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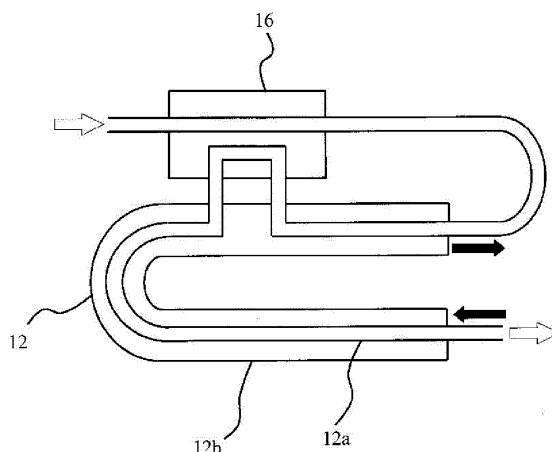
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(54) **HEAT EXCHANGER AND HEAT PUMP TYPE HOT WATER GENERATING DEVICE USING SAME**

(57) An object is to provide a heat exchanger that can effectively suppress scale precipitation without decreasing the flowrate of water flowing inside and that can simplify maintenance work, and a heat-pump hot-water generating device including this heat exchanger. To achieve this object, the heat exchanger includes: a first pipe carrying a heating medium; and a second pipe carrying

water that exchanges heat with the heating medium. The heating medium flowing through the first pipe and the water flowing through the second pipe form a counterflow, and the first pipe includes an internal heat exchanger for heat exchange between the heating medium flowing upstream of the first pipe and the heating medium flowing in the first pipe.

Figure 2



Description**[Citation List]****[Technical Field]****[Patent Literature]**

[0001] The present invention relates to a heat exchanger used in a heat-pump hot-water supply system, for example, to generate hot water by using heat of condensation of a refrigerant, and a heat-pump hot-water generating device using the heat exchanger.

5 **[0007]** [Patent Literature 1] Japanese Patent Laid-Open No. 2005-77062

[Summary of Invention]**[Background Art]**10 **[Technical Problem]**

[0002] A conventional heat-pump hot-water generating device in a heat-pump hot-water supply system or other systems uses a refrigerating circuit, which is used for circulation of a refrigerant, as a heat-pump unit to generate hot water to be supplied. In this case, the heat exchanger for the refrigerating circuit includes a first pipe for circulating a refrigerant, such as carbon dioxide, and a second pipe for circulating a heating object, such as water (hot water), such that heat can be exchanged. In general, a refrigerant flowing through the first pipe and water flowing through the second pipe are arranged to generate counterflow for high thermal efficiency. Accordingly, a hot water that just exchanged heat with a hot refrigerant is ejected from the outlet of the second pipe.

[0008] As described above, in the structure disclosed in Patent Literature 1, the water outlet pipe is enlarged toward the water flow direction, thereby decreasing the water flowrate and hot-water supply performance. Besides, this structure does not suppress scale precipitation but just delays a complete blockage of the pipe due to scale. Further, this structure, which features a large size of water pipe, may lead to increases in heat exchange size and cost.

[0003] Here, water flowing through the second pipe is often running water or groundwater containing minerals such as calcium and magnesium. These minerals, mainly calcium carbonate, precipitate at the high-temperature outlet of the second pipe as so-called scale.

[0009] Accordingly, there has been a need in the market for development of a heat exchanger that can efficiently suppress scale precipitation without decreasing the flowrate of water flowing inside and that can simplify maintenance work, and a heat-pump hot-water generating device including this heat exchanger.

[Solution to Problem]

[0004] A deposit of scale on the inner wall of the second pipe, which transfers heat, causes a decrease in the efficiency of heat exchange with the first pipe. A decrease in heat exchange efficiency makes it difficult to achieve a target temperature of ejected water and results in consumption of excess energy for achieving the target temperature of ejected water.

30 **[0010]** To solve this problem, the present inventors have arrived, after eager research, at providing a heat exchanger that can efficiently suppress scale precipitation without disadvantageously affecting hot-water supply performance, and a heat-pump hot water generating device including the heat exchanger.

[0005] If the deposit of scale on the inner wall of the second pipe is left, the scale may block the second pipe. For this reason, in areas using water with high contents of scale components, scale precipitation becomes a serious problem requiring frequent maintenance.

35 **[0011]** In particular, a heat exchanger of the present invention includes: a first pipe carrying a heating medium; and a second pipe carrying water that exchanges heat with the heating medium. The heating medium flowing through the first pipe and the water flowing through the second pipe form a counterflow, and the first pipe includes an internal heat exchanger for heat exchange between the heating medium flowing upstream of the first pipe and the heating medium flowing in the first pipe.

[0006] A technique for suppressing such scale precipitation is a heat-pump hot-water supply disclosed in Patent Literature 1. The heat-pump hot-water supply disclosed in Patent Literature 1 includes a heat-pump circuit consisting of at least a compressor, a radiator, an expansion valve, and an evaporator. The radiator is a refrigerant-water heat exchanger in which the refrigerant dissipates heat into water and thus obtains hot water, and the internal space of the water outlet pipe connected to the water outlet expands toward the water flow direction. This structure improves reliability against adhesion of scale or other materials by removing water stagnation portions at a scale-adherable high-temperature outlet of a cold-water path in the heat-pump hot-water supply.

40 **[0012]** In the heat exchanger of the present invention, it is preferable that, assuming that the length of a portion of the first pipe used for heat exchange with the second pipe is 100%, the internal heat exchanger provides heat exchange between the heating medium flowing in any of positions of 4% to 50% from the edge of a heating medium inlet of the first pipe, and the heating medium flowing upstream of the first pipe.

45 **[0013]** It is preferable that the heat exchanger of the present invention include a double pipe including an outer pipe forming the second pipe and a thermally conductive inner pipe forming the first pipe and residing inside the outer pipe, and the internal heat exchanger be connected by piping to the inner pipe that passes through the outer

pipe and is drawn to the outside.

[0014] In the heat exchanger, it is preferable that a plurality of inner pipes forming the first pipe be provided in the outer pipe forming the second pipe.

[0015] In the heat exchanger, it is also preferable that the first pipe includes a double pipe.

[0016] In the heat exchanger of the present invention, it is also preferable that outer walls of the first pipe and the second pipe be in contact with each other to allow heat exchange between the heating medium flowing through the first pipe and the water flowing through the second pipe.

[0017] A heat-pump hot-water generating device of the present invention includes: a refrigerant circuit including a compressor, a use-side heat exchanger, a pressure reducing device, and a heat source side heat exchanger and sealing a refrigerant; and a heating medium circuit carrying hot-water generating water. The use-side heat exchanger is a heat exchanger according to any one of Claim 1 to 3, the heating medium flowing through the first pipe is the refrigerant ejected from the compressor in the refrigerant circuit, and the water flowing through the second pipe is the hot-water generating water in the heating medium circuit.

[0018] In the heat-pump hot-water generating device of the present invention, it is preferable that the refrigerant be a carbon dioxide refrigerant.

[Advantageous Effects of Invention]

[0019] In the heat exchanger of the present invention, the heating medium flowing through the first pipe and the water flowing through the second pipe form a counter-flow, and the first pipe includes an internal heat exchanger for heat exchange between the heating medium flowing upstream of the first pipe and the heating medium flowing in the first pipe. Accordingly, a decrease in heat exchange efficiency in the entire heat exchanger can be suppressed and the temperature of the hottest portion that resides around the heating medium inlet of the first pipe can be decreased. Accordingly, water that flows around the water outlet of the second pipe and exchanges heat with a portion of the first pipe around the heating medium inlet is prevented from being disadvantageously locally heated to a high temperature, thereby effectively suppressing scale precipitation around the water outlet of the second pipe. This simplifies maintenance work required for dealing with scale precipitation.

[0020] In addition, the present invention involves heat exchange between the heating medium flowing upstream of the first pipe and the heating medium flowing into the first pipe in the internal heat exchanger without extending the diameter of the second pipe around the water outlet unlike in a conventional technique, thereby decreasing the temperature around the heating medium inlet of the first pipe and removing the need for a decrease in the flow rate of the water flowing through the second pipe. Therefore, the present invention can effectively

suppress scale precipitation without disadvantageously affecting hot-water supply performance.

[0021] A heat-pump hot-water generating device of the present invention includes: a refrigerant circuit including a compressor, a use-side heat exchanger, a pressure reducing device, and a heat source side heat exchanger and sealing a refrigerant; and a heating medium circuit carrying hot-water generating water. The use-side heat exchanger is a heat exchanger of the present invention, the refrigerant in the refrigerant circuit flows through the first pipe, and the hot-water generating water in the heating medium circuit flows through the second pipe. Thus, the temperature of the hottest portion that resides around the refrigerant inlet of the first pipe can be decreased. Accordingly, hot-water generating water that flows around the water outlet of the second pipe and exchanges heat with a portion of the first pipe around the refrigerant inlet is prevented from being disadvantageously locally heated to a high temperature, thereby effectively suppressing scale precipitation around the water outlet of the second pipe. This simplifies maintenance work required for dealing with scale precipitation in the heat-pump hot-water generating device as well.

[Brief Description of Drawings]

[0022]

[Figure 1] Figure 1 is a schematic view of a heat-pump hot-water supply system according to one embodiment of the present invention.

[Figure 2] Figure 2 is a schematic view of a use-side heat exchanger in Figure 1.

[Figure 3] Figure 3 shows the performance of the entire use-side heat exchanger provided when an internal heat exchanger is placed in particular portions.

[Figure 4] Figure 4 shows changes in the temperatures of the refrigerant and the heating water in the case where the internal heat exchanger is placed at the edge of the refrigerant inlet (Comparative Example).

[Figure 5] Figure 5 shows changes in the temperatures of the refrigerant and the heating water in the case where the internal heat exchanger is placed in a position of 8% from the edge of the refrigerant inlet (Example).

[Figure 6] Figure 6 shows changes in the temperatures of the refrigerant and the heating water in the case where the internal heat exchanger is placed in a position of 50% from the edge of the refrigerant inlet (Example).

[Description of Embodiment]

[0023] A heat exchanger according to one embodiment of the present invention will now be described taking a heat-pump hot-water supply system H, which is an ex-

ample of a heat-pump hot-water generating device including a heat exchanger of the present invention, as an example. Figure 1 is a schematic view of a heat-pump hot-water supply system H according to this embodiment. The heat-pump hot-water supply system H according to this embodiment of the present invention includes a heat-pump unit 1 with a refrigerant circuit 10, and a tank unit 2 with a heating medium circuit 20.

[0024] The refrigerant circuit 10 in the heat-pump unit 1 includes a compressor 11, a use-side heat exchanger 12, an expansion valve 13 serving as a pressure reducing device, and a heat source side heat exchanger 14, and these components are sequentially connected in a loop through piping to form a known refrigerant circuit. The heat source side heat exchanger 14 uses an air-cooling scheme in which heat is taken from the air from an adjacent air blower 15 for evaporation of the refrigerant. A predetermined amount of refrigerant is sealed in this refrigerant circuit 10. This refrigerant is preferably a carbon dioxide refrigerant which is one of natural refrigerants. However, the refrigerant used in a heat-pump hot-water supply system of the present invention can be any refrigerant other than a carbon dioxide refrigerant.

[0025] The heating medium circuit 20 in the tank unit 2 includes a hot-water tank 21, a circulation pump 22, and the aforementioned use-side heat exchanger 12 which are sequentially connected in a loop through piping. The hot-water tank 21 is supplied with running water, groundwater, or other heating water serving as hot-water generating water depending on the hot water consumption, and stores a predetermined amount of heating water. The operation of the circulation pump 22 circulates heating water, which is fed from the hot-water tank 21, in the heating medium circuit 20.

[0026] The use-side heat exchanger 12 for the refrigerant circuit 10 and the heating medium circuit 20 corresponds to a heat exchanger of the present invention. The use-side heat exchanger 12 according to this embodiment will now be described in detail with reference to Figure 2.

[0027] The use-side heat exchanger 12 according to this embodiment includes a first pipe 12a which carries a heating medium, i.e., a high-temperature refrigerant on the high-pressure side in the refrigerant circuit 10, and a second pipe 12b which carries water that exchanges heat with the heating medium, i.e., heating water in the heating medium circuit 20. To be specific, the use-side heat exchanger 12 in this embodiment is preferably a double pipe consisting of an outer pipe corresponding to the second pipe 12b and a thermally conductive inner pipe corresponding to the first pipe 12a. When the use-side heat exchanger 12 is a double pipe, the refrigerant flows through the inner pipe corresponding to the first pipe 12a and heating water flows between the inner wall of the second pipe 12b and the outer wall of the first pipe 12a. Although one first pipe 12a serving as the inner pipe carrying the refrigerant is provided on the inner side of the second pipe 12b serving as the outer pipe carrying heat-

ing water here, a plurality of first pipes 12a may be provided. In addition, although the use-side heat exchanger 12 is a double pipe here, the first pipe 12a inside the second pipe 12b may be a multi-pipe (a double pipe).

5 This is because, in some cases, detection of leakage of the refrigerant is a purpose of providing a double pipe as the first pipe 12a. Although this embodiment takes a multi-pipe, including a double pipe, as an example of the use-side heat exchanger 12, this is not necessarily the case and outer walls of the first pipe and the second pipe may be brazed together in contact with each other so that the heating medium flowing through the first pipe and water flowing through the second pipe can exchange heat with each other. When the outer walls are in contact with each other, the first pipe carrying the heating medium may be branched into narrow pipes and these narrow pipes for the first pipe may be wrapped around the second pipe to achieve heat exchange. Here, to draw it to the inner heat exchanger, the narrow pipes are joined so that it can exchange heat with the heating medium flowing upstream of the first pipe, and the first pipe is branched into narrow pipes again and then wrapped around the second pipe.

[0028] In the use-side heat exchanger 12, the refrigerant flowing through the first pipe 12a and the heating water flowing through the second pipe 12b generate counterflow. To be specific, the high-temperature refrigerant flowing near the inlet of the first pipe 12a exchanges heat with heating water at a relatively high temperature flowing near the outlet of the second pipe 12b, and low-temperature heating water flowing near the inlet of the second pipe 12b exchanges heat with the refrigerant at a relatively low temperature flowing near the outlet of the first pipe 12a. For example, the refrigerant flowing through the first pipe 12a flows into the first pipe 12a while this refrigerant is at 100°C, and exchanges heat with the heating water to decrease to around 10°C and drains out of the first pipe 12a. The heating water flowing through the second pipe 12b flows into the second pipe 12b while this heating water is at 5°C, and exchanges heat with the high-temperature refrigerant to rise to around 65°C and drains out of the second pipe 12b.

[0029] The diameter of the second pipe 12b for the heat exchanger 12 of the present invention is preferably uniform at least from the inlet to the outlet for the heating water.

[0030] The heat exchanger 12 according to the present invention is characterized by including an internal heat exchanger 16 in which the first pipe 12a carrying the refrigerant involves heat exchange between the high-temperature refrigerant flowing upstream of the first pipe 12a and the refrigerant flowing into the first pipe 12a. The use-side heat exchanger 12 according to this embodiment has a double pipe structure in which the refrigerant flows into the first pipe 12a serving as an inner pipe and the heating water flows into the second pipe 12b serving as an outer pipe; therefore, the internal heat exchanger 16 is connected to the first pipe 12a which is the inner

pipe passing through the second pipe 12b, which serves as an outer pipe, and drawn to the outside.

[0031] To be specific, the refrigerant that flows into the first pipe 12a and exchanges heat with the high-temperature refrigerant flowing upstream of the first pipe 12a is preferably a refrigerant flowing in a position of 4% to 50% from the edge of the refrigerant (heating medium) inlet of the first pipe 12a assuming that the length of a portion of the first pipe 12a used for heat exchange with the second pipe 12b is 100%. In other words, the internal heat exchanger 16 is preferably connected to a position of 4% to 50% from the edge of the refrigerant inlet of the first pipe 12a assuming that the length of a portion of the first pipe 12a used for heat exchange with the second pipe 12b is 100%.

[0032] In this case, considering the thermal efficiency, the refrigerant flowing in the first pipe 12a and exchanging heat with the high-temperature refrigerant before the first pipe 12a in the internal heat exchanger 16 is preferably a refrigerant flowing in a position of 4% to 40% from the edge of the refrigerant (heating medium) inlet of the first pipe 12a assuming that the length of a portion of the first pipe 12a used for heat exchange with the second pipe 12b is 100%. Less than 4% is too close to the refrigerant outlet of the first pipe 12a to perform internal heat exchange and makes it difficult to suppress heating of local portions, which decreases the effects of suppression of scale precipitating on the inner wall of the second pipe 12b that carries heating water. In contrast, more than 40% results in a heat exchange efficiency of below 90% of that gained without the internal heat exchanger 16.

[0033] On the other hand, considering the production efficiency, the refrigerant flowing in the first pipe 12a and exchanging heat with the high-temperature refrigerant before the first pipe 12a in the internal heat exchanger 16 is preferably a refrigerant flowing in a position of 50% from the edge of the refrigerant (heating medium) inlet of the first pipe 12a, i.e., the midpoint of the first pipe 12a assuming that the length of a portion of the first pipe 12a used for heat exchange with the second pipe 12b is 100%. A heat exchanger generally consists of a plurality of joined pipes. When one first pipe 12a is composed of two joined components, the internal heat exchanger 16 can be connected to the joint and the production efficiency is improved.

[0034] With this structure, the operation of the compressor 11 causes a high-temperature and high-pressure gas refrigerant compressed in the compressor 11 to flow into the internal heat exchanger 16 and exchange heat with a refrigerant that is already in the first pipe 12a in the use-side heat exchanger 12. At this time, the internal heat exchanger 16 preferably dissipates heat from the high-temperature refrigerant that is about to flow into the first pipe 12a in the use-side heat exchanger 12 by 10degree to 25degree. The refrigerant from the internal heat exchanger 16 then flows into the first pipe 12a in the use-side heat exchanger 12 and exchanges heat with the heating water flowing in the second pipe 12b in the

use-side heat exchanger 12 for dissipation.

[0035] In the use-side heat exchanger 12, the refrigerant flowing from the inlet of the first pipe 12a is once dissipated in the internal heat exchanger 16, so that the refrigerant has a lower temperature than before flowing into the internal heat exchanger 16. The refrigerant flowing from the inlet of the first pipe 12a, taken to the outside, passing through the internal heat exchanger 16, and then flowing into the first pipe 12a again exchanges heat with the high-temperature refrigerant which resides before the first pipe 12a to be reheated and return to the downstream of the position where it was extracted to the internal heat exchanger 16 in the first pipe 12a. Accordingly, the temperature of the refrigerant flowing through the first pipe 12a in the use-side heat exchanger 12 does not uniformly decrease from the inlet to the outlet and, unlike the case where the internal heat exchanger 16 is not used, is lower in a position closer to the inlet. Further, the temperature of the refrigerant peaks again in the position into which the refrigerant flows from the internal heat exchanger 16. Since this embodiment uses a carbon dioxide refrigerant as the refrigerant, the refrigerant is compressed to a supercritical pressure in the compressor 11 and maintained with the supercritical pressure without condensation in the use-side heat exchanger 12.

[0036] Subsequently, the refrigerant flowing from the use-side heat exchanger 12 is decompressed in the expansion valve 13, in which process the carbon dioxide refrigerant goes into a gas-liquid mixture state and flows into the heat source side heat exchanger 14. The refrigerant flowing into the heat source side heat exchanger 14 exchanges heat with outside air blown by the air blower 15 and evaporates, taking heat from the outside air. The refrigerant evaporating in the heat source side heat exchanger 14 is sucked to the compressor 11 to be compressed and ejected to the internal heat exchanger 16 again, and this cycle is repeated.

[0037] Meanwhile, in the heating medium circuit 20, the operation of the circulation pump 22 causes heating water fed from the circulation pump 22 and residing in the hot-water tank 21 to flow into the second pipe 12b in the use-side heat exchanger 12. The heating water in the second pipe 12b in the use-side heat exchanger 12 exchanges heat with the high-temperature refrigerant acting as the counterflow in the first pipe 12a in the refrigerant circuit 10. After being heated in the use-side heat exchanger 12, the heating water is fed back to the hot-water tank 21. This circle is repeated until the heating water in the hot-water tank 21 reaches a predetermined temperature.

[0038] At this time, the refrigerant once dissipated by the internal heat exchanger 16 as described above flows into the first pipe 12a from the refrigerant inlet. Afterwards, the refrigerant heated in the internal heat exchanger 16 flows into the first pipe 12a again. Accordingly, the temperature of heating water flowing through the second pipe 12b while exchanging heat with the refrigerant flowing in the opposite direction through the first

pipe 12a is gradually increased from the inlet side and steepens in a position which is just after the internal heat exchanger 16 and where the heating water exchanges heat with the refrigerant flowing through the first pipe 12a. Subsequently, the heating water exchanges heat with the refrigerant flowing in the opposite direction and into the first pipe 12a from the inlet, and the temperature of the heating water gradually increases toward the outlet of the second pipe 12b. Since the refrigerant flowing into the first pipe 12a from the inlet is a refrigerant that was once dissipated in the internal heat exchanger 16, heating of local portions around the inlet of the first pipe 12a is suppressed.

[0039] Thus, in the internal heat exchanger 16 in the present invention, the high-temperature refrigerant flowing into the first pipe 12a in the use-side heat exchanger 12 exchanges heat with the refrigerant flowing in the first pipe 12a, thereby suppressing a decrease in heat exchange efficiency in the entire use-side heat exchanger 12 and decreasing the temperature of the hottest portion that resides around the refrigerant inlet of the first pipe 12a. Consequently, the heating water that exchanges heat with the refrigerant while flowing near the outlet of the second pipe 12b is prevented from being disadvantageously locally heated to a high temperature of 90°C or more, which effectively suppresses a disadvantage of precipitation of scale, which is mainly calcium carbonate contained in the heating water, on the inner wall of the second pipe 12b. This simplifies maintenance work required for dealing with scale precipitation.

[0040] In addition, the present invention involves heat exchange between the refrigerant flowing upstream of the first pipe 12a and the refrigerant flowing into the first pipe 12a in the internal heat exchanger 16 without extending the diameter of the second pipe around the water outlet unlike in a conventional technique, thereby decreasing the temperature around the refrigerant inlet of the first pipe 12a and removing the need for a decrease in the flow rate of the heating water flowing through the second pipe 12b. Therefore, the present invention can effectively suppress scale precipitation without disadvantageously affecting hot-water supply performance.

[Example]

[0041] An example using a heat-pump hot-water supply system H of the present invention will now be explained. This example used a heat-pump hot-water supply system H according to the aforementioned embodiment. In this example, the internal heat exchanger 16 is placed in different positions relative to the first pipe 12a in the use-side heat exchanger 12. To be specific, the internal heat exchanger 16 is placed in positions of 5%, 8%, 13%, 25%, 38%, and 50% from the edge of the refrigerant inlet of the first pipe 12a assuming that the length of a portion of the first pipe 12a used for heat exchange with the second pipe 12b is 100%.

[Comparative Example]

[0042] In a comparative example, the internal heat exchanger 16 is placed in a position of 0% from the edge of the refrigerant inlet of the first pipe 12a, i.e., at the edge of refrigerant inlet of the first pipe 12a assuming that the length of a portion of the first pipe 12a used for heat exchange with the second pipe 12b is 100%.

[0043] The performance of the entire use-side heat exchanger 12 provided when the internal heat exchanger 16 is placed in these positions will now be explained with reference to Figure 3. Assuming that the heat exchange efficiency produced without the internal heat exchanger 16 is 100%, the performance of the use-side heat exchanger 12 provided with the internal heat exchanger 16 placed in these positions decreases as the position of the internal heat exchanger 16 moves from the inlet toward the outlet of the first pipe 12a. Figure 4 shows changes in the temperatures of the heating water and the refrigerant from the inlet to the outlet in the case where the internal heat exchanger 16 is placed at the edge of the refrigerant inlet of the first pipe 12a.

[0044] As shown in Figure 4, in the case where the internal heat exchanger 16 is placed at the edge of the refrigerant inlet of the first pipe 12a, the refrigerant at 92°C flows into the first pipe 12a in the use-side heat exchanger 12, is gradually cooled while moving toward the outlet, and then flows out at 15°C. Heating water at 10°C flows into the second pipe 12b in the use-side heat exchanger 12, is gradually heated while moving toward the outlet, and then flows out at 65°C. Accordingly, heating of local portions occurs as an increase in the temperature around the inlet of the first pipe 12a to 92°C, and the heating water that flows near the outlet of the second pipe 12b and exchanges heat with the refrigerant flowing near the inlet of the first pipe 12a is locally heated, causing minerals contained in the heating water to easily precipitate as scale on the inner wall of the second pipe 12b.

[0045] Meanwhile, as shown in Figure 3, assuming that the heat exchanger performance produced without the internal heat exchanger 15 was 100%, the heat exchanger performance was 99.6% with the internal heat exchanger 16 placed in a position of 8% from the edge of the refrigerant inlet of the first pipe 12a. Similarly, the heat exchanger performance was 99.2% with the internal heat exchanger 16 placed in a position of 13% from the edge of the refrigerant inlet of the first pipe 12a, 96.9% with the internal heat exchanger 16 placed in a position of 25% from the edge of the refrigerant inlet of the first pipe 12a, 91.3% with the internal heat exchanger 16 placed in a position of 38% from the edge of the refrigerant inlet of the first pipe 12a, and 77.5% with the internal heat exchanger 16 placed in a position of 50% from the edge of the refrigerant inlet of the first pipe 12a.

[0046] As an example, Figures 5 and 6 show changes in the temperatures of the heating water and the refrigerant from the inlet to the outlet in the case where the internal heat exchanger 16 is placed in positions of 8%

and 50% from the edge of the refrigerant inlet of the first pipe 12a, respectively.

[0047] As shown in Figure 5, in the case where the internal heat exchanger 16 is placed in a position of 8% from the edge of the refrigerant inlet of the first pipe 12a, the refrigerant at 78°C flows into the first pipe 12a in the use-side heat exchanger 12, is gradually cooled to 65°C by heat exchange with heating water, and then heated again to 80°C by heat exchange with the high-temperature refrigerant that is before the first pipe 12a in the internal heat exchanger 16. The refrigerant is then cooled as it flows toward the outlet and flows out at 18°C. The heating water at 12°C flows into a second pipe b of the use-side heat exchanger 12, is gradually heated therein, and is rapidly heated to 61°C in a position of 8% from the edge of the refrigerant inlet of the first pipe 12a, i.e., in a position of 8% from the edge of the heating water outlet of the second pipe 12b. The heating water is then gradually heated as it flows toward the outlet and flows out at 65°C. Therefore, the entire first pipe 12a cannot be heated to above 80°C while the heating water flowing through the second pipe 12b can be heated to 65°C.

[0048] Thus, it is understood that this example of the present invention related to Figure 5 and later does not involve heating of local portions in the first pipe 12a that carries the refrigerant, so that the heating water that exchanges heat with the refrigerant flowing through the first pipe 12a and flows through the second pipe 12b is effectively prevented from being locally heated to a high temperature. It is therefore understood that, as shown in Figure 5, the present invention effectively suppresses a disadvantage of precipitation of scale, which is minerals contained in the heating water, on the inner wall of the second pipe 12b.

[0049] Meanwhile, as shown in Figure 6, in the case where the internal heat exchanger 16 is placed in a position of 50% from the edge of the refrigerant inlet of the first pipe 12a, the refrigerant at 81°C flows into the first pipe 12a in the use-side heat exchanger 12, is gradually cooled to 52°C by heat exchange with heating water, and then heated again to 61°C by heat exchange with the high-temperature refrigerant that is before the first pipe 12a in the internal heat exchanger 16. The refrigerant is then cooled as it flows toward the outlet and flows out at 22°C. The heating water at 11°C flows into the second pipe b of the use-side heat exchanger 12, is gradually heated therein, and is rapidly heated to 51°C in a position of 50% from the edge of the refrigerant inlet of the first pipe 12a, i.e., in a position of 50% from the edge of the heating water outlet of the second pipe 12b. The heating water is then gradually heated as it flows toward the outlet and flows out at 65°C. Therefore, also in this case, the entire first pipe 12a cannot be heated to above 80°C while the heating water flowing through the second pipe 12b can be heated to 65°C.

[0050] However, assuming that the length of a portion of the first pipe 12a used for heat exchange with the second pipe 12b is 100%, the heat exchange efficiency is

as low as 78.0% with the internal heat exchanger 16 placed in a position of 50% from the edge of the refrigerant inlet of the first pipe 12a, unlike in the case where the internal heat exchanger 16 is not used. As described above, it is therefore understood that, considering the heat exchange efficiency, the internal heat exchanger 16 is preferably placed in a position of 4% to 40% from the edge of the refrigerant inlet assuming that the length of a portion of the first pipe 12a used for heat exchange with the second pipe 12b is 100%. Meanwhile, considering the case where one first pipe 12a consists of two joined components, it is advantageous for higher production efficiency to provide the internal heat exchanger 16 joined between the components for the first pipe 12a. Since scale precipitation can be effectively suppressed even when the internal heat exchanger 16 is placed in a position of 50% from the edge of the refrigerant inlet of the first pipe 12a as described above, it is advantageous for higher production efficiency to provide the internal heat exchanger 16 in a position of 50% from the edge of the refrigerant inlet.

[0051] Although this embodiment takes a heat-pump hot-water supply system as an example of a system using a heat exchanger of the present invention, the heat-pump hot-water supply system is taken merely as an example of a heat-pump hot-water generating device that generates hot water by heat exchange between water and a heating medium. Therefore, a heat-pump hot-water generating device of the present invention is not limited to the aforementioned hot-water supply system and includes a heat-pump heating system, which generates hot water by heat exchange between water and a heating medium and uses the hot water for heating, and a heat-pump hot-water supply heating system including the same.

[Industrial Applicability]

[0052] A heat exchanger of the present invention can effectively suppress scale precipitation without extending the diameter of the second pipe carrying water. This is particularly advantageous for use of heat-pump hot-water supply systems which should be made small with high hot-water supply performance and less maintenance work needed.

[Reference Signs List]

[0053]

H	heat-pump hot-water supply system
1	heat-pump unit
2	tank unit
10	refrigerant circuit
11	compressor
12	use-side heat exchanger (heat exchanger)
12a	first pipe (inner pipe)
12b	second pipe (outer pipe)

- 13 pressure reducing device (expansion valve)
- 14 heat source side heat exchanger
- 15 air blower
- 16 internal heat exchanger
- 20 heating medium circuit
- 21 hot-water tank
- 22 circulation pump

Claims

1. A heat exchanger comprising:

a first pipe carrying a heating medium; and
 a second pipe carrying water that exchanges heat with the heating medium, wherein the heating medium flowing through the first pipe and the water flowing through the second pipe form a counterflow, and
 the first pipe includes an internal heat exchanger for heat exchange between the heating medium flowing upstream of the first pipe and the heating medium flowing in the first pipe.

2. The heat exchanger according to Claim 1, wherein, assuming that the length of a portion of the first pipe used for heat exchange with the second pipe is 100%, the internal heat exchanger provides heat exchange between the heating medium flowing in any of positions of 4% to 50% from the edge of a heating medium inlet of the first pipe, and the heating medium flowing upstream of the first pipe.

3. The heat exchanger according to Claim 1 or 2, comprising a double pipe including an outer pipe forming the second pipe and a thermally conductive inner pipe forming the first pipe and residing inside the outer pipe, wherein the internal heat exchanger is connected by piping to the inner pipe that passes through the outer pipe and is drawn to the outside.

4. The heat exchanger according to Claim 3, wherein a plurality of inner pipes forming the first pipe is provided in the outer pipe forming the second pipe.

5. The heat exchanger according to Claim 3 or 4, wherein the first pipe includes a double pipe.

6. The heat exchanger according to Claim 1 or 2, wherein outer walls of the first pipe and the second pipe are in contact with each other to allow heat exchange between the heating medium flowing through the first pipe and the water flowing through the second pipe.

7. A heat-pump hot-water generating device comprising:

a refrigerant circuit including a compressor, an use-side heat exchanger, a pressure reducing device, and an heat source side heat exchanger and sealing a refrigerant; and
 a heating medium circuit carrying hot-water generating water, wherein
 the use-side heat exchanger is a heat exchanger according to any one of Claims 1 to 6, the heating medium flowing through the first pipe is the refrigerant ejected from the compressor in the refrigerant circuit, and the water flowing through the second pipe is the hot-water generating water in the heating medium circuit.

8. The heat-pump hot-water generating device according to Claim 7, wherein the refrigerant is a carbon dioxide refrigerant.

Figure 1

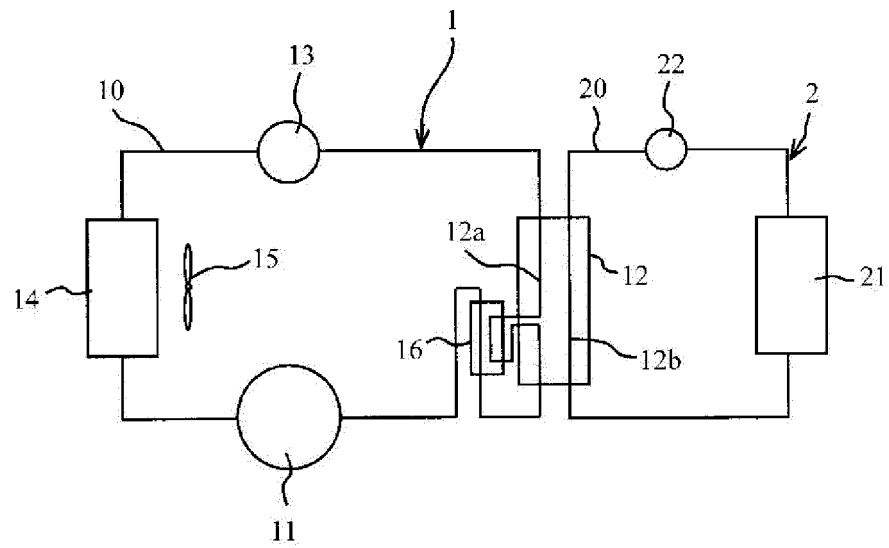


Figure 2

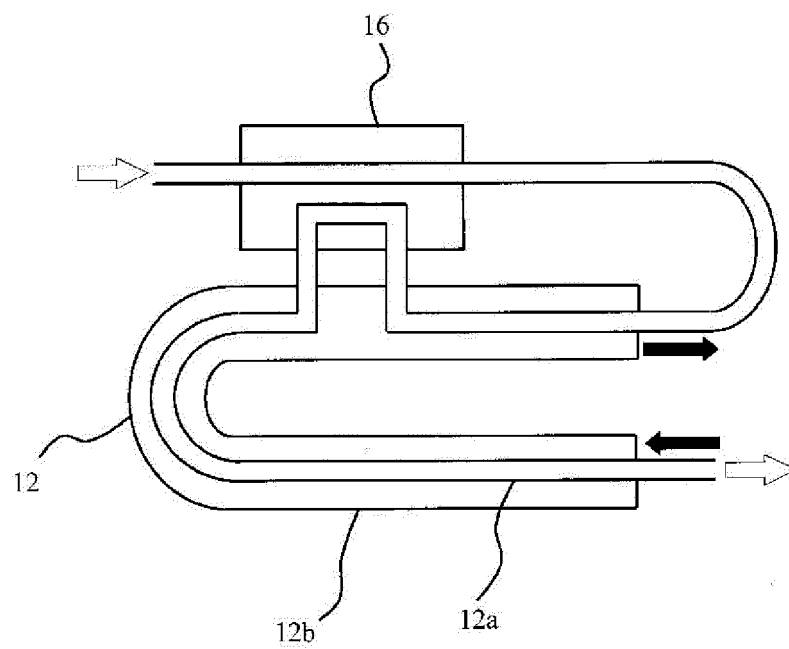


Figure 3

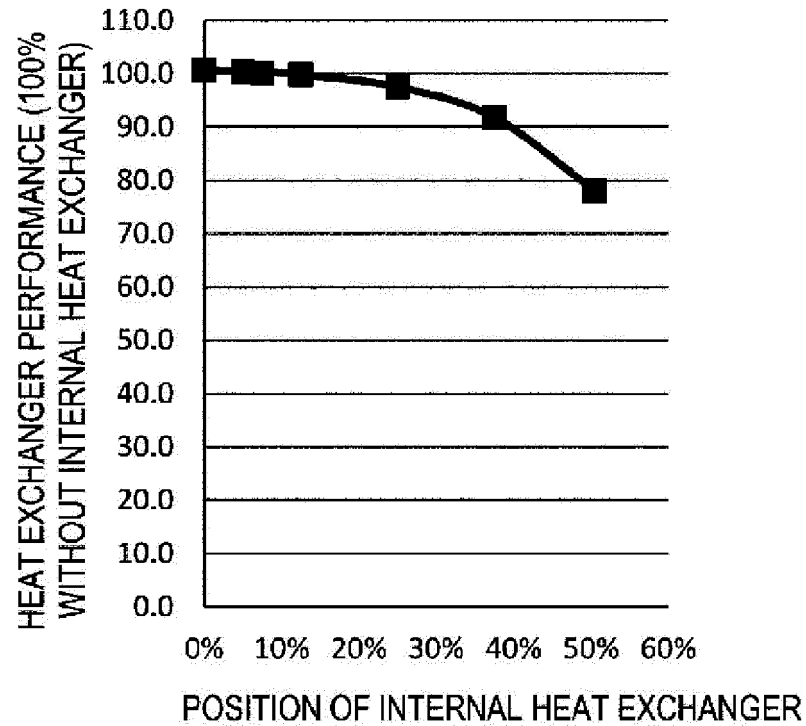


Figure 4

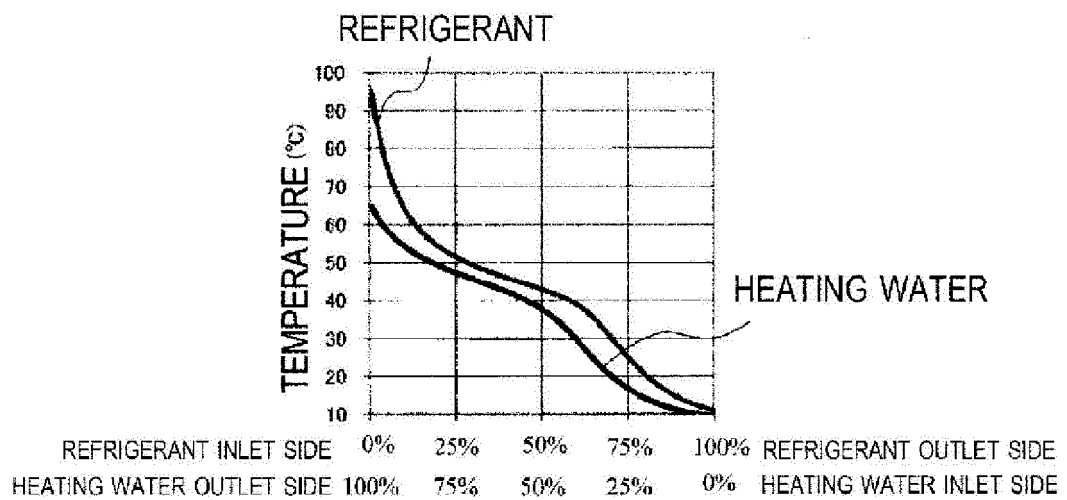


Figure 5

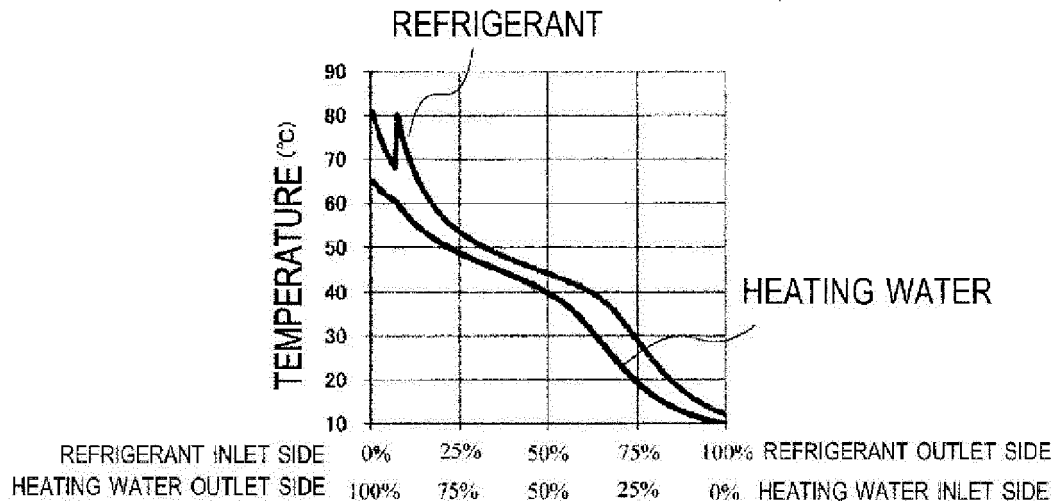
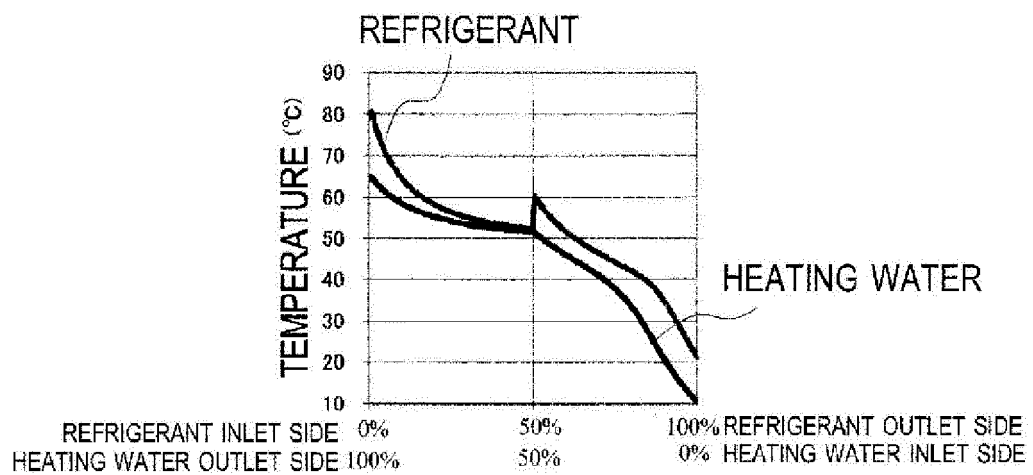


Figure 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/083799

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00(2006.01)i, F24D3/18(2006.01)i, F24H1/00(2006.01)i, F25B6/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B1/00, F24D3/18, F24H1/00, F25B6/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	WO 2010/119642 A1 (Panasonic Corp.), 21 October 2010 (21.10.2010), entire text; all drawings (particularly, paragraphs [0013] to [0043]; fig. 1 to 3) & JP 5470374 B & US 2012/0000236 A1 & EP 2420746 A1 & CN 102369397 A	1-2, 7-8 6 3-5
Y	JP 2014-181870 A (Panasonic Corp.), 29 September 2014 (29.09.2014), entire text; all drawings (particularly, paragraph [0029]; fig. 2) (Family: none)	6

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search
19 March 2015 (19.03.15)

Date of mailing of the international search report
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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/083799

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-242056 A (Mitsubishi Electric Corp.), 01 December 2011 (01.12.2011), entire text; all drawings (particularly, paragraph [0061]; fig. 12(b)) (Family: none)	6
A	JP 2008-180447 A (Fujitsu General Ltd.), 07 August 2008 (07.08.2008), entire text; all drawings (particularly, paragraphs [0013] to [0024]; fig. 1, 3) (Family: none)	1, 7
A	JP 2012-255603 A (Denso Corp.), 27 December 2012 (27.12.2012), entire text; all drawings (particularly, paragraphs [0033] to [0153]; fig. 1 to 2, 5 to 7) & WO 2012/169146 A1 & DE 112012002377 T & CN 103597296 A	1
A	JP 2012-233685 A (Mitsubishi Electric Corp.), 29 November 2012 (29.11.2012), entire text; all drawings (particularly, paragraphs [0018] to [0023]; fig. 2 to 4) (Family: none)	1, 7
A	JP 2009-264644 A (Panasonic Corp.), 12 November 2009 (12.11.2009), entire text; all drawings (particularly, paragraphs [0004] to [0010], [0035] to [0042], [0069] to [0076]; fig. 1 to 4, 8 to 10, 13 to 14) (Family: none)	4-5, 7
A	JP 2001-201275 A (Daikin Industries, Ltd.), 27 July 2001 (27.07.2001), entire text; all drawings (particularly, paragraphs [0001] to [0048]; fig. 1 to 12) (Family: none)	4-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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