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(54) HEAT EXCHANGER AND AIR CONDITIONER

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(52) U.S. Cl.

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(57) ABSTRACT

Disclosed herein is a heat exchanger including: a plurality of banks, each of which includes a plurality of flat tubes, arranged in an air flow direction. The refrigerants in the plurality of banks flow in parallel with each other, and each of the flat tubes in the plurality of banks has one or more bent portions which are bent in a width direction of the flat tubes such that the flat tubes of a pair of the banks adjacent to each other in the air flow direction extend along with each other.

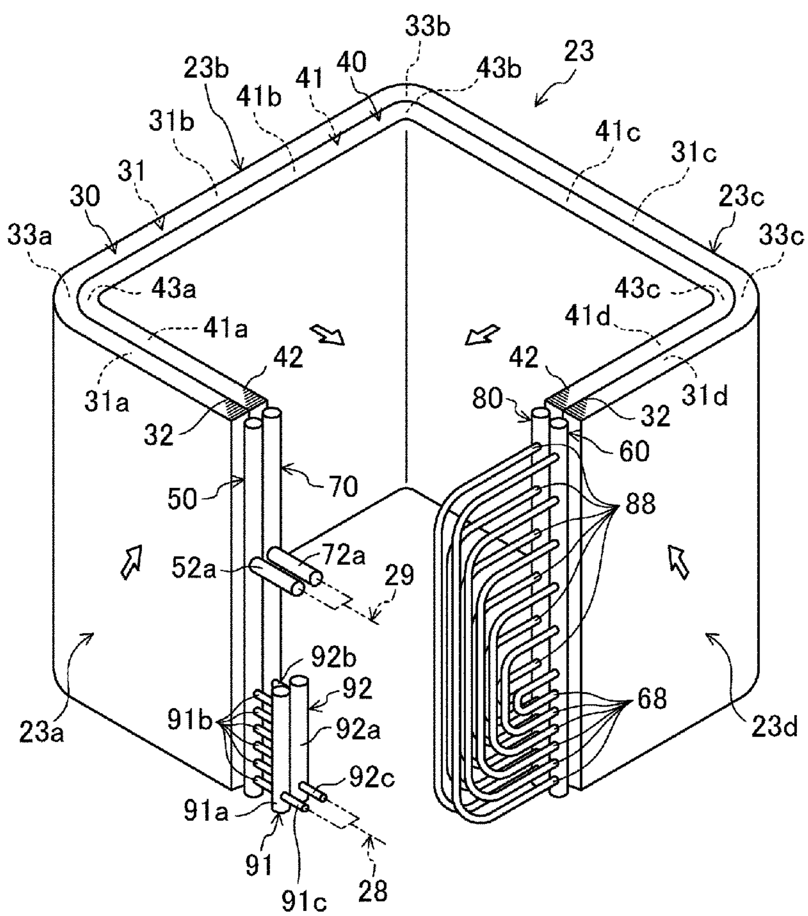


FIG. 1

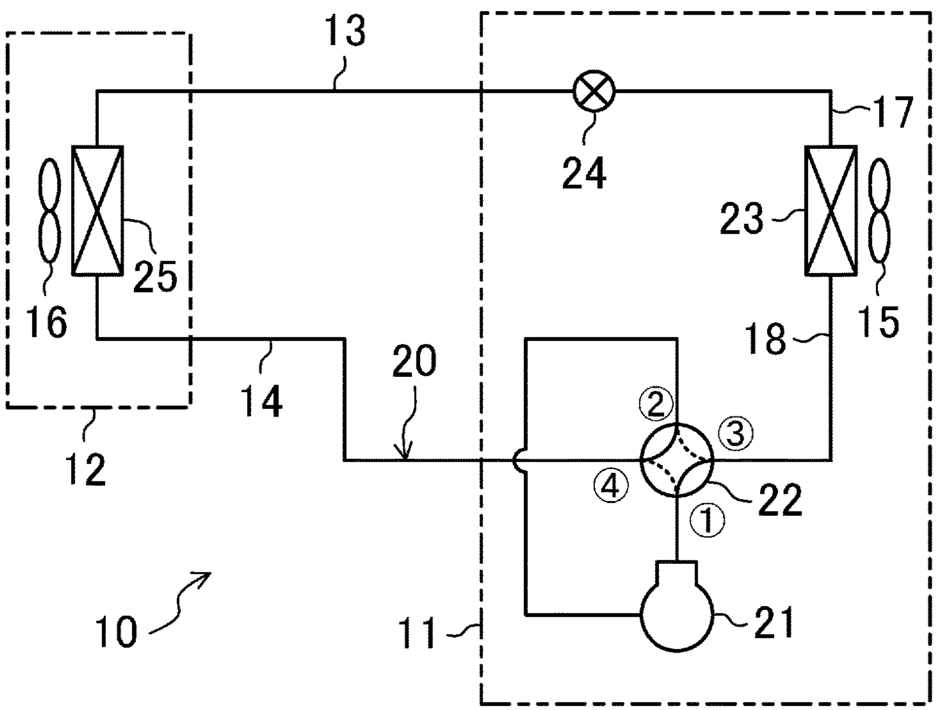
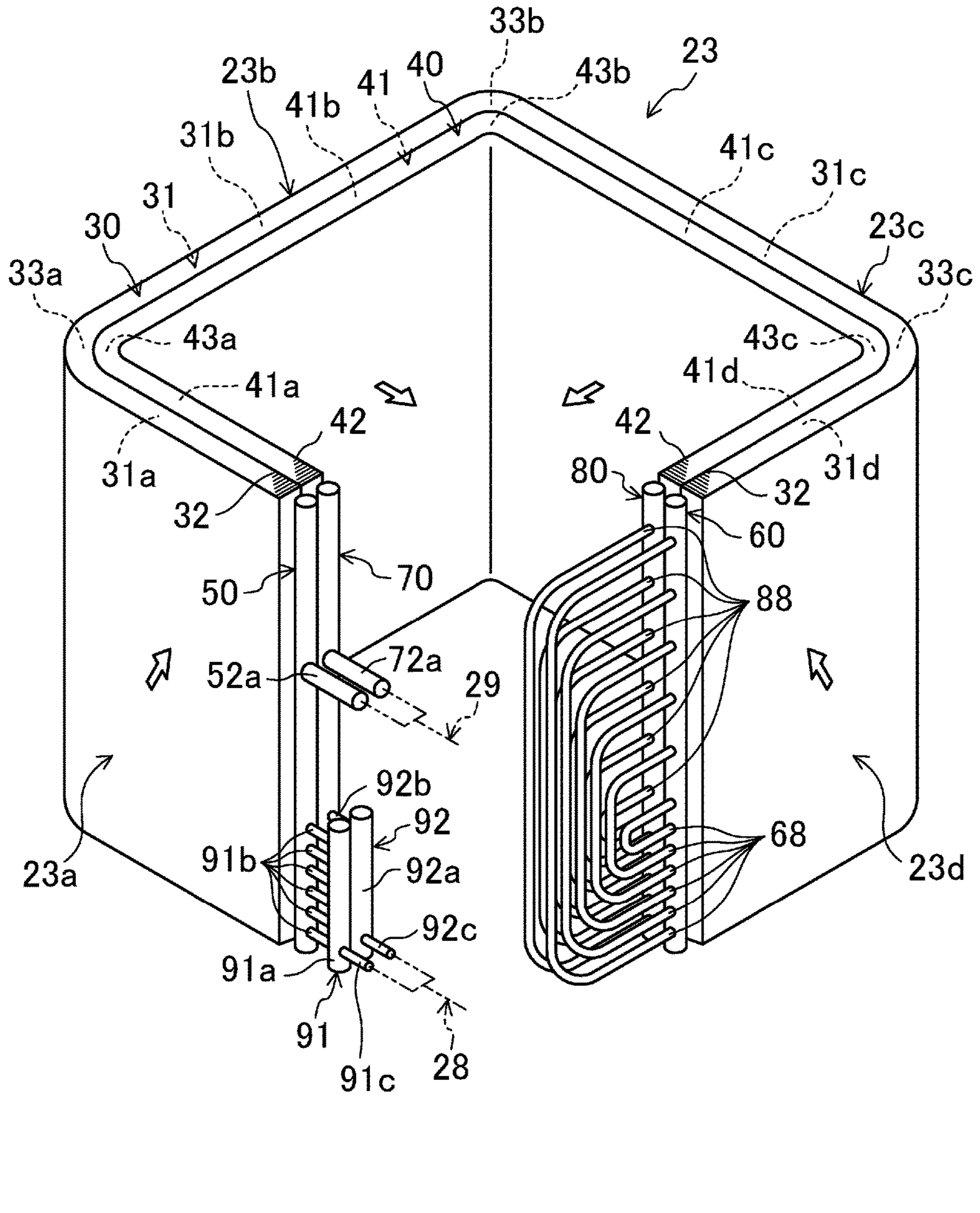


FIG. 2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23b
41
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43b
23
41b
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41c
31c
31
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23c
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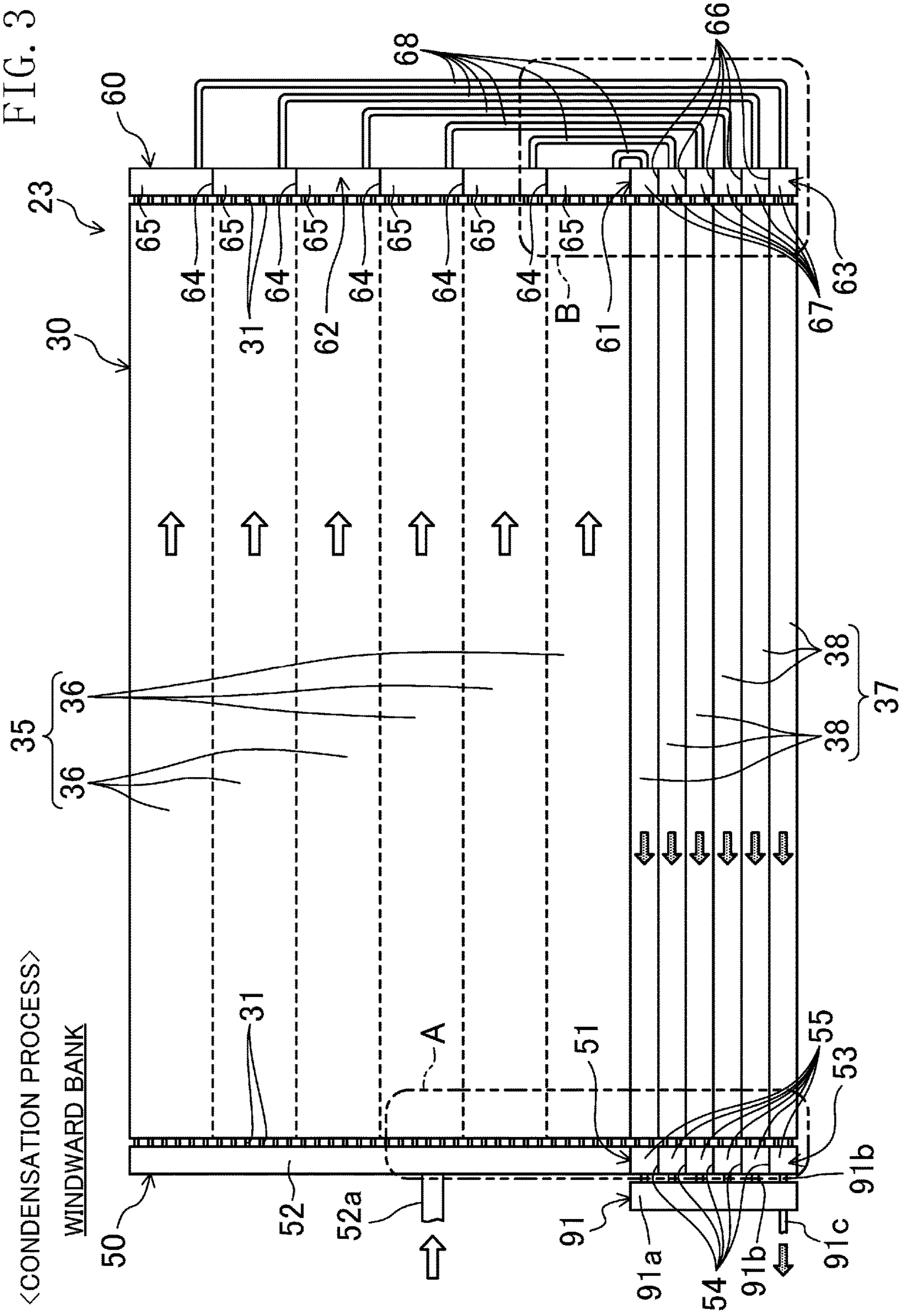
41a
41d
42
42
31a
80
31d
32
32
60
50
70
88
52a
72a
29
92b
92
68
91b
92a
23a
23d
92c
91a
91
28
91c

FIG. 3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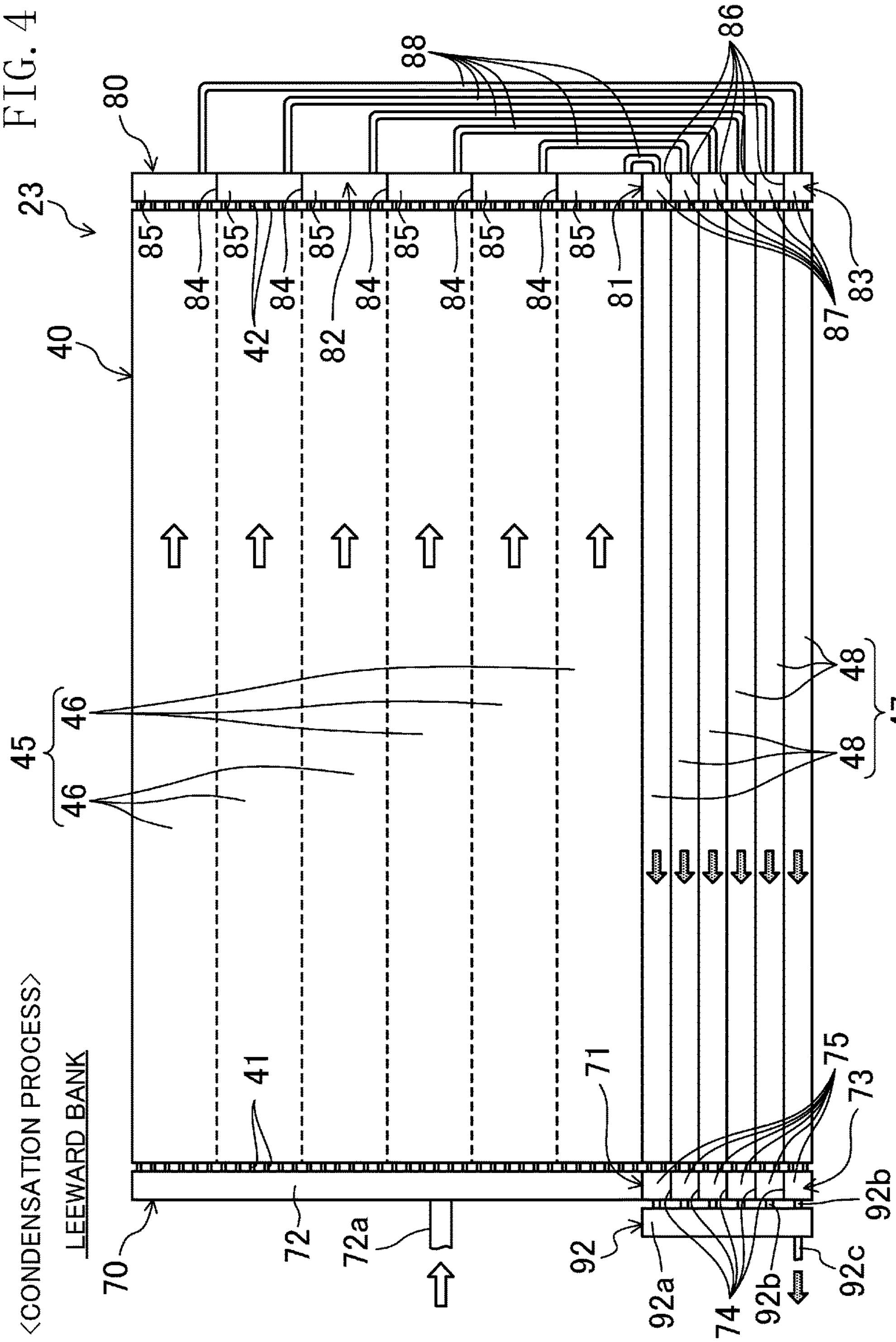
WINDWARD BANK
23
30
35
36
36
37
38
38
31
31
50
51
52
52a
53
54
55
60
61
62
63
64
65
66
67
68
A
B
91
91a
91b
91b
91c

FIG. 4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23
40
45
46
46
47
48
48
80
81
82
83
84
85
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87
88
41
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70
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72
72a
73
74
75
92
92a
92b
92c

FIG. 5

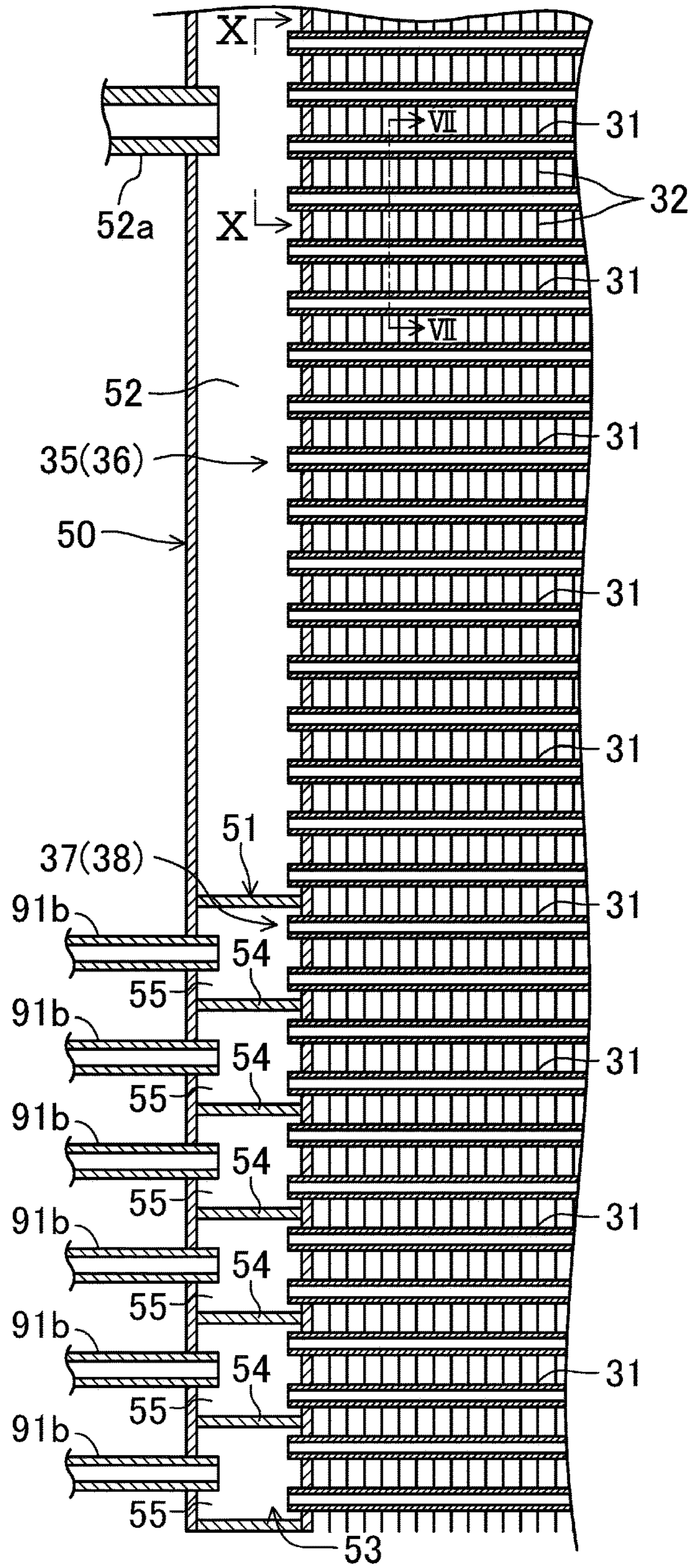
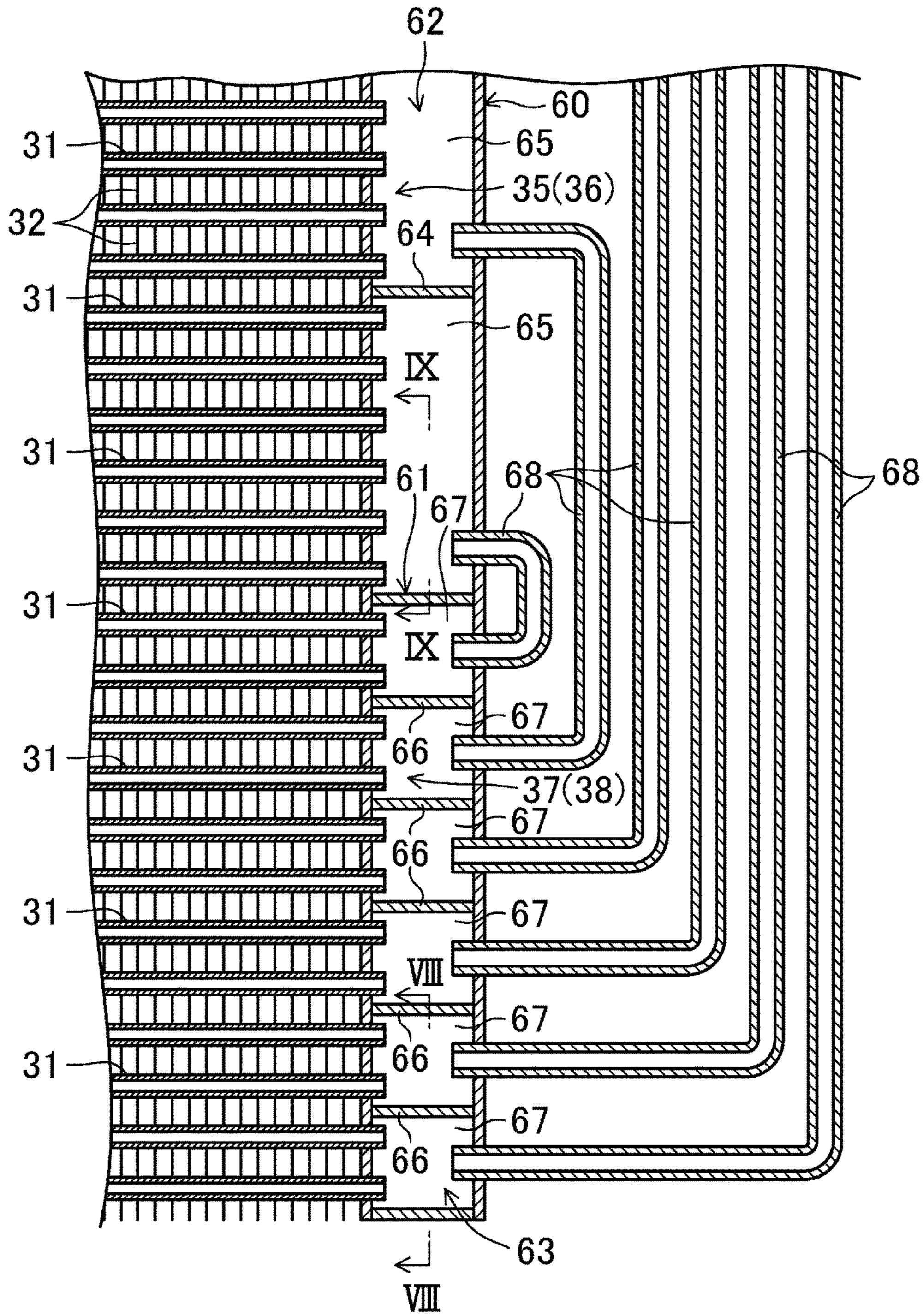


FIG. 6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35(36)
32
64
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65
IX
31
61
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63
VIII

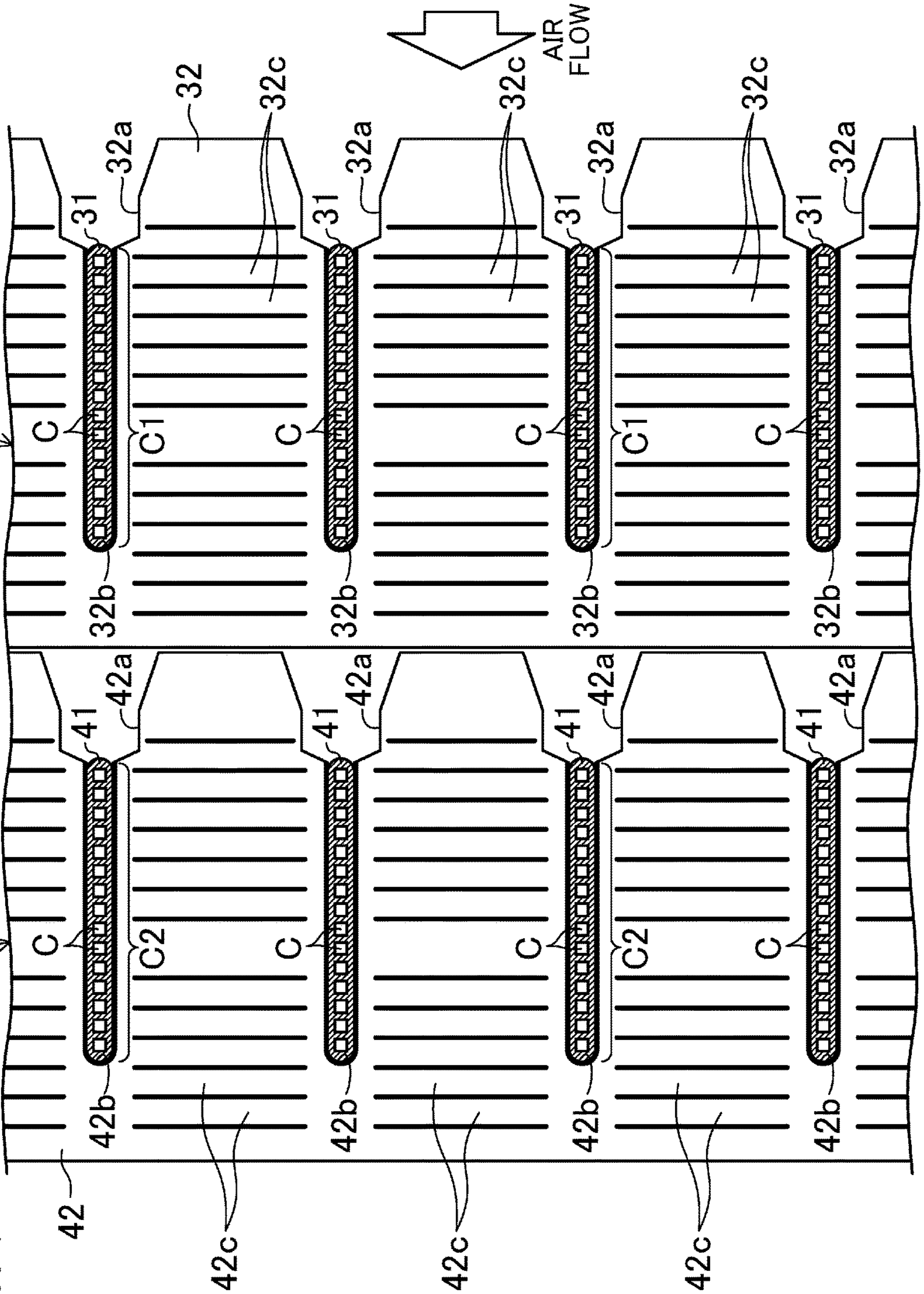


FIG. 7

FIG. 8

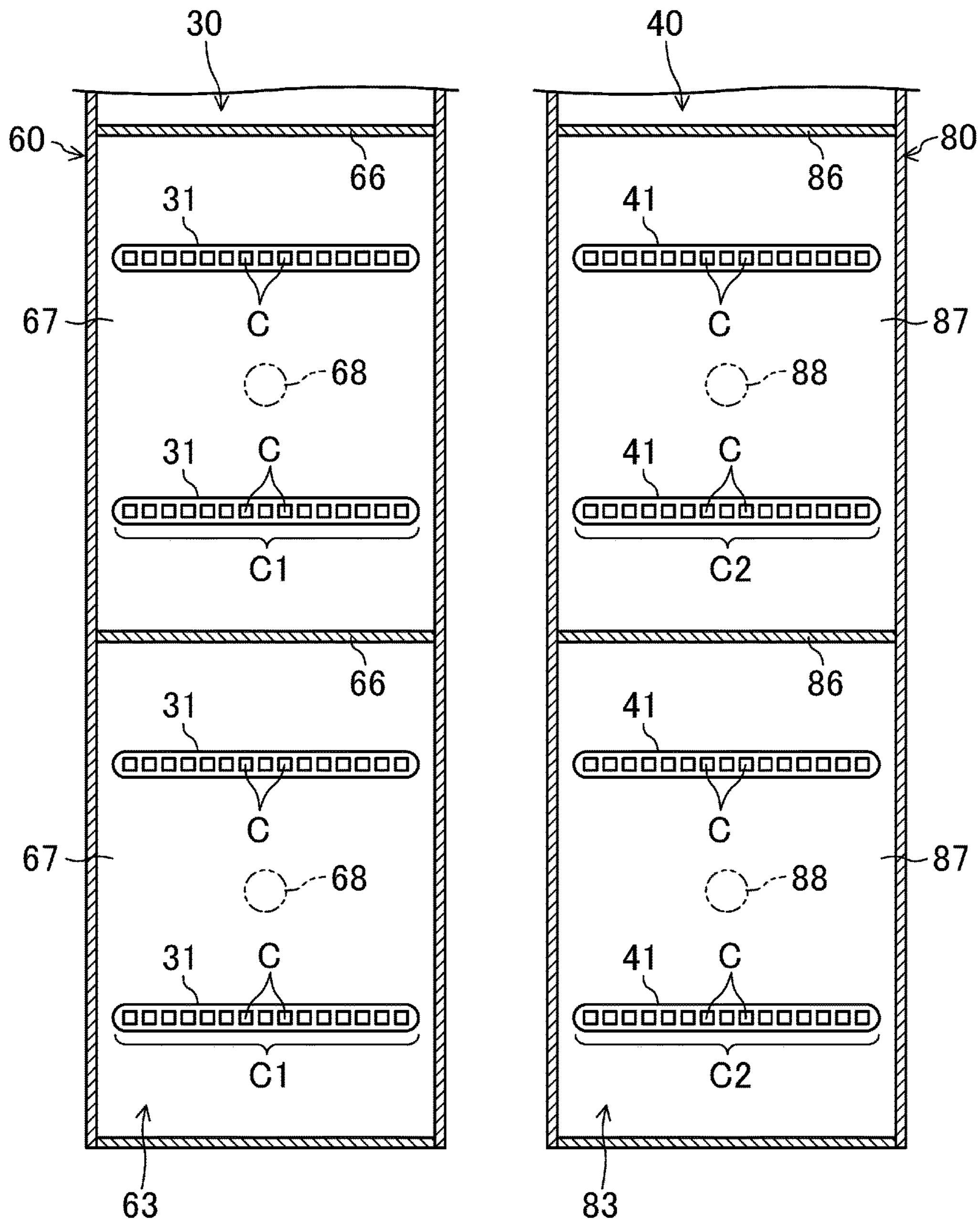


FIG. 9

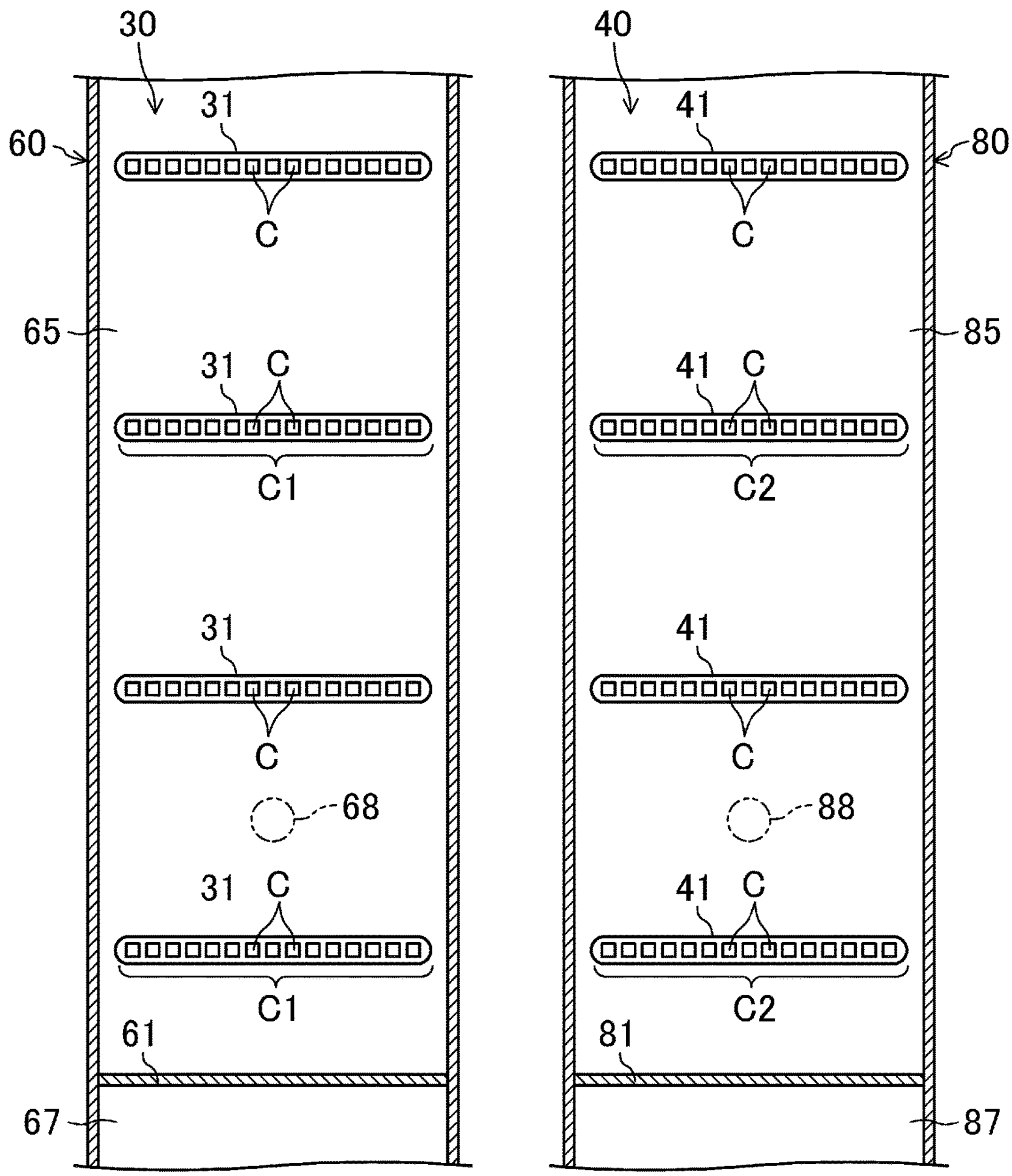


FIG. 10

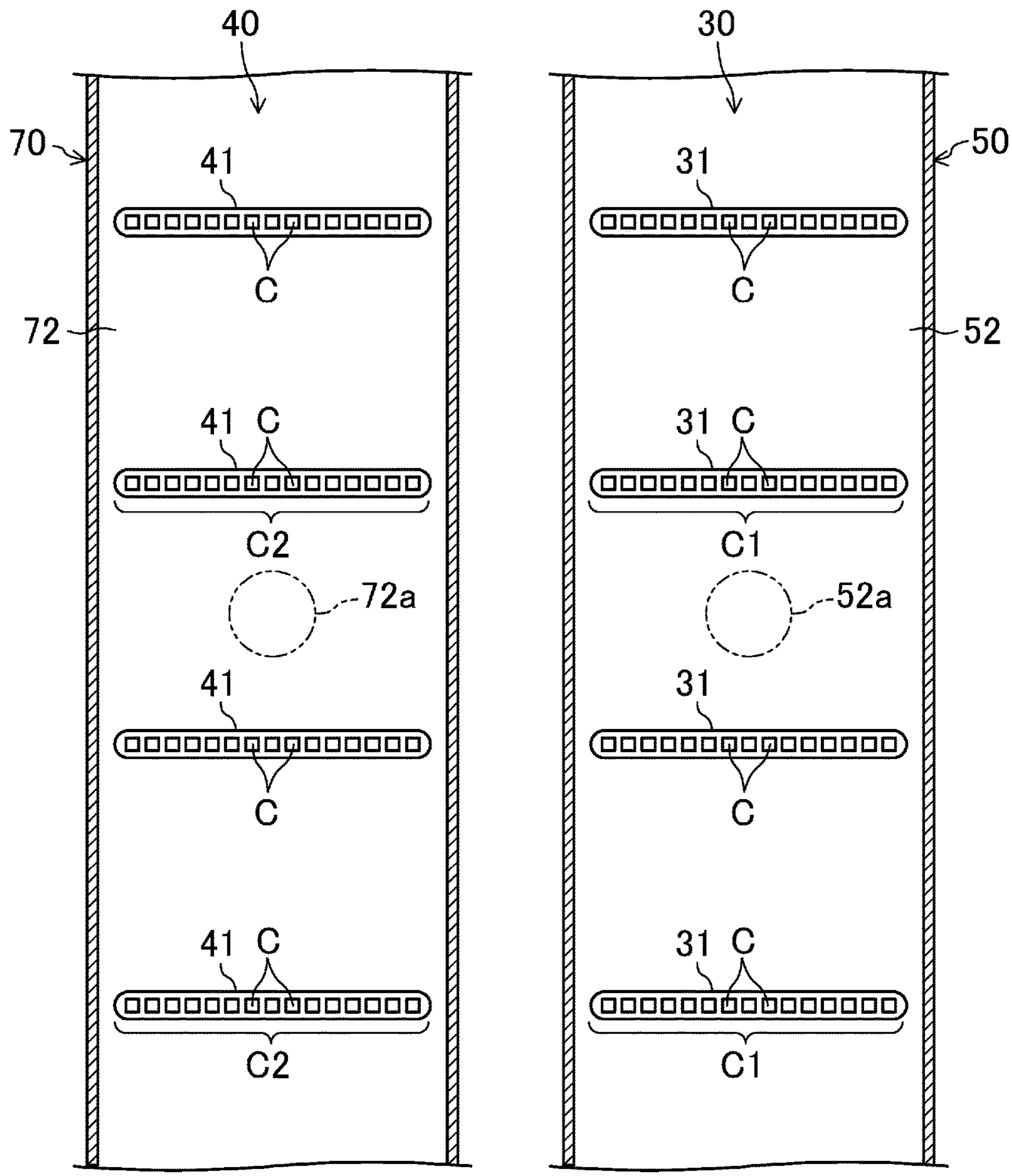


FIG. 11

<CONDENSATION PROCESS>

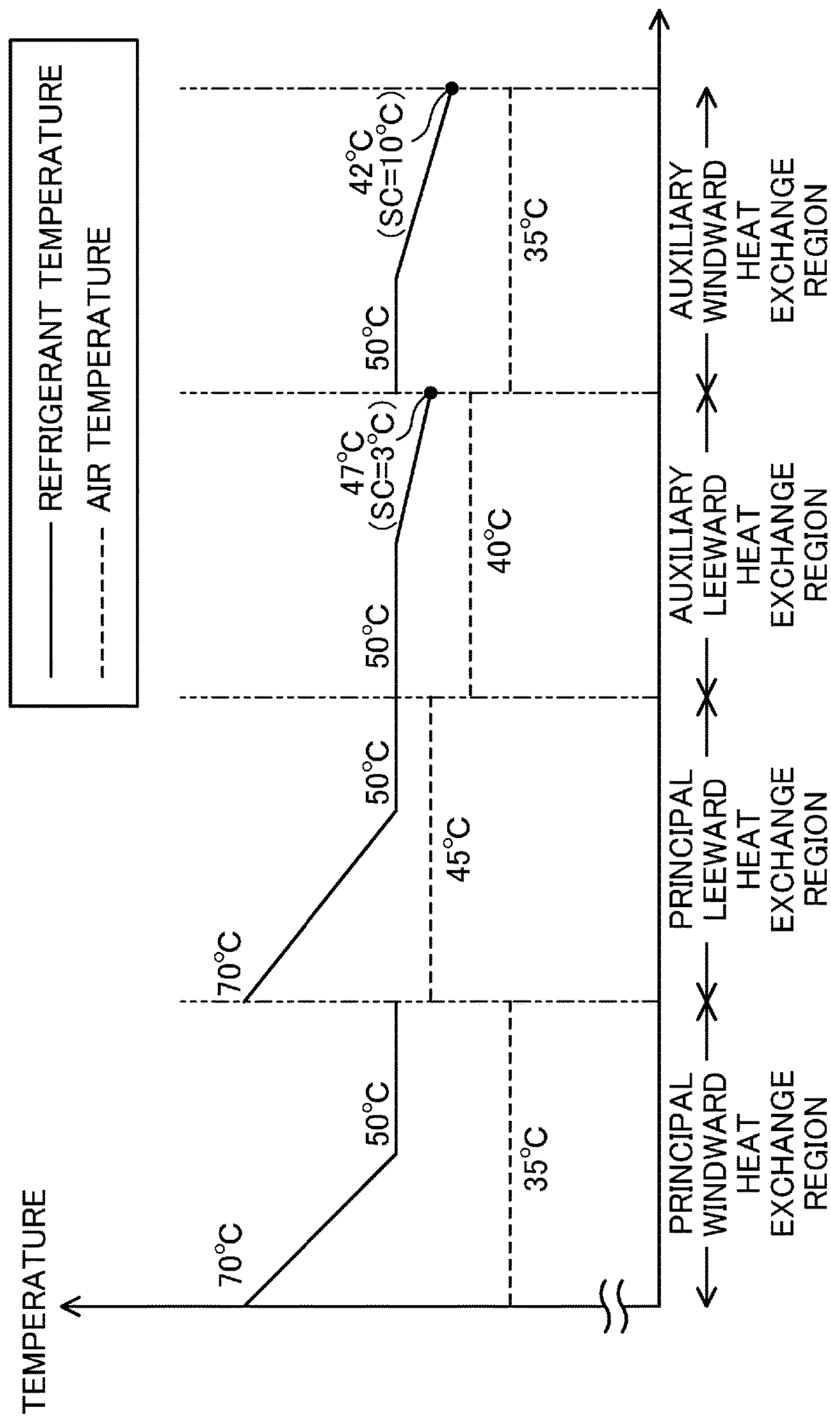


FIG. 12

<EVAPORATION PROCESS>

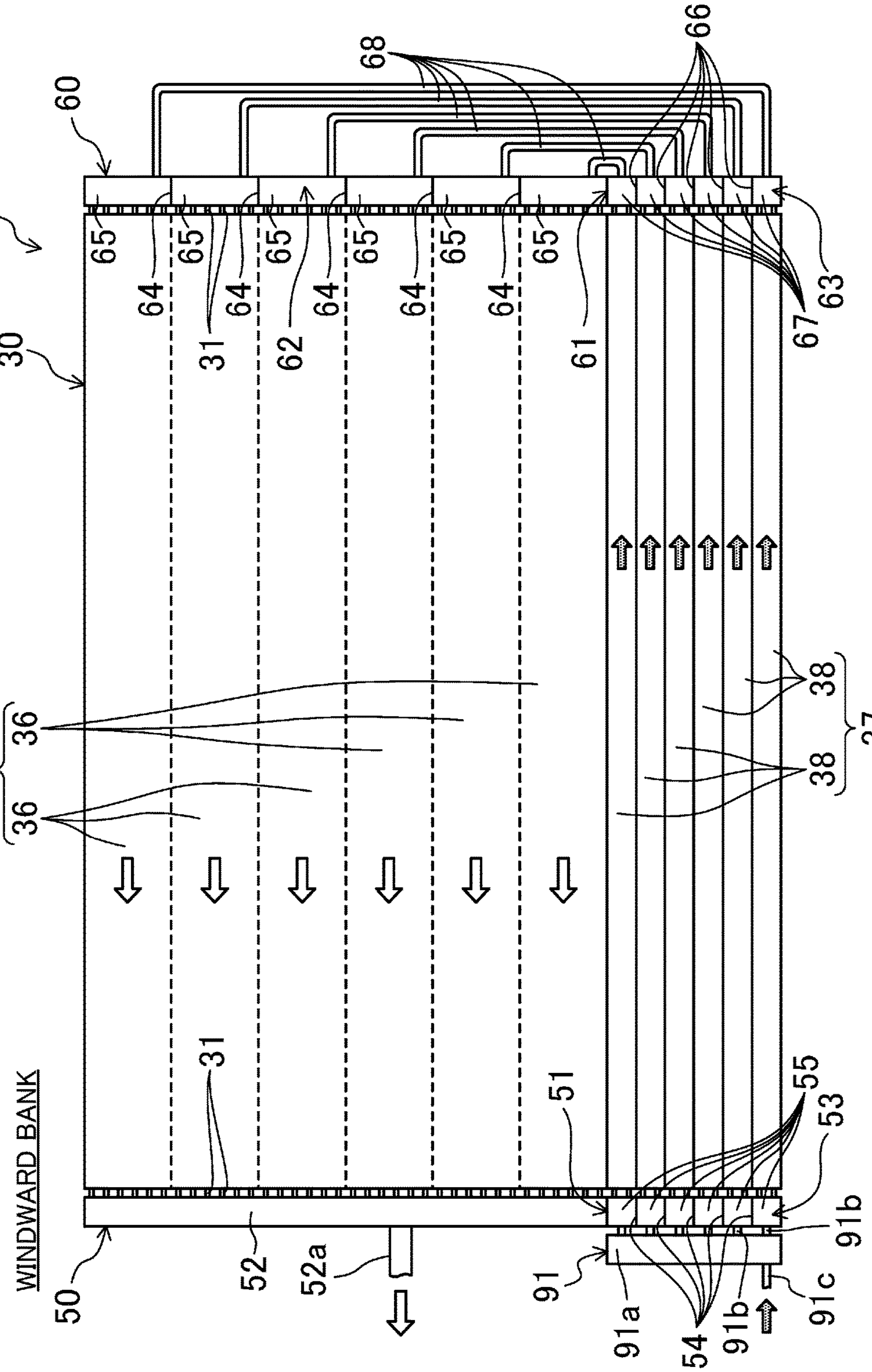


FIG. 13

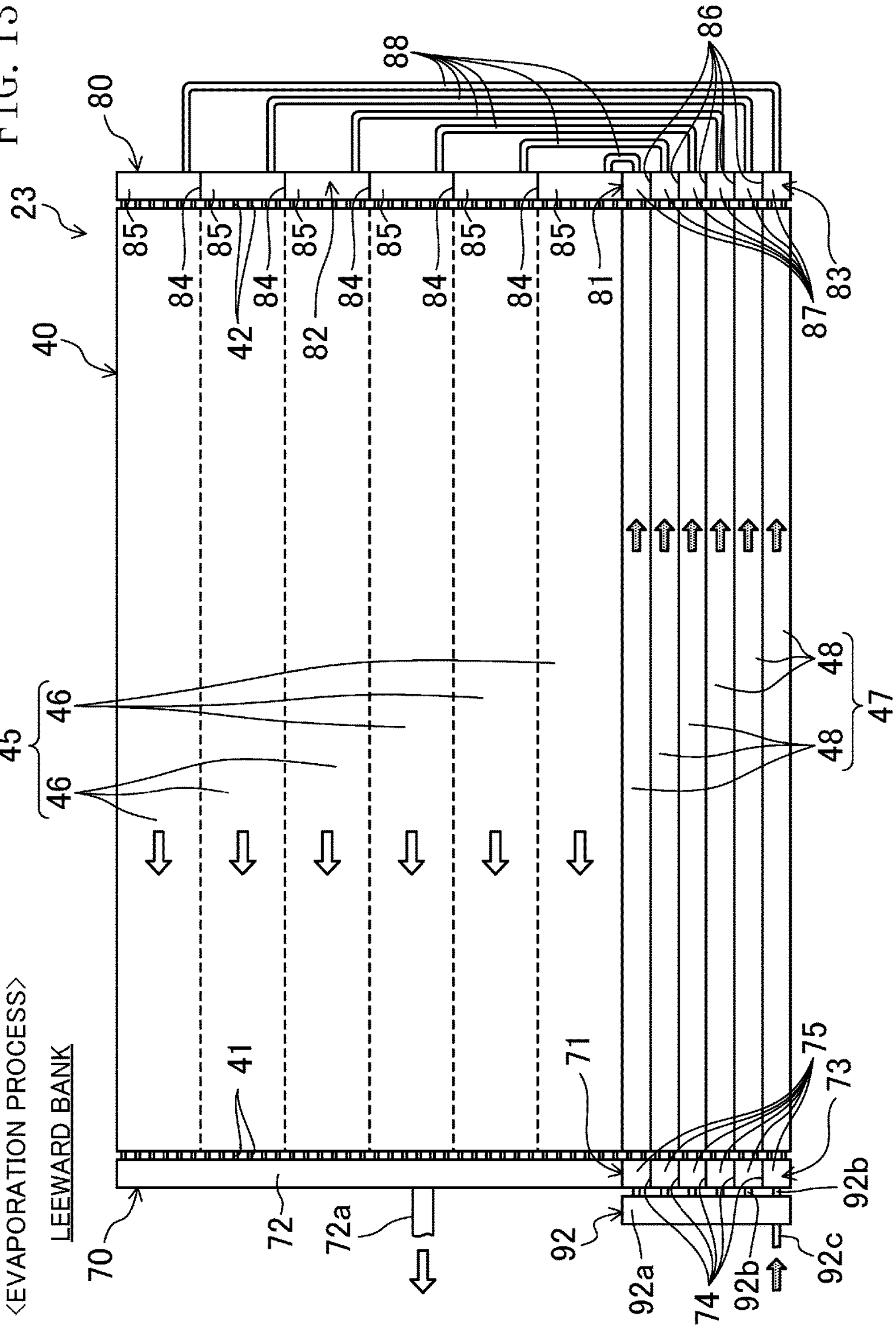

〈EVAPORATION PROCESS〉
LEEWARD BANK
23
40
41
42
45
46
47
48
70
71
72
72a
73
74
75
80
81
82
83
84
85
86
87
88
92
92a
92b
92c

FIG. 14

<EVAPORATION PROCESS>

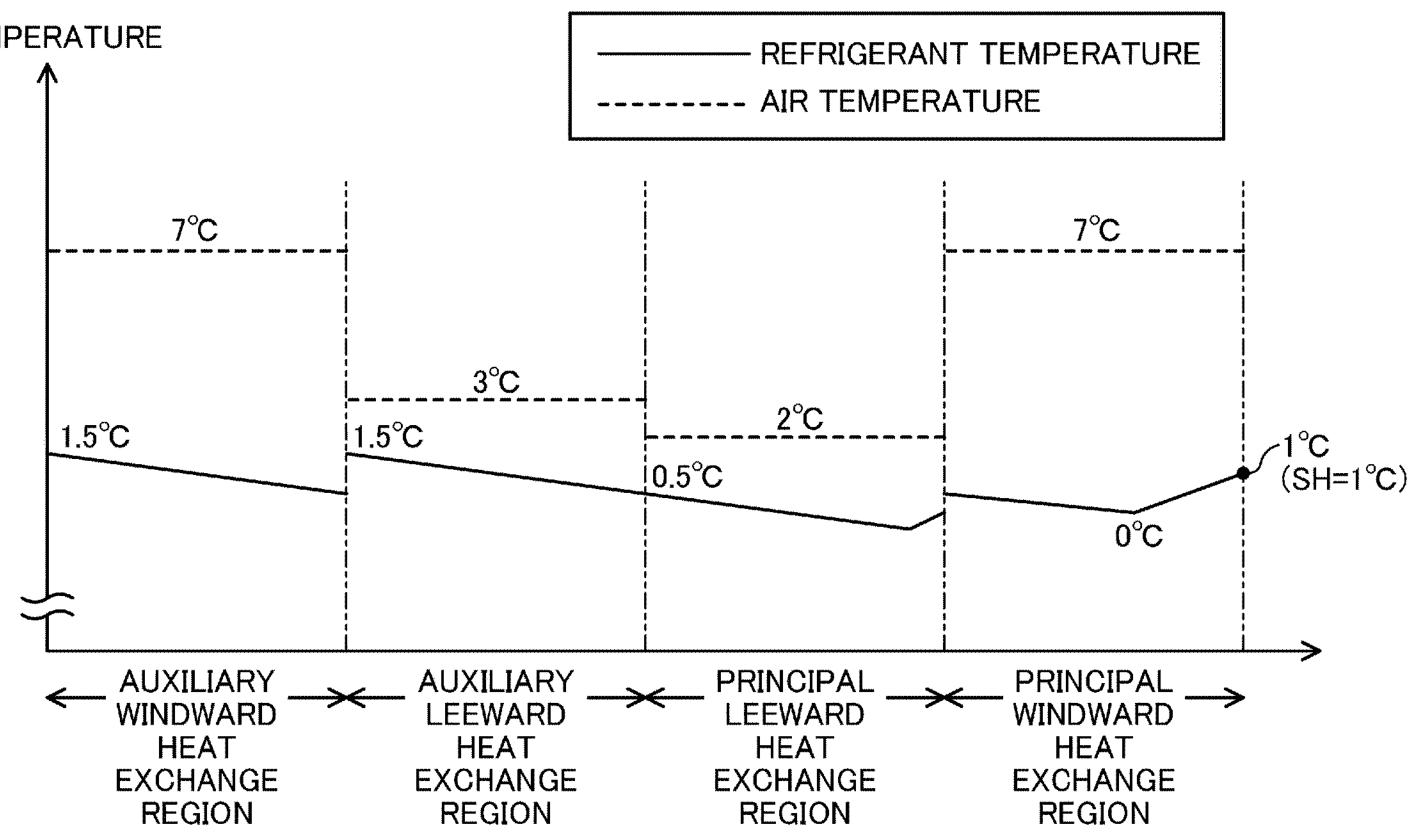
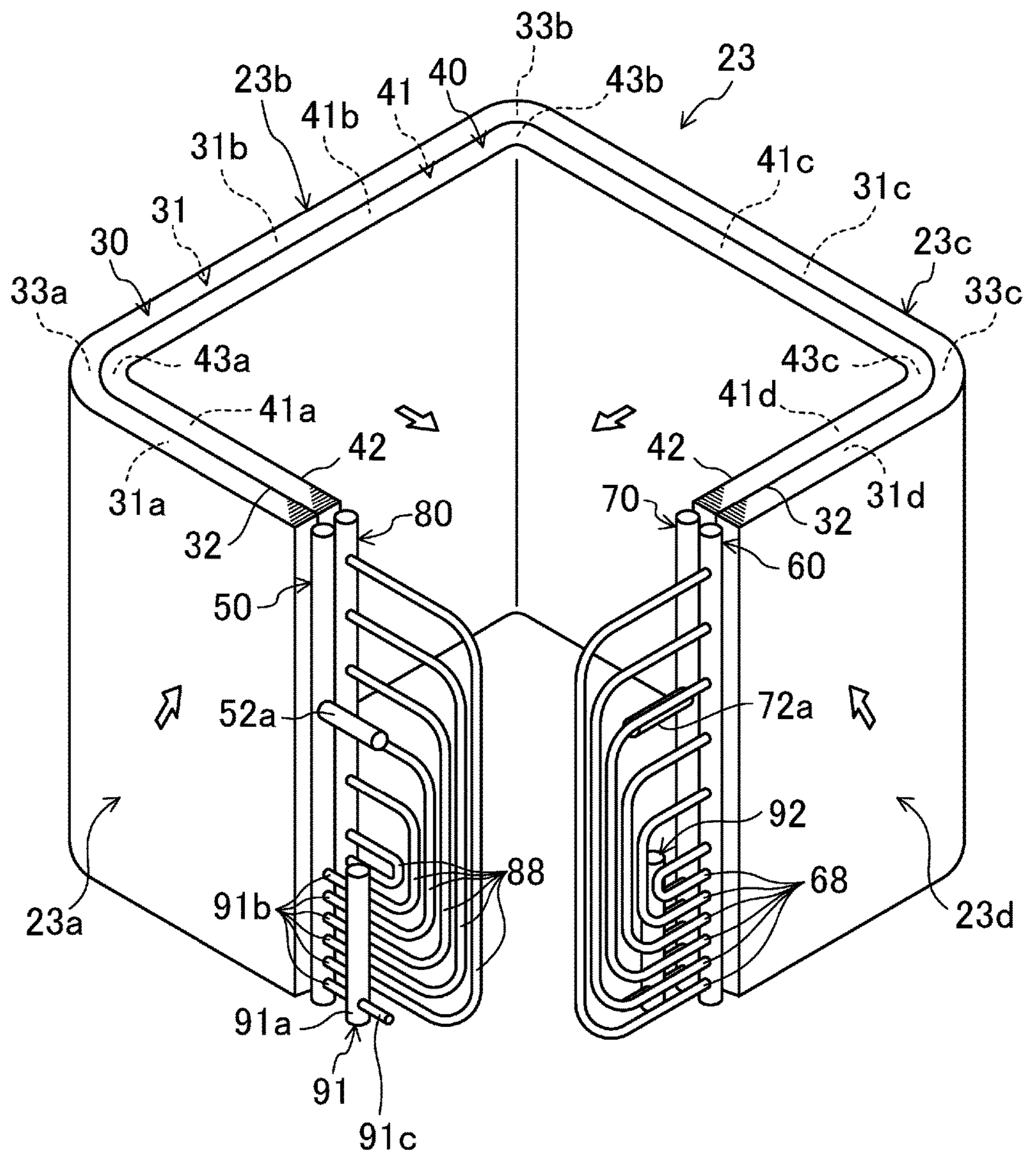


FIG. 15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23
23b
40
43b
41
41b
31b
41c
31c
31
30
23c
33a
33c
43a
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41a
41d
42
42
31a
70
31d
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32
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50
52a
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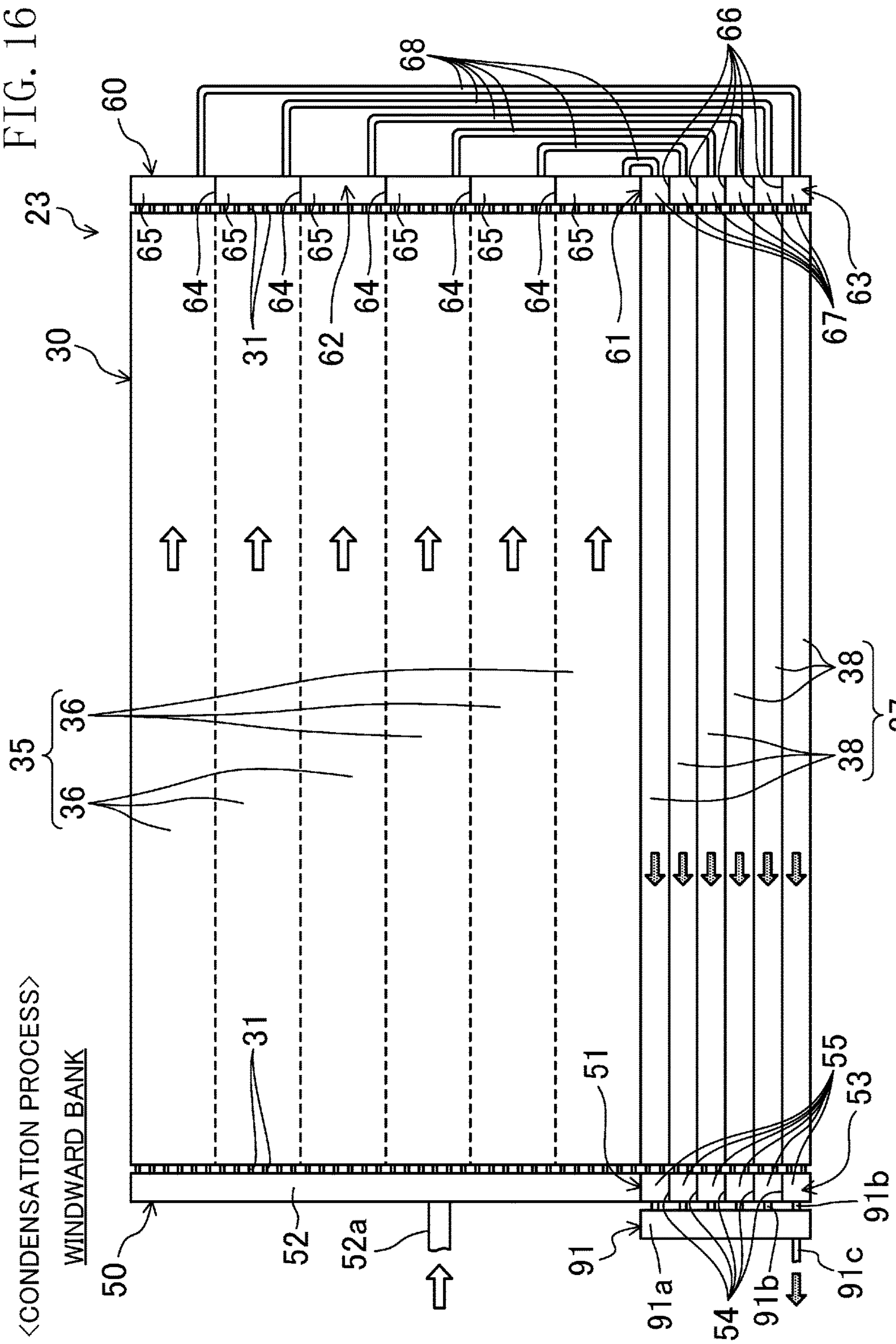
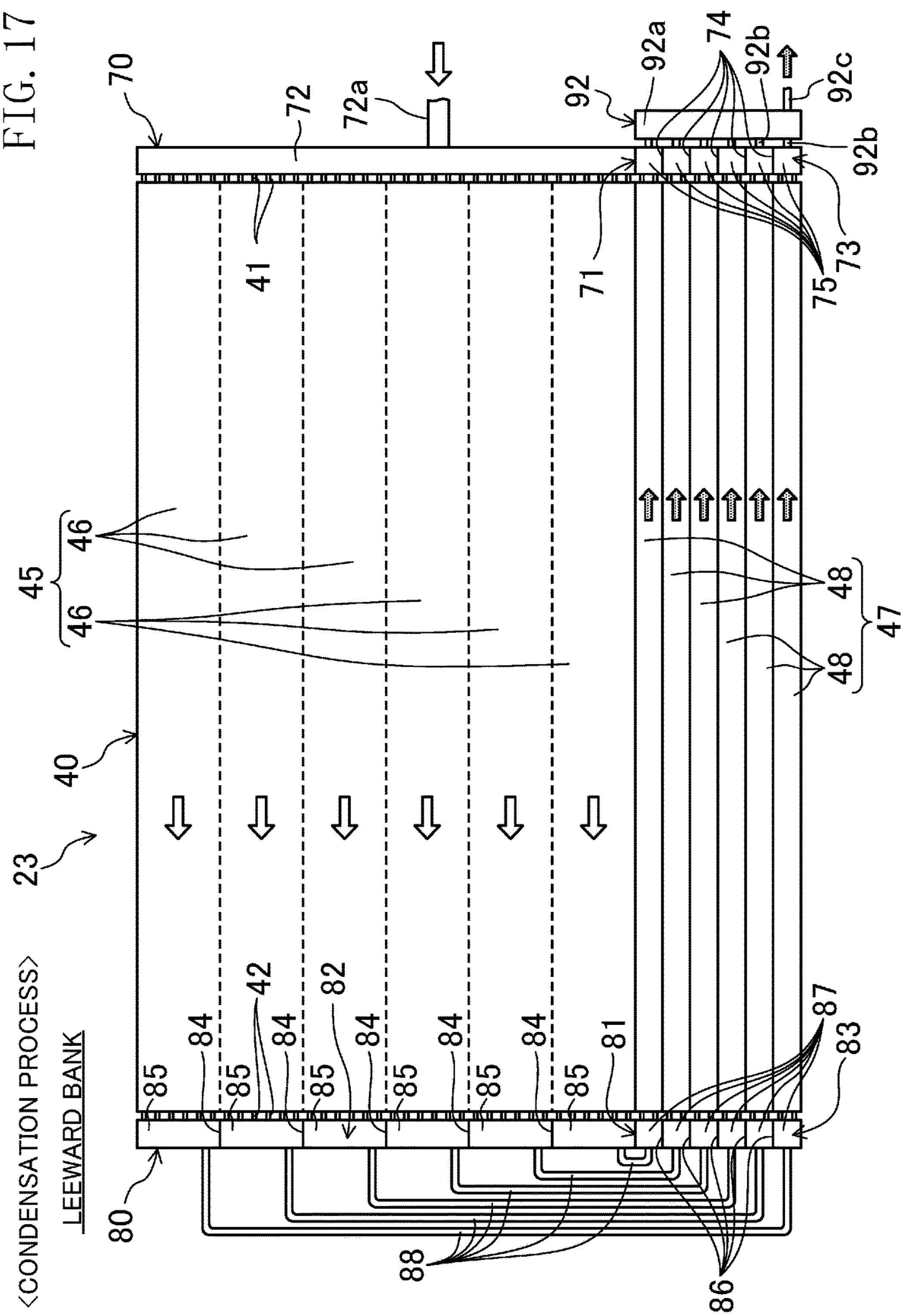
92
88
68
91b
23a
23d
91a
91
91c



<CONDENSATION PROCESS>
WINDWARD BANK
23
30
35
36
36
37
38
38
31
31
50
51
52
52a
53
54
55
60
61
62
63
64
65
66
67
68
91
91a
91b
91b
91c

FIG. 16


〈CONDENSATION PROCESS〉
LEEWARD BANK
70
72
72a
92
92a
74
92b
92c
92b
73
75
71
41
45
46
46
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48
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23
42
82
84
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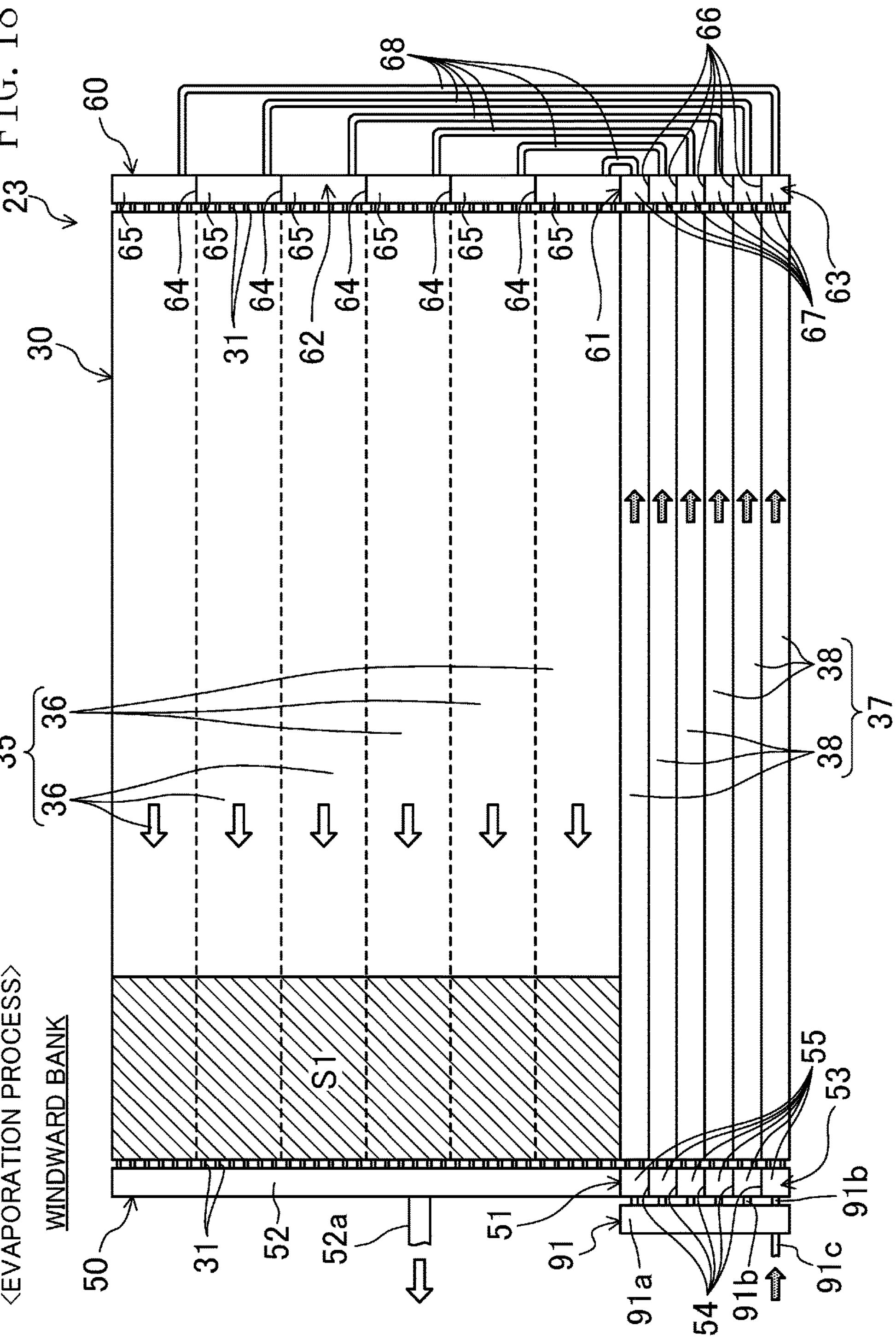
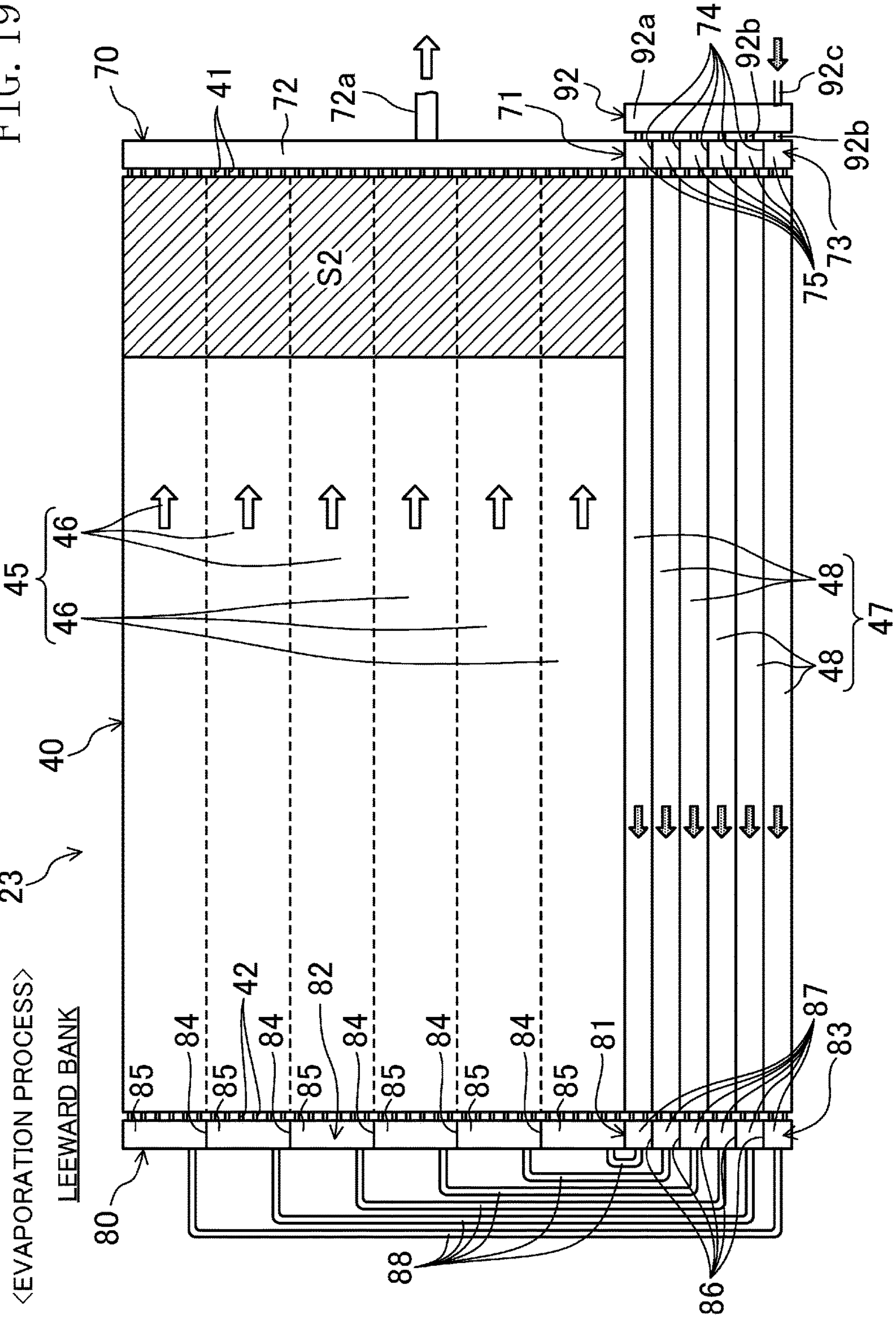
81
87
83
80
88
86

FIG. 17

FIG. 18


〈EVAPORATION PROCESS〉
WINDWARD BANK
23
30
31
35
36
37
38
50
51
52
52a
53
54
55
60
61
62
63
64
65
66
67
68
91
91a
91b
91c
S1



〈EVAPORATION PROCESS〉
LEEWARD BANK
70
41
72
72a
71
92
92a
74
92b
92c
92b
73
75
S2
45
46
46
48
48
47
40
23
42
82
84
85
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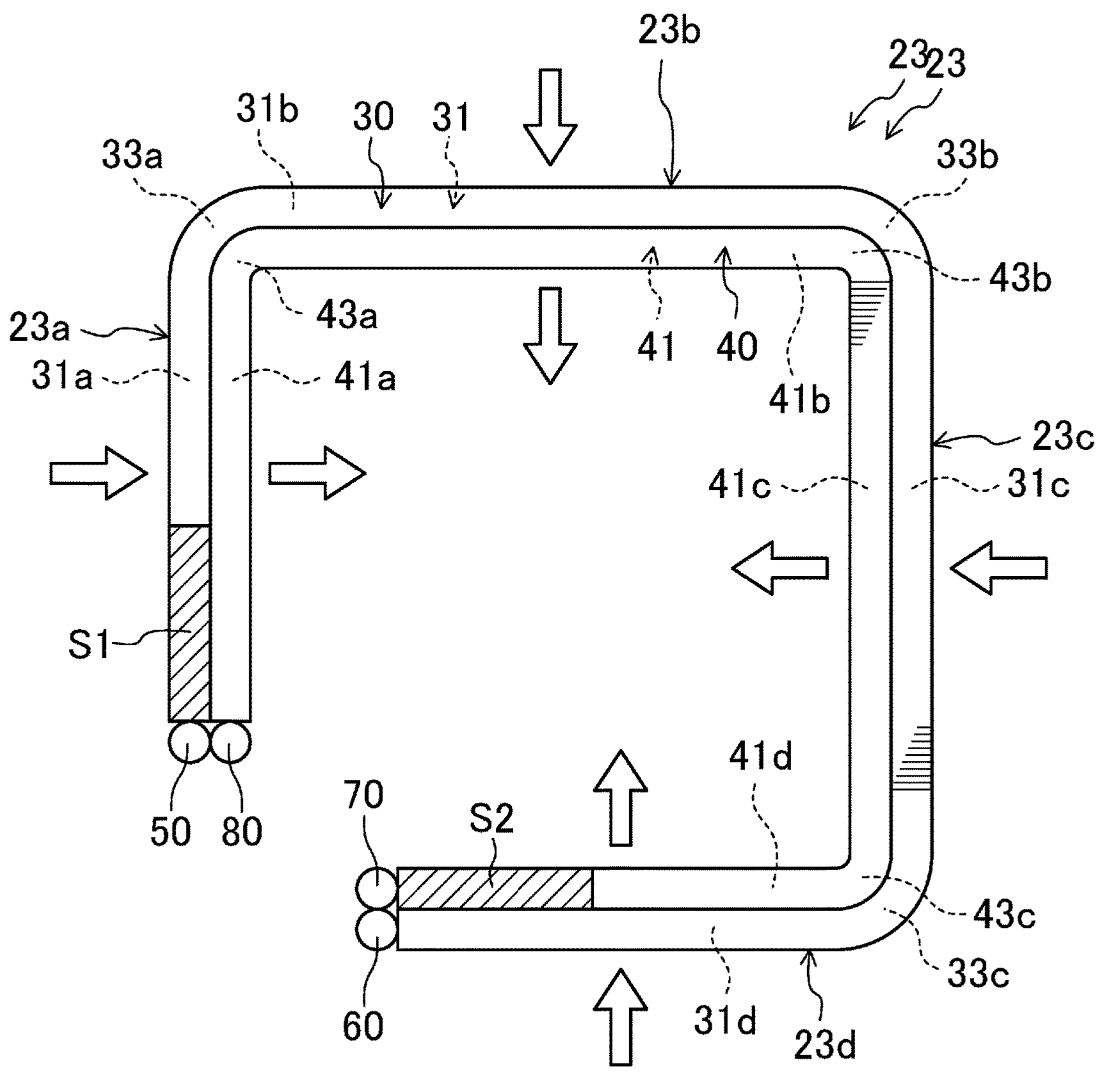
87
83
80
88
86

FIG. 19

FIG. 20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33a
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33c
60
31d
23d

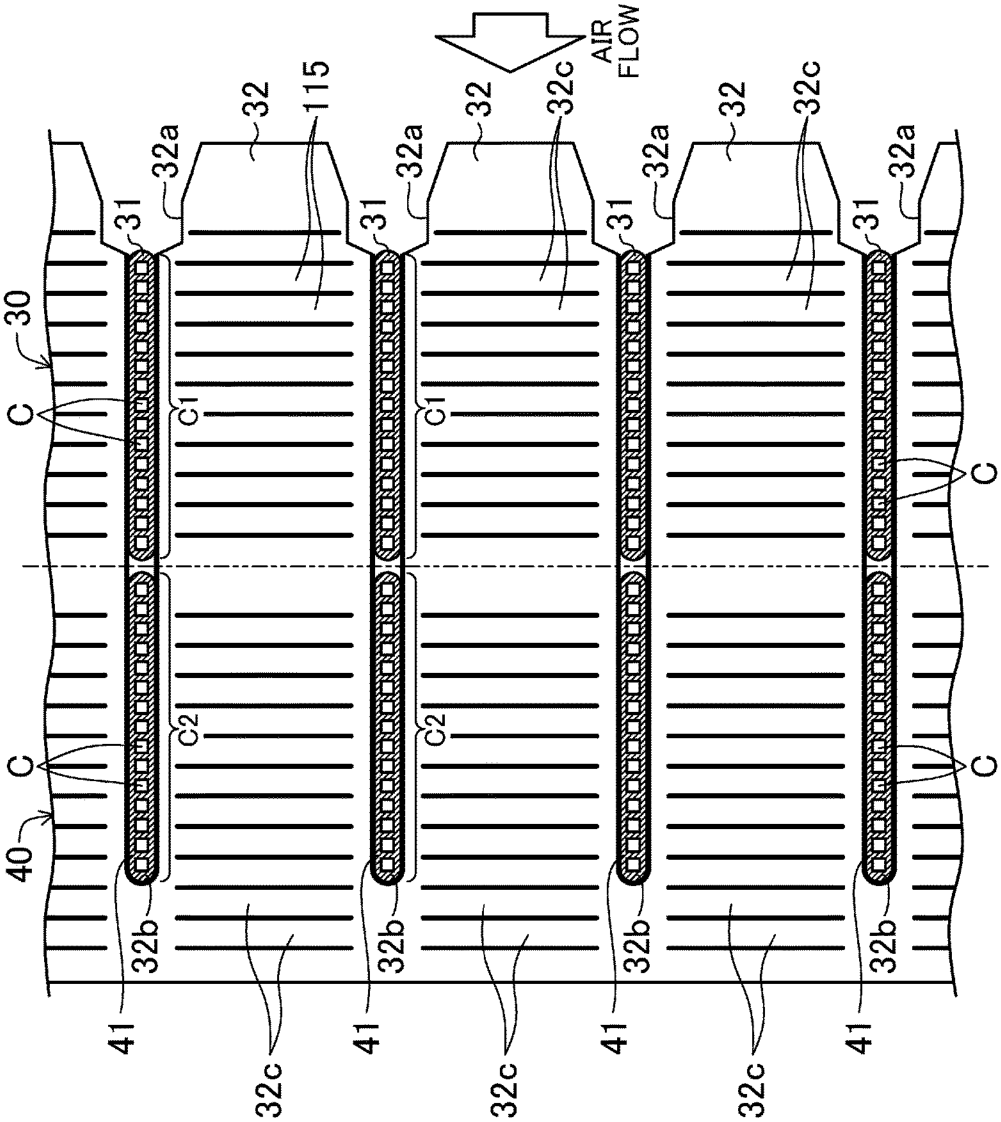

FIG. 21

HEAT EXCHANGER AND AIR CONDITIONER

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger and an air conditioner.

BACKGROUND ART

[0002] Heat exchangers including multiple flat tubes arranged parallel to each other, and fins joined to the flat tubes have been known. Patent Document 1 discloses a heat exchanger of this type (see FIG. **2**). This heat exchanger is a single-bank heat exchanger in which flat tubes are arranged in a single bank in an air flow direction. The heat exchanger includes an upper heat exchange region (principal heat exchange region), and a lower heat exchange region (auxiliary heat exchange region). The number of the flat tubes in the lower heat exchange region is smaller than that in the upper heat exchange region.

[0003] When this heat exchanger functions as an evaporator, for example, a refrigerant in a saturated liquid state flows through the lower heat exchange region to evaporate through absorption of heat from the air. This refrigerant further evaporates by flowing through the upper heat exchange region to be a superheated refrigerant, which then flows out of the heat exchanger.

CITATION LIST

Patent Document

[0004] Patent Document 1: Japanese Unexamined Patent Publication No. 2012-163328

SUMMARY OF THE INVENTION

Technical Problem

[0005] In order to improve the performance of a heat exchanger such as the one disclosed in Patent Document 1, the flat tubes may have their length extended so as to increase the channel length of refrigerant channels formed in the flat tubes. However, the increase in the total length of the refrigerant channels may result in an increase in the pressure loss of the refrigerant passing through the refrigerant channels.

[0006] Further, in a heat exchanger including multiple refrigerant channels in each of the flat tubes, each of the refrigerant channels has a relatively small channel area. Thus, the flow velocity of the refrigerant may easily increase in each of the refrigerant channels. As a result, the pressure loss of the refrigerant flowing through each of the refrigerant channels may further increase.

[0007] On the other hand, in order to reduce the increase in pressure loss, the flat tubes may be elongated in a width direction (an air flow direction) to increase the number of refrigerant channels. However, as the width of the flat tubes increases, it becomes increasingly difficult to bend the flat tubes in the width direction. This makes it difficult to manufacture a multi-surface heat exchanger (e.g., a four-surface heat exchanger) having a plurality of side surfaces through which the air passes.

[0008] In view of the foregoing background, it is therefore an object of the present invention to reduce the increase in the pressure loss of a refrigerant flowing through a plurality of refrigerant channels formed in a flat tube of a heat exchanger, and to facilitate bending of the flat tube in the width direction.

Solution to the Problem

[0009] A first aspect of the present invention is directed to a heat exchanger including: a plurality of flat tubes (**31**, **41**) arranged parallel to each other, in each of which a plurality of refrigerant channels (C) are formed; and fins (**32**, **42**) joined to the flat tubes (**31**, **41**), the heat exchanger allowing a refrigerant flowing through each of the refrigerant channels (C) to exchange heat with air. In this heat exchanger, a plurality of banks (**30**, **40**), each of which includes two or more of the flat tubes (**31**, **41**), are arranged in an air flow direction. The refrigerants in the plurality of banks (**30**, **40**) flow in parallel with each other. Each of the flat tubes (**31**, **41**) in the plurality of banks (**30**, **40**) has one or more bent portions (**33***a*, **33***b*, **33***c*) which are bent in a width direction of the flat tubes (**31**, **41**) such that the flat tubes (**31**, **41**) of a pair of the banks (**30**, **40**) adjacent to each other in the air flow direction extend along with each other.

[0010] According to the first aspect of the invention, the plurality of banks (**30**, **40**) are arranged in the air flow direction. In each of the banks (**30**, **40**), two or more of the flat tubes (**31**, **41**) are arranged parallel to each other. When the refrigerant flows through the heat exchanger, the refrigerants in the flat tubes (**31**, **41**) of each bank (**30**, **40**) flow in parallel with each other. For example, in such a bank (**30**, **40**), if the refrigerant were allowed to flow through the flat tubes (**31**, **41**) that are connected in series, the flow rate of the refrigerant passing through the refrigerant channels (C) would increase, thereby increasing the velocity of the refrigerant flowing through the refrigerant channels (C). In addition, the length of the refrigerant channels (C) would also increase. In contrast, according to the present invention, the refrigerants in the flat tubes (**31**, **41**) of each bank (**30**, **40**) flow in parallel with each other. Thus, the flow rate of the refrigerant passing through the refrigerant channels (C) decreases, thereby decreasing the velocity of the refrigerant flowing through the refrigerant channels (C) as well. In addition, the length of the refrigerant channels (C) also decreases. A pressure loss of the refrigerant flowing through the refrigerant channels (C) is proportional to the square of the velocity of the refrigerant and the length of the refrigerant channels (C). Thus, in this configuration, the pressure loss can be reduced.

[0011] Further, in the heat exchanger, the flat tubes (**31**, **41**) in an adjacent pair of the banks (**30**, **40**) extend along with each other, and each of the flat tubes (**31**, **41**) has one or more bent portions (**33***a*, **33***b*, **33***c*). Further, as compared to the configuration in which the dimension of the flat tubes (**31**, **41**) arranged in a single bank is increased in a width direction, the flat tubes (**31**, **41**) can be bent more easily.

[0012] A second aspect of the invention is an embodiment of the first aspect. In the second aspect, each of the banks (**30**, **40**) includes a principal heat exchange region (**35**, **45**) provided for two or more of the flat tubes (**31**, **41**) arranged side by side in an arrangement direction of the flat tubes (**31**, **41**) in each bank (**30**, **40**), and an auxiliary heat exchange region (**37**, **47**) provided for the flat tubes (**31**, **41**) which are smaller in number than the two or more of the flat tubes (**31**, **41**) of the principal heat exchange region (**35**, **45**). In the plurality of banks (**30**, **40**), the refrigerants in the principal heat exchange regions (**35**, **45**) adjacent to each other in the air flow direction flow in parallel with each other, and the refrigerants in the auxiliary heat exchange regions (**37**, **47**) adjacent to each other in the air flow direction flow in parallel with each other.

[0013] According to the second aspect, each of the banks (**30**, **40**) includes the principal heat exchange region (**35**, **45**) and the auxiliary heat exchange region (**37**, **47**). The refrigerants in the flat tubes (**31**, **41**) in the principal heat exchange regions (**35**, **45**) of the banks (**30**, **40**) flow in parallel with each other, and the refrigerants in the flat tubes (**31**, **41**) in the auxiliary heat exchange regions (**37**, **47**) of the banks (**30**, **40**) also flow in parallel with each other. This reduces the pressure loss of the refrigerants flowing through the principal heat exchange regions (**35**, **45**) and the auxiliary heat exchange regions (**37**, **47**).

[0014] A third aspect of the invention is an embodiment of the second aspect of the invention. In the third aspect, the refrigerant in the flat tubes (**31**, **41**) in the principal heat exchange region (**35**, **45**) and the refrigerant in the flat tubes (**31**, **41**) in the auxiliary heat exchange region (**37**, **47**) in a pair of the banks (**30**, **40**) adjacent to each other in the air flow direction flow in the same direction. The heat exchanger further includes: a branched gas pipe (**29**) having branches communicating with one end of each of the flat tubes (**31**, **41**) in the principal heat exchange region (**35**, **45**) of each bank (**30**, **40**), a branched liquid pipe (**28**) having branches communicating with one end of each of the flat tubes (**31**, **41**) in the auxiliary heat exchange region (**37**, **47**) of each bank (**30**, **40**), the one end being adjacent to the branched gas pipe (**29**), and a communicating pipe (**68**, **88**) which allows the other end of each of the flat tubes (**31**, **41**) in the principal heat exchange region (**35**, **45**) of the bank (**30**, **40**) to communicate with the other end of an associated one of the flat tubes (**31**, **41**) in the auxiliary heat exchange region (**37**, **47**) of the bank (**30**, **40**).

[0015] According to the third aspect, the refrigerant in the flat tubes (**31**, **41**) in the principal heat exchange region (**35**, **45**) and the refrigerant in the flat tubes (**31**, **41**) in the auxiliary heat exchange region (**37**, **47**) in an adjacent pair of the banks (**30**, **40**) flow in the same direction. Each of the banks (**30**, **40**) is connected to a communicating pipe (**68**, **88**), a branched liquid pipe (**28**), and a branched gas pipe (**29**). Specifically, in each of the banks (**30**, **40**), the branched liquid pipe (**28**) and the branched gas pipe (**29**) are provided for an end of each of the flat tubes (**31**, **41**), and the communicating pipe (**68**, **88**) is provided for the other end of each of the flat tubes (**31**, **41**). This reduces space for the branched gas pipe (**29**) and the branched liquid pipe (**28**) in the heat exchanger.

[0016] A fourth aspect of the present invention is an embodiment of the first or second aspect of the present invention. In the fourth aspect, the plurality of banks (**30**, **40**) are configured such that when the heat exchanger functions as an evaporator, the refrigerants in the flat tubes (**31**, **41**) in a pair of the banks (**30**, **40**) adjacent to each other in the air flow direction flow in opposite directions.

[0017] According to the fourth aspect, when the heat exchanger functions as an evaporator, the refrigerants in the flat tubes (**31**, **41**) of the banks (**30**, **40**) adjacent to each other in the air flow direction flow in parallel with each other. Further, the refrigerants in the flat tubes (**31**, **41**) of the adjacent banks (**30**, **40**) flow in opposite directions. If the refrigerants in the flat tubes (**31**, **41**) of the adjacent banks (**30**, **40**) were allowed to flow in the same direction, superheated regions of the flat tubes (**31**, **41**) of the adjacent banks (**30**, **40**), through both of which a superheated refrigerant flows, would tend to overlap with each other in the air flow direction. On the other hand, other regions of the flat tubes (**31**, **41**) of each bank (**30**, **40**) than the superheated regions are low in temperature. Thus, moisture condensed in the air would tend to frost the surfaces of the flat tubes (**31**, **41**) and fins (**32**, **42**). In such a state, ventilation resistance of the air would decrease around the superheated regions of the banks (**30**, **40**). Thus, drift of the air would tend to occur around these regions. As a result, the air would not flow uniformly throughout the heat exchanger, which would result in a decrease in heat exchange efficiency.

[0018] According to the present invention, in contrast, the refrigerants in the flat tubes (**31**, **41**) of the adjacent banks (**30**, **40**) flow in opposite directions. Thus, the superheated regions of the flat tubes (**31**, **41**) of the banks (**30**, **40**) are located distant from each other. This substantially prevents the drift of the air.

[0019] A fifth aspect of the invention is an embodiment of the fourth aspect of the invention. In the fifth aspect, when the heat exchanger functions as the evaporator, superheated refrigerant regions (S**1**, S**2**) of the flat tubes (**31**, **41**) of a pair of the banks (**30**, **40**) adjacent to each other in the air flow direction do not overlap with each other in the air flow direction.

[0020] According to the fifth aspect, the refrigerants in the flat tubes (**31**, **41**) of the adjacent banks (**30**, **40**) among the plurality of banks (**30**, **40**) flow in opposite directions. Thus, the superheated refrigerant regions of the flat tubes (**31**, **41**) of the banks (**30**, **40**) do not overlap with each other. If the superheated refrigerant regions (S**1**, S**2**) of the banks (**30**, **40**) overlapped with each other in the air flow direction, the air would flow only toward the overlapping regions. According to the present invention, however, the superheated refrigerant regions (S**1**, S**2**) do not overlap with each other. Thus, the drift of the air can be effectively prevented.

[0021] A sixth aspect of the invention is an embodiment of any one of the first to fifth aspects of the invention. According to the sixth aspect, the heat exchanger (**23**) of any one of the first to fifth aspects is provided for a refrigerant circuit (**20**) of an air conditioner (**10**). In the heat exchanger (**23**), the refrigerant circulating through the refrigerant circuit (**20**) evaporates through absorption of heat from the air, or condenses through dissipation of heat to the air.

Advantages of the Invention

[0022] According to the present invention, the refrigerants in the flat tubes (**31**, **41**) of the banks (**30**, **40**) are allowed to flow in parallel with each other. Thus, the pressure loss of the refrigerants flowing through the refrigerant channels (C) of the flat tubes (**31**, **41**) can be drastically reduced. Consequently, with an increase in power caused by the increase in pressure loss reduced, a desired heat exchange efficiency can be achieved.

[0023] Further, there is no need to increase the width of the flat tubes (**31**, **41**). This facilitates the bending of the flat tubes (**31**, **41**) of each bank (**30**, **40**). Thus, the flat tubes (**31**, **41**) of each bank (**30**, **40**) may be bent to fabricate a four-surface heat exchanger. This allows for downsizing of the heat exchanger. Reducing the width of the flat tubes (**31**, **41**) allows the ventilation resistance between the flat tubes (**31**, **41**) of each bank (**30**, **40**) to be reduced, thus curbing a decline in thermal transmittance. Further, the decrease in the width of the flat tubes (**31**, **41**) also precludes the possibility of condensed water stagnating on the flat tubes (**31**, **41**). This substantially prevents the surfaces of the flat tubes (**31**, **41**) from being frosted.

[0024] According to the second aspect, the pressure loss of the refrigerants can be cut down in both of the principal heat exchange region (**35**, **45**) and the auxiliary heat exchange region (**37**, **47**).

[0025] According to the third aspect, the branched liquid pipe (**28**) and the branched gas pipe (**29**) allowing the refrigerant to flow in parallel through the banks (**30**, **40**) may be collectively arranged. This configuration can reduce the space occupied by the pipes, or facilitate the installation of the pipes.

[0026] According to the fourth and fifth aspects, when the heat exchanger functions as an evaporator, the superheated refrigerant regions (S**1**, S**2**) can be prevented from overlapping with each other. Thus, the drift of the air toward the superheated regions (S**1**, S**2**) can be prevented. As a result, even if frosting occurs on the surfaces of the flat tubes (**31**, **41**) and fins (**32**, **42**) other than the superheated refrigerant regions (S**1**, S**2**), the air can still flow uniformly throughout the heat exchanger. This improves the heat exchange efficiency, and eventually the evaporation performance, of the heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. **1** is a refrigerant circuit diagram illustrating a general configuration of an air conditioner according to a first embodiment.

[0028] FIG. **2** is a schematic perspective view illustrating an outdoor heat exchanger.

[0029] FIG. **3** is a schematic developed plan view showing the configuration of a windward bank of the outdoor heat exchanger, illustrating how a refrigerant flows when the heat exchanger functions as a condenser.

[0030] FIG. **4** is a schematic developed plan view showing the configuration of a leeward bank of the outdoor heat exchanger, illustrating how a refrigerant flows when the heat exchanger functions as a condenser.

[0031] FIG. **5** is a vertical cross-sectional view illustrating a region A of FIG. **3** on an enlarged scale.

[0032] FIG. **6** is a vertical cross-sectional view illustrating a region B of FIG. **3** on an enlarged scale.

[0033] FIG. **7** is a cross-sectional view taken along a plane VII-VII of FIG. **5**.

[0034] FIG. **8** is a cross-sectional view taken along the plane VIII-VIII of FIG. **6**.

[0035] FIG. **9** is a cross-sectional view taken along the plane VIIII-VIIII of FIG. **6**.

[0036] FIG. **10** is a cross-sectional view taken along the plane X-X of FIG. **5**.

[0037] FIG. **11** is a graph showing changes in the temperatures of a refrigerant and air in the outdoor heat exchanger functioning as a condenser.

[0038] FIG. **12** is a schematic developed plan view showing the configuration of a windward bank of the outdoor heat exchanger, illustrating how a refrigerant flows when the heat exchanger functions as an evaporator.

[0039] FIG. **13** is a schematic developed plan view showing the configuration of a leeward bank of the outdoor heat exchanger, illustrating how a refrigerant flows when the heat exchanger functions as an evaporator.

[0040] FIG. **14** is a graph showing changes in the temperatures of a refrigerant and air in the outdoor heat exchanger functioning as an evaporator.

[0041] FIG. **15** is a view corresponding to FIG. **2**, illustrating an outdoor heat exchanger according to a second embodiment.

[0042] FIG. **16** is a view corresponding to FIG. **3**, illustrating the outdoor heat exchanger according to the second embodiment.

[0043] FIG. **17** is a view corresponding to FIG. **4**, illustrating the outdoor heat exchanger according to the second embodiment.

[0044] FIG. **18** is a view corresponding to FIG. **12**, illustrating the outdoor heat exchanger according to the second embodiment.

[0045] FIG. **19** is a view corresponding to FIG. **13**, illustrating the outdoor heat exchanger according to the second embodiment.

[0046] FIG. **20** is a schematic top view illustrating the outdoor heat exchanger functioning as a condenser.

[0047] FIG. **21** is a view corresponding to FIG. **7**, illustrating an outdoor heat exchanger according to another embodiment.

DETAILED DESCRIPTION

[0048] Embodiments of the present invention will be described in detail with reference to the drawings. The following embodiments are merely exemplary ones in nature, and are not intended to limit the scope, application, or uses of the invention.

First Embodiment

[0049] A heat exchanger of the present embodiment is an outdoor heat exchanger (**23**) provided in an air conditioner (**10**). The air conditioner (**10**) will now be described first, and then the outdoor heat exchanger (**23**) will be described in detail later.

<General Configuration of Air Conditioner>

[0050] The air conditioner (**10**) will be described below with reference to FIG. **1**.

[0051] The air conditioner (**10**) includes an outdoor unit (**11**) and an indoor unit (**12**). The outdoor and indoor units (**11**) and (**12**) are connected to each other via a liquid interconnecting pipe (**13**) and a gas interconnecting pipe (**14**). In this air conditioner (**10**), the outdoor unit (**11**), the indoor unit (**12**), the liquid interconnecting pipe (**13**), and the gas interconnecting pipe (**14**) are connected together to form a refrigerant circuit (**20**).

[0052] The refrigerant circuit (**20**) includes a compressor (**21**), a four-way switching valve (**22**), an outdoor heat exchanger (**23**), an expansion valve (**24**), and an indoor heat exchanger (**25**). The compressor (**21**), the four-way switching valve (**22**), the outdoor heat exchanger (**23**), and the expansion valve (**24**) are housed in the outdoor unit (**11**). The outdoor unit (**11**) is provided with an outdoor fan (**15**) for supplying outdoor air to the outdoor heat exchanger (**23**). The indoor heat exchanger (**25**) is housed in the indoor unit (**12**). The indoor unit (**12**) is provided with an indoor fan (**16**) for supplying indoor air to the indoor heat exchanger (**25**).

[0053] The refrigerant circuit (**20**) is a closed circuit filled with a refrigerant. In the refrigerant circuit (**20**), the compressor (**21**) has a discharge pipe connected to a first port of the four-way switching valve (**22**), and a suction pipe connected to a second port of the four-way switching valve (**22**). In this refrigerant circuit (**20**), the outdoor heat exchanger (**23**), the expansion valve (**24**), and the indoor heat exchanger (**25**) are arranged in this order from a third port to a fourth port of the four-way switching valve (**22**). The outdoor heat exchanger (**23**) in the refrigerant circuit (**20**) is connected to the expansion valve (**24**) via a pipe (**17**), and to the third port of the four-way switching valve (**22**) via a pipe (**18**).

[0054] The compressor (**21**) is a hermetic scroll or rotary compressor. The four-way switching valve (**22**) switches between a first state in which the first port communicates with the third port, and the second port communicates with the fourth port (indicated by solid curves FIG. **1**), and a second state in which the first port communicates with the fourth port, and the second port communicates with the third port (indicated by broken curves in FIG. **1**). The expansion valve (**24**) is a so-called "electronic expansion valve."

[0055] The outdoor heat exchanger (**23**) allows outdoor air and a refrigerant to exchange heat. The outdoor heat exchanger (**23**) will be described in detail later. The indoor heat exchanger (**25**) allows indoor air and the refrigerant to exchange heat. The indoor heat exchanger (**25**) is configured as a so-called "cross-fin, fin-and-tube heat exchanger" including circular heat transfer tubes.

—Operation of Air Conditioner—

[0056] The air conditioner (**10**) selectively performs cooling operation and heating operation.

[0057] During the cooling operation, the refrigerant circuit (**20**) performs a refrigeration cycle with the four-way switching valve (**22**) set to the first state. In this state, the refrigerant circulates through the outdoor heat exchanger (**23**), the expansion valve (**24**), and the indoor heat exchanger (**25**) in this order, the outdoor heat exchanger (**23**) functions as a condenser, and the indoor heat exchanger (**25**) functions as an evaporator. In the outdoor heat exchanger (**23**), a gas refrigerant coming from the compressor (**21**) is condensed through dissipation of heat to the outdoor air. Then, the condensed refrigerant flows toward the expansion valve (**24**).

[0058] During the heating operation, the refrigerant circuit (**20**) performs a refrigeration cycle with the four-way switching valve (**22**) set to the second state. In this state, the refrigerant circulates through the indoor heat exchanger (**25**), the expansion valve (**24**), and the outdoor heat exchanger (**23**) in this order, the indoor heat exchanger (**25**) functions as a condenser, and the outdoor heat exchanger (**23**) functions as an evaporator. The refrigerant, which has expanded while passing through the expansion valve (**24**) and turned into a two-phase gas-liquid refrigerant, flows into the outdoor heat exchanger (**23**). The refrigerant that has flowed into the outdoor heat exchanger (**23**) evaporates through absorption of heat from the outdoor air, and then flows toward the compressor (**21**).

<General Configuration of Outdoor Heat Exchanger>

[0059] The outdoor heat exchanger (**23**) according to the first embodiment will be described with reference to FIGS. **2** to **11** as needed. Note that the number of flat tubes (**31**, **41**) described below is merely an example.

[0060] As shown in FIG. **2**, the outdoor heat exchanger (**23**) is a four-surface air heat exchanger having four side surfaces (**23***a*, **23***b*, **23***c*, **23***d*). Specifically, the outdoor heat exchanger (**23**) includes a first side surface (**23***a*), a second side surface (**23***b*), a third side surface (**23***c*), and a fourth side surface (**23***d*), which are arranged continuously. Referring to FIG. **2**, the first side surface (**23***a*) is a lower left surface, the second side surface (**23***b*) is an upper left surface, the third side surface (**23***c*) is an upper right surface, and the fourth side surface (**23***d*) is a lower right surface. The side surfaces (**23***a*, **23***b*, **23***c*, **23***d*) have approximately the same height. The first and fourth side surfaces (**23***a*) and (**23***d*) have a smaller width than the second and third side surfaces (**23***b*) and (**23***c*).

[0061] When the outdoor fan (**15**) in the outdoor heat exchanger (**23**) is operated, the outdoor air outside of the side surfaces (**23***a*, **23***b*, **23***c*, **23***d*) flows inward through the side surfaces (**23***a*, **23***b*, **23***c*, **23***d*) as indicated by the arrows in FIG. **2**. The air is exhausted through a blowout port formed in an upper portion of an outdoor casing (not shown).

[0062] As shown in FIGS. **2**-**4**, the outdoor heat exchanger (**23**) is a double-bank heat exchanger including two banks (**30**, **40**), each having flat tubes (**31**, **41**) and fins (**32**, **42**). Alternatively, the outdoor heat exchanger (**23**) may include three or more banks. In the outdoor heat exchanger (**23**) of the present embodiment, one of the two banks on the windward side in an air flow direction is configured as a windward bank (**30**), and the other bank on the leeward side is configured as a leeward bank (**40**). FIGS. **3** and **4** schematically show the windward and leeward banks (**30**) and (**40**) respectively developed in separate plan views.

[0063] The outdoor heat exchanger (**23**) includes a first header collecting pipe (**50**), a second header collecting pipe (**60**), a third header collecting pipe (**70**), a fourth header collecting pipe (**80**), a first divergence unit (**91**), and a second divergence unit (**92**). The first header collecting pipe (**50**) is arranged to stand upright near one end of the windward bank (**30**) adjacent to the first side surface (**23***a*). The second header collecting pipe (**60**) is arranged to stand upright near the other end of the windward bank (**30**) adjacent to the fourth side surface (**23***d*). The third header collecting pipe (**70**) is arranged to stand upright near one end of the leeward bank (**40**) adjacent to the first side surface (**23***a*). The fourth header collecting pipe (**80**) is arranged to stand upright near the other end of the leeward bank (**40**) adjacent to the fourth side surface (**23***d*). The first divergence unit (**91**) is arranged to stand upright near the first header collecting pipe (**50**). The second divergence unit (**92**) is arranged to stand upright near the third header collecting pipe (**70**).

[0064] The flat tubes (**31**, **41**), the fins (**32**, **42**), the first to fourth header collecting pipes (**50**, **60**, **70**, **80**), and the first and second divergence units (**91**, **92**) are all members made of an aluminum alloy, and are joined to one another by brazing.

[Windward Bank]

[0065] As shown in FIGS. **2**, **3**, and **5**-**10**, the windward bank (**30**) includes multiple flat tubes (**31**) and multiple fins (**32**).

[0066] Each of the flat tubes (**31**) is a heat transfer tube having a flat, substantially oval cross section when viewed in a section cut along a plane perpendicular to its axis (see

FIG. **7**). The plurality of flat tubes (**31**) are arranged such that upper and lower flat surfaces of each of the flat tubes face those of adjacent flat tubes. That is, the plurality of flat tubes (**31**) are vertically arranged at regular intervals, with their axes extending substantially parallel to each other.

[0067] As shown in FIG. **2**, each of the flat tubes (**31**) includes a first windward tube portion (**31***a*) extending along the first side surface (**23***a*), a second windward tube portion (**31***b*) extending along the second side surface (**23***b*), a third windward tube portion (**31***c*) extending along the third side surface (**23***c*), and a fourth windward tube portion (**31***d*) extending along the fourth side surface (**23***d*). Further, as shown in FIG. **2**, the flat tube (**31**) includes a first windward bent portion (**33***a*) which is bent horizontally at approximately right angles from the first windward tube portion (**31***a*) toward the second windward tube portion (**31***b*), a second windward bent portion (**33***b*) which is bent horizontally at approximately right angles from the second windward tube portion (**31***b*) toward the third windward tube portion (**31***c*), and a third windward bent portion (**33***c*) which is bent horizontally at approximately right angles from the third windward tube portion (**31***c*) toward the fourth windward tube portion (**31***d*).

[0068] An end of the first windward tube portion (**31***a*) of each of the flat tubes (**31**) is inserted in the first header collecting pipe (**50**) (see FIG. **5**), and an end of the fourth windward tube portion (**31***d*) of each of the flat tubes (**31**) is inserted in the second header collecting pipe (**60**) (see FIG. **6**).

[0069] As shown in FIG. **7**, a plurality of refrigerant channels (C) are formed in each of the flat tubes (**31**). The plurality of refrigerant channels (C) extend in the axial direction of the flat tubes (**31**), and are aligned in the width direction of the flat tubes (**31**) (an air flow direction). Each of the refrigerant channels (C) opens at both end faces of an associated one of the flat tubes (**31**). A refrigerant supplied to the windward bank (**30**) exchanges heat with air while flowing through the refrigerant channels (C) in the flat tubes (**31**). The plurality of refrigerant channels (C) in each of the flat tubes (**31**) of the windward bank (**30**) constitute a set of windward refrigerant channels (C1).

[0070] Each of the fins (**32**) is a vertically elongated plate fin formed by pressing a metal plate as shown in FIG. **7**. The plurality of fins (**32**) are arranged at regular intervals in the axial direction of the flat tubes (**31**). Each of the fins (**32**) has a plurality of long narrow notches (**32***a*) extending in the width direction of the fin (**32**) from an outer edge (i.e., a windward edge) of the fin (**32**). The plurality of notches (**32***a*) are formed in the fin (**32**) at regular intervals in the longitudinal direction of the fins (**32**) (the vertical direction). A windward portion of each notch (**32***a*) serves as a tube receiving portion (**32***b*). The flat tube (**31**) is inserted in the tube receiving portion (**32***b*), and is joined to a peripheral edge portion of the tube receiving portion (**32***b*) by brazing. Further, the fin (**32**) is provided with louvers (**32***c*) for promoting heat transfer.

[0071] As shown in FIG. **3**, the windward bank (**30**) is divided into two heat exchange regions (**35**, **37**) arranged one above the other. The upper heat exchange region serves as a principal windward heat exchange region (**35**), and the lower heat exchange region serves as an auxiliary windward heat exchange region (**37**). The number of the flat tubes (**31**) allocated to the auxiliary windward heat exchange region (**37**) is smaller than that of the flat tubes (**31**) forming the principal windward heat exchange region (**35**).

[0072] The principal windward heat exchange region (**35**) is divided into six vertically arranged, principal windward heat exchange sections (**36**). The auxiliary windward heat exchange region (**37**) is divided into six vertically arranged, auxiliary windward heat exchange sections (**38**). That is, the principal and auxiliary windward heat exchange regions (**35**) and (**37**) are each divided into the same number of heat exchange sections. Note that the number of the principal and auxiliary windward heat exchange sections (**36**) and (**38**) is merely an example, and is suitably two or more.

[0073] As shown in FIGS. **3** and **6**, the principal windward heat exchange sections (**36**) each include the same number of flat tubes (**31**), e.g., six flat tubes (**31**). The number of the flat tubes (**31**) provided for each of the principal windward heat exchange sections (**36**) is merely an example, and may be two or more, or one.

[0074] As shown in FIGS. **3** and **5**, the auxiliary windward heat exchange sections (**38**) each include the same number of flat tubes (**31**), e.g., two flat tubes (**31**). The number of the flat tubes (**31**) provided for each of the auxiliary windward heat exchange sections (**36**) is merely an example, and may be two or more, or one.

[Leeward Bank]

[0075] As shown in FIGS. **2**, **4**, and **5-10**, the leeward bank (**40**) includes multiple flat tubes (**41**) and multiple fins (**42**).

[0076] Each of the flat tubes (**41**) is a heat transfer tube having a flat, substantially oval cross section when viewed in a section cut along a plane perpendicular to its axis (see FIG. **7**). The plurality of flat tubes (**41**) are arranged such that upper and lower flat surfaces of each of the flat tubes face those of adjacent flat tubes. That is, the plurality of flat tubes (**41**) are vertically arranged at regular intervals, with their axes extending substantially parallel to each other.

[0077] As shown in FIG. **2**, each of the flat tubes (**41**) includes a first leeward tube portion (**41***a*) extending along an inner edge of the first windward tube portion (**31***a*), a second leeward tube portion (**41***b*) extending along an inner edge of the second windward tube portion (**31***b*), a third leeward tube portion (**41***c*) extending along an inner edge of the third windward tube portion (**31***c*), and a fourth leeward tube portion (**41***d*) extending along an inner edge of the fourth windward tube portion (**31***d*). The flat tube (**41**) includes a first leeward bent portion (**43***a*) which is bent horizontally at approximately right angles from the first leeward tube portion (**41***a*) toward the second leeward tube portion (**41***b*), a second leeward bent portion (**43***b*) which is bent horizontally at approximately right angles from the second leeward tube portion (**41***b*) toward the third leeward tube portion (**41***c*), and a third leeward bent portion (**43***c*) which is bent horizontally at approximately right angles from the third leeward tube portion (**41***c*) toward the fourth leeward tube portion (**41***d*).

[0078] An end of the first leeward tube portion (**41***a*) of each of the flat tubes (**41**) is inserted in the third header collecting pipe (**70**), and an end of the fourth leeward tube portion (**41***d*) is inserted in the fourth header collecting pipe (**80**) as shown in FIG. **4**.

[0079] As shown in FIGS. **7-10**, a plurality of refrigerant channels (C) are formed in each of the flat tubes (**41**). The plurality of refrigerant channels (C) extend in the axial direction of the flat tubes (**41**), and are aligned in the width direction of the flat tubes (**41**) (an air flow direction). Each of the refrigerant channels (C) opens at both end faces of an associated one of the flat tubes (**41**). A refrigerant supplied to the leeward bank (**40**) exchanges heat with air while flowing through the refrigerant channels (C) in the flat tubes (**41**). The plurality of refrigerant channels (C) in each of the flat tubes (**41**) of the leeward bank (**40**) constitute a set of leeward refrigerant channels (C**2**).

[0080] Each of the fins (**42**) is a vertically elongated plate fin formed by pressing a metal plate as shown in FIG. **7**. The plurality of fins (**42**) are arranged at regular intervals in the axial direction of the flat tubes (**41**). Each of the fins (**42**) has a plurality of long narrow notches (**42***a*) extending in the width direction of the fin (**42**) from an outer edge (i.e., a windward edge) of the fin (**42***a*). The plurality of notches (**42***a*) are formed in the fin (**42**) at regular intervals in the longitudinal direction of the fin (**42**) (the vertical direction). A windward portion of each notch (**42***a*) serves as a tube receiving portion (**42***b*). The flat tube (**41**) is inserted in the tube receiving portion (**42***b*), and is joined to a peripheral edge portion of the tube receiving portion (**42***b*) by brazing. Further, the fin (**42**) is provided with louvers (**42***c*) for promoting heat transfer.

[0081] As shown in FIG. **4**, the leeward bank (**40**) is divided into two heat exchange regions (**45**, **47**) arranged one above the other. The upper heat exchange region serves as a principal leeward heat exchange region (**45**), and the lower heat exchange region serves as an auxiliary leeward heat exchange region (**47**). The number of the flat tubes (**41**) allocated to the auxiliary leeward heat exchange region (**47**) is smaller than that of the flat tubes (**41**) forming the principal leeward heat exchange region (**45**).

[0082] The principal leeward heat exchange region (**45**) is divided into six vertically arranged, principal leeward heat exchange sections (**46**). The auxiliary leeward heat exchange region (**47**) is divided into six vertically arranged, auxiliary leeward heat exchange sections (**48**). That is, the principal and auxiliary leeward heat exchange regions (**45**) and (**47**) are each divided into the same number of heat exchange sections. Note that the number of the principal and auxiliary leeward heat exchange sections (**46**) and (**48**) is merely an example, and is suitably two or more.

[0083] As shown in FIG. **4**, the principal leeward heat exchange sections (**46**) each include the same number of flat tubes (**41**), e.g., six flat tubes (**41**). The number of the flat tubes (**41**) provided for each of the principal leeward heat exchanger portions (**46**) is merely an example, and may be two or more, or one.

[0084] As shown in FIGS. **5** and **6**, the auxiliary leeward heat exchange sections (**48**) each include the same number of flat tubes (**41**), e.g., two flat tubes (**41**). The number of the flat tubes (**41**) provided for each of the auxiliary leeward heat exchange sections (**48**) is merely an example, and may be two or more, or one.

[Third Header Collecting Pipe]

[0085] As shown in FIGS. **2** and **4**, the third header collecting pipe (**70**) is a cylindrical member having closed top and bottom. The third header collecting pipe (**70**) has a length (height) which is approximately the same as the heights of the windward and leeward banks (**30**) and (**40**).

[0086] The third header collecting pipe (**70**) has substantially the same internal configuration as the first header collecting pipe (**50**) shown in FIG. **5**. Specifically, as shown in FIG. **4**, the internal space of the third header collecting pipe (**70**) is horizontally divided into two by a principal divider (**71**). The space above the principal divider (**71**) is an upper leeward space (**72**) corresponding to the principal leeward heat exchange region (**45**). The space below the principal divider (**71**) is a lower leeward space (**73**) corresponding to the auxiliary leeward heat exchange region (**47**). One end of a second principal gas pipe (**72***a*) is connected to a vertical middle portion of the upper leeward space (**72**). The other end of the second principal gas pipe (**72***a*) communicates with the gas interconnecting pipe (**14**).

[0087] The lower leeward space (**73**) is divided into six auxiliary leeward spaces (**75**) by five dividers (**74**) vertically arranged at regular intervals. The six auxiliary leeward spaces (**75**) respectively correspond to the six auxiliary leeward heat exchange sections (**48**). The first leeward tube portions (**41***a*) of the two flat tubes (**41**), for example, communicate with each of the auxiliary leeward spaces (**75**).

[Fourth Header Collecting Pipe]

[0088] As shown in FIGS. **2**, **4**, and **8-10**, the fourth header collecting pipe (**80**) is a cylindrical member with closed top and bottom. The fourth header collecting pipe (**80**) has a length (height) which is approximately the same as the heights of the windward and leeward banks (**30**) and (**40**).

[0089] The fourth header collecting pipe (**80**) has substantially the same internal configuration as the second header collecting pipe (**60**) shown in FIG. **6**. Specifically, as shown in FIG. **4**, the internal space of the fourth header collecting pipe (**80**) is horizontally divided into two by a principal divider (**81**). The space above the principal divider (**81**) is an upper leeward space (**82**) corresponding to the principal leeward heat exchange region (**45**). The space below the principal divider (**81**) is a lower leeward space (**83**) corresponding to the auxiliary leeward heat exchange region (**47**).

[0090] The upper leeward space (**82**) is divided into six principal leeward communicating spaces (**85**) by five dividers (**84**) vertically arranged at regular intervals. The six principal leeward communicating spaces (**85**) respectively correspond to the six principal leeward heat exchange sections (**46**). The first leeward tube portions (**41***a*) of the six flat tubes (**41**), for example, communicate with each of the principal leeward communicating spaces (**85**).

[0091] The lower leeward space (**83**) is divided into six auxiliary leeward communicating spaces (**87**) by five dividers (**86**) vertically arranged at regular intervals. The six auxiliary leeward communicating spaces (**87**) respectively correspond to the six auxiliary leeward heat exchange sections (**48**). The fourth leeward tube portions (**41***d*) of the two flat tubes (**41**), for example, communicate with each of the auxiliary leeward communicating spaces (**87**).

[0092] Six leeward communicating pipes (**88**) are connected to the fourth header collecting pipe (**80**). Each of the leeward communicating pipes (**88**) connects associated ones of the ends of the flat tubes (**41**) in the principal leeward heat exchange region (**45**) of the leeward bank (**40**) to associated ones of the ends of the flat tubes (**41**) in the auxiliary leeward heat exchange region (**47**).

[0093] Specifically, a first leeward communicating pipe (**88**) connects the uppermost auxiliary leeward communicating space (**87**) and the lowermost principal leeward communicating space (**85**). A second leeward communicating pipe (**88**) connects the second uppermost auxiliary leeward communicating space (**87**) and the second lowermost principal leeward communicating space (**85**). A third leeward communicating pipe (**88**) connects the third uppermost auxiliary leeward communicating space (**87**) and the third lowermost principal leeward communicating space (**85**). A fourth leeward communicating pipe (**88**) connects the fourth uppermost auxiliary leeward communicating space (**87**) and the fourth lowermost principal leeward communicating space (**85**). A fifth leeward communicating pipe (**88**) connects the fifth uppermost auxiliary leeward communicating space (**87**) and the fifth lowermost principal leeward communicating space (**85**). A sixth leeward communicating pipe (**88**) connects the lowermost auxiliary leeward communicating space (**87**) and the uppermost principal leeward communicating space (**85**).

[First Divergence Unit]

[0094] As shown in FIGS. **2** and **3**, the first divergence unit (**91**) is attached to the first header collecting pipe (**50**). The first divergence unit (**91**) includes a cylindrical part (**91***a*), six liquid connecting pipes (**91***b*), and one first principal liquid pipe (**91***c*).

[0095] The cylindrical part (**91***a*) is a cylindrical member shorter in height than the first header collecting pipe (**50**), and stands upright along a lower portion of the first header collecting pipe (**50**). The six liquid connecting pipes (**91***b*) are arranged in the vertical direction and connected to the cylindrical part (**91***a*). The number of the liquid connecting pipes (**91***b*) is the same as that of the auxiliary windward communicating spaces (**67**) (six in this embodiment). The liquid connecting pipes (**91***b*) respectively communicate with the windward auxiliary communicating spaces (**67**). One end of the first principal liquid pipe (**91***c*) is connected to the lower portion of the cylindrical part (**91***a*). The first principal liquid pipe (**91***c*) and each of the liquid connecting pipes (**91***b*) communicate with each other via a space inside the cylindrical part (**91***a*).

[Second Divergence Unit]

[0096] As shown in FIGS. **2** and **4**, the second divergence unit (**92**) is attached to the third header collecting pipe (**70**). The second divergence unit (**92**) includes a cylindrical part (**92***a*), six liquid connecting pipes (**92***b*), and one second principal liquid pipe (**92***c*).

[0097] The cylindrical part (**92***a*) is a cylindrical member shorter in height than the third header collecting pipe (**70**), and stands upright along a lower portion of the third header collecting pipe (**70**). The six liquid connecting pipes (**92***b*) are arranged in the vertical direction, and connected to the cylindrical part (**92***a*). The number of the liquid connecting pipes (**92***b*) is the same as that of the auxiliary leeward spaces (**75**) (six in this embodiment). The liquid connecting pipes (**92***b*) respectively communicate with the leeward auxiliary spaces (**85**). One end of the second principal liquid pipe (**92***c*) is connected to the lower portion of the cylindrical part (**92***a*). The second principal liquid pipe (**92***c*) communicates with the liquid connecting pipes (**92***b*) via a space inside the cylindrical part (**92***a*).

[Branched Liquid Pipe]

[0098] As schematically shown in FIG. **2**, a branched liquid pipe (**28**) is connected to the first principal liquid pipe (**91***c*) of the first divergence unit (**91**) and the second principal liquid pipe (**92***c*) of the second divergence unit (**92**). The branched liquid pipe (**28**) has two branches respectively communicating with the divergence units (**91**, **92**) and the auxiliary spaces (**55**, **75**). Specifically, one of the branches of the branched liquid pipe (**28**) communicates with the other end (the first windward tube portion (**31***a*)) of each of the flat tubes (**31**) in the windward bank (**30**), and the other branch communicates with the other end (the first leeward tube portion (**41***a*)) of each of the flat tubes (**41**) in the leeward bank (**40**).

[Branched Gas Pipe]

[0099] As schematically shown in FIG. **2**, a branched gas pipe (**29**) is connected to the first principal gas pipe (**52***a*) of the windward bank (**30**) and the second principal gas pipe (**72***a*) of the leeward bank (**40**). The branched gas pipe (**29**) has two branches respectively communicating with the upper windward space (**52**) and the upper leeward space (**72**).

[0100] Specifically, one of the branches of the branched gas pipe (**29**) communicates with the other end of the windward bank (**30**) (the first windward tube portion (**31***a*)), and the other branch communicates with the other end of the leeward bank (**40**) (the first leeward tube portion (**41***a*)).

—How Refrigerant Flows in Outdoor Heat Exchanger—

[0101] The outdoor heat exchanger (**23**) is configured to allow a refrigerant in the flat tubes (**31**) of the windward bank (**30**) and a refrigerant in the flat tubes (**41**) of the leeward bank (**40**) to flow in parallel with each other when the outdoor heat exchanger (**23**) functions as a condenser and an evaporator. Specifically, the outdoor heat exchanger (**23**) which functions as a condenser and an evaporator is configured to allow a refrigerant in the flat tubes (**31**) of the principal windward heat exchange region (**35**) of the windward bank (**30**) and a refrigerant in the flat tubes (**41**) of the principal leeward heat exchange region (**45**) of the leeward bank (**40**) to flow in parallel with each other, and also allow a refrigerant in the flat tubes (**31**) of the auxiliary windward heat exchange region (**37**) of the windward bank (**30**) and a refrigerant in the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**) of the leeward bank (**40**) to flow in parallel with each other. That is, the outdoor heat exchanger (**23**) which functions as a condenser and an evaporator is configured to allow a refrigerant in the sets of windward refrigerant channels (C**1**) in the principal windward heat exchange region (**35**) to flow in parallel with a refrigerant in the sets of leeward refrigerant channels (C**2**) in the principal leeward heat exchange region (**45**).

[0102] Further, the outdoor heat exchanger (**23**) is configured to allow, when functioning as a condenser and an evaporator, the refrigerant in the flat tubes (**31**) of the windward bank (**30**) and the refrigerant in the flat tubes (**41**) of the leeward bank (**40**) to flow in the same direction. Specifically, the outdoor heat exchanger (**23**) which functions as a condenser and an evaporator is configured to allow the refrigerant in the flat tubes (**31**) of the principal windward heat exchange region (**35**) of the windward bank (**30**) to flow in the same direction as the refrigerant in the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**) of the leeward bank (**40**). In other words, the outdoor heat exchanger (**23**) which functions as a condenser and an evaporator is configured to allow the refrigerant in the sets of windward refrigerant channels (C**1**) in the principal windward heat exchange region (**35**) to flow in the same direction as the refrigerant in the sets of leeward refrigerant channels (C**2**) in the principal leeward heat exchange region (**45**).

[Refrigerant Flow in Outdoor Heat Exchanger Functioning as Condenser]

[0103] During the cooling operation of the air conditioner (**10**), the indoor heat exchanger (**25**) functions as an evaporator, and the outdoor heat exchanger (**23**) functions as a condenser. In this section, it will be described how the refrigerant flows in the outdoor heat exchanger (**23**) during the cooling operation.

[0104] In the outdoor heat exchanger (**23**), a gas refrigerant discharged from the compressor (**21**) flows into the branched gas pipe (**29**), and diverges into the first and second principal gas pipes (**52***a*) and (**72***a*).

[0105] As shown in FIG. **3**, the refrigerant supplied to the first principal gas pipe (**52***a*) flows into the upper windward space (**52**) of the first header collecting pipe (**50**), and is distributed to the principal windward heat exchange sections (**36**). Flows of the refrigerant passing through the set of windward refrigerant channels (C**1**) in each of the flat tubes (**31**) of the principal windward heat exchange sections (**36**) are condensed through dissipation of heat to the air. Thereafter, the flows of the refrigerant are respectively supplied to the principal windward communicating spaces (**65**) of the second header collecting pipe (**60**), and enter the windward communicating pipes (**68**). The flows of the refrigerant that have passed through the windward communicating pipes (**68**) are respectively supplied to the auxiliary windward communicating spaces (**67**) of the second header collecting pipe (**60**), and enter the auxiliary windward heat exchange sections (**38**). The flows of the refrigerant passing through the sets of windward refrigerant channels (C**1**) in the flat tubes (**31**) of each of the auxiliary windward heat exchange sections (**38**) are condensed through further dissipation of heat to the air, and supercooled (turn to a single liquid phase).

[0106] The flows of the supercooled liquid refrigerant are supplied to the auxiliary windward spaces (**55**) of the first header collecting pipe (**50**), merge together in the first divergence unit (**91**), and the merged refrigerant passes through the first principal liquid pipe (**91***c*).

[0107] As shown in FIG. **4**, the refrigerant supplied to the second principal gas pipe (**82***a*) flows into the upper leeward space (**72**) of the third header collecting pipe (**70**), and is distributed to the principal leeward heat exchange sections (**46**). Flows of the refrigerant passing through the sets of leeward refrigerant channels (C**2**) in the flat tubes (**41**) of each of the principal leeward heat exchange sections (**46**) are condensed through dissipation of heat to the air. Thereafter, the flows of the refrigerant are respectively supplied to the principal leeward communicating spaces (**85**) of the fourth header collecting pipe (**80**), and enter the leeward communicating pipes (**88**). The flows of the refrigerant that have passed through the leeward communicating pipes (**88**) are respectively supplied to the auxiliary leeward communicating spaces (**87**) of the fourth header collecting pipe (**80**), and enter the auxiliary leeward heat exchange sections (**48**). The flows of the refrigerant passing through the sets of leeward refrigerant channels (C**2**) in the flat tubes (**41**) of each of the auxiliary leeward heat exchange sections (**48**) are condensed through further dissipation of heat to the air, and supercooled (turn to a single liquid phase).

[0108] The flows of the supercooled liquid refrigerant are supplied to the auxiliary leeward spaces (**75**) of the third header collecting pipe (**70**), merge together in the second divergence unit (**92**), and then pass through the second principal liquid pipe (**92***c*).

[0109] The refrigerant passing through the first principal liquid pipe (**91***c*) and the refrigerant passing through the second principal liquid pipe (**92***c*) merge together in the branched liquid pipe (**28**), and are sent to the liquid interconnecting pipe (**13**).

[Changes in Temperatures of Refrigerant and Air in Outdoor Heat Exchanger Functioning as Condenser]

[0110] FIG. **11** shows exemplary changes in the temperatures of the air and the refrigerant in the outdoor heat exchanger (**23**) functioning as a condenser.

[0111] A superheated gas refrigerant at 70° C. flows into the flat tubes (**31**) of the principal windward heat exchange region (**35**). This refrigerant turns to a saturated gas refrigerant at 50° C. while passing through the sets of windward refrigerant channels (C**1**) of the flat tubes (**31**) of the principal windward heat exchange region (**35**), and then is gradually condensed. The refrigerant flowing out of the principal windward heat exchange region (**35**) flows into the flat tubes (**31**) of the auxiliary windward heat exchange region (**37**). This refrigerant turns to a saturated, single-phase liquid refrigerant (saturated temperature: 50° C.) while passing through the sets of windward refrigerant channels (C**1**) in the flat tubes (**31**) of the auxiliary windward heat exchange region (**37**), and further dissipates heat to become a supercooled refrigerant (at 42° C., for example).

[0112] A superheated gas refrigerant at 70° C. flows into the flat tubes (**41**) of the principal leeward heat exchange region (**45**). This refrigerant turns to a saturated gas refrigerant at 50° C. while passing through the sets of leeward refrigerant channels (C**2**) of the flat tubes (**41**) of the principal leeward heat exchange region (**45**), and then is gradually condensed. The refrigerant flowing out of the principal leeward heat exchange region (**45**) flows into the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**). This refrigerant turns to a saturated, single-phase liquid refrigerant (saturated temperature: 50° C.) while passing through the sets of windward refrigerant channels (C**2**) in the flat tubes (**41**) of the auxiliary windward heat exchange region (**47**), and further dissipates heat to become a supercooled refrigerant (at 47° C., for example).

[0113] On the other hand, the air at 35° C., for example, flows into the principal windward heat exchange region (**35**) and the auxiliary leeward heat exchange region (**37**). The air heated to 45° C. in the principal windward heat exchange region (**35**) flows into the principal leeward heat exchange region (**45**), and the air heated to 40° C. while passing through the auxiliary windward heat exchange region (**37**) flows into the auxiliary leeward heat exchange region (**47**).

[0114] As can be seen from the foregoing, when the outdoor heat exchanger (**23**) functions as a condenser, the temperature of the refrigerant becomes higher than the temperature of the air throughout the outdoor heat exchanger (**23**). This ensures a sufficient quantity of heat released from the refrigerant to the air (a sufficient quantity of heat dissipated from the refrigerant).

[Refrigerant Flow in Outdoor Heat Exchanger Functioning as Evaporator]

[0115] During the heating operation of the air conditioner (**10**), the indoor heat exchanger (**25**) functions as a condenser, and the outdoor heat exchanger (**23**) functions as an evaporator. In this section, it will be described how the refrigerant flows in the outdoor heat exchanger (**23**) during the heating operation.

[0116] A refrigerant that has expanded while passing through the expansion valve (**24**) and turned into a two-phase gas and liquid refrigerant is supplied to the outdoor heat exchanger (**23**) via the pipe (**17**). This refrigerant flows into the branched liquid pipe (**28**), and diverges into the first and second principal liquid pipes (**91***c*) and (**92***c*).

[0117] As shown in FIG. **12**, the refrigerant supplied to the first divergence unit (**91**) diverges to the liquid connecting pipes (**91***b*), and is distributed to the auxiliary windward heat exchange sections (**38**) via the auxiliary windward spaces (**55**) of the first header collecting pipe (**50**). Flows of the refrigerant passing through the sets of windward refrigerant channels (C**1**) in the flat tubes (**31**) of each of the auxiliary windward heat exchange sections (**38**) evaporate through absorption of heat from the air. Thereafter, the flows of the refrigerant are respectively supplied to the auxiliary windward communicating spaces (**67**) of the second header collecting pipe (**60**), and enter the windward communicating pipes (**68**). The flows of the refrigerant that have passed through the windward communicating pipes (**68**) are respectively supplied to the principal windward communicating spaces (**65**) of the second header collecting pipe (**60**), and enter the principal windward heat exchange sections (**36**). The flows of the refrigerant passing through the sets of windward refrigerant channels (C**1**) in the flat tubes (**31**) of each of the principal windward heat exchange sections (**36**) evaporate through further absorption of heat from the air to be superheated (turn to a single gas phase).

[0118] The flows of the superheated gas refrigerant merge together in the upper windward space (**52**) of the first header collecting pipe (**50**), and then the merged refrigerant is sent to the gas interconnecting pipe (**14**) via the first principal gas pipe (**52***a*).

[0119] As shown in FIG. **13**, the refrigerant supplied to the second divergence unit (**92**) diverges to the liquid connecting pipes (**92***b*), and enter the auxiliary leeward heat exchange sections (**48**) via the auxiliary leeward spaces (**75**) of the third header collecting pipe (**70**). Flows of the refrigerant passing through the sets of leeward refrigerant channels (C**2**) in the flat tubes (**41**) of each of the auxiliary leeward heat exchange sections (**48**) evaporate through absorption of heat from the air. Thereafter, the flows of the refrigerant are respectively supplied to the auxiliary leeward communicating spaces (**87**) of the fourth header collecting pipe (**80**), and enter the leeward communicating pipes (**88**). The flows of the refrigerant that have passed through the leeward communicating pipes (**88**) are respectively supplied to the principal leeward communicating spaces (**85**) of the fourth header collecting pipe (**80**), and enter the principal leeward heat exchange sections (**46**). The flows of the refrigerant passing through the sets of leeward refrigerant channels (C**2**) in the flat tubes (**41**) of each of the principal leeward heat exchange sections (**46**) evaporate through further absorption of heat from the air to be superheated (turn to a single gas phase).

[0120] The flows of the superheated gas refrigerant merge together in the upper leeward space (**72**) of the third header collecting pipe (**70**), and then go through the second principal gas pipe (**72***a*).

[0121] The refrigerant passing through the first principal gas pipe (**52***a*) and the refrigerant passing through the second principal gas pipe (**72***a*) merge together in the branched gas pipe (**29**), and the merged refrigerant is sent to the gas interconnecting pipe (**14**).

[Changes in Temperatures of Refrigerant and Air in Outdoor Heat Exchanger Functioning as Evaporator]

[0122] Exemplary changes in the temperatures of the air and the refrigerant in the outdoor heat exchanger (**23**) functioning as a condenser will be described below with reference to FIG. **14**.

[0123] A two-phase gas and liquid refrigerant at a saturation temperature of 1.5° C. flows into the flat tubes (**31**) of the auxiliary windward heat exchange region (**37**). In each of the flat tubes (**31**) of the auxiliary windward heat exchange region (**37**), the saturation temperature of the refrigerant gradually decreases to about 0.5° C. due to the pressure loss of the refrigerant passing through the set of windward refrigerant channels (C**1**).

[0124] The two-phase gas and liquid refrigerant, flowing out of the auxiliary windward heat exchange region (**37**), flows into the flat tubes (**41**) of the principal windward heat exchange region (**35**). In each of the flat tubes (**31**) of the principal windward heat exchange region (**35**), the saturation temperature of the refrigerant further decreases (to 0° C., for example) due to the pressure loss of the refrigerant passing through the set of windward refrigerant channels (C**1**). This refrigerant turns to a single-phase gas refrigerant while passing through the flat tubes (**31**) in the principal windward heat exchange region (**35**), has its temperature raised to 1° C., and then flows out of the flat tubes (**31**) of the principal windward heat exchange region (**35**).

[0125] A two-phase gas and liquid refrigerant at a saturation temperature of 1.5° C. flows into the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**). In each of the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**), the saturation temperature of the refrigerant gradually decreases to about 0.5° C. due to the pressure loss of the refrigerant passing through the set of leeward refrigerant channels (C**2**).

[0126] A two-phase gas and liquid refrigerant at a saturation temperature of 1.5° C. flows into the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**). In each of the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**), the saturation temperature of the refrigerant gradually decreases to about 0.5° C. due to the pressure loss of the refrigerant passing through the set of leeward refrigerant channels (C**2**).

[0127] The two-phase gas and liquid refrigerant, flowing out of the auxiliary leeward heat exchange region (**47**), flows into the flat tubes (**41**) of the principal leeward heat exchange region (**45**). In each of the flat tubes (**41**) of the principal leeward heat exchange region (**45**), the saturation temperature of the refrigerant further decreases (to 0° C., for example) due to the pressure loss of the refrigerant passing through the set of leeward refrigerant channels (C**2**). This refrigerant turns to a single gas phase refrigerant while passing through the flat tubes (**41**) of the principal leeward heat exchange region (**45**), has its temperature raised to 1°

C., and then flows out of the flat tubes (**41**) of the principal leeward heat exchange region (**45**).

[0128] On the other hand, the air of 7° C., for example, flows into the auxiliary windward heat exchange region (**37**) and the principal windward heat exchange region (**35**). Further, the air cooled to 3° C. while passing through the auxiliary windward heat exchange region (**37**) flows into the auxiliary leeward heat exchange region (**47**), and the air cooled to 2° C. while passing through the principal windward heat exchange region (**35**) flows into the principal leeward heat exchange region (**45**).

[0129] As can be seen from the foregoing, when the outdoor heat exchanger (**23**) functions as an evaporator, the temperature of the refrigerant becomes lower than the temperature of the air throughout the outdoor heat exchanger (**23**). This ensures a sufficient quantity of heat absorbed from the air to the refrigerant (a sufficient quantity of heat absorbed by the refrigerant).

[Reduction of Pressure Loss]

[0130] As can be seen, according to the embodiment described above, in both of the situation where the outdoor heat exchanger (**23**) functions as a condenser and the situation where the heat exchanger (**23**) functions as an evaporator, the refrigerant in the sets of windward refrigerant channels (C**1**) and the refrigerant in the sets of leeward refrigerant channels (C**2**) flow in parallel with each other.

[0131] For example, in a configuration where the refrigerants in the two sets of refrigerant channels (C**1**, C**2**) flow in series (in a comparative example), not only the flow velocity of the refrigerant flowing through each of the flat tubes (**31**, **41**) but also the total length of the refrigerant channels (C) will double, compared to the present embodiment. The pressure loss of the refrigerant channels (C) is proportional to the square of the velocity of a refrigerant flow, and to the total length of the refrigerant channels. Thus, the pressure loss of the refrigerant in the refrigerant channels (C) of the comparative example is approximately eight times larger than that of the present embodiment (=2×22). Specifically, in this embodiment, the refrigerant in the sets of refrigerant channels (C**1**) in the windward bank (**30**) and the refrigerant in the sets of refrigerant channels (C**2**) in the leeward bank (**40**) are allowed to flow in parallel with each other. This configuration reduces the pressure loss of the refrigerant in the refrigerant channels (C) to ⅛ of that of the comparative example.

[0132] Reducing the pressure loss of the refrigerant in this manner substantially prevents the pressure of the refrigerant from decreasing in the outdoor heat exchanger (**23**) functioning as an evaporator, for example. Specifically, in the outdoor heat exchanger (**23**) functioning as an evaporator, the magnitude of the decrease in refrigerant pressure due to the pressure loss can be reduced. Thus, the difference between an inlet pressure and an outlet pressure of the outdoor heat exchanger (**23**), i.e., the difference between the suction pressure of the compressor (**21**) and the pressure of the refrigerant flowing into the outdoor heat exchanger (**23**), can be reduced. As a result, when the suction pressure of the compressor (**21**) is set to a predetermined value, an evaporating pressure, and eventually an evaporating temperature, of the refrigerant flowing into the outdoor heat exchanger (**23**) can be reduced as compared to that of the comparative example. This configuration increases the difference in temperature between the refrigerant flowing through the sets of refrigerant channels (C**1**) of the windward bank (**30**) and the air passing through the windward bank (**30**) in the outdoor heat exchanger (**23**), thereby improving the evaporation performance of the outdoor heat exchanger (**23**).

Advantages of First Embodiment

[0133] The first embodiment achieves the following advantages and effects.

[0134] The refrigerants in the flat tubes (**31**, **41**) of the banks (**30**, **40**) are allowed to flow in parallel with each other. Thus, the pressure loss of the refrigerants flowing through the refrigerant channels (C) of the flat tubes (**31**, **41**) can be drastically reduced. Consequently, with an increase in power caused by the increase in pressure loss reduced, a desired heat exchange efficiency can be achieved.

[0135] Further, there is no need to increase the width of the flat tubes (**31**, **41**). This facilitates the bending of the flat tubes (**31**, **41**) of each bank (**30**, **40**). Thus, the flat tubes (**31**, **41**) of each bank (**30**, **40**) may be bent to fabricate a four-surface heat exchanger. This allows for downsizing of the heat exchanger.

[0136] As shown in FIG. **2**, the branched liquid pipe (**28**) and the branched gas pipe (**29**) for providing parallel refrigerant flows in the banks (**30**, **40**) may be collectively arranged. This configuration can reduce the space occupied by the pipes, or facilitate the installation of the pipes.

[0137] Reducing the width of the flat tubes (**31**, **41**) allows the ventilation resistance between the flat tubes (**31**, **41**) of each bank (**30**, **40**) to be reduced, thus curbing a decline in thermal transmittance. Further, the decrease in the width of the flat tubes (**31**, **41**) also precludes the possibility of condensed water stagnating on the flat tubes (**31**, **41**). This substantially prevents the surfaces of the flat tubes (**31**, **41**) from being frosted.

Second Embodiment

[0138] An air conditioner (**10**) according to a second embodiment includes an outdoor heat exchanger (**23**) configured differently from the counterpart of the first embodiment. The outdoor heat exchanger (**23**) of the second embodiment has a windward bank (**30**) configured in the same manner as the counterpart of the first embodiment. The following description of the second embodiment with reference to FIGS. **15-20** will be focused on only differences from the first embodiment.

[0139] According to the second embodiment, the third header collecting pipe (**70**) is arranged to stand upright near one end of the leeward bank (**40**) adjacent to the fourth side surface (**23***d*). The fourth header collecting pipe (**80**) is arranged to stand upright near the other end of the leeward bank (**40**) adjacent to the first side surface (**23***a*). That is to say, in the second embodiment, the positions where the third and fourth header collecting pipes (**70**) and (**80**) are arranged in the longitudinal direction of the flat tubes (**31**, **41**) are interchanged, compared to the first embodiment. As in the first embodiment, the second divergence unit (**92**) is also arranged to stand upright near the third header collecting pipe (**70**).

[0140] The first and second principal gas pipes (**52***a*) and (**72***a*) communicate with the gas interconnecting pipe (**14**) via a branch pipe (not shown). The first and second principal liquid pipes (**91***c*) and (**92***c*) communicate with the liquid interconnecting pipe (**13**) via a branch pipe (not shown).

—Refrigerant Flow in Outdoor Heat Exchanger—

[0141] As shown in FIGS. **16-19**, when the outdoor heat exchanger (**23**) functions as a condenser and an evaporator, the refrigerant in the flat tubes (**31**) of the windward bank (**30**) and the refrigerant in the flat tubes (**41**) of the leeward bank (**40**) flow in parallel with each other. Specifically, the outdoor heat exchanger (**23**) which functions as a condenser and an evaporator is configured to allow a refrigerant in the flat tubes (**31**) of the principal windward heat exchange region (**35**) of the windward bank (**30**) and a refrigerant in the flat tubes (**41**) of the principal leeward heat exchange region (**45**) of the leeward bank (**40**) to flow in parallel with each other, and also allow a refrigerant in the flat tubes (**31**) of the auxiliary windward heat exchange region (**37**) of the windward bank (**30**) and a refrigerant in the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**) of the leeward bank (**40**) to flow in parallel with each other. That is, the outdoor heat exchanger (**23**) which functions as a condenser and an evaporator is configured to allow a refrigerant in the sets of windward refrigerant channels (C**1**) in the principal windward heat exchange region (**35**) to flow in parallel with a refrigerant in the sets of leeward refrigerant channels (C**2**) in the principal leeward heat exchange region (**45**).

[0142] Further, when the outdoor heat exchanger (**23**) functions a condenser and an evaporator, the refrigerant in the flat tubes (**31**) of the windward bank (**30**) and the refrigerant in the flat tubes (**41**) of the leeward bank (**40**) flow in opposite directions. Specifically, the outdoor heat exchanger (**23**) which functions as a condenser and an evaporator is configured to allow the refrigerant in the flat tubes (**31**) of the principal windward heat exchange region (**35**) of the windward bank (**30**) to flow in the opposite direction to the refrigerant in the flat tubes (**41**) of the auxiliary leeward heat exchange region (**47**) of the leeward bank (**40**). In other words, the outdoor heat exchanger (**23**) which functions as a condenser and an evaporator is configured to allow the refrigerant in the sets of windward refrigerant channels (C**1**) in the principal windward heat exchange region (**35**) to flow in the opposite direction to the refrigerant in the sets of leeward refrigerant channels (C**2**) in the principal leeward heat exchange region (**45**).

[When Outdoor Heat Exchanger Functions as Condenser]

[0143] During the cooling operation of the air conditioner (**10**), the indoor heat exchanger (**25**) functions as an evaporator, and the outdoor heat exchanger (**23**) functions as a condenser. In this section, it will be described how the refrigerant flows in the outdoor heat exchanger (**23**) during the cooling operation.

[0144] The gas refrigerant discharged from the compressor (**21**) is supplied to the outdoor heat exchanger (**23**) via the pipe (**18**). This refrigerant in the pipe (**18**) diverges into the first and second principal gas pipes (**52***a*) and (**82***a*).

[0145] As shown in FIG. **16**, the refrigerant supplied to the first principal gas pipe (**52***a*) flows into the upper windward space (**52**) of the first header collecting pipe (**50**), and is distributed to the principal windward heat exchange sections (**36**). Flows of the refrigerant passing through the sets of windward refrigerant channels (C**1**) in the flat tubes (**31**) of each of the principal windward heat exchange sections (**36**) are condensed through dissipation of heat to the air. Thereafter, the flows of the refrigerant are respectively supplied to the principal windward communicating spaces (**65**) of the second header collecting pipe (**60**), and enter the windward communicating pipes (**68**). The flows of the refrigerant that have passed through the windward communicating pipes (**68**) are respectively supplied to the auxiliary windward communicating spaces (**67**) of the second header collecting pipe (**60**), and enter the auxiliary windward heat exchange sections (**38**). The flows of the refrigerant passing through the sets of windward refrigerant channels (C**1**) in the flat tubes (**31**) of each of the auxiliary windward heat exchange sections (**38**) are condensed through further dissipation of heat to the air, and supercooled (turn to a single liquid phase).

[0146] The flows of the supercooled liquid refrigerant are respectively supplied to the auxiliary windward spaces (**55**) of the first header collecting pipe (**50**), merge together in the first divergence unit (**91**), and are sent to the liquid interconnecting pipe (**13**) via the first principal liquid pipe (**91***c*).

[0147] As shown in FIG. **17**, the refrigerant supplied from the pipe (**18**) to the second principal gas pipe (**72***a*) flows into the upper leeward space (**72**) of the third header collecting pipe (**70**), and is distributed to the principal leeward heat exchange sections (**46**). Flows of the refrigerant passing through the sets of leeward refrigerant channels (C**2**) in the flat tubes (**41**) of each of the principal leeward heat exchange sections (**46**) are condensed through dissipation of heat to the air. Thereafter, the flows of the refrigerant are respectively supplied to the principal leeward communicating spaces (**85**) of the fourth header collecting pipe (**80**), and enter the leeward communicating pipes (**88**). The flows of the refrigerant that have passed through the leeward communicating pipes (**88**) are respectively supplied to the auxiliary leeward communicating spaces (**87**) of the fourth header collecting pipe (**80**), and enter the auxiliary leeward heat exchange sections (**48**). The flows of the refrigerant passing through the sets of leeward refrigerant channels (C**2**) in the flat tubes (**41**) of each of the auxiliary leeward heat exchange sections (**48**) are condensed through further dissipation of heat to the air, and supercooled (turn to a single liquid phase).

[0148] The flows of the supercooled liquid refrigerant are supplied to the auxiliary leeward spaces (**75**) of the third header collecting pipe (**70**), merge together in the second divergence unit (**92**), and then the merged refrigerant is sent to the liquid interconnecting pipe (**13**) together with the refrigerant flowing out of the first divergence unit (**91**).

[When Outdoor Heat Exchanger Functions as Evaporator]

[0149] During the heating operation of the air conditioner (**10**), the indoor heat exchanger (**25**) functions as a condenser, and the outdoor heat exchanger (**23**) functions as an evaporator. In this section, it will be described how the refrigerant flows in the outdoor heat exchanger (**23**) during the heating operation.

[0150] A refrigerant that has expanded while passing through the expansion valve (**24**) and turned into a two-phase gas and liquid refrigerant is supplied to the outdoor heat exchanger (**23**) via the pipe (**17**). This refrigerant diverges from the pipe (**17**) into the first and second divergence units (**91**) and (**92**).

[0151] As shown in FIG. **18**, the refrigerant supplied to the first divergence unit (**91**) diverges to the liquid connecting pipes (**91***b*), and is distributed to the auxiliary windward heat exchange sections (**38**) via the auxiliary windward spaces

(**55**) of the first header collecting pipe (**50**). Flows of the refrigerant passing through the sets of windward refrigerant channels (C**1**) in the flat tubes (**31**) of each of the auxiliary windward heat exchange sections (**38**) evaporate through absorption of heat from the air. Thereafter, the flows of the refrigerant are respectively supplied to the auxiliary windward communicating spaces (**67**) of the second header collecting pipe (**60**), and enter the windward communicating pipes (**68**). The flows of the refrigerant that have passed through the windward communicating pipes (**68**) are respectively supplied to the principal windward communicating spaces (**65**) of the second header collecting pipe (**60**), and enter the principal windward heat exchange sections (**36**). The flows of the refrigerant passing through the sets of windward refrigerant channels (C**1**) in the flat tubes (**31**) of each of the principal windward heat exchange sections (**36**) evaporate through further absorption of heat from the air to be superheated (turn to a single gas phase).

[0152] The flows of the superheated gas refrigerant merge together in the upper windward space (**52**) of the first header collecting pipe (**50**), and then the merged refrigerant is sent to the gas interconnecting pipe (**14**) via the first principal gas pipe (**52***a*).

[0153] As shown in FIG. **19**, the refrigerant supplied to the second divergence unit (**92**) diverges to the liquid connecting pipes (**92***b*), and enter the auxiliary leeward heat exchange sections (**48**) via the auxiliary leeward spaces (**75**) of the third header collecting pipe (**70**). Flows of the refrigerant passing through the sets of leeward refrigerant channels (C**2**) in the flat tubes (**41**) of each of the auxiliary leeward heat exchange sections (**48**) evaporate through absorption of heat from the air. Thereafter, the flows of the refrigerant are respectively supplied to the auxiliary leeward communicating spaces (**87**) of the fourth header collecting pipe (**80**), and enter the leeward communicating pipes (**88**). The flows of the refrigerant that have passed through the leeward communicating pipes (**88**) are respectively supplied to the principal leeward communicating spaces (**85**) of the fourth header collecting pipe (**80**), and enter the principal leeward heat exchange sections (**46**). The flows of the refrigerant passing through the sets of leeward refrigerant channels (C**2**) in the flat tubes (**41**) of each of the principal leeward heat exchange sections (**46**) evaporate through further absorption of heat from the air to be superheated (turn to a single gas phase).

[0154] The flows of the superheated gas refrigerant merge together in the upper leeward space (**72**) of the third header collecting pipe (**70**), and the merged refrigerant is sent to the gas interconnecting pipe (**14**) together with the refrigerant flowing out of the first principal gas pipe (**52***a*).

<How to Reduce Drift of Air>

[0155] When the outdoor heat exchanger (**23**) functions as an evaporator, there has been a problem that the air flowing through the outdoor heat exchanger (**23**) tends to drift. Specifically, in the outdoor heat exchanger (**23**), each of the two banks (**30**, **40**) is provided with the sets of refrigerant channels (C**1**, C**2**), and refrigerants in the sets of refrigerant channels (C**1**, C**2**) are allowed to flow in parallel with each other. In each of the sets of refrigerant channels (C**1**, C**2**), the two-phase gas and liquid refrigerant is used to cool the air. Thus, moisture in the air may sometimes be condensed to frost the surfaces of the flat tubes (**31**, **41**) and fins (**32**, **42**).

[0156] On the other hand, when the two-phase gas and liquid refrigerant further evaporates in each set of refrigerant channels (C**1**, C**2**), the refrigerant becomes superheated to raise the temperature. Thus, moisture in the air is not easily condensed in a portion of the flat tubes (**31**, **41**) where the superheated refrigerant flows, thus almost eliminating frost from the surfaces of the flat tubes (**31**, **41**) and fins (**32**, **42**).

[0157] For these reasons, when the liquid, or two-phase gas and liquid refrigerant flows through a portion of one of adjacent sets of refrigerant channels (C**1**, C**2**), and the superheated refrigerant flows through a portion of the other set of refrigerant channels (C**1**, C**2**), the former and latter portions may overlap with each other in the air flow direction. In that case, the air flowing through the outdoor heat exchanger (**23**) tends to drift.

[0158] Specifically, for example, when a portion of one of two adjacent sets of refrigerant channels (C**1**, C**2**) and a portion of the other set of refrigerant channels (C**1**, C**2**), through each of which the liquid, or two-phase gas and liquid refrigerant flows, overlap with each other in the air flow direction, the surfaces of the flat tubes (**31**, **41**) and fins (**32**, **42**) corresponding to these portions tends to be frosted as described above. In particular, water condensed on the surfaces of the flat tubes (**31**, **41**) tends to stagnate there. Thus, the amount of frost on the surfaces tends to increase. In such a state, the flat tubes (**31**, **41**) and fins (**32**, **42**) of both of the windward and leeward banks (**30**) and (**40**) will be continuously frosted. As a result, the ventilation resistance tends to increase around the frosted flat tubes and fins.

[0159] On the other hand, when a portion of one of the adjacent sets of refrigerant channels (C**1**, C**2**) and a portion of the other set of refrigerant channels (C**1**, C**2**), through each of which the superheated refrigerant flows, overlap with each other in the air flow direction, the surfaces of the flat tubes (**31**, **41**) and fins (**32**, **42**) corresponding to these portions are hardly frosted. Thus, in such a state, the ventilation resistance around the superheated portions overlapping with each other in two banks becomes lower than anywhere else, allowing the air to drift more easily around the superheated portions.

[0160] If the drift of the air occurs in this way, not all of the flat tubes (**31**, **41**) and fins (**32**, **42**) of the outdoor heat exchanger (**23**) can be effectively used for heat transfer between the refrigerant and the air. This lay lead to a decrease in heat exchange efficiency. According to this embodiment, superheated regions (S**1**, S**2**) of the banks (**30**, **40**) are configured not to overlap with each other in the air flow direction so as to prevent the drift of the air.

[0161] Specifically, as shown in FIGS. **19-21**, in the outdoor heat exchanger (**23**), the refrigerant in the sets of windward refrigerant channels (C**1**) and the refrigerant in the sets of leeward refrigerant channels (C**2**) flow in opposite directions as described above. Thus, the superheated region (S**1**) of the windward bank (**30**) is formed near an end of each of the first windward tube portions (**31***a*) of the flat tubes (**31**), while the superheated region (S**2**) of the leeward bank (**40**) is formed near an end of each of the fourth leeward tube portions (**41***d*) of the flat tubes (**41**). That is, the superheated regions (S**1**) and (S**2**) are disposed most distant from each other in the longitudinal direction of the flat tubes (**31**, **41**). This can effectively prevent the superheated regions (S**1**) and (S**2**) from overlapping with each other in the air flow direction, and also substantially eliminates the above-described drift of the air.

[0162] In the outdoor heat exchanger (**23**), various parameters, such as the number and size of the flat tubes (**31**, **41**), the number and size of the refrigerant channels (C), the amount of the refrigerant circulating, and the volume of the air, are set to prevent the superheated regions (S**1**) and (S**2**) from overlapping with each other in the air flow direction.

Advantages of Second Embodiment

[0163] According to the second embodiment, the pressure loss of the refrigerant can also be reduced as in the first embodiment.

[0164] As shown in FIGS. **18-20**, when the outdoor heat exchanger (**23**) functions as an evaporator, the superheated regions (S**1**, S**2**) where the superheated refrigerants flow can be substantially prevented from overlapping with each other. Thus, the biased drift of the air only toward the superheated regions (S**1**, S**2**) can be prevented. As a result, even if frosting occurs on the surfaces of the flat tubes (**31**, **41**) and fins (**32**, **42**) other than the superheated regions (S**1**, S**2**), the air can still flow uniformly throughout the heat exchanger. This improves the heat exchange efficiency, and eventually the evaporation performance, of the heat exchanger.

Other Embodiments

[0165] The embodiments of the present disclosure may be modified in the following manner.

[0166] In the outdoor heat exchanger (**23**), each adjacent pair of the header collecting pipes (**50**, **70**) and (**60**, **80**) is comprised of two separate members. Alternatively, at least one pair of these header collecting pipes may be configured as a single member, and the internal space thereof may be divided into two.

[0167] In the outdoor heat exchanger (**23**), the superheated regions (S**1**, S**2**) of the sets of refrigerant channels (C**1**, C**2**) adjacent to each other in the two banks of the flat tubes (**31**, **41**) do not overlap with each other. Alternatively, each adjacent pair of the superheated regions among three or more sets of refrigerant channels (C**1**, C**2**), for example, may be configured not to overlap with each other.

[0168] The auxiliary heat exchange regions (**37**, **47**) of the outdoor heat exchanger (**23**) may be omitted.

[0169] The heat exchanger of the present disclosure is implemented as the outdoor heat exchanger (**23**). Alternatively, the heat exchanger of the present disclosure may also be implemented as the indoor heat exchanger (**25**). In such a case, the indoor heat exchanger (**25**) is suitably a four-surface heat exchanger built in a ceiling-mounted, or -suspended indoor unit, for example. The outdoor and indoor heat exchangers (**23**) and (**25**) do not necessarily have four surfaces, but may have three surfaces or less.

[0170] The heat exchanger of the present disclosure has, as shown in FIG. **7**, for example, the fins (**32**, **42**) separately provided on the windward and leeward sides for the windward and leeward banks (**30**) and (**40**), respectively. Alternatively, as shown in FIG. **21**, for example, the flat tubes (**31**, **41**) may form two banks arranged in the air flow direction, and the windward and leeward fins (**32**, **42**) may be configured as a single fin covering both of the windward and leeward banks (**30**) and (**40**).

[0171] Each of the fins (**32**, **42**) of the heat exchanger of the present disclosure is provided with the tube receiving portions (**32***b*, **42***b*) extending from a windward edge portion, and the flat tubes (**31**, **41**) are inserted in the tube receiving portions (**32***b*, **42***b*). Alternatively, the heat exchanger may be configured such that the tube receiving portions are formed to extend from a leeward edge portion of the fin (**32**, **42**), and the flat tubes (**31**, **41**) may be inserted in the tube receiving portions. Further, each of the fins (**32**, **42**) of the present disclosure is provided with the louvers (**32***c*, **42***c*) as heat transfer accelerators. Alternatively, bulges (projections) protruding from the fins (**32**, **42**) in the thickness direction, slits, or any other suitable feature may be provided as the heat transfer accelerator.

[0172] The two banks (**30**, **40**) of the above-described embodiments may have different configurations. Specifically, the flat tubes (**31**, **41**) disposed in two banks, for example, may have different widths, may be arranged at different intervals in the thickness direction (the vertical direction), and may have the refrigerant channels (C) of different channel areas and in different numbers. Moreover, the fins (**32**, **42**) disposed in two banks may have different widths (lengths measured in the air flow direction), may be arranged at different pitches (intervals) in the thickness direction of the fins (**32**, **42**), or may have different shapes.

[0173] In the air conditioner of the present disclosure, a refrigerant regulating valve may be provided for each of the plurality of banks (**30**, **40**). Specifically, if the degrees of opening of the refrigerant regulating valves are controlled separately, the amounts of refrigerants flowing in parallel into the banks (**30**, **40**) may be separately controlled.

INDUSTRIAL APPLICABILITY

[0174] As can be seen from the foregoing description, the present invention is useful for a heat exchanger and an air conditioner.

DESCRIPTION OF REFERENCE CHARACTERS

[0175] **10** Air Conditioner
[0176] **23** Outdoor Heat Exchanger (Heat Exchanger)
[0177] **28** Branched Liquid Pipe
[0178] **29** Branched Gas Pipe
[0179] **30** Windward Bank (Bank)
[0180] **31** Flat Tube
[0181] **32** Fin
[0182] **33***a* First Bent Portion (Bent Portion)
[0183] **33***b* Second Bent Portion (Bent Portion)
[0184] **33***c* Third Bent Portion (Bent Portion)
[0185] **40** Leeward Bank (Bank)
[0186] **41** Flat Tube
[0187] **42** Fin
[0188] **68** Windward Communicating Pipe
[0189] **88** Leeward Communicating Pipe
[0190] C Refrigerant Channel
[0191] S1 Superheated Region
[0192] S2 Superheated Region

1. A heat exchanger, comprising:

a plurality of flat tubes arranged parallel to each other, in each of which a plurality of refrigerant channels are formed; and fins joined to the flat tubes, the heat exchanger allowing a refrigerant flowing through each of the refrigerant channels to exchange heat with air, wherein

a plurality of banks, each of which includes two or more of the flat tubes, are arranged in an air flow direction,

the refrigerants in the plurality of banks flow in parallel with each other, and each of the flat tubes in the plurality of banks has one or more bent portions which are bent in a width direction of the flat tubes such that the flat tubes of a pair of the banks adjacent to each other in the air flow direction extend along each other.

2. The heat exchanger of claim **1**, wherein

each of the banks includes a principal heat exchange region provided for two or more of the flat tubes arranged side by side in an arrangement direction of the flat tubes in each bank, and an auxiliary heat exchange region provided for the flat tubes, which are smaller in number than the two or more of the flat tubes of the principal heat exchange region, and

in the plurality of banks, the refrigerants in the principal heat exchange regions adjacent to each other in the air flow direction flow in parallel with each other, and the refrigerants in the auxiliary heat exchange regions adjacent to each other in the air flow direction flow in parallel with each other.

3. The heat exchanger of claim **2**, wherein

the refrigerant in the flat tubes in the principal heat exchange region and the refrigerant in the flat tubes in the auxiliary heat exchange region in a pair of the banks adjacent to each other in the air flow direction flow in the same direction, and

the heat exchanger further comprises: a branched gas pipe having branches communicating with one end of each of the flat tubes in the principal heat exchange region of each bank,

a branched liquid pipe having branches communicating with one end of each of the flat tubes in the auxiliary heat exchange region of each bank, the one end being adjacent to the branched gas pipe, and

a communicating pipe which allows the other end of each of the flat tubes in the principal heat exchange region of the bank to communicate with the other end of an associated one of the flat tubes in the auxiliary heat exchange region of the bank.

4. The heat exchanger of claim **1**, wherein

the plurality of banks are configured such that when the heat exchanger functions as an evaporator, the refrigerants in the flat tubes in a pair of the banks adjacent to each other in the air flow direction flow in opposite directions.

5. The heat exchanger of claim **4**, wherein

when the heat exchanger functions as the evaporator, superheated refrigerant regions of the flat tubes of a pair of the banks adjacent to each other in the air flow direction do not overlap with each other in the air flow direction.

6. An air conditioner, comprising:

a refrigerant circuit which includes the heat exchanger of claim **1**, and performs a refrigeration cycle, wherein

the air conditioner is switchable between an operation in which the heat exchanger functions as an evaporator, and an operation in which the heat exchanger functions as a condenser.

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