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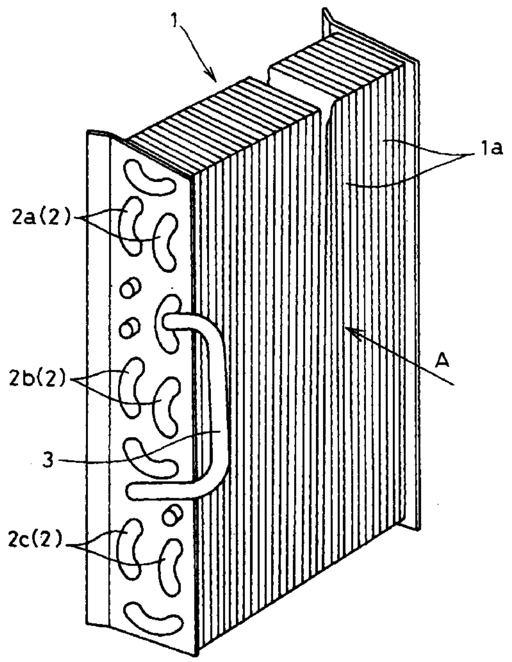
(54) Heat exchanger

(57) The present invention provides a heat exchanger capable of improving heat exchange efficiency. The heat exchanger, in which a plurality of flat plate-shaped fins 1a are stacked at predetermined intervals, heat exchanger tubes 2 for passing refrigerant therethrough are inserted in a stacking direction, air is caused to pass through between each fin group 1, and the heat exchanger tubes 2 are disposed in a plurality of rows in an air passage direction A, is characterized in that: the heat exchanger tube 2 is partitioned into a portion for containing gas and a high proportion of gaseous phase of a gas-liquid two-layer flow of the refrigerant flowing in said tube, and a portion for containing liquid and a high proportion of liquid phase of the gas-liquid two-layer flow of the refrigerant; first heat exchanger tubes 2a and 2b of a 2-pass structure are disposed as the former portion, and a second heat exchanger tube 2c of a 1-pass structure is disposed as the latter portion; these first and second heat exchanger tubes 2a, 2b and 2c are communicated to each other through a coupling member 3; each pass of these first and second heat exchanger tubes 2a, 2b and 2c has, when the heat exchanger is operated as a condenser, an inlet in a leeward-side row and an outlet in a windward-side row; and at least part of the passes are of a counterflow type, being overlapped between a plurality of rows in the air passage direction.

FIG.1



EP 1 031 801 A2

Description

Field of the Invention

[0001] The present invention relates to a heat exchanger for use in an air conditioner.

Background of the Invention

[0002] The necessity for protecting global environment has been increasingly recognized by people recently. As means for promoting the protection of global environment, there are energy savings in equipment for preventing global warming, and replacing the existing refrigerant with refrigerant for not destroying the ozone layer. Particularly, of household electrical appliance groups, it has been one of the most important issues in view of the protection of global environment to enhance the efficiency and to replace with a refrigerant substitute in air conditioners having high power consumption.

[0003] As the major techniques for enhancing the efficiency of an air conditioner, the shape of tubes, the form of fins, the form of passes and the like in the heat exchanger have been improved so as to enhance the efficiency. A general cross-fin tube type heat exchanger is, as shown in FIG. 9, constructed of a fin group 1 comprising a plurality of flat plate-shaped fins arranged at predetermined intervals in parallel with each other, and heat exchanger tubes 2 (2i, 2j, 2k) inserted substantially orthogonally to this fin group 1, that is, along a stacking direction of the fins. Also, the heat exchanger tubes 2 in this type of heat exchangers are arranged in a plurality of rows (two rows in FIG. 9) in an air current direction (lateral direction in FIG. 9) for passing air.

[0004] In a case where it is used as, for example, a condenser, a heat exchanger of this type is constructed by piping 2-pass heat exchanger tubes 2i and 2j in parallel on a refrigerant inlet-side of the heat exchanger where there are contained gas and a high proportion of gaseous phase component, and by piping an 1-pass heat exchanger tube 2k in a piping portion, where there will be contained liquid and a high proportion of liquid phase component. Refrigerant within the piping of each pass described above flows in a predetermined direction (downward from above in FIG. 9) in each of the heat exchanger tubes 2, which is called "2-pass rectangular flow to 1-pass rectangular flow system." In this respect, a reference numeral 3c designates a coupling member for causing the 2-pass heat exchanger tubes 2i and 2j and the 1-pass heat exchanger tube 2k to communicate to each other. Also, an arrow in FIG. 9 indicates a refrigerant flowing direction when the condenser is operating.

[0005] FIG. 10 schematically shows relationship between temperatures of refrigerant flowing through a heat exchanger shown in FIG. 9, air temperatures at an inlet and an outlet of the heat exchanger, and a state of the refrigerant within the heat exchanger.

[0006] In a case where this heat exchanger of the 2-pass rectangular flow to 1-pass rectangular flow system is used as a condenser, heat exchange is performed between superheated gas and air on the inlet side, and the refrigerant temperature changes from a superheating temperature T1 to a saturation temperature T2. At this saturation temperature T2, heat exchange is performed and the refrigerant which was gaseous condenses into liquid. Further, when the refrigerant has an increased proportion of liquid component and its liquid content reaches 100%, the temperature decreases from the temperature T2 to a temperature T3.

[0007] Generally, a heat exchange amount Q is expressed by $Q=c \cdot q \cdot \Delta Tm$, where c is air specific heat, Q is an air flow rate, and ΔTm is an average temperature difference between an air outlet and an air inlet in the heat exchanger. When the air specific heat c and the air flow rate q are constant, the heat exchange amount Q depends upon the average temperature difference ΔTm between the air outlet and the air inlet.

[0008] When refrigerant temperature within the heat exchanger tube in a windward-side row is compared with refrigerant temperature within the heat exchanger tube on its leeward side, they are almost entirely the same temperature except for a short portion at the inlet. In heat exchange using this 2-pass rectangular flow to 1-pass rectangular flow system of the heat exchanger, therefore, a temperature difference between the refrigerant within the heat exchanger tube in a leeward-side row and an air flow becomes smaller than a temperature difference between the refrigerant within the heat exchanger tube on the windward side and the air flow, and as a result, a heat passage rate lowers to cause a loss. Generally, in the case of an air conditioner using HCFC-22, which is one type of flon, as the refrigerant, when a number of tubes in the 1-pass portion is increased, a pressure loss is actually increased by the increased velocity of the refrigerant flow, posing a problem that the evaporator performance is threatened to be deteriorated.

Disclosure of the Invention

[0009] The present invention has been achieved to solve the above-described problems, and is aimed to provide a heat exchanger capable of improving heat exchange efficiency.

[0010] According to the invention defined in claim 1, there is provided a heat exchanger in which a plurality of flat plate-shaped fins are stacked at predetermined intervals, heat exchanger tubes for passing refrigerant therethrough are inserted along a stacking direction, air is caused to pass through between each fin group, and the heat exchanger tubes are disposed in a plurality of rows in an air passage direction, wherein the heat exchanger tube is partitioned into a portion for containing gas and a high proportion of gaseous phase of a gas-liquid two-layer flow of the refrigerant flowing in the tube, and a portion for containing liquid and a high proportion of liquid phase of the gas-liquid two-layer flow of the refrigerant, wherein there are disposed first heat exchanger tubes of a 2-pass structure as the former portion, and a second heat exchanger tube of a 1-pass structure as the latter portion, wherein these first and second heat exchanger tubes are communicated to each other through a coupling member, wherein each pass of these first and second heat exchanger tubes has, when the heat exchanger is operated as a condenser, an inlet in a leeward-side row and an outlet in a windward-side row, and wherein at least part of the passes are of a counterflow type, being overlapped between a plurality of rows in the air passage direction.

[0011] More specifically, the portion containing gas and a high proportion of gaseous phase of the gas-liquid two-layer flow of the refrigerant is comprised of a counterflow type first heat exchanger tube of the 2-pass structure, and the portion containing a high proportion of liquid and liquid phase of a gas-liquid two-layer flow, is comprised of a counterflow type second heat exchanger tube of the 1-pass structure. The counterflow here means that when the heat exchanger is used as a condenser, the refrigerant containing a high proportion of gas first goes through the heat exchanger tube in the leeward-side row, and next goes through the heat exchanger tube in the windward-side row which substantially overlap with the heat exchanger tube in the leeward-side row in the air current direction, and that when the heat exchanger is used as an evaporator, the refrigerant first goes through the heat exchanger tube in the windward-side row, and next goes through the heat exchanger tube in the leeward-side row.

[0012] With this structure, when the heat exchanger is used as the condenser, superheated gas refrigerant flows through the leeward-side row in the first heat exchanger tube of the 2-pass structure on the inlet side, the refrigerant temperature somewhat decreases due to heat exchange with air, the refrigerant containing a high proportion of gaseous phase of the gas-liquid two-layer flow flows into the windward-side row in the first heat exchanger tube to exchange heat with air, and the gas refrigerant is gradually liquefied. Subsequently, this refrigeran8¥t containing a high proportion of liquid phase component flows through the leeward-side row in the second heat exchanger tube of the 1-pass structure, the refrigerant which has further decreased in temperature due to heat exchange with air, flows through the windward-side row in the second heat exchanger tube to exchange heat with air, so that the refrigerant is further cooled. In this manner, the refrigerant temperature within the first and second heat exchanger tubes in the leeward-side row is higher substantially in the whole area than the refrigerant temperature within the respectively corresponding first and second heat exchanger tubes in the windward-side row, and therefore, a temperature difference between the refrigerant and air can be taken large, and the heat exchange efficiency can be enhanced.

[0013] Also, when the heat exchanger is used as an evaporator, the above-described refrigerant flow is reversed, and in a similar manner, the refrigerant temperature within the first and second heat exchanger tubes in the leeward-side row is higher substantially in the whole area than the refrigerant temperature within the respectively corresponding first and second heat exchanger tubes in the windward-side row, and therefore, a temperature difference between the refrigerant and air can be taken large, and the heat exchange efficiency can be enhanced.

[0014] According to the invention defined in claim 2, there is provided a heat exchanger specified in claim 1, wherein the outlet of the windward-side row in the pass of the second heat exchanger tube is located at the lowest end of the windward-side row.

[0015] With this structure, when the heat exchanger is used as a condenser, the outlet portion of the second heat exchanger tube, at which the liquid refrigerant is at the lowest temperature, can be arranged at the lower end of the heat exchanger, and therefore, the windward and leeward second heat exchanger tube can be of a more complete counterflow type, the condensation performance can be further enhanced, and liquid seal can be prevented in an inverter type air conditioner.

[0016] According to the invention defined in claim 3, there is provided a heat exchanger defined in claim 1 or 2, wherein the coupling member is a Y-branch type (Y-shaped branch type) flow divider.

[0017] With this structure, when the heat exchanger is used as an evaporator, it becomes possible to uniformly distribute the refrigerant to each row of the first heat exchanger tube, to improve the evaporator performance, and to reduce the cost by a large amount through the use of the Y-branch type flow divider having multipurpose properties.

[0018] According to the invention defined in claim 4, there is provided a heat exchanger defined in any of claims 1 to 3, wherein part of the first heat exchanger tube is located below the second heat exchanger tube.

[0019] According to the invention defined in claim 5, there is provided a heat exchanger defined in claim 4, wherein an inlet of one pass of the first heat exchanger tube is located in the vicinity of the lower end of the leeward-side row.

[0020] With the structure of the heat exchanger defined in these claims 4 and 5, when the heat exchanger is used as a heat source-side heat exchanger in a heat pump type air conditioner, the first heat exchanger tube at a higher temperature than the second heat exchanger tube is located below the heat exchanger, and therefore, if this heat exchanger is positioned in the vicinity of the substrate of an outdoor unit, it becomes possible to improve the defrosting performance during the heating and defrosting operation, and to prevent the substrate of the outdoor unit from being frozen.

[0021] According to the invention specified in claim 6, there is provided a heat exchanger defined in any of claims 1 to 5, wherein HFC-32 or a combined refrigerant containing HFC-32, or a hydrocarbon refrigerant is used as the refrigerant.

[0022] With this structure, through the use of HFC-32, one type of flon substitutes generally used, which is about 20 to 30% lower in pressure loss within the system than HCFC-22, or a combined refrigerant containing HFC-32, or a hydrocarbon refrigerant, it is possible to improve the condenser performance and to prevent any loss in the evaporator performance.

Brief Description of the Drawings

[0023]

FIG. 1 is a perspective view of an essential portion of a heat exchanger according to a first embodiment of the present invention;
FIG. 2 is a side view showing the heat exchanger according to the embodiment;
FIG. 3 is a view schematically showing changes, when the heat exchanger is used as a condenser, in refrigerant temperature, air temperature in a heat exchange and a state of refrigerant within the heat exchanger according to the embodiment;
FIG. 4 is a side view showing a heat exchanger according to a second embodiment of the present invention;
FIG. 5 is a side view showing a heat exchanger according to a third embodiment of the present invention;
FIG. 6 is a side view showing a heat exchanger according to a fourth embodiment of the present invention;
FIG. 7 is a view schematically showing a refrigerating cycle in an air conditioner equipped with the heat exchanger according to the fourth embodiment;
FIG. 8 is a side view showing a heat exchanger according to a fifth embodiment of the present invention;
FIG. 9 is a side view showing a conventional heat exchanger; and
FIG. 10 is a view schematically showing changes, when the conventional heat exchanger is used as a condenser, in refrigerant temperature, air temperature in a heat exchange and a state of refrigerant within the heat exchanger.

Description of the Embodiments

[0024] Hereinafter, with reference to the drawings, descriptions will be made of embodiments of the present invention. In this respect, for each element which has the same function as the conventional heat exchanger, the same reference numeral is provided, and the description thereof will be omitted.

[0025] FIG. 1 is a perspective view of the essential portion showing a first embodiment in which a heat exchanger according to the present invention has been applied to a condenser, and FIG. 2 is a side view (an arrow indicating a refrigerant flowing direction shows when the condenser is operating) showing this heat exchanger.

[0026] Even in this heat exchanger, as shown in FIGS. 1 and 2, a plurality of flat plate-shaped fins 1a are stacked at predetermined intervals, a heat exchanger tube 2 for a refrigerant is inserted substantially orthogonally to this fin group 1, that is, along a stacking direction of the fins so as to cause air to pass through between each fin group 1. Also, the heat exchanger tube 2 is partitioned into a portion for containing gas and a high proportion of gaseous phase of a gas-liquid two-layer flow of the refrigerant flowing in the tube, and a portion for containing liquid and a high proportion of liquid phase of the gas-liquid two-layer flow of the refrigerant, wherein there are disposed first heat exchanger tubes 2a and 2b of a 2-pass structure as the former portion, and a second heat exchanger tube 2c of a 1-pass structure as the latter portion, and wherein these first heat exchanger tubes 2a and 2b and a second heat exchanger tube 2c are communicated to each other through a coupling member 3.

[0027] In this heat exchanger, however, each pass of the first heat exchanger tubes 2a and 2b and the second heat exchanger tube 2c has, when the heat exchanger is operated as a condenser, an inlet in a leeward-side row, and an outlet in a windward-side row, and at least part of the passes are of a counterflow type, being overlapped between a plurality of rows in the air passage direction.

[0028] Next, a description will be made of an operation of this heat exchanger. FIG. 3 is a view schematically showing temperature changes of the refrigerant between the inlet and the outlet, air temperatures in heat exchange and a state of refrigerant within the heat exchanger when the heat exchanger is used as a condenser.

[0029] When the heat exchanger is used as a condenser, superheated gas refrigerant flows in the leeward-side row in the first heat exchanger tubes 2a and 2b on the inlet side, and the refrigerant temperature decreases from T1 to T2 due to the heat exchange with air. The refrigerant flows in the windward-side row in the first heat exchanger tubes 2a and 2b at the temperature T2 to exchange heat with air, and the gas refrigerant is gradually liquefied. Subsequently, this refrigerant containing a high proportion of the liquid phase component flows in the leeward-side row in the second heat exchanger tube 2c of the 1-pass structure through the coupling member 3 to decrease the temperature from T2 to T3 due to heat exchange with air. Further, it flows in the windward-side row in the second heat exchanger tube 2c at the temperature T3 to decrease the temperature from T3 to T4 due to heat exchange with air.

[0030] Since the arrangement is thus made such that the refrigerant first flows in the leeward-side row and thereafter, flows into the windward-side row, refrigerant temperatures within the heat exchanger tubes 2a, 2b and 2c in the leeward-side row become higher than refrigerant temperatures in the windward-side row substantially in the whole area as shown in FIG. 3, and a temperature difference between the refrigerant and air can be taken large. Therefore, an average air temperature difference ΔTm between before and after the heat exchange becomes large, the heat exchange efficiency can be improved by a large amount, and a heat exchange amount Q was improved by 5% as compared with the conventional pass structure as experimentally shown.

[0031] The above-described embodiment is a case where the heat exchanger is used as a condenser, and in the case of an evaporator, the action can be applied in quite the same manner although the flow of refrigerant is reversed. More specifically, in the case of the evaporator, a refrigerant containing liquid and a high proportion of liquid phase component, adiabatically expanded by a throttle, first flows in the second heat exchanger tube 2c of the 1-pass structure, and a refrigerant containing gas and a high proportion of gaseous phase component flows into the first heat exchanger tubes 2a and 2b of the 2-pass structure through the coupling member 3 while heat exchange. Therefore, a temperature difference between the windward and the leeward is lower in the evaporator (about 1 to 2K) than in the condenser (about 5 to 50K). However, each pass for the first heat exchanger tubes 2a and 2b and the second heat exchanger tube 2c has, when the heat exchanger is operated as an evaporator, the inlet in the windward-side row and the outlet in the leeward-side row, and at least part of the passes are made to be a counterflow type, being overlapped between a plurality of rows in the air passage direction. Therefore, the temperature difference between the refrigerant and air can be taken large, and the heat exchange efficiency can be improved.

[0032] Next, with reference to FIG. 4, a description will be made of a second embodiment of the present invention. FIG. 4 is a side view (an arrow indicating a refrigerant flowing direction shows when a condenser is operating) showing the second embodiment in which a heat exchanger according to the present invention is applied to the condenser. A different point from the first embodiment is that the outlet of the windward-side row in the pass of the second heat exchanger tube 2c is constructed to be located at the lowest end of the windward-side row.

[0033] A description will be made of an operation of a heat exchanger according to the second embodiment. Generally, at the lowest end portion of the heat exchanger, a wind velocity is low. An outlet portion 2f of the windward-side heat exchanger tube in the second heat exchanger tube 2c, which is a feature of a heat exchanger according to the second embodiment, becomes, when the heat exchanger is operated as a condenser, the lowest in temperature, and therefore, by locating the outlet portion 2f at the lowest end, the heat exchanger ability of the second heat exchanger tube 2c constructed to be a 1-pass counterflow type becomes larger than that of the first embodiment, and it can be seen that the heat exchanger performance can be improved. Further, according to the heat exchanger according to the second embodiment, the second heat exchanger tube 2c does not have such a concave type pass structure as the heat exchanger has in the first embodiment, but since the pass in the vicinity of the outlet portion 2f does not rise upward from below, it is possible to prevent liquid seal which occurs particularly in an inverter type air conditioner at a low speed, that is, when the refrigerant flow rate is slow.

[0034] Next, with reference to FIG. 5, a description will be made of a heat exchanger according to a third embodiment. FIG. 5 is a side view (an arrow indicating a refrigerant flowing direction shows when an evaporator is operating) showing the third embodiment in which the heat exchanger according to the present invention is applied to the evaporator. A different point from the heat exchanger according to the above-described second embodiment is that as a coupling member 3 for coupling the first and second heat exchanger tubes 2a, 2b and 2c, a Y-branch type flow divider 3a is used.

[0035] In a case where this heat exchanger is operated as an evaporator, when refrigerant 5c of a gas-liquid two-layer flow from the second heat exchanger tube 2c is branched into the first heat exchanger tubes 2a and 2b, the Y-branch type flow divider 3a is employed as the coupling member 3 and is provided horizontally or vertically, whereby it becomes possible to substantially uniformly distribute refrigerants 5a and 5b which flow into the first heat exchanger tubes 2a and 2b respectively, so that the evaporator performance can be improved by a large amount. Further, since the Y-branch type flow divider 3a having multipurpose properties is used, it is possible to reduce the cost as compared with the case where any component having no multipurpose properties is used.

[0036] Next, with reference to FIG. 6, a description will be made of a fourth embodiment. FIG. 6 is a side view (an arrow indicating a refrigerant flowing direction shows when a condenser is operating) showing the fourth embodiment in which the heat exchanger according to the present invention is applied to the condenser. A different point from the above-described third embodiment is that one heat exchanger tube 2b in the first heat exchanger tubes 2a and 2b of the 2-pass structure is arranged below the other first heat exchanger tube 2a and the second heat exchanger tube 2c.

[0037] With reference to FIGS. 6 and 7, a description will be made of an operation of the heat exchanger according to the fourth embodiment. FIG. 7 shows a general refrigerating cycle for a heat pump type air conditioner, and this refrigerating cycle is constructed by piping and connecting, in an annular shape, a compressor 11, a four-way type valve 12, an application-side heat exchanger 13, a heat source-side heat exchanger (outdoor unit) 14, and a throttle 15, respectively. When a heat exchanger according to the fourth embodiment is used, the heat exchanger 14 operates as a condenser during a cooling operation, and as an evaporator during a heating operation. When heating at a low temperature (for example, outdoor temperature of 2°C/wet-bulb temperature of 1°C), the heat source-side heat exchanger 14 operates as the evaporator, and therefore, frost forms on the fins, and when a continuous operation is performed, defrosting becomes necessary to recover the heating ability. During defrosting, the operation is made in the refrigerating cycle, and the heat source-side heat exchanger 14 operates as the condenser, and the frost is caused to break to flow down from the upper portion of the heat exchanger 14 to the lower portion.

[0038] In the case of the heat exchanger according to the third embodiment shown in FIG. 5, the lower portion of the heat exchanger has the heat exchanger tube corresponding to the outlet portion of the condenser, which is the lowest in temperature, and therefore, water which has collected on a substrate provided in the outdoor unit, grows into ice, possibly resulting in deterioration of the heating ability or causing growth of ice formed on the substrate by continuous operation.

[0039] In contrast, in the case of a heat exchanger according to the fourth embodiment, one first heat exchanger tube 2b of the 2-pass structure, is arranged below the other first heat exchanger tube 2a and the second heat exchanger tube 2c as shown in FIG. 6, whereby refrigerant at comparatively high temperature, which flows through the first heat exchanger tube 2b, can be located in a position nearest to the substrate 6 of the heat source-side heat exchanger (outdoor unit) 14 during the defrosting operation. Therefore, the temperature at the substrate 6 can be increased as compared with the heat exchanger according to the third embodiment, and it is possible to prevent ice from being formed and growing on the substrate 5 after the defrosting operation. Further, since the first heat exchanger tubes 2a and 2b and the second heat exchanger tube 2c maintain to be in the 2-pass counterflow to 1-pass counterflow form, respectively, it is possible to secure the performance equivalent to the heat exchanger efficiencies obtained in the first to third embodiments.

[0040] Next, with reference to FIG. 8, the description will be made of a heat exchanger according to a fifth embodiment. FIG. 8 is a side view (an arrow indicating a refrigerant flowing direction shows when a condenser is operating) showing the fifth embodiment in which a heat exchanger according to the present invention is applied to the condenser. A different point from the above-described fourth embodiment is that an inlet heat exchanger tube portion 2h of the first heat exchanger tube 2b located in the lower portion of the second heat exchanger tube 2c is caused to be located between the lower stage of the heat exchanger and the second tube, and be positioned in the vicinity of the substrate 6 of the outdoor unit in which the heat source-side heat exchanger 14 is disposed.

[0041] In a case where this heat exchanger is used in a refrigerating cycle similar to that used in the fourth embodiment, an inlet heat exchanger tube portion 2h leading to the condenser, which is at the highest temperature, can be disposed in a position nearest to the substrate 6 of the outdoor unit during a defrosting operation, and therefore, the temperature at the substrate x6 can be further increased as compared with the heat exchanger according to the fourth embodiment, and it becomes possible to prevent ice formed on the substrate 6 from growing after the defrosting operation. This structure is particularly useful for a heat pump type air conditioner using a constant-speed compressor having low defrosting performance. Further, since the first heat exchanger tubes 2a and 2b and the second heat exchanger tube 2c maintain the 2-pass counterflow to 1-pass counterflow form, respectively, it is possible to secure the performance equivalent to the heat exchanger efficiencies obtained in the first to fourth embodiments.

[0042] As refrigerant for use in the heat exchangers according to each embodiment described above, HCFC-22, which is one type of flon, can be used, and it may be possible to use HFC-32 which is one of flon substitutes, or combined refrigerant containing HFC-32, or hydrocarbon refrigerant in place of the HCFC-22.

[0043] In the case of the heat pump type room air conditioner using refrigerant HCFC-22 which is one type of flon, it has already been described that in practical use, a decrease in number of passes or addition of valves generally affects the performance to be deteriorated to a significant extent because of an increase in pressure loss resulting from the increased flow rate and the addition of valves. The following Table 1 shows the rate of reduction in pressure loss for each refrigerant in the refrigerating cycle system using HCFC-22.

Table 1

Type of Refrigerant	Rate of Pressure Loss within System (when pressure loss of HCFC-22 is set to 100%)
HCFC-22	100%

Table 1 (continued)

Type of Refrigerant	Rate of Pressure Loss within System (when pressure loss of HCFC-22 is set to 100%)
HFC-407C	100 - 103%
HFC-410A	70 - 80%
HC-290	70 - 80%

[0044] HFC-407C and HFC-410A in the Table 1 are combined refrigerants respectively containing HFC-32 which is one of the flon substitutes, and HC-290 is a hydrocarbon refrigerant. It can be seen that HFC-32 or a part of the combined refrigerant containing HFC-32 (HFC-410A), or the hydrocarbon refrigerant (HC-290) is about 20 to 30% less in pressure loss than HCFC-22 which is one type flon refrigerant. Therefore, by using HFC-32 or the combined refrigerant containing HFC-32, or the hydrocarbon refrigerant as described above in the heat exchangers in each embodiment described above, it is possible to reduce the pressure loss in the evaporator by a large amount, and it becomes also possible to enhance the heat exchanger efficiencies in both evaporator and condenser as compared with the case where the conventional HCFC-22 is used.

[0045] In this respect, in the above-described embodiments, the descriptions have been made of the heat exchanger in which the heat exchanger tubes 2a, 2b and 2c are disposed in two rows in the air passage direction, however the present invention is not limited thereto, but it goes without saying that it is also applicable to any heat exchanger in which the heat exchanger tubes 2 are disposed in three or more rows in the air passage direction.

Claims

1. A heat exchanger in which a plurality of flat plate-shaped fins (1a) are stacked at predetermined intervals, heat exchanger tubes (2) for passing refrigerant therethrough are inserted along a stacking direction, air is caused to pass through between each fin group (1), and said heat exchanger tubes are disposed in a plurality of rows in an air passage direction, characterized in that:

    the heat exchanger tube is partitioned into a portion for containing gas and a high proportion of gaseous phase of a gas-liquid two-layer flow of the refrigerant flowing in said tube, and a portion for containing liquid and a high proportion of liquid phase of the gas-liquid two-layer flow of the refrigerant;
    first heat exchanger tubes (2a and 2b) of a 2-pass structure are disposed as the former portion;
    a second heat exchanger tube (2c) of a 1-pass structure is disposed as the latter portion;
    these first and second heat exchanger tubes are communicated to each other through a coupling member (3);
    each pass of these first and second heat exchanger tubes has, when the heat exchanger is operated as a condenser, an inlet in a leeward-side row and an outlet in a windward-side row; and
    at least part of said passes are of a counterflow type, being overlapped between a plurality of rows in the air passage direction.

2. The heat exchanger according to claim 1, characterized in that the outlet of the windward-side row in the pass of the second heat exchanger tube is located at the lowest end of the windward-side row.

3. The heat exchanger according to claim 1 or 2, characterized in that said coupling member is a Y-branch type flow divider.

4. The heat exchanger according to any one of claims 1 to 3, characterized in that part of said first heat exchanger tube is located below said second heat exchanger tube.

5. The heat exchanger according to claim 4, characterized in that an inlet of one pass of said first heat exchanger tube is located in the vicinity of the lower end of said leeward-side row.

6. The heat exchanger according to any one of claims 1 to 5, characterized in that HFC-32 or a combined refrigerant containing HFC-32, or a hydrocarbon refrigerant is used as the refrigerant.

FIG.1

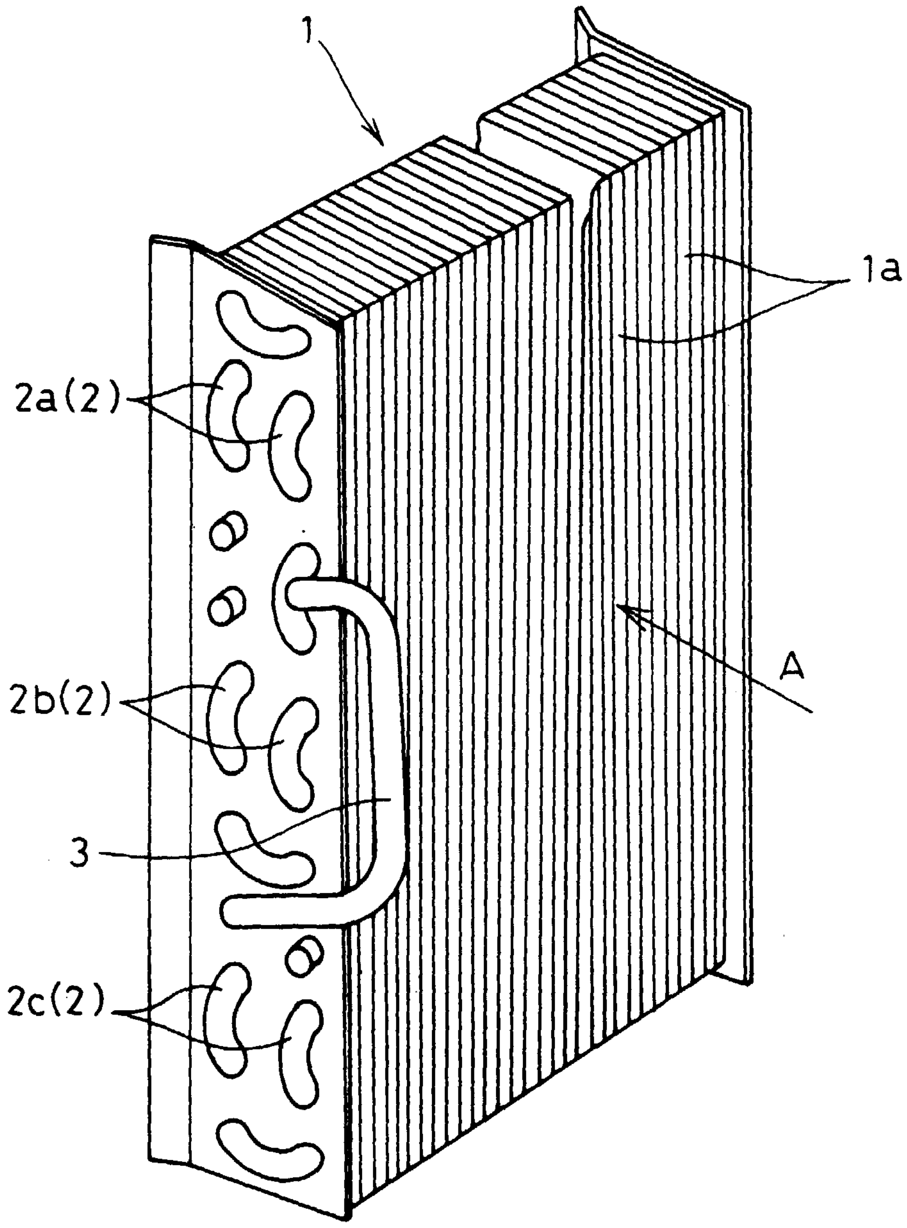


FIG. 2

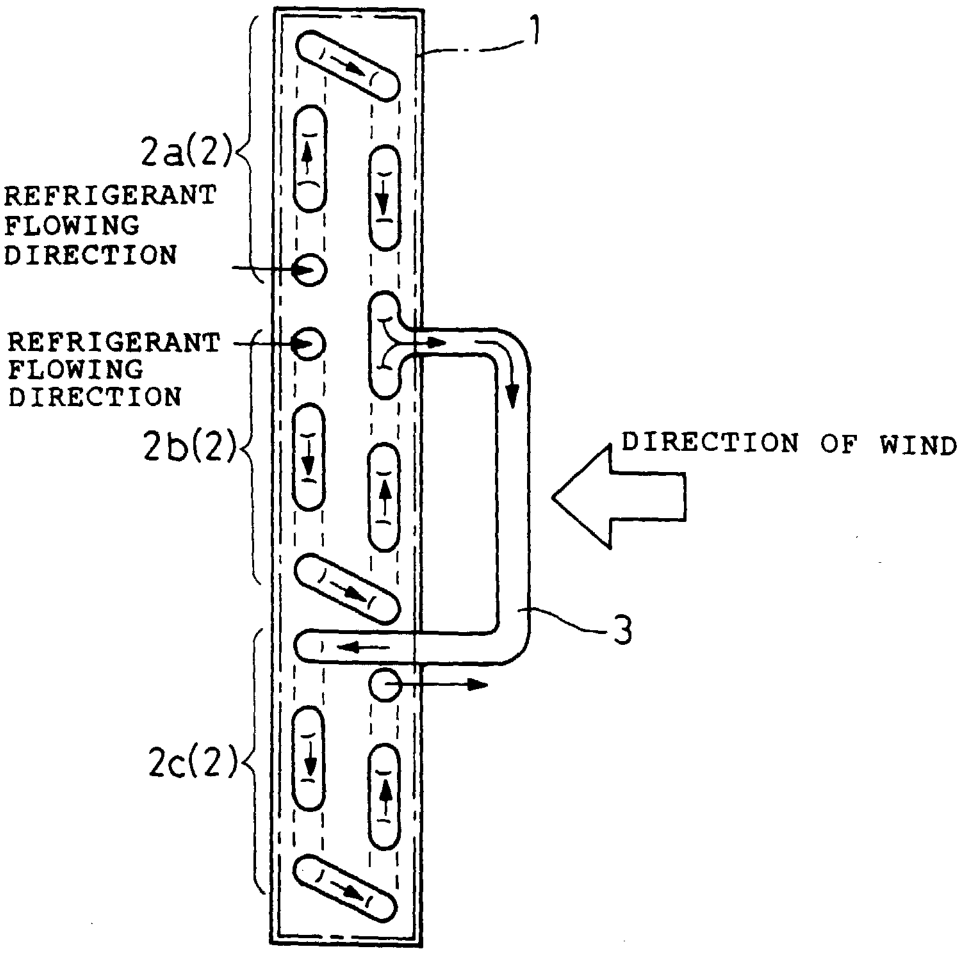

1
2a(2)
REFRIGERANT
FLOWING
DIRECTION
REFRIGERANT
FLOWING
DIRECTION
2b(2)
DIRECTION OF WIND
3
2c(2)

FIG.3

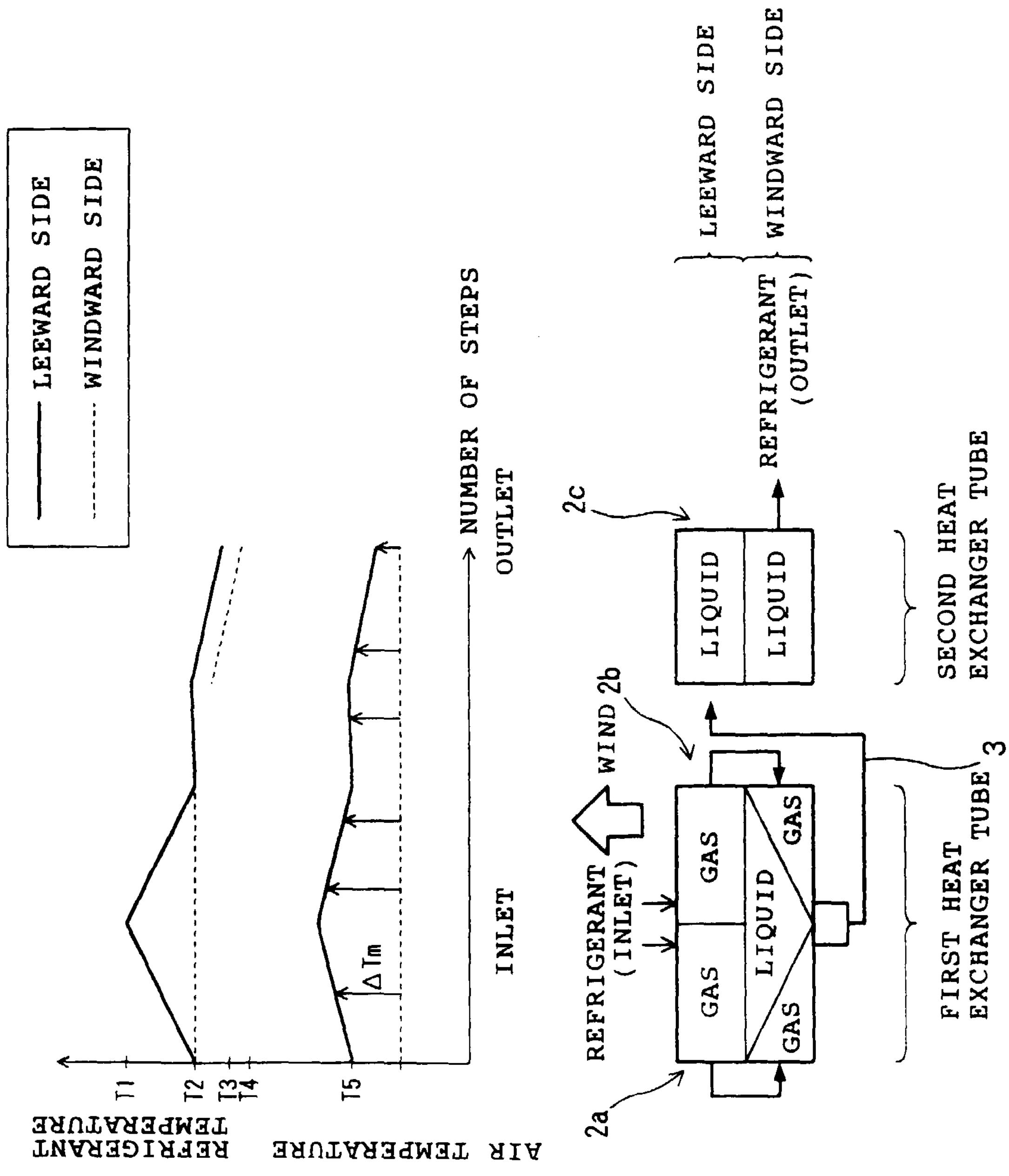

LEEWARD SIDE
WINDWARD SIDE
REFRIGERANT TEMPERATURE
AIR TEMPERATURE
T1
T2
T3
T4
T5
ΔTm
INLET
OUTLET
NUMBER OF STEPS
WIND
REFRIGERANT (INLET)
GAS
LIQUID
GAS
GAS
GAS
LIQUID
LIQUID
2a
2b
2c
3
REFRIGERANT (OUTLET)
LEEWARD SIDE
WINDWARD SIDE
FIRST HEAT EXCHANGER TUBE
SECOND HEAT EXCHANGER TUBE

FIG.4

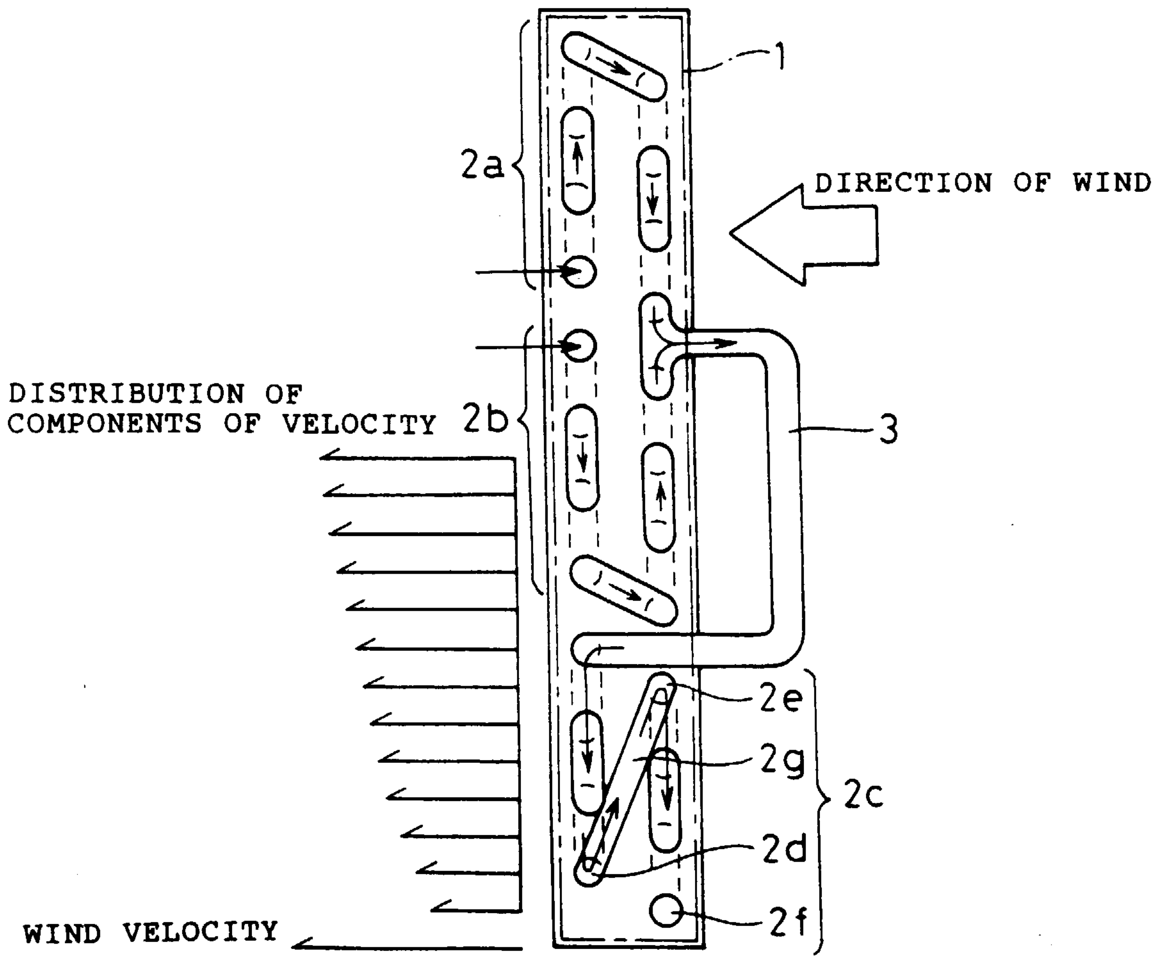

1
2a
DIRECTION OF WIND
DISTRIBUTION OF
COMPONENTS OF VELOCITY
2b
3
2e
2g
2c
2d
2f
WIND VELOCITY

FIG.5

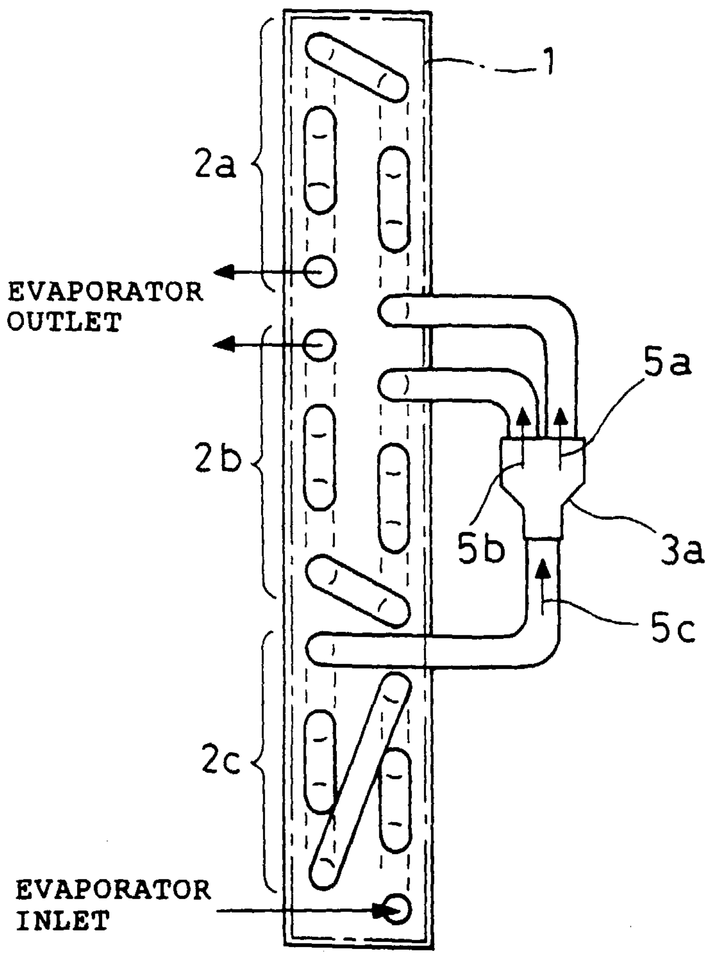
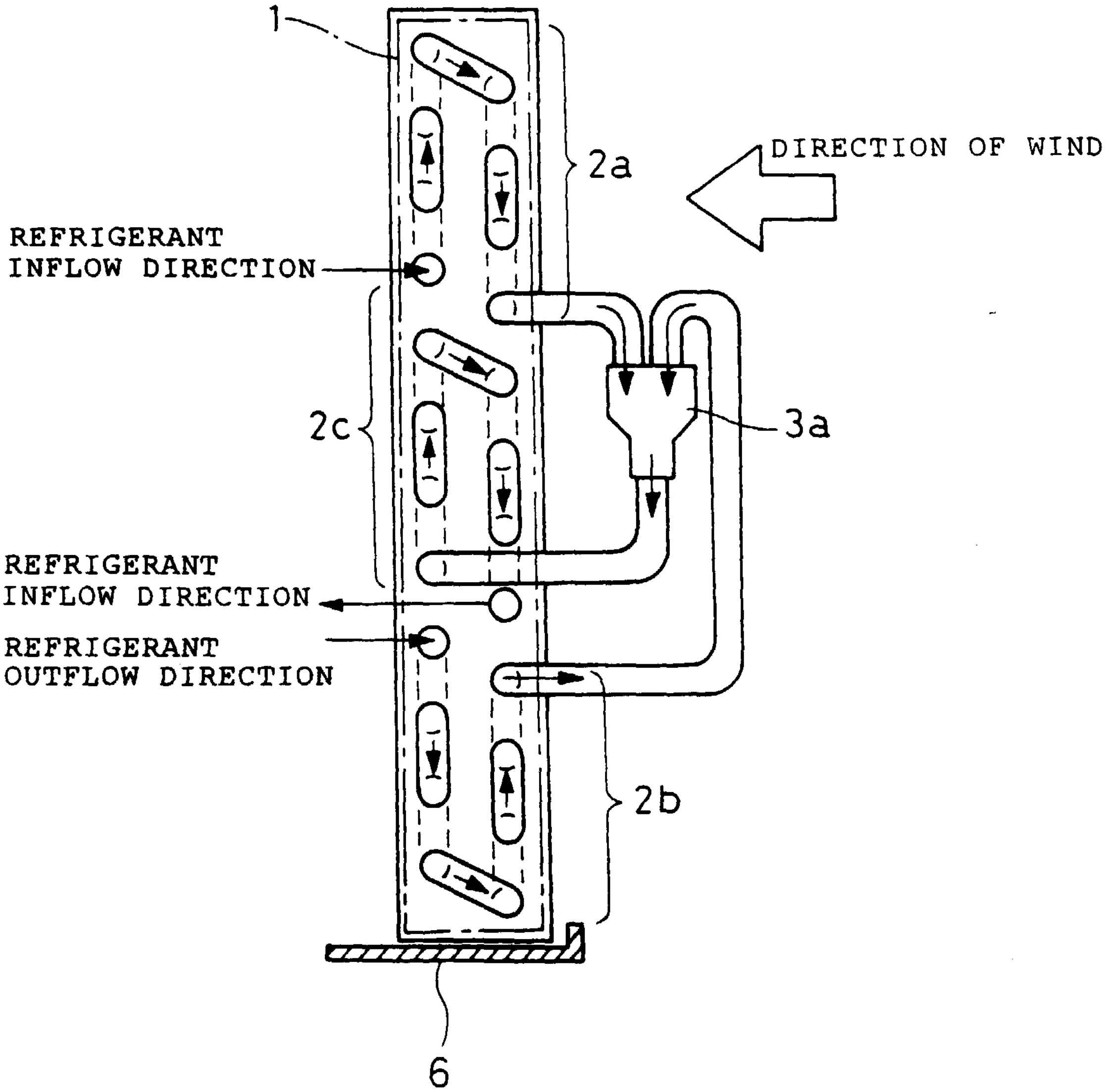


FIG.6



1
2a
DIRECTION OF WIND
REFRIGERANT INFLOW DIRECTION
2c
3a
REFRIGERANT INFLOW DIRECTION
REFRIGERANT OUTFLOW DIRECTION
2b
6

FIG.7

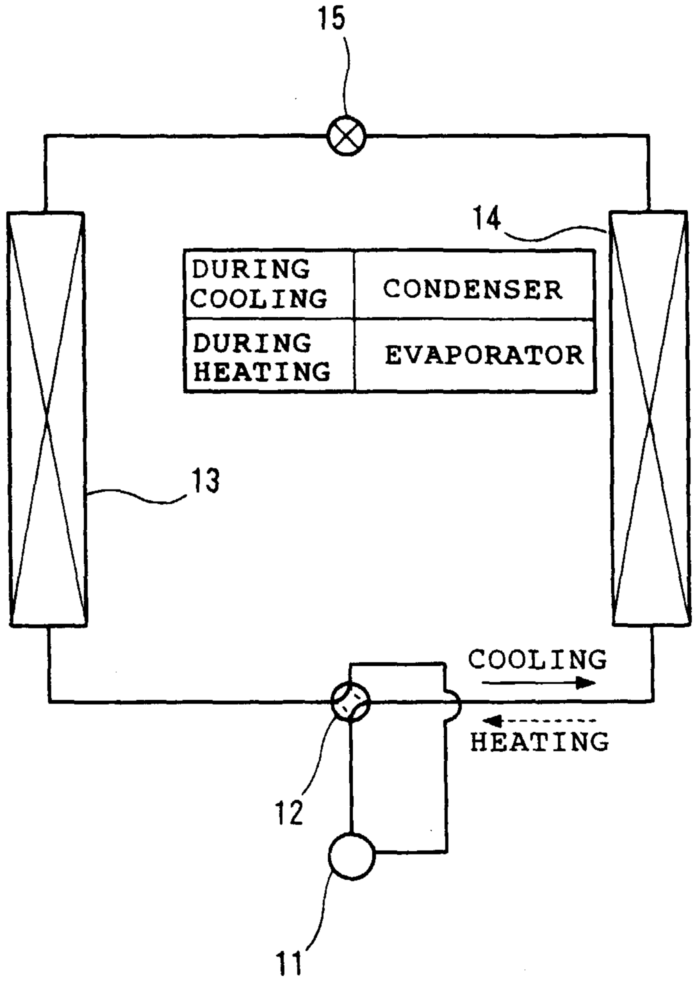

15
14
DURING COOLING
CONDENSER
DURING HEATING
EVAPORATOR
13
COOLING
HEATING
12
11

FIG.8

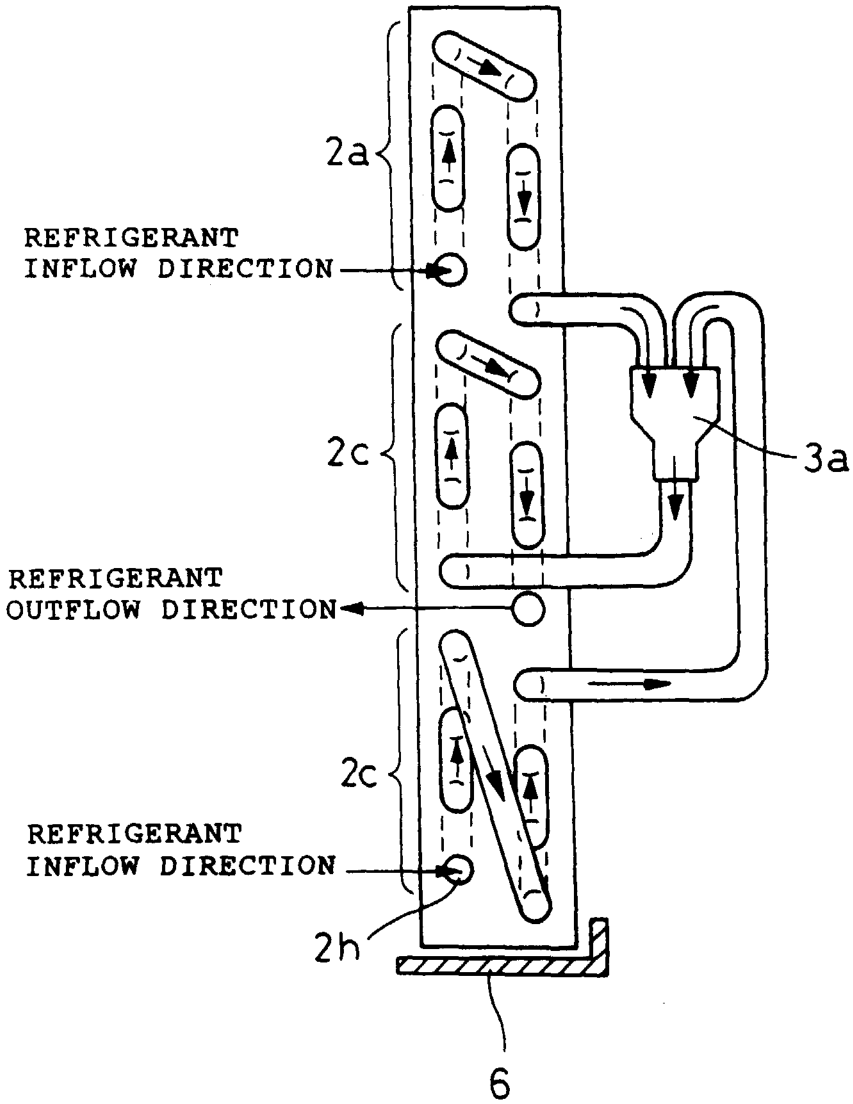

2a
REFRIGERANT
INFLOW DIRECTION
2c
3a
REFRIGERANT
OUTFLOW DIRECTION
2c
REFRIGERANT
INFLOW DIRECTION
2h
6

FIG.9

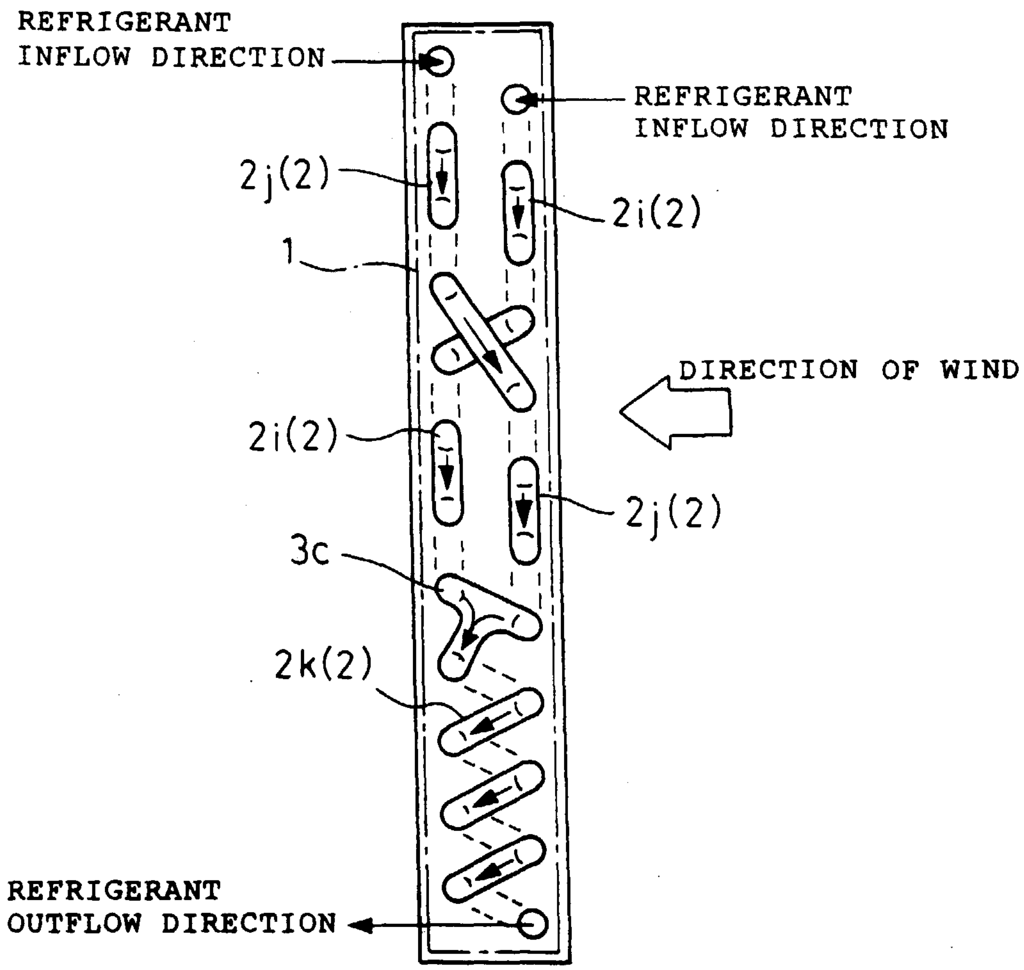
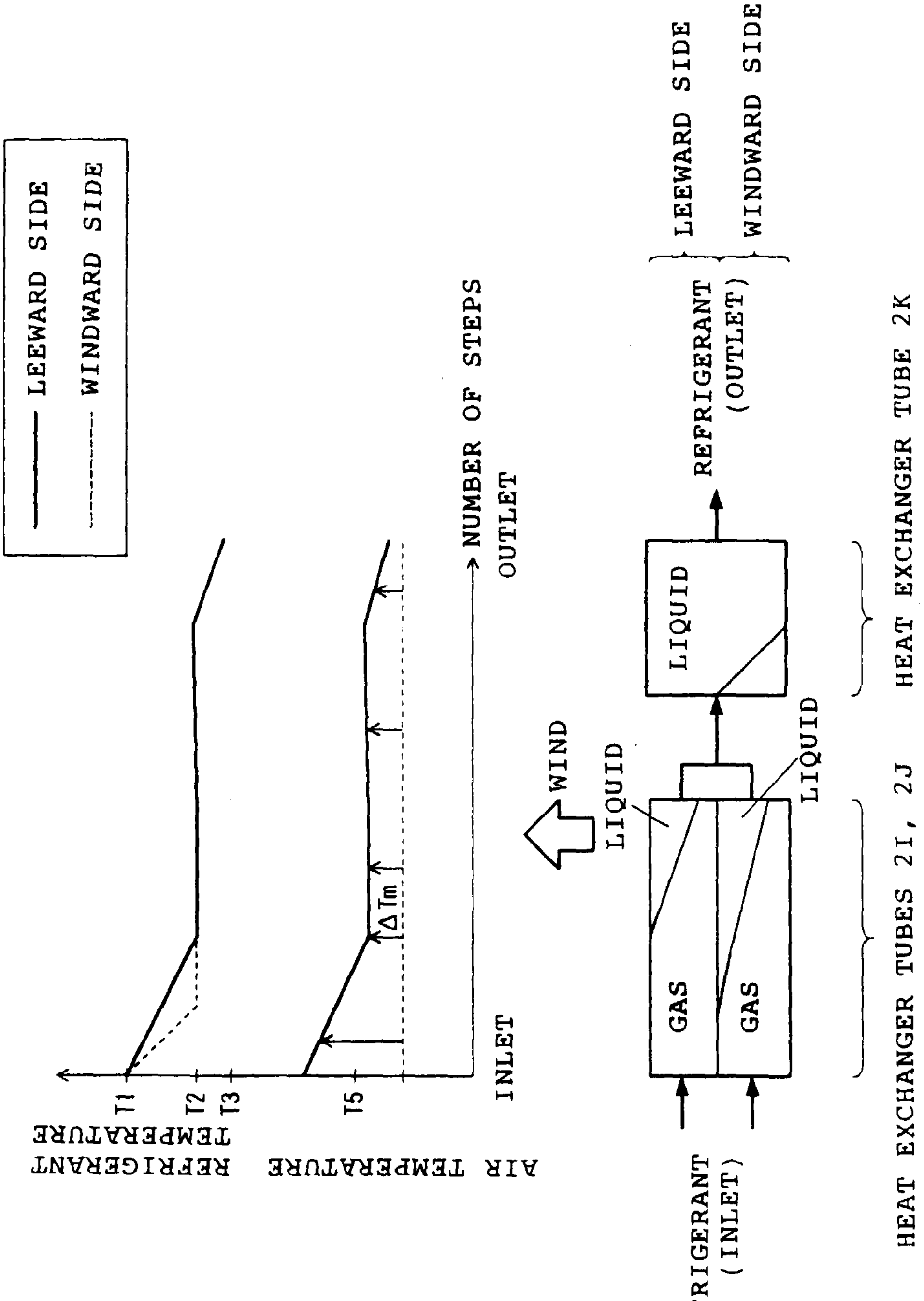

REFRIGERANT
INFLOW DIRECTION
REFRIGERANT
INFLOW DIRECTION
2j(2)
2i(2)
1
DIRECTION OF WIND
2i(2)
2j(2)
3c
2k(2)
REFRIGERANT
OUTFLOW DIRECTION

FIG.10


LEEWARD SIDE
WINDWARD SIDE
REFRIGERANT TEMPERATURE
AIR TEMPERATURE
T1
T2
T3
T5
ΔTm
INLET
OUTLET
NUMBER OF STEPS
WIND
LIQUID
GAS
GAS
LIQUID
LIQUID
REFRIGERANT (INLET)
REFRIGERANT (OUTLET)
LEEWARD SIDE
WINDWARD SIDE
HEAT EXCHANGER TUBES 2I, 2J
HEAT EXCHANGER TUBE 2K