



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

(43) Date of publication:
01.05.2019 Bulletin 2019/18

(21) Application number: **16906317.9**

(22) Date of filing: **24.06.2016**

(51) Int Cl.:
F25B 47/02 ^(2006.01) **F25B 39/00** ^(2006.01)
F25B 39/02 ^(2006.01) **F28F 17/00** ^(2006.01)

(86) International application number:
PCT/JP2016/068810

(87) International publication number:
WO 2017/221400 (28.12.2017 Gazette 2017/52)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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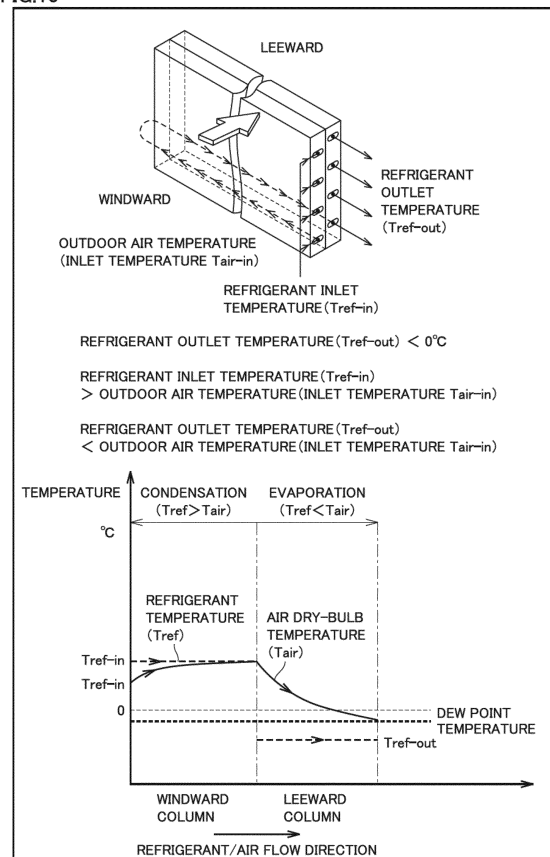
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(54) **REFRIGERATING CYCLE DEVICE AND OUTDOOR HEAT EXCHANGER USED IN SAME**

(57) An outdoor heat exchanger (11) of an air conditioning apparatus (1) includes a main heat exchange unit (13) and an auxiliary heat exchange unit (15). When the outdoor heat exchanger (11) is operated to function as an evaporator, in the outdoor heat exchanger (11), refrigerant flows from the auxiliary heat exchange unit (15) into the main heat exchange unit (13), and in the auxiliary heat exchange unit (15), refrigerant flows from a first heat transfer tube (33a) of an auxiliary heat exchange unit (15a) into a second heat transfer tube (33b) of an auxiliary heat exchange unit (15b). When a refrigerant outlet temperature is lower than a freezing point of water, the operation is performed such that a refrigerant inlet temperature of the refrigerant flowing into the auxiliary heat exchange unit (15) is higher than an outdoor air temperature and that a refrigerant outlet temperature of the refrigerant delivered out of the auxiliary heat exchange unit (15) is lower than the outdoor air temperature.

FIG.10



Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigeration cycle apparatus and an outdoor heat exchanger used for the refrigeration cycle apparatus, and particularly to: a refrigeration cycle apparatus including an outdoor heat exchanger equipped with a main heat exchange unit and an auxiliary heat exchange unit; and such an outdoor heat exchanger.

BACKGROUND ART

[0002] As an outdoor heat exchanger used in an air conditioning apparatus as an example of a refrigeration cycle apparatus, there is an outdoor heat exchanger configured such that a heat transfer tube through which refrigerant flows is disposed so as to penetrate a plurality of plate-shaped fins. Such an outdoor heat exchanger is referred to as a fin-and-tube type heat exchanger. In this type of outdoor heat exchanger, a flat tube having a cross section formed in a flat shape is used as a heat transfer tube such that heat exchange is efficiently conducted.

[0003] There is one type of outdoor heat exchanger including a main heat exchange unit for condensation and an auxiliary heat exchange unit for supercooling. In general, the main heat exchange unit is disposed on the auxiliary heat exchange unit. When a cooling operation of the refrigeration cycle apparatus is performed, the refrigerant having flown into the outdoor heat exchanger is heat-exchanged with air while the refrigerant flows through the main heat exchange unit, and then, condensed into liquid refrigerant. Then, the liquid refrigerant flows through the auxiliary heat exchange unit, so that the liquid refrigerant is further cooled. PTD 1 is listed herein as an example of a patent literature disclosing a refrigeration cycle apparatus including an outdoor heat exchanger of the above-described type.

CITATION LIST

PATENT LITERATURE

[0004] PTL 1: Japanese Patent Laying-Open No. 2013-83419

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] However, the air conditioning apparatus including the outdoor heat exchanger as described above poses the following problem. When a heating operation of the air conditioning apparatus is performed, the outdoor heat exchanger is operated as an evaporator. When the air temperature on the outside where the outdoor heat exchanger is installed becomes closer to a temperature

below the freezing point, the surface temperature of the outdoor heat exchanger falls below the freezing point in order to maintain the heat exchange performance. Consequently, frost may adhere to the outdoor heat exchanger.

[0006] Particularly when the air conditioning apparatus is operated while the auxiliary heat exchange unit is also used as an evaporator, frost may adhere also to this auxiliary heat exchange unit. When frost adheres to the outdoor heat exchanger, the ventilation resistance increases, so that the heat exchange performance deteriorates. In order to prevent adhesion of frost, a defrosting operation is performed in the air conditioning apparatus.

[0007] When the defrosting operation is performed in the state where frost adheres to the outdoor heat exchanger, water resulting from melting of frost flows through the outdoor heat exchanger from its upper portion to its lower portion, so that it falls as drainage water downward through the outdoor heat exchanger. In this case, in the heat exchanger using a flat tube as a heat transfer tube, water resulting from melting of frost is less likely to fall downward but is more likely to accumulate in the auxiliary heat exchange unit located on the lower side.

[0008] Consequently, it takes longer time to perform the defrosting operation for melting the adhering frost, with the result that power consumption is increased. On the other hand, when the heating operation is resumed in the state where frost or water still remains, the remaining water is cooled and frozen by the refrigerant, with the result that the outdoor heat exchanger may become damaged.

[0009] The present invention has been made to solve the above-described problems. One object of the present invention is to provide a refrigeration cycle apparatus including an outdoor heat exchanger configured to prevent adhesion of frost to an auxiliary heat exchange unit. Another object of the present invention is to provide an outdoor heat exchanger including such an auxiliary heat exchange unit.

SOLUTION TO PROBLEM

[0010] A refrigeration cycle apparatus according to the present invention is a refrigeration cycle apparatus comprising an outdoor heat exchanger. The outdoor heat exchanger includes a first heat exchange unit and a second heat exchange unit that is disposed adjacent to the first heat exchange unit. The first heat exchange unit includes a plurality of fins each formed in a plate shape, a first heat transfer tube, a second heat transfer tube, and a pressure loss mechanism. The first heat transfer tube is disposed to penetrate the plurality of fins. The second heat transfer tube is disposed to penetrate the plurality of fins and located at a distance from the first heat transfer tube in a direction crossing a direction in which the first heat transfer tube extends. The pressure loss mechanism is configured to lower pressure of refrigerant flowing

through the first heat exchange unit. During an operation of the outdoor heat exchanger functioning as an evaporator, when a temperature of refrigerant flowing out of the first heat exchange unit is lower than a freezing point of water, the refrigeration cycle apparatus operates such that a temperature of refrigerant flowing into the first heat exchange unit is higher than an outdoor air temperature and that the temperature of the refrigerant flowing out of the first heat exchange unit is lower than the outdoor air temperature.

[0011] An outdoor heat exchanger according to the present invention is an outdoor heat exchanger comprising a first heat exchange unit and a second heat exchange unit that is disposed adjacent to the first heat exchange unit. The first heat exchange unit includes a plurality of fins each formed in a plate shape, a first heat transfer tube, a second heat transfer tube, and a pressure loss unit. The first heat transfer tube is disposed to penetrate the plurality of fins. The second heat transfer tube is disposed to penetrate the plurality of fins and located at a distance from the first heat transfer tube in a direction crossing a direction in which the first heat transfer tube extends. The pressure loss unit is disposed between the first heat transfer tube and the second heat transfer tube.

ADVANTAGEOUS EFFECTS OF INVENTION

[0012] According to the refrigeration cycle apparatus of the present invention, during the operation of the outdoor heat exchanger functioning as an evaporator, when the temperature of the refrigerant flowing out of the first heat exchange unit is lower than the freezing point of water, the refrigeration cycle apparatus operates such that the temperature of the refrigerant flowing into the first heat exchange unit is higher than the outdoor air temperature and that the temperature of the refrigerant flowing out of the first heat exchange unit is lower than the outdoor air temperature. Thereby, adhesion of frost to the first heat exchange unit of the outdoor heat exchanger can be prevented.

[0013] According to the outdoor heat exchanger of the present invention, a pressure loss unit configured to lower the pressure of the refrigerant is provided between the first heat transfer tube and the second heat transfer tube, each of which is disposed so as to penetrate a plurality of fins. Thereby, when the outdoor heat exchanger is operated to function as an evaporator, the temperature of the refrigerant is controlled according to the relation with the temperature of air, so that adhesion of frost to the first heat exchange unit of the outdoor heat exchanger can be prevented.

BRIEF DESCRIPTION OF DRAWINGS

[0014]

Fig. 1 is a diagram showing an example of a refrigerant circuit in an air conditioning apparatus accord-

ing to an embodiment.

Fig. 2 is a perspective view showing an outdoor heat exchanger in the embodiment.

Fig. 3 is a cross-sectional view showing an example of a refrigerant path of a heat transfer tube in the embodiment.

Fig. 4 is a cross-sectional view showing another example of the refrigerant path of the heat transfer tube in the embodiment.

Fig. 5 is a diagram showing each flow of refrigerant in the outdoor heat exchanger at the time when the outdoor heat exchanger is operated to function as a condenser or at the time when the outdoor heat exchanger is operated to function as an evaporator, in the embodiment.

Fig. 6 is a perspective view showing the flow of the refrigerant in the outdoor heat exchanger in the case where the outdoor heat exchanger is operated to function as a condenser in the embodiment.

Fig. 7 is a perspective view showing the flow of the refrigerant in the outdoor heat exchanger in the case where the outdoor heat exchanger is operated to function as an evaporator in the embodiment.

Fig. 8 is a diagram for illustrating the relation between the temperature of the refrigerant flowing through an auxiliary heat exchange unit in the outdoor heat exchanger and the temperature of air in the case where the outdoor heat exchanger is operated to function as an evaporator in an air conditioning apparatus according to the first comparative example.

Fig. 9 is a diagram for illustrating the relation between the temperature of the refrigerant flowing through an auxiliary heat exchange unit in the outdoor heat exchanger and the temperature of air in the case where the outdoor heat exchanger is operated to function as an evaporator in an air conditioning apparatus according to the second comparative example.

Fig. 10 is a diagram for illustrating the relation between the temperature of the refrigerant flowing through the auxiliary heat exchange unit in the outdoor heat exchanger and the temperature of air in the case where the outdoor heat exchanger is operated to function as an evaporator, in the embodiment.

Fig. 11 is a diagram showing the flow of refrigerant in an outdoor heat exchanger in the case where the outdoor heat exchanger is operated to function as an evaporator in an air conditioning apparatus according to the third comparative example.

Fig. 12 is a diagram for illustrating the relation between the temperature of the refrigerant flowing through an auxiliary heat exchange unit in the outdoor heat exchanger and the temperature of air in the case where the outdoor heat exchanger is operated to function as an evaporator in the air conditioning apparatus according to the third comparative example.

Fig. 13 is a diagram for illustrating the relation be-

tween the temperature of the refrigerant flowing through the auxiliary heat exchange unit in the outdoor heat exchanger and the temperature of air in the case where the outdoor heat exchanger is operated to function as an evaporator in the air conditioning apparatus including a heat transfer tube applied as a pressure loss unit, according to the embodiment.

Fig. 14 is a side view schematically showing the auxiliary heat exchange unit equipped with a throttle device as the first example of the pressure loss unit, in the embodiment.

Fig. 15 is a side view schematically showing the auxiliary heat exchange unit equipped with a throttle device as the second example of the pressure loss unit, in the embodiment.

Fig. 16 is a perspective view schematically showing the auxiliary heat exchange unit equipped with an inter-columnar header as the third example of the pressure loss unit, in the embodiment.

Fig. 17 is a cross-sectional view taken along a cross-sectional line XVII-XVII shown in Fig. 16 in the embodiment.

Fig. 18 is a cross-sectional view taken along a cross-sectional line XVIII-XVIII shown in Fig. 16 in the embodiment.

Fig. 19 is a cross-sectional view taken along a cross-sectional line XIX-XIX shown in Fig. 16 in the embodiment.

Fig. 20 is a perspective view schematically showing the auxiliary heat exchange unit equipped with a header as the fourth example of the pressure loss unit, in the embodiment.

Fig. 21 is a perspective view schematically showing the auxiliary heat exchange unit equipped with a U-shaped tube as the fifth example of the pressure loss unit, in the embodiment.

DESCRIPTION OF EMBODIMENTS

First Embodiment

[0015] First, the entire configuration (a refrigerant circuit) of an air conditioning apparatus as an example of a refrigeration cycle apparatus will be hereinafter described. As shown in Fig. 1, an air conditioning apparatus 1 includes a compressor 3, an indoor heat exchanger 5, an indoor fan 7, a throttle device 9, an outdoor heat exchanger 11, an outdoor fan 21, a four-way valve 23, and a control unit 51. Compressor 3, indoor heat exchanger 5, throttle device 9, outdoor heat exchanger 11, and four-way valve 23 are connected through a refrigerant pipe.

[0016] Furthermore, air conditioning apparatus 1 is provided with: two temperature sensors 53 and 55 each configured to detect the temperature of refrigerant in outdoor heat exchanger 11; and a temperature sensor 57 configured to sense the outdoor air temperature. Temperature sensors 53, 55, and 57 are electrically connect-

ed to control unit 51. As will be described later, in air conditioning apparatus 1, control unit 51 controls the temperature of the refrigerant according to the relation with the temperature of the outdoor air (air) in order to prevent adhesion of frost to outdoor heat exchanger 11 when outdoor heat exchanger 11 is operated to function as an evaporator.

[0017] Then, outdoor heat exchanger 11 will be hereinafter described. As shown in Fig. 2, outdoor heat exchanger 11 includes a main heat exchange unit 13 and an auxiliary heat exchange unit 15. Main heat exchange unit 13 is disposed on auxiliary heat exchange unit 15. In auxiliary heat exchange unit 15, a plurality of first heat transfer tubes 33a and a plurality of second heat transfer tubes 33b are disposed so as to penetrate a plurality of plate-shaped fins 31 that are disposed at a distance from one another.

[0018] As each of first heat transfer tubes 33a and second heat transfer tubes 33b, a flat tube is used, which has a flat cross-sectional shape having a major axis and a minor axis. As an example of the flat tube, Fig. 3 shows a flat tube having one refrigerant path 35 formed therein. As another example of the flat tube, Fig. 4 shows a flat tube having a plurality of refrigerant paths 35 formed therein. In addition, each of the first heat transfer tube and the second heat transfer tube is not limited to a flat tube, but may be a heat transfer tube having a cross section, for example, formed in a circular shape, an elliptical shape, and the like.

[0019] The plurality of first heat transfer tubes 33a are disposed to be spaced apart from each other in the direction in which the minor axis extends. The plurality of first heat transfer tubes 33a are disposed in the first column. The first column serves as an auxiliary heat exchange unit 15a. The plurality of second heat transfer tubes 33b are disposed to be spaced apart from each other in the direction in which the minor axis extends. The plurality of second heat transfer tubes 33b are disposed in the second column. The second column serves as an auxiliary heat exchange unit 15b. As will be described later, when the air conditioning apparatus operates, auxiliary heat exchange unit 15a (a windward column) is located on the windward side while auxiliary heat exchange unit 15b (a leeward column) is located on the leeward side.

[0020] The plurality of first heat transfer tubes 33a each have one end (the first end) connected to a distributor 25. Distributor 25 of auxiliary heat exchange unit 15 is connected to throttle device 9 (see Fig. 5). At a portion of the refrigerant pipe in the vicinity of distributor 25, temperature sensor 53 configured to sense the temperature of the refrigerant is provided. The other ends (the second ends) of the plurality of first heat transfer tubes 33a and the other ends (the third ends) of the plurality of second heat transfer tubes 33b are connected through a pressure loss unit 17 (a pressure loss mechanism) configured to lose pressure of the refrigerant. A specific structure of pressure loss unit 17 will be described later.

[0021] The plurality of second heat transfer tubes 33b each have one end (the fourth end) connected to main heat exchange unit 13. At a portion of refrigerant pipe 37 that is connected to one end of second heat transfer tube 33b, temperature sensor 55 configured to sense the temperature of the refrigerant is provided. Fig. 2 representatively shows the case where temperature sensor 55 is provided in the refrigerant pipe that is connected to one end of second heat transfer tube 33b disposed at the lowermost position, but temperature sensors may be provided at portions of the refrigerant pipes that are connected to their respective one ends of the plurality of second heat transfer tubes 33b.

[0022] In main heat exchange unit 13, a plurality of third heat transfer tubes 33c and a plurality of fourth heat transfer tubes 33d are disposed to penetrate the plurality of plate-shaped fins 31 that are disposed to be spaced apart from one another. As each of third heat transfer tubes 33c and fourth heat transfer tubes 33d, a flat tube is used as in the case of first heat transfer tubes 33a and second heat transfer tubes 33b. Fig. 2 shows a series of third heat transfer tube 33c and fourth heat transfer tube 33d for simplification of illustration.

[0023] The plurality of third heat transfer tubes 33c are disposed to be spaced apart from each other in the direction in which the minor axis extends. The plurality of third heat transfer tubes 33c are disposed in the first column (a windward column). The first column serves as main heat exchange unit 13a. The plurality of fourth heat transfer tubes 33d are disposed to be spaced apart from each other in the direction in which the minor axis extends. The plurality of fourth heat transfer tubes 33d are disposed in the second column (a leeward column). The second column serves as a main heat exchange unit 13b.

[0024] The plurality of fourth heat transfer tubes 33d each have one end connected to a corresponding one of one ends of the plurality of second heat transfer tubes 33b through distributor 29. The plurality of fourth heat transfer tubes 33d each have the other end connected to a corresponding one of the other ends of the plurality of third heat transfer tubes 33c. The plurality of third heat transfer tubes 33c each have one end connected to a header 27. Header 27 is connected to four-way valve 23 (see Fig. 5). Outdoor heat exchanger 11 of air conditioning apparatus 1 is configured as described above.

[0025] Then, as an operation (the flow of the refrigerant) of air conditioning apparatus 1 described above, the operation of outdoor heat exchanger 11 functioning as a condenser (a cooling operation) will be first described.

[0026] As shown in Fig. 5, by driving compressor 3, high-temperature and high-pressure gaseous refrigerant is discharged from compressor 3. The refrigerant flows thereafter as indicated by a dotted line arrow. The discharged high-temperature and high-pressure gas refrigerant (a single phase) flows through four-way valve 23 into outdoor heat exchanger 11. In outdoor heat exchanger 11, heat exchange is conducted between the refrigerant flown therethrough and the air supplied by outdoor

fan 21, so that the high-temperature and high-pressure gas refrigerant is condensed into high-pressure liquid refrigerant (a single phase).

[0027] By throttle device 9, the high-pressure liquid refrigerant delivered out of outdoor heat exchanger 11 is turned into refrigerant in a two-phase state including low-pressure gas refrigerant and low-pressure liquid refrigerant. The refrigerant in a two-phase state flows into indoor heat exchanger 5. In indoor heat exchanger 5, heat exchange is conducted between the incoming refrigerant in a two-phase state and the air supplied by indoor fan 7. Then, as a result of evaporation of the liquid refrigerant, the refrigerant in a two-phase state is turned into low-pressure gas refrigerant (a single phase). Through this heat exchange, the indoor area is cooled. The low-pressure gas refrigerant delivered out of indoor heat exchanger 5 flows through four-way valve 23 into compressor 3, and then compressed into high-temperature and high-pressure gas refrigerant, which is again discharged from compressor 3. This cycle is repeated thereafter.

[0028] In the following, an explanation will be given with regard to the flow of the refrigerant in outdoor heat exchanger 11 in the case where outdoor heat exchanger 11 is operated to function as a condenser. As shown in Fig. 6, in outdoor heat exchanger 11, the refrigerant first flows through main heat exchange unit 13, and then flows through auxiliary heat exchange unit 15. Also, by outdoor fan 21 (see Fig. 1), air flows from auxiliary heat exchange unit 15a and main heat exchange unit 13a in the first column (a windward column) toward auxiliary heat exchange unit 15b and main heat exchange unit 13b in the second column (a leeward column), as indicated by an arrow.

[0029] The refrigerant delivered from compressor 3 flows into header 27 and passes through header 27. Then, the refrigerant flows through third heat transfer tube 33c of main heat exchange unit 13a in the direction as indicated by an arrow. The refrigerant having flown through third heat transfer tube 33c then flows through fourth heat transfer tube 33d of main heat exchange unit 13b in the direction as indicated by an arrow, and thereafter flows into distributor 29.

[0030] The refrigerant having flown into distributor 29 then flows through second heat transfer tube 33b of auxiliary heat exchange unit 15b in the direction as indicated by an arrow. The refrigerant having flown through second heat transfer tube 33b then flows through first heat transfer tube 33a of auxiliary heat exchange unit 15a in the direction as indicated by an arrow. The refrigerant having flown through first heat transfer tube 33a is discharged to the outside of outdoor heat exchanger 11.

[0031] Then, an explanation will be hereinafter given with regard to the operation of outdoor heat exchanger 11 functioning as an evaporator (a heating operation). As shown in Fig. 5, by driving compressor 3, high-temperature and high-pressure gaseous refrigerant is discharged from compressor 3. The refrigerant flows thereafter as indicated by a solid line arrow.

[0032] The discharged high-temperature and high-pressure gas refrigerant (single phase) flows through four-way valve 23 into indoor heat exchanger 5. In indoor heat exchanger 5, heat exchange is conducted between the gas refrigerant having flown thereinto and the air supplied by indoor fan 7. Then, the high-temperature and high-pressure gas refrigerant is condensed into high-pressure liquid refrigerant (a single phase). Through this heat exchange, the indoor area is heated. By throttle device 9, the high-pressure liquid refrigerant delivered out of indoor heat exchanger 5 is turned into refrigerant in a two-phase state including low-pressure gas refrigerant and low-pressure liquid refrigerant.

[0033] The refrigerant in a two-phase state flows into outdoor heat exchanger 11. In outdoor heat exchanger 11, heat exchange is conducted between the incoming refrigerant in a two-phase state and the air supplied by outdoor fan 21. Then, as a result of evaporation of the liquid refrigerant, the refrigerant in a two-phase state is turned into low-pressure gas refrigerant (a single phase). The low-pressure gas refrigerant delivered out of outdoor heat exchanger 11 flows through four-way valve 23 into compressor 3 and then compressed into high-temperature and high-pressure gas refrigerant, which is again discharged from compressor 3. This cycle is repeated thereafter.

[0034] In the following, an explanation will be described with regard to the flow of the refrigerant in outdoor heat exchanger 11 in the case where outdoor heat exchanger 11 is operated to function as an evaporator. As shown in Fig. 7, in outdoor heat exchanger 11, the refrigerant first flows through auxiliary heat exchange unit 15, and then flows through main heat exchange unit 13. Also, by outdoor fan 21 (see Fig. 1), air flows from auxiliary heat exchange unit 15a and main heat exchange unit 13a in the first column (a windward column) toward auxiliary heat exchange unit 15b and main heat exchange unit 13b in the second column (a leeward column), as indicated by an arrow.

[0035] The refrigerant delivered from throttle device 9 flows into distributor 25 of auxiliary heat exchange unit 15 and passes through distributor 25. Then, the refrigerant flows through first heat transfer tube 33a of auxiliary heat exchange unit 15a in the direction as indicated by an arrow. The refrigerant having flown through first heat transfer tube 33a then flows through second heat transfer tube 33b of auxiliary heat exchange unit 15b in the direction as indicated by an arrow.

[0036] The refrigerant having flown through second heat transfer tube 33b then flows into distributor 29 of main heat exchange unit 13. The refrigerant having flown into distributor 29 then flows through fourth heat transfer tube 33d of main heat exchange unit 13b in the direction as indicated by an arrow. The refrigerant having flown through fourth heat transfer tube 33d then flows through third heat transfer tube 33c of main heat exchange unit 13a in the direction as indicated by an arrow. The refrigerant having flown through third heat transfer tube 33c

then flows into header 27 and passes through header 27. Then, the refrigerant is delivered to the outside of outdoor heat exchanger 11.

[0037] In outdoor heat exchanger 11 of air conditioning apparatus 1 as described above, the temperature of the refrigerant flowing into auxiliary heat exchange unit 15 (a refrigerant inlet temperature), the temperature of the refrigerant delivered out of auxiliary heat exchange unit 15 (a refrigerant outlet temperature), and the outdoor air temperature are sensed. Then, air conditioning apparatus 1 is operated such that the refrigerant temperature establishes a prescribed temperature relation with the outdoor air temperature. Thereby, adhesion of frost to auxiliary heat exchange unit 15 can be prevented. This will be described below.

[0038] First, a general idea about adhesion of frost to an outdoor heat exchanger will be hereinafter described. As an example of the condition that frost adheres to an outdoor heat exchanger, an explanation will be given with regard to the case where the air dry-bulb temperature is 2 °C and the air wet-bulb temperature is 1 °C. On the above-mentioned condition, since the dew point temperature of air is about -0.4 °C, the outdoor heat exchanger functions as an evaporator. When the air dry-bulb temperature falls below the dew point temperature, moisture condenses in the outdoor heat exchanger. Since the air dry-bulb temperature is lower than the freezing point at this time, the condensed moisture is to adhere as frost. Thus, in the outdoor heat exchanger, the ventilation resistance increases to thereby reduce the volume of air that passes through the outdoor heat exchanger, with the result that the heat exchange performance deteriorates.

[0039] In this case, for ensuring the air conditioning performance of the indoor heat exchanger, it is necessary to increase the temperature difference between the temperature of the refrigerant flowing through the outdoor heat exchanger and the temperature of air. Thus, the temperature of the refrigerant flowing through the outdoor heat exchanger lowers, thereby causing further adhesion of frost to the outdoor heat exchanger. When frost adheres to the outdoor heat exchanger, the defrosting operation for melting the adhering frost is performed to thereby ensure the air conditioning performance, after which the normal operation is performed. It is a common practice to repeat the above-described operation when the outdoor air is at a low temperature.

[0040] Then, as an example of the case where the outdoor air temperature is higher than the above-described condition, an explanation will be given with regard to the case where the air dry-bulb temperature is 5 °C and the air wet-bulb temperature is 4 °C. On the above-described condition, the dew point temperature of air is about 2.8 °C. Thus, when the air dry-bulb temperature falls below the dew point temperature due to heat exchange with the refrigerant, the moisture in air condenses and then adheres as water droplets to the outdoor heat exchanger. In this case, air that passes through the outdoor heat

exchanger flows toward the leeward side of the outdoor heat exchanger at a temperature lower than the dew point temperature. Accordingly, when the refrigerant temperature is lower than the freezing point of water (for example, 0 °C), both the air dry-bulb temperature and the dew point temperature may reach the temperature close to the refrigerant temperature. Thus, when the dew point temperature is lower than the freezing point of water (for example, 0 °C), there is a possibility that frost may adhere to the outdoor heat exchanger.

[0041] Then, adhesion of frost to the auxiliary heat exchange unit of the outdoor heat exchanger will be hereinafter specifically described. In this case, as an example of the operating condition, the air dry-bulb temperature is 2 °C, the air wet-bulb temperature is 1 °C, and the dew point temperature is -0.4 °C.

[0042] First, as to an outdoor heat exchanger 11 of an air conditioning apparatus in a comparative example, an explanation will be hereinafter given with regard to the case where when this outdoor heat exchanger 11 is operated to function as an evaporator, both main heat exchange unit 13 and auxiliary heat exchange unit 15 are used as evaporators (the first comparative example). Fig. 8 shows: a graph showing transition of the temperature of the refrigerant that flows through auxiliary heat exchange unit 15 with respect to the refrigerant flow direction (a dashed line); a graph showing transition of the air dry-bulb temperature with respect to the air flow direction (a solid line); and a graph showing transition of the dew point temperature with respect to the air flow direction (a dotted line).

[0043] On this operating condition, the refrigerant inlet temperature (Tref-in) of the refrigerant flowing into auxiliary heat exchange unit 15 is lower than the outdoor air temperature (air inlet temperature (Tair-in)). In this case, the air dry-bulb temperature immediately reaches approximately the same temperature as the dew point temperature. Since the dew point temperature is lower than the freezing point of water (for example, 0 °C), frost is to adhere to the most part of outdoor heat exchanger 11 including auxiliary heat exchange unit 15.

[0044] When the defrosting operation for removing the frost adhering to outdoor heat exchanger 11 is performed, water (drainage water) resulting from melting of frost is caused to flow by gravity toward the lower portion of outdoor heat exchanger 11 so as to be discharged from outdoor heat exchanger 11. However, in outdoor heat exchanger 11 employing a flat tube as a heat transfer tube, the rate at which drainage water flows down is decreased, with the result that drainage water keeps flowing down from above toward auxiliary heat exchange unit 15 disposed below main heat exchange unit 13. This may consequently require an extra quantity of heat for defrosting auxiliary heat exchange unit 15. Furthermore, the defrosting operation may require extra time.

[0045] Furthermore, the defrosting operation is generally performed in the same operation mode as that in the operation of the outdoor heat exchanger functioning as

a condenser. Also, the direction in which the refrigerant flows is opposite to the direction in which the refrigerant flows during the operation of outdoor heat exchanger 11 functioning as an evaporator. Thus, the refrigerant flows through auxiliary heat exchange unit 15 after it flows through main heat exchange unit 13 (see Fig. 6). Auxiliary heat exchange unit 15 is disposed below main heat exchange unit 13. Accordingly, the quantity of heat of the refrigerant is removed in main heat exchange unit 13 on the upstream side of the refrigerant flow. Thus, in auxiliary heat exchange unit 15 on the downstream side, the performance of defrosting adhering frost deteriorates, which may lengthen the defrosting time. In this case, for example, the indoor temperature gradually lowers, so that a comfortable state may not be able to be maintained.

[0046] Furthermore, after the defrosting operation is ended in the state where frost still remains, and when the operation of outdoor heat exchanger 11 functioning as an evaporator is resumed, frost may further grow to thereby damage auxiliary heat exchange unit 15 and the like. Thus, it is conceivable that a significant problem may occur, for example, that a heat transfer tube is damaged to thereby cause leakage of refrigerant, and the like.

[0047] Then, as to an outdoor heat exchanger 11 of another air conditioning apparatus in a comparative example, an explanation will be hereinafter given with regard to the case where, when this outdoor heat exchanger 11 is operated to function as an evaporator, main heat exchange unit 13 is used as an evaporator and auxiliary heat exchange unit 15 is used as a condenser (the second comparative example). Fig. 9 shows: a graph showing transition of the temperature of the refrigerant that flows through auxiliary heat exchange unit 15 with respect to the refrigerant flow direction (a dashed line); a graph showing transition of the air dry-bulb temperature with respect to the air flow direction (a solid line); and a graph showing transition of the dew point temperature with respect to the air flow direction (a dotted line).

[0048] On this operating condition, the refrigerant outlet temperature (Tref-out) of the refrigerant delivered out of auxiliary heat exchange unit 15 is higher than the outdoor air temperature (air inlet temperature (Tair-in)). In this case, frost does not adhere to auxiliary heat exchange unit 15, so that auxiliary heat exchange unit 15 is not damaged. Thus, the reliability as auxiliary heat exchange unit 15 is ensured.

[0049] However, on the above-described operating condition, in auxiliary heat exchange unit 15 used as a condenser, the refrigerant changes so as to be liquefied. Accordingly, in main heat exchange unit 13 used as an evaporator, for evaporating the liquefied refrigerant, the load for heat exchange in main heat exchange unit 13 is increased. Therefore, the heat exchange performance significantly deteriorates.

[0050] In contrast to the first comparative example and the second comparative example, in outdoor heat exchanger 11 of air conditioning apparatus 1 according to the embodiment, when outdoor heat exchanger 11 is op-

erated to function as an evaporator, main heat exchange unit 13 is used as an evaporator while auxiliary heat exchange unit 15 is used as a condenser and an evaporator. Fig. 10 shows: a graph showing transition of the temperature of the refrigerant that flows through auxiliary heat exchange unit 15 with respect to the refrigerant flow direction (a dashed line); a graph showing transition of the air dry-bulb temperature with respect to the air flow direction (a solid line); and a graph showing transition of the dew point temperature with respect to the air flow direction (a dotted line).

[0051] This operation of outdoor heat exchanger 11 functioning as an evaporator is performed on the conditions that, in the case where the refrigerant outlet temperature (Tref-out) is lower than the freezing point of water (for example, 0 °C), the refrigerant inlet temperature (Tref-in) of the refrigerant flowing into auxiliary heat exchange unit 15 is higher than the outdoor air temperature (air inlet temperature (Tair-in)), and the refrigerant outlet temperature of the refrigerant delivered out of auxiliary heat exchange unit 15 (Tref-out) is lower than the outdoor air temperature (air inlet temperature (Tair-in)).

[0052] The refrigerant flowing through auxiliary heat exchange unit 15 is in a two-phase state including liquid refrigerant and gas refrigerant. Thus, adjusting the pressure loss of the refrigerant in auxiliary heat exchange unit 15 means the same as adjusting the refrigerant temperature. In this auxiliary heat exchange unit 15, pressure loss unit 17 is provided between auxiliary heat exchange unit 15a located in the first column and auxiliary heat exchange unit 15b located in the second column, so that auxiliary heat exchange unit 15a is caused to function as a condenser and auxiliary heat exchange unit 15b is caused to function as an evaporator.

[0053] When auxiliary heat exchange unit 15a located in the windward column is caused to function as a condenser, the air temperature rises. Thus, even when auxiliary heat exchange unit 15b located in the leeward column is caused to function as an evaporator, the air temperature is less likely to fall below the dew point temperature. Thereby, auxiliary heat exchange unit 15 can be caused to entirely function as an evaporator in the state where the temperature of the refrigerant lowers, and also, adhesion of frost to auxiliary heat exchange unit 15 can be prevented. In order to reliably prevent adhesion of frost to auxiliary heat exchange unit 15, it is only necessary to perform the operation in such a manner such that the refrigerant outlet temperature (Tref-out) of the refrigerant delivered out of auxiliary heat exchange unit 15 is higher than the dew point temperature.

[0054] In addition, in outdoor heat exchanger 11 of air conditioning apparatus I according to the embodiment as described above, the refrigerant flows through auxiliary heat exchange unit 15a located on the windward side, and thereafter, flows through auxiliary heat exchange unit 15b located on the leeward side. In other words, the refrigerant flows from the windward side toward the leeward side in the same manner as with the

flow of air. Such the refrigerant flow is referred to as a parallel flow. In contrast to the parallel flow, the flow of the refrigerant from the leeward side toward the windward side is referred to as a counterflow.

[0055] In the following, an explanation will be given with regard to the case where the refrigerant is caused to flow as a counterflow through auxiliary heat exchange unit 15 of outdoor heat exchanger 11 when outdoor heat exchanger 11 is operated to function as an evaporator (the third comparative example). As shown in Fig. 11, in outdoor heat exchanger 11, the refrigerant first flows through auxiliary heat exchange unit 15, and then flows through main heat exchange unit 13. In this case, in auxiliary heat exchange unit 15, the refrigerant first flows through second heat transfer tube 33b of auxiliary heat exchange unit 15b in the direction as indicated by an arrow. The refrigerant having flown through second heat transfer tube 33b then flows through first heat transfer tube 33a of auxiliary heat exchange unit 15a in the direction as indicated by an arrow. The refrigerant having flown through auxiliary heat exchange unit 15a is caused to flow through main heat exchange unit 13 and thereafter delivered out of outdoor heat exchanger 11, in the same manner as shown in Fig. 7.

[0056] Fig. 12 represents the case where the refrigerant flows as a counterflow, and shows: a graph showing transition of the temperature of the refrigerant that flows through auxiliary heat exchange unit 15 with respect to the refrigerant flow direction (a dashed line); a graph showing transition of the air dry-bulb temperature with respect to the air flow direction (a solid line); and a graph showing transition of the dew point temperature with respect to the air flow direction (a dotted line).

[0057] In this case, even when pressure loss unit 17 for lowering the pressure of the refrigerant is disposed, the temperature of the refrigerant flowing through auxiliary heat exchange unit 15a located on the windward side falls below the temperature of the refrigerant flowing through auxiliary heat exchange unit 15b located on the leeward side. At this time, when the temperature of air falls below the dew point temperature, there is a possibility that frost may adhere to auxiliary heat exchange unit 15a.

[0058] In this case, when the temperature of the refrigerant flowing through auxiliary heat exchange unit 15a located on the windward side is set to be higher than the outdoor air temperature (air inlet temperature (Tair-in)), the temperature of the refrigerant flowing through auxiliary heat exchange unit 15b located on the leeward side is also higher than the outdoor air temperature (air inlet temperature (Tair-in)). Thereby, auxiliary heat exchange unit 15 entirely functions as a condenser, so that the heat exchange performance deteriorates, as having been described with reference to Fig. 9. Therefore, in order that outdoor heat exchanger 11 is operated to function as an evaporator so as to prevent adhesion of frost to auxiliary heat exchange unit 15, it is desirable to perform the operation such that the refrigerant flows as a parallel flow

along the flow of air.

(Variations of Pressure Loss Unit (Pressure Loss Mechanism))

(First Example)

[0059] As to outdoor heat exchanger 11 of air conditioning apparatus 1 as described above, an explanation has been given with regard to the case where pressure loss unit 17 is disposed between auxiliary heat exchange unit 15a and auxiliary heat exchange unit 15b. As a pressure loss unit, for example, the friction loss inside the heat transfer tube such as first heat transfer tube 33a and second heat transfer tube 33b may be employed.

[0060] Fig. 13 represents the case where outdoor heat exchanger 11 is operated to function as an evaporator, and shows: a graph showing transition of the temperature of the refrigerant flowing through auxiliary heat exchange unit 15 with respect to the refrigerant flow direction (a dashed line); a graph showing transition of the air dry-bulb temperature with respect to the air flow direction (a solid line); and a graph showing transition of the dew point temperature with respect to the air flow direction (a dotted line).

[0061] As shown in Fig. 13, as the refrigerant flows through a heat transfer tube (first heat transfer tube 33a and second heat transfer tube 33b), the temperature of the refrigerant lowers gradually by the friction loss inside the heat transfer tube. The friction loss inside the heat transfer tube is defined by the flow velocity of the refrigerant, the inside shape of the heat transfer tube, and the length of the heat transfer tube. Accordingly, the amount of the refrigerant circulating in the air conditioning apparatus, the dimensions of the heat transfer tube inside the outdoor heat exchanger, the number of paths in the heat transfer tube, and the like are set at their respective prescribed values based on the design. Then, on the condition that the refrigerant temperature establishes a prescribed temperature relation, outdoor heat exchanger 11 is operated to function as an evaporator, with the result that adhesion of frost to auxiliary heat exchange unit 15 can be prevented.

[0062] In other words, in the case where the refrigerant outlet temperature (Tref-out) is lower than the freezing point of water (for example, 0 °C), the operation is performed such that the refrigerant inlet temperature (Tref-in) is higher than the outdoor air temperature (air inlet temperature (Tair-in)), and that the refrigerant outlet temperature (Tref-out) is lower than the outdoor air temperature (air inlet temperature (Tair-in)), so that adhesion of frost to auxiliary heat exchange unit 15 can be prevented. Furthermore, by performing the operation such that the refrigerant outlet temperature (Tref-out) of the refrigerant delivered out of auxiliary heat exchange unit 15 is higher than the dew point temperature, adhesion of frost to auxiliary heat exchange unit 15 can be reliably prevented.

(Second Example)

[0063] As pressure loss unit 17 disposed between auxiliary heat exchange unit 15a and auxiliary heat exchange unit 15b, a throttle device may be used, for example.

[0064] Fig. 14 shows throttle devices 39 each of which is provided for a corresponding one of a plurality of first heat transfer tubes 33a disposed in auxiliary heat exchange unit 15a and a corresponding one of a plurality of second heat transfer tubes 33b disposed in auxiliary heat exchange unit 15b, such that each of throttle devices 39 is disposed for a route (path) extending from a corresponding one of first heat transfer tubes 33a to a corresponding one of second heat transfer tubes 33b. Fig. 15 shows throttle device 39 provided such that the refrigerants having flown through first heat transfer tubes 33a are joined on the upstream side of the throttle device, and then branched (divided) again on the downstream side of the throttle device so as to be delivered to their respective second heat transfer tubes 33b.

[0065] In auxiliary heat exchange unit 15, the opening degree of throttle device 39 is adjusted with respect to the temperature of the refrigerant on the upstream side of throttle device 39, so that the temperature of the refrigerant on the downstream side of throttle device 39 can be adjusted. In other words, when throttle device 39 is placed between auxiliary heat exchange unit 15a and auxiliary heat exchange unit 15b (between the columns), the temperature of the refrigerant flowing through auxiliary heat exchange unit 15a located on the windward side and the temperature of the refrigerant flowing through auxiliary heat exchange unit 15b located on the leeward side can be separately adjusted.

[0066] Thereby, auxiliary heat exchange unit 15a located on the windward side can be entirely functioned as a condenser while auxiliary heat exchange unit 15b located on the leeward side can be entirely functioned as an evaporator. Consequently, as having been described in the first embodiment, adhesion of frost to auxiliary heat exchange unit 15 of outdoor heat exchanger 11 can be prevented during the operation of outdoor heat exchanger 11 functioning as an evaporator.

(Third Example)

[0067] As pressure loss unit 17 disposed between auxiliary heat exchange unit 15a and auxiliary heat exchange unit 15b, a header (an inter-columnar header) may be used, for example.

[0068] Fig. 16 shows an inter-columnar header 41 disposed between auxiliary heat exchange unit 15a and auxiliary heat exchange unit 15b. As shown in Figs. 17, 18 and 19, a flow path through which refrigerant flows is provided inside inter-columnar header 41 for each route (path) extending from first heat transfer tube 33a to second heat transfer tube 33b. At some midpoint of the flow path, a throttle portion 43 is provided in such a manner that the cross-sectional area of this midpoint in the flow

path is narrower than the cross-sectional area of another portion in the flow path.

[0069] By adjusting the width of throttle portion 43 and the length of the flow path in throttle portion 43, the pressure loss can be adjusted before and after inter-columnar header 41. Also, the temperature of the refrigerant flowing through auxiliary heat exchange unit 15a and the temperature of the refrigerant flowing through auxiliary heat exchange unit 15b can be separately adjusted. Thereby, auxiliary heat exchange unit 15a can be functioned as a condenser while auxiliary heat exchange unit 15b can be functioned as an evaporator. Consequently, during the operation of outdoor heat exchanger 11 functioning as an evaporator, adhesion of frost to auxiliary heat exchange unit 15 of outdoor heat exchanger 11 can be prevented.

(Fourth Example)

[0070] As pressure loss unit 17 disposed between auxiliary heat exchange unit 15a and auxiliary heat exchange unit 15b, for example, two headers may be used, including a header connected to auxiliary heat exchange unit 15a and a header connected to auxiliary heat exchange unit 15b.

[0071] Fig. 20 shows a header including a header 45a, a header 45b, and a header connection tube 47. Header 45a is connected to first heat transfer tube 33a of auxiliary heat exchange unit 15a. Header 45b is connected to second heat transfer tube 33b of auxiliary heat exchange unit 15b. Header connection tube 47 provides connection between header 45a and header 45b.

[0072] In this case, for example, by adjusting the inner diameter and the like of header connection tube 47 so as to provide throttle portion 43, the temperature of the refrigerant flowing through auxiliary heat exchange unit 15a and the temperature of the refrigerant flowing through auxiliary heat exchange unit 15b can be separately adjusted. Thus, adhesion of frost to auxiliary heat exchange unit 15 of outdoor heat exchanger 11 can be prevented during the operation of outdoor heat exchanger 11 functioning as an evaporator. Furthermore, flow paths causing friction loss may be separately provided inside the flow paths of headers 45a and 45b. Then, also by adjusting the shapes of these flow paths to thereby adjust the pressure loss, adhesion of frost can be prevented.

(Fifth Example)

[0073] As pressure loss unit 17 disposed between auxiliary heat exchange unit 15a and auxiliary heat exchange unit 15b, for example, a U-shaped tube may be used other than a header.

[0074] As shown in Fig. 21, a U-shaped tube 49 is connected for each route (path) extending from first heat transfer tube 33a to second heat transfer tube 33b. In this case, by adjusting the inner diameter of U-shaped

tube 49, the temperature of the refrigerant flowing through auxiliary heat exchange unit 15a and the temperature of the refrigerant flowing through auxiliary heat exchange unit 15b can be separately adjusted. Thus, adhesion of frost to auxiliary heat exchange unit 15 of outdoor heat exchanger 11 can be prevented during the operation of outdoor heat exchanger 11 functioning as an evaporator.

[0075] As refrigerant used in air conditioning apparatus 1 having been described in the above embodiment, by using any kind of refrigerant such as refrigerant R410A, refrigerant R407C, refrigerant R32, refrigerant R507A, refrigerant HFO1234yf, and the like, adhesion of frost to auxiliary heat exchange unit 15 of outdoor heat exchanger 11 can be prevented.

[0076] Each of refrigerant R410A and refrigerant R407C is a refrigerant mixture and particularly referred to as a non-azeotropic refrigerant mixture. A non-azeotropic refrigerant mixture has different compositions in a vapor phase and in a liquid phase in a moist vapor state, and also has a characteristic that it undergoes a phase change of evaporation or condensation while it undergoes a temperature change and a composition conversion between two phases of gas refrigerant and liquid refrigerant under fixed pressure. Among such non-azeotropic refrigerant mixtures, refrigerant R407C and the like undergo extremely small temperature change during a phase change, and particularly, is referred to as a pseudo-azeotropic refrigerant mixture.

[0077] Refrigerant R32 and refrigerant HFO1234yf each are refrigerant formed of a single component. Refrigerant R507A is a refrigerant mixture and referred to as an azeotropic refrigerant mixture. The azeotropic refrigerant mixture has a composition that is identical in a vapor phase and a liquid phase in moist vapor in a certain component ratio, and also has a characteristic that it undergoes a phase change of evaporation or condensation at a fixed temperature under fixed pressure, as in the case of the refrigerant formed of a single component.

[0078] Also in the case where such a non-azeotropic refrigerant mixture, a pseudo-azeotropic refrigerant mixture, refrigerant formed of a single component, or an azeotropic refrigerant mixture is used, when the refrigerant outlet temperature is lower than the freezing point of water (for example, 0 °C), the operation is performed such that the refrigerant inlet temperature is higher than the outdoor air temperature and that the refrigerant outlet temperature is lower than the outdoor air temperature, with the result that adhesion of frost to auxiliary heat exchange unit 15 of outdoor heat exchanger 11 can be prevented. Furthermore, when the operation is performed such that the refrigerant outlet temperature of the refrigerant delivered out of auxiliary heat exchange unit 15 is higher than the dew point temperature, adhesion of frost to auxiliary heat exchange unit 15 can be reliably prevented.

[0079] Furthermore, as refrigeration oil used in the air conditioning apparatus, refrigeration oil having compat-

ibility is employed in consideration of the mutual solubility to the refrigerant to be applied. For fluorocarbon-based refrigerant such as refrigerant R410A, for example, alkylbenzene oil-based refrigeration oil, ester oil-based refrigeration oil or ether oil-based refrigeration oil is used. Other than the above, mineral oil-based refrigeration oil or fluorine oil-based refrigeration oil may be used.

[0080] Also in the case where the refrigeration oil as described above is used, when the refrigerant outlet temperature is lower than the freezing point of water (for example, 0 °C), the operation is performed such that the refrigerant inlet temperature is higher than the outdoor air temperature and that the refrigerant outlet temperature is lower than the outdoor air temperature, with the result that adhesion of frost to auxiliary heat exchange unit 15 of outdoor heat exchanger 11 can be prevented.

[0081] In the above-described embodiment, an explanation has been given with regard to the air conditioning apparatus as an example of a refrigeration cycle apparatus. The refrigeration cycle apparatus is not limited to an air conditioning apparatus, but may be applicable, for example, also to an apparatus including an outdoor heat exchanger such as a heat pump water heater configured to perform heat exchange with air. Furthermore, various combinations can be made as appropriate for the refrigeration cycle apparatus including an outdoor heat exchanger, which has been described in the embodiments.

[0082] The embodiments disclosed herein are merely by way of example and not limited thereto. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

INDUSTRIAL APPLICABILITY

[0083] The present invention is effectively utilized in a refrigeration cycle apparatus such as an air conditioning apparatus including an outdoor heat exchanger equipped with a main heat exchange unit and an auxiliary heat exchange unit.

REFERENCE SIGNS LIST

[0084] 1 air conditioning apparatus, 3 compressor, 5 indoor heat exchanger, 7 indoor fan, 9 throttle device, 11 outdoor heat exchanger, 13 main heat exchange unit, 13a, 13b main heat exchange unit, 15 auxiliary heat exchange unit, 15a, 15b auxiliary heat exchange unit, 17 pressure loss unit, 21 outdoor fan, 23 four-way valve, 25 distributor, 27 header, 29 distributor, 31 fin, 33a first heat transfer tube, 33b second heat transfer tube, 33c third heat transfer tube, 33d fourth heat transfer tube, 35 refrigerant path, 37 refrigerant pipe, 39 throttle device, 41 inter-columnar header, 43 throttle portion, 45a, 45b header, 47 header connection tube, 49 U-shaped tube, 51 control unit, 53, 55, 57 temperature sensor.

Claims

1. A refrigeration cycle apparatus comprising an outdoor heat exchanger, the outdoor heat exchanger including
 - a first heat exchange unit, and
 - a second heat exchange unit that is disposed adjacent to the first heat exchange unit, the first heat exchange unit including
 - a plurality of fins each formed in a plate shape,
 - a first heat transfer tube disposed to penetrate the plurality of fins,
 - a second heat transfer tube disposed to penetrate the plurality of fins and located at a distance from the first heat transfer tube in a direction crossing a direction in which the first heat transfer tube extends, and
 - a pressure loss mechanism configured to lower pressure of refrigerant flowing through the first heat exchange unit,
 during an operation of the outdoor heat exchanger functioning as an evaporator, when a temperature of refrigerant flowing out of the first heat exchange unit is lower than a freezing point of water, the refrigeration cycle apparatus operating such that a temperature of refrigerant flowing into the first heat exchange unit is higher than an outdoor air temperature and that the temperature of the refrigerant flowing out of the first heat exchange unit is lower than the outdoor air temperature.
2. The refrigeration cycle apparatus according to claim 1, wherein the operation is performed such that the temperature of the refrigerant flowing out of the first heat exchange unit is higher than a dew point temperature.
3. The refrigeration cycle apparatus according to claim 1, wherein
 - the first heat transfer tube has a first end and a second end,
 - the second heat transfer tube has a third end and a fourth end,
 - the third end of the second heat transfer tube is connected to the second end of the first heat transfer tube, and
 - the fourth end of the second heat transfer tube is connected to the second heat exchange unit.
4. The refrigeration cycle apparatus according to claim 3, wherein the pressure loss mechanism includes a throttle portion disposed between the second end of the first heat transfer tube and the third end of the second heat transfer tube, and the throttle portion includes

- a first flow path having a first cross-sectional area, and
a second flow path having a second cross-sectional area that is smaller than the first cross-sectional area. 5
5. The refrigeration cycle apparatus according to claim 4, wherein the throttle portion includes a throttle adjustment unit configured to adjust the second cross-sectional area of the second flow path. 10
6. The refrigeration cycle apparatus according to claim 1, wherein the pressure loss mechanism includes the first heat transfer tube and the second heat transfer tube. 15
7. The refrigeration cycle apparatus according to claim 1, wherein
the first heat transfer tube is formed as a first flat tube having a flat cross-sectional shape that has a major axis and a minor axis, and
the second heat transfer tube is formed as a second flat tube having the flat cross-sectional shape, the second flat tube being located at a distance from the first flat tube in a direction in which the major axis extends. 20 25
8. The refrigeration cycle apparatus according to claim 1, further comprising an air blower unit configured to blow air from a side on which the first heat transfer tube is disposed toward a side on which the second heat transfer tube is disposed, wherein refrigerant flows from the first heat transfer tube into the second heat transfer tube. 30 35
9. An outdoor heat exchanger comprising a first heat exchange unit and a second heat exchange unit that is disposed adjacent to the first heat exchange unit, the first heat exchange unit including 40
a plurality of fins each formed in a plate shape,
a first heat transfer tube disposed to penetrate the plurality of fins,
a second heat transfer tube disposed to penetrate the plurality of fins and located at a distance from the first heat transfer tube in a direction crossing a direction in which the first heat transfer tube extends, and 45
a pressure loss unit disposed between the first heat transfer tube and the second heat transfer tube, the pressure loss unit being configured to lower pressure of refrigerant. 50
10. The outdoor heat exchanger according to claim 9, wherein 55
the pressure loss unit includes a throttle portion,
the throttle portion includes
- a first flow path having a first cross-sectional area, and
a second flow path having a second cross-sectional area that is smaller than the first cross-sectional area.
11. The outdoor heat exchanger according to claim 10, wherein the throttle portion includes a throttle adjustment unit configured to adjust the second cross-sectional area of the second flow path.
12. The outdoor heat exchanger according to claim 9, wherein
the first heat transfer tube is formed as a first flat tube having a flat cross-sectional shape that has a major axis and a minor axis, and
the second heat transfer tube is formed as a second flat tube having the flat cross-sectional shape, the second flat tube being located at a distance from the first flat tube in a direction in which the major axis extends.

FIG.1

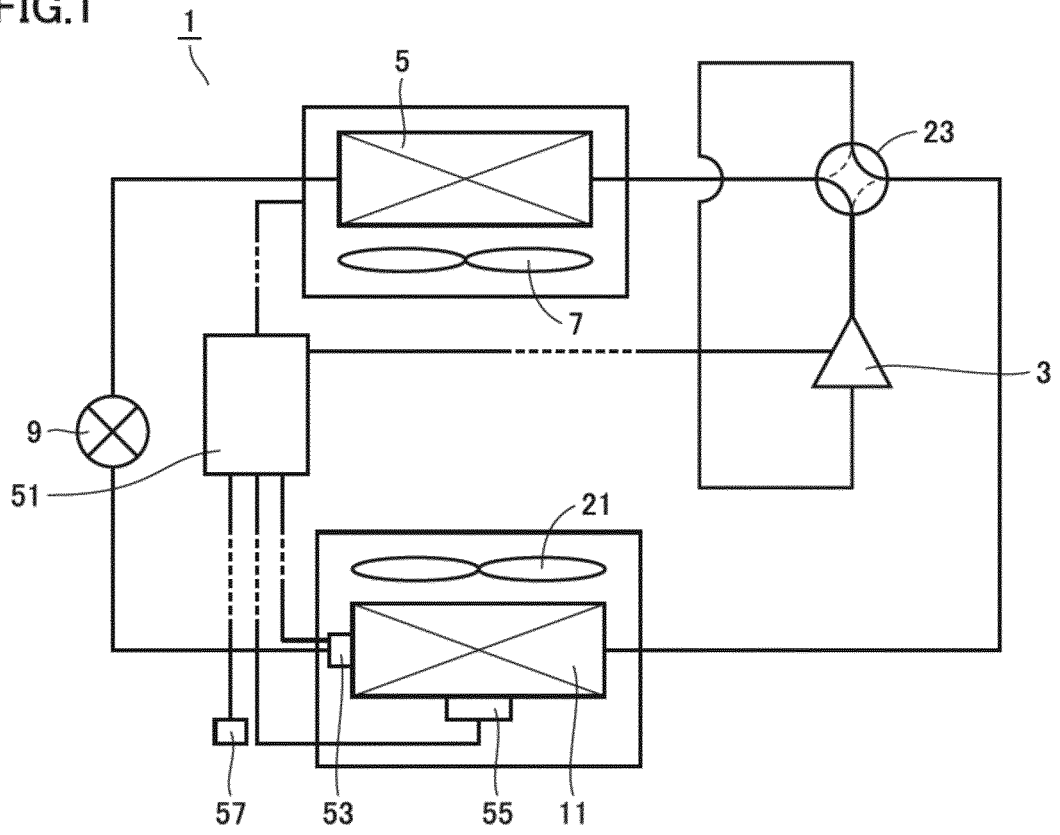


FIG.2

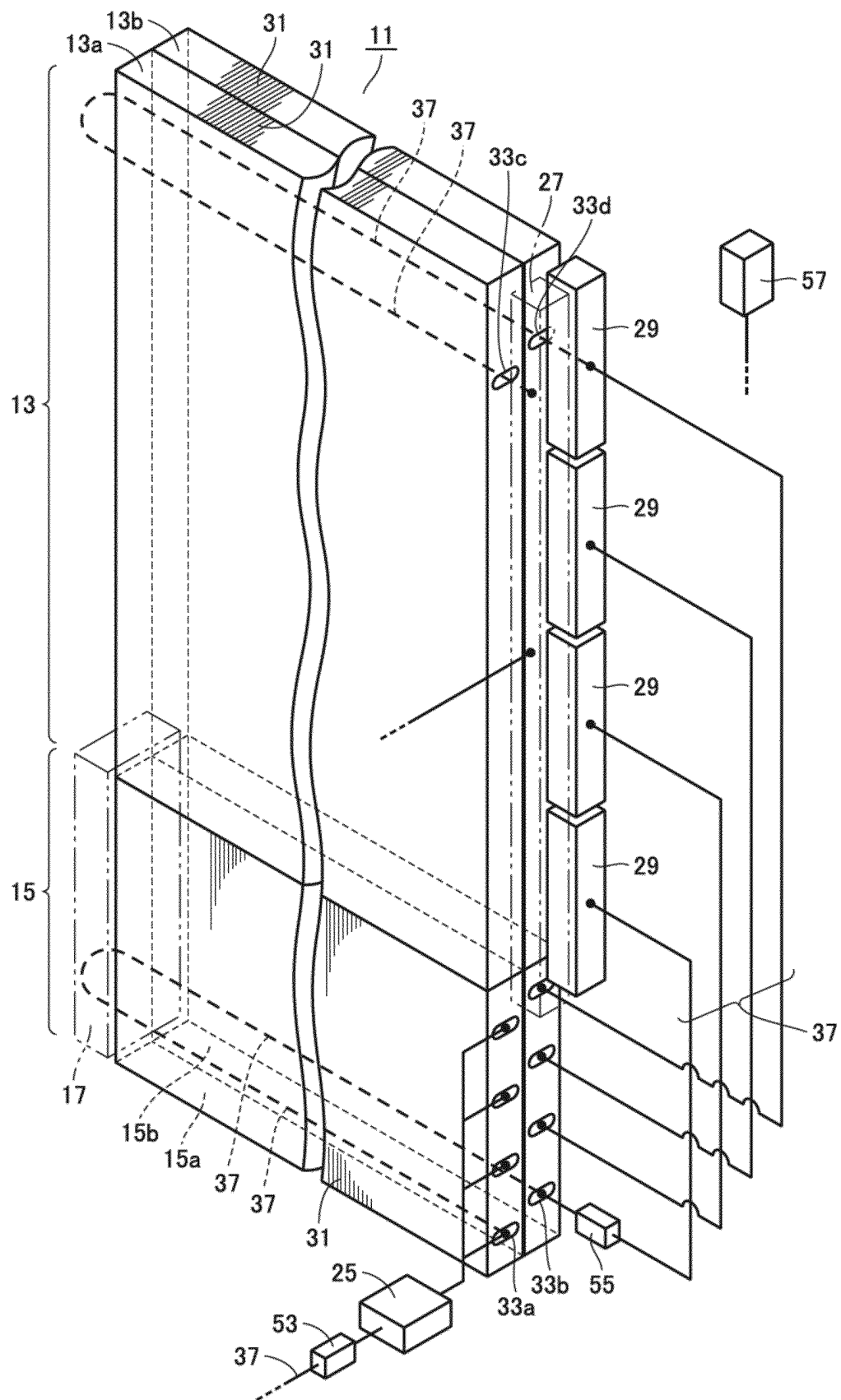


FIG.3

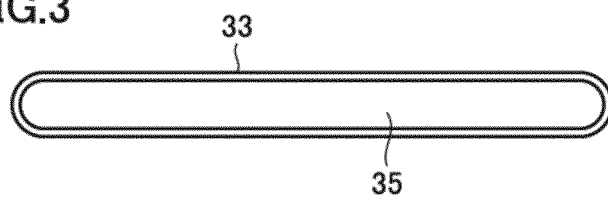


FIG.4

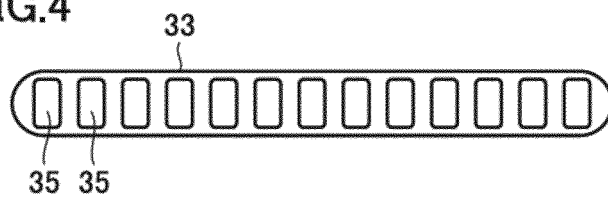


FIG.5

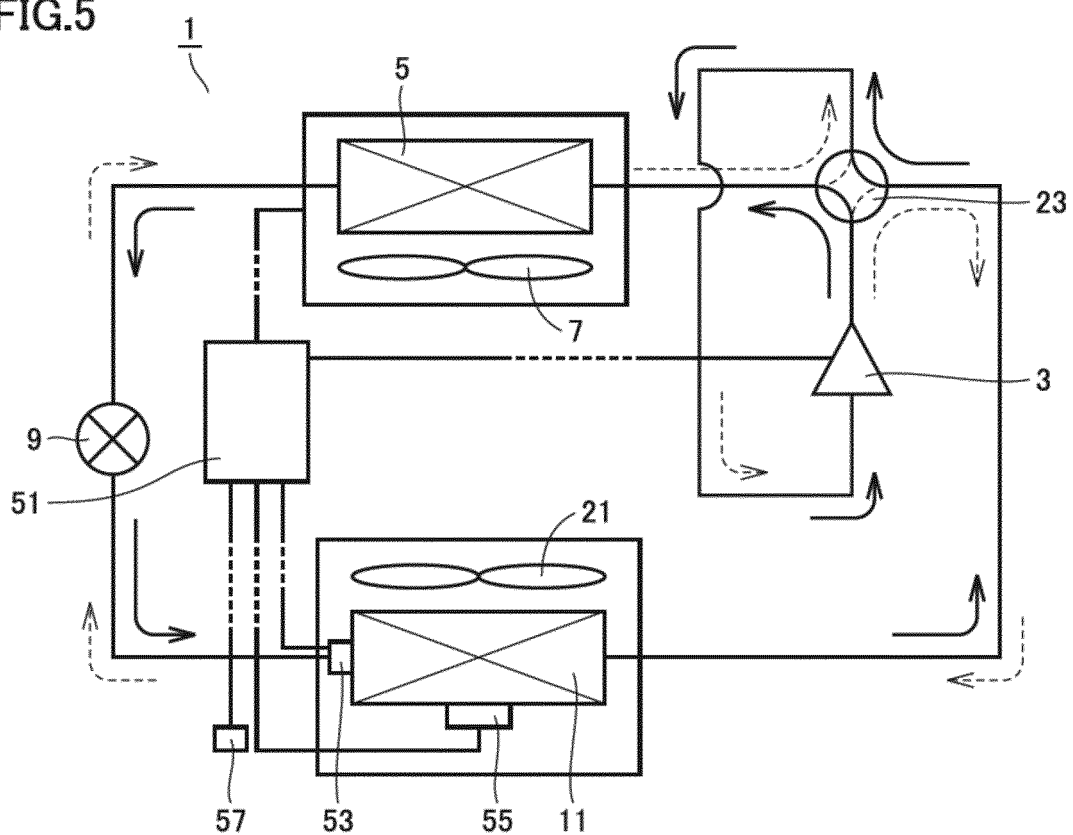


FIG.6

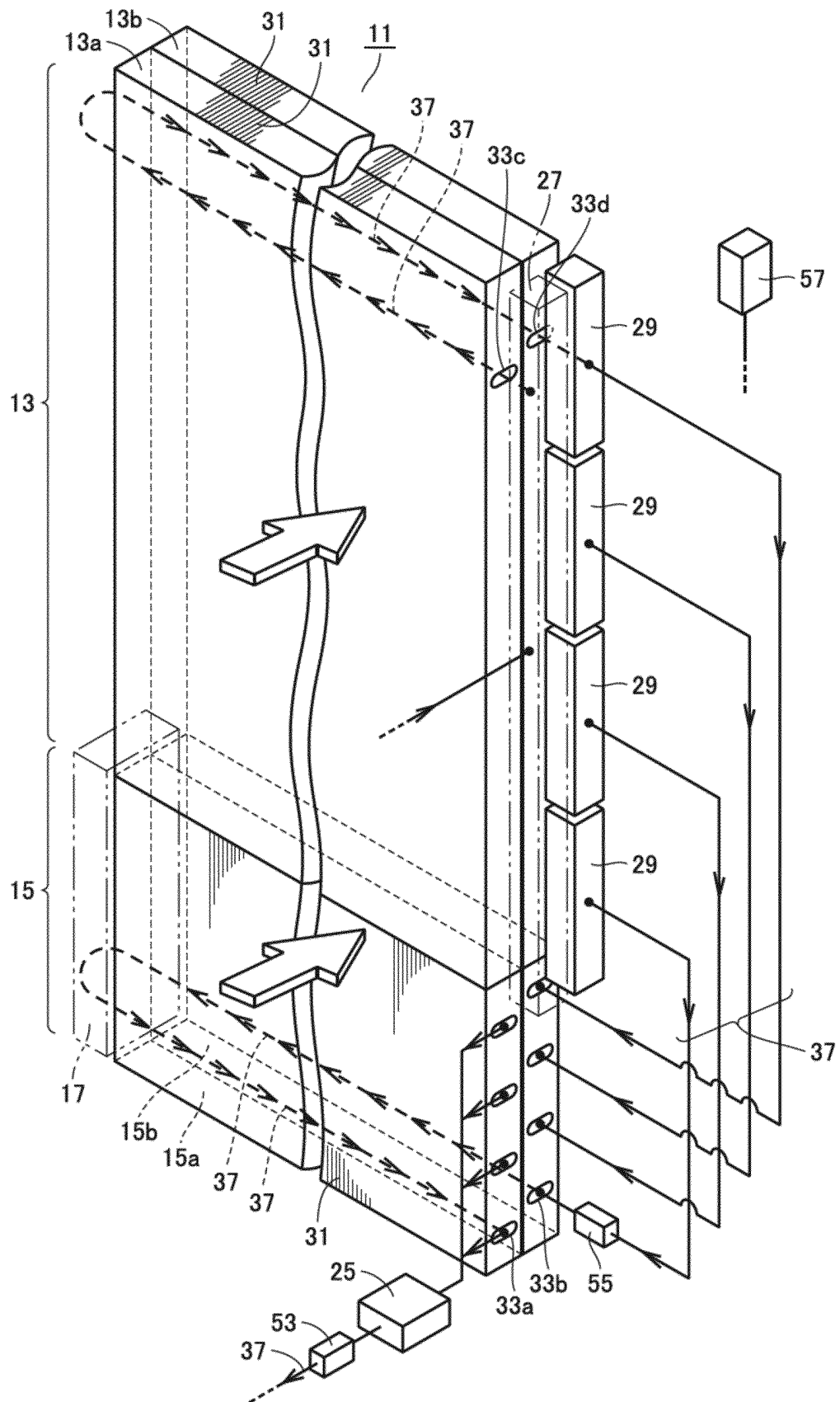


FIG. 7

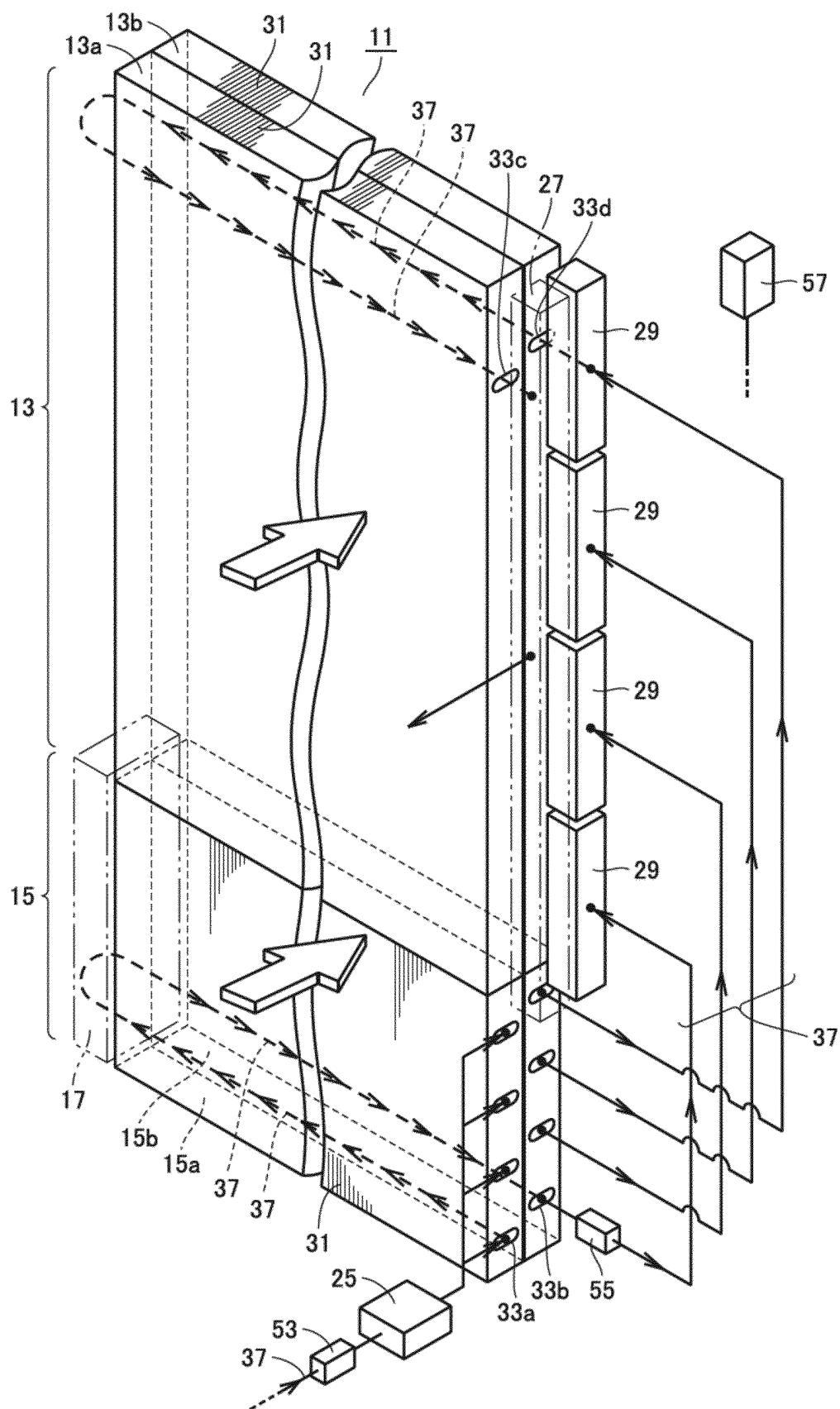


FIG.8

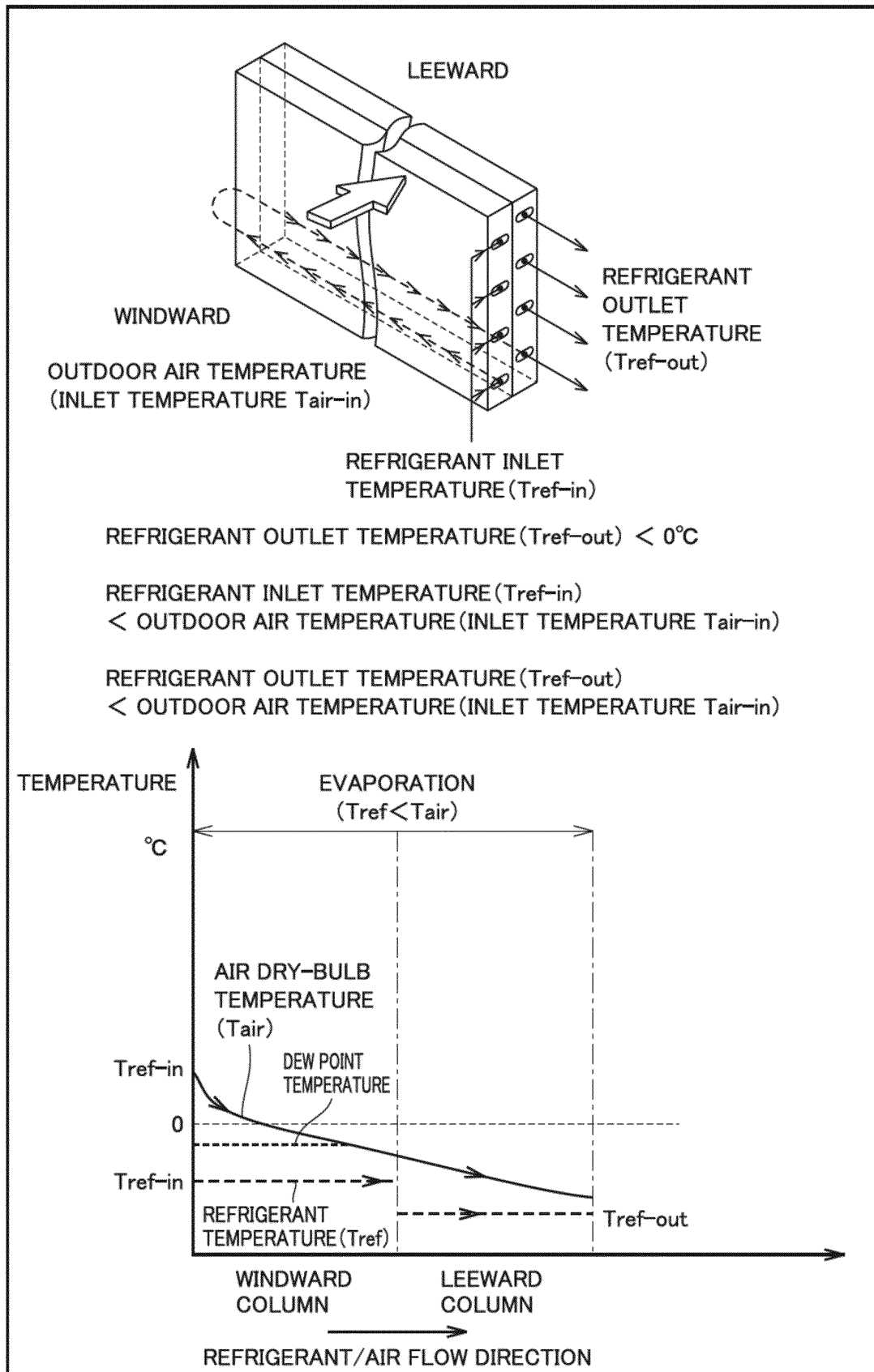


FIG.9

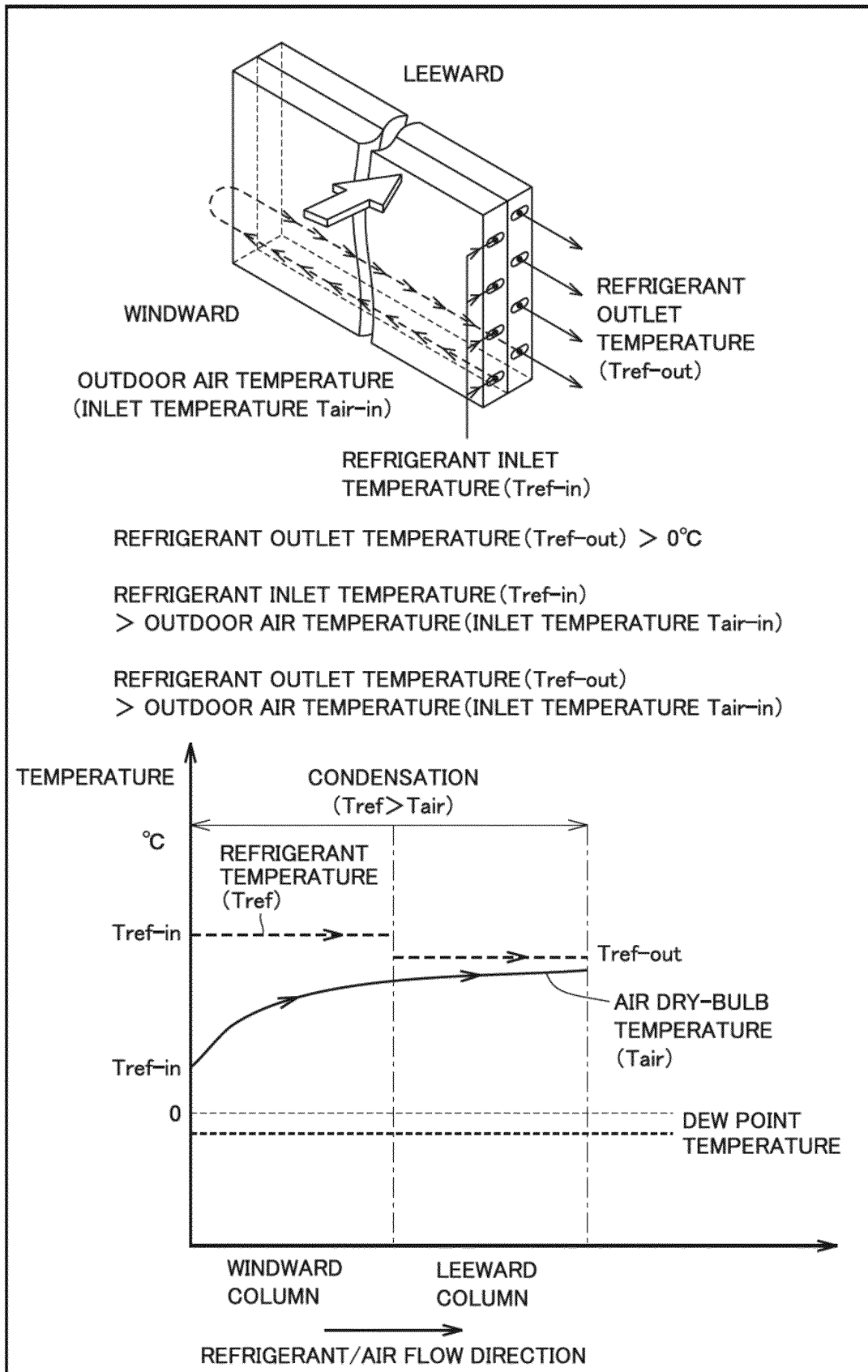


FIG.10

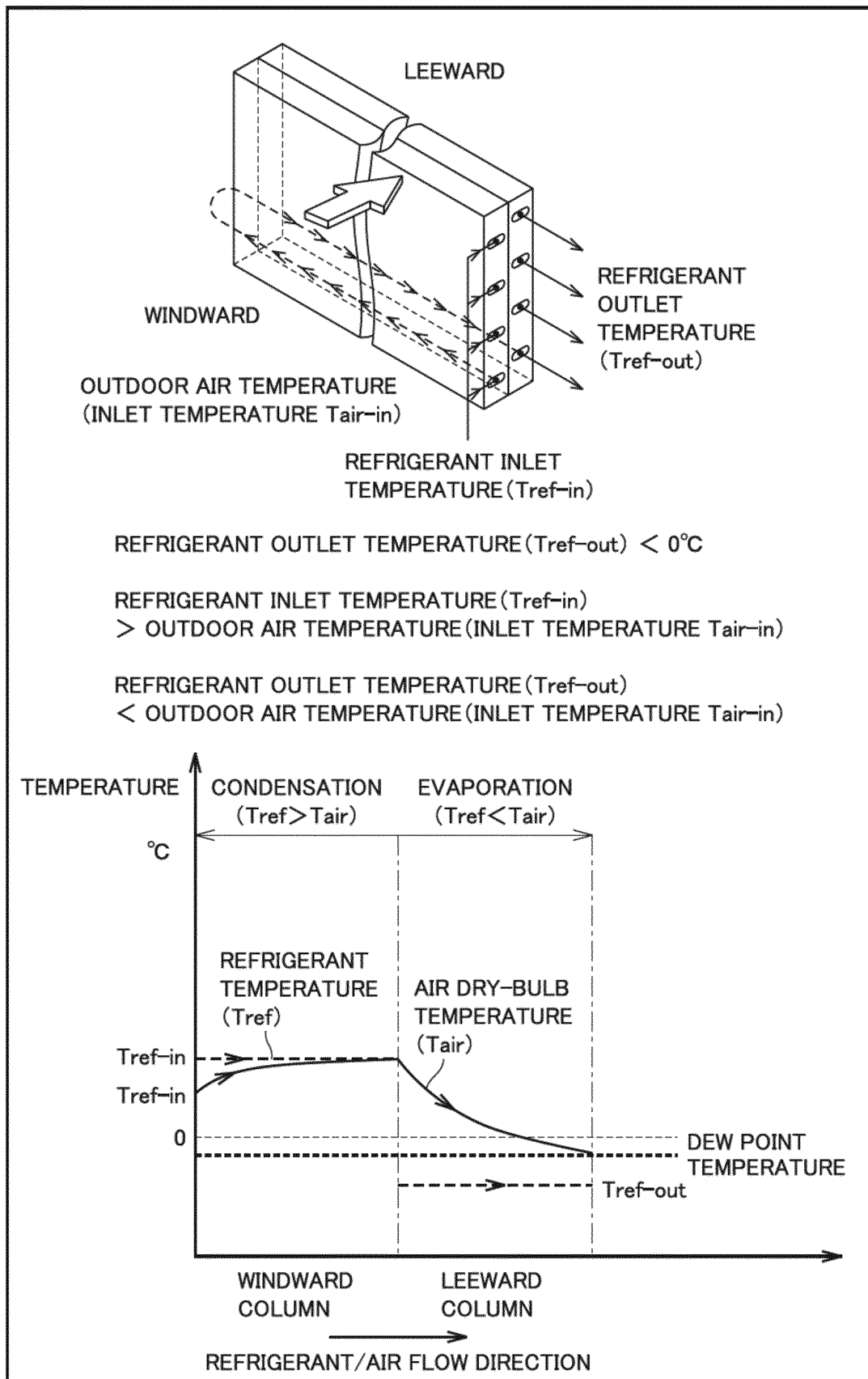


FIG.11

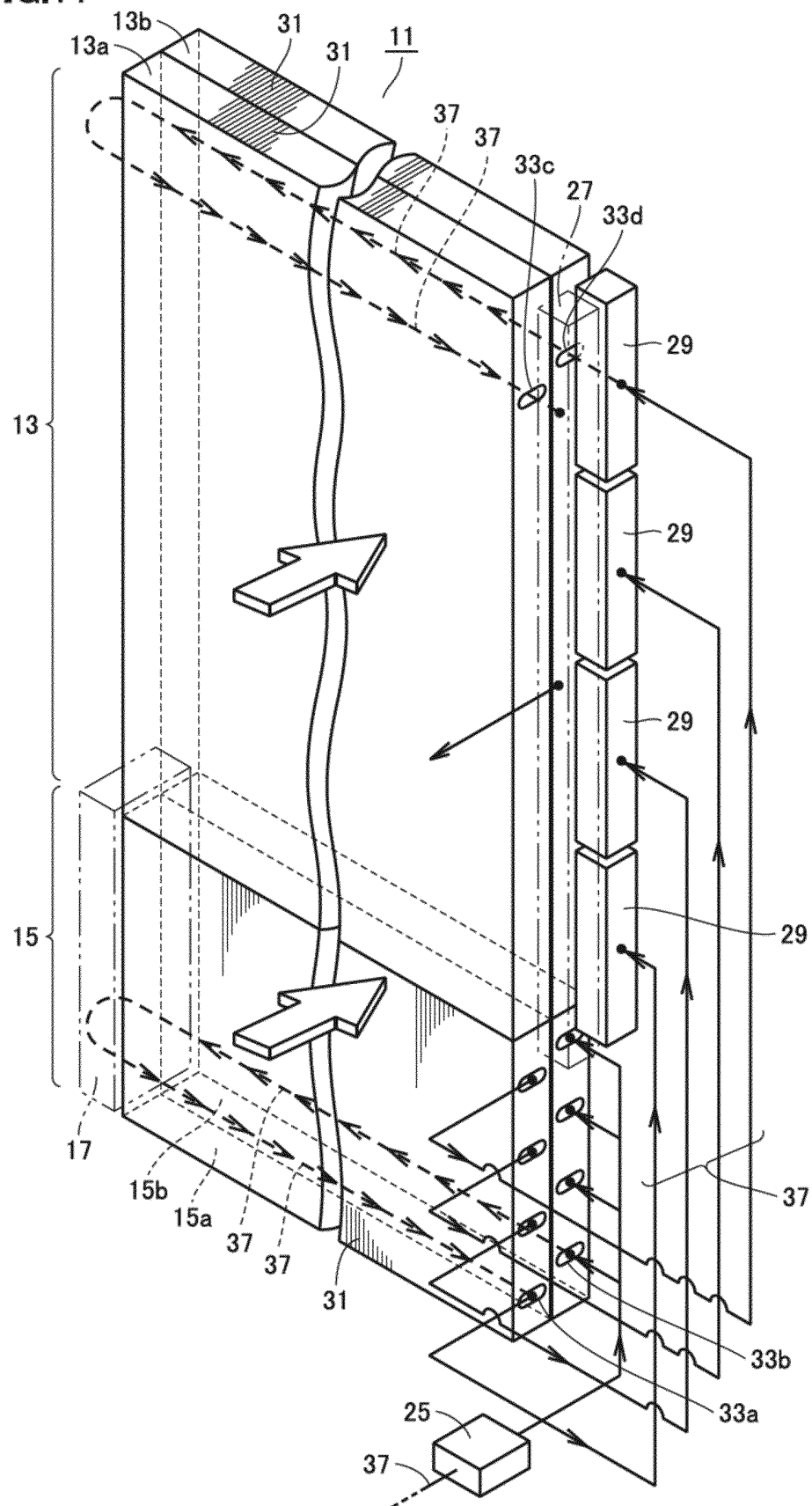


FIG.12

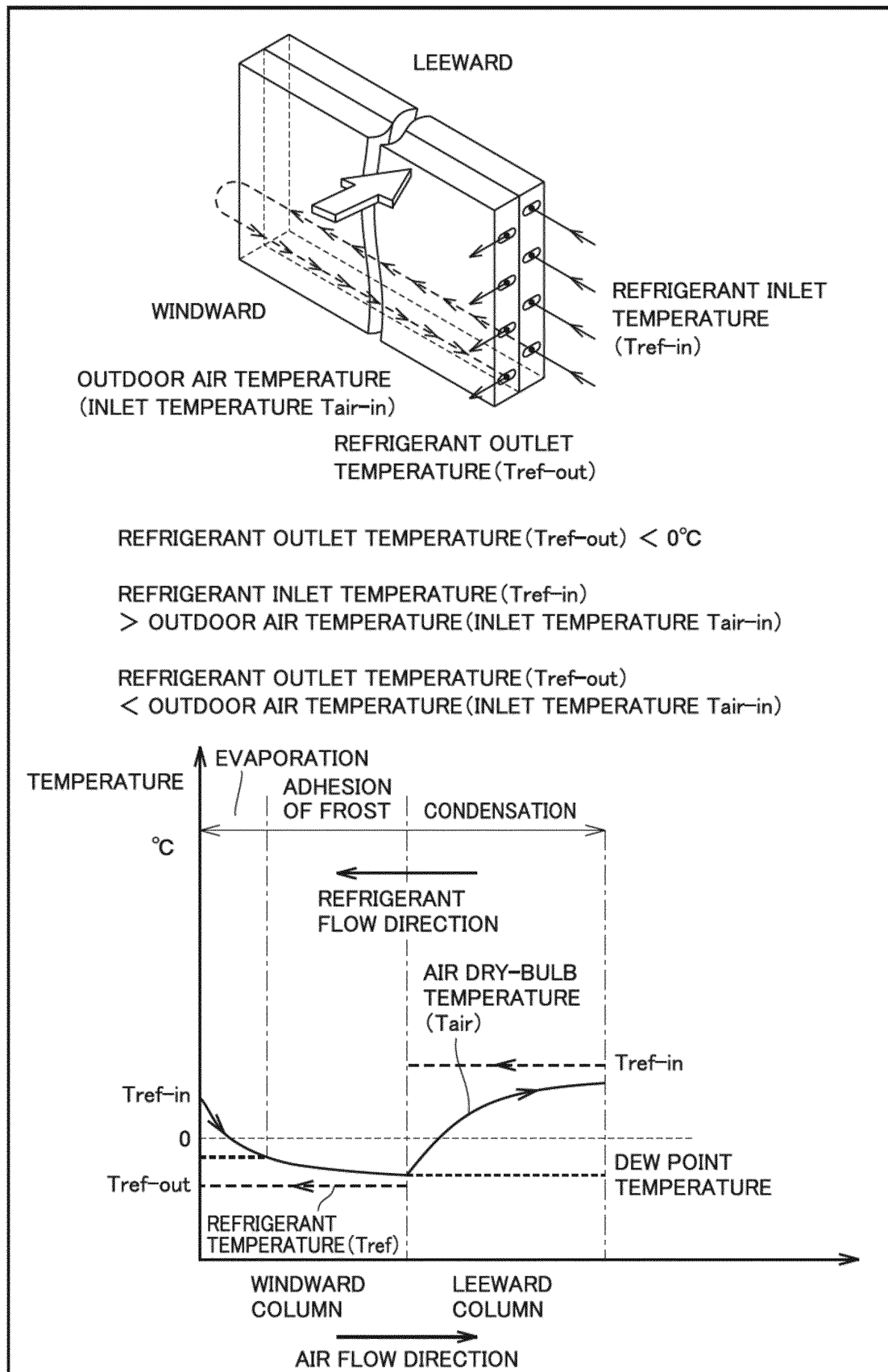


FIG.13

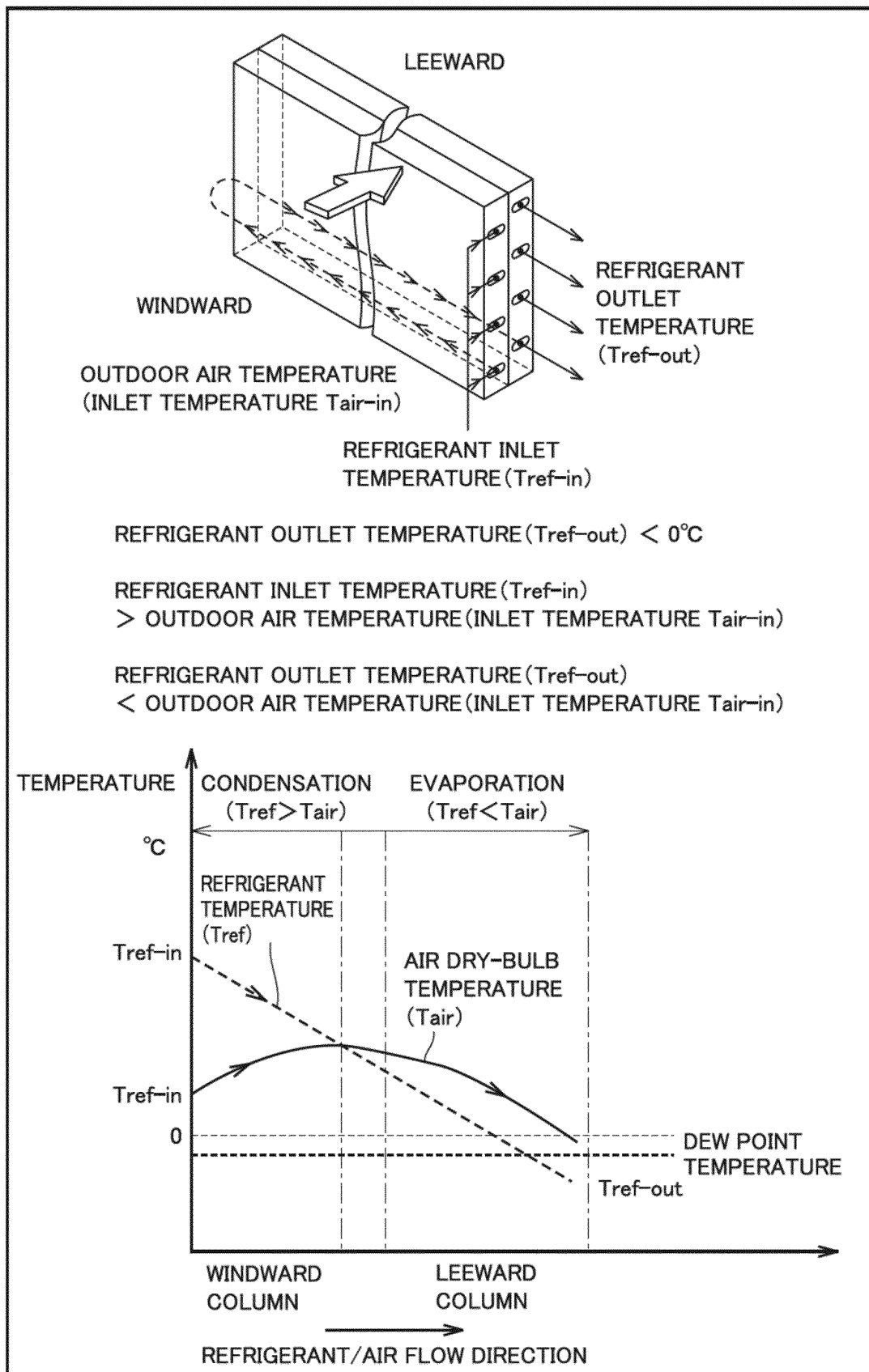


FIG.14

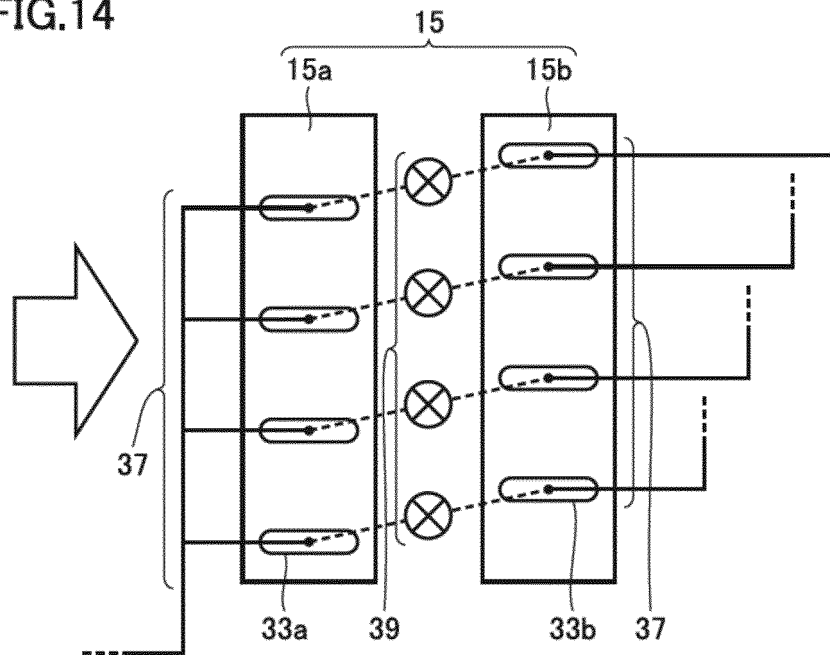


FIG.15

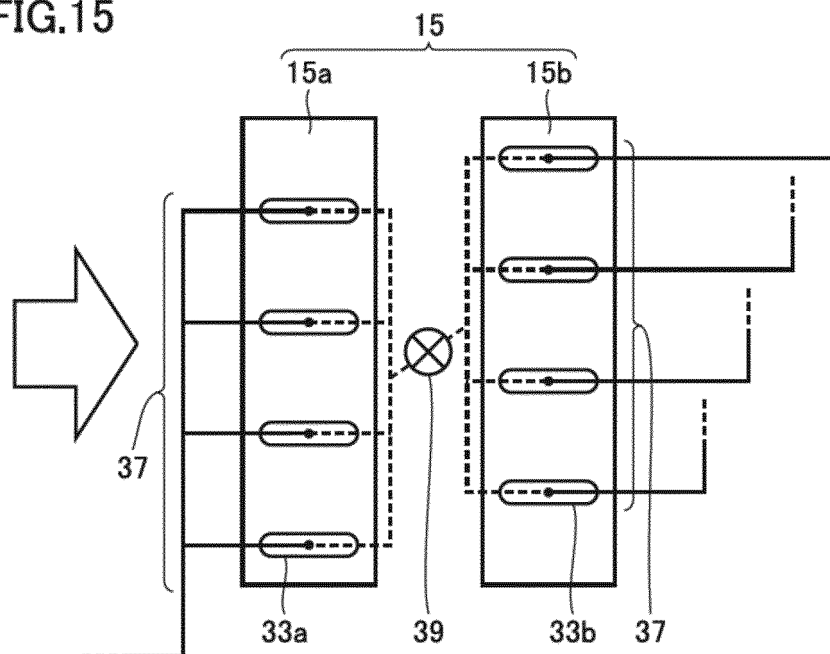


FIG.16

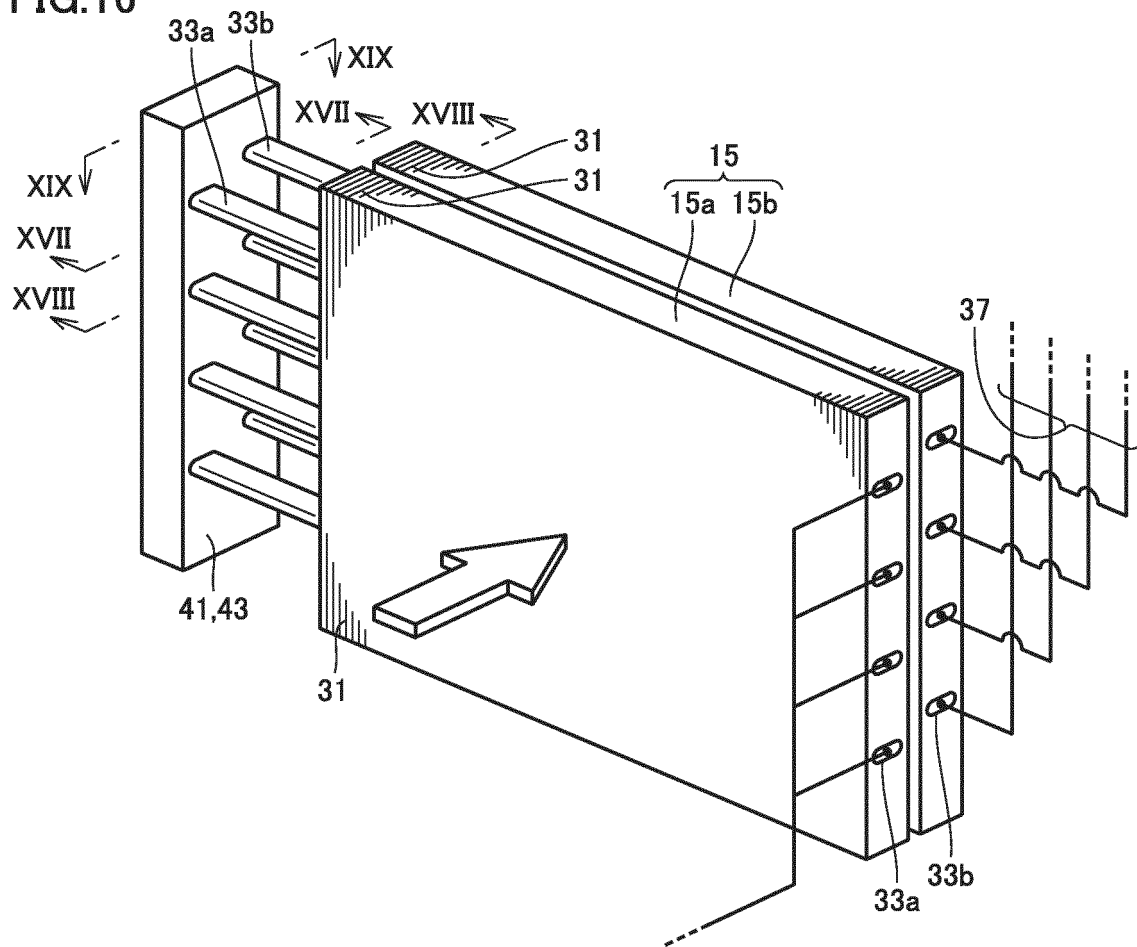


FIG.17

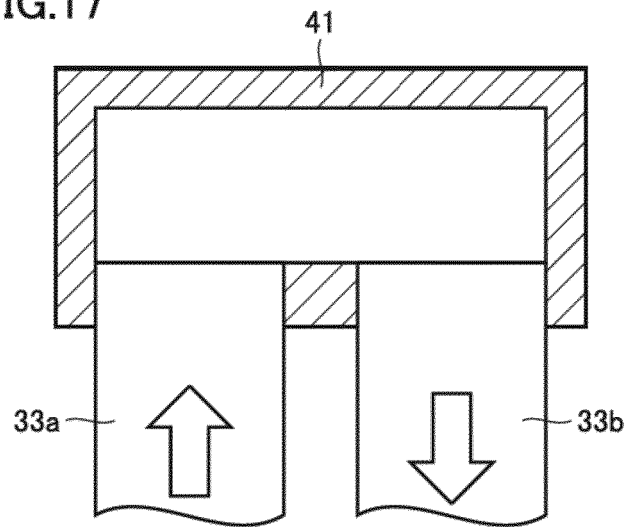


FIG.18

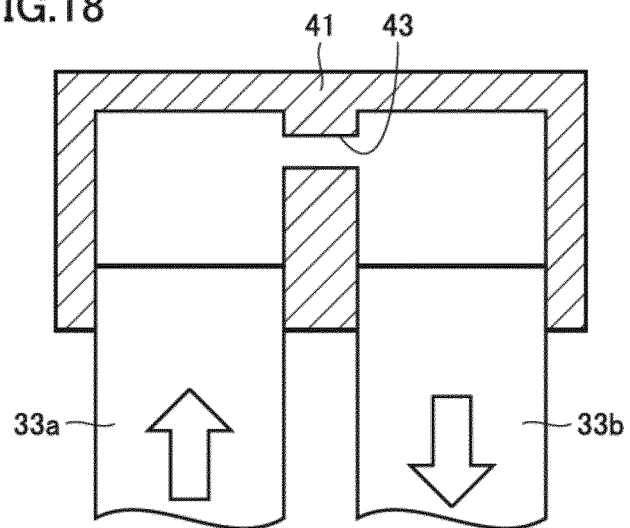


FIG.19

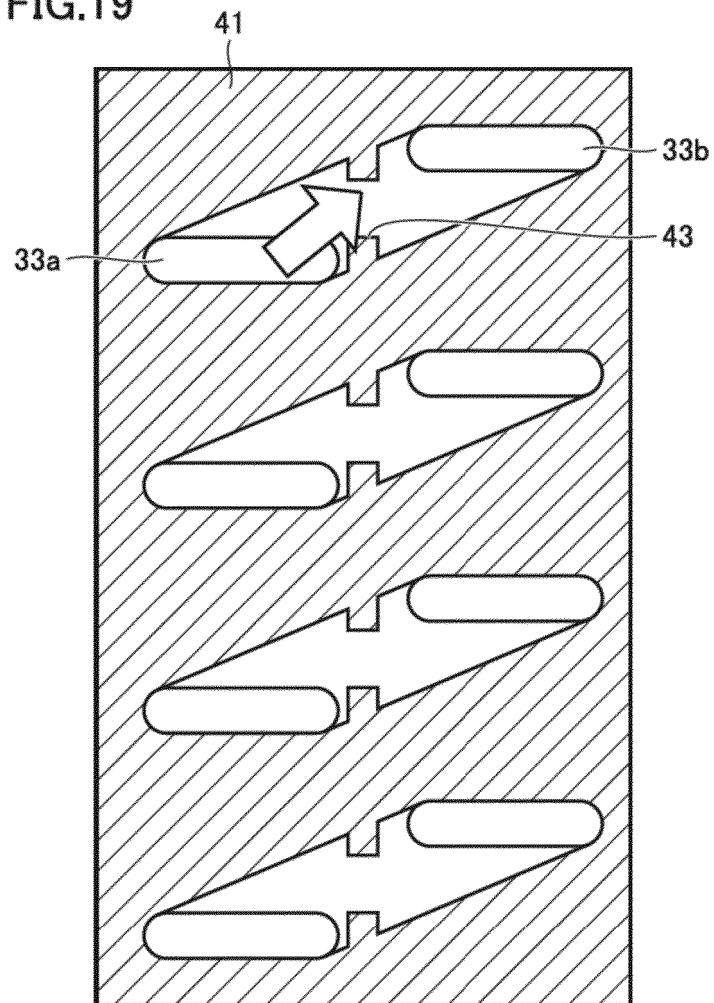


FIG.20

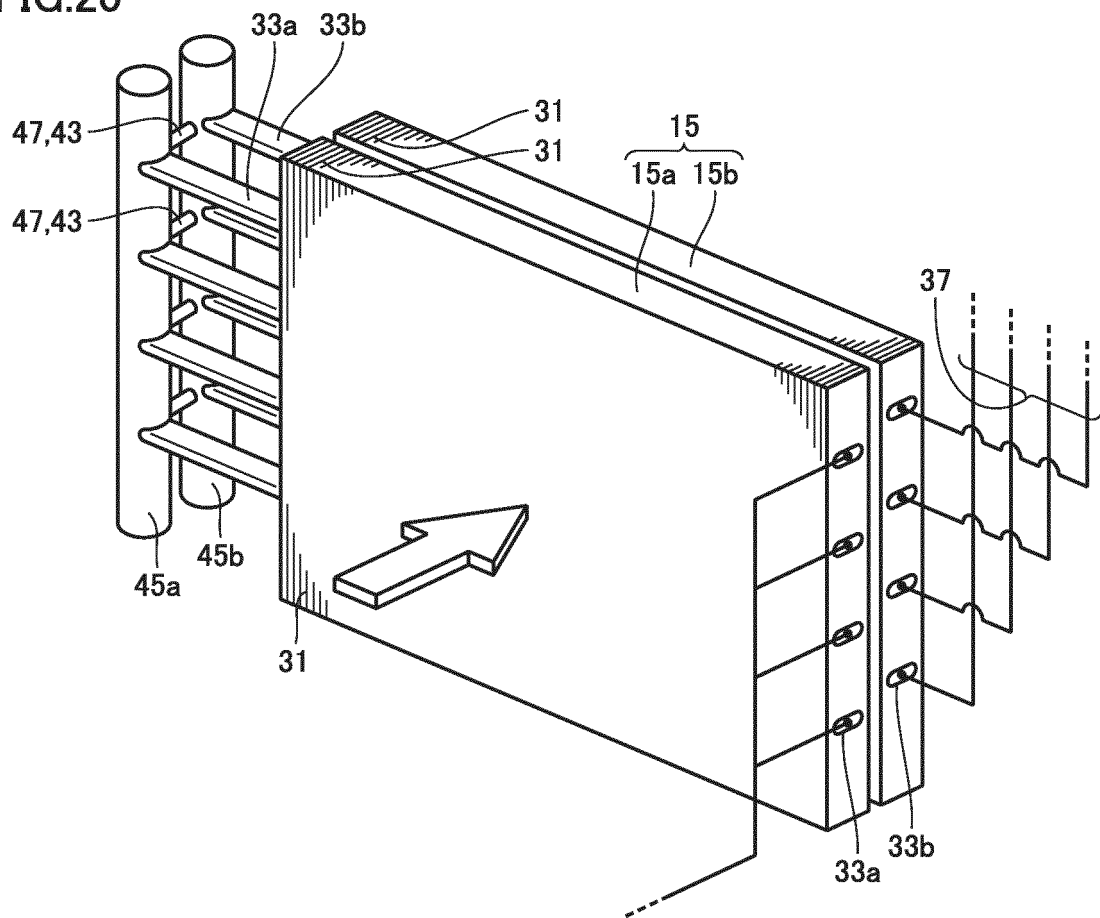
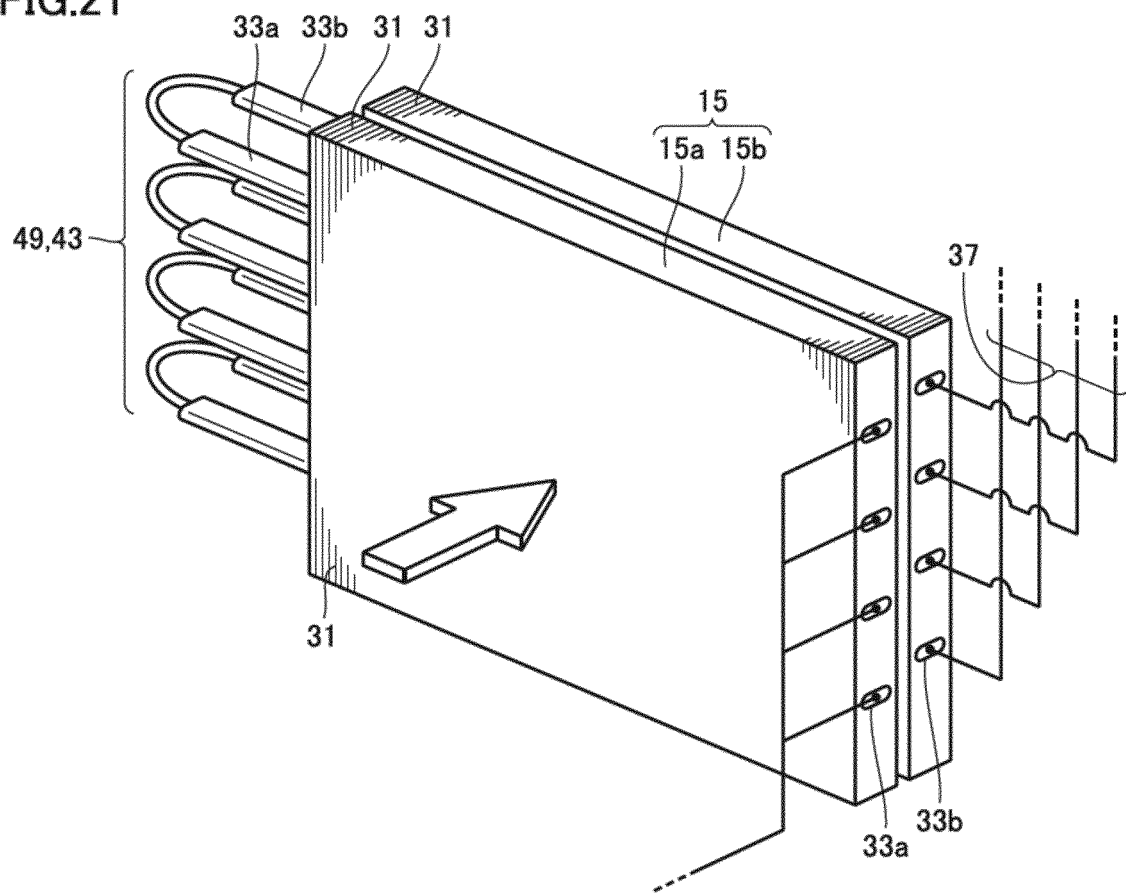


FIG.21



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/068810

A. CLASSIFICATION OF SUBJECT MATTER

F25B47/02(2006.01)i, F25B39/00(2006.01)i, F25B39/02(2006.01)i, F28F17/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B47/02, F25B39/00, F25B39/02, F28F17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2015-078830 A (Daikin Industries, Ltd.), 23 April 2015 (23.04.2015), fig. 1 to 10; paragraphs [0124], [0134] to [0152], [0171] & JP 5679084 B & WO 2015/037240 A & EP 3032182 A & AU 2014319777 A & CN 105518392 A	9-10, 12 11 1-8
X Y A	WO 2016/056063 A1 (Mitsubishi Electric Corp.), 14 April 2016 (14.04.2016), fig. 11 to 15; paragraphs [0049] to [0060] (Family: none)	9-10, 12 11 1-8
X Y A	WO 2016/056064 A1 (Mitsubishi Electric Corp.), 14 April 2016 (14.04.2016), fig. 11 to 15; paragraphs [0051] to [0063] (Family: none)	9-10, 12 11 1-8

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
13 September 2016 (13.09.16)

Date of mailing of the international search report
27 September 2016 (27.09.16)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/068810

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2002-372320 A (Matsushita Electric Industrial Co., Ltd.), 26 December 2002 (26.12.2002), claims; fig. 1 to 5 (Family: none)	11
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 186463/1980 (Laid-open No. 109467/1982) (Hitachi, Ltd.), 06 July 1982 (06.07.1982), entire text; all drawings (Family: none)	1-12
A	JP 02-078844 A (Hokkaido Electric Power Co., Inc., Toshiba Corp.), 19 March 1990 (19.03.1990), entire text; all drawings (Family: none)	1-12
A	JP 49-128349 A (Mayekawa Mfg., Co., Ltd.), 09 December 1974 (09.12.1974), entire text; all drawings (Family: none)	1-12

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013083419 A [0004]