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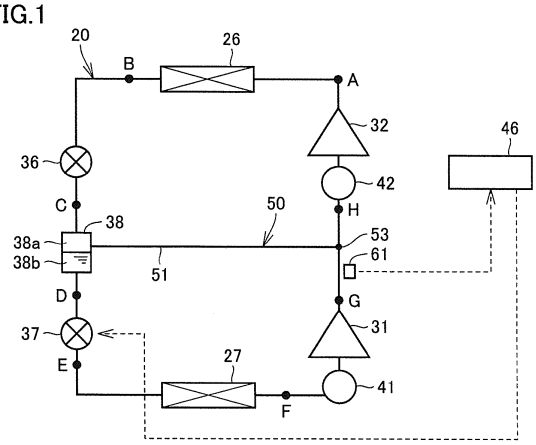
(54) **HEAT-PUMP-TYPE HEATING DEVICE**

(57) A heat pump type heating device includes: an indoor side heat exchanger (26); an outdoor side heat exchanger (27); low-pressure side compressor (31) and high-pressure side compressor (32) sequentially compressing refrigerant sent from the outdoor side heat exchanger (27); a first decompression device (36) decompressing the refrigerant sent from the indoor side heat exchanger (26); a gas-liquid separator (38) separating the refrigerant sent from the first decompression device (36), into a gas phase and a liquid phase; a second decompression device (37) connected to a liquid phase side of the gas-liquid separator (38) and decompressing the refrigerant sent from the gas-liquid separator (38); an injection pipe path (51) connected to a gas phase side of the gas-liquid separator (38) and guiding the refrigerant sent from the gas-liquid separator (38), to between the low-pressure side compressor (31) and the high-pressure side compressor (32); and a control unit (46) controlling a decompression ratio of the refrigerant in the second decompression device (37) such that the refrigerant flowing in the injection pipe path (51) is brought into a gas-liquid two-phase state. With such a configuration, there can be provided a heat pump type heating device having a simple configuration and having sufficiently improved heating ability.

FIG.1

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## Description

TECHNICAL FIELD

**[0001]** The present invention generally relates to a heat pump type heating device, more particularly, a two-stage compression heat pump type heating device provided with two compressors on a heat pump cycle.

BACKGROUND ART

**[0002]** Regarding a conventional heat pump type heating device, for example, Japanese Patent Laying-Open No. 8-210709 discloses a heat pump air conditioner for cold districts so as to achieve a heating operation even when the outdoor air temperature is - 20°C (Patent Document 1).

**[0003]** In the heat pump air conditioner disclosed in Patent Document 1, a scroll compressor, a four-way valve, an indoor air heat exchanger, a receiver, an outdoor refrigerant control valve, and an outdoor air heat exchanger are connected sequentially to one another via a pipe. Between the receiver and the scroll compressor, a bypass flow path for injecting liquid refrigerant into the scroll compressor is provided together with a liquid injection refrigerant control valve. The liquid injection refrigerant control valve is controlled in accordance with a difference between a temperature at the discharge side of the compressor and a target discharge temperature, and the outdoor refrigerant control valve is controlled such that a difference between temperatures provided by temperature sensors provided at the front and rear sides relative to the outdoor air heat exchanger becomes a degree of superheating of the refrigerant at the refrigerant outlet of the outdoor air heat exchanger.

**[0004]** Meanwhile, Japanese Patent Laying-Open No. 11-132575 discloses an air conditioner so as to prevent reliability of a compressor from being decreased due to introduction of liquid refrigerant into gas refrigerant flowing from a gas-liquid separator, which is inserted in a liquid pipe, back to the compressor via a gas injection bypass pipe (Patent Document 2).

**[0005]** In the air conditioner disclosed in Patent Document 2, an outdoor heat exchanger and an indoor heat exchanger are sequentially connected to the compressor, thereby forming a refrigerant circulation circuit. In the liquid pipe between the outdoor heat exchanger and the indoor heat exchanger, the gas-liquid separator is inserted. Provided between the gas-liquid separator and the suction side of the compressor are: the gas injection bypass pipe for flowing the gas refrigerant in the gas-liquid separator back to the compressor; and an opening/closing valve for opening/closing the flow path through the bypass pipe. The opening/closing valve is operated to be closed when a difference between the discharge temperature of the compressor and the condensation temperature of the refrigerant circulating in the refrigerant circulation circuit becomes less than a reference temperature difference. The reference temperature difference is set to be larger as the operation frequency of the compressor is higher.

**[0006]** Meanwhile, Japanese Patent Laying-Open No. 2007-263440 discloses an air conditioning device to operate at a high operating efficiency under a low load and improve heating ability under a high load by appropriately adjusting an amount of injection of refrigerant into a compressor in a compressing process during a heating operation (Patent Document 3).

**[0007]** The air conditioning device disclosed in Patent Document 3 includes: an injection pipe for injecting part of refrigerant, which flows out from an indoor heat exchanger, to the compressor in the compression process via an injection decompression device; compressor rotation speed control means for controlling the rotation speed of the compressor in accordance with a magnitude of load; and injection control means for controlling the injection decompression device such that the degree of superheating or discharge temperature of the discharged gas at the outlet portion of the compressor becomes a target value. The target value is set to be smaller as the rotation speed of the compressor controlled by the compressor rotation speed control means is higher, and is set to be larger as the rotation speed of the compressor is lower.

CITATION LIST

PATENT DOCUMENT

**[0008]**

PTD1: Japanese Patent Laying-Open No. 8-210709
PTD2: Japanese Patent Laying-Open No. 11-132575
PTD3: Japanese Patent Laying-Open No. 2007-263440

SUMMARY OF INVENTION

TECHNICAL PROBLEM

**[0009]** As a heat pump type heating device such as an air conditioning device or a water heating device, there is a two-stage compression heat pump type heating device provided with two compressors, i.e., a low-pressure side compressor and a high-pressure side compressor, on a heat pump cycle. However, in the two-stage compression heat pump type heating device, the suction temperature and discharge temperature of the refrigerant in the high-pressure side compressor are increased to exceed the operating range of the compressor, disadvantageously. As a method to solve such a problem, the following method can be contemplated: an injection pipe is provided to connect a pipe path between the low-pressure side compressor and the high-pressure side compressor to a pipe path between the indoor heat exchanger (condenser) and the outdoor heat exchanger (evaporator), and then part of the refrigerant distributing in the pipe path between the indoor heat exchanger and the outdoor heat exchanger is injected, via the injection pipe, into the pipe path between the low-pressure side compressor and the high-pressure side compressor. In this case, the suction temperature of the refrigerant in the high-pressure side compressor is decreased, thereby achieving an operation with maintained reliability.

**[0010]** In such a heat pump type heating device employing the injection pipe, it is required to improve the heating ability by injecting an optimum amount of refrigerant between the low-pressure side compressor and the high-pressure side compressor. Further, in each of the various types of devices employing the injection pipes as disclosed in Patent Documents 1 to 3 described above, the injection of refrigerant is controlled by the opening/closing valve or the decompression device provided on the pipe path of the injection pipe. In this case, the device cannot be manufactured inexpensively, disadvantageously.

**[0011]** In view of this, the present invention has an object to solve the above-described problems, specifically, provide a heat pump type heating device having a simple configuration and having sufficiently improved heating ability.

SOLUTION TO PROBLEM

**[0012]** A heat pump type heating device according to the present invention includes: a first heat exchanger performing heat exchange between refrigerant and heat-receiving fluid; a second heat exchanger performing heat exchange between the refrigerant and outdoor air; a low-pressure side compressor compressing the refrigerant sent from the second heat exchanger; a high-pressure side compressor compressing the refrigerant sent from the low-pressure side compressor; a first decompression device decompressing the refrigerant sent from the first heat exchanger; a gas-liquid separator separating the refrigerant sent from the first decompression device, into a gas phase and a liquid phase; a second decompression device connected to a liquid phase side of the gas-liquid separator and decompressing the refrigerant sent from the gas-liquid separator; an injection pipe path connected to a gas phase side of the gas-liquid separator and guiding the refrigerant sent from the gas-liquid separator, to a pipe path between the low-pressure side compressor and the high-pressure side compressor; and a control unit controlling a decompression ratio of the refrigerant in the second decompression device such that the refrigerant flowing in the injection pipe path is brought into a gas-liquid two-phase state.

**[0013]** According to the heat pump type heating device thus configured, the high-pressure side compressor receives the refrigerant having been brought into a saturated vapor state or a similar state as a result of merging of the refrigerant in the gas-liquid two-phase state flowing in the injection pipe path and the high-temperature and high-pressure gas phase refrigerant discharged from the low-pressure side compressor. Accordingly, an optimum amount of refrigerant can be injected between the low-pressure side compressor and the high-pressure side compressor, thereby sufficiently improving the heating ability. In doing so, the refrigerant flowing in the injection pipe path is brought into the gas-liquid two-phase state using the second decompression device decompressing the refrigerant sent from the gas-liquid separator, so that the heat pump type heating device can be provided with a simple configuration.

**[0014]** More preferably, the control unit further controls the decompression ratio of the refrigerant in the second decompression device such that a ratio of the liquid phase in the refrigerant, which flows in the injection pipe path and is in the gas-liquid two-phase state, does not become equal to or more than a predetermined value.

**[0015]** According to the heat pump type heating device thus configured, the compressor can be prevented from being decreased in reliability and operating efficiency due to the liquid refrigerant flowing into the high-pressure side compressor.

**[0016]** More preferably, the heat pump type heating device further includes a first temperature detecting unit provided on the pipe path between the low-pressure side compressor and the high-pressure side compressor and detecting a temperature of the refrigerant having yet to be merged with the refrigerant flowing in the injection pipe path. The control unit controls the decompression ratio of the refrigerant in the second decompression device based on a time history of the temperature of the refrigerant detected by the first temperature detecting unit.

**[0017]** More preferably, the heat pump type heating device further includes: a second temperature detecting unit provided on the injection pipe path and detecting the temperature of the refrigerant flowing in the injection pipe path; and a third temperature detecting unit provided on the pipe path between the low-pressure side compressor and the high-pressure side compressor and detecting the temperature of the refrigerant having been merged with the refrigerant flowing in the injection pipe path. The control unit controls the decompression ratio of the refrigerant in the second decompression device based on a difference between the temperature of the refrigerant detected by the second temperature detecting unit and the temperature of the refrigerant detected by the third temperature detecting unit.

**[0018]** More preferably, the heat pump type heating device further includes a fourth temperature detecting unit provided on the pipe path between the low-pressure side compressor and the high-pressure side compressor and detecting the temperature of the refrigerant having been merged with the refrigerant flowing in the injection pipe path. The control unit controls the decompression ratio of the refrigerant in the second decompression device based on a time history of the temperature of the refrigerant detected by the fourth temperature detecting unit.

**[0019]** According to the heat pump type heating device thus configured, the decompression ratio of the refrigerant in the second decompression device is controlled using various types of temperature histories and temperature differences correlated with the state of the refrigerant flowing in the injection pipe path.

**[0020]** More preferably, the heat pump type heating device further includes a buffer unit provided on the pipe path, which is between the low-pressure side compressor and the high-pressure side compressor and in which the refrigerant having been merged with the refrigerant flowing in the injection pipe path flows, and storing liquid refrigerant.

**[0021]** According to the heat pump type heating device thus configured, the compressor can be more securely prevented from being decreased in reliability due to the liquid refrigerant flowing into the high-pressure side compressor.

ADVANTAGEOUS EFFECTS OF INVENTION

**[0022]** As described above, according to the present invention, there can be provided a heat pump type heating device having a simple configuration and having sufficiently improved heating ability.

BRIEF DESCRIPTION OF DRAWINGS

**[0023]**

Fig. 1 is a circuit diagram showing a heat pump type heating device in a first embodiment of the present invention.

Fig. 2 is a Mollier diagram showing a refrigerating cycle by the heat pump type heating device in Fig. 1.

Fig. 3 shows a flowchart of control over an amount of injection refrigerant in the heat pump type heating device in Fig. 1.

Fig. 4 is a circuit diagram showing a first modification of the heat pump type heating device in Fig. 1.

Fig. 5 is a graph showing a relation between a ratio of the amount of injection to the amount of the refrigerant having yet to be branched in the gas-liquid separator and each of heating ability and COP.

Fig. 6 is a circuit diagram showing a second modification of the heat pump type heating device in Fig. 1.

Fig. 7 shows a flowchart of control over the amount of the injection refrigerant in the heat pump type heating device in Fig. 6.

Fig. 8 is a circuit diagram showing a third modification of the heat pump type heating device in Fig. 1.

Fig. 9 shows a flowchart of control over the amount of the injection refrigerant in the heat pump type heating device in Fig. 8.

DESCRIPTION OF EMBODIMENTS

**[0024]** The following describes embodiments of the present invention with reference to figures. It should be noted that the same or corresponding members are given the same numbers in the figures referenced below.

(First Embodiment)

**[0025]** Fig. 1 is a circuit diagram showing a heat pump type heating device in a first embodiment of the present invention. With reference to Fig. 1, the heat pump type heating device in the present embodiment is representatively applied to a heat pump type water heater or a heat pump type heating machine. The heat pump type heating device includes a refrigeration circuit 20 and an injection circuit 50 as its circuit configuration. R410A is enclosed in refrigeration circuit 20 and injection circuit 50 as refrigerant, for example.

**[0026]** Refrigeration circuit 20 extends annularly to form a heat pump cycle. On the path of refrigeration circuit 20, an indoor side heat exchanger (condenser) 26 and an outdoor side heat exchanger (evaporator) 27 are provided. Indoor side heat exchanger 26 performs heat exchange between the refrigerant circulating in the heat pump cycle and heat-receiving fluid (water or air). Outdoor side heat exchanger 27 performs heat exchange between the refrigerant circulating in the heat pump cycle and the external air (outdoor air).

**[0027]** On the path of refrigeration circuit 20, a first decompression device 36, a gas-liquid separator 38 and a second decompression device 37 are further provided. First decompression device 36, gas-liquid separator 38, and second decompression device 37 are provided between indoor side heat exchanger 26 and outdoor side heat exchanger 27. First decompression device 36, gas-liquid separator 38 and second decompression device 37 are arranged in series in the flow direction of the refrigerant in refrigeration circuit 20. On the path of refrigeration circuit 20 from indoor side heat exchanger 26 to outdoor side heat exchanger 27, first decompression device 36, gas-liquid separator 38 and second decompression device 37 are arranged in this order.

**[0028]** First decompression device 36 decompresses the refrigerant sent from indoor side heat exchanger 26. First decompression device 36 is provided as a decompression device for controlling supercooling of the refrigerant in indoor side heat exchanger 26. Gas-liquid separator 38 separates the refrigerant sent from first decompression device 36 into refrigerant in a gas phase state and refrigerant in a liquid phase state (liquid refrigerant). Gas-liquid separator 38 includes: a gas phase refrigerant space 38a in which the refrigerant in the gas phase state is disposed; and a liquid phase refrigerant space 38b in which the refrigerant in the liquid phase state is disposed. Second decompression device 37 is connected to liquid phase refrigerant space 38b of gas-liquid separator 38 via a pipe. Second decompression device 37 decompresses the liquid refrigerant sent from gas-liquid separator 38. Second decompression device 37 is provided as a decompression device for controlling a degree of superheating of the refrigerant in outdoor side heat exchanger 27 and an amount of injection refrigerant provided by injection circuit 50 described below. In the present embodiment, expansion valves are used as first decompression device 36 and second decompression device 37.

**[0029]** On the path of refrigeration circuit 20, a low-pressure side compressor 31 and a high-pressure side compressor 32 are further provided. Low-pressure side compressor 31 and high-pressure side compressor 32 are provided between outdoor side heat exchanger 27 and indoor side heat exchanger 26. Low-pressure side compressor 31 and high-pressure side compressor 32 are arranged in series in the flow direction of the refrigerant in refrigeration circuit 20. On the path of refrigeration circuit 20 from outdoor side heat exchanger 27 to indoor side heat exchanger 26, low-pressure side compressor 31 and high-pressure side compressor 32 are arranged in this order. Low-pressure side compressor 31 compresses the refrigerant, which has a low pressure and is sent from outdoor side heat exchanger 27, to an intermediate pressure. High-pressure side compressor 32 further compresses, to a high pressure, the refrigerant having the intermediate pressure and sent from low-pressure side compressor 31.

**[0030]** In the present embodiment, low-pressure side compressor 31 is a variable displacement type compressor capable of controlling the discharge displacement of the refrigerant (for example, an inverter compressor capable of changing the rotation speed), and high-pressure side compressor 32 is a constant rotation speed type compressor. It should be noted that at least one of low-pressure side compressor 31 and high-pressure side compressor 32 may be of the variable displacement type, and there may be employed a combination of a constant rotation speed low-pressure side compressor and a variable displacement high-pressure side compressor or a combination of a variable displacement low-pressure side compressor and a variable displacement high-pressure side compressor. It should be noted that a variable displacement type low-pressure side compressor provides a wider operable range under a high load.

**[0031]** Injection circuit 50 is constructed of an injection pipe path 51 in which the refrigerant can be distributed. Injection pipe path 51 is provided to guide part of the refrigerant separated to come into gas phase refrigerant space 38a of gas-liquid separator 38, to refrigeration circuit 20 between low-pressure side compressor 31 and high-pressure side compressor 32.

**[0032]** More specifically, injection pipe path 51 is provided to have both ends respectively connected to gas phase refrigerant space 38a of gas-liquid separator 38 and refrigeration circuit 20 between low-pressure side compressor 31 and high-pressure side compressor 32. Injection pipe path 51 has a refrigerant inlet connected to gas phase refrigerant space 38a of gas-liquid separator 38, and has a refrigerant outlet connected to refrigeration circuit 20 between low-pressure side compressor 31 and high-pressure side compressor 32.

**[0033]** In the present embodiment, no opening/closing valve for permitting/blocking the flow of the refrigerant or no flow adjusting valve capable of adjusting a refrigerant flow rate is provided on injection pipe path 51.

**[0034]** On the path of refrigeration circuit 20, a buffer unit 41 and a buffer unit 42 are further provided. Each of buffer unit 41 and buffer unit 42 is constructed of an accumulator capable of storing liquid refrigerant therein. On the path of refrigeration circuit 20, buffer unit 41 is provided between outdoor side heat exchanger 27 and low-pressure side compressor 31. On the path of refrigeration circuit 20, buffer unit 42 is provided between low-pressure side compressor 31 and high-pressure side compressor 32. Assuming that a position of refrigeration circuit 20 to which injection pipe path 51 is connected is a "connection portion 53", buffer unit 42 is provided between connection portion 53 and high-pressure side compressor 32. Buffer unit 41 and buffer unit 42 are provided to prevent the reliability of the compressors from being decreased due to introduction of liquid refrigerant into low-pressure side compressor 31 and high-pressure side compressor 32.

**[0035]** Fig. 2 is a Mollier diagram showing a refrigerating cycle by the heat pump type heating device in Fig. 1.

**[0036]** The Mollier diagram is also called a "P-h diagram", and the vertical axis represents a pressure [MPa] whereas the horizontal axis represents a specific enthalpy [kJ/kg]. The Mollier diagram is a diagram showing characteristics specific to the refrigerant used for the refrigerating cycle, such as pressure, specific enthalpy, temperature, phase state, enthalpy, and specific volume of the refrigerant. Refrigerant states A to H shown in Fig. 2 respectively correspond to refrigerant states A to H in Fig. 1.

**[0037]** With reference to Fig. 1 and Fig. 2, first, gas refrigerant (state A) discharged from high-pressure side compressor 32 flows into indoor side heat exchanger (condenser) 26, and becomes a condensed high-temperature liquid refrigerant (state B). By the high-temperature liquid refrigerant passing through first decompression device 36, the pressure and temperature of the refrigerant is decreased (state C).

**[0038]** Next, the refrigerant flows into gas-liquid separator 38, and is separated into the gas phase and the liquid phase. By the separated liquid refrigerant (state D) passing through second decompression device 37, the pressure and temperature of the refrigerant is further decreased (state E). Next, by the refrigerant passing through outdoor side heat exchanger 27, the refrigerant absorbs heat from the external air to evaporate (state F). The refrigerant in state F flows into low-pressure side compressor 31 and is compressed to the intermediate pressure (state G).

**[0039]** Meanwhile, the refrigerant (injection refrigerant) separated to come into gas phase refrigerant space 38a of gas-liquid separator 38 passes through injection pipe path 51, and is then merged with the refrigerant discharged from low-pressure side compressor 31. The temperature of the injection refrigerant is lower than the temperature of the refrigerant discharged from low-pressure side compressor 31, so that the temperature of the refrigerant having been merged with the injection refrigerant is decreased (state H).

**[0040]** When the temperature of the external air becomes low during the heating operation to decrease the evaporating pressure, the compression ratio becomes large, but heating (warming) ability can be secured without abnormally increasing the discharge temperature, by injecting the injection refrigerant into the refrigerant having the intermediate pressure so as to increase the refrigerant flow rate at a stage after the compression process performed by low-pressure side compressor 31 and before the compression process performed by high-pressure side compressor 32. Thus, with the effect provided by the injection refrigerant, sufficient heating ability can be obtained even when the external air temperature is a very low temperature of about -20°C, for example.

**[0041]** The heat pump type heating device further includes a temperature detecting unit 61 and a control unit 46. Temperature detecting unit 61 is provided between low-pressure side compressor 31 and high-pressure side compressor 32. Temperature detecting unit 61 is provided between low-pressure side compressor 31 and connection portion 53. Temperature detecting unit 61 detects the temperature of the refrigerant discharged from low-pressure side compressor 31 and having yet to be merged with the refrigerant flowing in injection pipe path 51. Based on a time history of the temperature of the refrigerant detected by temperature detecting unit 61, control unit 46 controls the decompression ratio of the refrigerant in second decompression device 37.

**[0042]** In the heat pump type heating device according to the present embodiment, by controlling a degree of opening of second decompression device 37 based on the temperature history of the refrigerant discharged from low-pressure side compressor 31, the injection refrigerant is brought from the state in which the injection refrigerant is only in the gas phase to a gas-liquid two-phase state just after the liquid phase is started to be mixed. In this way, the heating ability can be increased with an appropriate amount of injection refrigerant being maintained irrespective of a magnitude of load of the compressors.

**[0043]** Furthermore, in the heat pump type heating device according to the present embodiment, second decompression device 37 provided at the upstream side relative to outdoor side heat exchanger 27 in the flow direction of the refrigerant during the heating operation is used instead of providing, on injection pipe path 51, a device for controlling the state of the injection refrigerant, so as to obtain an effect comparable to that in the case where a decompression device is provided on the injection pipe path to directly control the flow rate of the injection refrigerant. In addition, because no opening/closing valve or decompression device needs to be disposed on the injection pipe path, the device can be constructed inexpensively.

**[0044]** The following specifically describes the above-described method of controlling the amount of the injection refrigerant. First, the rotation speed of a compressor is an amount of operation with which heating ability can be adjusted most directly, so that the rotation speed of variable displacement type low-pressure side compressor 31 is controlled in accordance with a load. For example, the rotation speed of low-pressure side compressor 31 is increased/decreased in accordance with a deviation between a target heating temperature set by a user or a target heating temperature set in advance in the device and a measured heating temperature.

**[0045]** Fig. 3 shows a flowchart of control over the amount of the injection refrigerant in the heat pump type heating device in Fig. 1. The control flow shown in the figure is performed by control unit 46.

**[0046]** With reference to Fig. 1 and Fig. 3, before controlling the amount of the injection refrigerant, when starting the operation, the following controls are performed: control over the rotation speed of low-pressure side compressor 31; control over supercooling at the outlet of indoor side heat exchanger 26 through adjustment of the degree of opening of first decompression device 36; and control over a degree of superheating at the outlet of outdoor side heat exchanger 27 through adjustment of the degree of opening of second decompression device 37. The refrigerant enclosed is set such that the injection refrigerant is brought into the gas phase state when the series of controls are completed.

**[0047]** For the control over the amount of the injection refrigerant, temperature T1 of the refrigerant discharged from low-pressure side compressor 31 is first detected by temperature detecting unit 61 and temperature T1 is stored in control unit 46 (S101). Next, the degree of opening of second decompression device 37 is decreased by an appropriate number of steps (S102). When the degree of opening of second decompression device 37 is decreased, the decompression ratio of the refrigerant in second decompression device 37 is increased. On this occasion, the amount of the liquid refrigerant in gas-liquid separator 38 is increased and subsequently overflows in gas-liquid separator 38 to flow into injection pipe path 51, with the result that the refrigerant in the gas phase state in injection pipe path 51 is changed into the gas-liquid two-phase state.

**[0048]** After passage of a certain time t, temperature T1' of the refrigerant discharged from low-pressure side compressor 31 is detected again by temperature detecting unit 61 and temperature T1' is stored in control unit 46 (S103). Control unit 46 calculates T1' - T1 and determines whether or not the resulting value is equal to or more than $\Delta$T4 (S104). $\Delta$T4 represents a temperature difference in the refrigerant discharged from low-pressure side compressor 31 until the injection refrigerant is brought from the gas phase state into a state in which part of the gas phase is started to be changed into the liquid phase, and ΔT4 is specified in advance through an experiment in which the state of the injection refrigerant is observed while changing ΔT4. By way of example, when t = 30 sec, ΔT4 = 3°C.

**[0049]** When T1' - T1 < ΔT4 is satisfied, the process returns to S102, in which the degree of opening of second decompression device 37 is further decreased. When T1' - T1 ≥ ΔT4 is satisfied, control unit 46 determines whether or not the value of T1' - T1 is equal to or less than ΔT5 (S105). ΔT5 represents a temperature difference in the refrigerant discharged from low-pressure side compressor 31 until the injection refrigerant is brought from the gas phase state into a state in which part of the gas phase is changed into the liquid phase and too much liquid refrigerant flows in injection pipe path 51, and ΔT5 is specified in advance through an experiment in which the state of the injection refrigerant is observed while changing ΔT5. By way of example, when t = 30 sec, ΔT5 = 15°C.

**[0050]** In the control flow described above, temperature T1 is detected when starting the control and is thereafter assumed as a constant, but the present invention is not limited to this. Temperature T1 can be also defined as a value detected at a certain time before T1'. For example, temperature T1 can be always variable as a temperature T1 at t seconds before T1'.

**[0051]** It should be noted that there is a certain correlation between the temperature difference in the refrigerant discharged from low-pressure side compressor 31 and the state of the injection refrigerant, and the correlation is not affected by the rotation speed of low-pressure side compressor 31 and the degree of opening of each of first decompression device 36 and second decompression device 37.

**[0052]** When T1' - T1 > ΔT5 is satisfied, the liquid phase ratio in the injection refrigerant is too large, so that the degree of opening of second decompression device 37 is increased (S106). When T1' - T1 ≤ ΔT5 is satisfied, the process returns to S103, in which temperature T1' of the refrigerant discharged from low-pressure side compressor 31 is detected again by temperature detecting unit 61.

**[0053]** In other words, in the method of controlling the amount of the injection refrigerant in the present embodiment, a difference is found between the temperature of the refrigerant discharged from low-pressure side compressor 31 before changing the degree of opening of second decompression device 37 and the temperature of the refrigerant at the same location after changing the degree of opening of second decompression device 37, and then the degree of opening of second decompression device 37 is adjusted such that the value thereof falls within an appropriate range. In doing so, the number of steps in adjusting the degree of opening of second decompression device 37 may be set at a small value when control precision is intended to be increased, whereas the number of steps in adjusting the degree of opening of second decompression device 37 may be set at a large value when control is performed to achieve a target degree of opening quickly.

**[0054]** When the degree of supercooling of indoor side heat exchanger 26 is controlled by first decompression device 36 and the degree of superheating of outdoor side heat exchanger 27 is controlled by second decompression device 37, the state of the refrigerant flowing into injection pipe path 51 is the gas phase as a result of the function of gas-liquid separator 38. When the degree of opening of second decompression device 37 is further decreased from this state, an amount of liquid refrigerant flowing out to the outdoor side heat exchanger 27 side is restricted, with the result that the liquid refrigerant overflows in gas-liquid separator 38 to flow into injection pipe path 51. In this case, the liquid refrigerant flows into high-pressure side compressor 32, which is followed by liquid compression, presumably resulting in deterioration of reliability of the compressor. However, in the present embodiment, such a concern can be eliminated by buffer unit 42 provided at the suction side of high-pressure side compressor 32.

**[0055]** However, there is a limit in terms of an amount of refrigerant that can be stored in buffer unit 42. When the amount of the liquid refrigerant flowing in injection pipe path 51 is increased too much, the compressor is more likely to be deteriorated in reliability. In addition, when the amount of the liquid refrigerant flowing in injection pipe path 51 is increased too much, the COP (Coefficient Of Performance) of the heat pump type heating device is decreased, disadvantageously.

**[0056]** To address this, in the heat pump type heating device in the present embodiment, in the process of decreasing the degree of opening of second decompression device 37, control is performed to maintain the gas-liquid two-phase state just after the injection refrigerant only in the gas phase is changed into the state in which the liquid phase is started to be mixed. The state of the refrigerant before the refrigerant discharged from low-pressure side compressor 31 and the injection refrigerant are merged is changed from the gas phase + gas phase state to the gas phase + gas-liquid two-phase state, whereby the liquid refrigerant of the gas-liquid two-phase refrigerant is changed into the gas phase through the phase change. As a result, the flow rate of the refrigerant into indoor side heat exchanger 26 is increased, thereby increasing the heating ability. In other words, in the present embodiment, irrespective of the rotation speed of the compressor or the external air temperature, the cycle can be readily controlled by controlling second decompression device 37 such that the injection refrigerant having yet to be merged with the refrigerant discharged from low-pressure side compressor 31 is brought into the state just after it is changed from the gas phase state to the gas-liquid two-phase state.

**[0057]** The following describes why the heating ability is improved in the heat pump type heating device according to the present embodiment.

**[0058]** The supply of the injection refrigerant has a function of increasing the refrigerant flow rate at the heating side to increase the heating ability, and increases the limit of operating pressure ratio in the compressor. In order to increase the refrigerant flow rate at the heating side, the injection refrigerant in the liquid phase state is more effective than the injection refrigerant in the gas phase state. However, when the injection refrigerant in the liquid phase state is supplied too much, the COP may be deteriorated and the reliability of the compressor may be decreased due to liquid compression. Hence, it is preferable to perform injection to such an extent that the liquid phase in the injection refrigerant is phase-changed into a saturated vapor state by the high-temperature gas refrigerant discharged from low-pressure side compressor 31.

**[0059]** In view of this, in the present embodiment, the cycle involving the increased refrigerant flow rate at the heating side is maintained by maintaining the state just after the injection refrigerant is brought from the gas phase state into the gas-liquid two-phase state. The state just after that can be readily determined based on the temperature history of the refrigerant discharged from low-pressure side compressor 31. When the condensation temperature, the evaporating temperature, and the rotation speed of the compressor are in the same conditions, it can be said that the greatest factor that determines the ability of the cycle is the suction pressure of high-pressure side compressor 32 (state H in Fig. 2). With the suction pressure being set at a value comparable to the conventional value, the refrigerant flow rate at the heating side can be increased to increase the heating ability in the present embodiment, thereby achieving the heating ability as good as or better than the conventional heating ability.

**[0060]** When the refrigerant in the liquid phase flows before the suctioning of high-pressure side compressor 32, the starting point of the high-pressure side compression process comes closer to the saturated vapor state. Accordingly, the temperature of the refrigerant discharged from low-pressure side compressor 31 is more securely decreased by the injection refrigerant, thereby reducing the temperature of the refrigerant discharged from high-pressure side compressor 32. Accordingly, the limit of the operating pressure ratio in the compressor can be increased.

**[0061]** The following describes why controllability is improved in the heat pump type heating device in the present embodiment.

**[0062]** The control method in the present embodiment includes: the control over the rotation speed of the compressor in accordance with the heating load; the control over the injection in accordance with the temperature of the refrigerant discharged from low-pressure side compressor 31; and the control means for controlling the decompression device subsequent to indoor side heat exchanger 26 in the flow direction of the refrigerant. The cycle can be controlled using the two decompression devices. Accordingly, the number of the decompression devices and control means, which are control factors, can be suppressed to the minimum and controllability can be improved.

**[0063]** Fig. 4 is a circuit diagram showing a first modification of the heat pump type heating device in Fig. 1. With reference to Fig. 4, in the heat pump type heating device according to the present modification, an internal heat exchanger 43 is further provided on the path of refrigeration circuit 20. Internal heat exchanger 43 is provided between indoor side heat exchanger 26 and first decompression device 36. Injection pipe path 51 is provided to pass through internal heat exchanger 43. Internal heat exchanger 43 performs heat exchange between the refrigerant flowing from indoor side heat exchanger 26 and the refrigerant flowing in injection pipe path 51.

**[0064]** According to such a configuration, when the refrigerant in the liquid phase state flows into injection pipe path 51, the liquid phase is heated in internal heat exchanger 43 and is accordingly evaporated, with the result that the heating ability is improved due to the increase of the flow rate of the injection refrigerant.

**[0065]** Under a low load, for example, when the external air temperature is high, a large amount of the injection refrigerant causes excessive decrease of the COP, disadvantageously. Such a problem can be solved by providing an opening/closing valve in injection pipe path 51 and opening/closing it based on the external air temperature or the like.

**[0066]** Fig. 5 is a graph showing a relation between the ratio of the injection amount to the amount of the refrigerant having yet to be branched in the gas-liquid separator and each of the heating ability and the COP. In Fig. 5, the horizontal axis represents the ratio of the injection amount whereas the vertical axis represents experimental values of the heating ability and the COP.

**[0067]** With reference to Fig. 5, when increasing the flow rate of the injection refrigerant with the degree of opening of second decompression device 37 being made small, the heating ability is improved. Furthermore, when the injection state is brought into the gas-liquid two-phase state, the flow rate of the injection refrigerant is increased further, so that the heating ability attains a high value. However, when a large amount of the liquid refrigerant flows into injection pipe path 51, the heating ability is decreased. On the other hand, the COP is gradually decreased according to increase of the injection amount.

**[0068]** The above-described heat pump type heating device according to the first embodiment of the present invention includes: indoor side heat exchanger 26 serving as a first heat exchanger performing heat exchange between refrigerant and heat-receiving fluid; outdoor side heat exchanger 27 serving as a second heat exchanger performing heat exchange between the refrigerant and outdoor air; low-pressure side compressor 31 compressing the refrigerant sent from outdoor side heat exchanger 27; high-pressure side compressor 32 compressing the refrigerant sent from low-pressure side compressor 31; first decompression device 36 decompressing the refrigerant sent from indoor side heat exchanger 26; gas-liquid separator 38 separating the refrigerant sent from first decompression device 36, into a gas phase and a liquid phase; second decompression device 37 connected to a liquid phase side of gas-liquid separator 38 and decompressing the refrigerant sent from gas-liquid separator 38; injection pipe path 51 connected to a gas phase side of gas-liquid separator 38 and guiding the refrigerant sent from gas-liquid separator 38, to a pipe path between low-pressure side compressor 31 and high-pressure side compressor 32; and control unit 46 controlling a decompression ratio of the refrigerant in second decompression device 37 such that the refrigerant flowing in injection pipe path 51 is brought into a gas-liquid two-phase state.

**[0069]** According to the heat pump type heating device thus configured in the first embodiment of the present invention, a heat pump type heating device can be realized which is excellent in controllability and achieves sufficient improvement of the heating ability.

(Second Embodiment)

**[0070]** Described in the present embodiment are various types of modifications of the method of controlling the state of the injection refrigerant. In the description below, the same structures as those in the heat pump type heating device in the first embodiment are not described repeatedly.

**[0071]** Fig. 6 is a circuit diagram showing a second modification of the heat pump type heating device in Fig. 1. Fig. 7 shows a flowchart of control over the amount of the injection refrigerant in the heat pump type heating device in Fig. 6.

**[0072]** With reference to Fig. 6 and Fig. 7, the heat pump type heating device has a temperature detecting unit 62 and a temperature detecting unit 63 instead of temperature detecting unit 61 in Fig. 1. Temperature detecting unit 62 is provided in injection pipe path 51. Temperature detecting unit 62 detects the temperature of the refrigerant flowing in injection pipe path 51 and having yet to be merged on the pipe path between low-pressure side compressor 31 and high-pressure side compressor 32. Temperature detecting unit 63 is provided between low-pressure side compressor 31 and high-pressure side compressor 32. Temperature detecting unit 63 is provided between connection portion 53 and high-pressure side compressor 32. Temperature detecting unit 63 detects the temperature of the refrigerant discharged from low-pressure side compressor 31 and merged with the refrigerant flowing in injection pipe path 51. Temperature detecting unit 63 detects the temperature of the refrigerant suctioned to high-pressure side compressor 32. Control unit 46 controls the decompression ratio of the refrigerant in second decompression device 37 based on a difference between the temperature of the refrigerant detected by temperature detecting unit 62 and the temperature of the refrigerant detected by temperature detecting unit 63.

**[0073]** Also in the present modification, before controlling the amount of the injection refrigerant, when starting the operation, the following controls are performed: control over the rotation speed of low-pressure side compressor 31; control over supercooling at the outlet of indoor side heat exchanger 26 through adjustment of the degree of opening of first decompression device 36; and control over a degree of superheating at the outlet of outdoor side heat exchanger 27 through adjustment of the degree of opening of second decompression device 37. The refrigerant enclosed is set such that the injection refrigerant is brought into the gas phase state when the series of controls are completed.

**[0074]** For the control over the amount of the injection refrigerant, temperature detecting unit 62 first detects temperature T2 of the refrigerant having yet to be merged with the injection refrigerant, temperature detecting unit 63 detects temperature T3 of the refrigerant suctioned to high-pressure side compressor 32, and these temperatures T2 and T3 are stored in control unit 46 (S111). Next, control unit 46 calculates T3 - T2 and determines whether or not the resulting value is more than 0 (S112). When $T3 - T2 > 0$ is satisfied, the degree of opening of second decompression device 37 is decreased by a certain number of steps (S113). On the other hand, when $T3 - T2 \leq 0$ is satisfied, the degree of opening of second decompression device 37 is increased by a certain number of steps (step 114).

**[0075]** Specifically, in the method of controlling the amount of the injection refrigerant in the present embodiment, the degree of opening of second decompression device 37 is made small to increase the flow rate of the injection refrigerant when the degree of superheating of outdoor side heat exchanger 27 is attained at temperature T3 of the refrigerant suctioned to high-pressure side compressor 32, as compared with temperature T2 of the injection refrigerant. On the other hand, when the degree of superheating of outdoor side heat exchanger 27 is not attained, the degree of opening of second decompression device 37 is controlled to be increased such that the state of the refrigerant becomes saturated vapor at the suction portion of high-pressure side compressor 32.

**[0076]** The number of steps in adjusting the degree of opening of second decompression device 37 may be set at a small value when control precision is intended to be increased, whereas the number of steps in adjusting the degree of opening of second decompression device 37 may be set at a large value when control is performed to achieve a target degree of opening quickly. Further, in the present modification, whether or not the degree of superheating is attained is determined based on 0 as a reference, but in the case where one wishes to set the injection refrigerant at a small value, it may be set at a certain value T6, and it may be determined in S112 whether or not T3 - T2 > T6 is satisfied.

**[0077]** Fig. 8 is a circuit diagram showing a third modification of the heat pump type heating device in Fig. 1. Fig. 9 shows a flowchart of control over the amount of the injection refrigerant in the heat pump type heating device in Fig. 8.

**[0078]** With reference to Fig. 8 and Fig. 9, the heat pump type heating device has a temperature detecting unit 64 instead of temperature detecting unit 61 in Fig. 1. Temperature detecting unit 64 is provided between low-pressure side compressor 31 and high-pressure side compressor 32. Temperature detecting unit 64 is provided between connection portion 53 and high-pressure side compressor 32. Temperature detecting unit 64 detects the temperature of the refrigerant discharged from low-pressure side compressor 31 and merged with the refrigerant flowing in injection pipe path 51. Temperature detecting unit 64 detects the temperature of the refrigerant suctioned to high-pressure side compressor 32. Based on time history of the refrigerant temperature detected by temperature detecting unit 64, control unit 46 controls the decompression ratio of the refrigerant in second decompression device 37.

**[0079]** Also in the present modification, before controlling the amount of injection refrigerant, when starting the operation, the following controls are performed: control over the rotation speed of low-pressure side compressor 31; control over supercooling at the outlet of indoor side heat exchanger 26 through adjustment of the degree of opening of first decompression device 36; and control over a degree of superheating at the outlet of outdoor side heat exchanger 27 through adjustment of the degree of opening of second decompression device 37. The refrigerant enclosed is set such that the injection refrigerant is brought into the gas phase state when the series of controls are completed.

**[0080]** For the control over the amount of the injection refrigerant, temperature T3 of the refrigerant suctioned to high-pressure side compressor 32 is first detected by temperature detecting unit 64 and temperature T3 is stored in control unit 46 (S121). Next, the degree of opening of second decompression device 37 is decreased by an appropriate number of steps such that the decompression ratio of the refrigerant in second decompression device 37 becomes large (S122).

**[0081]** After passage of a certain time t, temperature T3' of the refrigerant suctioned to high-pressure side compressor 32 is detected again by temperature detecting unit 64 and temperature T3' is stored in control unit 46 (S123). When the liquid refrigerant starts to flow in injection pipe path 51, the refrigerant flow rate is increased, so that the temperature of the refrigerant discharged from low-pressure side compressor 31 can be effectively decreased. As a result, the temperature of the refrigerant suctioned to high-pressure side compressor 32 is also decreased. Control unit 46 calculates T3-T3' and determines whether or not the resulting value is equal to or more than ΔT7 (S124). ΔT7 represents a temperature difference in the refrigerant suctioned to high-pressure side compressor 32 until the injection refrigerant is brought from the gas phase state into a state in which part of the gas phase is started to be changed into the liquid phase, and ΔT7 is specified in advance through an experiment in which the state of the injection refrigerant is observed while changing ΔT7. By way of example, when t = 30 sec, ΔT7 = 3°C.

**[0082]** When T3 - T3' < ΔT7 is satisfied, the process returns to S122, in which the degree of opening of second decompression device 37 is further decreased. When T3 - T3' ≥ ΔT7 is satisfied, control unit 46 determines whether or not the value of T3 - T3' is equal to or less than ΔT8 (S125). ΔT8 represents a temperature difference in the refrigerant suctioned to high-pressure side compressor 32 until the injection refrigerant is brought from the gas phase state into a state in which part of the gas phase is changed into the liquid phase and too much liquid refrigerant flows in inject pipe path 51, and ΔT8 is specified in advance through an experiment in which the state of the injection refrigerant is observed while changing ΔT8. By way of example, when t = 30 sec, ΔT8 = 15°C.

**[0083]** When T3 - T3' > ΔT8 is satisfied, the liquid phase ratio in the injection refrigerant is too large, so that the degree of opening of second decompression device 37 is increased (S126). When T3 - T3' ≤ ΔT8 is satisfied, the process returns to S123, in which temperature T3' of the refrigerant discharged from low-pressure side compressor 31 is detected again by temperature detecting unit 61.

**[0084]** The number of steps in adjusting the degree of opening of second decompression device 37 may be set at a small value when control precision is intended to be increased, whereas the number of steps in adjusting the degree of opening of second decompression device 37 may be set at a large value when control is performed to achieve a target degree of opening quickly.

**[0085]** According to the heat pump type heating device thus configured in the second embodiment of the present invention, an effect similar to that in first embodiment can be obtained.

**[0086]** The embodiments disclosed herein are illustrative and non-restrictive in any respect. The scope of the present invention is defined by the terms of the claims, rather than the embodiments described above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

## INDUSTRIAL APPLICABILITY

**[0087]** The present invention is applied to a heat pump type water heater, a heat pump type heating machine, or the like, for example.

## REFERENCE SIGNS LIST

**[0088]** 20: refrigeration circuit; 26: indoor side heat exchanger; 27: outdoor side heat exchanger; 31: low-pressure side compressor; 32: high-pressure side compressor; 36: first decompression device; 37: second decompression device; 38: gas-liquid separator; 38a: gas phase refrigerant space; 38b: liquid phase refrigerant space; 41, 42: buffer unit; 43: internal heat exchanger; 46: control unit; 50: injection circuit; 51: injection pipe path; 53: connection portion; 61, 62, 63, 64: temperature detecting unit.

## Claims

**1.** A heat pump type heating device comprising:

a first heat exchanger performing heat exchange between refrigerant and heat-receiving fluid;
a second heat exchanger performing heat exchange between the refrigerant and outdoor air;
a low-pressure side compressor compressing the refrigerant sent from said second heat exchanger;
a high-pressure side compressor compressing the refrigerant sent from said low-pressure side compressor;
a first decompression device decompressing the refrigerant sent from said first heat exchanger;
a gas-liquid separator separating the refrigerant sent from said first decompression device, into a gas phase and a liquid phase;
a second decompression device connected to a liquid phase side of said gas-liquid separator and decompressing the refrigerant sent from said gas-liquid separator;
an injection pipe path connected to a gas phase side of said gas-liquid separator and guiding the refrigerant sent from said gas-liquid separator, to a pipe path between said low-pressure side compressor and said high-pressure side compressor; and
a control unit controlling a decompression ratio of the refrigerant in said second decompression device such that the refrigerant flowing in said injection pipe path is brought into a gas-liquid two-phase state.

**2.** The heat pump type heating device according to claim 1, wherein said control unit further controls the decompression ratio of the refrigerant in said second decompression device such that a ratio of the liquid phase in the refrigerant, which flows in said injection pipe path and is in the gas-liquid two-phase state, does not become equal to or more than a predetermined value.

**3.** The heat pump type heating device according to claim 1 or 2, further comprising a first temperature detecting unit provided on the pipe path between said low-pressure side compressor and said high-pressure side compressor and detecting a temperature of the refrigerant having yet to be merged with the refrigerant flowing in said injection pipe path, wherein
said control unit controls the decompression ratio of the refrigerant in said second decompression device based on a time history of the temperature of the refrigerant detected by said first temperature detecting unit.

**4.** The heat pump type heating device according to claim 1 or 2, further comprising:

a second temperature detecting unit provided on said injection pipe path and detecting the temperature of the refrigerant flowing in said injection pipe path; and
a third temperature detecting unit provided on the pipe path between said low-pressure side compressor and said high-pressure side compressor and detecting the temperature of the refrigerant having been merged with the refrigerant flowing in said injection pipe path, wherein
said control unit controls the decompression ratio of the refrigerant in said second decompression device based on a difference between the temperature of the refrigerant detected by said second temperature detecting unit and the temperature of the refrigerant detected by said third temperature detecting unit.

**5.** The heat pump type heating device according to claim 1 or 2, further comprising a fourth temperature detecting unit provided on the pipe path between said low-pressure side compressor and said high-pressure side compressor and detecting the temperature of the refrigerant having been merged with the refrigerant flowing in said injection pipe path, wherein said control unit controls the decompression ratio of the refrigerant in said second decompression device based on a time history of the temperature of the refrigerant detected by said fourth temperature detecting unit.

**6.** The heat pump type heating device according to any one of claims 1 to 5, further comprising a buffer unit provided on the pipe path, which is between said low-pressure side compressor and said high-pressure side compressor and in which the refrigerant having been merged with the refrigerant flowing in said injection pipe path flows, and storing liquid refrigerant.

FIG.1

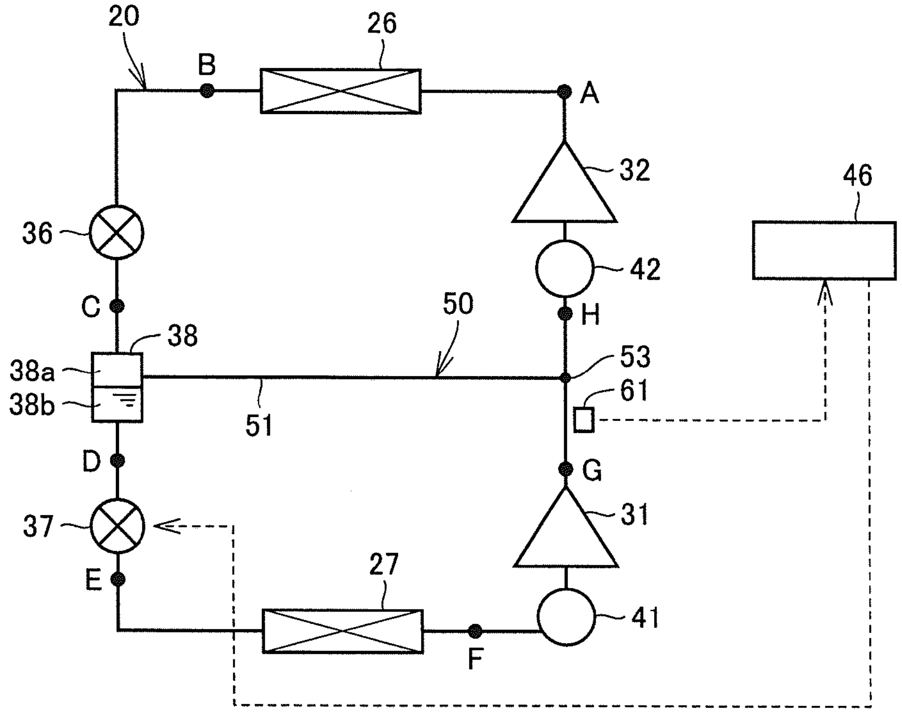

20
B
26
A
32
46
36
42
C
50
H
38
53
38a
61
38b
51
D
G
37
31
E
27
41
F

FIG.2

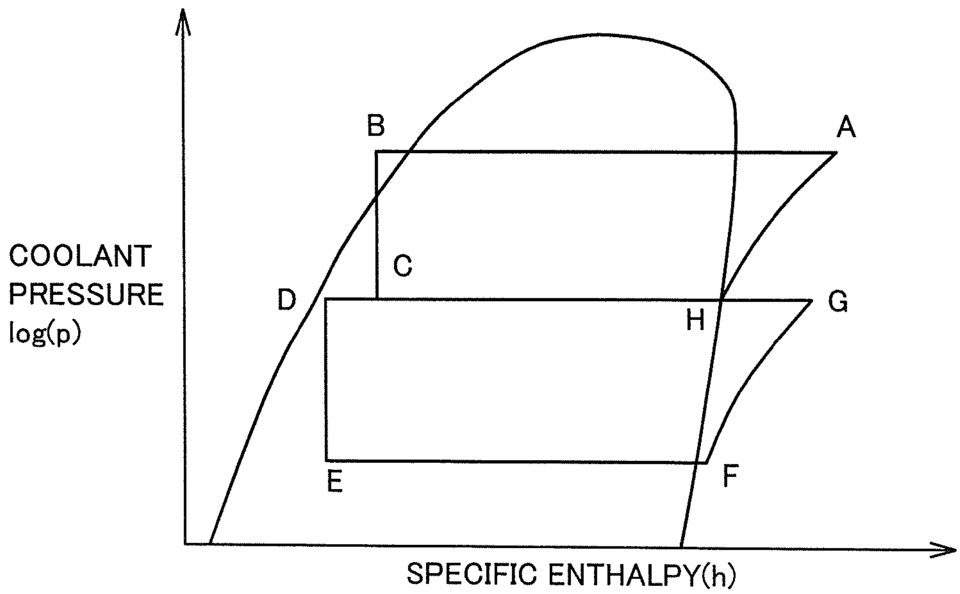

B
A
COOLANT
PRESSURE
log(p)
C
D
G
H
E
F
SPECIFIC ENTHALPY(h)

FIG.3

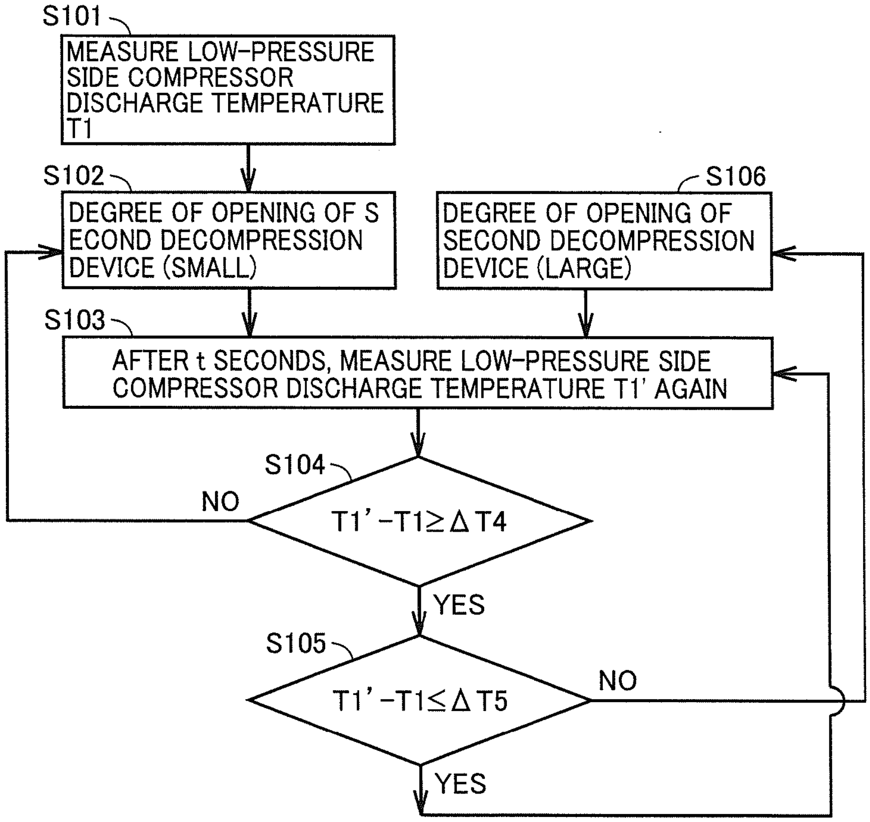
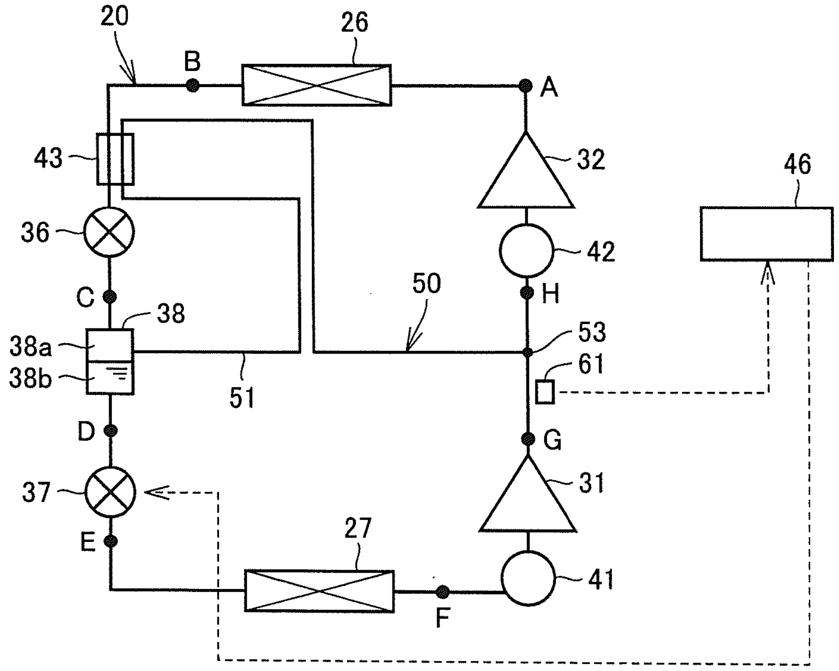

S101
MEASURE LOW-PRESSURE SIDE COMPRESSOR DISCHARGE TEMPERATURE T1
S102
DEGREE OF OPENING OF S ECOND DECOMPRESSION DEVICE (SMALL)
S106
DEGREE OF OPENING OF SECOND DECOMPRESSION DEVICE (LARGE)
S103
AFTER t SECONDS, MEASURE LOW-PRESSURE SIDE COMPRESSOR DISCHARGE TEMPERATURE T1' AGAIN
S104
NO
T1'-T1≥ΔT4
YES
S105
T1'-T1≤ΔT5
NO
YES

FIG.4


20
B
26
A
43
32
46
36
42
C
H
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38
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38a
61
38b
51
D
G
37
31
E
27
41
F

FIG.5

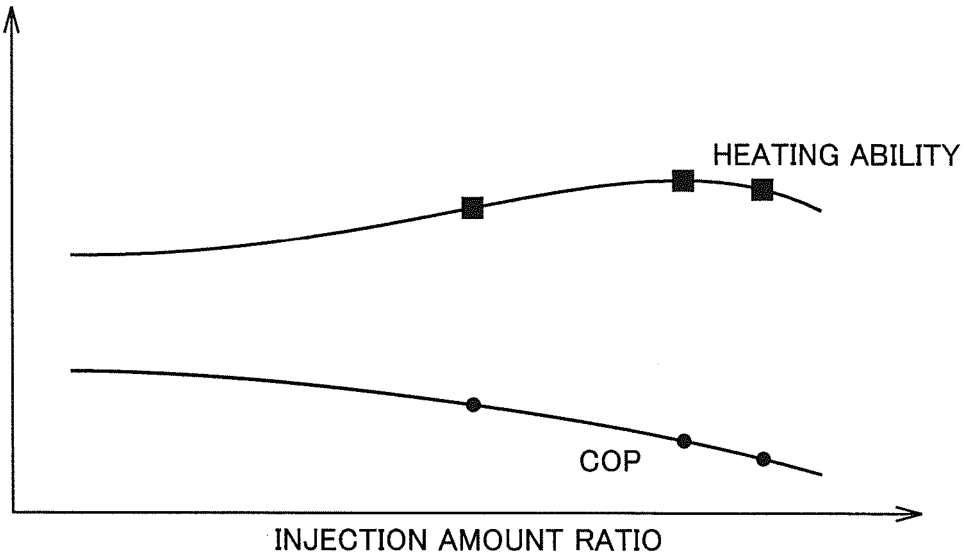

HEATING ABILITY
COP
INJECTION AMOUNT RATIO

FIG.6

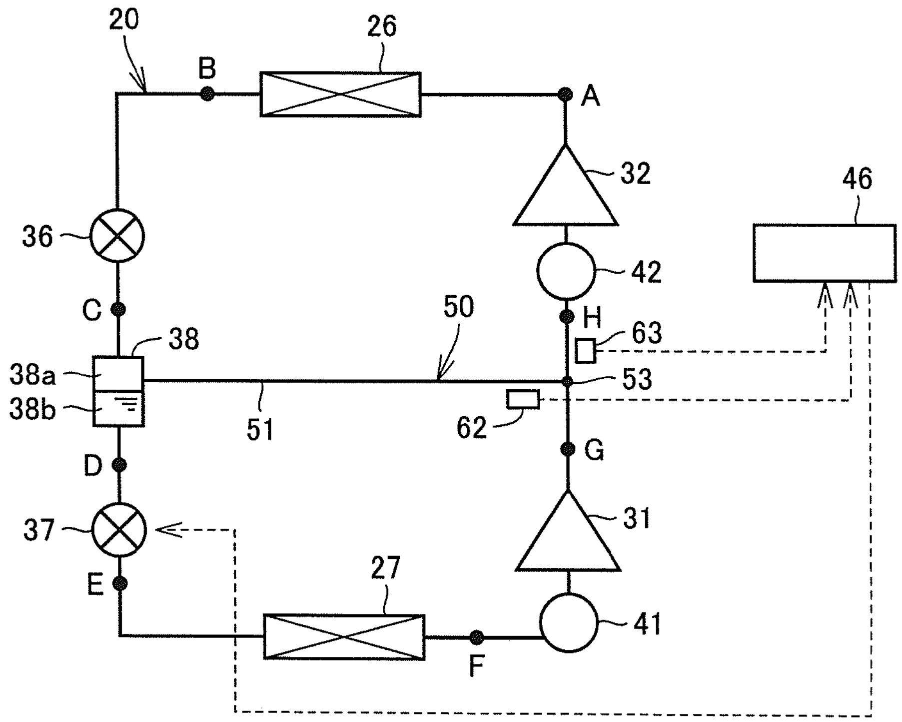

20
26
B
A
32
46
36
42
C
H
50
63
38
38a
53
38b
51
62
G
D
37
31
27
E
41
F

FIG.7

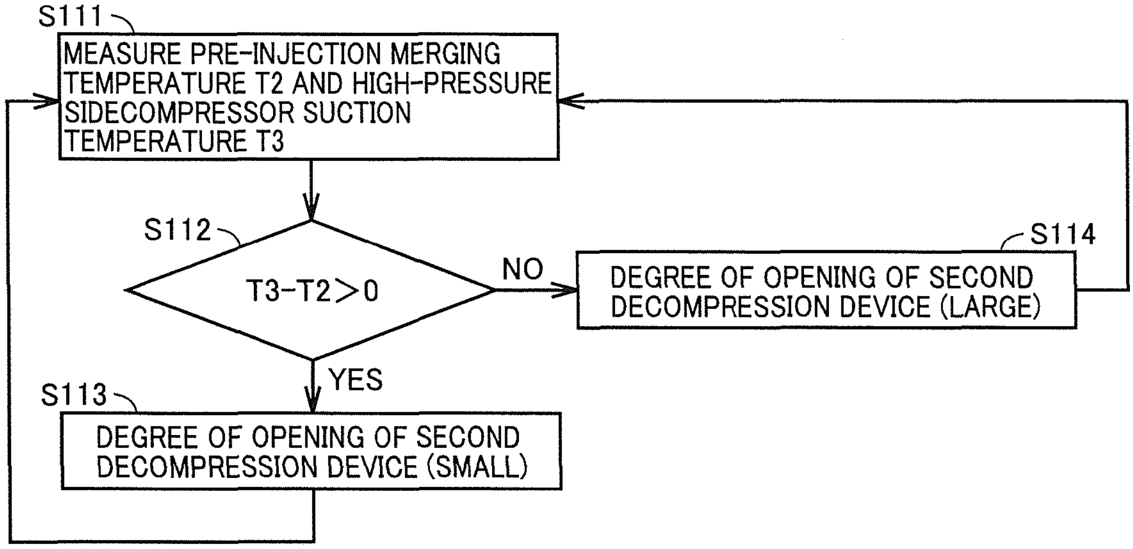

S111
MEASURE PRE-INJECTION MERGING TEMPERATURE T2 AND HIGH-PRESSURE SIDECOMPRESSOR SUCTION TEMPERATURE T3
S112
T3-T2>0
NO
S114
DEGREE OF OPENING OF SECOND DECOMPRESSION DEVICE (LARGE)
YES
S113
DEGREE OF OPENING OF SECOND DECOMPRESSION DEVICE (SMALL)

FIG.8

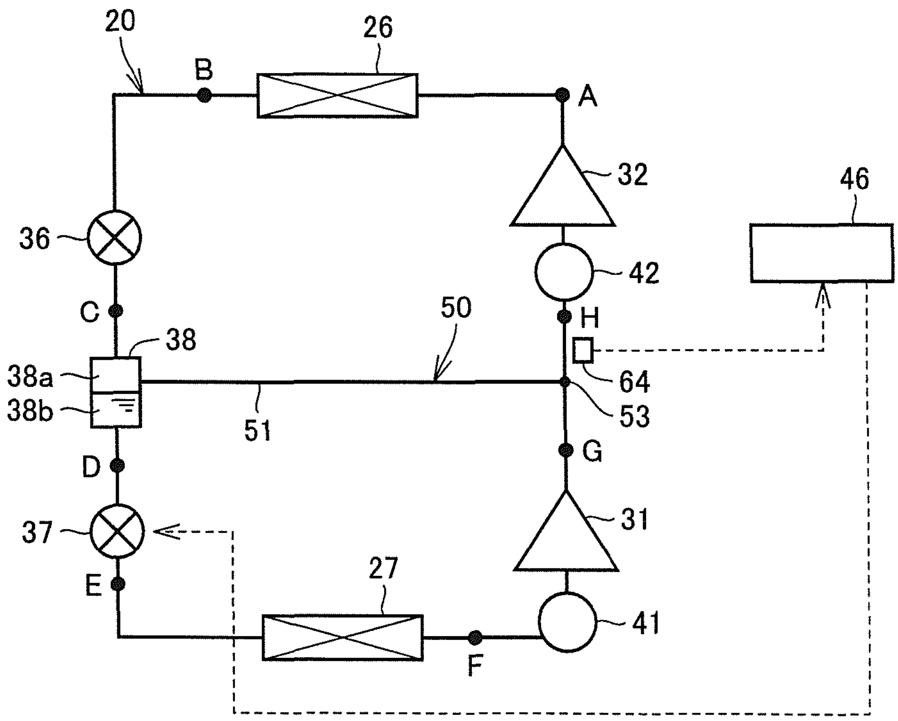
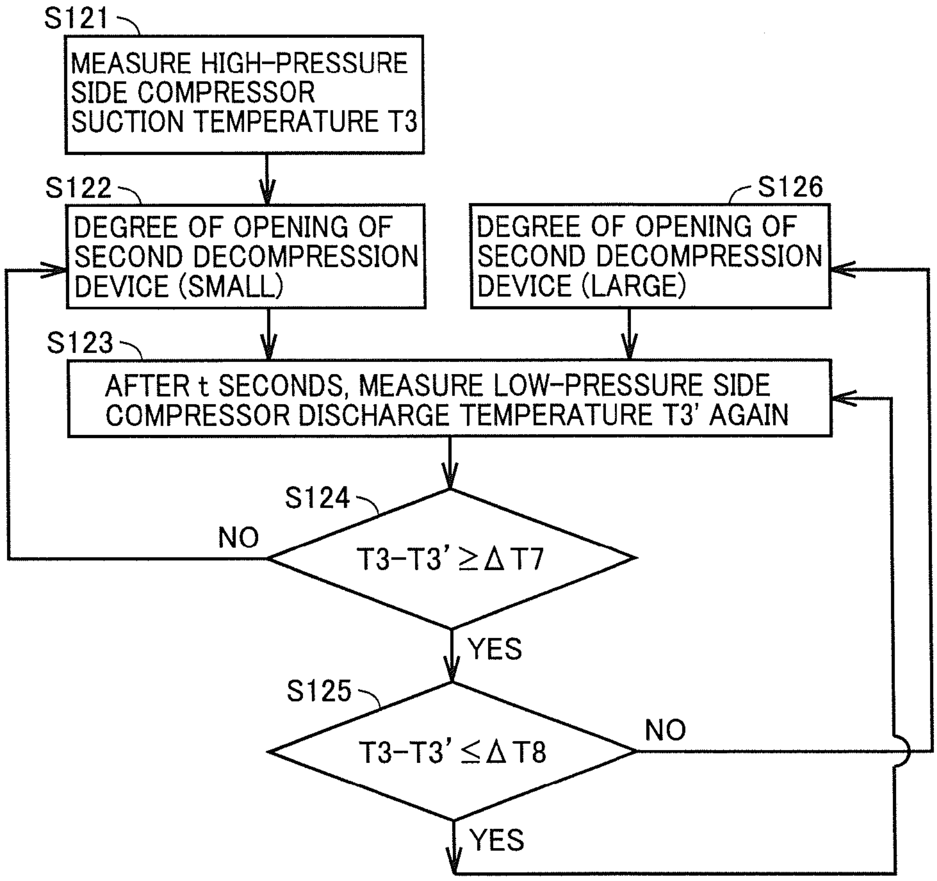

20
B
26
A
32
46
36
42
C
50
H
38
38a
64
38b
53
51
D
G
37
31
27
E
41
F

FIG.9


S121
MEASURE HIGH-PRESSURE SIDE COMPRESSOR SUCTION TEMPERATURE T3
S122
DEGREE OF OPENING OF SECOND DECOMPRESSION DEVICE (SMALL)
S126
DEGREE OF OPENING OF SECOND DECOMPRESSION DEVICE (LARGE)
S123
AFTER t SECONDS, MEASURE LOW-PRESSURE SIDE COMPRESSOR DISCHARGE TEMPERATURE T3' AGAIN
S124
NO
T3-T3' ≥ΔT7
YES
S125
T3-T3' ≤ΔT8
NO
YES

## INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/068515

A. CLASSIFICATION OF SUBJECT MATTER
*F25B1/10*(2006.01)i, *F25B1/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B1/10, F25B1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

| | | | |
|---|---|---|---|
| Jitsuyo Shinan Koho | 1922-1996 | Jitsuyo Shinan Toroku Koho | 1996-2013 |
| Kokai Jitsuyo Shinan Koho | 1971-2013 | Toroku Jitsuyo Shinan Koho | 1994-2013 |

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>A | JP 2009-300023 A (Mitsubishi Electric Corp.), 24 December 2009 (24.12.2009), paragraph [0048]; fig. 1 (Family: none) | 1-2,6<br>3-5 |
| A | JP 2008-2688 A (Sanyo Electric Co., Ltd.), 10 January 2008 (10.01.2008), fig. 1 to 3 (Family: none) | 1-6 |

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| | |
|---|---|
| Date of the actual completion of the international search<br>15 August, 2013 (15.08.13) | Date of mailing of the international search report<br>27 August, 2013 (27.08.13) |
| Name and mailing address of the ISA/<br>Japanese Patent Office<br>Facsimile No. | Authorized officer<br><br>Telephone No. |

Form PCT/ISA/210 (second sheet) (July 2009)

## REFERENCES CITED IN THE DESCRIPTION

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- JP 11132575 A **[0004] [0008]**
- JP 2007263440 A **[0006] [0008]**