at a heat exchanger inlet (condenser inlet), and gas-liquid two-phase distributor 33 is provided at a heat exchanger outlet (condenser outlet). Gas-liquid two-phase distributor 33 is configured to be capable of evenly distributing a gas-liquid two-phase flow. Gas-liquid two-phase distributor 33 has a distributor 33*a* and a capillary tube 34.

[0053] As shown in FIGS. 3 and 4, each of the plurality of first heat transfer tubes T1 and the plurality of first connection portions C1 is a circular tube. Each of the plurality of second heat transfer tubes T2 and the plurality of second connection portions C2 is a circular tube.

[0054] As shown in FIGS. 2 and 5, capillary tube 34 includes a first capillary tube 34*a* connected to first heat exchange portion 31*a* in the first row, and a second capillary tube 34*b* connected to second heat exchange portion 31*b* in the second row. An inner diameter of first capillary tube 34*a* may be larger than an inner diameter of second capillary tube 34*b*. A length of first capillary tube 34*a* may be longer than a length of second capillary tube 34*b*.

[0055] Referring to FIG. 6, in a modification of first heat transfer tube T1 and second heat transfer tube T2 of heat exchanger HE according to the first embodiment, each of first heat transfer tube T1 and second heat transfer tube T2 is a flat tube.

[0056] Next, the operation of refrigeration cycle apparatus 100 according to the first embodiment will be described with reference to FIGS. 1 to 3.

[0057] Refrigeration cycle apparatus 100 can selectively perform the cooling operation and the heating operation. During the cooling operation, the refrigerant circulates in refrigerant circuit 10 in the order of compressor 1, four-way valve 2, outdoor heat exchanger 3, expansion valve 4, indoor heat exchanger 5, and four-way valve 2. During the cooling operation, outdoor heat exchanger 3 functions as a condenser. Heat exchange is performed between the refrigerant flowing through outdoor heat exchanger 3 and the air blown by outdoor blower 6. During the cooling operation, indoor heat exchanger 5 functions as an evaporator. Heat exchange is performed between the refrigerant flowing through indoor heat exchanger 5 and the air blown by indoor blower 7.

[0058] The high-pressure gas refrigerant discharged from compressor 1 flows through header distributor 32 of heat exchanger HE into first heat transfer tubes T**1** of first heat exchange portion **31***a* in the first row and second heat transfer tubes T**2** of second heat exchange portion **31***b* in the second row, and flows orthogonally to the air flow. By making a flow path resistance of first capillary tube **34***a* placed on the outlet side of first heat exchange portion **31***a* smaller than a flow path resistance of second capillary tube **34***b* placed on the outlet side of second heat exchange portion **31***b*, a larger amount of the refrigerant flows through first capillary tube **34***a* than second capillary tube **34***b*. Heat exchange between the high-pressure gas refrigerant and the air is performed through the plurality of first fins F**1**, the plurality of first heat transfer tubes T**1**, the plurality of second fins F**2**, and the plurality of second heat transfer tubes T**2**, and as a result, the high-pressure gas refrigerant changes into high-pressure liquid refrigerant.

[0059] During the heating operation, the refrigerant circulates in refrigerant circuit **10** in the order of compressor **1**, four-way valve **2**, indoor heat exchanger **5**, expansion valve **4**, outdoor heat exchanger **3**, and four-way valve **2**. During the heating operation, indoor heat exchanger **5** functions as a condenser. Heat exchange is performed between the refrigerant flowing through indoor heat exchanger **5** and the air blown by indoor blower **7**. During the heating operation, outdoor heat exchanger **3** functions as an evaporator. Heat exchange is performed between the refrigerant flowing through outdoor heat exchanger **3** and the air blown by outdoor blower **6**. The low-pressure gas-liquid two-phase refrigerant having a low degree of dryness is decompressed and stirred in distributor **33***a* of gas-liquid two-phase distributor **33** of heat exchanger HE, and thus, is distributed at an equal degree of dryness in a gas-liquid two-phase atomized state. By making the flow path resistance of first capillary tube **34***a* connected to first heat exchange portion **31***a* in the first row smaller than the flow path resistance of second capillary tube **34***b* connected to second heat exchange portion **31***b* in the second row, a larger amount of the refrigerant flows through first capillary tube **34***a* than second capillary tube **34***b*. Heat exchange between the low-pressure gas-liquid two-phase refrigerant having a low degree of dryness and the air is performed through the plurality of first fins F**1**, the plurality of first heat transfer tubes T**1**, the plurality of first fins F**1**, and the plurality of second heat transfer tubes T**2**, and as a result, the low-pressure gas-liquid two-phase refrigerant having a low degree of dryness changes into low-pressure gas refrigerant.

[0060] Next, modifications of outdoor heat exchanger **3** to which heat exchanger HE according to the first embodiment is applied will be described.

[0061] Referring to FIG. **7**, in a first modification of outdoor heat exchanger **3** according to the first embodiment, a plurality of header distributors **32** and a plurality of gas-liquid two-phase distributors **33** are arranged for the respective rows. In the first modification of outdoor heat exchanger **3** according to the first embodiment, two header distributors **32** and two gas-liquid two-phase distributors **33** are arranged. Two electronic expansion valves **35** are arranged downstream of two gas-liquid two-phase distributors **33**, respectively.

[0062] When electronic expansion valves **35** are not arranged, the inner diameter of first capillary tube **34***a* connected to first heat exchange portion **31***a* in the first row is made larger than the inner diameter of second capillary tube **34***b* connected to second heat exchange portion **31***b* in the second row. Furthermore, the length of first capillary tube **34***a* connected to first heat exchange portion **31***a* in the first row is made longer than the length of second capillary tube **34***b* connected to second heat exchange portion **31***b* in the second row.

[0063] Referring to FIG. **8**, in a second modification of outdoor heat exchanger **3** according to the first embodiment, only first heat exchange portion **31***a* is shown for convenience of description. Second heat exchange portion **31***b* is configured similarly to first heat exchange portion **31***a*.

[0064] In the second modification of outdoor heat exchanger **3** according to the first embodiment, each of the plurality of first fins F**1** is a corrugated fin. Each of the plurality of first heat transfer tubes T**1** is a linear flat tube. Each of the plurality of first fins F**1** is arranged between corresponding two of the plurality of first heat transfer tubes T**1**. A header **36** is connected to each of both ends of each of the plurality of first heat transfer tubes T**1**.

[0065] Next, the function and effect of the present embodiment will be described.

[0066] The heat exchange efficiency of a counter flow, a parallel flow and an orthogonal flow in each of the condenser and the evaporator will be described with reference to FIG. **9**. The counter flow, the parallel flow and the orthogonal flow indicate a relationship of the refrigerant flow with respect to the air flow. In both of the condenser and the evaporator, the heat exchange efficiency becomes lower in the order of the counter flow, the orthogonal flow and the parallel flow.

[0067] The refrigerant temperature in each path with respect to the refrigerant flow when heat exchanger HE functions as a condenser or an evaporator in the present embodiment will be described with reference to FIG. **10**. In the condenser, the refrigerant temperature becomes lower in both of the first row and the second row, as the refrigerant flow increases. The refrigerant temperature in the first row becomes lower than the refrigerant temperature in the second row. In the evaporator, the refrigerant temperature becomes higher in both of the first row and the second row, as the refrigerant flow increases. The refrigerant temperature in the first row becomes higher than the refrigerant temperature in the second row.

[0068] In heat exchanger HE according to the present embodiment, first heat transfer portion HP**1** has the plurality of first heat transfer tubes T**1** arranged to allow the flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes T**1** to be orthogonal to the flow of the air flowing across first heat transfer portion HP**1**. Therefore, the flow of the zeotropic refrigerant with respect to the air flow is the orthogonal flow. Thus, the heat exchange efficiency can be higher than that of the parallel flow, whether heat exchanger HE functions as a condenser or as an evaporator. Accordingly, it is possible to averagely ensure the heat exchange efficiency in the condenser and the evaporator, while using the zeotropic refrigerant.

[0069] If the counter flow is requested in both of the condenser and the evaporator, the following problems arise. First, in the condenser, a pressure loss of the high-pressure gas refrigerant increases due to gas-liquid two-phase distributor **33**. In addition, an amount of the refrigerant increases due to an increase in capacity of an outlet header. Furthermore, a pressure loss of an extension pipe portion increases. In heat exchanger HE according to the present embodiment, these problems do not arise.

[0070] In addition, by making the flow path resistance of first capillary tube **34***a* smaller than the flow path resistance of second capillary tube **34***b*, a large amount of the refrigerant can flow through first heat transfer tubes T**1** in the first row having a high heat load. Therefore, a difference in outlet temperature of the refrigerant between first heat transfer tubes T**1** in the first row and second heat transfer tubes T**2** in the second row decreases, and thus, the heat exchange efficiency can be increased.

[0071] Refrigeration cycle apparatus **100** according to the present embodiment includes above-described heat exchanger HE. Therefore, there can be provided refrigeration cycle apparatus **100** including heat exchanger HE that makes it possible to averagely ensure the heat exchange efficiency in the condenser and the evaporator, while using the zeotropic refrigerant.

Second Embodiment

[0072] Heat exchanger HE according to a second embodiment has the same configuration, operation, and function and effect as those of heat exchanger HE according to the first embodiment, unless otherwise specified.

[0073] Referring to FIG. **11**, in heat exchanger HE according to the second embodiment, an inlet and an outlet for the zeotropic refrigerant in first heat transfer portion HP**1** and an inlet and an outlet for the zeotropic refrigerant in second heat transfer portion HP**2** are arranged opposite to each other. In first heat transfer portion HP**1**, the refrigerant inlet is arranged in the uppermost column, and the refrigerant outlet is arranged in the lowermost column. In second heat transfer portion HP**2**, the refrigerant inlet is arranged in the lowermost column, and the refrigerant outlet is arranged in the uppermost column. That is, the inlet and the outlet for the zeotropic refrigerant in first heat transfer portion HP**1** and the inlet and the outlet for the zeotropic refrigerant in second heat transfer portion HP**2** are arranged upside down.

[0074] Next, a modification of outdoor heat exchanger **3** to which heat exchanger HE according to the second embodiment is applied will be described.

[0075] Referring to FIG. **12**, in the modification of outdoor heat exchanger **3** according to the second embodiment, heat exchange portion **31** includes a third heat exchange portion **31***c*. Third heat exchange portion **31***c* is arranged on the windward side relative to first heat exchange portion **31***a* in air flow direction D**1**. Third heat exchange portion **31***c* is arranged in a first row in air flow direction D**1**.

[0076] Third heat exchange portion **31***c* includes a third heat transfer portion HP**3**. In the present embodiment, third heat exchange portion **31***c* includes a plurality of third heat transfer portions HP**3**. Third heat exchange portion **31***c* has a plurality of third fins F**3**, a plurality of third heat transfer tubes T**3**, and a plurality of third connection portions C**3** (not shown). The plurality of third fins F**3**, the plurality of third heat transfer tubes T**3** and the plurality of third connection portions C**3** (not shown) are configured similarly to the plurality of first fins F**1**, the plurality of first heat transfer tubes T**1** and the plurality of first connection portions C**1** (not shown). The zeotropic refrigerant flows through the plurality of third heat transfer tubes T**3** of third heat transfer portion HP**3**. The zeotropic refrigerant continuously flows through the plurality of third heat transfer tubes T**3** and the plurality of third connection portions C**3** (not shown).

[0077] Capillary tube **34** includes a third capillary tube **34***c* connected to third heat exchange portion **31***c*. An inner diameter of third capillary tube **34***c* may be larger than the inner diameter of first capillary tube **34***a*. A length of third capillary tube **34***c* may be longer than the length of first capillary tube **34***a*.

[0078] Next, the function and effect of the present embodiment will be described.

[0079] The refrigerant temperature in each path with respect to the refrigerant flow when heat exchanger HE functions as a condenser or an evaporator in the present embodiment will be described with reference to FIG. **13**. In both of the condenser and the evaporator, the difference in refrigerant temperature between the first row and the second row is smaller than that in the first embodiment.

[0080] In heat exchanger HE according to the present embodiment, the inlet and the outlet for the zeotropic refrigerant in first heat transfer portion HP**1** and the inlet and the outlet for the zeotropic refrigerant in second heat transfer portion HP**2** are arranged opposite to each other. Therefore, an air blowout temperature distribution in a height direction of heat exchanger HE can be averaged.

[0081] Therefore, when heat exchanger HE is applied to outdoor heat exchanger **3**, an amount of frost formation at low outdoor air temperature is made uniform, and thus, the average heating capacity can be enhanced. In addition, when heat exchanger HE is applied to indoor heat exchanger **5**, dew scattering is less likely to occur, and thus, the comfortability and the quality performance can be enhanced.

Third Embodiment

[0082] Heat exchanger HE according to a third embodiment has the same configuration, operation, and function and effect as those of heat exchanger HE according to each of the first and second embodiments, unless otherwise specified.

[0083] Referring to FIG. **14**, in heat exchanger HE according to the third embodiment, first heat transfer portion HP**1** and second heat transfer portion HP**2** have a first path PS**1** and a second path PS**2**. First path PS**1** is arranged to allow a flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes T**1** and the plurality of second heat transfer tubes T**2** to be parallel to a flow of the air flowing across first heat transfer portion HP**1** and second heat transfer portion HP**2**. Second path PS**2** is arranged to allow the flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes T**1** and the plurality of second heat transfer tubes T**2** to counter the flow of the air flowing across first heat transfer portion HP**1** and second heat transfer portion HP**2**. First path PS**1** and second path PS**2** are combined.

[0084] Next, modifications of outdoor heat exchanger **3** to which heat exchanger HE according to the third embodiment is applied will be described.

[0085] Referring to FIG. **15**, in a first modification of outdoor heat exchanger **3** according to the third embodiment, an inlet and an outlet for the zeotropic refrigerant in first heat transfer portion HP**1** and an inlet and an outlet for the zeotropic refrigerant in second heat transfer portion HP**2** are arranged opposite to each other.

[0086] Referring to FIG. **16**, in a second modification of outdoor heat exchanger **3** according to the third embodiment, heat exchange portion **31** includes third heat exchange portion **31***c*. Third heat exchange portion **31***c* is arranged between first heat exchange portion **31***a* and second heat exchange portion **31***b* in air flow direction D**1**.

[0087] Next, the function and effect of the present embodiment will be described.

[0088] The refrigerant temperature in each path with respect to the refrigerant flow when heat exchanger HE functions as a condenser or an evaporator in the present embodiment will be described with reference to FIG. **17**. In both of the condenser and the evaporator, the difference in refrigerant temperature between the first row and the second row is smaller than that in the first embodiment.

[0089] In heat exchanger HE according to the present embodiment, first path PS**1** is arranged to allow the flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes T**1** and the plurality of second heat transfer tubes T**2** to be parallel to the flow of the air flowing across first heat transfer portion HP**1** and second heat transfer portion HP**2**. Second path PS**2** is arranged to allow the flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes T**1** and the plurality of second heat transfer tubes T**2** to counter the flow of the air flowing across first heat transfer portion HP**1** and second heat transfer portion HP**2**. Therefore, the air blowout temperature distribution in the height direction of heat exchanger HE can be further averaged. As a result, the heat load of each path can be further made uniform, and thus, the heat exchange efficiency can be increased.

[0090] Therefore, when heat exchanger HE is applied to outdoor heat exchanger **3**, an amount of frost formation at low outdoor air temperature is made uniform, and thus, the average heating capacity can be enhanced. In addition, when heat exchanger HE is applied to indoor heat exchanger **5**, dew scattering is less likely to occur, and thus, the comfortability and the quality performance can be enhanced.

[0091] In addition, even when electronic expansion valve **35** is not arranged as in the first embodiment, adjustment of the inner diameter and the length of capillary tube **34** is unnecessary.

[0092] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present disclosure is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0093] **1** compressor; **2** four-way valve; **3** outdoor heat exchanger; **4** expansion valve; **5** indoor heat exchanger; **6** outdoor blower; **7** indoor blower; **8** controller; **10** refrigerant circuit; **31** heat exchange portion; **31***a* first heat exchange portion; **31***b* second heat exchange portion; **31***c* third heat exchange portion; **32** header distributor; **33** gas-liquid two-phase distributor; **100** refrigeration cycle apparatus; HE heat exchanger; HP**1** first heat transfer portion; HP**2** second heat transfer portion; HP**3** third heat transfer portion; PS**1** first path; PS**2** second path; T**1** first heat transfer tube; T**2** second heat transfer tube; T**3** third heat transfer tube.

1. A heat exchanger comprising:
a first heat transfer portion having a plurality of first heat transfer tubes;
a zeotropic refrigerant flowing through the plurality of first heat transfer tubes of the first heat transfer portion,
the plurality of first heat transfer tubes being arranged in a line, and
the first heat transfer portion having the plurality of first heat transfer tubes arranged to allow flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes to be orthogonal to flow of air flowing across the first heat transfer portion; and
a second heat transfer portion having a plurality of second heat transfer tubes, wherein
the second heat transfer portion is arranged adjacent to the first heat transfer portion,
the plurality of second heat transfer tubes are arranged in a line, and aligned along a direction in which the plurality of first heat transfer tubes are arranged,
the zeotropic refrigerant flows through the plurality of second heat transfer tubes of the second heat transfer portion, and
the second heat transfer portion has the plurality of second heat transfer tubes arranged to allow flow of the zeotropic refrigerant flowing through the plurality of second heat transfer tubes to be orthogonal to flow of air flowing across the second heat transfer portion,
an inlet and an outlet for the zeotropic refrigerant in the first heat transfer portion and an inlet and an outlet for the zeotropic refrigerant in the second heat transfer portion are connected to a heat exchanger inlet and a heat exchanger outlet respectively.

2. (canceled)

3. The heat exchanger according to claim **1**, wherein the inlet and the outlet for the zeotropic refrigerant in the first heat transfer portion and the inlet and the outlet for the zeotropic refrigerant in the second heat transfer portion are arranged opposite to each other.

4. The heat exchanger according to claim **1**, wherein
the first heat transfer portion and the second heat transfer portion have a first path and a second path,
the first path is arranged to allow flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes and the plurality of second heat transfer tubes to be parallel to flow of air flowing across the first heat transfer portion and the second heat transfer portion, and
the second path is arranged to allow the flow of the zeotropic refrigerant flowing through the plurality of first heat transfer tubes and the plurality of second heat transfer tubes to counter the flow of air flowing across the first heat transfer portion and the second heat transfer portion.

5. A refrigeration cycle apparatus comprising:
the heat exchanger as recited in claim **1**; and
a compressor configured to compress the zeotropic refrigerant flowing into the heat exchanger.

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