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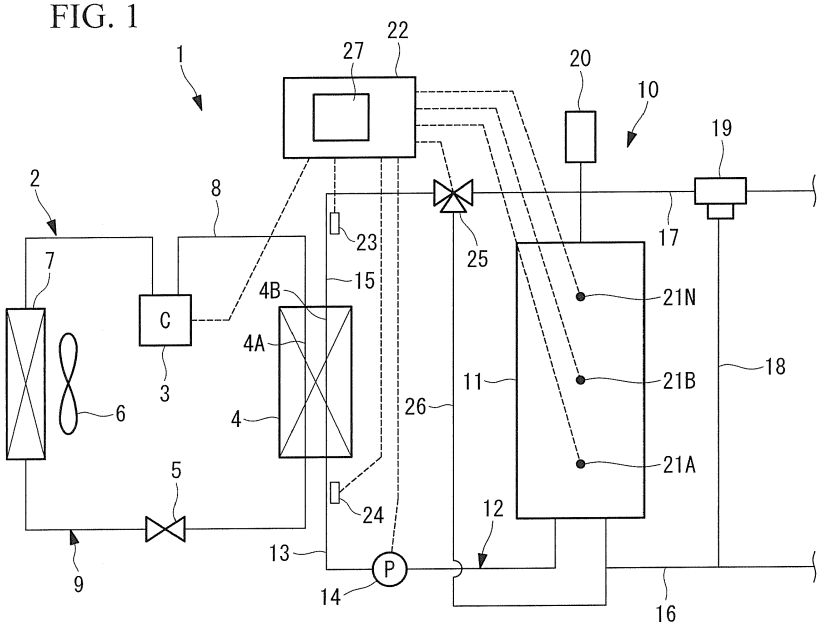
(54) Hot water supply system and control method thereof

(57) A hot water supply system 1 configured to sequentially store high-temperature water produced in a heat source machine 2 while forming temperature stratification, and maintain a set temperature, the system including: a bypass circuit 26 that is provided between a high-temperature water pipe 15 so as to bypass warm water spouted from the heat source machine 2 to the low-temperature water system by a switch valve 25 when the warm water has a low temperature at initiation of a heat retaining operation for maintaining the warm water stored at a given temperature; and a valve control section 27 that switches to the hot water storage tank 11 the warm water having a low temperature bypassed to the bypass circuit 26 by using an R value, which is a mixture characteristic value of the temperature-stratified hot water storage tank based on the temperature of the warm water, as an index.

FIG. 1



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Description

{Technical Field}

[0001] The present invention relates to a hot water supply system including at least one hot water storage tank that sequentially stores high-temperature water produced in a heat source machine while forming temperature stratification from an upper portion side, and a control method thereof.

{Background Art}

[0002] In a hot water supply system including at least one hot water storage tank that is connected to a heat source machine through a low-temperature water pipe and a high-temperature water pipe, and sequentially stores high-temperature water produced in the heat source machine while forming temperature stratification from an upper portion side as described above, a heat retaining operation (an additional boiling operation) for maintaining warm water in the hot water storage tank at a given temperature is performed after completion of 100% storage in the hot water storage tank. However, at the initiation of the heat retaining operation (the additional boiling operation), insufficiently-heated low-temperature warm water may be spouted from the heat source machine under startup. When the warm water is mixed into the high-temperature water from the upper portion of the hot water storage tank, the temperature stratification may be disturbed.

[0003] To cope with the above problem, PTL 1 proposes a system in which when warm water spouted from a heat source machine has a low temperature at the initiation of a heat retaining operation, the warm water is discharged to the outside of the system, or bypassed to a low-temperature water system via a bypass circuit by a switch valve, and when the temperature of the warm water spouted from the heat source machine reaches a set temperature or more, the switch valve is switched to cause the high-temperature water from the heat source machine to flow into an upper portion of a hot water storage tank.

[0004] Meanwhile, PTL 2 proposes a system in which when heat is stored forming temperature stratification in a heat storage tank by using water as a medium, the Archimedes number Ar of water returning to the heat storage tank is calculated, and a water feed amount by a water feed pump to an air conditioner is controlled such that the Archimedes number Ar approaches a preset reference Archimedes number, so that the heat storage is enabled while preventing a disturbance of the temperature stratification of the water in the heat storage tank.

{Citation List}

{Patent Literature}

[0005]

{PTL 1}
the Publication of Japanese Patent No. 5069955
{PTL 2}
Japanese Unexamined Patent Application, Publication No. Hei10-148374

{Summary of Invention}

{Technical Problem}

[0006] As described above, when the temperature of the warm water spouted from the heat source machine reaches a set temperature or more at the initiation of the heat retaining operation (the additional boiling operation), the switch valve is switched to cause the high-temperature water from the heat source machine to flow into the upper portion of the hot water storage tank. Accordingly, a disturbance of the temperature stratification can be avoided, and a decrease in the warm water temperature in the upper portion of the hot water storage tank can be prevented. In this case, however, before the temperature of the warm water from the heat source machine reaches the set temperature or more, the warm water whose temperature has been increased close to the set temperature is bypassed to the low-temperature water system side via the bypass circuit.

[0007] As a result, in the case of a system having a configuration in which the bypass circuit is connected to a water supply system leading to the hot water storage tank, a lower portion of the hot water storage tank, or a low-temperature water pipe leading from the hot water storage tank to the heat source machine, low-temperature water whose temperature has been increased is supplied to the heat source machine. Accordingly, in the heat pump-type heat source machine,

the efficiency is disadvantageously reduced, and the COP (coefficient of performance) is also disadvantageously reduced.

[0008] Thus, there is a demand for a technique capable of minimizing the influences on the disturbance of the temperature stratification in the hot water storage tank, and the decrease in the COP of the heat source machine, and achieving stable spouting of the high-temperature water to a load side, and maintenance of a high COP for the heat source machine at the same time.

[0009] The present invention has been made in view of such circumstances, and an object thereof is to provide a hot water supply system which can minimize the respective influences on the temperature stratification in a hot water storage tank, and the COP of a heat source machine at the initiation of a heat retaining operation (an additional boiling operation), stably spout high-temperature water, and maintain a high COP for the heat source machine, and a control method thereof.

{Solution to Problem}

[0010] A first aspect of the present invention is a hot water supply system including: a heat source machine that heats low-temperature water to produce high-temperature water; and at least one hot water storage tank that is connected to the heat source machine through a low-temperature water pipe and a high-temperature water pipe, and sequentially stores the high-temperature water produced in the heat source machine while forming temperature stratification from an upper portion side, and configured to maintain a set temperature after completion of storage of warm water having the set temperature in the hot water storage tank, the system further including: a bypass circuit that is provided between the high-temperature water pipe and a low-temperature water system including a water supply pipe leading to the hot water storage tank so as to bypass warm water spouted from the heat source machine to the low-temperature water system by a switch valve when the warm water has a low temperature at initiation of a heat retaining operation for maintaining the warm water stored in the hot water storage tank at a given temperature; and a valve control section that switches to the hot water storage tank side the warm water having a low temperature bypassed to the bypass circuit by using an R value, which is a mixture characteristic value of the temperature-stratified hot water storage tank based on the temperature of the warm water, as an index.

[0011] In accordance with the configuration, at the initiation of the heat retaining operation (an additional boiling operation), the warm water having a low temperature spouted from the heat source machine is bypassed to the low-temperature water system via the bypass circuit, and is mixed with low-temperature water in the low-temperature water system without forming stratification in a region having a large R value. Accordingly, a temperature increase in the low-temperature water system is suppressed, and mixture of the warm water having a low temperature into the high-temperature water in the upper portion of the hot water storage tank is prevented so as to avoid a disturbance of the temperature stratification. On the other hand, the warm water bypassed to the bypass circuit side is switched to the hot water storage tank side by using the R value, which is the mixture characteristic value of the temperature-stratified hot water storage tank, as the index (a region where the R value is equal to or less than a predetermined value). The temperature stratification by the high-temperature water in the upper portion of the hot water storage tank is thereby maintained, so that high-temperature water having a given temperature or more can be always spouted to a load side at the time of spouting. Therefore, at the initiation of the heat retaining operation (the additional boiling operation), the influences on the temperature stratification in the hot water storage tank and the COP of the heat source machine can be respectively minimized. The high-temperature water can be stably spouted to the load side, and a high COP can be maintained for the heat source machine.

[0012] Also, the bypass circuit may be connected to any one of the water supply pipe leading to the hot water storage tank, a low-temperature water region in a lower portion of the hot water storage tank, and the low-temperature water pipe leading from the hot water storage tank to the heat source machine, which constitute the low-temperature water system.

[0013] In accordance with the configuration, the warm water having a low temperature spouted from the heat source machine is injected into and mixed with the low-temperature water in any one of the water supply pipe leading to the hot water storage tank, the low-temperature water region in the lower portion of the hot water storage tank, and the low-temperature water pipe leading from the lower portion of the hot water storage tank. A temperature increase in the low-temperature water system can be thereby suppressed. Accordingly, a decrease in efficiency caused when the low-temperature water having a high temperature is supplied to a water/refrigerant heat exchanger in the heat source machine, particularly, a heat pump-type heat source machine, is suppressed, so that a high COP can be maintained for the heat source machine.

[0014] Also, the switch valve may be switched to the hot water storage tank side at a point where an R value of a case in which the warm water having a low temperature spouted from the heat source machine is caused to flow into the hot water storage tank from the lower portion, and an R value of a case in which the warm water is caused to flow into the hot water storage tank from the upper portion cross each other in a state in which low-temperature water is stored in the lower portion of the hot water storage tank, and high-temperature water having a set temperature is stored in the upper portion.

[0015] In accordance with the configuration, at the initiation of the heat retaining operation (the additional boiling operation), the temperature of the warm water spouted from the heat source machine is low, and the warm water having a low temperature from the heat source machine and the low-temperature water in the low-temperature water system are mixed together without forming stratification in the region having a large R value. Thus, a temperature increase in the low-temperature water system can be minimized. On the other hand, the switch valve is switched at a point where the above R value, and an R value obtained when the temperature of the warm water spouted from the heat source machine increases high enough to form the temperature stratification without being mixed with the high-temperature water in the hot water storage tank cross each other. The warm water spouted from the heat source machine is thereby caused to flow into the upper portion of the hot water storage tank, so that a disturbance of the temperature stratification can be avoided. Therefore, the switch valve can be switched at a timing at which the influence caused when the warm water having a low temperature spouted from the heat source machine is caused to flow into the hot water storage tank from the upper portion, and the influence caused when the warm water is caused to flow into the hot water storage tank from the lower portion can be minimized at the initiation of the heat retaining operation (the additional boiling operation). Accordingly, the high-temperature water can be stably spouted to the load side while maintaining the temperature stratification by the high-temperature water in the upper portion of the hot water storage tank. A high COP can be also maintained for the heat source machine.

[0016] A second aspect of the present invention is a method for controlling a hot water supply system including: a heat source machine that heats low-temperature water to produce high-temperature water; and at least one hot water storage tank that is connected to the heat source machine through a low-temperature water pipe and a high-temperature water pipe, and sequentially stores the high-temperature water produced in the heat source machine while forming temperature stratification from an upper portion side, and configured to maintain a set temperature after completion of storage of warm water having the set temperature in the hot water storage tank, wherein a bypass circuit is provided between the high-temperature water pipe and a low-temperature water system including a water supply pipe leading to the hot water storage tank so as to bypass warm water spouted from the heat source machine to the low-temperature water system by a switch valve when the warm water has a low temperature at initiation of a heat retaining operation for maintaining the warm water stored in the hot water storage tank at a given temperature, and the warm water having a low temperature bypassed to the bypass circuit is switched to the hot water storage tank side by using an R value, which is a mixture characteristic value of the temperature-stratified hot water storage tank based on the temperature of the warm water, as an index.

[0017] In accordance with the second aspect, at the initiation of the heat retaining operation (an additional boiling operation), the warm water having a low temperature spouted from the heat source machine is bypassed to the low-temperature water system via the bypass circuit, and is mixed with low-temperature water in the low-temperature water system without forming stratification in a region having a large R value. Accordingly, a temperature increase in the low-temperature water system is suppressed, and mixture of the warm water having a low temperature into the high-temperature water in the upper portion of the hot water storage tank is prevented so as to avoid a disturbance of the temperature stratification. On the other hand, the warm water bypassed to the bypass circuit side is switched to the hot water storage tank side by using the R value, which is the mixture characteristic value of the temperature-stratified hot water storage tank, as the index (a region where the R value is equal to or less than a predetermined value). The temperature stratification by the high-temperature water in the upper portion of the hot water storage tank is thereby maintained, so that high-temperature water having a given temperature or more can be always spouted to a load side at the time of spouting. Therefore, at the initiation of the heat retaining operation (the additional boiling operation), the influences on the temperature stratification in the hot water storage tank and the COP of the heat source machine can be respectively minimized. The high-temperature water can be stably spouted to the load side, and a high COP can be maintained for the heat source machine.

{Advantageous Effects of Invention}

[0018] In accordance with the hot water supply system and the control method thereof according to the present invention, at the initiation of the heat retaining operation, the warm water having a low temperature spouted from the heat source machine is bypassed to the low-temperature water system via the bypass circuit, and is mixed with the low-temperature water in the low-temperature water system without forming stratification in the region having a large R value. Accordingly, a temperature increase in the low-temperature water system is suppressed, and mixture of the warm water having a low temperature into the high-temperature water in the upper portion of the hot water storage tank is prevented so as to avoid a disturbance of the temperature stratification. On the other hand, the warm water bypassed to the bypass circuit side is switched to the hot water storage tank side by using the R value, which is the mixture characteristic value of the temperature-stratified hot water storage tank, as the index (the region where the R value is equal to or less than a predetermined value). The temperature stratification by the high-temperature water in the upper portion of the hot water storage tank is thereby maintained, so that the high-temperature water having a given temperature or more can

be always spouted to the load side at the time of spouting. Therefore, at the initiation of the heat retaining operation, the influences on the temperature stratification in the hot water storage tank and the COP of the heat source machine can be respectively minimized. The high-temperature water can be stably spouted to the load side, and a high COP can be maintained for the heat source machine.

{Brief Description of Drawings}

[0019]

{Fig. 1}
Fig. 1 is a system configuration diagram of a hot water supply system according to one embodiment of the present invention.
{Fig. 2}
Figs. 2 are explanatory views illustrating a state of startup of the hot water supply system.
{Fig. 3}
Fig. 3 is an explanatory view illustrating characteristics when warm water flows into water in a hot water storage tank.
{Fig. 4}
Figs. 4 are views illustrating a relationship between an inflow temperature and an R value when water spouted from a heat source machine flows into a hot water storage tank where high-temperature water is stored in an upper portion and low-temperature water is stored in a lower portion from the top, and when the water flows into the hot water storage tank from the bottom.

{Description of Embodiments}

[0020] In the following, one embodiment of the present invention is described by reference to Figs. 1 to 4.

[0021] Fig. 1 shows a system configuration diagram of a hot water supply system according to one embodiment of the present invention.

[0022] In a hot water supply system 1 of the present embodiment, a supercritical cycle heat pump using a CO2 refrigerant is used as a heat source machine 2 as an example. The heat source machine 2 is not limited to the heat pump of the present embodiment, and, of course, may be other components such as a boiler and a fuel cell.

[0023] The heat pump-type heat source machine (the heat source machine) 2 includes a closed-cycle refrigerant circuit 9 in which a compressor 3, a water/refrigerant heat exchanger (a gas cooler) 4, a decompressing means 5, and an evaporator 7 are sequentially connected through a refrigerant pipe 8. The compressor 3 compresses a refrigerant. The water/refrigerant heat exchanger 4 functions as a gas cooler, and performs heat exchange between the refrigerant and water. The decompressing means 5 is composed of an electronic expansion valve or the like for decompressing the refrigerant. The evaporator 7 evaporates the refrigerant by heat exchange with outside air drawn by a fan 6. While the heat pump-type heat source machine 2 is the supercritical cycle heat pump filled with the CO2 refrigerant as a working medium, a known technique may be used as the heat pump itself.

[0024] The water/refrigerant heat exchanger (the gas cooler) 4 generates high-temperature water by performing heat exchange between a high-temperature and high-pressure refrigerant gas flowing through a refrigerant flow channel 4A, and water flowing through a water flow channel 4B. The refrigerant gas flowing through the refrigerant flow channel 4A, and the water flowing through the water flow channel 4B flow in a countercurrent manner to be heat-exchanged.

[0025] On the other hand, a hot water supply unit 10 includes a hot water storage tank 11 with a required volume that stores warm water produced in the heat pump-type heat source machine 2, and a water circuit 12 that conveys water to the water flow channel 4B of the water/refrigerant heat exchanger 4 of the heat pump-type heat source machine 2 via the hot water storage tank 11. The hot water storage tank 11 is configured to store water so as to form temperature stratification by removing and supplying low-temperature water from a bottom portion of the tank to the heat source machine 2, and sequentially supplying high-temperature water produced in the heat pump-type heat source machine 2 from an upper portion of the tank.

[0026] The hot water storage tank 11 may be also composed of a plurality of relatively small tanks with a small volume connected in series with each other through a connection pipe. In this case, a hot water storage tank, to which a high-temperature water pipe leading from the heat source machine 2 is connected, is employed as a most upstream tank. A hot water spout pipe leading to a load side is connected to an upper portion of the hot water storage tank, and a bottom portion of the hot water storage tank and an upper portion of a downstream hot water storage tank are connected through a connection pipe. The plurality of hot water storage tanks are thereby sequentially connected in series. A low-temperature water pipe leading to the heat source machine 2, and a water supply pipe are connected to a bottom portion of a most downstream hot water storage tank. A known technique may be employed as the hot water storage tank 11.

[0027] The water circuit 12 includes a low-temperature water pipe 13, a water pump 14, a high-temperature water

pipe 15, a water supply pipe 16, a hot water spout pipe 17, a bypass pipe 18, a thermostatic mixing valve 19, and an air vent 20. The low-temperature water pipe 13 supplies the low-temperature water from the bottom portion of the hot water storage tank 11 to the water flow channel 4B of the water/refrigerant heat exchanger 4. The water pump 14 is provided in the low-temperature water pipe 13. The high-temperature water pipe 15 supplies the high-temperature water generated in the water/refrigerant heat exchanger 4 to the upper portion of the hot water storage tank 11. The water supply pipe 16 supplies water to the hot water storage tank 11. The hot water spout pipe 17 spouts the high-temperature water stored in the hot water storage tank 11 to the load side. The bypass pipe 18 is provided between the water supply pipe 16 and the hot water spout pipe 17. The thermostatic mixing valve 19 mixes the water from the bypass pipe 18 and the high-temperature water from the hot water storage tank 11 to obtain warm water having a predetermined temperature, and supplies the warm water to the load side. The air vent 20 discharges air mixed into the water circuit 12 to the outside.

[0028] A plurality of temperature sensors 21A, 21B, and 21N are also provided in the hot water storage tank 11 along its vertical direction. Out of the plurality of temperature sensors 21A, 21B, and 21N, the temperature sensor 21A is a first temperature sensor provided at a 100% storage position, the temperature sensor 21B is a second temperature sensor provided at, for example, a 60% storage position, and the temperature sensor 21N is a third temperature sensor provided at, for example, a 20% storage position. The detection values of the respective temperature sensors 21A, 21B, and 21N are input to a control unit 22. The number of the temperature sensors is not limited to three, and two to N temperature sensors may be provided at an appropriate interval.

[0029] The control unit 22 controls a warm water production capacity to produce high-temperature water having a set temperature by controlling the rotational speeds of the compressor 3 of the heat pump-type heat source machine 2 and the water pump 14 based on the detection values of temperature sensors 23 and 24 installed in the low-temperature water pipe 13 and the high-temperature water pipe 15 during the operation of the hot water supply system 1. The control unit 22 also performs control to stop the operations of the heat pump-type heat source machine 2 and the water pump 14 to perform a so-called boiling operation and additional boiling operation based on the detection values of the temperature sensors 21A, 21B, and 21N during the operation of the hot water supply system 1.

[0030] In the hot water supply system 1 as described above, the high-temperature water having a set temperature is stored in the hot water storage tank 11 up to the 100% storage position by performing the boiling operation at nighttime by use of midnight power that is generally inexpensive. The high-temperature water is consumed by spouting the high-temperature water to the load side through the hot water spout pipe 17 during a consumption period. However, when the temperature of the high-temperature water in the hot water storage tank 11 is lowered by natural heat dissipation or heat transfer with the high-temperature water left after completion of the boiling operation, or when the amount of the high-temperature water becomes insufficient by consuming the high-temperature water, a heat retaining operation (the additional boiling operation) is performed according to need.

[0031] Moreover, in the above hot water supply system 1, the water pump 14 is started first, and the rotational speed is gradually increased so as to discharge the water in the water circuit 12 to the outside at the time of operation initiation (startup) as shown in Fig. 2A. After that, the compressor of the heat pump-type heat source machine 2 is delay-started, and the rotational speed is increased to a target value as shown in Fig. 2B. Accordingly, the spouting temperature from the heat pump-type heat source machine 2 is gradually increased, and reaches a target temperature as shown in Fig. 2C. When warm water having a low temperature spouted from the heat pump-type heat source machine 2 immediately after the initiation of the heat retaining operation (the additional boiling operation) as described above directly flows into the hot water storage tank 11, the temperature stratification of the high-temperature water stored therein is disturbed.

[0032] Thus, a three-way switch valve (a switch valve) 25 is provided in the high-temperature water pipe 15 leading from the heat source machine 2 such that the warm water having a low temperature spouted from the heat source machine 2 can be bypassed to the water supply pipe 16 via the three-way switch valve (the switch valve) 25 and a bypass circuit 26. The bypass circuit 26 may be also connected to a low-temperature water region in a lower portion of the hot water storage tank 11, or the upstream side of the water pump 14 in the low-temperature water pipe 13 leading from the hot water storage tank 11 to the heat source machine 2.

[0033] Switching of the three-way switch valve 25 from the bypass circuit 26 to the hot water storage tank 11 is not performed simply by detecting that the temperature of the warm water reaches a set temperature. Instead, a valve control section 27 is provided in the control unit 22 such that the three-way switch valve 25 is switched to the hot water storage tank 11 by using an R value, which is a mixture characteristic value for determining the formation of the temperature stratification in the temperature-stratified hot water storage tank 11, as an index.

[0034] That is, the R value is a characteristic value obtained when hot water is caused to flow into water in the tank from the upper portion as shown in Fig. 3. The R value is calculated by the following expression (1) indicating the ratio of a complete mixture region depth L to a depth Lo of the temperature-stratified hot water storage tank 11. The complete mixture region depth L is calculated by the following expression (2).

$$R=L/Lo \quad (1)$$

$$L=m\cdot Ar^{-0.5}\cdot ds \quad (2)$$

where m is the parameter depending on a pipe connection structure (for example, in the case of a circular pipe horizontal connection type, the parameter is 0.7, in the case of a circular pipe vertical connection type, the parameter is 1.3, and in the case of a horizontal disk (baffle plate) type, the parameter is 1.8), Ar is the Archimedes number, and ds is the pipe diameter or the distance between disks.

[0035] The Archimedes number Ar is expressed by the following expression (3).

$$Ar=ds\cdot g\cdot|\rho o-\rho|/\rho\cdot 1/u^2 \quad (3)$$

where g is the gravitational acceleration (m/s^2), ρ is the inflowing low-temperature water density (kg/m^3), po is the water temperature density in the hot water storage tank (kg/m^3), and u is the water entrance flow velocity (m/s) (u=f/A(f is the flow rate (m^3/s), and A is the tank inlet sectional area (m^2)).

[0036] When the R value is large, the inflowing water is mixed with the water in the tank. When the R value is small, 0.4 or less, the inflowing water is not mixed with the water in the tank, and forms the temperature stratification.

[0037] In the present embodiment, as shown in Figs. 4, the high-temperature water of, for example, 80°C is stored in the upper portion of the hot water storage tank 11, and the low-temperature water of, for example, 10°C is stored in the lower portion. In this state, the low-temperature water in the lower portion is supplied to the heat source machine 2 at the initiation of the heat retaining operation (the additional boiling operation). When the warm water spouted from the heat source machine 2 has a low temperature, the warm water is caused to flow into the low-temperature water region of the hot water storage tank 11 from the lower portion via the bypass circuit 26. The three-way switch valve 25 is switched at a point where an R value of a case in which the warm water is caused to flow into the hot water storage tank 11 from the lower portion, and an R value of a case in which the warm water is caused to flow into the hot water storage tank 11 from the upper portion cross each other as shown in Fig. 4B by using an R value, which is a mixture characteristic value of the temperature-stratified hot water storage tank 11 based on the temperature of the warm water spouted from the heat source machine 2, as an index.

[0038] Because of the configuration described above, the following effects are produced by the present embodiment.

[0039] In the above hot water supply system 1 and a control method thereof, the heat pump-type heat source machine 2 and the water pump 14 are operated to convey the high-temperature and high-pressure refrigerant gas to the refrigerant flow channel 4A of the water/refrigerant heat exchanger (the gas cooler) 4, and convey the low-temperature water from the hot water storage tank 11 to the water flow channel 4B. The high-temperature and high-pressure refrigerant gas and the low-temperature water are thereby heat-exchanged with each other to heat the low-temperature water by the high-temperature and high-pressure refrigerant gas. Accordingly, the high-temperature water can be generated. By supplying the high-temperature water to the upper portion of the hot water storage tank 11, and sequentially storing the high-temperature water so as to form the temperature stratification, the high-temperature water can be stored in a required amount.

[0040] As for the storage amount of the high-temperature water, it can be determined that the warm water having a set temperature (e.g., 80°C) has been stored up to the installation positions of the plurality of temperature sensors 21N, 21B, and 21A provided along the vertical direction of the hot water storage tank 11 when the temperature sensors sequentially detect the set temperature (80°C). When the first temperature sensor 21A provided at the 100% storage position detects the set temperature, the boiling is determined to be completed. The operations of the heat pump-type heat source machine 2 and the water pump 14 are thereby stopped.

[0041] After completion of the boiling, the system assumes a heat retention state. When the temperature of the warm water is lowered to a set temperature by natural heat dissipation or heat transfer from the upper portion to the lower portion of the tank, the heat retaining operation (the additional boiling operation) is performed. At this point, the compressor 3 of the heat source machine 2 is delay-started at the initiation of the heat retaining operation, and the temperature of the warm water spouted from the heat source machine 2 remains low until the rotational speed reaches a target speed as shown in Figs. 2. Thus, the valve control section 27 of the control unit 22 switches the three-way switch valve 25 to the bypass circuit 26 so as to bypass the warm water having a low temperature to a low-temperature water system. The

warm water is thereby bypassed to the low-temperature water region in the lower portion of the hot water storage tank 11 through the water supply pipe 16. Accordingly, the warm water having a low temperature is prevented from flowing into the high-temperature water in the upper portion of the hot water storage tank 11.

[0042] Since the warm water having a low temperature bypassed to the low-temperature water region in the lower portion of the hot water storage tank 11 has a low temperature, and has a large R value, the warm water is mixed well with the water in the hot water storage tank 11 without forming stratification, and suppresses a temperature increase in the low-temperature water region as much as possible. On the other hand, the temperature of the warm water spouted from the heat source machine 2 increases over time after the operation initiation as shown in Fig. 2C. In the present embodiment, the tree-way switch valve 25 is switched to the hot water storage tank 11 at the point where the R value of the case in which the warm water is caused to flow into the hot water storage tank 11 from the lower portion, and the R value of the case in which the warm water is caused to flow into the hot water storage tank 11 from the upper portion cross each other as shown in Fig. 4B by using the R value, which is the mixture characteristic value of the temperature-stratified hot water storage tank 11 based on the temperature of the warm water, as the index. The warm water spouted from the heat source machine 2 is thereby caused to flow into the upper portion of the hot water storage tank 11. Although the three-way switch valve 25 is preferably switched before the initiation of the spouting temperature control as shown in Figs. 2, the present invention is not limited thereto. The three-way switch valve 25 may be also switched after the initiation of the spouting temperature control.

[0043] As described above, in the present embodiment, at the initiation of the heat retaining operation (the additional boiling operation), the warm water having a low temperature spouted from the heat source machine 2 is bypassed to the low-temperature water system via the bypass circuit 26, and is mixed with low-temperature water in the low-temperature water system without forming stratification in a region having a large R value. Accordingly, a temperature increase in the low-temperature water system is suppressed, and mixture of the warm water having a low temperature into the high-temperature water in the upper portion of the hot water storage tank 11 is prevented so as to avoid a disturbance of the temperature stratification. On the other hand, the warm water bypassed to the bypass circuit 26 by the three-way switch valve 25 is switched to the hot water storage tank 11 by using the R value, which is the mixture characteristic value of the temperature-stratified hot water storage tank 11, as the index (a region where the R value is equal to or less than a predetermined value). The temperature stratification by the high-temperature water in the upper portion of the hot water storage tank 11 is thereby maintained, so that high-temperature water having a given temperature or more can be always stably spouted to the load side at the time of spouting.

[0044] That is, immediately after the initiation of the heat retaining operation (the additional boiling operation), the temperature of the warm water spouted from the heat pump-type heat source machine 2 is low, and the warm water having a low temperature from the heat source machine 2 and the low-temperature water in the low-temperature water system are mixed together without forming stratification in the region having a large R value. Thus, a temperature increase in the low-temperature water system can be minimized. On the other hand, the switch valve 25 is switched at a point where the above R value, and an R value obtained when the temperature of the warm water spouted from the heat source machine 2 increases high enough to form the temperature stratification without being mixed with the high-temperature water in the hot water storage tank 11 cross each other. The warm water spouted from the heat source machine 2 is thereby caused to flow into the upper portion of the hot water storage tank 11, so that a disturbance of the temperature stratification can be avoided.

[0045] Therefore, the switch valve 25 can be switched at a timing at which the influence caused when the warm water having a low temperature spouted from the heat source machine 2 is caused to flow into the hot water storage tank 11 from the upper portion, and the influence caused when the warm water is caused to flow into the hot water storage tank 11 from the lower portion can be minimized at the initiation of the heat retaining operation (the additional boiling operation). Accordingly, the high-temperature water can be stably spouted to the load side while maintaining the temperature stratification by the high-temperature water in the upper portion of the hot water storage tank 11. A decrease in efficiency on the heat source machine side caused when the low-temperature water whose temperature has been increased is supplied to the heat source machine 2 can be also prevented, so that a high COP can be maintained for the heat source machine 2.

[0046] The bypass circuit 26 leading from the three-way switch valve 25 is connected to any one of the water supply pipe 16 leading to the hot water storage tank 11, the low-temperature water region in the lower portion of the hot water storage tank 11, and the low-temperature water pipe 13 leading from the hot water storage tank 11 to the heat source machine 2, which constitute the low-temperature water system. The warm water having a low temperature spouted from the heat source machine 2 is injected into and mixed with the low-temperature water in any one of the water supply pipe 16 leading to the hot water storage tank 11, the low-temperature water region in the lower portion of the hot water storage tank 11, and the low-temperature water pipe 13 leading from the lower portion of the hot water storage tank 11. A temperature increase in the low-temperature water system can be thereby suppressed. Accordingly, a decrease in efficiency caused when the low-temperature water having a high temperature is supplied to the water/refrigerant heat exchanger 4 in the heat source machine 2, particularly, the heat pump-type heat source machine 2, is suppressed, so

that a high COP can be maintained for the heat source machine 2.

[0047] The present invention is not limited to the invention according to the above embodiment, and may be changed as appropriate without departing from the scope. For example, in the above embodiment, a two-stage compression-type heat pump machine may be employed as the heat pump-type heat source machine 2 so as to improve the capacity, and an instant hot water supply-type unit may be employed as the hot water supply unit 10. Although the example of using the three-way switch valve as the switch valve 25 is described in the above embodiment, the switch valve 25 is not limited thereto. The three-way switch valve may be replaced by two electromagnetic valves.

{Reference Signs List}

[0048]

1 Hot Water Supply System
2 Heat Pump-type Heat Source Machine (Heat Source Machine)
10 Hot Water Supply Unit
11 Hot Water Storage Tank
12 Water Circuit
13 Low-Temperature Water Pipe
14 Water Pump
15 High-Temperature Water Pipe
16 Water Supply Pipe
22 Control Unit
25 Switch Valve
26 Bypass Circuit
27 Valve Control Section

Claims

1. A hot water supply system (1) comprising:

a heat source machine (2) that heats low-temperature water to produce high-temperature water; and
at least one hot water storage tank (11) that is connected to the heat source machine (2) through a low-temperature water pipe (13) and a high-temperature water pipe (15), and sequentially stores the high-temperature water produced in the heat source machine (2) while forming temperature stratification from an upper portion side, and
configured to maintain a set temperature after completion of storage of warm water having the set temperature in the hot water storage tank (11),
the system further comprising:

a bypass circuit (26) that is provided between the high-temperature water pipe (15) and a low-temperature water system including a water supply pipe (16) leading to the hot water storage tank (11) so as to bypass warm water spouted from the heat source machine (2) to the low-temperature water system by a switch valve (25) when the warm water has a low temperature at initiation of a heat retaining operation for maintaining the warm water stored in the hot water storage tank (11) at a given temperature; and
a valve control section (27) that switches to the hot water storage tank (11) side the warm water having a low temperature bypassed to the bypass circuit (26) by using an R value, which is a mixture characteristic value of the temperature-stratified hot water storage tank (11) based on the temperature of the warm water, as an index.

2. The hot water supply system according to claim 1, wherein the bypass circuit (26) is connected to any one of the water supply pipe (16) leading to the hot water storage tank (11), a low-temperature water region in a lower portion of the hot water storage tank (11), and the low-temperature water pipe (13) leading from the hot water storage tank (11) to the heat source machine (2), which constitute the low-temperature water system.

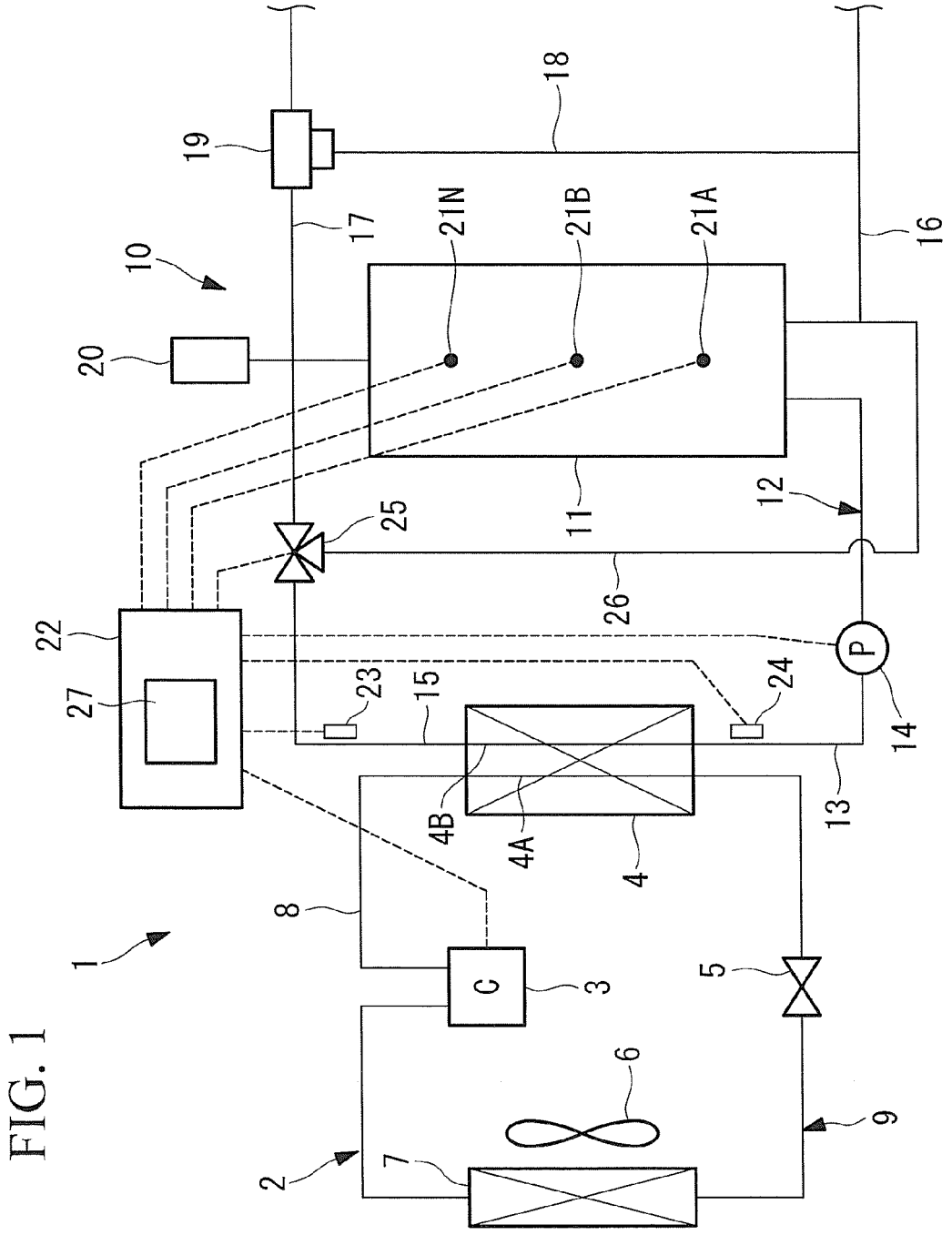
3. The hot water supply system according to claim 1 or 2, wherein the switch valve (25) is switched to the hot water storage tank (11) side at a point where an R value of a case in which the warm water having a low temperature spouted from the heat source machine (2) is caused to flow into the hot water storage tank (11) from the lower

portion, and an R value of a case in which the warm water is caused to flow into the hot water storage tank (11) from the upper portion cross each other in a state in which low-temperature water is stored in the lower portion of the hot water storage tank (11), and high-temperature water having a set temperature is stored in the upper portion.

4. A method for controlling a hot water supply system (1) comprising:

a heat source machine (2) that heats low-temperature water to produce high-temperature water; and
at least one hot water storage tank (11) that is connected to the heat source machine (2) through a low-temperature water pipe (13) and a high-temperature water pipe (15), and sequentially stores the high-temperature water produced in the heat source machine (2) while forming temperature stratification from an upper portion side, and
configured to maintain a set temperature after completion of storage of warm water having the set temperature in the hot water storage tank (11),
wherein a bypass circuit (26) is provided between the high-temperature water pipe (15) and a low-temperature water system including a water supply pipe (16) leading to the hot water storage tank (11) so as to bypass warm water spouted from the heat source machine (2) to the low-temperature water system by a switch valve (25) when the warm water has a low temperature at initiation of a heat retaining operation for maintaining the warm water stored in the hot water storage tank (11) at a given temperature, and
the warm water having a low temperature bypassed to the bypass circuit (26) is switched to the hot water storage tank (11) side by using an R value, which is a mixture characteristic value of the temperature-stratified hot water storage tank (11) based on the temperature of the warm water, as an index.

FIG. 1


1
2
3
4
4A
4B
5
6
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12
13
14
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20
21A
21B
21N
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26
27
C
P

FIG. 2

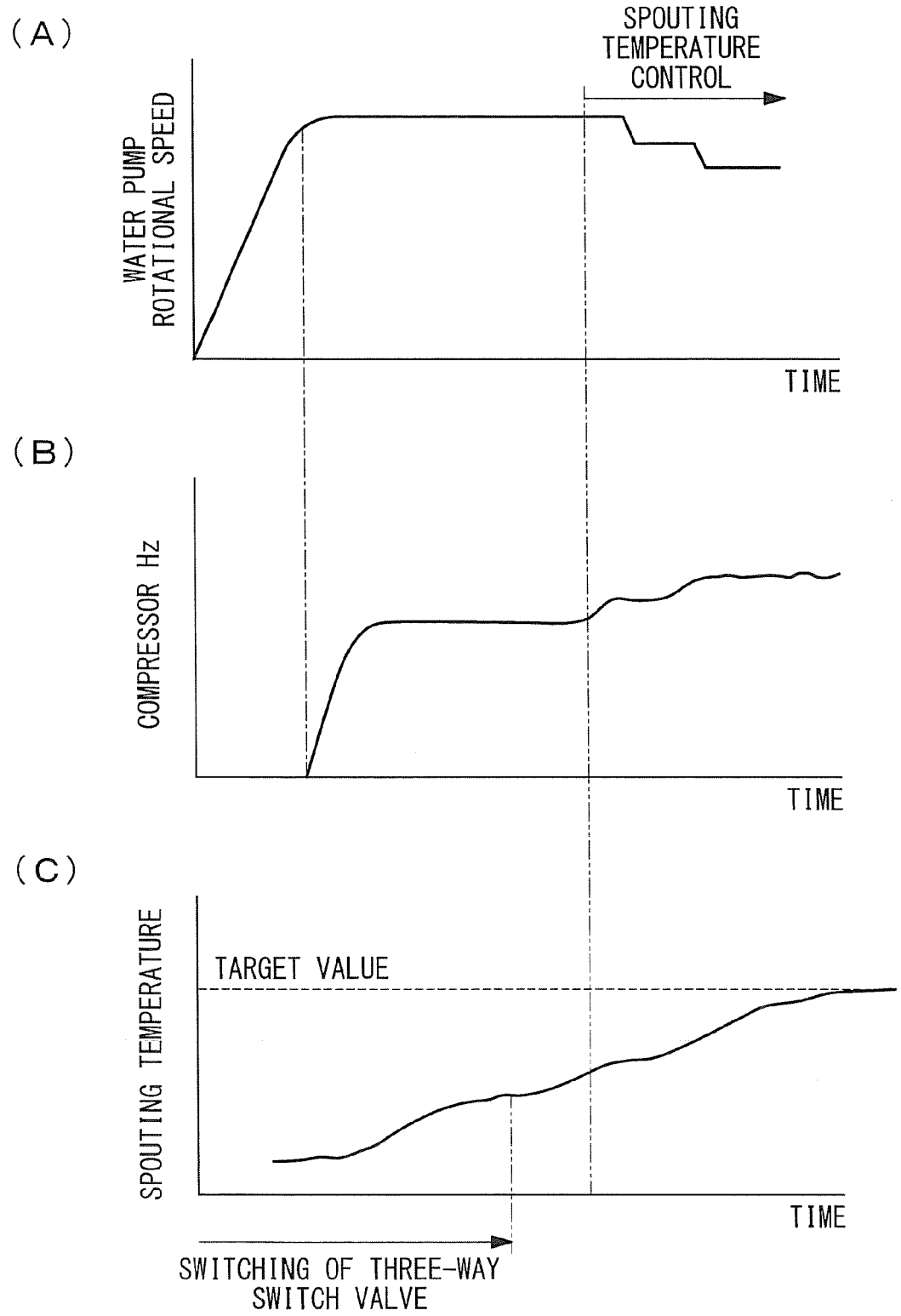

(A)
SPOUTING TEMPERATURE CONTROL
WATER PUMP ROTATIONAL SPEED
TIME
(B)
COMPRESSOR Hz
TIME
(C)
SPOUTING TEMPERATURE
TARGET VALUE
TIME
SWITCHING OF THREE-WAY SWITCH VALVE

FIG. 3

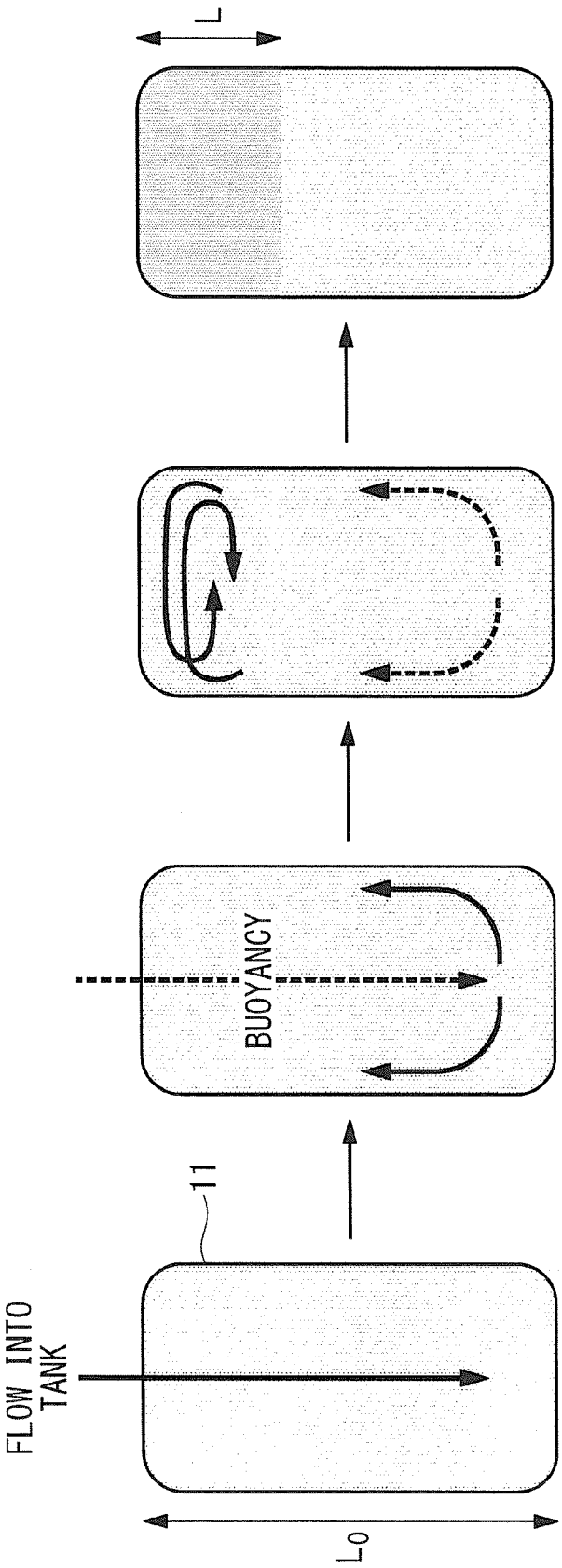
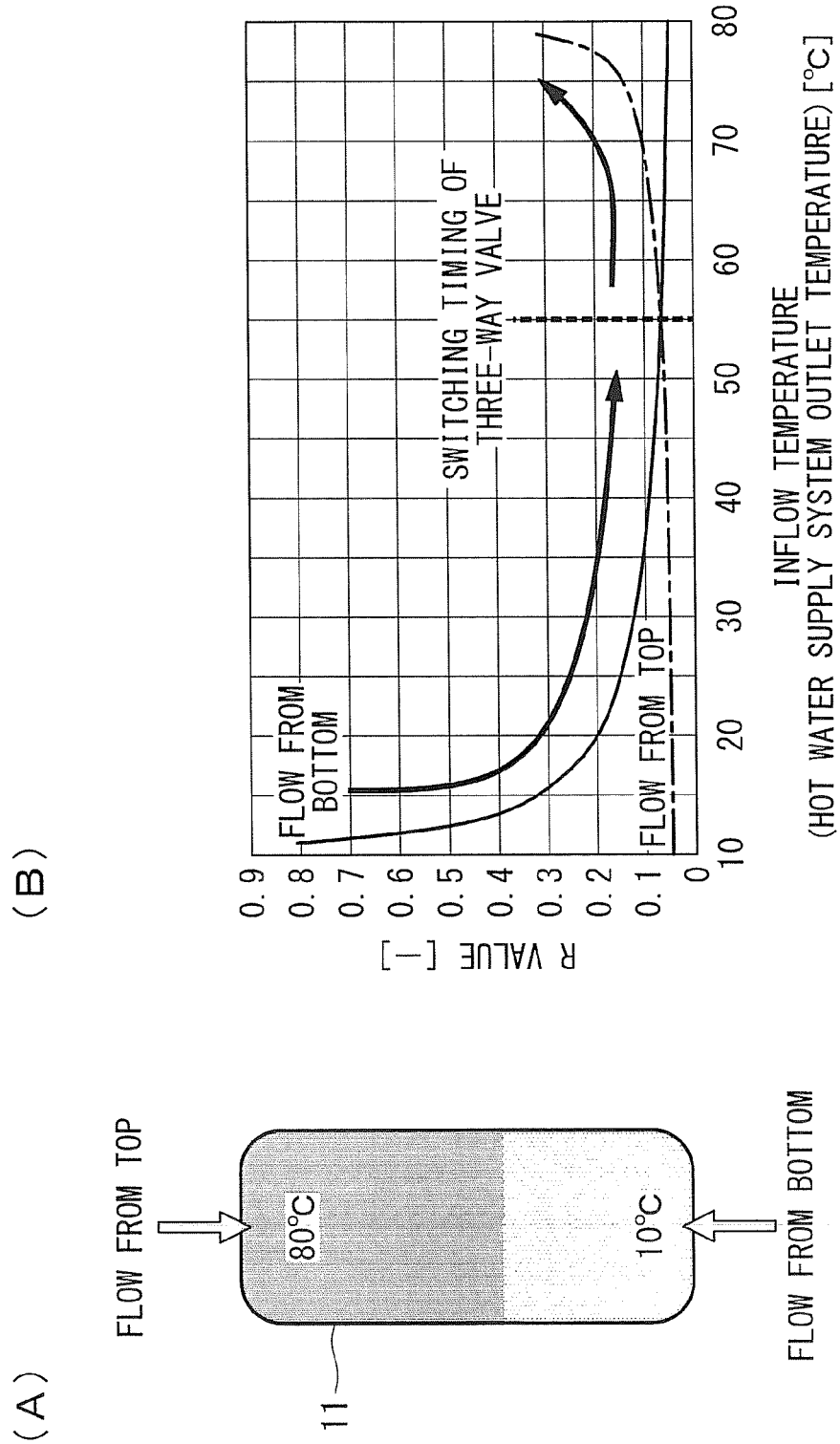


FIG. 4


(A)
FLOW FROM TOP
80°C
10°C
FLOW FROM BOTTOM
11
(B)
R VALUE [—]
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40
50
60
70
80
FLOW FROM BOTTOM
FLOW FROM TOP
SWITCHING TIMING OF THREE-WAY VALVE
INFLOW TEMPERATURE
(HOT WATER SUPPLY SYSTEM OUTLET TEMPERATURE) [°C]

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 6060

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F24H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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