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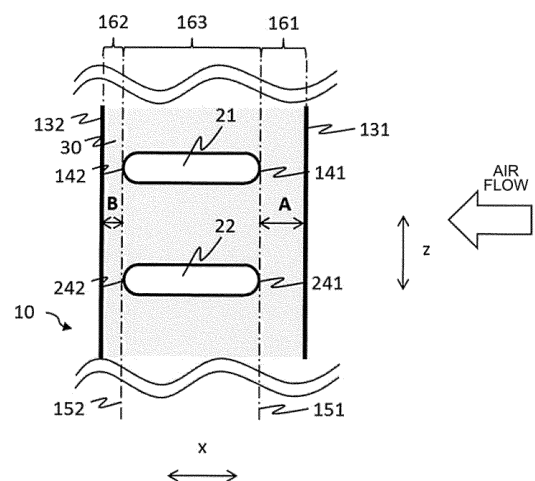
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(54) **HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE**

(57) A heat exchanger that is supplied with air by a fan includes a fin that is plate-shaped, a first heat transfer tube that is flat and extends through the fin, and a second heat transfer tube that is flat and extends through the fin and is disposed at a distance from the first heat transfer tube in a gravity direction. The first heat transfer tube has a first upwind end located upwind and a first downwind end located downwind. The second heat transfer tube has a second upwind end located upwind and a second downwind end located downwind. The fin has an upwind fin end and a downwind fin end. Where the first upwind end and the second upwind end are connected by a first imaginary line and the first downwind end and the second downwind end are connected by a second imaginary line, the fin has an upwind fin region defined by the upwind fin end and the first imaginary line and a downwind fin region defined by the second imaginary line and the downwind fin end. A dimension of the upwind fin region is larger than a dimension of the downwind fin region in a passing direction.

FIG. 3



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Description

Technical Field

[0001] The present invention relates to a fin-and-tube heat exchanger and a refrigeration cycle apparatus including the fin-and-tube heat exchanger.

Background Art

[0002] A fin-and-tube heat exchanger known in the art includes a plurality of fins that are plate-shaped and arranged at a predetermined fin pitch and a plurality of heat transfer tubes extending through the fins in a direction in which the fins are arranged.

[0003] The plurality of fins each have a plurality of openings, such as through-holes and cuts, and into which the heat transfer tubes penetrate. As a result, the heat transfer tubes extend through the fins in the direction in which the fins are arranged. Each heat transfer tube has an end connected to a distribution pipe or a header that forms a refrigerant passage together with the heat transfer tubes. In the heat exchanger, a heat exchange fluid, such as air, flowing through the spaces between the fins exchanges heat with a heat-exchange target fluid, such as water and refrigerant, flowing inside the heat transfer tubes.

[0004] A heat exchanger having raised cuts, called slits or louvers, that open to a direction in which air mainly flows is known in the art. A heat exchanger including protrusions, called scratches or a waffled pattern that protrude to the direction in which air mainly flows is also known in the art. In such a heat exchanger, the raised cuts or the protrusions increase the surface area on which heat is exchanged, thus improving the performance of heat exchange.

[0005] Furthermore, for example, a heat exchanger including heat transfer tubes each having, in the heat transfer tube, a plurality of passages and a heat exchanger including heat transfer tubes each having an inner surface with grooves are known in the art. In such a heat exchanger, the passages or the grooves increase the surface area on which heat is exchanged, thus improving the heat exchange performance.

[0006] The types of heat transfer tubes included in the above-described heat exchangers include flat heat transfer tubes having a substantially elliptical cross-section or a substantially oblong cross-section. When a heat exchanger operates as an evaporator in an environment in which an outdoor air temperature is at or below the freezing point, frost tends to form on a region located upwind in an air passing direction on the heat exchanger because this region serves as a thermal entrance region in which the absolute humidity of air is high and the thermal boundary layer is thin. In particular, on an outer surface of the heat exchanger, parts surrounding the heat transfer tubes and closest to the refrigerant flowing inside the flat heat transfer tubes decrease in temperature, leading to

an increase in temperature difference between the air and the parts of the heat exchanger. Thus, much frost forms on the parts. To solve this problem, a heat exchanger has been proposed that includes fins each having an adequate fin region for anti-blocking located upwind in the air passing direction to reduce or eliminate the likelihood that the spaces between heat transfer tubes may be blocked with frost (refer to Patent Literature 1, for example).

[0007] Frost is melted into water droplets by a defrosting operation. At completion of the defrosting operation, an operation that can cause frost formation is resumed and the air starts to pass through the heat exchanger. Consequently, the water droplets formed in the defrosting operation move backward and accumulate on upper parts or lower parts of the flat heat transfer tubes. Disadvantageously, the water droplets fail to appropriately flow out of the heat exchanger. A heat exchanger has been proposed that includes fins each having a fin region located downwind in the air passing direction to reduce or eliminate the likelihood that water droplets may accumulate on the heat exchanger after air starts to pass through the heat exchanger (refer to Patent Literature 2, for example).

Citation List

Patent Literature

[0008]

Patent Literature 1: Japanese Patent No. 3264525
Patent Literature 2: Japanese Patent No. 5736794

Summary of Invention

Technical Problem

[0009] However, the heat exchanger disclosed in Patent Literature 1 has the following disadvantage. As described above, after the start of the operation that can cause frost formation, water droplets accumulate on upper parts or lower parts of the flat heat transfer tubes and fail to appropriately flow out of the heat exchanger. This heat exchanger thus has poor drainage performance. The heat exchanger disclosed in Patent Literature 2 has a configuration in which upwind parts of heat transfer tubes are exposed. Disadvantageously, frost may form on and grow from the exposed upwind parts, so that air passages tend to be blocked with the frost.

[0010] When a heating operation is started after the defrosting operation and water droplets remain in a heat-transfer-tube region in which heat transfer tubes are arranged, the water droplets will refreeze, resulting in growth of ice. In other words, the water droplets remaining in the heat-transfer-tube region at the start of the heating operation after the defrosting operation cause a reduction in reliability, which is due to, for example, damage

of the heat transfer tubes. Furthermore, the refreezing causes the spaces between the heat transfer tubes to be blocked with frost, resulting in an increase in resistance to air flow and a reduction in resistance to frost. The resistance to frost is the retention of performance against frost. Furthermore, in the next defrosting operation, it is necessary to melt not only frost that has formed on a heat exchanger in the heating operation but also the frozen water droplets. Consequently, an increase in duration of defrosting is caused, resulting in a reduction in comfort. In addition, repeating the heating operation and the defrosting operation causes a reduction in average heating capacity over a predetermined period of time. Additionally, the blocking of the air passages with frost causes a reduction in air flow rate, resulting in a reduction in capacity in the heating operation.

[0011] In other words, the heat exchangers including the flat heat transfer tubes disclosed in Patent Literature 1 and Patent Literature 2 fail to have good drainage performance and good resistance to frost, and have the above-described disadvantages.

[0012] The present invention has been made to overcome the above-described disadvantages and aims to provide a heat exchanger that includes flat heat transfer tubes and has improved drainage performance and improved resistance to frost as compared to those in the art and a refrigeration cycle apparatus including the heat exchanger.

Solution to Problem

[0013] An embodiment of the present invention provides a heat exchanger that is supplied with air by a fan. The heat exchanger according to the embodiment of the present invention includes a fin that is plate-shaped, a first heat transfer tube extending through the fin and having a flat cross-section, and a second heat transfer tube extending through the fin and having a flat cross-section. The second heat transfer tube is disposed at a distance from the first heat transfer tube in a gravity direction. The first heat transfer tube has a first upwind end located upwind in a passing direction in which the air passes and a first downwind end located downwind in the passing direction. The second heat transfer tube has a second upwind end located upwind in the passing direction and a second downwind end located downwind in the passing direction. The fin has an upwind fin end located upwind in the passing direction and a downwind fin end located downwind in the passing direction. Where the first upwind end and the second upwind end are connected by a first imaginary line and the first downwind end and the second downwind end are connected by a second imaginary line, the fin has an upwind fin region defined by the upwind fin end and the first imaginary line, a heat-transfer-tube region defined by the first imaginary line and the second imaginary line, and a downwind fin region defined by the second imaginary line and the downwind fin end. A dimension of the upwind fin region is larger than a dimen-

sion of the downwind fin region in the passing direction.

Advantageous Effects of Invention

[0014] When the heat exchanger is installed as an outdoor heat exchanger in a refrigeration cycle and a heating operation is performed, moisture in outdoor air sent from the air-sending fan deposits as frost on the heat exchanger. Subsequently, when a defrosting operation is performed, the frost is melted. The heat exchanger according to an embodiment of the present invention is configured in such a manner that a dimension of the upwind fin region of the fin is larger than a dimension of the downwind fin region in the passing direction of the air supplied from the fan. In other words, the fin has a relatively long region located upwind and with which the air from the air-sending fan first comes into contact. Such a configuration reduces or eliminates the likelihood that frost may block the space between the heat transfer tubes on upwind part, on which relatively much frost can form in the heating operation, of the fin, and allows frost melted in the defrosting operation, or water droplets, to promptly flow downwardly out of the upwind fin region. In addition, as the fin has the downwind fin region in an embodiment of the present invention, air supply from the fan causes water droplets formed by melting frost in the defrosting operation to move on upper and lower parts of the heat transfer tubes and promptly flow downwardly out of the downwind fin region.

[0015] As described above, the heat exchanger according to an embodiment of the present invention and a refrigeration cycle apparatus including the heat exchanger have improved resistance to frost and improved drainage performance.

Brief Description of Drawings

[0016]

Fig. 1 is a refrigerant circuit diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 1 of the present invention.

Fig. 2 is a perspective view of an example of an outdoor heat exchanger in the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

Fig. 3 is an enlarged view of essential part of the outdoor heat exchanger of Fig. 2.

Fig. 4 is an enlarged view of essential part of the outdoor heat exchanger of Fig. 2.

Fig. 5 is a perspective view illustrating a process of inserting heat transfer tubes into fins.

Fig. 6 is an enlarged view of essential part of an outdoor heat exchanger according to Comparative Example 1.

Fig. 7 is an enlarged view of essential part of an outdoor heat exchanger according to Comparative Example 2.

Fig. 8 is an enlarged view of essential part of an outdoor heat exchanger according to Comparative Example 3.

Fig. 9 is an enlarged view of essential part of an outdoor heat exchanger according to Embodiment 2 of the present invention.

Fig. 10 is an enlarged view of essential part of an outdoor heat exchanger according to Embodiment 3 of the present invention.

Fig. 11 is an enlarged view of essential part of an outdoor heat exchanger according to Embodiment 4 of the present invention.

Description of Embodiments

[0017] Embodiments of the present invention will be described below with reference to the drawings as necessary. Note that the relative sizes of components illustrated in Fig. 1 and subsequent figures may differ from the actual relative sizes of the components. Furthermore, note that components denoted by the same reference signs in Fig. 1 and the subsequent figures are the same components or equivalents. The same applies to the entire description herein. Furthermore, note that the forms of components described herein are intended to be illustrative only and are not limited to the descriptions.

Embodiment 1

[0018] A refrigeration cycle apparatus 501 according to Embodiment 1 of the present invention will be described first. Fig. 1 is a refrigerant circuit diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 1 of the present invention. In Fig. 1, the direction of refrigerant flow in a cooling operation is represented by dotted-line arrows and that in a heating operation is represented by full-line arrows. The refrigeration cycle apparatus 501 is an exemplary refrigeration cycle apparatus according to the present invention.

[Configuration of Refrigeration Cycle Apparatus 501]

[0019] As illustrated in Fig. 1, the refrigeration cycle apparatus 501 includes a compressor 502, an indoor heat exchanger 503, an indoor fan 504, an expansion device 505, an outdoor heat exchanger 10, an outdoor fan 506, and a four-way valve 507. The compressor 502, the indoor heat exchanger 503, the expansion device 505, the outdoor heat exchanger 10, and the four-way valve 507 are connected by refrigerant pipes, thus forming a refrigerant circuit.

[0020] The compressor 502 compresses refrigerant. The refrigerant compressed by the compressor 502 is discharged from the compressor 502 and is sent to the four-way valve 507. The compressor 502 can be, for example, a rotary compressor, a scroll compressor, a screw compressor, or a reciprocating compressor.

[0021] The indoor heat exchanger 503 acts as a con-

denser in the heating operation, and acts as an evaporator in the cooling operation. The indoor heat exchanger 503 can be, for example, a fin-and-tube heat exchanger, a microchannel heat exchanger, a shell-and-tube heat exchanger, a heat pipe heat exchanger, a double-pipe heat exchanger, or a plate heat exchanger.

[0022] The expansion device 505 expands the refrigerant flowing through the indoor heat exchanger 503 or the outdoor heat exchanger 10 to reduce the pressure of the refrigerant. The expansion device 505 is preferably, for example, an electric expansion valve capable of regulating the flow rate of refrigerant. Usable examples of the expansion device 505 include a mechanical expansion valve including a diaphragm, serving as pressure receiving part, and a capillary tube in addition to the electric expansion valve.

[0023] The outdoor heat exchanger 10 acts as an evaporator in the heating operation, and acts as a condenser in the cooling operation. The outdoor heat exchanger 10 may be configured in such a manner that the heat exchanger is bent in a direction in which heat transfer tubes extend to increase the efficiency of installation in an outdoor unit. The outdoor heat exchanger 10 will be described in detail later.

[0024] The four-way valve 507 switches between a refrigerant flow direction for the heating operation and a refrigerant flow direction for the cooling operation. Specifically, the four-way valve 507 is switched to connect a discharge outlet of the compressor 502 to the indoor heat exchanger 503 and connect a suction inlet of the compressor 502 to the outdoor heat exchanger 10 in the heating operation. Furthermore, the four-way valve 507 is switched to connect the discharge outlet of the compressor 502 to the outdoor heat exchanger 10 and connect the suction inlet of the compressor 502 to the indoor heat exchanger 503 in the cooling operation.

[0025] The indoor fan 504 is disposed adjacent to the indoor heat exchanger 503, and supplies air, serving as a heat exchange fluid, to the indoor heat exchanger 503. The outdoor fan 506 is disposed adjacent to the outdoor heat exchanger 10, and supplies air, serving as a heat exchange fluid, to the outdoor heat exchanger 10.

[Operations of Refrigeration Cycle Apparatus 501]

[0026] Operations of the refrigeration cycle apparatus 501 will be described with the flow of the refrigerant. The cooling operation performed by the refrigeration cycle apparatus 501 will be described first. In Fig. 1, the dotted-line arrows represent the refrigerant flow direction in the cooling operation. As an example, in a case in which air is a heat exchange fluid and the refrigerant is a heat-exchange target fluid, an operation of the refrigeration cycle apparatus 501 will be described below.

[0027] As illustrated in Fig. 1, driving the compressor 502 causes the compressor 502 to discharge high-temperature, high-pressure gas refrigerant. The refrigerant flows as represented by the dotted-line arrows. The high-

temperature, high-pressure, single-phase gas refrigerant discharged from the compressor 502 passes through the four-way valve 507 and flows into the outdoor heat exchanger 10, serving as a condenser. In the outdoor heat exchanger 10, the high-temperature, high-pressure gas refrigerant that has flowed into the outdoor heat exchanger 10 exchanges heat with the air supplied by the outdoor fan 506, so that the high-temperature, high-pressure gas refrigerant condenses into high-pressure, single-phase liquid refrigerant.

[0028] The high-pressure liquid refrigerant sent from the outdoor heat exchanger 10 is turned into low-pressure, two-phase gas-liquid refrigerant by the expansion device 505. The two-phase refrigerant flows into the indoor heat exchanger 503, serving as an evaporator. In the indoor heat exchanger 503, the two-phase refrigerant that has flowed into the indoor heat exchanger 503 exchanges heat with the air supplied by the indoor fan 504, so that liquid refrigerant included in the two-phase refrigerant evaporates. Thus, the refrigerant turns into low-pressure, single-phase gas refrigerant. This heat exchange allows an indoor space to be cooled. The low-pressure gas refrigerant sent from the indoor heat exchanger 503 passes through the four-way valve 507 and flows into the compressor 502, in which the refrigerant is compressed into high-temperature, high-pressure gas refrigerant. Then, the refrigerant is again discharged from the compressor 502. Subsequently, such a cycle is repeated.

[0029] The heating operation performed by the refrigeration cycle apparatus 501 will be described below. In Fig. 1, the full-line arrows represent the refrigerant flow direction in the heating operation.

[0030] As illustrated in Fig. 1, driving the compressor 502 causes the compressor 502 to discharge high-temperature, high-pressure gas refrigerant. The refrigerant flows as represented by the full-line arrows. The high-temperature, high-pressure, single-phase gas refrigerant discharged from the compressor 502 passes through the four-way valve 507 and flows into the indoor heat exchanger 503, serving as a condenser. In the indoor heat exchanger 503, the high-temperature, high-pressure gas refrigerant that has flowed into the indoor heat exchanger 503 exchanges heat with the air supplied by the indoor fan 504, so that the high-temperature, high-pressure gas refrigerant condenses into high-pressure, single-phase liquid refrigerant. This heat exchange allows the indoor space to be heated.

[0031] The high-pressure liquid refrigerant sent from the indoor heat exchanger 503 is turned into low-pressure, two-phase gas-liquid refrigerant by the expansion device 505. The two-phase refrigerant flows into the outdoor heat exchanger 10, serving as an evaporator. In the outdoor heat exchanger 10, the two-phase refrigerant that has flowed into the outdoor heat exchanger 10 exchanges heat with the air supplied by the outdoor fan 506, so that liquid refrigerant included in the two-phase refrigerant evaporates. Thus, the refrigerant turns into

low-pressure, single-phase gas refrigerant.

[0032] The low-pressure gas refrigerant sent from the outdoor heat exchanger 10 passes through the four-way valve 507 and flows into the compressor 502, in which the refrigerant is compressed into high-temperature, high-pressure gas refrigerant. Then, the refrigerant is again discharged from the compressor 502. Subsequently, such a cycle is repeated.

[0033] In the above-described cooling and heating operations, liquid refrigerant flowing into the compressor 502 leads to liquid compression, causing a failure of the compressor 502. It is therefore preferred that the refrigerant flowing out of the evaporator be single-phase gas refrigerant. The indoor heat exchanger 503 acts as an evaporator in the cooling operation, and the outdoor heat exchanger 10 acts as an evaporator in the heating operation.

[0034] In the evaporator, while the air supplied from the fan is exchanging heat with the refrigerant flowing inside the heat transfer tubes included in the evaporator, moisture in the air condenses into water droplets on the evaporator. The water droplets, formed on the evaporator, downwardly move on the heat transfer tubes and fins and downwardly flow, as drain water, out of the evaporator.

[0035] In the heating operation under low outdoor-air temperature conditions, the outdoor heat exchanger 10 acts as an evaporator. In the heating operation, thus, moisture included in the air may deposit as frost on the outdoor heat exchanger 10. For example, a refrigeration cycle apparatus capable of performing the heating operation typically performs a defrosting operation for removing frost when outdoor air is at or below a predetermined temperature (for example, 0 degrees C).

[0036] The defrosting operation is an operation in which hot gas, which is high-temperature, high-pressure gas refrigerant, is supplied from the compressor 502 to the outdoor heat exchanger 10 to prevent frost from forming on the outdoor heat exchanger 10 acting as an evaporator. The defrosting operation may be performed when the duration of the heating operation reaches a predetermined value (e.g., 30 minutes). Furthermore, the defrosting operation may be performed before the heating operation when the outdoor heat exchanger 10 is at or below a predetermined temperature (e.g., -6 degrees C). Frost or ice on the outdoor heat exchanger 10 is melted by hot gas supplied to the outdoor heat exchanger 10 in the defrosting operation.

[0037] For example, the discharge outlet of the compressor 502 can be connected to the outdoor heat exchanger 10 by a bypass refrigerant pipe (not illustrated) so that hot gas can be supplied directly to the outdoor heat exchanger 10 from the compressor 502 in the defrosting operation. Furthermore, the discharge outlet of the compressor 502 can be connected to the outdoor heat exchanger 10 through a refrigerant flow switching device, for example, the four-way valve 507, so that hot gas can be supplied to the outdoor heat exchanger 10

from the compressor 502.

[Details of Outdoor Heat Exchanger 10]

[0038] Fig. 2 is a perspective view illustrating an example of an outdoor heat exchanger in the refrigeration cycle apparatus according to Embodiment 1 of the present invention. Figs. 3 and 4 are enlarged views of essential part of the outdoor heat exchanger of Fig. 2. Fig. 5 is a perspective view illustrating a process of inserting heat transfer tubes into fins. In Fig. 2 and subsequent figures, the X direction is a horizontal direction and corresponds to the lateral direction, or width direction, of fins 30 of the outdoor heat exchanger 10. The Y direction is a horizontal direction and corresponds to a direction in which the fins 30 included in a single heat exchanger element are arranged. The Z direction is a vertical direction, or the direction of gravity, and corresponds to the longitudinal direction of the fins 30. Outlined arrows represent the flow direction of the fins 30. As seen from Fig. 2, the outdoor heat exchanger 10 according to Embodiment 1 is supplied with air flowing in the X direction from the outdoor fan 506 in Fig. 1. Fig. 3 illustrates the essential part of the outdoor heat exchanger 10 viewed in the Y direction. Fig. 4 illustrates the essential part of the outdoor heat exchanger 10 viewed in the X direction.

[0039] The outdoor heat exchanger 10 is, for example, a heat exchanger having a two-column structure, and includes an upwind heat exchanger element 601 and a downwind heat exchanger element 602. The upwind heat exchanger element 601 and the downwind heat exchanger element 602 are each a fin-and-tube heat exchanger and are arranged in the X direction corresponding to the flow direction, or passing direction, of the air supplied from the outdoor fan 506 in Fig. 1. The upwind heat exchanger element 601 is disposed upwind in the passing direction of the air supplied from the outdoor fan 506. The downwind heat exchanger element 602 is disposed downwind in the passing direction of the air supplied from the outdoor fan 506. First ends of heat transfer tubes included in the upwind heat exchanger element 601 are connected to an upwind header collecting pipe 603. First ends of heat transfer tubes included in the downwind heat exchanger element 602 are connected to a downwind header collecting pipe 604. Second ends of the heat transfer tubes of the upwind heat exchanger element 601 and those of the downwind heat exchanger element 602 are connected to a column connecting part 605.

[0040] Specifically, in the outdoor heat exchanger 10 according to Embodiment 1, the refrigerant is distributed from one of the upwind header collecting pipe 603 and the downwind header collecting pipe 604 to the heat transfer tubes in the corresponding one of the upwind heat exchanger element 601 and the downwind heat exchanger element 602. Then, the refrigerant distributed to the heat transfer tubes in one of the upwind heat exchanger element 601 and the downwind heat exchanger

element 602 flows into the heat transfer tubes in the other one of the upwind heat exchanger element 601 and the downwind heat exchanger element 602 through the column connecting part 605. The refrigerant flowing into the heat transfer tubes in the other one of the upwind heat exchanger element 601 and the downwind heat exchanger element 602 divides into a plurality of streams flowing through the heat transfer tubes and then the plurality of streams join together in the corresponding one of the upwind header collecting pipe 603 and the downwind header collecting pipe 604. Subsequently, the refrigerant flows to the suction inlet of the compressor 502 or the expansion device 505.

[0041] In Embodiment 1, the upwind heat exchanger element 601 and the downwind heat exchanger element 602 have the same configuration. Consequently, the upwind heat exchanger element 601 will be described below as a representative of the two heat exchanger elements. The upwind heat exchanger element 601 and the downwind heat exchanger element 602 correspond to a heat exchanger according to the present invention. As a matter of course, when either one of the upwind heat exchanger element 601 and the downwind heat exchanger element 602 can handle a heat exchange load of the outdoor heat exchanger 10, only one of the upwind heat exchanger element 601 and the downwind heat exchanger element 602 may constitute the outdoor heat exchanger 10.

[0042] As illustrated in Figs. 3, 4, and 5, the outdoor heat exchanger 10 includes the plurality of fins 30 and the plurality of heat transfer tubes. Specifically, each of the fins 30 is a plate-shaped part, which is long in the vertical direction. For example, the fin has a vertically long rectangular shape. As illustrated in Fig. 4, the fins 30 are arranged at a predetermined fin pitch FP in each heat exchanger element.

[0043] As for the plurality of heat transfer tubes, two representative heat transfer tubes are each illustrated in Figs. 3 to 5. In the following description, an upper one of the heat transfer tubes in the Z direction will be referred to as a first heat transfer tube 21 and a lower one of the heat transfer tubes in the Z direction will be referred to as a second heat transfer tube 22. As illustrated in Figs. 3 and 4, the first heat transfer tube 21 and the second heat transfer tube 22 are arranged at a predetermined distance from each other in the vertical direction. As illustrated in Fig. 5, the first heat transfer tube 21 and the second heat transfer tube 22 are each inserted into the plurality of fins 30 in the Y direction, in which the plurality of fins 30 are arranged. The first heat transfer tube 21 and the second heat transfer tube 22 each extend through the fins 30. The first heat transfer tube 21 and the second heat transfer tube 22 are each a flat tube having a flat cross-section taken along a plane perpendicular to the longitudinal direction of the first heat transfer tube 21 and the second heat transfer tube 22.

[0044] In Embodiment 1, each of the fins 30 of the outdoor heat exchanger 10 has an upwind fin end 131 and

a downwind fin end 132, serving as opposite ends in the X direction corresponding to the lateral direction of the fin 30. For the heat transfer tubes extending through the fins 30, the first heat transfer tube 21 has an upwind end 141 and a downwind end 142, serving as opposite ends in the X direction corresponding to the lateral direction of the fins 30, and the second heat transfer tube 22 has an upwind end 241 and a downwind end 242, serving as opposite ends in the X direction corresponding to the lateral direction of the fins 30. The upwind end 141 of the first heat transfer tube 21 and the upwind end 241 of the second heat transfer tube 22 are located upwind in the passing direction of the air supplied from the outdoor fan 506. The downwind end 142 of the first heat transfer tube 21 and the downwind end 242 of the second heat transfer tube 22 are located downwind in the passing direction of the air supplied from the outdoor fan 506.

[0045] The following terms are defined for description of the resistance to frost and the drainage performance of the outdoor heat exchanger 10 according to Embodiment 1.

[0046] As used herein, the term "first imaginary line", denoted by 151, refers to a straight line connecting the upwind ends of the heat transfer tubes located upwind in the passing direction of the air supplied from the outdoor fan 506, and the term "second imaginary line", denoted by 152, refers to a straight line connecting the downwind ends of the heat transfer tubes located downwind in the passing direction of the air supplied from the outdoor fan 506. These lines are represented by alternate long and short dashed lines. In Fig. 3, the upwind end 141 of the first heat transfer tube 21 and the upwind end 241 of the second heat transfer tube 22 are connected by the first imaginary line 151, and the downwind end 142 of the first heat transfer tube 21 and the downwind end 242 of the second heat transfer tube 22 are connected by the second imaginary line 152. Furthermore, the term "upwind fin region", denoted by 161, refers to a region defined by the upwind fin end 131 and the first imaginary line 151, the term "downwind fin region", denoted by 162, refers to a region defined by the downwind fin end 132 and the second imaginary line 152, and the term "heat-transfer-tube region", denoted by 163, refers to a region defined by the first imaginary line 151 and the second imaginary line 152. The heat-transfer-tube region 163 is a region in which the heat transfer tubes are located in the Z direction. In Fig. 3, the first heat transfer tube 21 and the second heat transfer tube 22 are located in the heat-transfer-tube region 163. The dimension of the upwind fin region 161 in the X direction or the passing direction is denoted by A, and the dimension of the downwind fin region 162 in the X direction or the passing direction is denoted by B. The dimension A is larger than the dimension B.

[Resistance to Frost and Drainage Performance of Outdoor Heat Exchanger 10]

[0047] The resistance to frost and the drainage performance of the outdoor heat exchanger 10 according to Embodiment 1 will be described below. For the sake of easy understanding of advantages of the outdoor heat exchanger 10 according to Embodiment 1, the configurations of outdoor heat exchangers according to Comparative Examples 1, 2, and 3 will be described first. The resistance to frost and the drainage performance of the outdoor heat exchanger 10 according to Embodiment 1 will then be described.

[0048] In the configurations according to Comparative Examples 1 to 3, components in Comparative Examples are denoted by reference signs obtained by adding 1000, 2000, and 3000 to the reference signs of the corresponding components in Embodiment 1. For example, an outdoor heat exchanger according to Comparative Example 1 is denoted by 1010, an outdoor heat exchanger according to Comparative Example 2 is denoted by 2010, and an outdoor heat exchanger according to Comparative Example 3 is denoted by 3010.

[Comparative Example 1]

[0049] Fig. 6 is an enlarged view of essential part of the outdoor heat exchanger according to Comparative Example 1. Fig. 6 illustrates the essential part of the outdoor heat exchanger 1010 according to Comparative Example 1 viewed in the Y direction. The outdoor heat exchanger 1010 differs from the outdoor heat exchanger 10 according to Embodiment 1 in that the outdoor heat exchanger 1010 has no downwind fin region 162, which is illustrated in Fig. 3. In the outdoor heat exchanger 1010 according to Comparative Example 1, consequently, a downwind end 1142 of a first heat transfer tube 1021, a downwind end 1242 of a second heat transfer tube 1022, and a downwind fin end 1132 are located at the same position in the X direction. A dimension A1 of an upwind fin region 1161 in the X direction is larger than the dimension A, illustrated in Fig. 3, of the upwind fin region 161 in the X direction in Embodiment 1.

[0050] As the dimension of the upwind fin region 1161 in the X direction is large, the outdoor heat exchanger 1010 according to Comparative Example 1 is highly resistant to frost. However, the outdoor heat exchanger 1010 has no downwind fin region. When frost is melted in the defrosting operation and the fan is again actuated to start an operation that can cause frost formation, water droplets formed by melting the frost accumulate on upper and lower parts of the first heat transfer tube 1021 and the second heat transfer tube 2022 in proximity to the downwind fin end 1132 and fail to properly flow out of the outdoor heat exchanger 1010. In other words, the outdoor heat exchanger 1010 according to Comparative Example 1 has poor drainage performance. Disadvantageously, accumulating water droplets refreeze again and

become an obstacle in air passages, thus reducing the resistance to frost. An increase in amount of heat required for defrosting is thus caused, resulting in an increase in duration of defrosting.

[Comparative Example 2]

[0051] Fig. 7 is an enlarged view of essential part of the outdoor heat exchanger according to Comparative Example 2. Fig. 7 illustrates the essential part of the outdoor heat exchanger 2010 according to Comparative Example 2 viewed in the Y direction. The outdoor heat exchanger 2010 differs from the outdoor heat exchanger 10 according to Embodiment 1 in that the outdoor heat exchanger 2010 has no upwind fin region 161, which is illustrated in Fig. 3. In the outdoor heat exchanger 2010 according to Comparative Example 2, consequently, an upwind end 2141 of a first heat transfer tube 2021, an upwind end 2241 of a second heat transfer tube 2022, and an upwind fin end 2131 are located at the same position in the X direction. A dimension B2 of a downwind fin region 2162 in the X direction is larger than the dimension B, illustrated in Fig. 3, of the downwind fin region 162 in the X direction in Embodiment 1.

[0052] As the dimension of the downwind fin region 2162 in the X direction is large, the outdoor heat exchanger 2010 according to Comparative Example 2 has relatively good drainage performance because, even when frost is melted in the defrosting operation and the fan is again actuated to start the operation that can cause frost formation, air flow causes water droplets formed by melting the frost to flow to the rear of fins and flow out of the outdoor heat exchanger 2010. However, upwind parts of the first heat transfer tube 2021 and the second heat transfer tube 2022 are exposed. Disadvantageously, frost may form on and grow from the exposed parts and thus tend to block air passages. The outdoor heat exchanger 2010 has poor resistance to frost.

[Comparative Example 3]

[0053] Fig. 8 is an enlarged view of essential part of the outdoor heat exchanger according to Comparative Example 3. Fig. 8 illustrates the essential part of the outdoor heat exchanger 3010 according to Comparative Example 3 viewed in the Y direction. The outdoor heat exchanger 3010 differs from the outdoor heat exchanger 10 according to Embodiment 1 in that a dimension A3 of an upwind fin region 3161 in the X direction is equal to a dimension B3 of a downwind fin region 3162 in the X direction. Such a configuration has relatively good drainage performance because, even when frost is melted in the defrosting operation and the fan is again actuated to start the operation that can cause frost formation, air flow causes water droplets formed by melting the frost to flow to the rear of fins and flow out of the outdoor heat exchanger 3010. However, upwind part of a first heat transfer tube 3021 and upwind part of a second heat transfer

tube 3022 are in close proximity to an upwind fin end 3131. Disadvantageously, the outdoor heat exchanger 3010 has poor resistance to frost.

[0054] As illustrated in Fig. 3, the outdoor heat exchanger 10 according to Embodiment 1 has the downwind fin region 162 as in Comparative Example 3. Consequently, even when frost is melted in the defrosting operation and the fan is again actuated to start the operation that can cause frost formation, air flow causes water droplets formed by melting the frost to flow to the rear of the fins and flow out of the outdoor heat exchanger 10. The outdoor heat exchanger 10 has relatively good drainage performance. In addition, as the dimension A of the upwind fin region 161 in the X direction is larger than the dimension B of the downwind fin region 162 in the X direction, the outdoor heat exchanger 10 has good resistance to frost in the operation that can cause frost formation.

[0055] In other words, the upwind heat exchanger element 601 in Embodiment 1 has improved drainage performance in the defrosting operation and has improved resistance to frost in the operation that can cause frost formation. As described above, the downwind heat exchanger element 602 has the same configuration as that of the upwind heat exchanger element 601. Consequently, the downwind heat exchanger element 602 has the same advantages.

[0056] Furthermore, in the refrigeration cycle apparatus 501 including the outdoor heat exchanger 10 having a two-column structure in which the upwind heat exchanger element 601 and the downwind heat exchanger element 602 are arranged adjacent to each other, the time required for the defrosting operation is reduced, resulting in a reduction in amount of heat required for the defrosting operation. Additionally, in the refrigeration cycle apparatus 501 according to Embodiment 1, improved reliability, reduced resistance to air flow, and improved resistance to frost are achieved by reducing water remaining in the outdoor heat exchanger 10 in the operation that can cause frost formation and retarding blocking of air passages in the outdoor heat exchanger 10 in the operation that can cause frost formation. In other words, the refrigeration cycle apparatus 501 according to Embodiment 1 has increased average heating capacity in a defrosting and frosting cycle.

Embodiment 2

[0057] In Embodiment 1, the first heat transfer tube 21 and the second heat transfer tube 22 are arranged parallel to each other in the flow direction of the air supplied from the outdoor fan 506, and extend perpendicular to the Z direction or the gravity direction. The angle of the first heat transfer tube 21 and the second heat transfer tube 22 is not limited to that in the configuration in Embodiment 1. For example, the first heat transfer tube 21 and the second heat transfer tube 22 may be arranged as will be described below in Embodiment 2. Items not

particularly mentioned in Embodiment 2 are similar to those in Embodiment 1, and the same functions and components as those in Embodiment 1 are denoted by the same reference signs in the following description.

[0058] Fig. 9 is an enlarged view of essential part of an outdoor heat exchanger according to Embodiment 2 of the present invention. Similarly to Fig. 3, Fig. 9 illustrates the essential part of the outdoor heat exchanger 10 viewed in the Y direction. Embodiment 2 differs from Embodiment 1 in that heat transfer tubes slope from the upwind ends downwardly in the gravity direction to the downwind ends in fins 31. As illustrated in Fig. 9, the first heat transfer tube 21 is inclined in such a manner that the downwind end 142 is located at a lower level than the upwind end 141 in the gravity direction. Similarly, the second heat transfer tube 22 is inclined in such a manner that the downwind end 242 is located at a lower level than the upwind end 241 in the gravity direction. In other words, the first heat transfer tube 21 slopes from the upwind end 141 downwardly in the gravity direction to the downwind end 142, and the second heat transfer tube 22 slopes from the upwind end 241 downwardly in the gravity direction to the downwind end 242.

[0059] Consequently, in the outdoor heat exchanger 10 according to Embodiment 2 in a state in which air is not supplied to the outdoor heat exchanger 10 from the outdoor fan 506 in Fig. 1, for example, even in the defrosting operation, water droplets formed by melting frost on the heat-transfer-tube region 163 are directed downwind due to the gravity and the slope of the first heat transfer tube 21 and the second heat transfer tube 22, so that the water droplets are allowed to flow out of the outdoor heat exchanger 10 through the downwind fin region 162. Furthermore, in a state in which air is supplied to the outdoor heat exchanger 10 from the outdoor fan 506, that is, in an operation that can cause frost formation and that is performed after the defrosting operation, the arrangement of the first heat transfer tube 21 and the second heat transfer tube 22 sloping downwardly in the gravity direction along the air flow allows water droplets to be directed downwind and thus promotes drainage. As described above, the outdoor heat exchanger 10 according to Embodiment 2 has further improved drainage performance.

Embodiment 3

[0060] In Embodiments 1 and 2, the outdoor heat exchanger 10 has a two-column structure, and the upwind heat exchanger element 601 and the downwind heat exchanger element 602, which constitute the outdoor heat exchanger 10, have the same configuration. The heat exchanger according to the present invention may include heat exchanger elements, serving as columns, having different configurations. Items not particularly mentioned in Embodiment 3 are similar to those in Embodiment 1 or Embodiment 2, and the same functions and components as those in Embodiment 1 or Embodi-

ment 2 are denoted by the same reference signs in the following description.

[0061] Fig. 10 is an enlarged view of essential part of an outdoor heat exchanger according to Embodiment 3 of the present invention. Fig. 10 illustrates the essential part of the outdoor heat exchanger 10 when the upwind heat exchanger element 601 and the downwind heat exchanger element 602 constituting the outdoor heat exchanger 10 are viewed in the Y direction.

[0062] The fins 31 of the upwind heat exchanger element 601 of the outdoor heat exchanger 10 according to Embodiment 3 have the same configuration as that of the fins 31 in Embodiment 2. The outdoor heat exchanger 10 according to Embodiment 3 differs from that according to Embodiment 2 in that a dimension A_2 of an upwind fin region 161' in the X direction in each fin 32 of the downwind heat exchanger element 602 is smaller than a dimension A_1 of the upwind fin region 161 in the X direction in each fin 31 of the upwind heat exchanger element 601.

[0063] To increase the efficiency of installation in an outdoor unit, the outdoor heat exchanger 10 may have a bent configuration. The downwind fin region 162 of the fin 31 of the upwind heat exchanger element 601 faces the upwind fin region 161' of the fin 32 of the downwind heat exchanger element 602. When the outdoor heat exchanger 10 is bent, consequently, the downwind fin region 162 and the upwind fin region 161' are each likely to receive a load from the other one of the downwind fin region 162 and the upwind fin region 161'. Disadvantageously, the fins 31 and the fins 32 may buckle.

[0064] As illustrated in Fig. 10, the outdoor heat exchanger 10 according to Embodiment 3 is configured in such a manner that the dimension A_2 of the upwind fin region 161' in the X direction in the fin 32 of the downwind heat exchanger element 602 is smaller than the dimension A_1 of the upwind fin region 161 in the X direction in the fin 31 of the upwind heat exchanger element 601. Such a configuration enhances the buckling strength of the upwind fin region 161' in the fin 32 of the downwind heat exchanger element 602. Furthermore, the downwind fin region 162 in the fin 31 of the upwind heat exchanger element 601 has relatively high buckling strength as in Embodiment 2 because a dimension B_1 of the downwind fin region 162 in the X direction is smaller than the dimension A_1 of the upwind fin region 161 in the X direction. The above-described configuration enables the fins 31 and the fins 32 to be less likely to buckle when the outdoor heat exchanger 10 is bent and installed in an outdoor unit.

[0065] The resistance to frost of the outdoor heat exchanger 10 according to Embodiment 3 will be described below. In the heating operation, air flowing through the outdoor heat exchanger 10 first comes into contact with the upwind heat exchanger element 601. Moisture included in the air deposits as frost on the upwind heat exchanger element 601. The flowing air then comes into contact with the downwind heat exchanger element 602.

At this time, the moisture in the air is reduced to some extent, and the amount of frost on the downwind heat exchanger element 602 is smaller than that on the upwind heat exchanger element 601. Consequently, the dimension A₂, which is small, of the upwind fin region 161' in the X direction in the fin 32 of the downwind heat exchanger element 602 has little influence on the resistance to frost of the outdoor heat exchanger 10.

[0066] As described above, as well as having the resistance to frost, the outdoor heat exchanger 10 according to Embodiment 3 has higher product quality, such as buckling strength, than those in the art.

[0067] Although Fig. 10 illustrates an exemplary configuration in which the heat transfer tubes slope, the configuration is not limited to this example. It is only required that the dimension A₂ of the upwind fin region 161' in the X direction in the fin 32 of the downwind heat exchanger element 602 is smaller than the dimension A₁ of the upwind fin region 161 in the X direction in the fin 31 of the upwind heat exchanger element 601. The heat transfer tubes do not necessarily have to slope.

Embodiment 4

[0068] Fig. 11 is an enlarged view of essential part of an outdoor heat exchanger according to Embodiment 4 of the present invention. As in Embodiments 1 to 3, the dimension A₁ of the upwind fin region 161 in the X direction is larger than the dimension B₁ of the downwind fin region 162 in the X direction in each fin 31 of the upwind heat exchanger element 601 according to Embodiment 4. Furthermore, a dimension B₂ of a downwind fin region 162' in the X direction in each fin 33 of the downwind heat exchanger element 602 is equal to the dimension A₁ of the upwind fin region 161 in the X direction in the fin 31 of the upwind heat exchanger element 601, and the dimension A₂ of the upwind fin region 161' in the X direction in the fin 33 of the downwind heat exchanger element 602 is equal to the dimension B₁ of the downwind fin region 162 in the X direction in the fin 31 of the upwind heat exchanger element 601. Specifically, the downwind heat exchanger element 602 has a configuration obtained by flipping the upwind heat exchanger element 601 horizontally and vertically. In other words, to manufacture the outdoor heat exchanger 10 having a two-column structure, the upwind heat exchanger element 601 can be flipped horizontally and vertically and be used as the downwind heat exchanger element 602. Consequently, as long as a facility to manufacture the upwind heat exchanger elements 601 is prepared, it is unnecessary to prepare a facility to manufacture the downwind heat exchanger elements 602, thus reducing an increase in manufacturing cost.

[0069] Although Fig. 11 illustrates an exemplary configuration in which the heat transfer tubes slope, the configuration is not limited to this example. It is only required that the dimension A₁ of the upwind fin region 161 in the X direction is larger than the dimension B₁ of the

downwind fin region 162 in the X direction in the fin 31 of the upwind heat exchanger element 601 and the downwind heat exchanger element 602 has a configuration obtained by flipping the upwind heat exchanger element 601 horizontally and vertically. The heat transfer tubes do not necessarily have to slope.

[0070] Although the heat exchanger according to each of Embodiments 1 to 4 described above is used as the outdoor heat exchanger 10, the use of the heat exchanger is not limited to this example. The heat exchanger according to each of Embodiments 1 to 4 may be used as the indoor heat exchanger 503 in Fig. 1. In such a case, reducing moisture to accumulate on the indoor heat exchanger 503 can reduce power to be supplied to the indoor fan 504, leading to a reduction in energy consumed by the refrigeration cycle apparatus 501.

Reference Signs List

[0071] 10 outdoor heat exchanger 21 first heat transfer tube 22 second heat transfer tube 30 fin 31 fin 32 fin 33 fin 131 upwind fin end 132 downwind fin end 141 upwind end 142 downwind end 151 first imaginary line 152 second imaginary line 161 upwind fin region 161' upwind fin region 162 downwind fin region 162' downwind fin region 163 heat-transfer-tube region 163' heat-transfer-tube region 241 upwind end 242 downwind end 501 refrigeration cycle apparatus 502 compressor 503 indoor heat exchanger 504 indoor fan 505 expansion device 506 outdoor fan 507 four-way valve 601 upwind heat exchanger element 602 downwind heat exchanger element 603 upwind header collecting pipe 604 downwind header collecting pipe 605 column connecting part 1010 outdoor heat exchanger 1021 first heat transfer tube 1022 second heat transfer tube 1132 downwind fin end 1142 downwind end 1161 upwind fin region 1242 downwind end 2010 outdoor heat exchanger 2021 first heat transfer tube 2022 second heat transfer tube 2131 upwind fin end 2141 upwind end 2162 downwind fin region 2241 upwind end 3010 outdoor heat exchanger 3021 first heat transfer tube 3022 second heat transfer tube 3131 upwind fin end 3161 upwind fin region 3162 downwind fin region FP fin pitch

Claims

1. A heat exchanger that is supplied with air by a fan, the heat exchanger comprising:

- a fin that is plate-shaped;
- a first heat transfer tube extending through the fin, the first heat transfer tube having a flat cross-section; and
- a second heat transfer tube extending through the fin, the second heat transfer tube being disposed at a distance from the first heat transfer tube in a gravity direction, the second heat trans-

- fer tube having a flat cross-section,
the first heat transfer tube having a first upwind
end located upwind in a passing direction in
which the air passes and a first downwind end
located downwind in the passing direction,
the second heat transfer tube having a second
upwind end located upwind in the passing direc-
tion and a second downwind end located down-
wind in the passing direction,
the fin having an upwind fin end located upwind
in the passing direction and a downwind fin end
located downwind in the passing direction,
where the first upwind end and the second up-
wind end are connected by a first imaginary line
and the first downwind end and the second
downwind end are connected by a second imag-
inary line, the fin having an upwind fin region
defined by the upwind fin end and the first im-
aginary line, a heat-transfer-tube region defined
by the first imaginary line and the second imag-
inary line, and a downwind fin region defined
by the second imaginary line and the downwind fin
end,
a dimension of the upwind fin region being larger
than a dimension of the downwind fin region in
the passing direction.
2. The heat exchanger of claim 1,
wherein the heat exchanger has a two-column struc-
ture and includes an upwind heat exchanger element
that is disposed upwind in the passing direction and
that is configured as described in claim 1 and a down-
wind heat exchanger element that is disposed down-
wind in the passing direction and that is configured
as described in claim 1, and
wherein a dimension of the upwind fin region in the
downwind heat exchanger element is smaller than
a dimension of the upwind fin region in the upwind
heat exchanger element in the passing direction.
3. A heat exchanger that is supplied with air by a fan,
the heat exchanger comprising:
- a fin that is plate-shaped;
a first heat transfer tube extending through the
fin, the first heat transfer tube having a flat cross-
section; and
a second heat transfer tube extending through
the fin, the second heat transfer tube being dis-
posed at a distance from the first heat transfer
tube in a gravity direction, the second heat trans-
fer tube having a flat cross-section,
the first heat transfer tube having a first upwind
end located upwind in a passing direction in
which the air passes and a first downwind end
located downwind in the passing direction,
the second heat transfer tube having a second
upwind end located upwind in the passing direc-
tion and a second downwind end located down-
wind in the passing direction,
the fin having an upwind fin end located upwind
in the passing direction and a downwind fin end
located downwind in the passing direction,
where the first upwind end and the second up-
wind end are connected by a first imaginary line
and the first downwind end and the second
downwind end are connected by a second imag-
inary line, the fin having an upwind fin region
defined by the upwind fin end and the first im-
aginary line, a heat-transfer-tube region defined
by the first imaginary line and the second imag-
inary line, and a downwind fin region defined
by the second imaginary line and the downwind fin
end,
the heat exchanger having a two-column struc-
ture and including an upwind heat exchanger
element disposed upwind in the passing direc-
tion and a downwind heat exchanger element
disposed downwind in the passing direction,
in the upwind heat exchanger element, a dimen-
sion of the upwind fin region being larger than a
dimension of the downwind fin region in the
passing direction,
a dimension of the upwind fin region in the down-
wind heat exchanger element being equal in the
passing direction to the dimension of the down-
wind fin region in the upwind heat exchanger
element,
a dimension of the downwind fin region in the
downwind heat exchanger element being equal
in the passing direction to the dimension of the
upwind fin region in the upwind heat exchanger
element.
4. The heat exchanger of any one of claims 1 to 3,
wherein the first heat transfer tube slopes from the
first upwind end downwardly in the gravity direc-
tion to the first downwind end and the second heat
transfer tube slopes from the second upwind end
downwardly in the gravity direction to the second
downwind end.
5. A refrigeration cycle apparatus, comprising:
- the heat exchanger of any one of claims 1 to 4;
and
an air-sending fan configured to supply air to the
heat exchanger.

FIG. 1

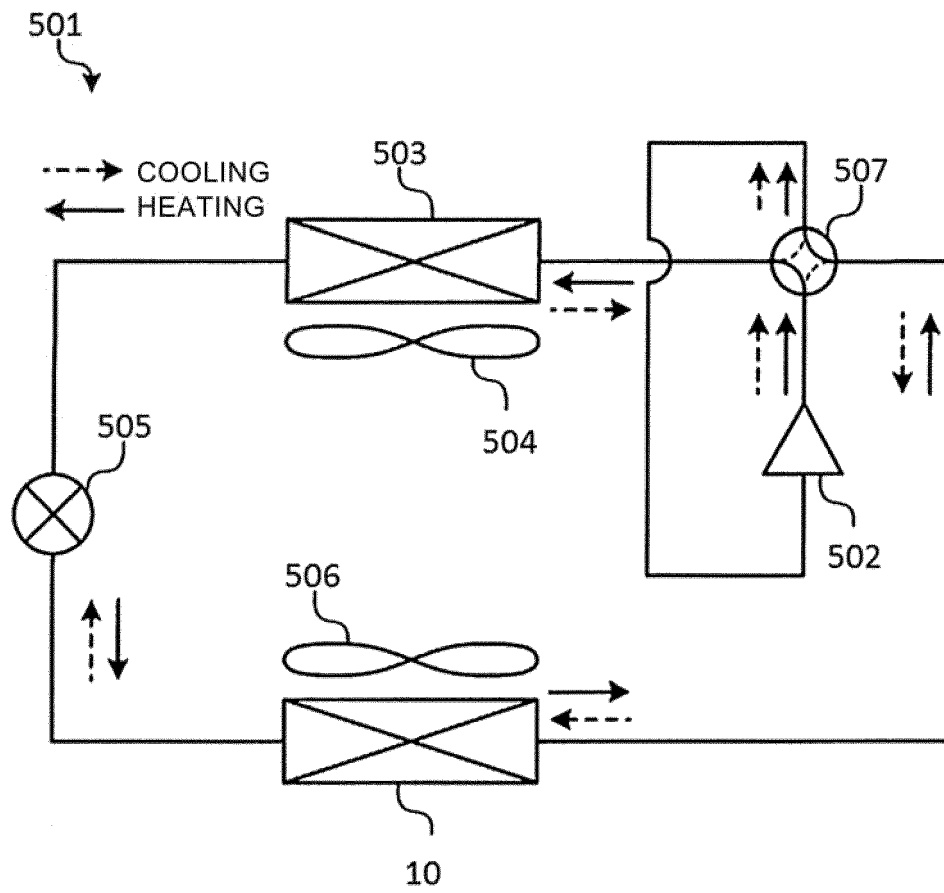


FIG. 2

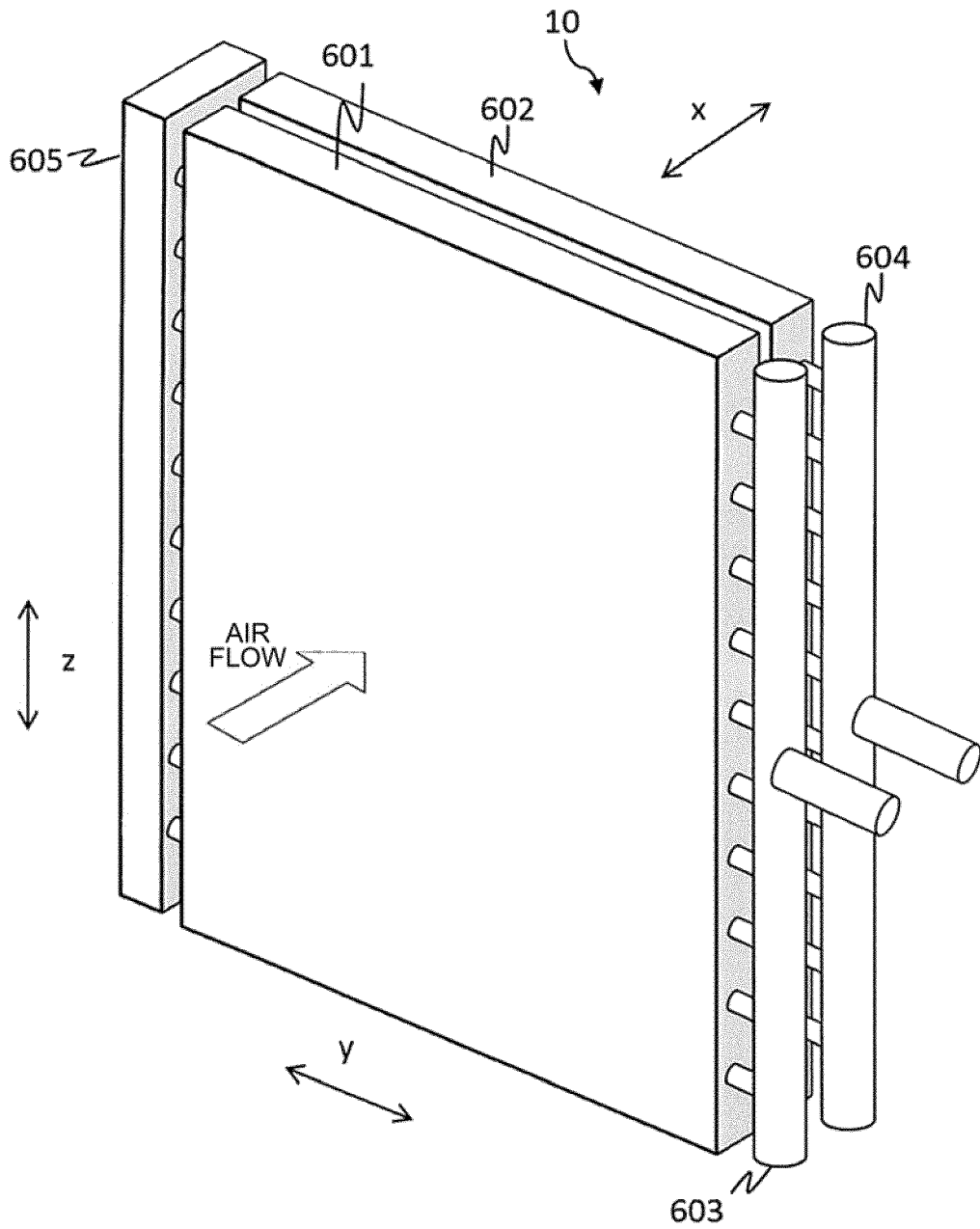


FIG. 3

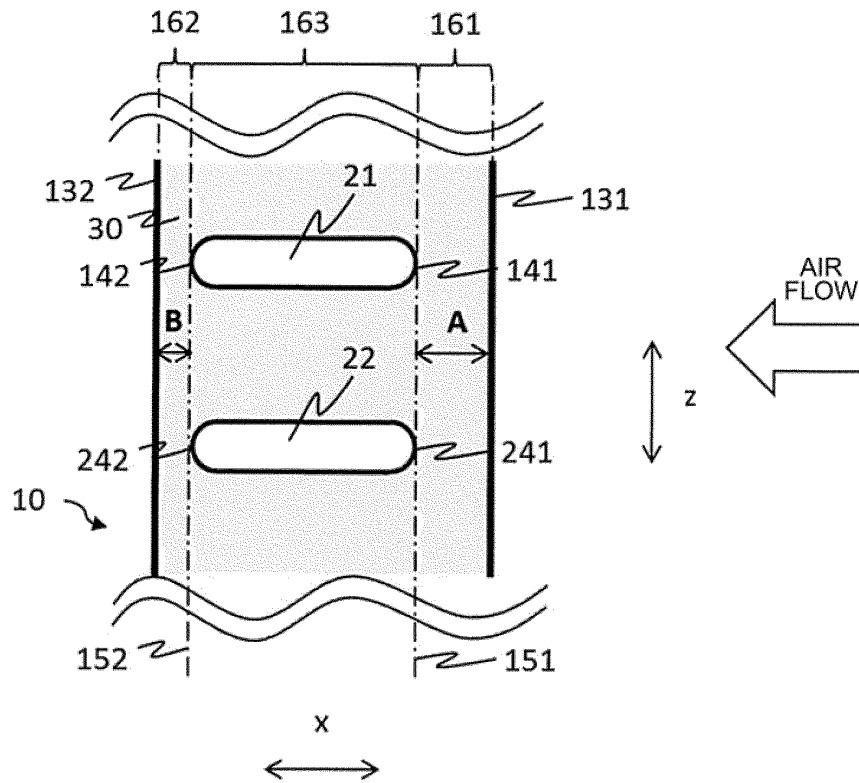


FIG. 4

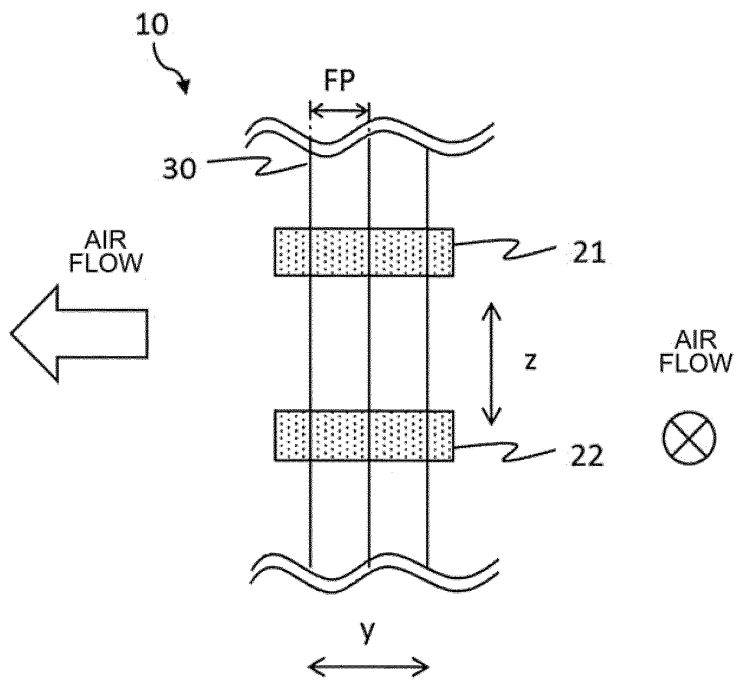


FIG. 5

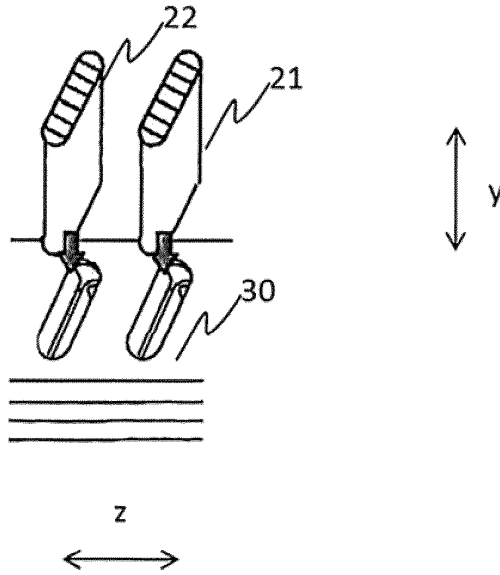


FIG. 6

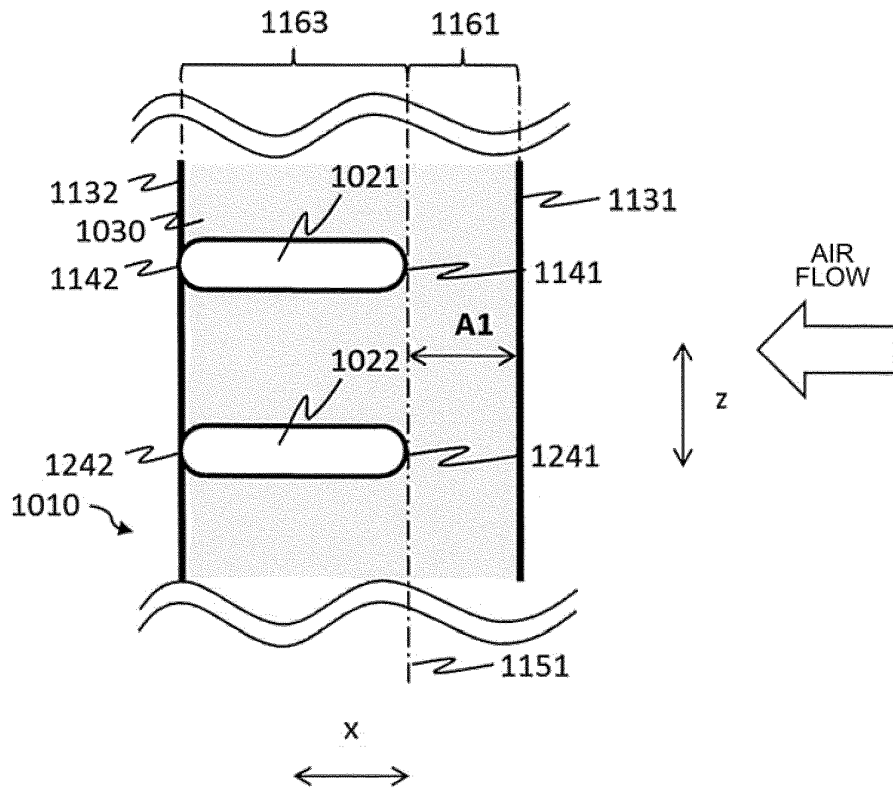


FIG. 7

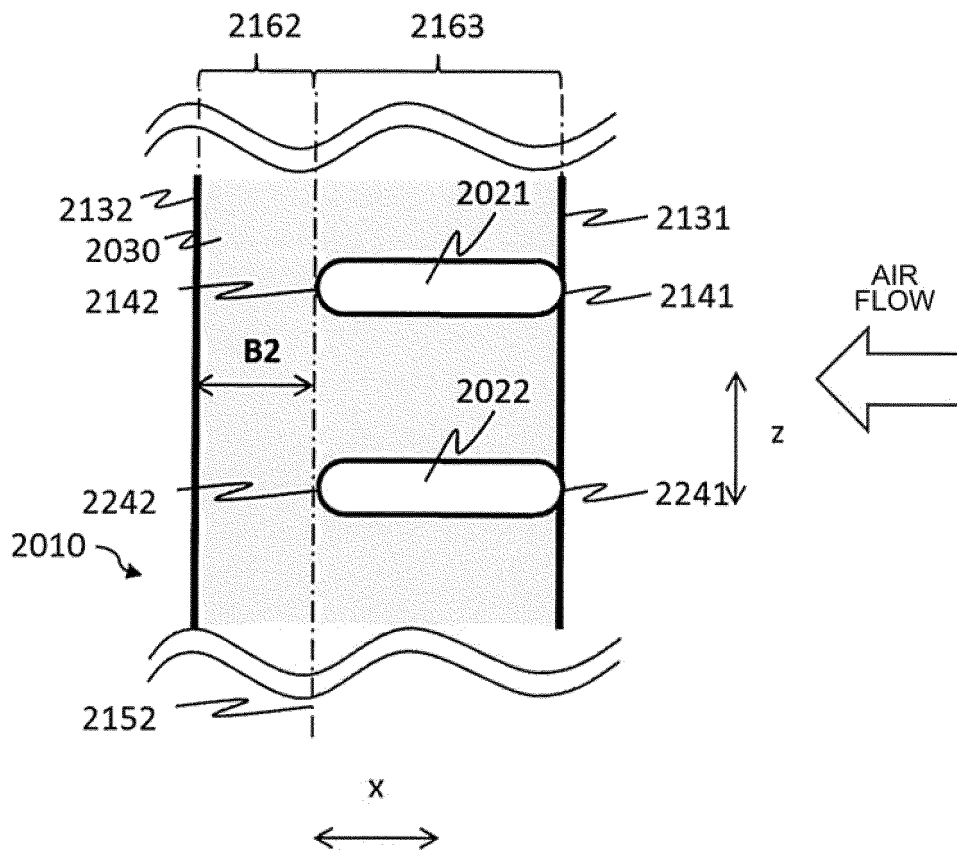


FIG. 8

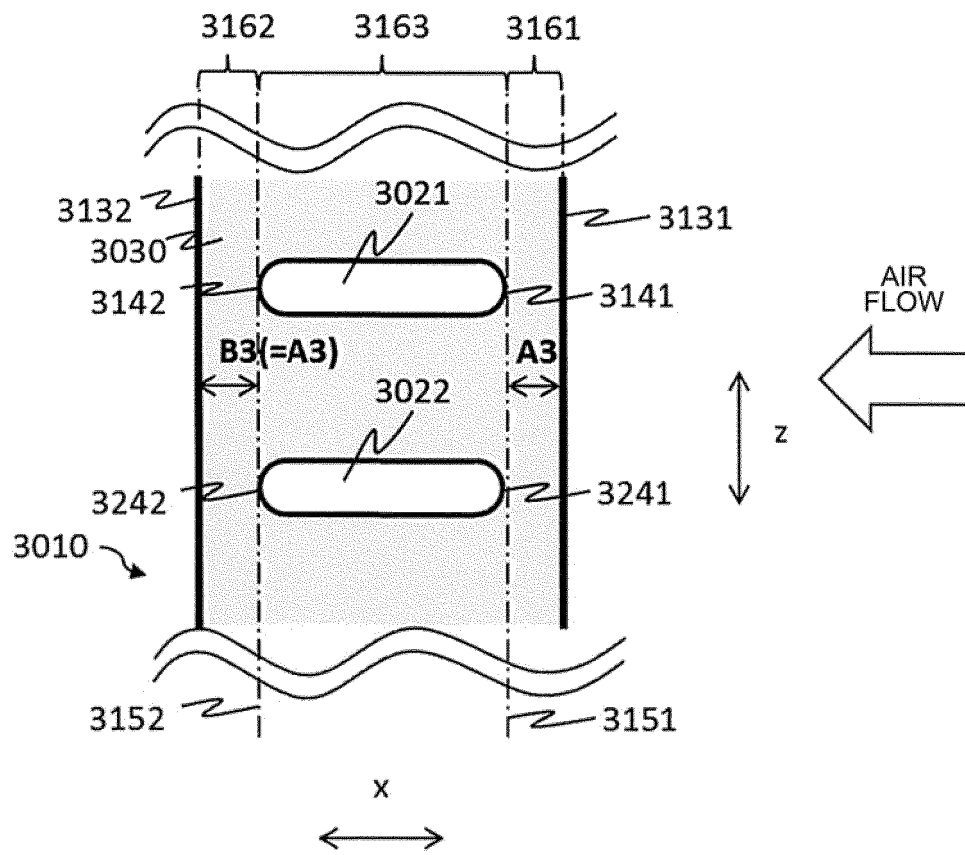
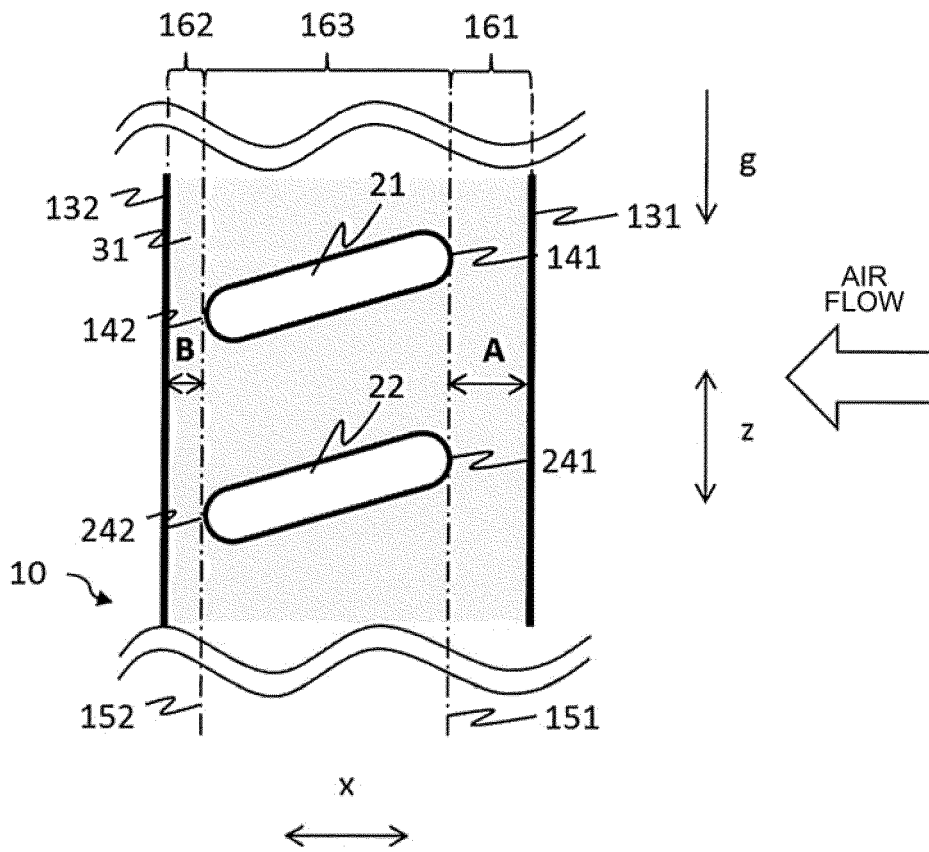


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/082072

A. CLASSIFICATION OF SUBJECT MATTER

F28F1/02(2006.01)i, F25B39/02(2006.01)i, F28D1/053(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F1/02, F25B39/02, F28D1/053

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-193389 A (Hitachi, Ltd.), 14 July 2000 (14.07.2000), paragraph [0022]; fig. 1 (Family: none)	1-2, 4-5
Y	JP 2016-176646 A (Johnson Controls-Hitachi Air Conditioning Technology (Hong Kong) Ltd.), 06 October 2016 (06.10.2016), claim 1; fig. 2 (Family: none)	1-2, 4-5
Y	WO 2016/013100 A1 (Mitsubishi Electric Corp.), 28 January 2016 (28.01.2016), paragraphs [0022], [0044]; fig. 4, 9 (Family: none)	2, 4-5

 Further documents are listed in the continuation of Box C.
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"&" document member of the same patent family

Date of the actual completion of the international search
10 November 2016 (10.11.16)Date of mailing of the international search report
13 December 2016 (13.12.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/082072

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 17903/1984 (Laid-open No. 130375/1985) (Matsushita Electric Industrial Co., Ltd.), 31 August 1985 (31.08.1985), page 4, lines 16 to 20; fig. 6 (Family: none)	4-5
A	JP 2006-153290 A (Daikin Industries, Ltd.), 15 June 2006 (15.06.2006), paragraphs [0057] to [0060]; fig. 4 (Family: none)	3

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REFERENCES CITED IN THE DESCRIPTION

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- JP 3264525 B [0008]
- JP 5736794 B [0008]