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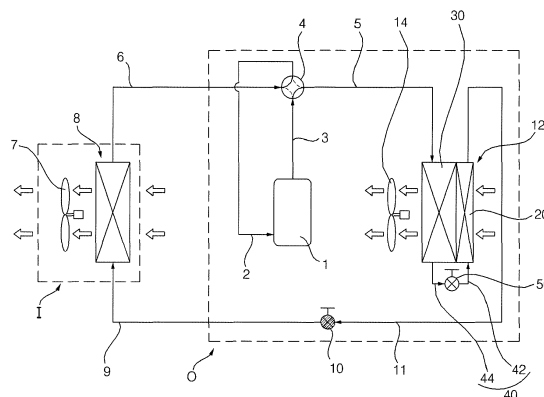
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(54) **Heat pump**

(57) The present invention provides a heat pump that includes: a compressor, a switching valve, an indoor heat exchanger, a first expansion valve, and an outdoor heat exchanger, in which the outdoor heat exchanger includes: a primary heat exchanging unit that is connected with the first expansion valve through a refrigerant pipe and through which outdoor air exchanges heat; a secondary heat exchanging unit that is connected with the switching valve through a refrigerant pipe, disposed behind the primary heat exchanging unit in the flow direction

of outdoor air, and through which the outdoor air, which has exchanged heat through the primary heat exchanging unit, exchanges heat; a connection pipe that connects the primary heat exchanging unit and the secondary heat exchanging unit with each other; and a second expansion valve that is disposed in the connection pipe. Therefore, it is possible to improve both of cooling performance and heating performance with minimum parts and a simple structure.

Fig. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a heat pump, and more particularly, to a heat pump including an outdoor heat exchanger having a plurality of heat exchanging units.

2. Description of the Conventional Art

[0002] In general, a heat pump is a heating/cooling device that transfers heat from a low-temperature heat sink to a high-temperature destination or from a high-temperature heat sink to a low-temperature destination, using evaporating or condensing heat of a refrigerant.

[0003] Heat pumps include a compressor, a switching valve, an outdoor heat exchanger, an expansion device, and an indoor heat exchanger.

[0004] In cooling operation of a heat pump, a refrigerant can flow sequentially through the compressor, the switching valve, the outdoor heat exchanger, the expansion device, the indoor heat exchanger, the switching valve, and the compressor.

[0005] In heating operation of a heat pump, a refrigerant can flow sequentially through the compressor, the switching valve, the indoor heat exchanger, the expansion device, the outdoor heat exchanger, the switching valve, and the compressor.

[0006] When a heat pump operates for heating at low outdoor temperature, the outdoor heat exchanger may frost due to low-temperature outdoor air.

[0007] A heat pump may be equipped with a separate defrosting heater for heating the outdoor heat exchanger, and in this case, when the outdoor heat exchanger frosts too much, it is possible to defrost the outdoor heat exchanger by heating it with the defrosting heater.

[0008] Further, when the outdoor heat exchanger frosts too much in the heating operation of a heat pump, it is possible to defrost the outdoor heat exchanger by performing defrosting operation in which a refrigerant of the heat pump flows as in the cooling operation.

[0009] Frequent defrosting operation may deteriorate the heating performance of heat pumps, so it is preferable to use the defrosting operation as little as possible.

SUMMARY OF THE INVENTION

[0010] The present invention has been made in an effort to provide a heat pump that can minimize or prevent frosting in heating operation with a simple structure and minimum parts.

[0011] According to an aspect of the present invention, there is provided a heat pump including a compressor, a switching valve, an indoor heat exchanger, a first expansion valve, and an outdoor heat exchanger, in which

a refrigerant flows sequentially through the compressor, the switching valve, the outdoor heat exchanger, the first expansion valve, the indoor heat exchanger, the switching valve, and the compressor in cooling, and the refrigerator flows sequentially through the compressor, the switching valve, the indoor heat exchanger, the first expansion valve, the outdoor heat exchanger, the switching valve, and the compressor in heating. The outdoor heat exchanger includes: a primary heat exchanging unit that is connected with the first expansion valve through a refrigerant pipe and through which outdoor air exchanges heat; a secondary heat exchanging unit that is connected with the switching valve through a refrigerant pipe, disposed behind the primary heat exchanging unit in the flow direction of outdoor air, and through which the outdoor air, which has exchanged heat through the primary heat exchanging unit, exchanges heat; a heat exchanging unit connection pipe that connects the primary heat exchanging unit and the secondary heat exchanging unit with each other; and a second expansion valve that is disposed in the heat exchanging unit connection pipe.

[0012] The primary heat exchanging unit and the secondary heat exchanging unit may be integrally combined.

[0013] The primary heat exchanging unit may include a primary microchannel heat exchanger having a pair of headers connected by a microchannel, and the secondary heat exchanging unit may include at least one secondary microchannel heat exchanger having a pair of headers connected by a microchannel and disposed behind the primary microchannel heat exchanger in the flow direction of outdoor air.

[0014] The secondary microchannel heat exchanger may include: a first secondary microchannel heat exchanger disposed behind the primary microchannel heat exchanger in the flow direction of outdoor; and a second secondary microchannel heat exchanger disposed behind the first secondary microchannel heat exchanger in the flow direction of outdoor air.

[0015] The headers of the primary microchannel heat exchanger and the headers of the first secondary microchannel heat exchanger may be coupled to each other, and the headers of the first secondary microchannel heat exchanger and the headers of the second secondary microchannel heat exchanger may be coupled to each other.

[0016] The first secondary microchannel heat exchanger may be connected with the primary microchannel heat exchanger through the heat exchanging unit connection pipe.

[0017] The second secondary microchannel heat exchanger may be connected with the first secondary microchannel heat exchanger through a microchannel heat exchanger connection pipe.

[0018] The second secondary microchannel heat exchanger may be connected with the switching valve through a refrigerant pipe.

[0019] The primary heat exchanging unit may include a primary tube, and the secondary heat exchanging unit

may include at least one secondary tube disposed behind the primary tube in the flow direction of outdoor air.

[0020] The outdoor heat exchanger may further include common fins being in contact with the primary tube and the secondary tube.

[0021] The secondary tube may include: a first secondary tube disposed behind the primary tube in the flow direction of outdoor air; and a second secondary tube disposed behind the first secondary tube in the flow direction of outdoor air.

[0022] The first secondary tube may be connected with the primary tube through the heat exchanging unit connection pipe.

[0023] The second secondary tube may be connected with the first secondary tube through a tube connection pipe.

[0024] The second secondary tube may be connected with the switching valve through a refrigerant pipe.

[0025] In a heating operation at an outdoor temperature over a predetermined temperature, the first expansion valve may be controlled to open at a degree for expanding a refrigerant and the second expansion valve may fully open.

[0026] In a heating operation at an outdoor temperature less than a predetermined temperature, the first expansion valve may fully open and the second expansion valve may be controlled to open at a degree for expanding a refrigerant.

[0027] The heat exchanging unit connection pipe may include: a primary heat exchanging unit connection pipe that connects the primary heat exchanging unit with the second expansion valve with each other; and a secondary heat exchanging unit connection pipe that connects the secondary heat exchanging unit and the second expansion valve.

[0028] The secondary heat exchanging unit may have a larger heat exchange area for heat exchange with outdoor air than the primary heat exchanging unit.

[0029] The secondary heat exchanging unit may have a longer pipe through which a refrigerant passes than the primary heat exchanging unit.

[0030] The secondary heat exchanging unit may be larger in number than the primary heat exchanging unit.

[0031] According to the heat pump of the present invention which the configuration described above, it is possible to delay or prevent frosting in a heating operation and improve cooling performance and heating performance with minimum parts and a simple structure in which the second expansion valve is disposed between the primary heat exchanging unit and the secondary heat exchanging unit of the outdoor heat exchanger.

[0032] Further, since the outdoor air increases in temperature and decrease in relative humidity through the primary heat exchanging unit and then flows to the secondary heat exchanging unit, it is possible to delay or prevent frosting in a large area of the secondary heat exchanging unit and to achieve excellent effect on frosting delay.

[0033] Further, since the primary heat exchanging unit and the secondary heat exchanging unit are integrated, it is easy to assemble and service the outdoor heat exchanger.

[0034] Further, when a separate supercooling heat exchanger is additionally provided for the outdoor heat exchanger, it is possible to reduce the volume occupied by the outdoor heat exchanger and to achieve a compact outdoor heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035]

FIG. 1 is a view showing refrigerant flow in a cooling mode of a heat pump according to an embodiment of the present invention;

FIG. 2 is a view showing refrigerant flow in a first heating mode of the heat pump according to an embodiment of the present invention;

FIG. 3 is a view showing refrigerant flow in a second heating mode of the heat pump according to an embodiment of the present invention;

FIG. 4 is a perspective view showing the outdoor heat exchanger shown in FIGS. 1 to 3 through which outdoor air exchanges heat; and

FIG. 5 is a perspective view showing an outdoor heat exchanger of a heat pump according to another embodiment of the present invention through which outdoor air exchanges heat.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0036] Hereinafter, embodiments of a heat pump according to the present invention are described with reference to the accompanying drawings.

[0037] FIG. 1 is a view showing refrigerant flow in a cooling mode of a heat pump according to an embodiment of the present invention, FIG. 2 is a view showing refrigerant flow in a first heating mode of the heat pump according to an embodiment of the present invention, FIG. 3 is a view showing refrigerant flow in a second heating mode of the heat pump according to an embodiment of the present invention, and FIG. 4 is a perspective view showing heat exchange between an outdoor heat exchanger shown in FIGS. 1 to 3 and the outdoor air.

[0038] A heat pump according to the present embodiment may include a compressor 1, a switching valve 4, an indoor heat exchanger 8, a first expansion valve 10, and an outdoor heat exchanger 12.

[0039] The heat pump can operate in a cooling mode. In the cooling mode of the heat pump, a refrigerant can flow sequentially through the compressor 1, the switching valve 4, the outdoor heat exchanger 12, the first expansion valve 10, the indoor heat exchanger 8, the switching valve 4, and the compressor 1.

[0040] The heat pump can operate in a heating mode.

In the heating mode of the heat pump, the refrigerant can flow sequentially through the compressor 1, the switching valve 4, the indoor heat exchanger 8, the first expansion valve 10, the outdoor heat exchanger 12, the switching valve 4, and the compressor 1.

[0041] A compressor inflow pipe 2 through which the refrigerant that has passed through the switching valve 4 enters the compressor 1 may be connected to the compressor 1. A compressor exit pipe 3 through which the refrigerant that has been compressed by the compressor 1 is discharged to the switching valve 4 may be connected to the compressor 1.

[0042] The switching valve 4 may be connected with the outdoor heat exchanger 12 through a refrigerant pipe. The refrigerant pipe connecting the switching valve 4 and the outdoor heat exchanger 12 to each other may be a switching valve-outdoor heat exchanger connection pipe 5. The switching valve 4 may be connected with the indoor heat exchanger 8 through a refrigerant pipe. The refrigerant pipe connecting the switching valve 4 and the indoor heat exchanger 8 to each other may be a switching valve-indoor heat exchanger connection pipe 6.

[0043] The heat pump may further include an indoor fan 7 that allows indoor air to exchange heat with the indoor heat exchanger 8.

[0044] The indoor heat exchanger 8 may be a heat exchanger that allows indoor air to exchange heat with the refrigerant. The indoor heat exchanger 8 may be connected with the first expansion valve 10 through a refrigerant pipe. The refrigerant pipe connecting the indoor heat exchanger 8 with the first expansion valve 10 may be an indoor heat exchanger-first expansion valve connection pipe 9.

[0045] The heat pump may be used as a separation type air conditioner, in which the indoor fan 7 and the indoor heat exchanger 8 may be disposed in an indoor unit I and the indoor fan 7 can suck indoor air into the indoor unit I and then supply it back to the indoor through the indoor heat exchanger 8.

[0046] The first expansion valve 10 may be connected with the outdoor heat exchanger 12 through a refrigerant pipe. The refrigerant pipe connecting the first expansion valve 10 with the outdoor heat exchanger 12 may be a first expansion valve-outdoor heat exchanger connection pipe 11. The first expansion valve 10 may be controlled to open at the degree for expanding the refrigerant in the cooling mode. The first expansion valve 10 may be controlled to open at the degree for expanding the refrigerant or fully open in the heating mode.

[0047] The outdoor heat exchanger 12 may include a pipe through which the refrigerant passes. The pipe of the outdoor heat exchanger 12 may include a heat exchange pipe through which the refrigerant exchanges heat with the outdoor air and an expansion pipe for expanding the refrigerant.

[0048] The outdoor heat exchanger 12 may include a plurality of heat exchange pipes spaced from each other in the flow direction of the refrigerant. In the outdoor heat

exchanger 12, an expansion pipe may be disposed between the heat exchange pipes.

[0049] When the refrigerant passes through the outdoor heat exchanger 12, it can pass through the expansion pipe after passing through a first one of the heat exchange pipes and then pass through a second one of the heat exchange pipes. In the cooling mode of the heat pump, the refrigerant can pass through the expansion pipe after passing through a first one of the heat exchange pipes and then pass through a second one of the heat exchange pipes. In the heating mode of the heat pump, opposite to the cooling mode, the refrigerant can pass through the expansion valve after passing through the second one of the heat exchange pipes and then pass through the first one of the heat exchange pipes.

[0050] In the outdoor heat exchanger 12, the refrigerant may pass through the expansion pipe without expanding and all of the heat exchange pipes may function as evaporation pipes for evaporating the refrigerant. In the outdoor heat exchanger 12, the refrigerant may pass through the expansion pipe without expanding and all of the heat exchange pipes may function as condensation pipes for condensing the refrigerant. In the outdoor heat exchanger 12, refrigerant can expand through the expansion pipe, some of the heat exchange pipes can function as condensation pipes for condensing the refrigerant, and the other of the heat exchange pipes can function as evaporation pipes for evaporating the refrigerant.

[0051] The outdoor heat exchanger 12 may include a plurality of heat exchanging units 20 and 30. The heat exchanging units 20 and 30 may be sequentially arranged in the flow direction of outdoor air. The outdoor heat exchanger 12 may include a primary heat exchanging unit 20 through which outdoor air exchanges heat. The primary heat exchanging unit 20 may be connected with the first expansion valve 10 through the refrigerant pipe 11. The outdoor heat exchanger 12 may include a secondary heat exchanging unit 30 that is disposed behind the primary heat exchanging unit 20 in the flow direction of the outdoor air and allows the outdoor air, which has exchanged heat through the primary heat exchanging unit 20, to exchange heat. The secondary heat exchanging unit 30 may be connected with the switching valve 4 through the refrigerant pipe 5. The outdoor heat exchanger 12 may include a heat exchanging unit connection pipe 40 that connects the heat exchanging units 20 and 30 with each other. The heat exchanging unit connection pipe 40 may connect the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 with each other. The outdoor heat exchanger 12 may include a second expansion valve 50 disposed in the heat exchanging unit connection pipe 40.

[0052] The heat pump may further include an indoor fan 7 that allows outdoor air to exchange heat with the outdoor heat exchanger 12. The outdoor fan 14 can blow the outdoor air into the outdoor heat exchanger 12 regardless of the cooling mode and the heating mode. The outdoor fan 14 can blow the outdoor air through the pri-

mary heat exchanging unit 20 and then the secondary heat exchanging unit 30. The outdoor air can exchange heat primarily through the primary heat exchanging unit 20 and secondarily through the secondary heat exchanging unit 30, regardless of the cooling mode and the heating mode.

[0053] The heat pump may be a separation type air conditioner, in which the compressor 1, the switching valve 4, the first expansion valve 10, the outdoor heat exchanger 12, and the outdoor fan 14 may be disposed in the outdoor unit O, and the outdoor fan 14 may suck the outdoor air into the outdoor unit O and then discharge it back to the outdoor through the outdoor heat exchanger 12.

[0054] The first expansion valve-outdoor heat exchanger connection pipe 11 that is the refrigerant pipe connecting the first expansion valve 10 and the outdoor heat exchanger 12 with each other may be the refrigerant pipe 11 connecting the primary heat exchanging unit 20 and the first expansion valve 10 with each other.

[0055] The switching valve-outdoor heat exchanger connection pipe 5 that is the refrigerant pipe connecting the switching valve 4 and the outdoor heat exchanger 12 with each other may be the refrigerant pipe 5 connecting the secondary heat exchanging unit 30 and the switching valve 4 with each other.

[0056] In the cooling mode of the heat pump, the refrigerant flowing in the switching valve-outdoor heat exchanger connection pipe 5 from the switching valve 4, as shown in FIG. 1, can flow to the secondary heat exchanging unit 30, sequentially pass through the secondary heat exchanging unit 30, the second expansion valve 50, and the primary heat exchanging unit 20, and then flow in the first expansion valve-outdoor heat exchanger connection pipe 11.

[0057] In the heating mode of the heat pump, the refrigerant flowing in the first expansion valve-outdoor heat exchanger connection pipe 11 from the first expansion valve 10, as shown in FIGS. 2 and 3, can flow to the primary heat exchanging unit 20, sequentially pass through the primary heat exchanging unit 20, the second expansion valve 50, and the secondary heat exchanging unit 30, and then flow to the switching valve-outdoor heat exchanger connection pipe 5.

[0058] The heat pump can operate in the cooling mode in which the refrigerant expands through the first expansion valve 10 but it does not expand through the second expansion valve 50. In the cooling mode of the heat pump, the first expansion valve 10 may be controlled to open at the degree for expanding the refrigerant and the second expansion valve 50 may be controlled to fully open.

[0059] The heat pump can operate in a first heating mode in which the refrigerant expands through the first expansion valve 10 but it does not expand through the second expansion valve 50. In the first heating mode of the heat pump, the first expansion valve 10 may be controlled to open at the degree for expanding the refrigerant

and the second expansion valve 50 may be controlled to fully open.

[0060] The heat pump can operate in a second heating mode in which the refrigerant does not expand through the first expansion valve 10 but it expands through the second expansion valve 50. In the second heating mode of the heat pump, the first expansion valve 10 may be controlled to fully open and the second expansion valve 50 may be controlled to open at the degree for expanding the refrigerant.

[0061] In the cooling mode of the heat pump, the secondary heat exchanging unit 30 may function as a condenser that condenses a refrigerant and the primary heat exchanging unit 20 may function as a supercooling heat exchanger that supercools the refrigerant condensed through the secondary heat exchanging unit 30.

[0062] In the cooling mode of the heat pump, the refrigerant compressed by the compressor 1 may flow sequentially through the secondary heat exchanging unit 30, the second expansion valve 50, and the primary heat exchanging unit 20. The refrigerant flowing in the secondary heat exchanging unit 30 may condense by exchanging heat with the outdoor air that has passed through the primary heat exchanging unit 20. The refrigerant condensed through the secondary heat exchanging unit 30 may flow into the primary heat exchanging unit 20 after passing through the second expansion valve 50. The refrigerant flowing in the primary heat exchanging unit 20 may exchange heat with the outdoor air and may be supercooled by the outdoor air through the primary heat exchanging unit 20.

[0063] In the first heating mode of the heat pump, the primary heat exchanging unit 20 may function as an evaporator through which the refrigerant that has expanded through the first expansion valve 10 evaporates before evaporating through the secondary heat exchanging unit 30. In the first heating mode of the heat pump, the secondary heat exchanging unit 30 may function as an evaporator through which the refrigerant that has passed through the second expansion valve 50 after evaporating through the primary heat exchanging unit 20 evaporates. That is, in the first heating mode of the heat pump, the refrigerant condensed through the indoor heat exchanger 8 may flow into the primary heat exchanging unit 20 after expanding through the first expansion valve 10 and then sequentially flow through the primary heat exchanging unit 20, the second expansion valve 50, and the secondary heat exchanging unit 30, and the refrigerant expanding through the first expansion valve 10 may additionally evaporate through the secondary heat exchanging unit 30 after evaporating first through the primary heat exchanging unit 20.

[0064] In the second heating mode of the heat pump, the primary heat exchanging unit 20 may function as a supercooling heat exchanger that supercools the refrigerant that has passed through the first expansion valve 10 after being condensed through the indoor heat exchanger 8. In the second heating mode of the heat pump,

the secondary heat exchanging unit 30 may function as an evaporator through which the refrigerant that has expanded through the second expansion valve 50 evaporates by exchanging heat with the outdoor air. In the second heating mode of the heat pump, the refrigerant that has condensed through the indoor heat exchanger 8 may flow into the primary heat exchanging unit 20 without expanding through the first expansion valve 10 and then flow sequentially through the primary heat exchanging unit 20, the second expansion valve 50, and the secondary heat exchanging unit 30. The refrigerant that has condensed through the indoor heat exchanger 8 may supercool through the primary heat exchanging unit 20 by exchanging heat with the outdoor air. The refrigerant that has supercool through the primary heat exchanging unit 20 may flow into the secondary heat exchanging unit 30 after expanding through the second expansion valve 50 and then evaporate through the secondary heat exchanging unit 30.

[0065] The secondary heat exchanging unit 30 may have a larger heat exchange area for heat exchange with the outdoor air than the primary heat exchanging unit 20. The secondary heat exchanging unit 30 may be thicker than the primary heat exchanging unit 20. The secondary heat exchanging unit 30 may have a longer pipe through which a refrigerant passes than the primary heat exchanging unit 20. The secondary heat exchanging unit 30 may be larger in number than the primary heat exchanging unit 20.

[0066] The heat exchanging unit connection pipe 40 may include a primary heat exchanging unit connection pipe 42 connecting the primary heat exchanging unit 20 and the second expansion valve 50 with each other. The heat exchanging unit connection pipe 40 may include a secondary heat exchanging unit connection pipe 44 connecting the secondary heat exchanging unit 30 and the second expansion valve 50 with each other.

[0067] The primary heat exchanging unit connection pipe 42 may be formed by a first refrigerant tube between the primary heat exchanging unit 20 and the second expansion valve 50. The secondary heat exchanging unit connection pipe 44 may be formed by a second refrigerant tube between the secondary heat exchanging unit 30 and the second expansion valve 50.

[0068] The refrigerant may, as shown in FIG. 1, pass sequentially through the secondary heat exchanging unit 30, the secondary heat exchanging unit connection pipe 44, the second expansion valve 50, the primary heat exchanging unit connection pipe 42, and the primary heat exchanging unit 20. The refrigerant may, as shown in FIGS. 2 and 3, pass sequentially through the primary heat exchanging unit 20, the primary heat exchanging unit connection pipe 42, the second expansion valve 50, the secondary heat exchanging unit connection pipe 44, and the secondary heat exchanging unit 30.

[0069] The second expansion pipe 50 may be connected to the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 through the heat ex-

changing unit connection pipe 40 and may be integrated with the primary heat exchanging unit 20 and the secondary heat exchanging unit 30.

[0070] The primary heat exchanging unit 20 and the secondary heat exchanging unit 30 may be integrally combined.

[0071] In the outdoor heat exchanger 12, the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 both may be microchannel heat exchangers, the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 both may be fin-tube heat exchangers, and any one of the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 may be a microchannel heat exchanger and the other one may be a fin-tube heat exchanger.

[0072] Hereafter, an example that the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 are both microchannel heat exchangers is described with reference to FIG. 4.

[0073] The primary heat exchanging unit 20, as shown in FIG. 4, may include a primary microchannel heat exchanger 20A with a pair of headers 21 and 22 connected by a microchannel 23. The microchannel may have a channel through which a refrigerant passes and may be a primary heating member allowing a refrigerant passing through the channels to exchange heat with outdoor air. The microchannel 23 may have a plurality of channels and a refrigerant can exchange heat with outdoor air through the channels of the microchannel 23. The primary heat exchanging unit 20 may include a plurality of microchannels 23. The microchannels 23 may connect the pair of headers 21 and 22. The primary heat exchanging unit 20 may further include fins 24 that promote heat transfer of the microchannels 23. The fins 24 may be disposed between the microchannels 23. One 21 of the pair of headers of the primary microchannel heat exchanger 20A may be connected with the first expansion valve-outdoor heat exchanger connection pipe 11.

[0074] The secondary heat exchanging unit 30 may include one or more secondary microchannel heat exchangers 30A and 30B that have a pair of headers 31 and 32 connected by a microchannel (not shown) and are disposed behind the primary microchannel heat exchanger in the flow direction of outdoor air.

[0075] The secondary microchannel heat exchangers 30A and 30B may have the same structure as that of the primary microchannel heat exchanger 20A and may include a plurality of microchannels. A plurality of microchannels (not shown) may connect the pair of headers 31 and 32 and the secondary microchannel heat exchangers 30A and 30B may include fins (not shown) that promote heat transfer of the microchannels connecting the pair of headers 31 and 32.

[0076] The secondary microchannel heat exchangers 30A and 30B may include a first secondary microchannel heat exchanger 30A disposed behind the primary microchannel heat exchanger 20A in the flow direction of outdoor air and a second secondary microchannel heat ex-

changer 30B disposed behind the first secondary microchannel heat exchanger 30A in the flow direction of outdoor air.

[0077] The first secondary microchannel heat exchanger 30A may be connected with the primary microchannel heat exchanger 20A by the heat exchanging unit connection pipe 40. The first secondary microchannel heat exchanger 30A may be connected with the heat exchanging unit connection pipe 40 at one of the pair of headers 31 and 32. The headers of the first secondary microchannel heat exchanger 30A may be coupled to the headers of the primary microchannel heat exchanger 20A by welding or an adhesive. The headers of the first secondary microchannel heat exchanger 30A may be coupled to the headers of the second secondary microchannel heat exchanger 30B by welding or an adhesive.

[0078] The second secondary microchannel heat exchanger 30B may be connected with the first secondary microchannel heat exchanger 30A by a microchannel heat exchanger connection pipe 34. The second secondary microchannel heat exchanger 30B may be connected with the heat exchanging unit connection pipe 40 at one of the pair of headers 31 and 32. The second secondary microchannel heat exchanger 30B may be connected with the switching valve-outdoor heat exchanger connection pipe 5 at one of the pair of headers.

[0079] In the cooling mode, the refrigerant in the switching valve-outdoor heat exchanger connection pipe 5 can pass sequentially through the second secondary microchannel heat exchanger 30B, the microchannel heat exchanger connection pipe 34, the first secondary microchannel heat exchanger 30A, the heat exchanging unit connection pipe 40, and the primary microchannel heat exchanger 20A and then flow to the first expansion valve-outdoor heat exchanger connection pipe 11.

[0080] In the first heating mode and the second heating mode, the refrigerant in the first expansion valve-outdoor heat exchanger connection pipe 11 can pass sequentially through the primary microchannel heat exchanger 20A, heat exchanging unit connection pipe 40, the first secondary microchannel heat exchanger 30A, the microchannel heat exchanger connection pipe 34, and the second secondary microchannel heat exchanger 30B and then flow to the switching valve-outdoor heat exchanger connection pipe 5.

[0081] The heat pump may include an outdoor temperature sensor that senses the outdoor temperature and one of the first heating mode and the second heating mode may be performed in accordance with the outdoor temperature sensed by the outdoor temperature sensor in the heating operation.

[0082] In the cooling operation of the heat pump, the cooling mode may be performed regardless of the outdoor temperature, in which the first expansion valve 10 may be controlled to open at the degree for expanding the refrigerant and the second expansion valve 50 may fully open.

[0083] When the heat pump operates for heating at an

outdoor temperature over a predetermined temperature, the first heating mode may be performed, in which the first expansion valve 10 may be controlled to open at the degree for expanding the refrigerant and the second expansion valve 50 may fully open.

[0084] When the heat pump operates for heating at an outdoor temperature over a predetermined temperature, there is a small possibility that the outdoor heat exchanger 12 frosts, in which both of the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 can function as an evaporator.

[0085] When the heat pump operates for heating at an outdoor temperature less than a predetermined temperature, the second heating mode may be performed, in which the first expansion valve 10 may fully open and the second expansion valve 50 may be controlled to open at the degree for expanding the refrigerant. In a heating operation at an outdoor temperature less than a predetermined temperature, there is a large possibility that the outdoor heat exchanger 12 frosts, in which when the high-temperature refrigerant that has condensed through the indoor heat exchanger 8 flows into the primary heat exchanging unit 20, it is possible to delay or prevent frosting of the primary heat exchanging unit 20. On the other hand, the outdoor air decreasing in humidity and increasing in temperature by exchanging heat through the primary heat exchanging unit 20 can delay or prevent frosting of the secondary heat exchanging unit 30 by flowing into it.

[0086] The operation of the heat pump according to the present invention is described hereafter.

[0087] First, in the cooling mode, the compressor 1 may be in operation, the indoor fan 7 and the outdoor fan 14 may be in operation, the first expansion valve 10 may be open at the degree of expanding the refrigerant, and the second expansion valve 50 may be fully open.

[0088] When the indoor fan 7 operates, the indoor air can be supplied to the interior through the indoor heat exchanger 8, and when the outdoor fan 14 operates, the outdoor air can pass through the primary heat exchanging unit 20 and then the secondary heat exchanging unit 30.

[0089] In the cooling mode, as shown in FIG. 1, the refrigerant is compressed through the compressor 1 and then guided to the switching valve-outdoor heat exchanger connection pipe 5 by the switching valve 4. The refrigerant passing through the switching valve-outdoor heat exchanger connection pipe 5 flows to the secondary heat exchanging unit 30 and condenses through the secondary heat exchanging unit 30 by exchanging heat with the outdoor air. The refrigerant that has condensed through the secondary heat exchanging unit 30 flows to the primary heat exchanging unit 20 after passing through the second expansion valve 50. The refrigerant flowing in the primary heat exchanging unit 20 supercools through the primary heat exchanging unit 20 by exchanging heat with the outdoor air. The refrigerant that has passed through the primary heat exchanging unit 20 flows into

the first expansion valve-outdoor heat exchanger connection pipe 11, expands through the first expansion valve 10, and then exchanges heat with the indoor air through the indoor heat exchanger 8. The refrigerant passing through the indoor heat exchanger 8 is evaporated by the indoor air and then guided into the compressor 1 by the switching valve 4.

[0090] In the first heating mode, the compressor 1 may be in operation, the indoor fan 7 and the outdoor fan 14 may be in operation, the first expansion valve 10 may be open at the degree of expanding the refrigerant, and the second expansion valve 50 may be fully open.

[0091] When the indoor fan 7 operates, the indoor air can be supplied to the interior through the indoor heat exchanger 8, and when the outdoor fan 14 operates, the outdoor air can pass through the primary heat exchanging unit 20 and then the secondary heat exchanging unit 30.

[0092] The refrigerant is compressed by the compressor 1 and then guided to the indoor heat exchanger 8 by the switching valve 4. The refrigerant in the indoor heat exchanger 8 is condensed through the indoor heat exchanger 8 by the indoor air. The refrigerant that has condensed through the indoor heat exchanger 8 expands through the first expansion valve 10 and then flows to the first expansion valve-outdoor heat exchanger connection pipe 11. The refrigerant in the first expansion valve-outdoor heat exchanger connection pipe 11 flows to the primary heat exchanging unit 20 and exchanges heat with the outdoor air through the primary heat exchanging unit 20. The refrigerant that has evaporated through the primary heat exchanging unit 20 flows to the secondary heat exchanging unit 30 after passing through the second expansion valve 50. The refrigerant flowing in the secondary heat exchanging unit 30 evaporates through the secondary heat exchanging unit 30 by exchanging heat with the outdoor air. The refrigerant that has passed through the secondary heat exchanging unit 30 flows to the switching valve-outdoor heat exchanger connection pipe 5 and is then guided into the compressor 1 by the switching valve 4. The refrigerant is evaporated by the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 while sequentially passing through the primary heat exchanging unit 20 and the secondary heat exchanging unit 30 and the entire outdoor heat exchanger 12 may function as an evaporator.

[0093] In the second heating mode, the compressor 1 may be in operation, the indoor fan 7 and the outdoor fan 14 may be in operation, the first expansion valve 10 may be fully open, and the second expansion valve 50 may be open at the degree of expanding the refrigerant.

[0094] When the indoor fan 7 operates, the indoor air can be supplied to the interior through the indoor heat exchanger 8, and when the outdoor fan 14 operates, the outdoor air can pass through the primary heat exchanging unit 20 and then the secondary heat exchanging unit 30.

[0095] The refrigerant is compressed by the compressor 1 and then guided to the indoor heat exchanger 8 by the switching valve 4. The refrigerant in the indoor heat exchanger 8 is condensed through the indoor heat exchanger 8 by the indoor air. The refrigerant that has condensed through the indoor heat exchanger 8 passes through the first expansion valve 10 and then flows to the first expansion valve-outdoor heat exchanger connection pipe 11. The refrigerant in the first expansion valve-outdoor heat exchanger connection pipe 11 flows to the primary heat exchanging unit 20 and exchanges heat with the outdoor air through the primary heat exchanging unit 20. The refrigerant passing through the primary heat exchanging unit 20 does not expand through the first expansion valve 10 after condensing through the indoor heat exchanger 8. Further, The refrigerant passing through the primary heat exchanging unit 20 passes through the primary heat exchanging unit 20, at a higher temperature than in the first heating mode and it not only increases the temperature of the outdoor air passing through the primary heat exchanging unit 20, but decreases the relative humidity of the outdoor air passing through the primary heat exchanging unit 20. For example, when the outdoor air flowing to the primary heat exchanging unit 20 has a temperature of 2 °C and relative humidity of 84%, it may increase in temperature to 3.5 °C and decrease in relative humidity to 75% while passing through the primary heat exchanging unit 20, by the refrigerant passing through the primary heat exchanging unit 20. The refrigerant passing through the primary heat exchanging unit 20 may supercool by exchanging heat with the outdoor air and the supercooling refrigerant expands through the second expansion valve 50. The refrigerant that has expanded through the second expansion valve 50 flows to the secondary heat exchanging unit 30. The refrigerant flowing in the secondary heat exchanging unit 30 evaporates through the secondary heat exchanging unit 30 by exchanging heat with the outdoor air that has increased in temperature and decreased in relative humidity through the primary heat exchanging unit 20. When the refrigerant passes through the secondary heat exchanging unit 30, it exchanges heat with the outdoor air that has increased in temperature and decreased in relative humidity through the primary heat exchanging unit 20 and frosting of the secondary heat exchanging unit 30 can be delayed or prevented. The refrigerant that has evaporated through the secondary heat exchanging unit 30 flows to the switching valve-outdoor heat exchanger connection pipe 5 and is then guided into the compressor 1 by the switching valve 4.

[0096] FIG. 5 is a perspective view showing an outdoor heat exchanger of a heat pump according to another embodiment of the present invention through which outdoor air exchanges heat.

[0097] In an outdoor heat exchanger 12 according to the present embodiment, a primary heat exchanging unit 20 may include a primary tube 26 and a secondary heat exchanging unit 30 may include one or more secondary

tubes 36 and 37 disposed behind the primary tube 26 in the flow direction of outdoor air. Other configuration and operation of the outdoor heat exchanger 12 are the same as or similar to those of the previous embodiment of the present invention, so the same reference numerals are used and the detailed description is not provided.

[0098] The primary tube 26 and the secondary tubes 36 and 37 may each include a plurality of straight tubes elongated perpendicular to the flow direction of the outdoor air and may each include a plurality of return bands each connecting two straight tubes. The primary tube 26 and the secondary tubes 36 and 37 may be generally arranged in a zigzag shape.

[0099] The outdoor heat exchanger 12 may further include common fins 27 being in contact with the primary tube 26 and the secondary tubes 36 and 37. A plurality of common fins 27 may be coupled to the primary tube 26 and the secondary tubes 36 and 37. The outdoor heat exchanger 12 may further include a pair of end plates 28 and 29. The common fins 27 may be disposed between the pair of end plates 28 and 29. The common fins 27, in a second heating mode, can receive the heat from the refrigerant passing through the primary tube 26 and transfer it to the secondary tubes 36 and 37 by means of conduction. The straight tubes of the primary tubes 26 and the secondary tubes 36 and 37 may be arranged through the common fins 27, and holes through which the primary tube 26 is disposed and holes through which the secondary tubes 36 and 37 are disposed may be formed in the common fins 27.

[0100] The secondary tubes 36 and 37 may include a first secondary tube 36 disposed behind the primary tube 26 in the flow direction of outdoor air and a second secondary tube 37 disposed behind the first secondary tube 36 in the flow direction of outdoor air.

[0101] When the outdoor heat exchanger 12 includes the primary tube 26, the first secondary tube 36, and the second secondary tube 37, holes through which the straight tubes of the primary tube 26 is disposed and holes through which the straight tubes of the first secondary tube 36 are disposed, and holes through which the straight tubes of the second secondary tube 37 are disposed may be formed in the common fins 27.

[0102] A first expansion valve-outdoor heat exchanger connection pipe 11 may be connected to the primary tube 26. The first expansion valve-outdoor heat exchanger connection pipe 11 may be connected to one of the straight tubes of the primary tube 26.

[0103] The first secondary tube 36 may be connected with the primary tube 26 through a heat exchanging unit connection pipe 40 and a second expansion valve 50 may be disposed in the heat exchanging unit connection pipe 40. The heat exchanging unit connection pipe 40 may include a primary tube connection tube that connects the primary tube 26 and the second expansion valve 50 with each other and a secondary tube connection tube that connects the second expansion valve 50 and the first primary tube 36 with each other. The primary

tube connection tube may be the primary heat exchanging unit connection pipe 42 of the previous embodiment and the secondary tube connection tube may be the secondary heat exchanging unit connection pipe 44 of the previous embodiment.

[0104] The second secondary tube 37 may be connected with the first secondary tube 36 through a tube connection pipe 38. The tube connection pipe 38 may be a straight tube connection tube that connects one of the straight tubes of the first secondary tube 36 and one of the straight tubes of the second secondary tube 37 with each other. The straight tube connection tube that is the tube connection pipe 38 may be the same as the return bands of the primary tube 26, the second secondary tube 37, and the first secondary tube 36.

[0105] The second secondary tube 37 is connected with a switching valve 4 through a refrigerant pipe 5, that is, a switching valve-outdoor heat exchanger connection pipe 5 may be connected to the second secondary tube 37. The switching valve-outdoor heat exchanger connection pipe 5 may be connected to one of the straight tubes of the second secondary tube 37.

[0106] According to the outdoor heat exchanger of the present embodiment, in a cooling mode, the refrigerant in the switching valve-outdoor heat exchanger connection pipe 5 can pass sequentially through the second secondary tube 37, the tube connection pipe 38, the first secondary tube 36, the heat exchanging unit connection pipe 40, and the primary tube 26 and then flow to the first expansion valve-outdoor heat exchanger connection pipe 11.

[0107] According to the outdoor heat exchanger 12 of the present embodiment, in a first heating mode and a second heating mode, the refrigerant in the first expansion valve-outdoor heat exchanger connection pipe 11 can pass sequentially through the primary tube 26, the heat exchanging unit connection pipe 40, the first secondary tube 36, the tube connection pipe 38, and the second secondary tube 37, and then flow to the switching valve-outdoor heat exchanger connection pipe 5.

[0108] It should be understood that the present invention is not limited to the embodiments and may be implemented in various ways within the scope of the present invention.

Claims

1. A heat pump comprising a compressor (1), a switching valve (4), an indoor heat exchanger (8), a first expansion valve (10), and an outdoor heat exchanger (12), in which a refrigerant is flowable sequentially through the compressor (1), the switching valve (4), the outdoor heat exchanger (12), the first expansion valve (10), the indoor heat exchanger (8), the switching valve (4), and the compressor (1) in cooling, and the refrigerant is flowable sequentially through the compressor (1), the switching valve (4), the indoor

heat exchanger (8), the first expansion valve (10), the outdoor heat exchanger (12), the switching valve (4), and the compressor (1) in heating, wherein the outdoor heat exchanger (12) includes:

- a primary heat exchanging unit (20) that is connected with the first expansion valve (10) through a refrigerant pipe (11) and for the outdoor air to exchange heat;
 - a secondary heat exchanging unit (30) that is connected with the switching valve (4) through a refrigerant pipe (5) and disposed behind the primary heat exchanging unit (20) in the flow direction of outdoor air, and through which the outdoor air, which has exchanged heat through the primary heat exchanging unit (20), exchanges heat;
 - a heat exchanging unit connection pipe (40) that connect the primary heat exchanging unit (20) and the secondary heat exchanging unit (30) with each other; and
 - a second expansion valve (50) that is disposed in the heat exchanging unit connection pipe (40).
2. The heat pump of claim 1, wherein the primary heat exchanging unit (20) and the secondary heat exchanging unit (30) are integrally combined.
 3. The heat pump according to claim 1 or 2, wherein the primary heat exchanging unit (20) includes a primary microchannel heat exchanger (20A) having a pair of headers (21, 22) connected by a microchannel (23), and the secondary heat exchanging unit (30) includes at least one secondary microchannel heat exchanger (30A) having a pair of headers (31, 32) connected by a microchannel and disposed behind the primary microchannel heat exchanger (20A) in the flow direction of outdoor air.
 4. The heat pump according to any one of claims 1 to 3, wherein the secondary microchannel heat exchanger includes:
 - a first secondary microchannel heat exchanger (30A) disposed behind the primary microchannel heat exchanger (20A) in the flow direction of outdoor air; and
 - a second secondary microchannel heat exchanger (30B) disposed behind the first secondary microchannel heat exchanger (30A) in the flow direction of outdoor air.
 5. The heat pump according to any one of claims 1 to 4, wherein the headers (21, 22) of the primary microchannel heat exchanger (20A) and the headers of the first secondary microchannel heat exchanger (30A) are coupled to each other, and

the headers of the first secondary microchannel heat exchanger (30A) and the headers of the second secondary microchannel heat exchanger (30B) are coupled to each other.

6. The heat pump according to any one of claims 1 to 5, wherein the first secondary microchannel heat exchanger (30A) is connected with the primary microchannel heat exchanger (20A) through the heat exchanging unit connection pipe (40).
7. The heat pump according to any one of claims 1 to 6, wherein the second secondary microchannel heat exchanger (30B) is connected with the first secondary microchannel heat exchanger (30A) through a microchannel heat exchanger connection pipe (34).
8. The heat pump according to any one of claims 1 to 7, wherein the second secondary microchannel heat exchanger (30B) is connected with the switching valve (4) through a refrigerant pipe (5).
9. The heat pump according to any one of claims 1 to 8, wherein the primary heat exchanging unit (20) includes a primary tube (26), and the secondary heat exchanging unit (30) includes at least one secondary tube (36, 37) disposed behind the primary tube (26) in the flow direction of outdoor air.
10. The heat pump according to any one of claims 1 to 9, wherein the outdoor heat exchanger (12) further includes common fins (27) in contact with the primary tube (26) and the secondary tube (36, 37).
11. The heat pump according to any one of claims 1 to 10, wherein the secondary tube (36, 37) includes:
 - a first secondary tube (36) disposed behind the primary tube (26) in the flow direction of outdoor air; and
 - a second secondary tube (37) disposed behind the first secondary tube (36) in the flow direction of outdoor air.
12. The heat pump according to any one of claims 1 to 11, wherein the first secondary tube (36) is connected with the primary tube (26) through the heat exchanging unit connection pipe (40).
13. The heat pump according to any one of claims 1 to 12, wherein the second secondary tube (37) is connected with the first secondary tube (36) through a tube connection pipe (38).
14. The heat pump according to any one of claims 1 to 13, wherein the second secondary tube (37) is connected with the switching valve (4) through a refrigerant pipe (5).

erant pipe (5).

15. The heat pump according to any one of claims 1 to 14, wherein in a heating operation at an outdoor temperature over a predetermined temperature, the first expansion valve (10) is configured to be controlled to open at a degree for expanding a refrigerant and the second expansion valve (50) configured to be fully opened, and
in a heating mode at an outdoor temperature less than a predetermined temperature, the first expansion valve (10) configured to be fully opened and the second expansion valve (50) is configured to be controlled to open at a degree for expanding a refrigerant.

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Fig. 1

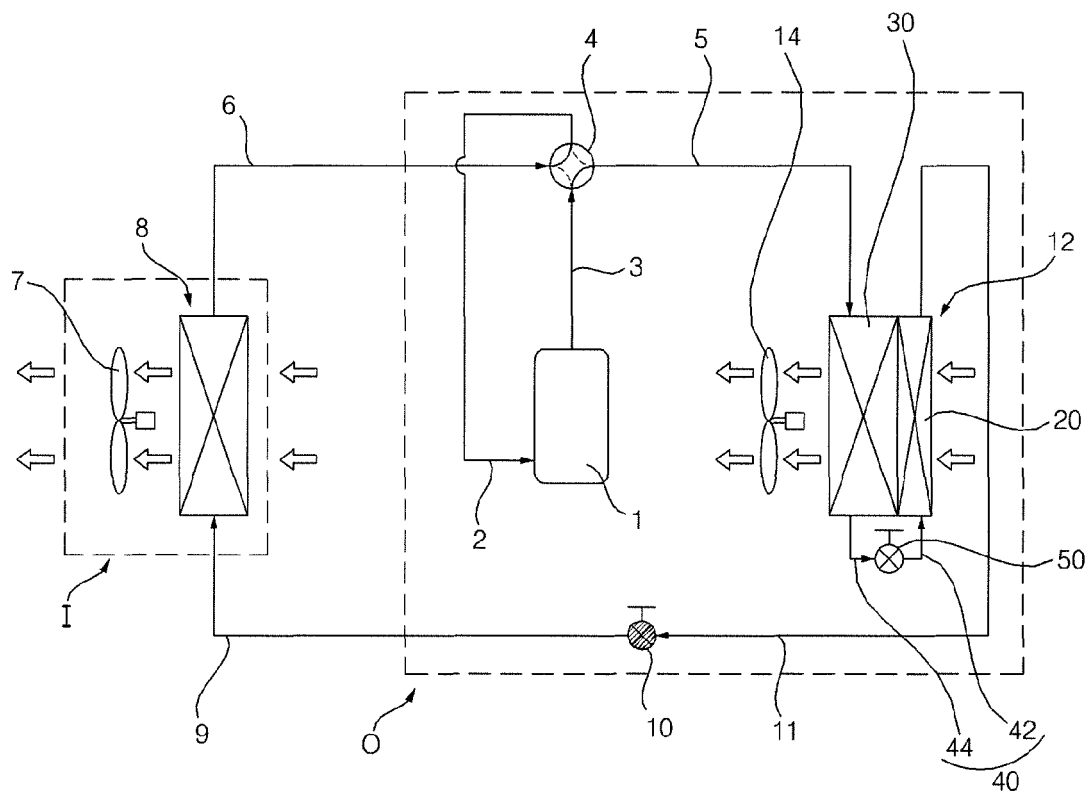


Fig. 2

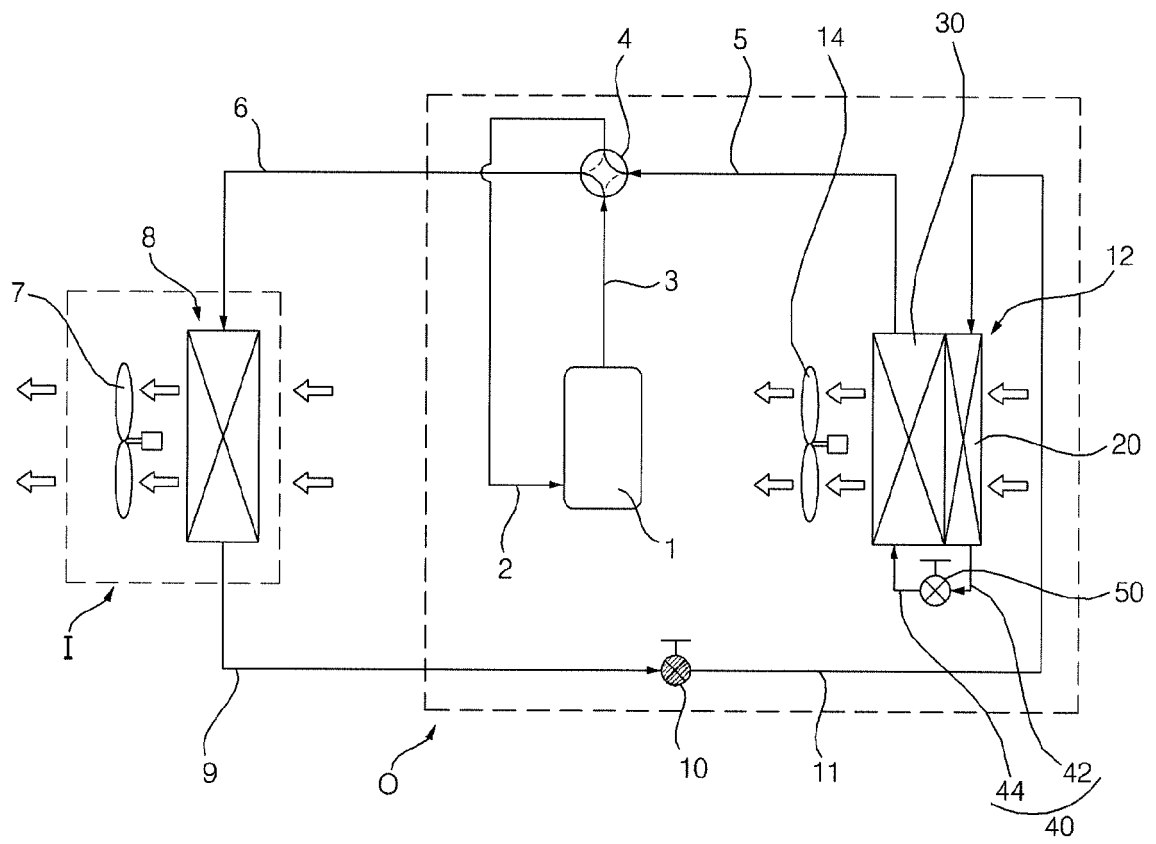


Fig. 3

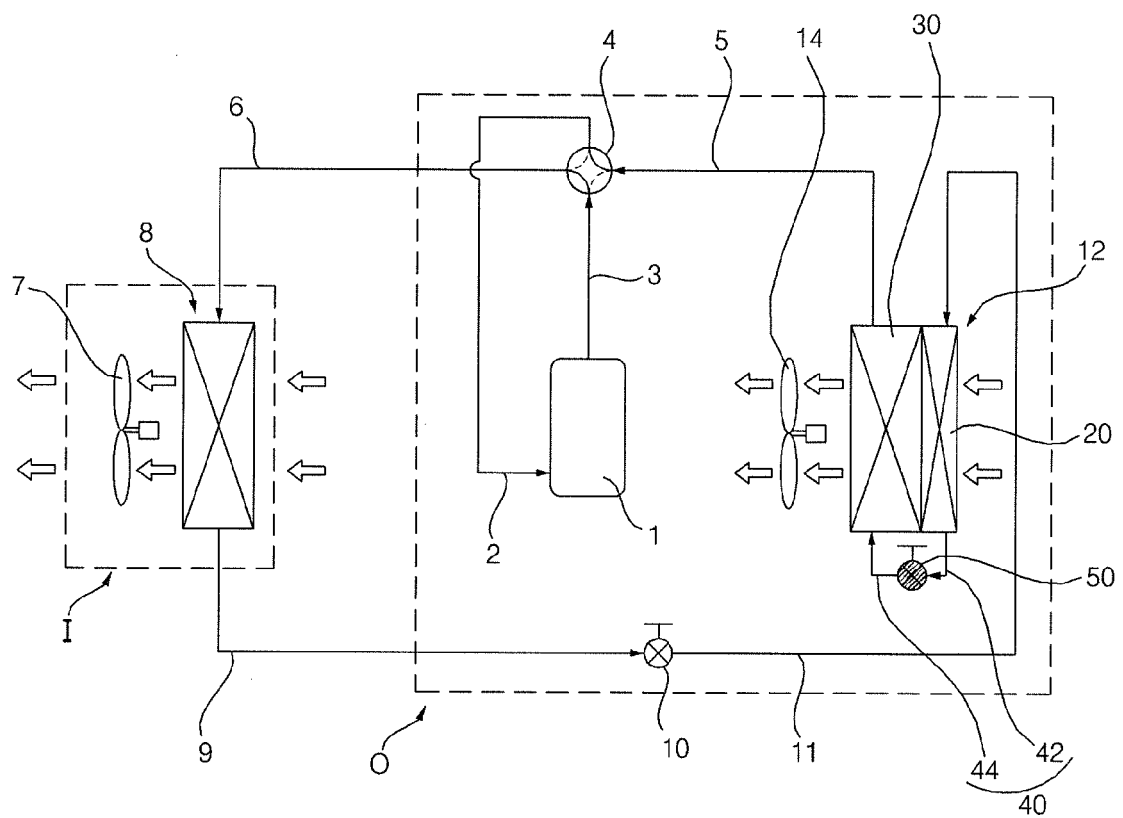


Fig. 4

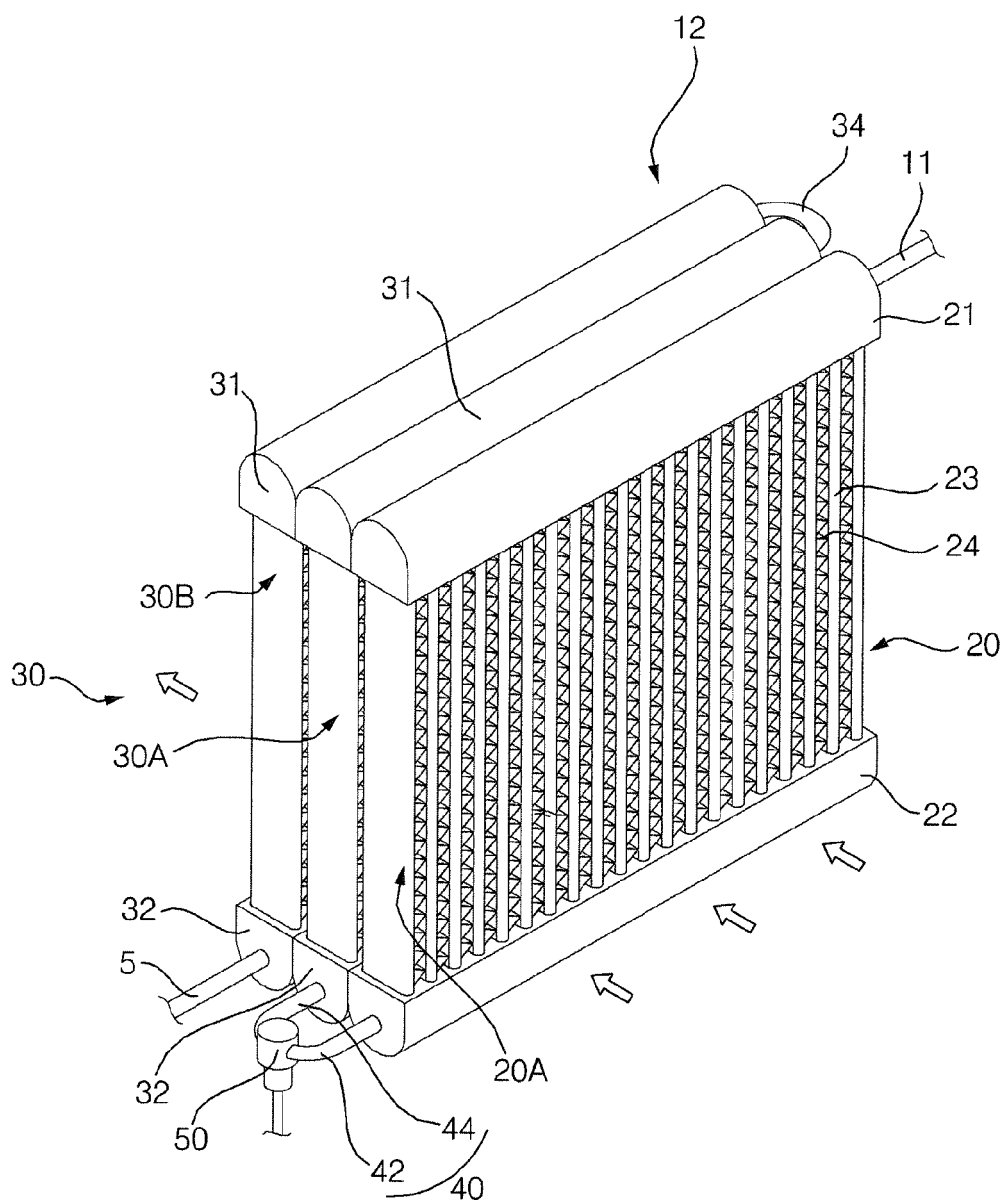
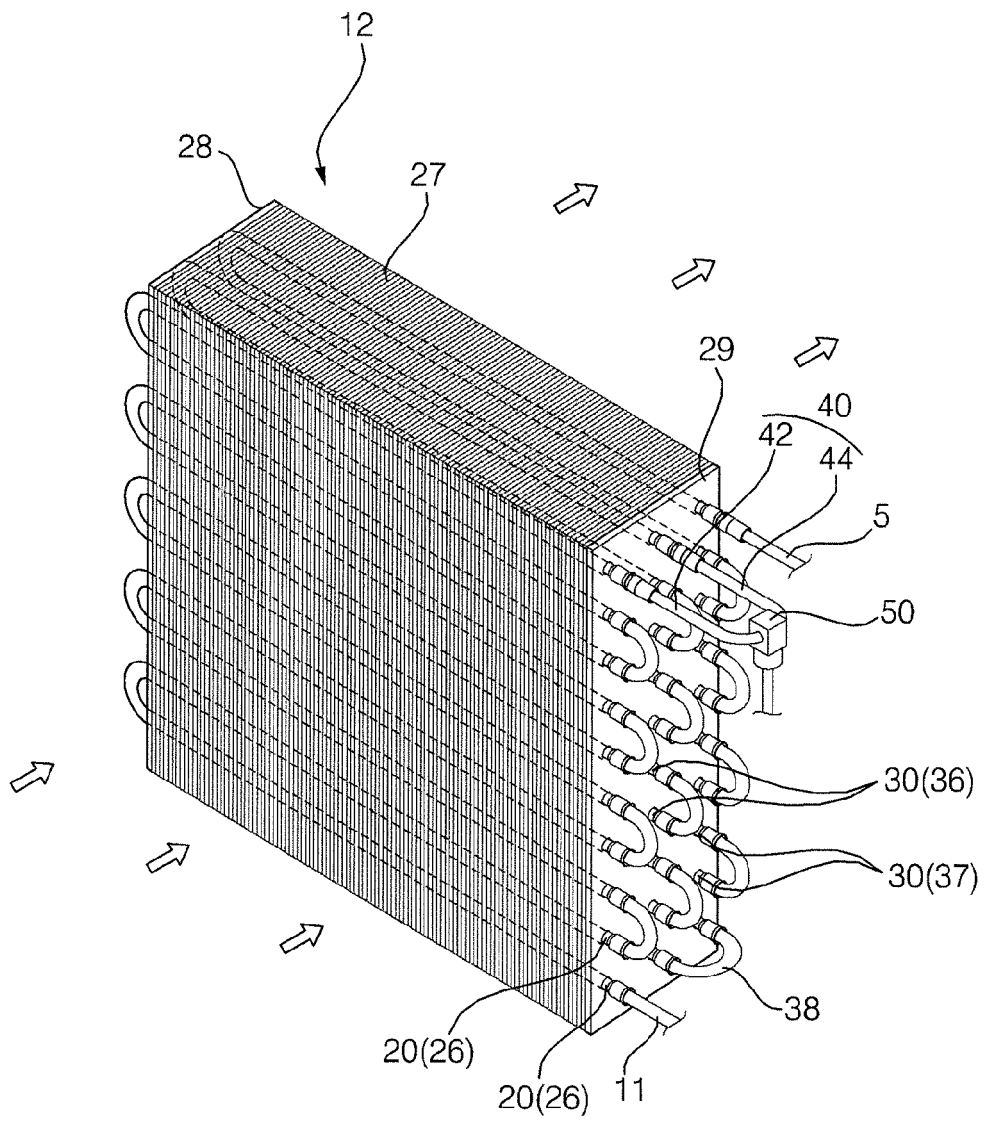


Fig. 5





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Application Number
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