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(54) Heat pump type hot water supply system

(57) A heat pump type hot water supply system includes a hot water storage tank (3), and a circulation line (12) connecting a water outlet (10) at the lower part of the storage tank (3) and a hot water inlet (11) at the upper part thereof. The circulation line (12) is provided partway therealong with a heat exchange line (14) to be heated by a heat pump heat source. The system is configured to return hot water heated up in the heat exchange line (14) to the hot water storage tank (3) through the hot water inlet (11) When the heated water temperature of the heat exchange line (14) is equal to or below a set point, the return of the water to the hot water storage tank (3) through the hot water inlet (11) is hindered, and when the heated temperature of the heat exchange line (14) is above the set point, the outgoing water from the heat exchange line (14) is returned to the hot water storage tank (3) through the hot water inlet (11).

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Description

[0001] This invention relates to heat pump type hot water supply systems.

[0002] As an example of conventional heat pump type hot water supply systems, there is known one, as shown in Figure **8,** which includes a hot water storage tank **50,** and a circulation line **53** connecting between a water outlet **51** and a hot water inlet **52** each formed in the hot water storage tank **50.** In addition, a heat exchange line **54** is provided partway along the circulation line 53 and can be heated by a heat pump type heating source. This heat pump type hot water supply system performs a hot water return operation in which unheated water from the water outlet **51** is heated up to a predetermined temperature in the heat exchange line **54** and the water heated up to the predetermined temperature is returned to the storage tank **50** through the hot water inlet **52.** The heat pump type hot water supply system is composed of a tank unit **55** and a heat source unit **56,** and the tank unit **55** includes the above-mentioned hot water storage tank **50.** The heat source unit **56** includes a compressor **57,** a water heat exchanger **58** (forming the heat exchange line **54),** an expansion valve **59,** and a heat exchanger **60.**

[0003] With the above configuration, when the compressor **57** is driven, refrigerant flows from the compressor **57** to the water heat exchanger **58,** the expansion valve **59** and the heat exchanger **60** in this order. During the time, the heat exchanger **60** functions as an evaporator, and the water heat exchanger **58** functions as a condenser. On the other hand, a pump **61** is provided in the circulation line **53,** and the driving of the pump **61** enables circulation of water through the circulation line **53.** Therefore, the water passing through the water heat exchanger **58,** which is acting as a condenser, is heated up therein and then returns to the hot water storage tank **50** through the hot water inlet **52.**

[0004] Heated water being stored in the hot water storage tank **50,** however, exists at high temperatures in the upper part of the tank and at low temperatures in the lower part thereof. If water is returned from the circulation line **53** directly to the storage tank **50** in the above-described manner at the start-up or in similar cases, cold water or low-temperature hot water will be undesirably sent to the upper part of the storage tank **50** because the water to be returned does not reach a desired high temperature. To cope with this, there is proposed a solution as shown in the dash-double-dot line in Figure **8.** In this solution, a three way valve **62** is provided in the circulation line **53** and the circulation line **53** is connected at the three way valve **62** to a bypass line **63** to form a bypass circuit that bypasses the storage tank **50.** When the water heated up in the heat exchange line **54** has a low temperature, the bypass line **63** is put into the on state so that the heated water circulates through the bypass circuit so as not to return to the storage tank **50,** resulting in heating the water up to a predetermined high temperature.

[0005] However, for the conventional heat pump type hot water supply system described above, when the bypass line **63** is in the on state (in bypass operation), the temperature of the water heated up in the heat exchange line **54** is substantially equal to that of the water incoming to the heat exchange line **54** as shown in Figure **9** (a graph showing the relationship between the incoming water temperature and the outgoing water temperature of the water heat exchanger **58).** In this case, the heat source unit of heat pump type can no longer operate because of its performance limit. Therefore, the heat source unit stops the bypass operation and performs a normal hot water return operation in which the heated water is returned to the tank through the hot water inlet **52.** This results in the return of the hot water at a low temperature (in this case, 60°C) not reaching a desired temperature (in this case, 85°C) to the upper part of the hot water storage tank **50.** At this time, as can be seen from the graph of Figure **9,** the incoming water temperature of the heat exchange line **54** abruptly changes, which makes it difficult to maintain the temperature of water heated up by the heat exchange line **54** (hereinafter, referred to as the heated water temperature of the heat exchange line **54)** constant. To solve this problem, conventional systems require improved start-up performance and a complicated control system for storage of hot water at a constant temperature, resulting in its complicated entire configuration and design difficulties.

[0006] Furthermore, as shown in Figure **8,** the conventional heat pump type hot water supply system may be provided with a bypass line **65** that is interposed between a connection line connecting the compressor **57** and the water heat exchanger **58** and a connection line connecting the expansion valve **59** and the heat exchanger **60** and that has a defrost valve **64** placed in the bypass line **65** to perform a defrosting operation. Here, the defrosting operation means the operation in which the expansions valve **59** is fully closed, hot gas discharged from the compressor **57** is supplied to the heat exchanger **60** through the bypass line **65,** and the heat exchanger **60** is thereby heated with heat of the hot gas. In this case, when the outside air temperature is low, such as in winter, the defrosting operation is repeatedly conducted, i.e., the start-up operating condition is repeated, so that the average storage hot water temperature in the storage tank drops. Therefore, in order to raise the average storage hot water temperature to the degree as in the cases other than the defrosting operation, it is necessary to raise the heated water temperature of the heat exchange line **54.** If it is done, the COP may in turn drop as shown in Figure **10** (a graph showing the relationship between the heated water temperature and the COP). Alternatively, if the heated water temperature of the heat exchange line is not raised as expected, the amount of heat of the stored hot water cannot be sufficiently ensured by counting on only night-time hot water storage operation which is low in electricity cost. The system is therefore required to perform a day-time reheating operation which is high in electricity cost, resulting in increased cost.

[0007] The present invention has been made in view of the foregoing problems, and therefore its object is to provide a heat pump type hot water supply system which prevents drop in the average storage hot water temperature of the hot water storage tank and enables to avoid day-time reheating operation and to achieve reduced cost owing to energy conservation.

[0008] To solve the above problems, a first heat pump type hot water supply system is directed to a heat pump type hot water supply system which includes a hot water storage tank **3,** and a circulation line **12** connecting a water outlet **10** at the lower part of the storage tank **3** and a hot water inlet **11** at the upper part thereof, the circulation line **12** being provided partway therealong with a heat exchange line **14** to be heated by a heat pump heat source, and in which water heated up in the heat exchange line **14** is returned to the hot water storage tank **3** through the hot water inlet **11.** The first heat pump type hot water supply system is **characterised in that** when the heated water temperature of the heat exchange line **14** is equal to or below a set point, the return of the water to the hot water storage tank **3** through the hot water inlet **11** is hindered, and when the heated water temperature of the heat exchange line **14** is above the set point, the outgoing water from the heat exchange line **14** is returned to the hot water storage tank **3** through the hot water inlet **11.**

[0009] With the first heat pump type hot water supply system, when the heated water temperature of the heat exchange line **14** is above the set point, water having flowed out of the storage tank **3** through the water outlet **10** flows through the circulation line **12** and then returns to the storage tank **3** through the hot water inlet **11.** On the other hand, when the water outgoing from the heat exchange line **14** has a temperature equal to or below the set point because it has been insufficiently heated in the heat exchange line **14,** the return of the water to the storage tank **3** through the hot water inlet **11** is hindered. As a result, low-temperature water or low-temperature hot water is not returned to the upper part of the storage tank **3** and is therefore not mixed with the hot water existing at high temperatures in the upper part of the storage tank **3,** thereby preventing temperature drop of the high-temperature storage water.

[0010] A second heat pump type hot water supply system is **characterised in that** when the heated water temperature of the heat exchange line **14** is equal to or below the set point, the outgoing water from the heat exchange line **14** is returned to the hot water storage tank **3** through a supply water inlet **5** formed in the bottom of the hot water storage tank **3.**

[0011] With the second heat pump type hot water supply system, when the heated water temperature of the heat exchange line **14** is equal to or below the set point, the outgoing water from the heat exchange line **14** is returned to the hot water storage tank **3** through the supply water inlet **5** in the bottom of the hot water storage tank **3.** As a result, low-temperature water or low-temperature hot water from the heat exchange line **14** is mixed with the low-temperature storage water in the lower part of the storage tank **3** without being mixed with the high-temperature storage water in the upper part of the storage tank **3.** In particular, since a baffle (baffle plate) is generally provided near to the supply water inlet **5** inside of the storage tank **3,** low-temperature water or low-temperature hot water entering the storage tank **3** through the supply water inlet **5** will impinge on the baffle and therefore will not reach the high-temperature storage water in the upper part of the storage tank **3.** Thereafter, when the heated water temperature of the heat exchange line **14** rises and exceeds the set point, the system returns to its normal operation in which the outgoing water at a sufficiently high temperature from the heat exchange line **14** is returned to the storage tank **3** through the hot water inlet **11.** Regardless of whether the system is in the normal operating condition or in a circulation condition (bypass operation) using the supply water inlet **5,** the storage water in the storage tank **3** flows out through the water outlet **10** to the heat exchange line **14.** Accordingly, as shown in Figure **3** (a graph showing the relationship between the incoming and outgoing water temperatures of the heat exchange line), the incoming waters to the heat exchange line **14** in both the cases have no temperature difference, so that the heated water temperature of the heat exchange line **14** is kept substantially constant.

[0012] A third heat pump type hot water supply system is **characterised in that** a flow return port **43** is formed in a portion of the outer wall of the hot water storage tank **3** located below the vertically middle of the hot water storage tank **3,** wherein the outgoing water from the heat exchange line **14** is returned to the hot water storage tank **3** through the flow return port **43** when the heated water temperature of the heat exchange line **14** is equal to or below the set point.

[0013] With the third heat pump type hot water supply system, when the heated water temperature of the heat exchange line **14** is equal to or below the set point, the outgoing water at a low temperature from the heat exchange line **14** is returned to the hot water storage tank **3** through the flow return port **43** located in a portion of the outer wall of the hot water storage tank **3** below the vertically middle of the hot water storage tank **3.** Therefore, low-temperature water or low-temperature hot water is not mixed with the high-temperature storage water in the upper part of the storage tank **3.** Thereafter, when the heated water temperature of the heat exchange line **14** rises and exceeds the set point, the system returns to its normal operation in which the water having reached a sufficiently high temperature is returned to the storage tank **3** through the hot water inlet **11.** Also with this configuration, the temperature of the incoming water to the heat exchange line **14** is not different from that of the incoming water in the other operating conditions, so that the heated water temperature of the heat exchange line **14** is kept substantially constant.

[0014] A fourth heat pump type hot water supply system is **characterised in that** the water outlet **10** is composed of a supply water inlet **5** formed in the bottom of the hot water storage tank **3,** the storage water in the hot water storage tank **3** is allowed to flow out to the circulation line **12** through the supply water inlet **5,** and when the heated water temperature of the heat exchange line **14** is equal to or below the set point, the water heated up in the heat exchange line **14** is returned to the hot water storage tank **3** through a port **10** formed in the bottom of the hot water storage tank **3.**

[0015] With the fourth heat pump type hot water supply system, when the heated water temperature of the heat exchange line **14** is equal to or below the set point, the outgoing water at a low temperature from the heat exchange line **14** is returned to the hot water storage tank **3** through the port **10** in the bottom of the storage tank **3.** Therefore, low-temperature water or low-temperature hot water is not mixed with the high-temperature storage water in the upper part of the storage tank **3.** Thereafter, when the heated water temperature of the heat exchange line **14** rises and exceeds the set point, the system returns to its normal operation in which the water having reached a sufficiently high temperature is returned to the storage tank **3** through the hot water inlet **11.** Accordingly, also with this configuration, the incoming water temperature of the heat exchange line **14** has not difference between various operating conditions, so that the heated water temperature of the heat exchange line **14** is kept substantially constant. In addition, since this configuration avoids the need to additionally provide a flow return port, it has the advantage of allowing use of existing hot water storage tanks.

[0016] A fifth heat pump type hot water supply system is **characterised in that** when the heated water temperature of the heat exchange line **14** is equal to or below the set point, the outgoing water from the heat exchange line **14** is drained from the circulation line **12** to the outside.

[0017] With the fifth heat pump type hot water supply system, when the heated water temperature of the heat exchange line **14** is equal to or below the set point, the outgoing water at a low temperature from the heat exchange line **14** is drained to the outside without being returned to the storage tank **3.** Therefore, if this operation is continued, the heated water temperature of the heat exchange line **14** rises with time and then exceeds the set point. When the heated water temperature of the heat exchange line **14** exceeds the set point, the operation to drain the water to the outside is cancelled. As a result, the hot water that has been heated up to a sufficiently high temperature in the heat exchange line **14** can be returned to the storage tank **3** through the hot water inlet **11.**

[0018] As described so far, according to the heat pump type hot water supply system of the present invention, when the water has not been sufficiently heated up in the heat exchange line, the low-temperature water or low-temperature hot water is not returned to the upper part of the storage tank and therefore is not mixed with the high-temperature storage water in the upper part of the storage tank. This prevents drop of the average storage hot water temperature and avoids a day-time reheating operation, resulting in reduced cost owing to energy conservation.

[0019] According to the second heat pump type hot water supply system, since a baffle is generally provided near to the supply water inlet inside of the storage tank, low-temperature water or low-temperature hot water returned therein impinges on the baffle so as not to reach the high-temperature storage water in the upper part of the storage tank, which provides the average storage hot water temperature with further stability. Furthermore, since the storage water in the tank is taken to the heat exchange line through the water outlet in both the normal operating condition and the circulation operating condition (bypass operation) using the supply water inlet, there is no difference in the incoming water temperature of the heat exchange line between both the operating conditions. Therefore, the heated water temperature of the heat exchange line can be kept substantially constant. In other words, even if the system has switched from the bypass operation to the normal operation, there is no substantial variation in the incoming water temperature between both the operations and therefore the heated water temperature of the heat exchange line can be kept substantially constant. Accordingly, the start-up performance of the system can be improved with a simple control system, and the outgoing water temperature can be kept stably at a high temperature.

[0020] According to the third or fourth heat pump type hot water supply system, like the second heat pump type hot water supply system, the incoming water temperature of the heat exchange line does not vary substantially even at the switchover from the bypass operation to the normal operation, and therefore the heated water temperature of the heat exchange line can be kept substantially constant. As a result, as compared with conventional hot water supply systems of this kind, the start-up performance can be improved with a simple control system. In addition, the fourth heat pump type hot water supply system avoids the need to additionally provide a flow return port or the like and allows use of existing (already installed) hot water storage tanks, which contributes to cost reduction.

[0021] According to the fifth heat pump type hot water supply system, since no low-temperature water is returned to the storage tank, variations in the average storage hot water temperature can certainly be reduced, which ensures achievement of energy conservation.

Figure **1** is a circuit diagram schematically showing a heat pump type hot water supply system according to an embodiment of the present invention.

Figure **2** is a block diagram of a control section of the above heat pump type hot water supply system.

Figure **3** is a graph showing the relationship between the incoming water temperature and the outgoing water temperature in the above heat pump type hot water supply system.

Figure **4** is a circuit diagram schematically showing a modified example of a selector means in the above heat pump type hot water supply system.

Figure **5** shows another embodiment of the heat pump type hot water supply system of the present invention, wherein Figure **5A** is a circuit diagram schematically showing an essential part, and Figure **5B** is a circuit diagram schematically showing the essential part using the selector means shown in Figure **4.**

Figure **6** shows still another embodiment of the heat pump type hot water supply system of the present invention, wherein Figure **6A** is a circuit diagram schematically showing an essential part, and Figure **6B** is a circuit diagram schematically showing the essential part using the selector means shown in Figure **4.**

Figure **7** shows still another embodiment of the heat pump type hot water supply system of the present invention, wherein Figure **7A** is a circuit diagram schematically showing an essential part, and Figure **7B** is a circuit diagram schematically showing the essential part using the selector means shown in Figure **4.**

Figure **8** is a circuit diagram schematically showing a conventional heat pump type hot water supply system.

Figure **9** is a graph showing the relationship between the incoming water temperature and the outgoing water temperature in the conventional heat pump type hot water supply system.

Figure **10** is a graph showing the relationship between the heated water temperature and the COP in the conventional heat pump type hot water supply system.

[0022] Description will be made in detail about embodiments of the present invention with reference to the drawings. Figure **1** is a schematic circuit diagram of a heat pump type hot water supply system according to an embodiment of the present invention. The hot water supply system includes a tank unit **1** and a heat source unit **2,** and is configured to heat water (warm water) in the tank unit **1** with the heat source unit **2.**

[0023] The tank unit **1** includes a hot water storage tank **3.** The hot water stored in the storage tank **3** is supplied to a bath tub and so on. For this purpose, the storage tank **3** has a supply water inlet **5** formed in the bottom wall thereof and a hot water outlet **6** formed in the top wall thereof, so that water is fed to the storage tank **3** through the supply water inlet **5** and high-temperature hot water goes out through the hot water outlet **6.** In this case, the supply water inlet **5** is connected to a supply water line **8** having a check valve **7,** and a baffle **9** is provided near to the supply water inlet **5** inside of the storage tank **3.** Furthermore, a water outlet **10** is formed in the bottom wall of the storage tank **3,** and a hot water inlet **11** is formed in the upper part of the side wall (peripheral wall) of the storage tank **3.**

[0024] The water outlet **10** and the hot water inlet **11** are connected together through a circulation line **12.** In the circulation line **12,** a pump **13** and a heat exchange line **14** are provided. Furthermore, a three-way valve **16** as a selector means **15** described later is provided in a portion of the circulation line **12** close to the hot water inlet **11.** The three-way valve **16** is connected to a bypass line **17** connecting in return to the supply water line **8.** Therefore, this heat pump type hot water supply system can perform two operations: a normal operation in which water (warm water) flows through the water outlet **10** into the circulation line **12** and passes through the circulation line **12,** and the water heated up in the circulation line **12** then returns to the storage tank **3** through the hot water inlet **11** without flowing through the bypass line **17;** and a bypass operation in which the water (warm water) flows through the water outlet **10** into the circulation line **12,** passes through the circulation line **12,** flows into the bypass line **17** through the three-way valve **16** and then returns from the bypass line **17** through the supply water inlet **5** to the storage tank **3.**

[0025] Furthermore, the storage tank **3** includes four remaining water amount sensors **18a, 18b, 18c** and **18d** vertically spaced at regular pitches on the side wall thereof, and a temperature sensor **19** on the top wall thereof. Each of the remaining water amount sensors **18a, 18b, 18c** and **18d** and the temperature sensor **19** is formed of a thermistor, for example. Moreover, the circulation line **12** is provided with an incoming water thermistor **20** at its side upstream of the heat exchange line **14** (more specifically, upstream of the pump **13),** and an outgoing water thermistor **21** (forming a sensor **22** for sensing the temperature of water heated up by the heat exchange line **14** (i.e., heated water temperature)) at its side downstream of the heat exchange line **14.**

[0026] Referring to Figure **2,** a control section of the heat pump type hot water supply system is provided with a controller **23** for controlling the selector means **15** according to the heated water temperature sensed by the sensor **22.** Specifically, when the heated water temperature sensed by the sensor **22** is equal to or below a set point (e.g., 85°C) preset by a setting means **24,** the controller **23** causes the three-way valve **16** as the selector means **15** to change to the position for the bypass operation in which the water flows through the bypass line **17.** On the other hand, when the heated water temperature exceeds the set point, the controller **23** causes the three-way valve **16** to change to the position for the normal operation in which the hot water does not flow through the bypass line **17.** Here, the set point means a high temperature substantially equal to the temperature of the hot water in the upper part of the storage tank **3.** The controller **23** and the other means in the control section are each formed using, for example, a microcomputer containing a CPU, a memory, and an input/output interface.

[0027] Referring again to Figure **1,** the heat source unit **2** includes a refrigerant circuit, and the refrigerant circuit includes a compressor **25,** a water heat exchanger **26** constituting the heat exchange line **14,** a subcooling heat exchanger **27,** a receiver **28,** an expansion valve **29,** and a heat exchanger **30.** The refrigerant circuit further includes a refrigerant line **31** through which the compressor **25** and the water heat exchanger **26** are connected, and another refrigerant line **32** through which the expansion valve **29** and the heat exchanger **30** are connected. A bypass line **33** is connected between both the refrigerant lines **31** and **32,** and is provided with a defrosting valve **34.** The refrigerant circuit **31** is provided with a thermistor **35,** an HPS **36** as a pressure protective switch, and a pressure sensor **37,** while the heat exchanger **30** is provided with a heat exchanger thermistor **38.** Furthermore, a supercritical refrigerant for use in a supercritical state, such as carbon dioxide ($CO2$), is used as a refrigerant. In Figure **1,** the reference numeral **39** indicates an outside air thermistor.

[0028] The bypass line **33** is for performing a defrosting operation to supply a hot gas discharged from the compressor **25** to the heat exchanger **30** for defrosting of the heat exchanger **30.** For this purpose, the heat source unit **2** includes a defrosting controller (not shown) for changeover between a normal water heating operation and the defrosting operation. Specifically, in the normal water heating operation, the water heat exchanger **26** and the heat exchanger **30** act as a condenser and an evaporator, respectively, thereby heating the water passing through the heat exchange line **14.** In the defrosting operation, the hot gas flows through the heat exchanger **30** so that it heats up the heat exchanger **30.** The defrosting controller is formed using, for example, a microcomputer containing a CPU, a memory, and an input/ output interface, like the controller **23.**

[0029] Next, description will be made about operations of the heat pump type hot water supply system having the above-described configuration. First, the compressor **25** is driven, so that the water heat exchanger **26** acts as a condenser and the heat exchanger **30** acts as an evaporator. Next, the pump **13** is driven (operated). Thereby, storage water (warm water) flows out of the storage tank **3** through the water outlet **10** in the tank bottom, and then flows through the heat exchange line **14** of the circulation line **12.** During the time, the water is heated up by the water heat exchanger **26** functioning as a condenser. Thereafter, the heated water returns to the upper part of the storage tank **3** through the three-way valve **16** and the hot water inlet **11.** This operation is conducted repeatedly so that high-temperature hot water is stored in the storage tank **3.** It is to be noted that this operation is preferably conducted in late night hours when the electricity rates are low for the purpose of cost reduction.

[0030] During start-up or in like conditions, water heating in the heat exchange line **14** may not be sufficiently conducted and therefore the heated water temperature of the heat exchange line **14** may not reach the set point. In the heat pump type hot water supply system of this embodiment, however, if the heated water temperature of the heat exchange line **14** is equal to or below the set point, the sensor **22** senses that and the controller **23** causes the three-way valve **16** as the selector means **15** to change the position so that the water in the circulation line **12** flows through the bypass line **17.** In other words, when the heated water temperature is equal to or below the set point, the system performs the bypass operation to return the hot water at a low temperature below the set point to the storage tank **3** through the supply water line **8** and the supply water inlet **5** without returning it to the storage tank **3** through the hot water inlet **11.** Thereafter, when the heated water temperature exceeds the set point, the controller **23** allows the selector means **15** to change the position so that the system enters into the normal operating condition in which the hot water does not flow through the bypass line **17.** In short, the hot water reaching a desired high temperature can be returned to the storage tank **3** through the hot water inlet **11.**

[0031] As can be seen from the above, in the heat pump type hot water supply system of this embodiment, when the heated water temperature of the heat exchange line **14** is at a low temperature, the outgoing water is returned to the lower side of the storage tank **3.** Therefore, as shown in Figure **3** (a graph showing the relationship between the incoming water temperature and the outgoing water temperature of the water heat exchanger **26),** the temperature of water incoming from the tank lower side water outlet **10** to the heat exchange line **14** is kept low. Accordingly, even if the system is changed from the bypass operation to the normal water heating operation (i.e., even if the system is turned to a bypass OFF operating condition), the incoming water temperature of the heat exchange line **14** substantially does not change and the heated water temperature thereof can be kept substantially constant. Furthermore, as a result of the bypass operation, the heated water temperature can be raised to a sufficiently high temperature. This makes it possible to keep hot water fed from the storage tank **3** at a stable high temperature. Consequently, improvement in the start-up performance and hot water storage at a constant temperature can be achieved with a simple control system.

[0032] Furthermore, when the outside air is at low temperatures, such as in winter, the system performs a defrosting operation by the defrosting controller. Specifically, when the temperature of the heat exchanger thermistor **38** is equal to or below a reference value, the defrosting controller fully closes the expansion valve **29** and opens the defrosting valve **34.** Here, the reference value is the temperature indicating that it is undesirable to continue the normal operation any more, because temperature drop beyond the reference value invites the frosting of the heat exchanger **30** and eventually performance drop. In such a case, a hot gas discharged from the compressor **25** is supplied to the heat exchanger **30** to defrost the heat exchanger **30** by the heat from the hot gas. When the temperature of the heat exchanger **30** exceeds the reference value, the defrosting controller fully closes the defrosting valve **34** and opens the expansion valve **29,** thereby returning the system to the normal operation. Thereafter, the same switchover from normal to defrosting operation is made at appropriate times so as not to frost the heat exchanger **30.** Then, when the defrosting operation is completed, the system enters into the same state as in the start-up, i.e., in the state where the water returned from the circulation line **12** to the storage tank **3** has a low temperature. Even in this case, however, the water is not returned to the storage tank **3** through the hot water inlet **11** to avoid drop in the average storage hot water temperature until the outgoing water from the heat exchange line **14** reaches a high temperature by the bypass operation. In this manner, the heated water temperature of the heat exchange line **14** can be sufficiently raised to ensure a sufficient outgoing water temperature by night-hours operation (off-peak operation). This avoids the need for reheating operation in day hours when the electricity rates are high, resulting in cost reduction.

[0033] As described above, the heat pump type hot water supply system of this embodiment includes the receiver **28** and the subcooling heat exchanger **27.** The receiver **28** is for keeping the amount of circulation of the refrigerant in the refrigerant circuit at an adequate amount. The subcooling heat exchanger **27** is for adjusting the amount of refrigerant charged into the receiver **28.** Provision of these elements enables a proper refrigeration cycle and a stable heated water temperature of the heat exchange line **14** to be kept.

[0034] Next, Figure **4** shows a modified example of the selector means **15.** In this example, the selector means **15** is composed of two two-way valves **40** and **41** without using the three-way valve **16.** Specifically, one of the two-way valves **40** is disposed near to the hot water inlet **11** in the circulation line **12,** while the other two-way valve **41** is disposed in the bypass line **17.** During the normal operation, the two-way valve **40** is opened while the two-way valve **41** closed. During the bypass operation, the two-way valve **40** is closed while the two-way valve **41** opened. In these manners, the two-way valves **40** and **41** have the same function as the three-way valve **16.** Therefore, also when the system uses the selector means **15** shown in Figure **4,** the outgoing water from the heat exchange line **14** is not returned to the storage tank **3** through the hot water inlet **11** to avoid drop in the average storage hot water temperature until the heated water temperature of the heat exchange line **14** reaches a high temperature. It is to be noted that the opening/closing operations on the two-way valves **40** and **41** are made of course by the controller **23** according to the temperature sensed by the sensor **22.**

[0035] Next, Figure **5** shows a heat pump type hot water supply system according to another embodiment of the present invention. Figure **5A** is a schematic circuit diagram of an essential part, and Figure **5B** is a schematic circuit diagram of the essential part using the selector means **15** shown in Figure **4.** In these cases, the supply water inlet **5** of the storage tank **3** in Figure **1** is used as a water outlet **10,** and the water outlet **10** of the storage tank **3** in Figure **1** is used as a flow return port **43.** Specifically, in the normal operation, the low-temperature storage water flows out of the storage tank **3** through the water outlet **10** doubling as the supply water inlet **5** to the circulation line **12** and is heated up by the heat exchange line **14** in the circulation line **12,** and the water heated up to a high temperature is returned to the storage tank **3** through the selector means **15** and the hot water inlet **11.** On the other hand, when the heated water temperature of the heat exchange line **14** is equal to or below the set point, such as at the start-up or during the defrosting operation, the controller **23** (not shown in this embodiment), like the heat pump type hot water supply system of Figure **1,** causes the selector means **15** to change to the position in which the water in the circulation line **12** flows through the bypass line **17.** In this case, the opening which functions as the water outlet **10** in Figure **1** is used as the flow return port **43** so that the water is returned to the storage tank **3** through the bypass line **17.** Since the heat pump type hot water supply system shown in Figure **5B** uses the two-way valves **40** and **41** instead of the three-way valve **16,** it can perform the same operations as the heat pump type hot water supply system shown in Figure **5A.**

[0036] Next, Figure **6** shows a heat pump type hot water supply system according to still another embodiment of the present invention. Figure **6A** is a schematic circuit diagram of an essential part, and Figure **6B** is a schematic circuit diagram of the essential part using the selector means **15** shown in Figure **4.** In the case of Figure **6A,** the flow return port **43** is formed in the vertically intermediate portion of the side wall of the storage tank **3,** and is connected to the bypass line **17** connecting to the selector means **15.** Therefore, in the normal operation, the low-temperature storage water flows out of the storage tank **3** through the water outlet **10** to the circulation line **12** and is heated up by the heat exchange line **14** in the circulation line **12,** and the water heated up to a high temperature is returned to the storage tank **3** through the selector means **15** and the hot water inlet **11.** On the other hand, when the heated water temperature of the heat exchange line **14** is equal to or below the set point, such as at the start-up or during the defrosting operation, the controller **23** (not shown in this embodiment), like the heat pump type hot water supply system shown in Figure **1,** causes the selector means **15** to change positions. As a result, the water in the circulation line **12** flows through the bypass line **17,** and is returned to the storage tank **3** through the bypass line **17** and the flow return port **43.** Since the heat pump type hot water supply system shown in Figure **6B** uses the two-way valves **40** and **41** instead of the three-way valve **16,** it can perform the same operations as the heat pump type hot water supply system shown in Figure **6A.**

[0037] As can be seen from the above, the heat pump type hot water supply systems shown in Figures **5** and **6** can also have the same effect as the heat pump type hot water supply system shown in Figure **1,** i.e., the effect of preventing drop in the average storage hot water temperature by avoiding the return of the water from the heat exchange line **14** to the storage tank **3** through the hot water inlet **11** until the heated water temperature of the heat exchange line **14** reaches a high temperature.

[0038] Next, Figure **7** shows a heat pump type hot water supply system according to still another embodiment of the present invention. Figure **7A** is a schematic circuit diagram of an essential part, and Figure **7B** is a schematic circuit diagram of the essential part using the selector means **15** shown in Figure **4.** In the case of Figure **7A,** the bypass line **17** is not connected to the storage tank **3,** but the water entering the bypass line **17** is drained (discharged) to the outside. Specifically, in the normal operation, the low-temperature storage water flows out of the storage tank **3** through the water outlet **10** to the circulation line **12** and is heated up by the heat exchange line **14** in the circulation line **12,** and the water heated up to a high temperature is returned to the storage tank **3** through the selector means **15** and the hot water inlet **11.** On the other hand, when the heated water temperature of the heat exchange line **14** is equal to or below the set point, such as at the start-up or during the defrosting operation, the controller **23** (not shown in this embodiment), like the heat pump type hot water supply system shown in Figure **1,** causes the selector means **15** to change positions. As a result, the water in the circulation line **12** flows through the bypass line **17,** and is then drained to the outside through the bypass line **17.** In this case, the drained water may be discharged directly to sewers or may be discharged after being used for washing or any other purposes.

[0039] Accordingly, the heat pump type hot water supply system shown in Figure **7** can also have the same effect, i.e., the effect of preventing drop in the average storage hot water temperature by avoiding the return of the water from the heat exchange line **14** to the storage tank **3** through the hot water inlet **11** until the heated water temperature of the heat exchange line **14** reaches a high temperature. Since the heat pump type hot water supply system shown in Figure **7B** uses the selector means **15** shown in Figure **4,** it can perform the same operations as the heat pump type hot water supply system shown in Figure **7A.**

[0040] The embodiments of the present invention have been described so far. The present invention, however, is not limited to the above-described embodiments but can be put into practice also in the form of various changes and modifications which fall within the scope of this invention. For example, the set point as a reference for the changeover between the normal water heating operation and the bypass operation can be freely preset. However, the set point is preferably set around the temperature in the upper part of the storage tank **3,** and more preferably set at about 85°C. Furthermore, the position of the flow return port **43** can be freely changed so long as it is not above the vertically middle point of the side wall of the storage tank **3.** Furthermore, the subcooling heat exchanger **27** and/or the receiver **28** may be omitted from the heat source unit **2.**

[0041] Accordingly, the above-described embodiments should be considered in all respects as illustrative only and not restrictive of the invention. The scope of the invention is defined by the scope of the appended claims and is not restricted to the description. Furthermore, all changes and modifications belonging to equivalents of the scope of the invention fall within the scope of the invention.

Claims

1. A heat pump type hot water supply system which includes a hot water storage tank (3), a bypass line (17), and a circulation line (12) connecting a water outlet (10) at the lower part of the storage tank (3) and a hot water inlet (11) at the upper part thereof, the circulation line (12) being provided partway therealong with a heat exchange line (14) to be heated by a heat pump heat source, and in which water heated up in the heat exchange line (14) is returned to the hot water storage tank (3) through the hot water inlet (11),

characterised in that

the hot water storage tank (3) includes a flow return port (43) formed in a portion of the outer wall of the hot water storage tank (3) located below the vertically middle of the hot water storage tank (3), wherein the outgoing water from the bypass line (17) is returned to the hot water storage tank (3) through the flow return port (43) when the heated water temperature of the heat exchange line (14) is equal to or below the set point in the flow return port (43) connected to the bypass line (17), and the outgoing water from the heat exchange line (14) is returned to the hot water storage tank (3) through the hot water inlet (11) when the heated water temperature of the heat exchange line (14) is above the set point.

FIG. 1

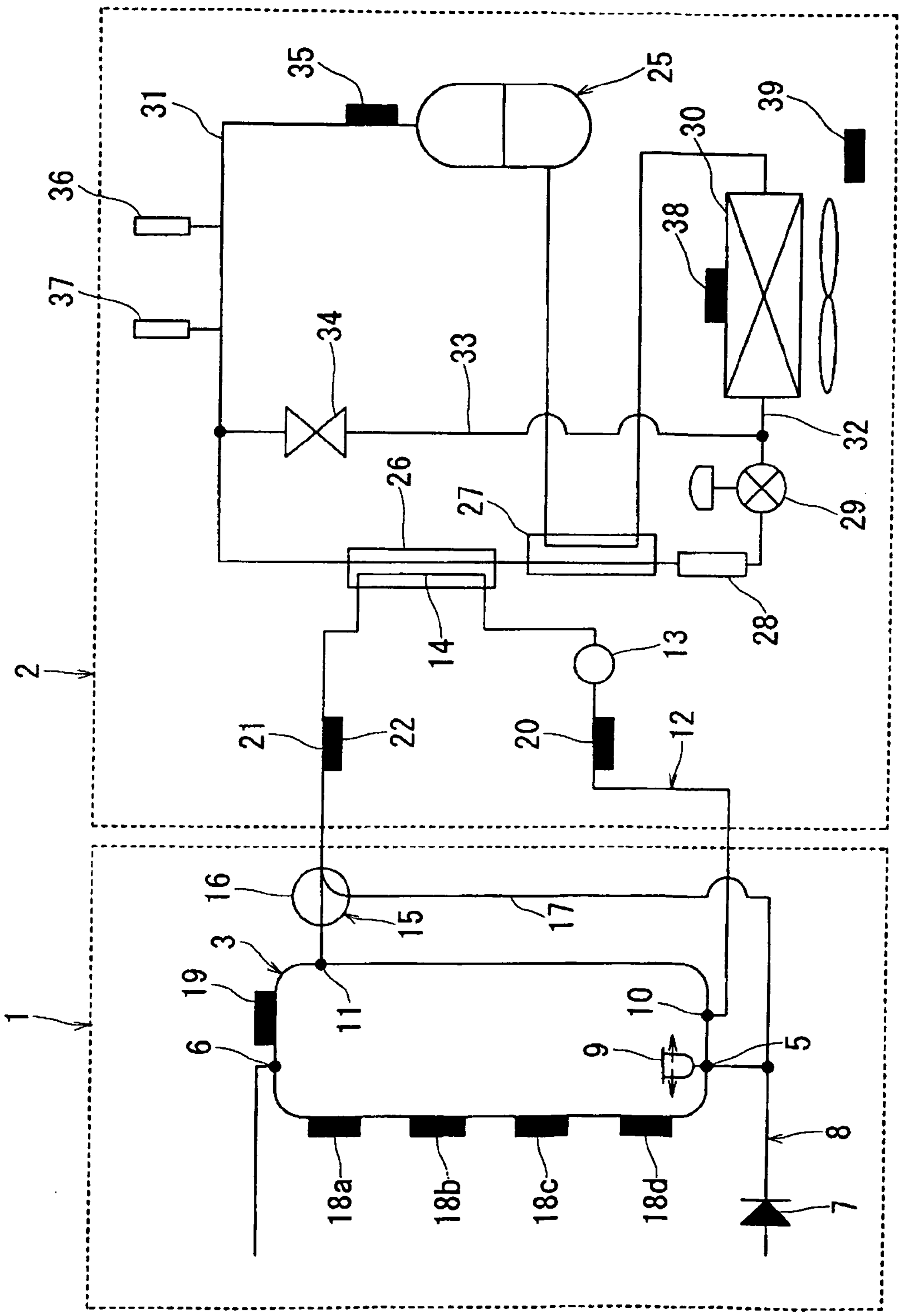

1
2
3
5
6
7
8
9
10
11
12
13
14
15
16
17
18a
18b
18c
18d
19
20
21
22
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39

FIG. 2

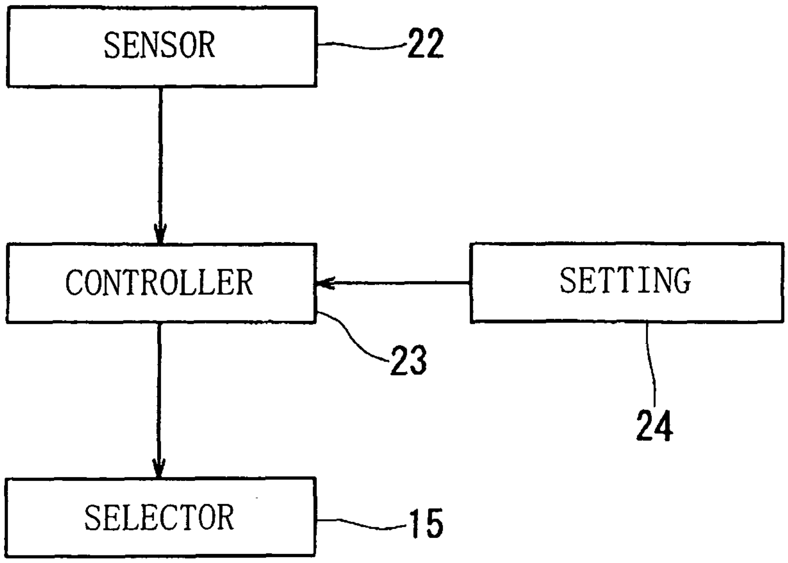

SENSOR
22
CONTROLLER
SETTING
23
24
SELECTOR
15

FIG. 3

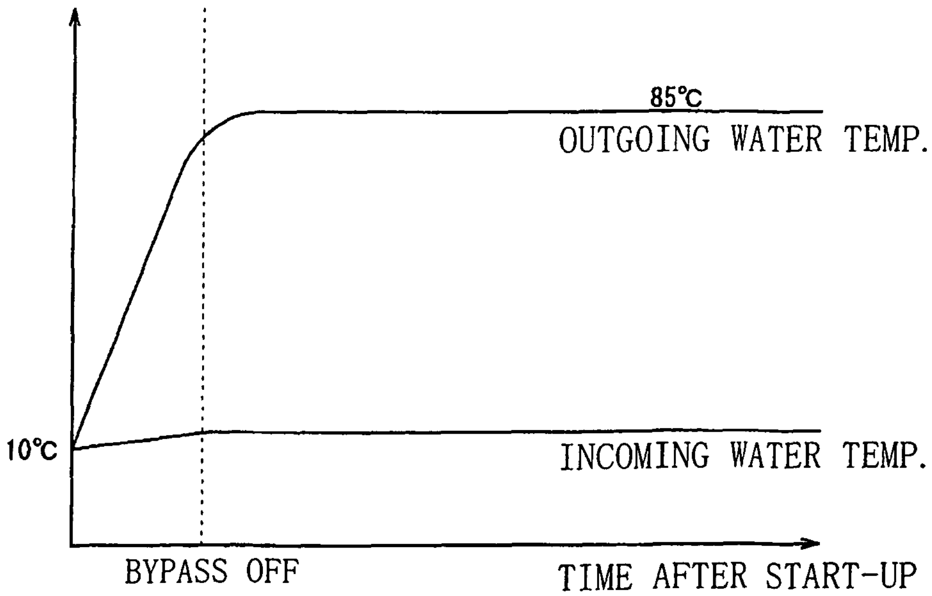

85℃
OUTGOING WATER TEMP.
10℃
INCOMING WATER TEMP.
BYPASS OFF
TIME AFTER START-UP

FIG. 4

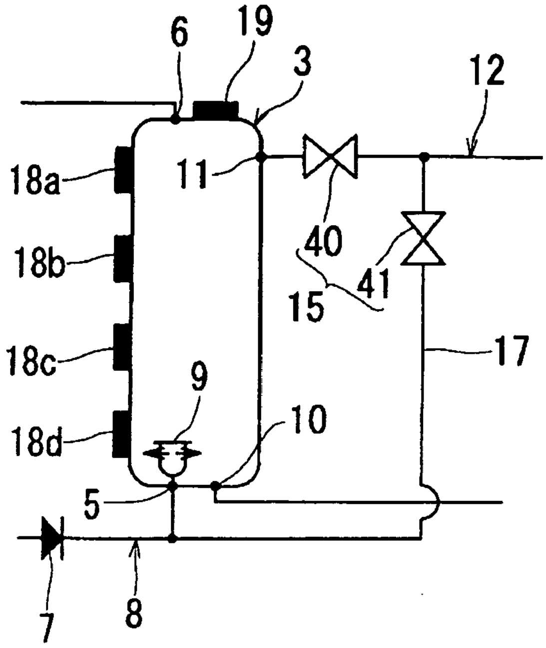


FIG. 5A

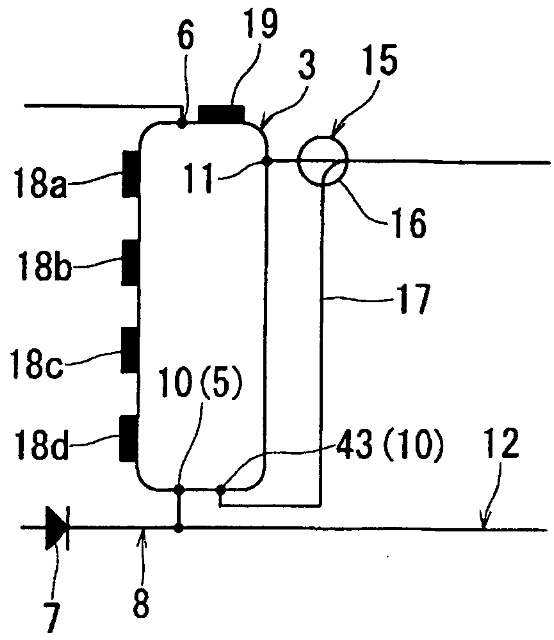

6
19
3
15
18a
11
16
18b
17
18c
10 (5)
18d
43 (10)
12
7
8

FIG. 5B

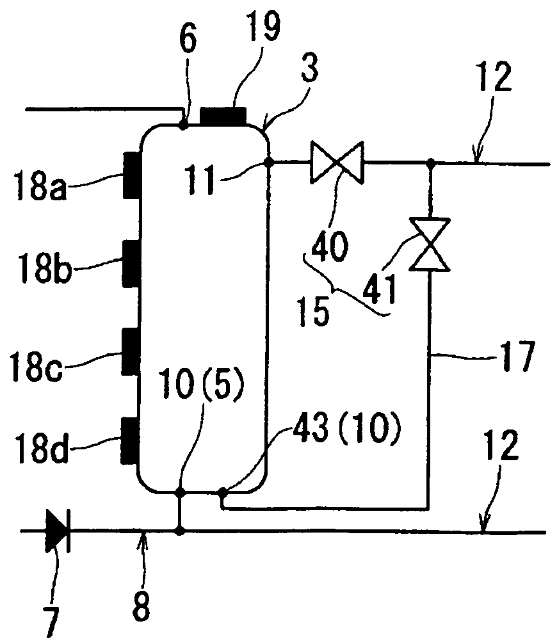

6
19
3
12
18a
11
40
18b
41
15
17
18c
10 (5)
43 (10)
18d
12
7
8

FIG. 6A

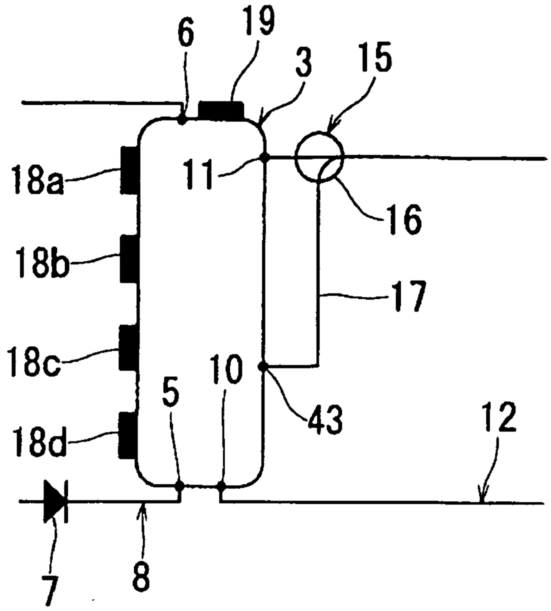

6
19
3
15
18a
11
16
18b
17
18c
10
5
43
12
18d
7
8

FIG. 6B

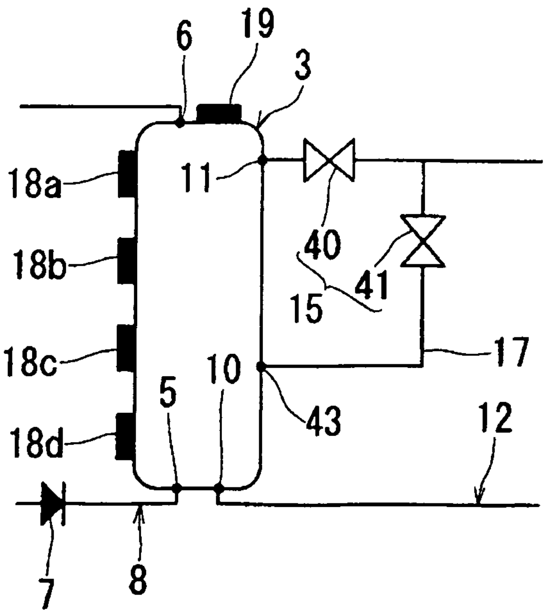

6
19
3
18a
11
40
18b
41
15
17
18c
10
5
43
12
18d
7
8

FIG. 7A

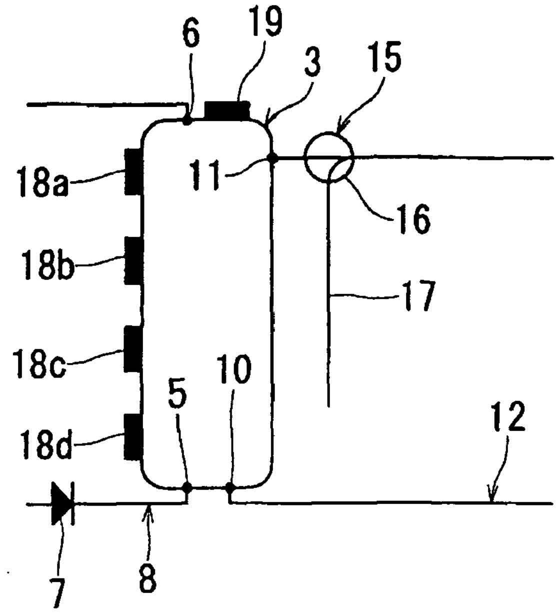

6
19
3
15
18a
11
16
18b
17
18c
5
10
18d
12
7
8

FIG. 7B

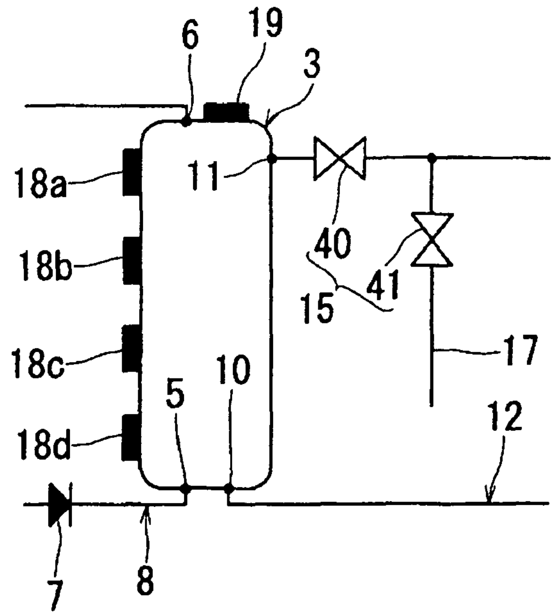

6
19
3
18a
11
40
41
18b
15
17
18c
5
10
18d
12
7
8

FIG. 8

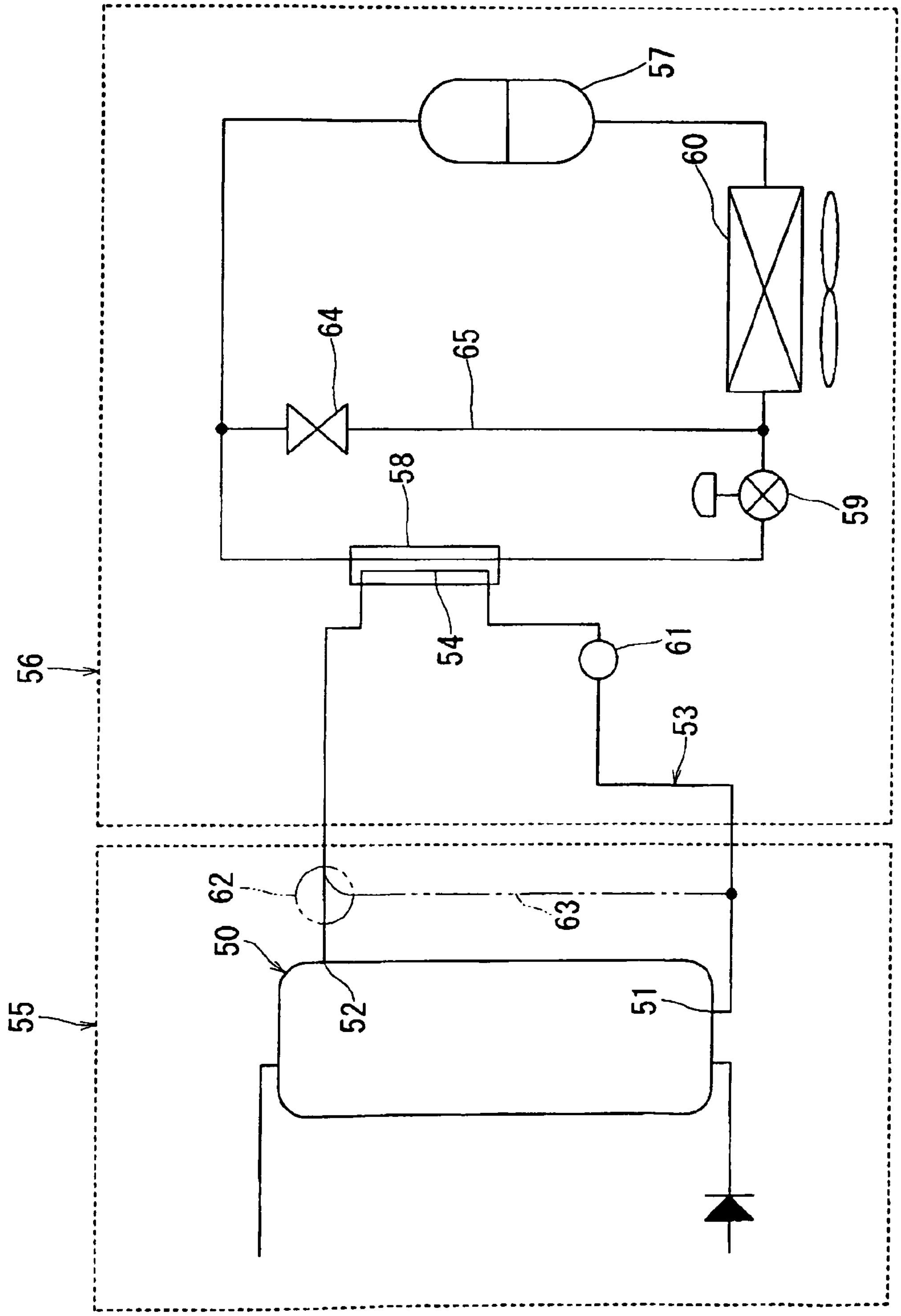


FIG. 9

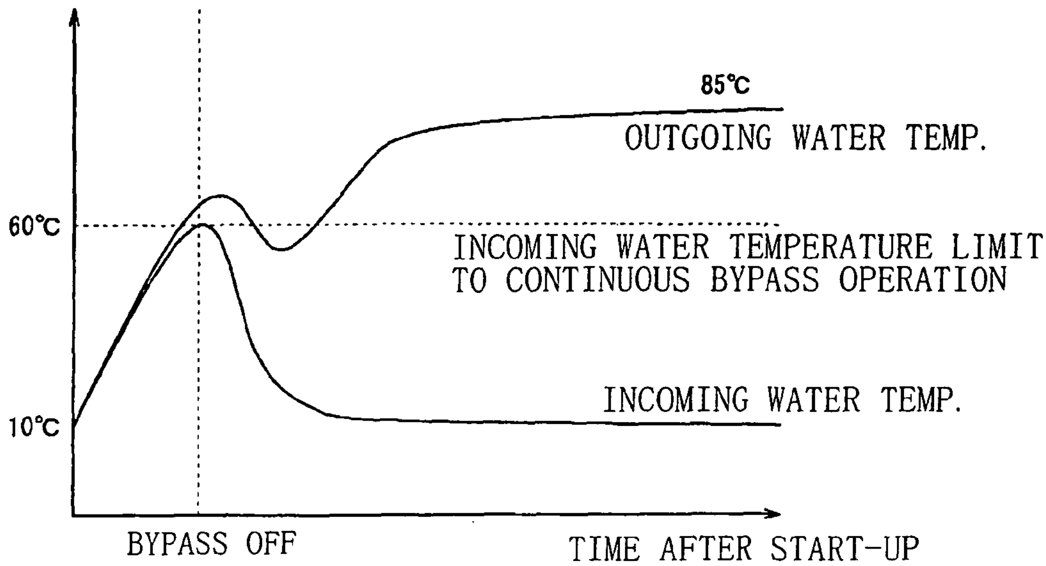
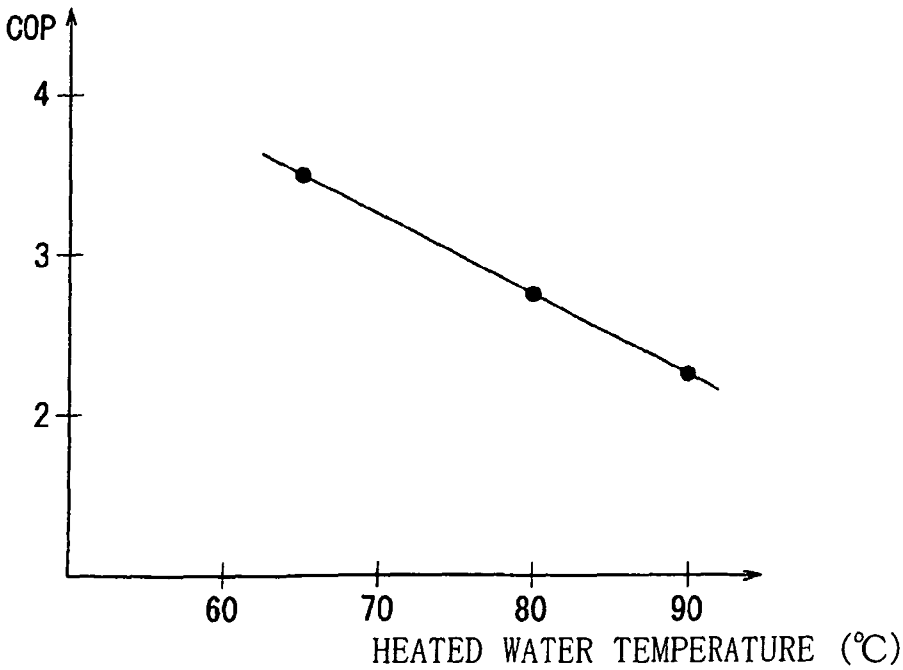

85℃
OUTGOING WATER TEMP.
60℃
INCOMING WATER TEMPERATURE LIMIT
TO CONTINUOUS BYPASS OPERATION
10℃
INCOMING WATER TEMP.
BYPASS OFF
TIME AFTER START-UP

FIG. 10


COP
4
3
2
60
70
80
90
HEATED WATER TEMPERATURE (℃)