(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 826 510 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.08.2007 Bulletin 2007/35

(21) Application number: **07003911.0**

(22) Date of filing: **26.02.2007**

(51) Int Cl.:
F25B 29/00 *(2006.01)* *F25B 6/02* *(2006.01)*
F25B 6/04 *(2006.01)* *F25B 9/00* *(2006.01)*
F25B 49/02 *(2006.01)*

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **27.02.2006 JP 2006050549**

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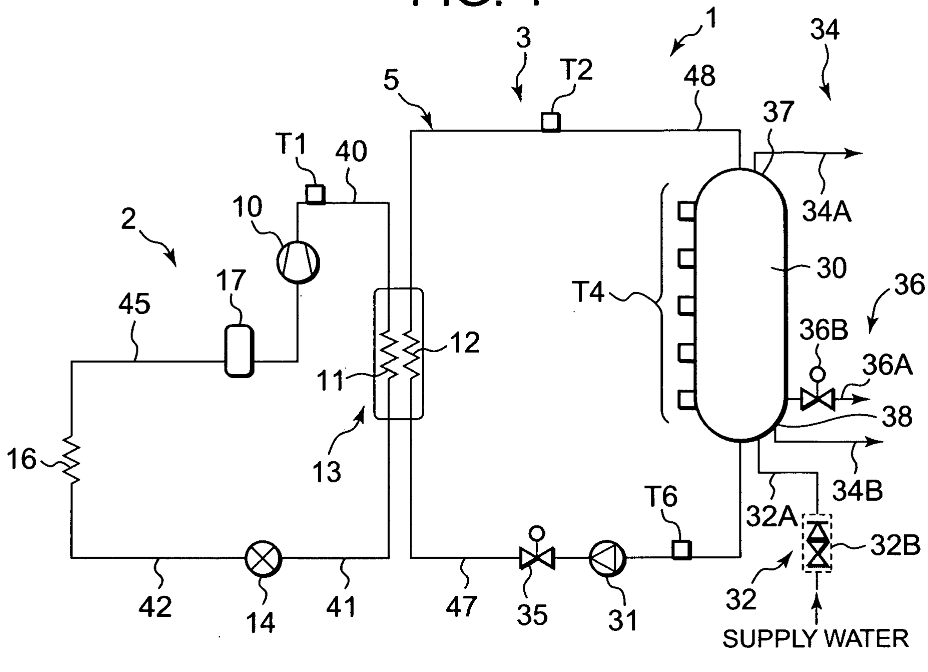
(54) **Refrigeration cycle device**

(57) In a refrigeration cycle device (2) in which heat generated by heat absorption of an evaporator (16) is used for heating in a condenser (11), a disadvantage that a cooling capacity of the evaporator (16) deteriorates owing to shortage or drop of an amount of the heat to be rejected from the condenser (11) is securely avoided and a cooling function is maintained. In the refrigeration cycle device which is provided with a refrigerant circuit including a compressor (10), a condenser (11), an expansion valve (14) and an evaporator (16) and which exhibits a heating function by the heat rejected from the condenser (11) and which exhibits the cooling function by the heat absorption of the evaporator (16), an operation to secure a predetermined amount of the heat to be rejected from the condenser (11) is executed in order to maintain the cooling function of the evaporator (16) based on an index capable of grasping the amount of the heat to be rejected from the condenser (11).

FIG. 1



EP 1 826 510 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a refrigeration cycle device provided with a refrigerant circuit including a compressor, a condenser (or condensing heat exchanger or gas cooler or gas cooling heat exchanger), a throttling means and an evaporator. The present invention more particularly relates to a refrigeration cycle device which exhibits a heating function by heat rejected (or transferred) from a condenser and which exhibits a cooling function by heat absorption of an evaporator.

[0002] Heretofore, as methods such as cooling and freezing to cool an object to be cooled, a refrigeration cycle device has broadly been used in which a vapor compression type refrigeration cycle (vapor-compression refrigeration cycle) is used. This type of refrigeration cycle device exhibits a cooling function by absorbing heat of a refrigerant in an evaporator to cool the object to be cooled, and rejects the heat generated by heat rejected from the refrigerant in a condenser to reject the heat to the atmospheric air and the like

[0003] In recent years, in this type of refrigeration cycle device, attempts have been made to effectively use energy by use of the heat which has heretofore been rejected from the condenser to the atmospheric air and which has not been used. As one example of the device, for example, a device has been developed in which the heat rejected from the condenser is used in hot water supply.

[0004] As described above, the heat heretofore discharged to the atmospheric air is used in supplying hot water. In consequence, the energy can effectively be used. In a case where the heat is discharged from the condenser to the atmospheric air as in a conventional example, a disadvantage occurs that a temperature rise is caused by the discharged heat around the refrigeration cycle device. However, when the heat of the condenser is used in supplying the hot water as described above, such a disadvantage can be eliminated (e.g., see Japanese Patent Application Laid-Open No. 2005-106360).

[0005] However, in a case where the heat generated in the evaporator as described above is used for heating in the condenser, an amount of the heat to be rejected from the refrigerant in the condenser falls short or lowers owing to increase of a cooling load or decrease of a heating load. This has caused a problem that a cooling capacity of the evaporator deteriorates to hinder the cooling of the object to be cooled.

SUMMARY OF THE INVENTION

[0006] The present invention has been developed to solve a problem of such a conventional technology, and an object is to provide a refrigeration cycle device in which heat generated by heat absorption in an evaporator is used for heating in a condenser. The device securely avoids a disadvantage that a cooling capacity of the evaporator deteriorates owing to shortage or drop of an amount of the heat to be rejected from the condenser, and maintains a cooling function.

[0007] To achieve the object, a refrigeration cycle device of a first invention is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator, exhibits a heating function by heat rejected from the condenser and exhibits a cooling function by heat absorption of the evaporator. An operation to secure a predetermined amount of heat to be rejected from the condenser is executed in order to maintain the cooling function of the evaporator based on an index capable of grasping the amount of the heat to be rejected from the condenser.

[0008] A refrigeration cycle device of a second invention is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator; and a hot water storage tank, performs heat exchange between water stored in the hot water storage tank and the condenser to generate hot water by heat rejected from the condenser and store the hot water in the hot water storage tank, and exhibits a cooling function by heat absorption of the evaporator. The device comprises: a water supply unit which supplies water into the hot water storage tank; and a discharge unit which discharges the water from the hot water storage tank. In a case where a temperature of the water stored in the hot water storage tank, a temperature of water to be circulated through a heat exchanger which performs heat exchange between the condenser and the water stored in the hot water storage tank, a temperature in the condenser or a temperature of a refrigerant discharged from the condenser rises to a predetermined value or more, the water is discharged from the hot water storage tank by the discharge unit.

[0009] A refrigeration cycle device of a third invention is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator, performs heat exchange between water and the condenser to generate hot water by heat rejected from the condenser, and exhibits a cooling function by heat absorption of the evaporator. The device comprises: a water cooling unit which cools the water to be subjected to the heat exchange between the water and the condenser. In a case where a temperature of the water to be subjected to the heat exchange between the water and the condenser, a temperature in the condenser or a temperature of a refrigerant discharged from the condenser rises to a predetermined value or more, the water is cooled by the water cooling unit.

[0010] A refrigeration cycle device of a fourth invention is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator, performs heat exchange between water and the condenser to generate hot water by heat rejected from the condenser, and exhibits a cooling function by heat absorption of the evaporator. The device comprises: a second condenser which cools a refrigerant discharged from the condenser. In a case where a temperature of the water to be subjected to the heat exchange between the water and the condenser, a temperature in the condenser or a temperature of the refrigerant discharged from the condenser rises to a predetermined value or more, the refrigerant discharged from the condenser is cooled by the second condenser.

[0011] A refrigeration cycle device of a fifth invention is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator, performs heat exchange between water and the condenser to generate hot water by heat rejected from the condenser, and exhibits a cooling function by heat absorption of the evaporator. The device comprises: a second condenser connected to the condenser and disposed in parallel with the condenser. In a case where a temperature of the water to be subjected to the heat exchange between the water and the condenser, a temperature in the condenser or a temperature of a refrigerant discharged from the condenser rises to a predetermined value or more, the refrigerant is passed through the second condenser.

[0012] According to the first invention, the refrigeration cycle device is provided with the refrigerant circuit including the compressor, the condenser, the throttling means and the evaporator, exhibits the heating function by heat rejected from the condenser, and exhibits the cooling function by the heat absorption in the evaporator. In the device, the operation to secure the predetermined amount of the heat to be rejected from the condenser is executed in order to maintain the cooling function of the evaporator based on the index capable of grasping the amount of the heat to be rejected from the condenser. Therefore, deterioration of the cooling capacity of the evaporator can securely be avoided.

[0013] According to the second invention, the refrigeration cycle device is provided with the refrigerant circuit including the compressor, the condenser, the throttling means and the evaporator; and the hot water storage tank. The device performs the heat exchange between the water stored in the hot water storage tank and the condenser to generate the hot water by the heat rejected from the condenser and store the hot water in the hot water storage tank. Furthermore, the device exhibits the cooling function by the heat absorption of the evaporator. The device comprises the water supply unit which supplies the water into the hot water storage tank; and the discharge unit which discharges the water from the hot water storage tank. In a case where the temperature of the water stored in the hot water storage tank, the temperature of the water to be circulated through the heat exchanger which performs the heat exchange between the condenser and the water stored in the hot water storage tank, the temperature in the condenser or the temperature of the refrigerant discharged from the condenser rises to the predetermined value or more, the water is discharged from the hot water storage tank by the discharge unit. Therefore, since the water is discharged by the discharge unit, water at a temperature lower than that of the water discharged from the water supply unit to the hot water storage tank can be supplied. Therefore, the temperature of the water subjected to the heat exchange between the water and the condenser can be lowered.

[0014] In consequence, the amount of the heat to be rejected from the refrigerant in the condenser can be secured. Therefore, the cooling capacity of the evaporator can be maintained.

[0015] Moreover, in the second invention, for example, it is assumed that the device includes a high-temperature water takeout port disposed at an upper portion of the hot water storage tank and a low-temperature water takeout port disposed at a lower portion of the hot water storage tank and that the discharge unit is disposed below the high-temperature water takeout port and above the low-temperature water takeout port. In this case, a thermal loss is suppressed as much as possible. Moreover, the use of high-temperature water (hot water) stored in the hot water storage tank is not hindered, the water is discharged from the hot water storage tank by the discharge unit, and the temperature of the water to be subjected to the heat exchange between the water and the condenser can be lowered.

[0016] According to the third invention, the refrigeration cycle device is provided with the refrigerant circuit including the compressor, the condenser, the throttling means and the evaporator, performs the heat exchange between the water and the condenser to generate the hot water by the heat rejected from the condenser, and exhibits the cooling function by the heat absorption of the evaporator. The device comprises: the water cooling unit which cools the water to be subjected to the heat exchange between the water and the condenser. In a case where the temperature of the water to be subjected to the heat exchange between the water and the condenser, the temperature in the condenser or the temperature of the refrigerant discharged from the condenser rises to the predetermined value or more, the water is cooled by the water cooling unit. Therefore, the temperature of the water subjected to the heat exchange between the water and the condenser can be lowered. In consequence, the amount of the heat to be rejected from the refrigerant in the condenser can be secured. Therefore, the cooling capacity of the evaporator can be maintained.

[0017] According to the fourth invention, the refrigeration cycle device is provided with the refrigerant circuit including the compressor, the condenser, the throttling means and the evaporator, performs the heat exchange between the water and the condenser to generate the hot water by the heat rejected from the condenser, and exhibits the cooling function by the heat absorption of the evaporator. The device comprises: the second condenser which cools the refrigerant discharged from the condenser. In a case where the temperature of the water to be subjected to the heat exchange between the water and the condenser, the temperature in the condenser or the temperature of the refrigerant discharged from the condenser rises to the predetermined value or more, the refrigerant discharged from the condenser is cooled by the second condenser. Therefore, it is possible to secure the amount of the heat to be rejected which is required for the refrigerant to maintain the cooling function of the condenser. In consequence, the cooling capacity of the evaporator can be maintained.

[0018] According to the fifth invention, the refrigeration cycle device is provided with the refrigerant circuit including the compressor, the condenser, the throttling means and the evaporator, performs the heat exchange between the water and the condenser to generate the hot water by the heat rejected from the condenser, and exhibits the cooling function by the heat absorption of the evaporator. The device comprises: the second condenser connected to the condenser and disposed in parallel with the condenser. In a case where the temperature of the water to be subjected to the heat exchange between the water and the condenser, the temperature in the condenser or the temperature of the refrigerant discharged from the condenser rises to the predetermined value or more, the refrigerant is passed through the second condenser. Therefore, the second condenser can secure the amount of the heat to be rejected which is required for the refrigerant to maintain the cooling function of the evaporator. In consequence, the cooling capacity of the evaporator can be maintained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a schematic constitution diagram of a refrigeration cycle device of Embodiment 1 to which the present invention is applied;

FIG. 2 is a schematic constitution diagram of a refrigeration cycle device of Embodiment 2 to which the present invention is applied;

FIG. 3 is a schematic constitution diagram of a refrigeration cycle device of Embodiment 3 to which the present invention is applied;

FIG. 4 is a schematic constitution diagram of a refrigeration cycle device of Embodiment 4 to which the present invention is applied;

FIG. 5 is a schematic constitution diagram of a refrigeration cycle device of Embodiment 5 to which the present invention is applied;

FIG. 6 is a sectional view showing a schematic structure of a cooling vessel of the refrigeration cycle device shown in FIG. 5; and

FIG. 7 is a sectional view showing a schematic structure of an evaporator of the refrigeration cycle device shown in FIG. 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Embodiments of a refrigeration cycle device of the present invention will hereinafter be described in detail with reference to the drawings.

(Embodiment 1)

[0021] FIG. 1 is a schematic constitution diagram of a refrigeration cycle device of one embodiment to which the present invention is applied. A refrigeration cycle device 1 of the present embodiment is provided with a refrigerant circuit 2 including a compressor 10, a condenser 11, an expansion valve 14 as a throttling means and an evaporator 16; and a hot water supply circuit 3 including a hot water storage tank 30. The device exhibits a heating function by heat rejected from the condenser 11 and exhibits a cooling function by heat absorption of the evaporator 16. That is, the refrigeration cycle device 1 performs heat exchange between water or hot water circulated from the hot water storage tank 30 through the hot water supply circuit 3 and the condenser 11 to generate high-temperature water by the heat rejected from the condenser 11 and store the hot water in the hot water storage tank 30. Moreover, the device exhibits the cooling function by the heat absorption of the evaporator 16 to cool an object to be cooled.

[0022] The refrigerant circuit 2 is constituted so that the compressor 10, the condenser 11, the expansion valve 14 as diaphragm means and the evaporator 16 are successively connected to one another in an annular form via pipes to form a closed circuit. Specifically, a high-pressure refrigerant pipe 40 connected to the compressor 10 on a discharge side is connected to an inlet of the condenser 11. The condenser 11 is a refrigerant passage constituting a part of a heat exchanger 13, and disposed so that heat exchange between the condenser and a water passage 12 of the hot water supply circuit 3 can be performed. This heat exchanger 13 is a heat exchanger of heat exchange between water and a refrigerant, which performs the heat exchange between the condenser 11 and the water stored in the hot water storage tank 30 of the hot water supply circuit 3. The heat exchanger is constituted of the refrigerant passage as the condenser 11 and the water passage 12 of the hot water supply circuit 3. One end of the heat exchanger 13 is provided with an inlet of the refrigerant passage of the condenser 11 and an outlet of the water passage 12, and the other end of the heat exchanger is provided with an outlet of the refrigerant passage of the condenser 11 and an inlet of the water passage 12. Therefore, in the heat exchanger 13, a high-temperature high-pressure refrigerant discharged from the compressor 10 and flowing through the condenser 11 and the water flowing through the water passage 12 form a counterflow.

[0023] On the other hand, a refrigerant pipe 41 connected to the outlet of the condenser 11 is connected to an inlet of the expansion valve 14. The expansion valve 14 is a throttling means to reduce the pressure of the refrigerant which has rejected the heat in the condenser 11, and a refrigerant pipe 42 connected to an outlet of the expansion valve 14 is connected to an inlet of the evaporator 16. Moreover, an outlet of the evaporator 16 is connected to one end of a suction pipe 45, and the other end of the suction pipe 45 is connected to the compressor 10 on a low-pressure side (a suction portion). Along the suction pipe 45 which connects the evaporator 16 to the compressor on the low-pressure side, an accumulator 17 is interposed which protects the compressor 10 from a disadvantage that a liquid refrigerant is sucked into the compressor 10 to damage the compressor or the like.

[0024] Moreover, a discharge temperature sensor T1 which detects a temperature of the high-temperature high-pressure refrigerant discharged from the compressor 10 is disposed at the high-pressure refrigerant pipe 40 of the refrigerant circuit 2. This discharge temperature sensor T1 is connected to a control unit described later.

[0025] Furthermore, carbon dioxide which is a natural refrigerant is introduced as the refrigerant in the refrigerant circuit 2. Moreover, since the pressure of the refrigerant circuit 2 on a high-pressure side rises in excess of a critical pressure, the refrigerant cycle is a transient critical cycle. As a lubricant of the compressor 10, for example, mineral oil, alkyl benzene oil, ether oil, ester oil, polyalkylene glycol (PAG), polyol ether (POE) or the like is used.

[0026] On the other hand, the hot water supply circuit 3 is constituted of a hot water storage circuit 5 which receives the heat from the refrigerant flowing through the condenser 11 of the refrigerant circuit 2 to heat the water and generate the high-temperature water and which stores the hot water in the hot water storage tank 30; a water supply unit 32 which supplies water into the hot water storage tank 30; a hot water supply unit 34 which supplies, to a hot water supply load facility, the hot water stored in the hot water storage tank 30; and a discharge unit 36 described later.

[0027] The hot water storage circuit 5 is constituted by successively connecting the hot water storage tank 30, a circulation pump 31, a flow rate adjustment valve 35 and the water passage 12 of the heat exchanger 13 to one another in an annular form via pipes. That is, a low-temperature pipe 47 connected to a lower portion of the hot water storage tank 30 is connected to the inlet of the water passage 12 formed at the other end of the heat exchanger 13 through the circulation pump 31 and the flow rate adjustment valve 35. The low-temperature pipe 47 connects the lower portion of the hot water storage tank 30 to the inlet of the water passage 12 of the heat exchanger 13 in order to take out low-temperature water stored in the hot water storage tank 30 from below the hot water storage tank 30 and to pass the water through the heat exchanger 13. The circulation pump 31 circulates the water through the hot water storage circuit 5. The circulation pump 31 of the present embodiment discharges the water taken out of the lower portion of the hot water storage tank 30 on a heat exchanger 13 side, and circulates the water through the hot water storage circuit 5 so that a water flow through the water passage 12 of the heat exchanger 13 forms a counterflow against a refrigerant flow through the condenser 11 described above (circulates the water in a clockwise direction in FIG. 1). The flow rate adjustment valve 35 is a valve unit which adjusts a flow rate of the warm water in the hot water storage circuit 5, the water being circulated by the circulation pump 31. The above control unit controls opening/closing of the valve and an open degree of the valve.

[0028] On the other hand, one end of a high-temperature pipe 48 is connected to the outlet of the water passage 12 formed at one end of the heat exchanger 13, and the other end of the high-temperature pipe 48 is connected to an upper portion (an upper end in this embodiment) of the hot water storage tank 30. At a middle portion of this high-temperature pipe 48, a hot water temperature sensor T2 is disposed which detects a temperature of the high-temperature water generated by the heat rejected from the condenser 11 in the heat exchanger 13 and entering the hot water storage tank 30. At a middle portion of the low-temperature pipe 47, a temperature sensor T6 which detects a temperature of the water circulated through the heat exchanger 13. Moreover, the hot water temperature sensor T2 and the temperature sensor T6 are connected to the control unit, respectively.

[0029] On the other hand, the hot water storage tank 30 is a tank in which the high-temperature water generated by the heat rejected from the condenser 11 in the heat exchanger 13 is stored. The whole outer peripheral surface of the tank is covered with an insulation material, and the tank is structured so that the stored hot water does not easily cool.

[0030] The upper portion of this hot water storage tank 30 is connected to the high-temperature pipe 48 and provided with a high-temperature water takeout port 37 through which the high-temperature water is taken out of the hot water storage tank 30. The high-temperature water takeout port 37 is connected to a high-temperature water takeout pipe 34A of the hot water supply unit 34. The lower portion of the hot water storage tank 30 is connected to the low-temperature pipe 47 and provided with a low-temperature water takeout port 38 which takes out the low-temperature water from the hot water storage tank 30. The low-temperature water takeout port 38 is connected to a low-temperature water takeout pipe 34B of the hot water supply unit 34.

[0031] The hot water supply unit 34 mixes the high-temperature water taken out of the hot water storage tank 30 from the high-temperature water takeout pipe 34A with the low-temperature water taken out of the low-temperature water takeout pipe 34B as needed, adjusts a temperature into an optimum temperature, and then supplies the water to the hot water supply load facility. The hot water is supplied to the hot water supply load facility by opening a hot water supply valve (not shown). The hot water supply valve is, for example, a faucet for hot water supply or the like. The number of the valves it not limited to one, and a plurality of valves may be disposed.

[0032] Furthermore, the lower portion of the hot water storage tank 30 is connected to a water supply pipe 32A of the water supply unit 32 via a pressure reduction valve 32B. The water supply unit 32 supplies water into the hot water storage tank 30. Water such as city water having an amount corresponding to an amount of the hot water of the hot water storage tank 30 to be used is supplied from the lower portion of the hot water storage tank 30 to the hot water storage tank 30 through the water supply pipe 32A. A water supply valve (not shown) is interposed along this water supply pipe 32A, and the water supply valve is constantly brought into an open state.

[0033] In addition, the lower portion of the hot water storage tank 30 is connected to a discharge pipe (not shown) via a discharge valve. The discharge pipe discharges the hot water from the hot water storage tank 30 when unused.

[0034] Here, the discharge unit 36 discharges the water (the hot water) from the hot water storage tank 30, and is disposed below the high-temperature water takeout port 37 and above the low-temperature water takeout port 38. In the present embodiment, a hot water discharge pipe 36A of the discharge unit 36 is connected to a portion of the hot water storage tank 30 below the high-temperature water takeout port 37 and above the low-temperature water takeout port 38 via a hot water discharge valve 36B. Since the discharge unit 36 is disposed below the high-temperature water takeout port 37 and above the low-temperature water takeout port 38 in this manner, the hot water taken out of the hot water storage tank 30 by the discharge unit 36 is medium-temperature water having a temperature which is lower than that of the hot water taken from the high-temperature water takeout port 37 and higher than that of the water taken from the low-temperature water takeout port 38. Therefore, when the hot water discharge valve 36B is opened, the medium-temperature water can be discharged from the hot water storage tank 30.

[0035] On the other hand, an outer surface of the hot water storage tank 30 is provided with a plurality of stored hot water sensors T4 arranged at appropriate intervals from the upper portion to the lower portion. The stored hot water sensors T4 are sensors which detect temperatures of portions of the hot water stored in the hot water storage tank 30 and which detect whether or not there is hot water. Since the plurality of stored hot water sensors T4 are arranged at varied heights to detect the temperatures of the portions in this manner, it is possible to detect the amount of the hot water stored in the hot water storage tank 30 while grasping a temperature distribution from the upper portion to the lower portion of the hot water storage tank 30. The stored hot water sensors T4 are connected to the above control unit.

[0036] Moreover, the above control unit is control means for controlling the refrigeration cycle device 1 of the present invention, and controls operations of the compressor 10 and the circulation pump 31, and the opening/closing and the open degree of each valve unit (the expansion valve 14, the flow rate adjustment valve 35 and hot water discharge valve 36B). The control unit is connected to the sensors T1, T2, T4 and T6, and is further connected to a temperature sensor (not shown) which detects a temperature of the object to be cooled by the evaporator 16 or a space where the object to be cooled is stored or an outside air temperature. The control unit controls an operation of the refrigeration cycle device 1 based on these input information.

[0037] It is to be noted that it is necessary to determine a capacity of the hot water storage tank 30 in due consideration of a cooling load of the object to be cooled by the evaporator 16 of the refrigerant circuit 2, a required hot water supply load, a generation time of each load and the like. That is, during a cooling operation, if the high-temperature water is taken out of the lower portion of the hot water storage tank 30 instead of the low-temperature water and the water enters the water passage 12 of the heat exchanger 13, an amount of the heat to be rejected from the condenser 11 remarkably decreases. As a result, a cooling capacity and COP of the refrigerant circuit 2 deteriorate. Therefore, when the capacity of the hot water storage tank 30 is considered, a hot water storage tank having a sufficient volume should be used so that the low-temperature water can constantly be taken out of the lower portion of the hot water storage tank 30 and can be passed through the water passage 12 of the heat exchanger 13. It is preferable that a specific capacity is appropriately investigated in accordance with use applications and conditions.

[0038] It is to be noted that the water mentioned above in the present invention is generically water flowing through the hot water supply circuit 3 and having all temperature zones, including not only cold water supplied from the water supply unit 32 to the hot water storage tank 30 but also the high-temperature water stored in the hot water storage tank 30. Therefore, it is assumed in the present invention that the hot water is interpreted as a part of the water.

[0039] The operation of the refrigeration cycle device 1 of the present embodiment constituted as described above will be described.

(1) Operation of Refrigerant Circuit during Cooling Operation

[0040] First, an operation of the refrigerant circuit 2 during the cooling operation will be described. The control unit starts the compressor 10 of the refrigerant circuit 2 in accordance with a required cooling load based on each input information (information input from the sensors and the like). When the compressor 10 is driven by the control unit, a low-temperature low-pressure gas is sucked and compressed on the low-pressure side (the suction portion) of the compressor 10 from the suction pipe 45. In consequence, the refrigerant gas which has obtained a high temperature and a high pressure enters the high-pressure refrigerant pipe 40 from the discharge side, and is discharged from the compressor 10. At this time, the refrigerant is compressed under an appropriate supercritical pressure.

[0041] The high-temperature high-pressure refrigerant discharged from the compressor 10 enters the heat exchanger 13 from the inlet of the condenser 11 via the high-pressure refrigerant pipe 40. Moreover, while passing through the condenser 11 of the heat exchanger 13, the high-temperature high-pressure refrigerant gas releases the heat to the water of the hot water storage circuit 5 flowing through the water passage 12 disposed so as to perform the heat exchange between the water and the condenser 11. In consequence, the gas is cooled at a low temperature. On the other hand, the water in the water passage 12 is heated by a radiation function of this condenser 11, and the high-temperature water is generated.

[0042] At this time, in the condenser 11, the refrigerant usually has a state of a liquid phase at a pressure which is not less than a critical pressure. That is, since carbon dioxide is used as the refrigerant in the present embodiment, the refrigerant pressure in the condenser 11 is not less than the critical pressure, and condensation of the refrigerant does not occur in the condenser 11. Therefore, from the inlet to the outlet of the condenser 11, the temperature of the refrigerant gradually drops as the heat is rejected into the water in the water passage 12. On the other hand, from the inlet to the outlet of the water passage 12 of the heat exchanger 13, the temperature of the water gradually rises as the heat is absorbed from the refrigerant. Since the refrigerant pressure of the condenser 11 is set to be not less than the critical pressure by use of the carbon dioxide refrigerant in this manner, the heat exchange can efficiently be performed and the high-temperature water can be generated as compared with condensation heat radiation of a conventional refrigerant such as an HFC-based refrigerant at a constant temperature. In the heat exchanger 13, the refrigerant passage and the water passage 12 constituting the condenser 11 are arranged so as to form the counterflow as described above. Therefore, the heat exchange between the water and the refrigerant can efficiently be performed.

[0043] The low-temperature high-pressure refrigerant cooled by the condenser 11 exits from the heat exchanger 13 via the outlet of the condenser 11, passes through the refrigerant pipe 41, expands at the expansion valve 14 to obtain a low pressure and reaches the evaporator 16 via the refrigerant pipe 42. It is to be noted that the refrigerant at the inlet of the evaporator 16 has a two-phase mixed state in which the liquid refrigerant is mixed with a vapor refrigerant. Moreover, when the liquid-phase refrigerant absorbs the heat from the object to be cooled in the evaporator 16, the refrigerant evaporates to form the vapor refrigerant. At this time, the object to be cooled is cooled by the heat absorption. It is to be noted that examples of the above object to be cooled include food and beverage required to be cooled and insulated, air in a case where air conditioning is performed, water in a system using heat conveyance and accumulated heat, brine and ice.

[0044] Moreover, the refrigerant evaporated in the evaporator 16 repeats a cycle of exiting from the evaporator 16 to enter the suction pipe 45 and being again sucked from the low-pressure side (the suction portion) to the compressor 10 via the accumulator 17. When the above cycle is repeated, the object to be cooled is cooled by the heat absorption of the evaporator 16. Moreover, the hot water is generated by the heat rejected from the condenser 11.

[0045] The open degree of the expansion valve 14 is adjusted by the control unit so that the temperature of the discharged refrigerant detected by the discharge temperature sensor T1 disposed at the high-pressure refrigerant pipe 40 of the refrigerant circuit 2 is a predetermined temperature during the cooling operation. Specifically, when the refrigerant temperature detected by the discharge temperature sensor T1 rises above a predetermined value, the open degree of the expansion valve 14 is enlarged by the control unit. Conversely, when the refrigerant temperature detected by the discharge temperature sensor T1 drops below the predetermined value, the open degree of the expansion valve 14 is reduced by the control unit. In consequence, a highly efficient operation can be performed on conditions preferable for an operation of generating the high-temperature water to supply the hot water.

[0046] It is to be noted that the compressor 10 during the cooling operation may have the constant number of rotations. Alternatively, a frequency may be adjusted by an inverter or the like in accordance with the cooling load.

(2) Operation of Hot Water Supply Circuit 3 during Cooling Operation

[0047] Next, the operation of the hot water supply circuit 3 during the cooling operation will be described. When the above cooling operation is started, the circulation pump 31 of the hot water supply circuit 3 is started by the above control unit. The low-temperature water or the water (hereinafter referred to simply as the water) is sucked from the lower portion of the hot water storage tank 30 to the circulation pump 31 via the low-temperature pipe 47, and pushed out to the low-temperature pipe 47 connected to the outlet of the circulation pump 31 on the heat exchanger 13 side. In consequence, the water pushed out of the circulation pump 31 enters the heat exchanger 13 from the inlet of the water passage 12 via the flow rate adjustment valve 35. In the heat exchanger 13, as described above, the water flowing through the water passage 12 receives the heat from the condenser 11 by the heat exchange between the water and the refrigerant flowing through the condenser 11, and is heated. In consequence, the high-temperature water is generated. Moreover, the high-temperature water discharged from the heat exchanger 13 via the outlet of the water passage 12 passes through the high-temperature pipe 48 of the hot water storage circuit 5, and is injected into the hot water storage tank 30 from the upper portion (an upper end) of the hot water storage tank 30. The high-temperature water generated by the heat exchanger 13 is injected into the upper portion of the hot water storage tank 30, and the water is taken out of the lower portion of the tank. Therefore, the high-temperature water is stored in an upper part of the tank and the low-temperature water is stored in a lower part of the tank by use of a density difference due to a water temperature difference.

[0048] Moreover, the flow rate adjustment valve 35 adjusts the flow rate of the water so that the temperature of the hot water at the outlet of the water passage 12 of the heat exchanger 13 indicates a predetermined value. In the present embodiment, the control unit controls the flow rate adjustment valve 35 based on the temperature of the hot water at the outlet of the water passage 12 of the heat exchanger 13 detected by the hot water temperature sensor T2. That is, when the temperature of the hot water at the outlet of the water passage 12 detected by the hot water temperature sensor T2 is higher than the predetermined temperature, the open degree of the flow rate adjustment valve 35 is enlarged by the control unit. In consequence, an amount (the flow rate) of the water to be circulated through the hot water storage circuit 5 can be increased.

[0049] On the other hand, when the temperature of the hot water at the outlet of the water passage 12 detected by the hot water temperature sensor T2 is lower than the predetermined temperature, the open degree of the flow rate adjustment valve 35 is reduced by the control unit. In consequence, the amount (the flow rate) of the water to be circulated through the hot water storage circuit 5 can be reduced. It is to be noted that in the present embodiment, the temperature of the hot water at the outlet of the water passage 12 is detected by the hot water temperature sensor T2 installed at the middle portion of the high-temperature pipe 48. However, the present invention is not limited to this example. Needless to say, the temperature may be detected by the temperature sensor disposed at the outlet of the water passage 12 of the heat exchanger 13. It is preferable to determine the predetermined temperature at a temperature suitable for an application of the supplied hot water, specifically in a range of about 50°C to 85°C in accordance with a use application.

[0050] It is to be noted that the flow rate of the water may be adjusted using, for example, an inverter type circulation pump without using the flow rate adjustment valve 35. In this case, when the temperature of the hot water at the outlet of the water passage 12 is higher than a predetermined temperature, the control unit sets the large number of the rotations of the inverter type circulation pump. In consequence, the amount of the water to be circulated through the hot water storage circuit 5 can be increased. Conversely, in a case where the temperature of the hot water at the outlet of the water passage 12 is lower than the predetermined temperature, when the control unit sets the small number of the rotations of the inverter type circulation pump, the amount of the water to be circulated through the hot water storage circuit 5 can be reduced.

[0051] Moreover, when a hot water valve (the faucet or the like) (not shown) is operated, the hot water generated by the heat exchanger 13 and stored in the hot water storage tank 30 is supplied to the hot water supply load facility. Specifically, when the hot water supply valve is opened, the high-temperature water stored in the hot water storage tank 30 flows through a mixture valve (not shown) from the high-temperature water takeout port 37 formed at the upper portion of the hot water storage tank 30 via the high-temperature water takeout pipe 34A. Similarly, the low-temperature water stored in the hot water storage tank 30 flows through the mixture valve from the low-temperature water takeout port 38 formed at the lower portion of the hot water storage tank 30 via the low-temperature water takeout pipe 34B. Moreover, the high-temperature water is mixed with the low-temperature water (or the water) at the mixture valve, the temperature is adjusted into the predetermined temperature, and the water is then supplied to each load facility via the hot water supply valve.

[0052] It is to be noted that the temperature of the hot water supplied to the load facilities is detected by a hot water supply temperature sensor (not shown) disposed at a pipe which connects the mixture valve to the hot water supply valve. Since the water supply valve of the water supply unit 32 is usually constantly opened, the amount of the city water corresponding to the amount of the hot water supplied to each load facility is supplied into a system of the hot water supply circuit 3 from the water supply pipe 32A of the water supply unit 32.

[0053] As described above, the refrigeration cycle device 1 can exhibit the cooling function by the heat absorption of the evaporator 16 to cool the object to be cooled, generate the hot water by effectively using the heat generated in a cooling process, that is, the heat rejected from the condenser 11 and supply the generated hot water to the hot water supply load facility. Especially, when the transient critical cycle is used by use of the carbon dioxide refrigerant as in the present embodiment, the temperature of the hot water generated by the condenser 11 can be set to be high. Therefore, as compared with a hot water supply device which boils the water to supply the hot water with a conventional boiler or the like, consumption energy can largely be reduced. When the heat of the refrigeration cycle device on the high-temperature side is used, the heat heretofore released from the high-pressure side to atmospheric air can be reduced. Therefore, a rise of an ambient temperature of the refrigeration cycle device can be inhibited.

(3) Operation to secure Amount of Heat to be rejected from Condenser 11 during Cooling Operation

[0054] In addition, in such a refrigeration cycle device, when the excessively large amount of the high-temperature water is stored in the hot water storage tank 30 owing to the increase of the cooling load during the cooling operation or the decrease of the hot water supply load, the temperature of the hot water taken out of the lower portion of the hot water storage tank 30 rises. As a result, a disadvantage that the high-temperature water enters the heat exchanger 13 occurs.

[0055] When the high-temperature water enters the heat exchanger 13 in this manner, in the condenser 11 of the heat exchanger 13, the amount of the heat to be rejected from the refrigerant remarkably lowers or falls short. The refrigerant releases the heat to the water flowing through the water passage 12, while flowing through the condenser 11. Therefore, the refrigerant cannot be set to the low temperature in the condenser 11. This causes a problem that a specific enthalpy of the refrigerant flowing through the evaporator 16 increases, the cooling capacity of the evaporator 16 and an efficiency of the refrigeration cycle device 1 remarkably deteriorate, and the cooling of the object to be cooled in the evaporator 16 is hindered.

[0056] To solve such a problem, in the present invention, it is assumed that an operation to secure the predetermined amount of the heat to be rejected from the condenser 11, required for the evaporator 16 to maintain the cooling function, is executed based on an index capable of grasping the amount of the heat to be rejected from the condenser 11. Specifically, it is assumed that the refrigeration cycle device 1 of the present embodiment allows the discharge unit 36 to discharge the water from the hot water storage tank 30, in a case where the temperature of the water in the hot water storage tank 30, the temperature of the water to be circulated through the heat exchanger 13 for the heat exchange between the condenser 11 and the water of the hot water storage tank 30, the temperature in the condenser 11 or the temperature of the refrigerant discharged from the condenser 11 rises to a predetermined value or more.

[0057] Here, an operation to discharge the water from the hot water storage tank 30 by the discharge unit 36 will be described. It is assumed in the refrigeration cycle device 1 of the present embodiment that the discharge unit 36 discharges the water from the hot water storage tank 30 in a case where the temperature of the water circulated through the heat exchanger 13 for the heat exchange between the condenser 11 and the water of the hot water storage tank 30, detected by the temperature sensor T6, rises to the predetermined value or more, for example, 25°C to 30°C or more. It is to be noted that the temperature at which the water is discharged from the hot water storage tank 30 by the discharge unit 36 is not limited to the temperature of the water to be circulated through the heat exchanger 13 for the heat exchange between the condenser 11 and the water of the hot water storage tank 30 as in the present embodiment, and may be the temperature of the water in the hot water storage tank 30, detected by the stored hot water sensors T4. Alternatively, the temperature may be the temperature of the refrigerant in the condenser 11 of the heat exchanger 13 or the temperature of the refrigerant discharged from the condenser 11.

[0058] Moreover, the hot water discharge valve 36B disposed at the hot water discharge pipe 36A of the discharge unit 36 is usually closed by the control unit. In this state, it is assumed that the water of the hot water storage tank 30 is not discharged from the hot water discharge pipe 36A.

[0059] Furthermore, in a case where the temperature of the water detected by the temperature sensor T6 rises to the predetermined value or more (25°C to 30°C or more in the present embodiment) during the cooling operation, the hot water discharge valve 36B of the hot water discharge pipe 36A is opened by the above control unit. In consequence, the medium-temperature water at the temperature which is lower than that of the hot water taken out of the high-temperature water takeout port 37 of the hot water storage tank 30 and which is higher than that of the water taken out of the low-temperature water takeout port 38 is discharged from the hot water storage tank 30 via the hot water discharge pipe 36A.

[0060] At the same time the hot water is discharged from the hot water discharge pipe 36A, an amount of cold water corresponding to the amount of the discharged hot water is supplied into the hot water storage tank 30 from the water supply pipe 32A of the water supply unit 32. It is to be noted that the hot water discharged from the hot water storage tank 30 via the hot water discharge pipe 36A can be used in an appropriate application if any.

[0061] When the hot water is discharged from the hot water storage tank 30 via the hot water discharge pipe 36A and the cold water having the amount corresponding to the amount of the discharged hot water is simultaneously supplied into the hot water storage tank 30, the temperature of the hot water stored in the lower part of the hot water storage tank 30 can be lowered, and the hot water stored in the lower part of the hot water storage tank 30 or the cold water supplied from the water supply unit 32 to the hot water storage tank 30 can be supplied to the heat exchanger 13.

[0062] In consequence, it is possible to secure the amount of the heat to be rejected from the refrigerant of the heat exchanger 13, which is required for the evaporator 16 to maintain the cooling function. That is, in the heat exchanger 13, the heat of the refrigerant flowing through the condenser 11 is sufficiently released to the water flowing through the water passage 12, and the temperature of the refrigerant can be set to be low. Therefore, the cooling capacity of the evaporator 16 can be maintained, and the object to be cooled can securely be cooled.

[0063] Especially, in the refrigeration cycle device 1 of the present embodiment, the hot water discharge pipe 36A of the discharge unit 36 is disposed below the high-temperature water takeout port 37 of the hot water storage tank 30 and above the low-temperature water takeout port 38. Specifically, to position the hot water discharge pipe 36A, it is preferable that the hot water discharge pipe 36A of the discharge unit 36 is attached to a position where the volume of the water stored in the lower part of the hot water storage tank 30 is about 20 L to 50 L. That is, if the hot water discharge pipe 36A is attached below the position, an effect of introducing the cold water is not sufficiently obtained, because the cold water entering the hot water storage tank from the water supply pipe 32A of the water supply unit 32 is mixed with the warm water of the hot water storage tank 30 and the heat is conducted. Conversely, if the hot water discharge pipe is attached above the position, the hot water stored in the hot water storage tank 30 is discharged from the hot water storage tank 30 by the discharge unit 36, and a thermal loss increases.

[0064] To solve the problem, the hot water discharge pipe 36A of the discharge unit 36 is attached to the position below the high-temperature water takeout port 37 of the hot water storage tank 30 and above the low-temperature water takeout port 38, the position being the position where the volume of the water stored in the lower part of the hot water storage tank 30 is about 20 L to 50 L. In consequence, without hindering the hot water supply to the hot water supply load facility, the hot water can be discharged by the discharge unit 36 to secure the amount of the heat to be rejected from the condenser 11 of the heat exchanger 13.

[0065] In addition, if an excessively small amount of the hot water is discharged by the discharge unit 36, an insufficient amount of the cold water enters the hot water storage tank 30. As a result, an excessively large amount of the high-temperature water is stored in the hot water storage tank 30, and the cooling capacity and efficiency might adversely be affected. Therefore, a remarkably small effect might only be obtained, even when the discharge unit 36 is disposed. On the other hand, if an excessively large amount of the hot water is discharged by the discharge unit 36, it is difficult to control the amount of the water flowing through the heat exchanger 13 as the hot water is discharged. As a result, the excessively large amount of the water is circulated in the hot water storage circuit 5, and the temperature of the hot water to be generated by the heat exchanger 13 might drop. Furthermore, thermal stratification in the hot water storage tank 30 is disturbed by the cold water rapidly flowing from the water supply pipe 32A, and the thermal loss in the hot water storage tank 30 might increase.

[0066] Therefore, the amount of the hot water to be discharged by the discharge unit 36 is set beforehand to be appropriate. Specifically, the hot water discharge valve 36B or the hot water discharge pipe 36A is provided with an appropriate diaphragm portion (not shown), and the amount of the hot water to be discharged by the discharge unit 36 per unit time is set to a predetermined value beforehand. It is assumed that the predetermined value is larger than the amount (a rated flow rate or the flow rate of the generated hot water) of the hot water to be circulated in the hot water storage circuit 5, obtained in accordance with a heating capability of the refrigeration cycle device 1 and the temperature of the generated hot water. Moreover, it is assumed that the value is small to such an extent that the temperature of the generated hot water is not influenced, and the thermal stratification (the high-temperature water is stored in the upper part of the hot water storage tank 30, and the temperature of the hot water drops toward the lower part of the tank) of the hot water storage tank 30 is not disturbed. Specifically, it is preferable that the value is about 1.2 to 2 times the rated flow rate of the hot water storage circuit 5. For example, in a system in which the amount of the hot water to be generated per minute is 1 L, it is preferable that a discharge rate of the hot water is 1.2 L/minute to 2 L/minute.

[0067] As described above in detail, according to the refrigeration cycle device 1 of the present embodiment, even in a case where the excessively large amount of the hot water is stored in the hot water storage tank 30 owing to the increase of the cooling load or decrease of a heating load, the water is discharged from the hot water storage tank 30 by the discharge unit 36, the cold water is taken into the hot water storage tank 30 from the water supply unit 32, and the water can be supplied to the heat exchanger 13. Therefore, the amount of the heat to be rejected from the refrigerant in the condenser 11 is secured, and it is possible to avoid in advance a disadvantage that the cooling capacity of the evaporator 16 deteriorates. In consequence, the object to be cooled can securely be cooled.

(Embodiment 2)

[0068] Next, another embodiment of a refrigeration cycle device according to the present invention will be described. FIG. 2 is a schematic constitution diagram of the refrigeration cycle device of the embodiment to which the present invention is applied. In FIG. 2, components denoted with the same reference numerals as those of FIG. 1 are the same components or components which produce similar functions or effects. Therefore, description thereof is omitted, and a part of the present embodiment different from the above embodiment will mainly be described.

[0069] First, a difference between a constitution of a refrigeration cycle device 100 of the present embodiment and that of the refrigeration cycle device 1 of Embodiment 1 will be described. The refrigeration cycle device 1 of Embodiment 1 includes a discharge unit 36 which discharges hot water from a hot water storage tank 30 as needed. On the other hand, the refrigeration cycle device

100 of the present embodiment does not include the discharge unit 36. The refrigeration cycle device 100 of the present embodiment includes a water cooling unit 80 disposed at a low-temperature pipe 47 to connect a lower portion of the hot water storage tank 30 to an outlet of a water passage 12 of a heat exchanger 13. This water cooling unit 80 is a heat exchanger which cools water flowing from the hot water storage tank 30 to the heat exchanger 13 and subjected to heat exchange between the water and a condenser 11 of the heat exchanger 13.

[0070] The water cooling unit 80 of the present embodiment is, for example, a so-called tube and fin type heat exchanger, and constituted of a copper tube and a thermal conduction promoting aluminum fin disposed at this copper tube. Moreover, in the copper tube, a channel is constituted through which the water taken out of a lower part of the hot water storage tank 30 and supplied to the heat exchanger 13 flows. In the vicinity of the water cooling unit 80, a fan 80F and a fan motor 80M which drives the fan 80F are installed. The fan supplies, to the water cooling unit 80, air to be subjected to heat exchange between the air and the water flowing through the copper tube. It is assumed that an operation of the fan motor 80M is controlled by a control unit (not shown) which controls the refrigeration cycle device 100. It is to be noted that a type of the water cooling unit 80 is not limited to this example, and another type of heat exchanger may be applied. Examples of the heat exchanger include a so-called micro channel type heat exchanger, a micro tube type heat exchanger and a rolled tube on sheet type heat exchanger in which an aluminum extruded porous flat tube is used and a plurality of holes made in the flat tube are used as refrigerant passages. A heat medium which cools the water subjected to the heat exchange between the water and the condenser 11 is not limited to the air, and any heat medium such as water or brine may be used. When a fluid such as the water or the brine is used as the heat medium, for example, a counterflow type double tube heat exchanger, a copper tube bonded type heat exchanger or the like may be used.

[0071] Next, an operation of the refrigeration cycle device 100 of the present embodiment constituted as described above will be described. It is to be noted that operations of a refrigerant circuit 2 and a hot water storage circuit 5 during a usual cooling operation, and an operation of supplying hot water to a hot water supply load facility, that is, an operation of exhibiting a cooling function by heat absorption of an evaporator 16 of the refrigerant circuit 2 to cool an object to be cooled, generating high-temperature water by heat rejected from a refrigerant in the condenser 11 and storing the water in the hot water storage tank 30 to use this water are similar to those of Embodiment 1. Therefore, detailed description thereof is omitted.

[0072] During the usual cooling operation, the fan motor 80M for supplying air to the water cooling unit 80 is stopped by the control unit. In this state, the air for performing the heat exchange between the air and the water is not supplied to the water cooling unit 80. Therefore, the heat exchange between the water flowing through the water cooling unit 80 and the air is hardly performed.

[0073] Moreover, it is assumed in the refrigeration cycle device 100 of the present embodiment that the water is cooled by the water cooling unit 80, in a case where a temperature (a temperature of the water in the hot water storage tank 30 or the water to be circulated through the heat exchanger 13 for the heat exchange between the condenser 11 and the water in the hot water storage tank 30) of the water to be subjected to the heat exchange between the water and the condenser 11, a temperature in the condenser 11 or a temperature of the refrigerant discharged from the condenser 11 rises to a predetermined value or more.

[0074] Here, an operation of the water cooling unit 80 which cools the water will be described in detail. In the refrigeration cycle device 100 of the present embodiment, when the temperature (the temperature of the water at the inlet of the heat exchanger 13) of the water to be circulated through the heat exchanger 13 for the heat exchange between the condenser 11 and the water stored in the hot water storage tank 30, detected by a temperature sensor T6 installed along the low-temperature pipe 47, reaches a predetermined value or more, the control unit drives the fan motor 80M to rotate the fan 80F. It is to be noted that the temperature at which the fan motor 80M is driven is not limited to the temperature of the water at the inlet of the heat exchanger 13, detected by the temperature sensor T6 as in the present embodiment. The temperature may be the temperature of the water stored in the hot water storage tank 30, detected by stored hot water sensors T4, the temperature of the refrigerant in the condenser 11 of the heat exchanger 13 or the temperature discharged from the condenser 11.

[0075] Moreover, the predetermined value at which the fan motor 80M is driven can be determined based on, for example, the temperature of the air to be subjected to the heat exchange between the air and the water in the water cooling unit 80. That is, when the temperature of the water at the inlet of the heat exchanger 13, detected by the temperature sensor T6, is higher than the temperature of the air, the control unit drives the fan motor 80M to rotate the fan 80F, and supplies the air to the water cooling unit 80.

[0076] In consequence, the water taken out of the lower part of the hot water storage tank 30 enters the copper tube of the water cooling unit 80 via the low-temperature pipe 47. Therefore, while the water taken out of the hot water storage tank 30 passes through the copper tube, the water releases the heat to the air by ventilation of the fan 80F to obtain a low temperature. In consequence, the low-temperature water can be supplied to the heat exchanger 13.

[0077] Therefore, even if an excessively large amount of the high-temperature water is stored in the hot water storage tank 30 owing to increase of a cooling load, decrease of a hot water supply load or the like and the high-temperature water is taken out of the lower part of the hot water storage tank 30 and supplied to the heat exchanger 13, the water cooling unit 80 can cool the water taken out of the lower part of the hot water storage tank 30 to supply the water to the heat exchanger 13.

[0078] In consequence, it is possible for the heat exchanger 13 to secure an amount of the heat to be rejected from the refrigerant, required for the evaporator 16 to maintain the cooling function. That is, in the heat exchanger 13, the heat of the refrigerant flowing through the condenser 11 can sufficiently be released to the water flowing through the water passage 12 to set the temperature of the refrigerant to a low temperature. Therefore, a cooling capacity of the evaporator 16 can be maintained to securely cool the object to be cooled.

[0079] In the present embodiment, blowing to the water cooling unit 80 is controlled by an operation (driving and stopping) of the fan motor 80M to switch whether or not to perform the cooling by the water cooling unit 80. However, the present invention is not limited to this example. A bypass pipe which bypasses the water cooling unit 80 may be disposed, a changeover valve may be disposed which is capable of selectively switching whether the water taken out of the lower part of the hot water storage tank 30 is passed through the bypass pipe or the water cooling unit 80, and the changeover valve may be operated. Even in this case, the operation can be controlled in the same manner as in the present embodiment.

[0080] That is, during the usual cooling operation, the changeover valve is controlled so that the water supplied from the hot water storage tank 30 to the heat exchanger 13 flows through the bypass pipe (e.g., the above control unit controls an operation of the changeover valve). Moreover, in a case where the temperature of the water at the inlet of the heat exchanger 13, detected by the temperature sensor T6, indicates the predetermined value or more, the changeover valve is switched so that the water from the hot water storage tank 30 flows through the water cooling unit 80. In consequence, only when the temperature of the water supplied to the heat exchanger 13 rises, the water can be passed through the water cooling unit 80 to cool the water supplied to the heat exchanger 13.

[0081] It is to be noted that in the present embodiment, the water supplied from the hot water storage tank 30 to the heat exchanger 13 is cooled by the air in the water cooling unit 80, but the present invention is not limited to this example. Another heat medium may be used as described above. In a case where a fluid such as the water or the brine is circulated as the heat medium by a circulation pump, it can be controlled whether or not the cooling is performed by an operation (driving and stopping) of the circulation pump. Alternatively, a pipe which supplies the heat medium may be provided with a block valve, and it may be controlled whether or not the cooling is performed by opening or closing the block valve.

[0082] As described above in detail, even according to the refrigeration cycle device 100 of the present embodiment, in the same manner as in the refrigeration cycle device 1 of Embodiment 1, the cooling function is exhibited by heat absorption of the evaporator 16 to cool the object to be cooled. Moreover, the heat generated in a cooling process is effectively used. That is, the hot water is generated by the heat rejected from the condenser 11, and the generated hot water can be supplied to the hot water supply load facility. Therefore, it is possible to reduce energy consumption by effectively using the heat generated in the cooling process, which has heretofore been rejected to atmospheric air without being used.

[0083] Furthermore, according to the refrigeration cycle device 100 of the present embodiment, even in a case where the excessively large amount of the high-temperature water is stored in the hot water storage tank 30 owing to the increase of the cooling load or decrease of a heating load, the water supplied from the hot water storage tank 30 to the heat exchanger 13 can be cooled by the water cooling unit 80. Therefore, the amount of the heat to be rejected from the refrigerant in the condenser 11 is secured, and it is possible to avoid in advance a disadvantage that the cooling capacity of the evaporator 16 deteriorates. In consequence, the object to be cooled can securely be cooled.

(Embodiment 3)

[0084] Next, still another embodiment of a refrigeration cycle device according to the present invention will be described. FIG. 3 is a schematic constitution diagram of the refrigeration cycle device of Embodiment 3 to which the present invention is applied. It is to be noted that in FIG. 3, components denoted with the same reference numerals as those of FIGS. 1 and 2 are the same components or components which produce similar functions or effects. Therefore, description thereof is omitted, and a part of the present embodiment different from the above embodiments will mainly be described,

[0085] First, a difference between a constitution of a refrigeration cycle device 200 of the present embodiment and that of the refrigeration cycle device 1 of Embodiment 1 will be described. The refrigeration cycle device 1 of Embodiment 1 includes a discharge unit 36 which discharges hot water from a hot water storage tank 30 as needed. On the other hand, the refrigeration cycle device 200 of the present embodiment does not include the discharge unit 36. The refrigeration cycle device 200 of the present embodiment includes a second condenser 90 which is disposed at a refrigerant pipe 41 to connect a condenser 11 to an expansion valve 14 of a refrigerant circuit 2 and which cools a refrigerant discharged from the condenser 11. The refrigerant pipe 41 between the condenser 11 and the second condenser 90 is provided with a temperature sensor T7 which detects a temperature (a temperature of the refrigerant passed through the condenser 11) of the refrigerant discharged from the condenser 11.

[0086] The second condenser 90 is, for example, a so-called tube and fin type heat exchanger, and constituted of a copper tube and a thermal conduction promoting aluminum fin disposed at this copper tube. Moreover, in the copper tube, a channel is constituted through which the refrigerant discharged from the condenser 11 flows. In the vicinity of the second condenser 90, a fan 90F and a fan motor 90M which drives the fan 90F are installed. The fan supplies, to the second condenser 90, air to be subjected to heat exchange between the air and the refrigerant flowing through the copper tube. It is assumed that an operation of the fan motor 90M is controlled by a control unit (not shown) which controls the refrigeration cycle device 200. It is to be noted that a shape of the second condenser 90 is not limited to this example, and another type of heat exchanger may be applied. Examples of the heat exchanger include a micro channel type heat exchanger and a rolled tube on sheet type heat exchanger.

[0087] Next, an operation of the refrigeration cycle device 200 of the present embodiment constituted as described above will be described. It is to be noted that operations of the refrigerant circuit 2 and a hot water storage circuit 5 during a usual cooling operation, and an operation of supplying hot water to a hot water supply load facility, that is, an operation of exhibiting a cooling function by heat absorption of an evaporator 16 of the refrigerant circuit 2 to cool an object to be cooled, generating high-temperature water by heat rejected from the refrigerant in the condenser 11 and storing the water in the hot water storage tank 30 to use this water are similar to those of Embodiment 1. Therefore, detailed description thereof is omitted.

[0088] During the usual cooling operation, the fan motor 90M for supplying air to the second condenser 90 is stopped by the control unit. In this state, the air for performing the heat exchange between the air and the refrigerant is not supplied to the second condenser 90. Therefore, the heat exchange between the water flowing through the second condenser 90 and the air is hardly performed.

[0089] Moreover, it is assumed in the refrigeration cycle device 200 of the present embodiment that the refrigerant discharged from the condenser 11 is cooled by the second condenser 90, in a case where a temperature (a temperature of the water stored in the hot water storage tank 30 or the water to be circulated through a heat exchanger 13 for the heat exchange between the condenser 11 and the water in the hot water storage tank 30) of the water to be subjected to the heat exchange between the water and the condenser 11, a temperature in the condenser 11 or a temperature of the refrigerant discharged from the condenser 11 rises to a predetermined value or more.

[0090] Here, an operation of the second condenser 90 which cools the refrigerant will be described in detail. In the refrigeration cycle device 200 of the present embodiment, when the temperature of the refrigerant discharged from the condenser 11, detected by the temperature sensor T7 installed along the refrigerant pipe 41, reaches a predetermined value or more, the control unit drives the fan motor 90M to rotate the fan 90F. It is to be noted that the temperature at which the fan motor 90M is driven is not limited to the temperature of the refrigerant discharged from the condenser 11, detected by the temperature sensor T7 as in the present embodiment. The temperature may be the temperature of the water stored in the hot water storage tank 30, detected by stored hot water sensors T4, a temperature (a temperature of water at an inlet of the heat exchanger 13) of water to be circulated through the heat exchanger 13 for the heat exchange between the condenser 11 and the water stored in the hot water storage tank 30, detected by a temperature sensor T6 or the temperature of the refrigerant of the condenser 11 in the heat exchanger 13.

[0091] Moreover, the predetermined value at which the fan motor 90M is driven can be determined based on, for example, the temperature of the air to be subjected to the heat exchange between the air and the refrigerant in the second condenser 90. That is, when the temperature of the refrigerant discharged from the condenser 11, detected by the temperature sensor T7, is higher than the temperature of the air, the control unit drives the fan motor 90M to rotate the fan 90F, and supplies the air to the second condenser 90.

[0092] In consequence, the refrigerant subjected to the heat exchange between the refrigerant and the water flowing through a water passage 12 to lower the temperature of the refrigerant in the condenser 11 of the heat exchanger 13 enters the copper tube of the second condenser 90 via the refrigerant pipe 41. Therefore, while the refrigerant discharged from the condenser 11 passes through the copper tube, the refrigerant releases the heat to the air by ventilation of the fan 90F to obtain a lower temperature. In consequence, a specific enthalpy of the refrigerant entering the evaporator 16 can be reduced.

[0093] Therefore, in the same manner as in Embodiment 1, even if an excessively large amount of the high-temperature water is stored in the hot water storage tank 30 owing to increase of a cooling load, decrease of a hot water supply load or the like and the water taken out of the lower part of the hot water storage tank 30 and supplied to the heat exchanger 13 reaches the high temperature to decrease the amount of the heat to be rejected from the condenser 11, the second condenser 90 can cool the refrigerant passed through the condenser 11 to lower the temperature of the refrigerant.

[0094] In consequence, it is possible for the second condenser 90 to secure an amount of the heat to be rejected from the refrigerant, required for the evaporator 16 to maintain the cooling function. That is, in the condenser 11, the heat of the refrigerant cannot sufficiently be released, and the temperature does not drop owing to the high temperature of the water passage 12. However, the second condenser 90 can release the heat of the refrigerant to the air to lower the temperature of the refrigerant. Therefore, a cooling capacity of the evaporator 16 can be maintained to securely cool the object to be cooled.

[0095] In the present embodiment, blowing to the second condenser 90 is controlled by an operation (driving and stopping) of the fan motor 90M to switch whether or not to perform the cooling by the second condenser 90. However, the present invention is not limited to this example. A bypass pipe which bypasses the second condenser 90 may be disposed, a changeover valve may be disposed which is capable of selectively switching whether the refrigerant discharged from the condenser 11 is passed through the bypass pipe or the second condenser 90, and the changeover valve may be operated. Even in this case, the operation can be controlled in the same manner as in the present embodiment.

[0096] That is, during the usual cooling operation, the changeover valve is controlled so that the refrigerant discharged from the condenser 11 flows through the bypass pipe (e.g., the above control unit controls an operation of the changeover valve). Moreover, in a case where the temperature of the refrigerant discharged from the condenser 11, detected by the temperature sensor T7, indicates the predetermined value or more, the changeover valve is switched so that the refrigerant discharged from the condenser 11 flows through the second condenser 90. In consequence, only when the temperature of the refrigerant passed through the condenser 11 rises, that is, a predetermined amount of the heat to be rejected from the condenser 11 cannot be secured, the refrigerant can be passed through the second condenser 90 to cool the refrigerant supplied to the evaporator 16.

[0097] It is to be noted that in the present embodiment, the refrigerant discharged from the condenser 11 is cooled by the air in the second condenser 90, but a heat medium other than the air may be used in order to cool the refrigerant, and a heat medium such as water or brine may be used. In a case where a fluid such as the water or the brine is used, for example, a counterflow type double tube heat exchanger, a copper tube bonded heat exchanger or the like may be used as the second condenser. When the fluid is used as the heat medium and the heat medium is circulated with a circulation pump, it can be controlled whether or not the cooling is performed by an operation (driving and stopping) of the circulation pump. Alternatively, a pipe which supplies the heat medium may be provided with a block valve, and it may be controlled whether or not the cooling is performed by opening or closing the block valve.

[0098] Furthermore, according to the refrigeration cycle device 200 of the present embodiment, in addition to the cooling of the refrigerant in the second condenser 90, an operation to stop a circulation pump 31 and close a flow rate adjustment valve 35 is performed, in a case where the temperature of the water at the inlet of the heat exchanger 13, detected by the temperature sensor T6 installed a low-temperature pipe 47, the temperature of the water stored in the hot water storage tank 30, detected by the stored hot water sensors T4 disposed on the hot water storage tank 30, or a temperature of the high-temperature water entering the hot water storage tank 30, detected by a hot water temperature sensor T2 installed along a high-temperature pipe 48 indicates a predetermined value or more.

[0099] The predetermined temperature is determined in consideration of a set temperature (i.e., a set boiling temperature) of the high-temperature water generated by the heat exchanger 13 and stored in the hot water storage tank 30. At this value, it can be judged that the hot water storage tank 30 is filled with predetermined high-temperature water. For example, in a case where the temperature of the water at the inlet of the heat exchanger 13, detected by the temperature sensor T6 disposed at the low-temperature pipe 47, sufficiently comes close to the set temperature as a target, it can be judged that the hot water storage tank 30 is filled with the high-temperature water. In a case where the temperatures of the hot water stored in the hot water storage tank 30, detected by the plurality of stored hot water sensors T4 disposed at varied heights of the hot water storage tank 30, substantially reach the set temperature and the temperatures at the heights are substantially equal to one another, it can be judged that the hot water storage tank 30 is filled with the high-temperature water. Furthermore, although the flow rate adjustment valve 35 is completely open, the temperature of the high-temperature water entering the hot water storage tank 30, detected by the hot water temperature sensor T2 disposed at the high-temperature pipe 48, rises in excess of a target hot water temperature. Even in this case, it can be judged that the hot water storage tank 30 is filled with the high-temperature water.

[0100] As described above, when the temperature of the hot water detected by the temperature sensor T6, the stored hot water sensors T4 or the hot water temperature sensor T2 indicates the predetermined value or more, the circulation pump 31 is stopped, and the flow rate adjustment valve 35 is closed. In consequence, useless water (hot water) circulation can be avoided in a case where the hot water storage tank 30 is filled with the high-temperature water and the hot water does not have to be generated any more. It is to be noted that in this case, since the water is not circulated through the hot water storage circuit 5, the heat exchange between the refrigerant and the water is not performed in the heat exchanger 13. Therefore, the radiation of the heat from the refrigerant is all performed in the second condenser 90.

[0101] As described above in detail, even according to the refrigeration cycle device 200 of the present embodiment, in the same manner as in the refrigeration cycle device 1 of Embodiment 1, the cooling function is exhibited by the heat absorption of the evaporator 16 to cool the object to be cooled. Moreover, the heat generated in a cooling process is effectively used. That is, the hot water is generated by the heat rejected from the condenser 11, and the generated hot water can be supplied to the hot water supply load facility. Therefore, it is possible to reduce energy consumption by effectively using the heat generated in the cooling process, which has heretofore been rejected to atmospheric air without being used.

[0102] Furthermore, according to the refrigeration cycle device 200 of the present embodiment, even in a case where the excessively large amount of the high-temperature water is stored in the hot water storage tank 30 owing to the increase of the cooling load or decrease of a heating load, the refrigerant passed through the condenser 11 can be cooled by the second condenser 90. Therefore, the amount of the heat to be rejected from the refrigerant is secured, and it is possible to avoid in advance a disadvantage that the cooling capacity of the evaporator 16 deteriorates. In consequence, the object to be cooled can securely be cooled. Especially in the refrigeration cycle device 200 of the present embodiment, since the refrigerant passed through the condenser 11 is cooled, the device has an excellent effect of preventing the deterioration of the cooling capacity as compared with the refrigeration cycle device 100 of Embodiment 2 having the constitution to cool the water supplied to the heat exchanger 13. Moreover, since the hot water stored in the hot water storage tank 30 can be kept at the high temperature, a hot water supply capability can be improved.

(Embodiment 4)

[0103] Next, a further embodiment of a refrigeration cycle device according to the present invention will be described. FIG. 4 is a schematic constitution diagram of the refrigeration cycle device of Embodiment 4 to which the present invention is applied. It is to be noted that in FIG. 4, components denoted with the same reference numerals as those of FIGS. 1 to 3 are the same components or components which produce similar functions or effects. Therefore, description thereof is omitted, and a part of the present embodiment different from the above embodiments will mainly be described.

[0104] First, a difference between a constitution of a refrigeration cycle device 300 of the present embodiment and that of the refrigeration cycle device 1 of Embodiment 1 will be described. The refrigeration cycle device 1 of Embodiment 1 includes a discharge unit 36 which discharges hot water from a hot water storage tank 30 as needed. On the other hand, the refrigeration cycle device 300 of the present embodiment does not include the discharge unit 36. The refrigeration cycle device 300 of the present embodiment includes a second condenser 95 connected to a condenser 11 of a refrigerant circuit 2 so as to be disposed in parallel with the condenser. It is possible to selectively switch whether a refrigerant compressed by a compressor 10 is passed through the condenser 11 or the second condenser 95. Specifically, a middle portion of a high-pressure refrigerant pipe 40 connected to an inlet of the condenser 11 is connected to a middle portion of a refrigerant pipe 41 connected to an outlet of the condenser 11 via a bypass pipe 98. The second condenser 95 is disposed at the bypass pipe 98. Moreover, changeover valves 98B, 40B are arranged at the bypass pipe 98 on an inlet side of the second condenser 95 and the high-pressure refrigerant pipe 40 on a downstream side of a connection point of the bypass pipe 98, respectively. Opening/closing of each of the changeover valves 98B, 40B is switched to selectively pass the refrigerant through the condenser 11 or the second condenser 95 from the compressor 10. Furthermore, check valves 99, 41B are arranged at the bypass pipe 98 on an outlet side of the second condenser 95 and the refrigerant pipe 41 on an upstream side of the connection point of the bypass pipe 98, respectively, so as to prevent backflow of the refrigerant. It is to be noted that the present invention is not limited to a case where the changeover valves are arranged at the bypass pipe 98 on the inlet side of the second condenser 95 and the high-pressure refrigerant pipe 40 on the downstream side of the connection point of the bypass pipe 98, respectively, as in the present embodiment. A three-way valve may be disposed at the connection point of the bypass pipe 98 so that the refrigerant from the compressor 10 is selectively passed through the condenser 11 or the second condenser 95 via the three-way valve.

[0105] The second condenser 95 is, for example, a so-called tube and fin type heat exchanger, and constituted of a copper tube and a thermal conduction promoting aluminum fin disposed at this copper tube. Moreover, in the copper tube, a channel is constituted through which the refrigerant discharged from the compressor 10 flows. In the vicinity of the second condenser 95, a fan 95F and a fan motor 95M which drives the fan 95F are installed. The fan supplies, to the second condenser 95, air to be subjected to heat exchange between the air and the refrigerant flowing through the copper tube. It is assumed that an operation of the fan motor 95M is controlled by a control unit (not shown) which controls the refrigeration cycle device 300. It is to be noted that a shape of the second condenser 95 is not limited to this example, and another type of heat exchanger may be applied. Examples of the heat exchanger include a micro channel type heat exchanger and a rolled tube on sheet type heat exchanger.

[0106] Next, an operation of the refrigeration cycle device 300 of the present embodiment constituted as described above will be described. It is to be noted that operations of the refrigerant circuit 2 and a hot water storage circuit 5 during a usual cooling operation, and an operation of supplying hot water to a hot water supply load facility, that is, an operation of exhibiting a cooling function by heat absorption of an evaporator 16 of the refrigerant circuit 2 to cool an object to be cooled, generating high-temperature water by heat rejected from the refrigerant in the condenser 11 and storing the water in the hot water storage tank 30 to use this water are similar to those of Embodiment 1. Therefore, detailed description thereof is omitted.

[0107] During the usual cooling operation, the changeover valve 40B is opened, the changeover valve 98B is completely closed, and circulation of the refrigerant through the second condenser 95 is blocked. A refrigerant gas compressed by the compressor 10 to obtain a high temperature and a high pressure all enters the condenser 11 without flowing through the second condenser 95. The fan motor 95M is stopped by the control unit. Therefore, in this state, the heat exchange between the air and the refrigerant in the second condenser 95 is not performed.

[0108] Moreover, it is assumed in the refrigeration cycle device 300 of the present embodiment that the refrigerant is passed through the second condenser 95, in a case where a temperature (a temperature of the water stored in the hot water storage tank 30 or the water to be circulated through a heat exchanger 13 for the heat exchange between the condenser 11 and the water in the hot water storage tank 30) of the water to be subjected to the heat exchange between the water and the condenser 11, a temperature in the condenser 11 or a temperature of the refrigerant discharged from the condenser 11 rises to a predetermined value or more.

[0109] Here, an operation of the second condenser 95 which cools the refrigerant will be described in detail. In the refrigeration cycle device 300 of the present embodiment, when the temperature (the temperature of the water at the inlet of the heat exchanger 13) of the water to be circulated through the heat exchanger 13 for the heat exchange between the condenser 11 and the water stored in the hot water storage tank 30, detected by a temperature sensor T6 installed at a low-temperature pipe 47, reaches a predetermined value or more, the changeover valve 40B is completely closed, the circulation of the refrigerant through the condenser 11 is blocked and the changeover valve 98B is opened to pass the refrigerant through the second condenser 95 from the compressor 10. Furthermore, the control unit drives the fan motor 95M to rotate the fan 95F. It is to be noted that the temperature at which the changeover valve 98B is opened and the fan motor 95M is driven is not limited to the temperature of the water at the inlet of the heat exchanger 13, detected by the temperature sensor T6 as in the present embodiment. The temperature may be the temperature of the water stored in the hot water storage tank 30, detected by stored hot water sensors T4 or the temperature of the refrigerant of the refrigerant discharged from the condenser 11.

[0110] Moreover, the predetermined value at which the changeover valve 98B is opened and the fan motor 95M is driven is determined based on, for example, the amount of the hot water stored in the hot water storage tank 30 and the temperature of the object to be cooled in the evaporator 16. At the value, it can be judged that the hot water storage tank 30 is nearly filled with the high-temperature water. Moreover, at the value, a sufficient cooling capacity can be exhibited, and it is further assumed that the value is determined in consideration of an outside air temperature. For example, when the temperature of the water supplied from a water supply unit 32 to the hot water storage tank 30 is about +17°C, the predetermined value is set to +25°C. When the temperature of the water at the inlet of the heat exchanger 13, detected by the temperature sensor T6 disposed at the low-temperature pipe 47, is +25°C or more, the changeover valve 40B is completely closed and the changeover valve 98B is opened. Moreover, the fan motor 95M is driven to rotate the fan 95F, and the heat is rejected from the second condenser 95.

[0111] Thus, when the temperature of the water at the inlet of the heat exchanger 13, detected by the temperature sensor T6, indicates the predetermined value or more, the changeover valve 40B is completely closed and the changeover valve 98B is opened. Moreover, the fan motor 95M is started to rotate the fan 95F, and the radiation of the heat from the second condenser 95 is started.

[0112] In consequence, the high-temperature high-pressure refrigerant from the compressor 10 enters the copper tube of the second condenser 95 via the bypass pipe 98. Therefore, while the refrigerant discharged from the compressor 10 passes through the copper tube, the refrigerant releases the heat to the air by ventilation of the fan 95F to obtain a lower temperature. In consequence, the refrigerant entering the evaporator 16 can effectively be cooled to set the temperature of the refrigerant to a predetermined low temperature.

[0113] Therefore, in the same manner as in Embodiment 1, even if an excessively large amount of the high-temperature water is stored in the hot water storage tank 30 owing to increase of a cooling load, decrease of a hot water supply load or the like and the water taken out of the lower part of the hot water storage tank 30 and supplied to the heat exchanger 13 reaches the high temperature to decrease the amount of the heat to be rejected from the condenser 11, the second condenser 95 can cool the refrigerant discharged from the compressor 10 to lower the temperature of the refrigerant.

[0114] In consequence, it is possible for the second condenser 95 to secure an amount of the heat to be rejected from the refrigerant, required for the evaporator 16 to maintain the cooling function. Therefore, a cooling capacity of the evaporator 16 can be maintained to securely cool the object to be cooled.

[0115] Furthermore, in this case, a circulation pump 31 of the hot water storage circuit 5 is stopped, and a flow rate adjustment valve 35 is closed in the same manner as in Embodiment 3. In consequence, the hot water storage tank 30 is filled with the high-temperature water, and the hot water does not have to be generated any more. In this case, useless water (hot water) circulation can be avoided.

[0116] It is to be noted that in the present embodiment, the refrigerant is cooled by the air in the second condenser 95, but a heat medium other than the air may be used in order to cool the refrigerant, and a heat medium such as water or brine may be used in the same manner as in Embodiment 3.

[0117] As described above in detail, even according to the refrigeration cycle device 300 of the present embodiment, in the same manner as in the refrigeration cycle devices of the above embodiments, the cooling function is exhibited by the heat absorption of the evaporator 16 to cool the object to be cooled. Moreover, the heat generated in a cooling process is effectively used. That is, the hot water is generated by the heat rejected from the condenser 11, and the generated hot water can be supplied to the hot water supply load facility. Therefore, it is possible to reduce energy consumption by effectively using the heat generated in the cooling process, which has heretofore been rejected to atmospheric air without being used.

[0118] Furthermore, according to the refrigeration cycle device 300 of the present embodiment, even in a case where the excessively large amount of the high-temperature water is stored in the hot water storage tank 30 owing to the increase of the cooling load or decrease of a heating load, the high-temperature high-pressure refrigerant compressed by the compressor 10 is passed through the second condenser 95 to reject the heat in the second condenser 95. In consequence, the amount of the heat to be rejected from the refrigerant is secured, and it is possible to avoid in advance a disadvantage that the cooling capacity of the evaporator 16 deteriorates. In consequence, the object to be cooled can securely be cooled.

(Embodiment 5)

[0119] FIG. 5 is a schematic constitution diagram of a refrigeration cycle device of Embodiment 5 to which the present invention is applied. The refrigeration cycle device of the present embodiment cools and insulates milk (an object to be cooled of the present embodiment) immediately after drawn in a cooling vessel. Moreover, the device generates hot water by heat obtained by cooling the milk, and uses the hot water in automatic washing of the cooling vessel. A refrigeration cycle device 500 is provided with a refrigerant circuit 502 including a compressor 510, a condenser 511, an expansion valve 514 as a throttling means and an evaporator 516; a second refrigerant circuit 508 including a second compressor 580, a second condenser 581, an expansion valve 584 as a throttling means and an evaporator 586; a hot water supply circuit 503 including a hot water storage tank 530; and an automatic washing unit 509 described later.

[0120] The refrigerant circuit 502 is constituted so that the compressor 510, the condenser 511, the expansion valve 514 and the evaporator 516 are successively connected to one another in an annular form via pipes to form a closed circuit. Specifically, a high-pressure refrigerant pipe 540 connected to the compressor 510 on a discharge side is connected to an inlet of the condenser 511. The condenser 511 is a refrigerant passage constituting a part of a heat exchanger 513, and disposed so that heat exchange between the condenser and a water passage 512 of the hot water supply circuit 503 can be performed. This heat exchanger 513 is a heat exchanger of heat exchange between water and a refrigerant, which performs the heat exchange between the condenser 511 and the water stored in the hot water storage tank 530 of the hot water supply circuit 503. The heat exchanger is constituted of the refrigerant passage as the condenser 511 and the water passage 512 of the hot water supply circuit 503. One end of the heat exchanger 513 is provided with an inlet of the refrigerant passage of the condenser 511 and an outlet of the water passage 512, and the other end of the heat exchanger is provided with an outlet of the refrigerant passage of the condenser 511 and an inlet of the water passage 512. Therefore, in the heat exchanger 513, a high-temperature high-pressure refrigerant discharged from the compressor 510 and flowing through the condenser 511 and the water flowing through the water passage 512 form a counterflow.

[0121] On the other hand, a refrigerant pipe 541 connected to the outlet of the condenser 511 is connected to an inlet of the expansion valve 514. The expansion valve 514 is a throttling means to reduce the pressure of the refrigerant which has rejected the heat in the condenser 511, and a refrigerant pipe 542 connected to an outlet of the expansion valve 514 is connected to an inlet of the evaporator 516. Moreover, an outlet of the evaporator 516 is connected to one end of a suction pipe 545, and the other end of the suction pipe 545 is connected to the compressor 510 on a low-pressure side (a suction portion). Along the suction pipe 545 which connects the evaporator 516 to the compressor 510 on the low-pressure side, a check valve 518 is interposed in which a compressor 10 side is a forward direction. Moreover, an accumulator 517 is interposed which protects the compressor 510 from a disadvantage that a liquid refrigerant is sucked into the compressor 510 to damage the compressor or the like. The check valve 518 is disposed in order to prevent backflow of the refrigerant from a high-pressure side of the refrigerant circuit 502 to the evaporator 516 during an insulating operation described later.

[0122] Moreover, a discharge temperature sensor T1 which detects a temperature of the high-temperature high-pressure refrigerant discharged from the compressor 510 is disposed at the high-pressure refrigerant pipe 540 of the refrigerant circuit 502

[0123] Furthermore, carbon dioxide which is a natural refrigerant is introduced as the refrigerant in the refrigerant circuit 502. Moreover, since the pressure of the refrigerant circuit 502 on the high-pressure side rises in excess of a critical pressure, the refrigerant circuit 502 constitutes a transient critical cycle. As a lubricant of the compressor 510, for example, mineral oil, alkyl benzene oil, ether oil, ester oil, polyalkylene glycol (PAG), polyol ether (POE) or the like is used.

[0124] On the other hand, the evaporator 516 cools the object to be cooled (the milk in the present embodiment) stored in an inner tank 570 of a cooling vessel 507, and is formed integrally with this cooling vessel 507. The cooling vessel 507 is provided with the inner tank 570 in which a space for storing the object to be cooled (the milk) is formed in an outer tank 572 constituting an outer shell. A space between the inner tank 570 and the outer tank 572 is filled with an insulation material 574 formed of a foaming material such as urethane. An outer plate 576 constituted of a plate material having a high thermal conductivity is disposed on an outer surface (a bottom surface in FIGS. 6 and 7) of the inner tank 570. The whole periphery of a peripheral portion of the outer plate 576 is secured to the bottom surface of the inner tank 570, and a sealed refrigerant passage space 577 is formed as a refrigerant channel of the evaporator 516 between the bottom surface of the inner tank 570 and the outer plate 576.

[0125] Moreover, a portion of the outer plate 576 other than the peripheral portion is provided with a secured inner portion 578 having a plurality of portions which are secured at predetermined intervals to the bottom surface of the inner tank 570. Specifically, the whole periphery of the peripheral portion of the outer plate 576 is secured to the bottom surface of the inner tank 570 by seam welding, and the portion other than the peripheral portion is secured to positions at predetermined intervals in a checkered arrangement or a zigzag arrangement by spot welding (the portion secured by the spot welding is the secured inner portion 578).

[0126] Here, the refrigerant channel (the refrigerant passage space 577) of the evaporator 516 is formed by pressurizing. Specifically, after the whole periphery of the peripheral portion of the outer plate 576 is secured to a bottom portion of the inner tank 570 as described above, a pressure is applied between the inner tank 570 and the outer plate 576. In consequence, the refrigerant passage space 577 is expanded and formed between the inner tank 570 and the outer plate 576. Therefore, portions other than the secured inner portion 578 of the outer plate 576 swell outwards substantially into circular sections, and a large number of swelled portions are continuously formed in the checkered arrangement or the zigzag arrangement.

[0127] In this case, it is preferable that the bottom surface of the inner tank 570 secured to the outer plate 576 is constituted of a material having a high thermal conductivity so that heat exchange between the refrigerant flowing through the refrigerant channel (the refrigerant passage space 577) of the evaporator 516 and the object to be cooled (the milk) stored in the inner tank 570 is easily performed. It is preferable that a material of the inner tank 570, the outer plate 576 and the outer tank 572 is selected in consideration of corrosion, durability and the like. For example, as the material of the inner tank 570, the outer plate 576 and the outer tank 572, a stainless steel may be used. It is assumed that after securing the outer plate 576 to the bottom portion of the inner tank 570 and further assembling the outer tank 572 externally from the outer plate, the insulation material 574 is injected into a space formed between an outer periphery of the inner tank 570 and the outer tank 572.

[0128] Moreover, as a shape of the cooling vessel 507, various shapes such as a columnar shape, a horizontally disposed elliptic cylinder shape and a rectangular parallelepiped shape are considered, but it is assumed in the present embodiment that the cooling vessel 507 has the horizontally disposed elliptic cylinder shape. It has been described in the present embodiment that the outer plate 576 is disposed on the bottom surface of the inner tank to form the refrigerant channel (the refrigerant passage space 577) of the evaporator 516 so that the object to be cooled (the milk) can efficiently be cooled, but the outer plate may further be formed on a side surface of the inner tank 570 if necessary. It is to be noted that as not shown in FIG. 6 for the sake of simplicity of the drawing, the cooling vessel 507 is provided with an introduction port 507A for introducing the milk as the object to be cooled and a takeout port (not shown) for taking out the milk.

[0129] Furthermore, a plurality of refrigerant inlet tubes 516A and refrigerant outlet tubes 516B are attached to the refrigerant passage space 577 (the refrigerant channel of the evaporator 516) formed between the bottom surface of the inner tank 570 and the outer plate 576 so that the tubes communicate with the refrigerant passage space 577. The refrigerant inlet tubes 516A allow the refrigerant to enter the evaporator 516 (the refrigerant passage space 577), and one end of each refrigerant inlet tube is connected to the refrigerant passage space 577. The other end of the refrigerant inlet tube 516A is connected to the refrigerant pipe 542 so that the refrigerant is branched from the refrigerant pipe 542 to the refrigerant passage space 577. The refrigerant outlet tubes 516B discharge the refrigerant from the evaporator 516 (the refrigerant passage space 577), and one end of each refrigerant outlet tube is connected to the refrigerant passage space 577. The other end of the refrigerant outlet tubes 516B is connected to the suction pipe 545 so as to combine the refrigerant from the refrigerant outlet tubes 516B.

[0130] The inner tank 570 has a plate thickness of 2 mm, and the outer plate 576 has a plate thickness of 1 mm. The secured inner portion 578 of the spot welding has a diameter of 6 mm, and it is preferable to set a spot pitch to 20 mm or less so as to bear use of a carbon dioxide refrigerant. In the present embodiment, the spot pitch is set to 18.5 mm. It is preferable that an outer diameter of each of the refrigerant inlet tube 516A and the refrigerant outlet tube 516B is 1/2 or less of the spot pitch in order to prevent deterioration of strength of a tube bonding portion. In the present embodiment, the outer diameter is set to ϕ6.35 mm (1/4 inch), and the plate thickness is set to 1.0 mm.

[0131] It is to be noted that the refrigerant passage space 577 as the refrigerant channel of the evaporator 516 may be divided by the seam welding and arbitrarily constituted. For example, a region may be divided into two in the center to constitute two refrigerant channels. As another method, the region may finely be divided to constitute three, four or more refrigerant channels. Furthermore, a meandering refrigerant channel or a spiral refrigerant channel may be formed by the seam welding.

[0132] It is to be noted that it has been described in the present embodiment that the inner tank 570 is secured to the outer plate 576 by the spot welding and the seam welding, but a securing method is not limited to this example, and the inner tank may be secured to the outer plate by another method such as laser welding.

[0133] On the other hand, as shown in FIG. 5, the introduction port 507A of the cooling vessel 507 is detachably connected to an introduction pipe 550 via an introduction port valve 550B. Furthermore, the milk takeout port is detachably connected to a takeout pipe 552 for taking out the milk via a takeout valve 552B. Moreover, the milk introduction pipe 550 is attached to the milk introduction port 507A only in a case where the milk is introduced into the inner tank 570 of the cooling vessel 507. In another case, the introduction pipe is detached from the introduction port 507A, and the introduction port 507A is tightly sealed. Similarly, the milk takeout pipe 552 is attached to the milk takeout port only in a case where the milk is taken out of the inner tank 570 of the cooling vessel 507. In another case, the takeout pipe is detached from the milk takeout port, and the milk takeout port is tightly sealed.

[0134] Moreover, a milk temperature sensor T5 for detecting a temperature of the milk as the object to be cooled is attached to an outer peripheral surface of the inner tank 570 of the cooling vessel 507. Furthermore, the cooling vessel 507 is provided with a stirrer 575 which stirs the milk in order to promote heat conduction during the cooling and correctly measure the temperature with reduced temperature unevenness. The stirrer 575 is constituted of a stirring blade, a stirring motor and a shaft which connects the blade to the motor.

[0135] On the other hand, the second refrigerant circuit 508 is constituted so that the compressor 580, the condenser 581, the expansion valve 584 and the evaporator 586 are successively connected to one another in an annular form via pipes to form a closed circuit. Specifically, a high-pressure refrigerant pipe 590 connected to the compressor 580 on a discharge side is connected to an inlet of the condenser 581. The condenser 581 is a refrigerant passage constituting a part of a heat exchanger 583, and disposed so that heat exchange between the condenser and a water passage 582 of the hot water supply circuit 503 can be performed. This heat exchanger 583 is a heat exchanger of heat exchange between water and a refrigerant, which performs the heat exchange between the condenser 581 and the water stored in the hot water storage tank 530 of the hot water supply circuit 503. The heat exchanger is constituted of the refrigerant passage as the condenser 581 and the water passage 582 of the hot water supply circuit 503. One end of the heat exchanger 583 is provided with an inlet of the refrigerant passage of the condenser 581 and an outlet of the water passage 582, and the other end of the heat exchanger is provided with an outlet of the refrigerant passage of the condenser 581 and an inlet of the water passage 582. Therefore, in the heat exchanger 583, a high-temperature high-pressure refrigerant discharged from the compressor 580 and flowing through the condenser 581 and the water flowing through the water passage 582 form a counterflow.

[0136] On the other hand, a refrigerant pipe 591 connected to the outlet of the condenser 581 is connected to an inlet of the expansion valve 584. The expansion valve 584 is a throttling means to reduce the pressure of the refrigerant which has rejected the heat in the condenser 581, and a refrigerant pipe 592 connected to an outlet of the expansion valve 584 is connected to an inlet of the evaporator 586. The evaporator 586 is, for example, a tube and fin type heat exchanger, and constituted of a copper tube and a thermal conduction promoting aluminum fin disposed at this copper tube. Moreover, in the copper tube, a channel is constituted through which the refrigerant from the expansion valve 584 flows. In the vicinity of the evaporator 586, a fan 586F and a fan motor 586M which drives the fan 586F are installed. The fan supplies, to the evaporator 586, atmospheric air (air) as a heat source to be subjected to heat exchange between the air and the water flowing through the copper tube. It is to be noted that the heat source of the evaporator 586 is not limited to the atmospheric air, and another heat source such as water, waste water, solar heat or underground water may be used.

[0137] Moreover, an outlet of the evaporator 586 is connected to one end of a suction pipe 595, and the other end of the suction pipe 595 is connected to the compressor 580 on a low-pressure side (a suction portion). Along the suction pipe 595 which connects the evaporator 586 to the compressor 580 on the low-pressure side, an accumulator 587 is interposed which protects the compressor 580 from a disadvantage that a liquid refrigerant is sucked into the compressor 580 to damage the compressor or the like.

[0138] Furthermore, the high-pressure refrigerant pipe 590 of the second refrigerant circuit 508 is provided with a discharge temperature sensor T7 which detects a temperature the high-temperature high-pressure refrigerant discharged from the compressor 580.

[0139] It is to be noted that carbon dioxide which is a natural refrigerant is introduced as the refrigerant in the second refrigerant circuit 508. That is, since the pressure of the second refrigerant circuit 508 on a high-pressure side rises in excess of a critical pressure, the second refrigerant circuit 508 constitutes a transient critical cycle. As a lubricant of the compressor 580, for example, mineral oil, alkyl benzene oil, ether oil, ester oil, polyalkylene glycol (PAG), polyol ether (POE) or the like is used in the same manner as in the compressor 510 of the refrigerant circuit 502.

[0140] On the other hand, the hot water supply circuit

503 is constituted of a hot water storage circuit 505 which receives the heat from the refrigerant flowing through the condenser 511 of the refrigerant circuit 502 or the refrigerant flowing through the condenser 581 of the second refrigerant circuit 508 to heat the water and generate the high-temperature water and which stores the hot water in the hot water storage tank 530; a water supply unit 532 which supplies water into the hot water storage tank 530; a hot water supply unit 534 which supplies, to a hot water supply load facility, the hot water stored in the hot water storage tank 530; and a discharge unit 536 described later.

[0141] The hot water storage tank 530 is a tank in which the high-temperature water generated by the heat rejected from the condenser 511 in the heat exchanger 513 or the second condenser 581 in the heat exchanger 583 is stored. The whole outer peripheral surface of the tank is covered with an insulation material, and the tank is structured so that the stored hot water does not easily cool.

[0142] Moreover, a lower portion of the hot water storage tank 530 is connected to a low-temperature pipe 547 which takes out low-temperature water (the water) stored in the hot water storage tank 530 from below the hot water storage tank 530. The low-temperature pipe 547 is connected to the inlet of the water passage 512 formed at the other end of the heat exchanger 513 via a circulation pump 531 and a flow rate adjustment valve 535. The circulation pump 531 circulates the water through the hot water storage circuit 505. The circulation pump 531 of the present embodiment discharges the water taken out of the lower portion of the hot water storage tank 530 on a heat exchanger 513 side or a heat exchanger 583 side, and circulates the water through the hot water storage circuit 505 so that a water flow in the water passage 512 or 582 of the heat exchanger 513 or 583 forms a counterflow against a refrigerant flow in the condenser 511 or 581 as described above (circulates the water in a clockwise direction in FIG. 5). The flow rate adjustment valve 535 is a valve unit which adjusts a flow rate of the warm water circulated in the hot water storage circuit 505 by the circulation pump 531.

[0143] Furthermore, a three-way valve 547A is disposed on an upstream side of the circulation pump 531 of the low-temperature pipe 547, and connected to one end of a bypass pipe 549 so that the pipe is branched from the low-temperature pipe 547 via the three-way valve 547A. The other end of the bypass pipe 549 is connected to a middle portion of a high-temperature pipe 548. Moreover, the three-way valve 547A can be switched to thereby selectively switch whether the water is passed through the circulation pump 531 from below the hot water storage tank 530, or the hot water (the water) passed through the heat exchanger 513 or the hot water (the water) passed through the heat exchanger 583 is passed through the circulation pump 531.

[0144] In addition, a three-way valve 547B is disposed on a downstream side of the flow rate adjustment valve 535 of the low-temperature pipe 547, and connected to a low-temperature pipe 597 so that the pipe is branched from the low-temperature pipe 547 via the three-way valve 547B. The low-temperature pipe 597 is connected to an inlet of the water passage 582 formed at the other end of the heat exchanger 583. The three-way valve 547B can selectively switch whether the water passed through the flow rate adjustment valve 535 is passed through the heat exchanger 513 or the heat exchanger 583.

[0145] Moreover, one end of a high-temperature pipe 598 is connected to an outlet of the water passage 582 formed at one end of the heat exchanger 583, and the other end of the high-temperature pipe 598 is connected to a middle portion of the high-temperature pipe 548.

[0146] On the other hand, an outlet of the water passage 512 formed at one end of the heat exchanger 513 is connected to one end of the high-temperature pipe 548, and the other end of the high-temperature pipe 548 is connected to an upper portion (an upper end in the present embodiment) of the hot water storage tank 530. On a downstream side of a connection point of this high-temperature pipe 548 to the high-temperature pipe 598, a hot water temperature sensor T2 is disposed which detects a temperature of the high-temperature water generated by the heat rejected from the condenser 511 in the heat exchanger 513 or the heat rejected from the condenser 581 in the heat exchanger 583 and entering the hot water storage tank 530.

[0147] The upper portion of the hot water storage tank 530 is connected to the high-temperature pipe 548, and provided with a high-temperature water takeout port 537 which takes the high-temperature water from the hot water storage tank 530. The high-temperature water takeout port 537 is connected to a high-temperature water takeout pipe 534A of the hot water supply unit 534. The lower portion of the hot water storage tank 530 is connected to the low-temperature pipe 547, and provided with a low-temperature water takeout port 538 which takes the low-temperature water from the hot water storage tank 530. This low-temperature water takeout port 538 is connected to a low-temperature water takeout pipe 534B of the hot water supply unit 534.

[0148] Moreover, the high-temperature water takeout pipe 534A is connected to a washing hot water supply pipe 600, and the high-temperature water taken out of the hot water storage tank 530 via the high-temperature water takeout port 537 is supplied to the automatic washing unit 509 via the washing hot water supply pipe 600. The automatic washing unit 509 is a unit for washing the cooling vessel 507, and the high-temperature water stored in the hot water storage tank 530 is taken from the washing hot water supply pipe 600 for use as washing water of the cooling vessel 507. The washing hot water supply pipe 600 is provided with a check valve 601 for preventing a disadvantage that the hot water flowing through the washing hot water supply pipe 600 flows back to the hot water storage tank 530; and a hot water supply valve 602 for supplying the hot water as the washing water. It is to be noted that although not shown in FIG. 5, the washing hot water supply pipe 600 may be provided with a temperature sensor which detects a temperature of the hot water flowing through the washing hot water supply pipe 600; a flow rate sensor which detects an amount of the hot water; a flow switch or the like if necessary.

[0149] Furthermore, it is assumed in the present embodiment that the high-temperature water supplied from the washing hot water supply pipe 600 is used in washing the cooling vessel 507. However, the washing hot water supply pipe 600 may be connected to, for example, a washing unit for washing a unit such as a milking machine or a milking pipeline other than the cooling vessel 507 (not shown: with the proviso that a part of the machine or the pipeline is connected to the milk introduction pipe 550) to use the hot water in washing the machine or the pipeline.

[0150] Moreover, a mixture valve 610 mixes the high-temperature water taken out of the hot water storage tank 530 via the high-temperature water takeout pipe 534A with the low-temperature water taken out of the hot water storage tank 530 via the low-temperature water takeout pipe 534B or the water supplied from the water supply unit 532 via the low-temperature water takeout pipe 534B, adjusts a temperature of the mixed water into an optimum temperature and supplies the water to the hot water supply load facility for use in an application other than the washing application. The mixture valve 610 is connected to the hot water supply load facility for use in an application other than the washing application. Moreover, the hot water is supplied to the hot water supply load facility by operating a hot water supply valve (not shown). The high-temperature water takeout pipe 534A and the low-temperature water takeout pipe 534B connected to the mixture valve 610 are provided with check valves 613 for preventing the backflow to the hot water storage tank 530, respectively.

[0151] Furthermore, a hot water supply pipe 612 leading from the mixture valve 610 to the hot water supply valve of each hot water supply load facility is provided with a check valve 614 for preventing the backflow to the hot water storage tank 530 and a temperature sensor T3 for use in hot water supply control. Moreover, a temperature of the hot water to be supplied to the hot water supply load facility is detected by the temperature sensor T3. It is to be noted that the hot water supply valve is, for example, a faucet for hot water supply or the like, and the number of the valves is not limited to one. A plurality of hot water supply valves may be disposed. The hot water supply pipe 612 may be provided with a flow rate sensor and a flow switch (both are not shown) if necessary.

[0152] In addition, the lower portion of the hot water storage tank 530 is connected to a water supply pipe 532A of the water supply unit 532 via a pressure reduction valve 532B. The water supply unit 532 supplies water into the hot water storage tank 530. Water such as city water having an amount corresponding to an amount of the hot water of the hot water storage tank 530 to be used is supplied into the hot water storage tank 530 from the lower portion of the hot water storage tank 530 via the water supply pipe 532A. A water supply valve (not shown) is interposed along this water supply pipe 532A, and the water supply valve is usually constantly brought into an open state.

[0153] Moreover, the lower portion of the hot water storage tank 530 is connected to a discharge pipe 560A via a discharge valve 560B. The discharge pipe discharges the hot water from the hot water storage tank 530, when the hot water storage tank 530 is unused.

[0154] Here, the discharge unit 536 discharges the water (the hot water) from the hot water storage tank 530, and is disposed below the high-temperature water takeout port 537 and above the low-temperature water takeout port 538. In the present embodiment, a hot water discharge pipe 536A of the discharge unit 536 is connected to a portion of the hot water storage tank 530 below the high-temperature water takeout port 537 and above the low-temperature water takeout port 538 via a hot water discharge valve 536B. Since the discharge unit 536 is disposed below the high-temperature water takeout port 537 and above the low-temperature water takeout port 538 in this manner, the hot water taken out of the hot water storage tank 530 by the discharge unit 536 is medium-temperature water having a temperature which is lower than that of the hot water taken from the high-temperature water takeout port 537 and higher than the water taken from the low-temperature water takeout port 538. Therefore, when the hot water discharge valve 536B is opened as needed, the medium-temperature water can be discharged from the hot water storage tank 530.

[0155] On the other hand, an outer surface of the hot water storage tank 530 is provided with a plurality of stored hot water sensors T4 arranged at appropriate intervals from the upper portion to the lower portion. The stored hot water sensors T4 are sensors which detect temperatures of portions of the hot water stored in the hot water storage tank 530 and which detect whether or not there is hot water. Since the plurality of stored hot water sensors T4 are arranged at varied heights to detect the temperatures of the portions in this manner, it is possible to detect the amount of the hot water stored in the hot water storage tank 530 while grasping a temperature distribution from the upper portion to the lower portion of the hot water storage tank 530.

[0156] It is to be noted that a capacity of the hot water storage tank 530 needs to be determined in due consideration of an amount of the milk as the object to be cooled, introduced into the cooling vessel 507; an assumed hot water supply load; a generation time of each load and the like. That is, during a cooling operation, if the high-temperature water is taken out of the lower portion of the hot water storage tank 530 instead of the low-temperature water and the water enters the water passage 512 of the heat exchanger 513, an amount of the heat to be rejected from the condenser 511 remarkably decreases. As a result, a cooling capacity and COP of the refrigerant circuit 502 deteriorate. Therefore, when the capacity of the hot water storage tank 530 is considered, a hot water storage tank having a sufficient volume should be used so that the low-temperature water can constantly be taken out of the lower portion of the hot water storage tank 530 and can be passed through the water passage 512 of the heat exchanger 513.

[0157] Specifically, each capacity needs to be investigated in accordance with use conditions. For example, in a case where the hot water is not used simultaneously with the cooling operation, it is preferable to use the hot water storage tank having a capacity which equals or exceeds the maximum amount of the milk as the object to be cooled, supposed to be introduced into the cooling vessel 507 during one cooling operation. For example, in a case where 500 liters of the object to be cooled (the milk) is introduced into the cooling vessel 507, it is preferable that the capacity of the hot water storage tank 530 equals or exceeds about 500 liters. In a case where it is assumed that the hot water is used during the cooling operation, the capacity of the hot water storage tank 530 can be set to be smaller than the above capacity.

[0158] Moreover, the automatic washing unit 509 is constituted of a circulation washing circuit 630 constituted by successively connecting a washing circulation pump 631, a washing pipe 632, the cooling vessel 507, the takeout valve 552B, a circulation changeover valve 634 and a washing return pipe 635; a washing water discharge passage 640 connected to the washing return pipe 635 of the circulation washing circuit 630 via a washing discharge valve 640B; and a washing buffer tank 650 connected to the washing return pipe 635 of the circulation washing circuit 630.

[0159] The washing buffer tank 650 is connected to at least one or more detergent supply pipes 652; a water supply pipe 654 for supplying the washing water (the city water in the present embodiment); and the washing hot water supply pipe 600 for supplying the washing hot water from the hot water supply circuit 503. The water supply pipe 654 is provided with a water supply valve 654B, and the water supply to the washing buffer tank 650 is controlled by the water supply valve 654B. The detergent supply pipe 652 is provided with a detergent supply pump (not shown) for supplying detergent, and the other end of the detergent supply pipe 652 is connected to a detergent vessel (not shown).

[0160] An operation of the refrigeration cycle device 500 of the present embodiment constituted as described above will be described.

(1) Cooling Operation of Object (Milk) to be cooled

[0161] First, an operation to cool the milk as the object to be cooled during the cooling operation will be described. The milking pipeline connected to the milking machine (not shown) is connected to the cooling vessel 507 via the milk introduction pipe 550, the introduction port valve 550B is opened, and the milk immediately after drawn is introduced into the cooling vessel 507. At this time, the milk takeout valve 552B is closed. A temperature of the milk immediately after drawn is substantially equal to or slightly lower than a body temperature of a cow, and is specifically in a range of about 35°C to 38°C. Then, the refrigerant circuit 502 is operated to cool and insulate the milk for the purpose of preventing generation of bacteria and maintaining a quality of the milk.

[0162] After starting the milking (after starting the introduction of the milk), the compressor 510 of the refrigerant circuit 502 is driven, and the stirrer 575 is simultaneously driven. Usually, it is assumed that after a predetermined amount of milk is stored in the cooling vessel 507, the compressor 510 is driven to start the cooling operation. However, the cooling operation may be started simultaneously with the start of the introduction of the milk or before the introduction of the milk as long as careful consideration is given so as to prevent freezing and idling of the stirrer 575 is prevented.

[0163] When the compressor 510 is driven, a low-temperature low-pressure refrigerant gas is sucked and compressed on the low-pressure side (the suction portion) of the compressor 510 from the suction pipe 545. In consequence, the refrigerant gas which has obtained a high temperature and a high pressure enters the high-pressure refrigerant pipe 540 from the discharge side, and is discharged from the compressor 510. At this time, the refrigerant is compressed under an appropriate supercritical pressure.

[0164] The high-temperature high-pressure refrigerant discharged from the compressor 510 enters the heat exchanger 513 from the inlet of the condenser 511 via the high-pressure refrigerant pipe 540. Moreover, while passing through the condenser 511 of the heat exchanger 513, the high-temperature high-pressure refrigerant gas releases the heat to the water of the hot water storage circuit 505 flowing through the water passage 512 disposed so as to perform the heat exchange between the water and the condenser 511. In consequence, the gas obtains a low temperature. On the other hand, the water in the water passage 512 is heated by a heat radiation function of this condenser 511, and the high-temperature water is generated.

[0165] At this time, in the condenser 511, the refrigerant usually has a state of a liquid phase at a pressure which is not less than a critical pressure. That is, since carbon dioxide is used as the refrigerant in the present embodiment, the refrigerant pressure in the condenser 511 is not less than the critical pressure, and condensation of the refrigerant does not occur in the condenser 11. Therefore, from the inlet to the outlet of the condenser 511, the temperature of the refrigerant gradually drops as the heat is rejected into the water in the water passage 512. On the other hand, from the inlet to the outlet of the water passage 512 of the heat exchanger 513, the temperature of the water gradually rises as the heat is absorbed from the refrigerant. Since the refrigerant pressure of the condenser 511 is set to be not less than the critical pressure by use of the carbon dioxide refrigerant in this manner, the heat exchange can efficiently be performed and the high-temperature water can be generated as compared with condensation heat radiation of a conventional refrigerant such as an HFC-based refrigerant at a constant temperature. In the heat exchanger 513, the refrigerant passage and the water passage 512 constituting the condenser 511 are arranged so as to form the counterflow as described above. Therefore, the heat exchange between the water and the refrigerant can further efficiently be performed.

[0166] The low-temperature high-pressure refrigerant cooled by the condenser 511 exits from the heat exchanger 513 via the outlet of the condenser 511, passes through the refrigerant pipe 541, expands at the expansion valve 514 to obtain a low pressure and reaches the evaporator 516 via the refrigerant pipe 542. It is to be noted that the refrigerant at the inlet of the evaporator 516 has a two-phase mixed state in which the liquid refrigerant is mixed with a vapor refrigerant. Moreover, when the liquid-phase refrigerant absorbs the heat from the milk as the object to be cooled in the evaporator 516, the refrigerant evaporates to form the vapor refrigerant. At this time, the milk is cooled by the heat absorption.

[0167] Moreover, the refrigerant evaporated in the evaporator 516 repeats a cycle of exiting from the evaporator 516 to enter the suction pipe 545 and being again sucked from the low-pressure side (the suction portion) to the compressor 510 via the check valve 518 and the accumulator 517. When the above cycle is repeated, the milk is cooled by the heat absorption of the evaporator 516. Moreover, the hot water is generated by the heat rejected from the condenser 511.

[0168] Furthermore, when the milking is completed, the introduction of the milk into the cooling vessel 507 is completed. However, the above cooling operation is continued until the milk reaches a predetermined temperature. Here, the temperature of the milk is detected by the milk temperature sensor T5 attached to the outer peripheral surface of the inner tank 570. The predetermined temperature at which the cooling operation ends is set from a viewpoint that the generation of the bacteria in the milk be inhibited and the quality be maintained, and is specifically about 4°C. Furthermore, the open degree of the expansion valve 514 is adjusted so that the temperature of the discharged refrigerant detected by the discharge temperature sensor T1 disposed at the high-pressure refrigerant pipe 540 of the refrigerant circuit 502 is a predetermined temperature during the cooling operation. Specifically, when the refrigerant temperature detected by the discharge temperature sensor T1 rises above the predetermined value, the open degree of the expansion valve 514 is enlarged. Conversely, when the refrigerant temperature detected by the discharge temperature sensor T1 drops below the predetermined value, the open degree of the expansion valve 514 is reduced. In consequence, a highly efficient operation can be performed on conditions preferable for an operation of generating the high-temperature water suitable for the washing application.

[0169] It is to be noted that the compressor 510 during the cooling operation may have the constant number of rotations. Alternatively, a frequency may be adjusted by an inverter or the like.

(2) Operation of Hot Water Supply Circuit 503 during Cooling Operation

[0170] Next, the operation of the hot water supply circuit 503 during the cooling operation will be described. First, the three-way valve 547A is switched so that the water flows through the circulation pump 531 from the lower portion of the hot water storage tank 530, and the three-way valve 547B is switched so that the water passed through the flow rate adjustment valve 535 flows through the heat exchanger 513 of the refrigerant circuit 502 (the refrigerant circuit 502 for cooling the milk).

[0171] Moreover, when the above cooling operation is started, the circulation pump 531 of the hot water supply circuit 503 is started. The low-temperature water or the water (hereinafter referred to simply as the water) is sucked from the lower portion of the hot water storage tank 530 to the circulation pump 531 via the low-temperature pipe 547, and pushed out to the low-temperature pipe 547 connected to the outlet of the circulation pump 531 on the heat exchanger 513 side. In consequence, the water pushed out of the circulation pump 531 enters the heat exchanger 513 from the inlet of the water passage 512 via the flow rate adjustment valve 535. In the heat exchanger 513, as described above, the water flowing through the water passage 512 receives the heat from the condenser 511 by the heat exchange between the water and the refrigerant flowing through the condenser 511, and is heated. In consequence, the high-temperature water is generated. Moreover, the high-temperature water discharged from the heat exchanger 513 via the outlet of the water passage 512 passes through the high-temperature pipe 548 of the hot water storage circuit 505, and is injected into the hot water storage tank 530 from the upper portion (the upper end) of the hot water storage tank 530. The high-temperature water generated by the heat exchanger 513 is injected into the upper portion of the hot water storage tank 530, and the water is taken out of the lower portion of the tank. Therefore, the high-temperature water is stored in an upper part of the tank and the low-temperature water is stored in a lower part of the tank by use of a density difference due to a water temperature difference.

[0172] Moreover, the flow rate adjustment valve 535 adjusts the flow rate of the water so that the temperature of the hot water at the outlet of the water passage 512 of the heat exchanger 513 indicates a predetermined value. In the present embodiment, the flow rate adjustment valve 535 is controlled based on the temperature of the hot water at the outlet of the water passage 512 of the heat exchanger 513 detected by the hot water temperature sensor T2. That is, when the temperature of the hot water at the outlet of the water passage 512 detected by the hot water temperature sensor T2 is higher than the predetermined temperature, the open degree of the flow rate adjustment valve 535 is enlarged. In consequence, an amount (the flow rate) of the water to be circulated through the hot water storage circuit 505 can be increased.

[0173] On the other hand, when the temperature of the hot water at the outlet of the water passage 512 detected by the hot water temperature sensor T2 is lower than the predetermined temperature, the open degree of the flow rate adjustment valve 535 is reduced. In consequence, the amount (the flow rate) of the water to be circulated through the hot water storage circuit 505 can be reduced. It is to be noted that in the present embodiment, the temperature of the hot water at the outlet of the water passage 512 is detected by the hot water temperature sensor T2 installed at the middle portion of the high-temperature pipe 548. However, the present invention is not limited to this example. Needless to say, the temperature may be detected by a temperature sensor disposed at the outlet of the water passage 512 of the heat exchanger 513. It is preferable to determine the predetermined temperature at a temperature suitable for an application of the supplied hot water, specifically in a range of about 50°C to 85°C in accordance with a use application.

[0174] As described above, during the cooling operation of the refrigeration cycle device 500 of the present embodiment, when the milk immediately after drawn is introduced into the cooling vessel 507, the milk is cooled at the predetermined temperature in order to maintain the quality of the milk. Moreover, the high-temperature water is generated by the heat rejected from the refrigerant circuit 502 on the high-pressure side, and the hot water can be stored in the hot water storage tank 530.

(3) Cold Insulating Operation of Object to be cooled (Milk)

[0175] When the temperature of the milk reaches the predetermined value during the above cooling operation, the compressor 510 is stopped, the expansion valve 514 is completely closed and the stirrer 575 is stopped to end the cooling operation, and a cold insulating operation of the milk stored in the cooling vessel 507 is performed. In this case, the cooling vessel 507 is insulated by the insulation material 574 as described above, but the temperature of the milk rises owing to the heat entering from the outside during storage for a long period.

[0176] To solve the problem, even when the compressor 510 and the like are stopped during the cold insulating operation, the milk temperature sensor T5 continuously detects the temperature of the milk stored in the cooling vessel 507 (this state will hereinafter be referred to as a standby state). When the milk temperature reaches the predetermined value or more, the cooling operation is started to cool the milk. Moreover, when the milk is cooled at the predetermined temperature by the cooling operation during the cold insulating operation, the cooling operation is stopped, and the device is brought into the standby state again. The predetermined temperature at which the cooling operation is started during the cold insulating operation is specifically about 4.5°C, and the predetermined temperature at which the cooling operation is stopped is about 4°C.

[0177] In the standby state, the expansion valve 514 is completely closed in order to prevent a refrigerant flow from the high-pressure side of the refrigerant circuit 502 to the evaporator 516 and suppress the incoming heat into the milk as the object to be cooled in combination with the function of the check valve 518 disposed between the evaporator 516 and the accumulator 517 along the suction pipe 545. It is to be noted that even in a case where a block valve or the like is disposed at the suction pipe 545 instead of the check valve 518 or at the refrigerant pipe 542 or 541 instead of the expansion valve 514 and the block valve is closed in the standby state during the cold insulating operation, a similar effect can be obtained.

[0178] Here, it is assumed that the stirrer 575 is driven intermittently at a constant interval in the standby state during the cold insulating operation. It is assumed that a stirring operation is performed for, for example, two minutes at an interval of 30 minutes. When the stirrer 575 is stopped, the temperature distortion is stratificationally generated in the cooling vessel 507 owing to the density difference due to the temperature difference of the milk. Therefore, correct temperature measurement cannot be performed.

[0179] Since a function of the refrigerant circuit 502, an operation of the hot water supply circuit 503 and the like during the cold insulating operation are similar to those during the above cooling operation, detailed description is omitted here. According to the refrigeration cycle device 500 of the present embodiment, even in the cooling operation during the cold insulating operation, the hot water can be stored by effectively using the discharged heat during the cooling simultaneously with the cooling of the milk.

(4) Operation Patterns of Cooling Operation and Cold Insulating Operation in general Farm

[0180] The cooling operation and the cold insulating operation of the introduced milk during the milking have been described above. Next, operation patterns of the cooling operation and the cold insulating operation in a general farm will be described.

[0181] In the general farm, the milking is performed about twice or three times a day. During and after the second milking, the milk immediately after drawn is additionally introduced into the cooling vessel 507 in which the cooled and insulated milk is stored. As a result, since the milk temperature in the cooling vessel 507 rises, the cooling operation is started. When the temperature reaches the predetermined temperature, the cooling operation is stopped to perform the cold insulating operation as described above.

[0182] Moreover, there is a case where the milk is taken out of the cooling vessel 507 (milk cargo collection) every day or every other day. Therefore, from the first milking till the milk cargo collection, the cooling operation and the cold insulating operation of the introduced milk are repeatedly performed twice to six times.

(5) Washing Operation

[0183] Next, a washing operation will be described. As described above, the milk cooled and insulated in the cooling vessel 507 as described above is taken from the takeout port during the milk cargo collection. Specifically, the milk takeout valve 552B is connected to the takeout pipe 552, the milk takeout valve 552B is opened and the milk is taken out of the cooling vessel 507. Moreover, after the milk is taken out, the washing operation is performed by the automatic washing unit 509 in order to keep the inside of the cooling vessel 507 to be clean, inhibit propagation of the bacteria and secure the quality of the milk.

[0184] Usually, the washing of the cooling vessel 507 is performed after taking the milk out of the cooling vessel 507. Therefore, in a case where the cargo is collected every day, the washing is performed once a day. When the cargo is collected every other day, the washing is performed once every two days. In the present embodiment, the washing hot water can be supplied even for the washing of the milking machine or the milking pipeline (not shown). However, since the milking machine and the milking pipeline are washed every time the milking is completed, the washing is performed twice or three times a day.

[0185] Washing steps in a case where the cooling vessel 507 is washed are basically the same as those in a case where the milking pipeline or the like is washed. That is, a rinsing step with the water, a rinsing step with the hot water, a washing step with a plurality of types of detergents such as an alkaline detergent and an acid detergent and a sterilization step with a germicide are performed. In each of such steps, the hot water or the water is supplied, predetermined amounts of predetermined types of detergent and germicide are supplied, then a washing liquid (a mixture liquid of the hot water or the water and the detergent and the like) is circulated through the device (through the cooling vessel 507 in a case where the cooling vessel 507 is washed) for a predetermined time if necessary, and the washing liquid is then discharged.

[0186] Moreover, the above steps are performed in a predetermined order the necessary number of times. For example, first the rinsing step with the water is performed. Subsequently, another rinsing step with the hot water, an alkali washing step with the hot water and the alkaline detergent, still another rinsing step with the hot water, an acid washing step with the hot water and the acid detergent and a further rinsing step with the water are performed. Subsequently, the sterilization step with the germicide is performed.

[0187] When the milk cargo collection is completed, prior to the washing, first the milk takeout pipe 552 is detached from the takeout valve 552B so that the washing water flows through the washing return pipe 635 via the takeout valve 552B, and the takeout valve 552B is opened. In the rinsing step with the water, the washing discharge valve 640B and the circulation changeover valve 634 are closed, and the washing circulation pump 631 is stopped. In this state, the water supply valve 654B is opened, and the predetermined amount of washing water is supplied to the washing buffer tank 650 via the water supply pipe 654. It is to be noted that it can be judged with, for example, a floating type level switch or the like whether or not an amount of the water in the washing buffer tank 650 reaches a predetermined value.

[0188] When the amount of the water in the washing buffer tank 650 reaches the predetermined value, the water supply valve 654B is closed, and the washing circulation pump 631 is brought into an operative state. In consequence, the water passes through the washing pipe 632 from the washing buffer tank 650, and is supplied into the cooling vessel 507. To inject the water into the cooling vessel 507 from the washing pipe 632, the water is jetted from nozzles and sprayed into each portion of the cooling vessel 507 without unevenness so that efficient washing can be performed. If necessary, the stirrer 575 may be operated.

[0189] If the water in the washing buffer tank 650 is used up, the operation of the washing circulation pump 631 is stopped, the circulation changeover valve 634 and the washing discharge valve 640B are opened, and the rinsing water is discharged from the washing water discharge passage 640. One rinsing step with the water has been described above. The predetermined number of the steps are repeatedly performed as needed.

[0190] The rinsing step with the hot water is basically an operation similar to that of the above rinsing step with the water, and is different only in that the high-temperature water is supplied instead of the water. That is, in the rinsing step with the water, the water supply valve 654B is opened to supply the water. However, in the rinsing step with the hot water, the hot water supply valve 602 is opened to thereby supply the high-temperature water stored in the hot water storage tank 530 to the washing buffer tank 650 via the washing hot water supply pipe 600. Description of another similar operation is omitted.

[0191] In the washing step with the detergent, the washing discharge valve 640B and the circulation changeover valve 634 are closed, and the washing circulation pump 631 is stopped. In this state, the hot water supply valve 602 is opened, and a predetermined amount of hot water is supplied to the washing buffer tank 650 via the washing hot water supply pipe 600. Moreover, a detergent supply pump (not shown) is driven to supply the predetermined amount of the predetermined type of detergent to the washing buffer tank 650 via the detergent supply pipe 652. The type and the amount of the supplied detergent are determined beforehand in accordance with the steps, and the amount of the detergent is adjusted in accordance with a driving time of the detergent supply pump (not shown).

[0192] When the amount of the hot water (the mixture liquid of the hot water and the detergent) in the washing buffer tank 650 reaches a predetermined value, the hot water supply valve 602 is closed, and the circulation pump 631 is brought into the operative state. In consequence, the detergent passes through the washing pipe 632 from the washing buffer tank 650, and is supplied into the cooling vessel 507. To inject the washing liquid into the cooling vessel 507 from the washing pipe 632, the washing liquid is jetted from nozzles and sprayed into each portion of the cooling vessel 507 without unevenness so that the efficient washing can be performed. If necessary, the stirrer 575 may be operated.

[0193] If the washing liquid in the washing buffer tank 650 is used up, the operation of the washing circulation pump 631 is stopped. The circulation changeover valve 634 and the washing discharge valve 640B remain to be closed until the predetermined amount of the washing liquid is stored in the cooling vessel 507. The hot water supply valve 602 is opened again, and the predetermined amount of the hot water is supplied into the washing buffer tank 650. Subsequently, the hot water supply valve 602 is closed, the washing circulation pump 631 is driven, and the hot water is supplied into the cooling vessel 507. This operation is repeated. Here, the amount of the hot water supplied and stored in the cooling vessel 507 can be known from the capacity of the buffer tank 650 and the number of the repeated operations. Therefore, in a case where the number of the times when the hot water is stored in the buffer tank 650 is determined beforehand, an appropriate amount can be controlled.

[0194] After the predetermined amount of the washing liquid (the mixture liquid of the hot water and the detergent) is stored in the cooling vessel 507, the circulation changeover valve 634 is opened, and the washing circulation pump 631 is driven for a predetermined time. The washing liquid successively flows from the cooling vessel 507 to the takeout valve 552B, the circulation changeover valve 634, the washing return pipe 635, the washing circulation pump 631 and the washing pipe 632 to return to the cooling vessel 507, and circulates through the circulation washing circuit 630. In consequence, dirt of the milk in the cooling vessel 507 can be removed. It is to be noted that to inject the washing liquid into the cooling vessel 507 from the washing pipe 632, the washing liquid is jetted from nozzles and sprayed into each portion of the cooling vessel 507 without unevenness so that efficient washing can be performed. If necessary, the stirrer 575 may be operated.

[0195] After the washing liquid is circulated for a predetermined time, the washing circulation pump 631 is stopped, the washing discharge valve 640B is opened, and the washing liquid is discharged from the circulation washing circuit 630 via the washing water discharge passage 640.

[0196] An operation of the sterilization step is basically similar to that of the washing step with the detergent, and is different only in that the detergent to be injected is the germicide, the water is used instead of the hot water and a different time for circulation or the like is set. The sterilization step is performed in accordance with the next use time, and a germicide liquid (a mixture liquid of the germicide and the water) is held in systems of the cooling vessel 507 and the circulation washing circuit 630 and left to stand for a predetermined time to improve a sterilization effect. Detailed description of an operation common to that of the rinsing step or the washing step with the detergent is omitted.

[0197] It is to be noted that in the standby state of the cold insulating operation, the expansion valve 514 is completely closed in order to reduce a thermal loss due to the incoming refrigerant in the evaporator 516. However, during the washing operation, especially when the washing with the hot water is performed, it is preferable to bring the expansion valve 514 into an open state in order to avoid an abnormally high pressure in the evaporator 516.

[0198] Moreover, in a case where a large hot water supply load is required and the only amount of the hot water generated by cooling the milk is insufficient, the hot water may be generated by performing the cooling operation even during the washing operation. For example, in the sterilization step, while the germicide liquid is held in the cooling vessel 507, the cooling operation is performed. In consequence, a hot water supply operation (a heat pump operation) can highly efficiently be performed using the germicide liquid as a heat source. Furthermore, if necessary, the water can be additionally introduced as the heat source into the cooling vessel 507 to perform the cooling operation (the hot water supply operation).

(6) Hot Water Supply Operation for Application other than Washing Application

[0199] Next, a hot water supply operation for an application other than the above washing application will be described. The hot water is supplied to a hot water supply load for the application other than the washing application by opening the hot water supply valve. When the hot water supply valve is opened, the high-temperature water stored in the hot water storage tank 530 flows through the mixture valve 610 from the upper portion of the hot water storage tank 530 via the high-temperature water takeout pipe 534A. Moreover, the water from the water supply unit 532, or the low-temperature water from the lower portion of the hot water storage tank 530 flows through the mixture valve 610 via the low-temperature water takeout pipe 534B connected to the lower portion of the hot water storage tank 530. Moreover, the mixture valve 610 mixes the high-temperature water and the water or the low-temperature water. After the temperature is adjusted into a predetermined temperature, the hot water is supplied to each hot water supply load facility via the hot water supply valve.

[0200] It is to be noted that the temperature of the hot water to be supplied is detected by the temperature sensor T3 disposed at the pipe which connects the mixture valve 610 to the hot water supply valve. It is to be noted that since the water supply valve is usually constantly opened, the city water having an amount corresponding to the amount of the hot water supplied to another hot water supply load facility is supplied into the hot water storage tank 530 of the hot water supply circuit 503 from the water supply pipe 532A of the water supply unit 532.

[0201] As described above, according to the refrigeration cycle device 500 of the present embodiment, at the same time the milk as the object to be cooled is cooled, the hot water is generated by effectively using the heat of the refrigerant circuit 502 on the high-temperature side, generated in the cooling process. Moreover, the high-temperature water can be supplied by using the transient critical cycle by use of the carbon dioxide refrigerant. This hot water can be used in washing the cooling vessel 507 and the like. Therefore, as compared with a conventional case in which the water is boiled with a boiler or the like to supply the hot water for the washing application, energy to be consumed can largely be reduced. Since the heat released from the high-temperature side of the refrigerant circuit 502 to the atmospheric air can be reduced, a rise of an ambient temperature can be inhibited.

(7) Hot Water Supply Operation by use of Second Refrigerant Circuit 508

[0202] Next, an operation of the second refrigerant circuit 508 will be described. The second refrigerant circuit 508 can perform a hot water supply operation (the heat pump operation) of absorbing the heat from a heat source such as air other than the milk in a case where a large hot water supply load is required and the only hot water obtained by cooling the milk is insufficient.

[0203] Since the operation of the second refrigerant circuit 508 is substantially the same as that of the refrigerant circuit 502, detailed description thereof is omitted. The operation is different from that of the refrigerant circuit 502 only in that the refrigerant in the evaporator 586 absorbs the heat from the atmospheric air. That is, in the evaporator 586, the refrigerant absorbs the heat from the atmospheric air, and the heat is rejected to the water passage 582 disposed so that the heat exchange between the water and the condenser 581 is performed. In consequence, the water flowing through the water passage 582 is heated, and the high-temperature water is generated.

[0204] During the hot water supply operation, the open degree of the expansion valve 584 is adjusted so that the temperature of the discharged refrigerant detected by the discharge temperature sensor T7 disposed at the high-pressure refrigerant pipe 590 of the second refrigerant circuit 508 indicates a predetermined value. Specifically, when the refrigerant temperature detected by the discharge temperature sensor T7 rises above the predetermined value, the open degree of the expansion valve 584 is enlarged. Conversely, when the refrigerant temperature detected by the discharge temperature sensor T7 drops below the predetermined value, the open degree of the expansion valve 584 is reduced. In consequence, a highly efficient operation can be performed on conditions preferable for an operation of generating the high-temperature water suitable for the washing application.

[0205] Next, an operation of the hot water supply circuit 503 during the hot water supply operation will be described. In this case, the three-way valve 547A is switched so that the water flows through the circulation pump 531 from the lower portion of the hot water storage tank 530, and the three-way valve 547B is switched so that the water passed through the flow rate adjustment valve 535 flows through the heat exchanger 513. During the hot water supply operation, the circulation pump 531 of the hot water supply circuit 503 is operated, and the low-temperature water or the water from the lower portion of the hot water storage tank 530 flows through the low-temperature pipe 547, the circulation pump 531 and the flow rate adjustment valve 535 to enter the inlet of the water passage 582 of the heat exchanger 583. In the heat exchanger 583, as described above, the water flowing through the water passage 582 is heated by the heat exchange between the water and the refrigerant flowing through the condenser 581 to generate the high-temperature water. Moreover, the high-temperature water exiting from the water passage 582 of the heat exchanger 583 successively flows through the high-temperature pipe 598 and the high-temperature pipe 548, and is injected into the hot water storage tank 530 from the upper portion of the hot water storage tank 530. The high-temperature water is injected from the upper portion of the hot water storage tank 530, and the low-temperature water is taken from the lower portion of the tank. Therefore, the high-temperature water is stored in an upper part of the hot water storage tank 530 and the low-temperature water is stored in a lower part of the tank by use of a density difference due to a water temperature difference.

[0206] Moreover, the flow rate adjustment valve 535 adjusts the flow rate of the water so that the temperature of the hot water at the outlet of the water passage 582 of the heat exchanger 583 indicates a predetermined value. Specifically, when the temperature of the hot water at the outlet of the water passage 582 is higher than the predetermined temperature, the open degree of the flow rate adjustment valve 535 is enlarged to increase the flow rate of the water. Conversely, when the temperature of the hot water at the outlet of the water passage 582 is lower than the predetermined temperature, the open degree of the flow rate adjustment valve 535 is reduced to decrease the flow rate of the water. The temperature of the hot water at the outlet of the water passage 582 is detected by the hot water temperature sensor T2 attached to the high-temperature pipe 548. Moreover, the predetermined temperature is a temperature suitable for the washing application or another hot water supply application. Specifically, it is preferable to set the temperature in a range of about 50 to 85°C in accordance with a use application.

[0207] As described above, the hot water supply operation of the second refrigerant circuit 508 is performed in a case where the amount of the hot water generated by the milk cooling operation falls short with respect to the required hot water supply load. A length of time when the hot water supply operation is performed, that is, the amount of the hot water to be generated is determined in accordance with the required amount of the hot water. However, when the hot water storage tank 530 is completely filled with the high-temperature water, the high-temperature water flows through the heat exchanger 513 from the lower portion of the hot water storage tank 530 during the cooling operation. The cooling capacity and efficiency remarkably deteriorate, and it is difficult to cool the milk. Therefore, during the hot water supply operation, the hot water storage tank 530 is not completely filled with the high-temperature water, and it is necessary to surely secure a cold water portion having an amount corresponding to an amount for use during the cooling operation in the lower part of the hot water storage tank 530.

[0208] The amount of the hot water to be stored in the hot water storage tank 530 during the hot water supply operation of the second refrigerant circuit 508 depends on conditions on which the refrigeration cycle device 500 is used, that is, the amount (a farming scale) of the milk, the amount of the hot water for use and the like. For example, when the amount of the hot water is 1/5 or less of that in the hot water storage tank 530, the hot water supply operation is started by the second refrigerant circuit 508. When the amount is 1/2 or more, the hot water supply operation of the second refrigerant circuit 508 is stopped. Such control is considered. It is to be noted that the amount of the hot water stored in the hot water storage tank 530 can be grasped by the stored hot water sensors T4.

[0209] As described above, since the refrigeration cycle device 500 of the present embodiment includes the second refrigerant circuit 508, the only hot water generated during the cooling of the milk cannot cover the required hot water supply load, the hot water supply operation is performed using the atmospheric air as the heat source. In consequence, the hot water can be generated to compensate for shortage. Therefore, an auxiliary boiler or the like for the additional hot water supply is not required. Moreover, heat pump hot water supply is highly efficiently performed. Therefore, energy consumption is further reduced.

(8) Changeover Operation of Three-Way Valve 547A

[0210] Next, an operation of the three-way valve 547A will be described. The three-way valve 547A prevents the low-temperature water from being passed through the upper portion of the hot water storage tank 530 to disturb thermal stratification in the hot water storage tank 530 during the starting and stopping of the cooling operation and the hot water supply operation. For a predetermined time TL1 after the start of the cooling operation or the hot water supply operation, the three-way valve 547A is blocked on a hot water storage tank 530 side, and switched so as to pass the hot water (or the water) through the circulation pump 531 from the bypass pipe 549. In consequence, for the predetermined time TL1 from the start of the cooling operation or the hot water supply operation, the hot water passed through the water passage 512 of the heat exchanger 513 or the water passage 582 of the heat exchanger 583 of the second refrigerant circuit 508 does not enter the hot water storage tank 530. The hot water flows through the closed circuit from the high-temperature pipe 548 via the bypass pipe 549, the three-way valve 547A and the circulation pump 531 to return to the water passage 512 of the heat exchanger 513 or the water passage 582 of the heat exchanger 583 of the second refrigerant circuit 508.

[0211] In addition, for a predetermined time TL2 from the start of the cooling operation or the hot water supply operation, the open degree of the flow rate adjustment valve 535 is fixed to a predetermined open degree so as to secure a sufficient flow rate. After elapse of the predetermined time TL2, the open degree is gradually reduced to decrease the flow rate. Finally, the open degree is adjusted so that the hot water temperature sensor T2 attached to the high-temperature pipe 548 indicates the predetermined value.

[0212] After elapse of the predetermined time TL1, the three-way valve 547A is blocked on a bypass pipe 549 side, and switched so as to pass the water through the circulation pump 531 from the lower portion of the hot water storage tank 530. As a result, the hot water flowing through the water passage 512 of the heat exchanger 513 or the water passage 582 of the heat exchanger 583 of the second refrigerant circuit 508 enters the hot water storage tank 530.

[0213] As the predetermined times TL1 and TL2, a certain time may be determined beforehand. Alternatively, the operation may be performed based on the temperature of the hot water at the outlet of the heat exchanger 513 or the heat exchanger 583 of the second refrigerant circuit 508, detected by the hot water temperature sensor T2. At the start of the cooling operation, the flow rate adjustment valve 535 is fixed to the predetermined open degree. When the outgoing hot water temperature rises to a predetermined value or more, the open degree of the flow rate adjustment valve 535 is gradually reduced. Furthermore, when the outgoing hot water temperature rises to a second predetermined temperature, the three-way valve 547A may be blocked on the bypass pipe 549 side, and switched so as to pass the water through the circulation pump 531 from the lower portion of the hot water storage tank 530.

[0214] As described above, it is possible to avoid a problem that the thermal stratification of the hot water already stored in the hot water storage tank 530 is disturbed to lower the temperature of the stored hot water. As a result, the thermal loss of the stored hot water can be reduced, and the hot water can effectively be used.

[0215] Moreover, the outgoing hot water temperature is not controlled by the flow rate adjustment valve 535 at the start of the cooling operation or the hot water storage operation. The sufficient flow rate is secured at the constant open degree of the valve. Therefore, it is possible to avoid an abnormal discharge temperature rise and an abnormally high pressure immediately after the compressor 510 (or the compressor 580) is started.

[0216] On the other hand, even immediately after the stopping of the cooling operation or the hot water supply operation, when a predetermined time elapses after the stopping of the operation of the compressor 510 (or the compressor 580) or the outgoing hot water indicates the predetermined value or less, the three-way valve 547A is blocked on the hot water storage tank 530 side, and switched so as to pass the hot water (or the water) through the circulation pump 531 from the bypass pipe 549. Subsequently, the circulation pump 531 is operated for a predetermined time. In consequence, the hot water passed through the water passage 512 of the heat exchanger 513 or the water passage 582 of the heat exchanger 583 of the second refrigerant circuit 508 does not enter the hot water storage tank 530. The hot water flows through the closed circuit from the high-temperature pipe 548 via the bypass pipe 549, the three-way valve 547A and the circulation pump 531 to return to the water passage 512 of the heat exchanger 513 or the water passage 582 of the heat exchanger 583 of the second refrigerant circuit 508.

[0217] Therefore, it is possible to prevent the low-temperature water from being passed from the upper portion of the hot water storage tank 530 into the hot water storage tank 530 to disturb the thermal stratification in the hot water storage tank 530. Moreover, the heat exchanger 513 or the heat exchanger 583 of the second refrigerant circuit 508 can appropriately be cooled.

[0218] It is to be noted that, when the usual cooling operation or hot water supply operation is performed except during the starting and stopping, the three-way valve 547A is blocked on the bypass pipe 549 side, and switched so as to pass the water through the circulation pump 531 from the lower portion of the hot water storage tank 530. When the cooling operation or the hot water supply operation is not performed, the three-way valve 547A is blocked on the hot water storage tank 530 side, and switched so as to communicate on the bypass pipe 549 side. When the cooling operation or the hot water supply operation is not performed, the valve is switched to the above state. In consequence, when the high-temperature water is supplied to the washing application or the like, the cold water entering the lower portion of the hot water storage tank 530 from the water supply unit 532 flows through the hot water storage circuit 505 on the heat exchanger 513 side or the side of the heat exchanger 583 of the second refrigerant circuit 508 to enter the upper portion of the hot water storage tank 530 and lower the temperature of the hot water to be supplied.

[0219] Next, an operation of discharging the water from the hot water storage tank 530 will be described. The operation is performed by the discharge unit 536 connected below the high-temperature water takeout port 537 connected to the high-temperature water takeout pipe 534A of the hot water storage tank 530 and above the low-temperature water takeout port 538 connected to the low-temperature water takeout pipe 534B. The hot water discharge valve 536B disposed at the hot water discharge pipe 536A of the discharge unit 536 is usually closed. In this state, it is assumed that the water is not discharged from the hot water storage tank 530 via the hot water discharge pipe 536A.

[0220] Moreover, during the cooling operation, when the temperature of the water (the temperature of the water at the inlet of the water passage 512 of the heat exchanger 513) to be circulated through the heat exchanger 513 for the heat exchange between the condenser 511 and the water of the hot water storage tank 530 rises to the predetermined value or more, the hot water discharge valve 536B of the hot water discharge pipe 536A is opened. In consequence, the medium-temperature water having a temperature which is lower than that of the hot water taken from the high-temperature water takeout port 537 of the hot water storage tank 530 and higher than that of the water taken from the low-temperature water takeout port 538 is discharged from the hot water storage tank 530 via the hot water discharge pipe 536A.

[0221] At the same time the hot water is discharged from the hot water discharge pipe 536A, the amount of the cold water corresponding to the amount of the discharged hot water is supplied into the hot water storage tank 530 via the water supply pipe 532A. It is to be noted that in the refrigeration cycle device 500 of the present embodiment, when the temperature of the water at the inlet of the water passage 512 of the heat exchanger 513 rises to a predetermined value or more, for example, 25°C to 30°C or more, the water is discharged from the hot water storage tank 530 by the discharge unit 536. However, the temperature at which the water is discharged from the hot water storage tank 530 by the discharge unit 536 is not limited to the temperature of the water at the inlet of the water passage 512 of the heat exchanger 513. The temperature may be the temperature of the water stored in the hot water storage tank 530, detected by the stored hot water sensors T4, the temperature of the refrigerant in the condenser 511 of the heat exchanger 513 or the temperature of the refrigerant discharged from the condenser 511. The hot water discharged from the hot water storage tank 530 from the hot water discharge pipe 536A may be used in an appropriate application if any.

[0222] When the hot water is discharged from the hot water storage tank 530 from the hot water discharge pipe 536 and the amount of the cold water corresponding to the amount of the discharged hot water is simultaneously supplied into the hot water storage tank 530, the temperature of the hot water stored in the lower part of the hot water storage tank 530 can be lowered. The hot water at the lowered temperature in the lower part of the hot water storage tank 530 or the cold water supplied from the water supply unit 532 to the hot water storage tank 530 can be supplied to the heat exchanger 513.

[0223] In consequence, in the heat exchanger 513, it is possible to secure the amount of the heat to be rejected as required for the refrigerant to maintain the cooling function of the evaporator 516. That is, in the heat exchanger 513, the heat of the refrigerant flowing through the condenser 511 can sufficiently be released to the water flowing through the water passage 512 to lower the temperature of the refrigerant. Therefore, the cooling capacity of the evaporator 516 can be maintained, and the object to be cooled (the milk) can securely be cooled.

[0224] It is to be noted that as the present invention that can be grasped from the above description, in addition to the inventions described in claims, the following is considered. That is, the second invention is also directed to a refrigeration cycle device including a high-temperature water takeout port disposed at an upper portion of the hot water storage tank and a low-temperature water takeout port disposed at a lower portion of the hot water storage tank, wherein a discharge unit is disposed below the high-temperature water takeout port and above the low-temperature water takeout port.

[0225] The present invention is usable in not only the device which cools and insulates the milk immediately after drawn as in Embodiment 5 but also another industrial field such as a cooling device related to processing of food and the like, an automatic dispenser or an air conditioner in which cooling and cold insulating are demanded.

Claims

1. A refrigeration cycle device which is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator and which exhibits a heating function by heat rejected from the condenser and which exhibits a cooling function by heat absorption of the evaporator,
wherein an operation to secure a predetermined amount of heat to be rejected from the condenser is executed in order to maintain the cooling function of the evaporator based on an index capable of grasping the amount of the heat to be rejected from the condenser.

2. A refrigeration cycle device which is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator; and a hot water storage tank and which performs heat exchange between water stored in the hot water storage tank and the condenser to generate hot water by heat rejected from the condenser and store the hot water in the hot water storage tank and which exhibits a cooling function by heat absorption of the evaporator,
the device comprising: a water supply unit which supplies water into the hot water storage tank; and a discharge unit which discharges the water from the hot water storage tank,
wherein in a case where a temperature of the water stored in the hot water storage tank, a temperature of water to be circulated through a heat exchanger which performs heat exchange between the condenser and the water stored in the hot water storage tank, a temperature in the condenser or a temperature of a refrigerant discharged from the condenser rises to a predetermined value or more, the water is discharged from the hot water storage tank by the discharge unit.

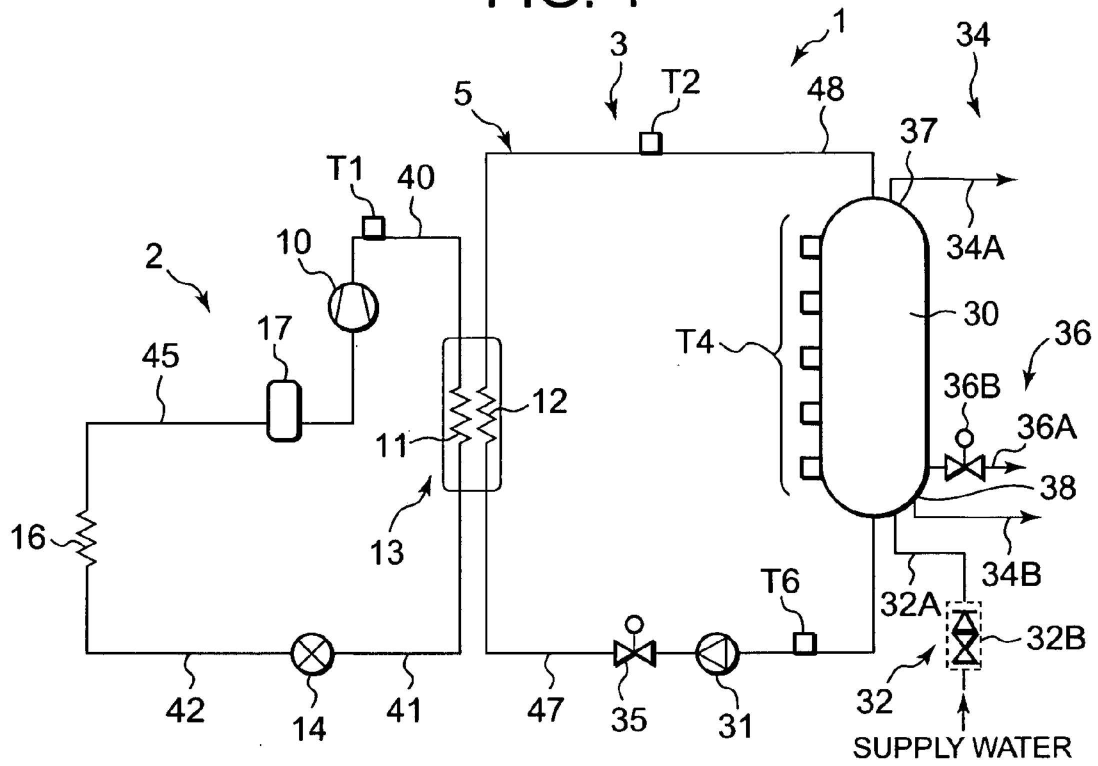
3. A refrigeration cycle device which is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator and which performs heat exchange between water and the condenser to generate hot water by heat rejected from the condenser and which exhibits a cooling function by heat absorption of the evaporator,
the device comprising: a water cooling unit which cools the water to be subjected to the heat exchange between the water and the condenser,
wherein in a case where a temperature of the water to be subjected to the heat exchange between the water and the condenser, a temperature in the condenser or a temperature of a refrigerant discharged from the condenser rises to a predetermined value or more, the water is cooled by the water cooling unit.

4. A refrigeration cycle device which is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator and which performs heat exchange between water and the condenser to generate hot water by heat rejected from the condenser and which exhibits a cooling function by heat absorption of the evaporator,
the device comprising: a second condenser which cools a refrigerant discharged from the condenser,
wherein in a case where a temperature of the water to be subjected to the heat exchange between the water and the condenser, a temperature in the con-

denser or a temperature of the refrigerant discharged from the condenser rises to a predetermined value or more, the refrigerant discharged from the condenser is cooled by the second condenser.

5. A refrigeration cycle device which is provided with a refrigerant circuit including a compressor, a condenser, a throttling means and an evaporator and which performs heat exchange between water and the condenser to generate hot water by heat rejected from the condenser and which exhibits a cooling function by heat absorption of the evaporator,
the device comprising: a second condenser connected to the condenser and disposed in parallel with the condenser,
wherein in a case where a temperature of the water to be subjected to the heat exchange between the water and the condenser, a temperature in the condenser or a temperature of a refrigerant discharged from the condenser rises to a predetermined value or more, the refrigerant is passed through the second condenser.

FIG. 1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T2
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11
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T4
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T6
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32B
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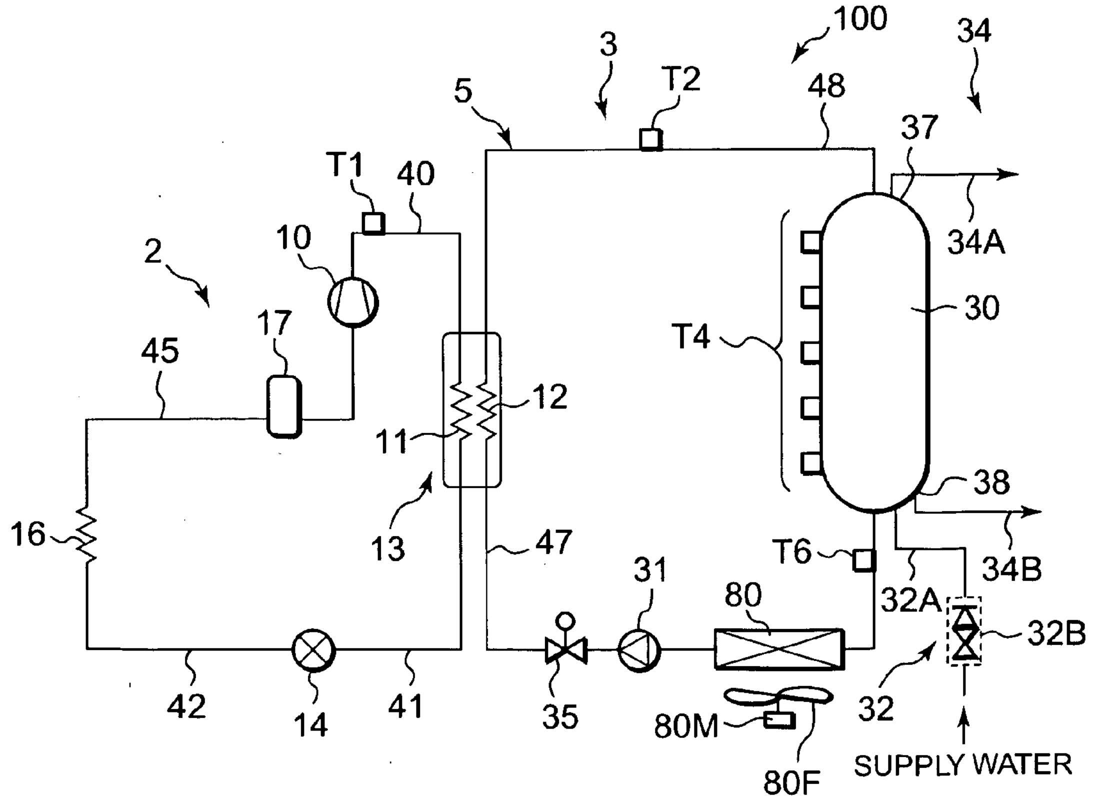
31
SUPPLY WATER

FIG. 2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16
47
T6
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32A
32B
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14
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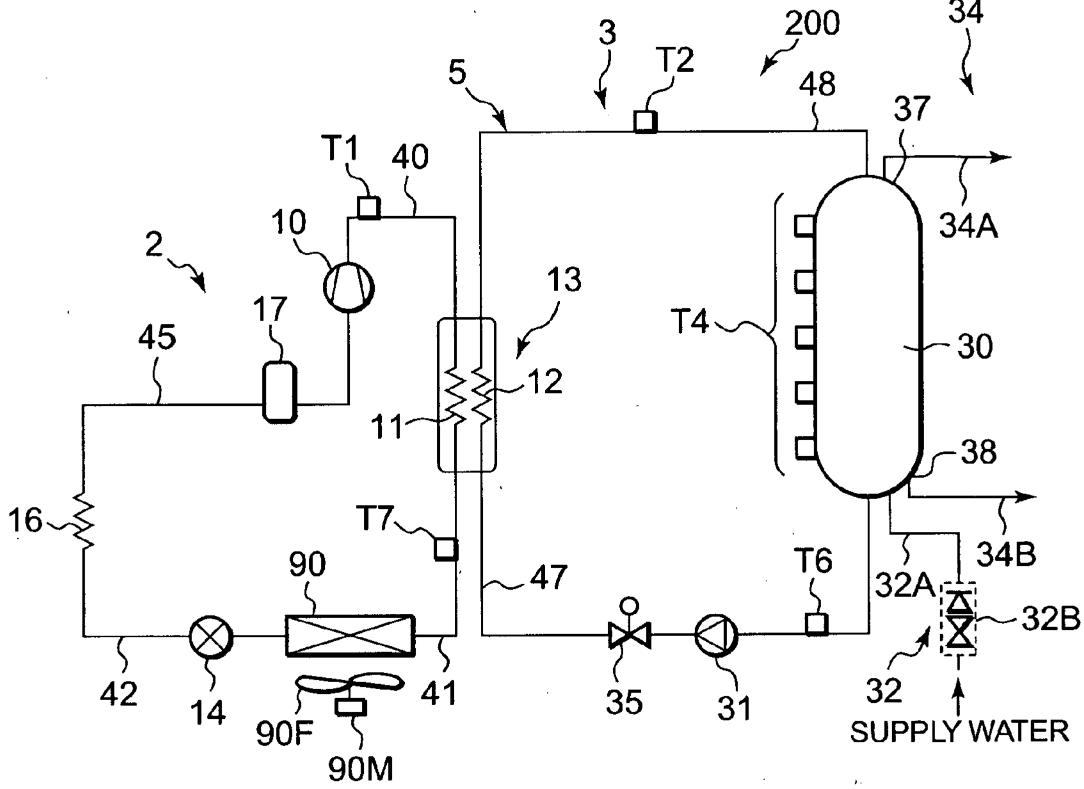
80M
80F
32
SUPPLY WATER

FIG. 3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T1
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38
16
T7
34B
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T6
32A
32B
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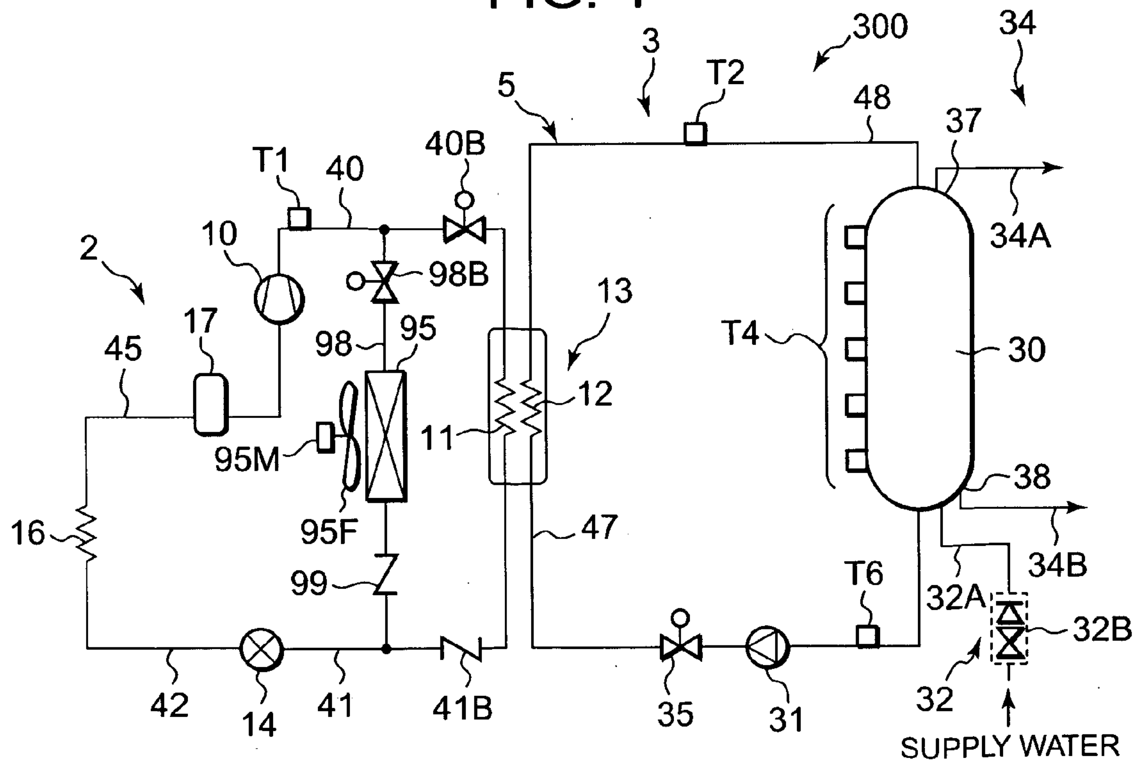
14
41
35
31
32
90F
SUPPLY WATER
90M

FIG. 4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30
12
95M
11
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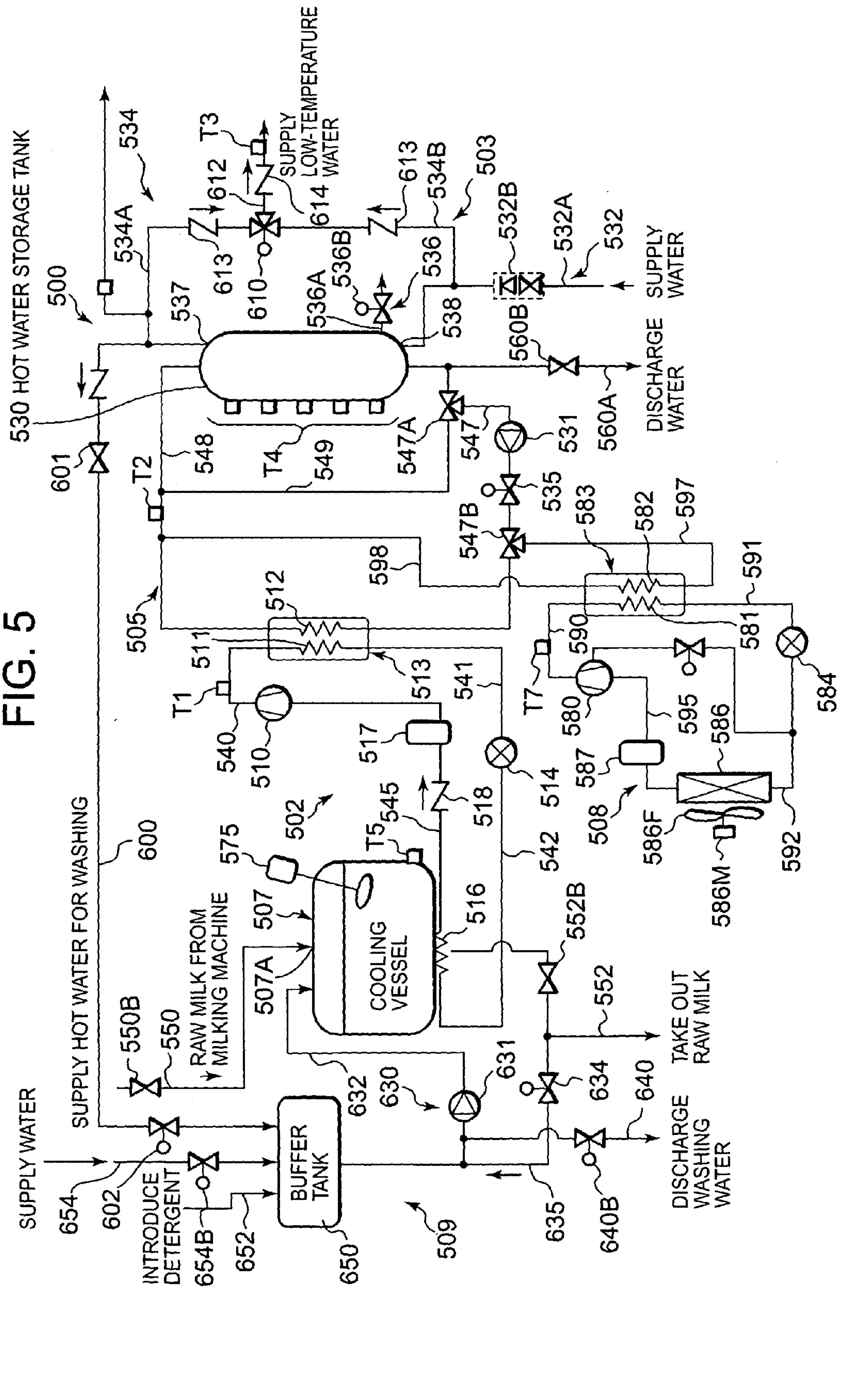
32
SUPPLY WATER


530 HOT WATER STORAGE TANK
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534
534A
537
T3
612
SUPPLY LOW-TEMPERATURE WATER
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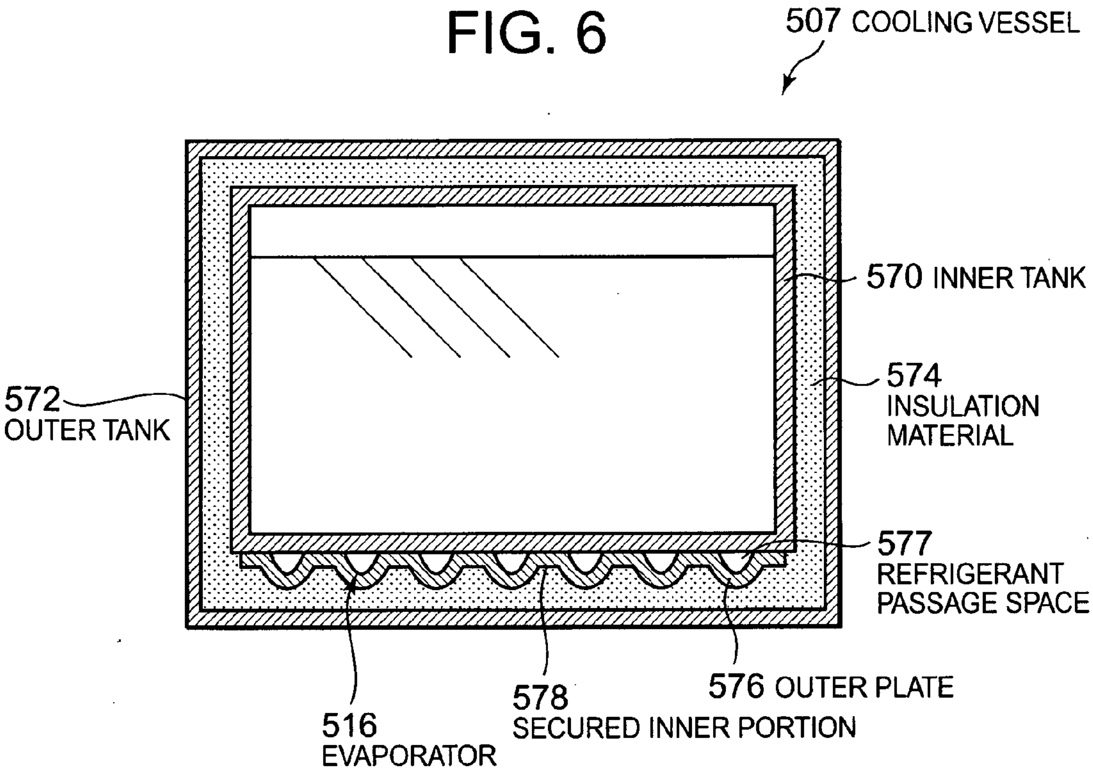
536A
536
538
613
534B
503
532B
532A
532
SUPPLY WATER
560B
DISCHARGE WATER
560A
601
T2
548
T4
549
547A
547
531
535
547B
583
582
597
598
505
512
511
513
541
T1
540
510
517
545
518
514
T7
590
580
595
587
586
581
591
584
508
586F
586M
592
600
SUPPLY HOT WATER FOR WASHING
575
T5
502
507
507A
RAW MILK FROM MILKING MACHINE
COOLING VESSEL
516
542
552B
552
TAKE OUT RAW MILK
550B
550
632
630
631
634
640
SUPPLY WATER
654
602
INTRODUCE DETERGENT
654B
652
BUFFER TANK
650
509
635
640B
DISCHARGE WASHING WATER

FIG. 5

FIG. 6


507 COOLING VESSEL
570 INNER TANK
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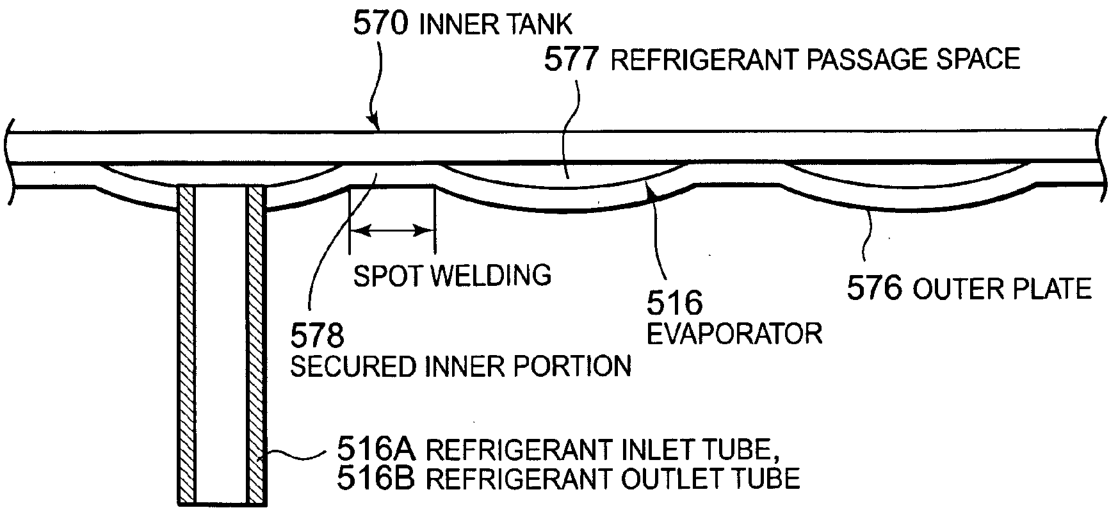
OUTER TANK
574
INSULATION
MATERIAL
577
REFRIGERANT
PASSAGE SPACE
576 OUTER PLATE
578
SECURED INNER PORTION
516
EVAPORATOR

FIG. 7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577 REFRIGERANT PASSAGE SPACE
SPOT WELDING
516
EVAPORATOR
576 OUTER PLATE
578
SECURED INNER PORTION
516A REFRIGERANT INLET TUBE,
516B REFRIGERANT OUTLET TUBE

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2005106360 A **[0004]**