

DESCRIPTION

REFRIGERATION UNIT

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TECHNICAL FIELD

The present invention relates to a refrigeration apparatus formed by a heat exchanger that has a heat exchanging surface.

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BACKGROUND ART

In a refrigeration apparatus in which a heat exchanger is operated as an evaporator, frost usually forms on a heat exchanging surface of the heat exchanger when the temperature of air with which the heat exchanger exchanges heat is low or when the evaporation temperature of the evaporator is low. The frost formation lowers the heat exchanging capability of the heat exchanger, and consequently lowers the refrigeration capability of the refrigeration apparatus.

For example, in the case of a heat pump type air conditioner, which is one type of refrigeration apparatus, the evaporation temperature of an outdoor heat exchanger operating as an evaporator decreases when the outdoor air temperature decreases during operation. As a result, frost forms on the outdoor heat exchanger. The frost formation lowers the evaporation capability of the outdoor heat exchanger, and consequently lowers the heating capability of the air conditioner. To prevent this, the air conditioner performs a defrosting operation when necessary to remove frost from the outdoor heat exchanger. However, the

defrosting operation may suspend the heating operation of the air conditioner or lower the heating capability of the air conditioner depending on the type of defrosting operation. This may lower the heating comfort of the air conditioner. Thus, it is required that the refrigeration operation (particularly, the heating operation for the heat pump type air conditioner which is a typical refrigeration apparatus) be extended by delaying frost formation on the heat exchanger and that the time taken by the defrosting operation be shortened.

To meet these requirements, methods for applying a frost formation prevention layer on a heat exchanging surface to reduce the amount of frost formed on a heat exchanger operating as an evaporator have been proposed. The methods for arranging a frost formation prevention layer prevent frost formation by increasing the water slippage and the water repellency of the heat exchanging surface.

Patent publication 1 describes one example of a method for applying a frost formation prevention layer. A coating film is formed by applying a composition containing 3 to 70 part by weight of a specific organo polysiloxane having a silanol group to 100 part by weight of specific organo polysiloxane to a heat exchanging surface and hardening the applied composition. The frost formation prevention layer increases the water slippage and the water repellency of the heat exchanging surface. When the heat exchanger operates as an evaporator in this state, water droplets that have condensed quickly run down on the heat exchanging surface. As a result, the amount of frost formation on the heat exchanging surface is reduced.

Fig. 15 is a cross-sectional view schematically showing the structure of a heat exchanger. A heat exchanger 42, which is the so-called cross fin and tube heat exchanger, includes many plate fins 43 and a heat exchanger pipe 45. The plate fins 43 form a heat exchanging surface, and are arranged in parallel at intervals in a direction perpendicular to an air circulation direction 44. Each plate fin 43, which is arranged in a manner that its longitudinal direction coincides with the vertical direction, forms a fin line. In Fig. 15, two fin lines are formed in the circulation direction 44. The heat exchanger pipe 45 is conventionally arranged to meander and extend through the plate fins 43. A refrigerant circulates inside the heat exchanger pipe 45. The heat exchanger pipe 45 has a plurality of portions that extend in a direction perpendicular to the air circulation direction 44. These portions of the heat exchanger pipe 45 are arranged at regular intervals in the longitudinal direction of the plate fins 43 between lower ends and upper ends of the plate fins 43. A frost formation prevention layer, which is for example the layer described above, is applied to the surface of the plate fins 43 to increase the water slippage and the water repellency of the plate fins 43.

A drain pan 46 for receiving water droplets that drip from the heat exchanger 42 and discharging the water droplets is arranged below the heat exchanger 42. An upper surface 46a of the drain pan 46 is inclined to discharge water. The heat exchanger 42 is arranged substantially horizontally relative to the drain pan 46 of which the upper surface 46a is inclined so that a lower end of the heat exchanger 42, or specifically the lower ends of the plate fins 43, partially comes into contact with the upper surface

46a of the drain pan 46.

When the heat exchanger 42 of this structure operates as an evaporator, water droplets 48 that condense on the plate fins 43 run down as indicated by arrow 47. The water droplets 48 that have run down may accumulate and freeze at portions of contact between the lower ends of the plate fins 43 and the upper surface 46a of the drain pan 46. If ice 49 forms at the lower ends of the plate fins 43, the water droplets 48 may run down and reach the ice 49 and freeze. As a result, frost 51 would grow upward from the lower ends of the plate fins 43 as indicated by arrow 50. In this way, the frost 51 grows from the ice 49 formed at the lower end of the heat exchanger 42. Thus, even if the water slippage and the water repellency of the surface of the plate fins 43 is increased, a refrigeration apparatus using the conventional heat exchanger 42 would not sufficiently benefit from the resulting formation reduction effect.

Patent Publication 1: Japanese Laid-Open Patent Publication No. 2002-323298

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

The present invention provides a refrigeration apparatus that reduces the amount of frost that forms when a heat exchanger is operated as an evaporator.

MEANS OF SOLVING THE PROBLEMS

One aspect of the present invention provides a

refrigeration apparatus including a heat exchanger and a drain pan. The heat exchanger has a heat exchanging surface and exchanges heat between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger. The drain pan is arranged below the heat exchanger. A space is formed entirely between a lower end of the heat exchanger and an upper surface of the drain pan.

Another aspect of the present invention provides a refrigeration apparatus including a refrigeration apparatus includes a heat exchanger and a drain pan. The heat exchanger has a heat exchanging surface and exchanges heat between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger. The drain pan is arranged below the heat exchanger. The heat exchanger is arranged in a manner that a lower end of the heat exchanger partially comes into contact with an upper surface of the drain pan. A projection is arranged on the lower end of the heat exchanger, and the partial contact between the lower end of the heat exchanger and the upper surface of the drain pan is performed by a distal end of the projection coming in contact with the upper surface of the drain pan.

A further aspect of the present invention provides a refrigeration apparatus including a heat exchanger. The heat exchanger has a heat exchanging surface and exchanges heat between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger. A high temperature portion is arranged below the heat exchanger and heats a water droplet that condenses and runs down the heat exchanging surface to 0°C or higher when the heat exchanger operates as an evaporator.

A further aspect of the present invention provides a refrigeration apparatus including a heat exchanger. The heat exchanger has a heat exchanging surface and exchanges heat
5 between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger. The heat exchanger is a cross fin and tube heat exchanger including a plurality of fins that form the heat exchanging surface and a heat exchanger pipe through which the heating
10 medium circulates. A projection is formed on lower ends of some of the plurality of fins, and the projection projects more downward than lower ends of the other fins.

A further aspect of the present invention provides a
15 refrigeration apparatus including a heat exchanger and a drain pan. The heat exchanger has a heat exchanging surface and exchanges heat between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger. The drain pan is arranged below the heat
20 exchanger. The drain pan has an upper surface subjected to a water slipping and water repellent treatment.

A further aspect of the present invention provides a refrigeration apparatus including a heat exchanger and a
25 drain pan. The heat exchanger has a heat exchanging surface and exchanges heat between air circulating on the heat exchanging surface and a heating medium circulating inside the heat exchanger. The drain pan is arranged below the heat exchanger. The drain pan has an upper surface subjected to
30 hydrophilic treatment.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view showing a portion of an outdoor heat exchanger used in an air conditioner according to a first embodiment;

Fig. 2 is a circuit diagram showing a refrigerant
5 circuit of the air conditioner;

Fig. 3 is a cross-sectional view showing a portion of an outdoor heat exchanger according to a second embodiment;

Fig. 4 is a rear view showing the outdoor heat exchanger as viewed from a downstream side in an air
10 circulation direction;

Fig. 5(a) is a cross-sectional view showing an inclined portion formed in the outdoor heat exchanger, and Figs. 5(b) and 5(c) are cross-sectional views showing projections formed in the outdoor heat exchanger;

Fig. 6 is a rear view showing a portion of an outdoor heat exchanger according to a third embodiment as viewed from a downstream side in an air circulation direction;

Fig. 7 is a cross-sectional view showing a portion of an outdoor heat exchanger according to a fourth embodiment;

Fig. 8 is a cross-sectional view showing a high temperature portion included in the outdoor heat exchanger;

Fig. 9 is a cross-sectional view showing a high temperature portion in a first modification;

Fig. 10 is a cross-sectional view showing a high temperature portion in a second modification;

Fig. 11 is a circuit diagram showing a refrigerant circuit of a high temperature portion in a third modification;

Fig. 12 is a cross-sectional view showing a portion of an outdoor heat exchanger;

Fig. 13 is a rear view showing an outdoor heat exchanger according to a fifth embodiment as viewed from a downstream side in an air circulation direction;

Fig. 14 is a cross-sectional view showing a portion of the outdoor heat exchanger of the fifth embodiment; and

Fig. 15 is a cross-sectional view showing a portion of a conventional heat exchanger.

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BEST MODE FOR CARRYING OUT THE INVENTION

A heat pump type air conditioner, which is one type of refrigeration apparatus, according to a first embodiment of the present invention will now be described with reference to the drawings.

(First Embodiment)

Fig. 1 is a cross-sectional view showing a portion of an outdoor heat exchanger 2 used in an air conditioner 1 according to a first embodiment of the present invention. Fig. 2 is a circuit diagram showing a refrigerant circuit of the air conditioner 1.

In the air conditioner 1, the outdoor heat exchanger 2, an expansion valve 9, an indoor heat exchanger 10, a four-way switch valve 11, and a compressor 12 are connected by a refrigerant pipe to form a refrigerant circuit as shown in Fig. 2. During a cooling operation of the air conditioner 1, the four-way switch valve 11 is set as indicated by solid lines in Fig. 2. In this state, a refrigerant serving as a heating medium discharged from the compressor 12 circulates in the order of the four-way switch valve 11, the outdoor heat exchanger 2, the expansion valve 9, the indoor heat exchanger 10, and the four-way switch valve 11, and is sucked into the compressor 12. As a result of circulation of the refrigerant, the outdoor heat exchanger 2 operates as a condenser and the indoor heat exchanger 10 operates as an

evaporator. In the outdoor heat exchanger 2 that operates as a condenser, a gasified refrigerant exchanges heat with the outdoor air and becomes a liquefied refrigerant so that the refrigerant releases heat into the outdoor air. In the indoor heat exchanger 10 that operates as an evaporator, a liquefied refrigerant exchanges heat with the indoor air and evaporates to become a gasified refrigerant. As a result, the refrigerant absorbs heat from the indoor air and cools the indoor air.

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During a heating operation of the air conditioner 1, the four-way switch valve 11 is set as indicated by broken lines as shown in Fig. 2. In this state, the refrigerant discharged from the compressor 12 circulates in the order of the four-way switch valve 11, the indoor heat exchanger 10, the expansion valve 9, the outdoor heat exchanger 2, and the four-way switch valve 11, and is then drawn into the compressor 12. As a result of circulation of the refrigerant, the indoor heat exchanger 10 operates as a condenser and the outdoor heat exchanger 2 operates as an evaporator. In the indoor heat exchanger 10 that operates as a condenser, a gasified refrigerant exchanges heat with the indoor air and condenses, so that the indoor air is heated by heat released from the refrigerant. In the outdoor heat exchanger 2 that operates as an evaporator, a liquefied refrigerant exchanges heat with the outdoor air and evaporates to become a gasified refrigerant. As a result, the refrigerant absorbs heat from the outdoor air.

30 As shown in Fig. 1, the outdoor heat exchanger 2, which is a so-called cross fin and tube heat exchanger, includes many plate fins 3 and a single heat exchanger pipe 5. The plate fins 3 form a heat exchanging surface and are

arranged in parallel at intervals in a direction perpendicular to an air circulation direction 4. The heat exchanger pipe 5 is formed to meander and extend through the plate fins 3. A refrigerant circulates inside the heat exchanger pipe 5.

In the outdoor heat exchanger 2, each plate fin 3, which is arranged in a manner such that its longitudinal direction coincides with the vertical direction, forms a fin line. Although two fin lines are formed in the circulation direction 4 in Fig. 1, one fin line or three or more fin lines may be formed. The heat exchanger pipe 5 has a plurality of portions that extend in the direction perpendicular to the air circulation direction 4. The portions of the heat exchanger pipe 5 are arranged at regular intervals in the longitudinal direction of the plate fins 3 between lower ends and upper ends of the plate fins 3. A coating film having water slippage and water repellency is applied to the surface of the plate fins 3 so that the surface of the plate fins 3 has high water slippage and high water repellency. Examples of the plate fins 3 include all plate-like fins, such as flat fins, slit fins, and waffle fins.

A drain pan 6 for receiving water droplets that drip from the outdoor heat exchanger 2 and discharging the water droplets is arranged below the outdoor heat exchanger 2. An upper surface 6a of the drain pan 6 is inclined to discharge water that drips from the outdoor heat exchanger 2. The outdoor heat exchanger 2 is arranged substantially horizontally to the drain pan 6 of which upper surface 6a is inclined.

In the first embodiment, space is formed between the entire lower end of the outdoor heat exchanger 2, or more specifically, lower ends 3a of the plate fins 3, and the upper surface 6a of the drain pan 6. Thus, water droplets 8, which condense when the outdoor heat exchanger 2 operates as an evaporator, run down the surface of the plate fins 3 and drip from the lower ends 3a of the plate fins 3 onto the upper surface 6a of the drain pan 6. With this structure, the outdoor heat exchanger 2 and the drain pan 6 have no contacting portions. The water droplets 8 that have run down do not accumulate at portions of contact between the outdoor heat exchanger 2 and the drain pan 6. This prevents frost from forming from water droplets and growing upward from the lower ends 3a of the plate fins 3.

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The first embodiment has the advantages described below.

(1) In the first embodiment, the outdoor heat exchanger 2 and the drain pan 6 have no contacting portions. Thus, the water droplets 8 that have run down the surface of the plate fins 3 do not accumulate at portions of contact between the outdoor heat exchanger 2 and the drain pan 6. As a result, frost is prevented from forming from water droplets and growing upward from the lower ends 3a of the plate fins 3. This reduces the amount of frost formed on the outdoor heat exchanger 2.

The first embodiment may be modified in the following form.

In the first embodiment, a space is formed entirely between the outdoor heat exchanger 2 and the drain pan 6.

Thus, air may circulate through the space and lower the heat exchanging efficiency of the outdoor heat exchanger 2. To reduce the amount of air circulating through the space, a shielding member may be arranged on the upper surface of the drain pan 6. In this case, the shielding member is arranged outward from the plate fins 3 so that the shielding member does not come into contact with the plate fins 3.

(Second Embodiment)

A second embodiment of the present invention will now be described with reference to Figs. 3 to 5. The structure of the second embodiment is the same as the structure of the first embodiment except in the shape of the outdoor heat exchanger 2 and the positional relationship between the outdoor heat exchanger 2 and the drain pan 6. The components of the second embodiment common to the first embodiment will not be described in detail.

Fig. 3 is a cross-sectional view showing a portion of an outdoor heat exchanger 2 according to the second embodiment of the present invention. Fig. 4 is a rear view showing the outdoor heat exchanger 2 as viewed from a downstream side in an air circulation direction 4.

As shown in Fig. 4, the outdoor heat exchanger 2 of the second embodiment is arranged in a manner such that its lower end partially comes into contact with an upper surface 6a of a drain pan 6. Thus, the lower end of the outdoor heat exchanger 2 is supported by the drain pan 6. The upper surface 6a of the drain pan 6 is inclined, and the outdoor heat exchanger 2 comes into contact with an upper part of the upper surface 6a. In Fig. 4, the outdoor heat exchanger 2 and the drain pan 6 come into contact with each other at

region R formed at the left side as viewed in the drawing.

In the second embodiment, the partial contact between the lower end of the outdoor heat exchanger 2, or specifically the lower ends of the plate fins 3, and the upper surface 6a of the drain pan 6 occurs at distal ends of inclined portions 3b, which are formed as projections, on the lower ends of the plate fins 3 that come into contact with the upper surface 6a of the drain pan 6. More specifically, the upper surface 6a of the drain pan 6 is inclined to discharge water, and the outdoor heat exchanger 2 is arranged substantially horizontally so that the lower end of the outdoor heat exchanger 2 partially comes into contact with the upper surface 6a of the drain pan 6. The inclined portions 3b are inclined relative to the air circulation direction 4. As shown in Fig. 3, the inclined portion 3b of the plate fin 3 in the left line is inclined downward from the outer side toward the middle of the outdoor heat exchanger 2, and the inclined portion 3b of the plate fin 3 of the right line is inclined upward from the middle toward the outer side of the outdoor heat exchanger 2. The inclined portions 3b may be formed by diagonally cutting the lower ends of the plate fins 3.

In the outdoor heat exchanger 2 shown in Fig. 3, the shape of the plate fin 3 at the upstream side of the airflow, or the left plate fin 3, is the same as the shape of the plate fin 3 at the downstream side of the airflow, or the right plate fin 3. The left and right plate fins 3 are arranged in a manner that inclined surfaces of the upstream inclined portion 3b and the downstream inclined portion 3b face opposite directions.

In this manner, the distal ends of the inclined portions 3b at the lower ends of the plate fins 3 come into contact with the upper surface 6a of the drain pan 6 in the second embodiment so that the area of contact between the plate fins 3 and the upper surface 6a of the drain pan 6 is reduced as compared with when the plate fins 3 have flat lower ends that come into contact with the upper surface 6a of the drain pan 6. Water droplets 8, which condense when the outdoor heat exchanger 2 operates as an evaporator, run down as indicated by arrow A1 in Fig. 3. Then, the water droplets 8 directly drip onto the drain pan 6, move along the inclined surfaces of the inclined portions 3b as indicated by arrow A2 and drip onto the drain pan 6 before reaching the distal ends of the inclined portions 3b, or move to the distal ends of the inclined portions 3b until reaching the drain pan 6. As a result, the amount of water accumulating at the contacting portions of the outdoor heat exchanger 2 and the drain pan 6 decreases. This decreases the amount of ice formed at the contacting portions.

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Figs. 5(a) to 5(c) are cross-sectional views showing projections having other shapes that are formed on the outdoor heat exchanger 2. The projections shown in Fig. 5(a) are formed in a manner that an inclined portion 3c of a plate fin 3 of an upstream side and an inclined portion 3c of a plate fin 3 of a downstream side with respect to the circulation direction 4 form a single continuous inclined portion. More specifically, the two inclined portions 3c are formed in a manner that an inclined surface of the upstream inclined portion 3c and an inclined surface of the downstream inclined portion 3c lie along the same plane. In this modification, a distal end of the inclined portion 3c of the plate fin 3 in the downstream direction comes into

contact with the upper surface 6a of the drain pan 6.

The projections 3d shown in Fig. 5(b) are each rectangular and are formed on plate fins 3 at downstream positions relative to the circulation direction 4. The projection 3d is formed by cutting a portion of a lower end of each plate fin 3 into a rectangular shape. The projections 3d shorten the length of the contacting portions of the outdoor heat exchanger 2 and the drain pan 6 in the circulation direction 4, and reduce the area of contact between the plate fins 3 and the upper surface 6a of the drain pan 6.

The projections 3e shown in Fig. 5(c) are formed on lower ends of plate fins 3 with a semi-circular cross-section.

The second embodiment has the advantages described below.

(1) In the second embodiment, the inclined portions 3b and 3c and the projections 3d and 3e of the outdoor heat exchanger 2 come into contact with the upper surface 6a of the drain pan 6. Thus, the area of contact between the plate fins 3 and the upper surface 6a of the drain pan 6 is reduced as compared with the conventional structure in which the lower end of the outdoor heat exchanger 2 is entirely flat and the lower end of the outdoor heat exchanger 2 comes into contact with the upper surface 6a of the drain pan 6. Thus, the amount of ice formed at the portions of contact between the lower end of the outdoor heat exchanger 2 and the upper surface 6a of the drain pan 6 decreases, and the amount of frost growing upward from the contacting portions

may be reduced.

(2) The inclined portions 3b and 3c serving as projections are formed easily by diagonally cutting the lower ends of the plate fins 3.

(Third Embodiment)

A third embodiment of the present invention will now be described with reference to Fig. 6. The structure of the third embodiment is the same as the structure of the second embodiment except in the shape of the outdoor heat exchanger 2. The components of the third embodiment common to the second embodiment will not be described in detail.

Fig. 6 is a rear view showing a portion of an outdoor heat exchanger 2 according to the third embodiment of the present invention as viewed from a downstream side in an air circulation direction 4.

In the third embodiment, projections are formed on lower ends of some plate fins 3L in such a manner that the projections extend more downward than lower ends of other plate fins 3S. More specifically, two types of plate fins 3L and 3S that differ in vertical length are used (reference numeral 3 refers generically to the two different plate fins), and each of the plate fins 3L with the long vertical length is arranged at every predetermined number of plate fins 3S with the short vertical length. In Fig. 6, the plate fins 3S and the plate fins 3L are alternately arranged.

In this way, distal ends of the projections formed on the lower ends of the plate fins 3L, that is, distal ends of the lower ends of the plate fins 3L having the long vertical

length come into contact with the upper surface 6a of the drain pan 6 in the third embodiment to enable the outdoor heat exchanger 2 and the drain pan 6 to partially come into contact with each other in the same manner as in the second embodiment. As compared with when all the plate fins 3 in the contact region R come into contact with the drain pan 6, the area of contact between the outdoor heat exchanger 2 and the drain pan 6 is reduced. As a result, the amount of water accumulating at the portions of contact between the outdoor heat exchanger 2 and the drain pan 6 decreases. This decreases the amount of ice formed on the contacting portions.

In the third embodiment, the plate fins 3S do not have any portions arranged between the lower ends of the adjacent plate fins 3L. This enlarges the air circulation passage at the lower end of the outdoor heat exchanger 2. In this case, the airflow resistance of the passage decreases and the airflow velocity increases. As a result, the surface temperature of the plate fins 3 increases. Thus, condensed water is less likely to freeze at the lower ends of the plate fins 3. Further, even if the condensed water freezes at the lower ends of the plate fins 3 and the ice 13 is formed on the plate fins 3, the ice 13 does not close the airflow passage because the airflow passage is large.

The third embodiment has the advantages described below.

(1) In the third embodiment, the lower ends of only the plate fins 3L having the long vertical length in the contact region R come into contact with the upper surface 6a of the drain pan 6. Thus, the area of contact between the

outdoor heat exchanger 2 and the drain pan 6 is reduced as compared with the conventional structure in which all the plate fins in the contact region R come into contact with the drain pan 6. As a result, the amount of ice 13 formed on the contacting portions of the lower end of the outdoor heat exchanger 2 and the upper surface 6a of the drain pan 6 is reduced. This reduces the amount of frost growing upward from the contacting portions. Further, the projections are formed easily using the two types of plate fins 3L and 3S having different vertical lengths.

(2) In the third embodiment, the plate fins 3S do not have any portions arranged between the lower ends of the adjacent plate fins 3L. This enlarges the air circulation passage at the lower end of the outdoor heat exchanger 2. In this case, the airflow resistance decreases and the airflow velocity increases. As a result, the surface temperature of the plate fins 3 increases. Thus, condensed water is less likely to freeze at the lower ends of the plate fins 3, and frost formation on lower parts of the plate fins 3 is suppressed. As a result, the amount of frost formation on the outdoor heat exchanger 2 may be reduced.

(3) In the third embodiment, the air circulation passage is enlarged at the lower end of the outdoor heat exchanger 2. Thus, even if the condensed water freezes at the lower ends of the plate fins 3L having the long vertical length and the ice 13 is formed on the plate fins 3L, the ice 13 does not close the passage. As a result, the airflow resistance is prevented from increasing.

The third embodiment may be modified in the following forms.

Portions arranged at large pitches, or more specifically, the surfaces of the projections of the plate fins 3L having the long vertical length, may be subjected to hydrophilic treatment. The projections of the plate fins 3L are portions of the plate fins 3L that project more downward than the plate fins 3S having the short vertical direction. The hydrophilic treatment may, for example, be performed by applying a hydrophilic agent, such as polyacrylic acid, to the plate fins 3 when the plate fins 3 are made of aluminum. When the plate fins 3 are subjected to a water slipping and water repellent treatment and the hydrophilic treatment, the water slipping and water repellent treatment may be performed after or before the hydrophilic treatment is performed. In this way, because the surfaces of the projections are subjected to the hydrophilic treatment, the condensed water spreads thinly on the surface of the plate fins 3. Even when the condensed water freezes, ice resulting from the freezing has a low height from the surface of the plate fins 3. In other words, the ice resulting from the freezing grows toward adjacent plate fins 3 only by a small amount. Thus, the air circulation passage is not closed, and the airflow resistance is prevented from increasing.

Although the third embodiment describes a case in which the outdoor heat exchanger 2 comes into contact with the drain pan 6, a space may be formed entirely between the outdoor heat exchanger 2 and the drain pan 6 in the same manner as in the first embodiment.

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(Fourth Embodiment)

A fourth embodiment of the present invention will now be described with reference to Figs. 7 to 12. The structure

of the fourth embodiment is the same as the structure of the second embodiment except in the structure of the outdoor heat exchanger 2. The components of the fourth embodiment common to the second embodiment will not be described in
5 detail.

Fig. 7 is a cross-sectional view showing a portion of an outdoor heat exchanger 2 according to a fourth embodiment of the present invention. In the fourth embodiment, the
10 lower part of the outdoor heat exchanger 2 includes a high temperature portion 14. The high temperature portion 14 heats water droplets 8 that condense and run down on the surface of plate fins 3 to 0°C or higher when the outdoor heat exchanger 2 operates as an evaporator. The high
15 temperature portion 14 corresponds to lower parts of the plate fins 3 of the outdoor heat exchanger 2 in which a heat exchanger pipe 5 is not arranged. The high temperature portion 14 includes only the plate fins 3. The high
20 temperature portion 14, which includes only the plate fins 3, has a piped structure having through holes 15 formed so that the heat exchanger pipe 5 can be extended through the plate fins 3 although the heat exchanger pipe 5 is actually not inserted through the through-holes 15.

25 In the example shown in Fig. 7, the heat exchanger pipe 5 is not inserted through the first and second through-holes 15 from the lower ends of the plate fins 3. With this structure, a region W1, which is defined from the lower ends of the plate fins 3 to the vicinity of the highest one of
30 the through-hole 15 free from the heat exchanger pipe 5, functions as the high temperature portion 14, and heat exchange is mainly performed in the remaining region W2 excluding the region W1. Because the heat exchanger pipe 5

is not arranged in the high temperature portion 14, the temperature of the high temperature portion 14 is higher than the temperature in the upper region W2 in which the heat exchanger pipe 5 is arranged when the outdoor heat
5 exchanger 2 operates as an evaporator. The size of the region W1 in which the heat exchanger pipe 5 is not arranged is appropriately set in a manner that the temperature of the lower ends of the plate fins 3 is at least 0°C or higher.

10 The high temperature portion 14 is arranged in this manner. In this case, water droplets 8 that have condensed and run down are heated to 0°C or higher by the high temperature portion 14 in the lower part when the outdoor
15 heat exchanger 2 operates as an evaporator. As a result, water droplets 8 that have run down do not freeze at the lower end of the outdoor heat exchanger 2.

Fig. 8 is a cross-sectional view describing a high temperature portion having another structure. In the high
20 temperature portion 14a shown in Fig. 8, the surface of plate fins 3 in a region W1 corresponding to the high temperature portion 14a is subjected to hydrophilic treatment. When the surface of the high temperature portion 14a is subjected to the hydrophilic treatment, water
25 droplets 8 that have run down from above and reached the high temperature portion 14a spread thinly on the surface of the high temperature portion 14a. Adjacent water droplets 8 combine and spread thinly on the surface of the high temperature portion 14a so as to form a thin film 7 of
30 water. Thus, the water droplets 8 are prevented from growing on the surface of the high temperature portion 14a. This consequently prevents the airflow resistance from increasing and enables the surface temperature of the high temperature

portion 14a to increase.

Fig. 9 is a rear view showing a high temperature portion having still another structure. The high temperature portion 14b shown in Fig. 9 is formed only by plate fins 3 by setting the distance from the lower ends of the plate fins 3 to the lowest part of the heat exchanger pipe 5 to be greater than the pitch of the heat exchanger pipe 5 (the interval of adjacent portions of the pipe 5 in the longitudinal direction of the plate fins 3). In the high temperature portion 14b, no through-holes are formed in region W1 of the plate fins 3. This high temperature portion 14b functions in the same manner as the high temperature portion 14 shown in Fig. 7. The high temperature portion 14b may also have its surface subjected to the hydrophilic treatment in the same manner as the high temperature portion 14a shown in Fig. 8.

Fig. 10 is a cross-sectional view showing a high temperature portion having still another structure. In the example shown in Fig. 10, a heater 16 is arranged to come into contact with a lower end surface of an outdoor heat exchanger 2, and lower parts of plate fins 3 are heated with the heater 16. Region W1 heated by the heater 16 to 0°C or higher serves as a high temperature portion 14c. This high temperature portion 14c also functions in the same manner as the high temperature portion 14 shown in Fig. 7. However, because the high temperature portion 14c is actively heated by the heater 16, the temperature of the high temperature portion 14c shown in Fig. 10 can be set higher than the temperature of the other high temperature portions 14, 14a, and 14b. The high temperature portion 14c may also have its surface subjected to the hydrophilic treatment in the same

manner as the high temperature portion 14a shown in Fig. 8.

Fig. 11 is a circuit diagram showing a refrigerant circuit for a high temperature portion having still another structure. Fig. 12 is a cross-sectional view showing a portion of an outdoor heat exchanger 2. The outdoor heat exchanger 2 is divided into an upper heat exchanging portion 2a and a lower heat exchanging portion 2b, and the upper heat exchanging portion 2a and the lower heat exchanging portion 2b are connected by an expansion valve 9. A refrigerant is supplied to the lower heat exchanging portion 2b, the expansion valve 9, and the upper heat exchanging portion 2a in the stated order so that the lower heat exchanging portion 2b operates as a condenser and the upper heat exchanging portion 2a operates as an evaporator. The lower heat exchanging portion 2b that operates as a condenser forms the high temperature portion 14d shown in Fig. 11.

In the air conditioner 1 shown in Fig. 11, a compressor 12, a four-way switch valve 11, an indoor heat exchanger 10, the lower heat exchanging portion 2b, the expansion valve 9, and the upper heat exchanging portion 2a are connected by a refrigerant pipe to form the refrigerant circuit. During a heating operation of the air conditioner 1, the four-way switch valve 11 is set as indicated by the solid line in Fig. 11. In this state, refrigerant discharged from the compressor 12 circulates in the order of the four-way switch valve 11, the indoor heat exchanger 10, the lower heat exchanging portion 2b, the expansion valve 9, the upper heat exchanging portion 2a, and the four-way switch valve 11, and is drawn into the compressor 12. As a result of circulation of the refrigerant, the indoor heat exchanger 10

and the lower heat exchanging portion 2b operate as a condenser and the upper heat exchanging portion 2a operates as an evaporator. In the indoor heat exchanger 10 that operates as a condenser, a gasified refrigerant exchanges
5 heat with the indoor air and condenses so that the indoor air is heated by heat released from the refrigerant. In the lower heat exchanging portion 2b that operates as a condenser, the refrigerant also releases heat so that the lower heat exchanging portion 2b functions as the high
10 temperature portion 14d. In the upper heat exchanging portion 2a that operates as an evaporator, a liquefied refrigerant exchanges heat with the outdoor air and evaporates to become a gasified refrigerant. As a result, the refrigerant absorbs heat from the outdoor air.

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During a cooling operation of the air conditioner 1, the four-way switch valve 11 is set as indicated by the broken line shown in Fig. 11. In this state, refrigerant discharged from the compressor 12 circulates in the order of
20 the four-way switch valve 11, the upper heat exchanging portion 2a, the expansion valve 9, the lower heat exchanging portion 2b, the indoor heat exchanger 10, and the four-way switch valve 11, and is drawn into the compressor 12. As a result of circulation of the refrigerant, the upper heat
25 exchanging portion 2a operates as a condenser and the lower heat exchanging portion 2b and the indoor heat exchanger 10 operate as an evaporator. In the upper heat exchanging portion 2a that operates as a condenser, a gasified refrigerant exchanges heat with the outdoor air and becomes
30 a liquefied refrigerant, so that the refrigerant releases heat to the outdoor air. In the indoor heat exchanger 10 that operates as an evaporator, the liquefied refrigerant exchanges heat with the indoor air and evaporates to become

a gasified refrigerant, so that the refrigerant absorbs heat from the indoor air and cools the indoor air. In the lower heat exchanging portion 2b that operates as an evaporator, liquefied refrigerant exchanges heat with the outdoor air and evaporates to become a gasified refrigerant, so that the refrigerant cools the outdoor air. In this way, the air conditioner 1 appropriately performs the cooling operation although unnecessary heat exchange occurs in the lower heat exchanging portion 2b.

10

The high temperature portion 14d functions in the same manner as the high temperature portion 14 shown in Fig. 7. The high temperature portion 14d, or the lower heat exchanging portion 2b, may also have its surface subjected to the hydrophilic treatment in the same manner as the high temperature portion 14a shown in Fig. 8.

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The fourth embodiment has the advantages described below.

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(1) In the fourth embodiment, if the water droplets 8 that have condensed run down when the outdoor heat exchanger 2 operates as an evaporator, the water droplets 8 are heated to 0°C or higher by the high temperature portions 14, 14a, 14b, 14c, and 14d. Thus, the water droplets 8 do not freeze at the lower end of the outdoor heat exchanger 2. As a result, frost is prevented from growing upward from the lower end of the outdoor heat exchanger 2, and the amount of frost formation on the outdoor heat exchanger 2 is reduced.

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(2) The high temperature portions 14 and 14b formed by only the plate fins 3 are easily formed by the piped structure or by changing the distance from the lower ends of

the plate fins 3 to the lowest position of the heat exchanger pipe 5.

(3) The high temperature portion 14a of which surface is subjected to the hydrophilic treatment prevents the water droplets 8 from growing on the surface of the high temperature portion 14a and prevents the airflow resistance from increasing. This enables the surface temperature of the high temperature portion 14a to increase. As a result, the temperature of the water droplets 8 increases more in the high temperature portion 14a.

(4) The high temperature portion 14c formed by heating the lower part of the outdoor heat exchanger 2 with the heater 16 is easily formed by arranging the heater 16 in the outdoor heat exchanger 2. Further, as compared with the high temperature portions 14, 14a, and 14b formed by only the plate fins 3, the temperature of the high temperature portion 14c can be set high. The high temperature portion 14c can quickly heat the water droplets to 0°C or higher.

(5) The temperature of the high temperature portion 14d formed by the lower heat exchanging portion 2b that is obtained by dividing the outdoor heat exchanger 2 into upper and lower parts can be set to be high as compared with the high temperature portions 14, 14a, and 14b formed only by the plate fins 3. The high temperature portion 14d can quickly heat the water droplets to 0°C or higher.

The fourth embodiment may be modified in the following forms.

Although the high temperature portion 14 is formed

only by the plate fins 3 using the pipe-extracted structure, a high temperature portion may be formed by avoiding circulation of the refrigerant in portions of the heat exchanger pipe 5 extended through the portions of the plate fins 3 corresponding to the high temperature portion. In this case, the heat exchanger pipe 5 is extended throughout the plate fins 3. This improves the strength of the structure of the outdoor heat exchanger 2.

10 (Fifth Embodiment)

A fifth embodiment of the present invention will now be described with reference to Figs. 13 and 14. The structure of the fifth embodiment is the same as the structure of the first embodiment except in the structure of the drain pan 6. The components of the fifth embodiment common to the first embodiment will not be described in detail.

In the fifth embodiment, the upper surface 6a of a drain pan 6 is subjected to a water slipping and water repellent treatment. The water slipping and water repellent treatment is performed by applying a coating film having water slippage and water repellency to the upper surface 6a of the drain pan 6. In this structure, water dripping from the outdoor heat exchanger 2 flows smoothly on the upper surface 6a without accumulating on the upper surface 6a of the drain pan 6.

The drain pan 6 shown in Fig. 13 includes a water outlet 17 in the middle portion of the outdoor heat exchanger 2 in the longitudinal direction. The upper surface 6a of the drain pan 6 is inclined from the two end portions of the drain pan 6 in the longitudinal direction toward the

water outlet 17 formed in the middle portion. The water outlet 17 formed in the middle portion shortens the distance from the highest position of the inclined upper surface 6a to the water outlet 17 as compared with when a water outlet is formed in an end portion of the drain pan 6 in the longitudinal direction, and enables water to be drained smoothly. When the upper surface 6a is subjected to the water slipping and water repellent treatment, water is drained more smoothly.

10

Further, the upper surface 6a of the drain pan 6 shown in Fig. 14 is inclined from an upstream side toward a downstream side in a manner that its downstream portion in the air circulation direction 4 is at the lower position.

15 The upper surface 6a inclined in the circulation direction 4 shortens the distance from the highest position of the inclined upper surface 6a to the lowest position of the inclined upper surface 6a as compared with when the upper surface 6a is inclined in a direction perpendicular to the circulation direction 4, and enables water to be drained smoothly. When the upper surface 6a is subjected to the water slipping and water repellent treatment, water is drained more smoothly.

25 The fifth embodiment has the advantages described below.

(1) The upper surface 6a of the drain pan 6 is subjected to the water slipping and water repellent treatment so that water dripping from the outdoor heat exchanger 2 flows smoothly without accumulating on the upper surface 6a of the drain pan 6, and the water is drained smoothly. The upper surface 6a of the drain pan 6 is

subjected to the water slipping and water repellent treatment and the distance from the highest position of the upper surface 6a to the lowest position of the upper surface 6a is shortened so that the water is drained more smoothly.

5

(Sixth Embodiment)

A sixth embodiment of the present invention will now be described. The structure of the sixth embodiment is the same as the structure of the fifth embodiment except in the structure of the drain pan 6. The components of the sixth
10 embodiment common to the fifth embodiment will not be described in detail.

In the sixth embodiment, an upper surface 6a of a drain pan 6 is subjected to the hydrophilic treatment. The hydrophilic treatment may, for example, be performed by
15 applying a hydrophilic agent, such as polyacrylic acid, to the upper surface 6a when the drain pan 6 is made of aluminum. Thus, water dripping from the outdoor heat exchanger 2 flows smoothly on the upper surface 6a of the
20 drain pan 6.

The sixth embodiment has the advantage described below.

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(1) The upper surface 6a of the drain pan 6 is subjected to the hydrophilic treatment so that water dripping from the outdoor heat exchanger 2 flows smoothly on the upper surface 6a of the drain pan 6, and the water is
30 drained smoothly. The upper surface 6a of the drain pan 6 is subjected to the hydrophilic treatment and the distance from the highest position of the upper surface 6a to the lowest position of the upper surface 6a is shortened so that the

water is drained more smoothly.

In the above embodiments, the present invention is applied to a heat pump type air conditioner serving as one
5 type of refrigeration apparatus. However, the present invention may be applied to, for example, a refrigerator or a freezer.

CLAIMS

1. A refrigeration apparatus including:

5 a heat exchanger having a heat exchanging surface and exchanging heat between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger; and

a drain pan arranged below the heat exchanger, the refrigeration apparatus being characterized by:

10 a space is formed entirely between a lower end of the heat exchanger and an upper surface of the drain pan.

2. A refrigeration apparatus including:

15 a heat exchanger having a heat exchanging surface and exchanging heat between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger; and

a drain pan arranged below the heat exchanger;

20 wherein the heat exchanger is arranged in a manner that a lower end of the heat exchanger partially comes into contact with an upper surface of the drain pan, the refrigeration apparatus being characterized by:

25 a projection is arranged on the lower end of the heat exchanger, and the partial contact between the lower end of the heat exchanger and the upper surface of the drain pan is performed by a distal end of the projection coming in contact with the upper surface of the drain pan.

3. The refrigeration apparatus according to claim 30 2, characterized in that:

the heat exchanger is a cross fin and tube heat exchanger including a plurality of fins that form the heat exchanging surface and a heat exchanger pipe through which

the heating medium circulates; and

the projection is arranged on a lower end of each of the plurality of fins and is formed as an inclined portion that is inclined relative to a direction in which the air
5 circulates.

4. The refrigeration apparatus according to claim 2, characterized in that:

the heat exchanger is a cross fin and tube heat
10 exchanger including a plurality of fins that form the heat exchanging surface and a heat exchanger pipe through which the heating medium circulates; and

the projection is arranged on lower ends of some of the plurality of fins and projects more outward than lower
15 ends of the other fins.

5. The refrigeration apparatus according to claim 4, characterized in that the projection has a surface subjected to a hydrophilic treatment.

20

6. A refrigeration apparatus including:

a heat exchanger having a heat exchanging surface and exchanging heat between air circulating along the heat exchanging surface and a heating medium circulating through
25 the heat exchanger, the refrigeration apparatus being characterized by:

a high temperature portion arranged below the heat exchanger and heating a water droplet that condenses and runs down the heat exchanging surface to 0°C or higher when
30 the heat exchanger operates as an evaporator.

7. The refrigeration apparatus according to claim 6, characterized in that:

the heat exchanger is a cross fin and tube heat exchanger including a plurality of fins that form the heat exchanging surface and a heat exchanger pipe through which the heating medium circulates; and

5 the high temperature portion is formed by only the fins.

8. The refrigeration apparatus according to claim 6, characterized in that:

10 the heat exchanger includes a heater, the heater is arranged in a state contact a lower end surface of the heat exchanger, and the heater heats a lower part of the heat exchanger to form the high temperature portion.

15 9. The refrigeration apparatus according to claim 6, characterized in that:

the heat exchanger is divided into an upper heat exchanging portion and a lower heat exchanging portion and includes an expansion valve, with the upper heat exchanging
20 portion and the lower heat exchanging portion being connected by the expansion valve, and the heating medium being supplied to the lower heat exchanging portion, the expansion valve, and the upper heat exchanging portion in this order so that the lower heat exchanging portion
25 operates as a condenser and the upper heat exchanging portion operates as an evaporator; and

the high temperature portion is formed by the lower heat exchanging portion that operates as the condenser.

30 10. The refrigeration apparatus according to any one of claims 6 to 9, characterized in that:

the high temperature portion has a surface subjected to a hydrophilic treatment.

11. A refrigeration apparatus including:

5 a heat exchanger having a heat exchanging surface and exchanging heat between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger, the refrigeration apparatus being characterized in that:

10 the heat exchanger is a cross fin and tube heat exchanger including a plurality of fins that form the heat exchanging surface and a heat exchanger pipe through which the heating medium circulates; and

a projection is formed on lower ends of some of the plurality of fins, and the projection projects more downward than lower ends of the other fins.

15

12. The refrigeration apparatus according to claim 11, characterized in that:

the heat exchanger includes a lower part with a surface subjected to a hydrophilic treatment.

20

13. A refrigeration apparatus including:

25 a heat exchanger having a heat exchanging surface and exchanging heat between air circulating along the heat exchanging surface and a heating medium circulating through the heat exchanger; and

a drain pan arranged below the heat exchanger, the refrigeration apparatus being characterized in that:

the drain pan has an upper surface subjected to a water slipping and water repellent treatment.

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14. A refrigeration apparatus comprising:

a heat exchanger having a heat exchanging surface and exchanging heat between air circulating on the heat

exchanging surface and a heating medium circulating inside the heat exchanger; and

a drain pan arranged below the heat exchanger,
wherein the drain pan has an upper surface subjected
5 to hydrophilic treatment.

15. The refrigeration apparatus according to any one of claims 1 to 14, characterized in that:

the heat exchanging surface has water slippage and
10 water repellency.