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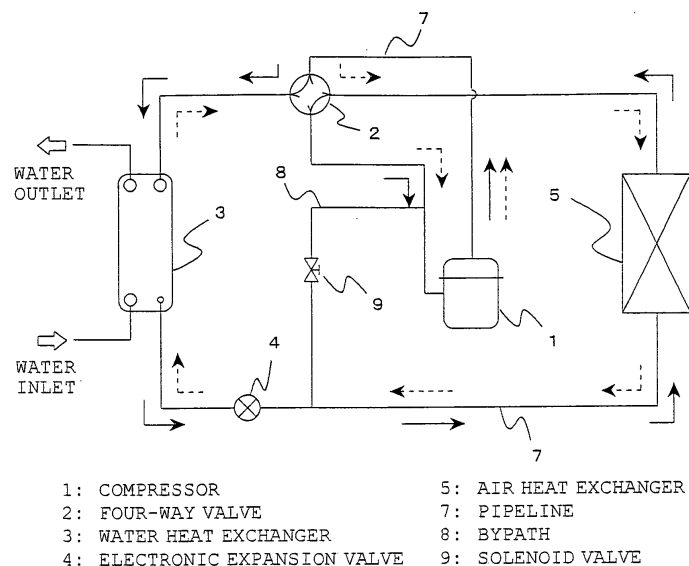
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(54) **Hot water system**

(57) A hot water system includes: a compressor (1); a four-way valve (2) for switching the direction of the refrigerating cycle during defrosting operation; a water heat exchanger (3) for transferring heat between water and the refrigerant; an electronic expansion valve (4) for controlling the flow rate of the refrigerant to reduce the pressure; and an air heat exchanger (5) for transferring heat between air and the refrigerant, which are connected in that order by a pipeline (7) to form a refrigerating cycle to heat the water. The hot water system further includes;

a bypass (8) for redirecting the refrigerant from a portion of the pipeline (7) in upstream of the electronic expansion valve (4) to the inlet of the compressor (1) during defrosting operation; and a solenoid valve (9) for switching installed in the bypass (8). When the solenoid valve (9) is opened to redirect part of the refrigerant to pass through the water heat exchanger (3) acting as an evaporator to the bypass (8) during defrosting operation, the amount of the refrigerant to pass through the bypass (8) is controlled by changing the degree of opening of the electronic expansion Valve (4).

FIG. 1



Description

[0001] The present invention relates to a heat-pump hot water system of reverse cycle defrosting type.

[0002] In conventional heat-pump hot water systems of reverse defrost type, water circulates during defrost operation. Therefore, water that has flowed into the hot water system exchanges heat with the refrigerant in a heat exchanger that exchanges heat between the water and the refrigerant during defrost operation, where it is cooled, and is discharged from the hot water system. Thus, the hot water system exhibits negative performance as a water heater during defrosting operation.

To prevent such negative performance, there may be a method of controlling the water so as not to flow into the hot water system by stopping the water pump during defrosting operation. However, if the water flow is stopped, temperature of the water is decreased to minus to be frozen in the heat exchanger for exchanging heat between the water and the refrigerant, so that volume expansion on freezing to ice may burst the heat exchanger or the water pipe. Therefore, the water is not stopped in general.

[0003] An example of conventional heat-pump hot water systems of non reverse cycle defrosting type is disclosed which employs a defrosting system in which a defrosting bypass valve is opened so that a high-temperature high-pressure gas refrigerant discharged from a compressor is allowed to bypass a water heat exchanger that exchanges heat between the water and the refrigerant, and introduced directly into an air heat exchanger that exchanges heat between air and the refrigerant through a defrosting bypass, and the air heat exchanger is heated by the heat of condensation of the refrigerant that is condensed into liquid so that the frost is melted by the heat (refer to Japanese Unexamined Patent Application Publication No. 2002-243276 (p. 9, Fig. 1)).

[0004] However, the bypass-type conventional heat-pump hot water system of non reverse cycle defrosting type has the problem of the possibility of decreasing the reliability of the compressor due to liquid reverse operation because the condensed fluid refrigerant is introduced into the inlet of the compressor without being converted to a gas refrigerant by the air heat exchanger serving as an evaporator.

[0005] The present invention is made to solve the above problems. Accordingly, a first object of the invention is to provide a hot water system in which the negative performance during defrosting operation is reduced.

A second object of the invention is to provide a hot water system in which a proper amount of circulation is ensured by controlling the condition of the refrigerant at the inlet of the compressor during defrosting operation so that the defrosting operation can be completed in a short time.

A third object of the invention is to provide a hot water system in which an overheated refrigerant is prevented from flowing into the compressor by controlling the refrigerant at the inlet of the compressor during defrosting

operation to prevent the compressor from being heated abnormally, thereby improving the reliability.

A fourth object of the invention is to provide a hot water system in which the backflow of liquid to the compressor is prevented by controlling the refrigerant at the inlet of the compressor during defrosting operation to prevent damages on the compressor, thereby improving the reliability.

[0006] A hot water system according to a first aspect of the invention includes: a compressor; a four-way valve for switching the direction of the refrigerating cycle during defrosting operation; a water heat exchanger for exchanging heat between water and a refrigerant; a first expansion valve for controlling the flow rate of the refrigerant to reduce the pressure; and an air heat exchanger for exchanging heat between air and the refrigerant, which are connected in that order by a pipeline to form a refrigerating cycle for circulating the refrigerant. The hot water system further includes; a bypass for redirecting the refrigerant from a portion of the pipeline in upstream of the first expansion valve to the inlet of the compressor during defrosting operation; and a solenoid valve disposed in the bypass, for switching. When the solenoid valve is opened to redirect part of the refrigerant passing through the water heat exchanger acting as an evaporator into the bypass during defrosting operation, the amount of the refrigerant passing through the bypass is controlled by changing the degree of opening of the first expansion valve.

[0007] The hot water system according to the first aspect of the invention has a bypass for redirecting the refrigerant from a portion of the pipeline in upstream of the first expansion valve to the inlet of the compressor during defrosting operation and a solenoid valve disposed in the bypass, for switching. The solenoid valve is opened to redirect part of the refrigerant passing through the water heat exchanger acting as an evaporator into the bypass during defrosting operation. Therefore, the amount of the refrigerant to the water heat exchanger is reduced. This offers the advantage of reducing the amount of heat exchange to decrease the negative performance during defrosting operation.

Moreover, when part of the refrigerant passing through the water heat exchanger is redirected to the bypass during defrosting operation, the amount of the refrigerant to the bypass is controlled by changing the degree of opening of the first expansion valve. This allows the refrigerant at the inlet of the compressor to be controlled, thus offering the advantage of ensuring proper amount of circulation to terminate the defrosting operation in a short time. Furthermore, the proper control of the state of the refrigerant to be sucked in the compressor offers the advantage of preventing abnormal overheating of the compressor by preventing the inflow of an overheated refrigerant and preventing damages to the compressor due to the backflow of liquid, thus improving the reliability of the compressor.

The invention will now be described by way of non-limiting

examples with reference to the accompanying drawings, in which:

Fig. 1 is a refrigerant circuit diagram of a hot water system according to a first embodiment of the invention;

Fig. 2 is a refrigerant circuit diagram of a hot water system according to a second embodiment of the invention;

Fig. 3 is a refrigerant circuit diagram of a hot water system according to a third embodiment of the invention;

Fig. 4 is a refrigerant circuit diagram of a hot water system according to a fourth embodiment of the invention;

Fig. 5 is a refrigerant circuit diagram of a hot water system according to a fifth embodiment of the invention; and

Fig. 6 is a refrigerant circuit diagram of a hot water system according to a sixth embodiment of the invention.

[0008] First Embodiment

Fig. 1 is a refrigerant circuit diagram of a hot water system according to a first embodiment of the invention. As shown in Fig. 1, the heat-pump hot water system according to the first embodiment of the invention includes a compressor 1, a four-way valve 2 for switching the refrigerant circuit during defrosting operation, a water heat exchanger 3 that exchanges heat between water and a refrigerant, an electronic expansion valve 4 that controls the flow rate of the refrigerant to decrease the pressure, an air heat exchanger 5 that exchanges heat between air and the refrigerant, and a pipeline 7 that connects the foregoing components.

One end of a bypath 8 is connected to a portion of the pipe 7 which is upstream of the electronic expansion valve 4 during defrosting operation, and the other end of the bypath 8 is connected to a portion of a pipe 7 adjacent to the inlet of the compressor 1.

The bypath 8 has therein a solenoid on-off valve 9. When the solenoid valve 9 is opened, the refrigerant can be passed through the bypath 8, and when the solenoid valve 9 is closed, the refrigerant can be stopped. The refrigerant flows from the portion of the pipe 7 in upstream of the high-pressure electronic expansion valve 4 to the inlet of the compressor 1 at a low pressure.

[0009] Fig. 1 shows the flow of the refrigerant in the refrigerating cycle when the hot water system is operated as a water heater by solid lines.

The refrigerant that has become high-pressure high-temperature gas in the compressor 1 is discharged from the outlet of the compressor 1 to the four-way valve 2. The four-way valve 2 is a valve for switching the circuit of the refrigerant. When the hot water system is operated as a water heater, the four-way valve 2 is fixed so as to feed the refrigerant discharged from the compressor 1 to the water heat exchanger 3.

The refrigerant fed to the water heat exchanger 3 exchanges heat with the water in the water heat exchanger 3. The high-pressure high-temperature gas refrigerant gives heat to the water, and is condensed into a high-pressure normal-temperature liquid refrigerant. In contrast, the water flowing into the water heat exchanger 3 receives the heat from the refrigerant to be increased in temperature and is discharged. The water heat exchanger 3 thus acts as a condenser of the refrigerating cycle.

[0010] The electronic expansion valve 4 controls the refrigerant condensed by the water heat exchanger 3 acting as a condenser according to the degree of subcooling. When the degree of subcooling is low, the degree of opening of the electronic expansion valve 4 is decreased so that the liquid of the refrigerant condensed by the water heat exchanger 3 is increased to thereby increase the degree of subcooling. In contrast, when the degree of subcooling is high, the degree of opening of the electronic expansion valve 4 is increased so that the liquid of the refrigerant condensed by the water heat exchanger 3 is decreased to thereby decrease the degree of subcooling.

[0011] The refrigerant discharged from the water heat exchanger 3 is reduced in pressure by the electronic expansion valve 4 that controls the flow rate of the refrigerant to decrease the pressure, and becomes a low-pressure low-temperature liquid refrigerant. The refrigerant flows from the electronic expansion valve 4 to the air heat exchanger 5 that exchanges heat between air and the refrigerant. Between the electronic expansion valve 4 and the air heat exchanger 5, the bypath 8 is connected. However, no refrigerant flows through the bypath 8 because the solenoid valve 9 is closed at a time when the hot water system is operated as a water heater.

Since the refrigerant flowing into the air heat exchanger 5 is low in temperature, the refrigerant receives heat from the air to evaporate into a low-pressure low-temperature gas refrigerant. In contrast, the air is cooled to low temperature and blows out. The air heat exchanger 5 thus acts as an evaporator of the refrigerating cycle.

[0012] The low-pressure low-temperature gas refrigerant exiting from the air heat exchanger 5 again flows into the four-way valve 2 for switching the circuit, with which it is fed to the inlet of the compressor 1. The low-pressure low-temperature gas refrigerant fed to the inlet of the compressor 1 is compressed in the compressor 1 into a high-pressure high-temperature gas refrigerant, and is discharged from the outlet.

When the refrigerating cycle is operated for heating water, the foregoing circulation is repeated so as to generate hot water by the heat pump action of transferring the heat obtained from air to water.

[0013] The use of a refrigerant such as R410A for use in air conditioners allows a low-cost refrigerating cycle and increases operation efficiency. For example, when a refrigerant such as CO₂ is used, higher-temperature water can be generated.

[0014] If such a heat-pump hot water system is operated at low outdoor temperatures, the air heat exchanger

5 acting as an evaporator is decreased in temperature to 0°C or lower, so that the air that has passed through the air heat exchanger 5 is cooled, and the water in the air is condensed on the surface of the air heat exchanger 5 into frost, thus closing the air path.

This reduces its draft performance to prevent the refrigerant from receiving sufficient evaporating heat. This decreases the evaporating pressure of the refrigerant to decreases the density of the refrigerant sucked in the compressor 1, thus decreasing the circulation amount of the refrigerant. With the decrease in circulation amount, the performance of the system is also decreased.

Accordingly, to ensure the performance, it is necessary to remove the frost formed on the surface of the air heat exchanger 5. The operation to remove the frost is generally referred to as a defrosting operation.

[0015] The reverse-cycle defrosting type hot water system according to the first embodiment of the invention executes the defrosting operation by switching the refrigerating cycle using the four-way valve 2.

Fig. 1 shows the flow of the refrigerant in the refrigerating cycle during defrosting operation by broken lines.

The high-pressure high-temperature gas refrigerant discharged from the compressor 1 flows into the four-way valve 2. The four-way valve 2 is fixed so as to feed the refrigerant discharged from the compressor 1 to the air heat exchanger 5 that exchanges heat between air and the refrigerant.

The high-pressure high-temperature refrigerant fed to the air heat exchanger 5 gives heat to the frost adhered to the air heat exchanger 5 to be condensed. The frost adhered on the air heat exchanger 5 is melted by the heat into liquid and flows down from the air heat exchanger 5. Thus, the air heat exchanger 5 acts as a condenser where air and the refrigerant exchange heat.

[0016] The condensed high-pressure normal-temperature liquid refrigerant is reduced in pressure by the electronic expansion valve 4 into a low-pressure low-temperature liquid refrigerant, and flows into the water heat exchanger 3. The water heat exchanger 3 exchanges heat between the water and the refrigerant, so that the water loses heat to be cooled, while the refrigerant obtains heat to evaporate into a low-pressure low-temperature gas refrigerant. Thus, the water heat exchanger 3 acts as an evaporator.

The low-pressure low-temperature gas refrigerant discharged from the water heat exchanger 3 again flows into the four-way valve 2 for switching the circuit, and is fed to the inlet of the compressor 1 by the four-way valve 2. The low-pressure low-temperature gas refrigerant fed to the inlet of the compressor 1 is compressed in the compressor 1 into a high-pressure high-temperature gas refrigerant and is discharge from the outlet. During defrosting operation, the foregoing cycle is repeated to melt the frost adhered to the air heat exchanger 5 into liquid and remove it from the air heat exchanger 5.

[0017] Thus, during the defrosting operation, the water flowing into the water heat exchanger 3 loses heat to be

cooled. Since the water discharged from the hot water system is decreased in temperature relative to the water flowing into the hot water system, the hot water system exhibits a negative performance as a water heater.

5 During the defrosting operation in which the solenoid valve 9 in the bypath 8 is closed, the bypath 8 being disposed so as to redirect the refrigerant from the portion of the pipe 7 in upstream of the electronic expansion valve 4 to the inlet of the compressor 1 during defrosting operation, all the low-pressure low-temperature liquid re-
10 frigerant flows into the water heat exchanger 3 acting as an evaporator during defrosting operation. Therefore, the amount of heat exchange between the water and the refrigerant increased, resulting in increased negative performance during the defrosting operation. Moreover,
15 the refrigerant is heated by the heat of the water into a low-pressure low-temperature gas refrigerant. However, if excessive heat exchange is made, the refrigerant becomes overheated gas and is sucked into the compressor 1. Thus, the density of the refrigerant sucked in the
20 compressor 1 during the defrosting operation decreases, thus decreasing the amount of circulation of the refrigerant in the refrigerating cycle.

[0018] Thus, by opening the solenoid valve 9 in the bypath 8 during defrosting operation, part of the refrigerant flowing in the water heat exchanger 3 acting as an
25 evaporator can be redirected into the inlet of the compressor 1.

The amount of the refrigerant flowing through the bypath 8 can be controlled by controlling the degree of opening of the electronic expansion valve 4 in downstream of the inlet of the bypath 8. When the degree of opening of the electronic expansion valve 4 is decreased, the amount of the refrigerant flowing to the water heat exchanger 3
30 decreases, and the refrigerant flowing through the bypath 8 increases. In contrast, when the degree of opening of the electronic expansion valve 4 is increased, the amount of the refrigerant flowing to the water heat exchanger 3 increases, and the refrigerant flowing through the bypath
35 8 decreases.

[0019] The refrigerant redirected to the inlet of the compressor 1 through the bypath 8 is mixed with the low-pressure low-temperature gas refrigerant that has passed through the water heat exchanger 3 and is sucked
40 into the compressor 1.

Thus, the low-pressure low-temperature liquid refrigerant flowing into the water heat exchanger 3 can be decreased, so that the amount of heat exchange between the water and the refrigerant can be decreased, and thus
45 the negative performance during defrosting operation can be reduced. Moreover, the refrigerant that has become overheated gas by excessive heat exchange is mixed with the normal-temperature liquid refrigerant that has passed through the bypath 8 and sucked into the
50 compressor 1. This increases the density of the refrigerant sucked into the compressor 1 during defrosting operation, resulting in an increase in the amount of circulation of the refrigerant during the refrigerating cycle.

[0020] When the overheated gas refrigerant is sucked into the compressor 1, the temperature of the refrigerant discharged from the compressor 1 also increases. In contrast, when the normal-temperature liquid refrigerant to be mixed through the bypath 8 increases, the temperature of the refrigerant discharged from the compressor 1 decreases.

Accordingly, the state of the refrigerant to be sucked into the compressor 1 can be controlled by controlling the amount of the refrigerant flowing into the water heat exchanger 3 and the amount of the refrigerant flowing through the bypath 8 by changing the degree of opening of the electronic expansion valve 4 according to the temperature of the refrigerant discharge from the compressor 1.

[0021] The control of the state of the refrigerant to be sucked into the compressor 1 leads to prevention of abnormal overheating of the compressor 1 by preventing the inflow of an overheated refrigerant and to prevention of damages to the compressor 1 due to the backflow of liquid, thus improving the reliability of the compressor 1. The electronic expansion valve 4 can provide the same advantages as those of the control according to the temperature of the refrigerant discharged from the compressor 1 even if controlled according to either the degree of superheat of the refrigerant sucked in the compressor 1 (degree of inlet superheat) or the degree of superheat of the refrigerant discharged from the compressor 1 (degree of discharge superheat).

[0022] Second Embodiment

Fig. 2 is a refrigerant circuit diagram of a hot water system according to a second embodiment of the invention.

While the hot water system according to the first embodiment controls the amount of the refrigerant flowing through the bypath 8 only with the electronic expansion valve 4, the hot water system of the second embodiment has a bypass electronic expansion valve 10 in series with the solenoid valve 9 in the bypath 8, as shown in Fig. 2. The bypass electronic expansion valve 10 disposed in series with the solenoid valve 9 in the bypath 8 allows controlling the amount of the refrigerant flowing through the bypath 8 with more conditions.

In the case where the amount of the refrigerant flowing through the bypath 8 is controlled only with the electronic expansion valve 4 during defrosting operation, and the amount of the refrigerant cannot be decreased with the electronic expansion valve 4 which is opened to the maximum, the amount of the refrigerant can be decreased by decreasing the degree of opening of the bypass electronic expansion valve 10.

The bypass electronic expansion valve 10 connected in series with the solenoid valve 9 in the bypath 8 may be disposed close to either the inlet or the outlet of the solenoid valve 9 because its action and effect are the same.

[0023] Third Embodiment

Fig. 3 is a refrigerant circuit diagram of a hot water system according to a third embodiment of the invention.

While the hot water system according to the first embod-

iment controls the amount of the refrigerant flowing through the bypath 8 only with the electronic expansion valve 4, the hot water system of the third embodiment has a capillary 11 in series with the solenoid valve 9 in the bypath 8, as shown in Fig. 3. Thus, the amount of the refrigerant flowing through the bypath 8 can be reduced, so that the flow rate of the refrigerant flowing through the bypath 8 can be controlled, thereby preventing the refrigerant from flowing into the bypath 8 excessively.

This structure allows the amount of the refrigerant flowing through the bypath 8 to be reduced by the capillary 11 during defrosting operation even with the same degree of opening of the electronic expansion valve 4 as that in the case where the amount of the refrigerant is controlled only by the electronic expansion valve 4. This is effective in the case where the refrigerant to be let flow through the bypath 8 may be little.

The capillary 11 disposed in series with the solenoid valve 9 in the bypath 8 may be disposed close to either the inlet or the outlet of the solenoid valve 9 because its action and effect are the same.

[0024] Fourth Embodiment

Fig. 4 is a refrigerant circuit diagram of a hot water system according to a fourth embodiment of the invention.

The hot water system of the fourth embodiment has a receiver 12 disposed between the water heat exchanger 3 and the air heat exchanger 5 in the refrigeration circuit of the hot water system of the first embodiment, and an additional electronic expansion valve 14 disposed between the receiver 12 and the air heat exchanger 5.

If there is a difference in internal volume between the water heat exchanger 3 and the air heat exchanger 5, a difference may occur between necessary amounts of the refrigerant during water heating operation and defrosting operation, causing excess refrigerant in the refrigerating cycle.

Thus, as shown in Fig. 4, disposition of the receiver 12 between the water heat exchanger 3 and the air heat exchanger 5 allows the excess refrigerant in the refrigerating cycle to be held therein.

Of the two pipes connected to the receiver 12, the pipe connected to the water heat exchanger 3 is provided with the electronic expansion valve 4, and the pipe connected to the air heat exchanger 5 is provided with the additional electronic expansion valve 14.

[0025] The electronic expansion valve 4 is in upstream of the receiver 12 during water heating operation, and controls the refrigerant condensed by the water heat exchanger 3 according to the degree of subcooling.

When the degree of subcooling is low, the degree of opening of the electronic expansion valve 4 is decreased to thereby increase the liquid in the refrigerant condensed by the water heat exchanger 3, thereby increasing the degree of subcooling. In contrast, when the degree of subcooling is high, the degree of opening of the electronic expansion valve 4 is increased to thereby decrease the liquid in the refrigerant condensed by the water heat exchanger 3, thereby decreasing the degree of subcooling.

[0026] The additional electronic expansion valve 14 is located in downstream of the receiver 12, and controls the refrigerant evaporated by the air heat exchanger 5 according to the degree of superheat.

When the degree of superheat is low, the degree of opening of the additional electronic expansion valve 14 is decreased to thereby decrease the amount of the refrigerant evaporated by the air heat exchanger 5 to increase the degree of dryness of the refrigerant due to evaporation, thereby increasing the degree of superheat.

[0027] In contrast, when the degree of superheat is high, the degree of opening of the additional electronic expansion valve 14 is increased to thereby increase the amount of the refrigerant evaporated by the air heat exchanger 5 to decrease the degree of dryness of the refrigerant due to evaporation, thereby decreasing the degree of superheat.

The degree of superheat to be controlled may be either the degree of inlet superheat indicative of the state of the refrigerant sucked in the compressor 1 or the degree of discharge superheat indicative of the state of the refrigerant discharged from the compressor 1 because they offer the same effects. In place of the degree of discharge superheat, an output temperature that is the temperature of the gas refrigerant discharged from the compressor 1 may be controlled because they offer the same effects.

[0028] In contrast, during defrosting operation, the degree of subcooling of the air heat exchanger 5 is controlled by the additional electronic expansion valve 14 and one of the degree of inlet superheat, the output degree of superheat, and the output temperature of the compressor 1 is controlled by the electronic expansion valve 4. In the refrigerating cycle with the receiver 12, a circuit in which one end of the bypath 8 is connected to the portion of the pipe 7 connecting the electronic expansion valve 4 and the receiver 9, and the other end of the bypath 8 is connected to the portion of the pipeline 7 adjacent to the inlet of the compressor 1. The bypath 8 has therein the solenoid on-off valve 9. When the solenoid valve 9 is opened, the refrigerant can pass through the bypath. 8, and when the solenoid valve 9 is closed, the refrigerant can be stopped.

The refrigerant flows from a high-pressure portion of the pipeline 7 in upstream of the electronic expansion valve 4 to a low-pressure portion of the pipeline 7 for the inlet of the compressor 1.

[0029] When the solenoid valve 9 is opened during defrosting operation, part of the refrigerant flowing to the water heat exchanger 3 acting as an evaporator can be redirected to the inlet of the compressor 1. The amount of the refrigerant flowing through the bypath 8 can be controlled by controlling the degree of opening of the electronic expansion valve 4 in downstream of the inlet of the bypath 8.

When the degree of the opening of the electronic expansion valve 4 is decreased, the amount of the refrigerant flowing to the water heat exchanger 3 is decreased, and the refrigerant flowing to the bypath 8 is increased. In

contrast, when the degree of the opening of the electronic expansion valve 4 is increased, the amount of the refrigerant flowing to the water heat exchanger 3 is increased, and the refrigerant flowing to the bypath 8 is decreased.

[0030] The refrigerant redirected to the inlet of the compressor 1 through the bypath 8 is mixed with the low-pressure low-temperature gas refrigerant that has passed through the water heat exchanger 3 and is sucked into the compressor 1. Thus, the low-pressure low-temperature liquid refrigerant flowing into the water heat exchanger 3 can be decreased, so that the amount of heat exchange between the water and the refrigerant can be decreased, and thus the negative performance during defrosting operation can be reduced. Moreover, the refrigerant that has become overheated gas by excessive heat exchange is mixed with the normal-temperature liquid refrigerant that has passed through the bypath 8 and sucked into the compressor 1. This increases the density of the refrigerant sucked into the compressor 1 during defrosting operation, resulting in an increase in the amount of circulation of the refrigerant in the refrigerating cycle.

[0031] When the overheated gas refrigerant is sucked into the compressor 1, the temperature of the refrigerant discharged from the compressor 1 also increases. In contrast, when the normal-temperature liquid refrigerant that is mixed through the bypath 8 increases, the temperature of the refrigerant discharged from the compressor 1 decreases.

Accordingly, the state of the refrigerant to be sucked into the compressor 1 can be controlled by controlling the amount of the refrigerant flowing into the water heat exchanger 3 and the amount of the refrigerant flowing through the bypath 8 by changing the degree of opening of the electronic expansion valve 4 according to the temperature of the refrigerant discharge from the compressor 1.

The control of the state of the refrigerant to be sucked into the compressor 1 leads to prevention of abnormal overheating of the compressor 1 by preventing the inflow of an overheated refrigerant and to prevention of damages to the compressor 1 due to the backflow of liquid, thus improving the reliability of the compressor 1.

The electronic expansion valve 4 can provide the same advantages as those of the control according to the temperature of the refrigerant discharged from the compressor 1 even if controlled according to either the degree of inlet superheat of the refrigerant sucked in the compressor 1 or the degree of discharge superheat of the refrigerant discharged from the compressor 1.

[0032] Fifth Embodiment

Fig. 5 is a refrigerant circuit diagram of a hot water system according to a fifth embodiment of the invention.

The hot water system of the fifth embodiment has an accumulator 15 disposed between the connection point of the four-way valve 2 and the bypath 8 and the inlet of the compressor 1 in the refrigeration circuit of the hot water system of the first embodiment.

If there is a difference in internal volume between the water heat exchanger 3 and the air heat exchanger 5, a difference may occur between necessary amounts of the refrigerant during water heating operation and defrosting operation, causing excess refrigerant in the refrigerating cycle.

Thus, as shown in Fig. 5, disposition of the accumulator 15 between the connection point of the four-way valve 2 and the bypath 8 and the inlet of the compressor 1 allows the excess refrigerant during the refrigerating cycle to be held therein.

The accumulator 15 allows the compressor 1 to suck only the gas refrigerant, preventing the liquid refrigerant to be sucked into the compressor 1, so as to improve the reliability of the compressor 1.

[0033] When the solenoid valve 9 in the bypath 8 is opened during defrosting operation, part of the refrigerant flowing to the water heat exchanger 3 can be redirected to the inlet of the compressor 1. The amount of the refrigerant flowing through the bypath 8 can be controlled by controlling the degree of opening of the electronic expansion valve 4 in downstream of the inlet of the bypath 8. When the degree of the opening of the electronic expansion valve 4 is decreased, the amount of the refrigerant flowing to the water heat exchanger 3 is decreased, and the refrigerant flowing to the bypath 8 is increased. In contrast, when the degree of the opening of the electronic expansion valve 4 is increased, the amount of the refrigerant flowing to the water heat exchanger 3 is increased, and the refrigerant flowing to the bypath 8 is decreased.

[0034] The refrigerant redirected to the inlet of the compressor 1 through the bypath 8 is mixed with the low-pressure low-temperature gas refrigerant that has passed through the water heat exchanger 3 and is sucked into the compressor 1. Thus, the low-pressure low-temperature liquid refrigerant flowing into the water heat exchanger 3 acting as an evaporator can be decreased, so that the amount of heat exchange between the water and the refrigerant can be decreased, and thus the negative performance during defrosting operation can be reduced. Moreover, the refrigerant that has become overheated gas by excessive heat exchange is mixed with the normal-temperature liquid refrigerant that has passed through the bypath 8 and sucked into the compressor 1. This increases the density of the refrigerant sucked into the compressor 1 during defrosting operation, resulting in an increase in the amount of circulation of the refrigerant in the refrigerating cycle.

[0035] When the overheated gas refrigerant is sucked into the compressor 1, the temperature of the refrigerant discharged from the compressor 1 also increases. In contrast, when the normal-temperature liquid refrigerant that is mixed through the bypath 8 increases, the temperature of the refrigerant discharged from the compressor 1 decreases.

Accordingly, the state of the refrigerant to be sucked into the compressor 1 can be controlled by controlling the amount of the refrigerant flowing into the water heat ex-

changer 3 and the amount of the refrigerant flowing through the bypath 8 by changing the degree of opening of the electronic expansion valve 4 according to the temperature of the refrigerant discharge from the compressor 1.

[0036] The control of the state of the refrigerant to be sucked into the compressor 1 leads to prevention of abnormal overheating of the compressor 1 by preventing the inflow of an overheated refrigerant and to prevention of damages to the compressor 1 due to the backflow of liquid, thus improving the reliability of the compressor 1. The electronic expansion valve 4 can provide the same advantages as those of the control according to the temperature of the refrigerant discharged from the compressor 1 even if controlled according to either the degree of inlet superheat of the refrigerant sucked in the compressor 1 or the degree of discharge superheat of the refrigerant discharged from the compressor 1.

Both the control of the suction to the compressor 1 using the bypath 8 and prevention of backflow of liquid to the compressor 1 by the accumulator 15 significantly improve the reliability of the compressor 1.

[0037] Sixth Embodiment

Fig. 6 is a refrigerant circuit diagram of a hot water system according to a sixth embodiment of the invention.

In the first to fifth embodiments, a water pump for circulating water is disposed outside the outside unit. The water fed from the water pump flows through a water pipe into the water heat exchanger 3 from the water inlet of the outside unit, exchanges heat with the refrigerant and is fed from the water outlet into the water pipe.

In the sixth embodiment, a water pump 16 for circulating water is disposed inside an outdoor unit housing 20, as shown in Fig. 6, so that the water pump 16 can be controlled by the controller of the outside unit.

Accordingly, the negative performance can be reduced by stopping the water pump 16 during defrosting operation. However, the stop of the water pump 16 may cause freezing.

However, when the solenoid valve 9 in the bypath 8 is opened during defrosting operation, part of the refrigerant flowing to the water heat exchanger 3 acting as an evaporator can be redirected to the inlet of the compressor 1. This reduces the negative performance without stopping the water circulating pump during defrosting operation, thus improving the performance. Moreover, since the built-in water pump 16 is not stopped, the water heat exchanger 3 and its pipe do not burst.

Claims

1. A hot water system comprising:

- a compressor (1);
- a four-way valve (2) for switching the direction of the refrigerating cycle during defrosting operation;

a water heat exchanger (3) for exchanging heat between water and a refrigerant;
 a first expansion valve (4) for controlling the flow rate of the refrigerant to reduce the pressure;
 and
 an air heat exchanger (5) for exchanging heat between air and the refrigerant, which are connected in that order by a pipeline (7) to form a refrigerating cycle for circulating the refrigerant, thereby heating water;
 the hot water system further comprising:

a bypass (8) for redirecting the refrigerant from a portion of the pipeline (7) in upstream of the first expansion valve (4) to the inlet of the compressor (1) during defrosting operation; and
 a solenoid valve (9) disposed in the bypass (8), for switching,

wherein

when the solenoid valve (9) is opened to redirect part of the refrigerant passing through the water heat exchanger (3) acting as an evaporator into the bypass (8) during defrosting operation, the amount of the refrigerant passing through the bypass (8) is controlled by changing the degree of opening of the first expansion valve (4).

2. The hot water system according to Claim 1, wherein the bypass (8) further includes a bypass expansion valve (10) for directly controlling the flow rate of the refrigerant flowing through the bypass (8), installed in series with the solenoid valve (9).

3. The hot water system according to Claim 1, wherein the bypass (8) further includes a capillary (11) capable of reducing the flow rate of the refrigerant flowing through the bypass (8), disposed in series with the solenoid valve (9) .

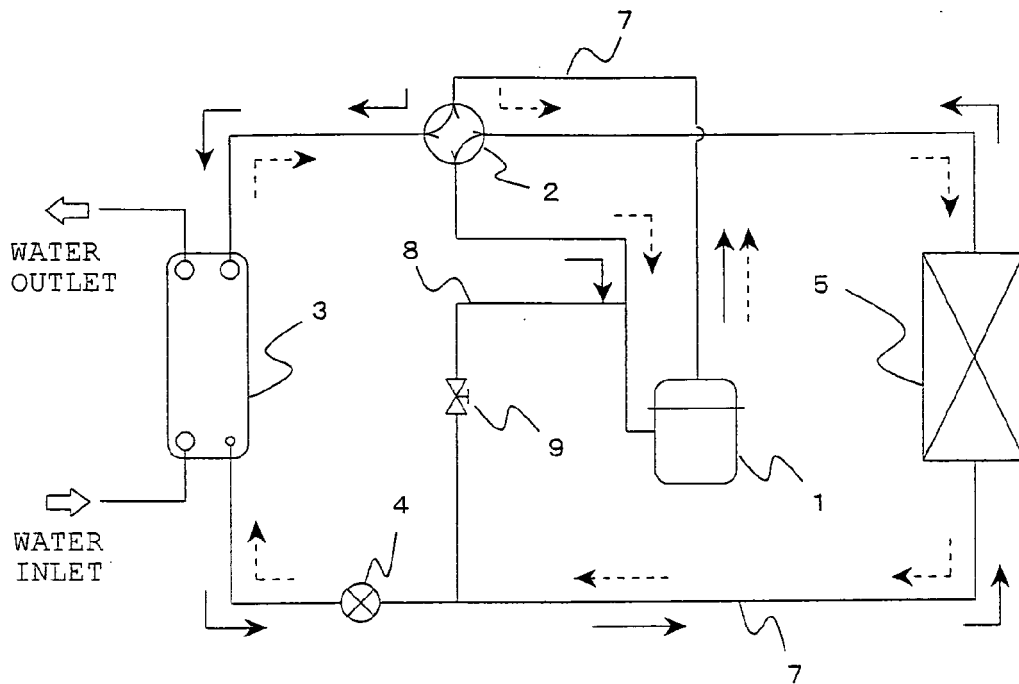
4. The hot water system according to any of Claims 1 to 3, further comprising:

a receiver (12) disposed between the first expansion valve (4) and the air heat exchanger (5); and
 a second expansion valve (14) disposed between the receiver (12) and the air heat exchanger (5), wherein
 the bypass (8) is connected to a portion of the pipeline (7) between the first expansion valve (4) in downstream of the receiver (12) and the receiver (12), wherein during defrosting operation, the amount of refrigerant passing through the bypass (8) is controlled by changing the degree of opening of the first expansion valve (4).

5. The hot water system according to any of Claims 1 to 3, further comprising an accumulator (15) between a connection point of the four-way valve (2) and the bypass (8) and the inlet of the compressor (1), wherein
 during defrosting operation, the amount of the refrigerant passing through the bypass path (8) is controlled by changing the degree of opening of the first expansion valve (4).

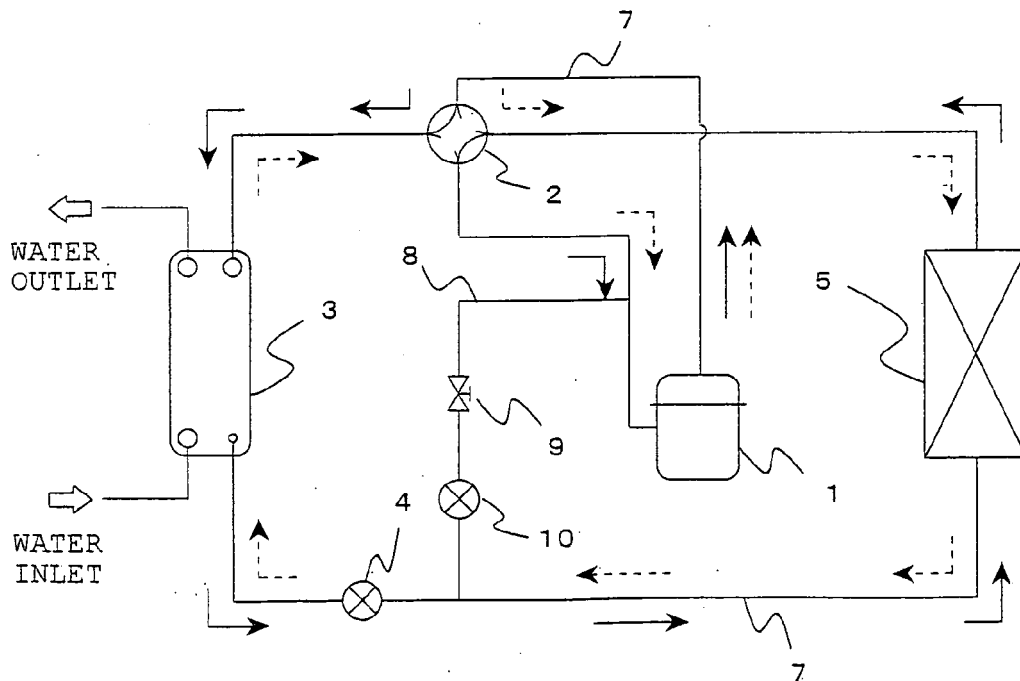
6. The hot water system according to any of Claims 1 to 5, wherein a pump (16) for circulating the water in the water circuit connected to the water heat exchanger (3) is disposed in an outdoor unit so that the pump (16) is not stopped during defrosting operation.

FIG. 1



- | | |
|-------------------------------|-----------------------|
| 1: COMPRESSOR | 5: AIR HEAT EXCHANGER |
| 2: FOUR-WAY VALVE | 7: PIPELINE |
| 3: WATER HEAT EXCHANGER | 8: BYPASS |
| 4: ELECTRONIC EXPANSION VALVE | 9: SOLENOID VALVE |

FIG. 2



- 10: BYPASS ELECTRONIC EXPANSION VALVE

FIG. 3

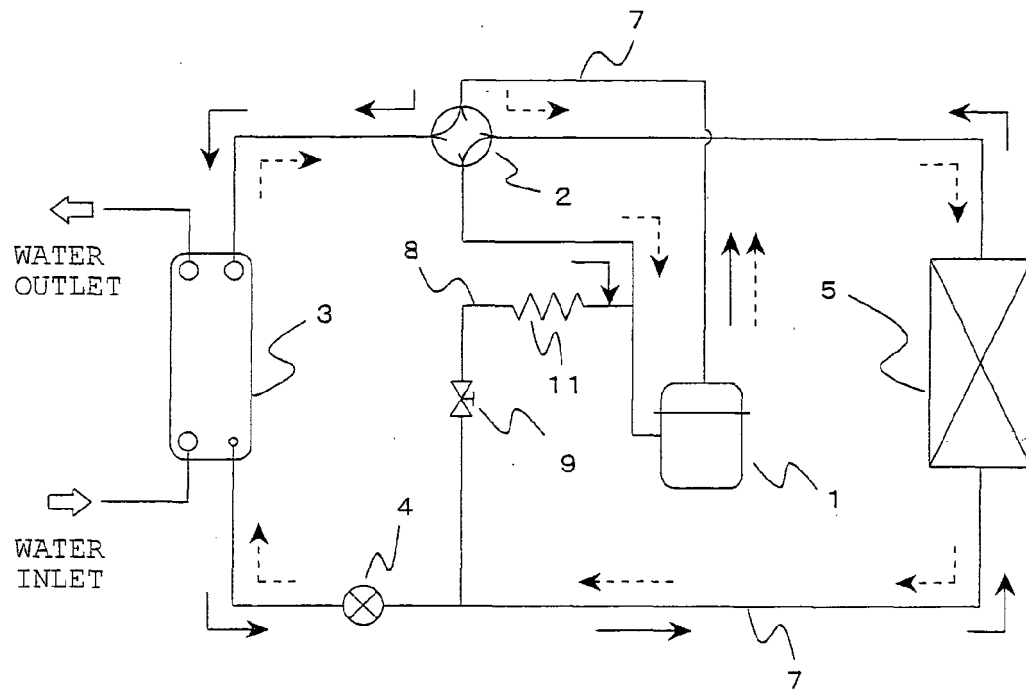


FIG. 4

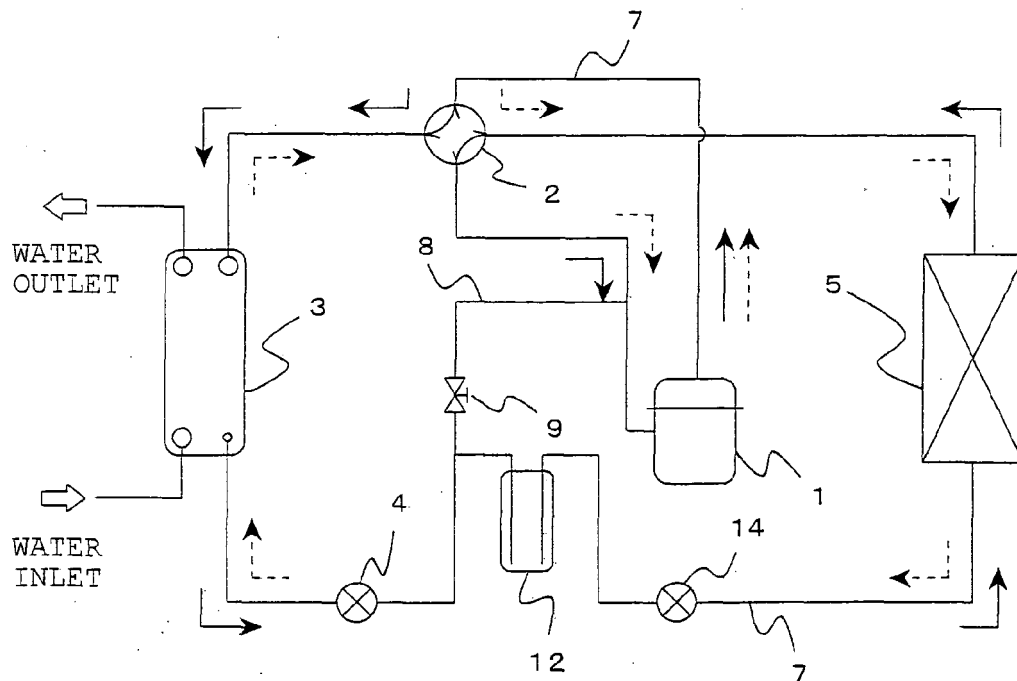


FIG. 5

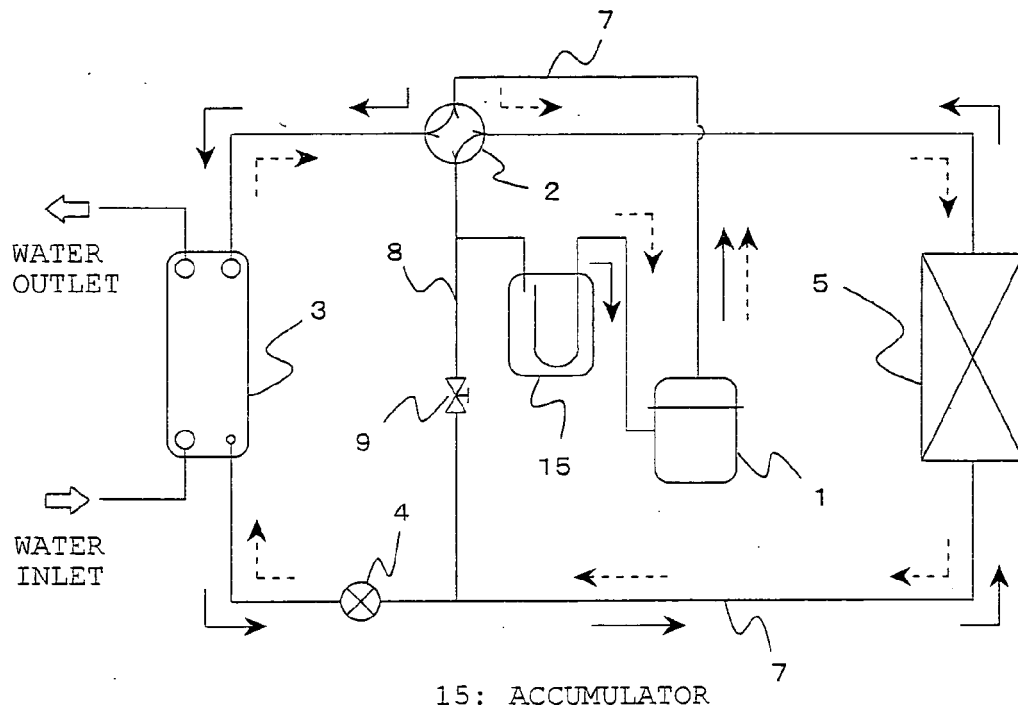
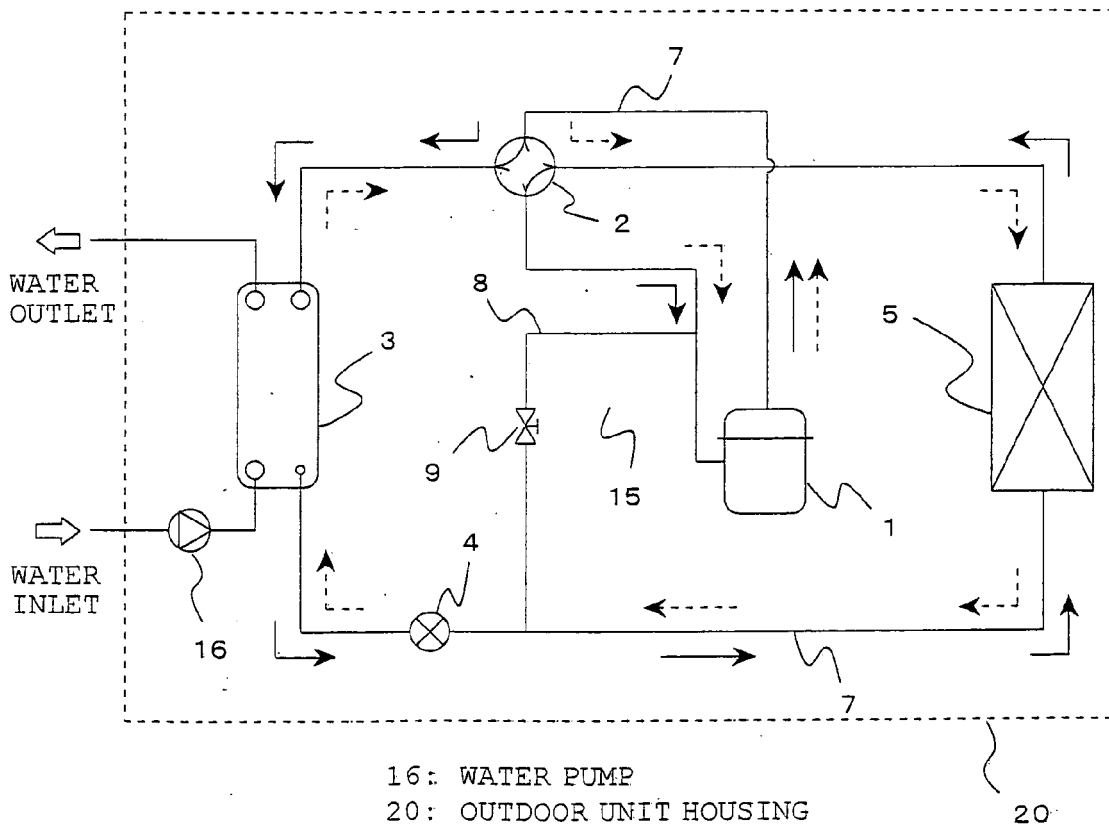


FIG. 6



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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