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VEHICULAR HEAT PUMP CYCLE DEVICE

Abstract

The configuration enables to suppress noise of a compressor while ensuring a necessary heating capacity. a compressor configured to draw, compress, and discharge refrigerant; a heating unit configured to heat an object to be heated using, as a heat source, refrigerant discharged from the compressor; a decompression unit configured to decompress refrigerant flowing out of the heating unit; and a heat absorbing unit configured to cause refrigerant, which is decompressed by the decompression unit, to absorb heat generated by a heat generating unit. The heat absorbing unit is configured to increase an amount of absorbed heat according to decrease in the allowable noise level of the compressor.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION [0001] The present application is a continuation application of International Patent Application No. PCT/JP2023/036970 filed on Oct. 12, 2023, which designated the U.S. and claims the benefit of priority from Japanese Patent Application No. 2022-179484 filed on Nov. 9, 2022. The entire disclosures of all of the above applications are incorporated herein by reference.

TECHNICAL FIELD
[0002] The present disclosure relates to a vehicular heat pump cycle device.
BACKGROUND
[0003] Conventionally, a vehicular heat pump cycle including a compressor and a heat exchanger has been used to produce a required heating capacity.
SUMMARY
[0004] According to an aspect of the present disclosure, a heat pump cycle device includes a compressor, a heating unit, a decompression unit, and a heat absorbing unit.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0005] The above object and other objects, features, and advantages of the present disclosure will become more apparent from the following detailed description with reference to the accompanying drawings.
[0006] FIG. **1** is a schematic overall configuration diagram showing a vehicular air conditioner according to a first embodiment.
[0007] FIG. **2** is a schematic configuration diagram showing an indoor air conditioning unit according to the first embodiment.
[0008] FIG. **3** is a block diagram showing an electric control unit of the vehicular air conditioner according to the first embodiment.
[0009] FIG. **4** is a control characteristic graph used in determination of an allowable compressor noise in the first embodiment.
[0010] FIG. **5** is a control characteristic graph used in determination of a target chiller inlet water temperature in the first embodiment.
[0011] FIG. **6** is a graph showing a relationship between a chiller inlet water temperature, a compressor rotation speed, a chiller heat absorption amount, and the amount of work of the compressor in the first embodiment.
[0012] FIG. **7** is a schematic overall configuration diagram showing a flow of refrigerant in a single hot gas dehumidification heating mode and a cooling hot gas heating mode of a heat pump cycle in the first embodiment.
[0013] FIG. **8** is a Mollier chart showing a change in the state of refrigerant in the single hot gas heating mode of the heat pump cycle in the first embodiment.
[0014] FIG. **9** is a schematic overall configuration diagram showing a vehicular air conditioner according to a second embodiment.
[0015] FIG. **10** is a schematic overall configuration diagram showing a vehicular air conditioner according to a third embodiment.

[0016] FIG. **11** is a schematic overall configuration diagram showing a vehicular air conditioner according to a fourth embodiment.
[0017] FIG. **12** is a graph showing a relationship between a chiller target superheat degree and a chiller heat absorption amount in a fifth embodiment.

DETAILED DESCRIPTION

[0018] Hereinafter, examples of the present disclosure will be described. A vehicular heat pump cycle device according to an example of the present disclosure includes a heating unit that heats an object to be heated using a refrigerant discharged from a compressor and heat generated by a heat generating unit as heat sources.
[0019] According to an example, a vehicular heat pump cycle provides a required heating capacity (specifically, the space heating capacity) by a sum of an amount of work of of a compressor and an amount of heat absorbed from a chiller. The chiller is a heat exchanger that exchanges heat between a low-pressure refrigerant in a heat pump cycle and a low-temperature side heat medium in a low-temperature side heat medium circuit, and absorbs heat from the low-temperature side heat medium. An electric heater is provided in the low-temperature side heat medium circuit as a heat generating unit for heating the low-temperature side heat medium.
[0020] In this configuration, when the amount of heat absorbed from the chiller is small, it is necessary to increase the rotation speed of the compressor to increase the amount of work of the compressor. Increasing in the compressor speed results in increase in the compressor noise. The compressor noise is easily suppressed when the vehicle speed is high and the driving noise is loud, or when the air-conditioning indoor blower has a large air volume and the operating noise and blowing noise of the indoor blower are loud. However, when the vehicle speed is low or the air volume of the indoor blower is low, the compressor noise becomes noticeable and it may not be possible to increase the compressor rotation speed. Therefore, it may be difficult to ensure the necessary heating capacity.
[0021] According to an example of the present disclosure, a heat pump cycle device includes a compressor, a heating unit, a decompression unit, and a heat absorbing unit.
[0022] The compressor is configured to draw, compress, and discharge refrigerant. The heating unit is configured to heat an object to be heated using, as a heat source, refrigerant discharged from the compressor. The decompression unit is configured to decompress refrigerant flowing out of the heating unit. The heat absorbing unit is configured to cause refrigerant, which is decompressed by the decompression portion, to absorb heat generated by a heat generating unit. The heat absorbing unit is configured to increase an amount of absorbed heat according to decrease in an allowable noise level of the compressor.
[0023] According to this, the amount of heat absorbed in the heat absorbing unit is increased, as the allowable noise level of the compressor decreases, so that the desired heating capacity can be ensured in the heating unit even when the amount of work of the compressor (in other words, the rotation speed of the compressor) is decreased. Therefore, it is possible to suppress the noise of the compressor while ensuring the necessary heating capacity.
[0024] According to an example of the present disclosure, a heat pump cycle device includes a compressor, a heating unit, a decompression unit, a heat absorbing unit, and an upper limit rotation speed determination unit.
[0025] The compressor is configured to draw, compress, and discharge refrigerant. The heating unit is configured to heat an object to be heated using, as a heat source, refrigerant discharged from the compressor. The decompression unit is configured to decompress refrigerant flowing out of the heating unit. The heat absorbing unit is configured to cause refrigerant, which is decompressed by the decompression portion, to absorb heat generated by a heat generating unit. The upper limit rotation speed determination unit is configured to determine an upper limit rotation speed of the compressor.
[0026] The upper limit rotation speed determination unit lowers the upper limit rotation speed in

accordance with decrease in the allowable noise level of the compressor. The heat absorbing unit is configured to increase an amount of absorbed heat according to decrease in an allowable noise level of the compressor.
[0027] This can produce the same effects as those of the first aspect.
[0028] Hereinafter, embodiments for implementing the present disclosure will be described referring to drawings. In the respective embodiments, parts corresponding to matters already described in the preceding embodiments are given reference numbers identical to reference numbers of the matters already described. The same description is therefore omitted depending on circumstances. In a case where only a part of the configuration is described in each embodiment, other embodiments previously described can be applied to other parts of the configuration. It is also possible to partially combine the embodiments even when it is not explicitly described, as long as there is no problem in the combination as well as the combination of the parts specifically and explicitly described that the combination is possible.
First Embodiment
[0029] A first embodiment of a heat pump cycle device according to the present disclosure will be described with reference to FIGS. **1** to **8**. In the present embodiment, the heat pump cycle device according to the present disclosure is applied to a vehicular air conditioner **1** mounted on an electric vehicle. The electric vehicle is a vehicle that obtains traveling drive force from an electric motor. The vehicular air conditioner **1** performs air conditioning in a vehicle interior, which is a space to be air conditioned, and adjusts the temperature of an in-vehicle device. Therefore, the vehicular air conditioner **1** can be referred to as an air conditioner with an in-vehicle device temperature adjustment function or an in-vehicle device temperature adjustment device with an air conditioning function.
[0030] The vehicular air conditioner **1** includes a heat pump cycle **10**, a high-temperature side heat medium circuit **30**, a low-temperature side heat medium circuit **40**, an indoor air conditioning unit **50**, a control device **60**, and the like.
[0031] The heat pump cycle **10** shown in FIG. **1** is a vapor compression refrigeration cycle that adjusts the temperatures of ventilation air blown into the vehicle interior, a high-temperature side heat medium circulating in the high-temperature side heat medium circuit **30**, and a low-temperature side heat medium circulating in the low-temperature side heat medium circuit **40**.
[0032] The heat pump cycle **10** is configured to switch the refrigerant circuit according to various operation modes in order to perform air conditioning inside the vehicle interior. The heat pump cycle **10** uses an HFO refrigerant (specifically, R1234yf) as the refrigerant. The heat pump cycle **10** forms a subcritical refrigeration cycle in which the pressure of a high-pressure side refrigerant does not exceed the critical pressure of the refrigerant.
[0033] A refrigerator oil for lubricating a compressor **11** is mixed in the refrigerant. The refrigerant oil is a PAG oil (that is, polyalkylene glycol oil) compatible with a liquid-phase refrigerant or POE (that is, polyol ester). A part of the refrigerant oil circulates in the heat pump cycle **10** together with the refrigerant.
[0034] The compressor **11** draws, compresses, and discharges the refrigerant in the heat pump cycle **10**. The compressor **11** is an electric compressor that rotationally drives a fixed capacity type compression mechanism that has a fixed discharge capacity by an electric motor. A refrigerant discharge capacity (i.e., the rotational speed) of the compressor **11** is controlled by a controlling signal transmitted from a control device **60**.
[0035] The compressor **11** is provided in a drive unit chamber formed on the front side of the vehicle interior. The drive unit chamber forms a space in which at least a part of a device (for example, a motor generator as a traveling electric motor) used for generating or regulating driving force for vehicle traveling is provided.
[0036] The inflow port side of a first three-way joint **12*a*** is connected to a discharge port of the compressor **11**. The first three-way joint **12*a*** has three inflow-outflow ports communicating with

each other. As the first three-way joint **12***a*, a joint portion formed by joining a plurality of pipes or a joint portion formed by providing a plurality of refrigerant passages in a metal block or a resin block can be used.
[0037] The heat pump cycle **10** includes a second three-way joint **12***b* to a sixth three-way joint **12***f*. The basic configuration of each of the second three-way joint **12***b*, a third three-way joint **12***c*, a fourth three-way joint **12***d*, a fifth three-way joint **12***e*, and the sixth three-way joint **12***f* is the same as that of the first three-way joint **12***a*. The basic configuration of each three-way joint in embodiments to be described later is also similar to that of the first three-way joint **12***a*.
[0038] When one of the three inflow and outflow ports is used as an inflow port and the remaining two are used as outflow ports in each of these three-way joints, the flow of the refrigerant is branched. When two of the three inflow and outflow ports are used as inflow ports and the remaining one is used as an outflow port, the flows of the refrigerant are joined. The first three-way joint **12***a* is a branch portion that branches the flow of the discharge refrigerant discharged from the compressor **11**.
[0039] The inlet side of a refrigerant passage in a water-refrigerant heat exchanger **13** is connected to one outflow port of the first three-way joint **12***a*. Another outflow port of the first three-way joint **12***a* is connected to one inflow port of the sixth three-way joint **12***f*.
[0040] The refrigerant passage from the other outflow port of the first three-way joint **12***a* to one inflow port of the sixth three-way joint **12***f* is a bypass passage **21***c*. A bypass-side flow rate regulating valve **14***d* is provided in the bypass passage **21***c*.
[0041] The bypass-side flow rate regulating valve **14***d* is a bypass-passage side decompression unit that decompresses a discharge refrigerant (that is, the other the discharge refrigerant branched at the first three-way joint **12***a*) flowing out of the other outflow port of the first three-way joint **12***a* in various operation modes such as the hot gas air-heating mode to be described later. The bypass-side flow rate regulating valve **14***d* is a bypass-side flow-rate regulating unit that regulates the flow rate (the mass flow rate) of the refrigerant flowing through the bypass passage **21***c*.
[0042] The bypass-side flow rate regulating valve **14***d* is an electric variable throttle mechanism including a valve body that changes a throttle opening and an electric actuator (specifically, stepping motor) as a drive unit that displaces the valve body. The operation of the bypass-side flow rate regulating valve **14***d* is controlled by a control pulse output from the control device **60**.
[0043] The bypass-side flow rate regulating valve **14***d* has a full open function of functioning as a simple refrigerant passage without exhibiting a refrigerant decompression action and a flow rate regulating action by setting the throttle opening to a fully open state. The bypass-side flow rate regulating valve **14***d* has a full close function of closing the refrigerant passage by bringing the throttle opening degree to a full close state.
[0044] The heat pump cycle **10** includes an air-heating expansion valve **14***a*, an air-cooling expansion valve **14***b*, and a cooling expansion valve **14***c*. Each of the basic configurations of the air-heating expansion valve **14***a*, the air-cooling expansion valve **14***b*, and the cooling expansion valve **14***c* is similar to that of the bypass-side flow rate regulating valve **14***d*.
[0045] The refrigerant circuit can be switched by the air-heating expansion valve **14***a*, the air-cooling expansion valve **14***b*, the cooling expansion valve **14***c*, and the bypass-side flow rate regulating valve **14***d* exhibiting the fully closing function. Therefore, the air-heating expansion valve **14***a*, the air-cooling expansion valve **14***b*, the cooling expansion valve **14***c*, and the bypass-side flow rate regulating valve **14***d* function as a refrigerant circuit switching unit.
[0046] The air-heating expansion valve **14***a*, the air-cooling expansion valve **14***b*, the cooling expansion valve **14***c*, and the bypass-side flow rate regulating valve **14***d* may be formed by combining a variable throttle mechanism that does not have a fully closing function and an on-off valve that opens and closes a throttle passage. In this case, each on-off valve functions as the refrigerant circuit switching unit.
[0047] The water-refrigerant heat exchanger **13** is a heat-radiating heat exchange unit that

exchanges heat between the high-pressure refrigerant discharged from the compressor **11** and the high-temperature side heat medium circulating in the high-temperature side heat medium circuit **30** to radiate heat of the high-pressure refrigerant to the high-temperature side heat medium. The water-refrigerant heat exchanger **13** is a heating unit that uses the refrigerant discharged from the compressor **11** as a heat source to heat the high-temperature side heat medium, which is an object to be heated.

[0048] In the present embodiment, a so-called sub-cool heat exchanger is used as the water-refrigerant heat exchanger **13**. For this reason, a condensing portion **13***a*, a receiver **13***b*, and a sub-cooling portion **13***c* are provided in the refrigerant passage of the water-refrigerant heat exchanger **13**.

[0049] The condensing portion **13***a* is a condensing heat exchange unit that exchanges heat between the high-pressure refrigerant discharged from the compressor **11** and the high-pressure side heat medium to condense the high-pressure refrigerant. The receiver **13***b* is a high-pressure side gas-liquid separating unit that separates the refrigerant flowing out of the condensing portion **13***a* into gas and liquid and stores the separated liquid-phase refrigerant as an excess refrigerant in the cycle. The sub-cooling portion **13***c* is a sub-cooling heat exchange unit that exchanges heat between the liquid-phase refrigerant flowing out of the receiver **13***b* and the high-temperature heat medium to sub-cool the liquid-phase refrigerant.

[0050] An inflow port side of the second three-way joint **12***b* is connected to an outflow port of the refrigerant passage of the water-refrigerant heat exchanger **13** (specifically, the outflow port of the sub-cooling portion **13***c*). An inlet side of an air-heating expansion valve **14***a* is connected to one outflow port of the second three-way joint **12***b*. One inflow port side of a four-way joint **12***x* is connected to the other outflow port of the second three-way joint **12***b*.

[0051] The refrigerant passage from the other outflow port of the second three-way joint **12***b* to one inflow port of the four-way joint **12***x* is a dehumidifying passage **21***a*. A dehumidifying on-off valve **22***a* is provided in the dehumidifying passage **21***a*.

[0052] The dehumidifying on-off valve **22***a* is an on-off valve that opens and closes the dehumidifying passage **21***a*. The dehumidifying on-off valve **22***a* is an electromagnetic valve whose opening and closing operation is controlled by a control voltage output from the control device **60**. The dehumidifying on-off valve **22***a* can switch the refrigerant circuit by opening and closing the dehumidifying passage **21***a*. Therefore, the dehumidifying on-off valve **22***a* is a refrigerant circuit switching unit.

[0053] The four-way joint **12***x* is a joint portion having four inflow and outflow ports communicating with each other. As the four-way joint **12***x*, a joint portion formed in the same manner as the above-described three-way joint can be adopted. As the four-way joint **12***x*, one formed by combining two three-way joints may be employed.

[0054] The air-heating expansion valve **14***a* is an outdoor heat-exchanger side decompression unit that decompresses the refrigerant flowing into an outdoor heat exchanger **15** in an air-heating mode and the like among the various operation modes. The air-heating expansion valve **14***a* is a flow-rate regulating unit on the outdoor heat exchanger side that regulates the flow rate (the mass flow rate) of the refrigerant flowing into the outdoor heat exchanger **15**.

[0055] A refrigerant inlet side of the outdoor heat exchanger **15** is connected to an outlet of the air-heating expansion valve **14***a*. The outdoor heat exchanger **15** is an outside air heat exchange unit that exchanges heat between the refrigerant flowing out of the air-heating expansion valve **14***a* and outside air blown by an outside air fan (not illustrated). The outdoor heat exchanger **15** is provided on the front side of the drive unit chamber. For this reason, during traveling of the vehicle, the traveling air flowing into the drive unit chamber through a grill can be blown against the outdoor heat exchanger **15**.

[0056] An inflow port of the third three-way joint **12***c* is connected to the refrigerant outlet of the outdoor heat exchanger **15**. Another inflow port side of the four-way joint **12***x* is connected to one outflow port of the third three-way joint **12***c* via a first check valve **16***a*. Another outflow port of the third three-way joint **12***c* is connected to one inflow port of the fourth three-way joint **12***d*.

[0057] The refrigerant passage from the other outflow port of the third three-way joint **12***c* to one inflow port of the fourth three-way joint **12***d* is an air-heating passage **21***b*. An air-heating on-off valve **22***b* is provided in the air-heating passage **21***b*.

[0058] The air-heating on-off valve **22***b* is an on-off valve that opens and closes the air-heating passage **21***b*. The basic configuration of the air-heating on-off valve **22***b* is the same as that of the dehumidifying on-off valve **22***a*. Therefore, the air-heating on-off valve **22***b* is a refrigerant circuit switching unit. The basic configuration of each on-off valve described in the embodiments to be described later is also similar to that of the dehumidifying on-off valve **22***a*.

[0059] The first check valve **16***a* allows the refrigerant to flow from the third three-way joint **12***c* side to the four-way joint **12***x* side, and inhibits the refrigerant from flowing from the four-way joint **12***x* side to the third three-way joint **12***c* side.

[0060] The refrigerant inflow port side of an indoor evaporator **18** is connected to one outflow port of the four-way joint **12***x* via the air-cooling expansion valve **14***b*.

[0061] The air-cooling expansion valve **14***b* is a decompression unit on the indoor evaporator side that decompresses the refrigerant flowing into the indoor evaporator **18** in an air-cooling mode, a hot gas dehumidifying air-heating mode, or the like among the various operation modes. Therefore, the air-cooling expansion valve **14***b* serves as a heating-unit side decompression unit in the hot gas dehumidifying air-heating mode or the like. The air-cooling expansion valve **14***b* is also a flow-rate regulating unit on the indoor evaporator side that regulates the flow rate (the mass flow rate) of the refrigerant flowing into the indoor evaporator **18**.

[0062] The indoor evaporator **18** is provided in an air conditioning case **51** of the indoor air conditioning unit **50** shown in FIG. **2**. The indoor evaporator **18** is an air-cooling heat exchange unit that exchanges heat between the low-pressure refrigerant decompressed by the air-cooling expansion valve **14***b* and ventilation air blown from an indoor blower **52** toward the vehicle interior. In the indoor evaporator **18**, the ventilation air is cooled by evaporating the low-pressure refrigerant to exhibit the heat absorbing action.

[0063] One inflow port side of the fifth three-way joint **12***e* is connected to a refrigerant outflow port of the indoor evaporator **18** via a second check valve **16***b*. The second check valve **16***b* allows the refrigerant to flow from the refrigerant outflow port side of the indoor evaporator **18** to the fifth three-way joint **12***e* side, and prohibits the refrigerant from flowing from the fifth three-way joint **12***e* side to the refrigerant outflow port side of the indoor evaporator **18**.

[0064] An inflow port side of a refrigerant passage in a chiller **20** is connected to another outflow port of the four-way joint **12***x* via the cooling expansion valve **14***c*.

[0065] The cooling expansion valve **14***c* is a chiller-side decompression unit that decompresses the refrigerant flowing into the chiller **20** in, for example, a cooling and air-cooling mode, the hot gas air-heating mode, or the like among the various operation modes. Therefore, the cooling expansion valve **14***c* serves as a heating-unit side decompression unit in the hot gas air-heating mode or the like. The cooling expansion valve **14***c* is also a chiller-side flow-rate regulating unit that regulates the flow rate (the mass flow rate) of the refrigerant flowing into the chiller **20**.

[0066] The chiller **20** is a temperature-regulating heat exchange unit that exchanges heat between the low-pressure refrigerant decompressed by the cooling expansion valve **14***c* and the low-temperature side heat medium circulating in the low-temperature side heat medium circuit **40**. In the chiller **20**, the low-pressure refrigerant is evaporated to exert a heat absorbing effect, so that the heat held by the low-temperature heat medium is absorbed by the low-pressure refrigerant.

[0067] The other inflow port side of the fourth three-way joint **12***d* is connected to an outflow port of the refrigerant passage in the chiller **20**. The other inflow port side of the fifth three-way joint **12***e* is connected to an outflow port of the fourth three-way joint **12***d*. The other inflow port side of the sixth three-way joint **12***f* is connected to an outflow port of the fifth three-way joint **12***e*. An

inflow port side of the compressor **11** is connected to an outflow port of the sixth three-way joint **12***f*.
[0068] Accordingly, in the hot gas air-heating mode or the like, the sixth three-way joint **12***f* serves as a joining unit that joins the flow of the heating-unit side refrigerant flowing out of the heating-unit side decompression unit and the flow of the bypass-side refrigerant flowing out of the bypass-side flow rate regulating valve **14***d*, and causes the joined flow to flow to the inflow port side of the compressor **11**.
[0069] The refrigerant passage from the outflow port of the sixth three-way joint **12***f* to the suction port of the compressor **11** is a suction-side passage **21***d* forming a suction-side passage.
[0070] The high-temperature side heat medium circuit **30** is a heat medium circulation circuit that circulates the high-temperature side heat medium. In the present embodiment, an ethylene glycol aqueous solution is used as the high-temperature side heat medium. In the high-temperature side heat medium circuit **30**, the heat medium passage of the water-refrigerant heat exchanger **13**, a high-temperature side pump **31**, a heater core **32**, and the like are provided.
[0071] The high-temperature side pump **31** is a high-temperature side heat medium pressure transfer unit that pressure-feeds the high-temperature side heat medium flowing out of the heat medium passage of the water-refrigerant heat exchanger **13** to the heat medium inlet side of the heater core **32**. The high-temperature side pump **31** is an electric pump whose rotation speed (that is, the pumping capability) is controlled by a control voltage output from the control device **60**.
[0072] The heater core **32** is a heating heat exchanger that exchanges heat between the high-temperature side heat medium heated by the water-refrigerant heat exchanger **13** and the ventilation air passing through the interior evaporator **18** to heat the ventilation air. The heater core **32** is provided in the air conditioning case **51** of the indoor air conditioning unit **50**. The inlet side of a heat medium passage of the water-refrigerant heat exchanger **13** is connected to the heat medium outlet of the heater core **32**.
[0073] Therefore, the constituent devices of the water-refrigerant heat exchanger **13** and the high-temperature side heat medium circuit **30** of the present embodiment are heating units that heat ventilation air as an object to be heated using one discharge refrigerant branched at the first three-way joint **12***a* as a heat source.
[0074] Next, the low-temperature side heat medium circuit **40** will be described. The low-temperature side heat medium circuit **40** is a heat medium circuit that circulates the low-temperature side heat medium. In the present embodiment, the same type of fluid as the high-temperature side heat medium is used as the low-temperature side heat medium. A low-temperature side pump **41**, a cooling water passage **70***a* of an electric heater **70**, the heat medium passage of the chiller **20**, and the like are connected to the low-temperature side heat medium circuit **40**.
[0075] The low-temperature side pump **41** is a low-temperature side heat medium pressure transfer unit that pressure-feeds the low-temperature side heat medium flowing out of the cooling water passage **70***a* of the electric heater **70** to the inlet side of the heat medium passage of the chiller **20**. The basic configuration of the low-temperature side pump **41** is similar to that of the high-temperature side pump **31**. The inlet side of the cooling water passage **70***a* of the electric heater **70** is connected to the outlet side of the heat medium passage of the chiller **20**. The electric heater **70** is a heating element that generates heat when electric power is supplied to heat the high-temperature side heat medium. The heat medium heating capacity (i.e., the heat generation amount) of the electric heater **70** is controlled by a control signal output from the control device **60**.
[0076] The cooling water passage **70***a* of the electric heater **70** is a cooling water passage formed to cool the electric heater **70** by causing the low-temperature side heat medium cooled by the chiller **20** to flow therethrough.
[0077] The passage configuration of the cooling water passage **70***a* is a passage configuration in which a plurality of passages are connected in parallel inside the battery-dedicated case. As a result, all the battery cells can be uniformly cooled in the cooling water passage **70***a*. The inflow port side

of the low-temperature side pump **41** is connected to the outlet of the cooling water passage **70***a*.

[0078] Next, the indoor air conditioning unit **50** will be described with reference to FIG. **2**. The indoor air conditioning unit **50** is a unit in which a plurality of components are integrated in order to blow ventilation air whose temperature has been adjusted to an appropriate temperature for air conditioning in the vehicle interior to an appropriate location in the vehicle interior. The indoor air conditioning unit **50** is provided inside an instrument panel (the instrument panel) at the foremost part of the vehicle interior.

[0079] The indoor air conditioning unit **50** is formed by housing the indoor blower **52**, the indoor evaporator **18**, the heater core **32**, and the like in the air conditioning case **51** forming an air passage for ventilation air. The air conditioning case **51** is made of resin (for example, polypropylene) with a certain degree of elasticity and excellent strength.

[0080] An inside and outside air switching device **53** is provided on the most upstream side of ventilation air flow in the air conditioning case **51**. The inside and outside air switching device **53** switchingly introduces inside air (that is, air inside vehicle interior) and outside air (that is, air outside vehicle interior) into the air conditioning case **51**. Operation of the inside and outside air switching device **53** is controlled by a control signal output from the control device **60**.

[0081] The indoor blower **52** is provided on the ventilation air flow downstream side of the inside and outside air switching device **53**. The indoor blower **52** is an air blower unit that blows air drawn through the inside and outside air switching device **53**, toward the vehicle interior. The rotation speed (that is, blowing capability) of the indoor blower **52** is controlled by a control voltage output from the control device **60**.

[0082] The indoor evaporator **18** and the heater core **32** are arranged on the ventilation air flow downstream side of the indoor blower **52**. The indoor evaporator **18** is provided on the ventilation air flow upstream side of the heater core **32**. A cold air bypass passage **55** through which the ventilation air having passed through the indoor evaporator **18** flows while bypassing the heater core **32** is formed in the air conditioning case **51**.

[0083] An air mix door **54** is provided on the ventilation air flow downstream side of the indoor evaporator **18** in the air conditioning case **51** and on the ventilation air flow upstream side of the heater core **32** and the cold air bypass passage **55** in the air conditioning case **51**.

[0084] The air mix door **54** adjusts the air volume ratio between the air volume of the ventilation air passing through the heater core **32** and the air volume of the ventilation air passing through the cold air bypass passage **55** in the ventilation air having passed through the indoor evaporator **18**. Operation of an actuator for driving the air mix door **54** is controlled by a control signal output from the control device **60**.

[0085] A mixing space **56** is formed on the ventilation air flow downstream side of the heater core **32** and the cold air bypass passage **55**. The mixing space **56** is a space where the ventilation air heated by the heater core **32** and the ventilation air that has passed through the cold air bypass passage **55** and has not been heated are mixed.

[0086] Therefore, in the indoor air conditioning unit **50**, by adjusting the opening of the air mix door **54**, the temperature of the ventilation air (that is, conditioned air) mixed in the mixing space **56** and blown into the vehicle interior can be adjusted. The air mix door **54** of the present embodiment is an air flow rate regulating unit that regulates the flow rate of the ventilation air subjected to heat exchange at the heater core **32**.

[0087] A plurality of opening holes (not illustrated) for blowing conditioned air to various locations in the vehicle interior are formed at the most downstream portion of the ventilation air flow in the air conditioning case **51**. A blowing mode door (not illustrated) that opens and closes each opening hole is provided in each of the plurality of opening holes. Operation of an actuator for driving the blowing mode door is controlled by a control signal output from the control device **60**.

[0088] Therefore, in the indoor air conditioning unit **50**, by switching the openings which are opened and closed by the blowing mode door, the air-conditioned air which is adjusted to a proper temperature can be blown to proper places in the vehicle interior.

[0089] Next, an electric control unit of the present embodiment will be described. The control device **60** includes a known microcontroller including a central processing device (i.e., CPU), a read only memory (i.e., ROM), a random access memory (i.e., RAM), and peripheral circuits thereof. The control device **60** performs various calculations and processes based on a control program stored in the ROM. The control device **60** then controls the operations of the various control target devices **11**, **14***a* to **14***d*, **22***a*, **22***b*, **31**, **41**, **52**, **53**, and the like connected to the output side on the basis of the calculation and processing results.

[0090] As illustrated in the block diagram of FIG. **3**, a control sensor group is connected to the input side of the control device **60**. The group of control sensors includes an inside air temperature sensor **61***a*, an outside air temperature sensor **61***b*, an insolation sensor **61***c*, a discharge refrigerant temperature sensor **62***a*, a high-pressure side refrigerant temperature and pressure sensor **62***b*, an outdoor unit side refrigerant temperature and pressure sensor **62***c*, an evaporator temperature sensor **62***d*, a chiller side refrigerant temperature and pressure sensor **62***e*, a suction refrigerant temperature sensor **62***f*, a high-temperature side heat medium temperature sensor **63***a*, a low-temperature side heat medium temperature sensor **63***b*, a heater temperature sensor **64**, and a conditioning air temperature sensor **65**.

[0091] The inside air temperature sensor **61***a* is an inside air temperature detection unit that detects a vehicle interior temperature (an inside air temperature) Tr. The outside air temperature sensor **61***b* is an outside air temperature detection unit that detects the vehicle outside air temperature (an outside air temperature) Tam. The insolation sensor **61***c* is an insolation amount detection unit that detects an insolation amount As of insolation irradiated into the vehicle interior.

[0092] The discharge refrigerant temperature sensor **62***a* is a discharge refrigerant temperature detection unit that detects a discharge refrigerant temperature Td of the discharge refrigerant discharged from the compressor **11**.

[0093] The evaporator temperature sensor **62***d* is an evaporator temperature detection unit that detects a refrigerant evaporation temperature (an evaporator temperature) Tefin in the indoor evaporator **18**. Specifically, the evaporator temperature sensor **62***d* detects a heat exchange fin temperature of the indoor evaporator **18**.

[0094] The high-pressure side refrigerant temperature and pressure sensor **62***b* is a high-pressure side refrigerant temperature-pressure detection unit that detects a high-pressure side refrigerant temperature T**1**, which is the temperature of the refrigerant flowing out of the water-refrigerant heat exchanger **13**, and a discharge refrigerant pressure Pd, which is the pressure of the refrigerant flowing out of the water-refrigerant heat exchanger **13**. The discharge refrigerant pressure Pd can be used as the pressure of the discharge refrigerant discharged from the compressor **11**.

[0095] The outdoor unit side refrigerant temperature and pressure sensor **62***c* is an outdoor unit side refrigerant temperature and pressure detection unit that detects an outdoor unit side refrigerant temperature T**2**, which is the temperature of the refrigerant flowing out of the outdoor heat exchanger **15**, and an outdoor unit side refrigerant pressure P**2**, which is the pressure of the refrigerant flowing out of the outdoor heat exchanger **15**. Specifically, the temperature and pressure of the refrigerant flowing through the refrigerant passage from the refrigerant outflow port of the outdoor heat exchanger **15** to one inflow port of the third three-way joint **12***c* are detected.

[0096] The chiller-side refrigerant temperature and pressure sensor **62***e* is a chiller-side refrigerant temperature-pressure detection unit that detects a chiller-side refrigerant temperature Tc, which is the temperature of the refrigerant flowing out of the refrigerant passage in the chiller **20**, and a chiller-side refrigerant pressure Pc, which is the pressure of the refrigerant flowing out of the refrigerant passage in the chiller **20**. The chiller-side refrigerant pressure Pc can be used as a suction refrigerant pressure Ps that is the pressure of the suction refrigerant sucked into the compressor **11**. Therefore, the chiller-side refrigerant temperature and pressure sensor **62***e* of the present embodiment is a suction pressure detection unit.

[0097] In the present embodiment, as the refrigerant temperature and pressure sensor, a detection unit in which the pressure detection unit and the temperature detection unit are integrated is used, but it is needless to mention that the pressure detection unit and the temperature detection unit configured separately may be used.
[0098] The suction refrigerant temperature sensor **62***f* is a suction refrigerant temperature detection unit that is provided in the suction-side passage **21***d* and detects a suction refrigerant temperature Ts, which is the temperature of the suction refrigerant sucked into the compressor **11**.
[0099] The high-temperature side heat medium temperature sensor **63***a* is a high-temperature side heat medium temperature detection unit that detects a high-temperature side heat medium temperature TWH, which is the temperature of the high-temperature side heat medium flowing into the heater core **32**. The low-temperature heat medium temperature sensor **63***b* is a low-temperature heat medium temperature detection unit detecting a low-temperature heat medium temperature TWL as the temperature of the low-temperature heat medium flowing in the cooling water passage **70***a* of the electric heater **70**.
[0100] The heater temperature sensor **64** is a battery temperature detection unit that detects a heater temperature TB, which is the temperature of the electric heater **70**.
[0101] The conditioned air temperature sensor **65** is a conditioned air temperature detection unit that detects a ventilation air temperature TAV of the air blown from the mixing space **56** into the vehicle interior. The ventilation air temperature TAV is an object temperature of the ventilation air as an object to be heated.
[0102] As illustrated in FIG. **3**, an operation panel **69** provided near the instrument panel at the front part of the vehicle interior is connected to the input side of the control device **60** in a wired or wireless manner. Operation signals from various operation switches provided on the operation panel **69** are input to the control device **60**.
[0103] Specific examples of the various operation switches provided on the operation panel **69** include an auto switch, an air conditioner switch, an air volume setting switch, and a temperature setting switch.
[0104] The auto switch is an automatic control setting unit that sets or cancels the automatic control operation of the vehicular air conditioner **1**. The air conditioner switch is a cooling request unit that requests the indoor evaporator **18** to cool ventilation air. The air volume setting switch is an air volume setting unit that manually sets an air blowing volume of the indoor blower **52**. The temperature setting switch is a temperature setting portion for setting a set temperature Tset of the vehicle interior.
[0105] The control device **60** of the present embodiment is integrally configured with a controller that controls various control target devices connected to an output side thereof. Therefore, a configuration (hardware and software) that controls the operation of each device to be controlled constitutes a controller that controls the operation of each device to be controlled.
[0106] For example, in the control device **60**, the configuration that controls the refrigerant discharge capability of the compressor **11** configures a discharge capability control unit **60***a*.
[0107] The discharge capacity control unit **60***a* controls the refrigerant discharge capacity of the compressor **11** so that the rotation speed of the compressor **11** does not exceed a maximum rotation speed and an upper limit rotation speed. The maximum rotation speed is determined based on the durability of the compressor **11**. The upper limit rotation speed is a rotation speed that is determined based on an allowable noise level of the compressor **11**. That is, since the noise of the compressor **11** increases as the rotation speed of the compressor **11** increases, the rotation speed of the compressor **11** at which the noise of the compressor **11** reaches the allowable noise level is set as the upper limit rotation speed. Therefore, the discharge capacity control unit **60***a* also functions as an upper limit rotation speed determination unit that determines the upper limit rotation speed of the compressor **11**.
[0108] The configuration of controlling the operation of the heating-unit side decompression unit

(in the present embodiment, the air-heating expansion valve **14***a* and the air-cooling expansion valve **14***b*, and the cooling expansion valve **14***c*) configures a heating-unit side control unit **60***b*. The configuration of controlling the operation of the bypass-side flow rate regulating valve **14***d* configures a bypass-side control unit **60***c*. The target heating capacity determination unit **60***d* determines a target heating capacity (in other words, the target heating capacity) in the indoor air conditioning unit **50**. For example, a target high-temperature side heat medium temperature (TWHO) is determined.

[0109] Next, the operation of the vehicular air conditioner **1** according to the present embodiment in the above configuration will be described. In the vehicular air conditioner of the present embodiment, various operation modes are switched in order to perform air conditioning of the vehicle interior. Switching of the operation mode is performed by executing a control program stored in advance in the control device **60**. Various operation modes will be described below.

[0110] First, an operation mode in which the refrigerant does not flow through the bypass passage **21***c* will be described. The operation modes in which the refrigerant is not circulated through the bypass passage **21***c* include (a) an air-cooling mode, (b) a series dehumidifying air-heating mode, (c) an outside air heat absorbing air-heating mode, and (d) a heater heat absorbing air-heating mode.

(a) Air-Cooling Mode

[0111] The air-cooling mode is an operation mode in which the air in the vehicle interior is cooled by blowing cooled ventilation air into the vehicle interior. In the control program, the air-cooling mode is selected mainly in summer when the outside air temperature Tam is relatively high (25° C. or higher in the present embodiment).

[0112] In the heat pump cycle **10** in the air-cooling mode, the control device **60** brings the air-heating expansion valve **14***a* into a fully open state, brings the air-cooling expansion valve **14***b* into a throttled state that exhibits the refrigerant decompression action, brings the cooling expansion valve **14***c* into a fully closed state, and brings the bypass-side flow rate regulating valve **14***d* into the fully closed state. In addition, the control device **60** closes the dehumidifying on-off valve **22***a* and also closes the air-heating on-off valve **22***b*.

[0113] Therefore, in the heat pump cycle **10** in the air-cooling mode, the refrigerant circuit is switched to a refrigerant circuit in which the refrigerant discharged from the compressor **11** circulates through the water-refrigerant heat exchanger **13**, the air-heating expansion valve **14***a* in the fully open state, the outdoor heat exchanger **15**, the air-cooling expansion valve **14***b* in the throttled state, the indoor evaporator **18**, the suction-side passage **21***d*, and the suction port of the compressor **11** in this order.

[0114] The control device **60** controls the refrigerant discharge performance of the compressor **11** in such a manner that the evaporator temperature Tefin detected by the evaporator temperature sensor **62***d* approaches a target evaporator temperature TEO. The target evaporator temperature TEO is determined, based on the target blowout temperature TAO, with reference to the controlling map stored in the control device **60** in advance.

[0115] The target blowout temperature TAO is a target temperature of ventilation air to be blown into the vehicle interior. The target blowout temperature TAO is calculated using the inside air temperature Tr detected by the inside air temperature sensor **61***a*, the outside air temperature Tam, the insolation amount As detected by the insolation sensor **61***c*, the set temperature Tset set by the temperature setting switch, and the like. In the control map, it is determined that the target evaporator temperature TEO increases as the target blowout temperature TAO increases.

[0116] The degree of superheating SH of the suction refrigerant can be determined using the chiller-side refrigerant pressure Pc detected by the chiller-side refrigerant temperature and pressure sensor **62***e* and the suction refrigerant temperature Ts detected by the suction refrigerant temperature sensor **62***f*.

[0117] In the high-temperature side heat medium circuit **30** in the air-cooling mode, the control

device **60** operates the high-temperature side pump **31** so as to exhibit a predetermined reference pumping capability. Therefore, in the high-temperature side heat medium circuit **30** in the air-cooling mode, the heat medium pumped from the high-temperature side pump **31** circulates through the heat medium passage of the water-refrigerant heat exchanger **13**, the heater core **32**, and the suction port of the high-temperature side pump **31** in this order.
[0118] In the indoor air conditioning unit **50** in the air-cooling mode, the control device **60** controls the blowing capacity of the indoor blower **52** with reference to a control map stored in advance in the control device **60** based on the target blowout temperature TAO. The control device **60** adjusts the opening of the air mix door **54** such that the ventilation air temperature TAV detected by the conditioned air temperature sensor **65** approaches the target blowout temperature TAO. Furthermore, the control device **60** appropriately controls the operations of the other control target devices.
[0119] Therefore, in the heat pump cycle **10** in the air-cooling mode, a vapor compression refrigeration cycle is configured in which the water-refrigerant heat exchanger **13** and the outdoor heat exchanger **15** function as condensers that radiate heat of the refrigerant and condense the refrigerant, and the indoor evaporator **18** functions as an evaporator that evaporates the refrigerant.
[0120] In the high-temperature side heat medium circuit **30** in the air-cooling mode, the high-temperature side heat medium heated by the water-refrigerant heat exchanger **13** flows into the heater core **32**.
[0121] In the indoor air conditioning unit **50** in the air-cooling mode, the ventilation air supplied by the indoor blower **52** is cooled by the indoor evaporator **18**. The ventilation air cooled by the indoor evaporator **18** is reheated by the heater core **32** so as to approach the target blowout temperature TAO based on the opening of the air mix door **54**. The ventilation air with a regulated temperature is blown into the vehicle interior, so that the air in the vehicle interior is cooled.
(b) Series Dehumidifying Air-Heating Mode
[0122] The series dehumidifying air-heating mode is an operation mode in which the air in the vehicle interior is dehumidified and heated by reheating cooled and dehumidified ventilation air and blowing the reheated ventilation air into the vehicle interior. In the control program, the series dehumidifying air-heating mode is selected when the outside air temperature Tam is a temperature in a predetermined medium to high temperature range (equal to or higher than 10° C. and lower than 25° C. in the present embodiment).
[0123] In the heat pump cycle **10** in the series dehumidifying air-heating mode, the control device **60** brings the air-heating expansion valve **14***a* into the throttled state, brings the air-cooling expansion valve **14***b* into the throttled state, brings the cooling expansion valve **14***c* into the fully closed state, and brings the bypass-side flow rate regulating valve **14***d* into the fully closed state. In addition, the control device **60** closes the dehumidifying on-off valve **22***a* and also closes the air-heating on-off valve **22***b*.
[0124] Therefore, in the heat pump cycle **10** in the series dehumidifying air-heating mode, the refrigerant circuit is switched to a refrigerant circuit in which the refrigerant discharged from the compressor **11** circulates through the water-refrigerant heat exchanger **13**, the air-heating expansion valve **14***a* in the throttled state, the outdoor heat exchanger **15**, the air-cooling expansion valve **14***b* in the throttled state, the indoor evaporator **18**, the suction-side passage **21***d*, and the suction port of the compressor **11** in this order.
[0125] In addition, the control device **60** controls the throttle opening of the air-heating expansion valve **14***a* and the throttle opening of the air-cooling expansion valve **14***b* with reference to the control map stored in advance in the control device **60**. In the control map, the throttle opening of the air-heating expansion valve **14***a* and the throttle opening of the air-cooling expansion valve **14***b* are determined in such a manner that the degree of superheating SH of the suction refrigerant approaches the reference degree of superheating KSH.
[0126] In the high-temperature side heat medium circuit **30** in the series dehumidifying air-heating

mode, the control device **60** operates the high-temperature side pump **31** as in the air-cooling mode.
[0127] In the indoor air conditioning unit **50** in the series dehumidifying air-heating mode, the control device **60** controls the ventilation performance of the indoor blower **52** and the opening of the air mix door **54** as in the air-cooling mode. Furthermore, the control device **60** appropriately controls the operations of the other control target devices.
[0128] Therefore, in the heat pump cycle **10** in the series dehumidifying air-heating mode, a vapor compression refrigeration cycle is configured in which the water-refrigerant heat exchanger **13** functions as a condenser, and the indoor evaporator **18** functions as an evaporator.
[0129] In addition, in the series dehumidifying air-heating mode, in a case where the saturation temperature of the refrigerant in the outdoor heat exchanger **15** is higher than the outside air temperature Tam, the outdoor heat exchanger **15** functions as a condenser. In a case where the saturation temperature of the refrigerant in the outdoor heat exchanger **15** is lower than the outside air temperature Tam, the outdoor heat exchanger **15** functions as an evaporator.
[0130] In the high-temperature side heat medium circuit **30** in the series dehumidifying air-heating mode, the high-temperature side heat medium heated by the water-refrigerant heat exchanger **13** flows into the heater core **32**.
[0131] In the indoor air conditioning unit **50** in the series dehumidifying air-heating mode, the ventilation air supplied by the indoor blower **52** is cooled and dehumidified by the indoor evaporator **18**. The ventilation air cooled and dehumidified by the indoor evaporator **18** is reheated by the heater core **32** so as to approach the target blowout temperature TAO based on the opening of the air mix door **54**. The ventilation air with a regulated temperature is blown into the vehicle interior, so that the air in the vehicle interior is dehumidified and heated.
(c) Outside Air Heat Absorbing Air-Heating Mode
[0132] The outside air heat absorbing air-heating mode is an operation mode in which the vehicle interior is heated by blowing heated ventilation air into the vehicle interior. In the control program, the outside air heat absorbing air-heating mode is selected mainly in winter when the outside air temperature Tam is relatively low (equal to or higher than −10° C. and lower than 0° C. in the present embodiment).
[0133] In the heat pump cycle **10** in the outside air heat absorbing air-heating mode, the control device **60** brings the air-heating expansion valve **14***a* into the throttled state, brings the air-cooling expansion valve **14***b* into the fully closed state, brings the cooling expansion valve **14***c* into the fully closed state, and brings the bypass-side flow rate regulating valve **14***d* into the fully closed state. In addition, the control device **60** closes the dehumidifying on-off valve **22***a* and also closes the air-heating on-off valve **22***b*.
[0134] Therefore, in the heat pump cycle **10** in the outside air heat absorbing air-heating mode, the refrigerant circuit is switched to a refrigerant circuit in which the refrigerant discharged from the compressor **11** circulates through the water-refrigerant heat exchanger **13**, the air-heating expansion valve **14***a* in the throttled state, the outdoor heat exchanger **15**, the air-heating passage **21***b*, the suction-side passage **21***d*, and the suction port of the compressor **11** in this order.
[0135] In addition, the control device **60** controls the refrigerant discharge performance of the compressor **11** in such a manner that the discharge refrigerant pressure Pd detected by the high-pressure side refrigerant temperature and pressure sensor **62***b* approaches a target high pressure PDO. The target high pressure PDO is determined based on the target blowout temperature TAO with reference to a control map stored in advance in the control device **60**. In the control map, the target high pressure PDO is determined to be increased as the target blowout temperature TAO increases.
[0136] The control device **60** also controls the throttle opening of the air-heating expansion valve **14***a* in a manner that the degree of superheating SH of the suction refrigerant approaches the reference degree of superheating KSH.
[0137] In the high-temperature side heat medium circuit **30** in the outside air heat absorbing air-

heating mode, the control device **60** operates the high-temperature side pump **31** as in the air-cooling mode.

[0138] In the indoor air conditioning unit **50** in the outside air heat absorbing air-heating mode, the control device **60** controls the blowing capacity of the indoor blower **52** and the opening of the air mix door **54** as in the air-cooling mode. Furthermore, the control device **60** appropriately controls the operations of the other control target devices.

[0139] Therefore, in the heat pump cycle **10** in the outside air heat absorbing air-heating mode, a vapor compression refrigeration cycle is configured in which the water-refrigerant heat exchanger **13** functions as a condenser and the outdoor heat exchanger **15** functions as an evaporator.

[0140] In the outside air heat absorbing air-heating mode, the high-temperature side heat medium heated by the water-refrigerant heat exchanger **13** flows into the heater core **32** as in the air-cooling mode.

[0141] In the indoor air conditioning unit **50** in the outside air heat absorbing air-heating mode, the ventilation air blown from the indoor blower **52** passes through the indoor evaporator **18**. The ventilation air having passed through the indoor evaporator **18** is heated by the heater core **32** so as to approach the target blowout temperature TAO depending on the opening of the air mix door **54**. The ventilation air whose temperature has been adjusted is blown into the vehicle interior, so that the vehicle interior is heated.

(d) Heater Heat Absorbing Air-Heating Mode

[0142] The heater heat absorbing air-heating mode is an operation mode in which heat generated by the electric heater **70** is used as a heat source to blow heated air into the vehicle interior, thereby heating the vehicle interior. In the control program, the outside air heat absorbing air-heating mode is selected mainly in winter when the outside air temperature Tam is relatively low (equal to or higher than −10° C. and lower than 0° C. in the present embodiment).

[0143] In the heat pump cycle **10** in the heater heat absorbing air-heating mode, the control device **60** brings the air-heating expansion valve **14***a* into the fully closed state, brings the air-cooling expansion valve **14***b* into the fully closed state, brings the cooling expansion valve **14***c* into the throttled state, and brings the bypass-side flow rate regulating valve **14***d* into the fully closed state. In addition, the control device **60** closes the dehumidifying on-off valve **22***a* and also closes the air-heating on-off valve **22***b*.

[0144] For this reason, in the heat pump cycle **10** in the heater heat absorbing air-heating mode, the refrigerant circuit is switched to a refrigerant circuit in which a refrigerant discharged from the compressor **11** circulates through the water refrigerant heat exchanger **13**, the throttled cooling expansion valve **14***c*, the chiller **20**, the suction-side passage **21***d* and the suction port of the compressor **11** in this order.

[0145] In addition, the control device **60** controls the refrigerant discharge performance of the compressor **11** in such a manner that the discharge refrigerant pressure Pd detected by the high-pressure side refrigerant temperature and pressure sensor **62***b* approaches a target high pressure PDO. The target high pressure PDO is determined based on the target blowout temperature TAO with reference to a control map stored in advance in the control device **60**. In the control map, the target high pressure PDO is determined to be increased as the target blowout temperature TAO increases.

[0146] The control device **60** may control the refrigerant discharge capacity of the compressor **11** so that the high-temperature side heat medium temperature TWH detected by the high-temperature side heat medium temperature sensor **63***a* approaches the target high-temperature side heat medium temperature TWHO. The target high-temperature side heat medium temperature TWHO is determined based on the target blowout temperature TAO with reference to a control map stored in advance in the control device **60**. In the control map, a target high-temperature side heat medium temperature TWHO is determined to be increased as the target blowout temperature TAO increases. The target high-temperature side heat medium temperature TWHO is an index indicating a target

heating capacity (in other words, target air-heating capacity) in the water-refrigerant heat exchanger **13** (in other words, the heater core **32**).
[0147] The control device **60** also controls the throttle opening of the air-heating expansion valve **14***a* in a manner that the degree of superheating SH of the suction refrigerant approaches the reference degree of superheating KSH.
[0148] In the high-temperature side heat medium circuit **30** in the heater air heat absorbing air-heating mode, the control device **60** operates the high-temperature side pump **31** as in the single air-cooling mode.
[0149] In the indoor air conditioning unit **50** in the heater heat absorbing air-heating mode, the control device **60** controls the blowing capacity of the indoor blower **52** and the opening of the air mix door **54** as in the air-cooling mode. Furthermore, the control device **60** appropriately controls the operations of the other control target devices.
[0150] Therefore, in the heat pump cycle **10** in the heater heat absorbing air-heating mode, a vapor compression refrigeration cycle is configured in which the water-refrigerant heat exchanger **13** functions as a condenser and the chiller **20** functions as an evaporator.
[0151] In the heater heat absorbing air-heating mode, the high-temperature side heat medium heated by the water-refrigerant heat exchanger **13** flows into the heater core **32** as in the air-cooling mode.
[0152] In the indoor air conditioning unit **50** in the heater heat absorbing air-heating mode, the ventilation air blown from the indoor blower **52** passes through the indoor evaporator **18**. The ventilation air having passed through the indoor evaporator **18** is heated by the heater core **32** so as to approach the target blowout temperature TAO depending on the opening of the air mix door **54**. The ventilation air whose temperature has been adjusted is blown into the vehicle interior, so that the vehicle interior is heated.
[0153] In the low-temperature side heat medium circuit **40** in the heater heat absorbing air-heating mode, the low-temperature side heat medium that has been heated by flowing through the cooling water passage **70***a* of the electric heater **70** absorbs heat in the chiller **20**. As a result, the heat generated by the electric heater **70** can be effectively used to heat the blown air, thereby achieving heating of the vehicle interior.
[0154] Herein, the control of the electric heater **70** in the heater heat absorbing air-heating mode will be described. The control device **60** determines the allowable noise level of the compressor **11** based on the vehicle speed and with reference to the control map shown in FIG. **4**. Specifically, when the vehicle speed is higher than a predetermined value, the allowable noise level of the compressor **11** is determined to be high, and when the vehicle speed is lower than the predetermined value, the allowable noise level of the compressor **11** is determined to be low. This is because when the vehicle speed is high, the noise of the compressor **11** is easily drowned out by the traveling noise.
[0155] When the allowable noise level of the compressor **11** is high, the control device **60** determines the upper limit rotation speed of the compressor **11** to be a first upper limit rotation speed NcImt**1**, and when the allowable noise level of the compressor **11** is low, the control device **60** determines the upper limit rotation speed of the compressor **11** to be a second upper limit rotation speed NcImt**2** which is smaller than the first upper limit rotation speed NcImt**1**.
[0156] The control device **60** determines a target chiller inlet water temperature TWO based on the allowable noise level of the compressor **11** and a required heating capacity. Specifically, the target chiller inlet water temperature TWO is determined based on the allowable noise level of the compressor **11**, the outside air temperature, and the target blowout temperature TAO and with reference to the control map shown in FIG. **5**.
[0157] Specifically, the greater the required heating capacity (e.g., the lower the outside air temperature, the higher the target blowout temperature TAO, the lower the intake air temperature of the indoor air conditioning unit **50**, etc.), the higher the target chiller inlet water temperature TWO

is set. In addition, the smaller the required heating capacity (e.g., the higher the outside air temperature, the lower the target blowout temperature TAO), the lower the target chiller inlet water temperature TWO is set.
[0158] Furthermore, when the allowable noise level of the compressor **11** is low, the target chiller inlet water temperature TWO is set higher than that when the allowable noise level of the compressor **11** is high.
[0159] The control device **60** controls the power supplied to the electric heater **70** (in other words, the amount of heat generated by the electric heater **70**) so that the chiller inlet water temperature TW approaches the target chiller inlet water temperature TWO. Specifically, when the chiller inlet water temperature TW is lower than the target chiller inlet water temperature TWO, the power supplied to the electric heater **70** (in other words, the amount of heat generated by the electric heater **70**) is increased, and when the chiller inlet water temperature TW is higher than the target chiller inlet water temperature TWO, the power supplied to the electric heater **70** (in other words, the amount of heat generated by the electric heater **70**) is decreased.
[0160] As a result, as shown in FIG. **6**, the amount of heat absorbed in the chiller **20** increases or decreases depending on the chiller inlet water temperature TW, and the amount of work of the compressor **11** (in other words, the rotation speed of the compressor **11**) increases or decreases in a manner opposite to the amount of heat absorbed in the chiller **20**, thereby achieving the desired heating capacity. Specifically, as the chiller inlet water temperature TW increases, the amount of heat absorbed in the chiller **20** increases, and the amount of work of the compressor **11** (in other words, the rotation speed of the compressor **11**) decreases.
[0161] As a result, when the allowable noise level of the compressor **11** is low, the rotation speed of the compressor **11** can be kept low to keep the noise of the compressor **11** low. Moreover, since the rotation speed of the compressor **11** can be brought as close as possible to the allowable rotation speed, the rotation speed of the compressor **11** can be prevented from becoming too low. Therefore, it is possible to prevent the amount of heat absorbed by the chiller **20** from becoming too large, resulting in increase in the heat loss.
[0162] Next, an operation mode in which the refrigerant flows through the bypass passage **21***c* will be described. Examples of the operation mode in which the refrigerant flows through the bypass passage **21***c* include (d) hot gas air-heating mode, (e) hot gas dehumidifying air-heating mode, and (f) hot-gas series dehumidifying air-heating mode.
(e) Hot Gas Air-Heating Mode
[0163] The hot gas air-heating mode is an operation mode for heating the vehicle interior. In the control program, the hot gas air-heating mode is selected when the outside air temperature Tam is extremely low (lower than −10° C. in the present embodiment) or when it is determined that the heating performance of the ventilation air in the water-refrigerant heat exchanger **13** is insufficient in the outside air heat absorbing air-heating mode.
[0164] In the control program, when the ventilation air temperature TAV is lower than the target blowout temperature TAO, it is determined that the heating performance of the ventilation air is insufficient. The same applies to other operation modes.
[0165] Examples of the hot gas air-heating mode include a single hot gas air-heating mode and a heater heat absorbing hot gas air-heating mode. The single hot gas air-heating mode is an operation mode in which the air in the vehicle interior is heated without absorbing heat of the electric heater **70**. The heater heat absorbing hot gas air-heating mode is an operation mode in which heat is absorbed from the electric heater **70** to heat the vehicle interior.
(e-1) Single Hot Gas Air-Heating Mode
[0166] In the heat pump cycle **10** in the single hot gas air-heating mode, the control device **60** brings the air-heating expansion valve **14***a* into the fully closed state, brings the air-cooling expansion valve **14***b* into the fully closed state, brings the cooling expansion valve **14***c* into the throttled state, and brings the bypass-side flow rate regulating valve **14***d* into the throttled state. The

control device **60** opens the dehumidifying on-off valve **22***a* and closes the air-heating on-off valve **22***b*.

[0167] Therefore, in the heat pump cycle **10** in the single hot gas air-heating mode, as indicated by solid arrows in FIG. **7**, the refrigerant discharged from the compressor **11** circulates through the first three-way joint **12***a*, the water-refrigerant heat exchanger **13**, the dehumidifying passage **21***a*, the cooling expansion valve **14***c* in the throttled state, the chiller **20**, the suction-side passage **21***d*, and the suction port of the compressor **11** in this order. At the same time, the refrigerant circuit is switched to a refrigerant circuit in which the refrigerant discharged from the compressor **11** circulates through the first three-way joint **12***a*, the bypass-side flow rate regulating valve **14***d* in the throttled state, which is provided in the bypass passage **21***c*, the suction-side passage **21***d*, and the suction port of the compressor **11** in this order.

[0168] Furthermore, the control device **60** controls the refrigerant discharge performance of the compressor **11** in such a manner that the chiller-side refrigerant pressure Pc approaches a predetermined first target low pressure PSO**1**.

[0169] Controlling the chiller-side refrigerant pressure Pc corresponding to the suction refrigerant pressure Ps so as to approach a constant pressure is effective for stabilizing a discharge flow rate Gr (the mass flow rate) of the compressor **11**. More specifically, by generating a saturated gas-phase refrigerant with a constant pressure as the suction refrigerant pressure Ps, the density of the suction refrigerant becomes constant. Therefore, when the suction refrigerant pressure Ps is controlled to approach a constant pressure, the discharge flow rate Gr of the compressor **11** at the same rotation speed is easily stabilized.

[0170] The control device **60** controls the throttle opening of the bypass-side flow rate regulating valve **14***d* such that the discharge refrigerant pressure Pd approaches the target high pressure PDO.

[0171] The control device **60** also controls the throttle opening of the cooling expansion valve **14***c* in a manner that the degree of superheating SH of the suction refrigerant approaches the reference degree of superheating KSH.

[0172] In the high-temperature side heat medium circuit **30** in the single hot gas air-heating mode, the control device **60** operates the high-temperature side pump **31** as in the single air-cooling mode.

[0173] In the low-temperature side heat medium circuit **40** in the single hot gas air-heating mode, the control device **60** stops the low-temperature side pump **41**.

[0174] In the indoor air conditioning unit **50** in the single hot gas air-heating mode, the control device **60** controls the opening degree of the air mix door **54**, similarly in the single air conditioning mode. In the hot gas air-heating mode, the opening of the air mix door **54** is often controlled such that almost the entire volume of ventilation air blown from the indoor blower **52** passes through the heater core **32**.

[0175] The control device **60** controls the operation of the inside air and inside and outside air switching device **53** so as to introduce inside air into the air conditioning case **51**. Furthermore, the control device **60** appropriately controls the operations of the other control target devices.

[0176] Therefore, in the heat pump cycle **10** in the single hot gas air-heating mode, the state of the refrigerant changes as illustrated in the Mollier chart of FIG. **8**.

[0177] First, the flow of the discharge refrigerant (point a**8** in FIG. **8**) discharged from the compressor **11** is branched at the first three-way joint **12***a*. One of the refrigerant divided at the first three-way joint **12***a* flows into the water-refrigerant heat exchanger **13** and radiates heat to the high-temperature side heat medium (from point a**8** to point b**8** in FIG. **8**). As a result, the high-temperature side heat medium is heated.

[0178] The refrigerant flowing out of the water-refrigerant heat exchanger **13** flows into the dehumidifying passage **21***a*. The refrigerant that has flown into the dehumidifying passage **21***a* flows into the cooling expansion valve **14***c* and is decompressed (from point b**8** to point c**8** in FIG. **8**).

[0179] The refrigerant depressurized at the cooling expansion valve **14***c* flows into the chiller **20**. In the hot gas air-heating mode, since the low-temperature side pump **41** is stopped, the chiller **20** does not exchange heat between the refrigerant and the low-temperature side heat medium. The refrigerant flowing out of the chiller **20** flows into the other inflow port of the sixth three-way joint **12***f* via the fourth three-way joint **12***d* and the fifth three-way joint **12***e*.

[0180] The other refrigerant branched at the first three-way joint **12***a* flows into the bypass passage **21***c*. The refrigerant flowing into the bypass passage **21***c* is decompressed when the flow rate is regulated by the bypass-side flow rate regulating valve **14***d* (from point a**8** to point d**8** in FIG. **8**). The refrigerant depressurized at the bypass-side flow rate regulating valve **14***d* flows into one inflow port of the sixth three-way joint **12***f*.

[0181] The refrigerant flowing out of the chiller **20** and the refrigerant flowing out of the bypass-side flow rate regulating valve **14***d* are joined and mixed at the sixth three-way joint **12***f*. The refrigerant flowing out of the sixth three-way joint **12***f* is mixed when flowing through the suction-side passage **21***d* (point e**8** in FIG. **8**), and is drawn into the compressor **11**.

[0182] As described above, in the heat pump cycle **10** in the hot gas air-heating mode, refrigerants with different enthalpies, such as the low-enthalpy refrigerant flowing out of the chiller **20** (point c**8** in FIG. **8**) and the high-enthalpy refrigerant flowing out of the bypass passage **21***c* (point d**8** in FIG. **8**), are mixed and drawn into the compressor **11**.

[0183] Therefore, in the heat pump cycle **10** in the hot gas air-heating mode, the cooling expansion valve **14***c* serves as the heating-unit side decompression unit.

[0184] In the high-temperature side heat medium circuit **30** in the hot gas air-heating mode, the high-temperature side heat medium heated by the water-refrigerant heat exchanger **13** flows into the heater core **32** as in the single air-cooling mode.

[0185] As in the outside air heat absorbing air-heating mode, the indoor air conditioning unit **50** in the single hot gas air-heating mode blows temperature-regulated ventilation air into the vehicle interior to achieve heating of the vehicle interior.

[0186] Here, the single hot gas air-heating mode is an operation mode performed when the outside air temperature Tam is extremely low. For this reason, when the refrigerant flowing out of the water-refrigerant heat exchanger **13** flows into the outdoor heat exchanger **15**, the refrigerant may radiate heat to the outside air in outdoor heat exchanger **15**. When the refrigerant radiates heat to the outside air in the outdoor heat exchanger **15**, the amount of heat by which the refrigerant radiates to the ventilation air in the water-refrigerant heat exchanger **13** decreases, and the heating performance of the ventilation air decreases accordingly.

[0187] In the single hot gas air-heating mode of the present embodiment, since the refrigerant circuit is switched to the refrigerant circuit that does not allow the refrigerant flowing out of the water-refrigerant heat exchanger **13** to flow into the outdoor heat exchanger **15**, it is possible to prevent the refrigerant from radiating heat to the outside air in the outdoor heat exchanger **15**.

[0188] In the single hot gas air-heating mode of the present embodiment, the throttle opening of the cooling expansion valve **14***c* is controlled in a manner that the degree of superheating SH of the suction refrigerant approaches the reference degree of superheating KSH. As a result, by increasing the refrigerant discharge performance of the compressor **11**, the state of the suction refrigerant (point e**8** in FIG. **8**) can be the gas-phase refrigerant with the degree of superheating even if the amount of heat radiated from the discharge refrigerant to the high-temperature side heat medium in the water-refrigerant heat exchanger **13** is increased.

[0189] Therefore, in the single hot gas air-heating mode, even when the outside air temperature Tam is extremely low, the heat generated by the amount of work of the compressor **11** can be effectively used to heat the ventilation air, and the air in the vehicle interior can be heated.

(e-2) Heater Heat Absorbing Hot Gas Air-Heating Mode

[0190] In the heater heat absorbing hot gas air-heating mode, the control device **60** operates the low-temperature side pump **41** of the low-temperature side heat medium circuit **40** so as to exhibit the predetermined reference pumping performance, as compared with the single hot gas air-heating mode. Therefore, in the heat pump cycle **10** in the heater heat absorbing hot gas air-heating mode, the refrigerant flowing into the chiller **20** absorbs heat from the low-temperature side heat medium. Due to this, the low temperature side heat medium is cooled. The other operations are similar to those in the single hot gas air-heating mode.

[0191] Therefore, in the heater heat absorbing hot gas air-heating mode, the heat generated by the amount of work of the compressor **11** can be effectively used to heat the ventilation air, and the air in the vehicle interior can be heated, as in the single hot gas air-heating mode. Furthermore, in the low-temperature side heat medium circuit **40** in the heater heat absorbing hot gas air-heating mode, the low-temperature side heat medium that has been heated by flowing through the cooling water passage **70***a* of the electric heater **70** absorbs heat in the chiller **20**. As a result, the heat generated by the electric heater **70** can be effectively used to heat the blown air, thereby achieving heating of the vehicle interior.

[0192] In the heater heat absorbing hot gas heating mode, the control device **60** operates the electric heater **70** in the same manner as in the heater heat absorbing heating mode. As a result, similarly to the heater heat absorbing air-heating mode, when the allowable noise level of the compressor **11** is low, the rotation speed of the compressor **11** can be kept low to keep the noise of the compressor **11** low. Moreover, since the rotation speed of the compressor **11** can be brought as close as possible to the allowable rotation speed, the rotation speed of the compressor **11** can be prevented from becoming too low. Therefore, it is possible to prevent the amount of heat absorbed by the chiller **20** from becoming too large, resulting in increase in the heat loss.

(f) Hot Gas Dehumidifying Air-Heating Mode

[0193] The hot gas dehumidifying air-heating mode is an operation mode in which the air in the vehicle interior is dehumidified and heated. In the control program, the hot gas dehumidifying air-heating mode is selected when the outside air temperature Tam is a temperature in a predetermined low to medium temperature range (equal to or higher than 0° C. and lower than 10° C. in the present embodiment).

[0194] In the heat pump cycle **10** in the hot gas dehumidifying air-heating mode, the control device **60** brings the air-heating expansion valve **14***a* into the fully closed state, brings the air-cooling expansion valve **14***b* into the throttled state, brings the cooling expansion valve **14***c* into the throttled state, and brings the bypass-side flow rate regulating valve **14***d* into the throttled state. The control device **60** opens the dehumidifying on-off valve **22***a* and closes the air-heating on-off valve **22***b*.

[0195] Therefore, in the heat pump cycle **10** in the hot gas dehumidifying air-heating mode, the refrigerant discharged from the compressor **11** circulates similarly to the single hot gas air-heating mode. At the same time, the refrigerant circuit is switched to a refrigerant circuit in which the refrigerant discharged from the compressor **11** circulates through the first three-way joint **12***a*, the water-refrigerant heat exchanger **13**, the dehumidifying passage **21***a*, the air-cooling expansion valve **14***b* in the throttled state, the indoor evaporator **18**, the suction-side passage **21***d*, and the suction port of the compressor **11** in this order. That is, the refrigerant circuit is switched to a refrigerant circuit in which the indoor evaporator **18** and the chiller **20** are connected in parallel to the refrigerant flow.

[0196] Furthermore, the control device **60** controls the refrigerant discharge performance of the compressor **11** in a manner that the suction refrigerant pressure Ps approaches a predetermined second target low pressure PSO**2**. The second target low pressure PSO**2** is determined in a manner that the refrigerant evaporating temperature in the indoor evaporator **18** is a temperature at which the ventilation air can be dehumidified without causing frosting on the indoor evaporator **18**.

[0197] In addition, the control device **60** controls the throttle opening of the bypass-side flow rate regulating valve **14***d* in a manner that the discharge refrigerant pressure Pd approaches the target high pressure PDO, as in the hot gas air-heating mode.

[0198] The control device **60** controls the throttle opening of the air-cooling expansion valve **14***b* to a predetermined throttle opening for the hot gas dehumidifying air-heating mode.

[0199] The control device **60** also controls the throttle opening of the cooling expansion valve **14***c* in a manner that the degree of superheating SH of the suction refrigerant approaches the reference degree of superheating KSH.

[0200] In the high-temperature side heat medium circuit **30** in the hot gas dehumidifying air-heating mode, the control device **60** operates the high-temperature side pump **31** as in the air-cooling mode.

[0201] In the low-temperature side heat medium circuit **40** in the hot gas dehumidifying air-heating mode, the control device **60** stops the low-temperature side pump **41**.

[0202] In the indoor air conditioning unit **50** in the hot gas dehumidifying air-heating mode, the control device **60** controls the ventilation performance of the indoor blower **52** and the opening of the air mix door **54** as in the air-cooling mode. Furthermore, the control device **60** appropriately controls the operations of the other control target devices.

[0203] Therefore, in the heat pump cycle **10** in the hot gas dehumidifying air-heating mode, the state of the refrigerant changes as follows.

[0204] The flow of the discharge refrigerant discharged from the compressor **11** is branched at the first three-way joint **12***a*. One of the refrigerant divided at the first three-way joint **12***a* flows into the water-refrigerant heat exchanger **13** and radiates heat to the high-temperature side heat medium. As a result, the high-temperature side heat medium is heated.

[0205] The refrigerant flowing out of the water-refrigerant heat exchanger **13** flows into the dehumidifying passage **21***a*. The flow of the refrigerant flowing into the dehumidifying passage **21***a* is branched at the four-way joint **12***x*. One of the refrigerant that branches at the four-way joint **12***x* flows into the air-cooling expansion valve **14***b* and is decompressed.

[0206] The refrigerant depressurized at the air-cooling expansion valve **14***b* flows into the indoor evaporator **18**. The refrigerant flowing into the indoor evaporator **18** exchanges heat with the ventilation air supplied by the indoor blower **52** and evaporates. Due to this, the ventilation air is cooled and dehumidified. The refrigerant flowing out of the indoor evaporator **18** flows into one inflow port of the fifth three-way joint **12***e* via the second check valve **16***b*.

[0207] The other of the refrigerant that branches at the four-way joint **12***x* flows into the cooling expansion valve **14***c* and is decompressed. The refrigerant depressurized at the cooling expansion valve **14***c* flows into the chiller **20**. In the hot gas dehumidifying air-heating mode, since the low-temperature side pump **41** is stopped, the chiller **20** does not exchange heat between the refrigerant and the low-temperature side heat medium. The refrigerant flowing out of the chiller **20** flows into the other inflow port of the fifth three-way joint **12***e*.

[0208] At the fifth three-way joint **12***e*, the flow of the refrigerant flowing out of the indoor evaporator **18** and the flow of the refrigerant flowing out of the chiller **20** are joined. The refrigerant flowing out of the fifth three-way joint **12***e* flows into the other inflow port of the sixth three-way joint **12***f*.

[0209] The other refrigerant branched at the first three-way joint **12***a* flows into the bypass passage **21***c*. The refrigerant flowing into the bypass passage **21***c* is decompressed when the flow rate is regulated by the bypass-side flow rate regulating valve **14***d*, as in the hot gas air-heating mode. The refrigerant depressurized at the bypass-side flow rate regulating valve **14***d* flows into one inflow port of the sixth three-way joint **12***f*.

[0210] The refrigerant flowing out of the fifth three-way joint **12***e* and the refrigerant flowing out of the bypass-side flow rate regulating valve **14***d* are joined and mixed at the sixth three-way joint **12***f*. The refrigerant flowing out of the sixth three-way joint **12***f* is mixed when flowing through the suction-side passage **21***d*, and is drawn into the compressor **11**.

[0211] As described above, in the heat pump cycle **10** in the hot gas dehumidifying air-heating mode, the refrigerant circuit is switched to a refrigerant circuit in which refrigerants with different enthalpies, such as the low-enthalpy refrigerant flowing out of the chiller **20**, the high-enthalpy refrigerant flowing out of the bypass passage **21***c*, and the refrigerant flowing out of the indoor evaporator **18**, are mixed and sucked into the compressor **11**.

[0212] Therefore, in the heat pump cycle **10** in the hot gas dehumidifying air-heating mode, the air-cooling expansion valve **14***b* and the cooling expansion valve **14***c* serve as the heating-unit side decompression unit.

[0213] In the high-temperature side heat medium circuit **30** in the hot gas dehumidifying air-heating mode, the high-temperature side heat medium heated by the water-refrigerant heat exchanger **13** flows into the heater core **32** as in the air-cooling mode. In the indoor air conditioning unit **50** in the hot gas dehumidifying air-heating mode, the ventilation air with a regulated temperature is blown into the vehicle interior, so that the air in the vehicle interior is dehumidified and heated, as in the series dehumidifying air-heating mode.

[0214] Here, the hot gas dehumidifying air-heating mode is an operation mode in which the ventilation air is cooled and dehumidified, and the dehumidified ventilation air is reheated to a desired temperature and blown into the vehicle interior. For this reason, in the hot gas dehumidifying air-heating mode, it is necessary to regulate the amount of work of the compressor **11** in a manner that the temperature of the ventilation air can be reheated to a desired temperature by the heating unit without causing frosting on the indoor evaporator **18**.

[0215] In the hot gas dehumidifying air-heating mode of the present embodiment, the refrigerant with relatively high enthalpy flows into the sixth three-way joint **12***f* via the bypass passage **21***c*. Even when the refrigerant discharge performance of the compressor **11** is increased, it is possible to prevent the suction refrigerant pressure Ps from decreasing. As a result, the amount of heat radiated from the discharge refrigerant to the high-temperature side heat medium in the water-refrigerant heat exchanger **13** can be increased without causing frost formation in the indoor evaporator **18**.

[0216] Therefore, in the hot gas dehumidifying air-heating mode, the ventilation air can be heated with higher heating performance than in the series dehumidifying air-heating mode.

(g) Hot Gas Series Dehumidifying Air-Heating Mode

[0217] The hot gas series dehumidifying air-heating mode is an operation mode in which the air in the vehicle interior is dehumidified and heated. In the control program, the hot gas series dehumidifying air-heating mode is selected when it is determined that the heating performance of the ventilation air in the water-refrigerant heat exchanger **13** is insufficient in the series dehumidifying air-heating mode.

[0218] In the heat pump cycle **10** in the hot gas series dehumidifying air-heating mode, the control device **60** brings the air-heating expansion valve **14***a* into the throttled state, brings the air-cooling expansion valve **14***b* into the throttled state, brings the cooling expansion valve **14***c* into the throttled state, and brings the bypass-side flow rate regulating valve **14***d* into the throttled state. In addition, the control device **60** closes the dehumidifying on-off valve **22***a* and also closes the air-heating on-off valve **22***b*.

[0219] Therefore, in the heat pump cycle **10** in the hot gas series dehumidifying air-heating mode, the refrigerant discharged from the compressor **11** circulates similarly to the cooling series dehumidifying air-heating mode. At the same time, the refrigerant circuit is switched to a refrigerant circuit in which the refrigerant discharged from the compressor **11** circulates through the first three-way joint **12***a*, the bypass-side flow rate regulating valve **14***d* in the throttled state, which is provided in the bypass passage **21***c*, the sixth three-way joint **12***f*, the suction-side passage **21***d*, and the suction port of the compressor **11** in this order.

[0220] Furthermore, the control device **60** controls the refrigerant discharge performance of the compressor **11** in a manner that the suction refrigerant pressure Ps approaches the predetermined second target low pressure PSO**2**, as in the hot gas dehumidifying air-heating mode.

[0221] In addition, the control device **60** controls the throttle opening of the bypass-side flow rate regulating valve **14***d* in a manner that the discharge refrigerant pressure Pd approaches the target high pressure PDO, as in the hot gas air-heating mode.

[0222] The control device **60** controls the throttle opening of the air-heating expansion valve **14***a* and the throttle opening of the air-cooling expansion valve **14***b* to a predetermined throttle opening for the hot gas series dehumidifying air-heating mode.
[0223] The control device **60** also controls the throttle opening of the cooling expansion valve **14***c* in a manner that the degree of superheating SH of the suction refrigerant approaches the reference degree of superheating KSH, as in the hot gas dehumidifying air-heating mode.
[0224] In the high-temperature side heat medium circuit **30** in the hot gas dehumidifying air-heating mode, the control device **60** operates the high-temperature side pump **31** as in the air-cooling mode.
[0225] In the low-temperature side heat medium circuit **40** in the hot gas dehumidifying air-heating mode, the control device **60** stops the low-temperature side pump **41**.
[0226] In the indoor air conditioning unit **50** in the hot gas dehumidifying air-heating mode, the control device **60** controls the ventilation performance of the indoor blower **52** and the opening of the air mix door **54** as in the air-cooling mode. Furthermore, the control device **60** appropriately controls the operations of the other control target devices.
[0227] Therefore, in the heat pump cycle **10** in the hot gas series dehumidifying air-heating mode, the state of the refrigerant changes as follows.
[0228] The flow of the discharge refrigerant discharged from the compressor **11** is branched at the first three-way joint **12***a*. One of the refrigerant divided at the first three-way joint **12***a* flows into the water-refrigerant heat exchanger **13** and radiates heat to the high-temperature side heat medium. As a result, the high-temperature side heat medium is heated.
[0229] The refrigerant flowing out of the water refrigerant heat exchanger **13** flows into the air-heating expansion valve **14***a* and is decompressed. The refrigerant decompressed at the air-heating expansion valve **14***a* flows into the outdoor heat exchanger **15**. The refrigerant that has has flowed into the outdoor heat exchanger **15** exchanges heat with the outside air and decreases its enthalpy.
[0230] The flow of the refrigerant flowing from the outdoor heat exchanger **15** is branched at the four-way joint **12***x*. One of the refrigerant that branches at the four-way joint **12***x* flows into the air-cooling expansion valve **14***b* and is decompressed.
[0231] The refrigerant decompressed by the air-cooling expansion valve **14***b* flows into the indoor evaporator **18**, exchanges heat with the ventilation air supplied by the indoor blower **52**, and evaporates, as in the hot gas dehumidifying air-heating mode. Due to this, the ventilation air is cooled and dehumidified. The refrigerant flowing out of the indoor evaporator **18** flows into one inflow port of the fifth three-way joint **12***e* via the second check valve **16***b*.
[0232] The other refrigerant branched at the four-way joint **12***x* flows into the cooling expansion valve **14***c* and is decompressed, as in the hot gas air-heating mode. The refrigerant depressurized at the cooling expansion valve **14***c* flows into the chiller **20**. The refrigerant flowing out of the chiller **20** flows into the other inflow port of the fifth three-way joint **12***e*.
[0233] The flow of the refrigerant flowing out of the indoor evaporator **18** and the flow of the refrigerant flowing out of the chiller **20** are joined at the fifth three-way joint **12***e*, as in the hot gas air-heating mode. The refrigerant flowing out of the fifth three-way joint **12***e* flows into the other inflow port of the sixth three-way joint **12***f*.
[0234] The other refrigerant branched at the first three-way joint **12***a* flows into the bypass passage **21***c*. The refrigerant flowing into the bypass passage **21***c* is decompressed when the flow rate is regulated by the bypass-side flow rate regulating valve **14***d*, as in the hot gas air-heating mode. The refrigerant depressurized at the bypass-side flow rate regulating valve **14***d* flows into one inflow port of the sixth three-way joint **12***f*.
[0235] The refrigerant flowing out of the fifth three-way joint **12***e* and the refrigerant flowing out of the bypass-side flow rate regulating valve **14***d* are joined and mixed at the sixth three-way joint **12***f*, as in the hot gas dehumidifying air-heating mode. The refrigerant flowing out of the sixth three-way joint **12***f* is mixed when flowing through the suction-side passage **21***d*, and is drawn into

the compressor **11**.

[0236] As described above, in the heat pump cycle **10** in the hot gas series dehumidifying air-heating mode, the refrigerant circuit is switched to a refrigerant circuit in which refrigerants with different enthalpies, such as the low-enthalpy refrigerant flowing out of the chiller **20**, the high-enthalpy refrigerant flowing out of the bypass passage **21***c*, and the refrigerant flowing out of the indoor evaporator **18**, are mixed and sucked into the compressor **11**.

[0237] Therefore, in the heat pump cycle **10** in the hot gas series dehumidifying air-heating mode, the air-heating expansion valve **14***a*, the air-cooling expansion valve **14***b*, and the cooling expansion valve **14***c* serve as the heating-unit side decompression unit.

[0238] In the high-temperature side heat medium circuit **30** in the hot gas series dehumidifying air-heating mode, the high-temperature side heat medium heated by the water-refrigerant heat exchanger **13** flows into the heater core **32** as in the air-cooling mode.

[0239] In the indoor air conditioning unit **50** in the hot gas series dehumidifying air-heating mode, the ventilation air with a regulated temperature is blown into the vehicle interior, so that the air in the vehicle interior is dehumidified and heated, as in the series dehumidifying air-heating mode.

[0240] In the hot gas series dehumidifying air-heating mode, it is necessary to regulate the refrigerant discharge performance of the compressor **11** in a manner that the heating unit can reheat the ventilation air to a desired temperature without causing frosting on the indoor evaporator **18**, as in the hot gas dehumidifying air-heating mode.

[0241] In the hot gas series dehumidifying air-heating mode of the present embodiment, the refrigerant with relatively high enthalpy flows into the sixth three-way joint **12***f* via the bypass passage **21***c*. Therefore, even when the refrigerant discharge performance of the compressor **11** is increased, it is possible to increase the amount of heat radiated from the discharge refrigerant to the ventilation air in the water-refrigerant heat exchanger **13** without causing frosting on the indoor evaporator **18**, as in the hot gas series dehumidifying air-heating mode.

[0242] As a result, in the hot gas series dehumidifying air-heating mode, the ventilation air can be heated with higher heating performance than in the series dehumidifying air-heating mode.

[0243] As described above, according to the vehicular air conditioner **1** of the present embodiment, comfortable air conditioning in the vehicle interior can be implemented by switching the operation mode.

[0244] In this embodiment, in the heater heat absorbing air-heating mode and the heater heat absorbing hot gas heating mode, the control device **60** lowers the upper limit rotation speed of the compressor **11** as the noise level acceptable for the compressor **11** decreases, and increases the amount of heat absorbed in the chiller **20** as the noise level acceptable for the compressor **11** decreases.

[0245] As a result, the amount of heat absorbed by the chiller **20** increases as the allowable noise level of the compressor **11** decreases, so that the desired heating capacity can be ensured even when the amount of work of the compressor **11** (in other words, the rotation speed of the compressor **11**) is decreased. Therefore, it is possible to suppress the noise of the compressor while ensuring the necessary heating capacity.

[0246] In particular, in the heater heat absorbing hot gas air-heating mode, refrigerants with different enthalpies, such as a refrigerant with low enthalpy flowing out from the chiller **20** and a refrigerant with high enthalpy flowing out from the bypass passage **21***c*, are mixed and drawn into the compressor, to enable to effectively use the heat generated by the amount of work of the compressor for heating, while simultaneously suppressing compressor noise and ensuring the necessary heating capacity.

[0247] In this embodiment, the control device **60** increases the amount of heat absorbed in the chiller **20** so that the heating capacity approaches the target heating capacity as the allowable noise level of the compressor **11** decreases. This allows the amount of heat absorbed in the chiller **20** to be appropriately controlled, to enable to suppress increase in heat loss caused by an excessive increase in the amount of heat absorbed in the chiller **20**.

[0248] In this embodiment, the control device **60** increases the heat generation amount of the electric heater **70** as the allowable noise level of the compressor **11** decreases. This ensures to increase the amount of heat absorbed by the chiller **20** in accordance with decrease in the allowable noise level of the compressor **11**.

[0249] In this embodiment, the control device **60** decreases the upper limit rotation speed of the compressor **11** as the vehicle speed decreases. This allows the rotation speed of the compressor **11** to be decreased in accordance with decrease in the allowable noise level of the compressor **11**.

Second Embodiment

[0250] In the present embodiment shown in FIG. **9**, an indoor condenser **131** is provided instead of the water-refrigerant heat exchanger **13** and the high-temperature side heat medium circuit **30** in the heat pump cycle **10** of the first embodiment. In this embodiment, an accumulator **23** is added to the heat pump cycle **10** in the vehicular air conditioner **1** of the first embodiment.

[0251] In the heat pump cycle **10**, an inflow port side of a refrigerant passage in the indoor condenser **131** is connected to one outflow port of the first three-way joint **12***a*. The indoor condenser **131** is provided in the air conditioning case **51** of the indoor air conditioning unit **50** similarly to the heater core **32** described in the first embodiment.

[0252] The indoor condenser **131** is a heating heat exchanger that exchanges heat between the high-pressure refrigerant discharged from the compressor **11** and ventilation air passing through the indoor evaporator **18** to heat ventilation air. Therefore, the indoor condenser **131** is a heating unit heating blown air as an object to be heated by using, as a heat source, one of the discharged refrigerant branched at the first three-way joint **12***a*.

[0253] The accumulator **23** is provided on the outlet side of the sixth three-way joint **12***f* in the suction-side passage **21***d*. The accumulator **23** is a low-pressure side gas-liquid separating unit that separates the refrigerant flowing through the suction-side passage **21***d* into gas and liquid and stores the separated liquid-phase refrigerant as an excess refrigerant in the cycle. The inflow port side of the compressor **11** is connected to a gas-phase refrigerant outlet of the accumulator **23**. The suction refrigerant temperature sensor **62***f* is provided on the downstream side in the refrigerant flow of the gas-phase refrigerant outflow port of the accumulator **23**.

[0254] The remaining configurations and operation are similar to those of the first embodiment. Therefore, effects similar to those of the first embodiment can be obtained.

Third Embodiment

[0255] In this embodiment, as shown in FIG. **10**, in the heat pump cycle **10**, the air-heating expansion valve **14***a* and the outdoor heat exchanger **15** are arranged in parallel with the cooling expansion valve **14***c* and the chiller **20**.

[0256] In this embodiment, the desired heating capacity is achieved by the sum of the amount of work of the compressor **11**, the amount of heat absorbed by the outdoor heat exchanger **15**, and the amount of heat generated by the electric heater **70**.

[0257] The control device **60** controls the amount of heat absorbed by the chiller **20** (i.e., the amount of heat generated by the electric heater **70**) according to the allowable noise level of the compressor **11**, similarly to the heater heat absorbing air-heating mode of the first and second embodiments.

[0258] As a result, similarly to the first and second embodiments, when the allowable noise level of the compressor **11** is low, the rotation speed of the compressor **11** can be kept low to keep the noise of the compressor **11** low.

[0259] In this embodiment, the desired heating capacity is achieved by the sum of the amount of work of the compressor **11**, the amount of heat absorbed by the outdoor heat exchanger **15**, and the amount of heat generated by the electric heater **70**. Therefore, as the amount of heat generated by the electric heater **70** increases, the rotation speed of the compressor **11** decreases, and the amount of heat absorbed by the outdoor heat exchanger **15** decreases. When the amount of heat absorbed by the outdoor heat exchanger **15** becomes too small, the system efficiency decreases.

[0260] In this regard, in the present embodiment, as the allowable noise level of the compressor **11** decreases, the amount of heat absorbed in the chiller **20** (i.e., the amount of heat generated by the electric heater **70**) is increased so that the heating capacity of the heater core **32** or the water-refrigerant heat exchanger **13** (the indoor condenser **131** in the configuration of the second embodiment described above) approaches the target heating capacity, so that the compressor **11** can be operated near its upper limit rotation speed. Therefore, it is possible to suppress decrease in the system efficiency caused by an excessively small amount of heat absorption in the outdoor heat exchanger **15**.

Fourth Embodiment

[0261] In this embodiment, as shown in FIG. **11**, in the low-temperature side heat medium circuit **40**, a radiator **42** is provided in series with the electric heater **70**. The radiator **42** is an outside air heat exchanger that exchanges heat between the low-temperature heat medium cooled by the chiller **20** and outside air blown by an outside air fan (not shown).

[0262] A radiator bypass passage **43** and a bypass on-off valve **44** are arranged in the low-temperature side heat medium circuit **40**. The radiator bypass passage **43** is a flow path through which the low-temperature side heat medium flows, while bypassing the radiator **42**. The bypass on-off valve **44** is an on-off valve that opens and closes the radiator bypass passage **43**. The bypass on-off valve **44** is an electromagnetic valve whose opening and closing operation is controlled by a control voltage output from the control device **60**.

[0263] When the temperature of the low-temperature heat medium is higher than the temperature of the outside air, the radiator **42** cannot absorb heat from the low-temperature heat medium, so the bypass on-off valve **44** is opened to stop the flow of the low-temperature heat medium to the radiator **42**.

[0264] In this embodiment, the desired heating capacity is achieved by the sum of the amount of work of the compressor **11**, the amount of heat absorbed by the radiator **42**, and the amount of heat generated by the electric heater **70**.

[0265] The control device **60** controls the amount of heat absorbed by the chiller **20** (i.e., the amount of heat generated by the electric heater **70**) according to the allowable noise level of the compressor **11**, similarly to the heater heat absorbing air-heating mode of the first and second embodiments.

[0266] As a result, similarly to the first and second embodiments, when the allowable noise level of the compressor **11** is low, the rotation speed of the compressor **11** can be kept low to keep the noise of the compressor **11** low.

[0267] In this embodiment, the desired heating capacity is achieved by the sum of the amount of work of the compressor **11**, the amount of heat absorbed by the radiator **42**, and the amount of heat generated by the electric heater **70**. Therefore, as the amount of heat generated by the electric heater **70** increases, the rotation speed of the compressor **11** decreases, and the amount of heat absorbed by the radiator **42** decreases. When the amount of heat absorbed by the radiator **42** becomes too small, the system efficiency decreases.

[0268] In this regard, in the present embodiment, as the allowable noise level of the compressor **11** decreases, the amount of heat absorbed in the chiller **20** (i.e., the amount of heat generated by the electric heater **70**) is increased so that the heating capacity of the heater core **32** or the water-refrigerant heat exchanger **13** (the indoor condenser **131** in the configuration of the second embodiment described above) approaches the target heating capacity, so that the compressor **11** can be operated near its upper limit rotation speed. Therefore, it is possible to suppress decrease in the system efficiency caused by an excessively small amount of heat absorption in the radiator **42**.

Fifth Embodiment

[0269] In the above first to fourth embodiments, the amount of heat absorbed in the chiller **20** is controlled by controlling the heat generation amount of the electric heater **70**. In this embodiment,

the amount of heat absorbed in the chiller **20** is controlled by controlling the degree of superheat SH of the refrigerant that has been heat exchanged in the chiller **20**.
[0270] Specifically, the control device **60** decreases a superheat target degree SHO of the degree of superheat SH of the refrigerant that has performed heat exchange in the chiller **20** as the allowable noise level of the compressor **11** decreases. The control device **60** controls the throttle opening degree of the cooling expansion valve **14***c* so that the degree of superheat SH of the refrigerant that has performed heat exchange in the chiller **20** approaches the superheat target degree SHO. That is, when the degree of superheat SH of the refrigerant that has performed heat exchange in the chiller **20** is greater than the target degree of superheat SHO, the throttle opening of the cooling expansion valve **14***c* is increased.
[0271] As a result, the flow rate of the refrigerant passing through the cooling expansion valve **14***c* increases, so that the flow rate of the refrigerant flowing through the chiller **20** also increases, and the amount of heat absorbed in the chiller **20** increases. That is, as shown in FIG. **12**, the amount of heat absorbed by the chiller **20** increases as the superheat target degree SHO of the degree of superheat SH of the refrigerant that has performed heat exchange in the chiller **20** decreases. As a result, similarly to the first embodiment, when the allowable noise level of the compressor **11** is low, the rotation speed of the compressor **11** can be kept low to keep the noise of the compressor **11** low.
[0272] In this embodiment, the control device **60** decreases the degree of superheat SH of the refrigerant that has performed heat exchange in the chiller **20** in accordance with decrease in the allowable noise level of the compressor **11**. This enables to quickly increase the amount of heat absorbed by the chiller **20** in accordance with decrease in the allowable noise level of the compressor **11**.
[0273] The present disclosure is not limited to the embodiments described above, and can be variously modified as follows without departing from the gist of the present disclosure.
[0274] In the first embodiment described above, the allowable noise level of the compressor **11** is determined to be two levels, high and low, based on the vehicle speed. The allowable noise level of the compressor **11** may also be determined continuously based on the vehicle speed.
[0275] That is, the allowable noise level of the compressor **11** may be continuously decreased as the vehicle speed decreases.
[0276] Furthermore, in the above-described embodiment, the upper limit rotation speed of the compressor **11** is determined in two stages, the first upper limit rotation speed NcImt**1** and the second upper limit rotation speed NcImt**2**, based on the allowable noise level of the compressor **11**. However, the upper limit rotation speed of the compressor **11** may be determined continuously based on the allowable noise level of the compressor **11**.
[0277] That is, the upper limit rotation speed of the compressor **11** may be continuously decreased as the allowable noise level of the compressor **11** decreases.
[0278] The configuration of the heat pump cycle device according to the present disclosure is not limited to the configurations disclosed in the above embodiments.
[0279] In the first and second embodiments described above, the other inflow port of the sixth three-way joint **12***f* is connected to the outlet side of the fifth three-way joint **12***e*, and the outflow port of the sixth three-way joint **12***f* is connected to the suction side of the compressor **11**. However, the other inflow port of the sixth three-way joint **12***f* may be connected to the outlet side of the cooling expansion valve **14***c*, and the outflow port of the sixth three-way joint **12***f* may be connected to the inlet side of the chiller **20**.
[0280] In the second embodiment described above, the refrigerant that has flowed through the bypass passage **21***c* flows into the accumulator **23** via the sixth three-way joint **12***f*. However, the refrigerant that has flowed through the bypass passage **21***c* may also flow directly into the accumulator **23** without passing through the sixth three-way joint **12***f*.
[0281] In the above-described embodiments, the heating element arranged in the low-temperature

side heat medium circuit **40** is the electric heater **70**, but this is not limited to this, and the heating element arranged in the low-temperature side heat medium circuit **40** may be various heating elements whose heat generation amount can be controlled by a control signal output from the control device **60**.

[0282] In the above embodiments, the example in which the second check valve **16***b* is used has been described, but an evaporation pressure regulating valve may be used instead of the second check valve **16***b*. The evaporation pressure regulating valve is a variable throttle mechanism that maintains a refrigerant evaporating temperature in the indoor evaporator **18** at a predetermined temperature (for example, temperature at which the indoor evaporator **18** can be suppressed) or higher.

[0283] As the evaporation pressure regulating valve, a variable throttle mechanism including a mechanical mechanism that increases a valve opening as the pressure of the refrigerant on the refrigerant outflow port side of the indoor evaporator **18** increases may be used. As the evaporation pressure regulating valve, a variable throttle mechanism including an electric mechanism similar to that of the air-heating expansion valve **14***a* or the like may be used.

[0284] The control sensor group connected to the input side of the control device **60** is not limited to the detection units disclosed in the above embodiments. Various detection units may be added as necessary.

[0285] In the above embodiment, the example in which R1234yf is employed as the refrigerant of the heat pump cycle **10** has been described, but the present embodiment is not limited thereto. For example, R134a, R600a, R410A, R404A, R32, R407C, and the like may be employed. Alternatively, a mixed refrigerant or the like in which multiple types of those refrigerants are mixed together may be employed. Furthermore, carbon dioxide may be used as the refrigerant to form a supercritical refrigeration cycle in which the high-pressure side refrigerant pressure is equal to or higher than the critical pressure of the refrigerant.

[0286] The example of using an ethylene glycol aqueous solution as the low-temperature side heat medium and the high-temperature side heat medium of the embodiments described above has been described, but it is not limited thereto. As the high-temperature side heat medium and the low-temperature side heat medium, for example, dimethylpolysiloxane, a solution containing nanofluid or the like, an antifreeze liquid, an aqueous liquid refrigerant containing alcohol or the like, a liquid medium containing oil or the like, and the like may be used.

[0287] The control mode of the heat pump cycle device according to the present disclosure is not limited to the control modes disclosed in the above embodiments.

[0288] In the above-described embodiment, the vehicular air conditioner **1** capable of executing various operation modes has been described. However, the heat pump cycle apparatus according to the present disclosure is not necessarily capable of executing all the above-described operation modes.

[0289] The heat pump cycle device according to the present disclosure can obtain effects similar to those of the above embodiments as long as the heat pump cycle device can perform at least one of the heater heat absorbing air-heating mode and the heater heat absorbing hot gas air-heating mode. That is, even in the heat pump cycle device in which refrigerants with different enthalpies are mixed and sucked into the compressor, the compressor **11** can be protected without deteriorating productivity. Furthermore, other operation modes may be able to be performed.

[0290] In addition, the control mode of the control device **60** in the heater heat absorbing air-heating mode is not limited to the examples disclosed in the above embodiments.

[0291] For example, in the above-described embodiment, the control device **60** determines the allowable noise level of the compressor **11** based on the vehicle speed. However, the control device **60** may also determine the allowable noise level of the compressor **11** based on the air volume (in other words, the rotation speed) of the indoor blower **52** or the air volume (in other words, the rotation speed) of an outdoor air fan not shown. This is because when the air volume of the indoor blower **52** or the outdoor air fan is large, the noise of the compressor **11** is easily drowned out by the operating sound and blowing sound of the indoor blower **52** and the outdoor air fan. This also applies to the heater heat absorbing hot gas air-heating mode.

[0292] In the present embodiment, the control device **60** decreases the upper limit rotation speed of the compressor **11** as the air flow rate of the indoor blower **52** decreases. This allows the rotation speed of the compressor **11** to be decreased in accordance with decrease in the allowable noise level of the compressor **11**.

[0293] In this embodiment, the control device **60** decreases the upper limit rotation speed of the compressor **11** in accordance with decrease in the blowing amount of the outside air fan that blows outside air. This allows the rotation speed of the compressor to be decreased in accordance with decrease in the allowable noise level of the compressor.

[0294] The present disclosure has been described in accordance with examples, but it is understood that the present disclosure is not limited to the examples and structures. The present disclosure encompasses various modifications and variations within the scope of equivalents. In addition, various combinations and modes, and other combinations and modes including only one element, more elements, or less elements are also within the scope and idea of the present disclosure.

[0295] The vehicle heat pump cycle device disclosed in this specification has the following features.

(Item **1**)

[0296] A vehicular heat pump cycle device includes: a compressor (**11**) configured to draw, compress, and discharge refrigerant; a heating unit (**13**, **131**) configured to heat an object to be heated using, as a heat source, refrigerant discharged from the compressor; a decompression unit (**14***c*) configured to decompress refrigerant flowing out of the heating unit; and a heat absorbing unit (**20**) configured to cause refrigerant, which is decompressed by the decompression unit, to absorb heat generated by a heat generating unit (**70**), in which the heat absorbing unit is configured to increase an amount of absorbed heat according to decrease in an allowable noise level of the compressor.

(Item **2**)

[0297] A vehicular heat pump cycle device includes: a compressor (**11**) configured to draw, compress, and discharge refrigerant; a heating unit (**13**, **131**) configured to heat an object to be heated using, as a heat source, refrigerant discharged from the compressor; a decompression unit (**14***c*) configured to decompress refrigerant flowing out of the heating unit; a heat absorbing unit (**20**) configured to cause refrigerant, which is decompressed by the decompression unit, to absorb heat generated by a heat generating unit (**70**); and an upper limit rotation speed determination unit (**60***a*) configured to determine an upper limit rotation speed of the compressor, in which the upper limit rotation speed determination unit is configured to lower the upper limit rotation speed according to decrease in an allowable noise level of the compressor, and the heat absorbing unit is configured to increase an amount of absorbed heat according to decrease in the allowable noise level of the compressor.

(Item **3**)

[0298] The vehicular heat pump cycle device according to item **2**, further includes: a target heating capacity determination unit (**60***d*) configured to determine a target heating capacity of the heating unit, in which the heat absorbing unit is configured to increase the amount of absorbed heat, so that the heating capacity of the heating unit approaches the target heating capacity according to decrease in the allowable noise level of the compressor.

(Item **4**)

[0299] The vehicular heat pump cycle device according to item **2** or **3**, in which the heat generating unit is configured to increase an amount of generated heat according to decrease in the allowable noise level of the compressor.

(Item **5**)

[0300] The vehicular heat pump cycle device according to item **2** or **3**, in which the decompression unit is configured to decrease a superheat degree of refrigerant, which has performed heat exchange in the heat absorbing unit, according to decrease in the allowable noise level of the compressor.

(Item **6**)

[0301] The vehicular heat pump cycle device according to any one of items **2** to **5**, in which the upper limit rotation speed determination unit is configured to decrease the upper limit rotation speed, as a vehicle speed decreases.

(Item **7**)

[0302] The vehicular heat pump cycle device according to any one of items **2** to **5**, in which the upper limit rotation speed determination unit is configured to decrease the upper limit rotation speed according to decrease in an air flow rate of a blower unit (**52**) that is configured to blow air toward a vehicle interior.

(Item **8**)

[0303] The vehicular heat pump cycle device according to any one of items **2** to **5**, in which the upper limit rotation speed determination unit is configured to decrease the upper limit rotation speed according to decrease in an air flow rate of an outside air fan that is configured to blow outside air.

(Item **9**)

[0304] The vehicular heat pump cycle device according to any one of items **1** to **8**, further includes: a branch portion (**12***a*) configured to branch flow of refrigerant discharged from the compressor into a side of the heating unit and an other side; a bypass passage (**21***c*) configured to circulate refrigerant branched to the other at the branch portion; a flow rate regulating unit (**14***d*) configured to regulate a flow rate of refrigerant flowing through the bypass passage; and a joining unit (**12***f*) configured to join refrigerant, which flows out of the decompression unit, and refrigerant, which flows out of the flow rate regulating unit, and cause the refrigerant to flow to an inflow port of the compressor.

Claims

1. A vehicular heat pump cycle device comprising: a compressor configured to draw, compress, and discharge refrigerant; a heating unit configured to heat an object to be heated using, as a heat source, refrigerant discharged from the compressor; a decompression unit configured to decompress refrigerant flowing out of the heating unit; and a heat absorbing unit configured to cause refrigerant, which is decompressed by the decompression unit, to absorb heat generated by a heat generating unit, wherein the heat absorbing unit is configured to increase an amount of absorbed heat according to decrease in an allowable noise level of the compressor.

2. A vehicular heat pump cycle device comprising: a compressor configured to draw, compress, and discharge refrigerant; a heating unit configured to heat an object to be heated using, as a heat source, refrigerant discharged from the compressor; a decompression unit configured to decompress refrigerant flowing out of the heating unit; a heat absorbing unit configured to cause refrigerant, which is decompressed by the decompression unit, to absorb heat generated by a heat generating unit; and an upper limit rotation speed determination unit configured to determine an upper limit rotation speed of the compressor, wherein the upper limit rotation speed determination unit is configured to lower the upper limit rotation speed according to decrease in an allowable noise level of the compressor, and the heat absorbing unit is configured to increase an amount of absorbed heat according to decrease in the allowable noise level of the compressor.

3. The vehicular heat pump cycle device according to claim 2, further comprising: a target heating capacity determination unit configured to determine a target heating capacity of the heating unit, wherein the heat absorbing unit is configured to increase the amount of absorbed heat, so that the heating capacity of the heating unit approaches the target heating capacity according to decrease in the allowable noise level of the compressor.

4. The vehicular heat pump cycle device according to claim 2, wherein the heat generating unit is configured to increase an amount of generated heat according to decrease in the allowable noise level of the compressor.

5. The vehicular heat pump cycle device according to claim 2, wherein the decompression unit is configured to decrease a superheat degree of refrigerant, which has performed heat exchange in the heat absorbing unit, according to decrease in the allowable noise level of the compressor.

6. The vehicular heat pump cycle device according to claim 2, wherein the upper limit rotation speed determination unit is configured to decrease the upper limit rotation speed, as a vehicle speed decreases.

7. The vehicular heat pump cycle device according to claim 2, wherein the upper limit rotation speed determination unit is configured to decrease the upper limit rotation speed according to decrease in an air flow rate of a blower unit that is configured to blow air toward a vehicle interior.

8. The vehicular heat pump cycle device according to claim 2, wherein the upper limit rotation speed determination unit is configured to decrease the upper limit rotation speed according to decrease in an air flow rate of an outside air fan that is configured to blow outside air.

9. The vehicular heat pump cycle device according to claim 2, further comprising: a branch portion configured to branch flow of refrigerant discharged from the compressor into a side of the heating unit and an other side; a bypass passage configured to circulate refrigerant branched to the other at the branch portion; a flow rate regulating unit configured to regulate a flow rate of refrigerant flowing through the bypass passage; and a joining unit configured to join refrigerant, which flows out of the decompression unit, and refrigerant, which flows out of the flow rate regulating unit, and cause the refrigerant to flow to an inflow port of the compressor.

10. A vehicular heat pump cycle device comprising: a compressor configured to draw, compress, and discharge refrigerant; a heating device configured to heat an object to be heated using, as a heat source, refrigerant discharged from the compressor; a decompressing device configured to decompress refrigerant flowing out of the heating device; a heat absorbing device configured to cause refrigerant, which is decompressed by the decompressing device, to absorb heat generated by a heat generating device; and at least one of (i) a circuit and (ii) a processor having a memory storing computer program code, wherein the at least one of the circuit and the processor having the memory is configured to cause the heat absorbing device to increase an amount of absorbed heat according to decrease in an allowable noise level of the compressor.

11. The vehicular heat pump cycle device according to claim 10, wherein the at least one of the circuit and the processor having the memory is further configured to determine an upper limit rotation speed of the compressor, and lower the upper limit rotation speed according to decrease in the allowable noise level of the compressor.