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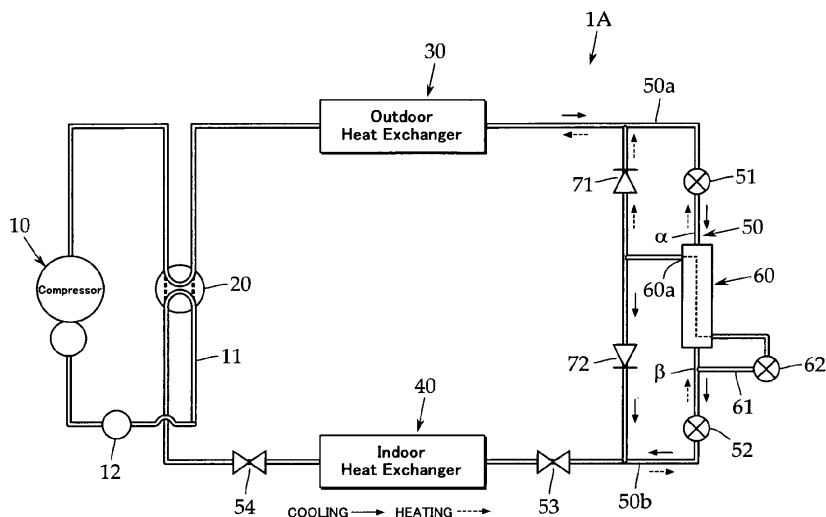
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(54) **Air conditioner**

(57) In an air conditioner having a double-pipe heat exchanger in a refrigerating cycle, the degree of opening of a bypass expansion valve is controlled easily without liquid return to a compressor and without considering the state of a low-pressure two-phase refrigerant in the double-pipe heat exchanger. In the air conditioner including a refrigerating cycle 1A in which a heating expansion valve 51 is provided between the outdoor heat exchanger 30 and the double-pipe heat exchanger 60; a cooling expansion valve 52 is provided between the indoor heat exchanger 40 and the double-pipe heat exchanger 60; and in the double-pipe heat exchanger 60, a high-pres-

sure liquid refrigerant flowing in a liquid-side refrigerant pipe 50 is heat-exchanged with a low-pressure two-phase refrigerant that is formed by decompressing some of the high-pressure liquid refrigerant by a bypass expansion valve 62, a low-pressure refrigerant outflow portion 60a of the double-pipe heat exchanger 60 is connected to a refrigerant pipe portion 50a between the outdoor heat exchanger 30 and the heating expansion valve 51 via a first check valve 71, and is connected to a refrigerant pipe portion 50b between the indoor heat exchanger 40 and the cooling expansion valve 52 via a second check valve 72.

FIG. 1



Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioner having a reversible refrigerating cycle. More particularly, it relates to an air conditioner having a double-pipe heat exchanger in a liquid-side refrigerant pipe connecting an outdoor heat exchanger and an indoor heat exchanger to each other.

BACKGROUND ART

[0002] As one of refrigerating cycles applied to an air conditioner, a refrigerating cycle having a double-pipe heat exchanger to increase the degree of supercooling has been known. In the refrigerating cycle of this type, some of a high-pressure liquid refrigerant condensed by a condenser is split and decompressed, and is heat-exchanged with a mainstream high-pressure liquid refrigerant. One example thereof is explained with reference to FIG. 3.

[0003] A refrigerating cycle 1B of this conventional example includes, as a basic configuration, a compressor 10, a four-way valve 20, an outdoor heat exchanger 30, and an indoor heat exchanger 40, and the discharge side of the compressor 10 is connected to either one of the outdoor heat exchanger 30 and the indoor heat exchanger 40 via the four-way valve 20.

[0004] That is, at the time of cooling operation, the discharge side of the compressor 10 is connected to the outdoor heat exchanger 30, the outdoor heat exchanger 30 functions as a condenser, and the indoor heat exchanger 40 functions as an evaporator. At the time of heating operation, contrarily, the discharge side of the compressor 10 is connected to the indoor heat exchanger 40, the indoor heat exchanger 40 functions as a condenser, and the outdoor heat exchanger 30 functions as an evaporator.

[0005] In both the cases, in a pipe leading from the four-way valve 20 to the outdoor heat exchanger 30 and the indoor heat exchanger 40, a gas refrigerant is caused to flow, and in a refrigerant pipe 11 leading from the four-way valve 20 to an accumulator 12 as well, the gas refrigerant is caused to flow. Therefore, these pipes are called gas-side refrigerant pipes.

[0006] In contrast, in a refrigerant pipe connecting the outdoor heat exchanger 30 and the indoor heat exchanger 40 to each other, a condensed liquid refrigerant is mainly caused to flow. Therefore, the refrigerant pipe connecting the outdoor heat exchanger 30 and the indoor heat exchanger 40 to each other is usually called a liquid-side refrigerant pipe 50.

[0007] The liquid-side refrigerant pipe 50 is provided with a double-pipe heat exchanger 60. Also, between the double-pipe heat exchanger 60 and the outdoor heat exchanger 30, a heating expansion valve 51 is provided, and between the double-pipe heat exchanger 60 and the

indoor heat exchanger 40, a cooling expansion valve 52 is provided.

[0008] The double-pipe heat exchanger 60 consists, for example, of an inner pipe and an outer pipe arranged coaxially, and a high-pressure liquid refrigerant is caused to flow in the inner pipe. To the outer pipe, a bypass pipe 61 branched from the liquid-side refrigerant pipe 50 is connected, and the bypass pipe 61 is provided with a bypass expansion valve 62.

[0009] A two-way valve 53 and a three-way valve 54 provided on both sides of the indoor heat exchanger 40 are connection pipes for connecting the indoor heat exchanger 40 to the refrigerating cycle when the air conditioner is installed.

[0010] At the time of cooling operation, the heating expansion valve 51 is fully opened, and the cooling expansion valve 52 is throttled to a predetermined degree of opening, so that the refrigerant flows as indicated by the solid-line arrow marks in FIG. 3. At the time of heating operation, the cooling expansion valve 52 is fully opened, and the heating expansion valve 51 is throttled to a predetermined degree of opening, so that the refrigerant flows as indicated by the broken-line arrow marks in FIG. 3.

[0011] In both the operations, in the inner pipe of the double-pipe heat exchanger 60, the high-pressure liquid refrigerant (mainstream) condensed by the outdoor heat exchanger 30 or the indoor heat exchanger 40 is caused to flow. In the outer pipe thereof, a low-pressure two-phase refrigerant that is split from the mainstream high-pressure liquid refrigerant and decompressed by the bypass expansion valve 62 is caused to flow. The low-pressure two-phase refrigerant is heat-exchanged with the mainstream high-pressure liquid refrigerant and is evaporated, and the mainstream high-pressure liquid refrigerant is cooled. In this case, the degree of opening of the bypass expansion valve 62 is controlled so that the degree of supercooling of the high-pressure liquid refrigerant becomes a target degree of supercooling.

[0012] As described above, the low-pressure two-phase refrigerant is evaporated by the heat exchange with the high-pressure liquid refrigerant, and is returned to a suction pipe 11 of the compressor 10 as a low-pressure gas refrigerant (for example, refer to Japanese Patent Application Publication No. 2006-23073).

[0013] Unfortunately, in the above-described conventional example, since the gas refrigerant evaporated by the heat exchange with the high-pressure liquid refrigerant in the double-pipe heat exchanger 60 is returned to the suction pipe 11 side of the compressor 10, there arise problems described below in controlling the bypass expansion valve 62 so that the degree of supercooling of high-pressure liquid refrigerant becomes the target degree of supercooling.

[0014] With reference to the Mollier chart of FIG. 4, the case of cooling operation is explained. In FIG. 4, the solid line indicates the mainstream of the high-pressure liquid refrigerant flowing in the liquid-side refrigerant pipe 50,

and the dash-and-dot line indicates a bypass stream flowing in the bypass pipe 61.

[0015] In particular, in the case where a pipe for connecting an outdoor unit and an indoor unit to each other must be lengthened on account of the circumstances of the place at which the air conditioner is installed, in order to optimize the state in which the refrigerant reaches the indoor heat exchanger 40 (to demonstrate the capacity of indoor unit to a maximum), supercooling as shown in FIG. 4A is needed.

[0016] FIG. 4A shows a refrigerating cycle in which the refrigerant circulates in the optimum state. Even if the refrigerant reaches the indoor heat exchanger 40 in the optimum state with the degree of supercooling being A and the mainstream and the bypass stream are mixed with each other, a state of gas phase is established.

[0017] That is, the low-pressure two-phase refrigerant that is split from the mainstream and decompressed by the bypass expansion valve 62 evaporates in the double-pipe heat exchanger 60, and becomes in an overheated state of (c1). The mainstream evaporates in the indoor heat exchanger 40 and returns to the compressor 10 in the state of (a1), and on the suction side of the compressor 10, (a1) and (c1) are mixed with each other, and the state of (b1) is formed.

[0018] On the other hand, as shown in FIG. 4B, in the case where the bypass amount to the double-pipe heat exchanger 60 is increased to change the degree of supercooling deep from A to A ϕ (in the left direction in FIG. 4B) because the refrigerant reaching the indoor unit is not optimal, the mainstream is heat-exchanged sufficiently by the indoor heat exchanger 40, and a gas phase (a2) is formed.

[0019] However, if all of the bypass refrigerant becomes impossible to evaporate, the refrigerant is returned in the two-phase state of (c2) in which the degree of overheating is zero. Therefore, the refrigerant mixed on the suction side of the compressor 10 becomes in the two-phase state (b2) containing the liquid refrigerant, and liquid back occurs.

[0020] Accordingly, in order to make (b2) in a gas-phase state to avoid liquid back, the degree of supercooling must be made shallow (from A ϕ to A, in the right direction in FIG. 4B). In this case, the refrigerant does not reach the indoor heat exchanger 40 in the optimum state, and the performance (COP) deteriorates.

[0021] Thus, in the above-described example, since there is a fear of liquid return to the compressor 10, the temperature of the bypass stream at the outlet of the double-pipe heat exchanger 60 is monitored to suppress the flow rate of bypass stream. As a result, there occurs the case where the target degree of supercooling is not reached. Also, the circulation amount of refrigerant in the evaporator (for example, the indoor heat exchanger 40) is only the amount of the mainstream, so that the heat exchange amount sometimes comes short.

[0022] As one method for making the bypass stream a gas refrigerant by evaporating all of the bypass stream,

a method is available in which the double-pipe heat exchanger 60 is increased in size. However, this method is unfavorable because the piping system becomes large in size.

5 **[0023]** Accordingly, an object of the present invention is to provide an air conditioner having a double-pipe heat exchanger in a refrigerating cycle, wherein the degree of opening of a bypass expansion valve can be controlled easily without liquid return to a compressor and without
10 considering the state of a low-pressure two-phase refrigerant in the double-pipe heat exchanger.

SUMMARY OF THE INVENTION

15 **[0024]** To achieve the above object, the present invention provides an air conditioner including a refrigerating cycle in which a double-pipe heat exchanger is provided in a liquid-side refrigerant pipe between an outdoor heat exchanger and an indoor heat exchanger which are selectively connected to the discharge side of a compressor via a four-way valve; a heating expansion valve is provided between the outdoor heat exchanger and the double-pipe heat exchanger; a cooling expansion valve is provided between the indoor heat exchanger and the double-pipe heat exchanger; and in the double-pipe heat exchanger, a high-pressure liquid refrigerant flowing in the liquid-side refrigerant pipe is heat-exchanged with a gas-liquid low-pressure two-phase refrigerant which is formed by decompressing some of the high-pressure liquid refrigerant by a bypass expansion valve, wherein a low-pressure refrigerant outflow portion of the double-pipe heat exchanger is branched in a fork form; one branch is connected to the refrigerant pipe between the outdoor heat exchanger and the heating expansion valve via first valve means; and the other branch is connected to the refrigerant pipe between the indoor heat exchanger and the cooling expansion valve via second valve means.
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[0025] In the present invention, at the time of cooling operation of the refrigerating cycle, the heating expansion valve is fully opened and the cooling expansion valve is throttled to a predetermined degree of opening; and the low-pressure refrigerant heat-exchanged by the double-pipe heat exchanger is supplied to the indoor heat exchanger on the evaporator side via the second valve means together with the refrigerant decompressed by the cooling expansion valve.
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[0026] Also, at the time of heating operation of the refrigerating cycle, the cooling expansion valve is fully opened and the heating expansion valve is throttled to a predetermined degree of opening; and the low-pressure refrigerant heat-exchanged by the double-pipe heat exchanger is supplied to the outdoor heat exchanger on the evaporator side via the first valve means together with the refrigerant decompressed by the heating expansion valve.
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[0027] In the present invention, as the first and second valve means, check valves which are opened with the low-pressure refrigerant outflow portion being on the high

pressure side or solenoid valves which are opened and closed by an external signal may be used.

[0028] According to the present invention, since the low-pressure refrigerant going out of the double-pipe heat exchanger is caused to flow to the evaporator side, the refrigerant is evaporated by the evaporator and is returned to the compressor even if not being evaporated completely by the double-pipe heat exchanger. Therefore, liquid return to the compressor can be eliminated.

[0029] Also, in controlling the bypass expansion valve, the state of the low-pressure refrigerant in the double-pipe heat exchanger need not be considered, and the control has only to be carried out so that the degree of supercooling of the high-pressure liquid refrigerant becomes a target degree of supercooling. Therefore, the bypass expansion valve can be controlled easily.

[0030] Also, since a large amount of low-pressure refrigerant can be caused to flow in the double-pipe heat exchanger, the degree of supercooling of the high-pressure liquid refrigerant can be made high, so that the improvement in performance of the refrigerating cycle can be expected accordingly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

FIG. 1 is a refrigerant circuit diagram showing an embodiment of a refrigerating cycle applied to an air conditioner of the present invention;

FIG. 2 is a Mollier chart of the refrigerating cycle shown in FIG. 1;

FIG. 3 is a refrigerant circuit diagram showing a conventional refrigerating cycle;

FIG. 4A is a Mollier chart in the case where the degree of overheating is established in a double-pipe heat exchanger of the conventional refrigerating cycle shown in FIG. 3; and

FIG. 4B is a Mollier chart in the case where the degree of overheating is not established in a double-pipe heat exchanger of the conventional refrigerating cycle shown in FIG. 3.

DETAILED DESCRIPTION

[0032] An embodiment of the present invention will now be described with reference to FIGS. 1 and 2. The present invention is not limited to this embodiment. In the explanation of this embodiment, the same reference numerals are applied to elements that are essentially the same as the elements in the conventional example explained with reference to FIG. 3.

[0033] As shown in FIG. 1, a refrigerating cycle 1A in accordance with this embodiment includes, as a basic configuration, a compressor 10, a four-way valve 20, an outdoor heat exchanger 30, and an indoor heat exchanger 40. The compressor 10 may be either a rotary compressor or a scroll compressor.

[0034] The discharge side of the compressor 10 is connected to either one of the outdoor heat exchanger 30 and the indoor heat exchanger 40 via the four-way valve 20, and in a liquid-side refrigerant pipe 50 that connects the outdoor heat exchanger 30 and the indoor heat exchanger 40 to each other, a double-pipe heat exchanger 60 is interposed.

[0035] Also, between the outdoor heat exchanger 30 and the double-pipe heat exchanger 60, a heating expansion valve 51 is provided, and between the indoor heat exchanger 40 and the double-pipe heat exchanger 60, a cooling expansion valve 52 is provided.

[0036] The double-pipe heat exchanger 60 consists, for example, of an inner pipe and an outer pipe arranged coaxially, and a high-pressure liquid refrigerant condensed by the outdoor heat exchanger 30 or the indoor heat exchanger 40 is caused to flow in the inner pipe. This high-pressure liquid refrigerant caused to flow in the inner pipe is a mainstream.

[0037] To the outer pipe of the double-pipe heat exchanger 60, a bypass pipe 61 branched from the liquid-side refrigerant pipe 50 is connected, and the bypass pipe 61 is provided with a bypass expansion valve 62. Some of the high-pressure liquid refrigerant split from the bypass pipe 61 is decompressed, and flows in the outer pipe as a low-pressure two-phase refrigerant. The high-pressure liquid refrigerant may be caused to flow on the outer pipe side, and the low-pressure two-phase refrigerant may be caused to flow on the inner pipe side.

[0038] According to the present invention, a low-pressure refrigerant outflow portion 60a of the double-pipe heat exchanger 60 is connected to a refrigerant pipe portion 50a between the outdoor heat exchanger 30 and the heating expansion valve 51 via a first check valve 71, and is also connected to a refrigerant pipe portion 50b between the indoor heat exchanger 40 and the cooling expansion valve 52 via a second check valve 72.

[0039] In both the check valves 71 and 72, the forward direction of flow is a direction directed from the low-pressure refrigerant outflow portion 60a to the refrigerant pipe portions 50a and 50b. In place of the check valve, a solenoid valve that is opened and closed by an external signal may be used.

[0040] At the time of cooling operation, the four-way valve 20 is changed over to the state indicated by the solid line in FIG. 1. In this state, the heating expansion valve 51 is fully opened, the cooling expansion valve 52 is throttled to a predetermined degree of opening, and the refrigerant circulates as indicated by the solid-line arrow marks in FIG. 1.

[0041] That is, a high-pressure gas refrigerant discharged from the compressor 10 reaches the outdoor heat exchanger 30 through the four-way valve 20, being condensed into the high-pressure liquid refrigerant by the outdoor heat exchanger 30, and is further cooled by the double-pipe heat exchanger 60.

[0042] The high-pressure liquid refrigerant from which the degree of supercooling is removed by the double-

pipe heat exchanger 60 is split in a portion of the bypass pipe 61. One stream (the mainstream) is sent to the cooling expansion valve 52, and the other stream (a bypass stream) is sent to the bypass expansion valve 62.

[0043] The bypass stream is decompressed into the gas-liquid low-pressure two-phase refrigerant by the bypass expansion valve 62, and is heat-exchanged with the high-pressure liquid refrigerant by the double-pipe heat exchanger 60 and is evaporated.

[0044] At the time of cooling operation, the refrigerant in the refrigerant pipe portion 50a on the outdoor heat exchanger 30 side has a pressure higher than the pressure of refrigerant at the low-pressure refrigerant outflow portion 60a, and the refrigerant in the refrigerant pipe portion 50b on the indoor heat exchanger 40 side has a pressure lower than the pressure of refrigerant at the low-pressure refrigerant outflow portion 60a.

[0045] Therefore, the evaporated gas refrigerant reaches the refrigerant pipe portion 50b via the second check valve 72, joining with the mainstream-side refrigerant decompressed by the cooling expansion valve 52, and is sent to the indoor heat exchanger 40 on the evaporator side. In the indoor heat exchanger 40, the refrigerant is heat-exchanged with indoor air and is evaporated, and the gas refrigerant is returned to the compressor 10 through a suction pipe 11 and an accumulator 12.

[0046] At the time of cooling operation, the flow rate of refrigerant in the refrigerating cycle is regulated by the cooling expansion valve 52, and the degree of opening of the bypass expansion valve 62 is controlled so that the degree of supercooling of the high-pressure liquid refrigerant becomes a target degree of supercooling.

[0047] At the time of heating operation, the four-way valve 20 is changed over to the state indicated by the broken line in FIG. 1. In this state, the cooling expansion valve 52 is fully opened, the heating expansion valve 51 is throttled to a predetermined degree of opening, and the refrigerant circulates as indicated by the broken-line arrow marks in FIG. 1.

[0048] That is, the high-pressure gas refrigerant discharged from the compressor 10 reaches the indoor heat exchanger 40 through the four-way valve 20, and is condensed into the high-pressure liquid refrigerant by the indoor heat exchanger 40.

[0049] Thereafter, the high-pressure liquid refrigerant is split in the portion of the bypass pipe 61 in front of the double-pipe heat exchanger 60. One stream (the mainstream) flows in the inner pipe of the double-pipe heat exchanger 60 and reaches the heating expansion valve 51, and the other stream (the bypass stream) is sent to the bypass expansion valve 62.

[0050] The bypass stream is decompressed into the gas-liquid low-pressure two-phase refrigerant by the bypass expansion valve 62, and is heat-exchanged with the high-pressure liquid refrigerant on the mainstream side by the double-pipe heat exchanger 60 and is evaporated.

[0051] At the time of heating operation, the refrigerant

in the refrigerant pipe portion 50b on the indoor heat exchanger 40 side has a pressure higher than the pressure of refrigerant at the low-pressure refrigerant outflow portion 60a, and the refrigerant in the refrigerant pipe portion 50a on the outdoor heat exchanger 30 side has a pressure lower than the pressure of refrigerant at the low-pressure refrigerant outflow portion 60a.

[0052] Therefore, the evaporated gas refrigerant reaches the refrigerant pipe portion 50a via the first check valve 71, joining with the mainstream-side refrigerant decompressed by the heating expansion valve 51, and is sent to the outdoor heat exchanger 30 on the evaporator side. In the outdoor heat exchanger 30, the refrigerant is heat-exchanged with the outside air and is evaporated, and the gas refrigerant is returned to the compressor 10 through the suction pipe 11 and the accumulator 12.

[0053] At the time of heating operation as well, the flow rate of refrigerant in the refrigerating cycle is regulated by the heating expansion valve 51, and the degree of opening of the bypass expansion valve 62 is controlled so that the degree of supercooling of the high-pressure liquid refrigerant becomes the target degree of supercooling.

[0054] As described above, according to the present invention, at both of the cooling operation time and the heating operation time, since the low-pressure refrigerant going out of the double-pipe heat exchanger 60 is caused to flow from the downstream side of the cooling expansion valve 52 or the heating expansion valve 51 toward the evaporator, the gas-liquid low-pressure two-phase refrigerant need not be evaporated completely in the double-pipe heat exchanger 60. Therefore, a large amount of low-pressure two-phase refrigerant can be caused to flow in the double-pipe heat exchanger 60 by increasing the target degree of supercooling of the high-pressure liquid refrigerant.

[0055] With reference to the Mollier chart of FIG. 2, the refrigerating cycle of the present invention (the case of cooling operation) is explained. In FIG. 2, the solid line indicates the mainstream of the high-pressure liquid refrigerant flowing in the liquid-side refrigerant pipe 50, and the dash-and-dot line indicates the bypass stream flowing in the bypass pipe 61.

[0056] At point D, the refrigerant is sucked into the compressor 10, and the compressed refrigerant becomes at high temperature and pressure (point x) and is condensed by the outdoor heat exchanger 30 (point a). The refrigerant is heat-exchanged with the later-described bypass stream (g-f) by the double-pipe heat exchanger 60 and becomes in a supercooled state (point b), and is decompressed by the cooling expansion valve 52 (point d).

[0057] On the other hand, in the bypass circuit, some of the mainstream heat-exchanged by the double-pipe heat exchanger 60 is split in the bypass pipe 61, and is decompressed by the bypass expansion valve 62 (point g). Thereafter, the refrigerant is heat-exchanged with the mainstream (a-b) (point f). The mainstream and the by-

pass stream are joined with each other (point e) and flow into the indoor heat exchanger 30. The refrigerant is evaporated by the indoor heat exchanger 30, and is sucked into the compressor 10 (point D).

[0058] In the present invention, as described above, the bypass stream used in the double-pipe heat exchanger 60 does not return directly to the suction side of the compressor 10, and is heat-exchanged by the indoor heat exchanger 30, so that no wasteful refrigerant is generated. Therefore, the performance (COP) is improved. Also, since there is no fear of liquid back, supercooling can be performed until the refrigerant can be supplied to the indoor heat exchanger 30 in the optimum state.

[0059] Also, conventionally, both of the electronic expansion valve for double-pipe heat exchanger and the electronic expansion valves of the whole of refrigerating cycle have been needed to be controlled exactly. According to the present invention, however, since liquid back does not occur, the control program for these electronic expansion valves can be simplified significantly.

Claims

1. An air conditioner including a refrigerating cycle in which a double-pipe heat exchanger is provided in a liquid-side refrigerant pipe between an outdoor heat exchanger and an indoor heat exchanger which are selectively connected to the discharge side of a compressor via a four-way valve; a heating expansion valve is provided between the outdoor heat exchanger and the double-pipe heat exchanger; a cooling expansion valve is provided between the indoor heat exchanger and the double-pipe heat exchanger; and in the double-pipe heat exchanger, a high-pressure liquid refrigerant flowing in the liquid-side refrigerant pipe is heat-exchanged with a gas-liquid low-pressure two-phase refrigerant which is formed by decompressing some of the high-pressure liquid refrigerant by a bypass expansion valve, wherein a low-pressure refrigerant outflow portion of the double-pipe heat exchanger is branched in a fork form; one branch is connected to the refrigerant pipe between the outdoor heat exchanger and the heating expansion valve via first valve means; and the other branch is connected to the refrigerant pipe between the indoor heat exchanger and the cooling expansion valve via second valve means.
2. The air conditioner according to claim 1, wherein at the time of cooling operation of the refrigerating cycle, the heating expansion valve is fully opened and the cooling expansion valve is throttled to a predetermined degree of opening; and the low-pressure refrigerant heat-exchanged by the double-pipe heat exchanger is supplied to the indoor heat exchanger on the evaporator side via the second valve means together with the refrigerant decompressed by the cooling expansion valve.
3. The air conditioner according to claim 1, wherein at the time of heating operation of the refrigerating cycle, the cooling expansion valve is fully opened and the heating expansion valve is throttled to a predetermined degree of opening; and the low-pressure refrigerant heat-exchanged by the double-pipe heat exchanger is supplied to the outdoor heat exchanger on the evaporator side via the first valve means together with the refrigerant decompressed by the heating expansion valve.
4. The air conditioner according to claim 1, wherein the first and second valve means consist of check valves which are opened with the low-pressure refrigerant outflow portion being on the high pressure side.
5. The air conditioner according to claim 1, wherein the first and second valve means consist of solenoid valves which are opened and closed by an external signal.

FIG. 1

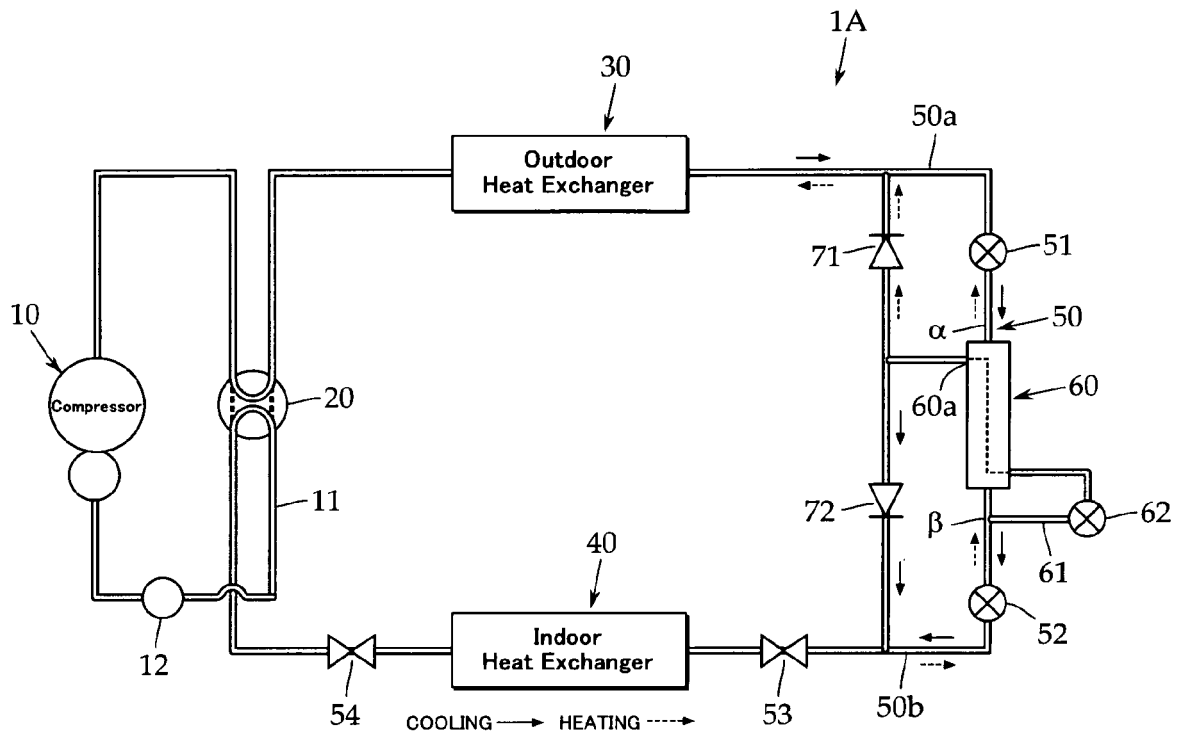


FIG. 2

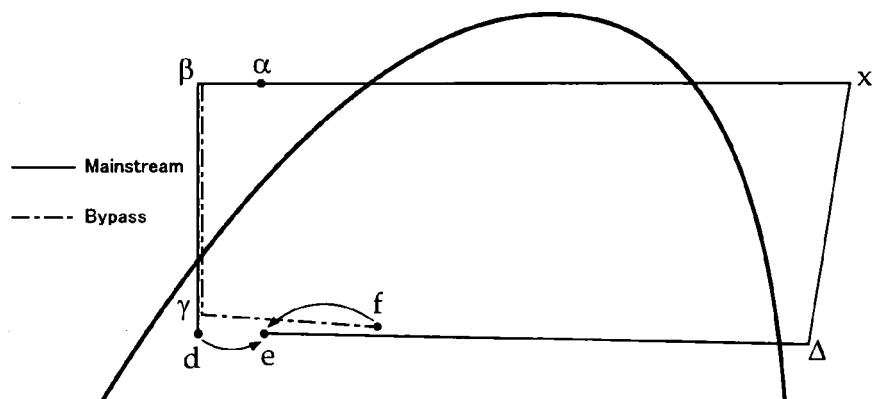


FIG. 3

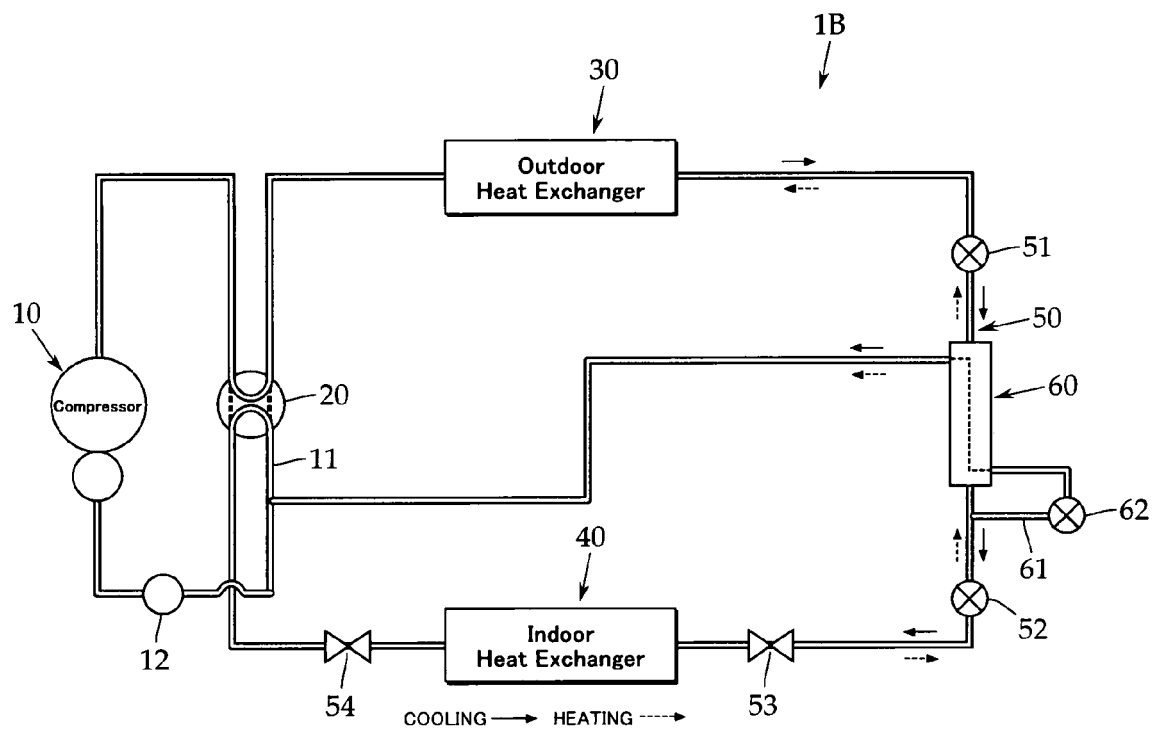


FIG. 4A
RELATED ART

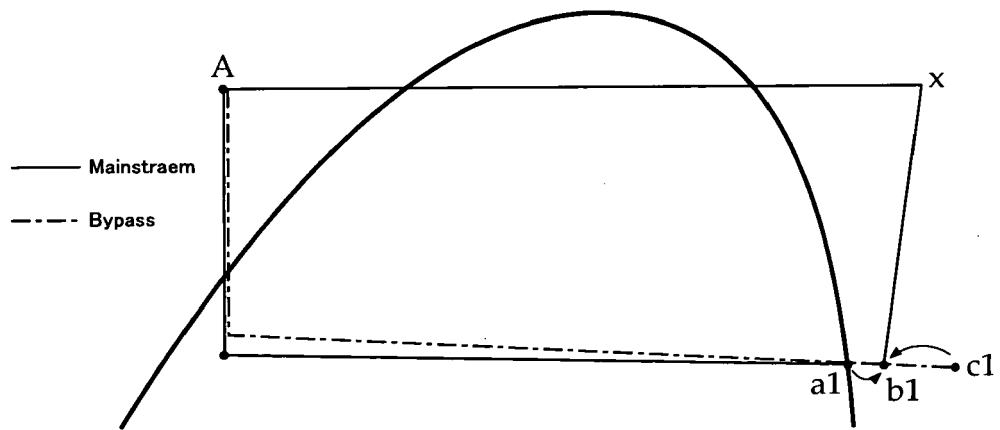
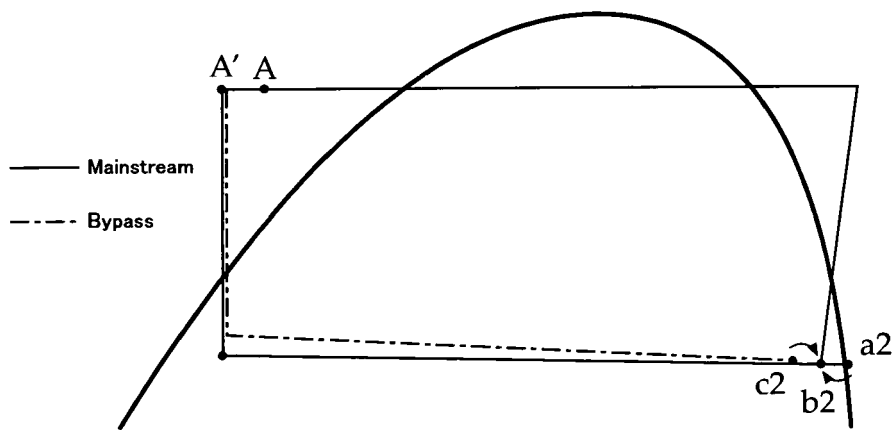


FIG. 4B
RELATED ART



REFERENCES CITED IN THE DESCRIPTION

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