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(19) **United States**(12) **Patent Application Publication**
Takahashi et al.(10) **Pub. No.: US 2012/0055178 A1**(43) **Pub. Date: Mar. 8, 2012**(54) **HEAT PUMP APPARATUS AND METHOD
FOR CONTROLLING REGULATING VALVE**(52) **U.S. Cl. 62/79; 62/189; 62/506**(57) **ABSTRACT**(75) **Inventors:** **Kengo Takahashi**, Tokyo (JP); **Ryo Oya**, Tokyo (JP); **Kazuki Okada**, Tokyo (JP); **Takahiro Ushijima**, Tokyo (JP); **Hirokazu Minamisako**, Tokyo (JP); **Shinichi Uchino**, Tokyo (JP)(73) **Assignee:** **mitsubishi electric corporation**, Tokyo (JP)(21) **Appl. No.:** **13/320,845**(22) **PCT Filed:** **May 18, 2009**(86) **PCT No.:** **PCT/JP2009/059138**§ 371 (c)(1),
(2), (4) Date: **Nov. 16, 2011****Publication Classification**(51) **Int. Cl.**
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It is aimed to provide a heat pump type hot-water supply outdoor apparatus that can control a temperature of a compressor shell, according to a water temperature of a water circuit and a temperature of the compressor. A heat pump type hot-water supply outdoor apparatus includes a refrigeration cycle including a compressor, a water-refrigerant heat exchanger, an expansion valve, and an air heat exchanger, a water jacket that is arranged on the shell of the compressor and connected in the middle of a branch water circuit branching in parallel to a main water circuit which starts from a hot water storage tank and returns to the hot water storage tank through a water-refrigerant heat exchanger, a water flow valve that is connected between a branch and the water jacket and regulates the quantity of water flow, according to a control signal, a shell temperature detection sensor that senses a temperature of the shell of the compressor, a water temperature sensor that is installed in the vicinity of the branch and senses a temperature of the water flowing out of the hot water storage tank, and a control apparatus that generates a control signal for controlling the water flow valve, based on the temperature sensed by the shell temperature detection sensor and the temperature sensed by the water temperature sensor, and outputs it to the water flow valve.

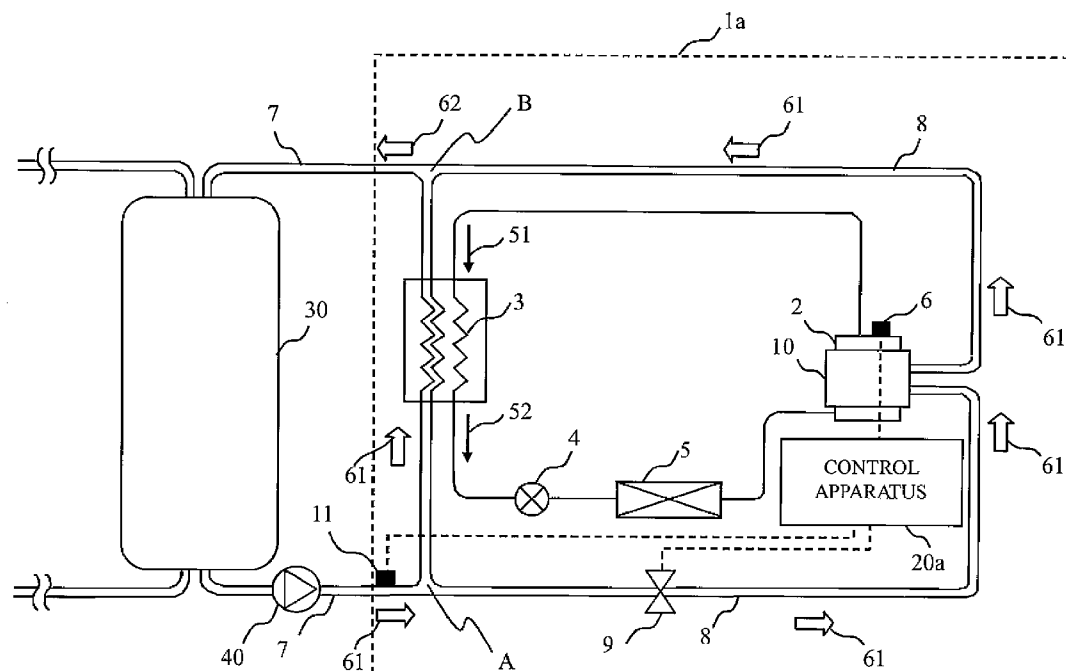


Fig. 2

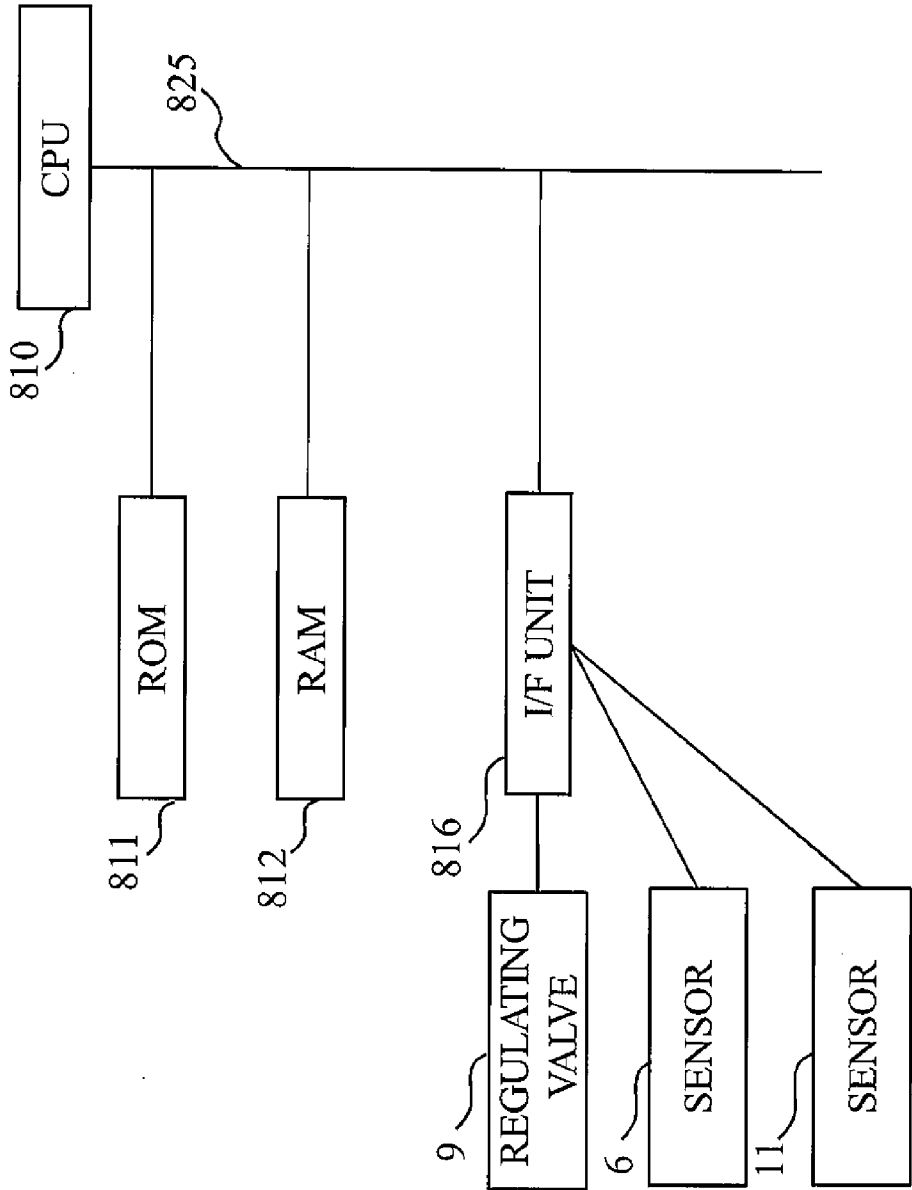


Fig. 3

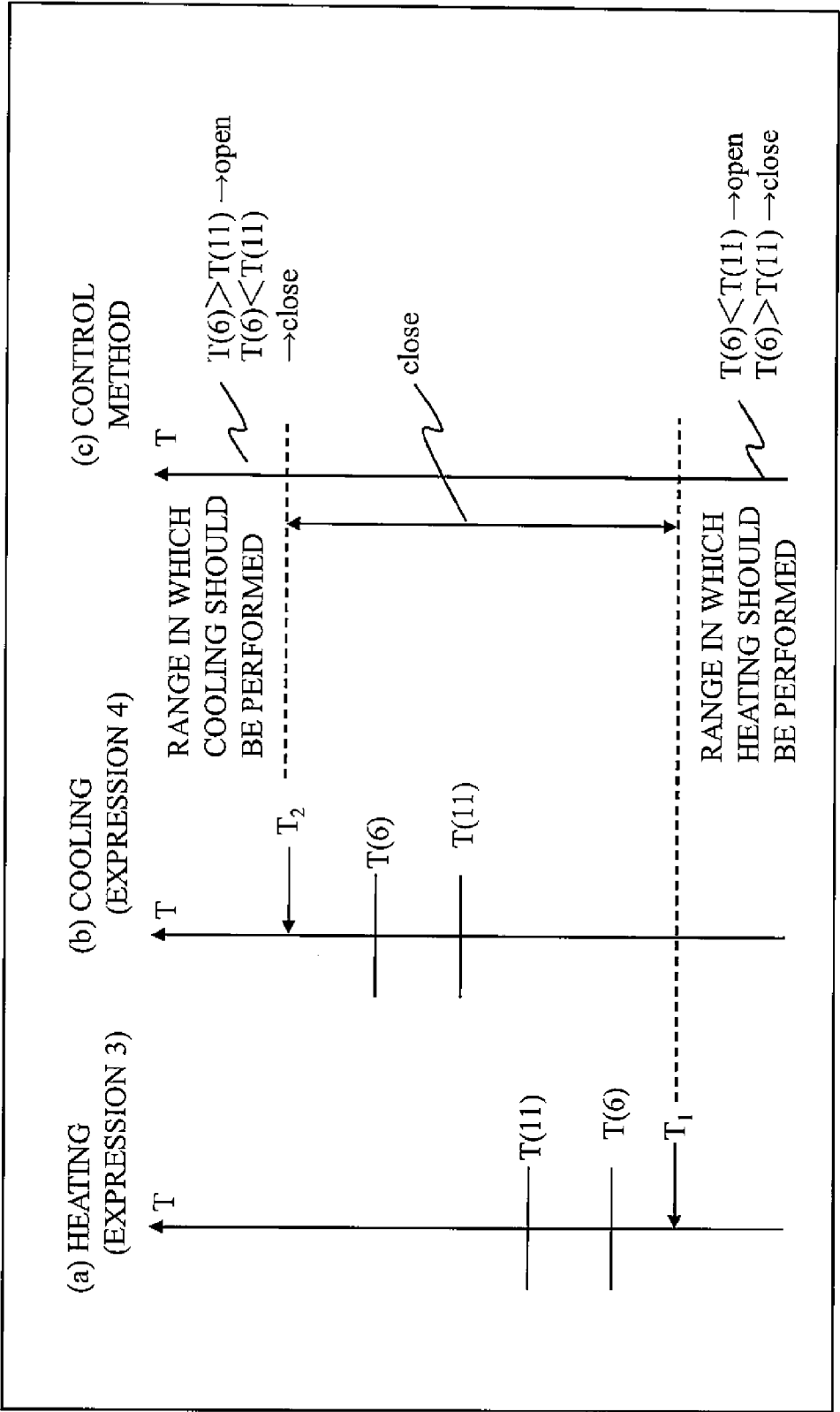


Fig. 4

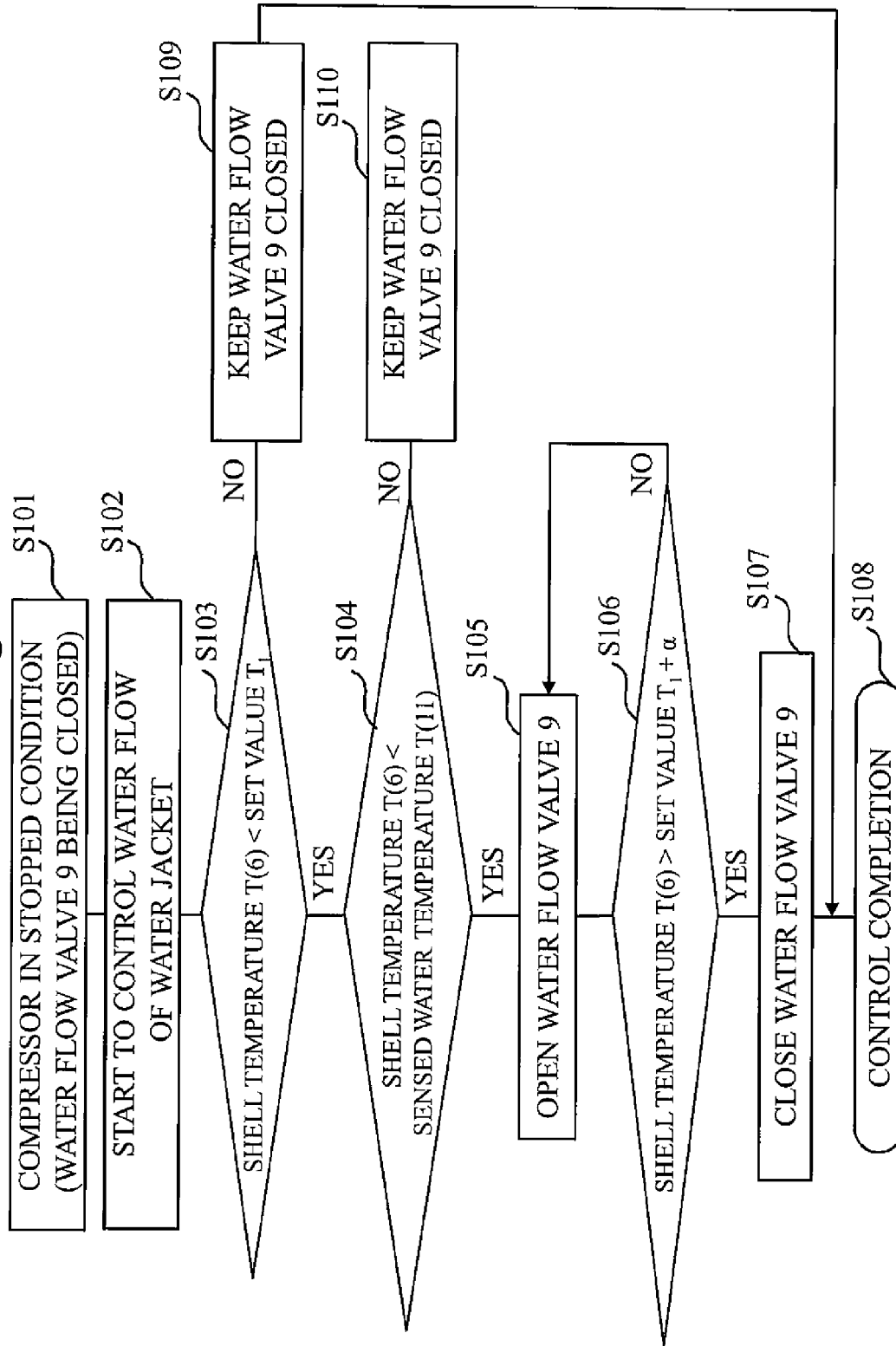


Fig. 5

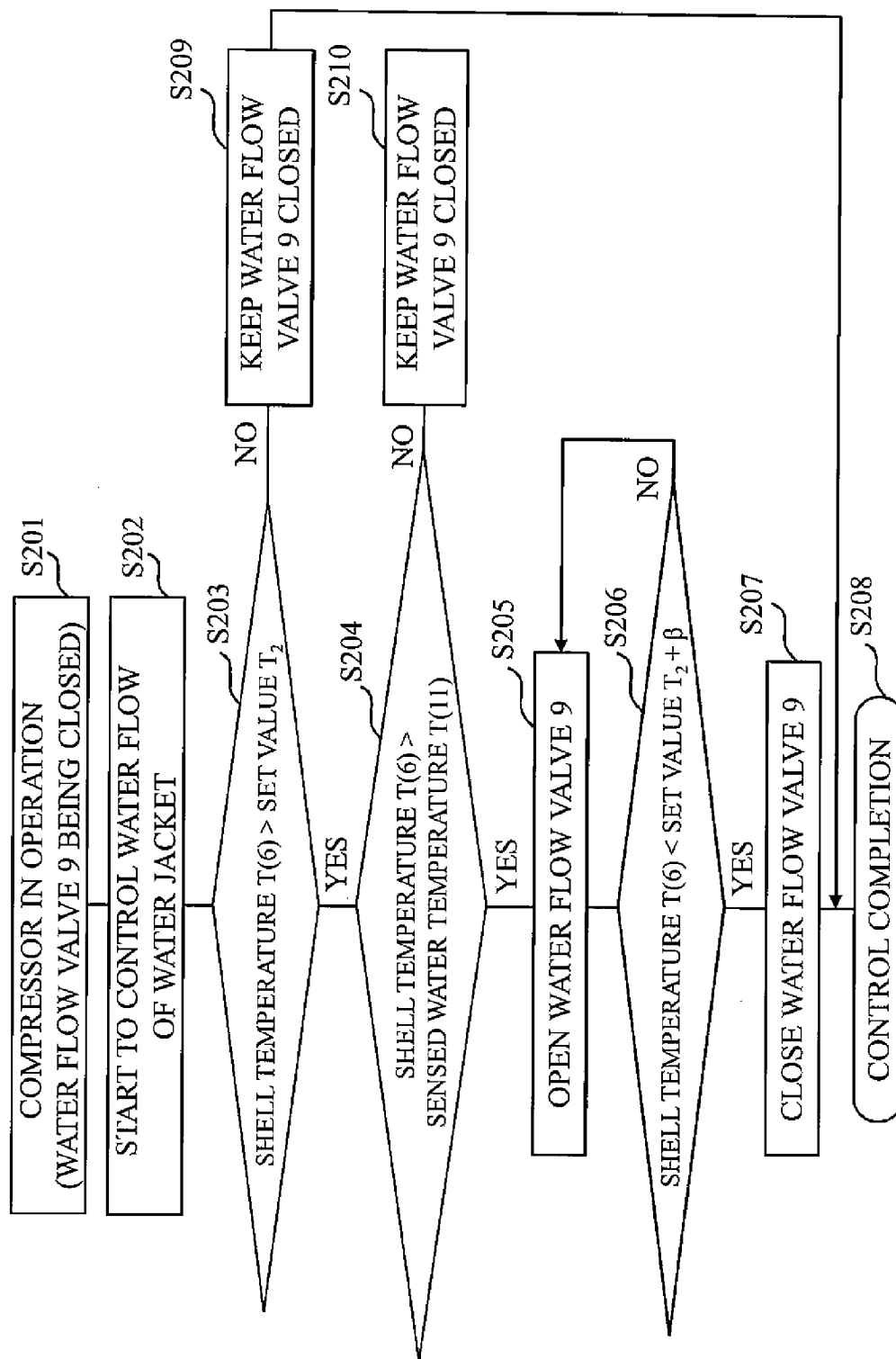


Fig. 6

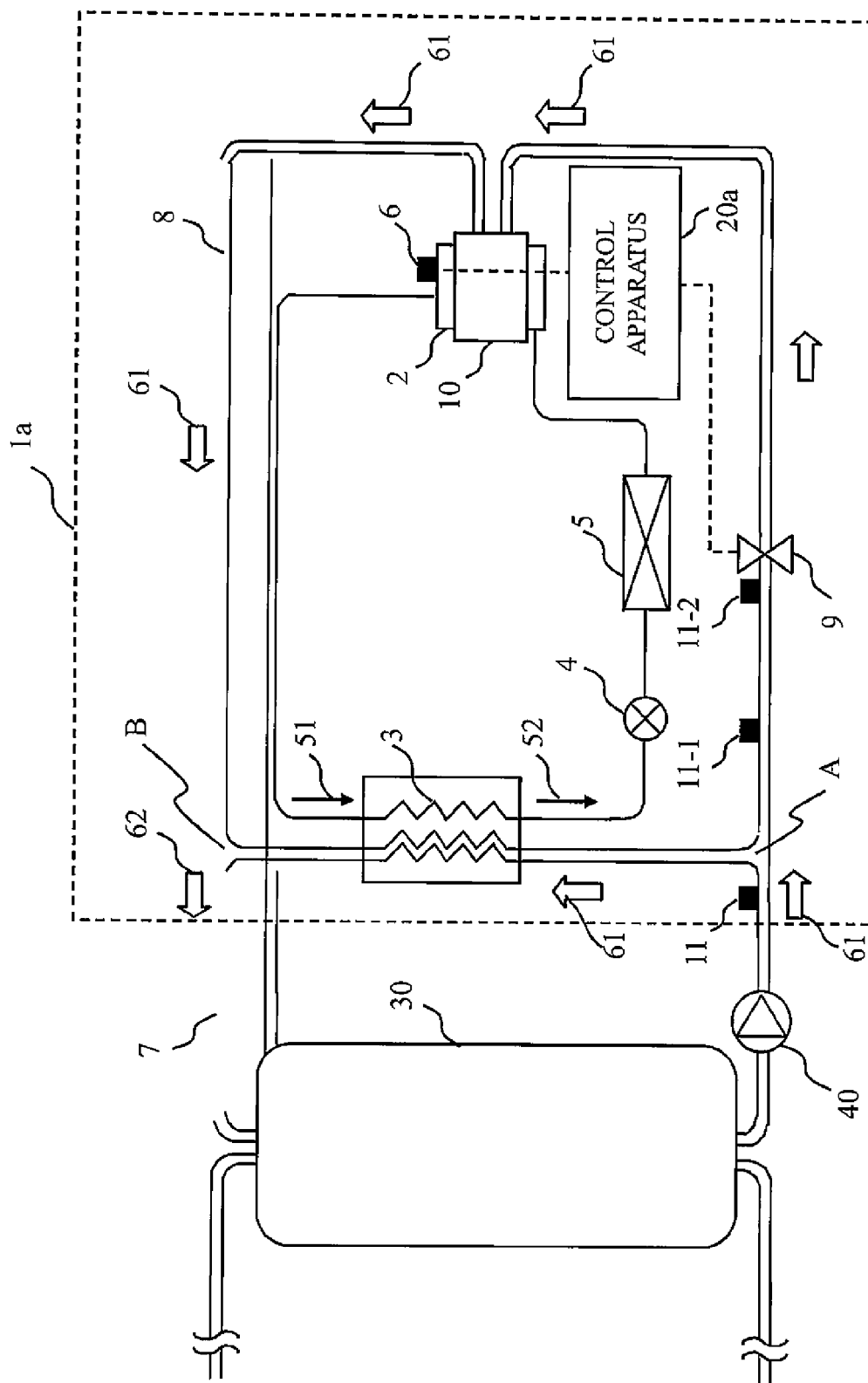
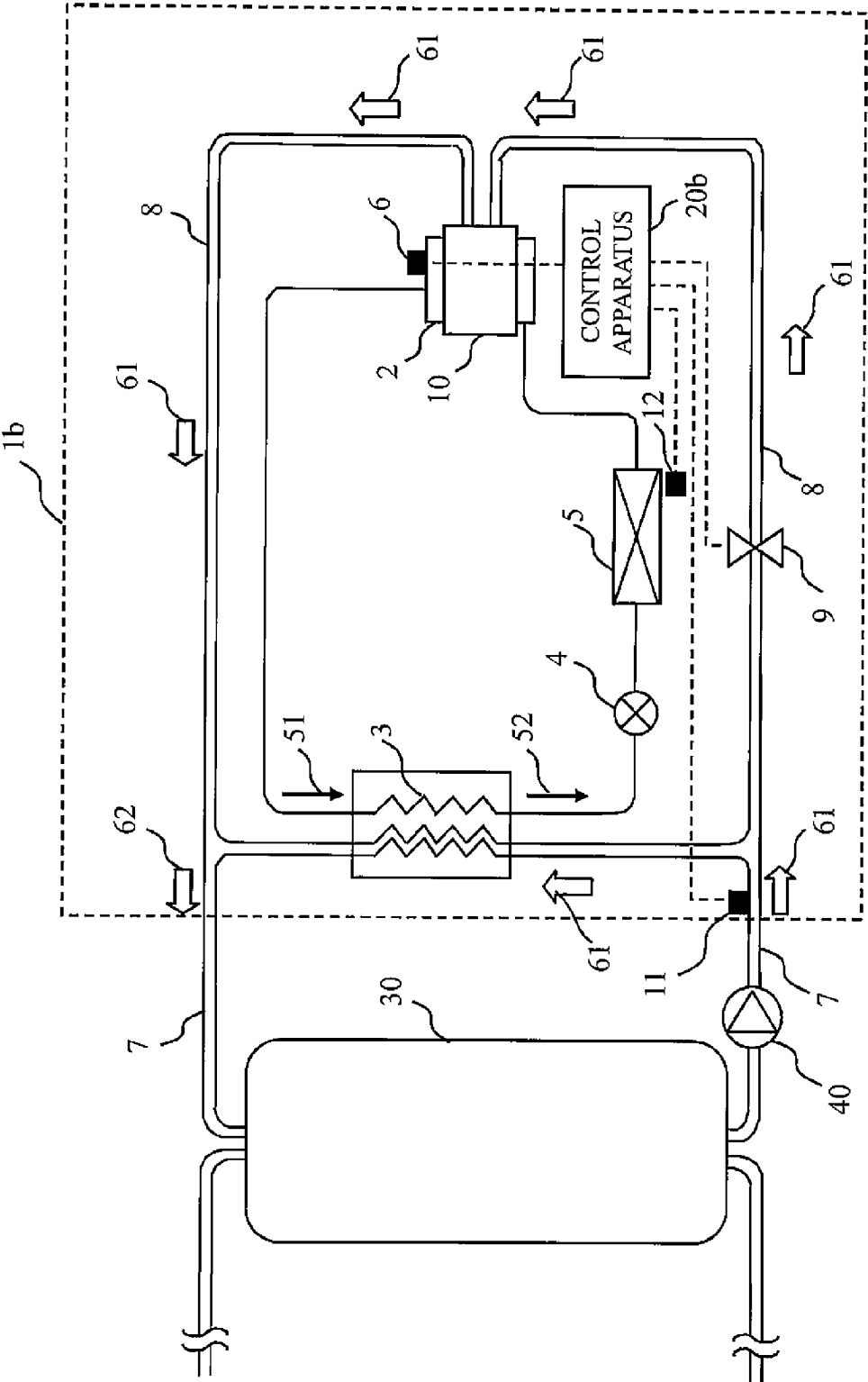


Fig. 7



HEAT PUMP APPARATUS AND METHOD FOR CONTROLLING REGULATING VALVE

TECHNICAL FIELD

[0001] The present invention relates to a heat pump type hot-water supply outdoor apparatus.

BACKGROUND ART

[0002] Since a compressor of a refrigeration cycle becomes a high temperature during the operation, it is sometimes expected to cool the compressor (Patent Literature 1). Moreover, as a measure for the state of refrigerant being accumulated (called accumulation/liquefaction) in the compressor, it is sometimes expected to heat the compressor (Patent Literature 2).

(Cooling)

[0003] In a conventional heat pump type hot-water supply outdoor apparatus, a water jacket connected to a flow passage branching from a water circuit is twisted around a compressor. The temperature of the water jacket is controlled by measuring an outlet temperature of the water jacket with a temperature sensor (e.g., Patent Literature 1).

(Heating)

[0004] There is disclosed a technique wherein a heating unit using warm water is provided at the lower part of a compressor, and the flow quantity of warm water to the heating unit is controlled based on a temperature sensed by a temperature sensor that detects a shell temperature of the compressor (e.g., Patent Literature 2).

CITATION LIST

Patent Literature

- [0005]** Patent Literature 1: Japanese Unexamined Patent Publication No. 2002-372318 (page 5, FIG. 5)
[0006] Patent Literature 2: Japanese Unexamined Patent Publication No. 2007-298254 (page 11, FIG. 1)

SUMMARY OF INVENTION

Technical Problem

[0007] According to Patent Literature 1, the quantity of water inflowing to the water jacket which is used for the compressor of the heat pump type hot-water supply outdoor apparatus is controlled based on a temperature sensed by a temperature sensor provided at the outlet of the water-jacket. For this reason, there is a problem that it is impossible to control the temperature of the compressor shell according to both the temperature of the water flowing into the water jacket and the temperature of the compressor shell.

[0008] Further, there is another problem that when the quantity of water inflowing to a water jacket is controlled based on only a temperature of the compressor shell, it is only possible to have either one of the functions of heating and cooling the compressor shell.

[0009] It is an object of the present invention to provide a heat pump type hot-water supply outdoor apparatus capable of controlling the temperature of the compressor shell according to the temperature of water and the temperature of the compressor.

[0010] Furthermore, it is another object of the present invention to provide a heat pump type hot-water supply outdoor apparatus having a function of switching between heating and cooling of the compressor shell.

Solution to Problem

[0011] A heat pump apparatus according to the present invention includes

[0012] a refrigeration cycle that includes a compressor, a condenser, an expansion valve, and an evaporator,

[0013] a water jacket that is arranged on a shell of the compressor and connected in a middle of a branch path branching in parallel to a main circuit which starts flowing from a hot water storage tank to the condenser and returns to the hot water storage tank from the condenser and branching at a branch located at an inlet side of the condenser and at a branch located at an outlet side of the condenser in the main circuit, and that lets water flowing out from the hot water storage tank pass through the water jacket itself,

[0014] a regulating valve that is connected in a middle of the branch path between the branch at the inlet side and the water jacket, and regulates, according to a control signal having been input, a water flow quantity,

[0015] a first temperature sensor that senses a temperature of the shell of the compressor,

[0016] a second temperature sensor that is installed upstream of the regulating valve and senses a temperature of water flowing out from the hot water storage tank, and

[0017] a control apparatus that generates the control signal for controlling the regulating valve, based on the temperature sensed by the first temperature sensor and the temperature sensed by the second temperature sensor, and outputs the control signal having been generated to the regulating valve.

[0018] The second temperature sensor is installed at one of positions in a vicinity of the branch at the inlet side, in a vicinity of the branch path between the branch at the inlet side and the regulating valve, and in a vicinity and upstream of the regulating valve.

[0019] The heat pump apparatus further includes a third temperature sensor that senses a temperature of an ambient air,

[0020] wherein the control apparatus generates the control signal, based on the temperature sensed by the first temperature sensor, the temperature sensed by the second temperature sensor, and the temperature sensed by the third temperature sensor, and outputs the control signal having been generated to the regulating valve.

[0021] The control apparatus calculates an ambient air temperature increase rate, which indicates an increase rate of an ambient air temperature, based on the temperature sensed by the third temperature sensor, and a shell temperature increase rate, which indicates an increase rate of a temperature of the shell of the compressor, based on the temperature sensed by the first temperature sensor, and generates a temperature increase rate dependent control signal, which is a second control signal for controlling the regulating valve, based on a high-low relation between the ambient air temperature increase rate and the shell temperature increase rate.

[0022] A method, according to the present invention, for controlling a regulating valve in a heat pump apparatus provided with a refrigeration cycle that includes a compressor, a

condenser, an expansion valve, and an evaporator; a water jacket that is arranged on a shell of the compressor and connected in a middle of a branch path branching in parallel to a main circuit which starts flowing from a hot water storage tank to the condenser and returns to the hot water storage tank from the condenser and branching at a branch located at an inlet side of the condenser and at a branch located at an outlet side of the condenser in the main circuit, and that lets water flowing out from the hot water storage tank pass through the water jacket itself, the regulating valve that is connected in a middle of the branch path between the branch at the inlet side and the water jacket, and, by being controlled, regulates a water flow quantity, a first temperature sensor that senses a temperature of the shell of the compressor, and a second temperature sensor that is installed upstream of the regulating valve and senses a temperature of water flowing out from the hot water storage tank, the method includes

[0023] controlling, by a control apparatus, the regulating valve based on the temperature sensed by the first temperature sensor and the temperature sensed by the second temperature sensor.

ADVANTAGEOUS EFFECTS OF INVENTION

[0024] According to the present invention, it is possible to provide a heat pump type hot-water supply outdoor apparatus that can control the temperature of the compressor, based on the water temperature of a water circuit and the temperature of the compressor.

BRIEF DESCRIPTION OF DRAWINGS

[0025] FIG. 1 shows a configuration diagram of a heat pump type hot-water supply outdoor apparatus 1a according to Embodiment 1;

[0026] FIG. 2 shows a hardware structure of a control apparatus 20a according to Embodiment 1;

[0027] FIG. 3 shows a control by the control apparatus 20a according to Embodiment 1;

[0028] FIG. 4 is a flowchart showing a heating control of a compressor 2 by the control apparatus 20a according to Embodiment 1;

[0029] FIG. 5 is a flowchart showing a cooling control of the compressor 2 by the control apparatus 20a according to Embodiment 1;

[0030] FIG. 6 shows an installation position of a water temperature sensor according to Embodiment 1; and

[0031] FIG. 7 shows a configuration diagram of a heat pump type hot-water supply outdoor apparatus 1b according to Embodiment 2.

DESCRIPTION OF EMBODIMENTS

Embodiment 1

[0032] FIG. 1 shows a configuration diagram of a heat pump type hot-water supply outdoor apparatus 1a (heat pump apparatus) according to Embodiment 1.

(Refrigerant Circuit Side)

[0033] As shown in FIG. 1, the refrigerant circuit side, through which refrigerant circulates, starts from the discharge side of a compressor 2, passes through a water-refrigerant heat exchanger 3 (condenser), an expansion valve 4, and an air heat exchanger 5 (evaporator), and connects to the inlet side of the compressor 2. The refrigeration cycle includes the

compressor 2, the water-refrigerant heat exchanger 3, the expansion valve 4, and the air heat exchanger 5.

(Water Circuit Side)

[0034] The water circuit side, through which a circulating pump 40 circulates water, configures a main water circuit 7 (main circuit) that starts from a hot water storage tank 30, passes through the water-refrigerant heat exchanger 3, and returns to the hot water storage tank 30. That is, the main water circuit 7 flows into the water-refrigerant heat exchanger 3 from the hot water storage tank 30, and flows out of the water-refrigerant heat exchanger 3 to return to the hot water storage tank 30.

(Branch Water Circuit)

[0035] As shown in FIG. 1, a branch water circuit 8 (branch path) is connected in parallel to the main water circuit 7. Before flowing to the water-refrigerant heat exchanger 3 from the main water circuit 7, the branch water circuit 8 branches from the main water circuit 7. That is, the branch water circuit 8 branches in parallel to the main water circuit 7, at the branch A at the inlet side of the water-refrigerant heat exchanger 3 and at the branch B at the outlet side of it. The branch water circuit 8 branches from the main water circuit 7 at the branch A before the flow into the water-refrigerant heat exchanger 3, and, through a water flow valve 9 and a water jacket 10, joins the main water circuit 7 having flowed out of the water-refrigerant heat exchanger 3 at the branch B.

(Structure of Heat Pump Type Hot-Water Supply Outdoor Apparatus 1a)

[0036] The heat pump type hot-water supply outdoor apparatus 1a is provided with the refrigeration cycle, which includes the compressor 2, the water-refrigerant heat exchanger 3, the expansion valve 4, and the air heat exchanger 5, the water flow valve 9 (regulating valve), the water jacket 10, a shell temperature detection sensor 6 (first sensor), a water temperature sensor 11 (second sensor), and a control apparatus 20a.

[0037] (1) The water jacket 10 is connected in the middle of the branch water circuit 8, and arranged on the shell of the compressor 2. Water flowing from the hot water storage tank 30 passes through a water flow passage formed inside the water jacket 10.

[0038] (2) The water flow valve 9 is connected in the middle of the branch water circuit 8, between the inlet side branch A and the water jacket 10, and regulates the quantity of water flow, according to an input control signal from the control apparatus 20a.

[0039] (3) The shell temperature detection sensor 6 senses a temperature of the shell of the compressor 2.

[0040] (4) The water temperature sensor 11, installed upstream of the water flow valve 9 and before the main water circuit 7 flowing into the water-refrigerant heat exchanger 3, senses a temperature of the water flowing out of the hot water storage tank 30 (water before inflowing to the water-refrigerant heat exchanger 3). FIG. 1 shows the case in which the water temperature sensor 11 is installed in the vicinity of the branch A at the inlet side of the water-refrigerant heat exchanger 3.

[0041] (5) The control apparatus 20a generates a control signal for controlling the water flow valve 9, based on temperatures sensed by the shell temperature detection sensor 6

and the water temperature sensor 11, and outputs the control signal to the water flow valve 9.

(Hardware Structure of Control Apparatus 20a)

[0042] FIG. 2 shows a hardware structure of the control apparatus 20a. In FIG. 2, the control apparatus 20a includes a CPU 810 (Central Processing Unit) which executes programs. The CPU 810 is connected via a bus 825 to a ROM (Read Only Memory) 811, a RAM (Random Access Memory) 812, and an I/F (Interface) unit 816, and controls these hardware devices.

[0043] The ROM 811 is an example of a nonvolatile memory. In the ROM 811, there are stored programs that execute functions of the control apparatus 20a and set values T_1 , T_2 , etc. that are to be described later. The programs of the ROM 811 are read out and executed by the CPU 810. The RAM 812 is an example of a volatile memory. In the RAM 812, there are stored temperatures sensed by the shell temperature detection sensor 6 and the water temperature sensor 11, a control signal to be transmitted to the water flow valve 9, information on “judgment result”, “calculation result”, “generation result”, “processing result”, etc. performed by the CPU 810, data, signal values, variable values, parameters, etc. The ROM 811 and the RAM 812 are examples of a storage device or a storage unit.

[0044] The I/F unit 816 is an example of a communication unit. The I/F unit 816 is connected to the water flow valve 9, the shell temperature detection sensor 6, the water temperature sensor 11, etc.

(Operations of Heat Pump Type Hot-Water Supply Outdoor Apparatus 1a)

[0045] Now, with reference to FIG. 1, the operation of the heat pump type hot-water supply outdoor apparatus 1a will be described.

(Flow of Refrigerant)

[0046] In the heat pump type hot-water supply outdoor apparatus 1a, high temperature refrigerant 51 discharged from the compressor 2 flows into the water-refrigerant heat exchanger 3. After giving heat to low temperature water 61 of the main water circuit 7, the high temperature refrigerant 51, as low temperature refrigerant 52, passes through the expansion valve 4 and the air heat exchanger 5, and returns to the inlet side of the compressor 2.

(Flow of Water)

[0047] As the movement of the water side, the low temperature water 61 flowing from the hot water storage tank 30 by the circulating pump 40 flows into the water-refrigerant heat exchanger 3, and since the temperature of the water increases by performing heat exchange with the high temperature refrigerant 51, becomes high temperature water 62 whose temperature is higher than that of the low temperature water 61 and returns to the hot water storage tank 30.

[0048] The brief summary of the basic operation of the heat pump type hot-water supply outdoor apparatus 1a is the following two points:

(Basic Operation 1: Heating of Compressor 2)

[0049] First, when a temperature $T(11)$ sensed by the water temperature sensor 11 is higher than a temperature $T(6)$ sensed by the shell temperature detection sensor 6, that is when

$$T(6) < T(11)$$

(Expression 1),

the control apparatus 20a opens the water flow valve 9 in order to flow water through the water jacket 10. The compressor 2 is heated due to letting the water flow through the water jacket 10. That is, the control apparatus 20a inputs temperatures (detection signals) sensed by the shell temperature detection sensor 6 and the water temperature sensor 11, and compares $T(6)$ with $T(11)$. Then, if it is judged that $T(6) < T(11)$, the control apparatus 20a generates a control signal indicating to open the water flow valve 9 and outputs it to the water flow valve 9.

[0050] Thus, by warming the compressor 2 by the heat of the water, it is possible to prevent accumulation/liquefaction of the refrigerant in the compressor 2 and improve rising capacity in the state of a low ambient air temperature.

(Basic Operation 2: Cooling of Compressor 2)

[0051] On the other hand, when the temperature $T(11)$ sensed by the water temperature sensor 11 is lower than the temperature $T(6)$ sensed by the shell temperature detection sensor 6, that is when

$$T(6) > T(11)$$

(Expression 2),

the compressor 2 is cooled due to opening the water flow valve 9 to let the water flow through the water jacket 10. That is, the control apparatus 20a inputs temperatures (detection signals) sensed by the shell temperature detection sensor 6 and the water temperature sensor 11, and compares $T(6)$ with $T(11)$. Then, if it is judged that $T(6) > T(11)$, the control apparatus 20a generates a control signal indicating to open the water flow valve 9 and outputs it to the water flow valve 9.

[0052] In the case of the basic operation 2, it is possible to effectively collect heat loss of the compressor 2 by making the heat loss from the compressor 2 be absorbed by water so as to return it to the main water circuit 7. Moreover, without a special protective device, it is possible to prevent the compressor 2 from becoming extraordinarily overheated.

[0053] The control apparatus 20a does not apply the Expressions 1 and 2 as they are. The Expressions 1 and 2 only show the outline of controlling heating and cooling of the compressor 2 performed by the control apparatus 20a. If the Expressions 1 and 2 are applied as they are, the control apparatus 20a would provide control to close the water flow valve 9 only when $T(6) = T(11)$, and provide control to open the water flow valve 9 when other than the above. Specifically, the control apparatus 20a performs the following control, for example.

[0054] Even when temperatures sensed by the sensors satisfy $T(6) < T(11)$ of the Expression 1, it may be acceptable not to open the water flow valve 9 (when not expecting to heat the compressor by the water any more) if the temperature sensed by the shell temperature detection sensor 6 is greater than or equal to a certain set value T_1 . That is, when the temperature sensed by the shell temperature detection sensor 6 is greater than or equal to the certain temperature T_1 , namely when

$$T_1 \leq T(6) < T(11)$$

(Expression 3),

the water flow valve 9 is not opened since it is not necessary to warm the compressor 2.

[0055] In contrast, even when $T(6) > T(11)$ is satisfied, it may be acceptable not to open the water flow valve 9 (when not expecting to cool the compressor by the water any more) if the temperature sensed by the shell temperature detection sensor 6 is less than or equal to a certain set value T_2 . That is, when

$$T_2 \geq T(6) > T(11)$$

(Expression 4),

the water flow valve 9 is not opened since it is not necessary to cool the compressor 2.

[0056] FIG. 3 typically shows the cases of Expressions 3 and 4. The arrow indicates a temperature T. (a) of FIG. 3 shows the Expression 3. That is, when T(6) is greater than or equal to the set value T₁, even if T(6) < T(11) is satisfied, the control apparatus 20a does not open the water flow valve 9. (b) of FIG. 3 shows the Expression 4. That is, when T(6) is less than or equal to the set value T₂, even if T(6) > T(11) is satisfied, the control apparatus 20a does not open the water flow valve 9.

[0057] (c) of FIG. 3 is a schematic diagram of the case where Expressions 3 and 4 are reflected in the control performed by the control apparatus 20a.

(Range of T₁ ≤ T(6) ≤ T₂)

[0058] When T(6) is in the range of T₁ ≤ T(6) ≤ T₂, the control apparatus 20a keeps the water flow valve 9 closed regardless of the value of T(11).

(Range of T(6) < T₁)

[0059] When T(6) < T₁, the compressor 2 needs to be heated. Therefore, under this condition, if T(6) < T(11) is further satisfied, the control apparatus 20a controls the water flow valve 9 to open.

[0060] If T(6) > T(11), since it is impossible to heat the compressor 2 by using the water flow, the control apparatus 20a controls the water flow valve 9 to close.

(Range of T(6) > T₂)

[0061] When T(6) > T₂, the compressor 2 needs to be cooled. Therefore, if T(6) > T(11) is further satisfied, the control apparatus 20a controls the water flow valve 9 to open.

[0062] If T(6) < T(11), since it is impossible to cool the compressor 2 by using the water flow, the control apparatus 20a controls the water flow valve 9 to close.

[0063] Furthermore, with reference to FIGS. 4 and 5, controlling the temperature of the compressor 2 performed by the control apparatus 20a shown in FIG. 3 will be described.

[0064] FIG. 4 shows a flowchart of heating the compressor 2 in order to prevent accumulation/liquefaction of the refrigerant, when starting the operation of the compressor 2.

[0065] FIG. 5 shows a flowchart of cooling the compressor 2 in order to prevent overheating of the compressor 2, while the compressor 2 is in operation.

[0066] In FIGS. 4 and 5, before starting the control performed by the control apparatus 20a, it is supposed that the water flow valve 9 is closed.

(Heating of Compressor 2)

[0067] First, with reference to FIG. 4, there will be explained the case of heating the compressor 2 by the control apparatus 20a when starting the operation of the compressor 2. The brief summary of FIG. 4 is as follows: In the case of a sensed temperature T(6) (hereinafter also called a shell temperature) sensed by the shell temperature detection sensor 6 being lower than a set value T₁ (in the case of the compressor 2 being cold), the shell temperature T(6) is further compared with a sensed temperature T(11) (hereinafter also called a sensed water temperature) sensed by the water temperature sensor 11. Since it is possible to perform heating when the

sensed water temperature T(11) is higher than the shell temperature T(6), the water flow valve 9 is opened to heat the compressor 2. Then, when the shell temperature T(6) exceeds a "set value T+α", the water flow valve 9 is closed (heating is stopped). The flowchart of FIG. 4 will now be explained.

[0068] In S101, the compressor 2 shall be in a stopped condition and the water flow valve 9 shall be closed.

[0069] In S102, the control apparatus 20a starts to control the water flow of the water jacket 10. By this control, it is possible to prevent the state (accumulation/liquefaction of refrigerant) in which refrigerant of the refrigeration cycle melts, as liquid refrigerant, into refrigerant oil of the compressor 2 in a stopped condition.

[0070] In S103, the control apparatus 20a compares a shell temperature T(6) with a set value T₁ (e.g., 5° C.). Since it is not necessary to perform heating when the shell temperature T(6) ≥ the set value T₁, the control apparatus 20a keeps the water flow valve 9 closed (S109).

[0071] On the other hand, since it is necessary to perform heating when the shell temperature T(6) < the set value T₁, the control apparatus 20a compares the shell temperature T(6) with a sensed water temperature T(11) in order to judge whether heating can be performed by using the water flow or not (S104).

[0072] Since it is impossible to perform heating when the shell temperature T(6) ≥ the sensed water temperature T(11), the control apparatus 20a keeps the water flow valve 9 closed (S110).

[0073] On the other hand, since it is possible to perform heating when the shell temperature T(6) < the sensed water temperature T(11), the control apparatus 20a controls the water flow valve 9 to open (S105).

[0074] In S106, the control apparatus 20a compares the shell temperature T(6) with a "set value T₁+α" (e.g., T₁=5° C., α=5° C.). That is, the control apparatus 20a judges whether the compressor 2 has been heated up to the required temperature "set value T₁+α" (10° C.) or not. When the shell temperature T(6) exceeds the "set value T₁+α" (judging that heating is completed), the control apparatus 20a provides control to close the water flow valve 9 (S107) to finish the control processing (S108).

(Cooling of Compressor 2)

[0075] Next, with reference to FIG. 5, there will be explained the case of cooling the compressor 2 by the control apparatus 20a while the compressor 2 is in operation. The brief summary of FIG. 5 is as follows: In the case of a shell temperature T(6) being higher than a set value T₂ (in the state of the compressor 2 being overheated), the shell temperature T(6) is further compared with a sensed water temperature T(11) detected by the water temperature sensor 11. Since it is possible to perform cooling when the sensed water temperature T(11) is lower than the shell temperature T(6), the water flow valve 9 is opened to cool the compressor 2. Then, when the shell temperature T(6) becomes less than a "set value T₂+β", the water flow valve 9 is closed (cooling is stopped). The flowchart of FIG. 5 will now be explained.

[0076] In S201, the compressor 2 shall be in operation and the water flow valve 9 shall be closed.

[0077] In S202, the control apparatus 20a starts to control the water flow of the water jacket 10. The compressor 2 in operation is prevented from being overheated by this control.

[0078] In S203, the control apparatus 20a compares a shell temperature T(6) with a set value T₂ (e.g., 90° C.). Since it is

not necessary to perform cooling when the shell temperature $T(6) \leq$ the set value T_2 , the control apparatus 20a keeps the water flow valve 9 closed (S209).

[0079] On the other hand, since it is necessary to perform cooling when the shell temperature $T(6) >$ the set value T_2 , the control apparatus 20a compares the shell temperature $T(6)$ with a sensed water temperature $T(11)$ in order to judge whether cooling can be performed by using the water flow or not (S204).

[0080] Since it is impossible to perform cooling when the shell temperature $T(6) \leq$ the sensed water temperature $T(11)$, the control apparatus 20a keeps the water flow valve 9 closed (S210).

[0081] On the other hand, since it is possible to perform cooling when the shell temperature $T(6) >$ the sensed water temperature $T(11)$, the control apparatus 20a controls the water flow valve 9 to open (S205).

[0082] In S206, the control apparatus 20a compares the shell temperature $T(6)$ with a “set value $T_2 + \beta$ ” (e.g., $T_2 = 90^\circ \text{C.}$, $\beta = -10^\circ \text{C.}$). That is, the control apparatus 20a judges whether the compressor 2 has been cooled down to the required temperature “set value $T_2 + \beta$ ” (80°C.) or not. When the shell temperature $T(11)$ becomes less than the “set value $T_2 + \beta$ ” (judging that cooling is completed), the control apparatus 20a provides control to close the water flow valve 9 (S207) to finish the control processing (S208).

(Installation Position of Water Temperature Sensor 11)

[0083] With reference to FIG. 6, an installation position of the water temperature sensor 11 will be explained. FIG. 6 shows the installation position of the water temperature sensor 11. Although FIG. 1 shows the case in which the water temperature sensor 11 is installed in the vicinity of the branch A at the inlet side of the water-refrigerant heat exchanger 3, since what is needed for the water temperature sensor 11 is only to sense a temperature of water before inflowing to the water-refrigerant heat exchanger 3, it is also preferable to install the water temperature sensor, as shown in FIG. 6 as a water temperature sensor 11-1, to be in the vicinity of the branch water circuit 8 between the branch A at the inlet side of the water-refrigerant heat exchanger 3 and the water flow valve 9. Alternatively, as shown as a water temperature sensor 11-2, the water temperature sensor may be installed to be upstream of and in the vicinity of the water flow valve 9, in the branch water circuit 8.

[0084] As described above, the control apparatus 20a judges to control the water flow valve 9 for flowing water to the water jacket 10, based on temperatures sensed by the shell temperature detection sensor 6 and the water temperature sensor 11. Therefore, depending on the compressor 2 (temperature of the compressor 2) and the water temperature, it is possible to collect useless heat loss from the compressor 2 or to reduce electric power for keeping the compressor 2 warm (to reduce standby electricity). The shell temperature detection sensor 6 is a sensor originally existing for controlling the refrigerant, and the water temperature sensor 11 is a sensor originally existing for controlling the temperature of hot water to be supplied. Thus, the above-described effect can be obtained without the time and effort to add sensors and cost increase caused by adding the sensors.

Embodiment 2

[0085] With reference to FIG. 7, a heat pump type hot-water supply outdoor apparatus 1b according to Embodiment

2 will be described. Compared with the heat pump type hot-water supply outdoor apparatus 1a of Embodiment 1, the heat pump type hot-water supply outdoor apparatus 1b of Embodiment 2 further includes an ambient air temperature sensor 12 (third temperature sensor) that senses an ambient air temperature.

[0086] In Embodiment 1, the control apparatus 20a judges to control the water flow valve 9, based on temperatures sensed by the shell temperature detection sensor 6 and the water temperature sensor 11. In Embodiment 2, a control apparatus 20b also uses a temperature sensed by the ambient air temperature sensor 12.

[0087] FIG. 7 shows a configuration diagram of the heat pump type hot-water supply outdoor apparatus 1b according to Embodiment 2. FIG. 7 differs from FIG. 1 of Embodiment 1 in that the ambient air temperature sensor 12 is arranged. Thereby, the function of the control apparatus 20b slightly differs from that of the control apparatus 20a. That is, the control apparatus 20b judges to control the water flow valve 9 for flowing water to the water jacket 10, based on three types of temperatures sensed by the shell temperature detection sensor 6, the water temperature sensor 11, and the ambient air temperature sensor 12. That is, the control apparatus 20b generates a signal for controlling the water flow valve 9, based on the temperatures sensed by the three types of sensors, and outputs it to the water flow valve 9.

[0088] In addition to the generation of the control signal of Embodiment 1, the control apparatus 20b generates a control signal (a temperature increase rate dependent control signal) described below, and outputs it to the water flow valve 9. That is, when an increase rate per unit time of an ambient air temperature (sensed by the ambient air temperature sensor 12) is faster than that of the shell temperature of the compressor 2 (sensed by the shell temperature detection sensor 6), the control apparatus 20b judges that there is a large amount of accumulation/liquefaction of refrigerant in the compressor 2, generates a control signal indicating to open the water flow valve 9, and outputs it to the water flow valve 9. That is, in such a case, regardless of high or low of the sensed temperature, the increase rate (speed) of each sensed temperature is subject to judgment.

[0089] By this control, the heat pump type hot-water supply outdoor apparatus having higher reliability can be provided. In addition, since the ambient air temperature sensor 12 is also a sensor originally existing, the above-described effect can be obtained without adding sensors and cost increase caused by adding the sensors.

[0090] Furthermore, specific explanation will be described. Refrigerant accumulation/liquefaction occurs only when the compressor 2 is in a stopped condition. If the compressor 2 begins to operate in the state where the refrigerant has accumulated and liquefied while the compressor 2 has been stopped (the state where lubricating oil in the compressor has been diluted by the refrigerant), seizure etc. occurs due to poor lubrication of the sliding part of the compressor 2. While the compressor is in a stopped condition, the refrigerant in the refrigerant circuit tends to be collected and condensed as liquid (accumulation/liquefaction) at the portion of the lowest temperature in the refrigerant circuit. When the shell temperature of the compressor 2 is low, though it is certain that refrigerant is easily accumulated/liquefied in the compressor 2, it is not an absolute value, in a precise sense, of the compressor shell temperature. Refrigerant tends to collect at a part, in each part of the refrigerant circuit, having a tempera-

ture increase rate slower than that of the ambient air temperature (surrounding temperature) because the part is colder at the time. Note that this phenomenon occurs while the compressor 2 is in a stopped condition. Generally, since the compressor 2 has a high heat capacity (difficult to warm) in the parts of the refrigerant circuit, refrigerant becomes collected (accumulated/liquefied) in the compressor 2. Therefore, when a difference between the increase rate of the ambient air temperature and that of the shell temperature of the compressor 2 can be sensed by dint of adding the ambient air temperature sensor 12, it becomes possible to judge whether it is in the state where accumulation/liquefaction of the refrigerant easily occurs in the compressor 2 or not. That is, according to Embodiment 2, the control apparatus 20b firstly compares the temperature variation range per unit time of the ambient air temperature and that of the compressor shell temperature. When the variation range in the direction of temperature increase of the ambient air temperature is larger than that of the shell temperature of the compressor 2, namely when the temperature increase rate of the ambient air temperature > the temperature increase rate of the compressor shell, since it can be judged that possibility of refrigerant accumulation/liquefaction in the compressor 2 is high (the range in which heating should be performed), the control apparatus 20b controls the water flow valve 9 to open. However, with regard to the temperature T(6) sensed by the shell temperature detection sensor 6 and the temperature T(11) sensed by the water temperature sensor 11, when $T(6) > T(11)$, it is impossible to heat the compressor 2 even if the water flow valve 9 is opened. Therefore, in such a case, the control apparatus 20b provides control to close the water flow valve 9.

[0091] According to Embodiment 1, since the water temperature in the hot water storage tank 30 may be affected (temperature decrease) by letting water flow through the water jacket 10, and since there may be a need for increasing output of the circulating pump 40 in order to let water flow through the water jacket 10 (in order to overcome the flow passage resistance), power consumption may increase as the whole system. Then, in such a case, the accuracy of judging whether it is in the state of refrigerant accumulation/liquefaction being likely to occur in the compressor 2 or not can be enhanced by adding the ambient air temperature sensor 12 compared with the case of using the two sensors of the shell temperature detection sensor 6 and the water temperature sensor 11. Thereby, it is possible to inhibit the influence on the water temperature in the hot water storage tank 30, and to inhibit the increase of power consumption of the circulating pump 40.

[0092] In Embodiments 1 and 2, the water flow valve 9 is explained as a stop valve which performs opening or closing. This however describes an example, and the function of the water flow valve 9 may be the one capable of regulating the quantity of water flow in multiple stages. The control apparatus 20a (or the control apparatus 20b) generates and outputs control signals responsive to the multiple stages, based on temperatures sensed by the sensors. The type of a control signal to be generated is programmed in advance. Moreover, the function of the water flow valve 9 may be the one capable of continuously regulating the quantity of water flow. Also, in that case, the control apparatus 20a (or the control apparatus 20b) generates and outputs a control signal responsive to the continuous regulating, based on temperatures sensed by the sensors. The type of a control signal to be generated is programmed in advance.

[0093] Although the heat pump apparatus is explained in Embodiments 1 and 2, it is also acceptable to comprehend the heat pump apparatus as a regulating valve control method by which a control apparatus controls a water flow valve (regulating valve). That is, with regard to a heat pump apparatus provided with a refrigeration cycle including a compressor, a condenser, an expansion valve, and an evaporator, the water jacket 10, the water flow valve 9 connected in the middle of the branch path between the branch at the inlet side and the water jacket and controlled according to an input control signal, the shell temperature detection sensor 6, and the water temperature sensor 11, it is possible to comprehend the heat pump apparatus as a regulating valve control method by which a control apparatus controls the water flow valve 9, based on the temperatures sensed by the shell temperature detection sensor 6 and the water temperature sensor 11.

REFERENCE SIGNS LIST

[0094] 1a, 1b Heat pump type hot-water supply outdoor apparatus, 2 Compressor, 3 Water-refrigerant heat exchanger, 4 Expansion valve, 5 Air heat exchanger, 6 Shell temperature detection sensor, 7 Main water circuit, 8 Branch water circuit, 9 Water flow valve, 10 Water jacket, 11 Water temperature sensor, 12 Ambient air temperature sensor, 20a, 20b Control apparatus, 30 Hot water storage tank, 40 Circulating pump

1. A heat pump apparatus comprising:

- a refrigeration cycle that includes a compressor, a condenser, an expansion valve, and an evaporator;
- a water jacket that is arranged on a shell of the compressor and connected in a middle of a branch path branching in parallel to a main circuit which starts flowing from a hot water storage tank to the condenser and returns to the hot water storage tank from the condenser and branching at a branch located at an inlet side of the condenser and at a branch located at an outlet side of the condenser in the main circuit, and that lets water flowing out from the hot water storage tank pass through the water jacket itself;
- a regulating valve that is connected in a middle of the branch path between the branch at the inlet side and the water jacket, and regulates, according to a control signal having been input, a water flow quantity;
- a first temperature sensor that senses a temperature of the shell of the compressor;
- a second temperature sensor that is installed upstream of the regulating valve and senses a temperature of water flowing out from the hot water storage tank; and
- a control apparatus that generates the control signal for controlling the regulating valve, based on the temperature sensed by the first temperature sensor and the temperature sensed by the second temperature sensor, and outputs the control signal having been generated to the regulating valve.

2. The heat pump apparatus according to claim 1,

wherein the second temperature sensor is installed at one of positions in a vicinity of the branch at the inlet side, in a vicinity of the branch path between the branch at the inlet side and the regulating valve, and in a vicinity and upstream of the regulating valve.

3. The heat pump apparatus according to claim 1, further comprising

- a third temperature sensor that senses a temperature of an ambient air,
- wherein the control apparatus generates the control signal, based on the temperature sensed by the first temperature

sensor, the temperature sensed by the second temperature sensor, and the temperature sensed by the third temperature sensor, and outputs the control signal having been generated to the regulating valve.

4. The heat pump apparatus according to claim 3, wherein the control apparatus calculates an ambient air temperature increase rate, which indicates an increase rate of an ambient air temperature, based on the temperature sensed by the third temperature sensor, and a shell temperature increase rate, which indicates an increase rate of a temperature of the shell of the compressor, based on the temperature sensed by the first temperature sensor, and generates a temperature increase rate dependent control signal, which is a second control signal for controlling the regulating valve, based on a high-low relation between the ambient air temperature increase rate and the shell temperature increase rate.
5. A method for controlling a regulating valve in a heat pump apparatus provided with a refrigeration cycle that includes a compressor, a condenser, an expansion valve, and an evaporator; a water jacket that is arranged on a shell of the compressor and connected in a middle of a branch path branching in parallel to a main circuit which starts flowing from a hot water storage tank to the condenser and returns to the hot water storage tank from the condenser and branching at a branch located at an inlet side of the condenser and at a branch located at an outlet side of the condenser in the main circuit, and that lets water flowing out from the hot water storage tank pass through the water jacket itself, the regulating valve that is connected in a middle of the branch path between the branch at the inlet side and the water jacket, and, by being controlled, regulates a water flow quantity, a first temperature sensor that senses a temperature of the shell of

the compressor, and a second temperature sensor that is installed upstream of the regulating valve and senses a temperature of water flowing out from the hot water storage tank, the method comprising:

- controlling, by a control apparatus, the regulating valve based on the temperature sensed by the first temperature sensor and the temperature sensed by the second temperature sensor.
6. The heat pump apparatus according to claim 2, further comprising
a third temperature sensor that senses a temperature of an ambient air,
wherein the control apparatus generates the control signal, based on the temperature sensed by the first temperature sensor, the temperature sensed by the second temperature sensor, and the temperature sensed by the third temperature sensor, and outputs the control signal having been generated to the regulating valve.
7. The heat pump apparatus according to claim 6, wherein the control apparatus calculates an ambient air temperature increase rate, which indicates an increase rate of an ambient air temperature, based on the temperature sensed by the third temperature sensor, and a shell temperature increase rate, which indicates an increase rate of a temperature of the shell of the compressor, based on the temperature sensed by the first temperature sensor, and generates a temperature increase rate dependent control signal, which is a second control signal for controlling the regulating valve, based on a high-low relation between the ambient air temperature increase rate and the shell temperature increase rate.

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