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(54) **HEAT EXCHANGER**

(57) A heat exchanger with improved heat exchange performance is provided. An indoor heat exchanger (6) is a heat exchanger that allows supercritical CO₂ refrigerant to radiate heat to the air, and includes a plurality of plate fins (11) and a plurality of heat transfer tubes (12). Four or more rows (61 to 72) of heat transfer tubes (12) arranged in the direction crossing the airflow are formed in the upstream-to-downstream direction of the airflow. Each plate fin (11) is divided between at least one pair of adjacent rows (61, 62). The refrigerant flows from the heat transfer tubes (12) in the row (72) on the downstream side of the airflow to the heat transfer tubes (12) in the row (61) on the upstream side of the airflow.

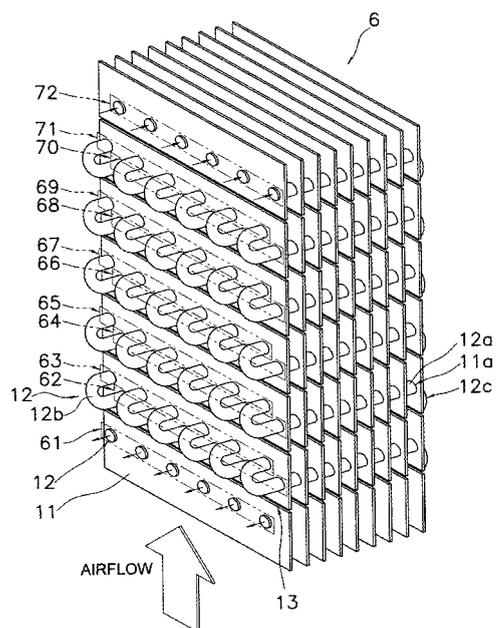


FIG. 3

EP 2 031 334 A1

Description**TECHNICAL FIELD**

[0001] The present invention relates to a heat exchanger of an air conditioner that uses CO₂ refrigerant.

BACKGROUND ART

[0002] Conventionally, an air conditioner that uses CO₂ refrigerant ensures the comfort of heating by raising the discharge air temperature during heating operation close to the compressor discharge temperature. Further, in order to improve heat exchange performance between CO₂ refrigerant and airflow, structural improvements to promote heat exchange have been made in a heat exchanger (gas cooler) that includes fins and heat transfer tubes. As one of the structural improvements, a method is employed which accelerates the refrigerant flow rate by making the cross section of heat transfer tubes on the downstream side of the refrigerant flow during heating operation smaller than the cross section of other heat transfer tubes, and thereby activates heat transfer from the refrigerant by the effect of turbulent flow (for example, see Patent Document 1).

<Patent Document 1> JP-A Publication No. H10-176867

DISCLOSURE OF THE INVENTION

<OBJECT TO BE ACHIEVED BY THE INVENTION>

[0003] However, with the method described in the cited document 1, because only two or three rows of heat transfer tubes of the heat exchanger to exchange heat with the airflow are formed in the flow direction of the airflow, it is not possible to achieve maximum heat exchange efficiency between the heat transfer tubes and the airflow in a critical state where the refrigerant temperature greatly varies.

[0004] An object of the present invention is to provide a heat exchanger with improved heat exchange performance.

<MEANS TO ACHIEVE THE OBJECT>

[0005] A heat exchanger according to a first aspect of the present invention is a heat exchanger that allows supercritical refrigerant to radiate heat to the air, including a plurality of plate fins and a plurality of heat transfer tubes. Each plate fin has a plurality of through-holes on the planar surface arranged substantially parallel to airflow. The heat transfer tubes are inserted into the through-holes in the plate fins. Four or more rows of heat transfer tubes arranged in the direction crossing the airflow are formed in the upstream-to-downstream direction of the airflow. Each plate fin is divided between at least one pair of adjacent rows. The refrigerant flows from the heat transfer tubes in the row on the downstream side of

the airflow to the heat transfer tubes in the row on the upstream side of the airflow.

[0006] In this heat exchanger, the airflow exchanges heat with higher temperature refrigerant as the airflow moves downstream. In addition, because each plate fin is divided, heat transfer on the plate fin surface is suppressed, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0007] A heat exchanger according to a second aspect of the present invention is the heat exchanger according to the first aspect of the present invention, wherein each plate fin is divided between all adjacent rows.

[0008] In this heat exchanger, because the number of divided sections on each plate fin is increased, heat transfer on the plate fin surface is further suppressed, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0009] A heat exchanger according to a third aspect of the present invention is the heat exchanger according to the first aspect of the present invention, wherein each plate fin is divided from one end to the other end.

[0010] In this heat exchanger, because the length of division of each plate fin is extended, heat transfer on the plate fin surface is further suppressed, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0011] A heat exchanger according to a fourth aspect of the present invention is the heat exchanger according to the first aspect of the present invention, wherein each plate fin is partially divided from one end to the other end.

[0012] In this heat exchanger, the dividing process of the plate fins is simplified, and also a function to suppress heat transfer on the plate fin surface is ensured. Thus, the processing cost is reduced and also heat exchange performance improves.

[0013] A heat exchanger according to a fifth aspect of the present invention is the heat exchanger according to the first aspect of the present invention, wherein a plurality of passages are formed through which the refrigerant flows from the heat transfer tubes in the row on the downstream side of the airflow to the heat transfer tubes in the row on the upstream side of the airflow.

[0014] In this heat exchanger, the distance in which the refrigerant moves in the row direction of the heat transfer tubes is shortened, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0015] A heat exchanger according to a sixth aspect of the present invention is the heat exchanger according to the first aspect of the present invention, wherein the heat transfer tubes extend in one of the height, width, and depth directions whichever is the shortest dimension.

[0016] In this heat exchanger, the distance in which the refrigerant moves in the long axis direction of the heat transfer tubes is shortened, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0017] A heat exchanger according to a seventh aspect of the present invention is the heat exchanger according to the first aspect of the present invention, wherein the tube outer diameter of the heat transfer tubes is equal to or less than 4 mm.

[0018] In this heat exchanger, the flow rate of the refrigerant flowing through the heat transfer tubes is accelerated and the flow of the refrigerant becomes a turbulent flow. Thus, the amount of heat exchange between the refrigerant and the heat transfer tubes increases, and heat exchange performance improves.

[0019] A heat exchanger according to an eighth aspect of the present invention is the heat exchanger according to the first aspect of the present invention, wherein the refrigerant is CO₂.

[0020] This heat exchanger uses CO₂ whose ozone destruction coefficient is low and thus does not lead to the destruction in the air environment.

[0021] A heat exchanger according to a ninth aspect of the present invention is the heat exchanger according to the fifth aspect of the present invention, further including a first plate attached to end portions of the plurality of passages, a connecting tube connected to a refrigerant pipe through which the refrigerant circulates, and a wide-mouth container. The wide-mouth container collects the refrigerant that flows out from each end portion of the plurality of passages, or guides the refrigerant that flows out from the connecting tube to each end portion of the plurality of passages. The wide-mouth container is closely attached to the first plate.

[0022] This heat exchanger is low in cost because there is no need to connect the refrigerant pipe to each end portion of the passages.

[0023] A heat exchanger according to a tenth aspect of the present invention is the heat exchanger according to the first aspect of the present invention, further including a second plate attached to end portions of the plurality of heat transfer tubes and a third plate having a plurality of depressed portions formed therein for interconnecting the end portions of the appropriate adjacent heat transfer tubes. The third plate is closely attached to the second plate. Consequently, the work to interconnect the end portions of the heat transfer tubes with U-shaped tubes becomes unnecessary, and therefore the cost is low.

<EFFECTS OF THE INVENTION>

[0024] In the heat exchanger according to the first aspect of the present invention, the airflow exchanges heat with higher temperature refrigerant as the airflow moves downstream. In addition, because each plate fin is divided, heat transfer on the plate fin surface is suppressed, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0025] In the heat exchanger according to the second and third aspects of the present invention, because the number of divided sections on each plate fin is increased, heat transfer on the plate fin surface is further suppressed, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0026] In the heat exchanger according to the fourth aspect of the present invention, the dividing process of the plate fins is simplified, and also a function to suppress heat transfer on the plate fin surface is ensured. Thus, the processing cost is reduced and also heat exchange performance improves.

[0027] In the heat exchanger according to the fifth and sixth aspects of the present invention, the distance of the passages through which the refrigerant flows is optimized, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0028] In the heat exchanger according to the seventh aspect of the present invention, the flow rate of the refrigerant flowing through the heat transfer tubes is accelerated and the flow of the refrigerant becomes a turbulent flow. Thus, the amount of heat exchange between the refrigerant and the heat transfer tubes increases, and heat exchange performance improves.

[0029] The heat exchanger according to the eighth aspect of the present invention uses CO₂ whose ozone destruction coefficient is low and thus does not lead to the destruction in the air environment.

[0030] The heat exchanger according to the ninth aspect of the present invention is low in cost because there is no need to connect the refrigerant pipe to each end portion of the passages.

[0031] The heat exchanger according to the tenth aspect of the present invention is low in cost because the work to interconnect the end portions of the heat transfer tubes with U-shaped tubes becomes unnecessary.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

Figure 1 is a refrigeration circuit of an air conditioner that uses CO₂ refrigerant.

Figure 2(a) is a pressure-enthalpy diagram for CO₂ refrigerant, and Figure 2(b) is a temperature-entropy diagram for CO₂ refrigerant.

Figure 3 is a perspective view to show the structure of an indoor heat exchanger according to an embodiment of the present invention.

Figure 4 is a view to describe passages of the indoor heat exchanger shown in the above Figure.

Figure 5 is a longitudinal cross sectional view of an indoor unit that uses the indoor heat exchanger according to the embodiment of the present invention.

Figure 6 is a perspective view of an indoor heat exchanger according to a first alternative embodiment of the embodiment shown in the above Figure.

Figure 7(a) is a rear view of the first alternative embodiment; Figure 7(b) is a cross sectional view taken along line D-D of the first alternative embodiment; and Figure 7(c) is a cross sectional view taken along line E-E of the first alternative embodiment.

Figure 8 is a configuration view of the indoor heat exchanger in Figure 4 with the passages being modified.

Figure 9 is a configuration view of the indoor heat exchanger in Figure 4 with the pitch of the heat transfer tubes and plate fins being modified.

Figure 10 is a configuration view of the indoor heat exchanger in Figure 8 with the pitch of the heat transfer tubes and plate fins being modified.

direction of the refrigerant, and the air conditioner 1 can switch between heating operation and cooling operation by switching the flow direction of the refrigerant by the four way valve 3.

5 [0035] During cooling operation, the outdoor heat exchanger 4 functions as a gas cooler, and the indoor heat exchanger 6 functions as an evaporator. On the other hand, during heating operation, the outdoor heat exchanger 4 functions as an evaporator, and the indoor heat exchanger 6 functions as a gas cooler. The outdoor heat exchanger 4 and the indoor heat exchanger 6 both include plate fins 11 (see Figure 3) and heat transfer tubes 12 (see Figure 3). The refrigerant in the heat transfer tubes 12 exchanges heat with the airflow through the plate fins 11.

10 [0036] In Figure 1, a point A is the suction side of the compressor 2 during heating operation, and a point B is the discharge side of the compressor 2 during heating operation. A point C is the refrigerant outlet side of the indoor heat exchanger 6 during heating operation, and a point D is the refrigerant inlet side of the outdoor heat exchanger 4 during heating operation.

15 [0037] Figure 2(a) is a pressure-enthalpy diagram for CO₂ refrigerant. The vertical axis represents pressure P and the horizontal axis represents enthalpy H. A line Tk is the isotherm that passes through a critical point K, and a line Tx is the isotherm of temperature Tx. Tx is greater than Tk ($T_x > T_k$), and the CO₂ refrigerant will not become liquefied or enter a two-phase state on the right side of the isotherm Tk. The region in which the pressure is equal to or greater than critical pressure Pk on the right side of the isotherm Tk is called a supercritical state. The air conditioner 1 that uses the heat exchanger of the present embodiment is operated in a refrigeration cycle that includes the supercritical state. Points A, B, C, and D in Figure 2(a) represent the states of the refrigerant corresponding to the points A, B, C, and D in Figure 1.

20 [0038] Figure 2(b) is a temperature-entropy diagram for CO₂ refrigerant. The vertical axis represents temperature T and the horizontal axis represents entropy S. Points A, B, C, and D in Figure 2(b) represent the states of the refrigerant corresponding to the points A, B, C, and D in Figure 1. The temperature of the refrigerant drops from the point B on the discharge side of the compressor 2 to the point C on the refrigerant outlet side of the indoor heat exchanger 6. Accordingly, the temperature distribution on the surface of the indoor heat exchanger 6 is such that the temperature on the upstream side of the refrigerant flow is higher and the temperature on the downstream side thereof is lower. Therefore, the difference in temperature between the air and the indoor heat exchanger 6 becomes more stabilized when the airflow passes from the downstream side of the refrigerant to the upstream side of the refrigerant, and the amount of heat exchange between the air and the indoor heat exchanger 6 increases.

DESCRIPTION OF THE REFERENCE SYMBOLS

[0033]

6	Heat exchanger
11	Plate fin
12	Heat transfer tube
31,32	Plates (first plates)
33	Plate (second plate)
61 to 72	Rows
81 to 86	Passages
91 a, 92a	Connecting tubes
91b, 92b	Wide-mouth containers
93	Plate (third plate)
93a	Depressed portion

BEST MODE FOR CARRYING OUT THE INVENTION

<REFRIGERATION CIRCUIT OF AIR CONDITIONER>

50 [0034] Figure 1 is a refrigeration circuit of an air conditioner that uses CO₂ refrigerant. An air conditioner 1 includes a refrigeration circuit in which a compressor 2, a four way valve 3, an outdoor heat exchanger 4, an expansion valve 5, and an indoor heat exchanger 6 are interconnected via a refrigerant pipe. In Figure 1, the solid line arrow and the broken line arrow indicate the flow

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<STRUCTURE OF INDOOR HEAT EXCHANGER>

[0039] Figure 3 is a perspective view to show the structure of the indoor heat exchanger according to the embodiment of the present invention. The indoor heat exchanger 6 is a cross fin-type heat exchanger. The plate fins 11 are thin and flat plates made of aluminum, and each plate fin 11 has a plurality of the through-holes 11a formed therein. Each heat transfer tube 12 includes a straight tube 12a to be inserted through the through-holes 11a in the plate fins 11, and U-shaped tubes 12b and 12c that interconnect the end portions of the adjacent straight tubes 12a. Note that the straight tubes 12a and the U-shaped tube 12b of each heat transfer tube 12 in the present embodiment are integrally formed, and the U-shaped tube 12c is connected to the end portion of the straight tube 12a by welding or the like after the straight tube 12a is inserted into the through-holes 11a in the plate fins 11.

[0040] Twelve rows of heat transfer tubes 12, i.e., rows 61 to 72 arranged in the direction crossing the airflow, are arranged in the upstream-to-downstream direction of the airflow. The refrigerant flows from the heat transfer tubes 12 in the row 72 on the downstream side of the airflow to the heat transfer tubes 12 in the row 61 on the upstream side of the airflow. Consequently, the flow of the airflow will be against the flow of the refrigerant, and thus the amount of heat exchange will increase compared with the case where these flows are not against each other. Note that experiments have shown that, in case of a heat exchanger with three or fewer rows of the heat transfer tubes, there is little difference in the effect whether the airflow is against the refrigerant or not.

[0041] Figure 4 is a configuration view of passages of the indoor heat exchanger according to the embodiment of the present invention. The solid lines in Figure 4 represent the U-shaped tubes 12b on the front side of the figure, and the broken lines represent the U-shaped tubes 12c on the opposite side. The refrigerant flows separately into the six heat transfer tubes 12 in the row 72 and flows out from the six heat transfer tubes 12 in the row 61 through six passages 81 to 86. In this way, because the refrigerant circulates separately through the plurality of passages 81 to 86, the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process, and the amount of heat exchanged with the airflow increases.

[0042] Each plate fin 11 is divided between the row 61 and the row 62. Each plate fin 11 is also divided between the following rows: the row 63 and the row 64; the row 65 and the row 66; the row 67 and the row 68; the row 69 and the row 70; and the row 71 and the row 72. Thereby, the heat on the surface of the plate fins 11 is prevented from transferring over divided portions 13. Thus, the surface temperature on the plate fins 11 is maintained high and the amount of heat exchanged with the airflow increases.

[0043] In addition, in Figure 3, the direction in which

the straight tubes 12a of the heat transfer tubes 12 extend is the depth of the indoor heat exchanger 6. In the present embodiment, the depth is the shortest dimension among the height, width, and depth. Thereby, the passages 81 to 86 through which the refrigerant flows are shortened, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process.

[0044] The heat transfer from the refrigerant flowing through the heat transfer tubes 12 to the heat transfer tubes 12 is more active when the flow of the refrigerant is laminar flow than when it is turbulent flow. Therefore, in the present embodiment, the tube outer diameter of the heat transfer tubes 12 is equal to or less than 4 mm such that the flow of the refrigerant in the heat transfer tubes 12 becomes turbulent flow.

<INDOOR UNIT OF AIR CONDITIONER>

[0045] Figure 5 is a longitudinal cross sectional view of an indoor unit that uses the indoor heat exchanger according to the embodiment of the present invention. An indoor unit 101 has the indoor heat exchanger 6 mounted in a casing 102. A fan 103 is arranged above the indoor heat exchanger 6, and an air discharge port 102a is provided above the fan 103. An air suction inlet 102b is provided below the indoor heat exchanger 6.

[0046] The indoor heat exchanger 6 has a first header 14 attached on the upstream side of the airflow for dividing and guiding the refrigerant to each inlet of the passages 81 to 86. In addition, the indoor heat exchanger 6 has a second header 15 attached on the downstream side of the airflow for guiding the refrigerant that flows out from each outlet of the passages 81 to 86 to the refrigerant pipe.

[0047] During heating operation, the refrigerant flows from the upside to the downside of each of the passages 81 to 86 of the indoor heat exchanger 6, and the airflow flows from the downside to the upside of the indoor heat exchanger 6. Consequently, the temperature of the airflow rises as a result of heat exchange with higher temperature refrigerant as the airflow moves closer to the air discharge port 102a. Thus, the indoor unit 101 can provide comfortable heating.

<CHARACTERISTICS>

(1)

[0048] The indoor heat exchanger 6 is a heat exchanger that allows supercritical CO₂ refrigerant to radiate heat to the air, and includes the plurality of plate fins 11 and the plurality of heat transfer tubes 12. Each plate fin 11 has the plurality of through-holes 11a on the planar surface arranged substantially parallel to the airflow. The heat transfer tubes 12 are inserted into the through-holes 11a in the plate fins 11. Four or more rows 61 to 72 of the heat transfer tubes 12 arranged in the direction cross-

ing the airflow are formed in the upstream-to-downstream direction of the airflow. Each plate fin 11 is divided between at least one pair of adjacent rows 61 and 62. The refrigerant flows from the heat transfer tubes 12 in the row 72 on the downstream side of the airflow to the heat transfer tubes 12 in the row 61 on the upstream side of the airflow.

[0049] In this indoor heat exchanger 6, the airflow exchanges heat with higher temperature refrigerant as the airflow moves downstream. In addition, because each plate fin 11 is divided, heat transfer on the surface of the plate fins 11 is suppressed, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0050] In addition, because CO₂ whose ozone destruction coefficient is low is used as refrigerant, the destruction in the air environment will not be resulted.

(2)

[0051] This indoor heat exchanger 6 has the plurality of passages 81 to 86 formed for allowing the refrigerant to flow from the heat transfer tubes 12 in the row 72 on the downstream side of the airflow to the heat transfer tubes 12 in the row 61 on the upstream side of the airflow.

[0052] In this indoor heat exchanger 6, the distance in which the refrigerant moves in the row direction of the heat transfer tubes 12 is shortened, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

[0053] In addition, the heat transfer tubes extend in one of the height, width, and depth directions of the indoor heat exchanger 6 whichever is the shortest dimension. As a result, the distance of the straight tubes 12a of the heat transfer tubes 12 is shortened, a decrease in temperature of the refrigerant is suppressed, and the difference in temperature between the refrigerant and the air is appropriately maintained throughout the radiation process. Thus, the amount of heat exchanged with the airflow increases, and heat exchange performance improves.

(3)

[0054] In the indoor heat exchanger 6, the tube outer diameter of the heat transfer tubes 12 is equal to or less than 4 mm. The flow rate of the refrigerant flowing through the heat transfer tubes 12 is accelerated and the flow of the refrigerant becomes a turbulent flow. Thus, the amount of heat exchange between the refrigerant and the heat transfer tubes 12 increases, and heat exchange performance improves.

<FIRST ALTERNATIVE EMBODIMENT>

[0055] Figure 6 is a perspective view of an indoor heat exchanger according to a first alternative embodiment of the embodiment of the present invention. The same components as those in the embodiment shown in Figure 3 are denoted by the same reference symbols, and the descriptions thereof are omitted. Plates 31 and 32 are attached to the end portions, i.e., inlet and outlet, of the plurality of passages 81 to 86 (see Figure 4), and the plates 31 and 32 are more rigid than the plate fins 11. An inlet side header 91 includes a connecting tube 91a connected to the refrigerant pipe, and a wide-mouth container 91b that covers the inlets of the plurality of passages 81 to 86. The inlet side header 91 is closely bonded to the plate 31. An outlet side header 92 includes a connecting tube 92a connected to the refrigerant pipe, and a wide-mouth container 92b that covers the outlets of the plurality of passages 81 to 86. The outlet side header 92 is closely bonded to the plate 32.

[0056] A plate 33 is attached to the end portions of the heat transfer tubes 12 as a whole and is more rigid than the plate fins 11. The plate 33 has a plate 93 closely bonded thereto. Figure 7(a) is a rear view of the first alternative embodiment, Figure 7(b) is a cross sectional view taken along line D-D of Figure 7(a), and Figure 7(c) is a cross sectional view taken along line E-E of Figure 7(a). The plate 93 in the figure has a plurality of depressed portions 93a each interconnecting the end portions of the heat transfer tubes 12. The depressed portions 93a correspond to the U-shaped tubes 12c of the embodiment shown in Figure 3. The plurality of depressed portions 93a are formed by drawing the plate 93, and therefore it is economical.

<CHARACTERISTICS OF THE FIRST ALTERNATIVE EMBODIMENT>

(1)

[0057] This indoor heat exchanger 6 further includes the plates 31 and 32 attached to the end portions of the plurality of passages 81 to 86; the connecting tubes 91a and 92a connected to the refrigerant pipe through which the refrigerant circulates; and the wide-mouth containers 91 b and 92b. The wide-mouth containers 91 b and 92b collect the refrigerant that flows out from each end portion of the plurality of passages 81 to 86 to the connecting tubes 91a and 92a, or guide the refrigerant that flows out from the connecting tubes 91a and 92a to each end portion of the plurality of passages 81 to 86. The wide-mouth containers 91 b and 92b are closely attached to the plates 31 and 32. Consequently, there is no need to connect the refrigerant pipe to each end portion of the passages 81 to 86, and therefore the cost is low.

(2)

[0058] This indoor heat exchanger 6 further includes the plate 33 attached to the end portions of the plurality of the heat transfer tubes 12; and the plate 93 having the plurality of depressed portions 93a formed therein for interconnecting the end portions of the heat transfer tubes 12. The plate 93 is closely attached to the plate 33. Consequently, the work to interconnect the end portions of the heat transfer tubes 12 with U-shaped tubes becomes unnecessary, and therefore the cost is low.

<SECOND ALTERNATIVE EMBODIMENT>

[0059] Figure 8 is a configuration view of the indoor heat exchanger in Figure 4 with the passages being modified. Similar to Figure 4, the solid lines in Figure 4 represent the U-shaped tubes 12b on the front side of the figure, and the broken lines represent the U-shaped tubes 12c on the opposite side. The refrigerant that flowed into the heat transfer tubes 12 in the row 72 of passages 87 to 89 flows to the respective adjacent heat transfer tubes 12 in the same row 72; then flows to the heat transfer tubes 12 in the row 71 disposed further upstream of the airflow by one row; subsequently flows to the respective adjacent heat transfer tubes 12 in the same row 71; then further flows to the heat transfer tubes 12 in next row 70 disposed further upstream of the airflow by one row. In the same manner, the refrigerant flows to the heat transfer tubes 12 in the row 61 on the most upstream side of the airflow while changing the direction of the flow.

[0060] In this way, by employing the three passages 87 to 89, although the distance of each passage becomes longer, the flow rate of the refrigerant can be accelerated due to the reduced number of passages, and the same heat exchange performance as obtained in the above described embodiment can be obtained.

<THIRD ALTERNATIVE EMBODIMENT>

[0061] Figure 9 is a configuration view of the indoor heat exchanger in Figure 4 with the pitch of the heat transfer tubes and the plate fins being modified, and Figure 10 is a configuration view of the indoor heat exchanger in Figure 8 with the pitch of the heat transfer tubes and the plate fins being modified. In Figures 9 and 10, the heat transfer tubes 12 are arranged at the same pitch therebetween in the vertical direction. A plate fin 21 is partially divided by slits 23 in the substantially middle of the pitch and also between all adjacent rows 61 to 72.

[0062] The slits 23 are formed by a single perforation per plate fin 11, and therefore the processing cost is reduced.

INDUSTRIAL APPLICABILITY

[0063] As described above, the present invention has

a good heat exchange performance, and is useful for a heat exchanger of an air conditioner that uses CO2 refrigerant.

Claims

1. A heat exchanger (6) that allows supercritical refrigerant to radiate heat to air, comprising:

a plurality of plate fins (11) each having a plurality of through-holes (11a) on the planar surface arranged substantially parallel to airflow; and

a plurality of heat transfer tubes (12) inserted into the through-holes (11a) in the plate fins (11),

wherein

four or more rows (61 to 72) of the heat transfer tubes (12) arranged in the direction crossing the airflow are formed in the upstream-to-downstream direction of the airflow, each of the plate fins (11) is divided between at least one pair of the adjacent rows (61, 62); and the refrigerant flows from the heat transfer tubes (12) in the row (72) on the downstream side of the airflow to the heat transfer tubes (12) in the row (61) on the upstream side of the airflow.

2. The heat exchanger (6) according to claim 1, wherein each of the plate fins (11) is divided between all the adjacent rows (61 to 72).

3. The heat exchanger (6) according to claim 1 or claim 2, wherein each of the plate fins (11) is divided from one end to the other end in the longitudinal direction of the rows (61 to 72).

4. The heat exchanger (6) according to claim 1 or claim 2, wherein each of the plate fins (11) is partially divided from one end to the other end in the longitudinal direction of the rows (61 to 72).

5. The heat exchanger (6) according to claim 1, wherein a plurality of passages (81 to 86) are formed through which the refrigerant flows from the heat transfer tubes (12) in the row (72) on the downstream side of the airflow to the heat transfer tubes (12) in the row (61) on the upstream side of the airflow.

6. The heat exchanger (6) according to claim 1, wherein the heat transfer tubes (12) extend in one of the height, width, and depth directions whichever is the shortest dimension.

7. The heat exchanger (6) according to claim 1, wherein the tube outer diameter of the heat transfer tubes (12) is equal to or less than 4 mm.
8. The heat exchanger (6) according to claim 1, wherein the refrigerant is CO₂. 5
9. The heat exchanger (6) according to claim 5, further comprising
a first plate (31, 32) attached to end portions of the plurality of passages (81 to 86), 10
a connecting tube (91a, 92a) connected to a refrigerant pipe (7a, 7b) through which the refrigerant circulates, and
a wide-mouth container (91b, 92b) configured to collect the refrigerant that flows out from each end portion of the plurality of passages (81 to 86) or to guide the refrigerant that flows out from the connecting tube (91a, 92a) to each end portion of the plurality of passages (81 to 86), 15
wherein
the wide-mouth container (91b, 92b) is closely attached to the first plate (31, 32). 20
10. The heat exchanger (6) according to claim 1, further comprising 25
a second plate (33) attached to end portions of the plurality of heat transfer tubes (12), and
a third plate (93) closely attached to the second plate (33) and having a plurality of depressed portions (93a) formed therein for interconnecting end portions of the appropriate adjacent heat transfer tubes (12). 30

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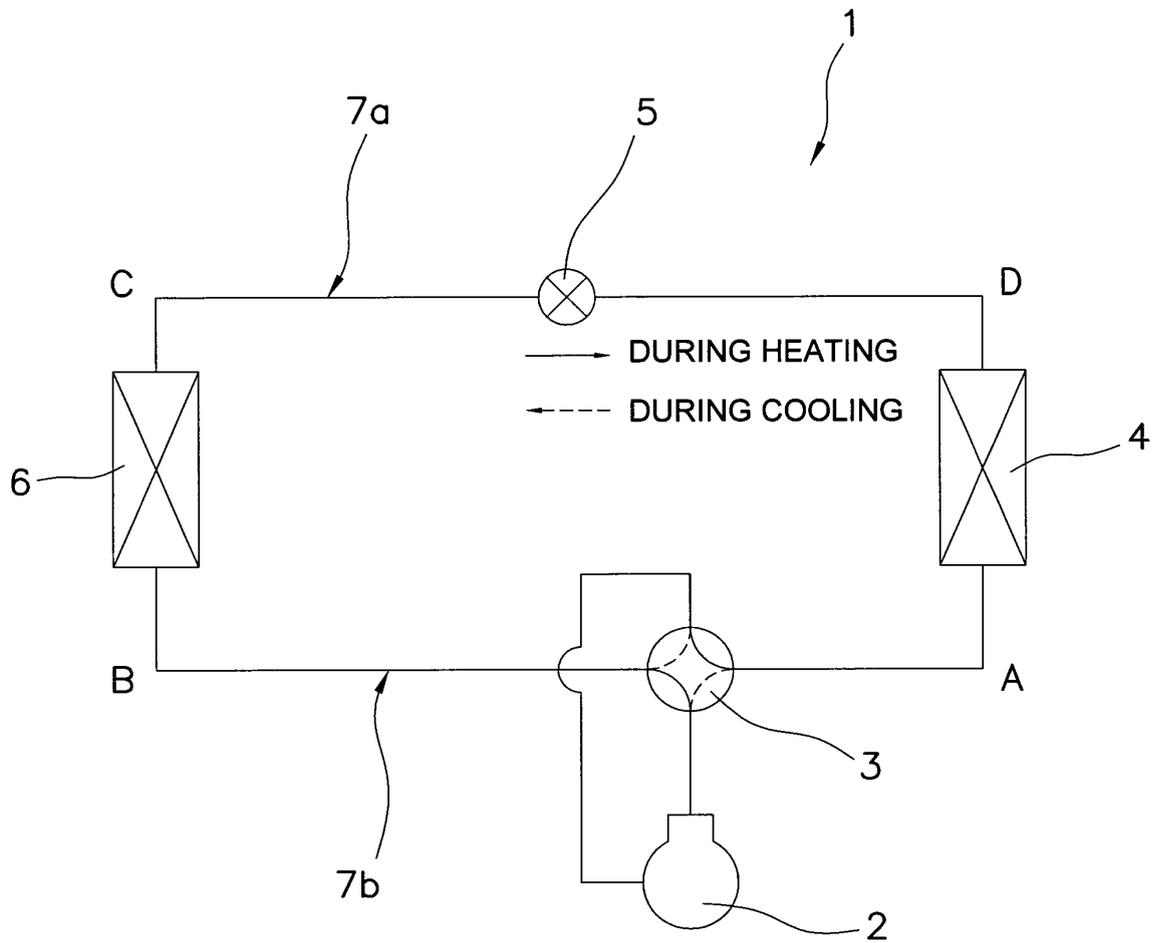
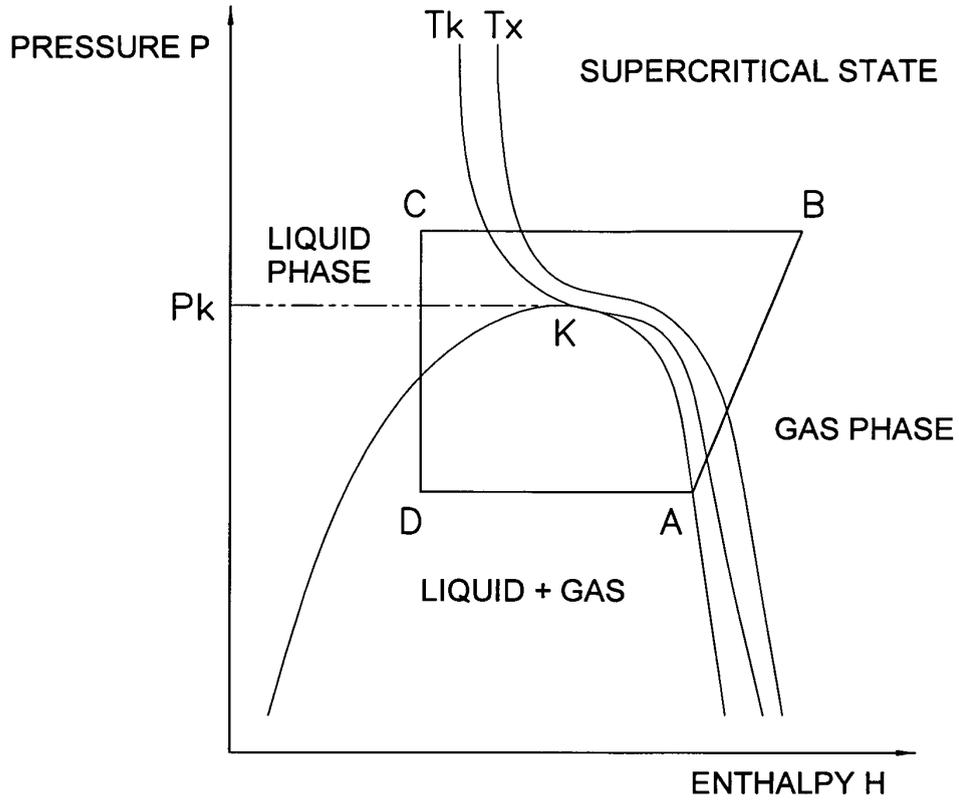
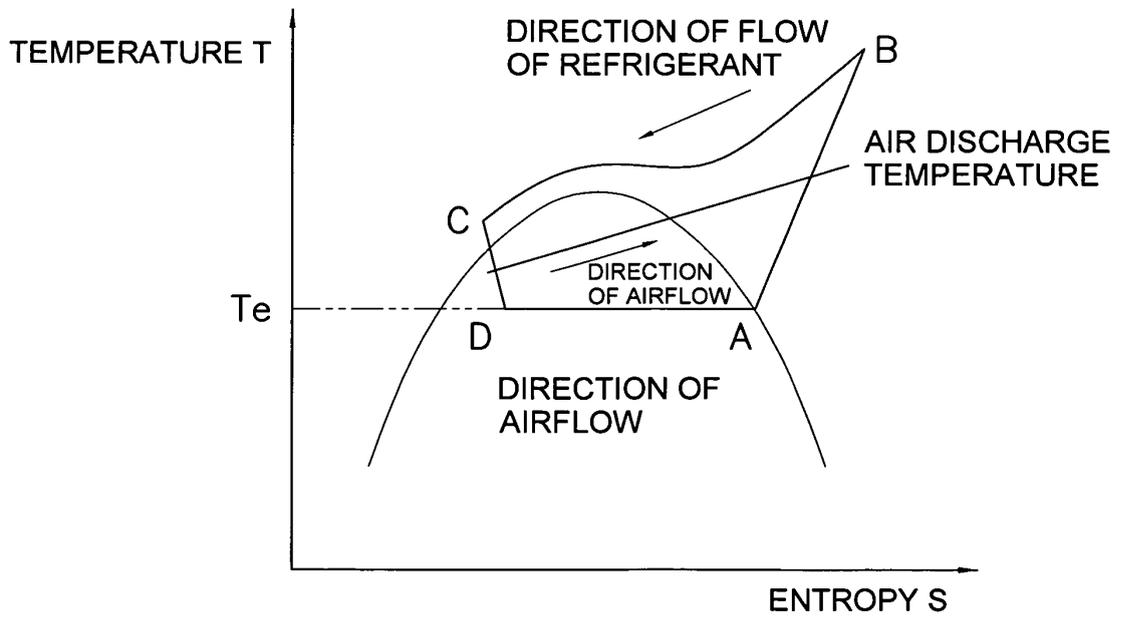


FIG. 1



(a)



(b)

FIG. 2

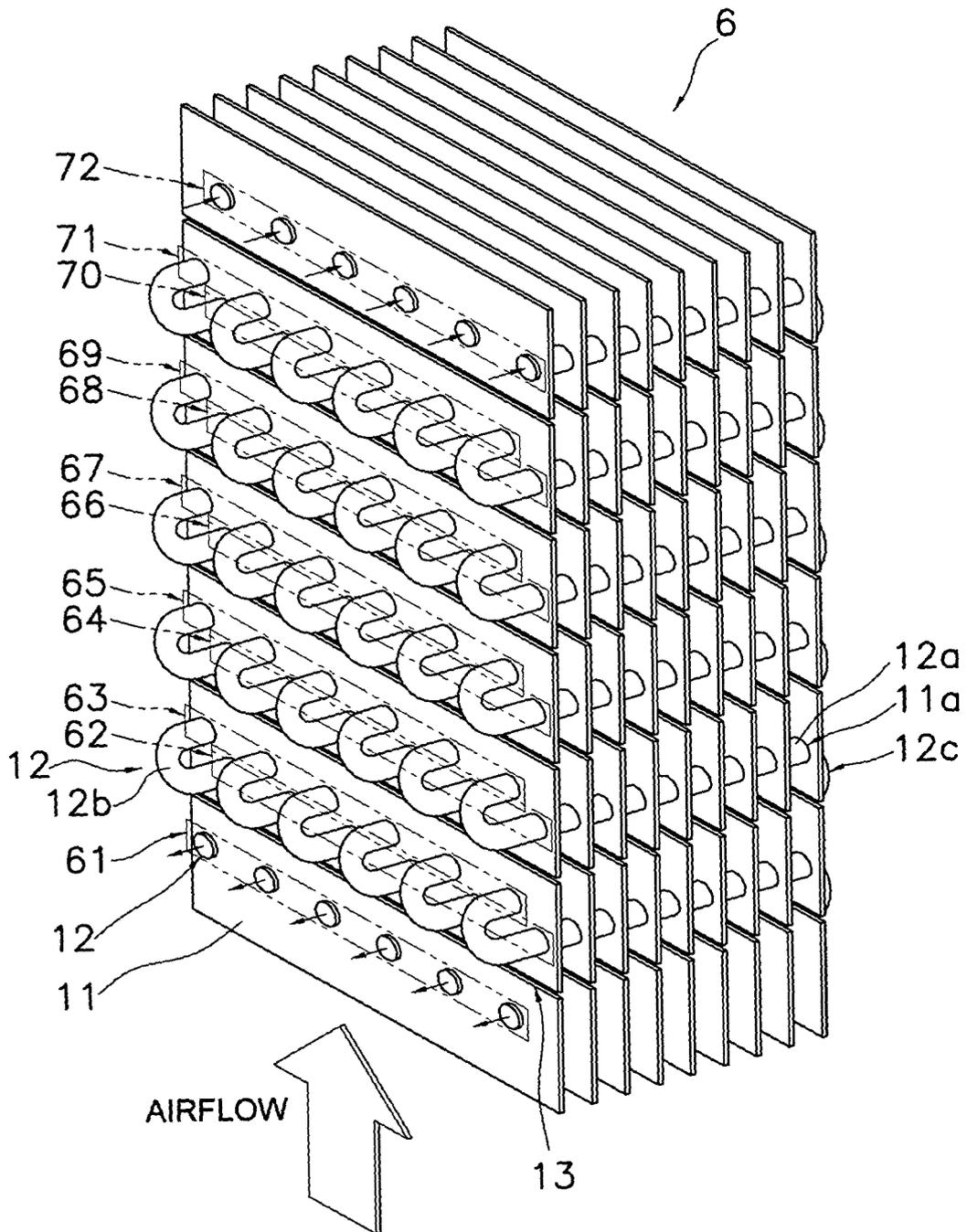


FIG. 3

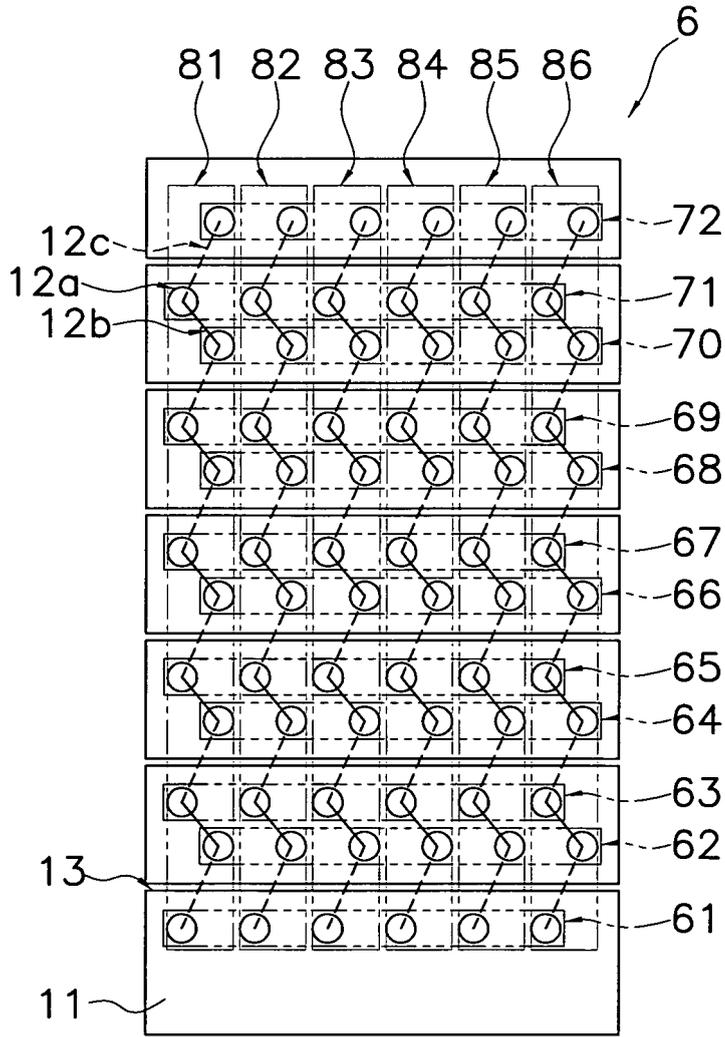


FIG. 4

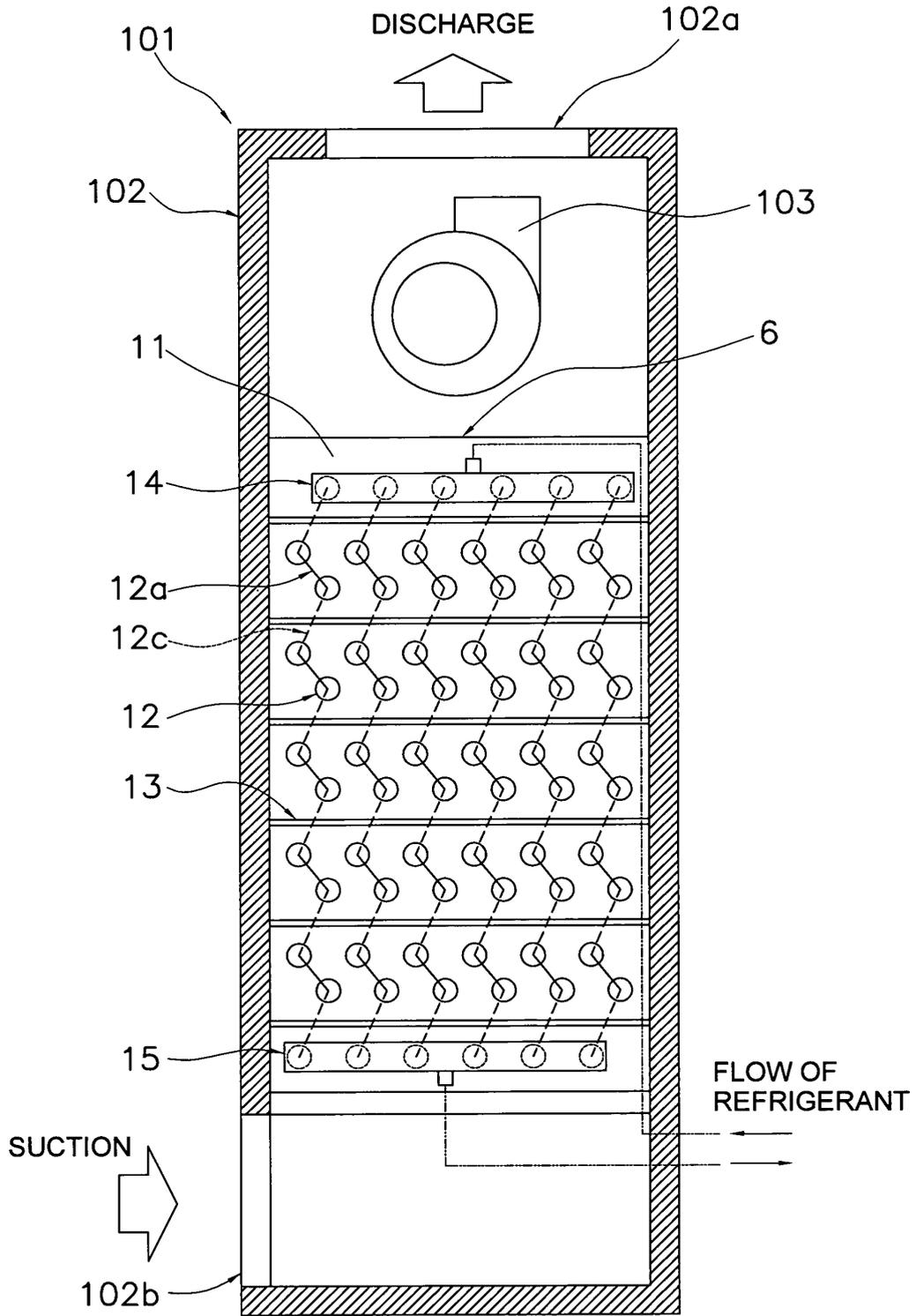


FIG. 5

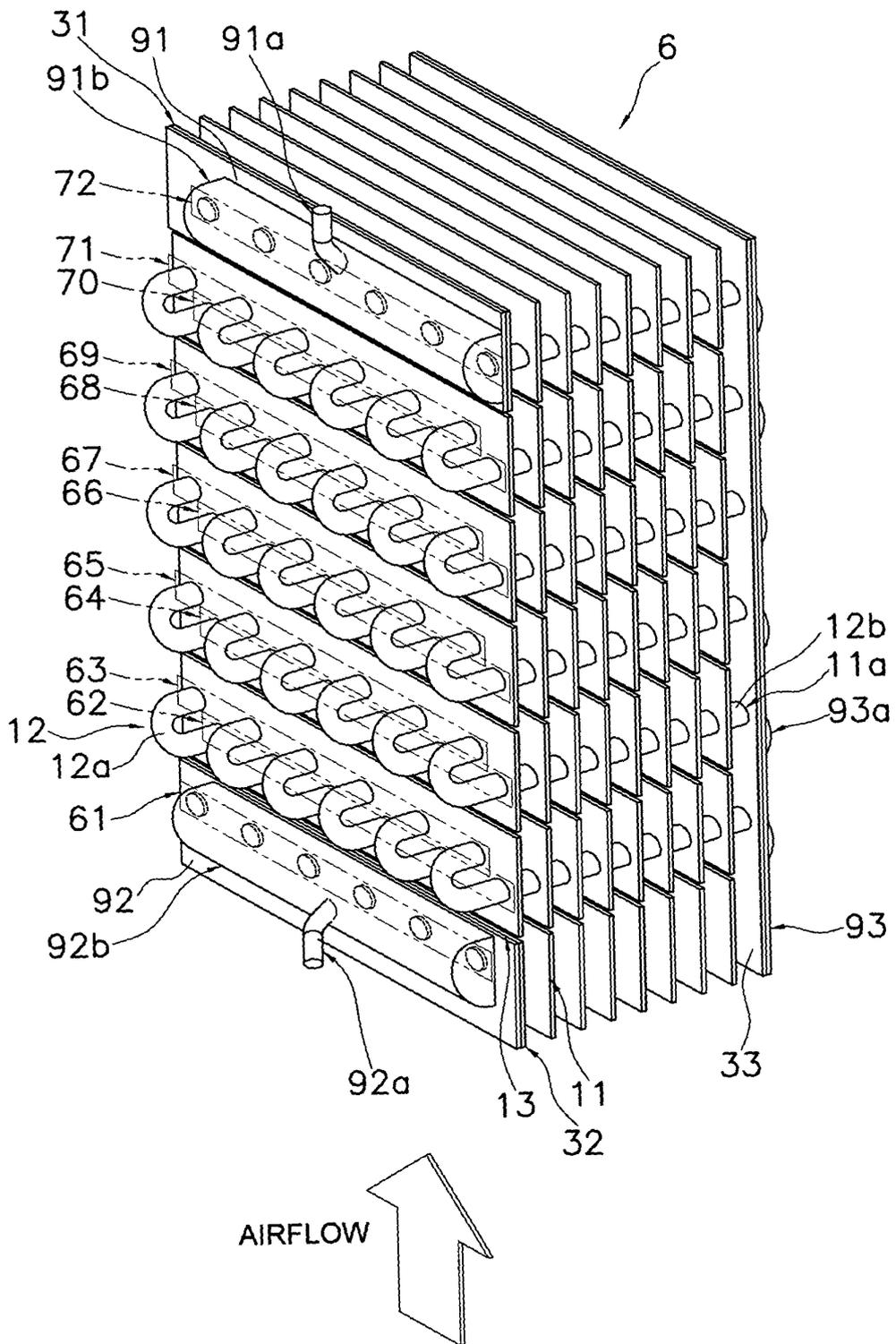
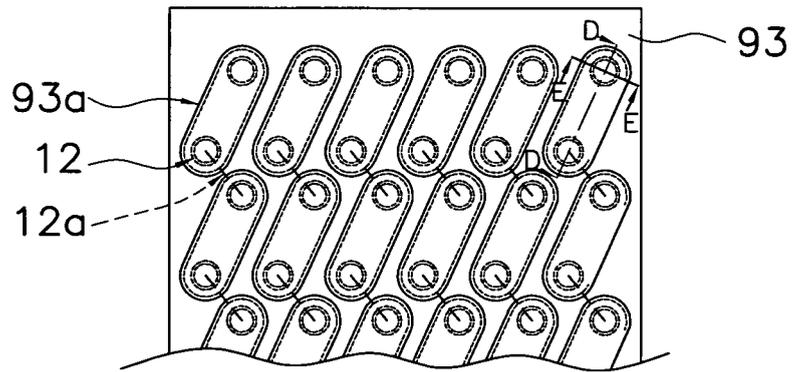
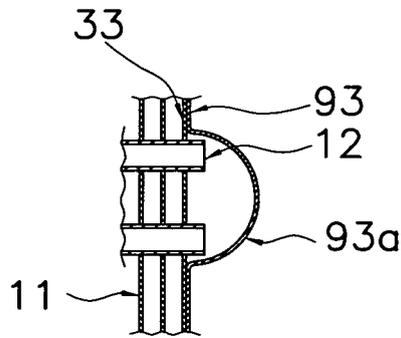


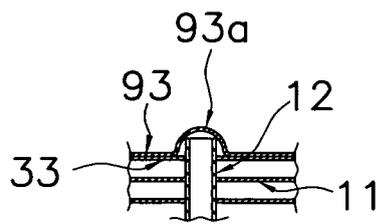
FIG. 6



(a)



(b)



(c)

FIG. 7

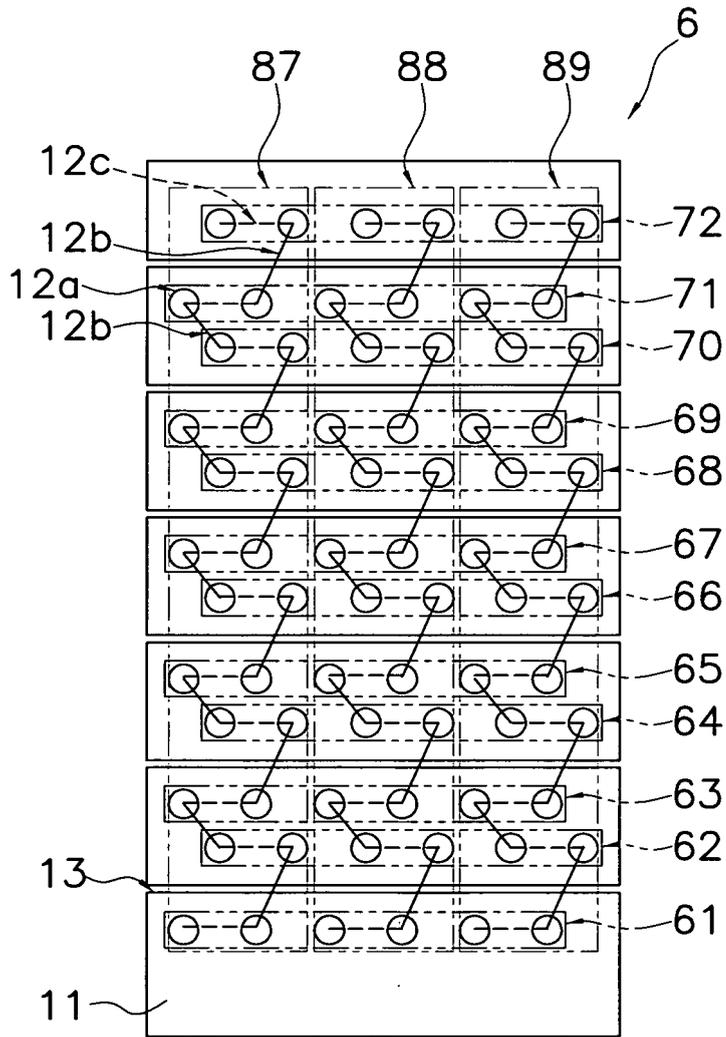


FIG. 8

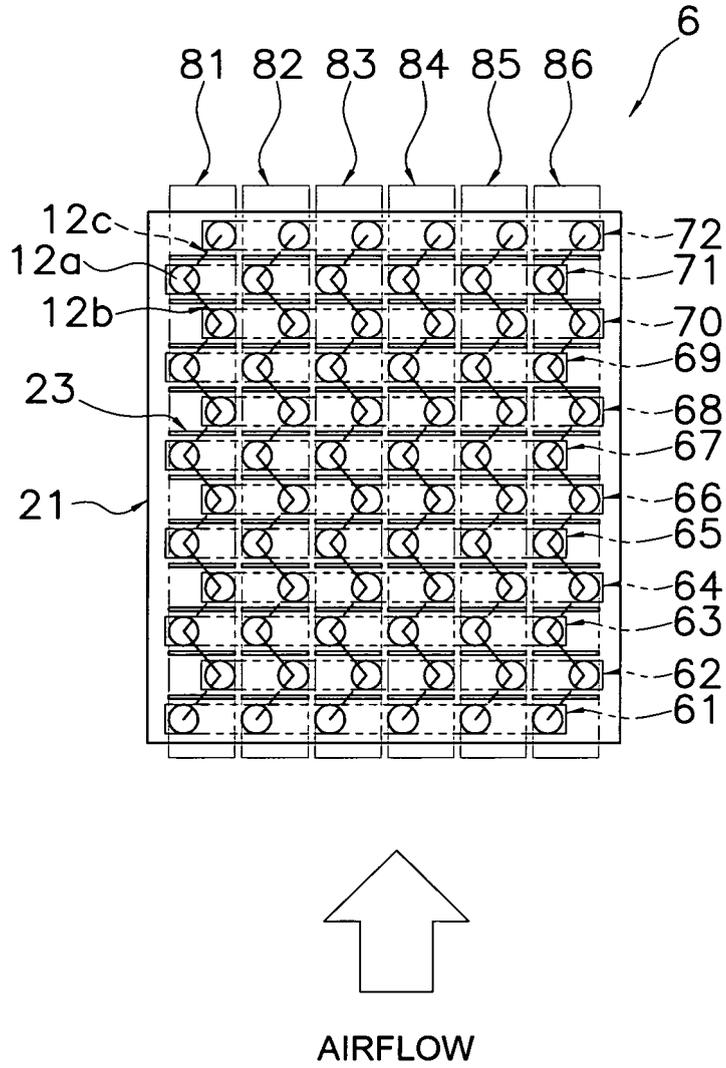
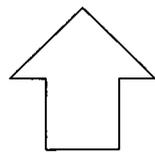
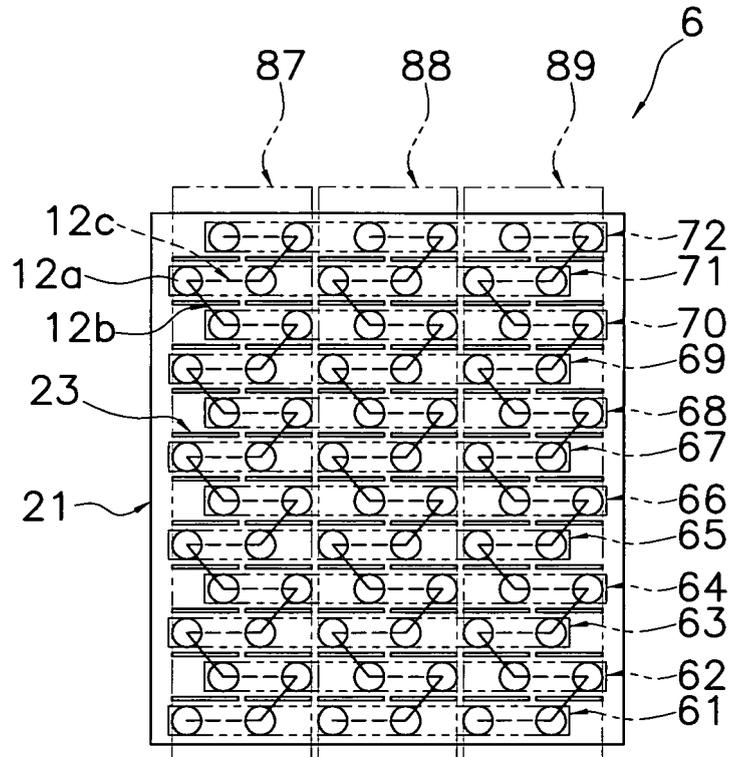


FIG. 9



AIRFLOW

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/060968

A. CLASSIFICATION OF SUBJECT MATTER <i>F28F1/32</i> (2006.01) i, <i>F25B1/00</i> (2006.01) i, <i>F25B39/00</i> (2006.01) i, <i>F28F1/00</i> (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) <i>F28F1/32</i> , <i>F25B1/00</i> , <i>F25B39/00</i> , <i>F28F1/00</i>		
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 1996-2007 Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007		
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.
Y	JP 10-274490 A (Kimura Koki Kabushiki Kaisha), 13 October, 1998 (13.10.98), Par. Nos. [0002], [0003], [0005] to [0009]; Figs. 1, 2 (Family: none)	1-10
Y	JP 2000-304380 A (Aisin Seiki Co., Ltd.), 02 November, 2000 (02.11.00), Par. No. [0026]; Fig. 3 (Family: none)	1-10
Y	JP 63-12081 U (Toyo Radiator Co., Ltd.), 26 January, 1988 (26.01.88), Description, page 3, line 19 to page 5, line 1; Fig. 1 (Family: none)	9
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
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"A"	document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search 21 June, 2007 (21.06.07)		Date of mailing of the international search report 03 July, 2007 (03.07.07)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/060968

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 2005-98672 A (Toyo Radiator Co., Ltd.), 14 April, 2005 (14.04.05), Par. Nos. [0023], [0024]; Figs. 5, 6 (Family: none)	10

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H10176867 B [0002]