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(54) **AIR-CONDITIONING APPARATUS**

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(Continued)

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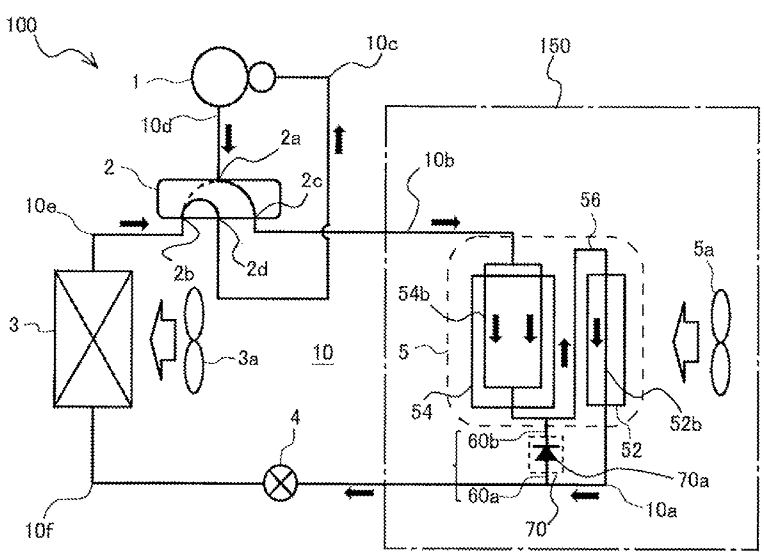
(57) **ABSTRACT**

An air-conditioning apparatus includes a load-side heat exchanger including a first heat exchanger disposed on a windward of a second heat exchanger in a direction of an air flow generated by an air-sending device. The air flow passing through the first heat exchanger passes through a second heat exchanger. During cooling operation, a bypass valve causes a part of refrigerant flowing through a first refrigerant pipe to flow through a coupling pipe through a bypass pipe. During heating operation, the bypass valve blocks a flow of the refrigerant flowing from the coupling pipe toward the first refrigerant pipe through the bypass pipe, and causes all of the refrigerant flowing through the coupling pipe to flow from the coupling pipe to the first heat exchanger.

8 Claims, 4 Drawing Sheets



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F25B 5/00 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
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See application file for complete search history.

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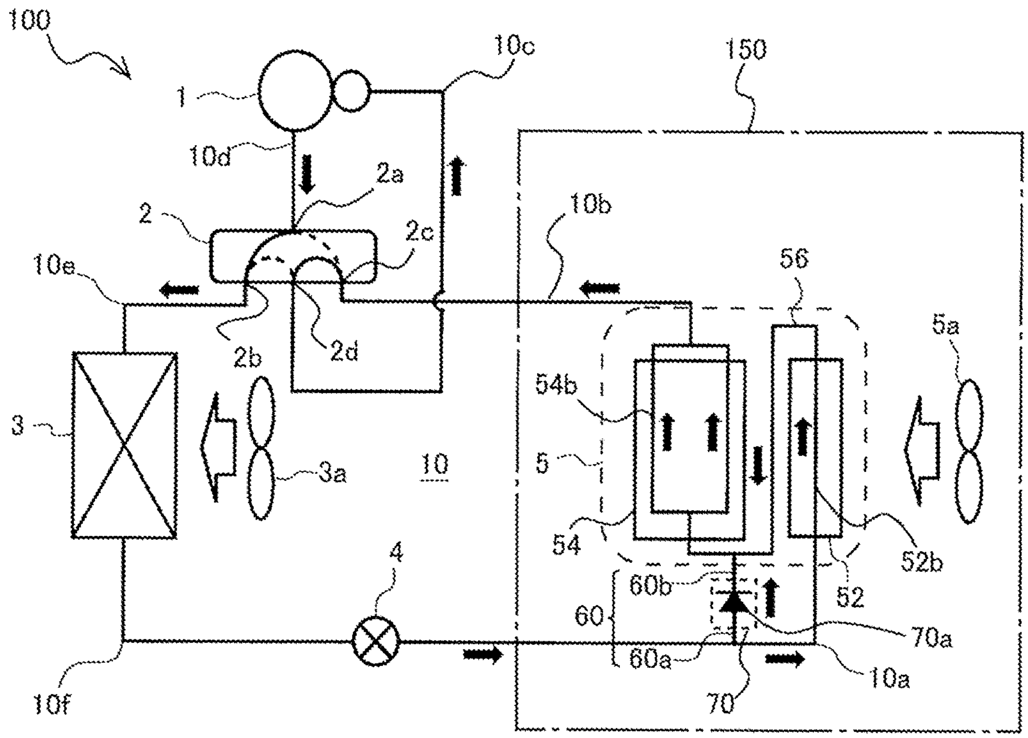
FIG. 1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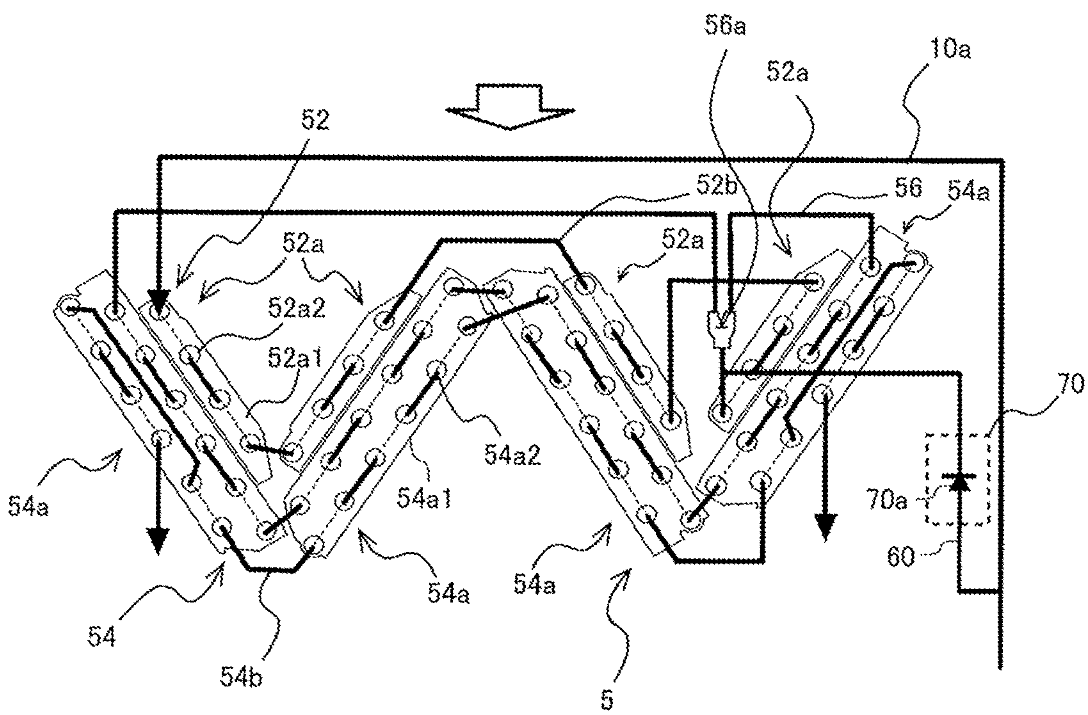
5
54
52b
4
60b
52
60
70a
60a
10a
10f
70

FIG. 2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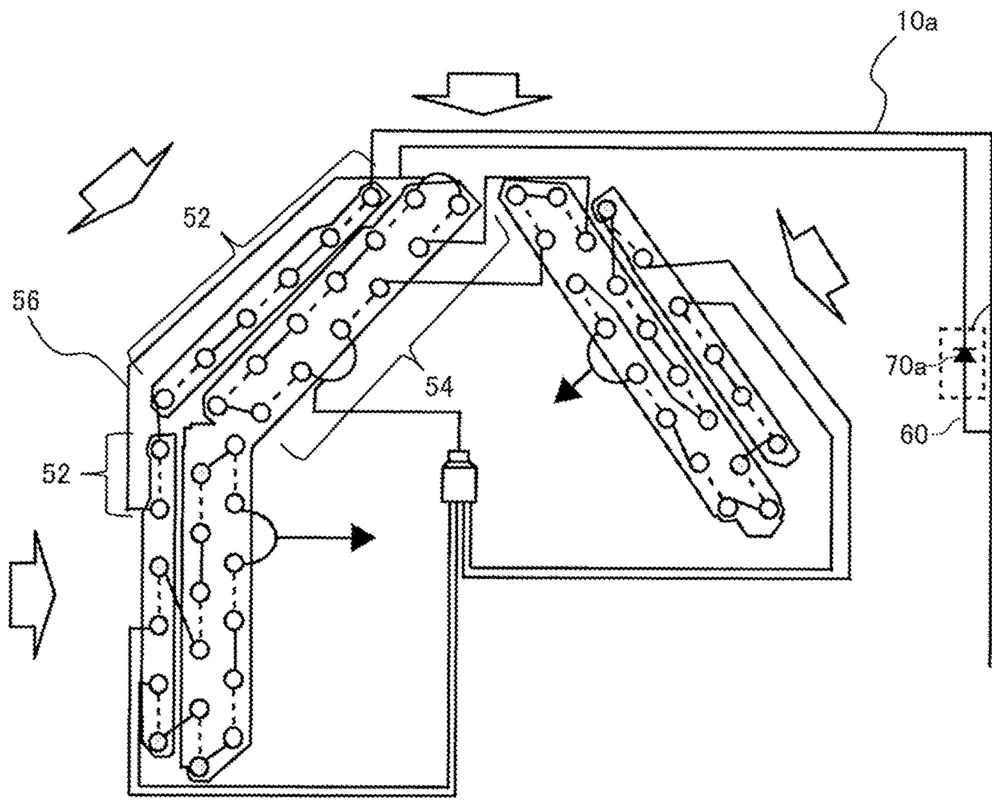
54a
60
54a
54a
54
54b
5

FIG. 3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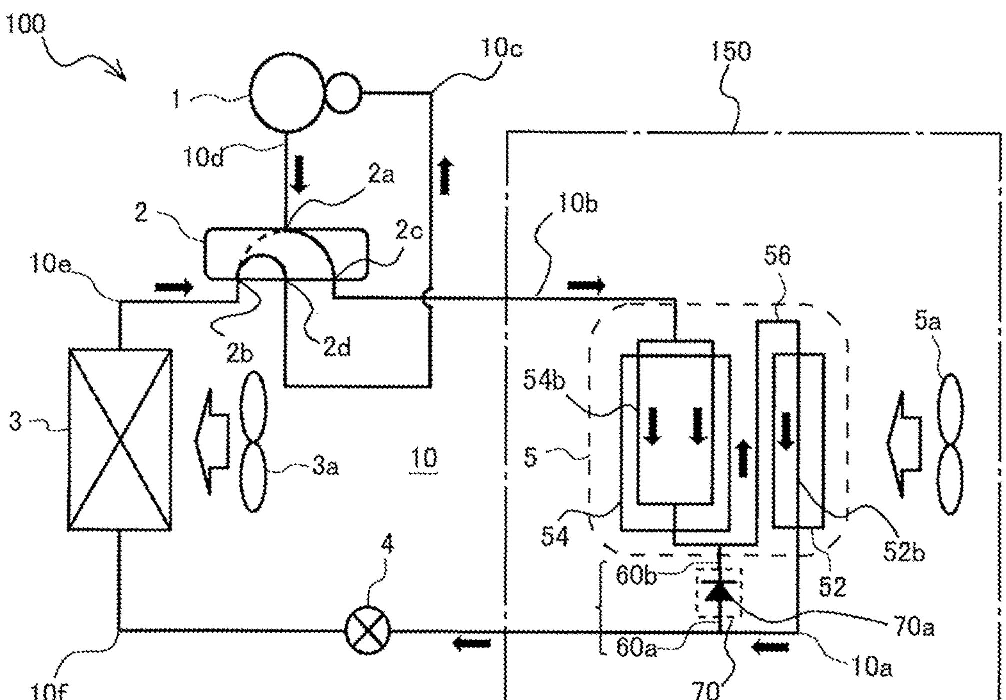
52

FIG. 4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2d
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3a
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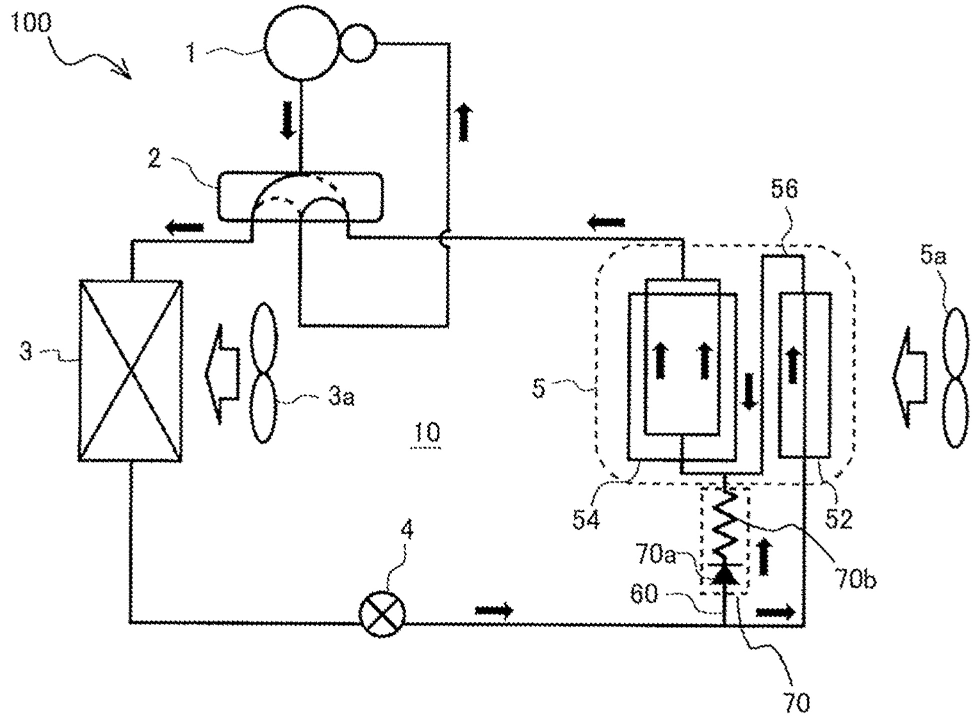
5
54
52b
60b
52
4
70a
60a
10a
70
10f

FIG. 5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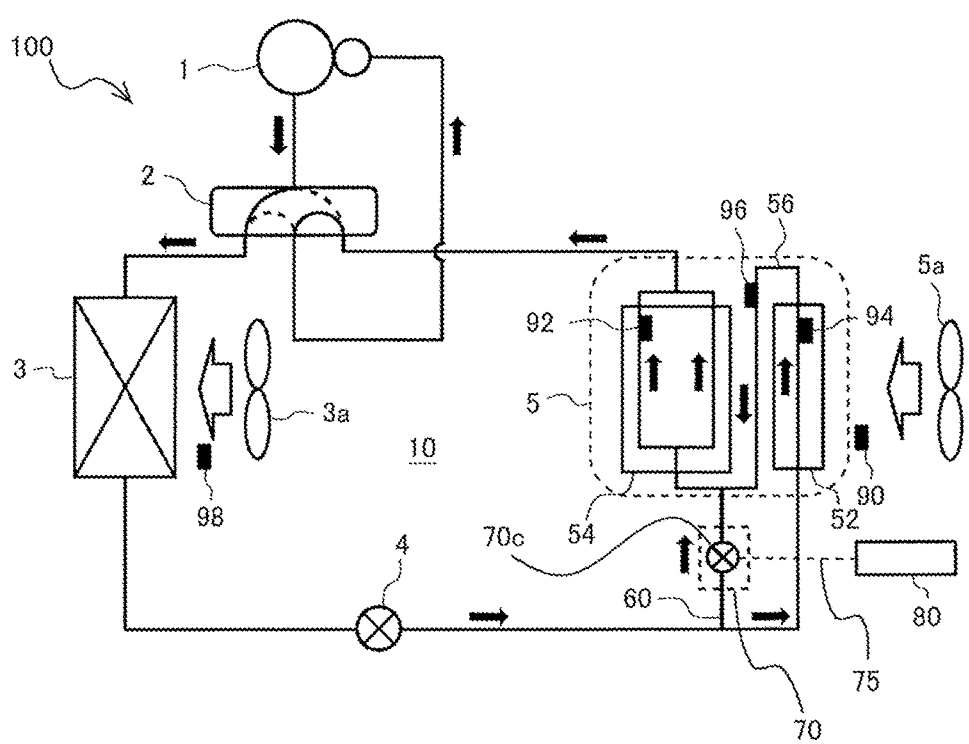
3a
10
4
5
56
5a
54
52
70a
70b
60
70

FIG. 6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2
3
3a
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98
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5a
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94
5
90
54
52
70c
60
70
75
80

FIG. 7

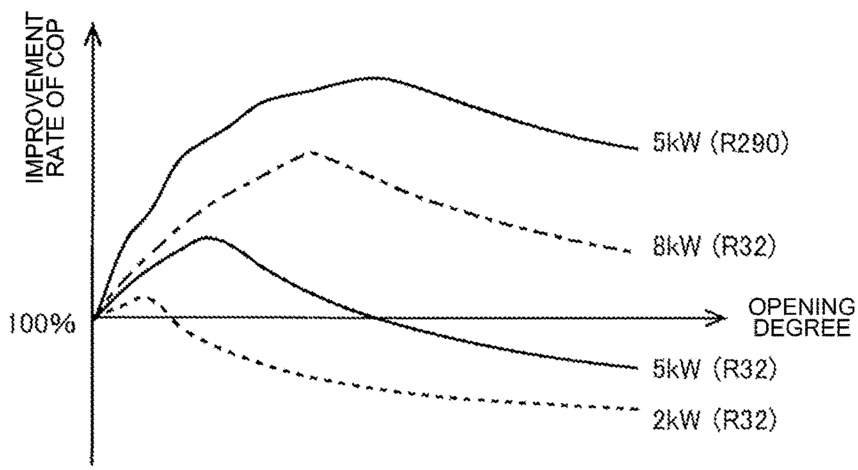


FIG. 8

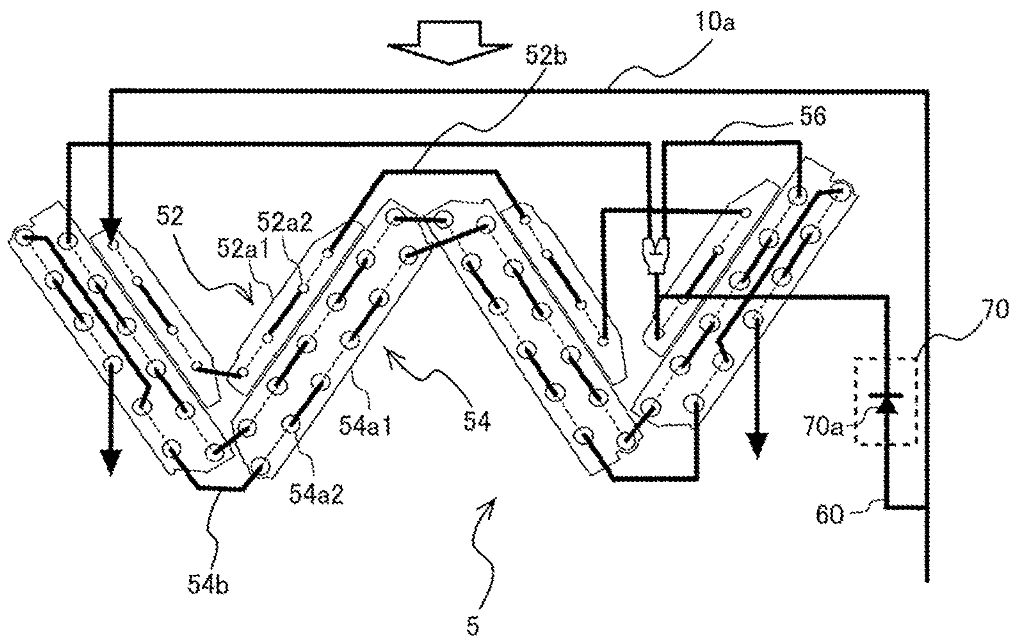
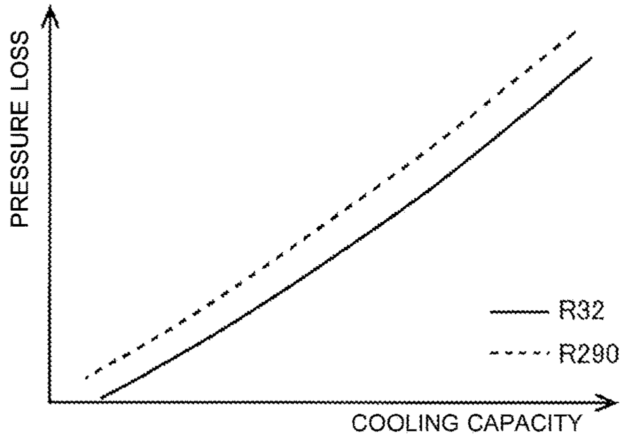


FIG. 9



AIR-CONDITIONING APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application is a U.S. national stage application of PCT/JP2019/001094 filed on Jan. 16, 2019, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to an air-conditioning apparatus including a plurality of heat exchangers on a load side.

BACKGROUND ART

For example, Patent Literature 1 discloses, as some air-conditioning apparatus including a plurality of heat exchangers on a load side, an air-conditioning apparatus configured to switch between cooling operation in which load-side heat exchangers are used as evaporators and heating operation in which the load-side heat exchangers are used as condensers. The air-conditioning apparatus disclosed in Patent Literature 1 includes, as the load-side heat exchangers, an upper-stage heat exchanger and a lower-stage heat exchanger. In Patent Literature 1, during the cooling operation, the upper-stage heat exchanger and the lower-stage heat exchanger are connected in parallel to each other to increase the number of refrigerant flow paths communicating with inlets and outlets of the load-side heat exchangers. This configuration prevents deterioration of evaporation performance caused by refrigerant pressure loss. Further, in Patent Literature 1, during the heating operation, the upper-stage heat exchanger and the lower-stage heat exchanger are connected in series to decrease the number of refrigerant flow paths communicating with the inlets and the outlets of the load-side heat exchangers. This configuration prevents lowering in a flow speed of refrigerant and lowering in in-pipe heat transfer coefficient. Further, in the air-conditioning apparatus disclosed in Patent Literature 1, flow control valves are each provided to refrigerant inflow ports of the upper-stage heat exchanger and the lower-stage heat exchanger during the cooling operation, and a flow rate of the refrigerant passing through an inside of each of the heat exchangers is controlled on the basis of air-volume distribution of air passing through each of the heat exchangers.

CITATION LIST

Patent Literature

Patent Literature 1: International Publication No. WO 2015/063853

SUMMARY OF INVENTION

Technical Problem

In the air-conditioning apparatus disclosed in Patent Literature 1, each of the plurality of heat exchangers is provided with a refrigerant control valve, and flow path control is exercised by the plurality of refrigerant control valves during the cooling operation and during the heating operation to mechanically switch the refrigerant flow paths, so that cooling performance and heating performance are improved to the extent possible. For example, to apply the air-conditioning apparatus disclosed in Patent Literature 1 to a home air-conditioning apparatus, it is necessary to downsize the air-conditioning apparatus because of restriction in installation dimensions. However, a problem remains in that downsizing of the air-conditioning apparatus is difficult as it is necessary for the air-conditioning apparatus disclosed in Patent Literature 1 to secure a space that houses a number of control valves exercising the flow path control.

Further, in the air-conditioning apparatus disclosed in Patent Literature 1, the upper-stage heat exchanger and the lower-stage heat exchanger, which are the load-side heat exchangers, are arranged in parallel to a direction in which air passes through the load-side heat exchangers. If the upper-stage heat exchanger and the lower-stage heat exchanger in the air-conditioning apparatus disclosed in Patent Literature 1 are uneven in wind speed distribution of the air passing through the upper-stage heat exchanger and the lower-stage heat exchanger, heat loads of the upper-stage heat exchanger and the lower-stage heat exchanger may be nonuniform. Further, even when the upper-stage heat exchanger and the lower-stage heat exchanger are uneven in wind speed distribution, if a heat transfer area of the upper-stage heat exchanger and a heat transfer area of the lower-stage heat exchanger are different from each other, the heat loads of the upper-stage heat exchanger and the lower-stage heat exchanger may be nonuniform.

In the air-conditioning apparatus disclosed in Patent Literature 1, in particular, in a case where the heat loads of the upper-stage heat exchanger and the lower-stage heat exchanger become nonuniform during the cooling operation in which the load-side heat exchangers are used as evaporators, the refrigerant may dry out in one of the upper-stage heat exchanger and the lower-stage heat exchanger. A phenomenon in which refrigerant dries out refers to a phenomenon in which two-phase refrigerant is changed to gas-phase refrigerant through phase change in the internal flow path of a heat exchanger and thus heat is not successfully exchanged at the heat exchanger for lack of two-phase refrigerant. If the refrigerant dries out in the heat exchanger, a heat transfer coefficient of the refrigerant is significantly decreased, and the cooling performance of the air-conditioning apparatus is decreased. To prevent the refrigerant from drying out in the air-conditioning apparatus disclosed in Patent Literature 1, it is necessary to further provide the flow control valves in the upper-stage heat exchanger and the lower-stage heat exchanger, so that more space that houses the flow control valves is required. In the air-conditioning apparatus disclosed in Patent Literature 1, a problem thus remains in that it is difficult to downsize the air-conditioning apparatus while maintaining the cooling performance.

The present disclosure is made to solve the above-described problems, and an object of the present disclosure is to provide an air-conditioning apparatus that achieves both of cooling performance and heating performance that are improved to the extent possible and reduction in size of the air-conditioning apparatus.

Solution to Problem

An air-conditioning apparatus of an embodiment of the present disclosure includes a refrigerant circuit through which refrigerant circulates, the refrigerant circuit including a compressor, a refrigerant flow switching device, a heat source-side heat exchanger, a decompression device, a load-side heat exchanger, a first refrigerant pipe, a coupling pipe, and a second refrigerant pipe, the load-side heat exchanger including a first heat exchanger and a second heat exchanger, the first refrigerant pipe connecting the decompression device and the first heat exchanger, the coupling pipe connecting the first heat exchanger and the second heat exchanger, the second refrigerant pipe connecting the second heat exchanger and the refrigerant flow switching device; an air-sending device configured to generate an air flow passing through the load-side heat exchanger; a bypass pipe connecting the first refrigerant pipe and the coupling pipe; and a bypass valve disposed in the bypass pipe. The refrigerant flow switching device is configured to switch between cooling operation that causes the refrigerant with low pressure flowing out from the load-side heat exchanger to be suctioned into the compressor and heating operation that causes the refrigerant with high pressure discharged from the compressor to flow into the load-side heat exchanger. The first heat exchanger is disposed on windward of the second heat exchanger in a direction of the air flow generated by the air-sending device, and the air flow passing through the first heat exchanger passes through the second heat exchanger. During the cooling operation, the bypass valve is configured to cause a part of the refrigerant flowing through the first refrigerant pipe to flow through the coupling pipe through the bypass pipe. During the heating operation, the bypass valve is configured to block a flow of the refrigerant flowing from the coupling pipe toward the first refrigerant pipe through the bypass pipe, and cause all of the refrigerant flowing through the coupling pipe to flow from the coupling pipe to the first heat exchanger.

Advantageous Effects of Invention

In the air-conditioning apparatus of an embodiment of the present disclosure, during the cooling operation, the refrigerant flowing out from the decompression device is divided into a main refrigerant flow flowing into the first heat exchanger and a bypass flow flowing into the coupling pipe through the bypass pipe and the bypass valve, before the refrigerant flows into the second heat exchanger. The main refrigerant flow with heat having been exchanged in the first heat exchanger is merged again with the bypass flow that has passed through the bypass valve, in the coupling pipe, and the resultant refrigerant flows into the second heat exchanger. Therefore, the pressure loss of the refrigerant passing through the first heat exchanger is reduced by a simple configuration including the bypass pipe and the bypass valve. Further, as the first heat exchanger is disposed on the windward of the second heat exchanger, and the air flow passing through the first heat exchanger passes through the second heat exchanger, the refrigerant does not dry out because of difference in heat load between the first heat exchanger and the second heat exchanger. Moreover, during the heating operation, as the first heat exchanger is connected in series with the second heat exchanger, the flow speed of the refrigerant in the second heat exchanger is increased to enhance the in-pipe heat transfer coefficient. Consequently, according to an embodiment of the present disclosure, it is possible to provide the air-conditioning apparatus that achieves both of the cooling performance and the heating performance that are improved to the extent possible and reduction in size of the air-conditioning apparatus.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic refrigerant circuit diagram illustrating an example of a refrigerant circuit during cooling operation of an air-conditioning apparatus according to Embodiment 1 of the present disclosure.

FIG. **2** is a schematic diagram illustrating an example of a specific configuration of a load-side heat exchanger in the air-conditioning apparatus of Embodiment 1 of the present disclosure.

FIG. **3** is a schematic diagram illustrating another example of the specific configuration of the load-side heat exchanger in the air-conditioning apparatus of Embodiment 1 of the present disclosure.

FIG. **4** is a schematic refrigerant circuit diagram illustrating an example of the refrigerant circuit during heating operation of the air-conditioning apparatus according to Embodiment 1 of the present disclosure.

FIG. **5** is a schematic refrigerant circuit diagram illustrating an example of a refrigerant circuit during cooling operation of an air-conditioning apparatus according to Embodiment 2 of the present disclosure.

FIG. **6** is a schematic refrigerant circuit diagram illustrating an example of a refrigerant circuit during cooling operation of an air-conditioning apparatus according to Embodiment 3 of the present disclosure.

FIG. **7** is a graph illustrating a relationship between an opening degree of a flow control valve and a coefficient of performance during the cooling operation.

FIG. **8** is a schematic diagram illustrating an example of a specific configuration of a load-side heat exchanger during cooling operation of an air-conditioning apparatus according to Embodiment 4 of the present disclosure.

FIG. **9** is a graph illustrating a relationship between cooling capacity of the air-conditioning apparatus and pressure loss in the load-side heat exchanger in a case where an R290 refrigerant or an R32 refrigerant is used as refrigerant of the air-conditioning apparatus.

DESCRIPTION OF EMBODIMENTS

Embodiment 1

An air-conditioning apparatus **100** according to Embodiment 1 of the present disclosure will be described. FIG. **1** is a schematic refrigerant circuit diagram illustrating an example of a refrigerant circuit **10** during cooling operation of the air-conditioning apparatus **100** according to Embodiment 1. Black arrows illustrated in FIG. **1** each indicate a flow direction of refrigerant during the cooling operation. Outlined block arrows illustrated in FIG. **1** each indicate a flow direction of an air flow.

In the following drawings including FIG. **1**, dimensional relationships of components and shapes of the respective components are different from actual dimensional relationships and actual shapes in some cases. Further, in the following drawings, the same or similar components are denoted by the same reference signs.

The air-conditioning apparatus **100** includes the refrigerant circuit **10** including a compressor **1**, a refrigerant flow switching device **2**, a heat source-side heat exchanger **3**, a decompression device **4**, and a load-side heat exchanger **5**. The refrigerant circuit **10** is formed such that the compressor **1**, the heat source-side heat exchanger **3**, the decompression device **4**, and the load-side heat exchanger **5** are connected through refrigerant pipes to circulate the refrigerant.

The compressor **1** is a fluid machine that compresses suctioned low-pressure refrigerant and discharges high-pressure refrigerant. For example, a reciprocating compressor, a rotary compressor, or a scroll compressor is used as the compressor **1**. Further, the compressor **1** may be a vertical compressor or a horizontal compressor.

The refrigerant flow switching device **2** is a switching device configured to switch refrigerant flow paths inside the refrigerant flow switching device **2** to switch the cooling operation to heating operation of the air-conditioning apparatus **100** and to switch the heating operation to the cooling operation of the air-conditioning apparatus **100**. The refrigerant flow switching device **2** includes a first port **2***a*, a second port **2***b*, a third port **2***c*, and a fourth port **2***d* each communicating with the refrigerant flow path inside the refrigerant flow switching device **2**. The first port **2***a* communicates with a discharge port of the compressor **1** by pipe. The second port **2***b* communicates with the heat source-side heat exchanger **3** by pipe. The third port **2***c* communicates with the load-side heat exchanger **5** by pipe. The fourth port **2***d* communicates with a suction port of the compressor **1** by pipe. The refrigerant flow switching device **2** is, for example, a four-way valve to which operation of a solenoid valve is applied. The refrigerant flow switching device **2** may include a two-way valve or a three-way valve in combination.

In the following description, the "cooling operation" refers to an operation state of the air-conditioning apparatus **100** that causes the low-pressure refrigerant flowing out from the load-side heat exchanger **5** to be suctioned into the compressor **1**. The "heating operation" refers to an operation state of the air-conditioning apparatus **100** that causes the high-pressure refrigerant discharged from the compressor **1** to flow into the load-side heat exchanger **5**.

The heat source-side heat exchanger **3** is a heat transfer device that transfers and exchanges heat energy between two fluids having different heat energies. The heat source-side heat exchanger **3** is used as a condenser during the cooling operation and is used as an evaporator during the heating operation. The heat source-side heat exchanger **3** illustrated in FIG. **1** is an air-cooled heat exchanger exchanging heat between an air flow passing through the heat source-side heat exchanger **3** and the high-pressure refrigerant flowing through the inside of the heat source-side heat exchanger **3**. The heat source-side heat exchanger **3** may be, for example, a fin-and-tube heat exchanger or a plate fin heat exchanger depending on an application of the air-conditioning apparatus **100**. Note that, in the air-conditioning apparatus **100**, the evaporator is referred to as a cooler and the condenser is referred to as a radiator in some cases.

The air flow passing through the heat source-side heat exchanger **3** is generated by a heat source-side air-sending device **3***a*. The heat source-side air-sending device **3***a* may be a propeller fan or other axial flow fan, a sirocco fan, a turbo fan, or other centrifugal fan, a diagonal flow fan, a transverse flow fan, or other fans depending on an application of the heat source-side heat exchanger **3**.

Alternatively, the heat source-side heat exchanger **3** may be a water-cooled heat exchanger exchanging heat between a heat medium passing through the heat source-side heat exchanger **3** and the high-pressure refrigerant passing through the heat source-side heat exchanger **3**, depending on the application of the air-conditioning apparatus **100**. In a case where the heat source-side heat exchanger **3** is the water-cooled heat exchanger, the air-conditioning apparatus **100** may not include the heat source-side air-sending device **3***a*. In the case where the heat source-side heat exchanger **3** is the water-cooled heat exchanger, the heat source-side heat exchanger **3** may be a shell-and-tube heat exchanger, a plate heat exchanger, or a double pipe heat exchanger depending on a form or the application of the air-conditioning apparatus **100**. In the case where the heat source-side heat exchanger **3** is the water-cooled heat exchanger, the air-conditioning apparatus **100** may include a heat medium circuit circulating the heat medium from a cooling tower.

The decompression device **4** is an expansion device that expands and decompresses high-pressure liquid-phase refrigerant. As the decompression device **4**, an expansion machine, an automatic thermal expansion valve, a linear electronic expansion valve, or another similar component is used depending on the application of the air-conditioning apparatus **100**. The expansion machine is a mechanical expansion valve to which a diaphragm is applied in a pressure receiving unit. The automatic thermal expansion valve is an expansion device adjusting a refrigerant amount on the basis of a degree of superheat of gas-phase refrigerant at the suction port of the compressor **1**. The linear electronic expansion valve is an expansion device configured to adjust the opening degree stepwise or continuously.

The load-side heat exchanger **5** is a heat transfer device that transfers and exchanges heat energy between two fluids having different heat energies. The load-side heat exchanger **5** is used as an evaporator during the cooling operation and is used as a condenser during the heating operation. The load-side heat exchanger **5** is an air-cooled heat exchanger exchanging heat between an air flow passing through the load-side heat exchanger **5** and the refrigerant flowing through the inside of the load-side heat exchanger **5**. The load-side heat exchanger **5** is a fin-and-tube heat exchanger that includes a plurality of fins arranged in parallel to each other and a heat transfer tube penetrating through the plurality of fins.

The air flow passing through the load-side heat exchanger **5** is generated by an air-sending device **5***a*. The air-sending device **5***a* may be a propeller fan or other axial flow fan, a sirocco fan, a turbo fan, or other centrifugal fan, a diagonal flow fan, a transverse flow fan, or other fans depending on a form of the load-side heat exchanger **5**.

The air-conditioning apparatus **100** includes the plurality of refrigerant pipes that connect the compressor **1**, the refrigerant flow switching device **2**, the heat source-side heat exchanger **3**, the decompression device **4**, and the load-side heat exchanger **5** to form the refrigerant circuit **10**. The refrigerant pipes included in the refrigerant circuit **10** include a first refrigerant pipe **10***a*, a second refrigerant pipe **10***b*, a third refrigerant pipe **10***c*, a fourth refrigerant pipe **10***d*, a fifth refrigerant pipe **10***e*, and a sixth refrigerant pipe **10***f*. The first refrigerant pipe **10***a* connects the decompression device **4** and the load-side heat exchanger **5**. The second refrigerant pipe **10***b* connects the load-side heat exchanger **5** and the third port **2***c* of the refrigerant flow switching device **2**. The third refrigerant pipe **10***c* connects the fourth port **2***d* of the refrigerant flow switching device **2** and the suction port of the compressor **1**. The fourth refrigerant pipe **10***d* connects the discharge port of the compressor **1** and the first port **2***a* of the refrigerant flow switching device **2**. The fifth refrigerant pipe **10***e* connects the second port **2***b* of the refrigerant flow switching device **2** and the heat source-side heat exchanger **3**. The sixth refrigerant pipe **10***f* connects the heat source-side heat exchanger **3** and the decompression device **4**. The second refrigerant pipe **10***b* is connected to the compressor **1** through the refrigerant flow switching device **2** and any of the third refrigerant pipe **10***c* and the fourth refrigerant pipe **10***d*. In other words, the second refrigerant pipe **10***b* connects the compressor **1** and the load-side heat exchanger **5**. In the following description, in a case where it is unnecessary to distinguish the first refrigerant pipe **10***a*, the second refrigerant pipe **10***b*, the third refrigerant pipe

10*c*, the fourth refrigerant pipe **10***d*, the fifth refrigerant pipe **10***e*, and the sixth refrigerant pipe **10***f* from one another, these pipes are simply referred to as the "refrigerant pipes".

The air-conditioning apparatus **100** may include devices other than the above-described devices, for example, an accumulator, a receiver, a silencing muffler, a gas-liquid separator, and an oil separator, depending on the application of the air-conditioning apparatus **100**. Further, the air-conditioning apparatus **100** may be designed as an indoor stationary integrated air-conditioning apparatus or as a separate air-conditioning apparatus in which only some of the devices including the load-side heat exchanger **5** are installed in an air-conditioned space.

Next, a configuration of the load-side heat exchanger **5** in the air-conditioning apparatus **100** of Embodiment 1 will be specifically described with reference to FIG. **2** and FIG. **3** in addition to FIG. **1**, Outlined block arrows illustrated in FIG. **2** and FIG. **3** each indicate a flow direction of the air flow generated by the air-sending device **5***a* or the heat source-side air-sending device **3***a*. Further, black arrows illustrated in FIG. **2** and FIG. **3** schematically indicate an inflow direction and an outflow direction of the refrigerant in the load-side heat exchanger **5** during the cooling operation of the air-conditioning apparatus **100**.

FIG. **2** is a schematic diagram illustrating an example of the specific configuration of the load-side heat exchanger **5** in the air-conditioning apparatus **100** of Embodiment 1. FIG. **3** is a schematic diagram illustrating another example of the specific configuration of the load-side heat exchanger **5** in the air-conditioning apparatus **100** of Embodiment 1.

As illustrated in FIG. **1**, the load-side heat exchanger **5** includes a first heat exchanger **52** and a second heat exchanger **54**. The first heat exchanger **52** is disposed on windward in the direction of the air flow generated by the air-sending device **5***a*. The second heat exchanger **54** is disposed on leeward in a direction of the air flow passing through the first heat exchanger **52**. The air-sending device **5***a* illustrated in FIG. **1** is disposed to face the first heat exchanger **52**; however, a position of the air-sending device **5***a* is not limited to the position illustrated in FIG. **1**. The air-sending device **5***a* illustrated in FIG. **1** may be disposed at a position different from the position of the air-sending device **5***a* illustrated in FIG. **1** as long as the air-sending device **5***a* is allowed to send air such that the first heat exchanger **52** is positioned on the windward of the second heat exchanger **54**. The first heat exchanger **52** is also referred to as an "auxiliary heat exchanger", and the second heat exchanger **54** is also referred to as a "main heat exchanger".

Further, in FIG. **1**, the first heat exchanger **52** includes one first internal flow path **52***b*, and the second heat exchanger **54** includes two second internal flow paths **54***b*. However, the number of first internal flow paths **52***b* and the number of second internal flow paths **54***b* are not limited to the numbers illustrated in FIG. **1**.

In the load-side heat exchanger **5**, a coupling pipe **56** connects the first heat exchanger **52** and the second heat exchanger **54**. In other words, the second heat exchanger **54** is connected in series with the first heat exchanger **52** through the coupling pipe **56**. The coupling pipe **56** is one of the refrigerant pipes included in the refrigerant circuit **10**. The first refrigerant pipe **10***a* that connects the decompression device **4** and the load-side heat exchanger **5** is connected to the decompression device **4** and the first heat exchanger **52**. The compressor **1** is connected to the second heat exchanger **54** of the load-side heat exchanger **5** by the second refrigerant pipe **10***b* and the third refrigerant pipe **10***c* through the refrigerant flow switching device **2**.

In FIG. **2**, the first heat exchanger **52** includes four first heat exchange units **52***a* arranged in a W-shape. The second heat exchanger **54** includes four second heat exchange units **54***a* that are connected in series with the four first heat exchange units **52***a* of the first heat exchanger **52**, and are arranged in a W-shape as with the first heat exchanger **52**. The first heat exchange units **52***a* of the first heat exchanger **52** are disposed on the windward in the direction of the air flow generated by the air-sending device **5***a*. The second heat exchange units **54***a* of the second heat exchanger **54** are disposed on the leeward in the direction of the air flow that is generated by the air-sending device **5***a* and passes through the first heat exchange units **52***a* of the first heat exchanger **52**.

Each of the first heat exchange units **52***a* is a fin-and-tube heat exchanger including a plurality of first fins **52***a***1** arranged in parallel to each other and a first heat transfer tube **52***a***2** penetrating through the plurality of first fins **52***a***1**. Each of the second heat exchange units **54***a* is a fin-and-tube heat exchanger including a plurality of second fins **54***a***1** arranged in parallel to each other and a second heat transfer tube **54***a***2** penetrating through the plurality of second fins **54***a***1**. Each of the first heat transfer tubes **52***a***2** and the second heat transfer tubes **54***a***2** is a circular tube as illustrated in FIG. **2**; however, each of the first heat transfer tubes **52***a***2** and the second heat transfer tubes **54***a***2** may be a flat tube.

The coupling pipe **56** connecting the first heat exchanger **52** and the second heat exchanger **54** includes a branch portion **56***a*. As the coupling pipe **56** includes the branch portion **56***a*, the first internal flow path **52***b* of the first heat exchanger **52** is branched such that the first internal flow path **52***b* is formed to communicate with each of the second internal flow paths **54***b* of the second heat exchanger **54**. In FIG. **2**, the first heat exchanger **52** includes one first internal flow path **52***b*, and the second heat exchanger **54** includes two second internal flow paths **54***b* as illustrated in FIG. **1**; however, the number of first internal flow paths **52***b* and the number of second internal flow paths **54***b* are not limited to the numbers illustrated in FIG. **1** and FIG. **2** as described above.

In the load-side heat exchanger **5** illustrated in FIG. **3**, the first heat exchanger **52** is disposed only in an air flow path of the air flow from upper left. The first heat exchanger **52** is disposed on the windward of the second heat exchanger **54** in a direction of the air flow generated by the air-sending device **5***a*. The second heat exchanger **54** is connected in series with the first heat exchanger **52**. A part of the second heat exchanger **54** is disposed on the leeward in the direction of the air flow that is generated by the air-sending device **5***a* and passes through the first heat exchanger **52**. As described above, the first heat exchanger **52** may be disposed on only a part of the air flow path through the load-side heat exchanger **5** as long as the first heat exchanger **52** is disposed on the windward in the direction of the air flow that is generated by the air-sending device **5***a* and passes through the first heat exchanger **52** and the second heat exchanger **54**.

In FIG. **1** to FIG. **3**, the first heat exchanger **52** and the second heat exchanger **54** are heat exchangers separated from each other. Alternatively, an integrated load-side heat exchanger **5** may be used in which the first fins **52***a***1** of the first heat exchanger **52** and the second fins **54***a***1** of the second heat exchanger **54** are integrally formed.

Next, a bypass structure in the air-conditioning apparatus **100** will be described.

As illustrated in FIG. **1** to FIG. **3**, the air-conditioning apparatus **100** includes a bypass pipe **60** and a bypass valve **70**. The bypass pipe **60** is the refrigerant pipe connecting the coupling pipe **56** and the first refrigerant pipe **10***a* that connects the decompression device **4** and the first heat exchanger **52**, and is one of the refrigerant pipes included in the refrigerant circuit **10**. The bypass pipe **60** includes a first bypass pipe **60***a* connecting the first refrigerant pipe **10***a* and the bypass valve **70**, and a second bypass pipe **60***b* connecting the bypass valve **70** and the coupling pipe **56**. In the following description, in a case where it is unnecessary to distinguish the first bypass pipe **60***a* and the second bypass pipe **60***b* from each other, the first bypass pipe **60***a* and the second bypass pipe **60***b* are simply referred to as the bypass pipe **60**.

The bypass valve **70** is a control device controlling a flow rate of the refrigerant in the bypass pipe **60**. During the cooling operation, the bypass valve **70** allows the refrigerant flowing from the first refrigerant pipe **10***a* toward the coupling pipe **56** of the load-side heat exchanger **5** through the bypass pipe **60** to pass through the bypass pipe **60**. In contrast, during the heating operation, the bypass valve **70** blocks the flow of the refrigerant flowing from the coupling pipe **56** of the load-side heat exchanger **5** toward the first refrigerant pipe **10***a* through the bypass pipe **60**. In other words, during the cooling operation, the bypass valve **70** opens the flow path inside the bypass pipe **60**. Therefore, the refrigerant circuit **10** includes a bypass connecting both ends of the first heat exchanger **52**. In contrast, during the heating operation, the bypass valve **70** closes the flow path inside the bypass pipe **60**. Therefore, the refrigerant circuit **10** does not include the bypass connecting both ends of the first heat exchanger **52**.

The bypass valve **70** may include an automatic valve, for example, a mechanical valve such as a pressure driven valve or an electric-operated valve such as a solenoid valve. As illustrated in FIG. **1** to FIG. **3**, the bypass valve **70** may include a check valve **70***a* as the pressure driven automatic valve. The check valve **70***a* is a mechanical valve that maintains the flow of the fluid in a fixed direction to prevent backflow.

In a case where the air-conditioning apparatus **100** is a separate air-conditioning apparatus, the air-conditioning apparatus **100** may include an indoor unit **150** that houses the load-side heat exchanger **5**, the air-sending device **5***a*, the bypass pipe **60**, and the bypass valve **70**.

Next, operation during the cooling operation of the air-conditioning apparatus **100** will be described with reference to FIG. **1**. In FIG. **1**, the refrigerant flow path inside the refrigerant flow switching device **2** during the cooling operation is illustrated by a solid line.

During the cooling operation, the refrigerant flow path inside the refrigerant flow switching device **2** is controlled to cause high-temperature and high-pressure gas refrigerant to flow from the compressor **1** to the heat source-side heat exchanger **3**. In other words, during the cooling operation, the refrigerant flow path inside the refrigerant flow switching device **2** is switched such that the first port **2***a* connected to the discharge port of the compressor **1** by pipe and the second port **2***b* connected to the heat source-side heat exchanger **3** by pipe communicate with each other. Further, the refrigerant flow path inside the refrigerant flow switching device **2** is switched such that the third port **2***c* connected to the load-side heat exchanger **5** by pipe and the fourth port **2***d* connected to the suction port of the compressor **1** by pipe communicate with each other.

The high-temperature and high-pressure gas-phase refrigerant discharged from the compressor **1** flows into the heat source-side heat exchanger **3** through the fourth refrigerant pipe **10***d*, the refrigerant flow path between the first port **2***a* and the second port **2***b* inside the refrigerant flow switching device **2**, and the fifth refrigerant pipe **10***e*. During the cooling operation, the heat source-side heat exchanger **3** is used as a condenser. The high-temperature and high-pressure gas-phase refrigerant flowing into the heat source-side heat exchanger **3** exchanges heat with the air flow that is generated by the heat source-side air-sending device **3***a* and passes through the heat source-side heat exchanger **3**. Subsequently, the resultant high-pressure liquid-phase refrigerant flows out.

The high-pressure liquid-phase refrigerant flowing out from the heat source-side heat exchanger **3** flows into the decompression device **4** through the sixth refrigerant pipe **10***f*. The high-pressure liquid-phase refrigerant flowing into the decompression device **4** is expanded and decompressed by the decompression device **4**. Subsequently, the resultant low-temperature and low-pressure two-phase refrigerant flows out from the decompression device **4** and flows into the first refrigerant pipe **10***a*. During the cooling operation, the flow path inside the bypass pipe **60** is opened by the bypass valve **70**. Therefore, the low-pressure two-phase refrigerant flowing into the first refrigerant pipe **10***a* is divided, and one of divided parts of the low-pressure two-phase refrigerant flows into the bypass pipe **60**, and flows into the coupling pipe **56** through the bypass valve **70**.

The other one of the divided parts of the low-temperature and low-pressure two-phase refrigerant flows into the first heat exchanger **52** of the load-side heat exchanger **5** through the first refrigerant pipe **10***a* During the cooling operation, the first heat exchanger **52** is used as an evaporator. The low-pressure two-phase refrigerant flowing into the first heat exchanger **52** exchanges heat with the air flow that is generated by the air-sending device **5***a* and passes through the first heat exchanger **52**. Subsequently, the resultant two-phase refrigerant flows out to the coupling pipe **56**.

The two-phase refrigerant flowing into the coupling pipe **56** is merged again with the two-phase refrigerant divided from the refrigerant in the first refrigerant pipe **10***a*, and the resultant refrigerant flows into the second heat exchanger **54**. During the cooling operation, the second heat exchanger **54** is used as an evaporator. The low-pressure two-phase refrigerant flowing into the second heat exchanger **54** exchanges heat with the air flow passing through the second heat exchanger **54**. Subsequently, the resultant low-pressure gas-phase refrigerant flows out.

The low-pressure gas-phase refrigerant flowing out from the second heat exchanger **54** is suctioned into the compressor **1** through the second refrigerant pipe **10***b*, the refrigerant flow path between the third port **2***c* and the fourth port **2***d* inside the refrigerant flow switching device **2**, and the third refrigerant pipe **10***c*. The low-pressure gas-phase refrigerant suctioned into the compressor **1** is compressed by the compressor **1**. Subsequently, the resultant high-temperature and high-pressure gas-phase refrigerant is discharged from the compressor **1**. During the cooling operation of the air-conditioning apparatus **100**, the above-described cycle is repeated.

Next, effects by the air-conditioning apparatus **100** during the cooling operation will be described.

In the case of the cooling operation in which the load-side heat exchanger **5** is used as an evaporator, the refrigerant flowing through the internal flow path through the load-side heat exchanger **5** is large in specific volume and is high in flow speed. Therefore, pressure loss of the refrigerant is large. For example, in the case of a configuration in which the first internal flow paths **52***b* of the first heat exchanger **52** are smaller in number than the second internal flow paths **54***b* of the second heat exchanger **54**, the flow speed of the refrigerant passing through the first internal flow path **52***b* is higher than the flow speed of the refrigerant passing through the second internal flow paths **54***b*. When the flow speed of the refrigerant in the internal flow path is increased, the refrigerant pressure loss in the internal flow path is increased. Therefore, in the first heat exchanger **52**, the refrigerant pressure loss is easily generated. However, as the low-temperature and low-pressure two-phase refrigerant flowing through the first refrigerant pipe **10***a* is divided, and one of divided parts of the low-temperature and low-pressure two-phase refrigerant flows into the bypass pipe **60**, it is possible to reduce the flow rate of the refrigerant flowing into the first heat exchanger **52**. When the flow rate of the refrigerant flowing into the first heat exchanger **52** is reduced, the refrigerant pressure loss in the first heat exchanger **52** is reduced, so that the cooling performance of the first heat exchanger **52** is improved.

All refrigerant flowing out from the decompression device **4** is divided into the flow path passing through the bypass pipe **60** and the bypass valve **70** and the flow path through which a part of the refrigerant flows into the first heat exchanger **52**. As a result, the refrigerant pressure loss in the first heat exchanger **52** is reduced. In contrast, if the flow rate of the refrigerant flowing through the first heat exchanger **52** is excessively reduced, a heat exchange amount at the first heat exchanger **52** may be reduced, and the improving effect of the cooling performance obtained by reduction of the refrigerant pressure loss may be canceled. The flow rate of the refrigerant bypassed to the flow path passing through the bypass pipe **60** and the bypass valve **70** that is improved to the extent possible is thus determined on the basis of the cooling capacity to be exerted by the load-side heat exchanger **5** or the total flow rate of the refrigerant. The bypass valve **70** may have a specification in which the flow rate becomes the flow rate that is improved to the extent possible when the bypass valve **70** is opened, or a specification in which the flow rate is set to the flow rate that is improved to the extent possible by adjustment of the opening degree of the bypass valve **70**.

Further, during the cooling operation, the first heat exchanger **52** and the second heat exchanger **54** are connected in series through the coupling pipe **56**. In addition, the second heat exchanger **54** is disposed downstream in the direction of the air flow that is generated by the air-sending device **5***a* and passes through the first heat exchanger **52**. Further, at least the second heat exchanger **54** is disposed over an entire region of the air flow path through which the air flow generated by the air-sending device **5***a* flows. Whether the refrigerant dries out at the outlet of the load-side heat exchanger **5** thus depends only on distribution of the heat exchange amount of each of the refrigerant flow paths in the second heat exchanger **54**, and does not relate to distribution of the heat exchange amount in the first heat exchanger **52**. For example, in the air-conditioning apparatus **100**, even when the specification of the first heat exchanger **52** or the second heat exchanger **54**, for example, a pitch width of the fins or the number of fins, or the number of heat transfer tubes is optionally set, the refrigerant does not dry out because of difference in heat load between the first heat exchanger **52** and the second heat exchanger **54**. In the air-conditioning apparatus **100**, a degree of freedom in design change of the first heat exchanger **52** and the second heat exchanger **54** is thus secured, so that the air-conditioning apparatus **100** having a high degree of freedom in design is provided.

Next, operation during the heating operation of the air-conditioning apparatus **100** will be described with reference to FIG. **4**. FIG. **4** is a schematic refrigerant circuit diagram illustrating an example of the refrigerant circuit **10** during the heating operation of the air-conditioning apparatus **100** according to Embodiment 1. Black arrows illustrated in FIG. **4** each indicate a flow direction of the refrigerant during the cooling operation. Further, outlined block arrows illustrated in FIG. **4** each indicate a flow direction of the air flow. In FIG. **4**, the refrigerant flow path inside the refrigerant flow switching device **2** during the heating operation is illustrated by a solid line. As illustrated in FIG. **4**, in the air-conditioning apparatus **100**, the direction of the flow of the refrigerant flowing through the internal flow paths of the load-side heat exchanger **5** during the heating operation is opposite to the direction of the flow of the refrigerant during the cooling operation.

During the heating operation, the refrigerant flow path inside the refrigerant flow switching device **2** is controlled to cause high-temperature and high-pressure gas refrigerant to flow from the compressor **1** to the load-side heat exchanger **5**. In other words, during the heating operation, the refrigerant flow path inside the refrigerant flow switching device **2** is switched such that the first port **2***a* connected to the discharge port of the compressor **1** by pipe and the third port **2***c* connected to the load-side heat exchanger **5** by pipe communicate with each other. Further, the refrigerant flow path inside the refrigerant flow switching device **2** is switched such that the second port **2***b* connected to the heat source-side heat exchanger **3** by pipe and the fourth port **2***d* connected to the suction port of the compressor **1** by pipe communicate with each other.

The high-temperature and high-pressure gas-phase refrigerant discharged from the compressor **1** flows into the second heat exchanger **54** of the load-side heat exchanger **5** through the fourth refrigerant pipe **10***d*, the refrigerant flow path between the first port **2***a* and the third port **2***c* inside the refrigerant flow switching device **2**, and the third refrigerant pipe **10***c*. During the heating operation, the second heat exchanger **54** is used as a condenser. The high-temperature and high-pressure gas-phase refrigerant flowing into the second heat exchanger **54** exchanges heat with the air flow that is generated by the air-sending device **5***a* and passes through the second heat exchanger **54**, and then flows out from the second heat exchanger **54**.

The refrigerant flowing out from the second heat exchanger **54** flows into the first heat exchanger **52** through the coupling pipe **56**. During the heating operation, the bypass valve **70** closes the flow path inside the bypass pipe **60**. Therefore, the refrigerant flowing into the coupling pipe **56** all flows into the first heat exchanger **52** without being divided and flowing into the bypass pipe **60**.

During the heating operation, the first heat exchanger **52** is used as a subcooling heat exchanger. The refrigerant flowing into the first heat exchanger **52** exchanges heat with the air flow that is generated by the air-sending device **5***a* and passes through the first heat exchanger **52**. Subsequently, the resultant subcooled high-pressure liquid-phase refrigerant flows out.

The subcooled high-pressure liquid-phase refrigerant flows into the decompression device **4** through the first refrigerant pipe **10***a*. The subcooled high-pressure gas-phase refrigerant flowing into the decompression device **4** is expanded and decompressed by the decompression device **4**. Subsequently, the resultant low-temperature and low-pressure two-phase refrigerant flows out from the decompression device **4**.

The low-temperature and low-pressure two-phase refrigerant flowing out from the decompression device **4** flows into the heat source-side heat exchanger **3** through the sixth refrigerant pipe **10***f*. During the heating operation, the heat source-side heat exchanger **3** is used as an evaporator. The low-temperature and low-pressure two-phase refrigerant flowing into the heat source-side heat exchanger **3** exchanges heat with the air flow that is generated by the heat source-side air-sending device **3***a* and passes through the heat source-side heat exchanger **3**. Subsequently, the resultant low-pressure gas-phase refrigerant flows out. Note that the refrigerant flowing out from the heat source-side heat exchanger **3** becomes low-pressure two-phase refrigerant that is high in quality in some cases.

The low-pressure gas-phase refrigerant flowing out from the heat source-side heat exchanger **3** is suctioned into the compressor **1** through the fifth refrigerant pipe **10***e*, the refrigerant flow path between the second port **2***b* and the fourth port **2***d* inside the refrigerant flow switching device **2**, and the fourth refrigerant pipe **10***d*. The low-pressure gas-phase refrigerant suctioned into the compressor **1** is compressed by the compressor **1**. Subsequently, the resultant high-temperature and high-pressure gas-phase refrigerant is discharged from the compressor **1**. During the heating operation of the air-conditioning apparatus **100**, the above-described cycle is repeated.

Next, effects by the air-conditioning apparatus **100** during the heating operation will be described.

In a case where the number of internal flow paths provided in parallel to each other inside the load-side heat exchanger **5** is increased during the heating operation in which the load-side heat exchanger **5** is used as a condenser, the flow speed of the refrigerant in each of the internal flow paths of the load-side heat exchanger **5** is lowered. When the flow speed of the refrigerant in each of the internal flow paths of the load-side heat exchanger **5** is lowered, an in-pipe heat transfer coefficient of the load-side heat exchanger **5** is lowered. However, in the load-side heat exchanger **5** during the heating operation, the first heat exchanger **52** is connected in series with the second heat exchanger **54** such that the first heat exchanger **52** is positioned downstream of the second heat exchanger **54**, and is not connected in parallel to the second heat exchanger **54**. Therefore, the number of internal flow paths provided in parallel to each other is not increased inside the load-side heat exchanger **5**. During the heating operation, the number of internal flow paths provided in parallel to each other inside the load-side heat exchanger **5** is not thus increased, and lowering of the flow speed of the refrigerant in each of the internal flow paths of the load-side heat exchanger **5** is prevented. This configuration makes it possible to maintain the in-pipe heat transfer coefficient of the load-side heat exchanger **5**.

Further, during the heating operation, the bypass valve **70** closes the flow path inside the bypass pipe **60**. Therefore, the high-pressure refrigerant flowing into the coupling pipe **56** all flows into the first heat exchanger **52**, and the flow speed is accordingly increased. This configuration makes it possible to enhance a heat transfer coefficient of the first heat transfer tube **52***a***2**. In contrast, the refrigerant passing through the first heat exchanger **52** is the high-pressure and high-density refrigerant, and the refrigerant pressure loss is small. Therefore, influence of pressure loss caused by increase in the flow speed of the refrigerant is ignorable. In the air-conditioning apparatus **100**, the flow path inside the bypass pipe **60** is thus closed during the heating operation, so that heating performance is enhanced.

As described above, as the air-conditioning apparatus **100** includes the bypass pipe **60** and the bypass valve **70**, the pressure loss is reduced and the cooling performance of the load-side heat exchanger **5** is improved during the cooling operation. In addition, during the heating operation, as the first heat exchanger **52** is connected in series with the second heat exchanger **54**, the flow speed of the refrigerant flowing through the second heat exchanger **54** is increased, so that the in-pipe heat transfer coefficient is enhanced. Therefore, in the air-conditioning apparatus **100**, the relationship between the refrigerant pressure loss and the heat transfer performance of the load-side heat exchanger **5** is improved to the extent possible during the cooling operation and during the heating operation. This configuration makes it possible to reduce energy consumption all year round.

Further, in the air-conditioning apparatus **100**, the energy consumption can be reduced by a simple configuration in which the bypass pipe **60** is connected to both ends of the first heat exchanger **52**, and the bypass valve **70** is provided in the bypass pipe **60**. It is thus possible to downsize the air-conditioning apparatus **100** while maintaining performance of the air-conditioning apparatus **100**. In addition, the design of the first heat exchanger **52** and the second heat exchanger **54**, for example, a dimension of each of the heat exchangers, a heat transfer area of each of the fins, the number of heat transfer tubes, a diameter of the heat transfer tube, an inner groove shape of the heat transfer tube, and the number of refrigerant flow paths of each of the heat exchangers are changeable in an optional combination. Therefore, in the air-conditioning apparatus **100**, the degree of freedom in design change of the load-side heat exchanger **5** is secured. It is thus possible to reduce the energy consumption by the air-conditioning apparatus **100** and to downsize the air-conditioning apparatus **100**, and high quality of the air-conditioning apparatus **100** is maintained.

For example, a case is considered where it is necessary to prevent the refrigerant from drying out in the second heat exchanger **54** during the cooling operation. First, a case where, unlike Embodiment 1, the first heat exchanger **52** and the second heat exchanger **54** of the load-side heat exchanger **5** are arranged in parallel to a direction in which air passes through the load-side heat exchanger **5**, is considered. In this case, to prevent the refrigerant from drying out in the second heat exchanger **54**, it is necessary to constantly consider a heat load relationship with the first heat exchanger **52**. For example, as a method of preventing the refrigerant from drying out in the second heat exchanger **54**, a method works in which the heat transfer area of the second heat exchanger **54** is designed to be smaller than the heat transfer area of the first heat exchanger **52**, and a method works in which the flow rate of the refrigerant distributed to the second heat exchanger **54** is specified to be larger than the flow rate of the refrigerant distributed to the first heat exchanger **52** by using a flow control valve. Next, the air-conditioning apparatus **100** of Embodiment 1 will be considered. In the air-conditioning apparatus **100** of Embodiment 1, during the cooling operation, the first heat exchanger **52** and the second heat exchanger **54** are connected in series through the coupling pipe **56**. Further, the second heat exchanger **54** is disposed downstream in the direction of the air flow that is generated by the air-sending device **5***a* and passes through the first heat exchanger **52**.

Further, at least the second heat exchanger **54** is disposed over the entire region of the air flow path through which the air flow generated by the air-sending device **5***a* flows. Therefore, in the air-conditioning apparatus **100** of Embodiment 1, whether the refrigerant dries out in the second heat exchanger **54** does not depend on the state such as the heat exchange amount of the refrigerant in the first heat exchanger **52**, so that independent redesign of only the second heat exchanger **54** is available. In the air-conditioning apparatus **100** of Embodiment 1, the degree of freedom in design change of the load-side heat exchanger **5** is thus secured. In addition, means for improving the performance and the quality of an optional heat exchanger may be independently or selectively added to the first heat exchanger **52** or the second heat exchanger **54**. In a case where the air-conditioning apparatus **100** of Embodiment 1 is a separate air-conditioning apparatus including the indoor unit **150**, a simple configuration may be used in which the load-side heat exchanger **5**, the air-sending device **5***a*, the bypass pipe **60**, and the bypass valve **70** are housed in the indoor unit **150**, It is thus possible to facilitate installation, in an installation space, of the indoor unit **150** that may be limited in an installation condition such as an installation dimension.

Embodiment 2

A configuration of the air-conditioning apparatus **100** of Embodiment 2 of the present disclosure will be described with reference to FIG. **5**. FIG. **5** is a schematic refrigerant circuit diagram illustrating an example of the refrigerant circuit **10** during the cooling operation of the air-conditioning apparatus **100** according to Embodiment 2. Black arrows illustrated in FIG. **5** each indicate a flow direction of the refrigerant during the cooling operation. Outlined block arrows illustrated in FIG. **5** each indicate a flow direction of the air flow.

As illustrated in FIG. **5**, in the air-conditioning apparatus **100** of Embodiment 2, the bypass valve **70** includes a capillary tube **70***b* in addition to the check valve **70***a*. The other configurations of the air-conditioning apparatus **100** are the same as the configurations of Embodiment 1 described above. Therefore, descriptions of the other configurations are omitted.

The capillary tube **70***b* is an expansion valve that is made of a thin and long copper tube, and allows a necessary amount of refrigerant to pass through the expansion valve by tube resistance to decompress the refrigerant. The capillary tube **70***b* is disposed between the check valve **70***a* and the coupling pipe **56**.

In Embodiment 1 described above, it is described that the design of the load-side heat exchanger **5** is changeable in an optional combination, and the degree of freedom in design change is secured; however, the refrigerant pressure loss in the load-side heat exchanger **5** may be varied depending on the design change. For example, a ratio of the flow rate of the refrigerant flowing through the bypass pipe **60** to the flow rate of the refrigerant flowing through the first heat exchanger **52** is increased as the pressure loss of the first heat exchanger **52** is increased. In a case where the design is changed in which the load-side heat exchanger **5** is configured such that the flow resistance of the first heat exchanger **52** is increased and the refrigerant pressure loss is increased, the flow rate of the refrigerant passing through the bypass pipe **60** is excessive, so that heat transfer performance of the load-side heat exchanger **5** is reduced.

In the case where the bypass valve **70** includes the capillary tube **70***b*, it is possible to adjust the flow resistance of the bypass pipe **60** and to reduce the flow rate of the refrigerant passing through the bypass pipe **60**. As a result, it is possible to maintain balance between the refrigerant pressure loss in the load-side heat exchanger **5** and the heat transfer performance of the load-side heat exchanger **5**, and to further reduce the energy consumption.

Embodiment 3

A configuration of the air-conditioning apparatus **100** of Embodiment 3 of the present disclosure will be described with reference to FIG. **6**. FIG. **6** is a schematic refrigerant circuit diagram illustrating an example of the refrigerant circuit **10** during the cooling operation of the air-conditioning apparatus **100** according to Embodiment 3. Black arrows illustrated in FIG. **6** each indicate a flow direction of the refrigerant during the cooling operation. Outlined block arrows illustrated in FIG. **6** each indicate a flow direction of the air flow.

As illustrated in FIG. **6**, in the air-conditioning apparatus **100** of Embodiment 3, the bypass valve **70** includes a flow control valve **70***c* having a controllable opening degree. The air-conditioning apparatus **100** further includes a controller **80** configured to control the opening degree of the flow control valve **70***c* through a communication line **75**. The air-conditioning apparatus **100** further includes one or more temperature sensors connected to the controller **80** by a cable or radio. The other configurations of the air-conditioning apparatus **100** are the same as the configurations in Embodiment 1 described above. Therefore, descriptions of the other configurations are omitted.

The flow control valve **70***c* is a control device that controls the opening degree of an internal flow path to control the flow rate of the refrigerant flowing through the inside the flow control valve **70***c*. The flow control valve **70***c* is, for example, a linear electronic expansion valve. The flow control valve **70***c* is configured to control the flow rate of the refrigerant passing through the bypass pipe **60** in accordance with an instruction from the controller **80**.

The controller **80** is, for example, dedicated hardware, a microcomputer including a central processing unit and a memory, or a micro processing unit. The controller **80** may be configured to exercise control of the operation state of the air-conditioning apparatus **100**, for example, frequency control of the compressor **1** and opening degree control of the decompression device **4**, or may only be configured to exercise the opening degree control of the flow control valve **70***c*. The communication line **75** between the flow control valve **70***c* and the controller **80** may be a cable or radio.

Each of the temperature sensors may include, for example, a semiconductor material such as a thermistor or a metal material such as a thermometric resistor. The plurality of temperature sensors provided in the air-conditioning apparatus **100** may have the same configuration or different configurations. In FIG. **6**, connection lines between the controller **80** and the temperature sensors are not illustrated.

As illustrated in FIG. **6**, the air-conditioning apparatus **100** may include, as the temperature sensors, a first temperature sensor **90**, a second temperature sensor **92**, a third temperature sensor **94**, a fourth temperature sensor **96**, and a fifth temperature sensor **98**. The air-conditioning apparatus **100** may have a configuration from which some of the temperature sensors are removed, or a configuration to which a temperature sensor is further added, depending on the form of the air-conditioning apparatus **100**.

The first temperature sensor **90** is disposed at an optional position around the load-side heat exchanger **5** and detects a temperature of the air-conditioned space. The second temperature sensor **92** detects a temperature of the refrigerant flowing through the second heat transfer tube **54***a***2** of the second heat exchanger **54**, through the second heat transfer tube **54***a***2**. The third temperature sensor **94** detects a temperature of the refrigerant flowing through the first heat transfer tube **52***a***2** of the first heat exchanger **52**, through the first heat transfer tube **52***a***2**. The fourth temperature sensor **96** detects a temperature of the refrigerant flowing through the coupling pipe **56**, through the coupling pipe **56**. The fifth temperature sensor **98** is an outside-air temperature sensor that is disposed at an optional position around the heat source-side heat exchanger **3**, and detects a temperature of outside air. In the following description, in a case where it is unnecessary to distinguish the first temperature sensor **90**, the second temperature sensor **92**, the third temperature sensor **94**, the fourth temperature sensor **96**, and the fifth temperature sensor **98** from one another, these temperature sensors are simply referred to as the "temperature sensors".

The controller **80** is configured to control the opening degree of the flow control valve **70***c* on the basis of information on an operation frequency transmitted from the compressor **1** and information on the temperatures detected by the respective temperature sensors. FIG. **7** is a graph illustrating a relationship between the opening degree of the flow control valve **70***c* and a coefficient of performance during the cooling operation. A horizontal axis illustrated in FIG. **7** refers to the opening degree of the flow control valve **70***c*, and the opening degree is increased in an arrow direction. A vertical axis illustrated in FIG. **7** refers to an improvement rate of the coefficient of performance that is defined such that the coefficient of performance is 100% when the flow control valve **70***c* is closed, namely, when the opening degree is zero. The coefficient of performance is increased in an arrow direction. In the following description, the coefficient of performance is described as its acronym "COP" in some cases. Further, the cooling capacity of each of lines in the graph is illustrated in kilowatts, and a type of the refrigerant is described in brackets.

As suggested in FIG. **7**, in the case of an R32 refrigerant, the opening degree of the flow control valve **70***c* at which the improvement rate of the coefficient of performance becomes the highest during the cooling operation is varied depending on the cooling capacity of the air-conditioning apparatus **100**, namely, a circulation amount of the refrigerant in the air-conditioning apparatus **100**. In addition, as suggested in FIG. **7**, increasing the opening degree of the flow control valve **70***c* with increase in the cooling capacity may improve the improvement rate of the coefficient of performance. The bypass valve **70** including the flow control valve **70***c* is provided and the opening degree of the flow control valve **70***c* is controlled depending on the cooling capacity, so that the balance is thus efficiently maintained between the refrigerant pressure loss in the load-side heat exchanger **5** and the heat transfer performance of the load-side heat exchanger **5**.

Further, the cooling capacity of the air-conditioning apparatus **100** corresponds to the circulation amount of the refrigerant in the air-conditioning apparatus **100**, and the circulation amount of the refrigerant in the air-conditioning apparatus **100** is increased with increase in the operation frequency of the compressor **1**. Therefore, controlling the opening degree of the flow control valve **70***c* over an entire operable frequency range of the air-conditioning apparatus **100** makes it possible to more efficiently maintain the balance between the refrigerant pressure loss in the load-side heat exchanger **5** and the heat transfer performance of the load-side heat exchanger **5**.

Further, as the controller **80** is provided, the opening degree of the flow control valve **70***c*, namely, the flow rate of the refrigerant passing through the bypass pipe **60** is adjustable to increase the coefficient of performance to the extent possible on the basis of the state during the cooling operation such as the temperature of the outside air, the temperature of the air-conditioned space, and the operation frequency of the compressor **1**. As the flow control valve **70***c*, the controller **80**, and the temperature sensors are provided, it is thus possible to further efficiently reduce the power consumption during a cooling period even in a case where any of the temperatures is varied.

Further, as suggested in FIG. **7**, in comparison at the same refrigeration capacity, an R290 refrigerant may improve the improvement rate of the coefficient of performance by adjustment of the opening degree of the flow control valve **70***c* more than does the R32 refrigerant.

The bypass valve **70** in the air-conditioning apparatus **100** of Embodiment 3 may further include the check valve **70***a*.

Embodiment 4

A configuration of the air-conditioning apparatus **100** of Embodiment 4 of the present disclosure will be described with reference to FIG. **8**. FIG. **8** is a schematic diagram illustrating an example of a specific configuration of the load-side heat exchanger **5** during the cooling operation of the air-conditioning apparatus **100** according to Embodiment 4. An outlined block arrow illustrated in FIG. **8** indicates the direction of the flow of the air flow generated by the air-sending device **5***a*. Black arrows illustrated in FIG. **8** schematically indicate an inflow direction and an outflow direction of the refrigerant in the load-side heat exchanger **5** during the cooling operation of the air-conditioning apparatus **100**.

As illustrated in FIG. **8**, in the load-side heat exchanger **5**, an inner diameter of the first heat transfer tube **52***a***2** of the first heat exchanger **52** is designed to be smaller than an inner diameter of the second heat transfer tube **54***a***2** of the second heat exchanger **54**. The other configurations of the load-side heat exchanger **5** are the same as the configurations in Embodiment 1 described above. Therefore, descriptions of the other configurations are omitted.

For example, the load-side heat exchanger **5** is formed such that, in a case where a thickness of the first heat transfer tube **52***a***2** and a thickness of the second heat transfer tube **54***a***2** are equal to each other, an outer diameter of the second heat transfer tube **54***a***2** is 7 mm and an outer diameter of the first heat transfer tube **52***a***2** is 5 mm.

As the refrigerant circulating through the air-conditioning apparatus **100**, a hydrocarbon refrigerant or a hydrofluorocarbon refrigerant, which are low in global warming potential, is used in some cases. With the hydrocarbon refrigerant, however, an amount of the refrigerant to be sealed is desirably small as the hydrocarbon refrigerant is flammable. Note that the hydrocarbon refrigerant is abbreviated as the HO refrigerant in some cases. Further, the hydrofluorocarbon refrigerant is abbreviated as the HFC refrigerant in some cases.

During the heating operation of the air-conditioning apparatus **100**, the first heat exchanger **52** is used as a subcooling heat exchanger, and the liquid-phase refrigerant flows inside the first heat transfer tube **52***a***2**. In a case where the liquid-phase refrigerant flows inside the first heat transfer tube **52**_a_**2**, the flow speed of the refrigerant inside the first heat transfer tube **52**_a_**2** is increased as the inner diameter of the first heat transfer tube **52**_a_**2** is decreased. The heat transfer coefficient of the first heat transfer tube **52**_a_**2** is improved accordingly to improve the heating performance. Further, an internal capacity of the first heat transfer tube **52**_a_**2** is decreased as the inner diameter of the first heat transfer tube **52**_a_**2** is decreased. A filling amount of the refrigerant necessary for operation of the refrigerant circuit **10** is reduced accordingly.

During the cooling operation, the refrigerant pressure loss is increased as the inner diameter of the first heat transfer tube **52**_a_**2** is decreased and the flow rate of the refrigerant is increased. However, as described in Embodiments 1 to 3 described above, as the bypass pipe **60** and the bypass valve **70** are provided, the pressure loss in the first heat exchanger **52** is reduced to improve the cooling performance of the first heat exchanger **52** during the cooling operation.

Further, as described in Embodiment 1 described above, the first internal flow paths **52**_b_ of the first heat exchanger **52** may be designed to be smaller in number than the second internal flow paths **54**_b_ of the second heat exchanger **54**. In a case where the liquid-phase refrigerant flows through the first internal flow path **52**_b_ during the heating operation of the air-conditioning apparatus **100**, the flow speed of the refrigerant inside the first internal flow path **52**_b_ is increased as the number of first internal flow paths **52**_b_ is decreased. The heat transfer coefficient of the first heat transfer tube **52**_a_**2** is improved accordingly to improve the heating performance. In addition, the internal capacity of the first internal flow path **52**_b_ in the first heat exchanger **52** is decreased as the number of first internal flow paths **52**_b_ of the first heat exchanger **52** is decreased. The filling amount of the refrigerant necessary for operation of the refrigerant circuit **10** is reduced accordingly. As illustrated in FIG. **7**, the load-side heat exchanger **5** may include, for example, one first internal flow path **52**_b_ and two second internal flow paths **54**_b_.

During the cooling operation, the refrigerant pressure loss is increased as the number of first internal flow paths **52**_b_ is decreased and the flow rate of the refrigerant is increased. However, as the bypass pipe **60** and the bypass valve **70** are provided, the pressure loss in the first heat exchanger **52** is reduced to improve the cooling performance of the first heat exchanger **52** during the cooling operation.

Note that the outer diameter of the first heat transfer tube **52**_a_**2** and the outer diameter of the second heat transfer tube **54**_a_**2** are not limited to the above-described specific examples. When a tube having an inner diameter smaller than the inner diameter of the second heat transfer tube **54**_a_**2** having the outer diameter of 7 mm is used as the first heat transfer tube **52**_a_**2**, similar effects are obtainable. Further, the number of first internal flow paths **52**_b_ and the number of second internal flow paths **54**_b_ are not limited to the above-described specific examples. For example, when the first heat transfer tube **52**_a_**2** is a flat tube, the number of internal flow paths may be two or more.

FIG. **9** is a graph illustrating a relationship between the cooling capacity of the air-conditioning apparatus **100** and the pressure loss in the load-side heat exchanger **5** in a case where the R290 refrigerant or the R32 refrigerant is used as the refrigerant of the air-conditioning apparatus **100**. A horizontal axis of the graph refers to the cooling capacity of the air-conditioning apparatus **100**, and the cooling capacity is improved in an arrow direction. A vertical axis of the graph refers to the pressure loss in the load-side heat exchanger **5**, and the pressure loss is increased in an arrow direction. Further, the R290 refrigerant is a hydrocarbon refrigerant, and the R32 refrigerant is a hydrofluorocarbon refrigerant.

In a case where the same cooling capacity is required, use of the R290 refrigerant is constantly larger in pressure loss than use of the R32 refrigerant. As described in Embodiment 3 with reference to FIG. **7**, however, in the comparison at the same refrigeration capacity, the R290 refrigerant may improve the improvement rate of the coefficient of performance by adjustment of the opening degree of the flow control valve **70**_c_ more than does the R32 refrigerant. Therefore, in particular, in the case where the hydrocarbon refrigerant is used as the refrigerant of the air-conditioning apparatus **100**, it is possible to enhance effects of reducing the refrigerant amount and the energy consumption.

Further, when the coefficient of performance is enhanced at the constant cooling capacity, the power consumption of the air-conditioning apparatus **100** is decreased. Therefore, the air-conditioning apparatus **100** may also be configured to improve the cooling capacity at the constant power consumption to achieve an effect of improving the cooling capacity of the air-conditioning apparatus **100** to the extent possible.

REFERENCE SIGNS LIST

1: compressor, **2**: refrigerant flow switching device, **2**_a_: first port, **2**_b_: second port, **2**_c_: third port, **2**_d_: fourth port, **3**: heat source-side heat exchanger, **3**_a_: heat source-side air-sending device, **4**: decompression device, **5**: load-side heat exchanger, **5**_a_: air-sending device, **10**: refrigerant circuit, **10**_a_: first refrigerant pipe, **10**_b_: second refrigerant pipe, **10**_c_: third refrigerant pipe, **10**_d_: fourth refrigerant pipe, **10**_e_: fifth refrigerant pipe, **10**_f_: sixth refrigerant pipe, **52**: first heat exchanger, **52**_a_: first heat exchange unit, **52**_a_**1**: first fin, **52**_a_**2**: first heat transfer tube, **52**_b_: first internal flow path, **54**: second heat exchanger, **54**_a_: second heat exchange unit, **54**_a_**1**: second fin, **54**_a_**2**: second heat transfer tube, **54**_b_: second internal flow path, **56**: coupling pipe, **56**_a_: branch portion, **60**: bypass pipe, **60**_a_: first bypass pipe, **60**_b_: second bypass pipe, **70**: bypass valve, **70**_a_: check valve, **70**_b_: capillary tube, **70**_c_: flow control valve, **75**: communication line, **80**: controller, **90**: first temperature sensor, **92**: second temperature sensor, **94**: third temperature sensor, **96**: fourth temperature sensor, **98**: fifth temperature sensor, **100**: air-conditioning apparatus, **150**: indoor unit

The invention claimed is:

1. An air-conditioning apparatus, comprising:

a refrigerant circuit through which refrigerant circulates, the refrigerant circuit including a compressor, a refrigerant flow switching device, a heat source-side heat exchanger, a decompression device, a load-side heat exchanger, a first refrigerant pipe, a coupling pipe, and a second refrigerant pipe, the load-side heat exchanger including a first heat exchanger and a second heat exchanger, the first refrigerant pipe connecting the decompression device and the first heat exchanger, the coupling pipe connecting the first heat exchanger and the second heat exchanger, the second refrigerant pipe connecting the second heat exchanger and the refrigerant flow switching device;

an air-sending device configured to generate an air flow passing through the load-side heat exchanger;

a bypass pipe connecting the first refrigerant pipe and the coupling pipe; and a bypass valve disposed in the bypass pipe,

the refrigerant flow switching device being configured to switch between cooling operation that causes the refrigerant with low pressure flowing out from the load-side heat exchanger to be suctioned into the compressor and heating operation that causes the refrigerant with high pressure discharged from the compressor to flow into the load-side heat exchanger,

the first heat exchanger being disposed on windward of the second heat exchanger in a direction of the air flow generated by the air-sending device,

the air flow that passes through the first heat exchanger passing through the second heat exchanger,

during the cooling operation, the bypass valve being configured to cause a part of the refrigerant flowing through the first refrigerant pipe to flow through the coupling pipe through the bypass pipe,

during the heating operation, the bypass valve being configured to block a flow of the refrigerant flowing from the coupling pipe toward the first refrigerant pipe through the bypass pipe, and cause all of the refrigerant flowing through the coupling pipe to flow from the coupling pipe to the first heat exchanger.

2. The air-conditioning apparatus of claim **1**, wherein the bypass valve includes a check valve.

3. The air-conditioning apparatus of claim **2**, wherein the bypass valve further includes a capillary tube.

4. The air-conditioning apparatus of claim **1**, wherein the bypass valve includes a flow control valve having a controllable opening degree.

5. The air-conditioning apparatus of claim **1**, wherein

the first heat exchanger includes at least one first internal flow path,

the second heat exchanger includes at least one second internal flow path, and

the at least one first internal flow path is smaller in number than the at least one second internal flow path.

6. The air-conditioning apparatus of claim **1**, wherein

the first heat exchanger includes a first heat transfer tube,

the second heat exchanger includes a second heat transfer tube, and

the first heat transfer tube has an inner diameter smaller than an inner diameter of the second heat transfer tube of the second heat exchanger.

7. The air-conditioning apparatus of claim **1**, wherein the refrigerant is flammable.

8. The air-conditioning apparatus of claim **1**, further comprising an indoor unit that houses the load-side heat exchanger, the air-sending device, the bypass pipe, and the bypass valve.

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