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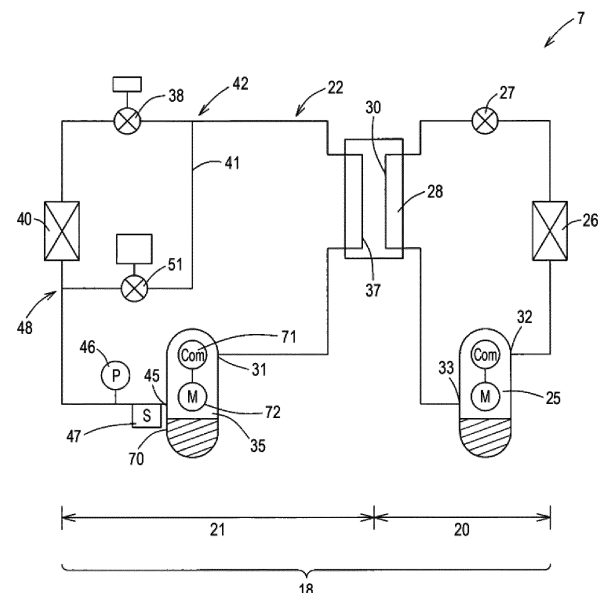
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(54) REFRIGERATING DEVICE AND ENVIRONMENTAL TESTING APPARATUS

(57) A refrigerating device includes a refrigerating circuit and a control portion. The refrigerating circuit includes a main flow path in which a compressor, a condenser, an expansion portion, and an evaporator are connected to each other, and a bypass flow path that connects a discharge side of the condenser and a suction side of the compressor, and a flow rate control portion is provided in the bypass flow path. The control portion is configured to set a target temperature of a coolant introduced into the compressor according to a pressure of the coolant on the suction side of the compressor and is configured to change an opening degree of the flow rate control portion such that a temperature of the coolant introduced into the compressor becomes the target temperature. The target temperature when the pressure is high is higher than that when the pressure is low.

FIG. 2

Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigerating device used for an environmental testing apparatus, a refrigerator, or the like. The present invention relates to an environmental testing apparatus.

BACKGROUND ART

[0002] In the environmental testing apparatus or the refrigerator, the refrigerating device is mounted. The refrigerating device is configured by a compressor, a condenser, an expansion portion, an evaporator, and the like, and includes a refrigerating circuit where a coolant is circulated. The coolant is compressed by the compressor, is condensed by the condenser, is expanded by the expansion portion, is evaporated by the evaporator, and returns to the compressor again for circulation. During the evaporation by the evaporator, the coolant takes heat from the surrounding for cooling.

[0003] As a test for inspecting the performance or durability of a product, a component, or the like, an environmental test is known. The environmental test is performed using a facility called the environmental testing apparatus.

[0004] In general, the environmental testing apparatus includes a test chamber and an air conditioning portion. The air conditioning portion includes an air conditioner such as a blower, a heating device, or a refrigerating device.

[0005] The test chamber and the air conditioning portion are configured by, for example, a series of circulation air ducts, air in the test chamber is introduced into the air conditioning portion such that the temperature or the humidity is adjusted, and the adjusted air returns to the test chamber. As a result, a desired temperature environment or humidity environment is generated in the test chamber.

CITATION LIST

PATENT LITERATURE

[0006] Patent Literature 1: JP2014-66593A

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0007] The environmental testing apparatus may continuously operate over a long period of time. During the continuous operation, the refrigerating device of the environmental testing apparatus may temporarily operate under harsh conditions.

[0008] Therefore, in the environmental testing apparatus in the related art, during the operation, a motor that

drives the compressor may generate heat, which may cause burnout of a winding of the motor, a decrease in viscosity or an early-stage deterioration of oil, damage of the compressor portion due to such problems, or the like.

Therefore, the reliability of environmental testing apparatus may decrease.

[0009] In a refrigerator or freezer for business use, the same concern may occur, and during the operation, the motor that drives the compressor may generate heat.

[0010] The present invention has been made to solve the above-described problems in the related art, and an object thereof is to provide a refrigerating device in which the heat generation of the compressor can be appropriately reduced. That is, an object of the present invention is to provide a refrigerating device in which the compressor can not only be merely cooled but also be cooled to the extent that the compressor does not become too cold.

SOLUTION TO PROBLEM

[0011] According to an aspect for achieving the above-described object, there is provided a refrigerating device including: a refrigerating circuit and a control portion configured to control the refrigerating circuit. The refrigerating circuit includes a main flow path in which a compressor, a condenser, an expansion portion, and an evaporator are connected to each other and in which a coolant undergoing a phase change is to be circulated, and a bypass flow path that connects a discharge side of the condenser and a suction side of the compressor, and a flow rate control portion whose opening degree is adjustable is provided in the bypass flow path. The control portion is configured to set a target temperature of the coolant introduced into the compressor according to a pressure of the coolant on the suction side of the compressor and is configured to change the opening degree of the flow rate control portion such that a temperature of the coolant introduced into the compressor becomes the target temperature. The target temperature when the pressure is high is higher than that when the pressure is low.

[0012] One measure for suppressing excessive heat generation of the compressor is a method of introducing a coolant having a cooling capacity into the suction side of the compressor. The refrigerating device according to the present aspect adopts such method, in which the discharge side of the condenser and the suction side of the compressor are connected through the bypass flow path, and the coolant having the cooling capacity (hereinafter, referred to as coolant for cooling) is introduced into the suction side of the compressor to decrease the temperature of the coolant introduced into the compressor.

[0013] Here, the basic technological concept of the refrigerating device according to the present aspect is to reduce the amount of the coolant for cooling when the amount (weight flow rate) of the coolant returned and introduced into the compressor is large.

[0014] The present inventors found that, when the

amount of the coolant introduced into the compressor is small, the temperature of the compressor tends to increase, and conversely when the amount of the coolant introduced into the compressor is large, the heat generation of the compressor tends to be reduced.

[0015] There is a positive correlation between the amount of the coolant introduced into the compressor and the pressure of the coolant on the suction side of the compressor, and when the amount of the coolant introduced into the compressor is large, the pressure of the coolant on the suction side of the compressor is high.

[0016] The refrigerating device according to the present invention is based on such findings, and the control portion sets a target temperature of the coolant introduced into the compressor according to a pressure of the coolant on the suction side of the compressor, changes the opening degree of the flow rate control portion such that a temperature of the coolant during being introduced becomes the set target temperature, and introduces the coolant for cooling into the suction side of the compressor.

[0017] With the configuration of the present invention, when the amount of the coolant introduced into the compressor is large, the amount of the coolant for cooling decreases. In the refrigerating device according to the present invention, excessive heat generation of the compressor can be suppressed, and the compressor is not likely to be excessively cooled.

[0018] According to another aspect for achieving the same object, there is provided a refrigerating device including: a refrigerating circuit and a control portion configured to control the refrigerating circuit. The refrigerating circuit includes a main flow path in which a compressor, a condenser, an expansion portion, and an evaporator are connected to each other and in which a coolant undergoing a phase change is to be circulated, and a bypass flow path that connects a discharge side of the condenser and a suction side of the compressor, and a flow rate control portion whose opening degree is adjustable is provided in the bypass flow path. The control portion is configured to set a target temperature of the coolant introduced into the compressor according to a requirement level of a refrigerating capacity and is configured to change the opening degree of the flow rate control portion such that a temperature of the coolant introduced into the compressor becomes the target temperature. The target temperature when the requirement level is high is higher than that when the requirement level is low.

[0019] There is a positive correlation between the amount of the coolant introduced into the compressor and the requirement level of the refrigerating capacity, and when the requirement level of the refrigerating capacity is high, the amount of the coolant introduced into the compressor is large.

[0020] The refrigerating device according to the present invention is based on such findings, and the control portion sets a target temperature of the coolant intro-

duced into the compressor according to a requirement level of a refrigerating capacity, changes the opening degree of the flow rate control portion such that a temperature of the coolant during being introduced becomes the set target temperature, and introduces the coolant for cooling into the suction side of the compressor. With the configuration of the present invention, when the amount of the coolant introduced into the compressor is large, the amount of the coolant for cooling decreases. In the refrigerating device according to the present invention, excessive heat generation of the compressor can be suppressed, and the compressor is not likely to be excessively cooled.

[0021] According to still another aspect for achieving the same object, there is provided a refrigerating device including: a refrigerating circuit and a control portion configured to control the refrigerating circuit. The refrigerating circuit includes a main flow path in which a compressor, a condenser, an expansion portion, and an evaporator are connected to each other and in which a coolant undergoing a phase change is to be circulated, and a bypass flow path that connects a discharge side of the condenser and a suction side of the compressor, and a flow rate control portion whose opening degree is adjustable is provided in the bypass flow path. The control portion is configured to set a target temperature of the coolant introduced into the compressor according to an amount of the coolant sucked into the compressor and is configured to change the opening degree of the flow rate control portion such that a temperature of the coolant introduced into the compressor becomes the target temperature. The target temperature when the amount of the sucked coolant is large is higher than that when the amount of the sucked coolant is small.

[0022] In the refrigerating device according to the present invention, the control portion sets a target temperature of the coolant introduced into the compressor according to an amount of the coolant sucked into the compressor, changes the opening degree of the flow rate control portion such that a temperature of the coolant during being introduced becomes the set target temperature, and introduces the coolant for cooling into the suction side of the compressor. With the configuration of the present invention, when the amount of the coolant introduced into the compressor is large, the amount of the coolant for cooling decreases. In the refrigerating device according to the present invention, excessive heat generation of the compressor can be suppressed, and the compressor is not likely to be excessively cooled.

[0023] In each of the above aspects, it is desirable that the target temperature is to change in a certain range of change rate.

[0024] In the present aspect, depending on a change in the amount of the coolant introduced, the target temperature can change linearly, substantially linearly, or in a curved shape having a slope in a certain range. Therefore, it is easy to deal with excessive heat generation of the compressor and excessive cooling of the compres-

sor.

[0025] In each of the above aspects, it is desirable that the target temperature changes in a certain range of change rate when any one of conditions below is in a first region of a predetermined value or less, and that the target temperature changes at a change rate more than the certain range of change rate when any one of the conditions below is in a second region of more than the predetermined value, the conditions including (1) a pressure of the coolant on the suction side of the compressor, (2) a requirement level of a refrigerating capacity, and (3) an amount of the coolant sucked into the compressor.

[0026] According to the present aspect, the target temperature can be more flexibly changed depending on a situation of the amount of the coolant introduced into the compressor. Therefore, it is easy to deal with excessive heat generation of the compressor and excessive cooling of the compressor.

[0027] The refrigerating device according to each of the above aspects is suitable for a refrigerating device of an environmental testing apparatus.

[0028] That is, an aspect relating to the environmental testing apparatus includes the refrigerating device according to any one of the above aspects.

ADVANTAGEOUS EFFECTS OF INVENTION

[0029] The refrigerating device according to the present invention has an effect that an appropriate amount of the coolant having the cooling capacity can be introduced into the compressor and excessive heat generation or the like of the motor of the compressor can be suppressed. That is, according to the present invention, not the compressor is merely cooled but the compressor can be cooled to the extent that the compressor does not become too cold.

BRIEF DESCRIPTION OF DRAWINGS

[0030]

FIG. 1 is a cross-sectional view illustrating an environmental testing apparatus according to an embodiment of the present invention.

FIG. 2 is a diagram illustrating an operating principle of a refrigerating device mounted on the environmental testing apparatus of FIG. 1.

FIG. 3 is a block diagram illustrating a control device of a refrigerating device according to a first embodiment of the present invention.

FIG. 4 is a graph illustrating one example of a relationship between a target temperature of a coolant and a coolant pressure or the like, in which the horizontal axis represents a pressure of the coolant on a suction side of a compressor of the refrigerating device and the vertical axis represents the target temperature of the coolant.

FIG. 5 is a block diagram illustrating a control device

of a refrigerating device according to a second embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0031] Hereinafter, an embodiment of the present invention will be described.

[0032] An environmental testing apparatus 1 according to the present embodiment includes a thermal insulation chamber 3 covered with a thermal insulation wall 2 as illustrated in FIG. 1. A test chamber 5 is formed in a part of the thermal insulation chamber 3. The test chamber 5 is a space where a test object 100 is provided.

[0033] The environmental testing apparatus 1 further includes a humidifying device 6, a refrigerating device (cooling portion) 7, a heater (heating portion) 8, and a blower 10. An air flow path 15 communicating with the test chamber 5 is provided in the environmental testing apparatus 1, and the humidifying device 6, the refrigerating device 7, the heater 8, and the blower 10 are provided in the air flow path 15.

[0034] A temperature sensor (in-chamber temperature detection portion) 12 and a humidity sensor 13 are provided on the outlet side of the air flow path 15. In the environmental testing apparatus 1, an air conditioning device 17 is configured by the above-described members in the air flow path 15, the temperature sensor 12, and the humidity sensor 13. The air conditioning device 17 is controlled by a control device (control portion) 16. There may be an environmental testing apparatus not having a function of adjusting the humidity, and such type of environmental testing apparatus does not include the humidifying device 6 or the humidity sensor 13.

[0035] The environmental testing apparatus 1 includes an input device 11, and desired environment conditions are input to the input device 11. For example, the temperature and the humidity are input. Alternatively, a condition of an increasing curve of the temperature or the humidity is input.

[0036] In the environmental testing apparatus 1, the temperature/humidity environment input to the input device 11 can be generated in the test chamber 5 by the air conditioning device 17 that is controlled by the control device 16. That is, the control device 16 controls the inside of the test chamber 5 to be in a predetermined environment.

[0037] The refrigerating device 7 adopted in the environmental testing apparatus 1 according to the present embodiment includes a refrigerating circuit 18 illustrated in FIG. 2.

[0038] Hereinafter, the refrigerating circuit 18 of the refrigerating device (cooling portion) 7 will be described.

[0039] The refrigerating device 7 has a binary cooling structure including a primary side refrigerating circuit 20 and a secondary side refrigerating circuit 21.

[0040] In the primary side refrigerating circuit 20, a coolant discharge port 32 of a high temperature side compressor 25, a high temperature side condenser 26,

a high temperature side expansion portion 27, a primary side flow path 30 of a cascade condenser 28, and a coolant suction port 33 of the high temperature side compressor 25 are sequentially disposed in a ring shape.

[0041] A high temperature side coolant undergoing a phase change is sealed in the primary side refrigerating circuit 20. The primary side refrigerating circuit 20 implements the same refrigerating cycle as a well-known cycle.

[0042] The secondary side refrigerating circuit 21 includes a main flow path 22 in which a coolant discharge port 31 of a low temperature side compressor 35, a secondary side flow path 37 of the cascade condenser (condenser) 28, a low temperature side expansion portion 38, a low temperature side evaporator (cooler) 40, and a coolant suction port 45 of the low temperature side compressor 35 are sequentially disposed in a ring shape. The cascade condenser 28 functions as the condenser of the secondary side refrigerating circuit 21. The low temperature side expansion portion 38 is an expansion valve, in which an opening degree is adjustable by an actuator such as a motor.

[0043] The coolant circulates in main flow path 22 of the secondary side refrigerating circuit 21 to decrease the temperature of the low temperature side evaporator (cooler) 40.

[0044] The low temperature side evaporator (cooler) 40 is disposed in the air flow path 15 as in FIG. 1.

[0045] A low temperature side coolant undergoing a phase change is sealed in the secondary side refrigerating circuit 21. The coolant sealed in the secondary side refrigerating circuit 21 can generate a low temperature of, for example, -70°C .

[0046] Although not limited thereto, the coolant sealed in the secondary side refrigerating circuit 21 has a characteristic that the specific volume largely changes depending on the temperature.

[0047] The secondary side refrigerating circuit 21 implements the same refrigerating cycle as a well-known cycle. As in the well-known binary cooling structure, the coolant of the primary side refrigerating circuit 20 is evaporated by the primary side flow path 30 of the cascade condenser 28 of the primary side refrigerating circuit 20, and the temperature of the cascade condenser 28 decreases.

[0048] Due to the low temperature generated here, the coolant passing through the cascade condenser (condenser) 28 of the secondary side refrigerating circuit 21 is condensed.

[0049] A bypass flow path 41 is provided in the secondary side refrigerating circuit 21.

[0050] The bypass flow path 41 is a flow path that is branched from a portion between the cascade condenser (condenser) 28 and the low temperature side expansion portion 38 and that is connected to a portion between the low temperature side evaporator 40 and the coolant suction port 45 of the low temperature side compressor 35. That is, the bypass flow path 41 is a flow path that connects the discharge side of the cascade condenser

(condenser) 28 and the suction side of the low temperature side compressor 35. The bypass flow path 41 is a flow path that is branched from the main flow path 22 at a branching point 42 provided between the cascade condenser (condenser) 28 and the low temperature side expansion portion 38 and that is joined to the main flow path 22 at a junction point 48 provided between the low temperature side evaporator 40 and the coolant suction port 45 of the low temperature side compressor 35.

[0051] A bypass expansion portion (flow rate control portion) 51 is provided in the bypass flow path 41. The bypass expansion portion 51 is a control valve including an actuator such as a motor, in which an opening degree can be freely changed based on an electric signal. It is desirable that the bypass expansion portion 51 can also be in a fully closed state.

[0052] In the secondary side refrigerating circuit 21, pressure detection portion 46 and coolant temperature detection portion 47 are provided.

[0053] Both of the pressure detection portion 46 and the coolant temperature detection portion 47 are provided between the junction point 48 of the bypass flow path 41 and the coolant suction port 45 of the low temperature side compressor 35. In the present embodiment, both of the pressure detection portion 46 and the coolant temperature detection portion 47 are provided at a position immediately before the coolant suction port 45 of the low temperature side compressor 35.

[0054] The pressure detection portion 46 detects the pressure of the coolant on the suction side of the low temperature side compressor 35. The coolant temperature detection portion 47 detects the temperature of the coolant on the suction side of the low temperature side compressor 35. The coolant temperature detection portion 47 is, for example, a thermistor or a thermocouple.

[0055] The coolant flowing through the bypass flow path 41 is in a liquid phase or in a gas-liquid mixed state, and thus has a sufficient cooling capacity. Therefore, the bypass flow path 41 can function as a coolant flow path for cooling that decreases the temperature of the low temperature side compressor 35.

[0056] The low temperature side compressor 35 adopted in the present embodiment is a closed compressor, in which a compression mechanism (compression portion) 71, a motor 72, and an oil pump (not illustrated) are built in a closed container 70 of the low temperature side compressor 35.

[0057] The form of the compression mechanism 71 is not limited and may be, for example, a reciprocating type, a rotary type, or a scroll type.

[0058] In the high temperature side compressor 25, as in the low temperature side compressor 35, a compression mechanism (compression portion), a motor, and an oil pump are built in a closed container of the high temperature side compressor 25.

[0059] The coolant suction port 45 and the coolant discharge port 31 are opened in the closed container 70.

[0060] The coolant suction port 45 is a pipeline com-

municating with the inside and outside of the closed container 70. The coolant discharge port 31 is a pipeline that connects a discharge portion of the compression mechanism 71 and the outside.

[0061] Next, the control device 16 will be described. The control device 16 is a device that includes a CPU or a memory and stores a computer program for executing a desired operation.

[0062] As illustrated in FIG. 3, the control device 16 includes temperature adjustment portion 80, suction pressure recognition portion 81, and coolant target temperature setting portion 82.

[0063] A signal from the input device 11 is input to the control device 16. A signal from the pressure detection portion 46 and a signal from the coolant temperature detection portion 47 are input to the control device 16.

[0064] The members configuring the main flow path 22 of the air conditioning device 17 and the bypass expansion portion 51 are connected to an output side of the control device 16.

[0065] As in a well-known environmental testing apparatus, the control device 16 includes the temperature adjustment portion 80, and controls the main flow path 22 of the air conditioning device 17 to become in an environment set by the input device 11. That is, the refrigerating device 7 is controlled by the temperature adjustment portion 80 of the control device 16 and operates such that the temperature in the test chamber 5 is maintained at the set temperature. In the present embodiment, the low temperature side expansion portion 38 is controlled by the control device 16 such that the temperature in the test chamber 5 approaches the set temperature. That is, the low temperature side expansion portion 38 is controlled such that the opening degree increases when a difference between the temperature in the test chamber 5 and the set temperature is large and the opening degree decreases when the temperature in the test chamber 5 approaches the set temperature and a refrigeration load decreases.

[0066] The suction pressure recognition portion 81 recognizes the actual coolant pressure on the suction side of the low temperature side compressor 35 that is detected by the pressure detection portion 46.

[0067] The coolant target temperature setting portion 82 calculates the coolant target temperature from the actual coolant pressure on the suction side of the low temperature side compressor 35 that is detected by the pressure detection portion 46. Here, the coolant target temperature is the target temperature of the coolant introduced into the low temperature side compressor 35.

[0068] The coolant target temperature is set using a predetermined mathematical expression or a numerical table.

[0069] Although not limited thereto, a relationship between the coolant pressure on the suction side of the low temperature side compressor 35 (hereinafter, simply referred to as the coolant pressure) and the coolant target temperature is set as illustrated in the graph of FIG. 4.

[0070] The coolant target temperature is divided into a plurality of regions depending on the range of the coolant pressure (the pressure of the coolant on the suction side). In the example of FIG. 4, the coolant target temperature is divided into two regions based on a predetermined coolant pressure (the pressure of the coolant on the suction side).

[0071] In a first region (hereinafter, referred to as a low pressure region) where the coolant pressure is a certain value or less, the coolant target temperature increases according to an increase in the coolant pressure. An increasing curve of the coolant target temperature in the low pressure region is almost linear. An increase in the coolant target temperature in the low pressure region is almost a straight line approximated to a linear function. That is, the coolant target temperature in the low pressure region changes in a certain range of change rate along with a change in pressure. In other words, the coolant target temperature increases or decreases in a certain range of constant of proportionality.

[0072] The increasing curve of the coolant target temperature in the low pressure region may be a straight line and the coolant target temperature may increase with a predetermined constant of proportionality. Here, the coolant target temperature changes at a certain change rate.

[0073] The change rate of the coolant target temperature in the low pressure region and the constant of proportionality of the increasing curve thereof are relatively small.

[0074] In a second region (hereinafter, referred to as a high pressure region) where the coolant pressure (the pressure of the coolant on the suction side) exceeds a certain value, the coolant target temperature rapidly increases. Focusing on an increase rate (change rate) of the coolant target temperature, in most of the high pressure region, the increase rate in the coolant target temperature is higher than the increase rate in the low pressure region. In the present embodiment, the increase rate in the coolant target temperature in the entire high pressure region is higher than the increase rate in the low pressure region. The high pressure region may have a region where the increase rate in the coolant target temperature is lower than the increase rate in the low pressure region.

[0075] In the low pressure region, the coolant target temperature when the coolant pressure is high is higher than that when the coolant pressure is low. In the present embodiment, in the low pressure region, the coolant target temperature when the coolant pressure is high is always higher than that when the coolant pressure is low.

[0076] Even in the high pressure region, the coolant target temperature when the coolant pressure is high is higher than that when the coolant pressure is low. In the present embodiment, in the high pressure region, the coolant target temperature when the coolant pressure is high is always higher than that when the coolant pressure is low.

[0077] In the entire region of the coolant pressure, the coolant target temperature when the coolant pressure is high is higher than that when the coolant pressure is low. Even in the entire region of the coolant pressure, the coolant target temperature when the coolant pressure is high is always higher than that when the coolant pressure is low.

[0078] The coolant target temperature is set to a temperature at which liquid return does not occur in the low temperature side compressor 35.

[0079] In the present embodiment, the signal from the coolant temperature detection portion 47 is input to the control device (control portion) 16. The bypass expansion portion (flow rate control portion) 51 is controlled based on the signal from the control device 16. In the present embodiment, the opening degree of the bypass expansion portion 51 is controlled such that the temperature of the coolant on the suction side of the low temperature side compressor 35 (the actual coolant temperature) that is detected by the coolant temperature detection portion 47 matches with the coolant target temperature.

[0080] Specifically, when the actual coolant temperature is higher than the coolant target temperature, the control device 16 increases the opening degree of the bypass expansion portion 51 such that the amount of the coolant flowing through the bypass flow path 41 increases. That is, when a relative value of the actual coolant temperature with respect to the coolant target temperature is high, the opening degree of the bypass expansion portion 51 increases such that the amount of the coolant flowing through the bypass flow path 41 increases.

[0081] As described above, the coolant flowing through the bypass flow path 41 is in a liquid phase or in a gas-liquid mixed state, and thus has a sufficient cooling capacity. By increasing the opening degree of the bypass expansion portion 51, a larger amount of the coolant having the cooling capacity flows to the downstream side of the low temperature side evaporator 40, and the temperature of the coolant supplied to the low temperature side compressor 35 decreases.

[0082] Conversely, when the actual coolant temperature is lower than the coolant target temperature, the control device 16 decreases the opening degree of the bypass expansion portion 51 such that the amount of the coolant flowing through the bypass flow path 41 decreases. That is, when a relative value of the actual coolant temperature with respect to the coolant target temperature is low, the opening degree of the bypass expansion portion 51 decreases such that the amount of the coolant flowing through the bypass flow path 41 decreases. As a result, the amount of the coolant having the cooling capacity and flowing to the downstream side of the low temperature side evaporator 40 decreases, and the temperature of the coolant supplied to the low temperature side compressor 35 increases.

[0083] Here, note that the opening degree of the by-

pass expansion portion 51 changes depending on the relative value of the actual coolant temperature with respect to the coolant target temperature, and does not change depending on the value of the actual coolant temperature. When the actual coolant temperature is high, the weight flow rate of the coolant circulating through the main flow path 22 is high, and the requirement level of the refrigerating capacity is high.

[0084] Next, an operation of the refrigerating device 7 will be described.

[0085] In the refrigerating device 7, the high temperature side compressor 25 of the primary side refrigerating circuit 20 and the low temperature side compressor 35 of the secondary side refrigerating circuit 21 are started and operated.

[0086] In the primary side refrigerating circuit 20, the coolant is compressed by the high temperature side compressor 25, and is cooled and condensed by the high temperature side condenser 26. The liquefied coolant passes through a narrow gap of the high temperature side expansion portion 27, enters the primary side flow path 30 of the cascade condenser 28, and is evaporated such that the temperature of the cascade condenser 28 decreases. The coolant discharged from the primary side flow path 30 of the cascade condenser 28 returns to the high temperature side compressor 25 and is compressed again.

[0087] In the secondary side refrigerating circuit 21, the coolant is compressed by the low temperature side compressor 35, and is cooled and condensed by the secondary side flow path 37 of the cascade condenser (condenser) 28. The liquefied coolant passes through a narrow gap of the low temperature side expansion portion 38, enters the low temperature side evaporator (cooler) 40, and is evaporated such that the temperature of the low temperature side evaporator (cooler) 40 decreases. The coolant discharged from the low temperature side evaporator (cooler) 40 returns to the low temperature side compressor 35 and is compressed again.

[0088] The refrigerating device 7 is controlled by the control device 16 and operates such that the temperature in the test chamber 5 is maintained at the set temperature. In the present embodiment, the low temperature side expansion portion 38 is controlled by the control device 16 such that the temperature in the test chamber 5 approaches the set temperature. That is, the low temperature side expansion portion 38 is controlled such that the opening degree increases when a difference between the temperature in the test chamber 5 and the set temperature is large, and the opening degree decreases when the temperature in the test chamber 5 approaches the set temperature and a refrigeration load decreases.

[0089] Depending on a change in opening degree of the low temperature side expansion portion 38, the amount of the coolant circulating through the main flow path 22 changes. That is, when the opening degree of the low temperature side expansion portion 38 increases, the

amount of the circulating coolant increases, and when the opening degree of the low temperature side expansion portion 38 decreases, the amount of the circulating coolant decreases.

[0090] In the present embodiment, when the temperature in the low temperature side compressor 35 is excessively high or there is a concern that the temperature in the low temperature side compressor 35 may become excessively high, the coolant for cooling is supplied from the bypass flow path 41 to the low temperature side compressor 35, and an overload operation of the motor 72, burnout of a coil, a decrease in viscosity of lubricating oil, or deterioration of lubricating oil is suppressed.

[0091] In the present embodiment, the coolant target temperature on the suction side of the low temperature side compressor 35 when the coolant pressure (the pressure of the coolant on the suction side) is high is set to be always higher than that when the coolant pressure is low. When the amount of the coolant circulating through the main flow path 22 is large and the amount of the coolant introduced into the low temperature side compressor 35 increases, the coolant pressure increases. As a result, the bypass flow path 41 is narrowed, and the coolant for cooling introduced from the bypass flow path 41 decreases.

[0092] The description will be made in order. When the amount of the coolant circulating through the main flow path 22 is large and the amount of the coolant introduced into the low temperature side compressor 35 increases, the pressure of the coolant on the suction side of the low temperature side compressor 35 increases. The pressure increase is detected by the pressure detection portion 46, and a signal regarding the pressure of the coolant on the suction side is transmitted to the control device 16. The coolant target temperature setting portion 82 of the control device 16 determines a relationship between the pressure of the coolant on the suction side and the coolant target temperature as illustrated in FIG. 4. Therefore, depending on an increase in the pressure of the coolant on the suction side, the target temperature changes such that the coolant target temperature increases.

[0093] As a result, the actual coolant temperature is lower than the coolant target temperature, the opening degree of the bypass expansion portion 51 decreases, and the amount of the coolant flowing through the bypass flow path 41 decreases. That is, when the amount of the coolant circulating through the main flow path 22 is large and the amount of the coolant introduced into the low temperature side compressor 35 increases, the opening degree of the bypass expansion portion 51 decreases, and the amount of the coolant for cooling introduced decreases.

[0094] Therefore, according to the present aspect, the low temperature side compressor 35 is suppressed from being excessively cooled.

[0095] According to an experiment by the present inventors, it was verified that, even when the above-described refrigerating device 7 operates according to a

wide range of requirement levels of the refrigerating capacity, the temperature of the low temperature side compressor 35 falls within a certain range. That is, the temperature of the low temperature side compressor 35 can be maintained at a certain level without being excessively high or excessively low. In the above-described refrigerating device 7, even when the required refrigerating capacity is low, the temperature of the low temperature side compressor 35 falls within a certain range, and even when the refrigerating capacity is high, the temperature of the low temperature side compressor 35 falls within a certain range.

[0096] In the refrigerating device 7 according to the present embodiment, the increasing curve of the coolant target temperature changes depending on whether the coolant pressure is in the low pressure region (first region) or in the high pressure region (second region) beyond the low pressure region. Therefore, in the low pressure region where the amount of the coolant introduced into the compressor is small, an excessive heat generation of the compressor can be suppressed. In the high pressure region where the amount of the coolant introduced into the compressor is large, the compressor is not likely to be excessively cooled.

[0097] A boundary between the low pressure region and the high pressure region is theoretically a pressure region where the specific volume of the coolant largely changes, but actually an appropriate value thereof is obtained by experiment.

[0098] Even for the increasing curve of the coolant target temperature, an optimal value is obtained by many experiments.

[0099] The technological concept of the refrigerating device 7 according to the above-described embodiment is to reduce the amount of the coolant for cooling introduced from the bypass flow path 41 when the weight flow rate of the coolant introduced into the low temperature side compressor 35 is high as described above.

[0100] The amount (weight flow rate) of the coolant flowing through the main flow path 22 has a positive correlation with the pressure of the coolant on the suction side of the low temperature side compressor 35 that is detected by the pressure detection portion 46. In the present embodiment, by detecting the pressure of the coolant on the suction side of the low temperature side compressor 35, the weight flow rate of the coolant flowing through the main flow path 22 is indirectly detected.

[0101] That is, the amount of the coolant introduced into the low temperature side compressor 35 has a positive correlation with the pressure of the coolant on the suction side of the low temperature side compressor 35 that is detected by the pressure detection portion 46. In the present embodiment, by detecting the pressure of the coolant on the suction side of the low temperature side compressor 35, the weight flow rate of the coolant introduced into the low temperature side compressor 35 is indirectly detected.

[0102] As the method of detecting the amount (weight

flow rate) of the coolant introduced into the low temperature side compressor 35, a method other than the above-described methods can be considered.

[0103] When the requirement level of the refrigerating capacity is high, the amount of the coolant introduced into the low temperature side compressor 35 increases. For example, when rapidly decreasing the temperature in the test chamber 5, the requirement level of the refrigerating capacity increases, and the amount of the coolant introduced into the low temperature side compressor 35 increases. Therefore, the coolant target temperature may be changed depending on the requirement level of the refrigerating capacity instead of the pressure of the coolant on the suction side.

[0104] A control device 90 illustrated in FIG. 5 sets the target temperature of the coolant introduced into the low temperature side compressor 35 according to the requirement level of the refrigerating capacity, and changes the opening degree of the bypass expansion portion 51 such that the temperature of the coolant introduced into the low temperature side compressor 35 becomes the target temperature.

[0105] The control device 90 includes requirement level recognition portion 91. The requirement level recognition portion 91 compares the set temperature of the test chamber 5 input by the input device 11 with the temperature detected by the temperature sensor (in-chamber temperature detection portion) 12 provided in the test chamber 5 to recognize the requirement level of the refrigerating capacity. When the set temperature of the test chamber 5 is lower than the temperature detected by the temperature sensor (in-chamber temperature detection portion) 12 and a difference therebetween is large, the requirement level of the refrigerating capacity is high, and when the difference therebetween is small, the requirement level of the refrigerating capacity is low.

[0106] Even when the present embodiment is adopted, the temperature of the low temperature side compressor 35 falls within a certain range.

[0107] As the method of detecting the amount of the coolant introduced into the low temperature side compressor 35, other methods are as follows: (1) the current of the low temperature side compressor 35; and (2) the opening degree of the low temperature side expansion portion 38.

[0108] When the current value of the low temperature side compressor 35 increases, the load of the low temperature side compressor 35 is high, and the amount of the coolant introduced into the low temperature side compressor 35 is large. Therefore, the coolant target temperature may be determined depending on the current of the low temperature side compressor 35 instead of the detection value of the pressure detection portion 46 or the requirement level of the refrigerating capacity.

[0109] When the opening degree of the low temperature side expansion portion 38 increases, the amount of the coolant introduced into the low temperature side compressor 35 increases. Therefore, the coolant target

temperature may be determined depending on the opening degree of the low temperature side expansion portion 38 instead of the detection value of the pressure detection portion 46 or the requirement level of the refrigerating capacity.

[0110] As the method of detecting the amount of the coolant introduced into the low temperature side compressor 35, when the requirement level of the refrigerating capacity, the current of the low temperature side compressor 35, and the opening degree of the low temperature side expansion portion 38 are used as indices, the coolant target temperature may change depending on whether each of the indices is in a first region where each of the indices is a certain value or less and a second region where each of the indices is more than a certain value, as when using the pressure of the coolant illustrated in FIG. 4 as the index. That is, when each of the indices is in the first region, the coolant target temperature may be set to change in a certain range of change rate, and when each of the indices is in the second region, the coolant target temperature may be set to change at a change rate more than the certain range of change rate.

[0111] In the above-described embodiment, the coolant pressure is divided into the low pressure region (first region) and the high pressure region (second region), and the increasing curves of the coolant target temperatures in the low pressure region and the high pressure region are clearly distinguished. However, the present invention is not limited thereto. The coolant target temperature may change linearly or in a smooth curved shape in all of the regions of the coolant pressure. The coolant pressure may be divided into three or more regions, and the change rate of the coolant target temperature may discontinuously change in each of the regions.

[0112] The above-described embodiment relates to an environmental testing apparatus mainly used for an application where a test object is exposed to a high temperature environment or a low temperature environment. However, the present invention is not limited to such type of environmental testing apparatus, and the present invention is also applicable to an environmental testing apparatus called a thermal shock testing apparatus or a thermal cycle testing apparatus.

[0113] In the above-described embodiment, the low temperature side evaporator 40 and the coolant suction port 45 of the low temperature side compressor 35 are directly connected, and the pressure detection portion 46 and the coolant temperature detection portion 47 are provided in the pipeline.

[0114] However, the present invention is not limited thereto, and any member may be interposed between the low temperature side evaporator 40 and the low temperature side compressor 35. For example, an accumulator may be provided between the low temperature side evaporator 40 and the low temperature side compressor 35.

[0115] The pressure detection portion 46 and the cool-

ant temperature detection portion 47 may be provided in a flow path on an introduction side of the accumulator. That is, the coolant temperature on the suction side of the accumulator may be regarded as the temperature of the coolant introduced into the low temperature side compressor 35.

[0116] In the above-described embodiment, as the flow rate control portion for adjusting the opening degree of the bypass flow path, an electronic expansion valve that can freely change the opening degree based on an electric signal is adopted. However, the present invention does not limit the flow rate control portion to the electronic expansion valve.

[0117] For example, a combination of a narrowing member such as a capillary tube and a valve such as a solenoid valve may be used as the flow rate control portion. Here, a configuration where a time interval of opening and closing of the solenoid valve is controlled to control the substantial opening degree is considered.

[0118] Flow rate control portion may also be configured by providing sub-bypass flow paths where a plurality of narrowing members such as capillary tubes are disposed in parallel and providing a valve in each of the sub-bypass flow paths. Here, by changing the number of opened valves, the substantial opening degrees of all the sub-bypass flow paths are controlled.

[0119] The above-described environmental testing apparatus 1 adopts the refrigerating device 7 having the binary cooling structure. The present invention is not limited thereto, and a refrigerating device having a unitary cooling structure may be adopted.

[0120] The representative refrigerating device having a unitary cooling structure includes one compressor, one condenser, one expansion portion, and one evaporator, and a coolant undergoing a phase change circulates therein. The refrigerating device that adopts the unitary cooling structure includes a bypass flow path that connects a discharge side of the condenser and a suction side of the compressor, and flow rate control portion is provided in the bypass flow path. The pressure detection portion and the coolant temperature detection portion are provided in the vicinity of the coolant suction port of the compressor.

[0121] In the above-described embodiment, the bypass flow path 41 is branched from the main flow path 22 at the branching point 42 between the cascade condenser (condenser) 28 of the main flow path 22 and the low temperature side expansion portion 38. However, a branching point may be provided between the low temperature side expansion portion 38 and the low temperature side evaporator 40.

[0122] The above-described refrigerating device 7 is incorporated into the environmental testing apparatus 1. However, the application of the refrigerating device 7 is not limited to the environmental testing apparatus 1, and the refrigerating device 7 can also be applied to a refrigerator, a vending machine, or the like.

REFERENCE SIGNS LIST

[0123]

- 1: environmental testing apparatus
- 7: refrigerating device (cooling portion)
- 16: control device (control portion)
- 18: refrigerating circuit
- 20: primary side refrigerating circuit
- 21: secondary side refrigerating circuit
- 22: main flow path
- 28: cascade condenser (condenser)
- 35: low temperature side compressor
- 38: low temperature side expansion portion
- 40: low temperature side evaporator
- 41: bypass flow path
- 46: pressure detection portion
- 47: coolant temperature detection portion
- 51: bypass expansion portion (flow rate control portion)
- 81: suction pressure recognition portion
- 82: coolant target temperature setting portion
- 90: control device
- 91: requirement level recognition portion

Claims

1. A refrigerating device (7) **characterized by** comprising a refrigerating circuit (21) and a control portion (16) configured to control the refrigerating circuit (21), wherein

the refrigerating circuit (21) includes a main flow path (22) in which a compressor (35), a condenser (28), an expansion portion (38), and an evaporator (40) are connected to each other and in which a coolant undergoing a phase change is to be circulated, and a bypass flow path (41) that connects a discharge side of the condenser (28) and a suction side of the compressor (35), and a flow rate control portion (51) whose opening degree is adjustable is provided in the bypass flow path (41),

the control portion (16) is configured to set a target temperature of the coolant introduced into the compressor (35) according to a pressure of the coolant on the suction side of the compressor (35) and is configured to change the opening degree of the flow rate control portion (51) such that a temperature of the coolant introduced into the compressor (35) becomes the target temperature, and

the target temperature when the pressure is high is higher than that when the pressure is low.

2. A refrigerating device (7) **characterized by** comprising a refrigerating circuit (21) and a control portion

(16) configured to control the refrigerating circuit (21), wherein

the refrigerating circuit (21) includes a main flow path (22) in which a compressor (35), a condenser (28), an expansion portion (38), and an evaporator (40) are connected to each other and in which a coolant undergoing a phase change is to be circulated, and a bypass flow path (41) that connects a discharge side of the condenser (28) and a suction side of the compressor (35), and a flow rate control portion (51) whose opening degree is adjustable is provided in the bypass flow path (41),

the control portion (16) is configured to set a target temperature of the coolant introduced into the compressor (35) according to a requirement level of a refrigerating capacity and is configured to change the opening degree of the flow rate control portion (51) such that a temperature of the coolant introduced into the compressor (35) becomes the target temperature, and the target temperature when the requirement level is high is higher than that when the requirement level is low.

3. A refrigerating device (7) **characterized by** comprising a refrigerating circuit (21) and a control portion (16) configured to control the refrigerating circuit (21), wherein

the refrigerating circuit (21) includes a main flow path (22) in which a compressor (35), a condenser (28), an expansion portion (38), and an evaporator (40) are connected to each other and in which a coolant undergoing a phase change is to be circulated, and a bypass flow path (41) that connects a discharge side of the condenser (28) and a suction side of the compressor (35), and a flow rate control portion (51) whose opening degree is adjustable is provided in the bypass flow path (41),

the control portion (16) is configured to set a target temperature of the coolant introduced into the compressor (35) according to an amount of the coolant sucked into the compressor (35) and is configured to change the opening degree of the flow rate control portion (51) such that a temperature of the coolant introduced into the compressor (35) becomes the target temperature, and

the target temperature when the amount of the sucked coolant is large is higher than that when the amount of the sucked coolant is small.

4. The refrigerating device (7) according to any one of claims 1 to 3, wherein the target temperature is to change in a certain range

of change rate.

5. The refrigerating device (7) according to any one of claims 1 to 3, wherein

the target temperature changes in a certain range of change rate when any one of conditions below is in a first region of a predetermined value or less, and the target temperature changes at a change rate more than the certain range of change rate when any one of the conditions below is in a second region of more than the predetermined value, the conditions including

- (1) a pressure of the coolant on the suction side of the compressor (35),
- (2) a requirement level of a refrigerating capacity, and
- (3) an amount of the coolant sucked into the compressor (35).

6. An environmental testing apparatus (1) comprising the refrigerating device (7) according to any one of claims 1 to 3.

FIG. 1

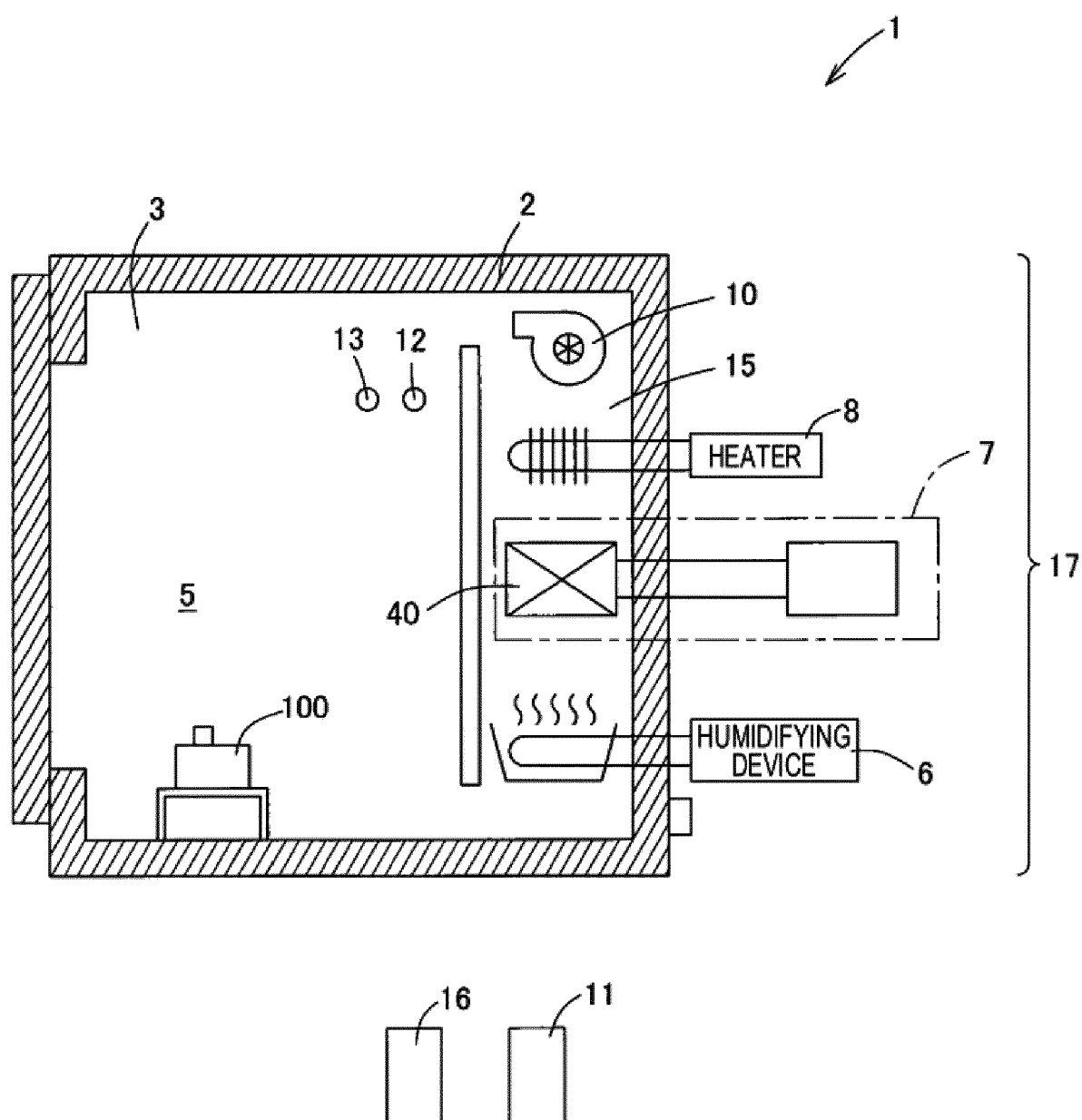


FIG. 2

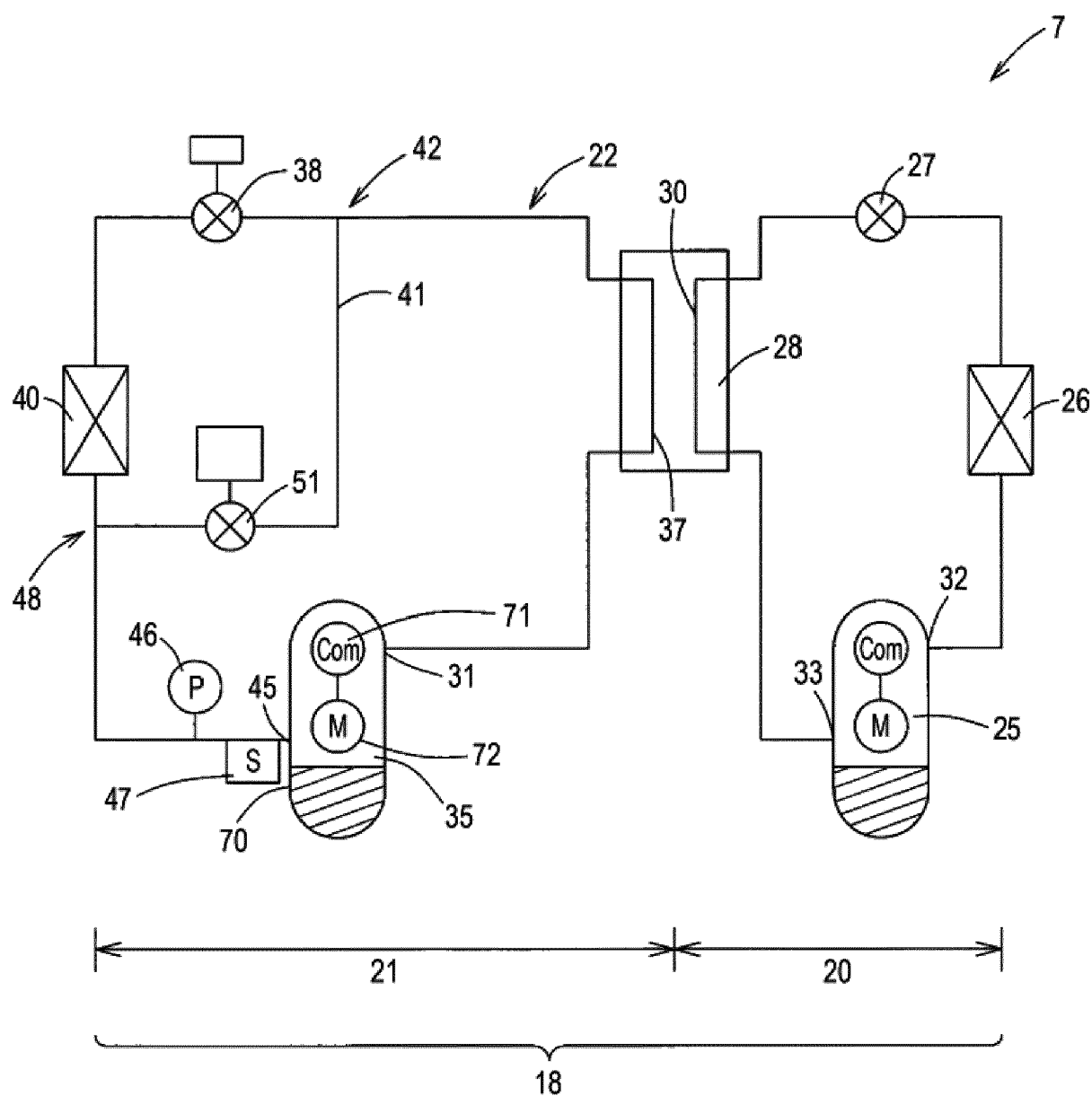


FIG. 3

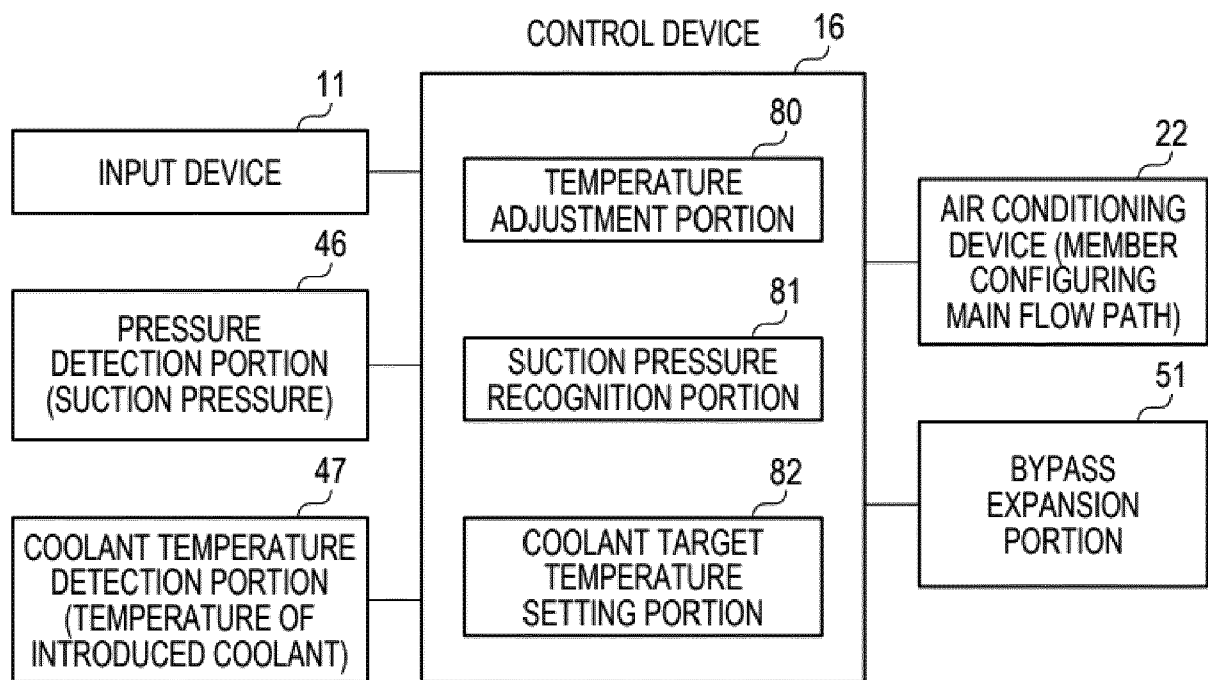


FIG. 4

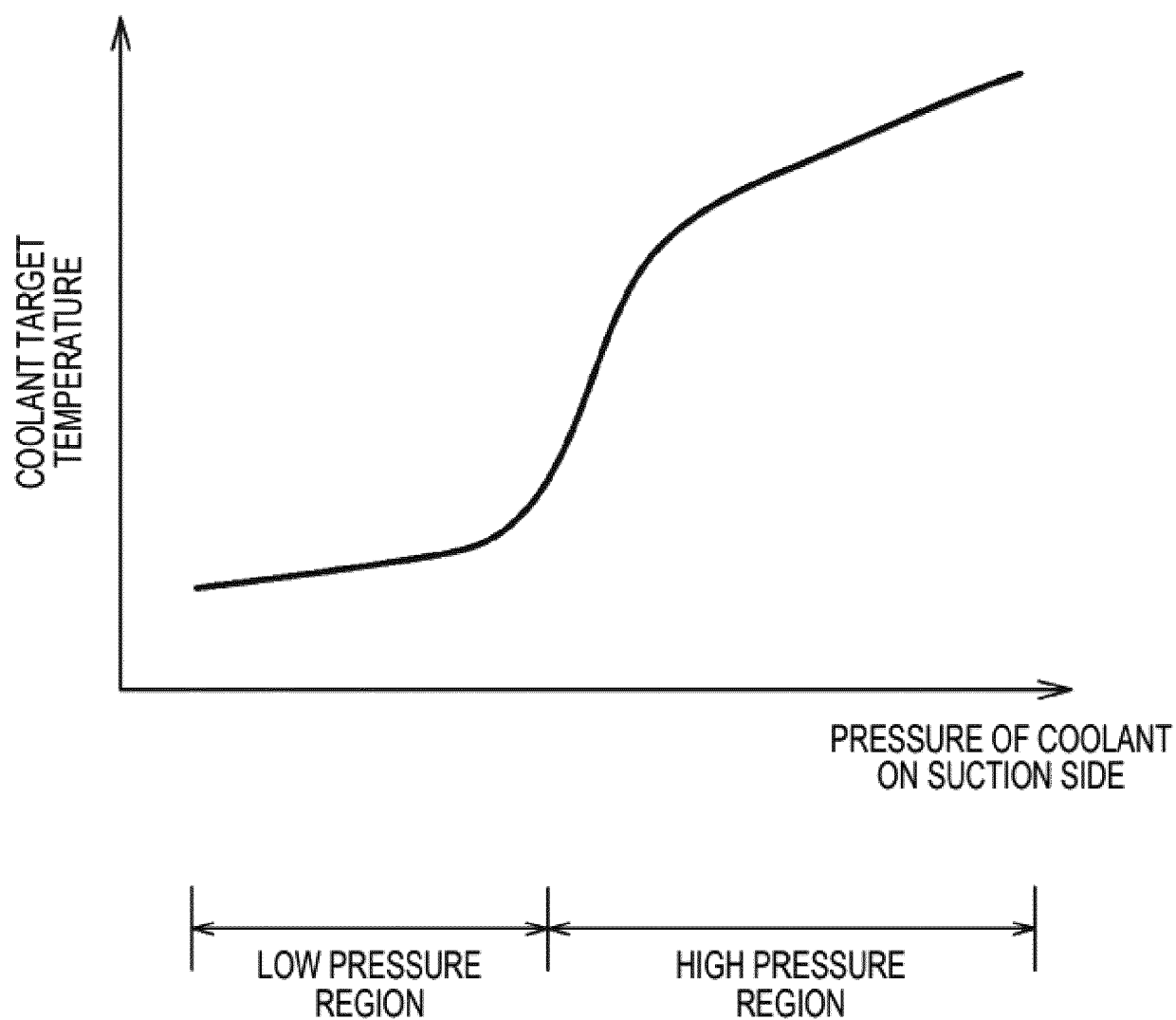
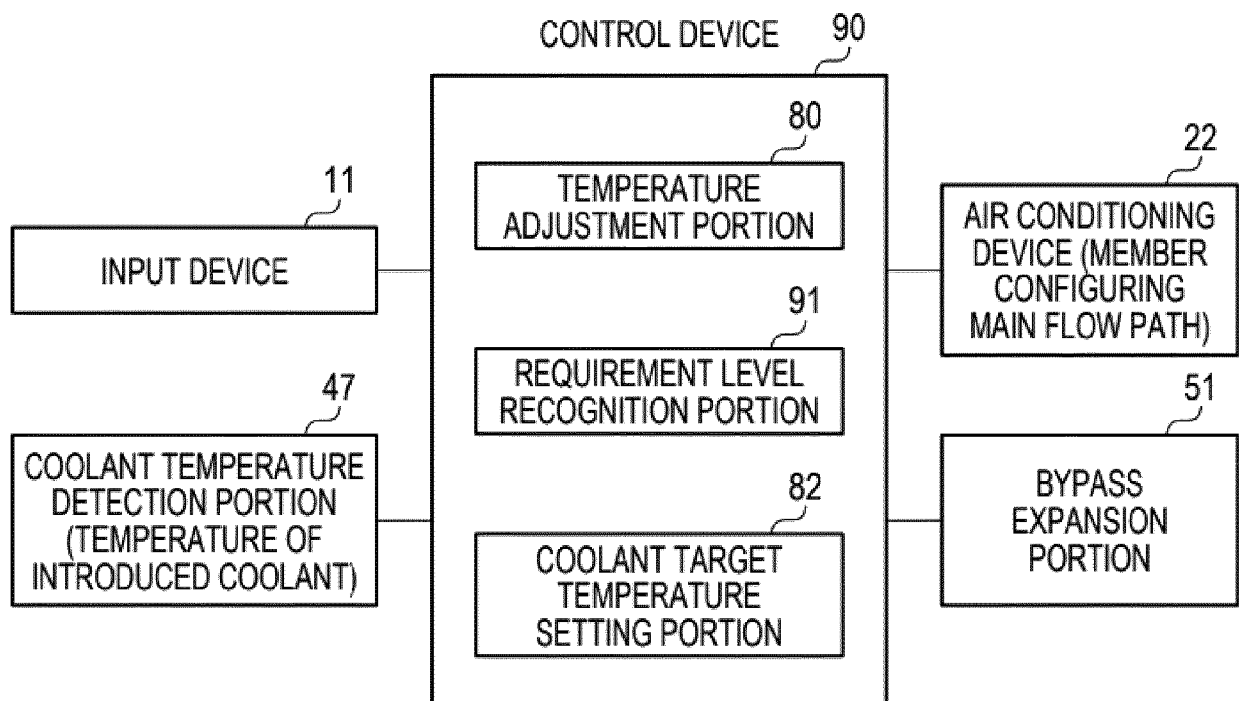


FIG. 5





EUROPEAN SEARCH REPORT

Application Number

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