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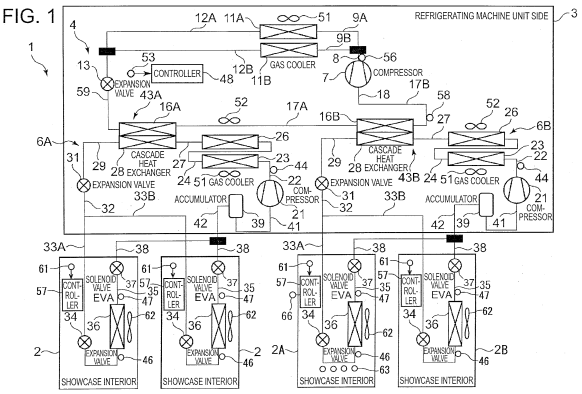
(54) REFRIGERATION DEVICE

(57) There is prevented burning or performance deterioration of a compressor which is caused by oil confined in an evaporator of a switchable showcase, when a solenoid valve is disposed on a refrigerant downstream side of the evaporator. A showcase 2A is a switchable showcase which is usable in switching a cooling mode to cool an interior of a display chamber, a non-cooling mode in which the interior of the display chamber is not cooled and/or a heating mode to heat the interior of the display chamber by an electric heater 63. A controller 57 of the showcase 2A controls a valve position of a low stage side expansion valve 34 and opens and closes a solenoid valve 37 in the cooling mode, and shuts off the low stage side expansion valve 34 and opens the solenoid valve 37 in the non-cooling mode and/or the heating mode.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a refrigeration device in which a refrigerant is distributed and supplied from a compressor to respective evaporators arranged in a plurality of showcases, thereby cooling interiors of display chambers of the respective showcases.

Background Art

[0002] Heretofore, in stores such as a convenience store and a supermarket, there have been installed a plurality of showcases to display and sell articles while cooling the articles in display chambers. Evaporators to cool interiors of the display chambers are arranged in the showcases, and to the evaporators, a refrigerant is distributed and supplied via expansion valves from a compressor of a refrigerating machine unit installed, for example, outside the store.

[0003] In this case, control of the compressor is executed on the basis of a pressure on a low pressure side, and a valve position of the expansion valve on a refrigerant upstream side of the evaporator of the showcase is controlled on the basis of a refrigerant superheat degree in the evaporator. The expansion valve is controlled in accordance with this refrigerant superheat degree to prevent the compressor from sucking a liquid refrigerant (so-called liquid backflow prevention), and the valve position of the expansion valve is controlled to adjust the superheat degree of the refrigerant in the evaporator to an appropriate value.

[0004] Furthermore, a solenoid valve (a liquid solenoid valve) is disposed on a refrigerant upstream side of the expansion valve disposed in each showcase, and the solenoid valve is closed, when a chamber inside temperature drops down to a target chamber inside temperature and the cooling of the interior of the display chamber is not required. Then, the control is executed to stop the compressor, when all the solenoid valves are closed to lower the pressure on the low pressure side.

[0005] Additionally, the compressor is also connected to a switchable showcase (H/C showcase) which is switchable and usable in a use state of cooling the interior of the display chamber (a cool case) and a use state of heating the interior of the chamber by a heater (a hot case). In such a switchable showcase, when the interior of the display chamber is cooled and used, the solenoid valve is opened, to supply the refrigerant to the evaporator via the expansion valve. On the other hand, when the interior of the display chamber is heated and used, the solenoid valve and the expansion valve are closed to cut off the supply of the refrigerant to the evaporator (e.g., see Patent Document 1).

[0006] Furthermore, in recent years, carbon dioxide has been used as the refrigerant also in this type of showcase, considering from global environmental problems, but a comparatively large type of compressor is required to compress this carbon dioxide. To eliminate such a problem, there has been developed a refrigeration device in which a high stage side refrigerant circuit and a low stage side refrigerant circuit are connected in cascade to independently constitute refrigerant closed circuits, respectively, and a refrigerant of the high stage side refrigerant circuit is evaporated to subcool a high pressure-side refrigerant of the low stage side refrigerant circuit, so that a required refrigerating capability is obtainable in an evaporator of the low stage side refrigerant circuit (e.g., see Patent Document 2).

Citation List

Patent Documents

[0007]

Patent Document 1: Japanese Patent Application Publication No. 2003-172556
Patent Document 2: Japanese Patent Application Publication No. 2000-205672

Summary of the Invention

Problems to be solved by the Invention

[0008] Here, in a refrigeration device using carbon dioxide as a refrigerant as described above, a pressure in a refrigerant circuit comparatively heightens, and hence a refrigerant pressure on a high pressure side conspicuously fluctuates due to opening/closing of a solenoid valve (a liquid solenoid valve). To eliminate such a problem, it is considered that the solenoid valve is not disposed on a refrigerant upstream side of an expansion valve as described above, but is disposed on a refrigerant downstream side of an evaporator, to utilize the evaporator as a so-called buffer tank.

[0009] In this case, when the expansion valve and the solenoid valve are closed to heat and use an interior of a display chamber of a switchable showcase as described above, there occurs the problem that a refrigerant to cool the other showcase connected to a compressor reversely flows via the solenoid valve into the evaporator of the switchable showcase which is heated and used, oil circulating together with the refrigerant in the refrigerant circuit is confined in the evaporator of this switchable showcase, and oil in the compressor runs out.

[0010] The reason for this problem lies in a structure of the solenoid valve. Hereinafter, the reason will be described with reference to FIG. 3. FIG. 3 is a partially perspective view showing the structure of a usual solenoid valve V (an after-mentioned solenoid valve 37 of an embodiment) for use in a refrigerant circuit of this type of refrigeration device. In this drawing, reference numeral 71 denotes a valve body which is always urged to be pressed onto a valve seat 73 from the upside by a spring

72. Reference numeral 35 denotes an inlet pipe opened to a side of the valve body 71, and 38 denotes an outlet pipe opened in the valve seat 73. When the solenoid valve V is disposed on a refrigerant downstream side of an evaporator as described above, the inlet pipe 35 communicates and connects with an outlet of the evaporator, and the outlet pipe 38 communicates and connects with a suction side of a compressor via an accumulator and the like.

[0011] Reference numeral 77 denotes a coil, and when the coil 77 is in a non-energized (OFF) state, the valve body 71 is pressed onto the valve seat 73 by the spring 72, to close an opening of the outlet pipe 38, thereby closing a flow path. Then, on energizing the coil 77 (ON), the valve body 71 is raised upward against an urging force of the spring 72 by an electromagnetic suction force, and is disposed away from the valve seat 73 to open the opening of the outlet pipe 38, thereby opening the flow path. When the flow path opens, the refrigerant flows from the inlet pipe 35 into the solenoid valve V (IN), and flows out from the outlet pipe 38 (OUT).

[0012] Here, when a solenoid valve V of the other showcase is closed, pressures on an evaporator side and a compressor side of the solenoid valve V of the switchable showcase (a coil 77 is off) are balanced. However, when the solenoid valve V of the other showcase is opened, on startup of the compressor, a phenomenon occurs in which the pressure on the compressor side of the solenoid valve V of the switchable showcase, i.e., the pressure on an outlet pipe 38 side rises under an influence of a pressure on a high pressure side. Therefore, although the coil 77 is non-energized (OFF), the valve body 71 is pushed upward against the urging force of the spring 72, and separated from the valve seat 73, and the refrigerant reversely flows from the inlet pipe 35 into the evaporator of the switchable showcase (as shown by a bold arrow in FIG. 3). Then, together with the refrigerant, a compressor lubricating oil reversely flows into the evaporator of the switchable showcase at this time.

[0013] Due to such a reverse inflow of the refrigerant, the pressure in the evaporator of the switchable showcase also rises, and hence the pressures on the evaporator side (an inlet pipe 35 side) of the solenoid valve V and on the compressor side (the outlet pipe 38 side) thereof are balanced. However, afterward, by an operation of the compressor, the pressure on the suction side of the compressor is lower than that on the evaporator side, and hence the refrigerant reversely flowing into the evaporator of the switchable showcase in a gas state leaks through a small clearance between the valve body 71 and the valve seat 73 due to a pressure difference, and flows out to the compressor side (the outlet pipe 38 side). However, the oil is liquefied, and hence the oil cannot flow out from the clearance between the valve body 71 and the valve seat 73, and as a result, the oil only remains in the evaporator of the switchable showcase.

[0014] On the other hand, the switchable showcase is used in a heating state over several months in winter. Therefore, when such a phenomenon as described is repeated, the oil circulating in the refrigerant circuit is confined in large amounts within the evaporator of the switchable showcase, and the oil in the compressor eventually runs out to cause burning or performance deterioration due to a seal defect.

[0015] The present invention has been developed to solve such conventional technical problems, and an object thereof is to provide a refrigeration device capable of preventing burning or performance deterioration of a compressor which is caused by oil confined in an evaporator of a switchable showcase, when a solenoid valve is disposed on a refrigerant downstream side of the evaporator.

Means for solving the Problems

[0016] To solve the above problems, a refrigeration device of the invention of claim 1 in which a refrigerant is distributed and supplied from a compressor to respective evaporators arranged in a plurality of showcases is characterized in that each showcase includes an expansion valve disposed on a refrigerant upstream side of the evaporator, a solenoid valve disposed on a refrigerant downstream side of the evaporator, and a controller which controls the expansion valve and the solenoid valve, at least one of the showcases is a switchable showcase which is usable in switching a cooling mode to cool an interior of a display chamber, a non-cooling mode in which the interior of the display chamber is not cooled and/or a heating mode to heat the interior of the display chamber by a heater, and the controller of the switchable showcase controls a valve position of the expansion valve and opens and closes the solenoid valve in the cooling mode, and shuts off the expansion valve and opens the solenoid valve in the non-cooling mode and/or the heating mode.

[0017] The refrigeration device of the invention of claim 2 is characterized in that in the above invention, the controller of the switchable showcase opens the expansion valve for a predetermined period of time, at a predetermined timing in the non-cooling mode and/or the heating mode.

[0018] A refrigeration device of the invention of claim 3 in which a refrigerant is distributed and supplied from a compressor to respective evaporators arranged in a plurality of showcases is characterized in that each showcase includes an expansion valve disposed on a refrigerant upstream side of the evaporator, a solenoid valve disposed on a refrigerant downstream side of the evaporator, and a controller which controls the expansion valve and the solenoid valve, at least one of the showcases is a switchable showcase which is usable in switching a cooling mode to cool an interior of a display chamber, a non-cooling mode in which the interior of the display chamber is not cooled and/or a heating mode to heat the interior of the display chamber by a heater, and the controller of this switchable showcase controls a valve

position of the expansion valve and opens and closes the solenoid valve in the cooling mode, and shuts off the expansion valve, closes the solenoid valve, and opens the expansion valve and the solenoid valve for a predetermined period of time, at a predetermined timing in the non-cooling mode and/or the heating mode.

[0019] The refrigeration device of the invention of claim 4 is characterized in that in the invention of claim 2 or claim 3, the controller of the switchable showcase opens the expansion valve, or this expansion valve and the solenoid valve for a predetermined period of time, at a timing after end of defrosting of the evaporator of the other showcase in the non-cooling mode and/or the heating mode.

[0020] The refrigeration device of the invention of claim 5 is characterized in that in the inventions of claim 2 to claim 4, the controller of the switchable showcase opens the expansion valve, or this expansion valve and the solenoid valve for a predetermined period of time, at a starting point issuing timing of the expansion valve of the other showcase in the non-cooling mode and/or the heating mode.

[0021] The refrigeration device of the invention of claim 6 is characterized in that in the inventions of claim 2 to claim 5, the controller of the switchable showcase forces the heater to generate heat, when opening the expansion valve, or this expansion valve and the solenoid valve in the non-cooling mode and/or the heating mode.

[0022] The refrigeration device of the invention of claim 7 is characterized in that in the above respective inventions, when cooling the interior of the display chamber, the controller controls a refrigerant superheat degree in the evaporator by the valve position of the expansion valve in a state where the solenoid valve is opened, and when the cooling of the interior of the display chamber is not required, the controller closes the solenoid valve.

[0023] The refrigeration device of the invention of claim 8 includes a low stage side refrigerant circuit including the compressor, the expansion valve, the solenoid valve and the evaporator, and a high stage side refrigerant circuit which is independent of this low stage side refrigerant circuit in the above respective inventions, and is characterized in that a high pressure side refrigerant of the low stage side refrigerant circuit is cooled by an evaporator of the high stage side refrigerant circuit.

[0024] The refrigeration device of the invention of claim 9 is characterized in that in the above respective inventions, carbon dioxide is used as the refrigerant in the refrigerant circuit.

Advantageous Effect of the Invention

[0025] According to the invention of claim 1, in a refrigeration device in which a refrigerant is distributed and supplied from a compressor to respective evaporators arranged in a plurality of showcases, each showcase includes an expansion valve disposed on a refrigerant upstream side of the evaporator, a solenoid valve disposed on a refrigerant downstream side of the evaporator, and a controller which controls the expansion valve and the solenoid valve, at least one of the showcases is a switchable showcase which is usable in switching a cooling mode to cool an interior of a display chamber, a non-cooling mode in which the interior of the display chamber is not cooled and/or a heating mode to heat the interior of the display chamber by a heater, and the controller of this switchable showcase controls a valve position of the expansion valve and opens and closes the solenoid valve in the cooling mode, and shuts off the expansion valve and opens the solenoid valve in the non-cooling mode and/or the heating mode. Therefore, for example, when carbon dioxide is used as the refrigerant as in the invention of claim 9, the expansion valve is disposed on the refrigerant upstream side of the evaporator and the solenoid valve is disposed on the refrigerant downstream side of the evaporator as described above. In the cooling mode, for example, as in the invention of claim 7, the controller controls a refrigerant superheat degree in the evaporator by the valve position of the expansion valve in a state where the solenoid valve is opened, and the controller performs control to close the solenoid valve when the cooling of the interior of the display chamber is not required, whereas in the non-cooling mode and/or the heating mode, the controller shuts off the expansion valve, and opens the solenoid valve, thereby eliminating the conventional problem that, due to a difference between a pressure on an evaporator side of the solenoid valve and a pressure on a compressor side thereof, the refrigerant reversely flows from the closed solenoid valve into the evaporator of the switchable showcase and oil is confined in the evaporator.

[0026] In consequence, it is possible to avoid, in advance, generation of the disadvantage that a compressor lubricating oil runs out to cause burning or performance deterioration of the compressor. At this time, the expansion valve of the switchable showcase is closed, and hence the interior of the display chamber of the switchable showcase is not unnecessarily cooled in the non-cooling mode or the heating mode.

[0027] Furthermore, when the controller of the switchable showcase opens the expansion valve for a predetermined period of time, at a predetermined timing in the non-cooling mode and/or the heating mode as in the invention of claim 2 in addition to the above invention, the oil adhering on an inner wall of the evaporator of the switchable showcase can be washed away to the compressor side by opening the expansion valve. In consequence, it is possible to effectively eliminate an oil shortage of the compressor.

[0028] According to the invention of claim 3, in a refrigeration device in which a refrigerant is distributed and supplied from a compressor to respective evaporators arranged in a plurality of showcases, each showcase includes an expansion valve disposed on a refrigerant upstream side of the evaporator, a solenoid valve disposed on a refrigerant downstream side of the evaporator, and

a controller which controls the expansion valve and the solenoid valve, at least one of the showcases is a switchable showcase which is usable in switching a cooling mode to cool an interior of a display chamber, a non-cooling mode in which the interior of the display chamber is not cooled and/or a heating mode to heat the interior of the display chamber by a heater, and the controller of this switchable showcase controls a valve position of the expansion valve and opens and closes the solenoid valve in the cooling mode, and shuts off the expansion valve, closes the solenoid valve, and opens the expansion valve and the solenoid valve for a predetermined period of time, at a predetermined timing in the non-cooling mode and/or the heating mode. Consequently, similarly when carbon dioxide is used as the refrigerant as in the invention of claim 9, the expansion valve is disposed on the refrigerant upstream side of the evaporator, and the solenoid valve is disposed on the refrigerant downstream side of the evaporator as described above. In the cooling mode, similarly as in the invention of claim 7, the controller controls a refrigerant superheat degree in the evaporator by the valve position of the expansion valve in a state where the solenoid valve is opened, and the controller executes control to close the solenoid valve when the cooling of the interior of the display chamber is not required, whereas in the non-cooling mode and/or the heating mode, the controller shuts off the expansion valve, closes the solenoid valve, and opens the expansion valve and the solenoid valve for the predetermined period of time at the predetermined timing. As in a conventional device, due to a difference between a pressure on an evaporator side of the solenoid valve and a pressure on a compressor side thereof, the refrigerant reversely flows from the closed solenoid valve into the evaporator of the switchable showcase and oil is confined in the evaporator. Even in this case, the controller opens the solenoid valve for the predetermined period of time, and hence this confined oil can be returned to the compressor side.

[0029] In consequence, it is possible to avoid, in advance, the generation of the disadvantage that the compressor lubricating oil runs out to cause the burning or performance deterioration of the compressor. Especially in this case, when the solenoid valve is opened, the controller also opens the expansion valve for the predetermined period of time. Therefore, the oil adhering on the inner wall of the evaporator of the switchable showcase can be washed away to the compressor side by opening the expansion valve, and it is possible to effectively eliminate the oil shortage of the compressor.

[0030] In the above invention of claim 2 or claim 3, the controller of the switchable showcase opens the expansion valve, or this expansion valve and the solenoid valve for a predetermined period of time, at a timing after end of defrosting of the evaporator of the other showcase in the non-cooling mode and/or the heating mode. Consequently, the oil can be washed away from the evaporator of the switchable showcase in a state where the refrigerant is comparatively stable, so that it is possible to prevent the disadvantage that the compressor stops, or the like when a protecting function works due to pressure fluctuation by the opening of the expansion valve.

[0031] Furthermore, after the end of the defrosting, when the expansion valve is opened, a temperature of the refrigerant flowing into the evaporator of the switchable showcase comparatively heightens. Therefore, an evaporation pressure also heightens, and it is also possible to effectively eliminate the disadvantage that dew condensation occurs on a wall surface in the vicinity of the evaporator of the switchable showcase, or the like. Furthermore, after the end of the defrosting, the compressor is also strongly operated, and hence it is possible to immediately suck the oil in the evaporator of the switchable showcase.

[0032] Additionally, as in the invention of claim 5, the controller of the switchable showcase may open the expansion valve, or this expansion valve and the solenoid valve for a predetermined period of time, at a starting point issuing timing of the expansion valve of the other showcase in the non-cooling mode and/or the heating mode. When issuing a starting point of the expansion valve, the compressor is usually stopped, and hence there is also eliminated the fear that the pressure fluctuates due to the opening of the expansion valve or solenoid valve of the switchable showcase.

[0033] Furthermore, as in the invention of claim 6, the controller of the switchable showcase forces the heater to generate heat, when opening the expansion valve, or this expansion valve and the solenoid valve in the non-cooling mode and/or the heating mode. Consequently, a temperature drop in the display chamber due to the inflow of the refrigerant into the evaporator of the switchable showcase in the non-cooling mode or the heating mode can be cancelled with the heat generation of the heater, and the occurrence of the dew condensation or the like can securely be eliminated.

[0034] Furthermore, especially when carbon dioxide is used as the refrigerant as in the invention of claim 9, the present invention is remarkably effectively applied to a low stage side refrigerant circuit of a so-called two-stage refrigeration device as in the invention of claim 8.

Brief Description of the Drawings

[0035]

FIG. 1 is a refrigerant circuit diagram of a refrigeration device of one embodiment to which the present invention is applied;

FIG. 2 is a timing chart to explain control of an expansion valve which is to be executed by a controller of a switchable showcase of FIG. 1; and

FIG. 3 is a view to explain a usual structure of this type of solenoid valve.

Mode for carrying out the Invention

[0036] Hereinafter, description will be made as to embodiments of the present invention in detail. FIG. 1 is a refrigerant circuit diagram of a refrigeration device 1 of one embodiment to which the present invention is applied.

Embodiment 1

[0037] A refrigeration device 1 of an embodiment supplies a refrigerant from a refrigerating machine unit 3 installed outside a store such as a convenience store or a supermarket to a plurality of showcases 2 (2A and 2B, four showcases in total in the embodiment) installed in the store, and is constituted of one unit of high stage side refrigerant circuit 4, and a plurality of (two systems in the embodiment) low stage side refrigerant circuits (a first low stage side refrigerant circuit 6A and a second low stage side refrigerant circuit 6B (the refrigerant circuit to which the present invention is applied)) which are independent of the high stage side refrigerant circuit 4.

[0038] The high stage side refrigerant circuit 4 of this embodiment includes a high stage side compressor 7 constituted of a scroll compressor, first and second (a plurality of) high stage side gas coolers (radiators) 11A and 11B which are disposed in parallel with each other and connected to branch pipes 9A and 9B branching from a discharge pipe 8 of the high stage side compressor 7, respectively, a high stage side expansion valve 13 connected to a downstream of a joining point between an outlet pipe 12A of the first high stage side gas cooler 11A and an outlet pipe 12B of the second high stage side gas cooler 11B, a first high stage side evaporator 16A connected to an outlet pipe 59 of the high stage side expansion valve 13, and a second high stage side evaporator 16B connected to an outlet pipe 17A of the first high stage side evaporator 16A, and an outlet pipe 17B of the second high stage side evaporator 16B is connected to a suction pipe 18 of the high stage side compressor 7 to constitute a refrigerating cycle. A predetermined amount of carbon dioxide is enclosed as the refrigerant in the high stage side refrigerant circuit 4. It is to be noted that reference numeral 58 denotes a temperature sensor attached to the outlet pipe 17B to detect a temperature or the refrigerant flowing out from the second high stage side evaporator 16B.

[0039] On the other hand, the low stage side refrigerant circuits 6A and 6B have the same constitution. Specifically, the low stage side refrigerant circuit 6A of the embodiment (the low stage side refrigerant circuit 6B similarly) includes a low stage side compressor (the compressor of the present invention) 21 also constituted of a scroll compressor, a first low stage side gas cooler (a radiator) 23 connected to a discharge pipe 22 of the low stage side compressor 21, a second low stage side gas cooler (a radiator) 26 connected to an outlet pipe 24 of the first low stage side gas cooler and disposed on a refrigerant downstream side of the first low stage side gas cooler 23, a subcooling heat exchanger 28 connected to an outlet pipe 27 of the second low stage side gas cooler 26, a pressure adjusting expansion valve 31 connected to an outlet pipe 29 of the subcooling heat exchanger 28, low stage side expansion valves (expansion valves of the present invention) 34 and 34 connected to branch pipes 33A and 33B branching from an outlet pipe 32 of the pressure adjusting expansion valve 31, respectively, and low stage side evaporators (evaporators of the present invention) 36 and 36 connected to outlet sides of the respective low stage side expansion valves 34 and 34. In other words, the expansion valve 34 is disposed on a refrigerant upstream side of the low stage side evaporator 36.

[0040] Two series circuits each including the low stage side expansion valve 34 and the low stage side evaporator 36 are connected in parallel with each other in the embodiment, and the respective series circuits are arranged in two (a plurality of) showcases 2 (2A and 2B), respectively. Next, an outlet of the low stage side evaporator 36 in each of the showcases 2 (2A and 2B) is connected to an inlet pipe 35 of a solenoid valve (the solenoid valve of the present invention) 37, and outlet pipes 38 of the respective solenoid valves 37 join each other, extend through an inlet pipe 42 and are then connected to an accumulator 39. Then, an outlet side of the accumulator 39 is connected to a suction pipe 41 of the low stage side compressor 21 to constitute a refrigerating cycle.

[0041] The solenoid valve 37 has the same structure as in the above-mentioned solenoid valve V (FIG. 3) and is disposed on a refrigerant downstream side of the low stage side evaporator 36, and the inlet pipe 35 and the outlet pipe 38 are denoted with the same reference numerals. The solenoid valve 37 is connected to the refrigerant downstream side of the low stage side evaporator 36, and consequently, the low stage side evaporators 36 are positioned on a high pressure side of the low stage side refrigerant circuits 6A and 6B to the solenoid valves 37. Consequently, also when the solenoid valve 37 is opened and closed, the low stage side evaporator 36 functions as a buffer tank, and fluctuations of a refrigerant pressure on the high pressure side are buffered. Furthermore, the accumulator 39 is a tank having a predetermined capacity. Furthermore, a predetermined amount of carbon dioxide is also enclosed as the refrigerant in each of the low stage side refrigerant circuits 6A and 6B.

[0042] Then, the first high stage side evaporator 16A of the high stage side refrigerant circuit 4 and the subcooling heat exchanger 28 of the low stage side refrigerant circuit 6A are arranged in a heat exchange relation to constitute a first cascade heat exchanger 43A, and the second high stage side evaporator 16B of the high stage side refrigerant circuit 4 and the subcooling heat exchanger 28 of the low stage side refrigerant circuit 6B are arranged in a heat exchange relation to constitute a second cascade heat exchanger 43B. Consequently, the

first high stage side evaporator 16A and the second high stage side evaporator 16B of the high stage side refrigerant circuit 4 are configured to cool a high pressure side refrigerant flowing through the subcooling heat exchangers 28 of the low stage side refrigerant circuits 6A and 6B. Furthermore, the branch pipes 33A and 33B and the outlet pipe 38 extend from the refrigerating machine unit 3 to each of the showcases 2 (2A and 2B).

[0043] In the drawing, reference numeral 44 denotes a pressure sensor attached to the discharge pipe 22 of the low stage side compressor 21 of each low stage side refrigerant circuit 6A or 6B, to detect a pressure of the high pressure side refrigerant discharged from the low stage side compressor 21. In the drawing, reference numeral 56 denotes a pressure sensor attached to the discharge pipe 8 of the high stage side compressor 7 to detect a discharge pressure of the high stage side compressor 7 (a high pressure-side pressure of the high stage side refrigerant circuit 4), and 58 denotes a pressure sensor attached to the outlet pipe 17B to detect a suction pressure of the high stage side compressor 7 (a low pressure-side pressure of the high stage side refrigerant circuit 4).

[0044] In the drawing, reference numerals 51 and 52 denote first and second blowers for the gas coolers, the first blower 51 for the gas cooler passes air through the respective high stage side gas coolers 11A and 11B and the first low stage side gas cooler 23 to perform air cooling of the coolers, and the second blower 52 for the gas cooler passes air through the second low stage side gas cooler 26 to perform the air cooling. Furthermore, in the drawing, reference numeral 53 denotes a temperature sensor 53 which detects an outdoor air temperature.

[0045] Furthermore, in the drawing, reference numeral 48 denotes a controller on a refrigerating machine unit 3 side, which controls an operation frequency of the high stage side compressor 7 of the high stage side refrigerant circuit 4, a valve position of the high stage side expansion valve 13, operation frequencies of the low stage side compressors 21 of the low stage side refrigerant circuits 6A and 6B, a valve position of the pressure adjusting expansion valve 31, and operations of the respective blowers 51 and 52 for the gas coolers, on the basis of outputs of the respective sensors 44, 53, 56, 58 and others.

[0046] Furthermore, also in each of the showcases 2 (2A and 2B), a showcase side controller (a controller of the present invention) 57 is disposed. Additionally, a refrigerant inlet temperature sensor (a refrigerant inlet temperature detecting means) 46 which detects a refrigerant inlet temperature of the low stage side evaporator 36 is attached to a refrigerant inlet side of the low stage side evaporator 36 of each of the showcases 2 (2A and 2B), and a refrigerant outlet temperature sensor (a refrigerant outlet temperature detecting means) 47 which detects a refrigerant outlet temperature of the low stage side evaporator 36 is attached to a refrigerant outlet side of the low stage side evaporator 36.

[0047] In the drawing, reference numeral 61 denotes a chamber inside temperature sensor (a chamber inside temperature detecting means) which detects a chamber inside temperature that is a temperature in the display chamber of each of the showcases 2 (2A and 2B). In the drawing, reference numeral 62 denotes a cold air circulating blower to circulate cold air subjected to heat exchange with the low stage side evaporator 36 in the display chamber of each of the showcases 2 (2A and 2B), and the controller 57 controls a valve position of the low stage side expansion valve 34, the opening/closing of the solenoid valve 37, and an operation of the cold air circulating blower 62 on the basis of outputs of the respective sensors 46, 47, 61 and others.

[0048] Here, the showcase (denoted with 2A in the drawing) to be cooled by the low stage side refrigerant circuit 6B is a switchable showcase (referred to as a hot and cold (H/C) type showcase) which is capable of switching a cooling mode to cool and use the interior of the display chamber, a non-cooling mode in which the interior of the display chamber is not cooled but is used at ambient temperature, and a heating mode to heat and use the interior of the display chamber in the embodiment, and an electric heater (a heater) 63 which heats the interior of the display chamber is disposed on a shelf or the like provided in the display chamber. Furthermore, reference numeral 66 denotes a change-over switch to change an operation mode of the showcase 2A to the cooling mode, the non-cooling mode, or the heating mode, and this switch is connected to the controller 57 of the showcase 2A.

[0049] Furthermore, the showcase (denoted with 2B in the drawing) to be cooled similarly by the low stage side refrigerant circuit 6B is a showcase to refrigerate and sell boxed lunches in the embodiment. Additionally, the refrigerant is distributed and supplied from the low stage side compressor 21 of the low stage side refrigerant circuit 6B to the low stage side evaporators 36 of the showcases 2A and 2B.

[0050] It is to be noted that the controllers 57 of the showcases 2 (2A and 2B) and the controller 48 of the refrigerating machine unit 3 are controlled in a centralized manner by an integrated control device (not shown) disposed in the store, and cooperate with one another.

(1) Operation of High Stage Side Refrigerant Circuit 4

[0051] In the above-mentioned constitution, when the controller 48 operates the high stage side compressor 7 of the high stage side refrigerant circuit 4, the low stage side compressors 21 of the low stage side refrigerant circuits 6A and 6B, and the respective blowers 51 and 52 for the gas coolers, a high-temperature high-pressure refrigerant (carbon dioxide) compressed by the high stage side compressor 7 is discharged to the discharge pipe 8 and distributed to the branch pipes 9A and 9B, and then the refrigerants flow into the respective high stage side gas coolers 11A and 11B. The refrigerants

flowing into the respective high stage side gas coolers 11A and 11B are cooled in a supercritical state by the blowers 51 for the gas coolers, and their temperatures lower.

[0052] The refrigerants cooled in the first high stage side gas cooler 11A and the second high stage side gas cooler 11B flow through the outlet pipes 12A and 12B to join each other, and then the refrigerant flows into the high stage side expansion valve 13, to be throttled (decompressed) therein, and flows into the first high stage side evaporator 16A constituting the first cascade heat exchanger 43A to evaporate, thereby cooling the refrigerant flowing through the subcooling heat exchanger 28 of the first low stage side refrigerant circuit 6A (subcooling).

[0053] The refrigerant flowing out from the first high stage side evaporator 16A flows through the outlet pipe 17A into the second high stage side evaporator 16B constituting the second cascade heat exchanger 43B to evaporate, thereby cooling the refrigerant flowing through the subcooling heat exchanger 28 of the second low stage side refrigerant circuit 6B (subcooling). Then, the refrigerant flowing out from the second high stage side evaporator 16B flows through the outlet pipe 17B to be sucked from the suction pipe 18 into the high stage side compressor 7, thereby repeating this circulation.

[0054] The controller 48 appropriately sets a target value of the low pressure-side pressure of the high stage side refrigerant circuit 4 (a target value of the suction pressure of the high stage side compressor 7) in accordance with the outdoor air temperature detected by the temperature sensor 53, to control the operation frequency of the high stage side compressor 7. In consequence, influence of the most suitable amount of the refrigerant to be enclosed that fluctuates with change of the outdoor air temperature is eliminated, and also when any accumulators are not disposed as in the embodiment, the high stage side compressor 7 of the high stage side refrigerant circuit 4 is controlled to operate with a high efficiency.

(2) Operation of Low Stage Side Refrigerant Circuits 6A and 6B

[0055] On the other hand, a high-temperature high-pressure refrigerant (carbon dioxide) compressed in the low stage side compressor 21 of the low stage side refrigerant circuit 6A (similarly of the second low stage side refrigerant circuit 6B) is discharged to the discharge pipe 22, and flows into the first low stage side gas cooler 23. The refrigerant flowing into the first low stage side gas cooler 23 is cooled in a supercritical state by the blower 51 for the gas cooler, its temperature lowers, and then the refrigerant flows through the outlet pipe 24 next into the second low stage side gas cooler 26.

[0056] The refrigerant flowing into the second low stage side gas cooler 26 is cooled in the supercritical state by the blower 52 for the gas cooler, its temperature further lowers, and then the refrigerant flows through the outlet pipe 27 into the subcooling heat exchanger 28 constituting the first cascade heat exchanger 43A (the second cascade heat exchanger 43B in the case of the second low stage side refrigerant circuit 6B).

[0057] The refrigerant flowing into the subcooling heat exchanger 28 is cooled (subcooled) by the refrigerant of the high stage side refrigerant circuit 4 which evaporates in the first high stage side evaporator 16A (the second high stage side evaporator 16B in the case of the second low stage side refrigerant circuit 6B), its temperature further lowers, and then the refrigerant flows through the outlet pipe 29 to reach the pressure adjusting expansion valve 31.

[0058] The high pressure side refrigerant of the low stage side refrigerant circuit 6A (6B) is throttled in the pressure adjusting expansion valve 31, flows through the outlet pipe 32, and is distributed to the branch pipes 33A and 33B, and the refrigerants flow out from the refrigerating machine unit 3 to enter the respective showcases 2 (2A and 2B). The refrigerants flowing through the branch pipes 33A and 33B reach the low stage side expansion valves 34 of the respective showcases 2 (2A and 2B), to be throttled therein, and then flow into the low stage side evaporators 36 to evaporate. In a heat absorbing operation at this time, the interior of the display chamber of each of the showcases 2 (2A and 2B) is cooled down to a predetermined temperature.

[0059] Then, the refrigerants flowing out from the low stage side evaporators 36 of the showcases 2 (2A and 2B) flow through the inlet pipes 35 into the solenoid valves 37. In the case of cooling the showcases 2 (2A and 2B) (the showcase 2A is in the cooling mode), the solenoid valves 37 are opened, and hence the refrigerants flow out from the solenoid valves 37 through the outlet pipes 38 to join each other, thereby flowing from the inlet pipe 42 into the accumulator 39. The refrigerant flowing into the accumulator 39 is subjected to gas-liquid separation therein, and a gas refrigerant flows through the suction pipe 41 to be sucked into the low stage side compressor 21, thereby repeating this circulation.

[0060] The controller 48 controls the valve position of the expansion valve 13 on the basis of the high pressure-side pressure of the high stage side refrigerant circuit 4 which is detected by the pressure sensor 56 in the same manner as in the after-mentioned control of the pressure adjusting expansion valves 31 of the low stage side refrigerant circuits 6A and 6B, thereby controlling the high pressure-side pressure of the high stage side refrigerant circuit 4 into a proper value (a target value of the high pressure-side pressure of the high stage side refrigerant circuit 4).

[0061] Thus, the refrigerant of the high stage side refrigerant circuit 4 is evaporated in the high stage side evaporators 16A and 16B of the respective cascade heat exchangers 43A and 43B, and there is subcooled the high pressure side refrigerant of each of the low stage side refrigerant circuits 6A and 6B which flows through the subcooling heat exchanger 28. Consequently, also

when carbon dioxide is used as the refrigerant, a required cooling capability is obtainable in the low stage side evaporator 36 of each of the showcases 2 (2A and 2B), without using comparatively large (large capability) compressors as the compressors 7 and 21 of the respective refrigerant circuits 4, 6A and 6B.

[0062] In this case, the accumulator 39 is disposed on a suction side of the low stage side compressor 21, and hence a liquid backflow to the low stage side compressor 21 is prevented. Furthermore, the accumulator 39 functions as a liquid reservoir, and hence it is possible to enclose a sufficient amount of the carbon dioxide refrigerant in each of the low stage side refrigerant circuits 6A and 6B.

[0063] Furthermore, the cascade heat exchangers 43A and 43B are configured to subcool the refrigerants flowing out from the low stage side gas coolers 26, and hence the carbon dioxide refrigerants of the low stage side refrigerant circuits 6A and 6B which are cooled by the low stage side gas coolers 23 and 26 are further subcooled by the cascade heat exchangers 43A and 43B so that further improvement of the cooling capability is achievable.

[0064] Additionally, in this embodiment, the refrigeration device includes the low stage side refrigerant circuits 6A and 6B of two systems, and two cascade heat exchangers 43A and 43B arranged in the low stage side refrigerant circuits 6A and 6B, respectively, and hence it is possible to subcool the high pressure side refrigerants of the two systems of (a plurality of) low stage side refrigerant circuits 6A and 6B in one high stage side refrigerant circuit 4.

[0065] In addition, the controller 48 controls the high pressure-side pressure of the low stage side refrigerant circuit 6A (6B) to the most suitable value by the pressure adjusting expansion valve 31. That is, the controller 48 defines the most suitable high pressure-side pressure as the target value to control the pressure adjusting expansion valve 31, on the basis of the high pressure-side pressure of each of the low stage side refrigerant circuits 6A and 6B. In consequence, a specific enthalpy difference between the high pressure side refrigerants of the low stage side refrigerant circuits 6A and 6B is acquired, and the improvement of the cooling capability and increase of the efficiency are achieved.

(2-1) Control of Low Stage Side Expansion Valve 34 (the switchable showcase 2A is in the cooling mode)

[0066] Next, description will be made as to the valve position control of the low stage side expansion valve 34 of each of the showcases 2 (2A and 2B) by the controller 57. It is to be noted that as to the switchable showcase 2A, the cooling mode is selected by operating the change-over switch 66.

[0067] Here, the controller 57 calculates a present refrigerant superheat degree PSH that is a temperature difference (a refrigerant outlet temperature-a refrigerant inlet temperature), from the refrigerant outlet temperature of the low stage side evaporator 36 which is detected by the refrigerant outlet temperature sensor 47 and the refrigerant inlet temperature of the low stage side evaporator 36 which is detected by the refrigerant inlet temperature sensor 46. Furthermore, the controller 57 sets a target chamber inside temperature ST (e.g., +5°C) that is a target value of the chamber inside temperature of each of the showcases 2 (2A and 2B), and further in the embodiment, a (differential) temperature lower as much as 1K than the target chamber inside temperature ST is set as a first temperature T1, and a temperature lower as much as 4K is set as a thermo-off temperature TOFF. Furthermore, it is considered that a target superheat degree SSH (e.g., 5K) that is a target value of the refrigerant superheat degree in the low stage side evaporator 36 is also set.

[0068] Now, when a chamber inside temperature PT detected by the chamber inside temperature sensor 61 is higher than the target chamber inside temperature ST, the controller 57 controls the valve position of the low stage side expansion valve 34 on the basis of the present refrigerant superheat degree PSH in the low stage side evaporator 36 which is calculated as described above, and the target superheat degree SSH. In this case, the controller 57 controls the valve position (a control amount) of the low stage side expansion valve 34 to adjust the refrigerant superheat degree PSH to the target superheat degree SSH, by PID control based on a difference e between the target superheat degree SSH and the refrigerant superheat degree PSH. Thus, the liquid backflow to the low stage side compressor 21 is prevented.

[0069] When the chamber inside temperature PT lowers from this state and becomes lower than the first temperature T1 mentioned above, the controller 57 changes to a state of controlling the valve position of the low stage side expansion valve 34 on the basis of the chamber inside temperature PT detected by the chamber inside temperature sensor 61. In this case, the controller 57 controls the valve position (the control amount) of the low stage side expansion valve 34 to adjust the chamber inside temperature PT to the target chamber inside temperature ST, by the PID control based on the difference e between the target chamber inside temperature ST and the present chamber inside temperature PT. Consequently, the chamber inside temperature PT turns to rise.

[0070] It is to be noted that when the chamber inside temperature PT lowers down to the thermo-off temperature TOFF mentioned above, the controller 57 judges that the cooling of the interior of the display chamber is not required, to close the solenoid valve 37. Consequently, freezing of articles in the display chamber is prevented, but the controller 57 changes to the control of the low stage side expansion valve 34 on the basis of the chamber inside temperature PT and the target chamber inside temperature ST, when the chamber inside temperature PT lowers below the first temperature T1, and hence the

controller prevents the disadvantage that the interior of the display chamber is subcooled, and also inhibits a situation where the solenoid valve 37 is closed.

[0071] In the control based on the chamber inside temperature PT and the target chamber inside temperature ST, the valve position of the low stage side expansion valve 34 is gradually lowered (throttled). Consequently, an amount of the refrigerant flowing into the low stage side evaporator 36 decreases, and hence the chamber inside temperature PT rises eventually up to the target chamber inside temperature ST. The controller 57 returns to a state of controlling the valve position of the low stage side expansion valve 34 on the basis of the refrigerant superheat degree in the low stage side evaporator 36, when the chamber inside temperature PT rises to the target chamber inside temperature ST or higher.

[0072] Thus, the controller 57 of each of the showcases 2 (2A and 2B) controls the low stage side expansion valve 34 to adjust the refrigerant superheat degree PSH to the target superheat degree SSH on the basis of the refrigerant superheat degree PSH in the low stage side evaporator 36, when the chamber inside temperature PT is the first temperature T1 or higher, and hence it is possible to prevent the liquid backflow to the low stage side compressor 21 or excessive frosting to the low stage side evaporator 36. On the other hand, when the chamber inside temperature PT is lower than the first temperature T1, the controller controls the low stage side expansion valve 34 to adjust the chamber inside temperature PT to the target chamber inside temperature ST, on the basis of the chamber inside temperature PT, and hence it is possible to prevent the display chamber from being excessively cooled.

[0073] Specifically, due to such simple change of the control, it is possible to smoothly eliminate all of the liquid backflow to the low stage side compressor 21, the excessive frosting of the low stage side evaporator 36, and the excessive cooling of the interior of the display chamber. Furthermore, the excessive cooling of the interior of the display chamber is eliminated by the low stage side expansion valve 34, and hence it is possible to avoid pressure fluctuations of the low stage side refrigerant circuit 6A or 6B due to the opening/closing of the solenoid valve 37. Consequently, also when a capacity of the accumulator 39 is small and carbon dioxide is used as the refrigerant, it is possible to inhibit the disadvantage that the low stage side compressor 21 is forcibly stopped by a safety device (not shown) for the purpose of cutting a high pressure, or the like, and it is possible to decrease the number of startup/stop times of the low stage side compressor 21 so that stable cooling of the interior of the display chamber is achievable.

[0074] In this case, when the controller 57 is in the state of controlling the low stage side expansion valve 34 on the basis of the chamber inside temperature PT and the chamber inside temperature PT rises to the target chamber inside temperature ST (a predetermined second temperature higher than the first temperature T1) or higher, the controller returns to the control of the low stage side expansion valve 34 on the basis of the refrigerant superheat degree PSH in the low stage side evaporator 36. Therefore, in a stage where the risk of the excessive cooling of the interior of the display chamber is eliminated, the controller can smoothly return to the control by the refrigerant superheat degree PSH in the low stage side evaporator 36. Especially, this return temperature (the second temperature) is adjusted to the target chamber inside temperature ST, and hence it is possible to smoothly control the interior of the display chamber at the target chamber inside temperature ST.

(2-2) Control of Heating Mode of Showcase (Switchable Showcase) 2A

[0075] Next, description will be made as to detailed control of the showcase 2A. The showcase 2A to be cooled by the second low stage side refrigerant circuit 6B as described above is a so-called hot and cold type of switchable showcase including the electric heater 63, and is usable in changing the operation mode to the cooling mode, the non-cooling mode, and the heating mode with the controller 57 of the showcase 2A by the operation of the change-over switch 66.

[0076] When the cooling mode is selected with the change-over switch 66, the controller 57 controls the low stage side expansion valve 34 and the solenoid valve 37, thereby cooling the interior of the display chamber as described above in the paragraphs of (2-1).

[0077] On the other hand, when the operation mode is changed to the heating mode (all hot) to heat and use the interior of the display chamber by the operation of the change-over switch 66, the controller 57 of the showcase 2A shuts off the valve position of the low stage side expansion valve 34 to stop the refrigerant supply from the high pressure side of the low stage side refrigerant circuit 6B to the low stage side evaporator 36 in this embodiment. Additionally, the solenoid valve 37 is opened. Therefore, outflow/inflow of the refrigerant from an accumulator 39 side (a low stage side compressor 21 side) to the low stage side evaporator 36 is possible. Then, the electric heater 63 is operated to generate heat, thereby heating (warming) the interior of the display chamber. It is to be noted that when the non-cooling mode is selected with the change-over switch 66, this mode is similar to the heating mode except that the electric heater 63 does not generate heat, and hence the description is omitted.

[0078] In this way, the controller 57 of the showcase 2A shuts off the low stage side expansion valve 34 disposed on the refrigerant upstream side of the low stage side evaporator 36 in the heating mode, whereas the solenoid valve 37 disposed on the refrigerant downstream side of the low stage side evaporator 36 is opened, thereby eliminating the conventional problem that oil in the refrigerant (the lubricating oil for the low stage side compressor 21) is confined in the low stage

side evaporator 36.

[0079] Furthermore, the controller 57 of the showcase 2A opens the low stage side expansion valve 34 for a predetermined period of time at a predetermined timing. This behavior will be described with reference to a timing chart of FIG. 2. A top stage of the timing chart of FIG. 2 shows a defrosting end timing of the showcase 2B, a middle stage shows an operation of the low stage side expansion valve 34 of the showcase 2A in the heating mode, and a bottom stage shows an operation of the solenoid valve 37 of the showcase 2A, respectively. It is to be noted that the solenoid valve 37 of the showcase 2A is opened (ON) in the heating mode as described above.

[0080] As described above, in the refrigeration device 1 of the embodiment, the controller 57 of each of the showcases 2 (2A and 2B) and the controller 48 of the refrigerating machine unit 3 are controlled in the centralized manner by the integrated control device, and cooperate with one another, but in the embodiment, the defrosting of the low stage side evaporator 36 of each of the showcases 2 (2A and 2B) is performed several times a day (when the showcase 2A is in the cooling mode).

[0081] During this defrosting (defrosting ON of FIG. 2), the controller 48 of the refrigerating machine unit 3 stops the high stage side compressor 7 and the respective low stage side compressors 21 and 21. On the other hand, the controller 57 of each of the showcases 2 (2A and 2B) operates the cold air circulating blower 62 for the low stage side evaporator 36, and hence the frost on the low stage side evaporator 36 is melted. This defrosting ends after the defrosting is executed for a predetermined period of time (defrosting OFF of FIG. 2), and the high stage side compressor 7 and the respective low stage side compressors 21 and 21 restart their operations, but the controller 57 of the showcase 2A opens the low stage side expansion valve 34 at a predetermined position for a predetermined period of time, at a timing after the end of the defrosting of the other showcase 2 or 2B in the heating mode.

[0082] The predetermined position (the valve position) of the low stage side expansion valve 34 in this case is determined at equilibrium reaching time when a refrigerant temperature Tin on the refrigerant upstream side of the low stage side evaporator 36 (between the low stage side expansion valve 34 and the low stage side evaporator 36) and a refrigerant temperature Tout on the refrigerant downstream side of the low stage side evaporator 36 (the refrigerant downstream side of the solenoid valve 37) are about the same (equilibrium), after the low stage side expansion valve 34 is opened. That is, when the refrigerant temperatures Tin and Tout are about the same (equilibrium), it is indicated that the low stage side expansion valve 34 is opened, and consequently, it can be judged that the refrigerant flows from the high pressure side into the low stage side evaporator 34 and that the refrigerant accumulated in the low stage side evaporator 34 and the oil adhered on an inner wall of the low stage side evaporator 34 are substantially all pushed outside.

[0083] When this equilibrium reaching time is short and the equilibrium temperature of Tin and Tout is high, the expansion valve is excessively opened, and when the equilibrium reaching time is long and the equilibrium temperature is low, the valve is insufficiently opened. Furthermore, when the low stage side expansion valve 34 of the showcase 2A is, for example, fully opened, an amount of the refrigerant to be supplied to the showcase 2B runs short, and hence in the embodiment, the controller 57 of the showcase 2A adjusts, to the predetermined position, the valve position (a predetermined intermediate value between a fully opened position and a shutoff position) at which the equilibrium reaching time and equilibrium temperature are most suitable and at which the showcase 2B is not adversely affected, thereby opening the low stage side expansion valve 34.

[0084] Furthermore, the predetermined time for which the low stage side expansion valve 34 is opened is actually a sum (t1+t2+t3) of a time t1 until the shutoff valve opens to the above predetermined position, a time t2 for which the predetermined position is maintained, and a time t3 until the valve is again shut off (FIG. 2), but the controller 57 of the showcase 2A adjusts the equilibrium reaching time at the predetermined position to the predetermined time in the heating mode, and opens the low stage side expansion valve 34 only for this predetermined time, at the timing after the end of the defrosting of the other showcase 2 or 2B.

[0085] In this way, the controller 57 of the showcase 2A of the embodiment shuts off the low stage side expansion valve 34 and opens the solenoid valve 37 in the heating mode (similarly in the non-cooling mode), thereby eliminating the conventional problem that, due to a difference between a pressure on a low stage side evaporator 36 side of the solenoid valve and a pressure on the low stage side compressor 21 side (the accumulator 39 side) thereof, the refrigerant reversely flows from the closed solenoid valve 37 into the low stage side evaporator 36 of the showcase 2A and the oil is confined in the low stage side evaporator 36.

[0086] In consequence, it is possible to avoid, in advance, generation of the disadvantage that the lubricating oil for the low stage side compressor 21 runs out to cause burning or performance deterioration of the low stage side compressor 21. Furthermore, the controller 57 of the showcase 2A closes the low stage side expansion valve 34 in the heating mode, and hence the interior of the display chamber of the showcase 2A is not unnecessarily cooled in the heating mode (similarly in the non-cooling mode).

[0087] Furthermore, the controller 57 of the showcase 2A opens the low stage side expansion valve 34 for the predetermined period of time at the predetermined timing in the heating mode (similarly in the non-cooling mode), and hence the oil adhering on the inner wall on the low stage side evaporator 36 of the showcase 2A can be washed away to the low stage side compressor 21 side

by opening the low stage side expansion valve 34. Consequently, it is possible to effectively eliminate an oil shortage of the low stage side compressor 21.

[0088] In this case, the controller 57 of the showcase 2A opens the low stage side expansion valve 34 for the predetermined period of time, at the timing after the end of the defrosting of the low stage side evaporator 36 of the other showcase 2 or 2B in the heating mode (similarly in the non-cooling mode). Therefore, it is possible to wash away the oil from the low stage side evaporator 36 of the showcase 2A in a state where the refrigerant is comparatively stable, so that it is possible to prevent the disadvantage that the low stage side compressor 21 of the second low stage side refrigerant circuit 6B stops, or the like, when a protecting function works due to the pressure fluctuation due to the opening of the low stage side expansion valve 34.

[0089] Furthermore, after the end of the defrosting, when the low stage side expansion valve 34 is opened, a temperature of the refrigerant flowing into the low stage side evaporator 36 of the showcase 2A comparatively heightens. Therefore, an evaporation pressure also heightens, and it is also possible to effectively eliminate the disadvantage that dew condensation occurs on a wall surface in the vicinity of the low stage side evaporator 36 of the showcase 2A, or the like. Additionally, after the end of the defrosting, the low stage side compressor 21 is operated with a large number of revolution, and hence it is possible to immediately suck the oil in the low stage side evaporator 36 of the showcase 2A.

Embodiment 2

(2-3) Another Control Example of Heating Mode of Showcase (Switchable Showcase) 2A

[0090] It is to be noted that in the above embodiment, the controller 57 of the showcase 2A shuts off the low stage side expansion valve 34 and opens the solenoid valve 37 in the heating mode or the non-cooling mode, but the present invention is not limited to the example, and the controller may shut off the low stage side expansion valve 34 and close the solenoid valve 37. However, when the solenoid valve 37 is closed, there still occurs the problem that oil is confined in a low stage side evaporator 36. To eliminate such a problem, the controller 57 of the showcase 2A opens the low stage side expansion valve 34 and the solenoid valve 37 for a predetermined period of time, at a timing after end of defrosting of the other showcase 2 (2B), in the same manner as described above.

[0091] In this case, a valve position of the low stage side expansion valve 34 and the predetermined period of time for which the low stage side expansion valve 34 and the solenoid valve 37 are opened are defined as the above-mentioned predetermined position and predetermined period of time (an equilibrium reaching time at the predetermined position) of FIG. 2 mentioned above. Thus, in the heating mode (similarly in the non-cooling mode), the controller 57 of the showcase 2A shuts off the low stage side expansion valve 34, closes the solenoid valve 37, and opens the low stage side expansion valve 34 and the solenoid valve 37 for the predetermined period of time at a predetermined timing. Consequently, in the same manner as described above, when due to a difference between a pressure on a low stage side evaporator 36 side of the solenoid valve and a pressure on a low stage side compressor 21 side thereof, a refrigerant reversely flows from the closed solenoid valve 37 into the low stage side evaporator 36 of the showcase 2A and the oil is confined in the low stage side evaporator 36 as in a conventional device, the controller opens the solenoid valve 37 for the predetermined period of time. In consequence, the confined oil can be returned to the low stage side compressor 21 side.

[0092] In consequence, it is possible to avoid, in advance, generation of the disadvantage that a lubricating oil for a low stage side compressor 21 runs out to cause burning or performance deterioration of the low stage side compressor 21. Especially in this case, when the solenoid valve 37 is opened, the controller also opens the low stage side expansion valve 34 for the predetermined period of time. Therefore, the oil adhering on an inner wall of the low stage side evaporator 36 of the showcase 2A can be washed away to the low stage side compressor 21 side by opening the low stage side evaporator 36, and it is possible to effectively eliminate an oil shortage of the low stage side compressor 21.

[0093] Furthermore, in the same manner as described above, the controller opens the low stage side expansion valve 34 and the solenoid valve 37 of the showcase 2A for the predetermined period of time, at a timing after end of defrosting of the low stage side evaporator 36 of the other showcase 2 or 2B. Therefore, it is possible to wash away the oil from the low stage side evaporator 36 of the showcase 2A in a state where the refrigerant is comparatively stable, so that it is possible to prevent the disadvantage that the low stage side compressor 21 of a low stage side refrigerant circuit 6B stops, or the like, when a protecting function works due to a pressure fluctuation due to the opening of the low stage side expansion valve 34.

[0094] Furthermore, similarly after the end of the defrosting, when the low stage side expansion valve 34 is opened, a temperature of the refrigerant flowing into the low stage side evaporator 36 of the showcase 2A comparatively heightens, and hence an evaporation pressure also heightens, and it is possible to effectively eliminate the disadvantage that dew condensation occurs on a wall surface in the vicinity of the low stage side evaporator 36 of the showcase 2A, or the like. Additionally, similarly after the end of the defrosting, the low stage side compressor 21 is also operated with a large number of revolution, and hence it is possible to immediately suck the oil in the low stage side evaporator 36 of the showcase 2A.

[0095] It is to be noted that in the above respective embodiments, the controller opens the low stage side expansion valve 34 of the showcase 2A, or the low stage side expansion valve 34 and the solenoid valve 37 for the predetermined period of time, at the timing after the end of the defrosting of the low stage side evaporator 36 of the other showcase 2 or 2B which is performed several times a day, but it is not necessary to open the valve every defrosting time, and the valve may be opened once a day at the timing after the end of the defrosting, or once a week or once a month at the timing after the end of the defrosting.

[0096] When the controller opens the low stage side expansion valve 34 of the showcase 2A or the low stage side expansion valve 34 and the solenoid valve 37 thereof, power is consumed to operate each valve, and there is the risk that the cooling capability of the other showcase 2B in the second low stage side refrigerant circuit 6B is also influenced. Therefore, in a range where the showcase 2B is not adversely affected, the valve does not have to be opened after each defrosting operation, and the number of valve opening times to be executed may suitably be decreased.

Embodiment 3

(2-4) Still Another Control Example of Heating Mode of Showcase (Switchable Showcase) 2A

[0097] Furthermore, in the above respective embodiments, the controller 57 of the showcase 2A in the heating mode (similarly in a non-cooling mode) opens the low stage side expansion valve 34, or the low stage side expansion valve 34 and the solenoid valve 37 at the timing after the end of the defrosting of the low stage side evaporator 36 of the other showcase 2 or 2B, but the present invention is not limited to this embodiment, and the controller 57 of the showcase 2A may open the low stage side expansion valve 34, or the low stage side expansion valve 34 and the solenoid valve 37 for a predetermined period of time, at a starting point issuing timing of the low stage side expansion valve 34 of the other showcase 2 or 2B.

[0098] Issuing of a starting point of the low stage side expansion valve 34 is an operation to calibrate the starting point of valve position control of the low stage side expansion valve 34, and is usually executed during the defrosting of the low stage side evaporator 36 (a low stage side compressor 21 is stopped). The controller 57 of the showcase 2A opens the low stage side expansion valve 34 of the showcase 2A, or the low stage side expansion valve 34 and the solenoid valve 37 for the predetermined period of time, at the starting point issuing timing of the low stage side expansion valve 34 of the other showcase 2 or 2B, thereby also eliminating the fear that a pressure of a low stage side refrigerant circuit 6B fluctuates due to the opening of the low stage side expansion valve 34 or the solenoid valve 37 of the showcase 2A.

[0099] It is to be noted that in the above respective embodiments, the controller opens the low stage side expansion valve 34 of the showcase 2A, or the low stage side expansion valve 34 and the solenoid valve 37 for the predetermined period of time, at the timing after the end of the defrosting of the low stage side evaporator 36 of the other showcase 2 or 2B or at the starting point issuing timing of the low stage side expansion valve 34, but the present invention is not limited to such a periodic timing, and when an amount of oil in the low stage side compressor 21 of the second low stage side refrigerant circuit 6B is detected and decreases below a certain amount, the controller may open the low stage side expansion valve 34 of the showcase 2A, or the low stage side expansion valve 34 and the solenoid valve 37 thereof for the predetermined period of time.

[0100] Furthermore, the controller may open the low stage side expansion valve 34 of the showcase 2A, or the low stage side expansion valve 34 and the solenoid valve 37 thereof for the predetermined period of time, at the timing after the end of the defrosting of the low stage side evaporator 36 of the other showcase 2 or 2B, after the oil amount in the low stage side compressor 21 of the second low stage side refrigerant circuit 6B decreases below the certain amount.

Embodiment 4

(2-5) Further Control Example of Heating Mode of Showcase (Switchable Showcase) 2A

[0101] Furthermore, in addition to the above respective embodiments, the controller 57 of the showcase 2A forces an electric heater 63 to generate heat, when opening the low stage side expansion valve 34, or the low stage side expansion valve 34 and the solenoid valve 37 in the heating mode (similarly in the non-cooling mode).

[0102] The controller 57 usually executes ON/OFF control of the electric heater 63 in accordance with a chamber inside temperature of the showcase 2A, but irrespective of such temperature control, the controller 57 forces the electric heater 63 to generate heat, when opening the low stage side expansion valve 34, or the low stage side expansion valve and the solenoid valve 37 to push out oil confined in a low stage side evaporator 36 of the showcase 2A.

[0103] Thus, the electric heater 63 generates heat, and consequently, a temperature drop in a display chamber due to inflow of a refrigerant into the low stage side evaporator 36 of the showcase 2A can be cancelled with the heat generation, and occurrence of dew condensation on a wall surface in the vicinity of the low stage side evaporator 36 or the like can securely be eliminated.

[0104] Here, the present invention has been described as the refrigeration device in which in the above respective embodiments, the high stage side refrigerant circuit 4 and the low stage side refrigerant circuits 6A and 6B

are connected in cascade, but the inventions other than those of claim 8 and a controller 9 are not limited to this example, and the present invention is also effective for a refrigeration device including a so-called single stage of refrigerant circuit only having a second low stage side refrigerant circuit 6B to cool a switchable showcase 2A and the other showcase 2B with the low stage side compressor 21 of the embodiment.

Description of Reference Numerals

[0105]

1 refrigeration device
2, 2A and 2B showcase
3 refrigerating machine unit
4 high stage side refrigerant circuit
6A and 6B low stage side refrigerant circuit (a refrigerant circuit)
7 high stage side compressor
11A and 11B high stage side gas cooler
13 high stage side expansion valve
16A and 16B high stage side evaporator
21 low stage side compressor (a compressor)
23 and 26 low stage side gas cooler
34 low stage side expansion valve (an expansion valve)
36 low stage side evaporator (an evaporator)
37 solenoid valve
48 and 57 controller

Claims

1. A refrigeration device in which a refrigerant is distributed and supplied from a compressor to respective evaporators arranged in a plurality of showcases,
wherein each showcase comprises:

an expansion valve disposed on a refrigerant upstream side of the evaporator,
a solenoid valve disposed on a refrigerant downstream side of the evaporator, and
a controller which controls the expansion valve and the solenoid valve,
at least one of the showcases is a switchable showcase which is usable in switching a cooling mode to cool an interior of a display chamber, a non-cooling mode in which the interior of the display chamber is not cooled and/or a heating mode to heat the interior of the display chamber by a heater, and
the controller of the switchable showcase controls a valve position of the expansion valve and opens and closes the solenoid valve in the cooling mode, and
shuts off the expansion valve and opens the solenoid valve in the non-cooling mode and/or the heating mode.

2. The refrigeration device according to claim 1, wherein the controller of the switchable showcase opens the expansion valve for a predetermined period of time, at a predetermined timing in the non-cooling mode and/or the heating mode.

3. A refrigeration device in which a refrigerant is distributed and supplied from a compressor to respective evaporators arranged in a plurality of showcases,
wherein each showcase comprises:

an expansion valve disposed on a refrigerant upstream side of the evaporator,
a solenoid valve disposed on a refrigerant downstream side of the evaporator, and
a controller which controls the expansion valve and the solenoid valve,
at least one of the showcases is a switchable showcase which is usable in switching a cooling mode to cool an interior of a display chamber, a non-cooling mode in which the interior of the display chamber is not cooled and/or a heating mode to heat the interior of the display chamber by a heater, and
the controller of the switchable showcase controls a valve position of the expansion valve and opens and closes the solenoid valve in the cooling mode, and
shuts off the expansion valve, closes the solenoid valve, and opens the expansion valve and the solenoid valve for a predetermined period of time, at a predetermined timing in the non-cooling mode and/or the heating mode.

4. The refrigeration device according to claim 2 or 3, wherein the controller of the switchable showcase opens the expansion valve, or the expansion valve and the solenoid valve for a predetermined period of time, at a timing after end of defrosting of the evaporator of the other showcase in the non-cooling mode and/or the heating mode.

5. The refrigeration device according to any one of claims 2 to 4,
wherein the controller of the switchable showcase opens the expansion valve, or the expansion valve and the solenoid valve for a predetermined period of time, at a starting point issuing timing of the expansion valve of the other showcase in the non-cooling mode and/or the heating mode.

6. The refrigeration device according to any one of claims 2 to 5,
wherein the controller of the switchable showcase

forces the heater to generate heat, when opening the expansion valve, or the expansion valve and the solenoid valve in the non-cooling mode and/or the heating mode.

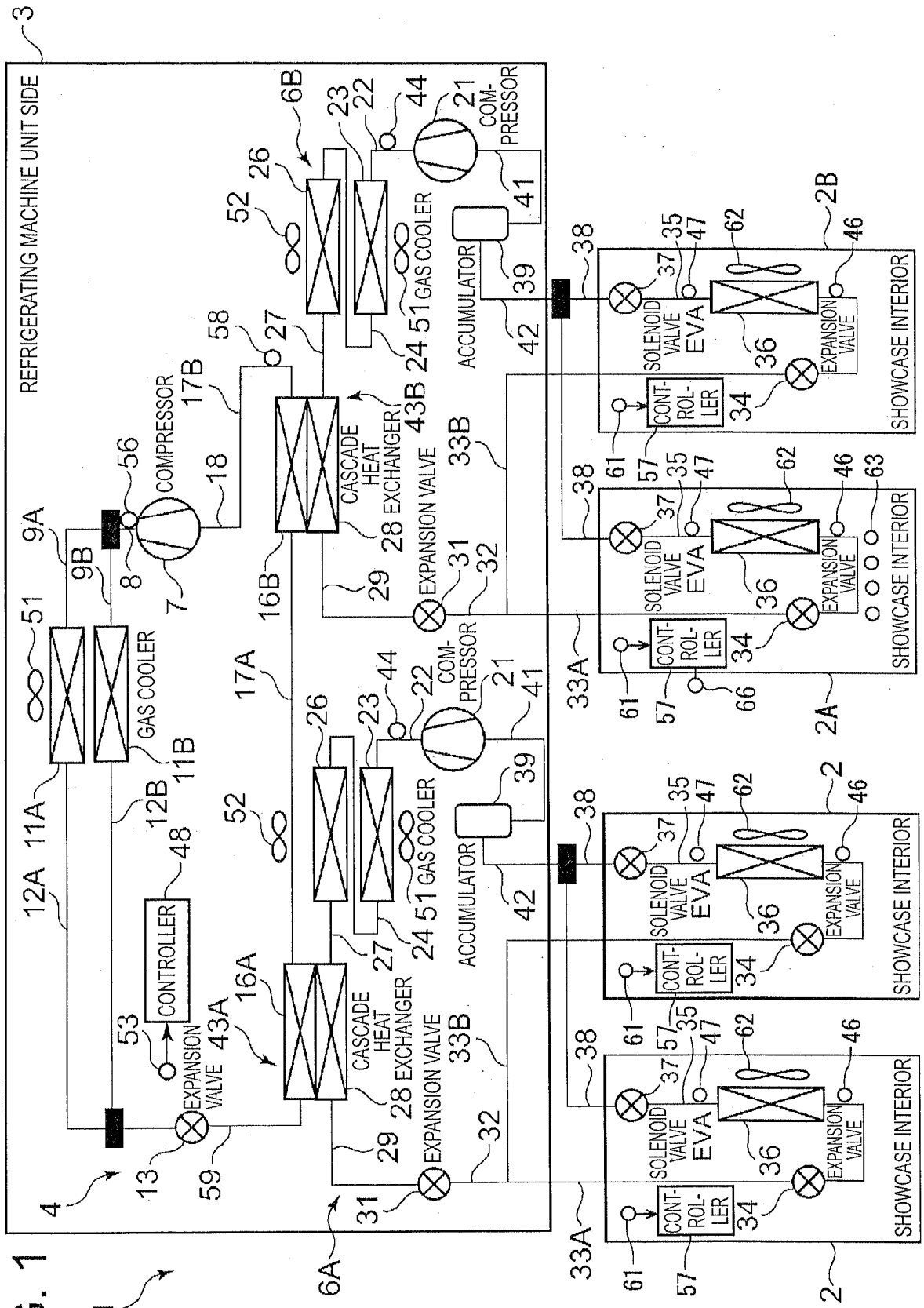
7. The refrigeration device according to any one of claims 1 to 6,
wherein when cooling the interior of the display chamber, the controller controls a refrigerant superheat degree in the evaporator by the valve position of the expansion valve in a state where the solenoid valve is opened, and when the cooling of the interior of the display chamber is not required, the controller closes the solenoid valve.

8. The refrigeration device according to any one of claims 1 to 7, comprising:

a low stage side refrigerant circuit comprising the compressor, the expansion valve, the solenoid valve and the evaporator, and a high stage side refrigerant circuit which is independent of the low stage side refrigerant circuit,
wherein a high pressure side refrigerant of the low stage side refrigerant circuit is cooled by an evaporator of the high stage side refrigerant circuit.

9. The refrigeration device according to any one of claims 1 to 8,
wherein carbon dioxide is used as the refrigerant in the refrigerant circuit.

FIG. 1


REFRIGERATING MACHINE UNIT SIDE
3
1
4
6A
6B
7
8
9A
9B
11A
11B
12A
12B
13
16A
16B
17A
17B
18
21
22
23
24
26
27
28
29
31
32
33A
33B
34
35
36
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41
42
43A
43B
44
46
47
48
51
52
53
56
57
58
59
61
62
63
66
2
2A
2B
COMPRESSOR
COM-PRESSOR
GAS COOLER
CASCADE HEAT EXCHANGER
EXPANSION VALVE
ACCUMULATOR
CONTROLLER
CONT-ROL-LER
SOLENOID VALVE
EVA
EXPANSION VALVE
SHOWCASE INTERIOR

FIG. 2

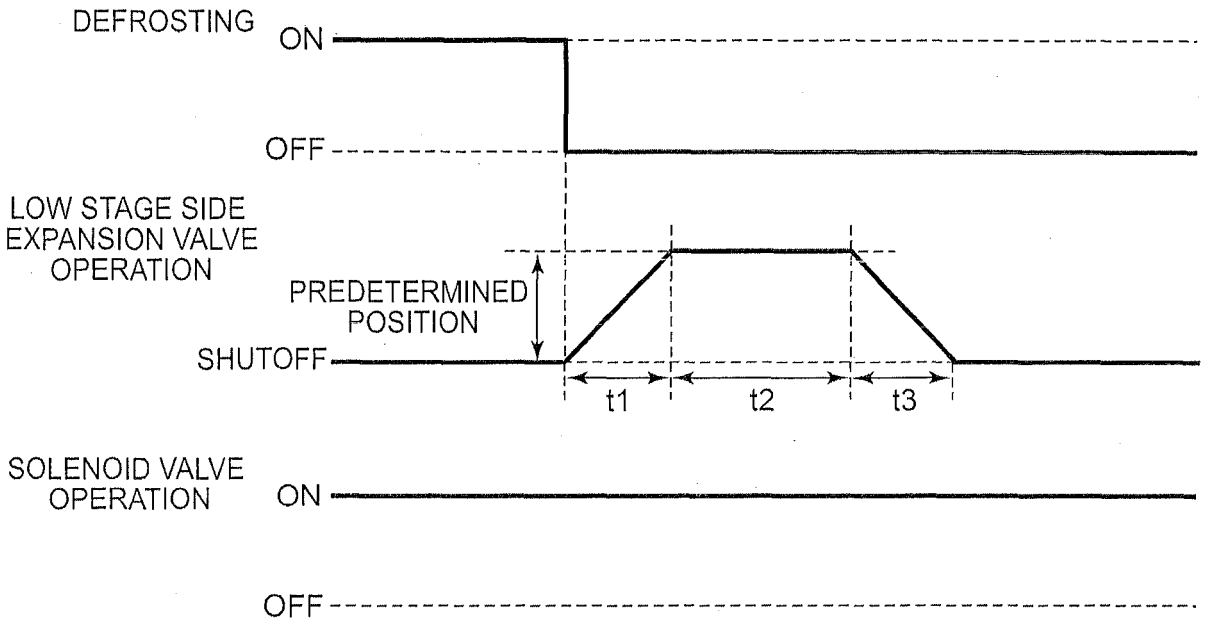
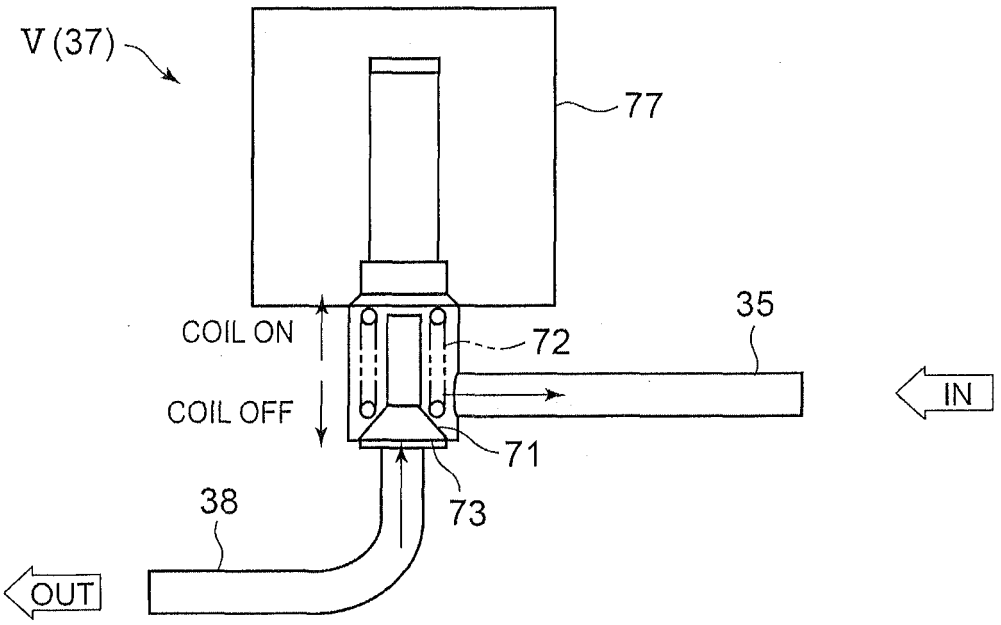

DEFROSTING
ON
OFF
LOW STAGE SIDE EXPANSION VALVE OPERATION
PREDETERMINED POSITION
SHUTOFF
t1
t2
t3
SOLENOID VALVE OPERATION
ON
OFF

FIG. 3


V (37)
77
COIL ON
COIL OFF
72
35
IN
71
73
38
OUT

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/067713

A. CLASSIFICATION OF SUBJECT MATTER
F25B5/02(2006.01)i, *A47F3/04*(2006.01)i, *F25B1/00*(2006.01)i, *F25B7/00*(2006.01)i, *F25D11/00*(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)
F25B5/02, A47F3/04, F25B1/00, F25B7/00, F25D11/00

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 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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.
A	US 2010/0199707 A1 (Star Refrigeration Ltd.), 12 August 2010 (12.08.2010), entire text; all drawings & GB 2469616 A	1-9
A	JP 8-115464 A (Fuji Electric Co., Ltd.), 07 May 1996 (07.05.1996), paragraphs [0002], [0013]; fig. 1, 7 (Family: none)	1-9
A	JP 10-205958 A (Toshiba Corp.), 04 August 1998 (04.08.1998), paragraphs [0043] to [0046]; fig. 2 (Family: none)	1-9

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 August 2016 (19.08.16)	30 August 2016 (30.08.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/067713

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012-93054 A (Mitsubishi Electric Corp.), 17 May 2012 (17.05.2012), paragraphs [0001], [0014]; fig. 1 (Family: none)	8-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003172556 A **[0007]**
- JP 2000205672 A **[0007]**