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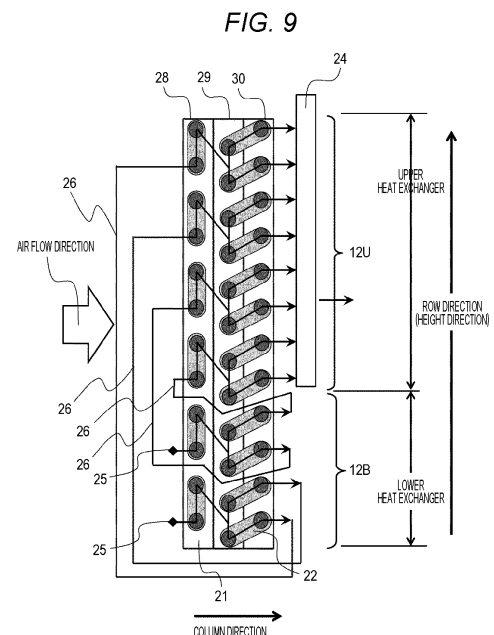
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(54) **OUTDOOR UNIT FOR AIR CONDITIONING DEVICE**

(57) An outdoor unit of an air conditioning device is provided, which is configured so that a pressure loss upon use as an evaporator can be reduced and a high heating capacity and improved cooling performance can be achieved at a low cost under influence of a liquid head in association with wind speed distribution in a heat exchanger and the height of the heat exchanger. The heat exchanger has a height of 1 m or more, and includes three columns of heat exchanger units arranged along an air flow direction. A first-column heat exchange unit as a windward-side heat exchange unit is configured such that U-shaped heat transfer pipes are arranged in a row direction, and U-shaped heat transfer pipes are arranged over two columns of a second-column heat exchange unit and a third-column heat exchange unit on the leeward side. The third-column heat exchange unit in an upper heat exchanger is connected to a gas header. The number of refrigerant paths connected to the gas header is greater than the half of a total row number in the heat exchanger, and the number of rows in the upper heat exchanger is equal to the number of refrigerant paths connected to the gas header. The first-column heat exchange unit in a lower heat exchanger is connected to a liquid refrigerant distributor. Each U-shaped heat transfer pipe of the third-column heat exchange unit in the lower heat exchanger is connected to a corresponding

one of the U-shaped heat transfer pipes of the first-column heat exchange unit in the upper heat exchanger through a path connection pipe.



Description

TECHNICAL FIELD

[0001] The present invention relates to an outdoor unit of an air conditioning device, and more specifically relates to a top flow type outdoor unit in which a blower fan is mounted above a heat exchanger.

BACKGROUND ART

[0002] An air conditioning device that heats or cools the inside of a room includes an outdoor unit placed outside the room and an indoor unit placed inside the room. Each of the indoor unit and the outdoor unit includes a heat exchanger that exchanges heat between air and refrigerant, a blower fan that supplies air to the heat exchanger, and a refrigerant pipe that connects the outdoor unit and the indoor unit to each other. The heat exchanger of the outdoor unit has a function of absorbing heat from outdoor air in the case of a heating operation of heating the inside of the room, and releasing heat to outdoor air in the case of a cooling operation of cooling the inside of the room.

[0003] In a building such as a commercial building, an air conditioning device called a variable refrigerant flow (VRF) type and including one or more outdoor units and multiple indoor units connected to the outdoor units through refrigerant pipes has been used, for example. Such an air conditioning device is so-called a "multi air-conditioner system."

[0004] A top flow type outdoor unit in which a blower fan is mounted above a heat exchanger has been often used as the outdoor unit used for the VRF type air conditioning device. As an example of the heat exchanger used for such a top flow type outdoor unit, one using flat pipes as heat transfer pipes is described in WO 2014/199501 A (Patent Literature 1).

[0005] The outdoor unit of Patent Literature 1 includes: the heat exchanger having the multiple flat heat transfer pipes arranged in parallel and used at least as a condenser in a refrigeration cycle; and a blower fan that generates the flow of air passing through the heat exchanger with predetermined wind speed distribution. A "refrigerant path" described below indicates a refrigerant flow path.

[0006] In Patent Literature 1, the heat exchanger as the condenser exchanges heat between air and refrigerant flowing in the heat transfer pipe, thereby releasing the heat of the refrigerant to the air. The heat exchanger has multiple refrigerant paths formed by one or more heat transfer pipes, and the multiple refrigerant paths include: multiple first refrigerant paths through which gas refrigerant flows in and two-phase refrigerant flows out; and multiple second refrigerant paths through which the two-phase refrigerant having flowed out of the multiple first refrigerant paths flows in and subcooled liquid refrigerant flows out.

[0007] The multiple second refrigerant paths are arranged in a region where the wind speed of air is lower than a region where the multiple first refrigerant paths are arranged. The multiple first refrigerant paths are arranged in regions different from each other in the wind speed of air, and the multiple second refrigerant paths are also arranged in regions different from each other in the wind speed of air.

[0008] The multiple first refrigerant paths and the multiple second refrigerant paths are configured such that the first refrigerant path and the second refrigerant path correspond to each other in a descending order of the wind speed of air in the region and outlet sides of the multiple first refrigerant paths are respectively coupled to inlet sides of the multiple corresponding second refrigerant paths.

[0009] JP-A-2014-126322 (Patent Literature 2) discloses that in an air conditioning device using, as heat transfer pipes, circular pipes bent in a U-shape for a heat exchanger of an outdoor unit, the number of refrigerant paths is increased in order to improve an air conditioning capacity in the outdoor heat exchanger.

[0010] The air conditioning device described in Patent Literature 2 is configured such that an outdoor unit having a compressor, the outdoor heat exchanger, and an outdoor expansion valve and an indoor unit inside a room are connected to each other through a liquid connection pipe and a gas connection pipe. The outdoor heat exchanger includes multiple plate-shaped heat exchange fins, multiple heat transfer pipes, and a liquid refrigerant distributor and a gas refrigerant distributor for converging the heat transfer pipes to multiple paths.

[0011] The number of refrigerant paths on a gas refrigerant distributor side is equal to or greater than twice as many as the number of refrigerant paths on a liquid refrigerant distributor side, and one outdoor heat exchanger is divided into multiple heat exchangers. Each of the multiple divided outdoor heat exchangers includes multiple plate-shaped heat exchange fins, multiple heat transfer pipes perpendicular to the plate-shaped heat exchanger fins, and a liquid refrigerant distributor and a gas refrigerant distributor for converging the heat transfer pipes to multiple paths. It is configured such that the total number of refrigerant paths on the liquid refrigerant distributor side in the multiple divided outdoor heat exchangers is greater than a value of the quarter of the number of rows of the heat transfer pipes of the outdoor heat exchanger before division.

CITATION LIST

PATENT LITERATURE

[0012]

PATENT LITERATURE 1: WO 2014/199501 A
PATENT LITERATURE 2: JP-A-2014-126322

SUMMARY OF INVENTION

PROBLEMS TO BE SOLVED BY INVENTION

[0013] Among air conditioning devices, improvement in a cooling/heating capacity per outdoor unit has been demanded for a large air conditioning device used for a building such as a commercial building.

[0014] In order to improve the heating capacity when a heat exchanger is used as an evaporator in heating operation, it is necessary to supply a large amount of liquid refrigerant to the heat exchanger to evaporate the refrigerant. The number of refrigerant paths in the heat exchanger is the number of refrigerant paths through which refrigerant flows so as to be branched in the heat exchanger. If the number of refrigerant paths is small, when liquid refrigerant is gasified, a flow speed in the refrigerant path is too high, and for this reason, an internal pressure loss increases.

[0015] Such an internal pressure loss causes unnecessary temperature distribution in the heat exchanger, leading to reduction in energy saving in the air conditioning device. Thus, it is necessary to increase the number of refrigerant paths in order to improve the heating capacity.

[0016] On the other hand, when the heat exchanger with the increased number of refrigerant paths is used as a condenser in cooling operation, if the proportion of liquid refrigerant increases due to progress of condensation of gas refrigerant, the flow speed of liquid refrigerant becomes too low due to the increased number of refrigerant paths, leading to degradation of heat exchange performance. Thus, in order to improve the heat exchange performance (cooling performance) in the cooling operation, it is necessary to decrease the number of refrigerant paths on a liquid refrigerant distributor side in the heat exchanger.

[0017] In a top flow type outdoor unit in which the height of a heat exchanger exceeds 1 m, in a case where the heat exchanger is used as a condenser during cooling, a difference in height between a liquid-side outlet of the uppermost refrigerant path and a liquid-side outlet of the lowermost refrigerant path is often close to 1 m. In this case, only the pressure of liquid refrigerant corresponding to the height acts on the liquid-side outlet of the lowermost refrigerant path, and is close to 10 kPa.

[0018] However, a pressure difference between a gas side and a liquid side upon use as a condenser is generally small, and in some cases, falls below 10 kPa specifically under a condition where the number of refrigerant paths is great. Sometimes in this case, no refrigerant flows in the lower refrigerant path of the heat exchanger on the liquid-side outlet of which the pressure acts. Since no heat exchange is substantially made in the refrigerant path in which no refrigerant flows, a heat transfer area in such a region is wasted, leading to degradation of the heat exchange performance (the cooling performance).

[0019] In addition, in the case of the top flow type out-

door unit, a blower fan is at an upper portion in the outdoor unit, and at a side surface of the outdoor unit, the heat exchanger is arranged perpendicularly to an installation surface (e.g., a ground surface or a floor of a roof of a building). Thus, a wind speed tends to be higher at the upper portion of the heat exchanger closer to the blower fan and to be lower at a lower portion of the heat exchanger farther from the blower fan.

[0020] Thus, a heat exchange amount at the lower portion of the heat exchanger is smaller than that at the upper portion of the heat exchanger. For this reason, it is necessary to adjust a refrigerant distribution amount according to the heat exchange amount by a liquid refrigerant distributor and a pressure loss body such as a small-diameter pipe, and a manufacturing cost increases by an amount corresponding to such adjustment.

[0021] In the air conditioning device of Patent Literature 1, the first refrigerant paths are arranged in the region where the wind speed is relatively high, and the second refrigerant paths are arranged in the region where the wind speed is relatively low. With this configuration, the proportion of the liquid phase in the heat transfer pipe can be decreased, and a heat exchange efficiency can be improved.

[0022] However, since the heat exchanger described in Patent Literature 1 employs the flat pipe, the internal flow path is thin. For this reason, a pressure loss specifically upon use as an evaporator increases, and interferes with improvement in a heating capacity. In addition, there are problems that the flat pipe has a complicated structure and a manufacturing cost therefor increases.

[0023] In Patent Literature 2, in the heat exchanger using the circular pipes, the total number of paths on the liquid refrigerant distributor side in the multiple divided outdoor heat exchangers is greater than the value of the quarter of the number of rows of the heat transfer pipes of the outdoor heat exchanger before division.

[0024] However, in the air conditioning device described in Patent Literature 2, the heat exchanger needs to be divided into two heat exchangers. For this reason, in a case where the heat exchanger cannot be divided into two heat exchangers or a case where a heating capacity needs to be further improved as compared to a state in which the heat exchanger is divided into two heat exchangers, there are problems that the number of refrigerant paths cannot be increased and the heating capacity cannot be improved.

[0025] The present invention is intended to provide an outdoor unit of an air conditioning device configured so that a high heating capacity and improved cooling performance can be achieved at a low cost under influence of a liquid head in association with wind speed distribution in a heat exchanger and the height of the heat exchanger.

SOLUTION TO PROBLEMS

[0026] According to a feature of the present invention, there is provided an outdoor unit of an air conditioning

device including at least: a compressor; a blower fan; and a heat exchanger. The blower fan is mounted above the heat exchanger. The heat exchanger includes an upper heat exchanger and a lower heat exchanger, and each heat exchanger includes: a U-shaped heat transfer pipe configured with a circular pipe bent in a U-shape; a heat exchange fin; a liquid refrigerant distributor; a gas header; and a path connection pipe connecting end portions of the U-shaped heat transfer pipes. The heat exchanger includes three columns of heat exchange units arranged along an air flow direction. A first-column heat exchange unit as a windward-side heat exchange unit is configured such that the U-shaped heat transfer pipes are arranged in a row direction, and the U-shaped heat transfer pipes are arranged over two columns of a second-column heat exchange unit and a third-column heat exchange unit on a leeward side. End portions of the U-shaped heat transfer pipes of the third-column heat exchange unit in the upper heat exchanger are connected to the gas header, a number of refrigerant paths connected to this gas header is greater than a half of a total row number in the heat exchanger, and a number of rows in the upper heat exchanger is equal to the number of refrigerant paths connected to the gas header. End portions of the U-shaped heat transfer pipes of the first-column heat exchange unit in the lower heat exchanger are connected to the liquid refrigerant distributor. Each U-shaped heat transfer pipe of the third-column heat exchange unit in the lower heat exchanger is connected to a corresponding one of the U-shaped heat transfer pipes of the first-column heat exchange unit in the upper heat exchanger through the path connection pipe.

EFFECTS OF INVENTION

[0027] According to the present invention, a high heating capacity and improved cooling performance can be achieved at a low cost under the influence of the liquid head in association with wind speed distribution in the heat exchanger and the height of the heat exchanger.

BRIEF DESCRIPTION OF DRAWINGS

[0028]

Fig. 1 is an external perspective view of an outdoor unit of an air conditioning device to which the present invention is applied;

Fig. 2 is an external perspective view showing an internal configuration of the outdoor unit shown in Fig. 1;

Fig. 3 is a configuration diagram showing a refrigeration cycle in the air conditioning device;

Fig. 4 is an external perspective view of a typical heat exchanger;

Fig. 5 is an external perspective view for describing a typical heat exchanger manufacturing method;

Fig. 6 is a configuration diagram for describing re-

frigerant paths in the typical heat exchanger;

Fig. 7 is a configuration diagram for describing refrigerant paths in another typical heat exchanger;

Fig. 8 is an external perspective view of a heat exchanger according to a first embodiment of the present invention from one side;

Fig. 9 is a configuration diagram for describing refrigerant paths in the first embodiment of the present invention;

Fig. 10 is an external perspective view of the heat exchanger according to the first embodiment of the present invention from the other side;

Fig. 11 is a configuration diagram for describing refrigerant paths in a second embodiment of the present invention; and

Fig. 12 is a configuration diagram for describing refrigerant paths in a third embodiment of the present invention.

20 DESCRIPTION OF EMBODIMENTS

[0029] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings, but the present invention is not limited to the embodiments below and various modifications and applications are also included in the scope of the technical idea of the present invention.

[0030] First, the outline of an outdoor unit to which the present invention is applied will be described with reference to Fig. 1. The outdoor unit to which the present invention is applied is a top flow type outdoor unit having a fan at an upper portion in a housing. In order to exhibit a high cooling capacity and a high heating capacity while keeping an installation area compact, the height of the outdoor unit exceeds 1 m, and the height of a heat exchanger also exceeds 1 m.

[0031] Further, as shown in Fig. 1, the outdoor unit to which the present invention is applied includes two blower fans 13, two bell mouths 16 corresponding thereto, and two heat exchangers 12. Note that these components are housed in the housing including a front panel 15, and the like.

[0032] Fig. 2 shows a perspective view in which the fans, the bell mouths, and the front panel 15 are detached from the outdoor unit shown in Fig. 1 so that the inside of the outdoor unit can be viewed. A compressor 10, a refrigerant tank 11, an accumulator 14, a control panel 17, and the like are arranged inside the outdoor unit. The outdoor unit is placed on a bottom installation board 18. The control panel 17 is equipped with an input unit of a sensor attached to the outdoor unit and an electrical component that controls operation of the compressor 10 or the blower fan 13. The refrigerant tank 11 is attached in the middle of a refrigeration cycle to absorb a difference in the amount of refrigerant necessary in the cycle between cooling operation and heating operation.

[0033] Fig. 3 shows the outline of the refrigeration cycle in a VRF type air conditioning device, and specifically

shows the refrigeration cycle in the heating operation. High-temperature high-pressure gas refrigerant discharged from the compressor 10 flows into a gas-side blocking valve through a refrigerant pipe 9 and a four-way valve 19. From this location, the gas-side blocking valve is connected to an indoor unit 103 through a gas refrigerant pipe 101. The gas refrigerant having flowed out of the gas-side blocking valve flows into an indoor heat exchanger 104 in the indoor unit 103. Note that the indoor units 103 are respectively provided in two rooms 300. Needless to say, the indoor units 103 may be provided in two or more rooms.

[0034] Air is supplied to the indoor heat exchanger 104 by an indoor blower fan 105, and after having taken heat from refrigerant, is supplied into the room. The refrigerant is cooled and liquefied inside the indoor heat exchanger 104. The liquefied refrigerant flows into a liquid-side blocking valve through a liquid refrigerant pipe 102. The refrigerant having flowed into the outdoor unit 100 from the liquid-side blocking valve is decompressed into a low-temperature low-pressure gas-liquid two-phase state by an outdoor expansion valve 20 housed in the outdoor unit 100, and flows into an outdoor heat exchanger 12 by way of, e.g., the refrigerant tank.

[0035] Outdoor air is supplied to the outdoor heat exchanger 12 by an outdoor blower fan 13, and the refrigerant is decompressed to a temperature lower than the temperature of the outdoor air flowing in the heat exchanger 12. Thus, heat of the outdoor air is absorbed by the refrigerant, and the refrigerant is evaporated in the heat exchanger 12.

[0036] The gas refrigerant evaporated and gasified in the outdoor heat exchanger 12 passes through the four-way valve 19, returns to the compressor 10 through the accumulator 14, and is compressed again into high-temperature high-pressure gas by compression action of the compressor 10. By repeating this process, the heating operation can be continued. On the other hand, in the cooling operation, connection at the four-way valve 19 is switched such that a discharge pipe of the compressor 10 and the outdoor heat exchanger 12 are connected to each other and the gas-side blocking valve and the accumulator 14 are connected to each other by the four-way valve 19.

[0037] Accordingly, the direction of the flow of refrigerant in the outdoor heat exchanger 12 and the indoor heat exchanger 104 is reversed. Gas refrigerant is condensed and liquefied in the outdoor heat exchanger 12, and liquid refrigerant is evaporated and gasified in the indoor heat exchanger 104. By repeating this process, the cooling operation can be continued.

[0038] Fig. 4 shows the structure of a typical heat exchanger using circular heat transfer pipes. As shown in Fig. 4, the heat exchanger includes U-shaped heat transfer pipes 22 as circular heat transfer pipes bent in a U-shape and plate-shaped heat exchange fins 21. The heat exchanger includes three columns, and a first-column heat exchange unit 28, a second-column heat exchange

unit 29, and a third-column heat exchange unit 30 are arranged in this order from a windward side along the flow of wind so as to extend in a longitudinal direction.

[0039] Fig. 5 shows an assembly structure of the heat exchanger. The heat exchanger shown in Fig. 4 is produced in such a manner that the U-shaped heat transfer pipes 22 are inserted into the heat exchange fins 21 stacked at equal pitches. Generally, after the U-shaped heat transfer pipe 22 has been inserted into the heat exchange fin 21, a pipe expansion machine is inserted into the U-shaped heat transfer pipe 22 from end portions thereof, and the U-shaped heat transfer pipe 22 is expanded from the inside. In this manner, the heat exchange fin 21 and the U-shaped heat transfer pipe 22 closely contact each other. There is also a pipe expansion method using a liquid pressure, other than mechanical pipe expansion.

[0040] For the typical heat exchanger, the U-shaped heat transfer pipes 22 are arranged in the longitudinal direction in each column (see Fig. 5) so that a heat exchanger assembling step of inserting the U-shaped heat transfer pipes 22 into the heat exchange fin 21 can be performed for each column.

[0041] Fig. 6 shows typical refrigerant paths (refrigerant flow paths) formed by the U-shaped heat transfer pipes 22. A lateral direction in Fig. 6 is taken as a column direction, and the heat exchange units are counted as the first-column heat exchange unit 28, the second-column heat exchange unit 29, and the third-column heat exchange unit 30 in this order from the left. In addition, a longitudinal direction in Fig. 6 is taken as a row direction, and the number of heat transfer pipes is counted as a first row or a second row. In the configuration shown in Fig. 6, the heat exchanger has 3 columns and 12 rows. The typical heat exchanger is configured such that the U-shaped heat transfer pipes 22 are arranged in the row direction and three columns thereof are arranged.

[0042] Black arrows in Fig. 6 indicate the flow of refrigerant. In the heating operation, a two-phase flow having flowed out of an expansion valve is distributed to each liquid-side refrigerant inlet/outlet port 25 of the heat exchanger through a not-shown liquid refrigerant distributor. Thereafter, the refrigerant flows into a gas header 24 from the third-column heat exchange unit 30 of the heat exchanger along the arrows in the figure. The refrigerant having joined together in the gas header 24 flows into a four-way valve.

[0043] In the air conditioning device, it is necessary to supply a large amount of refrigerant to the heat exchanger in order to ensure a high air conditioning capacity in both the cooling operation and the heating operation. In the heating operation, the heat exchanger of the outdoor unit needs to function as an evaporator to gasify a large amount of liquid refrigerant. Since a phase change from liquid to gas significantly increases the volume of refrigerant per same mass, the flow speed of refrigerant increases in the heat transfer pipe in the heat exchanger, leading to a great pressure loss. This pressure loss caus-

es refrigerant temperature distribution inside the heat exchanger, and degrades heat exchange performance of the heat exchanger.

[0044] For this reason, for a typical heat exchanger mounted on a model for a high heating capacity, the refrigerant paths as shown in Fig. 6 have been employed so that the maximum number of divisions can be formed using the U-shaped heat transfer pipes. In the refrigerant path structure as shown in Fig. 6, the number of refrigerant paths, which is the number of refrigerant flow paths, in the heat exchanger is increased as much as possible. Accordingly, the pipe length of one refrigerant path is shortened, and the amount of refrigerant flowing in one refrigerant path is reduced. In this manner, the pressure loss is reduced.

[0045] Specifically, in an air conditioning device having a high air conditioning capacity, a heat exchanger of an outdoor unit is, as in Patent Literature 2, divided so that the amount of refrigerant flowing in one heat exchanger can be reduced and the width of the heat exchanger can be shortened. Thus, the flow path length of one turn of a U-shaped heat transfer pipe can be shortened, and naturally, a refrigerant pressure loss can be reduced.

[0046] For the typical refrigerant path structure as shown in Fig. 6, the heat exchanger is used, which is configured such that the U-shaped heat transfer pipes are arranged in the row direction in each column. This structure leads to reduction in a manufacturing cost because it is only required that the same heat exchanger is produced for each column and these heat exchangers are combined with each other. A heat exchange amount is the greatest in the first-column heat exchange unit on the windward side, and decreases in the order of the second-column heat exchange unit and the third-column heat exchange unit on the leeward side.

[0047] Thus, in a case where the configuration in which the first- to third-column heat exchange units 28 to 30 are connected through one refrigerant path as in the typical refrigerant path structure shown in Fig. 6 is not employed, if, e.g., paths are provided such that refrigerant having passed through the first-column heat exchange unit 28 is branched into two paths, part of the refrigerant flows into the U-shaped heat transfer pipe of the second-column heat exchange unit 29, and the remaining part of the refrigerant flows into the U-shaped heat transfer pipe of the third-column heat exchange unit 30, refrigerant distribution needs to be adjusted accordingly. This is because the amount of heat exchangeable in the second-column heat exchange unit 29 is greater than the amount of heat exchangeable in the third-column heat exchange unit 30.

[0048] That is, it is necessary to provide a pressure loss body such as a small-diameter pipe at a connection portion between the first-column heat exchange unit 28 and the third-column heat exchange unit 30 such that refrigerant is less likely to flow into the U-shaped heat transfer pipe of the third-column heat exchange unit 30. Moreover, if such a distribution amount is not optimal,

the performance is degraded.

[0049] Similarly, in a configuration in which liquid-side refrigerant inlet/outlet ports 25 are provided at the second-column heat exchange unit 29 or the third-column heat exchange unit 30 without increasing the number of paths, an air temperature changes in the second-column heat exchange unit 29 or units subsequent thereto according to the heat exchange amount in the first-column heat exchange unit 28, and it is difficult to supply a proper amount of refrigerant and to improve the performance.

[0050] In addition, in the cooling operation, in a case where no liquid-side refrigerant inlet/outlet port 25 is provided at the first-column heat exchange unit 28, the temperature of cooling air increases due to heat exchange in the first-column heat exchange unit 28. For this reason, a condensed liquid refrigerant subcooling amount cannot be ensured as compared to a case where the liquid-side refrigerant inlet/outlet ports 25 are provided at the first-column heat exchange unit 28. Generally, the performance tends to be degraded if the subcooling amount cannot be ensured.

[0051] Further, in the typical refrigerant path structure as shown in Fig. 6, there is a difference in height between the uppermost refrigerant path and the lowermost refrigerant path in the heat exchanger when the heat exchanger is used as a condenser during cooling. Here, the outer diameter of the U-shaped heat transfer pipe 22 is 5 mm to 8 mm, whereas a row pitch is between 15 mm and 30 mm.

[0052] Thus, the height of the heat exchanger in Fig. 6 is approximately 240 mm, assuming that the row pitch is 20 mm. Some of heat exchangers of top flow type outdoor units for a high heating capacity actually have nearly 50 rows and a height exceeding 1 m.

[0053] The drawing shows 12 rows of the heat exchanger, but actually, refrigerant paths are further present at a similar ratio in the row direction (an upward direction). If the number of rows is 50, it means that the number of refrigerant paths in the typical structure shown in Fig. 6 is 25.

[0054] As an example, it is assumed that there is a height difference of 1 m between the liquid-side refrigerant inlet/outlet port 25 of the uppermost path and the liquid-side refrigerant inlet/outlet port 25 of the lowermost path in the heat exchanger. As refrigerant recently used in the air conditioning device, there are refrigerants such as "R410A" and "R32." The liquid density of such refrigerant at 2.2 MPa at 35°C is 1006 kg/m³ in the case of "R410A," and is 917 kg/m³ in the case of "R32." Thus, even in the case of the "R32" refrigerant having a low density, a liquid head of at least 8.9 kPa acts on the lower liquid-side refrigerant inlet/outlet port 25 of the heat exchanger. In a case where the heat exchanger is used as the condenser, the pressure loss between the gas header and the liquid refrigerant distributor is often about 10 kPa.

[0055] For this reason, a pressure difference of 10 kPa is generated only due to the refrigerant pressure loss in the upper refrigerant path on which no liquid head acts,

but a value obtained by addition of the liquid head to the refrigerant flow pressure loss needs to be 10 kPa in the lower refrigerant path on which the liquid head acts.

[0056] That is, in the refrigerant path on which the liquid head acts, a refrigerant circulation amount decreases by an amount corresponding to such a liquid head, and the refrigerant flow pressure loss decreases. This achieves a balance. In a heat exchanger with a much greater height, a liquid head alone exceeds 10 kPa, and a state in which almost no refrigerant flows is brought. No refrigerant flow means that no heat exchange is performed in such a refrigerant path, and the performance is degraded by an amount corresponding to a heat transfer area which cannot be effectively used.

[0057] As shown in Fig. 1, in the top flow type outdoor unit having the heat exchanger with a great height, the wind speed of air flowing into the heat exchanger is different between an upper portion and a lower portion. That is, it has been known that the wind speed is high on the upper side of the heat exchanger closer to the outdoor blower fan and is low on the lower side of the heat exchanger farther from the outdoor blower fan.

[0058] Since the heat exchange amount is greater at the upper portion at which the wind speed is high, it is necessary to supply a large amount of refrigerant. It is necessary to decrease the amount of refrigerant targeted for heat exchange at the lower portion at which the wind speed is low. In the typical refrigerant paths shown in Fig. 6, small-diameter pipes having different lengths are provided among the liquid-side refrigerant inlet/outlet ports 25 and the liquid refrigerant distributor connected thereto, and in this manner, the amount of refrigerant supplied to each refrigerant path is adjusted specifically in the case of use as the evaporator.

[0059] However, these small-diameter pipes are necessary for all the refrigerant paths, and a small-diameter pipe of 1 m or more might be necessary for a refrigerant path for which a refrigerant flow rate needs to be decreased. This leads to an increase in the manufacturing cost. In addition, it is necessary for a design with the small-diameter pipes for refrigerant amount adjustment to grasp an accurate pressure loss of a gas-liquid two-phase flow, and for this reason, such a design is difficult to be made.

[0060] On the other hand, refrigerant paths as shown in Fig. 7 have been employed for a model not requiring a high heating capacity. That is, in a refrigerant path configuration similar to that of Patent Literature 1, a heat exchanger is divided into an upper portion and a lower portion. In the heating operation, refrigerant having flowed into the lower heat exchanger passes through a path connection pipe 26, and flows out to a gas header through the upper heat exchanger.

[0061] With such a configuration, the number of paths with liquid-side refrigerant inlet/outlet ports 25 can be decreased when an outdoor heat exchanger is used as a condenser in the cooling operation. A two-phase flow of which liquid phase has been increased by progress of

condensation of refrigerant tends to decrease in a flow speed, but such a flow speed decrease can be suppressed if the number of paths with the liquid-side refrigerant inlet/outlet ports 25 can be reduced. As compared at least to one with a greater number of refrigerant paths, the refrigerant flow speed can be increased in one with a smaller number of refrigerant paths, and therefore, a thermal conductivity on a refrigerant side is likely to be high and the subcooling amount is easily ensured.

[0062] As described above, it has been known that the wind speed is higher at the upper portion of the heat exchanger and is lower at the lower portion. If the heat exchanger as shown in Fig. 7 is divided into the upper heat exchanger and the lower heat exchanger so that refrigerant can pass through both the upper and lower heat exchangers, a difference in the heat exchange amount between the refrigerant paths becomes smaller.

[0063] In the refrigerant paths shown in Fig. 6, there is a great difference in the heat exchange amount in the refrigerant path between the lower heat exchanger in which the wind speed is lower and the upper heat exchanger in which the wind speed is higher. However, in the refrigerant path configuration of Fig. 7, one refrigerant path passes through both the lower heat exchanger in which the wind speed is lower and the upper heat exchanger in which the wind speed is higher, and therefore, a difference in a total air volume between the refrigerant paths is reduced. Thus, refrigerant distribution adjustment is facilitated, and therefore, the manufacturing cost for distribution adjustment such as installation of the small-diameter pipe can be reduced.

[0064] However, in the refrigerant path configuration shown in Fig. 7, a great total number of refrigerant paths in the heat exchanger cannot be employed as compared to the number of refrigerant paths as shown in Fig. 6, and the heating capacity specifically in the heating operation cannot be improved.

First Embodiment

[0065] In view of the above-described background, a first embodiment of the present invention is intended to provide an outdoor unit of an air conditioning device configured so that a pressure loss upon use of a heat exchanger as an evaporator can be reduced and a high heating capacity and improved cooling performance can be achieved at a low cost under influence of a liquid head in association with wind speed distribution in the heat exchanger and the height of the heat exchanger.

[0066] Fig. 8 shows the structure of the heat exchanger used in the present embodiment. In the present embodiment, a windward-side first-column heat exchange unit 28 of the heat exchanger is configured such that U-shaped heat transfer pipes 22 are arranged in a row direction (a height direction), and a second-column heat exchange unit 29 and a third-column heat exchange unit 30 on the leeward side are configured such that U-shaped heat transfer pipes 22 are arranged over the second-

column heat exchange unit 29 and the third-column heat exchange unit 30. The U-shaped heat transfer pipe 22 is bent in a U-shape, and is configured such that a bent portion 22B is exposed on one surface of the heat exchanger 12 parallel with the flow of air and end portions 22E through which refrigerant flows in or out are exposed on the other surface of the heat exchanger 12 parallel with the flow of air.

[0067] Fig. 9 shows a refrigerant path configuration of the present embodiment. The heat exchanger 12 includes an upper heat exchanger 12U and a lower heat exchanger 12B, and the number of rows in the upper heat exchanger 12U is set greater than that in the lower heat exchanger 12B. In terms of the number of rows in the third-column heat exchange unit 30, the number of rows is doubled. Moreover, a refrigerant path formed by the U-shaped heat transfer pipes 22 is in a zigzag pattern as viewed in an air flow direction, and is configured so that an interval between the heat transfer pipes can be increased and an air flow pressure loss can be decreased without acceleration of the air flow.

[0068] When the heat exchanger of the present embodiment is used in heating operation, i.e., used as the evaporator, a two-phase flow having passed through an expansion valve is first distributed by way of a liquid refrigerant distributor, and thereafter, slightly passes through a small-diameter pipe for distribution adjustment and flows into two liquid-side refrigerant inlet/outlet ports 25 in Fig. 9.

[0069] The refrigerant having flowed in through each of two ports flows upward in the U-shaped heat transfer pipe of the first-column heat exchange unit 28, and then on the leeward side thereof, is distributed and flows into two U-shaped heat transfer pipes arranged over the columns of the second-column heat exchange unit 29 and the third-column heat exchange unit 30. Upon branching from the first-column heat exchange unit 28 into the second-column heat exchange unit 29, the refrigerant path is branched using a three-pronged joint 23 (see Fig. 10).

[0070] Then, the refrigerant having flowed in through two ports flows and passes through four refrigerant paths of the second-column heat exchange unit 29 and the third-column heat exchange unit 30 in the lower heat exchanger 12B. These four refrigerant paths reach the upper heat exchanger 12U through path connection pipes 26.

[0071] Next, the refrigerant having passed through four refrigerant paths, each of which is branched into two paths by a three-pronged joint 23 (see Fig. 10), of the first-column heat exchange unit 28 in the upper heat exchanger 12U flows into eight refrigerant paths between the first-column heat exchange unit 28 and the second-column heat exchange unit 29. Eventually, the gasified refrigerant flows into a gas header 24 from eight rows of the third-column heat exchange unit 30 in the upper heat exchanger 12U through eight refrigerant paths.

[0072] Note that a connection portion (the liquid-side refrigerant inlet/outlet port 25) of the lower heat exchanger

12B with the liquid refrigerant distributor is a lower end portion in the direction of the force of gravity of the U-shaped heat transfer pipe arranged in the row direction in the first-column heat exchange unit 28. Thus, in a case where the heat exchanger functions as the evaporator, refrigerant having flowed in through the liquid-side refrigerant inlet/outlet port 25 flows upward to the upper row in the same U-shaped heat transfer pipe. On the other hand, in a case where the heat exchanger functions as a condenser, the flow is reversed.

[0073] Fig. 10 shows a perspective view of the heat exchanger with a refrigerant path pipe of Fig. 9 assembled. The refrigerant path pipe includes the U-shaped heat transfer pipes 22, the three-pronged joints 23, the gas header 24, the path connection pipes 26, and the like. The U-shaped heat transfer pipe 22, the three-pronged joint 23, and the path connection pipe 26 are formed in a circular pipe shape, thereby reducing the pressure loss when the heat exchanger is used as the evaporator.

[0074] The three-pronged joints 23, the gas header 24, the end portions 22E of the U-shaped heat transfer pipes 22 as the liquid-side refrigerant inlet/outlet ports 25, and the path connection pipes 26 are arranged concentratedly on one surface of the heat exchanger parallel with the air flow, and the U-shaped bent portions 22B of the U-shaped heat transfer pipes 22 are arranged on the other surface of the heat exchanger parallel with the air flow.

[0075] As shown in Fig. 9, the first-column heat exchange unit 28 in which the U-shaped heat transfer pipes 22 are arranged in the row direction is combined with the second-column heat exchange unit 29 and the third-column heat exchange unit 30 over which the U-shaped heat transfer pipes 22 are arranged in the row direction, so that the refrigerant paths can be easily divided and increased in number only by means of the three-pronged joints 23 when refrigerant flows from the first-column heat exchange unit 28 to the second-column heat exchange unit 29.

[0076] Further, the heat exchanger is divided into the upper heat exchanger 12U and the lower heat exchanger 12B, and refrigerant passes through each heat exchanger. Thus, only by branching the refrigerant path into two paths from the first-column heat exchange unit 28 to the second-column heat exchange unit 29, one refrigerant path at the liquid-side refrigerant inlet/outlet port 25 can be easily increased to four refrigerant paths until reaching the gas header 24.

[0077] Using the path connection pipes 26, refrigerant can be branched by the three-pronged joints 23 even in the middle of moving from the refrigerant paths in the lower heat exchanger 12B to the refrigerant paths in the upper heat exchanger 12U. Thus, various refrigerant paths can be formed only by means of the three-pronged joints 23. This will be described in detail in second and third embodiments.

[0078] Although it is necessary to change the structure

of the three-pronged joint 23 in the positions of the end portions of three U-shaped heat transfer pipes 22 to be connected, inlet/outlet ports on a refrigerant path side are designed so that a common three-pronged joint 23 can be easily used. That is, the refrigerant paths can be formed only by the three-pronged joints 23 having the same shape. With this configuration, a component cost can be reduced without the need for newly preparing three-pronged joints having different shapes.

[0079] In the refrigerant paths of the present embodiment shown in Fig. 9, the gas header 24 is connected to all the U-shaped heat transfer pipes 22 of 2/3 of the rows in the third-column heat exchange unit 30 in the upper heat exchanger 12U. On the other hand, the liquid-side refrigerant inlet/outlet ports 25 for the liquid refrigerant distributor are connected to all the U-shaped heat transfer pipes 22 of 1/3 of the rows in the first-column heat exchange unit 28 in the lower heat exchanger 12B.

[0080] With this configuration, the number of refrigerant paths connected to the gas header 24 in Fig. 9 is eight refrigerant paths, which is greater than six refrigerant paths (the maximum number of refrigerant paths) in the typical heat exchanger shown in Fig. 6. Thus, the pressure loss when the heat exchanger is used as the evaporator can be effectively reduced.

[0081] Of the typical refrigerant paths of Fig. 6, the number of refrigerant paths connected to the gas header can be increased only to the half of the total row number at the maximum. However, in the present embodiment, the heat exchanger can be divided into the upper heat exchanger and the lower heat exchanger, and in addition, the number of refrigerant paths can be increased to the same number as the number of rows in the upper heat exchanger.

[0082] In the typical refrigerant path configuration as shown in Fig. 6, when the heat exchanger is, for example, used as the evaporator, if refrigerant having entered the first-column heat exchange unit 28 is equally distributed to the U-shaped heat transfer pipe of the second-column heat exchange unit 29 and the U-shaped heat transfer pipe of the third-column heat exchange unit 30, the refrigerant having flowed into the third-column heat exchange unit 30 might not be sufficiently evaporated because of a smaller amount of heat exchange in the third-column heat exchange unit 30 than that in the second-column heat exchange unit 29.

[0083] On the other hand, in the configuration in which the U-shaped heat transfer pipes 22 each placed over two columns of the heat exchange units on the leeward side are arranged in the row direction as in the present embodiment, there is no great difference in the heat exchange amount between two U-shaped heat transfer pipes 22. That is, even if refrigerant having entered the first-column heat exchange unit 28 is equally supplied to the leeward-side U-shaped heat transfer pipes 22 placed over two columns, such distribution does not lead to performance degradation.

[0084] In addition, in the refrigerant paths of the

present embodiment, refrigerant passes through both the upper heat exchanger 12U and the lower heat exchanger 12B, and therefore, effects similar to those of the refrigerant paths shown in Fig. 7 are produced. That is, it is not necessary to consider refrigerant amount distribution adjustment in association with wind speed distribution, an adjustment pressure loss body design, and performance degradation due to insufficient adjustment.

[0085] In the present embodiment, when the heat exchanger is used as the condenser in cooling operation, refrigerant gas having flowed in from the gas header 24 passes through the refrigerant paths provided in the upper heat exchanger 12U (an upper 2/3 region of the heat exchanger 12) from the leeward side to the windward side, and thereafter, passes through a subcooling region provided at the lower heat exchanger 12B (a lower 1/3 region of the heat exchanger 12) from the leeward side to the windward side. Since the liquid-side refrigerant inlet/outlet ports 25 of the refrigerant paths provided in the region of the lower heat exchanger 12B are connected to the liquid refrigerant distributor, a head difference between the liquid-side inlet/outlet ports 25 can be reduced.

[0086] When refrigerant flows from the refrigerant paths provided in the upper heat exchanger 12U to the refrigerant paths provided in the lower heat exchanger 12B, the refrigerant paths are joined such that the number of refrigerant paths is decreased. Thus, a refrigerant flow speed on a liquid side can be improved, and therefore, liquid refrigerant cooling performance can be enhanced.

[0087] In the air conditioning device, an increase in the degree of subcooling of refrigerant at the outlet of the condenser in the cooling operation leads to improvement in the performance. Thus, the subcooling region is provided in the lower heat exchanger 12B, so that the head difference can be eliminated, and in addition, the performance of the heat exchanger can be improved.

[0088] The present embodiment has been described using 12 rows of the heat exchanger in Fig. 9, but actually, it is assumed that 60 rows of the heat exchanger are employed with a row pitch of 20 mm. In this case, the height of the heat exchanger is about 1.2 m. Since the same ratio is applied, the upper heat exchanger 12U has 40 rows, and the number of connection paths for the gas header 24 is also 40. Similarly, the lower heat exchanger 12B has 20 rows, and the number of liquid-side refrigerant inlet/outlet ports 25 is 10. Note that in the heat exchanger 12 used in the present embodiment, the upper heat exchanger 12U and the lower heat exchanger 12B are formed to be arranged in the height direction on an installation surface of a bottom installation board 18 on which the heat exchanger 12 is placed, and the total length of the upper heat exchanger 12U and the lower heat exchanger 12B in the height direction is preferably 1 m or more.

[0089] Assuming that this heat exchanger is used as the evaporator in the heating operation, refrigerant divided into 10 paths after having passed through the expansion valve and the liquid refrigerant distributor flows into

10 liquid-side refrigerant inlet/outlet ports 25. The refrigerant having passed through the first-column heat exchange unit 28 in the lower heat exchanger 12B through 10 refrigerant paths is branched such that each refrigerant path is branched into two paths by the three-pronged joint 23 when reaching the second-column heat exchange unit 29, and therefore, passes through two columns of the leeward-side heat exchange units 29, 30 through 20 refrigerant paths in the lower heat exchanger 12B.

[0090] Then, the refrigerant having passed through 20 path connection pipes 26 passes through the first-column heat exchange unit 28 of the upper heat exchanger 12U through 20 refrigerant paths. When reaching the second-column heat exchange unit 29 from the first-column heat exchange unit 28 in the upper heat exchanger 12U, each refrigerant path is further branched into two paths by the three-pronged joint 23, and the refrigerant passes through two columns of the leeward-side heat exchange units 29, 30 through 40 refrigerant paths in the upper heat exchanger. Since 40 refrigerant paths are connected to the gas header 24, the refrigerant flows into the four-way valve after having been joined together in the gas header.

[0091] According to the present embodiment as described above, in the heat exchanger using the circular U-shaped heat transfer pipes, the refrigerant paths can be formed in two stages of the upper heat exchanger and the lower heat exchanger while the number of refrigerant paths on a gas side is ensured.

[0092] With this configuration, influence of wind speed distribution in each refrigerant path can be reduced, and therefore, a cost for distribution adjustment can be reduced. Even in a top flow type heat exchanger having a great height, liquid-side refrigerant inlet/outlet ports are concentrated on a lower heat exchanger, and therefore, a liquid head difference upon use as a condenser can be reduced and cooling performance can be improved.

[0093] Since the number of refrigerant paths in the lower heat exchanger can be reduced, a subcooling amount can be easily ensured and the cooling performance can be improved upon used as the condenser. Using the three-pronged joint, refrigerant is easily branched into two paths when flowing from the first-column heat exchange unit to the second-column heat exchange unit. Only the three-pronged joint is used for the first-column heat exchange unit and the second-column heat exchange unit in the upper heat exchanger and the lower heat exchanger, so that the number of refrigerant paths connected to the gas header can be easily increased to four times as many as the number of refrigerant paths of the liquid-side refrigerant inlet/outlet ports.

[0094] The three-pronged joint can be produced at a lower cost than that of a distributor or a distribution joint with three or more branches, and therefore, formation of the refrigerant paths only by the three-pronged joints leads to cost reduction.

[0095] In the present embodiment, the lowermost re-

frigerant path in which the wind speed is low is connected to the uppermost refrigerant path in which the wind speed is high. With this configuration, the air volume received by one refrigerant path is relatively uniform between the upper and lower portions of the heat exchanger. Thus, specifically in the case of use as the evaporator, a refrigerant distribution amount is relatively uniform among the refrigerant paths, and therefore, the heating performance can be improved.

[0096] That is, in the typical refrigerant path, it is necessary to adjust the refrigerant distribution amount according to wind speed distribution, and the small-diameter pipe is provided between the liquid refrigerant distributor and the liquid-side refrigerant path to adjust the distribution amount by, e.g., the length of the small-diameter pipe. For this reason, it is difficult to constantly adjust a distribution ratio to an optimal distribution ratio according to each refrigerant circulation amount. However, if the distribution ratio can be adjusted substantially uniformly, adjustment for each refrigerant path by the small-diameter pipe is not necessary. Even if the refrigerant circulation amount changes, performance close to an optimal level can be provided.

[0097] According to the present embodiment, in the heat exchanger using the circular pipes, a high heating capacity and improved cooling performance can be achieved at a low cost under the influence of the liquid head in association with wind speed distribution in the heat exchanger and the height of the heat exchanger.

Second Embodiment

[0098] Next, the second embodiment of the present invention will be described. Fig. 11 shows refrigerant paths of the present embodiment. In the first embodiment, the number of refrigerant paths is increased using the three-pronged joints 23 in the lower heat exchanger 12B. However, in the present embodiment, a configuration is proposed, in which the number of paths is not increased using three-pronged joints 23 in a lower heat exchanger 12B and each refrigerant path is branched into two paths by the three-pronged joint 23 at a position before a first-column heat exchange unit 28 in an upper heat exchanger 12U such that the number of refrigerant paths is increased.

[0099] In Fig. 11, when a heat exchanger is used as an evaporator in heating operation, refrigerant having entered a U-shaped heat transfer pipe of the first-column heat exchange unit 28 in the lower heat exchanger 12B flows into a U-shaped heat transfer pipe, which is placed over two columns, of a second-column heat exchange unit 29 on the leeward side of the U-shaped heat transfer pipe of the first-column heat exchange unit 28. Thereafter, the refrigerant having flowed from a third-column heat exchange unit 30 through the U-shaped heat transfer pipe placed over the columns flows toward an upper heat exchanger 12U side through a path connection pipe 26.

[0100] The refrigerant path is branched into two paths

by the three-pronged joint 23 at the position immediately before the first-column heat exchange unit 28 in the upper heat exchanger 12U such that the number of refrigerant paths is increased. After having passed through the first-column heat exchange unit 28, the refrigerant path is further branched into two paths by the three-pronged joint 23 at a position immediately before the second-column heat exchange unit 29 such that the number of refrigerant paths is increased.

[0101] On the other hand, when the heat exchanger is used as a condenser in cooling operation, the flow of refrigerant is opposite to the flow of refrigerant as described above in the case of the evaporator. That is, gas refrigerant having flowed into the upper heat exchanger 12U from a gas header through eight refrigerant paths passes through two columns of the leeward-side heat exchange units 29, 30 in the upper heat exchanger 12U, and thereafter, passes through the first-column heat exchange unit 28 in the upper heat exchanger 12U through four refrigerant paths converged from eight refrigerant paths by the three-pronged joints 23.

[0102] Further, the refrigerant having passed through the first-column heat exchange unit 28 in the upper heat exchanger 12U passes through two refrigerant paths converged from four refrigerant paths by the three-pronged joints 23, and flows into the lower heat exchanger 12B through two path connection pipes 26. In the lower heat exchanger, the refrigerant flows out of liquid-side refrigerant outlet ports 25 to a liquid refrigerant distributor through two refrigerant paths.

[0103] The same number of refrigerant paths as that of the liquid-side refrigerant inlet/outlet ports is formed across the entirety of the lower heat exchanger 12B, and therefore, a region where the flow speed of refrigerant is high is expanded and a subcooling amount is more easily ensured. Thus, a cooling capacity can be improved in such a manner that the number of refrigerant paths is not increased in the lower heat exchanger, as described above.

Third Embodiment

[0104] Next, the third embodiment of the present invention will be described. Fig. 12 shows refrigerant paths of the present embodiment. In the first embodiment, the number of refrigerant paths is increased using the three-pronged joints 23 in the lower heat exchanger 12B. However, in the present embodiment, a configuration is proposed, in which the number of refrigerant paths is increased using three-pronged joints 23 in a lower heat exchanger 12B and is subsequently changed back to an initial number and each refrigerant path is branched into two paths by a three-pronged joint 23 at a position before a first-column heat exchange unit 28 in an upper heat exchanger 12U such that the number of refrigerant paths is increased.

[0105] In Fig. 12, when a heat exchanger is used as an evaporator in heating operation, a two-phase flow of

refrigerant having passed through an expansion valve is first distributed by way of a liquid refrigerant distributor, and thereafter, slightly passes through a small-diameter pipe for distribution adjustment and flows into two liquid-side refrigerant inlet/outlet ports 25.

[0106] The refrigerant having flowed in through each of two liquid-side refrigerant inlet/outlet ports 25 flows upward in a U-shaped heat transfer pipe of the first-column heat exchange unit 28, and then immediately on the leeward side thereof, is distributed and flows into two U-shaped heat transfer pipes arranged over a second-column heat exchange unit 29 and a third-column heat exchange unit 30. Upon branching from the first-column heat exchange unit 28 into the second-column heat exchange unit 29, the refrigerant path is branched using the three-pronged joint 23 as already described above.

[0107] Then, the refrigerant having passed through the third-column heat exchange unit 30 flows into one refrigerant path converged from two refrigerant paths by a three-pronged joint 23, and reaches the upper heat exchanger 12U through a path connection pipe 26. Before reaching the first-column heat exchange unit 28 in the upper heat exchanger, the refrigerant path is branched into two paths again by a three-pronged joint 23, and the refrigerant flows into the first-column heat exchange unit 28 in the upper heat exchanger 12U through these two branched refrigerant paths.

[0108] Each refrigerant path is further branched into two paths by a three-pronged joint 23 between the first-column heat exchange unit 28 and the second-column heat exchange unit 29 in the upper heat exchanger 12U such that the number of refrigerant paths is increased. Eventually, the gasified refrigerant flows into a gas header 24 from eight (all) refrigerant paths of the third-column heat exchange unit 30 in the upper heat exchanger 12U.

[0109] With such a configuration, the number of path connection pipes in the middle can be two which is the half of that in the case of the refrigerant paths described in the first embodiment, and therefore, an increase in a manufacturing cost can be restrained.

[0110] In the present embodiment, a lower refrigerant path in which the wind speed is low is connected to an upper refrigerant path in which the wind speed is high. With this configuration, the air volume received by one refrigerant path is relatively uniform between the upper and lower portions of the heat exchanger. Thus, specifically in the case of use as the evaporator, a refrigerant distribution amount is relatively uniform among the refrigerant paths, and therefore, the heating performance can be improved.

[0111] That is, in the typical refrigerant path, it is necessary to adjust the refrigerant distribution amount according to wind speed distribution, and the small-diameter pipe is provided between the liquid refrigerant distributor and the liquid-side refrigerant path to adjust the distribution amount by, e.g., the length of the small-diameter pipe. For this reason, it is difficult to constantly adjust a distribution ratio to an optimal distribution ratio

according to each refrigerant circulation amount. However, if the distribution ratio can be adjusted substantially uniformly, adjustment for each refrigerant path by the small-diameter pipe is not necessary. Even if the refrigerant circulation amount changes, performance close to an optimal level can be provided.

[0112] In the present embodiment, the liquid-side refrigerant outlet in the lower heat exchanger is on the lower side of the U-shaped heat transfer pipe of the first-column heat exchange unit in the direction of the force of gravity. This is effective for enhancing drainability of liquid refrigerant from the heat transfer pipe by action of the force of gravity as much as possible and improving cooling performance when the heat exchanger is used as the condenser in the cooling operation.

[0113] Preferably in the first to third embodiments described above, the number of refrigerant paths (e.g., eight refrigerant paths) formed by the U-shaped heat transfer pipes of the upper heat exchanger 12U connected to the gas header 24 is preferably four times as many as the number of refrigerant paths (e.g., two refrigerant paths) formed by the U-shaped heat transfer pipes of the lower heat exchanger 12B connected to the liquid refrigerant distributor. With this configuration, the heating capacity and the cooling performance can be improved as described above.

[0114] Note that the present invention is not limited to the above-described embodiments, and includes various modifications. For example, the embodiments have been described above in detail in order to simply describe the present invention, and are not limited to those having all configurations described above. In addition, part of the configuration of a certain embodiment can be replaced with the configuration of another embodiment, and the configuration of a certain embodiment can be added to the configuration of another embodiment. Further, addition/omission/replacement of other configurations can be made to part of the configuration of each embodiment.

LIST OF REFERENCE SIGNS

[0115]

9	Refrigerant Pipe
10	Compressor
11	Refrigerant Tank
12	Heat Exchanger
12B	Lower Heat Exchanger
12U	Upper Heat Exchanger
13	Outdoor Blower Fan
14	Accumulator
15	Front Panel
16	Bell Mouth
17	Control Panel
18	Bottom Installation Board
19	Four-Way Valve
20	Outdoor Expansion Valve
21	Heat Exchange Fin

22	U-shaped Heat Transfer Pipe
22B	Bent Portion
22E	End Portion
23	Three-Pronged Joint
5 24	Gas Header
25	Liquid-Side Refrigerant Inlet/Outlet Port
26	Path Connection Pipe
28	First-Column Heat Exchange Unit
29	Second-Column Heat Exchange Unit
10 30	Third-Column Heat Exchange Unit
100	Outdoor Unit
101	Liquid-Side Connection Pipe
102	Gas-Side Connection Pipe
103	Indoor Unit
15 104	Indoor Heat Exchanger
105	Indoor Fan
106	Indoor Expansion Valve
300	Room

Claims

1. An outdoor unit of an air conditioning device, comprising at least: a compressor; a blower fan; and a heat exchanger,

wherein the blower fan is mounted above the heat exchanger,

the heat exchanger includes an upper heat exchanger and a lower heat exchanger, and the upper heat exchanger and the lower heat exchanger each include: a U-shaped heat transfer pipe formed of a circular pipe bent in a U-shape; a heat exchange fin; a liquid refrigerant distributor; a gas header; and a path connection pipe connecting end portions of the U-shaped heat transfer pipes,

the heat exchanger includes three columns of heat exchange units arranged along an air flow direction,

a first-column heat exchange unit as a windward-side heat exchange unit is configured such that the U-shaped heat transfer pipes are arranged in a row direction, and the U-shaped heat transfer pipes are arranged over two columns of a second-column heat exchange unit and a third-column heat exchange unit on a leeward side,

end portions of the U-shaped heat transfer pipes of the third-column heat exchange unit in the upper heat exchanger are connected to the gas header, a number of refrigerant paths connected to the gas header is greater than a half of a total row number in the heat exchanger, and a number of rows in the upper heat exchanger is equal to the number of refrigerant paths connected to the gas header,

end portions of the U-shaped heat transfer pipes

- of the first-column heat exchange unit in the lower heat exchanger are connected to the liquid refrigerant distributor, and
 an end portion of each U-shaped heat transfer pipe of the third-column heat exchange unit in the lower heat exchanger is connected to an end portion of a corresponding one of the U-shaped heat transfer pipes of the first-column heat exchange unit in the upper heat exchanger through the path connection pipe. 5 10
2. The outdoor unit of the air conditioning device according to claim 1, wherein
- the upper heat exchanger and the lower heat exchanger are formed in a height direction on a ground surface on which the heat exchanger is placed, and
 a total length of the upper heat exchanger and the lower heat exchanger in the height direction is 1 m or more. 15 20
3. The outdoor unit of the air conditioning device according to claim 1, wherein a number of refrigerant paths formed by the U-shaped heat transfer pipes connected to the gas header is set to be four times as many as a number of refrigerant paths formed by the U-shaped heat transfer pipes connected to the liquid refrigerant distributor. 25 30
4. The outdoor unit of the air conditioning device according to claim 3, wherein
- each refrigerant path of the lower heat exchanger connected to the liquid refrigerant distributor is branched into two paths by a three-pronged joint after having passed through the first-column heat exchange unit, and the two-branched refrigerant paths pass through the second-column heat exchange unit and the third-column heat exchange unit in the lower heat exchanger, and
 each of the two branched refrigerant paths is further branched into two paths by a three-pronged joint after having passed through the first-column heat exchange unit in the upper heat exchanger, and the two further-branched refrigerant paths pass through the second-column heat exchange unit and the third-column heat exchange unit in the upper heat exchanger and are connected to the gas header. 35 40 45 50
5. The outdoor unit of the air conditioning device according to claim 3, wherein
- each refrigerant path of the lower heat exchanger connected to the liquid refrigerant distributor passes through the second-column heat ex- 55

change unit and the third-column heat exchange unit in the lower heat exchanger after having passed through the first-column heat exchange unit,
 the each refrigerant path having passed through the third-column heat exchange unit in the lower heat exchanger is branched into two paths by a three-pronged joint before passing through the first-column heat exchange unit in the upper heat exchanger, and
 each of the two branched refrigerant paths is further branched into two paths by a three-pronged joint after having passed through the first-column heat exchange unit in the upper heat exchanger, and the two further-branched refrigerant paths pass through the second-column heat exchange unit and the third-column heat exchange unit in the upper heat exchanger and are connected to the gas header.

6. The outdoor unit of the air conditioning device according to claim 3, wherein
- each refrigerant path of the lower heat exchanger connected to the liquid refrigerant distributor is branched into two paths by a three-pronged joint after having passed through the first-column heat exchange unit, and the two branched refrigerant paths pass through the second-column heat exchange unit and the third-column heat exchange unit in the lower heat exchanger and are joined together by a three-pronged joint after having passed through the third-column heat exchange unit,
 the joined refrigerant path having passed through the third-column heat exchange unit in the lower heat exchanger is branched into two paths by a three-pronged joint before passing through the first-column heat exchange unit in the upper heat exchanger, and
 each of the two branched refrigerant paths is further branched into two paths by a three-pronged joint after having passed through the first-column heat exchange unit in the upper heat exchanger, and the two further-branched refrigerant paths pass through the second-column heat exchange unit and the third-column heat exchange unit in the upper heat exchanger and are connected to the gas header.
7. The outdoor unit of the air conditioning device according to any one of claims 4 to 6, wherein a connection portion of the lower heat exchanger with the liquid refrigerant distributor is a lower end portion in a direction of a force of gravity of each U-shaped heat transfer pipe arranged in the row direction in the first-column heat exchange unit.

8. The outdoor unit of the air conditioning device according to any one of claims 4 to 6, wherein at least the three-pronged joints, the gas header, the end portions of the U-shaped heat transfer pipes, and the path connection pipes are concentratedly arranged on one surface of the heat exchanger parallel with a flow of air passing through the heat exchanger.

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FIG. 1

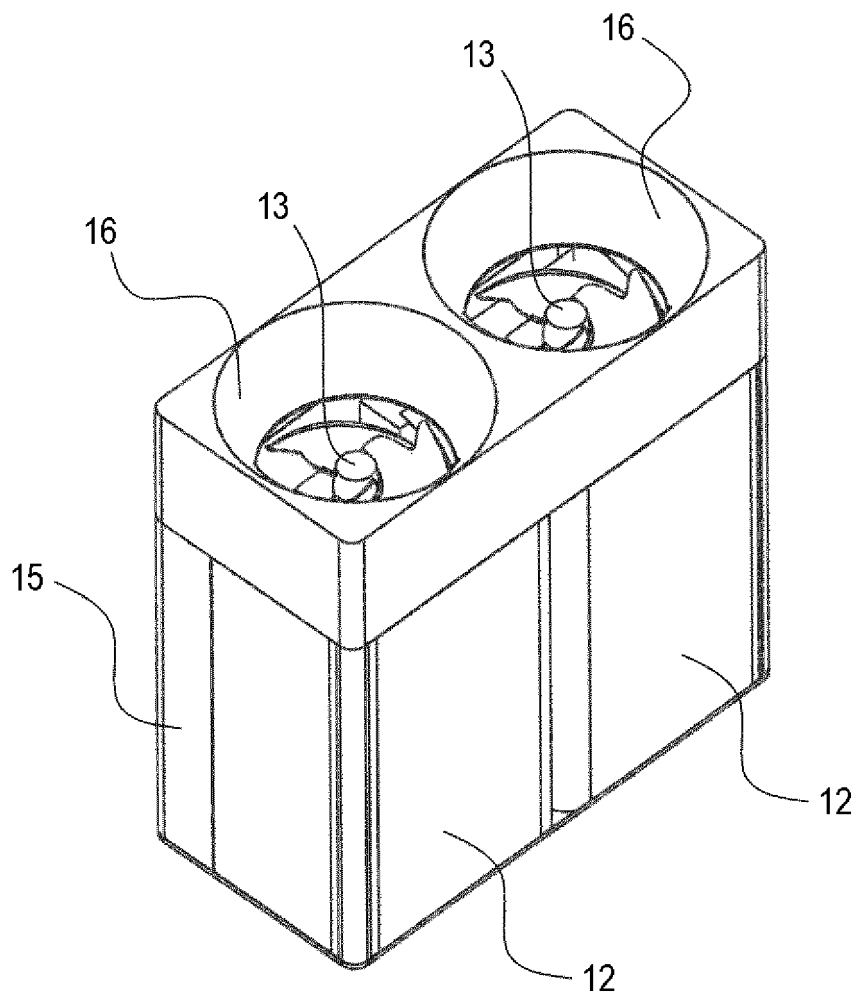


FIG. 2

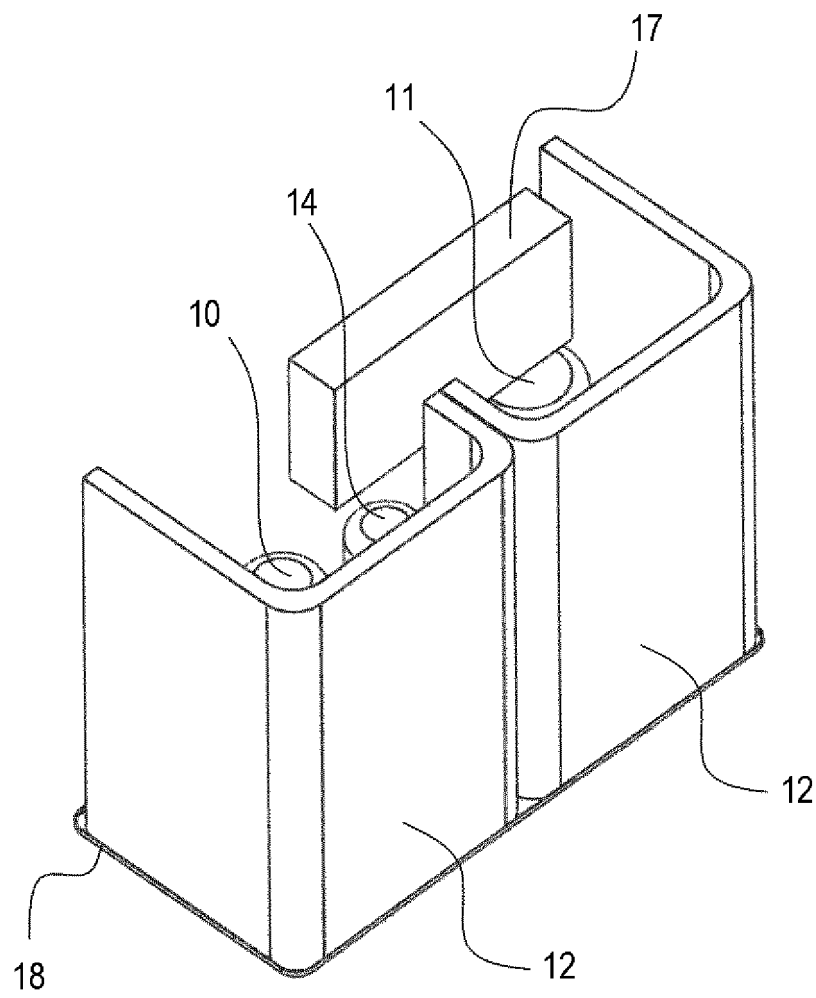


FIG. 3

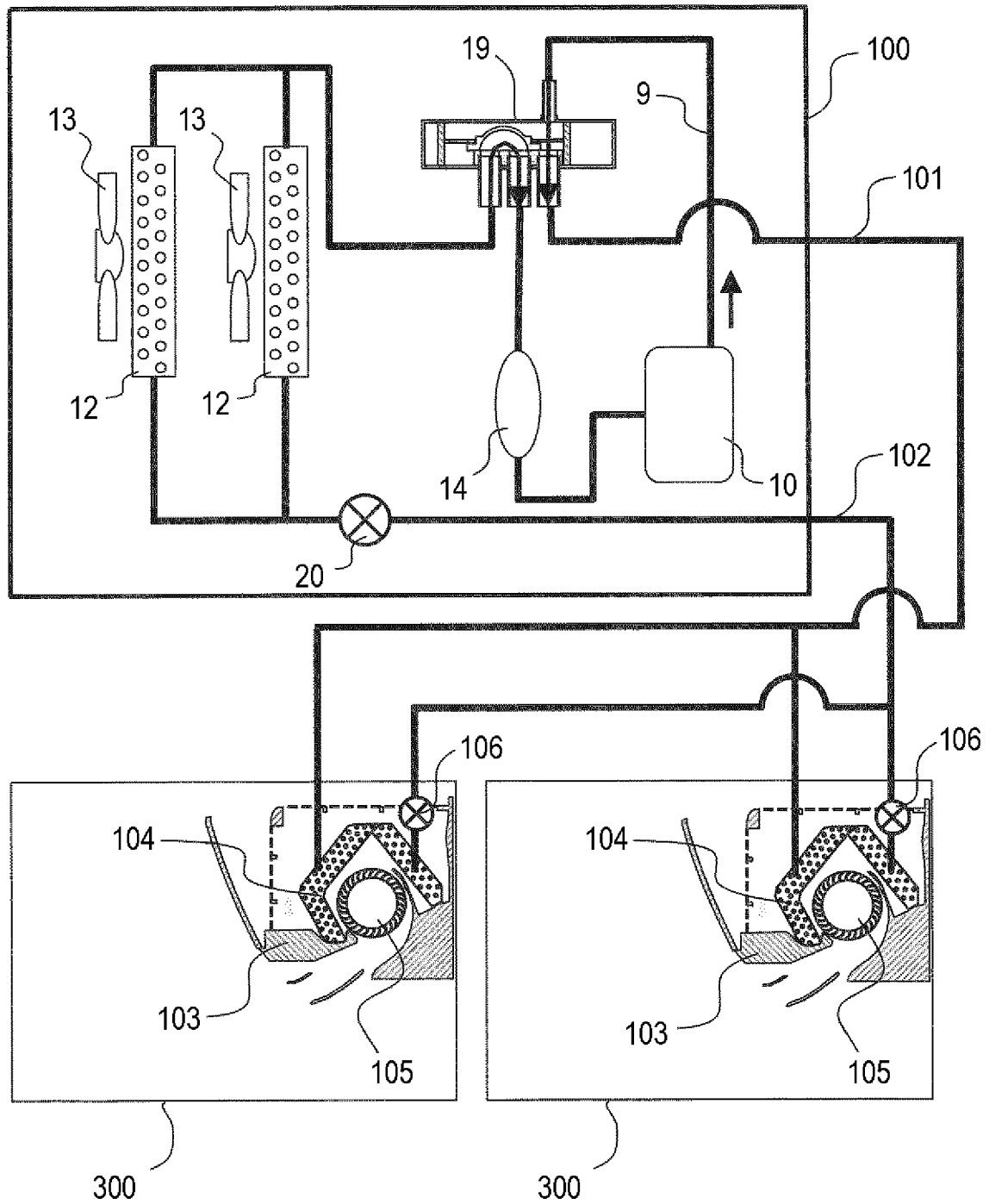


FIG. 4

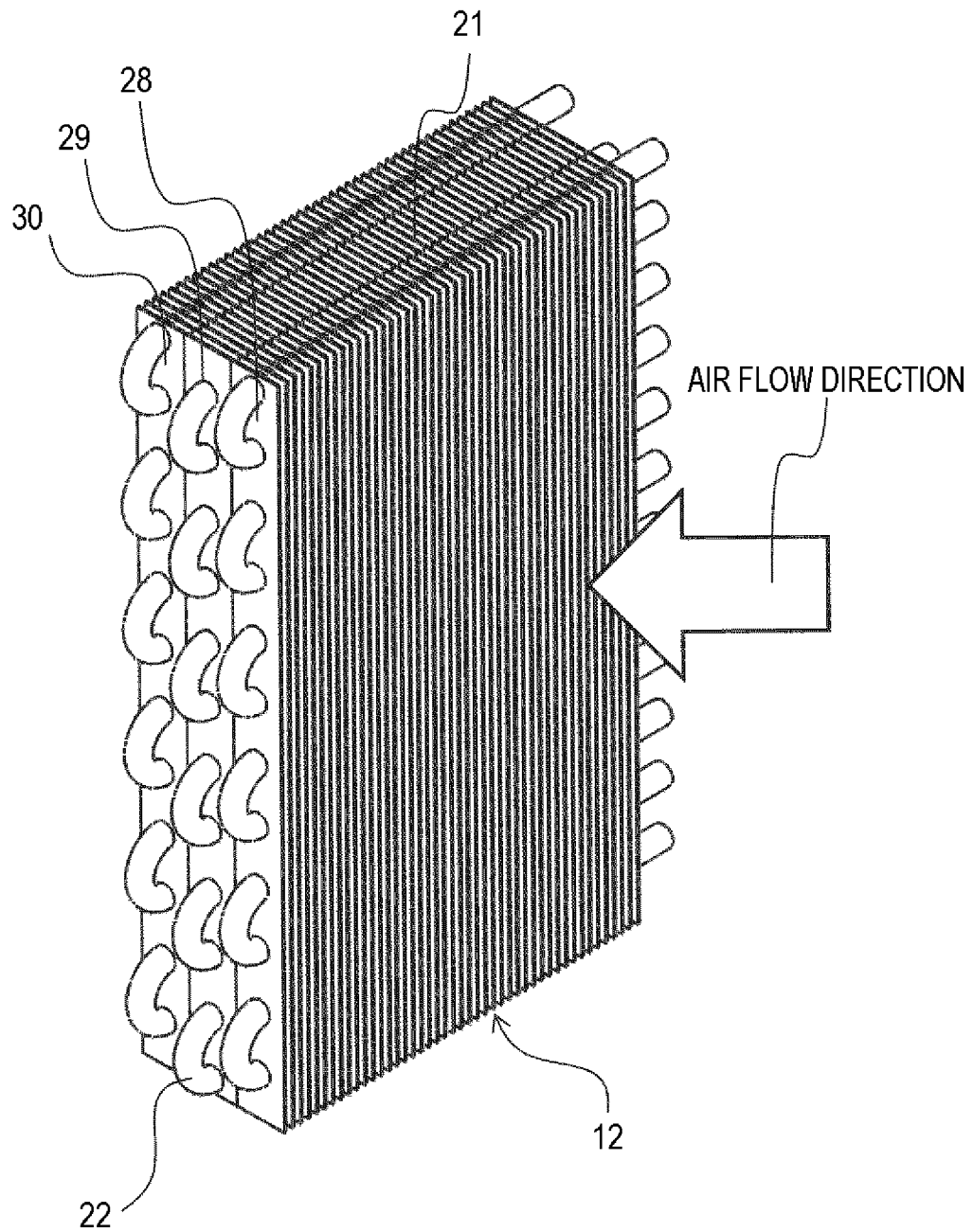


FIG. 5

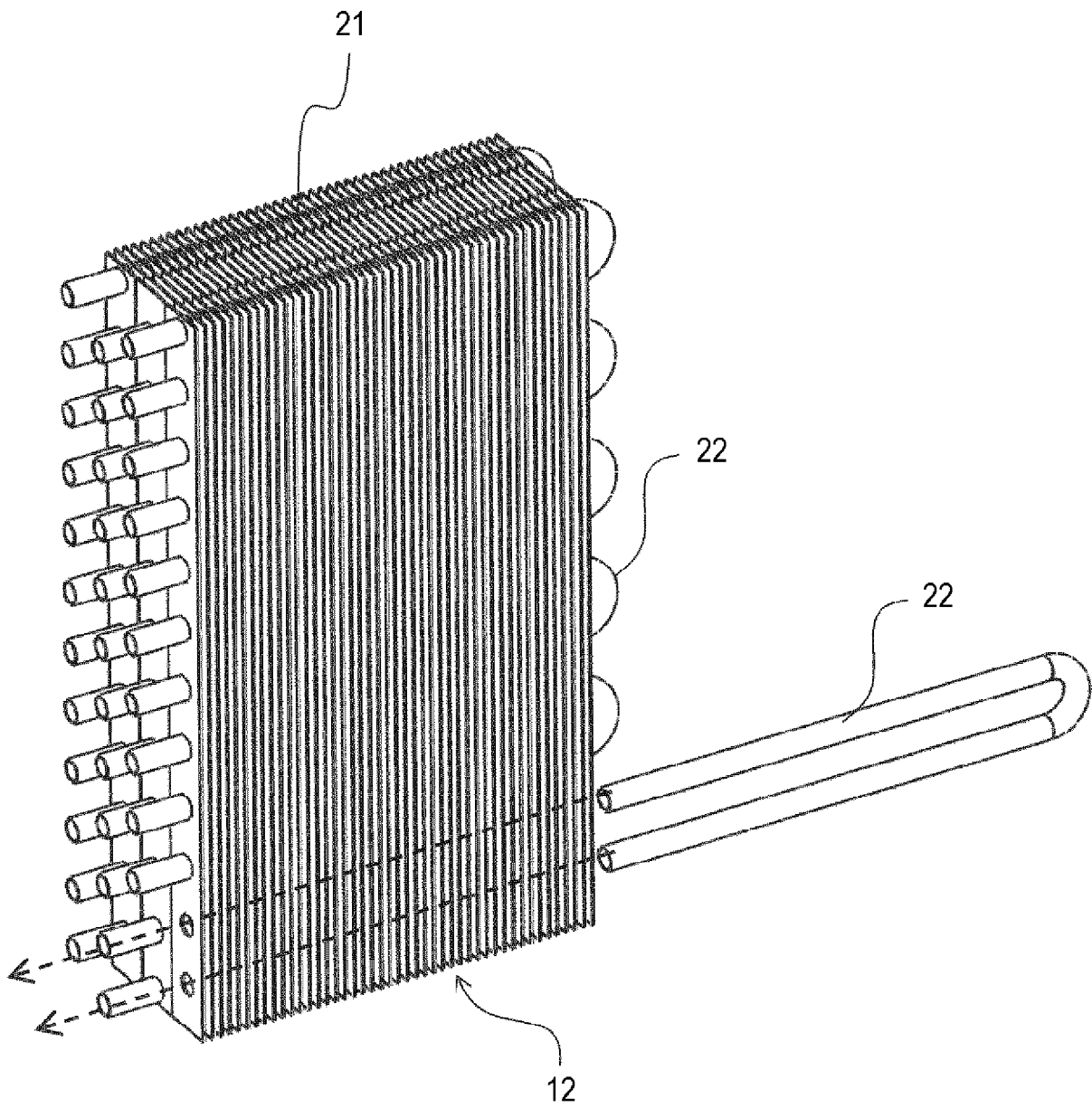


FIG. 6

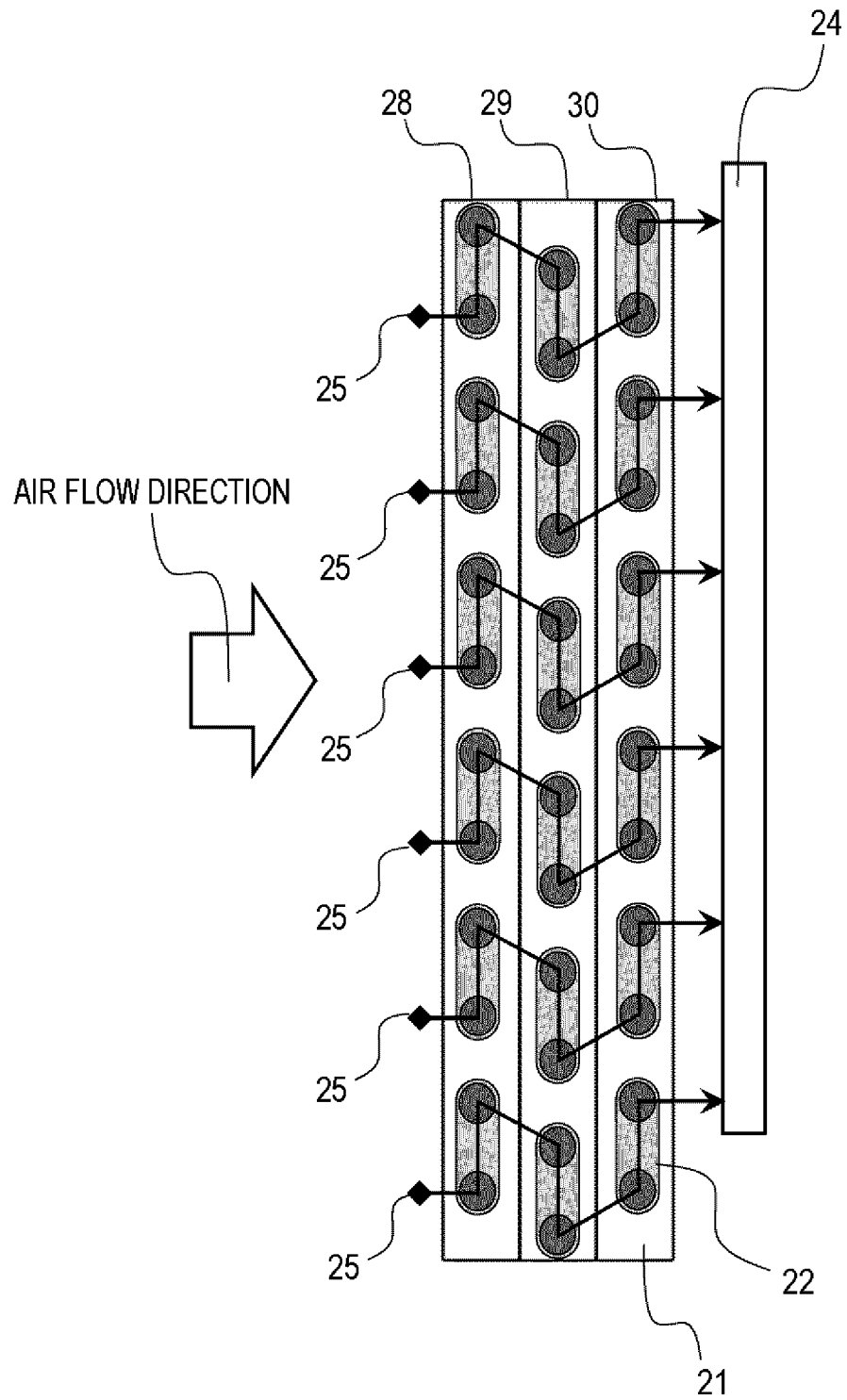


FIG. 7

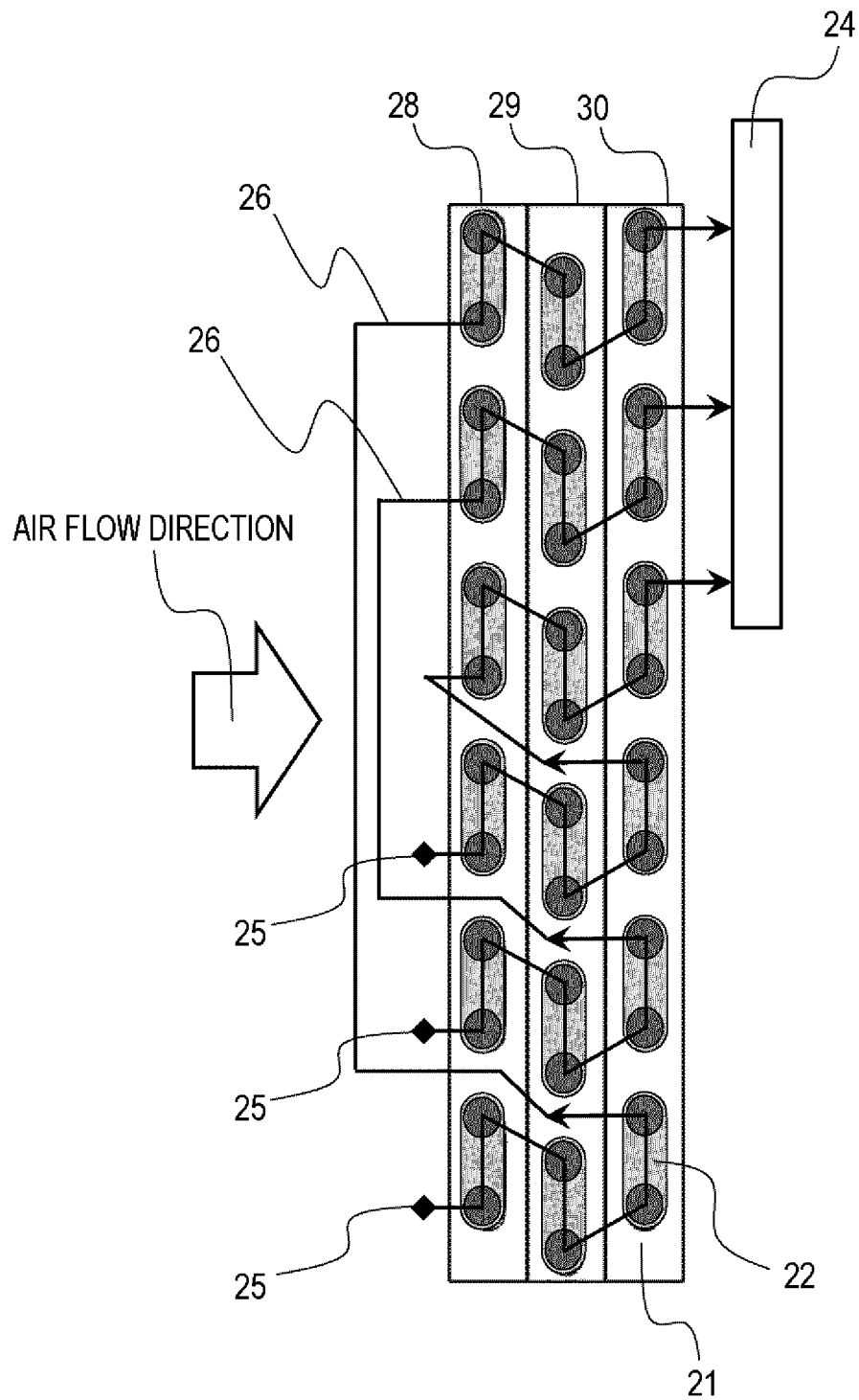


FIG. 8

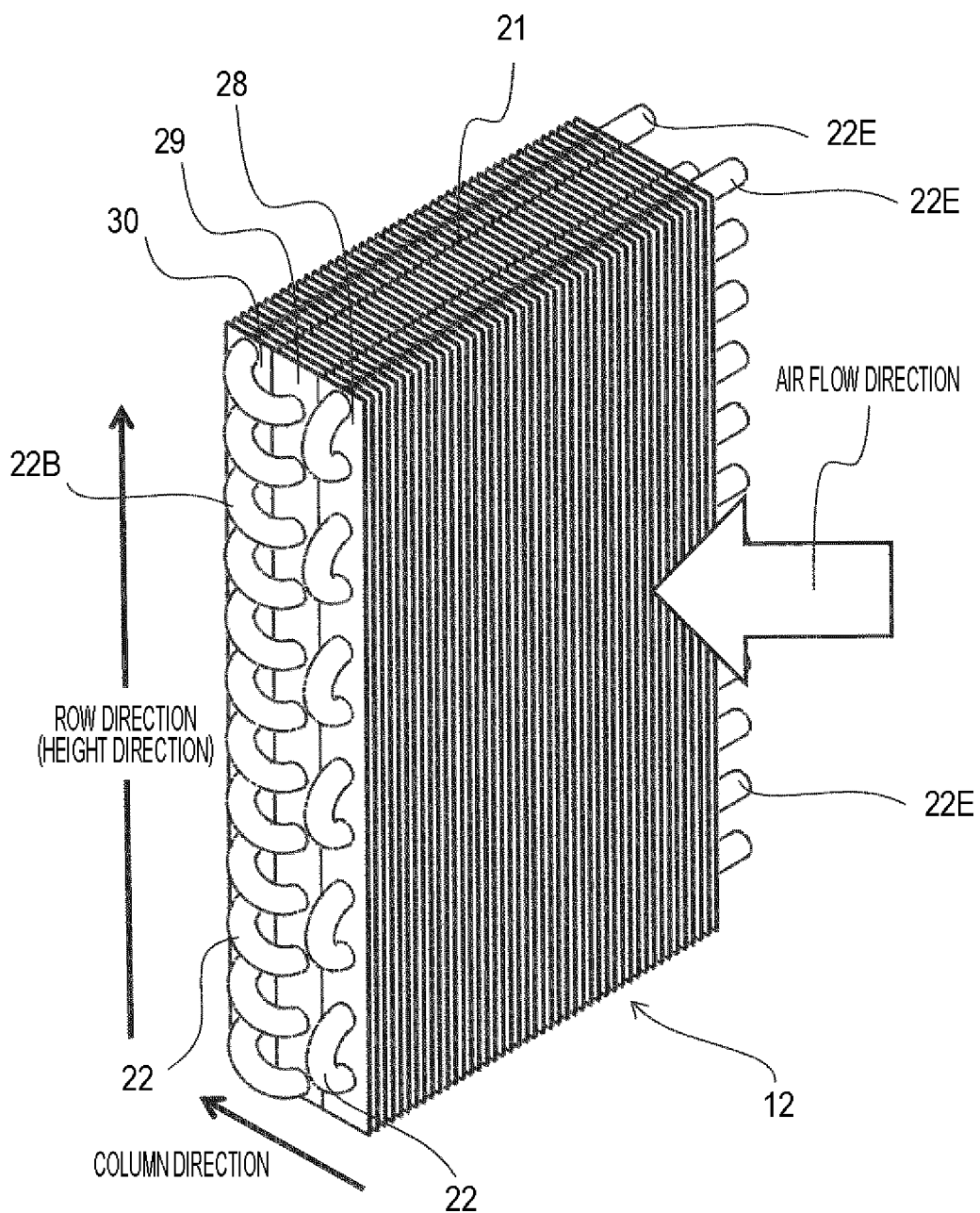


FIG. 9

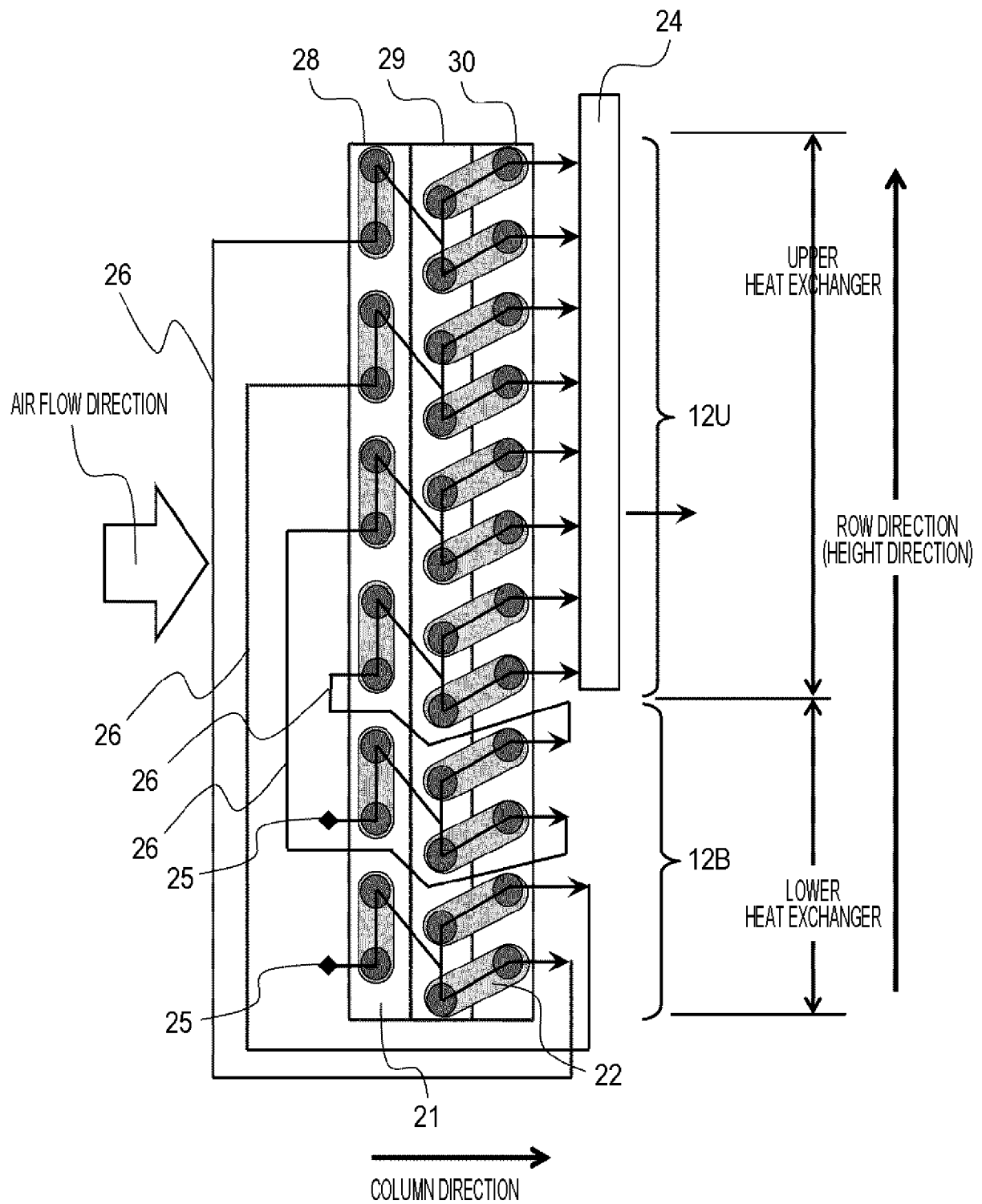


FIG. 10

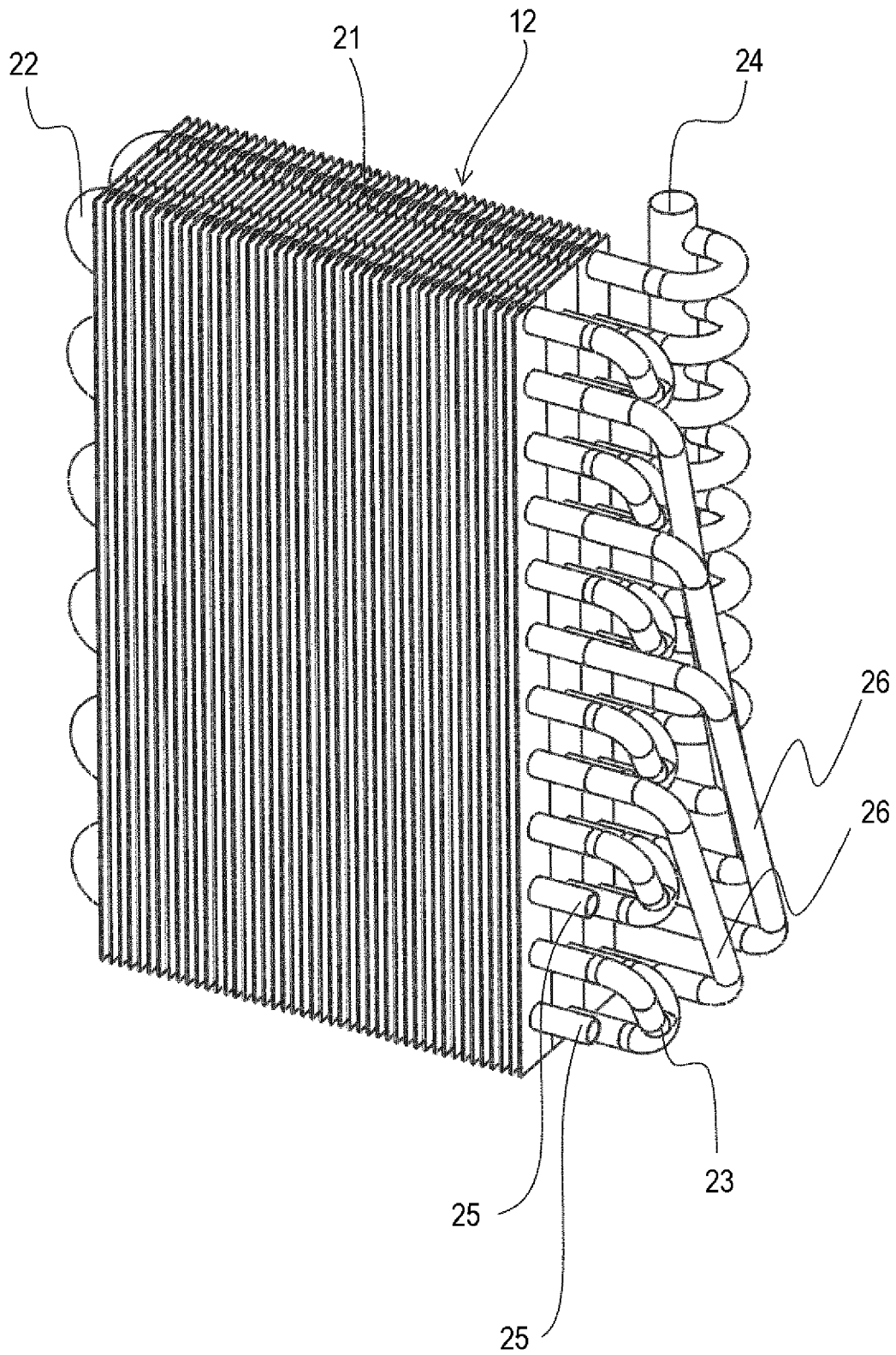


FIG. 11

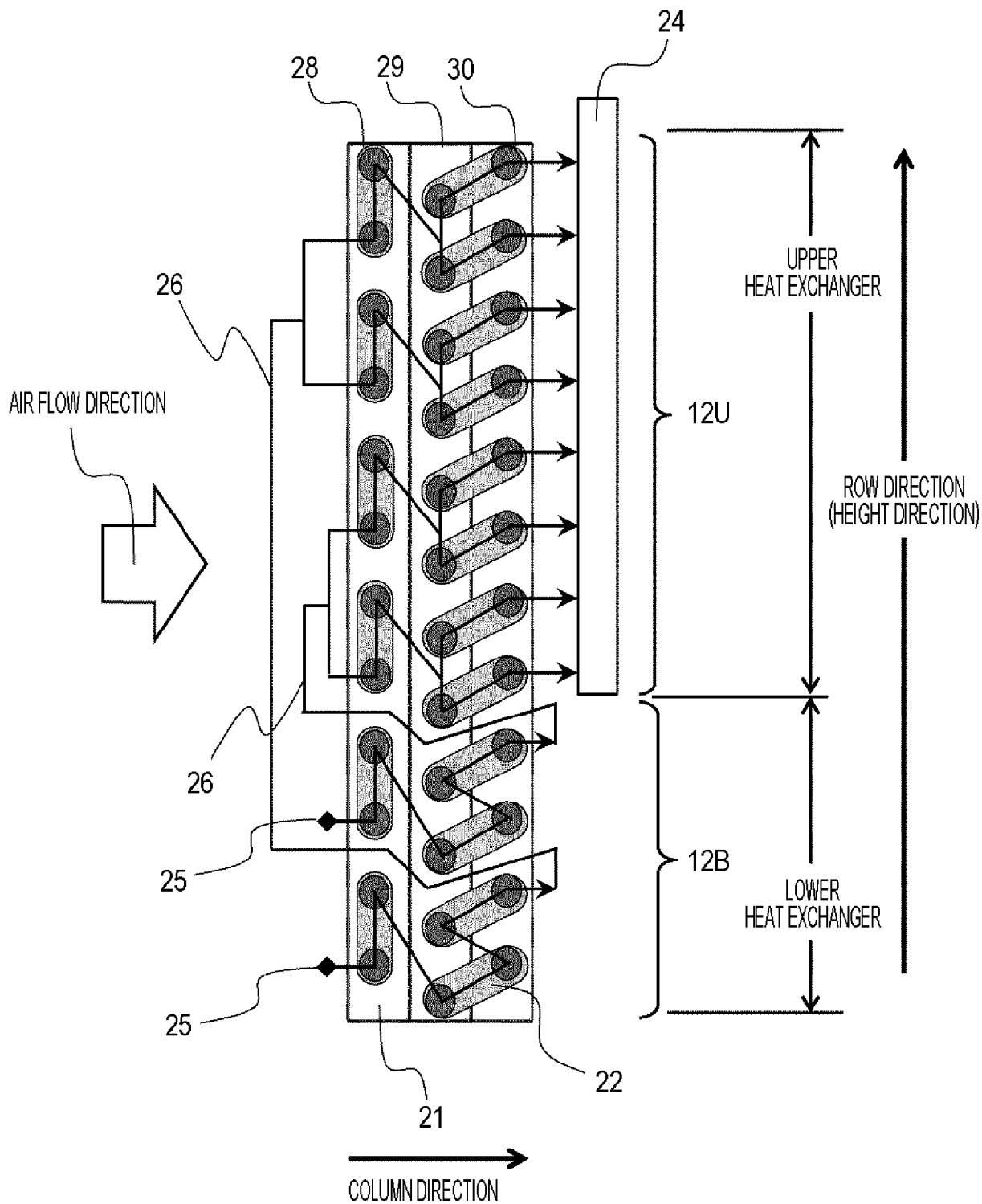
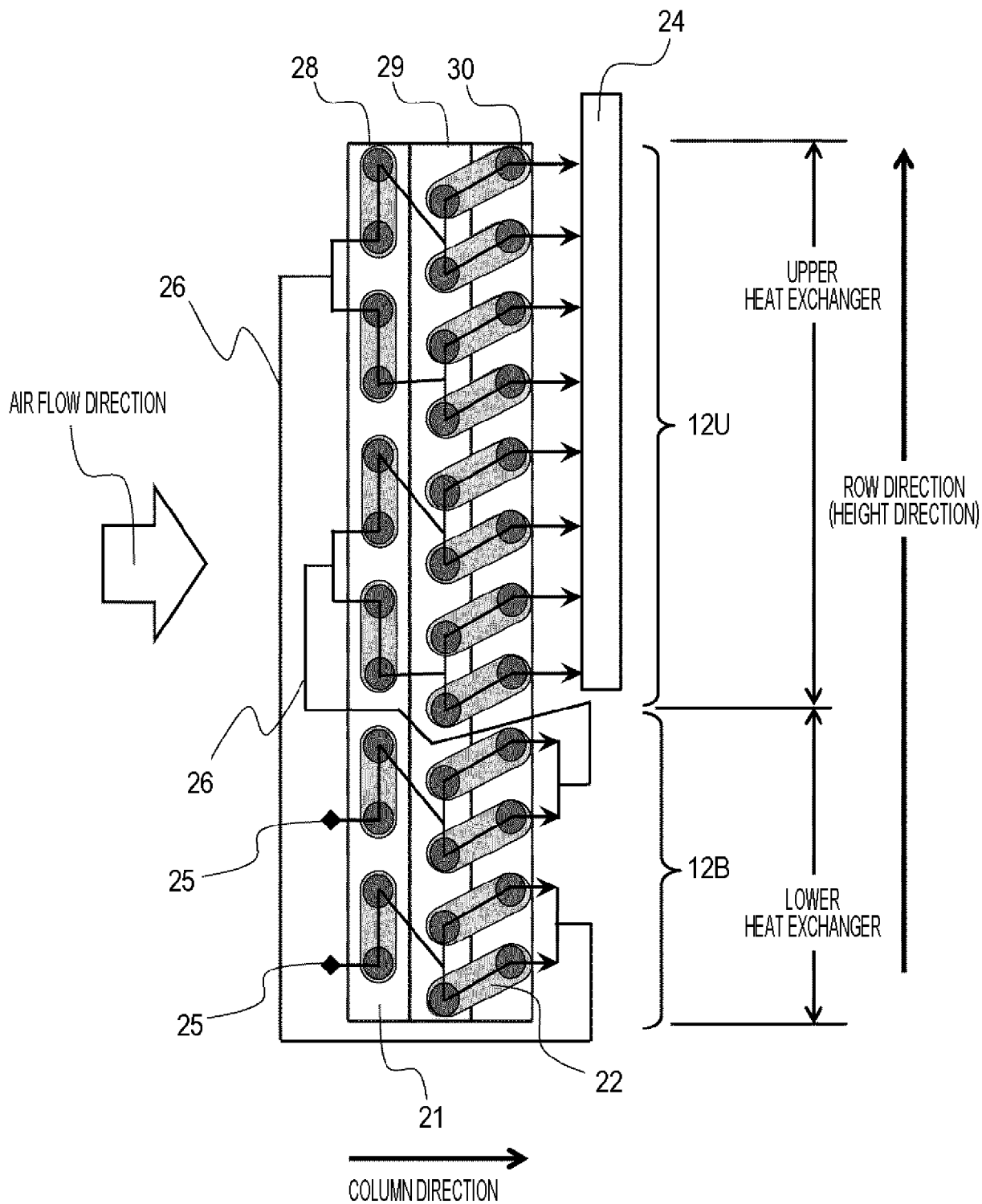


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/023375

A. CLASSIFICATION OF SUBJECT MATTER

F24F 1/14 (2011.01) i

FI: F24F1/14

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)

F24F1/14

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2020

Registered utility model specifications of Japan 1996-2020

Published registered utility model applications of Japan 1994-2020

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.
A	JP 9-196507 A (YANMAR DIESEL CO., LTD.) 31 July 1997 (1997-07-31) paragraphs [0008]-[0034]	1-8
A	JP 2015-141009 A (DAIKIN INDUSTRIES, LTD.) 03 August 2015 (2015-08-03) paragraphs [0020]-[0059]	1-8



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search

20 July 2020 (20.07.2020)

Date of mailing of the international search report

04 August 2020 (04.08.2020)

Name and mailing address of the ISA/

Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2020/023375

5	Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
	JP 9-196507 A	31 Jul. 1997	(Family: none)	
10	JP 2015-141009 A	03 Aug. 2015	(Family: none)	
15				
20				
25				
30				
35				
40				
45				
50				
55				

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2014199501 A [0004] [0012]
- JP 2014126322 A [0009] [0012]