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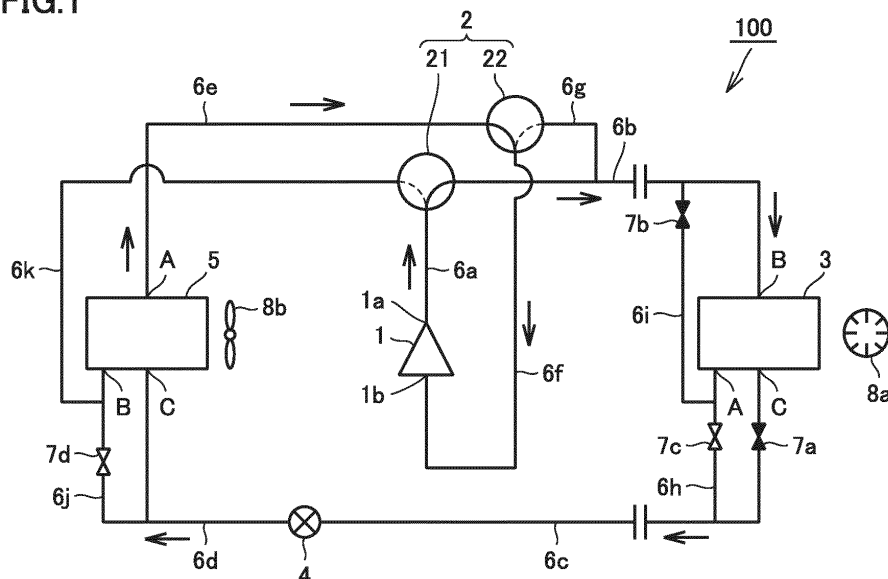
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(54) **AIR CONDITIONER**

(57) An air conditioner includes a compressor (1), a flow path switching device (2), a first heat exchanger (3), a fan (8a), a throttle device (4), and a second heat exchanger (5). At least one of a first heat exchange unit (3a) and a second heat exchange unit (3b) has a refrigerant inlet disposed leeward of air passed by the fan (8a) and a refrigerant outlet disposed windward of the air. Re-

frigerant flows successively through the first heat exchange unit (3a) and the second heat exchange unit (3b) when the first heat exchanger (3) is used as an evaporator, and flows in parallel through the first heat exchange unit (3a) and the second heat exchange unit (3b) when the first heat exchanger (3) is used as a condenser.

FIG.1



Description

TECHNICAL FIELD

[0001] The present invention relates to air conditioners.

BACKGROUND ART

[0002] An air conditioner conventionally includes a refrigerant circuit in which a compressor, a four-way valve, a condenser, a throttle device and an evaporator are connected via pipes. The direction of refrigerant flow through the refrigerant circuit is switched by the four-way valve depending on whether the air conditioner is performing heating operation or cooling operation. Specifically, during heating operation, refrigerant flows from the compressor, through the four-way valve, and into an indoor heat exchanger serving as a condenser, then flows through the throttle device and into an outdoor heat exchanger serving as an evaporator. During cooling operation, as a result of switching of the four-way valve from the state during the heating operation, refrigerant flows from the compressor, through the four-way valve, and into the outdoor heat exchanger serving as a condenser, then flows through the throttle device and into the indoor heat exchanger serving as an evaporator.

[0003] Each of the indoor heat exchanger and the outdoor heat exchanger is provided with a fan. This fan causes air to flow around each of the indoor heat exchanger and the outdoor heat exchanger. As a result, heat exchange takes place between the refrigerant flowing through each of the indoor heat exchanger and the outdoor heat exchanger, and the air flowing around each of the indoor heat exchanger and the outdoor heat exchanger. Japanese Patent Laying-Open No. 7-98166 (PTL 1), for example, proposes an air conditioner in which refrigerant flow through an outdoor heat exchanger is counterflow with respect to air flow around the outdoor heat exchanger during heating operation, in order to improve heat exchange efficiency.

CITATION LIST

PATENT LITERATURE

[0004] PTL 1: Japanese Patent Laying-Open No. 7-98166

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] In the air conditioner described in the above publication, refrigerant flow velocity varies depending on whether the outdoor heat exchanger is used as a condenser (during cooling operation) or the outdoor heat exchanger is used as an evaporator (during heating operation).

ation).

[0006] To improve the performance of a heat exchanger, it is effective for refrigerant to be used at high flow velocity when the heat exchanger is used as a condenser, and for refrigerant to be used at low flow velocity when the heat exchanger is used as an evaporator. This is because, in the condenser, heat transfer depending on the refrigerant flow velocity is dominant over the improvement in performance of the heat exchanger, whereas in the evaporator, reducing pressure loss depending on the flow velocity is dominant over the improvement in performance of the heat exchanger.

[0007] In the air conditioner described in the above publication, if operation is performed such that the heat exchanger has reduced pressure loss and improved heat transfer performance during one of cooling operation and heating operation, the heat exchanger has increased pressure loss and degraded heat transfer performance during the other of cooling operation and heating operation. In short, it is impossible to reduce the pressure loss and improve the heat transfer performance during both cooling operation and heating operation.

[0008] The present invention has been made in view of the above problem, and aims to provide an air conditioner capable of improving heat exchange efficiency, reducing pressure loss, and improving heat transfer performance at a heat exchanger.

SOLUTION TO PROBLEM

[0009] An air conditioner of the present invention includes a compressor, a flow path switching device, a first heat exchanger, a fan, a throttle device, and a second heat exchanger. The compressor is configured to compress refrigerant. The flow path switching device is connected to the compressor. The first heat exchanger is connected to the flow path switching device and has a first heat exchange unit and a second heat exchange unit. The fan is configured to pass air around the first heat exchange unit and the second heat exchange unit. The throttle device is connected to the first heat exchanger. The second heat exchanger is connected to the throttle device. The flow path switching device is configured to switch flow of the refrigerant compressed by the compressor between flow to the first heat exchanger and flow to the second heat exchanger. At least one of the first heat exchange unit and the second heat exchange unit has a refrigerant inlet disposed leeward of the air passed by the fan and a refrigerant outlet disposed windward of the air. The refrigerant flows successively through the first heat exchange unit and the second heat exchange unit when the first heat exchanger is used as an evaporator, and flows in parallel through the first heat exchange unit and the second heat exchange unit when the first heat exchanger is used as a condenser.

ADVANTAGEOUS EFFECTS OF INVENTION

[0010] According to the air conditioner of the present invention, at least one of the first heat exchange unit and the second heat exchange unit has the refrigerant inlet disposed leeward of the air passed by the fan and the refrigerant outlet disposed windward of the air. Accordingly, refrigerant flow from the refrigerant inlet toward the refrigerant outlet in at least one of the first heat exchange unit and the second heat exchange unit can be counter-flow with respect to air flow around the one of the first heat exchange unit and the second heat exchange unit. Heat exchange efficiency at the first heat exchanger can thereby be improved. Moreover, the refrigerant flows successively through the first heat exchange unit and the second heat exchange unit when the first heat exchanger is used as a condenser, and flows in parallel through the first heat exchange unit and the second heat exchange unit when the first heat exchanger is used as an evaporator. Accordingly, the refrigerant flows successively through the first heat exchange unit and the second heat exchange unit when the first heat exchanger is used as a condenser during heating operation, thereby allowing an increase in flow velocity of the refrigerant that has been turned into a liquid state by means of heat exchange at the first heat exchanger. Heat transfer performance can thereby be improved. In addition, the refrigerant flows in parallel through the first heat exchange unit and the second heat exchange unit when the first heat exchanger is used as an evaporator during cooling operation, thereby allowing a reduction in flow velocity of the refrigerant in a gas state and a gas-liquid two-phase state. Pressure loss can thereby be reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

Fig. 1 is a schematic configuration diagram of an air conditioner during cooling operation according to an embodiment of the present invention.

Fig. 2 is a schematic configuration diagram of the air conditioner during heating operation according to the embodiment of the present invention.

Fig. 3 is a schematic side view of an indoor heat exchanger and a fan of the air conditioner according to the embodiment of the present invention.

Fig. 4 is a schematic side view of the indoor heat exchanger of the air conditioner according to the embodiment of the present invention.

Fig. 5 is a schematic side view of an outdoor heat exchanger and a fan of the air conditioner according to the embodiment of the present invention.

Fig. 6 is a schematic perspective view of the outdoor heat exchanger of the air conditioner according to the embodiment of the present invention.

Fig. 7 is a schematic sectional view of the outdoor heat exchanger of the air conditioner according to

the embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0012] In the following, an embodiment of the present invention is described based on the drawings.

[0013] Referring to Fig. 1, the configuration of an air conditioner according to an embodiment of the present invention is described.

[0014] The air conditioner according to the embodiment of the present invention includes a compressor 1, a flow path switching device 2, a first heat exchanger 3, a throttle device 4, a second heat exchanger 5, pipes 6a to 6k, valves 7a to 7d, and fans 8a to 8b.

[0015] Compressor 1, flow path switching device 2, first heat exchanger 3, throttle device 4, and second heat exchanger 5 are communicated with one another through pipes 6a to 6k and valves 7a to 7d. A refrigerant circuit is thus formed. Refrigerant flows through the refrigerant circuit. That is, the refrigerant flows through compressor 1, flow path switching device 2, first heat exchanger 3, throttle device 4, and second heat exchanger 5 by passing through pipes 6a to 6k and valves 7a to 7d. One of a single refrigerant and an azeotropic refrigerant can be used as the refrigerant flowing through the refrigerant circuit. For example, R32 can be used as the single refrigerant. For example, R410a can be used as the azeotropic refrigerant. Alternatively, a non-azeotropic refrigerant can be used as the refrigerant. For example, R1234yf can be used as the non-azeotropic refrigerant.

[0016] The air conditioner also includes a controller (not shown). The controller is configured to perform operations and provide instructions to control means, devices and the like of a refrigeration cycle apparatus. Specifically, the controller is configured to control operations of flow path switching device 2 and valves 7a to 7d, for example.

[0017] In Fig. 1, first heat exchanger 3 is an indoor heat exchanger, and second heat exchanger 5 is an outdoor heat exchanger. Compressor 1, flow path switching device 2, throttle device 4, second heat exchanger 5, and fan 8b are provided in an outdoor unit (not shown). First heat exchanger 3 and fan 8a are provided in an indoor unit (not shown).

[0018] Compressor 1 is configured to compress and discharge the suctioned refrigerant. Compressor 1 has a discharge port 1a through which the refrigerant is discharged, and a suction port 1b through which the refrigerant is suctioned. Compressor 1 may be a constant speed compressor having a constant compressive capacity, or an inverter compressor having a variable compressive capacity. This inverter compressor is configured to have a variably controlled rotation speed. Specifically, the rotation speed of this inverter compressor is adjusted by changing a driving frequency based on an instruction from the controller (not shown). The compressive capacity is thereby varied. This compressive capacity is an amount of refrigerant delivered per unit time.

[0019] Flow path switching device 2 is connected to compressor 1. Flow path switching device 2 is configured to switch refrigerant flow depending on whether the air conditioner is performing cooling operation or heating operation. Flow path switching device 2 has a first three-way valve 21 and a second three-way valve 22. First three-way valve 21 and second three-way valve 22 are spaced from each other. That is, first three-way valve 21 and second three-way valve 22 are not in contact with each other.

[0020] First three-way valve 21 connects discharge port 1a of compressor 1 to first heat exchanger 3 or second heat exchanger 5. That is, first three-way valve 21 is configured to selectively pass the refrigerant discharged through discharge port 1a of compressor 1 to one of first heat exchanger 3 and second heat exchanger 5. Specifically, discharge port 1a of compressor 1 is connected to first three-way valve 21 via pipe 6a. First three-way valve 21 is connected to first heat exchanger 3 via pipe 6b. First three-way valve 21 is connected to second heat exchanger 5 via pipe 6k.

[0021] Second three-way valve 22 connects suction port 1b of compressor 1 to first heat exchanger 3 or second heat exchanger 5. That is, second three-way valve 22 is configured to selectively pass the refrigerant from one of first heat exchanger 3 and second heat exchanger 5 to suction port 1b of compressor 1. Specifically, suction port 1b of compressor 1 is connected to second three-way valve 22 via pipe 6f. Second three-way valve 22 is connected to second heat exchanger 5 via pipe 6e. Second three-way valve 22 is connected to pipe 6b via pipe 6g. Second three-way valve 22 is connected to first heat exchanger 3 via pipe 6g and pipe 6b.

[0022] First heat exchanger 3 is to exchange heat between refrigerant and air. First heat exchanger 3 is formed of a pipe (heat transfer tube) and a fin, for example. First heat exchanger 3 is connected to flow path switching device 2 and throttle device 4.

[0023] During cooling operation, first heat exchanger 3 serves as an evaporator to evaporate the refrigerant decompressed by throttle device 4. During heating operation, first heat exchanger 3 serves as a condenser to condense the refrigerant compressed by compressor 1.

[0024] First heat exchanger 3 is connected to throttle device 4 via pipe 6c. Pipe 6h branching from pipe 6c is connected to first heat exchanger 3. Pipe 6i branching from pipe 6h is connected to pipe 6b. Pipe 6h and pipe 6i are provided in the indoor unit (not shown).

[0025] Throttle device 4 is connected to first heat exchanger 3 and second heat exchanger 5. During cooling operation, throttle device 4 serves as a decompression device to decompress the refrigerant condensed by second heat exchanger (condenser) 5. During heating operation, throttle device 4 serves as a decompression device to decompress the refrigerant condensed by first heat exchanger (condenser) 3. Throttle device 4 is an expansion valve to expand (decompress) the refrigerant by adjustment of the degree of opening of the valve, for

example. More specifically, throttle device 4 may be an electronic expansion valve, for example.

[0026] Second heat exchanger 5 is to exchange heat between refrigerant and air. Second heat exchanger 5 is formed of a pipe (heat transfer tube) and a fin, for example. Second heat exchanger 5 is connected to flow path switching device 2 and throttle device 4.

[0027] During heating operation, second heat exchanger 5 serves as an evaporator to evaporate the refrigerant decompressed by throttle device 4. During cooling operation, second heat exchanger 5 serves as a condenser to condense the refrigerant compressed by compressor 1.

[0028] Second heat exchanger 5 is connected to throttle device 4 via pipe 6d. Second heat exchanger 5 is connected to second three-way valve 22 via pipe 6e. Pipe 6j branching from pipe 6d is connected to second heat exchanger 5. Pipe 6k branching from pipe 6j is connected to first three-way valve 21. Pipe 6d, pipe 6e, pipe 6j and pipe 6k are provided in the outdoor unit (not shown).

[0029] Valves 7a to 7d are configured to switch refrigerant flow through the refrigerant circuit. Valve 7a is provided on pipe 6c. Valve 7b is provided on pipe 6i. Valve 7c is provided on pipe 6h. Valve 7d is provided on pipe 6j. Valves 7a to 7d are each an on-off valve, for example. More specifically, valves 7a to 7d may each be an electronic on-off valve, for example. Valves 7a to 7d are controlled to be turned on/off to thereby control refrigerant flow to first heat exchanger 3 and second heat exchanger 5.

[0030] Fan 8a is configured to pass air around first heat exchanger 3. Fan 8a is a crossflow fan, for example. Fan 8b is configured to pass air around second heat exchanger 5. Fan 8b is a propeller fan, for example. Fan 8a and fan 8b are configured to pass air (blow air) around first heat exchanger 3 and second heat exchanger 5, respectively, based on instructions from the controller (not shown).

[0031] Referring now to Figs. 1 and 2, operation of the air conditioner in the present embodiment is described.

[0032] First, referring to Fig. 1, operation of the air conditioner during heating operation in the present embodiment is described in conjunction with refrigerant flow through the refrigerant circuit. During heating operation, valve 7a and valve 7b are closed, and valve 7c and valve 7d are opened. High-temperature and high-pressure gas refrigerant discharged through discharge port 1a of compressor 1 flows into first three-way valve 21 of flow path switching device 2. During heating operation, first three-way valve 21 of flow path switching device 2 is set such that the refrigerant flows into first heat exchanger 3. At first heat exchanger 3, the high-temperature and high-pressure gas refrigerant is condensed into liquid refrigerant at the condenser outlet side, by means of heat transfer between the air flowing around first heat exchanger 3 and the refrigerant flowing through first heat exchanger 3. In this case, the air flowing around first heat exchanger 3 is heated.

[0033] The refrigerant condensed at first heat exchanger 3 flows into throttle device 4, and is turned into a low-temperature and low-pressure state. The refrigerant turned into a low-temperature and low-pressure state at throttle device 4 flows into second heat exchanger 5. At second heat exchanger 5, the refrigerant is turned into low-temperature and low-pressure gas refrigerant by means of heat exchange with the air. The low-temperature and low-pressure gas refrigerant flows into second three-way valve 22 of flow path switching device 2. The refrigerant that flows into second three-way valve 22 flows into compressor 1 through suction port 1b of compressor 1. Compressor 1 compresses the refrigerant suctioned through suction port 1b and discharges the refrigerant again through discharge port 1a. That is, during heating operation, the refrigerant circulates through the refrigerant circuit as indicated by solid line arrows in Fig. 1.

[0034] First three-way valve 21 and second three-way valve 22 are spaced from each other. Accordingly, heat exchange between the high-temperature and high-pressure gas refrigerant flowing through first three-way valve 21 and the low-temperature and low-pressure gas refrigerant flowing through second three-way valve 22 can be prevented. The occurrence of heat loss can thereby be prevented. Moreover, since first three-way valve 21 and second three-way valve 22 are spaced from each other, leakage of the refrigerant from first three-way valve 21 to second three-way valve 22 can be prevented. The occurrence of heat loss can also thereby be prevented.

[0035] Referring now to Fig. 2, operation of the air conditioner during cooling operation in the present embodiment is described in conjunction with refrigerant flow through the refrigerant circuit. During cooling operation, valve 7a and valve 7b are opened, and valve 7c and valve 7d are closed. High-temperature and high-pressure gas refrigerant discharged through discharge port 1a of compressor 1 flows into first three-way valve 21 of flow path switching device 2. During cooling operation, first three-way valve 21 of flow path switching device 2 is set such that the refrigerant flows into second heat exchanger 5. At second heat exchanger 5, the high-temperature and high-pressure gas refrigerant is condensed into liquid refrigerant at the condenser outlet side, by means of heat exchange between the air flowing around second heat exchanger 5 and the refrigerant flowing through second heat exchanger 5.

[0036] The refrigerant condensed into a liquid phase state at second heat exchanger 5 flows into throttle device 4, and is turned into a gas-liquid two-phase state of low temperature and low pressure. The refrigerant turned into a gas-liquid two-phase state of low temperature and low pressure at throttle device 4 flows into first heat exchanger 3. At first heat exchanger 3, the refrigerant is turned into low-temperature and low-pressure gas refrigerant by means of heat exchange between the air flowing around first heat exchanger 3 and the refrigerant flowing through first heat exchanger 3. In this case, the air flowing

around first heat exchanger 3 is cooled. The refrigerant heated by the surrounding air is turned from the gas-liquid two-phase refrigerant into gas-phase refrigerant, and flows into second three-way valve 22 of flow path switching device 2. The refrigerant that flows into second three-way valve 22 flows into compressor 1 through suction port 1b of compressor 1. Compressor 1 compresses the refrigerant suctioned through suction port 1b and discharges the refrigerant again through discharge port 1a. That is, during cooling operation, the refrigerant circulates through the refrigerant circuit as indicated by solid line arrows in Fig. 2.

[0037] Referring now to Figs. 1 to 4, first heat exchanger 3 is described in more detail. First heat exchanger 3 has a first heat exchange unit 3a, a second heat exchange unit 3b, a third heat exchange unit 3c, and headers 30a to 30d.

[0038] As shown primarily in Fig. 3, first heat exchange unit 3a is connected to second heat exchange unit 3b via header 30b. Second heat exchange unit 3b is connected to header 30c. First heat exchange unit 3a is connected to third heat exchange unit 3c via header 30a. Third heat exchange unit 3c is connected to header 30d.

[0039] First heat exchange unit 3a is disposed opposite to second heat exchange unit 3b with respect to fan 8a. First heat exchange unit 3a, second heat exchange unit 3b and third heat exchange unit 3c are disposed to surround fan 8a from above.

[0040] It is also possible to configure first heat exchanger 3 to have only first heat exchange unit 3a and second heat exchange unit 3b, and to not have third heat exchange unit 3c.

[0041] As shown primarily in Fig. 4, first heat exchange unit 3a has refrigerant flow paths 3a1 to 3a4. Refrigerant flow paths 3a1 to 3a4 are each connected to header 30a and header 30b. Refrigerant flow paths 3a1 to 3a4 are configured such that the refrigerant flows in parallel through them. Refrigerant flow paths 3a1 to 3a4 are each formed by alternately connecting heat transfer tubes disposed closer to fan 8a and heat transfer tubes disposed farther from fan 8a.

[0042] Second heat exchange unit 3b has refrigerant flow paths 3b1 to 3b2. Refrigerant flow paths 3b1 to 3b2 are each connected to header 30b and header 30c. Refrigerant flow paths 3b1 to 3b2 are configured such that the refrigerant flows in parallel through them. Refrigerant flow paths 3b1 to 3b2 are each formed by alternately connecting heat transfer tubes disposed closer to fan 8a and heat transfer tubes disposed farther from fan 8a.

[0043] Third heat exchange unit 3c has refrigerant flow paths 3c1 to 3c4. Refrigerant flow paths 3c1 to 3c4 are each connected to header 30a and header 30d. Refrigerant flow paths 3c1 to 3c4 are configured such that the refrigerant flows in parallel through them. Refrigerant flow paths 3c1 to 3c4 are each formed by alternately connecting a heat transfer tube disposed closer to fan 8a and a heat transfer tube disposed farther from fan 8a.

[0044] Referring primarily to Figs. 3 and 4, during heat-

ing operation, the refrigerant flows from a heating inlet B, through header 30d, and into third heat exchange unit 3c, then flows in parallel through refrigerant flow paths 3c1 to 3c4 and merges at header 30a. The refrigerant flows from header 30a into first heat exchange unit 3a, flows in parallel through refrigerant flow paths 3a1 to 3a4 and merges at header 30b. The refrigerant flows from header 30b into second heat exchange unit 3b, flows in parallel through refrigerant flow paths 3b1 to 3b2 and merges at header 30c. The refrigerant flows through header 30c and flows out through a heating outlet A. That is, during heating operation, the refrigerant flows successively through third heat exchange unit 3c, first heat exchange unit 3a, and second heat exchange unit 3b.

[0045] During cooling operation, the refrigerant flows from a cooling inlet C, through header 30b, and into first heat exchange unit 3a and second heat exchange unit 3b. The refrigerant that flows into first heat exchange unit 3a flows in parallel through refrigerant flow paths 3a1 to 3a4 and merges at header 30a. The refrigerant flows from header 30a into third heat exchange unit 3c, flows in parallel through refrigerant flow paths 3c1 to 3c4 and merges at header 30d. The refrigerant flows through header 30d and flows out through a cooling outlet B. That is, during heating operation, the refrigerant flows in parallel through first heat exchange unit 3a and second heat exchange unit 3b. The refrigerant also flows successively through first heat exchange unit 3a and third heat exchange unit 3c.

[0046] Rotation of fan 8a in response to an instruction from the controller (not shown) causes the occurrence of air flow. The air flows from first heat exchanger 3 toward fan 8a as indicated by white arrows in Figs. 3 and 4.

[0047] During heating operation, the refrigerant flows from a refrigerant inlet toward a refrigerant outlet of first heat exchange unit 3a as indicated by broken line arrows in Figs. 3 and 4. Therefore, refrigerant flow from the refrigerant inlet toward the refrigerant outlet of first heat exchange unit 3a is parallel flow with respect to air flow around first heat exchange unit 3a. The refrigerant flows, on the other hand, from a refrigerant inlet toward a refrigerant outlet of second heat exchange unit 3b as indicated by the broken line arrows in Figs. 3 and 4. Therefore, refrigerant flow from the refrigerant inlet toward the refrigerant outlet of second heat exchange unit 3b is counterflow with respect to air flow around second heat exchange unit 3b.

[0048] During cooling operation, the refrigerant flows from the refrigerant inlet toward the refrigerant outlet of first heat exchange unit 3a as indicated by solid line arrows in Figs. 3 and 4. Therefore, refrigerant flow from the refrigerant inlet toward the refrigerant outlet of first heat exchange unit 3a is counterflow with respect to air flow around first heat exchange unit 3a. The refrigerant flows, on the other hand, from the refrigerant inlet toward the refrigerant outlet of second heat exchange unit 3b as indicated by the solid line arrows in Figs. 3 and 4. Therefore, refrigerant flow from the refrigerant inlet toward the

refrigerant outlet of second heat exchange unit 3b is counterflow with respect to air flow around second heat exchange unit 3b.

[0049] During heating operation, there are four refrigerant flow paths 3a1 to 3a4 of first heat exchange unit 3a, and there are two refrigerant flow paths 3b1 to 3b2 of second heat exchange unit 3b through which the refrigerant flows after flowing through first heat exchange unit 3a. Thus, the number of refrigerant flow paths (number of paths) during heating operation is four. During cooling operation, on the other hand, there are four refrigerant flow paths 3a1 to 3a4 of first heat exchange unit 3a, and there are two refrigerant flow paths 3b1 to 3b2 of second heat exchange unit 3b through which the refrigerant flows in parallel with first heat exchange unit 3a. Thus, the number of refrigerant flow paths (number of paths) during cooling operation is six. Accordingly, the number of refrigerant flow paths (number of paths) can be changed between heating operation and cooling operation.

[0050] Referring now to Figs. 1, 2, and 5 to 7, second heat exchanger 5 is described in more detail. Second heat exchanger 5 has a first heat exchange unit 5a, a second heat exchange unit 5b, and headers 50a to 50c.

[0051] As shown primarily in Figs. 5 and 6, first heat exchange unit 5a is connected to second heat exchange unit 5b via header 50c. First heat exchange unit 5a is connected to header 50a. Second heat exchange unit 5b is connected to header 50b.

[0052] First heat exchange unit 5a and second heat exchange unit 5b are aligned with respect to fan 8b. First heat exchange unit 5a and second heat exchange unit 5b may be disposed equidistant from fan 8b.

[0053] As shown primarily in Fig. 7, first heat exchange unit 5a has refrigerant flow paths 5a1 to 5a4. Refrigerant flow paths 5a1 to 5a4 are each connected to header 50a and header 50c. Refrigerant flow paths 5a1 to 5a4 are configured such that the refrigerant flows in parallel through them. Refrigerant flow paths 5a1 to 5a4 are each formed by alternately connecting heat transfer tubes disposed closer to fan 8b and heat transfer tubes disposed farther from fan 8b.

[0054] Second heat exchange unit 5b has refrigerant flow paths 5b1 to 5b2. Refrigerant flow paths 5b1 to 5b2 are each connected to header 50b and header 50c. Refrigerant flow paths 5b1 to 5b2 are configured such that the refrigerant flows in parallel through them. Refrigerant flow paths 5b1 to 5b2 are each formed by alternately connecting heat transfer tubes disposed closer to fan 8b and heat transfer tubes disposed farther from fan 8b.

[0055] Refrigerant flow paths 5a1 to 5a4 of first heat exchange unit 5a and refrigerant flow paths 5b1 to 5b2 of second heat exchange unit 5b penetrate through common fins. Refrigerant flow paths 5a1 to 5a4 of first heat exchange unit 5a and refrigerant flow paths 5b1 to 5b2 of second heat exchange unit 5b may be provided to penetrate through separate fins.

[0056] During heating operation, the refrigerant flows

from heating inlet B, through header 50a, and into first heat exchange unit 5a, and also flows from a heating inlet C, through header 50b, and into second heat exchange unit 5b. The refrigerant that flows into first heat exchange unit 5a flows in parallel through refrigerant flow paths 5a1 to 5a4 and merges at header 50c. The refrigerant that flows into second heat exchange unit 5b flows in parallel through refrigerant flow paths 5b1 to 5b2 and merges at header 50c. The refrigerant flows through header 50c and flows out through heating outlet A. That is, during heating operation, the refrigerant flows in parallel through first heat exchange unit 3a and second heat exchange unit 3b.

[0057] During cooling operation, the refrigerant flows from cooling inlet B, through header 50a, and into first heat exchange unit 5a, then flows in parallel through refrigerant flow paths 5a1 to 5a4 and merges at header 50c. The refrigerant flows from header 50c into second heat exchange unit 5b, flows in parallel through refrigerant flow paths 5b1 to 5b2 and merges at header 50b. The refrigerant flows through header 50b and flows out through a cooling outlet C. That is, during cooling operation, the refrigerant flows successively through first heat exchange unit 5a and second heat exchange unit 5b.

[0058] Rotation of fan 8b in response to an instruction from the controller (not shown) causes the occurrence of air flow. The air flows from second heat exchanger 5 toward fan 8b as indicated by white arrows in Figs. 5 to 7.

[0059] During heating operation, the refrigerant flows from a refrigerant inlet toward a refrigerant outlet of first heat exchange unit 5a as indicated by broken line arrows in Figs. 6 and 7. Therefore, refrigerant flow from the refrigerant inlet toward the refrigerant outlet of first heat exchange unit 5a is counterflow with respect to air flow around first heat exchange unit 5a. The refrigerant also flows from a refrigerant inlet toward a refrigerant outlet of second heat exchange unit 5b as indicated by the broken line arrows in Figs. 6 and 7. Therefore, refrigerant flow from the refrigerant inlet toward the refrigerant outlet of second heat exchange unit 5b is counterflow with respect to air flow around second heat exchange unit 5b.

[0060] During cooling operation, the refrigerant flows from the refrigerant inlet toward the refrigerant outlet of first heat exchange unit 5a as indicated by solid line arrows in Figs. 6 and 7. Therefore, refrigerant flow from the refrigerant inlet toward the refrigerant outlet of first heat exchange unit 5a is counterflow with respect to air flow around first heat exchange unit 5a. The refrigerant also flows from the refrigerant inlet toward the refrigerant outlet of second heat exchange unit 3b as indicated by the solid line arrows in Figs. 6 and 7. Therefore, refrigerant flow from the refrigerant inlet toward the refrigerant outlet of second heat exchange unit 5b is counterflow with respect to air flow around second heat exchange unit 5b.

[0061] During heating operation, there are four refrigerant flow paths 5a1 to 5a4 of first heat exchange unit 5a, and there are two refrigerant flow paths 5b1 to 5b2 of second heat exchange unit 5b through which the re-

frigerant flows in parallel with first heat exchange unit 5a. Thus, the number of refrigerant flow paths (number of paths) during heating operation is six. During cooling operation, on the other hand, there are four refrigerant flow paths 5a1 to 5a4 of first heat exchange unit 5a, and there are two refrigerant flow paths 5b1 to 5b2 of second heat exchange unit 5b through which the refrigerant flows after flowing through first heat exchange unit 5a. Thus, the number of refrigerant flow paths (number of paths) during heating operation is four. Accordingly, the number of refrigerant flow paths (number of paths) can be changed between heating operation and cooling operation.

[0062] Although both of first heat exchanger 3 serving as an indoor heat exchanger and second heat exchanger 5 serving as an outdoor heat exchanger are described as having the first heat exchange unit and the second heat exchange unit in the above description, the air conditioner according to the present embodiment is not limited to this configuration. Only first heat exchanger 3 serving as an indoor heat exchanger may have the first heat exchange unit and the second heat exchange unit. Alternatively, only second heat exchanger 5 serving as an outdoor heat exchanger may have the first heat exchange unit and the second heat exchange unit. In this case, second heat exchanger 5 corresponds to a first heat exchanger in the claims.

[0063] A function and effect of the present embodiment will now be described.

[0064] According to the air conditioner of the present embodiment, at least one of first heat exchange unit 3a and second heat exchange unit 3b has the refrigerant inlet disposed leeward of the air passed by fan 8a and the refrigerant outlet disposed windward of the air. Accordingly, refrigerant flow from the refrigerant inlet toward the refrigerant outlet in at least one of first heat exchange unit 3a and second heat exchange unit 3b can be counterflow with respect to air flow around the one of first heat exchange unit 3a and second heat exchange unit 3b. Heat exchange efficiency at first heat exchanger 3 can thereby be improved. Moreover, the refrigerant flows successively through first heat exchange unit 3a and second heat exchange unit 3b when first heat exchanger 3 is used as a condenser, and flows in parallel through first heat exchange unit 3a and second heat exchange unit 3b when first heat exchanger 3 is used as an evaporator. Accordingly, the refrigerant flows successively through first heat exchange unit 3a and second heat exchange unit 3b when first heat exchanger 3 is used as a condenser during heating operation, thereby allowing an increase in flow velocity of the refrigerant that has been turned into a liquid state by means of heat exchange at first heat exchanger 3. Heat transfer performance can thereby be improved. In addition, the refrigerant flows in parallel through first heat exchange unit 3a and second heat exchange unit 3b when first heat exchanger 3 is used as an evaporator during cooling operation, thereby allowing a reduction in flow velocity of the refrigerant in a gas state and a gas-liquid two-phase state. Pressure

loss can thereby be reduced.

[0065] Moreover, since first heat exchanger 3 has first heat exchange unit 3a and second heat exchange unit 3b, and second heat exchanger 5 has first heat exchange unit 5a and second heat exchange unit 5b, heat exchange efficiency can be improved, pressure loss can be reduced, and heat transfer performance can be improved at both of first heat exchanger 3 and second heat exchanger 5. As a result, the seasonal performance factor, that is, the annual performance factor (APF) can be improved.

[0066] When first heat exchanger 3 is used as a condenser during heating operation, the refrigerant is turned into a liquid state at the condenser outlet side and therefore has a low flow velocity, which is likely to result in degraded heat transfer performance. In the air conditioner of the present embodiment, however, second heat exchange unit 3b is disposed closer to the condenser outlet than first heat exchange unit 3a. In addition, the number of refrigerant flow paths (number of paths) of second heat exchange unit 3b is smaller than the number of refrigerant flow paths (number of paths) of first heat exchange unit 3a. Accordingly, the refrigerant flow velocity can be increased at second heat exchange unit 3b as compared to the flow velocity at first heat exchange unit 3a. The heat transfer performance can thereby be further improved.

[0067] According to the air conditioner of the present embodiment, flow path switching device 2 has first three-way valve 21 and second three-way valve 22. First three-way valve 21 connects discharge port 1a of compressor 1 to first heat exchanger 3 or second heat exchanger 5. Second three-way valve 22 connects suction port 1b of compressor 1 to first heat exchanger 3 or second heat exchanger 5. Accordingly, flow path switching device 2 can switch, by first three-way valve 21 and second three-way valve 22, flow of the refrigerant compressed by compressor 1 between flow to first heat exchanger 3 and flow to second heat exchanger 5.

[0068] Moreover, since first three-way valve 21 and second three-way valve 22 are spaced from each other, heat exchange between the high-temperature and high-pressure gas refrigerant flowing through first three-way valve 21 and the low-temperature and low-pressure gas refrigerant flowing through second three-way valve 22 can be prevented. The occurrence of heat loss can thereby be prevented. Moreover, since first three-way valve 21 and second three-way valve 22 are spaced from each other, leakage of the refrigerant from first three-way valve 21 to second three-way valve 22 can be prevented. The occurrence of heat loss can also thereby be prevented.

[0069] According to the air conditioner of the present embodiment, the refrigerant is one of a single refrigerant and an azeotropic refrigerant. Accordingly, a single refrigerant and an azeotropic refrigerant can be used as the refrigerant.

[0070] According to the air conditioner of the present embodiment, the refrigerant may be a non-azeotropic re-

frigerant. Accordingly, a non-azeotropic refrigerant can be used as the refrigerant. A non-azeotropic refrigerant produces a temperature gradient during condensation and compression. Thus, refrigerant in a later portion of the refrigerant flow can exchange heat with the air that has not yet been subjected to heat exchange, to ensure a sufficient temperature difference. As a result, subcooling can be ensured. Heat exchange performance can also be improved.

[0071] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. 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.

REFERENCE SIGNS LIST

[0072] 1 compressor; 2 flow path switching device; 3 first heat exchanger; 3a first heat exchange unit; 3b second heat exchange unit; 4 throttle device; 5 second heat exchanger; 6a to 6k pipe; 7a to 7d valve; 8a to 8b fan.

Claims

1. An air conditioner comprising:

- a compressor configured to compress refrigerant;
 - a flow path switching device connected to the compressor;
 - a first heat exchanger connected to the flow path switching device and having a first heat exchange unit and a second heat exchange unit;
 - a fan configured to pass air around the first heat exchange unit and the second heat exchange unit;
 - a throttle device connected to the first heat exchanger; and
 - a second heat exchanger connected to the throttle device,
- the flow path switching device being configured to switch flow of the refrigerant compressed by the compressor between flow to the first heat exchanger and flow to the second heat exchanger,
- at least one of the first heat exchange unit and the second heat exchange unit having a refrigerant inlet disposed leeward of the air passed by the fan and a refrigerant outlet disposed windward of the air,
- the refrigerant flowing successively through the first heat exchange unit and the second heat exchange unit when the first heat exchanger is used as an evaporator, and flowing in parallel through the first heat exchange unit and the sec-

ond heat exchange unit when the first heat exchanger is used as a condenser.

2. The air conditioner according to claim 1, wherein the compressor has a discharge port through which the refrigerant is discharged, and a suction port through which the refrigerant is suctioned, and the flow path switching device has a first three-way valve connecting the discharge port to the first heat exchanger or the second heat exchanger, and a second three-way valve connecting the suction port to the first heat exchanger or the second heat exchanger. 5 10
3. The air conditioner according to claim 1 or 2, wherein the refrigerant is one of a single refrigerant and an azeotropic refrigerant. 15
4. The air conditioner according to claim 1 or 2, wherein the refrigerant is a non-azeotropic refrigerant. 20

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FIG.1

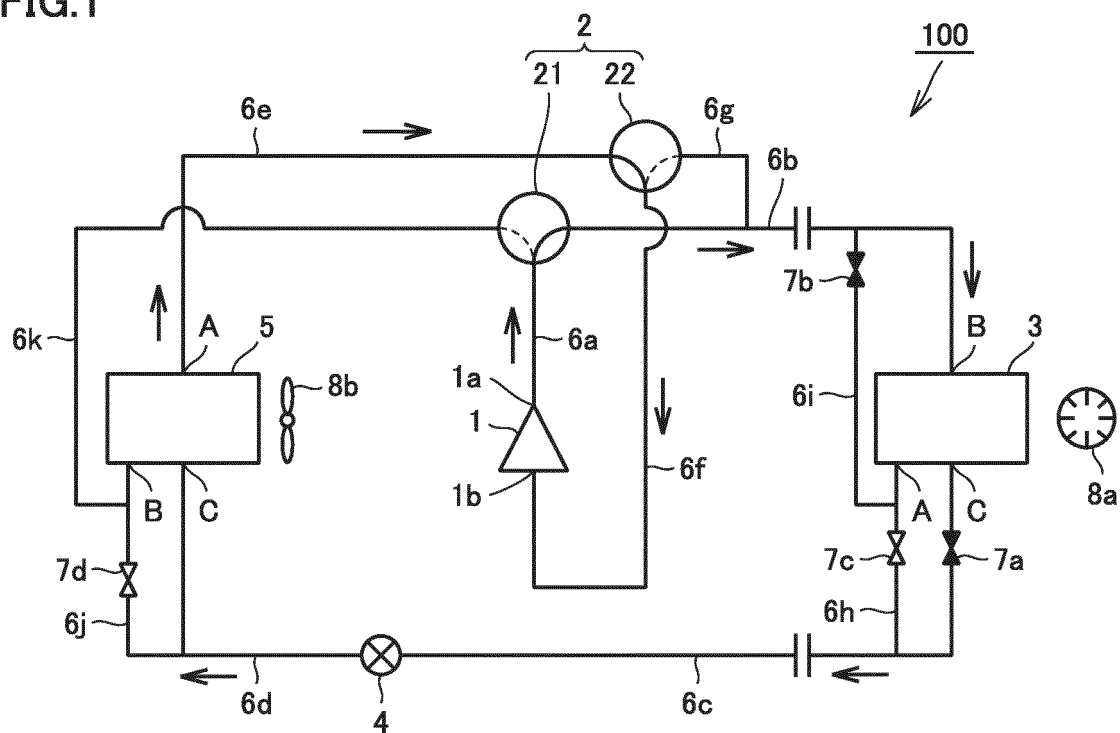


FIG.2

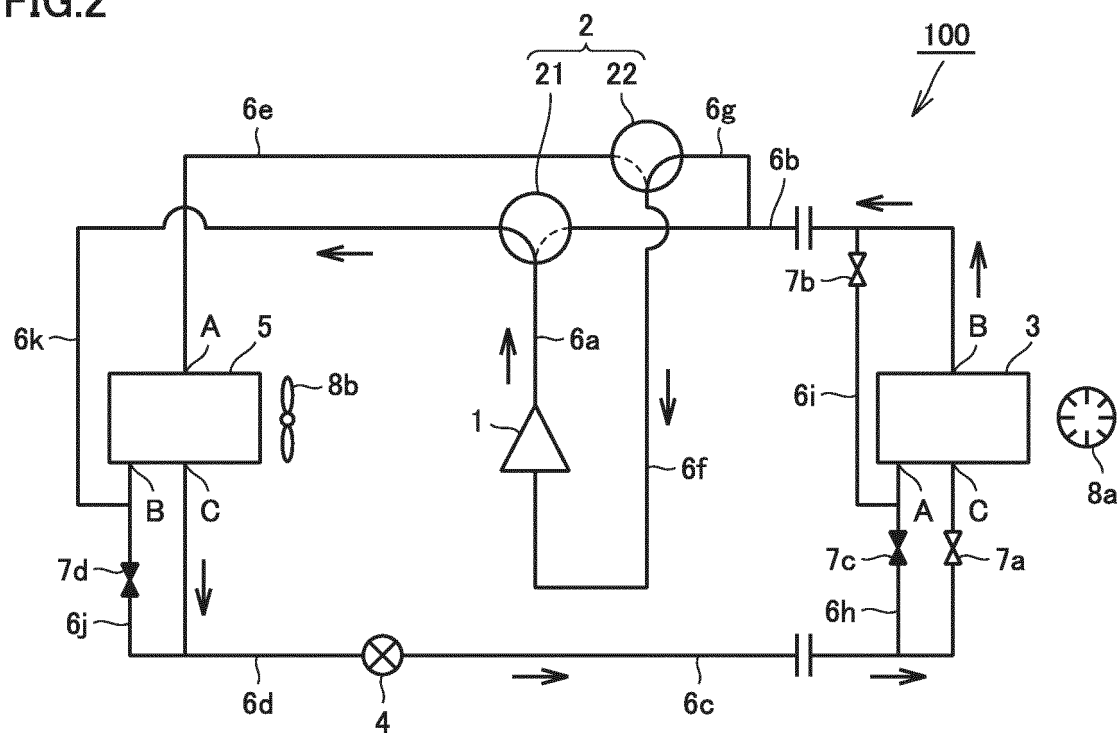


FIG.3

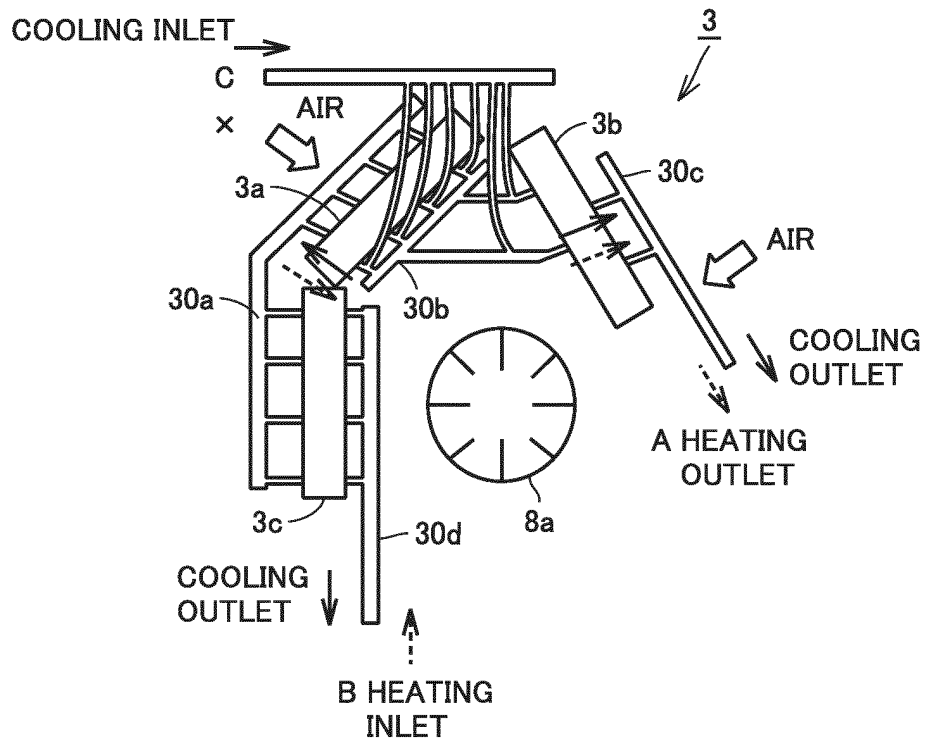


FIG.4

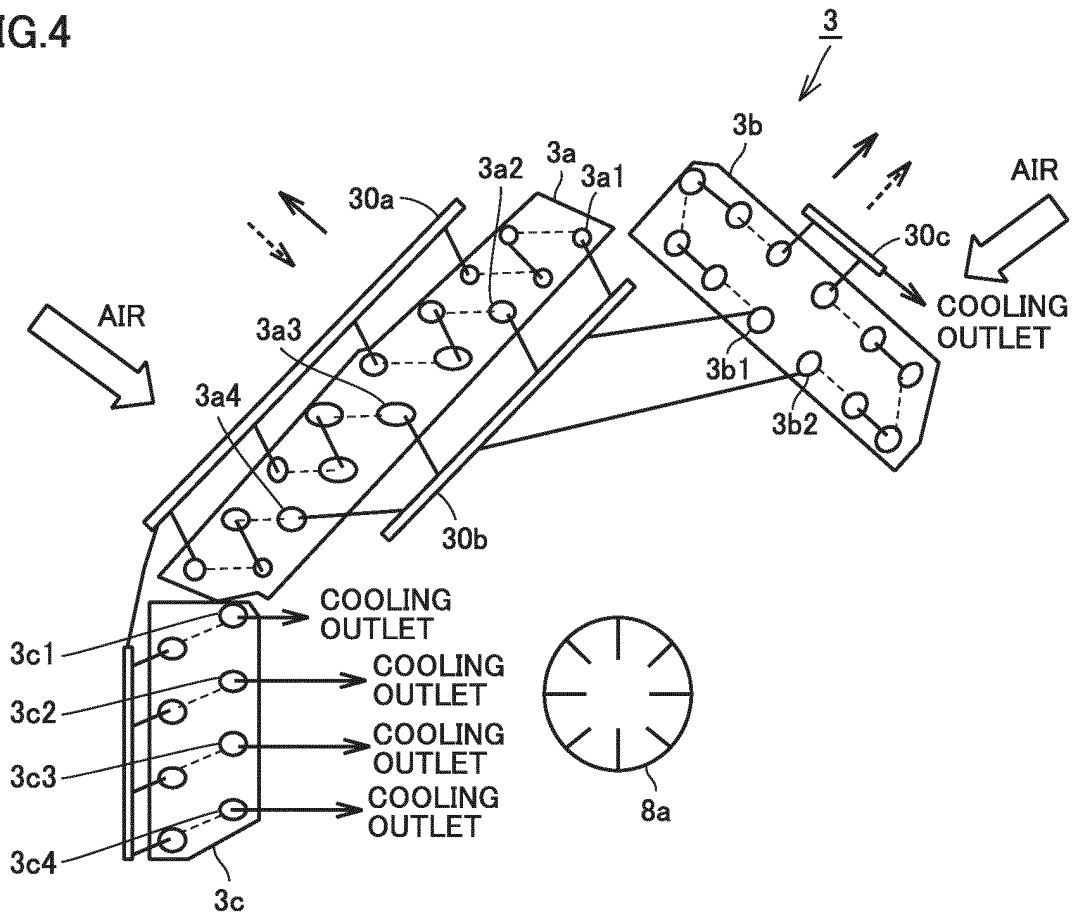


FIG.5

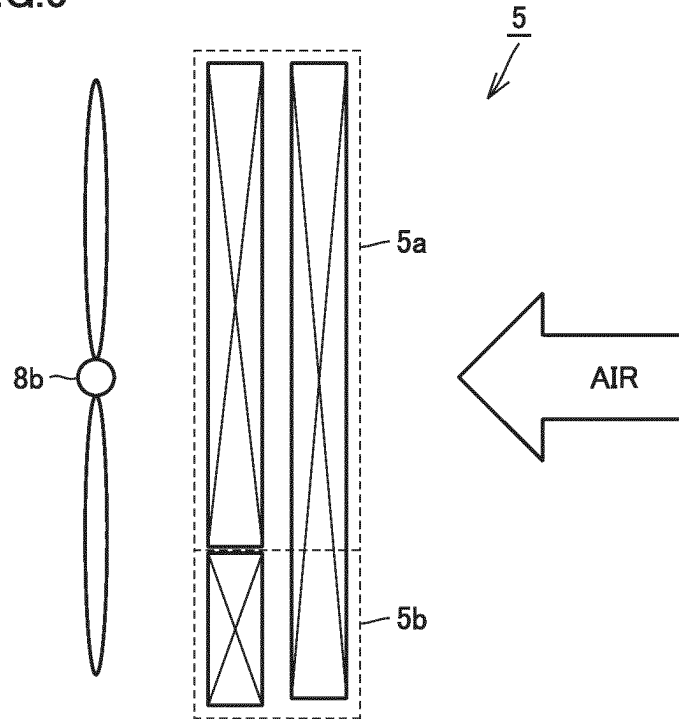


FIG.6

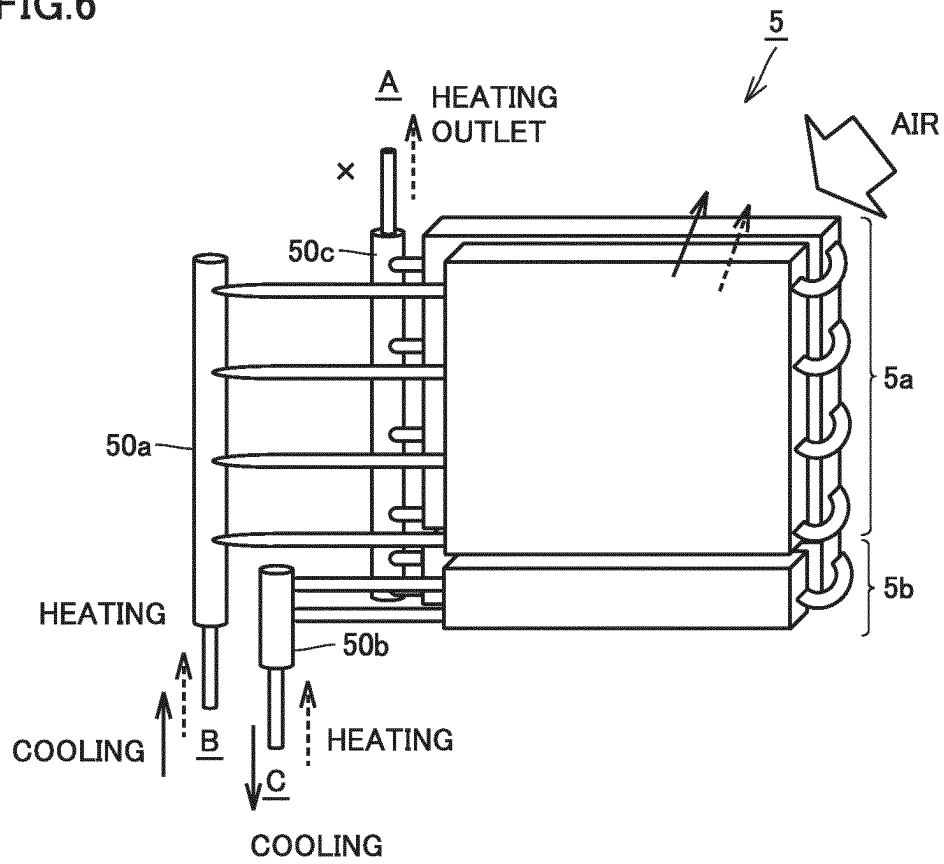
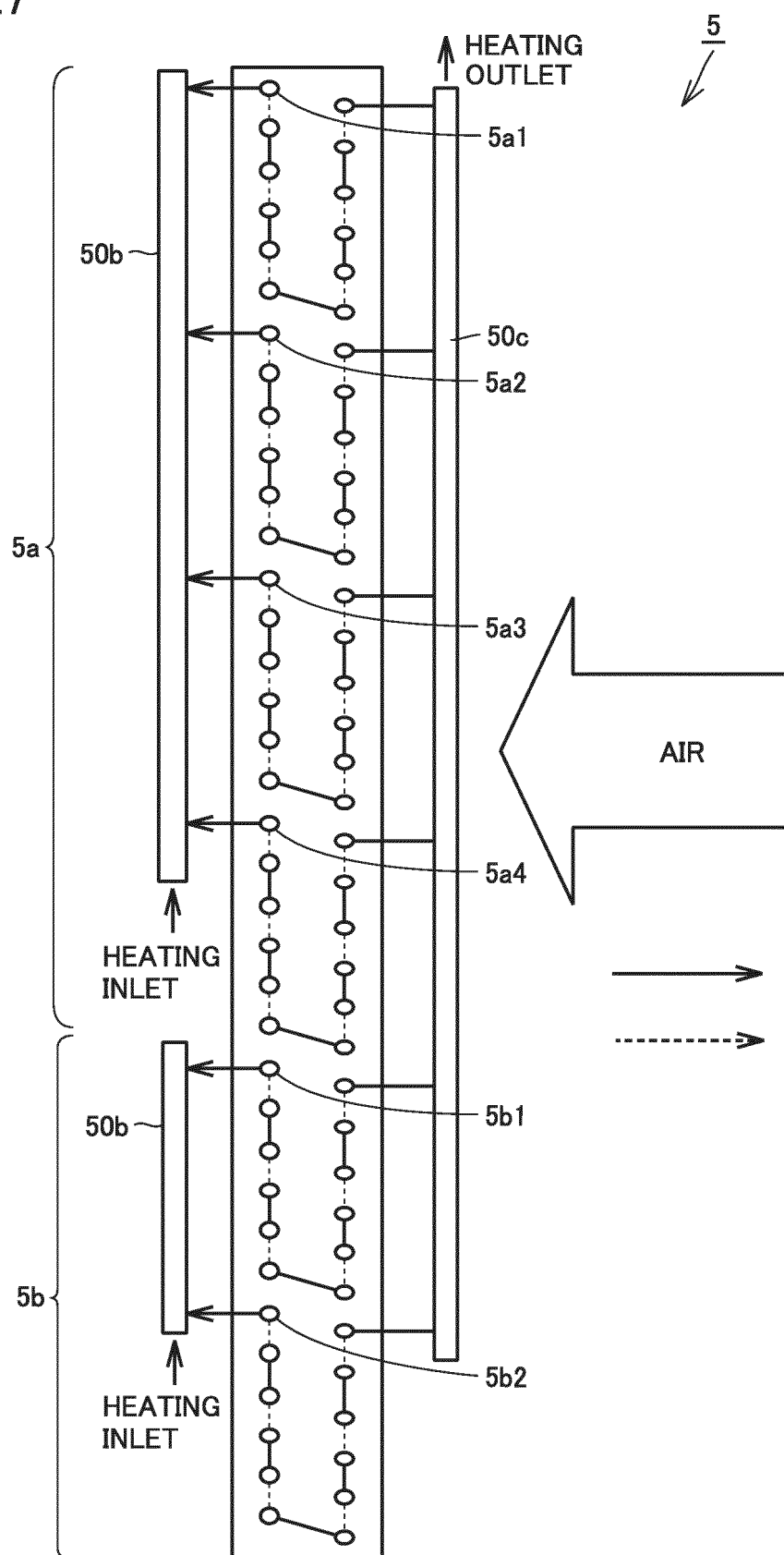


FIG.7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/072498

A. CLASSIFICATION OF SUBJECT MATTER

F25B39/00(2006.01)i, F25B1/00(2006.01)i, F25B41/04(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)

F25B39/00, F25B1/00, F25B41/04

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.
Y	WO 2012/147336 A1 (Panasonic Corp.), 01 November 2012 (01.11.2012), paragraphs [0061] to [0066]; fig. 13 to 15 & JP 2012-237543 A & CN 103518107 A	1-4
Y	JP 2001-066017 A (Hitachi, Ltd.), 16 March 2001 (16.03.2001), paragraphs [0012], [0016]; fig. 1 to 2 (Family: none)	1-4
Y	JP 2002-318031 A (Daikin Industries, Ltd.), 31 October 2002 (31.10.2002), paragraphs [0002] to [0003]; fig. 19 (Family: none)	1-4

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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search
07 October 2016 (07.10.16)Date of mailing of the international search report
18 October 2016 (18.10.16)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/JP2016/072498

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 59-012271 A (Hitachi, Ltd.), 21 January 1984 (21.01.1984), page 2, upper right column, line 8 to lower left column, line 19; fig. 2 (Family: none)	2
Y	JP 2009-287912 A (Eito MATSUO), 10 December 2009 (10.12.2009), paragraphs [0012] to [0016]; fig. 1 to 2 (Family: none)	2
Y	JP 2002-106982 A (Hitachi, Ltd.), 10 April 2002 (10.04.2002), paragraph [0001] (Family: none)	4
Y	JP 2003-028518 A (Fujitsu General Ltd.), 29 January 2003 (29.01.2003), paragraph [0001] (Family: none)	4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/072498

Opinion on this international application:

1. Specified in claim 1 is that "the refrigerant flows sequentially through the first heat exchange part and the second heat exchange part when the first heat exchanger is used as an evaporator, and the refrigerant flows in parallel through the first heat exchange part and the second heat exchange part when the first heat exchanger is used as a condenser."

On the other hand, specified in paragraph [0010] of the description is that "the refrigerant flows sequentially through the first heat exchange part and the second heat exchange part when the first heat exchanger is used as a condenser, and the refrigerant flows in parallel through the first heat exchange part and the second heat exchange part when the first heat exchanger is used as an evaporator." In addition, specified in paragraph [0062] is that "the refrigerant flows sequentially through the first heat exchange part 3a and the second heat exchange part 3b when the first heat exchanger 3 is used as a condenser, and the refrigerant flows in parallel through the first heat exchange part 3a and the second heat exchange part 3b when the first heat exchanger 3 is used as an evaporator. Thus, since the refrigerant flows sequentially through the first heat exchange part 3a and the second heat exchange part 3b when the first heat exchanger 3 is used as a condenser in a heating operation, it is possible to raise the flow rate of the refrigerant now in a liquid state by the heat exchange through the first heat exchanger 3. This makes it possible to improve heat transfer performance. Furthermore, since the refrigerant flows in parallel through the first heat exchange part 3a and the second heat exchange part 3b when the first heat exchanger 3 is used as an evaporator in a cooling operation, it is possible to reduce the flow rate of the refrigerant in a gas state and in a gas-liquid two-phase state. This makes it possible to reduce pressure loss."

Thus, the statement of the description is contradictory to the statement of claim 1 that "the refrigerant flows sequentially through the first heat exchange part and the second heat exchange part when the first heat exchanger is used as an evaporator, and the refrigerant flows in parallel through the first heat exchange part and the second heat exchange part when the first heat exchanger is used as a condenser."

Consequently, claim 1 is not fully supported by the description.

Note that taking into account the aforementioned statements of the description at the time of determining novelty and inventive step, this international search report was created on the assumption that the aforementioned description of claim 1 is that "the refrigerant flows sequentially through the first heat exchange part and the second heat exchange part when the first heat exchanger is used as a condenser, and the refrigerant flows in parallel through the first heat exchange part and the second heat exchange part when the first heat exchanger is used as an evaporator."

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 7098166 A [0003] [0004]