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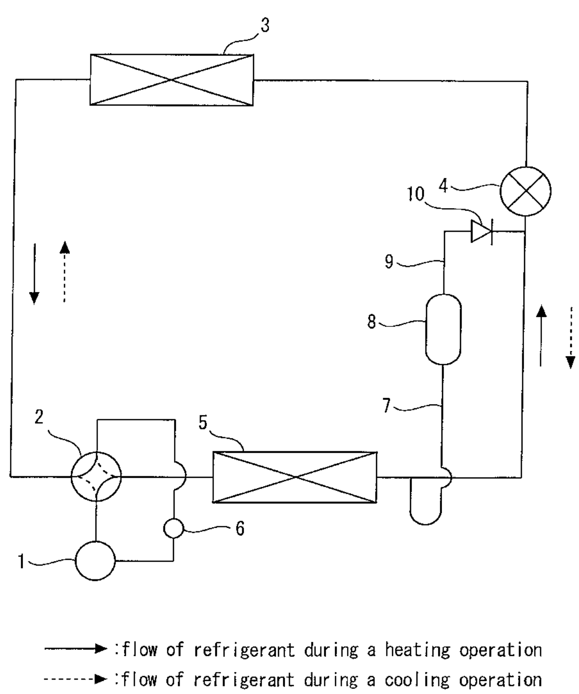
(54) Refrigerant circuit

(57) In a refrigerant circuit, an expansion valve 4 is connected to a heat exchanger 5 by a refrigerant pipe, and a bypass pipe 7/9 is provided. By way of a bypass pipe 9 having a check valve 10, a refrigerant is returned to a refrigerant circuit from a refrigerant amount control tank 8 that is installed in the bypass pipe 7/9.

Fig. 1



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Description

Background of the Invention

Field of the Invention

[0001] The invention relates to control of the amount of refrigerant flowing in a refrigeration cycle using a mixed refrigerant.

Background Art

[0002] Fig. 2 shows a refrigeration cycle as described in Japanese Patent Application Laid-Open No. 120119/1995, which is a conventional refrigeration cycle utilized for a heat pump and consists of a compressor, a four-way valve, a heat exchanger, an expansion valve, and an accumulator. In Fig. 2, reference numeral 101 designates a compressor; 102 designates a four-way valve for changing the flow of a refrigerant between a cooling operation and a heating operation; 103 designates an indoor heat exchanger; 104 through 107 designate check valves; 108 designates a receiver; 109 designates an expansion valve; 110 designates an outdoor heat exchanger; 111 designates an indoor blast fan; and 112 designates an outdoor blast fan.

[0003] Next, operation of the refrigeration cycle will be described.

[0004] During a cooling operation, the refrigerant compressed by the compressor 101 flows into the outdoor heat exchanger 110 by way of the four-way valve 102, sequentially flows through the check valve 104, the receiver 108, the expansion valve 109, the check valve 107, and the indoor heat exchanger 103, and returns to the compressor 101 by way of the four-way valve 102.

[0005] During a heating operation, the compressed refrigerant flows into the indoor heat exchanger 103 from the compressor 101 by way of the four-way valve 102, sequentially flows through the check valve 105, the receiver 108, the expansion valve 109, the check valve 106, and the outdoor heat exchanger 110, and returns to the compressor 101 by way of the four-way valve 102.

[0006] Here, the amount of refrigerant required by the refrigerant circuit during the cooling operation is compared with that required by the same during the heating operation. The indoor heat exchanger 103 is generally superior to the outdoor heat exchanger 110 in terms of an efficiency for condensing a refrigerant. Hence, the content volume of a portion of the heat exchanger through which the refrigerant flows can be reduced. A heating operation requires a smaller amount of refrigerant than does a cooling operation.

[0007] The receiver 108 provided upstream of the expansion valve 109 in a direction in which the refrigerant flows is for storing a refrigerant liquid, thereby adjusting a difference in the amount of refrigerant required for cooling operation and that required for heating operation.

[0008] Fig. 3 shows the refrigeration cycle of the refrigerant circuit shown in Fig. 2 in the form of a p-h diagram. In the diagram, an interval between "a" and "b" corresponds to a compression stroke of the compressor 101; an interval between "b" and "c" corresponds to a condensation stroke of the heat exchanger 103 or 110; an interval between "c" and "d" corresponds to an expansion stroke of the expansion valve 109; and an interval between "d" and "a" corresponds an evaporation stroke of the heat exchanger 110 or 103.

[0009] At this time, the refrigerant liquid and refrigerant gas are mixedly present in the receiver 108 of the refrigerant circuit. Hence, as indicated by the point "c" shown in Fig. 3, the refrigerant provided in the receiver has become saturated. After having left the receiver 108, the saturated liquid refrigerant flows into the evaporator by way of a liquid pipe, a strainer, a liquid line electromagnetic valve, these being not shown, and the expansion valve 109. Since the liquid refrigerant is not excessively cooled, the refrigerant is likely to enter a flash gas state in which a refrigerant liquid and the refrigerant gas are mixedly present if the liquid pipe or the like has resistance. When the refrigerant has entered a flash gas state, the amount of refrigerant flowing through the expansion valve 109 drops considerably, as a result of which predetermined refrigerating power is not achieved.

[0010] As a solution, there is a method of providing a refrigerant pipe connected to a liquid outlet port of the heat exchanger with a refrigerant amount control tank by way of a bypass pipe, to thereby temporarily store excessive refrigerant.

[0011] Fig. 4 shows an example of a basic refrigerant circuit disposed in another conventional air-cooling heat pump chiller.

[0012] In the drawing, reference numeral 201 designates a compressor; 202 designates a four-way valve for switching the flow of a refrigerant between a cooling operation and a heating operation; 203 designates an air-side heat exchanger; 204 designates an expansion valve; 205 designates a water-side heat exchanger; 206 designates an accumulator; and 208 designates a refrigerant amount control tank disposed at a liquid outlet side of the refrigerant pipe by way of a bypass pipe 207.

[0013] The operation of the refrigerant circuit will now be described.

[0014] During a cooling operation, the refrigerant compressed by the compressor 201 flows through the four-way valve 202, the air-side heat exchanger 203, the expansion valve 204, and the water-side heat exchanger 205, and then returns to the compressor 201 while passing through the four-way valve 202 and the accumulator 206.

[0015] During a heating operation, the compressed refrigerant flows through the four-way valve 202, and sequentially flows through the water-side heat exchanger 205, the expansion valve 204, the air-side heat exchanger 203 and returns to the compressor 201 byway of the four-way valve 202 and the accumulator 206.

[0016] Here, the amount of refrigerant required by the refrigerant circuit during the cooling operation is compared with that required by the same during the heating operation. The water-side heat exchanger 205 is generally superior to the air-side heat exchanger 203 in terms of an efficiency for condensing a refrigerant. Hence, the inner volume of the heat exchanger in the refrigerant side can be reduced. A heating operation requires a smaller amount of refrigerant than does a cooling operation. The excessive refrigerant flows into and is stored in the refrigerant amount control tank 208 by way of the bypass pipe 207. At this time, the refrigerant amount control tank 208 is filled with a refrigerant liquid.

[0017] If the operation is switched to a cooling operation after the heating operation, the amount of refrigerant required by the refrigerant circuit becomes deficient. Hence, the refrigerant stored in the refrigerant amount control tank 208 flows into a refrigerant circuit, thereby compensating for the deficiency. At this time, the refrigerant amount control tank 208 is filled with only a refrigerant gas.

[0018] Specifically, the amount of refrigerant required during a heating operation becomes smaller than that required during a cooling operation in the coolant circuit. Hence, excessive refrigerant flows into the refrigerant amount control tank 208. Conversely, the amount of refrigerant becomes deficient during the cooling operation, and the refrigerant flowing from the refrigerant amount control tank 208 compensates for the deficiency.

[0019] The volume of the refrigerant amount control tank 208 is determined by the amount of excessive refrigerant arising during a heating operation.

[0020] Under the foregoing method, when a mixed refrigerant HFC 407C, in which HFC 134a, HFC 32, and HFC 125 are mixed at predetermined proportions, is used as a refrigerant, the following problems will arise.

[0021] First, there will be described a case where a heating operation is started while a refrigerant remains accumulated in the accumulator 206.

[0022] During halts, the refrigerant liquid accumulating in the accumulator 206 assumes a composition largely consisting of HFC 134a, which among the components is the most susceptible to condensation. The refrigerant existing in the refrigerant circuit exclusive of the accumulator 206 is largely consisting of HFC 32 and HFC 125, which are remaining components. When a heating operation is started, the excessive refrigerant liquid, which flows into the refrigerant amount control tank 208, also assumes a composition largely consisting of HFC 32 and HFC 125.

[0023] Consequently, there is a decrease in the quantity of HFC 32 and HFC 125 contained in the refrigerant circuit exclusive of the refrigerant amount control tank 208. In contrast, the liquid refrigerant, which largely contains HFC 134a and is accumulated in the accumulator 206, flows through the refrigerant circuit while being evaporated. Hence, the refrigerant existing in the refrigerant circuit exclusive of the refrigerant amount control tank 208 assumes a composition largely consisting of HFC 134a. In light of characteristics of the refrigerant, the refrigerating power tends to decrease.

[0024] Next will be described a case where a heating operation is started while no refrigerant is accumulated in the accumulator 206.

[0025] During halts, the refrigerant existing in the refrigerant circuit assumes a standard composition. However, when a heating operation is started, HFC 134a, which is susceptible to condensation, becomes liquefied in the water-side heat exchanger 205 prior to the remaining components; that is, HFC 32 and HFC 125, in a transient state arising during startup. The excessive refrigerant liquid flowing into the refrigerant amount control tank 208 tends to contain a large amount of HFC 134a.

[0026] Consequently, the refrigerant existing in the refrigerant circuit exclusive of the refrigerant amount control tank 208 assumes a composition largely consisting of the remaining components; that is, HFC 32 and HFC 125. In accordance with characteristics of the refrigerant, the refrigerating power tends to increase.

[0027] However, a high pressure also tends to increase, and hence an unillustrated high-pressure switch, which is a protective device to be attached to a refrigerant pipe interposed between an outlet port of the compressor 201 and the four-way valve 202 for avoiding occurrence of an increase in high pressure, becomes apt to issue a warning or to halt operation.

[0028] Depending on an operating condition, the refrigerant gas and the refrigerant liquid are simultaneously stored in the refrigerant amount control tank 208. At this time, the refrigerant gas stored in the refrigerant amount control tank 208 contains HFC 32 and HFC 125, which are susceptible to evaporation, in larger quantity than does a standard composition. Hence, there arises a decrease in the amount of HFC 32 and HFC 125 contained in the refrigerant situated in the refrigerant circuit exclusive of the refrigerant amount control tank 208. The composition of the refrigerant situated in the refrigerant circuit exclusive of the refrigerant amount control tank 208 changes in accordance with the quantity of refrigerant gas stored in the refrigerant amount control tank 208. In association with a decrease in the quantity of refrigerant gas, the refrigerating power changes.

[0029] The invention has been conceived to solve the foregoing problem and aims at maintaining the composition of a mixed refrigerant flowing through a refrigerant circuit at a standard composition.

Summary of the Invention

[0030] The invention provides an improved refrigerant circuit, in which connection is made, by way of a refrigerant pipe, between a compressor, a four-way valve, a first heat exchanger serving as a condenser or an evaporator, an expansion valve, a second heat exchanger serving as an evaporator or a condenser, and an accumulator. The refrigerant circuit comprises a first bypass pipe connected to a refrigerant pipe provided between the expansion valve and the second heat exchanger. A refrigerant amount control tank is connected to the first bypass pipe. A second bypass pipe, which is connected to the refrigerant amount control tank at one end, is connected, at another end, to a position on a refrigerant pipe interposed between the expansionvalve and the second heat exchanger, and the position is closer to the expansion valve than to a position where the first bypass pipe is attached. A check valve is interposed into the second bypass pipe. Thus, the second bypass pipe plays the role of draining gas from the refrigerant amount control tank and enables smooth flow of refrigerant when excessive refrigerant is stored in the refrigerant amount control tank during a heating operation.

[0031] Other and further objects, features and advantages of the invention will appear more fully from the following description.

Brief Description of the Drawings

[0032]

Fig. 1 shows an example of a basic refrigerant circuit employed in an air-cooling heat pump chiller, showing a first embodiment of the present invention.

Fig. 2 shows an example of a conventional refrigeration cycle.

Fig. 3 shows a p-h diagram of the refrigeration cycle of the refrigerant circuit shown in Fig. 2.

Fig. 4 shows an example of a basic refrigerant circuit disposed in another conventional air-cooling heat pump chiller.

Detailed Description of the Preferred Embodiment

[0033] Fig. 1 shows an example of a basic refrigerant circuit employed in an air-cooling heat pump chiller, showing a preferred embodiment of the present invention.

[0034] In the drawing, reference numeral 1 designates a compressor; 2 designates a four-way valve for switching the flow of a refrigerant between a cooling operation and a heating operation; 3 designates an air-side heat exchanger; 4 designates an expansion valve; 5 designates a water-side heat exchanger; 6 designates an accumulator; 8 designates a refrigerant amount control tank disposed by way of a bypass pipe 7; and 9 designates a bypass pipe, which has a check valve 10, and which returns the refrigerant accumulating in the refrigerant amount control tank 8 to a refrigerant circuit. A pipe smaller in diameter than the bypass pipe 7 is used for the bypass pipe 9. For example, when a pipe having an outside diameter of 9.52 mm is used for the bypass pipe 7, a pipe having an outside diameter of 6.4 mm is used for the bypass pipe 9.

[0035] Non-azeotropic mixed refrigerant HFC 407C is used as refrigerant for the refrigerant circuit.

[0036] Operation of the refrigerant circuit will now be described.

[0037] In the refrigerant circuit shown in Fig. 1, during a heating operation excessive refrigerant flows into the refrigerant amount control tank 8 by way of the bypass pipe 7. During a cooling operation, the refrigerant flowing out of the refrigerant amount control tank 8 compensates for the deficiency. In these regards, the refrigerant circuit is identical with that shown in Fig. 4, which shows the related art technique.

[0038] A difference between them lies in that a portion of the refrigerant accumulating in the refrigerant amount control tank 8 is returned to the refrigerant circuit at all times by way of the bypass pipe 9, which is disposed at an upper portion of the refrigerant amount control tank 8 and which has the check valve 10, by virtue of the pressure developing in a position on a main pipe of the refrigerant circuit to which the bypass pipe 9 is attached being lower than the pressure developing in a position on the main pipe to which the bypass pipe 7 is attached.

[0039] Here, the refrigerant circuit is assumed to operate while a liquid refrigerant accumulates in the accumulator 6. At this time, the liquid refrigerant accumulating in the accumulator 6 assumes a composition largely consisting of HFC 134a, which among the components is the most susceptible to condensation. The refrigerant existing in the refrigerant circuit exclusive of the accumulator 6 largely consists of HFC 32 and HFC 125, which are remaining components.

[0040] When a heating operation is started, the excessive refrigerant liquid, which flows into the refrigerant amount control tank 8, also assumes a composition largely consisting of HFC 32 and HFC 125.

[0041] The liquid refrigerant, which largely consists of HFC 134a and is accumulated in the accumulator 206, flows through the refrigerant circuit while being evaporated. Hence, the refrigerant existing in the refrigerant circuit exclusive of the refrigerant amount control tank 8 assumes a composition largely consisting of HFC 134a.

[0042] Here, a portion of the refrigerant, which accumulates in the refrigerant amount control tank 8 and assumes a composition largely consisting of HFC 32 and HFC 125, is returned to the refrigerant circuit by way of the bypass pipe 9, which is disposed at an upper portion of the refrigerant amount control tank 8 and which has the check valve 10, by virtue of a difference between the pressure developing in a position on a main pipe of the refrigerant circuit to which the bypass pipe 7 is attached and the pressure developing in a position on the main pipe of the refrigerant circuit to which the bypass pipe 9 is attached. Hence, with lapse of time the portion of the refrigerant is mixed with a refrigerant largely consisting of HFC 134a. When the refrigerant circuit operates stably, the refrigerant flowing through the refrigerant circuit returns to a standard composition.

[0043] At this time, the quantity of refrigerant returning to the refrigerant circuit by way of the bypass pipe 9 is regulated by means of rendering the diameter of the bypass pipe 9 smaller than that of the bypass pipe 7, thus effecting a setting such that a constant quantity of excessive refrigerant can be ensured in the refrigerant amount control tank 8 during a stable heating operation.

[0044] Next, the refrigerant circuit is assumed to halt operations while no liquid refrigerant has accumulated in the accumulator 6. At this time, the refrigerant flowing through the refrigerant circuit assumes a standard composition.

[0045] When a heating operation is started in this state; i.e., when the refrigerant circuit is in a transient state arising during startup, HFC 134a, which is susceptible to condensation, becomes liquefied in the water-side heat exchanger 5 prior to the remaining components; that is, HFC 32 and HFC 125. The excessive refrigerant liquid flowing into the refrigerant amount control tank 8 tends to contain a large amount of HFC 134a.

[0046] Here, a portion of the refrigerant, which accumulates in the refrigerant amount control tank 8, is returned to the refrigerant circuit immediately before the expansion valve 4 by way of the bypass pipe 9, which is disposed at an upper portion of the refrigerant amount control tank 8 and which has the check valve 10, by virtue of a difference between the pressure developing in a position on a main pipe of the refrigerant circuit to which the bypass pipe 7 is attached and the pressure developing in a position on the main pipe of the refrigerant circuit to which the bypass pipe 9 is attached. Hence, a portion of the refrigerant assuming a composition largely consisting of HFC 134a returns to the refrigerant circuit and is mixed with the refrigerant assuming a composition largely consisting of HFC 32 and HFC 125. During stably-operating state, the refrigerant flowing through the refrigerant circuit is returned to a standard composition.

[0047] The bypass pipe 9 plays the role of draining gas from the refrigerant amount control tank 8. When excessive refrigerant liquid is accumulated in the refrigerant amount control tank 8 during a heating operation, the refrigerant can flow smoothly into the tank 8 by way of the bypass pipe 7. This effect is not limited to non-azeotropic mixed refrigerant HFC and is yielded by a single refrigerant or non-azeotropic refrigerant.

[0048] The embodiment has described a heat pump chiller involving a noticeable difference in the quantity of refrigerant required for heating operation and that required for cooling operation. Needless to say, the invention can also be applied to another air conditioner capable of changing flow of a refrigerant by means of a four-way valve.

[0049] The features and advantages of the present invention may be summarized as follows.

[0050] The invention provides an improved refrigerant circuit, in which connection is made, by way of a refrigerant pipe, between a compressor 1, a four-way valve 2, a first heat exchanger 3 serving as a condenser or an evaporator, an expansion valve 4, a second heat exchanger 5 serving as an evaporator or a condenser, and an accumulator 6. The refrigerant circuit comprises a first bypass pipe 7 connected to a refrigerant pipe provided between the expansion valve 4 and the second heat exchanger 5. A refrigerant amount control tank 8 is connected to the first bypass pipe 7. A second bypass pipe 9, which is connected to the refrigerant amount control tank 8 at one end, is connected, at another end, to a position on a refrigerant pipe interposed between the expansion valve 4 and the second heat exchanger 5, and the position is closer to the expansion valve 4 than to a position where the first bypass pipe 7 is attached. A check valve 10 is interposed into the second bypass pipe 9. Thus, the second bypass pipe 9 plays the role of draining gas from the refrigerant amount control tank 8 and enables smooth flow of refrigerant when excessive refrigerant is stored in the refrigerant amount control tank 8 during a heating operation.

[0051] When a mixed refrigerant is used, a portion of the liquid that has flowed into the refrigerant amount control tank by way of the second bypass pipe is circulated at all times, whereby a refrigerant whose composition differs from a standard composition in terms of component proportions is temporarily accumulated in the refrigerant amount control tank. Even when the composition of the refrigerant existing in the refrigerant circuit has changed, the refrigerant can be restored to a standard composition in during a normal operation.

[0052] In another aspect, the second bypass pipe is smaller in diameter than the first bypass pie. During a heating operation, the quantity of refrigerant accumulated in the refrigerant amount control tank is returned to the refrigerant circuit from the refrigerant amount control tank by way of the second bypass pipe. At the time of normal operation, the quantity of refrigerant accumulating in the refrigerant amount control tank can be maintained constant.

[0053] It is further understood that the foregoing description is a preferred embodiment of the disclosed device and that various changes and modifications may be made in the invention without departing from the spirit and scope thereof.

Claims

1. A refrigerant circuit, in which connection is made, by way of a refrigerant pipe, between a compressor (1), a four-way valve (2), a first heat exchanger (3) serving as a condenser or an evaporator, an expansion valve (4), a second heat exchanger (5) serving as an evaporator or a condenser, and an accumulator (6), the refrigerant circuit comprising:

   a first bypass pipe (7) connected to a refrigerant

pipe provided between the expansion valve (4) and the second heat exchanger (5);
a refrigerant amount control tank (8) connected to the first bypass pipe (7);
a second bypass pipe (9) which is connected to the refrigerant amount control tank (8) at one end and which is connected, at another end, to a position on a refrigerant pipe interposed between the expansion valve (4) and the second heat exchanger (5), the position being closer to the expansion valve (4) than to a position where the first bypass pipe (7) is attached; and
a check valve (10) which is interposed into the second bypass pipe (9), wherein
the second bypass pipe (9) plays the role of draining gas from the refrigerant amount control tank (8) and enables smooth flow of refrigerant when excessive refrigerant is stored in the refrigerant amount control tank (8) during a heating operation.

2. The refrigerant circuit according to claim 1, wherein a mixed refrigerant is used.

3. The refrigerant circuit according to claim 1 or 2, wherein the second bypass pipe (9) is smaller in diameter than the first bypass pipe (7).

Fig. 1

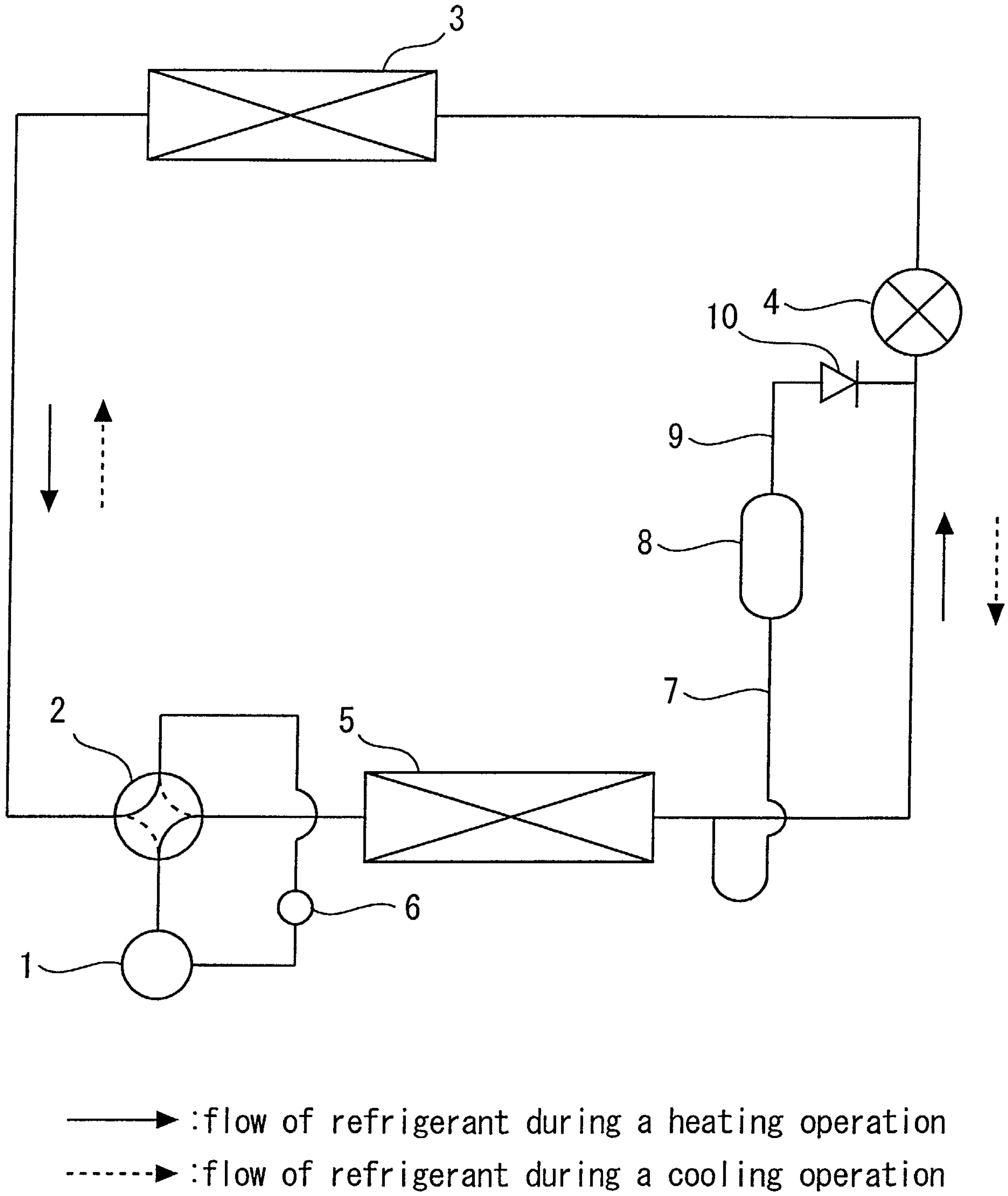
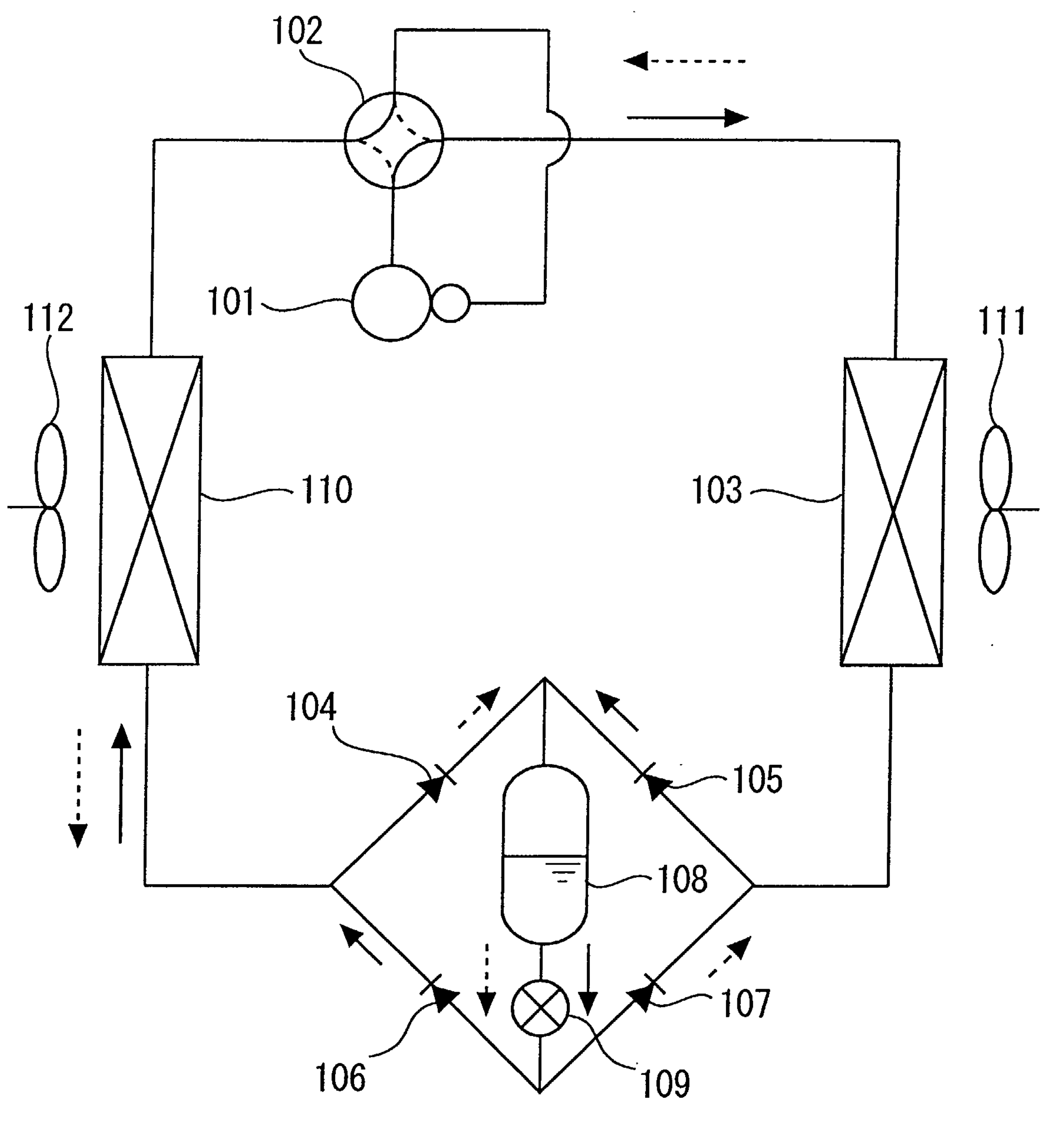

3
4
10
9
8
7
2
5
6
1
:flow of refrigerant during a heating operation
:flow of refrigerant during a cooling operation

Fig. 2

Related Art



→ :flow of refrigerant during a heating operation
- - -→ :flow of refrigerant during a cooling operation

Fig. 3

Related Art

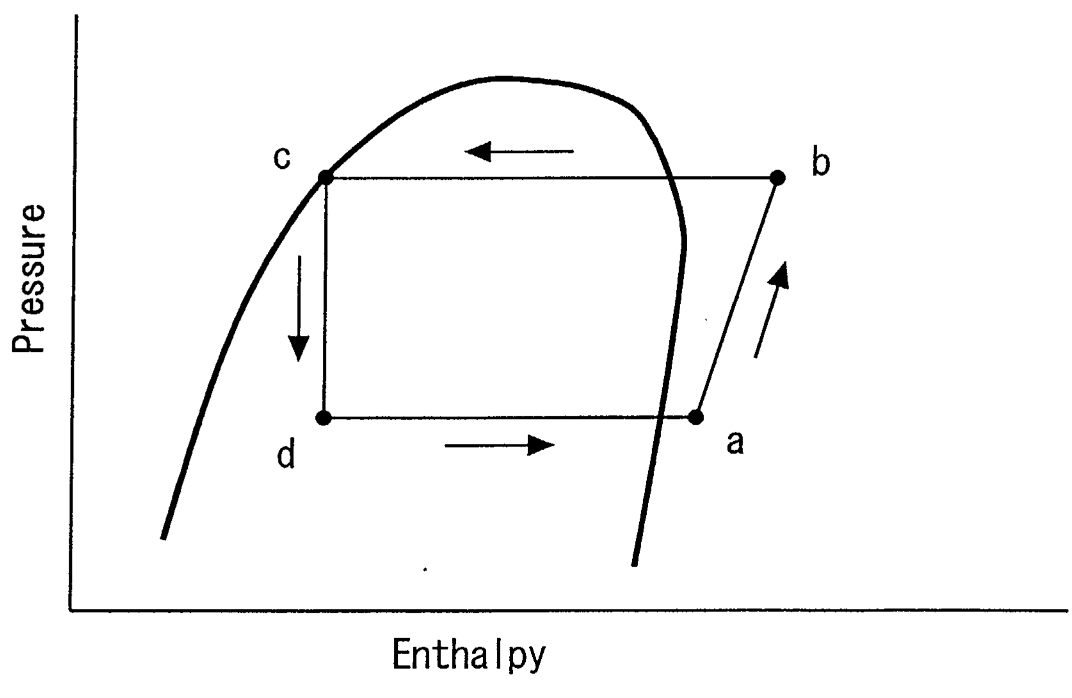
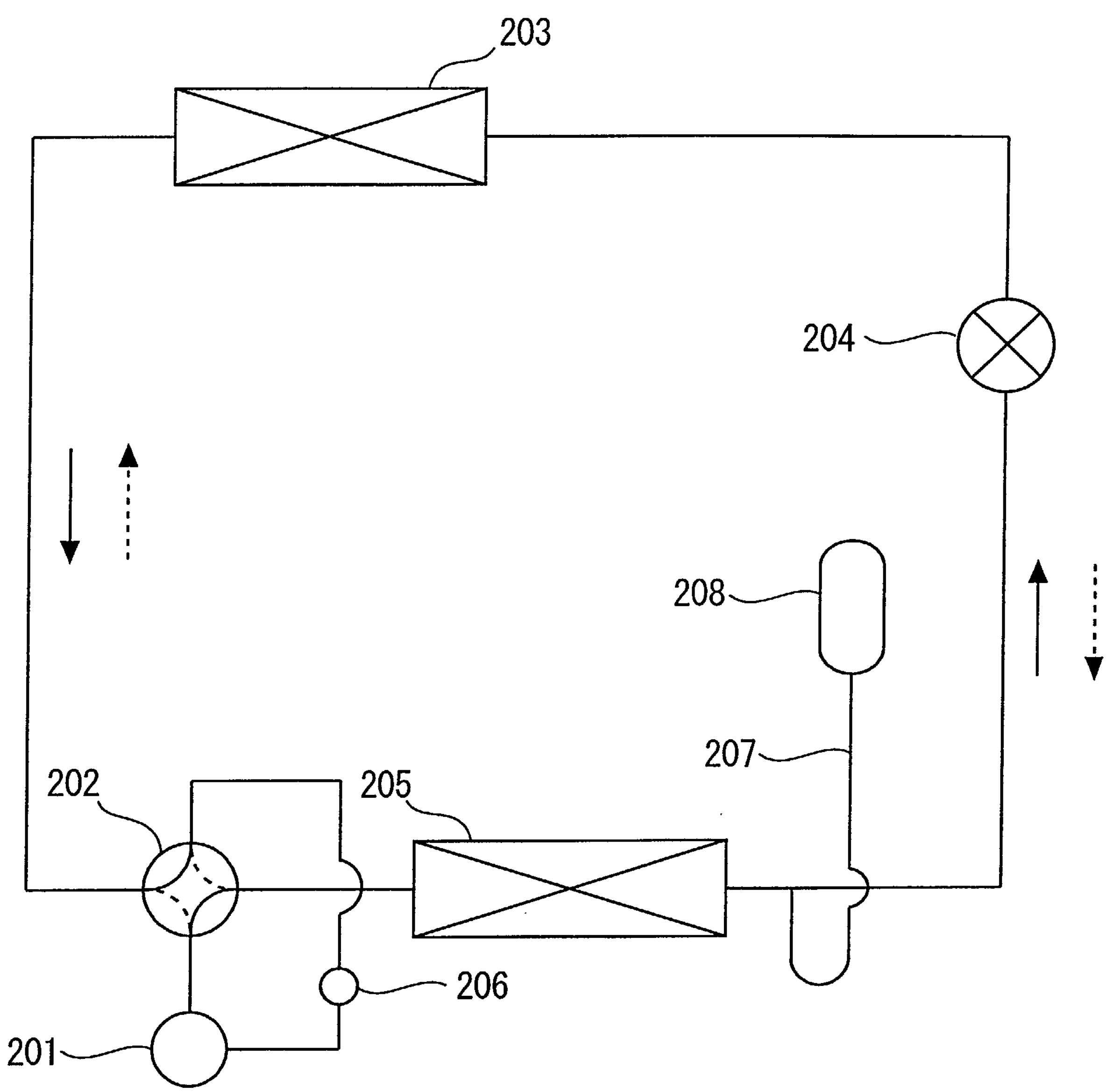


Fig. 4

Related Art



——► :flow of refrigerant during a heating operation
-------► :flow of refrigerant during a cooling operation