

DESCRIPTION

A HEAT EXCHANGER FOR AN AIR CONDITIONER OR THE LIKE

TECHNICAL FIELD

5 The present invention relates to a heat exchanger for use in an air conditioner or the like and more particularly, to a so-called crossed-fin-and-tube type heat exchanger in which heat transfer tubes penetrate a plurality of fins arranged side by side, in a crossed manner.

10 BACKGROUND ART

In heating the inside of a room by means of a heat pump type air conditioner employing a refrigerant circuit, its indoor heat exchanger is made to function as a condenser and its outdoor heat exchanger is made to function as an evaporator. In this case, a representative of the heat exchangers capable of functioning as a condenser is a crossed-fin-and-tube type heat exchanger, and its prior art example is shown in Fig. 10. In this heat exchanger, a plurality of fins 40 made of a metal, such as aluminum, having a good heat conduction are arranged in parallel with one another at predetermined intervals, and a plurality of hairpin type heat transfer

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tubes 11 are inserted in the fins with their end portions connected to one another by U-shaped communication tubes 12. With this arrangement, a plurality of heat transfer tubes 13 and a plurality of heat transfer tubes 14 are aligned, in a staggered form as a whole, at an upwind half 40a and a downwind half 40b, respectively, of each of the plurality of fins 40.

In this heat exchanger, a refrigerant from a compressor flows through an inlet tube 9 and diverges in two vertical directions to flow into the downwind heat transfer tubes 14, at which the refrigerant exchanges heat with air A passing the fins 40. Thereafter the refrigerant flows into the upwind heat transfer tubes 13. The refrigerant that has flowed into the upwind heat transfer tubes 13 further exchanges heat with the air A passing the fins 40. Then, after converging from the two vertical directions, the refrigerant flows out through an outlet tube 8 and returns to the compressor by way of a pressure reducing device and an evaporator.

The temperature of the refrigerant flowing through the heat exchanger gradually decreases according as it passes through the heat transfer tubes 13 and 14 while exchanging heat with the air A. Fig. 11 is a diagram showing the temperature at several portions of the hairpin type heat transfer tubes 11 and the U-shaped communication

tube 12 in the aforementioned prior art heat exchanger. The connection structure of the hairpin type heat transfer tubes 11 and the U-shaped communication tube 12 is shown on the left-hand side of the figure, and their temperatures are shown in the graph on the right-hand side. The temperature has the highest value of about 90 °C in the vicinity of the inlet tube 9. On the other hand, the temperature has the lowest value of about 30 °C in the vicinity of the outlet tube 8. The temperature gradually decreases along the flow path of the refrigerant from the vicinity of the inlet tube 9 to the vicinity of the outlet tube 8 by the heat exchange between the refrigerant and the air A. As shown in Fig. 11, disorder occurs in the temperature change at portions B and C enclosed by dashed lines. This is because the heat transfer tubes (inlet vicinity heat transfer tubes) 14a located in the vicinity of the inlet tube 9 and having the highest temperature and the heat transfer tubes (outlet vicinity heat transfer tubes) 13a located in the vicinity of the outlet tube 8 and having the lowest temperature are arranged close to each other and they share the same fins 40. That is, in regard to the portion B, the inlet vicinity heat transfer tubes 14a are arranged close to and above and below the outlet vicinity heat transfer tube 13a located on the lower side. Therefore, the high-temperature heat of a superheated gas

which flows through the inlet vicinity heat transfer tube 14a is transferred via the fin 40 and imparted to a supercooled liquid which flows through the outlet vicinity heat transfer tube 13a, so that a significant temperature rise occurs. In regard to the portion C, the outlet vicinity heat transfer tubes 13a is arranged close to and above and below the inlet vicinity heat transfer tube 14a on the upper side. Therefore, the low-temperature heat of the supercooled liquid which flows through the outlet vicinity heat transfer tube 13a is also imparted, transferred via the fin 40, to the superheated gas which flows through the inlet vicinity heat transfer tube 14a, so that a significant temperature fall occurs. When the heat conduction via the fins 40 as described above occurs between the inlet tube 9 side and the outlet tube 8 side, the thermal efficiency of the condenser is significantly reduced by the unnecessary heat flow.

In view of the above, there has been conventionally proposed an improved heat exchanger as shown in Fig. 12, in which a plurality of slits 41 are provided between the upwind heat transfer tubes 13 and the downwind heat transfer tubes 14 so that the slits 41 thermally separate the upwind halves 40a from the downwind halves 40b of the fins 40 (e.g., refer to Japanese Patent Laid-Open Publication No. HEI 3-194370).

However, when the slits 41 as shown in Fig. 12 are provided at the fins 40, the bending rigidity of the fins 40 is degraded in a direction in which the fins 40 are arranged (i.e., in the direction in which the heat transfer tubes 13 and 14 are inserted) as shown in the figure. This has consequently led to a problem that the workability is reduced in handling the press-formed fins 40, inserting the hairpin type heat transfer tubes 11 into the stack of fins 40 and other operations. Furthermore, the fins 40 are deformed during these works, and this causes problems that the heat exchanging ability, or performance, of the heat exchanger is reduced and that the ventilation resistance increases.

DISCLOSURE OF THE INVENTION

The present invention has been developed to solve the aforementioned problems, and its object is to provide a heat exchanger capable of securing a sufficient rigidity of the fins while preventing the possible occurrence of unnecessary heat conduction via the fins.

In order to solve the aforementioned object, the present invention provides a heat exchanger of a crossed-fin-and-tube type wherein a plurality of fins are placed side by side, a plurality of upwind heat transfer tubes penetrate an upwind half of each fin and are aligned in a

specified direction in the upwind half, a plurality of downwind heat transfer tubes penetrate a downwind half of each fin and are aligned in the downwind half in a direction substantially identical to the direction in which the upwind heat transfer tubes are aligned, and the upwind half is thermally separated from the downwind half by a plurality of cut lines which are arranged, spaced from each other, in a specified direction, characterized in that at least one of the cut lines is extended in a direction intersecting the direction of arrangement of the cut lines.

Assuming that an angle made between the direction in which the cut lines are arranged and the direction in which the at least one cut line extends is θ , preferably, a relationship of $5^\circ \leq \theta \leq 175^\circ$ is satisfied.

In this heat exchanger, since at least one, preferably all, of the plurality of cut lines are extended in a direction intersecting the direction in which the cut lines are arranged, it is possible to reduce such a degradation in the bending rigidity of the fins that will cause the bending of the fins with the direction of arrangement of the cut lines serving as a center of the bending. Thus, it is possible to secure the rigidity of the fins while preventing the possible occurrence of unnecessary heat conduction via the fins.

In an embodiment, the upwind heat transfer tubes and the downwind heat transfer tubes are arranged in a staggered form as a whole, and each cut line is located between mutually adjacent upwind heat transfer tube and downwind heat transfer tube, and extended intersecting an imaginary line which connects centers of the mutually adjacent upwind and downwind heat transfer tubes.

In this case, because the cut lines are provided across the imaginary lines and in each of spaces between the upwind heat transfer tubes and the downwind heat transfer tubes, the unnecessary heat conduction via the fins is surely prevented.

In an embodiment, the upwind heat transfer tubes and the downwind heat transfer tubes are made to have an approximately identical diameter whose magnitude is represented by $W1$, each cut line is extended in a region centered on the imaginary line and having a width represented by $W2$, and an expression of $0.4 \leq W2/W1 \leq 1.3$ holds.

According to this construction, the degradation in the rigidity of the fins is avoided under the normal working conditions while more surely preventing the unnecessary heat conduction via the fins.

Assuming that a distance between mutually facing outer peripheral portions of the upwind heat transfer tube

and downwind heat transfer tube on the imaginary line is L_1 and that a distance between a point at which the cut line intersects the imaginary line and the outer peripheral portion of the downwind heat transfer tube on the imaginary line is L_2 , then an expression of $0.2 \leq L_2/L_1 \leq 0.8$ preferably holds. With this arrangement, the possible occurrence of unnecessary heat conduction via the fins can be still more surely prevented.

In another embodiment, the upwind half and downwind half of each fin are formed with raised portions having cut edges which protrude into an air flow path and extend in a direction intersecting a direction of air flow, and the cut lines are arranged in a middle portion formed between the upwind raised portions and the downwind raised portions.

In this case, the heat exchanging ability, or performance, is enhanced by the raised portions. Furthermore, the degradation in the rigidity of the fins is reduced while preventing the possible occurrence of unnecessary heat conduction via the fins.

Assuming that the middle portion has a width W_3 in a direction in which the upwind heat transfer tubes are laterally spaced from the downwind heat transfer tubes and that a region in which the cut lines are extended has a width W_4 in the direction in which the upwind heat transfer

tubes are laterally spaced from the downwind heat transfer tubes, then an expression of $0.4 \leq W4/W3 \leq 0.9$, preferably, holds.

5 In this case, it is possible to avoid the degradation in the rigidity of the fins while more surely preventing the unnecessary heat conduction via the fins.

Furthermore, assuming that a distance between the centers of the mutually adjacent upwind and downwind heat transfer tubes in the vertical direction in which the upwind heat transfer tubes or the downwind heat transfer tubes are aligned is $L3$ and that a distance between the centers of the upwind heat transfer tube and cut line in the direction of alignment of the upwind heat transfer tubes or the downwind heat transfer tubes is $L4$, an expression of $0.3 \leq L4/L3 \leq 0.7$, preferably, may hold. In this case, the possible occurrence of unnecessary heat conduction via the fins is still more surely prevented.

20 In an embodiment, a higher-temperature refrigerant flows through the downwind heat transfer tubes and a lower-temperature refrigerant flows through the upwind heat transfer tubes, and the upwind half of each fin is formed with a fin connecting portion which is interposed between two upwind raised portions and which is located on an upwind side of the downwind heat transfer tubes.

With this arrangement, part of the higher-temperature heat of the downwind heat transfer tubes is transferred to the upwind half of the fin via the fin connecting portions. This enables prevention of an abnormal drop in temperature at those portions of the upwind half located between the upwind heat transfer tubes. Therefore, a sufficient heat exchanging ability, or a good performance, is secured.

In an embodiment, assuming that an angle made between the direction in which the upwind heat transfer tubes or the downwind heat transfer tubes are aligned and a direction in which the at least one cut line is extended is θ , then an expression of $5^\circ \leq \theta \leq 175^\circ$ holds. Preferably, mutually adjacent cut lines are extended in such a manner that they intersect the direction of alignment of the upwind heat transfer tubes or the downwind heat transfer tubes in opposite directions. In this case, the unnecessary heat conduction via the fins is still more surely prevented and a sufficient rigidity of the fins is also secured.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a refrigerant circuit diagram of a heat pump air conditioner which employs the heat exchanger of the present invention;

Fig. 2 is a perspective view of an embodiment of the heat exchanger of the present invention;

Fig. 3 is a front view of a part of a fin of the embodiment shown in Fig. 2;

5 Fig. 4 is a front view of a part of a fin of another embodiment of the heat exchanger of the present invention;

10 Fig. 5A is a perspective view showing the construction of a cut line formed at the fins shown in Figs. 3 and 4;

Figs. 5B, 5C and 5D are perspective views showing modification examples of the above cut line;

15 Fig. 6 is a graph showing a relationship between the configuration of a cut line and the heat exchanger performance, the graph showing values of the heat exchanger performance for each value of $W2/W1$ when it is assumed that the heat exchanger performance for $W2/W1=0$ has a value of 1.0;

20 Fig. 7 is a graph showing a relationship between the configuration of a cut line and the heat exchanger performance, the graph showing values of the heat exchanger performance for each value of $L2/L1$ when it is assumed that the heat exchanger performance for $L2/L1=0.5$ has a value of 1.0;

Fig. 8 is a graph showing a relationship between the configuration of a cut line and the heat exchanger performance, the graph showing values of the heat exchanger performance for each value of $W4/W3$ when it is assumed that the heat exchanger performance for $W4/W3=0$ has a value of 1.0;

Fig. 9 is a graph showing a relationship between the configuration of a cut line and the heat exchanger performance, the graph showing values of the heat exchanger performance for each value of $L4/L3$ when it is assumed that the heat exchanger performance for $L4/L3=0.5$ has a value of 1.0;

Fig. 10 is a perspective view of a prior art heat exchanger;

Fig. 11 is a graph showing the temperature at each portion of heat transfer tubes of the prior art heat exchanger; and

Fig. 12 is a perspective view of an improved example of the prior art heat exchanger.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the heat exchanger of the present invention will be described in detail with reference to the accompanying drawings.

Fig. 1 is a refrigerant circuit diagram of a heat pump air conditioner provided with a refrigerant circuit.

In the figure, a reference numeral 1 denotes a compressor, a reference numeral 2 denotes a four-way selector valve, a reference numeral 3 denotes an indoor heat exchanger provided with an indoor fan 7, reference numeral 4 denotes a pressure reducing device, such as a capillary tube, and a reference numeral 5 denotes an outdoor heat exchanger provided with an outdoor fan 6. Also, a reference numeral

8 denotes an accumulator. When executing a heating operation with this air conditioner, the four-way selector valve 2 is switched to the solid line side to drive the compressor 1. Then, a refrigerant flows from the compressor 1 through the indoor heat exchanger 3, pressure reducing device 4 and outdoor heat exchanger 5 and is thereafter fed back to the compressor 1. The indoor heat exchanger 3 functions as a condenser and the outdoor heat exchanger 5 functions as an evaporator. Fig. 2 schematically shows the construction of the above indoor heat exchanger 3 which functions as a condenser in the heating operation, wherein components similar to those of the prior art heat exchanger shown in Fig. 10 are denoted by the same reference characters. The structure of this indoor heat exchanger 3 is similar to that of the prior art shown in Fig. 10 except for the configuration of the fins

10. That is, a number of fins 10 made of a metal, such as aluminum, having a good heat conduction are arranged side by side in parallel with each other at specified intervals, and a plurality of hairpin type heat transfer tubes 11 are
5 inserted in the fins 10 with their end portions connected to one another by U-shaped communication tubes 12. With this arrangement, a plurality of heat transfer tubes 13 and a plurality of heat transfer tubes 14 are arranged in a vertical direction, in a staggered form as a whole, at an
10 upwind half 10a and a downwind half 10b, respectively, of the fins 10. The refrigerant from the compressor 1 flows through an inlet tube 9 and diverges in two vertical directions to flow into the downwind heat transfer tubes 14, at which the refrigerant exchanges heat with air A
15 passing the fins 10. Thereafter the refrigerant flows into the upwind heat transfer tubes 13. The refrigerant that has flowed into the upwind heat transfer tubes 13 further exchanges heat with the air A passing the fins 10. Then, after converging from the two vertical directions, the
20 refrigerant flows out through an outlet tube 8 and returns to the compressor 1 by way of the pressure reducing device 4 and the evaporator 5.

Next, the fins 10 of the above indoor heat exchanger 3 will be described in detail with reference to
25 Fig. 3. In the figure, reference numeral 13 denotes the

upwind heat transfer tube and reference numeral 14 denotes the downwind heat transfer tube. The figure shows the cross-sections of the heat transfer tubes. These heat transfer tubes 13 and 14 have an identical diameter, the magnitude of which is represented by W1 in the figure. In the same figure, a reference numeral 15 denotes a cut line. The cut lines 15 each extend intersecting an imaginary line 20 which connects the centers of the mutually adjacent upwind heat transfer tube 13 and downwind heat transfer tube 14. Assuming that a distance between mutually confronting outer peripheral portions of the upwind heat transfer tube 13 and the downwind heat transfer tube 14 on the imaginary line 20 is L1 and that a distance between the outer peripheral portion of the downwind heat transfer tube 14 and an intersection point at which the cut line intersects the imaginary line is L2, the intersection point is located in a position satisfying the following relationship:

$$0.2 \leq L2/L1 \leq 0.8$$

Further, the cut line 15 is provided in a region centered on the imaginary line 20 and having a width W2 which satisfies the following relationship:

$$0.4 \leq W2/W1 \leq 1.3$$

Further, assuming that an angle made between the cut line 15 and a vertical direction in which the downwind heat

transfer tubes 14 are aligned is θ , the cut line 15 is provided within a range of $5^\circ \leq \theta \leq 175^\circ$ so that the adjacent cut lines 15 intersect the direction in which the downwind heat transfer tubes are arranged, in the mutually reverse directions, as shown in Fig. 3. Its concrete shape is provided by an elongated hole as shown in Fig. 5A. It is to be noted that the downwind heat transfer tubes 14 and the upwind heat transfer tubes 13 are arranged mutually parallel to each other, and this means that the cut lines 15 are provided at same angles relative to the vertical direction in which the upwind heat transfer tubes 13 are aligned as relative to the direction in which the downwind heat transfer tubes are aligned.

In the heat exchanger constructed as above, the plurality of cut lines 15 are extended at the fins 10. The cut lines 15 are arranged along the vertical direction in which the downwind heat transfer tubes 14 and/or the upwind heat transfer tubes 13 are aligned, and the directions in which the cut lines extend make specified angles of 5° to 175° relative to the direction in which the downwind and/or upwind heat transfer tubes are arranged. Thus, the directions in which the cut lines 15 extend, do not coincide with the direction X in which the cut lines are arranged. This avoids the degradation in the rigidity of the fins which will cause the bending of the fins with the

direction X of arrangement of the cut lines serving as a center of the bending. Consequently, it is possible to enhance the workability in handling the fins 10 and also to prevent the reduction of the heat exchanging ability and the increase of the ventilation resistance which are caused by the deformation of the fins 10.

Furthermore, in the above heat exchanger, by providing the fins 10 with the cut lines 15 between the upwind heat transfer tubes 13 and the downwind heat transfer tubes 14, the possible occurrence of unnecessary heat conduction from the downwind half 10b to the upwind half 10a of the fin 10 is prevented. Also, assuming that the diameter of the heat transfer tubes 13 and 14 is $W1$ and that the width of a zone in which the cut lines 15 are provided is $W2$, an expression of $0.4 \leq W2/W1$ is satisfied. With this arrangement, the unnecessary heat conduction is surely suppressed, and a sufficient performance, or heat exchanging ability is displayed, as shown in the graph of Fig. 6. Furthermore, because of $W2/W1 \leq 1.3$, the degradation in the rigidity of the fins 10 can be avoided under the normal operating conditions. Furthermore, an expression of $0.2 \leq L2/L1 \leq 0.8$ is satisfied so that the cut lines 15 are each provided in a center portion of the imaginary line 20. With this arrangement, a sufficient

heat exchanger performance is displayed, as shown in the graph of Fig. 7.

Fig. 4 shows another embodiment of the heat exchanger of the present invention. In Fig. 4, components similar to those of the embodiment shown in Fig. 3 are denoted by the same reference characters. In this heat exchanger, upwind raised portions 16 and 17 are formed at an upwind half 100a of each fin 100, and downwind raised portions 18 are formed at a downwind half 100b of the fin 100. These raised portions 16, 17 and 18 are of the so-called slit type, formed by raising a part of the surface of each fin 100 (see Fig. 5B). Their cut edges 16a, 17a and 18a protrude in the air flow path of the air A so as to intersect the air flow direction A. Further, at the upwind half 100a of the fin 100, a fin connecting portion 19 interposed between two upwind raised portions 16 and 17 located at the most downwind side is formed on the upwind side (the left-hand side in Fig. 4) of the downwind heat transfer tubes 14. In a middle portion of the fin 100 formed between the downwind raised portion 18 located at the most upwind side and the upwind raised portions 16 and 17 located at the most downwind side, there are arranged a plurality of cut lines 15 which each intersect an imaginary line 20 connecting the centers of the mutually adjacent upwind heat transfer tube 13 and downwind heat transfer

tube 14. Assuming that the middle portion has a lateral width $W3$, the cut lines 15 are provided in a central part of the middle portion and within a lateral width $W4$ which satisfies the following expression:

5 $0.4 \leq W4/W3 \leq 0.9$

The direction X of arrangement of the cut lines 15 is approximately parallel to the direction of alignment of the downwind heat transfer tubes 14 and hence approximately parallel to the direction of alignment of the upwind heat transfer tubes 13 as well. Then, assuming that a distance between the centers of the upwind heat transfer tube 13 and the downwind heat transfer tube 14 in the direction of alignment of the tubes is $L3$ and that a distance between the centers of the upwind heat transfer tube 13 and the cut line 15 in the same direction is $L4$, the cut line 15 is provided in a position for which the following expression holds:

$0.3 \leq L4/L3 \leq 0.7$

Further, the cut lines 15 are provided so that an angle θ made between the direction X in which the cut lines are arranged and the direction in which the cut line extends is within a range of $5^\circ \leq \theta \leq 175^\circ$ and that the mutually adjacent cut lines 15 are extended in the mutually reverse directions.

In the heat exchanger constructed as above, the raised portions 16, 17 and 18 are provided on the surfaces of the fins 100 and their edges 16a, 17a and 18a are made to protrude in the air flow path of the air A. Therefore, the fins 100 have a high heat dissipation efficiency, and hence an improved heat exchanging ability. Then, by providing the heat exchanger having the thus improved heat exchanging ability with the cut lines 15, the unnecessary heat conduction via the fins 100 is prevented. Furthermore, similarly to the embodiment described with reference to Fig. 3, the cut lines 15 are arranged along the direction in which the downwind heat transfer tubes 14 or the upwind heat transfer tubes 13 are arranged, and the direction of extension of the cut line makes the specified angle of 5° to 175° relative to the direction of arrangement of the cut lines. Therefore, the directions of extension of the cut lines 15 do not coincide with the direction X of arrangement thereof, which enables the avoidance of the reduction in the rigidity of the fins 100 which may cause the fins to be bent along the direction X of arrangement of the cut lines. Consequently, the workability in handling the fins 100 is improved.

In the above heat exchanger, the cut lines 15 are provided between the upwind heat transfer tubes 13 and the downwind heat transfer tubes 14 at the fins 100, thereby

preventing the unnecessary heat conduction from the downwind half 100b to the upwind half 100a of each fin 100. Further, a relationship of $0.4 \leq W4/W3$ is made to hold, where W3 is the width of the middle portion formed between the upwind raised portions 16 and 17 and the downwind raised portions 18 and W3 is the width of the zone in which the cut lines 15 are provided. With this arrangement, the unnecessary heat conduction is infallibly suppressed, and as shown in the graph of Fig. 8, a good performance, or heat exchanging ability, is displayed as in the case of the aforementioned embodiment shown in Fig. 3. Furthermore, with the restraint of $W4/W3 \leq 0.9$, the degradation in the rigidity of the fins 100 is avoided. Further, with the restraint of $0.3 \leq L4/L3 \leq 0.7$, the cut lines 15 are each located in the center portion of the imaginary line 20. Therefore, in this case, a good heat exchanger performance or heat exchanging ability is also exhibited as shown in the graph of Fig. 9, as in the case of the aforementioned embodiment shown in Fig. 3.

Since the fins 100 provided with the raised portions 16, 17 and 18 have a good ability to exchange heat with the passing air A, the temperature tends to drop particularly in those portions that are located between the upwind heat transfer tubes 13 at the upwind half 100a, and this sometimes leads to an insufficient display of the heat

exchanging ability. However, since the fin connecting portions 19 are provided on the upwind side of the downwind heat transfer tubes 14 in the present embodiment, part of the high-temperature heat of the downwind heat transfer tubes 14 through which the higher-temperature refrigerant flows is transferred to the upwind half 100a by way of the fin connecting portions 19. Therefore, an abnormal temperature reduction at the aforementioned portions of the upwind half is prevented, which allows the heat exchanging ability to be improved.

Although the concrete embodiments of the present invention have been described above, the present invention is not limited to the aforementioned embodiments, which can be modified within the scope of the present invention. For example, instead of providing the cut line by the elongated hole as shown in Fig. 5A, it is acceptable to form the cut line 15 of a slit type as shown in Fig. 5B in which a part of the fin is raised, or a louver type as shown in Fig. 5C in which a side portion is sunk (or raised), or a burring type as shown in Fig. 5D in which a flange is provided around the elongated hole. In either case, the cut lines 15 are provided at the fins 10 and 100, and the cut lines 15 prevent the unnecessary heat conduction from the downwind halves 10b and 100b to the upwind halves 10a and 100a of the fins 10 and 100. Although the above describes

the case where the cut lines 15 are provided in the indoor heat exchanger 3 which functions as a condenser in the heating operation, the cut lines may be provided in the outdoor heat exchanger 5 which functions as a condenser in the cooling operation.

INDUSTRIAL APPLICABILITY

The heat exchanger of the present invention is used for a heat pump type air conditioner or the like provided with a refrigerant circuit.



C L A I M S

1. A heat exchanger of a crossed-fin-and-tube type wherein a plurality of fins (10, 100) are placed side by side, a plurality of upwind heat transfer tubes (13) penetrate an upwind half (10a, 100a) of each fin and are aligned in a specified direction in the upwind half, a plurality of downwind heat transfer tubes (14) penetrate a downwind half (10b, 100b) of each fin and are aligned in the downwind half in a direction substantially identical to the direction in which said upwind heat transfer tubes (13) are aligned, and said upwind half (10a, 100a) is thermally separated from said downwind half (10b, 100b) by a plurality of cut lines (15) which are arranged, spaced from each other, in a specified direction, characterized in that:

at least one of said cut lines (15) is extended in a direction intersecting the direction (X) of arrangement of the cut lines (15).

2. The heat exchanger as claimed in Claim 1, wherein said upwind heat transfer tubes (13) and said downwind heat transfer tubes (14) are arranged in a staggered form as a whole, and each cut line (15) is located between the mutually adjacent upwind heat transfer tube (13) and



downwind heat transfer tube (14), and extended intersecting an imaginary line (20) which connects centers of the mutually adjacent upwind and downwind heat transfer tubes (13) (14).

5 3. The heat exchanger as claimed in Claim 2, wherein said upwind heat transfer tubes (13) and said downwind heat transfer tubes (14) are made to have an approximately identical diameter whose magnitude is represented by $W1$, each cut line (15) is extended in a region centered on said
10 imaginary line (20) and having a width represented by $W2$, and an expression of $0.4 \leq W2/W1 \leq 1.3$ holds.

4. The heat exchanger as claimed in Claim 2, wherein, assuming that a distance between mutually facing outer peripheral portions of said upwind heat transfer tube
15 (13) and downwind heat transfer tube (14) on said imaginary line (20) is $L1$ and that a distance between a point at which the cut line (15) intersects said imaginary line (20) and said outer peripheral portion of said downwind heat transfer tube (14) on said imaginary line (20) is $L2$, then
20 an expression of $0.2 \leq L2/L1 \leq 0.8$ holds.

5. The heat exchanger as claimed in Claim 1, wherein said upwind half (100a) and downwind half (100b) of each



fin (100) are formed with raised portions (16, 17, 18) having cut edges (16a, 17a, 18a) which protrude into an air flow path and extend in a direction intersecting a direction of air flow, and said cut lines (15) are arranged
5 in a middle portion formed between the upwind raised portions (16, 17) and the downwind raised portions (18).

6. The heat exchanger as claimed in Claim 5, wherein, assuming that said middle portion has a width W3 in a direction in which said upwind heat transfer tubes
10 (13) are laterally spaced from said downwind heat transfer tubes (14) and that a region in which the cut lines (15) are extended has a width W4 in the direction in which said upwind heat transfer tubes are laterally spaced from said downwind heat transfer tubes, then an expression of $0.4 \leq$
15 $W4/W3 \leq 0.9$ holds.

7. The heat exchanger as claimed in Claim 5, wherein, assuming that a distance between the centers of the mutually adjacent upwind and downwind heat transfer tubes (13, 14) in the direction in which the upwind heat
20 transfer tubes (13) or the downwind heat transfer tubes (14) are aligned is L3 and that a distance between the centers of the upwind heat transfer tube (13) and cut line (15) in the direction of alignment of the upwind heat



transfer tubes or the downwind heat transfer tubes is L_4 ,
an expression of $0.3 \leq L_4/L_3 \leq 0.7$ holds.

8. The heat exchanger as claimed in Claim 5, wherein
a higher-temperature refrigerant flows through said
5 downwind heat transfer tubes (14) and a lower-temperature
refrigerant flows through said upwind heat transfer tubes
(13), and said upwind half (100a) of each fin (100) is
formed with a fin connecting portion (19) which is
interposed between two upwind raised portions (16, 17) and
10 located on an upwind side of the downwind heat transfer
tubes (14).

9. The heat exchanger as claimed in Claim 2, wherein
assuming that an angle made between the direction in which
the upwind heat transfer tubes (13) or the downwind heat
15 transfer tubes (14) are aligned and a direction in which
said at least one cut line (15) is extended is θ , then an
expression of $5^\circ \leq \theta \leq 175^\circ$ holds.

10. The heat exchanger as claimed in Claim 9, wherein
mutually adjacent cut lines (15) are extended in such a
20 manner that they intersect the direction of arrangement of
said upwind heat transfer tubes (13) or said downwind heat
transfer tubes (14) in opposite directions.