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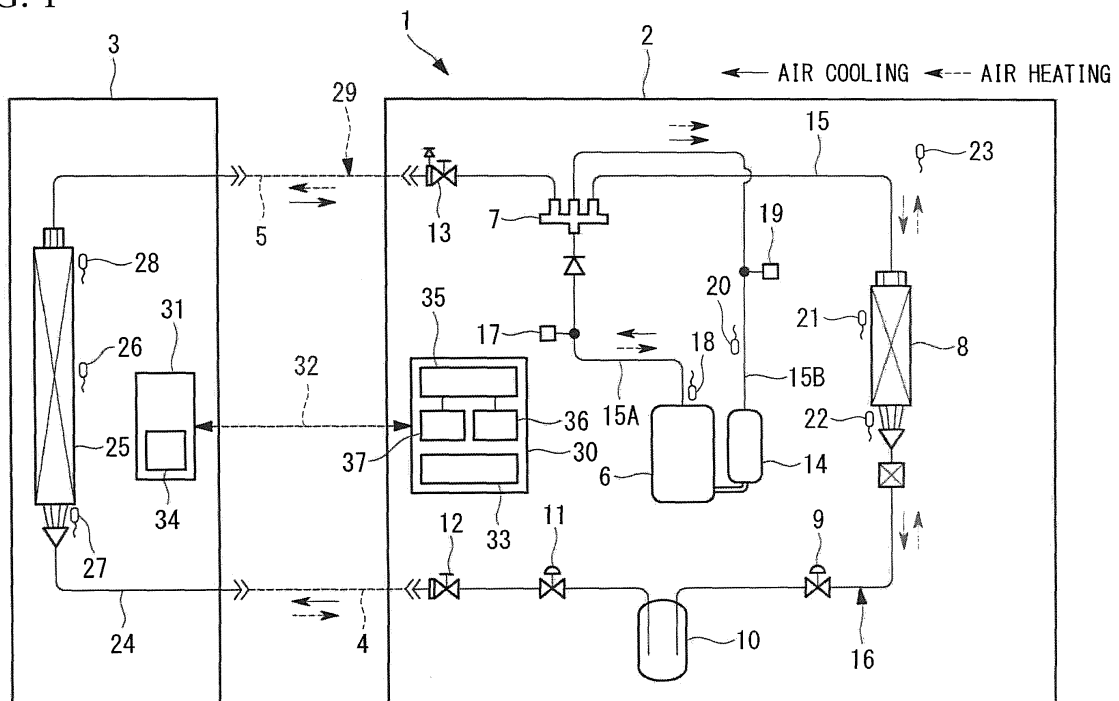
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(54) **REFRIGERATING/AIR-CONDITIONING DEVICE**

(57) In a refrigeration / air-conditioning device including a refrigeration cycle (29), and an expansion valve control means (35), the expansion valve control means (35) includes a target value switching means (36) which adopts the lower one of a target degree of discharge superheat T_{dSH} plus a high pressure saturation temperature and an upper-limit value of the discharge temperature T_d as a target value, or compares a target discharge

temperature T_d obtained by calculation from the rotational speed of a compressor and the high pressure saturation temperature with an upper-limit value and adopts the lower one of the target discharge temperature T_d and the upper-limit value as the target discharge temperature T_d while performing the control at the predetermined degree of discharge superheat T_{dSH} or the control at the predetermined discharge temperature T_d .

FIG. 1



Description

{Technical Field}

[0001] The present invention relates to a refrigeration / air-conditioning device using a refrigerant whose discharge temperature T_d easily increases, e.g., an R32 refrigerant.

{Background Art}

[0002] In various types of refrigerators, air conditioners, and heat pumps (hereinafter generically referred to as a refrigeration / air-conditioning device), a liquid flood-back to a compressor is prevented by controlling the aperture of an expansion valve so that a degree of suction gas superheat SH becomes constant, to ensure reliability. On the other hand, an R32 refrigerant or a mixed refrigerant rich in R32 refrigerant, which has a global warming potential (GWP) as low as approximately one-third that of an R410A refrigerant and an ozone depletion potential (ODP) of zero (hereinafter simply referred to as an R32 refrigerant) has been used in recent years to reduce an environmental load.

[0003] However, the discharge temperature T_d of the R32 refrigerant is higher by 10°C to 20°C than that of the R410A refrigerant due to its physical properties. The larger a high-low pressure difference of the refrigerant becomes, the higher the discharge temperature T_d tends to be. Thus, when the R410A refrigerant is used, the discharge temperature T_d thereof can be controlled to within a temperature range where no breakdown occurs in a compressor motor in a normal utilization range, as illustrated in a Mollier diagram of FIG. 6. However, when the R32 refrigerant is used, the discharge temperature T_d thereof exceeds a temperature at which a breakdown occurs in the compressor motor in control at the predetermined degree of suction gas superheat SH, as illustrated in a Mollier diagram of FIG. 7. Therefore, motor efficiency may decrease and it may not be possible to ensure a capability under the condition that the discharge temperature T_d easily increases (the high-low pressure difference is large). When an attempt to ensure an operation range is made by solving such a problem, the insulation grade of a motor winding needs to be increased, resulting in higher costs.

[0004] Therefore, Japanese Unexamined Patent Application, Publication No. 2001-174075 discusses a configuration in which the aperture of an electronic expansion valve (EEV) is controlled so that the degree of suction gas superheat SH becomes a predefined temperature while the aperture of the electronic expansion valve (EEV) is controlled based on a discharge temperature T_d of a compressor when the discharge temperature T_d exceeds an upper-limit value. Japanese Unexamined Patent Application, Publication No. 2014-190632 discusses a configuration in which the rotational speed of a compressor is adjusted so that the compression ratio of

the compressor becomes lower than an upper-limit value to set the degree of drying of a refrigerant at an inlet of the compressor to 0.85 or more while the aperture of an electronic expansion valve (EEV) is adjusted so that a degree of discharge superheat T_dSH comes closer to a target value.

{Citation List}

10 {Patent Literature}

[0005]

{PTL 1} Japanese Unexamined Patent Application, Publication No. 2001-174075

{PTL 2} Japanese Unexamined Patent Application, Publication No. 2014-190632

{Summary of Invention}

{Technical Problem}

[0006] Although the configurations discussed in Japanese unexamined Patent Application, Publication Nos. 2001-174075 and 2014-190632 can prevent the excessive increase in the discharge temperature T_d and the decrease in the motor efficiency caused thereby, they cannot sufficiently cope with an increase in a degree of suction gas superheat SH caused by changes in an operation condition and an operation point, a decrease in operation efficiency caused thereby, inhibition of a stable operation by the occurrence of an excessive liquid flood-back, or exceedance of a limit value of the discharge temperature T_d caused by a change in ambient temperature. Furthermore, the configurations must use control of the rotational speed of the compressor in addition to the control of the aperture of the electronic expansion valve. Therefore, a control system becomes complicated.

[0007] The present invention has been made in view of such a circumstance, and is directed to providing a refrigeration / air-conditioning device capable of ensuring an appropriate operation condition for changes in an operation condition and an operation point only by control of the aperture of an electronic expansion valve while ensuring reliability by operating a compressor within a utilization limit.

{Solution to Problem}

[0008] To solve the aforementioned issue, a refrigeration / air-conditioning device according to the present invention adopts the following solutions.

[0009] Specifically, according to an embodiment of the present invention, there is provided a refrigeration / air-conditioning device, including a refrigeration cycle in which at least a compressor, a heat source-side heat exchanger, an electronic expansion valve, and a utiliza-

tion-side heat exchanger are connected via refrigerant piping and which is filled with a refrigerant whose discharge temperature T_d more easily increases than that of an R410A refrigerant, and an expansion valve control means which controls the aperture of the electronic expansion valve at a predetermined degree of suction gas superheat SH when the discharge temperature T_d is not more than an upper-limit value and controls the aperture of the electronic expansion valve at a predetermined degree of discharge superheat T_dSH or a predetermined discharge temperature T_d when the discharge temperature T_d exceeds the upper-limit value, in which the expansion valve control means includes a target value switching means which switches, when the expansion valve control means is performing the control at the predetermined degree of discharge superheat T_dSH while controlling the aperture of the expansion valve at the predetermined degree of discharge superheat T_dSH or the predetermined discharge temperature T_d , the control at the predetermined degree of discharge superheat T_dSH to the control at the predetermined degree of discharge superheat T_dSH or the control at the predetermined discharge temperature T_d using as a target value a high pressure saturation temperature and an upper-limit value of the discharge temperature T_d and the lower one of a target degree of discharge superheat T_dSH obtained by calculation from the rotational speed of a compressor, and compares, when the expansion valve control means is performing the control at the predetermined discharge temperature T_d , a target discharge temperature T_d obtained by calculation from the rotational speed of the compressor and the high pressure saturation temperature with the upper-limit value and adopts the lower one of the target discharge temperature T_d and the upper-limit value as the target discharge temperature T_d .

[0010] According to the embodiment of the present invention, the aperture of the electronic expansion valve is controlled at the predetermined degree of suction gas superheat SH when the discharge temperature T_d of a refrigerant discharged from the compressor during an operation is not more than a previously set upper-limit value, and the aperture of the electronic expansion valve is controlled at the predetermined degree of discharge superheat T_dSH or the predetermined discharge temperature T_d when the discharge temperature T_d exceeds the upper-limit value. Therefore, even when an R32 refrigerant whose discharge temperature T_d easily increases is used, the discharge temperature T_d is prevented from exceeding a utilization upper-limit value, and the insulation grade of a compressor motor is made usable as it is so that an increase in cost can be avoided while the discharge temperature T_d is made difficult to increase so that refrigerant oil can be prevented from deteriorating. While the aperture of the expansion valve is being controlled at the predetermined degree of discharge superheat T_dSH or the predetermined discharge temperature T_d , when the control at the predetermined degree of discharge superheat T_dSH is being performed, the control

at the predetermined degree of discharge superheat T_dSH is switched to the control at the predetermined degree of discharge superheat T_dSH or the control at the predetermined discharge temperature T_d using the lower one of the target degree of discharge superheat T_dSH obtained by calculation from the rotational speed of the compressor and the high pressure saturation temperature and the upper-limit value of the discharge temperature T_d as a target value. When the control at the predetermined target discharge temperature T_d is being performed, the target discharge temperature T_d obtained by calculation from the rotational speed of the compressor and the high pressure saturation temperature is compared with the upper-limit value, and the lower one of the target discharge temperature T_d and the upper-limit value is adopted as the target discharge temperature T_d . Thus, even when an operation point has changed with the rotational speed of the compressor remaining the same, the aperture of the electronic expansion valve can be controlled using the lower one of the utilization upper-limit value of the discharge temperature T_d to be permitted and the target degree of discharge superheat T_dSH plus the high pressure saturation temperature as a target value. Therefore, the discharge temperature T_d is suppressed to not more than the utilization upper-limit value of the compressor so that a utilization limit can be reliably protected.

[0011] Furthermore, in the refrigeration / air-conditioning device according to an embodiment of the present invention, the expansion valve control means further includes a target value varying means which varies the target degree of discharge superheat T_dSH or the target discharge temperature T_d depending on the rotational speed of the compressor.

[0012] According to the embodiment of the present invention, the expansion valve control means further includes the target value varying means which varies the target degree of discharge superheat T_dSH or the target discharge temperature T_d depending on the rotational speed of the compressor. Therefore, when the rotational speed of the compressor decreases so that the compression ratio decreases while the aperture of the electronic expansion valve is being controlled at the predetermined degree of discharge superheat T_dSH or the predetermined discharge temperature T_d , the aperture of the electronic expansion valve is excessively throttled. As a result, the degree of suction gas superheat SH becomes too high, resulting in a degraded heat exchange performance. However, when the target degree of discharge superheat T_dSH or the discharge temperature T_d is varied depending on the rotational speed of the compressor, the electronic expansion valve is prevented from being excessively throttled so that an appropriate operation condition can be maintained. Therefore, the degradation of the heat exchange performance occurring because of the degree of suction gas superheat SH becoming too high is suppressed, enabling the refrigeration / air-conditioning device to perform efficient operations.

[0013] According to another embodiment of the present invention, there is provided a refrigeration / air-conditioning device, including a refrigeration cycle in which at least a compressor, a heat source-side heat exchanger, an electronic expansion valve, and a utilization-side heat exchanger are connected via refrigerant piping and which is filled with a refrigerant whose discharge temperature T_d more easily increases than that of an R410A refrigerant, and an expansion valve control means which controls the aperture of the electronic expansion valve at a predetermined degree of suction gas superheat SH when the discharge temperature T_d is not more than an upper-limit value and controls the aperture of the electronic expansion valve at a predetermined degree of discharge superheat T_dSH or a predetermined discharge temperature T_d when the discharge temperature T_d exceeds the upper-limit value, in which the expansion valve control means further comprises a target value varying means which varies a target degree of discharge superheat T_dSH or a target discharge temperature T_d depending on the rotational speed of the compressor.

[0014] According to the embodiment of the present invention, the aperture of the electronic expansion valve is controlled at the predetermined degree of suction gas superheat SH when the discharge temperature T_d of a refrigerant discharged from the compressor during an operation is not more than a previously set upper-limit value, and the aperture of the electronic expansion valve is controlled at the predetermined degree of discharge superheat T_dSH or the predetermined discharge temperature T_d when the discharge temperature T_d exceeds the upper-limit value. Therefore, even when an R32 refrigerant whose discharge temperature T_d easily increases is used, the discharge temperature T_d is prevented from exceeding a utilization upper-limit value, and the insulation grade of a compressor motor is made usable as it is so that an increase in cost can be avoided while the discharge temperature T_d is made difficult to increase so that refrigerant oil can be prevented from deteriorating. While the aperture of the electronic expansion valve is being controlled at the predetermined degree of discharge superheat T_dSH or the predetermined discharge temperature T_d , when the rotational speed of the compressor decreases so that the compression ratio decreases, the aperture of the electronic expansion valve is excessively throttled. As a result, the degree of suction gas superheat SH becomes too high, resulting in a degraded heat exchange performance. However, when the target degree of discharge superheat T_dSH or the discharge temperature T_d is varied depending on the rotational speed of the compressor, the electronic expansion valve is prevented from being excessively throttled so that an appropriate operation condition can be maintained. Therefore, the degradation of the heat exchange performance occurring because of the degree of suction gas superheat SH becoming too high is suppressed, enabling the refrigeration / air-conditioning device to per-

form efficient operations.

{Advantageous Effects of Invention}

[0015] According to the present invention, even when the R32 refrigerant whose discharge temperature T_d easily increases is used, the increase in cost can be avoided when the discharge temperature T_d is prevented from exceeding the utilization upper-limit value and the insulation grade of the compressor motor is made usable as it is while the refrigerant oil can be prevented from deteriorating when the discharge temperature T_d is made difficult to increase. Even when the operation point has changed with the rotational speed of the compressor remaining the same, the aperture of the electronic expansion valve can be controlled using the lower one of the utilization upper-limit value of the discharge temperature T_d to be permitted and the target degree of discharge superheat T_dSH plus the high pressure saturation temperature as the target value. Therefore, the discharge temperature T_d is suppressed to not more than the utilization upper-limit value of the compressor so that the utilization limit can be reliably protected.

[0016] According to the present invention, when the rotational speed of the compressor decreases so that the compression ratio decreases while the aperture of the electronic expansion valve is being controlled at the predetermined degree of discharge superheat T_dSH or the predetermined discharge temperature T_d , the aperture of the electronic expansion valve is excessively throttled. As a result, the degree of suction gas superheat SH becomes too high, resulting in the degraded heat exchange performance. However, when the target degree of discharge superheat T_dSH or the discharge temperature T_d is varied depending on the rotational speed of the compressor, the electronic expansion valve is prevented from being excessively throttled so that the appropriate operation condition can be maintained. Therefore, the degradation of the heat exchange performance occurring because of the degree of suction gas superheat SH becoming too high is suppressed, enabling the refrigeration / air-conditioning device to perform efficient operations.

{Brief Description of Drawings}

[0017]

FIG. 1 is a refrigerant circuit diagram of a refrigeration / air-conditioning device according to an embodiment of the present invention.

FIG. 2A is a Mollier diagram illustrating the meaning of controlling an electronic expansion valve in the refrigeration / air-conditioning device to switch between control at a degree of suction gas superheat SH and control at a degree of discharge superheat T_dSH or a discharge temperature T_d .

FIG. 2B is a Mollier diagram illustrating the meaning of controlling the electronic expansion valve in the

refrigeration / air-conditioning device to switch between control at a degree of suction gas superheat SH and control at a degree of discharge superheat TdSH or a discharge temperature Td.

FIG. 3 is a Mollier diagram illustrating the meaning of controlling the electronic expansion valve to switch a target value between a utilization upper-limit value of a discharge temperature Td to be permitted as a compressor and a target degree of discharge superheat TdSH or a target discharge temperature Td obtained by calculation.

FIG. 4 is a Mollier diagram illustrating the meaning of controlling the electronic expansion valve by varying a target degree of discharge superheat TdSH or a discharge temperature Td depending on the rotational speed of the compressor.

FIG. 5 is a graph illustrating a relationship between the rotational speed of the compressor and a target degree of discharge superheat TdSH or a discharge temperature Td to be varied depending thereon.

FIG. 6 is a Mollier diagram of a refrigeration cycle using an R410A refrigerant.

FIG. 7 is a Mollier diagram of a refrigeration cycle using an R32 refrigerant.

{Description of Embodiments}

[0018] An embodiment of the present invention will be described below with reference to FIGS. 1 to 5.

[0019] FIG. 1 is a refrigerant circuit diagram of a refrigeration / air-conditioning device according to an embodiment of the present invention.

[0020] The refrigeration / air-conditioning device 1 according to the present embodiment includes a heat source-side unit (outdoor unit) 2 installed outdoors, and a utilization-side unit (indoor unit) 3 installed in an indoor space to be air-conditioned, which are connected to each other via liquid-side piping 4 and gas-side piping 5.

[0021] The heat source-side unit (outdoor unit) 2 includes pieces of equipment such as a compressor 6 which compresses a refrigerant, a four-direction switching valve 7 which switches a circulation direction of the refrigerant, a heat source-side heat exchanger (outdoor heat exchanger) 8 which exchanges heat between the refrigerant and ambient air, an electronic expansion valve for heating (EEVH) 9 which depressurizes the refrigerant during heating, a receiver 10 which temporarily stores a liquid refrigerant, an electronic expansion valve for cooling (EEVC) 11 which depressurizes the refrigerant during cooling, a liquid-side operated valve 12 used to connect the liquid-side piping 4, a gas-side operated valve 13 used to connect the gas-side piping 5, and an accumulator 14 which separates a liquid and sucks only a gas refrigerant into the compressor 6. The pieces of equipment are connected, as illustrated, via refrigerant piping 15, to constitute a heat source-side refrigerant circuit 16.

[0022] The heat source-side refrigerant circuit 16 in the heat source-side unit 2 is provided with a high pressure

opening/closing unit 17 which opens and closes at the predetermined pressure of high pressure refrigerant gas discharged from the compressor 6 and a discharge temperature sensor (Td temperature sensor) 18 which detects the temperature of the high pressure refrigerant gas discharged from the compressor 6 for refrigerant discharge piping 15A from the compressor 6 while being provided with a low pressure sensor 19 which detects the pressure of low pressure refrigerant gas to be sucked into the compressor 6 and a suction temperature sensor 20 which detects the temperature of the low pressure refrigerant gas to be sucked into the compressor 6 for refrigerant suction piping 15B of the compressor 6.

[0023] The heat source-side heat exchanger 8 is provided with a heat exchange temperature sensor 21 which detects the temperature of an intermediate site and a heat exchange temperature sensor 22 which detects the temperature of one end site while being provided with an ambient temperature sensor 23 which detects the temperature of ambient air to be vented via an outdoor air blower (not illustrated) for the heat source-side heat exchanger 8.

[0024] On the other hand, the utilization-side unit (indoor unit) 3 includes a utilization-side heat exchanger (indoor heat exchanger) 25 which is provided for a utilization-side refrigerant circuit 24 and exchanges heat between a refrigerant and indoor air to be circulated via an indoor air blower (not illustrated) and cools or heats the indoor air, and is served for indoor cooling or heating by blowing out the indoor air cooled or heated by the utilization-side heat exchanger 25 into a room.

[0025] The utilization-side heat exchanger 25 is provided with a heat exchange temperature sensor 26 which detects the temperature of an intermediate site and a heat exchange temperature sensor 27 which detects the temperature of one end site while being provided with a suction temperature sensor 28 which detects the temperature of the indoor air to be sucked into the utilization-side heat exchanger 25 via the indoor air blower.

[0026] The heat source-side refrigerant circuit 16 and the utilization-side refrigerant circuit 24 are connected to each other by respectively flare-connecting the liquid-side piping 4 and the gas-side piping 5 using the liquid-side operated valve 12 and the gas-side operated valve 13, to constitute a refrigeration cycle 29 serving as a closed cycle, and the refrigeration cycle 29 is filled with a required amount of refrigerant, whose discharge temperature Td more easily increases than that of an R410A refrigerant, like the R32 refrigerant, to constitute the refrigerant and air conditioning apparatus 1.

[0027] In the aforementioned refrigeration cycle 29, the refrigerant, which has been compressed by the compressor 6, is circulated through the heat source-side heat exchanger 8, the receiver 10, the electronic expansion valve for cooling 11, the liquid-side piping 4, the utilization-side heat exchanger 25, the gas-side piping 5, the four-direction switching valve 7, the accumulator 14, and the compressor 6 in this order, as indicated by a solid-

line arrow by the four-direction switching valve 7, to form a cooling/air cooling cycle, and the heat source-side heat exchanger 8 and the utilization-side heat exchanger 25 are respectively made to function as a condenser and an evaporator. When air cooled by a heat absorption function of the refrigerant in the evaporator is blown out into a room, a cooling/air cooling operation can be performed.

[0028] The refrigerant, which has been compressed by the compressor 6, is circulated through the gas-side piping 5, the utilization-side heat exchanger 25, the liquid-side piping 4, the receiver 10, the electronic expansion valve for heating 9, the liquid-side piping 4, the heat source-side heat exchanger 8, the four-direction switching valve 7, the accumulator 14, and the compressor 6 in this order, as indicated by a broken-line arrow by the four-direction switching valve 7, to form a heating/air heating cycle, and the utilization-side heat exchanger 25 and the heat source-side heat exchanger 8 are respectively made to function as a condenser and an evaporator. When air heated by a heat dissipation function of the refrigerant in the condenser is blown out into a room, a heating/air heating operation can be performed.

[0029] The heat source-side unit (outdoor unit) 2 and the utilization-side unit (indoor unit) 3 are respectively provided with heat source-side and utilization-side controllers 30 and 31 which respectively control the operations of the units 2 and 3, and the controllers 30 and 31 are connected to each other via the communication line 32. Each of the controllers 30 and 31 controls operations of the refrigeration / air-conditioning device 1 by receiving a detection signal input from each of the aforementioned sensors and controlling ON/OFF and the rotational speed of the compressor 6, switching of the four-direction switching valve 7, ON/OFF and the rotational speed of the outdoor air blower (not illustrated), the respective apertures of the electronic expansion valve for heating 9 and the electronic expansion valve for cooling 11, ON/OFF and the rotational speed of the indoor air blower (not illustrated), and the like, as needed, via a microcomputer or the like according to respective control programs stored in storage sections 33 and 34 based on a detection value of the detection signal and an operation signal, a setting signal, or the like input from a remote control (not illustrated).

[0030] In the present embodiment, the heat source-side controller 30 is provided with an expansion valve control means 35 which controls the aperture of the electronic expansion valve for cooling (EEVC) 11 or the electronic expansion valve for heating (EEVH) 9 so that a degree of suction gas superheat SH, which is found from a difference between a detection value by the suction temperature sensor 20 and a detection value by the heat exchange temperature sensor 26 or a saturation temperature at pressure detected by the low pressure sensor 19 during a normal cooling operation while being found from a difference between the detection value by the suction temperature sensor 20 and a detection value by the heat exchange temperature sensor 21 or a saturation

temperature at pressure detected by the low pressure sensor 19 during a heating operation, becomes constant.

[0031] The expansion valve control means 35 has a function of switching control at the predetermined degree of suction gas superheat SH to control at a predetermined degree of discharge superheat TdSH or control at a predetermined discharge temperature Td when the temperature (discharge temperature) Td of the refrigerant discharged from the compressor 6, which is detected by the discharge temperature sensor (Td temperature sensor) 18, exceeds a previously set temperature (e.g., 95°C) during normal cooling and heating operations.

[0032] The degree of discharge superheat TdSH can be found from a difference between a detection value by the discharge temperature sensor 18 and the detection value by the heat exchange temperature sensor 21 during cooling or the detection value by the heat exchange temperature sensor 26 during heating (if a high pressure sensor is provided, a saturation temperature at pressure detected by the sensor (a high pressure saturation temperature may be used)).

[0033] In the aforementioned switching control, when the rotational speed of the compressor 6 increases, for example, so that the compression ratio thereof increases, as indicated by a hollow arrow during the control at the predetermined degree of suction gas superheat SH, as illustrated in FIG. 2A, if the predetermined degree of suction gas superheat SH is kept, the discharge temperature Td may exceed a utilization upper-limit value (a thick one-dot and dash line). If the discharge temperature Td exceeds a previously set temperature (a utilization upper-limit value; e.g., 95°C), control of the aperture of the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 is switched to control at the predetermined degree of discharge superheat TdSH or control at the predetermined discharge temperature Td.

[0034] When the control of the aperture of the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 is thus switched to the control at the predetermined degree of discharge superheat TdSH or the control at the predetermined discharge temperature Td, a function of compression by the compressor 6 is controlled as indicated by a hollow arrow, as illustrated in FIG. 2B, so that the discharge temperature Td can be suppressed to a temperature within a utilization limit where no breakdown occurs in a motor winding of the compressor 6. In this case, the degree of suction gas superheat SH becomes zero or less (in a region on the left side of a saturated gas line), as illustrated in FIG. 2B. Therefore, humid gas is sucked in so that an operation in a slight liquid floodback state is performed. However, when the degree of discharge superheat TdSH is kept sufficiently high, reliability can be ensured.

[0035] Furthermore, while the aforementioned expansion valve control means 35 is controlling the aperture of the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 at the predeter-

mined degree of discharge superheat TdSH or the predetermined discharge temperature Td, when an operation point has changed with the rotational speed of the compressor 6 remaining the same (e.g., an ambient temperature has increased and high pressure has increased during a cooling operation), the operation point may change, as indicated by a broken line in FIG. 3. Therefore, in this case, even if the degree of discharge superheat TdSH is controlled to be constant, the discharge temperature Td may exceed the utilization upper-limit value.

[0036] To avoid such a situation, a target value switching means 36 is provided for the expansion valve control means 35. The target value switching means 36 compares, while the control is being performed at the predetermined degree of discharge superheat TdSH or the predetermined discharge temperature Td, a target degree of discharge superheat TdSH obtained by calculation from the rotational speed of the compressor 6 and the high pressure saturation temperature with a utilization upper-limit value of the discharge temperature Td to be permitted as the compressor 6 when the control is being performed at the predetermined degree of discharge superheat TdSH, and switches between the control at the predetermined degree of discharge superheat TdSH and the control at the predetermined discharge temperature Td using the lower one of the values as a target value.

[0037] The aforementioned target value switching means 36 compares, while the control is being performed at the predetermined degree of discharge superheat TdSH or the predetermined discharge temperature Td, a target discharge temperature Td obtained by calculation from the rotational speed of the compressor 6 and the high pressure saturation temperature with the utilization upper-limit value of the discharge temperature Td to be permitted as the compressor 6 when the control is being performed at the predetermined discharge temperature Td, and performs the control at the predetermined discharge temperature Td using the lower one of the values as a target value.

[0038] Furthermore, in the present embodiment, a target value varying means 37, which varies a target value of the degree of discharge superheat TdSH or the discharge temperature Td depending on the rotational speed of the compressor 6 while the aperture of the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 is being controlled at the predetermined degree of discharge superheat TdSH or the predetermined discharge temperature Td, is provided for the expansion valve control means 35.

[0039] Generally, when the rotational speed of the compressor 6 decreases, the performance of the heat exchanger remains unused. Therefore, high pressure decreases, low pressure increases, and a compression ratio decreases. Thus, if the target degree of discharge superheat TdSH or the target discharge temperature Td remains constant, as illustrated in FIG. 4, the degree of suction gas superheat SH may be higher than a control value during the control at the predetermined degree of

suction gas superheat SH, as indicated by a fine broken line as a result. Therefore, the target value varying means 37 which varies the target value of the degree of discharge superheat TdSH or the discharge temperature Td depending on the rotational speed of the compressor 6 is provided, to prevent the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 from being excessively throttled.

[0040] In this case, a relationship between the rotational speed of the compressor 6 and the degree of discharge superheat TdSH or the discharge temperature Td may be set so that the target value of the degree of discharge superheat TdSH or the discharge temperature Td linearly varies within a predetermined rotation number range, as illustrated in FIG. 5. If the degree of discharge superheat TdSH or the discharge temperature Td becomes too low, a liquid floodback state occurs. Therefore, the target value (the degree of discharge superheat TdSH or the discharge temperature Td) which is a predetermined value or more is ensured. When the degree of discharge superheat TdSH or the discharge temperature Td becomes too high, the discharge temperature Td exceeds the utilization upper-limit value. Therefore, the discharge temperature Td is set to remain unchanged at a given value.

[0041] When the degree of suction gas superheat SH is becoming high, as illustrated in FIG. 4, the control at the predetermined degree of discharge superheat TdSH or the control at the predetermined discharge temperature Td is basically returned to the control at the predetermined degree of suction gas superheat SH. However, when the control is frequently switched, a stable operation is inhibited. Therefore, hysteresis may be provided so that the control is not switched until the degree of suction gas superheat SH increases to some extent or the degree of discharge superheat TdSH or the discharge temperature Td decreases by not less than a defined value if the control is switched once.

[0042] According to the present embodiment as described above, the following function and effect are produced.

[0043] In the aforementioned refrigeration / air-conditioning device 1, when the high temperature and pressure refrigerant gas discharged from the compressor 6 is circulated in the direction indicated by the solid-line arrow by the four-direction switching valve 7, to form the cooling/air cooling cycle, and the heat source-side heat exchanger 8 and the utilization-side heat exchanger 25 are respectively made to function as a condenser and an evaporator, the cooling/air cooling operation can be performed. On the other hand, when the high temperature and pressure refrigerant gas discharged from the compressor 6 is circulated in the direction indicated by the broken-line arrow by the four-direction switching valve 7, to form the heating/air heating cycle, and the utilization-side heat exchanger 25 and the heat source-side heat exchanger 8 are respectively made to function as a condenser and an evaporator, the heating/air heating operation can be performed.

[0044] During the cooling/air cooling and heating/air heating operations, the aperture of the electronic expansion valve for cooling (EEVC) 11 or the electronic expansion valve for heating (EEVH) 9 is controlled so that the degree of suction gas superheat SH becomes constant via the expansion valve control means 35. When the discharge temperature Td of the refrigerant detected by the discharge temperature sensor 18 exceeds the previously set utilization upper-limit value (95°C in the present embodiment) during the operations, the control at the predetermined degree of suction gas superheat SH is switched to the control at the predetermined degree of discharge superheat TdSH or the control at the predetermined discharge temperature Td.

[0045] As a result, even when the R32 refrigerant whose discharge temperature Td more easily increases than that of the R410A refrigerant is used, an operation having high reliability can be performed by controlling the degree of suction gas superheat SH to be constant to reliably prevent a liquid floodback in a low compression ratio region, and the discharge temperature Td can be prevented from exceeding the utilization upper-limit value by performing an operation in a slight liquid floodback state and an increase in cost can be avoided by making the insulation grade of a compressor motor usable as it is in a region where the discharge temperature Td easily increases in a high compression ratio. Moreover, when the discharge temperature Td is made difficult to increase, refrigerant oil can be prevented from deteriorating.

[0046] When the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 is controlled at the predetermined degree of discharge superheat TdSH or the predetermined discharge temperature Td, the discharge temperature Td may change depending on a high pressure level during an operation. For example, when the ambient temperature increases so that the high pressure increases during cooling, the operation point changes with the rotational speed of the compressor 6 remaining the same. When only the degree of discharge superheat TdSH is controlled, as illustrated in FIG. 3, the discharge temperature Td may exceed the permitted utilization upper-limit value.

[0047] However, while the control is being performed at the predetermined degree of discharge superheat TdSH or the predetermined discharge temperature Td, as described above, the target value switching means 36 compares the target degree of discharge superheat TdSH obtained by calculation from the rotational speed of the compressor 6 and the high pressure saturation temperature with the utilization upper-limit value of the discharge temperature Td to be permitted as the compressor 6 and switches between the control at the predetermined degree of discharge superheat TdSH and the control at the predetermined discharge temperature Td using the lower one of the values as a target value when the control is being performed at the predetermined degree of discharge superheat TdSH. The target value

switching means 36 compares the target discharge temperature Td obtained by calculation from the rotational speed of the compressor 6 and the high pressure saturation temperature with the utilization upper-limit value of the discharge temperature Td to be permitted as the compressor 6 and performs the control at the predetermined discharge temperature Td adopting the lower one of the values as a target value when the control is being performed at the predetermined discharge temperature Td.

[0048] Therefore, even if the operation point has changed with the rotational speed of the compressor 6 remaining the same, as described above, when the aperture of the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 is controlled using the lower one of the upper-limit value of the discharge temperature Td to be permitted and the target degree of discharge superheat TdSH plus the high pressure saturation temperature as a target value, the discharge temperature Td is suppressed to not more than the utilization upper-limit value of the compressor 6 so that the utilization limit can be protected.

[0049] Furthermore, in the present embodiment, the target value varying means 37, which varies the target value of the degree of discharge superheat TdSH or the discharge temperature Td depending on the rotational speed of the compressor 6, is provided for the expansion valve control means 35. More specifically, when the rotational speed of the compressor 6 decreases so that the compression ratio decreases while the aperture of the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 is being controlled at the predetermined degree of discharge superheat TdSH or the predetermined discharge temperature Td, the aperture of the electronic expansion valve for cooling 11 or the electronic expansion valve for heating 9 is excessively throttled if the target degree of discharge superheat TdSH or the discharge temperature Td is constant. As a result, the degree of suction gas superheat SH becomes too high, resulting in a degraded heat exchange performance.

[0050] Accordingly, when the target value varying means 37 varies the degree of discharge superheat TdSH or the discharge temperature Td serving as the target value, as illustrated in FIG. 5, depending on the rotational speed of the compressor 6, efficient operations can be performed with an appropriate operation condition maintained.

[0051] The present invention is not limited to the invention according to the aforementioned embodiment, and modifications can be made, as needed, without departing from the scope of the present invention. For example, in the aforementioned present embodiment, an example in which the degree of discharge superheat TdSH and the discharge temperature Td are conveniently treated equally, the degree of discharge superheat TdSH is made variable, and the discharge temperature Td is made constant has been described for a form for varying

the degree of discharge superheat TdSH or the discharge temperature Td serving as a control target value depending on the rotational speed of the compressor 6. However, a configuration using a relationship between the high pressure saturation temperature and the target discharge temperature Td as a map may be used without the degree of discharge superheat TdSH being used.

[0052] Furthermore, while an example of the refrigeration / air-conditioning device 1 in which the electronic expansion valve for heating (EEVH) 9 and the electronic expansion valve for cooling (EEVC) 11 are separately provided has been described in the aforementioned embodiment, a configuration using a single electronic expansion valve (EEV) may be used. Alternatively, a configuration in which the electronic expansion valve for cooling (EEVC) 11 is disposed within the utilization-side unit (indoor unit) 3 may be used. The refrigeration cycle 29 may have a basic cycle including a compressor, a heat source-side heat exchanger, an electronic expansion valve, and a utilization-side heat exchanger, is not limited to the refrigeration cycle in the aforementioned embodiment, and may be deformable to cycles having various configurations.

{Reference Signs List}

[0053]

1	Refrigeration / air-conditioning device	
6	Compressor	30
8	Heat source-side heat exchanger	
9	Electronic expansion valve for heating (EEVH)	
11	Electronic expansion valve for cooling (EEVC)	35
15	Refrigerant piping	
18	Discharge temperature sensor	
19	Low pressure sensor	
20	Suction temperature sensor	
21, 22, 26, 27	Heat exchange temperature sensor	40
29	Refrigeration cycle	
30	Heat source-side controller	
31	Utilization-side controller	
35	Expansion valve control means	
36	Target value switching means	45
37	Target value varying means	

Claims

1. A refrigeration / air-conditioning device comprising:

a refrigeration cycle in which at least a compressor, a heat source-side heat exchanger, an electronic expansion valve, and a utilization-side heat exchanger are connected via refrigerant piping and which is filled with a refrigerant whose discharge temperature Td increases more eas-

ily than that of an R410A refrigerant; and an expansion valve control means which controls an aperture of the electronic expansion valve at a predetermined degree of suction gas superheat SH when the discharge temperature Td is not more than an upper-limit value and controls the aperture of the electronic expansion valve at a predetermined degree of discharge superheat TdSH or a predetermined discharge temperature Td when the discharge temperature Td exceeds the upper-limit value,

wherein the expansion valve control means comprises a target value switching means which switches, when the expansion valve control means is performing the control at the predetermined degree of discharge superheat TdSH while controlling the aperture of the expansion valve at the predetermined degree of discharge superheat TdSH or the predetermined discharge temperature Td, the control at the predetermined degree of discharge superheat TdSH to the control at the predetermined degree of discharge superheat TdSH or the control at the predetermined discharge temperature Td using, as a target value, the lower one of an upper-limit value of the discharge temperature Td and a target degree of discharge superheat TdSH obtained by calculation from the rotational speed of a compressor and a high pressure saturation temperature, and compares, when the expansion valve control means is performing the control at the predetermined discharge temperature Td, a target discharge temperature Td obtained by calculation from the rotational speed of the compressor and the high pressure saturation temperature with the upper-limit value and adopts the lower one of the target discharge temperature Td and the upper-limit value as the target discharge temperature Td.

2. The refrigeration / air-conditioning device according to claim 1, wherein the expansion valve control means further comprises a target value varying means which varies the target degree of discharge superheat TdSH or the target discharge temperature Td depending on the rotational speed of the compressor.

3. A refrigeration / air-conditioning device comprising:

a refrigeration cycle in which at least a compressor, a heat source-side heat exchanger, an electronic expansion valve, and a utilization-side heat exchanger are connected via refrigerant piping and which is filled with a refrigerant whose discharge temperature Td increases more easily than that of an R410A refrigerant; and an expansion valve control means which controls an aperture of the electronic expansion

valve at a predetermined degree of suction gas
superheat SH when the discharge temperature
Td is not more than an upper-limit value and
controls the aperture of the electronic expansion
valve at a predetermined degree of discharge
superheat TdSH or a predetermined discharge
temperature Td when the discharge tempera-
ture Td exceeds the upper-limit value,

wherein the expansion valve control means further
comprises a target value varying means which varies
a target degree of discharge superheat TdSH or a
target discharge temperature Td depending on the
rotational speed of the compressor.

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FIG. 1

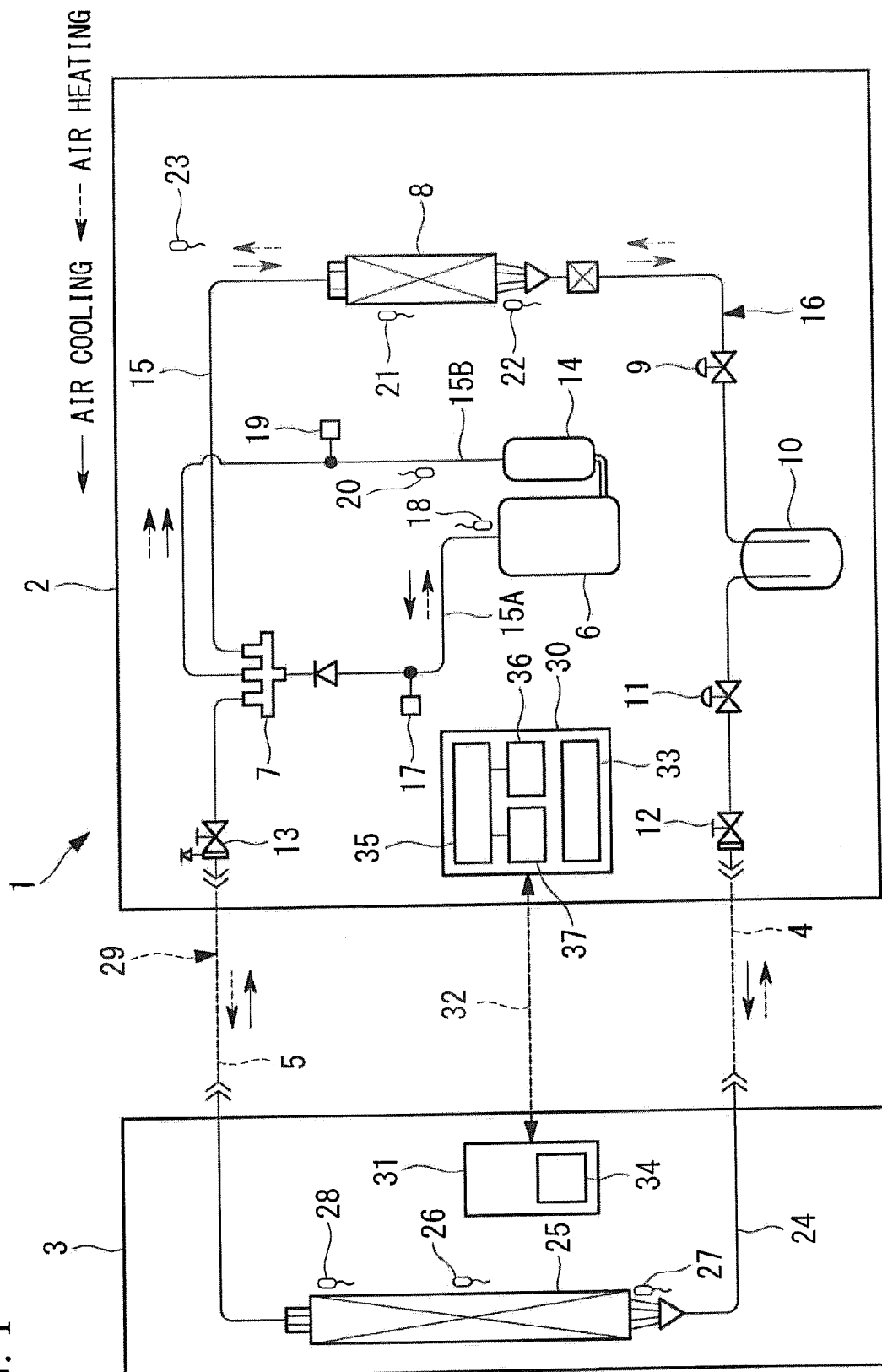


FIG. 2A

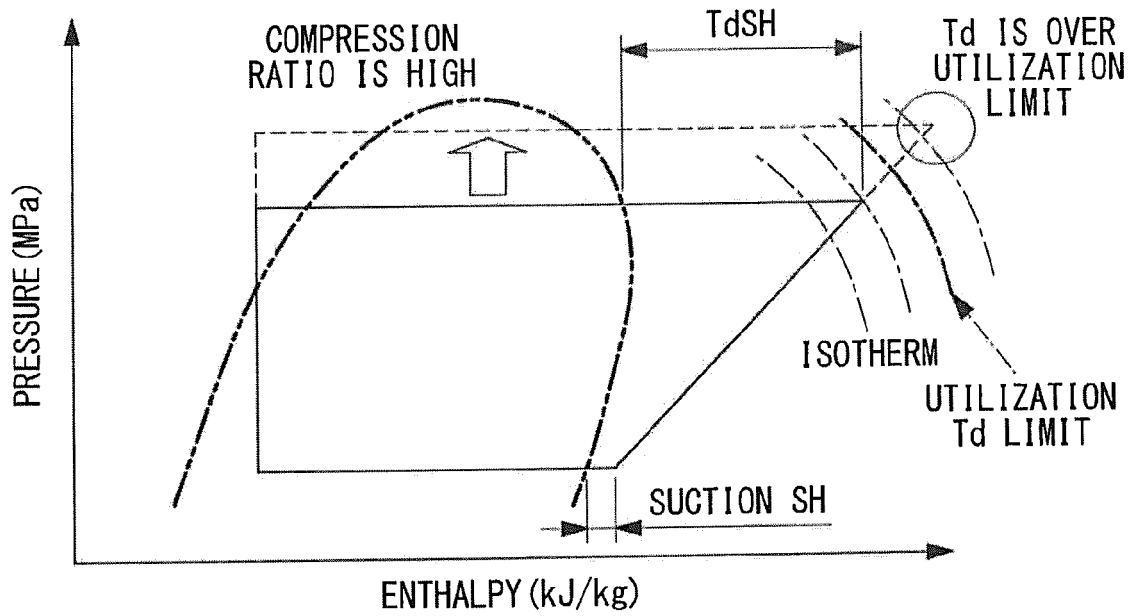


FIG. 2B

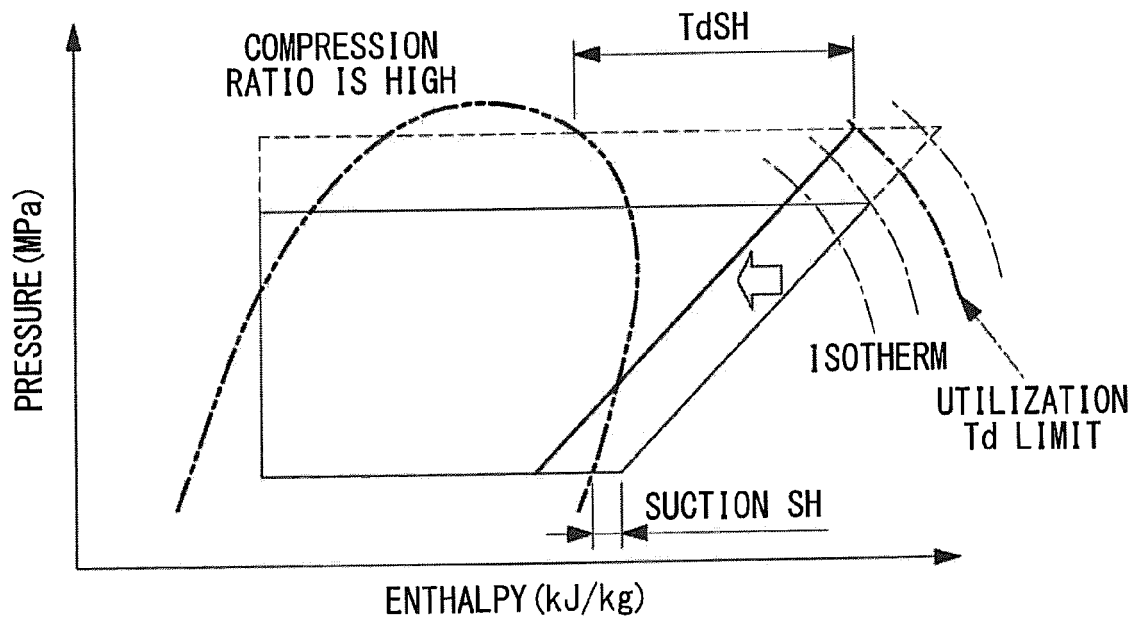


FIG. 3

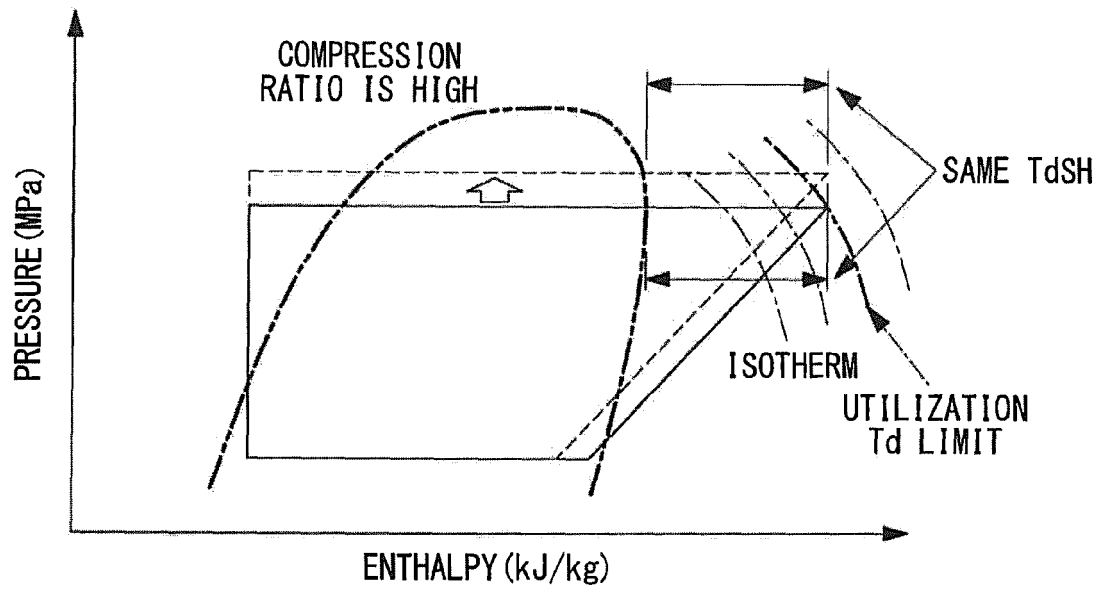


FIG. 4

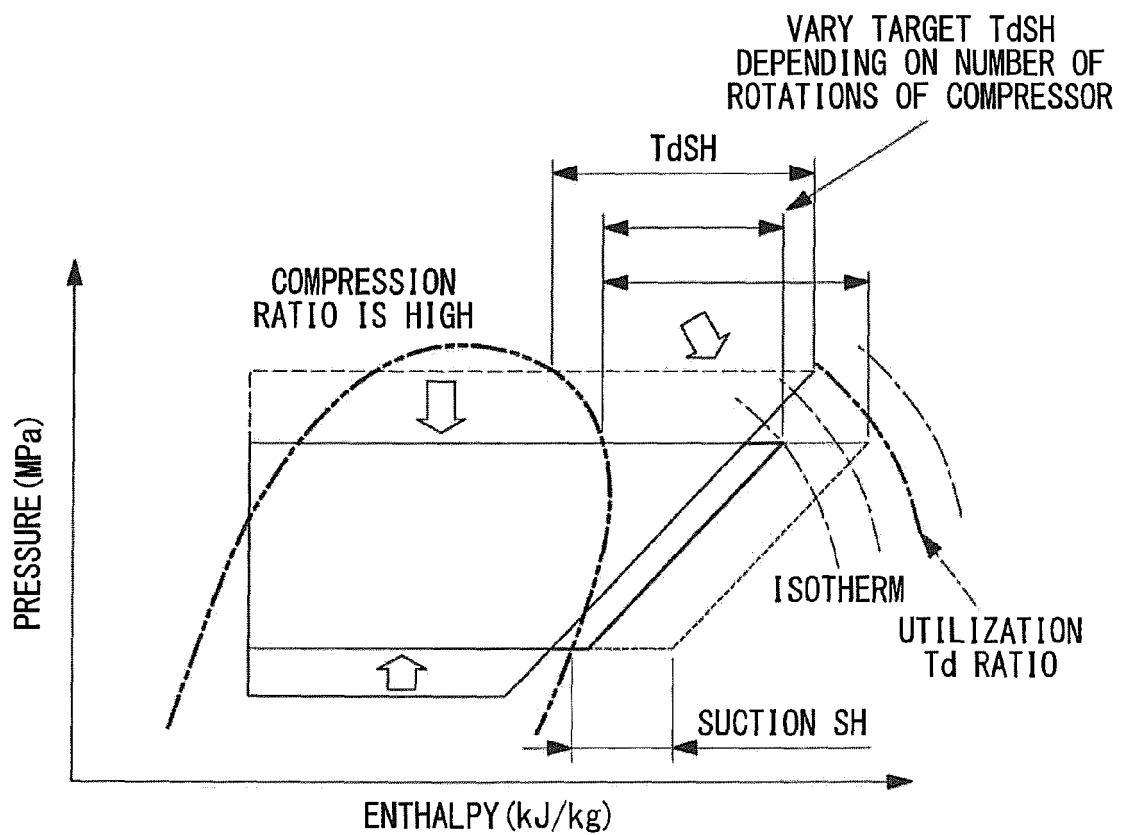


FIG. 5

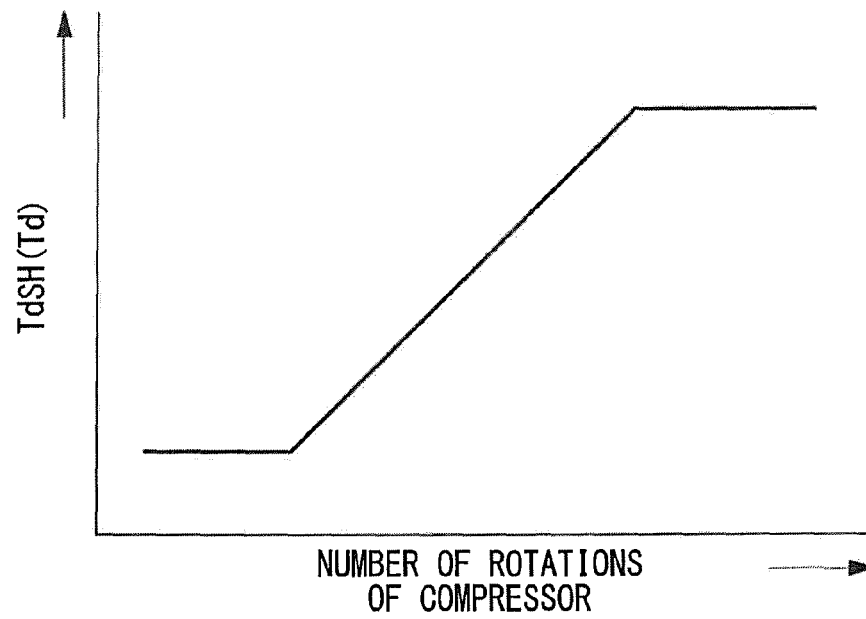


FIG. 6

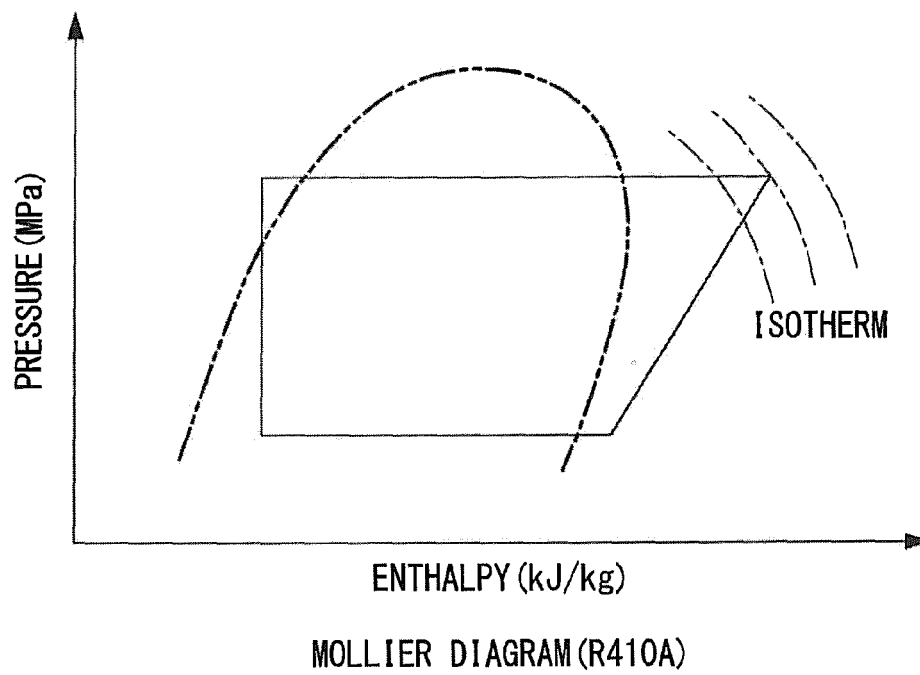
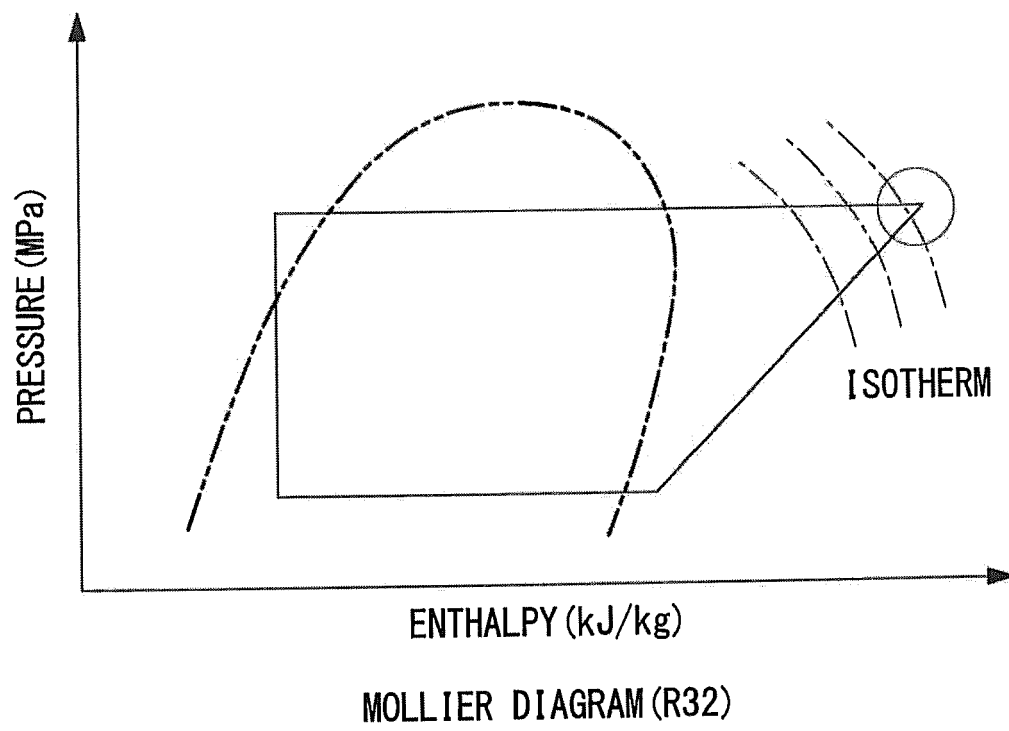


FIG. 7





EUROPEAN SEARCH REPORT

Application Number
EP 16 18 3268

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 December 2016	Examiner Gaspar, Ralf
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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