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

WÄRMETAUSCHER UND KÜHLZYKLUSVORRICHTUNG

ÉCHANGEUR THERMIQUE ET DISPOSITIF À CYCLE DE RÉFRIGÉRATION

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Description

Technical Field

[0001] The present invention relates to a heat exchanger in which both of drainage performance and heat transfer performance are improved, and a refrigeration cycle apparatus including the same.

Background Art

[0002] An existing heat exchanger has been known in which two or more fin-and-tube type heat exchanging parts are arranged in parallel along a flow direction of air blown out in a lateral direction from a fan. More specifically, each of the heat exchanging parts of this heat exchanger includes a plurality of fins extending in an up-down direction and a plurality of heat transfer tubes. The plurality of fins are arranged in parallel at a predetermined interval in the lateral direction substantially perpendicular to the air flow direction. The plurality of heat transfer tubes are arranged in parallel at a predetermined interval in the up-down direction and pass through the fins along an arrangement direction of these fins. Ends of each of the heat transfer tubes are connected to distribution pipes or headers to form refrigerant passages including these heat transfer tubes. In the heat exchanger, heat is exchanged between the air flowing into gaps between the fins and the refrigerant flowing through the heat transfer tubes.

[0003] The heat exchanger configured as described above is also proposed in which a flat tube is used as the heat transfer tube. The flat tube is a heat transfer tube that has, for example, an elliptical sectional shape in which the width is larger than the height in a cross-sectional view perpendicular to the flow direction of the refrigerant. Compared with the heat exchanger including circular tubes, the heat exchanger including the flat tubes can ensure a large area of heat transfer of the tubes and reduce the ventilation resistance of the air. Thus, compared with the heat exchanger including circular tubes, the heat exchanger including the flat tubes can provide improved heat transfer performance. In contrast, when the heat exchanger including the flat tubes is used as an evaporator, its drainage performance is inferior to that of the heat exchanger including circular tubes. This is because water droplets readily stay on the upper surfaces of the flat tubes.

[0004] For example, when in an air-conditioning apparatus and a refrigeration cycle apparatus such as a freezer, the heat exchanger for an outdoor unit is used as an evaporator at low outside air temperature, the water in the air condenses and forms frost on the heat exchanger. The frost formation leads to an increase in the ventilation resistance, impairment in the heat transfer performance, and damage to the heat exchanger. To avoid these problems, a typical refrigeration cycle apparatus has a defrosting operation mode for melting frost adhering to the heat exchanger. As described above, the water droplets readily stay on the heat exchanger including the flat tubes. When the water droplets stay on the heat exchanger, the water droplets freeze and form a large volume of frost. That is, the heat exchanger including the flat tubes requires a longer period of defrosting operation, resulting in impairment in comfortability and a reduction in average heating capacity.

[0005] Patent Literature 1 discloses that in a heat exchanger in which two fin-and-tube type heat exchanging parts using flat tubes having an elliptical sectional shape are arranged in parallel along a flow direction of air blown out in a lateral direction from a fan, the flat tubes are arranged in such a manner that the upper surfaces of the flat tubes are inclined.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2007-183088

JP2005114308Adiscloses a heat exchanger to reduce ventilation resistance and improve evaporation performance in the case of using a heat exchanger as an evaporator.

[0007] WO2014091536A1 discloses a flat tube heat exchange apparatus which is capable of being aligned in a zigzag arrangement, even if one identically-shaped flat tube heat exchange apparatus row is arranged in a plurality of rows, and in which the positions of fin end parts are not irregular. The flat tube heat exchange apparatus combines a plurality of rows of a single-row flat tube heat exchange apparatus which has: flat tubes which have a cross-sectional shape that is a rectangle having a large aspect ratio and rounded corners, and inside which a heat exchange medium flows; and a plurality of plate-shaped fins into which the flat tubes are inserted, and which are combined with the flat tubes in the orthogonal direction. The flat tubes are arranged at a regular pitch in the step direction of the fins. If the step direction pitch of the flat tubes is defined as Dp, and the coefficient of Dp is defined as k, and if $0<k<0.5$ or $0.5<k<1$, the distance between a fin end at one side in the step direction of the fin, and a flat tube is $k \cdot Dp$, and the distance between a fin end at the other side in the step direction of the fin, and a flat tube is $(1-k) \cdot Dp$. The second row of single row flat tube heat exchange apparatuses is arranged so as to be opposite in the step direction to the first row of single row flat tube heat exchange apparatuses . WO2014091536 discloses a heat exchanger according to the preamble of claim 1. JPH1089870A discloses a heat exchanger to improve a close fitness between heat exchanging pipes and plate-like fins of a heat exchanger and enable its assembling operation to be easily carried out.

Summary of Invention

Technical Problem

[0008] In the heat exchanger disclosed in Patent Literature 1, the upper surface of each of the flat tubes is inclined to cause condensed water droplets staying on the upper surfaces of the flat tubes to be readily drained off by the gravity. Consequently, the heat exchanger disclosed in Patent Literature 1 can reduce the period of defrosting operation. In contrast, the heat exchanger disclosed in Patent Literature 1 cannot exert the sufficient heat transfer performance, which is an advantage of the flat tubes.

[0009] More specifically, the air that has flowed into the heat exchanger reaches the leading edge of the flat tube and splits into two ways, that is, the way along the upper surface and the way along the lower surface of the flat tube. On the surface oriented to face the air flow, the air flows along the tube wall, and passes through the heat exchanger while maintaining the relatively high air velocity. On the other hand, on the surface that does not face the air flow, the air hardly flows along the tube wall, thereby causing the stagnation of the air flow, that is, a dead water region. When the heat exchanger disclosed in Patent Literature 1 is viewed in the air flow direction, the flat tubes of the heat exchanging part located downstream in the air flow direction are arranged behind the dead water region of the flat tubes of the heat exchanging part located upstream. Consequently, sufficient amount of air does not flow in the vicinity of the surfaces of the flat tubes of the heat exchanging part located downstream in the air flow direction, thereby causing a reduction in air velocity at such a position. As a result, the heat exchanger disclosed in Patent Literature 1 cannot exert the sufficient heat transfer performance, which is an advantage of the flat tubes.

[0010] As one method for solving the problem, it is proposed that the arrangement positions of the flat tubes located downstream in the air flow direction are changed in such a manner that the flat tubes located downstream are not located behind the flat tubes located upstream when the heat exchanger is viewed in the air flow direction. That is, it is proposed that the flat tubes located downstream are arranged not to overlap with the flat tubes located upstream when the heat exchanger is viewed in the air flow direction. However, in the heat exchanger thus configured, the ventilation resistance of the heat exchanger is increased, thereby causing impairment in the heat transfer performance.

[0011] An object of the present invention is to provide a heat exchanger in which both of drainage performance and heat transfer performance are improved, and a refrigeration cycle apparatus including the same.

Solution to Problem

[0012] A heat exchanger of an embodiment of the present invention is provided according to claim 1.

Advantageous Effects of Invention

[0013] An embodiment of the present invention provides a heat exchanger in which both of drainage performance and heat transfer performance are improved, and a refrigeration cycle apparatus including the same. Please note that embodiments 3 and 4 are merely used for a better understanding of the current application, and do not form part of the invention.

Brief Description of Drawings

[0014]

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

[Fig. 2] Fig. 2 is a front view illustrating a heat exchanger according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is an enlarged view (front view) illustrating a main portion of fins of the heat exchanger according to Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a cross-sectional view illustrating a heat transfer tube of the heat exchanger according to Embodiment 1 of the present invention.

[Fig. 5] Fig. 5 is an enlarged view of a main portion of a part of Fig. 2.

[Fig. 6] Fig. 6 is a front view illustrating a heat exchanger according to Embodiment 2 of the present invention.

[Fig. 7] Fig. 7 is an enlarged view (front view) illustrating a main portion of fins of the heat exchanger according to Embodiment 2 of the present invention.

[Fig. 8] Fig. 8 is an enlarged view of a main portion of a part of Fig. 6.

[Fig. 9] Fig. 9 is a front view illustrating a heat exchanger according to Embodiment 3.

[Fig. 10] Fig. 10 is an enlarged view (front view) illustrating a main portion of fins of the heat exchanger according to Embodiment 3.

[Fig. 11] Fig. 11 is an enlarged view of a main portion of a part of Fig. 9.

[Fig. 12] Fig. 12 is a front view illustrating a heat exchanger according to Embodiment 4.

[Fig. 13] Fig. 13 is an enlarged view (front view) illustrating a main portion of fins of the heat exchanger according to Embodiment 4.

[Fig. 14] Fig. 14 is an enlarged view of a main portion of a part of Fig. 12. Description of Embodiments

[0015] Embodiments of a heat exchanger and a refrigeration cycle apparatus according to the present invention will be described hereinafter with reference to the drawings.

[0016] Embodiment 1

[0017] Fig. 1 is a diagram illustrating a refrigerant circuit of a refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[0018] A refrigeration cycle apparatus 100 includes a compressor 200, a condenser 300, an expansion mechanism 400, and an evaporator 500. These components of the refrigeration cycle apparatus 100 are sequentially connected through refrigerant pipes.

[0019] The compressor 200 is configured to suck refrigerant and compress the sucked refrigerant into high-temperature and high-pressure gas refrigerant. The condenser 300 is configured to exchange heat between the refrigerant flowing through the condenser 300 and air or other heat-exchanging target. The condenser 300 is, for example, a fin-tube type heat exchanger. A fan 301 configured to supply the air serving as heat-exchanging target to the condenser 300 is provided in the vicinity of the condenser 300. The expansion mechanism 400 is, for example, an expansion valve, and is configured to decompress and expand the refrigerant. The evaporator 500 is configured to exchange heat between the refrigerant flowing through the evaporator 500 and air or other heat-exchanging target. The evaporator 500 according to Embodiment 1 is a fin-tube type heat exchanger. A fan 501 configured to supply the air serving as heat-exchanging target to the evaporator 500 is provided in the vicinity of the evaporator 500. The fan 501 is, for example, a propeller fan.

[0020] In the refrigeration cycle apparatus 100 according to Embodiment 1, a heat exchanger 1 having the following configuration is used as the evaporator 500 to improve both of the drainage performance and the heat transfer performance of the evaporator 500.

[0021] Fig. 2 is a front view illustrating a heat exchanger according to Embodiment 1 of the present invention. Fig. 3 is an enlarged view (front view) illustrating a main portion of fins of this heat exchanger. Fig. 4 is a cross-sectional view illustrating a heat transfer tube of this heat exchanger. Fig. 5 is an enlarged view of a main portion of a part of Fig. 2.

[0022] Fig. 2 illustrates heat transfer tubes 15 and 25 in cross section. A blank arrow shown in each of Fig. 2 and Fig. 5 represents a flow direction of air to be supplied to the heat exchanger 1 from the fan 501. That is, in Embodiment 1, the fan 501 is configured to supply air to the heat exchanger 1 in a substantially horizontal direction. In other words, a rotary shaft of the fan 501, which is a propeller fan, is positioned in the substantially horizontal direction. In each of Figs. 2, 3, and 5, this air flow direction is also represented by an arrow X. An arrow Z shown in each of Figs. 2, 3, and 5 represents the gravity direction.

[0023] In the heat exchanger 1, a plurality of fin-and-tube type heat exchanging parts are arranged in parallel along the air flow direction. In Embodiment 1, the description focuses on an example in which the heat exchanger 1 includes a first heat exchanging part 10 located upstream of the air flow direction, and a second heat exchanging part 20 located downstream of the air flow direction. The first heat exchanging part 10 and the second heat exchanging part 20 have a similar configuration.

[0024] More specifically, the first heat exchanging part 10 includes a plurality of plate-shaped fins 11 extending in the up-down direction. These fins 11 are arranged in parallel at a predetermined fin pitch (interval) in a lateral direction perpendicular to the air flow direction (a direction perpendicular to the paper plane of Fig. 2). A plurality of notches 12 are cut in a downstream end 11 d of each of the fins 11 at a predetermined tier pitch (space) in the up-down direction. These notches 12 are cut so that the respective heat transfer tubes 15 are to be inserted into the notches, and have a shape corresponding to an outer shape of the heat transfer tube 15. An upstream end 12a of each of the notches 12 is positioned away from an upstream end 11c of the fin 11 by a predetermined interval (a first predetermined interval). Each of the notches 12 has a shape in such a manner that a distance between an upper edge and a lower edge of the notch 12 is gradually increased from the upstream end 12a to an opening 12b. Consequently, the heat transfer tubes 15 can be readily inserted into the respective notches 12.

[0025] Here, the fin 11 corresponds to a first fin of the present invention. The upstream end 11 c corresponds to a first end of the present invention. The downstream end 11d corresponds to a second end of the present invention.

[0026] The first heat exchanging part 10 includes a plurality of heat transfer tubes 15 inserted into the respective notches 12 in each of the fins 11. That is, the heat transfer tubes 15 are arranged in parallel at a predetermined tier pitch in the up-down direction. Each of the heat transfer tubes 15 is provided to pass through the fins 11 in an arrangement direction of these fins 11. The fins 11 and the heat transfer tubes 15 are tightly integrated with each other by brazing. Each of these heat transfer tubes 15 has a larger width than height in a cross-sectional view perpendicular to the flow direction of the refrigerant. Each of the heat transfer tubes 15 accommodates a plurality of partitions, which define a plurality of refrigerant passages 16 inside the heat transfer tube 15.

[0027] The shape of the heat transfer tube 15 will be further described in detail. The heat transfer tube 15 has a planar upper surface 15a and a planar lower surface 15c. A distance between the upper surface 15a and the lower surface 15c is gradually increased from the upstream end 15b toward the downstream end 15d. In other words, the distance between the upper surface 15a and the lower surface 15c is gradually increased from the upstream end 11c toward the downstream end 11d of the fin 11. Such a heat transfer tube 15 is made of, for example, aluminum or an aluminum alloy, and is fabricated by, for example, extrusion molding. Thus, in Embodiment 1, the heat transfer tube 15 accommodates partitions, which define a plurality of refrigerant passages 16 inside the heat transfer tube 15, in such a manner that the upper surface 15a and the lower surface 15c are substantially symmetrical to a plane including a bisector of an angle formed by the upper surface 15a and the lower surface 15c. This shape can readily ensure the manufacturability in extrusion molding of the heat transfer tube 15. The heat transfer tube 15 may be fabricated by, for example, extrusion molding to have an elliptical sectional shape and then transformed into a final shape by an additional process such as a press. The wall surfaces of the refrigerant passages 16, that is, the inner wall surfaces of the heat transfer tube 15 may have grooves. This structure increases the area of contact between the inner wall surfaces of the heat transfer tube 15 and the refrigerant. The efficiency of heat exchange is improved, accordingly.

[0028] Here, any one of the heat transfer tubes 15 corresponds to a first heat transfer tube. The upper surface 15a of the heat transfer tube 15 corresponding to the first heat transfer tube corresponds to a first surface of the present invention.

[0029] As described above, the upstream ends 12a of the respective notches 12, into which the respective heat transfer tubes 15 are to be inserted, in each of the fins 11 are positioned away from the upstream end 11c of the fin 11 by the predetermined interval (the first predetermined interval). Consequently, in a state in which the heat transfer tubes 15 are fitted into the fin 11, the upstream ends 15b of the respective heat transfer tubes 15 are also positioned away from the upstream end 11c of the fin 11 by the predetermined interval (the first predetermined interval). Such an arrangement enables each of the fins 11 to have a first area 11a and a second area 11b. The first area 11a is an area in which a plurality of notches 12 are cut in a longitudinal direction corresponding to the gravity direction (represented by the arrow Z), and the heat transfer tubes 15 are provided. The second area 11b is an area in which no heat transfer tubes 15 are provided in the longitudinal direction (represented by the arrow Z), and is a water drainage area for draining off the water adhering to the fin 11. The second area 11b is positioned upstream of the first area 11a in the flow direction (represented by the arrow X) of air serving as heat exchange fluid. The boundary between the first area 11a and the second area 11b is a virtual straight line connecting the upstream ends 12a of the respective notches 12 arranged in parallel in the up-down direction, in other words, a virtual straight line connecting the upstream ends 15b of the respective heat transfer tubes 15 arranged in parallel in the up-down direction.

[0030] In the state in which the heat transfer tubes 15 are fitted into the fin 11, each of the upper surfaces 15a of the respective heat transfer tubes 15 is inclined downward from the downstream end 11d toward the upstream end 11c of the fin 11, in other words, toward the second area 11b, which is the water drainage area. That is, the upper surface 15a of the heat transfer tube 15 is inclined downward toward the upstream end 11c of the fin 11. In Embodiment 1, the upper surface 15a of the heat transfer tube 15 is inclined by an angle θ to the horizontal surface. On the other hand, in the state in which the heat transfer tubes 15 are fitted into the fin 11, each of the lower surfaces 15c of the respective heat transfer tubes 15 is substantially horizontal.

[0031] The second heat exchanging part 20 includes a plurality of plate-shaped fins 21 extending in the up-down direction. These fins 21 are arranged in parallel at a predetermined fin pitch (interval) in a lateral direction perpendicular to the air flow direction (a direction perpendicular to the paper plane of Fig. 2). A plurality of notches 22 are cut in a downstream end 21d of each of the fins 21 at a predetermined tier pitch (space) in the up-down direction. These notches 22 are cut so that the respective heat transfer tubes 25 are to be inserted into the notches 22, and have a shape corresponding to an outer shape of the heat transfer tube 25. An upstream end 22a of each of the notches 22 is positioned away from an upstream end 21c of each of the fins 21 by a predetermined interval (a second predetermined interval). Each of the notches 22 has a shape in such a manner that a distance between an upper edge and a lower edge of the notch 22 is gradually increased from the upstream end 22a to an opening 22b. Consequently, the heat transfer tube 25 can be readily inserted into the corresponding notch 22.

[0032] Here, the fin 21 corresponds to a second fin of the present invention. The upstream end 21c corresponds to a third end of the present invention. The downstream end 21d corresponds to a fourth end of the present invention.

[0033] The second heat exchanging part 20 includes a plurality of heat transfer tubes 25 inserted into the respective notches 22 in each of the fins 21. That is, the heat transfer tubes 25 are arranged in parallel at a predetermined tier pitch in the up-down direction. Each of the heat transfer tubes 25 is provided to pass through the fins 21 in an arrangement direction of these fins 21. The fins 21 and the heat transfer tubes 25 are tightly integrated with each other by brazing. Each of these heat transfer tubes 25 has a larger width than height in a cross-sectional view perpendicular to the flow direction of the refrigerant. Each of the heat transfer tubes 25 accommodates a plurality of partitions, which define a plurality of refrigerant passages 26 inside the heat transfer tube 25.

[0034] The shape of the heat transfer tube 25 will be further described in detail. The heat transfer tube 25 has a planar upper surface 25a and a planar lower surface 25c. A distance between the upper surface 25a and the lower surface 25c is gradually increased from the upstream end 25b toward the downstream end 25d. In other words, the distance between the upper surface 25a and the lower surface 25c is gradually increased from the upstream end 21c toward the downstream end 21d of the fin 21. Such a heat transfer tube 25 is made of, for example, aluminum or an aluminum alloy, and is fabricated by, for example, extrusion molding. Thus, in Embodiment 1, the heat transfer tube 25 accommodates partitions, which define a plurality of refrigerant passages

26 inside the heat transfer tube 25 in such a manner that the upper surface 25a and the lower surface 25c are substantially symmetrical to a plane including a bisector of an angle formed by the upper surface 25a and the lower surface 25c. This shape can readily ensure the manufacturability in extrusion molding of the heat transfer tube 25. The heat transfer tube 25 may be fabricated by, for example, extrusion molding to have an elliptical sectional shape and then transformed into a final shape by an additional process such as a press. The wall surfaces of the refrigerant passages 26, that is, the inner wall surfaces of the heat transfer tube 25 may have grooves. This structure increases the area of contact between the inner wall surfaces of the heat transfer tube 25 and the refrigerant. The efficiency of heat exchange is improved, accordingly.

[0035] Here, the heat transfer tube 25 laterally adjacent to the heat transfer tube 15 corresponding to the first heat transfer tube corresponds to a second heat transfer tube of the present invention. The upper surface 25a of the heat transfer tube 25 corresponding to the second heat transfer tube corresponds to a second surface of the present invention.

[0036] As described above, the upstream ends 22a of the respective notches 22, into which the respective heat transfer tubes 25 are to be inserted, in each of the fins 21 are positioned away from the upstream end 21c of the fin 21 by the predetermined interval (the second predetermined interval). Consequently, in a state in which the heat transfer tubes 25 are fitted into the fin 21, the upstream ends 25b of the respective heat transfer tubes 25 are also positioned away from the upstream end 21c of the fin 21 by the predetermined interval (the second predetermined interval). Such an arrangement enables each of the fins 21 to have a first area 21a and a second area 21b. The first area 21a is an area in which a plurality of notches 22 are cut in a longitudinal direction corresponding to the gravity direction (represented by the arrow Z), and the heat transfer tubes 25 are provided. The second area 21b is an area in which no heat transfer tubes 25 are provided in the longitudinal direction (represented by the arrow Z), and is a water drainage area for draining off the water adhering to the fin 21. The second area 21b is positioned upstream of the first area 21a in the flow direction (represented by the arrow X) of air serving as heat exchange fluid. The boundary between the first area 21a and the second area 21b is a virtual straight line connecting the upstream ends 22a of the respective notches 22 arranged in parallel in the up-down direction, in other words, a virtual straight line connecting the upstream ends 25b of the respective heat transfer tubes 25 arranged in parallel in the up-down direction.

[0037] In the state in which the heat transfer tubes 25 are fitted into the fin 21, each of the upper surfaces 25a of the respective heat transfer tubes 25 is inclined downward from the downstream end 21d toward the upstream end 21c of the fin 21, in other words, toward the second area 21b, which is the water drainage area. That is, the upper surface 25a of the heat transfer tube 25 is inclined downward toward the upstream end 21c of the fin 21. In Embodiment 1, the upper surface 25a of the heat transfer tube 25 is inclined by an angle θ to the horizontal surface. On the other hand, in the state in which the heat transfer tubes 25 are fitted into the fin 21, each of the lower surfaces 25c of the respective heat transfer tubes 25 is substantially horizontal.

[0038] The first heat exchanging part 10 and the second heat exchanging part 20 configured as described above are arranged in such a manner that the downstream ends 11d of the respective fins 11 of the first heat exchanging part 10 and the upstream ends 21c of the respective fins 21 of the second heat exchanging part 20 face each other. Even when the fins 11 of the first heat exchanging part 10 and the fins 21 of the second heat exchanging part 20 are displaced from each other in the direction perpendicular to the paper plane of Fig. 2, in Embodiment 1, the downstream ends 11d of the respective fins 11 of the first heat exchanging part 10 are each construed as facing the corresponding one of the upstream ends 21c of the respective fins 21 of the second heat exchanging part 20.

[0039] In the heat exchanger 1 according to Embodiment 1, the heat transfer tubes 15 of the first heat exchanging part 10 and the heat transfer tubes 25 of the second heat exchanging part 20, the heat transfer tubes 25 being laterally adjacent to the respective heat transfer tubes 15, are provided in an arrangement relationship as illustrated in Fig. 5 illustrating a vertical cross section perpendicular to the direction in which the heat transfer tubes 15 pass through the fins 11, in other words, as illustrated in Fig. 5 illustrating a vertical cross section perpendicular to the direction in which the heat transfer tubes 25 pass through the fins 21. To describe this arrangement relationship in detail, intersecting points A and B are defined as follows. An intersecting point at which an extension line of the second surface of the present invention (the upper surface 25a of the heat transfer tube 25 in Embodiment 1) or the second surface and an extension line of the lower surface 15c of the heat transfer tube 15 intersect is defined as the intersecting point A. An intersecting point at which the extension line of the second surface of the present invention (the upper surface 25a of the heat transfer tube 25 in Embodiment 1) or the second surface and an extension line of the lower surface 25c of the heat transfer tube 25 intersect is defined as the intersecting point B.

[0040] More specifically, the upper end (a point C in Fig. 5) of the heat transfer tube 25 is located higher than the lower surface 15c of the heat transfer tube 15 laterally adjacent to the heat transfer tube 25. The intersecting point A at which the upper surface 25a of the heat transfer tube 25 and the extension line of the lower surface 15c of the heat transfer tube 15 intersect is located closer to the heat transfer tube 25 than is the intersecting point B at which the extension line of the upper surface 25a and the extension line of the lower surface 25c of the heat transfer tube 25 intersect. That is, the intersecting point A is located downstream of the intersecting point B in the air flow direction. In such an arrangement relationship, the heat transfer tube 15 of the first heat exchanging part 10 and the heat transfer tube 25 of the second heat exchanging part 20, the heat transfer tube 25 being laterally adjacent to the heat transfer tube 15, overlap with each other when the heat exchanger 1 is viewed in the air flow direction. In the arrangement relationship between the heat transfer tube 15 and the heat transfer tube 25 that overlap with each other when the heat exchanger 1 is viewed in the air flow direction, the heat transfer tube 25 is located slightly lower than the heat transfer tube 15.

[0041] Subsequently, the operation of the heat exchanger 1 according to Embodiment 1 will be described.

[0042] First, the heat exchanging action between the air supplied from the fan 501 and the refrigerant flowing in the heat transfer tubes 15 and 25 will be described.

[0043] As described above, the fan 501 is, for example, a propeller fan, and the rotary shaft of the fan 501 is positioned in the substantially horizontal direction. As represented by the blank arrow in each of Figs. 2 and 5, the air supplied from the fan 501 flows in the substantially horizontal direction into the heat exchanger 1 from the upstream end 11c of the fin 11 of the first heat exchanging part 10. This air flows into the first heat exchanging part 10, and then flows out through the second heat exchanging part 20.

[0044] More specifically, the air supplied from the fan 501 flows into gaps between the fins 11 of the first heat exchanging part 10 from the upstream ends 11c of the respective fins 11. When this air reaches the upstream end 15b of the heat transfer tube 15, the air splits into two ways, that is, the way along the upper surface 15a and the way along the lower surface 15c.

[0045] As described above, the upper surface 15a of the heat transfer tube 15 is inclined downward toward the upstream end 11c of the fin 11. That is, the upper surface 15a of the heat transfer tube 15 is oriented to face the air flow. Thus, the air can flow along the upper surface 15a across the majority of the heat transfer tube 15 in the width direction. Thus, the air flow without significant separation can facilitate heat exchange between the air and the heat transfer tube 15, and can also reduce the ventilation resistance.

[0046] As described above, the lower surface 15c of the heat transfer tube 15 is substantially horizontal. That is, the direction of the lower surface 15c of the heat transfer tube 15 substantially coincides with the air flow direction. Thus, the air can flow along the lower surface 15c across substantially the entire heat transfer tube 15 in the width direction. Thus, the air flow without significant separation can facilitate heat exchange between the air and the surface of the heat transfer tube 15, and can also reduce the ventilation resistance.

[0047] When the attention is focused on the heat transfer tubes 15 adjacent to each other in the up-down direction, a gap between the lower surface 15c of the heat transfer tube 15 located higher and the upper surface 15a of the heat transfer tube 15 located lower narrows in the downstream direction of the air flow. This configuration can reduce creation of a low air velocity region (a dead water region) between the upper surface and the lower surface due to expansion of air passage, and can facilitate heat exchange between the air and the surface of the first heat exchanging part 10.

[0048] The air that has flowed around the heat transfer tubes 15 flows out of the first heat exchanging part 10 from the downstream ends 11d of the respective fins 11. Here, in each of the heat transfer tubes 15 of the first heat exchanging part 10, the upper surface 15a is inclined downward toward the upstream end 11c, and the lower surface 15c is substantially horizontal. The air flowing between the heat transfer tubes 15 adjacent to each other in the up-down direction flows more upward than the horizontal direction.

[0049] The air that has flowed out of the first heat exchanging part 10 flows into gaps between the fins 21 of the second heat exchanging part 20 from the upstream ends 21c of the respective fins 21. When this air reaches the upstream end 25b of the heat transfer tube 25, the air splits into two ways, that is, the way along the upper surface 25a and the way along the lower surface 25c.

[0050] The upper surface 25a of the heat transfer tube 25 is located behind the downstream end 15d of the heat transfer tube 15 located upstream of the heat transfer tube 25, in the air flow direction. That is, according to an existing art, the upper surface 25a of the heat transfer tube 25 is located behind the dead water region, resulting that sufficient amount of air cannot flow through the upper surface 25a, thereby reducing the air velocity and the efficiency of heat exchange. However, in Embodiment 1, the air flowing into gaps between the fins 21 flows more upward than the horizontal direction, and reaches the upstream ends 25b of the respective heat transfer tubes 25. Consequently, as represented by an arrow W illustrated in Fig. 5, a part of air that has reached the upstream end 25b of the heat transfer tube 25 can flow along the upper surface 25a. This configuration can facilitate heat exchange between the air and the upper surface 25a. In Embodiment 1, the upstream end 25b of the heat transfer tube 25 is located slightly lower than the heat transfer tube 15. Thus, the amount of air flowing along the upper surface 25a of the heat transfer tube 25 can be increased, thereby facilitating heat exchange between the air and the upper surface 25a.

[0051] On the other hand, as the air that has reached the upstream end 25b of the heat transfer tube 25 flows more upward than the horizontal direction, the lower surface 25c of the heat transfer tube 25 is oriented to face the air flow. Consequently, the air can flow along the lower surface 25c of the heat transfer tube 25. This configuration can facilitate heat exchange between the air and the lower surface 25c.

[0052] Next, the water draining action of draining off water droplets adhering to the heat exchanger 1 will be described.

[0053] The water draining action of the first heat exchanging part 10 is described below.

[0054] The water droplets adhering to the first area 11a of each of the fins 11 of the first heat exchanging part 10 flow along the surface of the fin 11 that is in the first area 11a to fall down. These water droplets reach the upper surface 15a of each of the heat transfer tubes 15. The water droplets that have reached the upper surface 15a of the heat transfer tube 15 flow along the upper surface 15a toward the upstream end 15b due to the influence of gravity. Most of the water droplets that have reached the upstream end 15b flow to the second area 11b using the momentum of the water droplets flowing along the upper surface 15a, and flow to the lower portion of the first heat exchanging part 10. As the second area 11b includes no heat transfer tubes 15, the water droplets flow along the surface of the fin 11, reach the lower portion of the first heat exchanging part 10, and are drained off without stopping. That is, the first heat exchanging part 10 can provide the improved drainage performance, even while using the heat transfer tubes 15 having a larger width than height in a cross-sectional shape.

[0055] Some of the water droplets that have not flowed from the first area 11a to the second area 11b flow along the upstream end 15b of the heat transfer tube 15 to the lower surface 15c. The water droplets that have flowed to the lower surface 15c of the heat transfer tube 15 stay and grow on the lower surface 15c of the heat transfer tube 15, while the surface tension, the gravity, the static frictional force, and other forces are balanced. The water droplets expand downward and become more susceptible to the gravity as the water droplets grow. When the gravity on the water droplets exceeds the component of the forces including the surface tension in the direction opposite to the gravity direction, the water droplets are not affected by the surface tension and leave the lower surface 15c of the heat transfer tube 15. The water droplets that have left the lower surface 15c of the heat transfer tube 15 flow downward along the first area 11a again and reach the upper surface 15a of the lower heat transfer tube 15. Then, the water droplets repeat the above-described operations and are finally drained off to the lower portion of the first heat exchanging part 10.

[0056] The water draining action of the second heat exchanging part 20 is also similar to that of the first heat exchanging part 10.

[0057] That is, the water droplets adhering to the first area 21a of each of the fins 21 of the second heat exchanging part 20 flow along the surface of the fin 21 that is in the first area 21a to fall down. These water droplets reach the upper surface 25a of each of the heat transfer tubes 25. The water droplets that have reached the upper surface 25a of the heat transfer tube 25 flow along the upper surface 25a toward the upstream end 25b due to the influence of gravity. Most of the water droplets that have reached the upstream end 25b flow to the second area 21b using the momentum of the water droplets flowing along the upper surface 25a, and flow to the lower portion of the second heat exchanging part 20. As the second area 21b includes no heat transfer tubes 25, the water droplets flow along the surface of the fin 21, reach the lower portion of the second heat exchanging part 20, and are drained off without stopping. That is, the second heat exchanging part 20 can provide the improved drainage performance, even while using the heat transfer tubes 25 having a larger width than height in a cross-sectional shape.

[0058] Some of the water droplets that have not flowed from the first area 21a to the second area 21b flow along the upstream end 25b of the heat transfer tube 25 to the lower surface 25c. The water droplets that have flowed to the lower surface 25c of the heat transfer tube 25 stay and grow on the lower surface 25c of the heat transfer tube 25, while the surface tension, the gravity, the static frictional force, and other forces are balanced. The water droplets expand downward and become more susceptible to the gravity as the water droplets grow. When the gravity on the water droplets exceeds the component of the forces including the surface tension in the direction opposite to the gravity direction, the water droplets are not affected by the surface tension and leave the lower surface 25c of the heat transfer tube 25. The water droplets that have left the lower surface 25c of the heat transfer tube 25 flow downward along the first area 21a again and reach the upper surface 25a of the lower heat transfer tube 25. Then, the water droplets repeat the above-described operations and are finally drained off to the lower portion of the second heat exchanging part 20.

[0059] As described above, the heat exchanger 1 according to Embodiment 1 includes the fins 11 each having the upstream end 11c and the downstream end 11d in the lateral direction, the fins 21 each having the upstream end 21c and the downstream end 21d in the lateral direction, the upstream end 21c being positioned to face the downstream end 11d, the heat transfer tubes 15 each positioned away from the upstream end 11c by the first predetermined interval and passing through the fins 11, and the heat transfer tubes 25 each positioned away from the upstream end 21c by the second predetermined interval and passing through the fins 21. The heat transfer tube 15 has the planar upper surface 15a and the planar lower surface 15c. The heat transfer tube 25 has the planar upper surface 25a and the planar lower surface 25c. Here, the upper surface 15a and the upper surface 25a shall be defined as a first surface and a second surface, respectively. When the heat transfer tube 15 and the heat transfer tube 25 are viewed in such a manner that the lower surface 15c is horizontal, in the vertical cross section perpendicular to the direction in which the heat transfer tube 15 passes through the fins 11, the first surface is inclined downward toward the upstream end 11c, the second surface is inclined downward toward the upstream end 21c, the upper end of the heat transfer tube 25 is located higher than the lower surface 15c, and the intersecting point A at which the second surface and the extension line of the lower surface 15c intersect is located closer to the heat transfer tube 25 than is the intersecting point B at which the extension line of the second surface and the extension line of the lower surface 25c intersect.

[0060] Consequently, the heat exchanger 1 according to Embodiment 1 can provide the improved drainage performance, even while using the heat transfer tubes 15 and 25 each having a larger width than height in a cross-sectional shape. In the heat exchanger 1 according to Embodiment 1, the arrangement relationship between the heat transfer tube 15 located upstream of the air flow and the heat transfer tube 25 located downstream of the air flow that overlap with each other when the heat exchanger 1 is viewed in the air flow direction can also facilitate heat exchange at the heat transfer tube 25, as described above. Thus, in the heat exchanger 1 according to Embodiment 1, both of drainage performance and heat transfer performance are improved.

[0061] In Embodiment 1, the lower surface 15c, 25c of the heat transfer tube 15, 25 is positioned to be horizontal. However, without limitation to this arrangement, the lower surface 15c, 25c of the heat transfer tube 15, 25 may be positioned to be inclined to the horizontal plane. When the upper surface 15a, 25a of the heat transfer tube 15, 25 is inclined downward toward the second area 11b, 21b, the drainage performance can be improved as described above. In addition, when the air is supplied from the fan 501 into the heat exchanger 1 so that the air flows along the lower surface 15c of the heat transfer tube 15, the heat transfer performance can be improved as described above. However, when the lower surface 15c, 25c of the heat transfer tube 15, 25 is positioned to be inclined downward from the upstream end 15b, 25b toward the downstream end 15d, 25d, the water droplets that have reached the upstream end 15b, 25b from the upper surface 15a, 25a of the heat transfer tube 15, 25 readily flow to the lower surface 15c, 25c. Consequently, the improved drainage performance described above is slightly reduced. Thus, it is preferable that the lower surface 15c, 25c of the heat transfer tube 15, 25 is positioned to be horizontal or to be inclined downward from the downstream end 15d, 25d toward the upstream end 15b, 25b. In other words, it is preferable that the lower surface 15c, 25c of the heat transfer tube 15, 25 is positioned to be horizontal or to be inclined downward from the downstream end 11d, 21d toward the upstream end 11c, 21c of the fin 11, 12.

[0062] In Embodiment 1, the heat transfer tubes 15 and 25 are fitted into the respective notches 12 and 22 of each of the fins 11 and 21, but the fins 11 and 21 may have through holes in the fins 11 and 21 so that the heat transfer tubes 15 and 25 are inserted into the respective through holes. This configuration of the heat exchanger 1 enables both of drainage performance and heat transfer performance to be improved.

[0063] In Embodiment 1, the fin 11 and the fin 21 are formed separately, but the fin 11 and the fin 21 may be integrally formed to form one piece of fin. In this case, the heat exchanger 1 is only required to be manufactured through regarding the virtual straight line extending in the up-down direction at the position away from the upstream end 25b of the heat transfer tube 25 by the predetermined interval (the second predetermined interval) as the downstream end 11d of the fin 11 and the upstream end 21c of the fin 21. This configuration of the heat exchanger 1 enables both of drainage performance and heat transfer performance to be improved.

Embodiment 2

[0064] In Embodiment 1, the inclination of the lower surface 15c of the heat transfer tube 15 is the same as that of the lower surface 25c of the heat transfer tube 25. However, without limitation to this configuration, the inclination of the lower surface 15c of the heat transfer tube 15 may be different from that of the lower surface 25c of the heat transfer tube 25, to configure the following heat exchanger 1. Note that items not particularly described in Embodiment 2 are similar to those of Embodiment 1 and the same functions or configurations are described with the same reference signs.

[0065]

> Fig. 6 is a front view illustrating a heat exchanger according to Embodiment 2 of the present invention. Fig. 7 is an enlarged view (front view) illustrating a main portion of fins of this heat exchanger. Fig. 8 is an enlarged view of a main portion of a part of Fig. 6. Fig. 6 illustrates the heat transfer tubes 15 and 25 in cross section. A blank arrow shown in each of Fig. 6 and Fig. 8 represents a flow direction of air to be supplied to the heat exchanger 1 from the fan 501. That is, in Embodiment 2, the fan 501 is configured to supply air to the heat exchanger 1 in a substantially horizontal direction. In other words, the rotary shaft of the fan 501, which is a propeller fan, is positioned in the substantially horizontal direction. In each of Figs. 6 to 8, this air flow direction is also represented by an arrow X. An arrow Z shown in each of Figs. 6 to 8 represents the gravity direction.

[0066] Also in the heat exchanger 1 according to Embodiment 2, the heat transfer tubes 15 of the first heat exchanging part 10 and the heat transfer tubes 25 of the second heat exchanging part 20, the heat transfer tubes 25 being laterally adjacent to the respective heat transfer tubes 15, are arranged in such a manner that the upper end of the heat transfer tube 25, and the intersecting points A and B are located in the same manner as in Embodiment 1 in a vertical cross section perpendicular to the direction in which the heat transfer tubes 15 pass through the fins 11, in other words, in a vertical cross section perpendicular to the direction in which the heat transfer tubes 25 pass through the fins 21.

[0067] More specifically, the upper end (a point C in Fig. 8) of the heat transfer tube 25 is located higher than the lower surface 15c of the heat transfer tube 15 laterally adjacent to the heat transfer tube 25. The intersecting point A at which the upper surface 25a of the heat transfer tube 25 and the extension line of the lower surface 15c of the heat transfer tube 15 intersect is located closer to the heat transfer tube 25 than is the intersecting point B at which the extension line of the upper surface 25a and the extension line of the lower surface 25c of the heat transfer tube 25 intersect. That is, the intersecting point A is located downstream of the intersecting point B in the air flow direction. Thus, also in the heat exchanger 1 according to Embodiment 2, the heat transfer tube 15 of the first heat exchanging part 10 and the heat transfer tube 25 of the second heat exchanging part 20, the heat transfer tube 25 being laterally adjacent to the heat transfer tube 15, overlap with each other when the heat exchanger 1 is viewed in the air flow direction in the same manner as in Embodiment 1. In the arrangement relationship between the heat transfer tube 15 and the heat transfer tube 25 that overlap with each other when the heat exchanger 1 is viewed in the air flow direction, the upstream end 25b of the heat transfer tube 25 is located slightly lower than the lower surface 15c of the heat transfer tube 15.

[0068] The heat exchanger 1 according to Embodiment 2 differs from that of Embodiment 1 in that the lower surface 25c of the heat transfer tube 25 is inclined downward from the downstream end 21d toward the upstream end 21c of the fin 21, in other words, toward the second area 21b, which is a water drainage area. That is, the lower surface 25c of the heat transfer tube 25 is inclined downward toward the upstream end 21c of the fin 21.

[0069] Also in the heat exchanger 1 according to Embodiment 2 thus configured, the water droplets that have reached the upper surface 15a, 25a of the heat transfer tube 15, 25 can be drained off to the second area 11b, 21b including no heat transfer tubes 15, 25, due to the influence of gravity, in the same manner as in Embodiment 1. Furthermore, in the heat exchanger 1 according to Embodiment 2, the lower surface 25c of the heat transfer tube 25 is also inclined downward toward the second area 21b. Consequently, the water droplets adhering to the lower surface 25c of the heat transfer tube 25 flow along the lower surface 25c toward the upstream end 25b due to the influence of gravity. Most of the water droplets that have reached the upstream end 25b are drained off to the second area 21b using the momentum of the water droplets flowing along the lower surface 25c. Thus, the heat exchanger 1 according to Embodiment 2 can provide further improved drainage performance as compared with the heat exchanger 1 according to Embodiment 1.

[0070] The heat exchanger 1 according to Embodiment 2 can provide further improved heat transfer performance as compared with the heat exchanger 1 according to Embodiment 1. More specifically, in the heat transfer tube 25 according to Embodiment 2, both of the upper surface 25a and the lower surface 25c are arranged to be inclined downward in the upstream direction of the air flow. Consequently, a plane including a bisector of an angle formed by the upper surface 25a and the lower surface 25c is inclined downward in the upstream direction of the air flow. In other words, a center line of the cross section of the heat transfer tube 25 is inclined downward in the upstream direction of the air flow in the cross section perpendicular to the direction in which the heat transfer tubes 25 pass through the fins 21. Here, as described in Embodiment 1, the air flowing into gaps between the fins 21 of the second heat exchanging part 20 flows more upward than the horizontal direction, and reaches the upstream ends 25b of the respective heat transfer tubes 25. That is, the heat exchanger 1 according to Embodiment 2 is configured in such a manner that the center line of the cross section of the heat transfer tube 25 is along the air flow as compared with the heat exchanger 1 according to Embodiment 1. Thus, in the heat exchanger 1 according to Embodiment 2, the ventilation resistance when the air flows around the heat transfer tube 25 can be further reduced, as compared with the heat exchanger 1 according to Embodiment 1. Thus, in the heat exchanger 1 according to Embodiment 2, heat exchange at the heat transfer tube 25 can be further facilitated and the heat transfer performance can be further improved, as compared with the heat exchanger 1 according to Embodiment 1.

Embodiment 3

[0071] In Embodiment 1 and Embodiment 2, the intersecting point A is located closer to the heat transfer tube 25 than is the intersecting point B. Embodiment 3 which does not form part of the invention will be described by illustrating an example in which the arrangement positions of the heat transfer tubes 25 in the heat exchanger 1 according to Embodiment 1 are shifted upward so that the intersecting point A coincides with the intersecting point B. Note that items not particularly described in Embodiment 3 are similar to those of Embodiment 1 or Embodiment 2 and the same functions or configurations are described with the same reference signs.

[0072] Fig. 9 is a front view illustrating a heat exchanger according to Embodiment 3 . Fig. 10 is an enlarged view (front view) illustrating a main portion of fins of this heat exchanger. Fig. 11 is an enlarged view of a main portion of a part of Fig. 9.

[0073] Fig. 9 illustrates the heat transfer tubes 15 and 25 in cross section. A blank arrow shown in each of Fig. 9 and Fig. 11 represents a flow direction of air to be supplied to the heat exchanger 1 from the fan 501. That is, in Embodiment 3, the fan 501 is configured to supply air to the heat exchanger 1 in a substantially horizontal direction. In other words, the rotary shaft of the fan 501, which is a propeller fan, is positioned in the substantially horizontal direction. In each of Figs. 9 to 11, this air flow direction is also represented by an arrow X. An arrow Z shown in each of Figs. 9 to 11 represents the gravity direction.

[0074] In the heat exchanger 1 according to Embodiment 3, the intersecting point A at which the extension line of the upper surface 25a of the heat transfer tube 25 and the extension line of the lower surface 15c of the heat transfer tube 15 intersect coincides with the intersecting point B at which the extension line of the upper surface 25a and the extension line of the lower surface 25c of the heat transfer tube 25 intersect. Also in Embodiment 3, the upper end (a point C in Fig. 11) of the heat transfer tube 25 is located higher than the lower surface 15c of the heat transfer tube 15 laterally adjacent to the heat transfer tube 25 in the same manner as in Embodiment 1 and Embodiment 2. The other configurations of the heat exchanger 1 according to Embodiment 3 are similar to Embodiment 1.

[0075] When the arrangement positions of the heat transfer tubes 25 in the heat exchanger 1 according to Embodiment 1 are shifted upward so that the intersecting point A coincides with the intersecting point B as in the heat exchanger 1 according to Embodiment 3, the heat transfer tube 15 and the heat transfer tube 25 that are laterally adjacent to each other, overlap with each other when the heat exchanger 1 is viewed in the air flow direction, in the same manner as in Embodiment 1. In the heat transfer tube 15 and the heat transfer tube 25 that overlap with each other when the heat exchanger 1 is viewed in the air flow direction, the position in the up-down direction of the lower surface 25c of the heat transfer tube 25 coincides with the position in the up-down direction of the lower surface 15c of the heat transfer tube 15.

[0076] When the arrangement positions of the heat transfer tubes 25 in the heat exchanger 1 according to Embodiment 2 are shifted upward so that the intersecting point A coincides with the intersecting point B, the heat transfer tube 15 and the heat transfer tube 25 that are laterally adjacent to each other, overlap with each other when the heat exchanger 1 is viewed in the air flow direction, in the same manner as in Embodiment 2. In the heat transfer tube 15 and the heat transfer tube 25 that overlap with each other when the heat exchanger 1 is viewed in the air flow direction, the upstream end 25b of the heat transfer tube 25 is located slightly higher than the lower surface 15c of the heat transfer tube 15.

[0077] Also in the heat exchanger 1 configured as in Embodiment 3, the water droplets that have reached the upper surface 15a, 25a of the heat transfer tube 15, 25 can be drained off to the second area 11b, 21b including no heat transfer tubes 15, 25, due to the influence of gravity, in the same manner as in Embodiment 1 and Embodiment 2. Thus, the heat exchanger 1 according to Embodiment 3 can provide the improved drainage performance in the same manner as in Embodiment 1 and Embodiment 2.

[0078] In the heat exchanger 1 according to Embodiment 3, the arrangement and orientation of the heat transfer tubes 15 that are adjacent to each other in the up-down direction in the first heat exchanging part 10 are the same as those in Embodiment 1 and Embodiment 2. Consequently, the air flowing into gaps between the fins 21 of the second heat exchanging part 20 flows more upward than the horizontal direction, and reaches the upstream ends 25b of the respective heat transfer tubes 25. Thus, even when the heat exchanger 1 is configured as in Embodiment 3, sufficient amount of air can flow along the upper surfaces 25a of the respective heat transfer tubes 25 of the second heat exchanging part 20. Thus, also in the heat exchanger 1 configured as in Embodiment 3, the heat transfer performance can be improved.

[0079] That is, also in the heat exchanger 1 according to Embodiment 3, both of drainage performance and heat transfer performance can be improved in the same manner as in Embodiment 1 and Embodiment 2.

[0080] When the arrangement positions of the heat transfer tubes 25 in the heat exchanger 1 according to Embodiment 1 are shifted upward so that the intersecting point A coincides with the intersecting point B, a degree of overlap between the heat transfer tube 15 and the heat transfer tube 25 that are laterally adjacent to each other when the heat exchanger 1 is viewed in the air flow direction become the largest as illustrated in Fig. 11 or other figures. For example, when the heat transfer tubes having the same shape are used as the heat transfer tube 15 and the heat transfer tube 25, the heat transfer tube 25 is completely hidden behind the heat transfer tube 15 when the heat exchanger 1 is viewed in the airflow direction as illustrated in Fig. 11 or other figures. Consequently, when the arrangement positions of the heat transfer tubes 25 in the heat exchanger 1 according to Embodiment 1 are shifted upward so that the intersecting point A coincides with the intersecting point B, the ventilation resistance can be reduced by increased degree of overlap between the heat transfer tube 15 and the heat transfer tube 25, and the heat transfer performance can be improved by reduced amount of the ventilation resistance.

Embodiment 4

[0081] In Embodiment 1 to Embodiment 3, the heat transfer tube 15, 25 having the planar upper surface 15a, 25a is used. Embodiment 4 discloses an example using the heat transfer tube 15, 25 having a curved upper surface 15a, 25a. Note that items not particularly described in Embodiment 4 are similar to those of any of Embodiment 1 to Embodiment 3 and the same functions or configurations are described with the same reference signs.

[0082] Fig. 12 is a front view illustrating a heat exchanger according to Embodiment which does not form part of the present invention. Fig. 13 is an enlarged view (front view) illustrating a main portion of fins of this heat exchanger. Fig. 14 is an enlarged view of a main portion of a part of Fig. 12.

[0083] Fig. 12 illustrates the heat transfer tubes 15 and 25 in cross section. A blank arrow shown in each of Fig.

12 and Fig. 14 represents a flow direction of air to be supplied to the heat exchanger 1 from the fan 501. That is, in Embodiment 4, the fan 501 is configured to supply air to the heat exchanger 1 in a substantially horizontal direction. In other words, the rotary shaft of the fan 501, which is a propeller fan, is positioned in the substantially horizontal direction. In each of Figs. 12 to 14, this air flow direction is also represented by an arrow X. An arrow Z shown in each of Figs. 12 to 14 represents the gravity direction.

[0084] In Embodiment 1 to Embodiment 3, a plurality of notches 12, into which the respective heat transfer tubes 15 are to be inserted, are cut in each of the fins 11 of the first heat exchanging part 10 at a predetermined tier pitch (space) in the up-down direction. On the other hand, in Embodiment 4, a plurality of through holes 13, into which the respective heat transfer tubes 15 are to be inserted, are provided in each of the fins 11 of the first heat exchanging part 10 at a predetermined tier pitch (space) in the up-down direction. Each of the through holes 13 has a shape corresponding to an outer shape of the heat transfer tube 15. The upstream end 13a of the through hole 13 is positioned away from the upstream end 11c of the fin 11 by the predetermined interval (the first predetermined interval). The downstream end 13b of the through hole 13 is also positioned away from the downstream end 11d of the fin 11 by the predetermined interval.

[0085] Each of the heat transfer tubes 15 according to Embodiment 4 is inserted into the corresponding through hole 13 in each of the fins 11, and is provided to pass through the fins 11 in an arrangement direction of these fins 11. The fins 11 and the heat transfer tubes 15 are tightly integrated with each other by brazing. Each of these heat transfer tubes 15 has a larger width than height in a cross-sectional view perpendicular to the flow direction of the refrigerant.

[0086] The shape of the heat transfer tube 15 will be further described in detail. The heat transfer tube 15 has a curved upper surface 15a projecting upward and a planar lower surface 15c. A distance between the upper surface 15a and the lower surface 15c is gradually increased from the upstream end 11c toward the downstream end 11d of the fin 11 at a portion (a portion of the fin 11 that is close to the upstream end 11c) that is upstream of the lateral center position in the air flow, when the heat transfer tube 15 is viewed in a cross-sectional view perpendicular to the flow direction of the refrigerant. In other words, when a tangent plane of the upper surface 15a is defined as a tangent plane 17, a distance between the tangent plane 17 and the lower surface 15c is gradually increased from the upstream end 11c toward the downstream end 11d of the fin 11. Note that, the lower surface 15c of the heat transfer tube 15 is substantially horizontal. That is, the tangent plane 17 is inclined downward toward the upstream end 11c of the fin 11.

[0087] Here, the tangent plane 17 corresponds to a first surface of the present invention.

[0088] As described above, the upstream end 13a of the through hole 13 of the fin 11, into which the heat transfer tube 15 is to be inserted, is positioned away from the upstream end 11c of the fin 11 by the predetermined interval (the first predetermined interval). The downstream end 13b of the through hole 13 of the fin 11, into which the heat transfer tube 15 is to be inserted, is positioned away from the downstream end 11d of the fin 11 by the predetermined interval. In the state in which the heat transfer tube 15 is fitted into the fin 11, the upstream end 15b of the heat transfer tube 15 is also positioned away from the upstream end 11c of the fin 11 by the predetermined interval (the first predetermined interval). In the state in which the heat transfer tube 15 is fitted into the fin 11, the downstream end 15d of the heat transfer tube 15 is also positioned away from the downstream end 11d of the fin 11 by the predetermined interval.

[0089] Thus, in Embodiment 4, the second area 11b in which no heat transfer tubes 15 is positioned in each of a portion close to the upstream end 11c and a portion close to the downstream end 11d of the fin 11. The boundary between the first area 11a and the second area 11b that is closed to the upstream end 11c is a virtual straight line connecting the upstream ends 13a of the respective through holes 13 provided in parallel in the up-down direction, in other words, a virtual straight line connecting the upstream ends 15b of the respective heat transfer tubes 15 arranged in parallel in the up-down direction. In addition, the boundary between the first area 11a and the second area 11b that is close to the downstream end 11d is a virtual straight line connecting the downstream ends 13b of the respective through holes 13 provided in parallel in the up-down direction, in other words, a virtual straight line connecting the downstream ends 15d of the respective heat transfer tubes 15 arranged in parallel in the up-down direction.

[0090] The second heat exchanging part 20 according to Embodiment 4 has a similar configuration as the first heat exchanging part 10 according to Embodiment 4. More specifically, a plurality of through holes 23, into which the respective heat transfer tubes 25 are to be inserted, are provided in each of the fins 21 of the second heat exchanging part 20 at a predetermined tier pitch (space) in the up-down direction. Each of the through holes 23 has a shape corresponding to an outer shape of the heat transfer tube 25. The upstream end 23a of the through hole 23 is positioned away from the upstream end 21c of the fin 21 by the predetermined interval (the second predetermined interval). The downstream end 23b of the through hole 23 is also positioned away from the downstream end 21d of the fin 21 by the predetermined interval.

[0091] Each of the heat transfer tubes 25 according to Embodiment 4 is inserted into the corresponding through hole 23 in each of the fins 21, and is provided to pass through the fins 21 in an arrangement direction of these fins 21. The fins 21 and the heat transfer tubes 25 are tightly integrated with each other by brazing. Each of these heat transfer tubes 25 has a larger width than height in a cross-sectional view perpendicular to the flow direction of the refrigerant.

[0092] The shape of the heat transfer tube 25 will be further described in detail. The heat transfer tube 25 has a curved upper surface 25a projecting upward and a planar lower surface 25c. A distance between the upper surface 25a and the lower surface 25c is gradually increased from the upstream end 21c toward the downstream end 21d of the fin 21 at a portion (a portion of the fin 21 that is close to the upstream end 21c) that is upstream of the lateral center position in the air flow, when the heat transfer tube 25 is viewed in a cross-sectional view perpendicular to the flow direction of the refrigerant. In other words, when a tangent plane of the upper surface 25a at a portion (a portion of the fin 21 that is close to the upstream end 21c) that is upstream of the lateral center position in the air flow is defined as a tangent plane 27, a distance between the tangent plane 27 and the lower surface 25c is gradually increased from the upstream end 21c toward the downstream end 21d of the fin 21. Note that, the lower surface 25c of the heat transfer tube 25 is substantially horizontal. That is, the tangent plane 27 is inclined downward toward the upstream end 21c of the fin 21.

[0093] Here, the tangent plane 27 corresponds to a second surface of the present invention.

[0094] As described above, the upstream end 23a of the through hole 23 of the fin 21, into which the heat transfer tube 25 is to be inserted, is positioned away from the upstream end 21c of the fin 21 by the predetermined interval (the second predetermined interval). The downstream end 23b of the through hole 23 of the fin 21, into which the heat transfer tube 25 is to be inserted, is positioned away from the downstream end 21d of the fin 21 by the predetermined interval. In the state in which the heat transfer tube 25 is fitted into the fin 21, the upstream end 25b of the heat transfer tube 25 is also positioned away from the upstream end 21c of the fin 21 by the predetermined interval (the second predetermined interval). In the state in which the heat transfer tube 25 is fitted into the fin 21, the downstream end 25d of the heat transfer tube 25 is also positioned away from the downstream end 21d of the fin 21 by the predetermined interval.

[0095] Thus, in Embodiment 4, the second area 21b in which no heat transfer tubes 25 are provided is positioned in each of a portion close to the upstream end 21c and a portion close to the downstream end 21d of the fin 21. The boundary between the first area 21a and the second area 21b that is close to the upstream end 21c is a virtual straight line connecting the upstream ends 23a of the respective through holes 23 provided in parallel in the up-down direction, in other words, a virtual straight line connecting the upstream ends 25b of the respective heat transfer tubes 25 arranged in parallel in the up-down direction. In addition, the boundary between the first area 21a and the second area 21b that is close to the downstream end 21d is a virtual straight line connecting the downstream ends 23b of the respective through holes 23 provided in parallel in the up-down direction, in other words, a virtual straight line connecting the downstream ends 25d of the respective heat transfer tubes 25 arranged in parallel in the up-down direction.

[0096] In the heat exchanger 1 thus configured, the water droplets that have reached the upper surface 15a, 25a of the heat transfer tube 15, 25 can be drained off to the second areas 11b, 21b including no heat transfer tubes 15, 25, due to the influence of gravity, in the same manner as in Embodiment 1 to Embodiment 3. Thus, the heat exchanger 1 according to Embodiment 4 can also provide the improved drainage performance in the same manner as in Embodiment 1 to Embodiment 3.

[0097] The above-described tangent plane 17 of the heat transfer tube 15 of the first heat exchanging part 10 is positioned to have the same inclination as the upper surface 15a of each of Embodiment 1 to Embodiment 3, and the above-described tangent plane 27 of the heat transfer tube 25 of the second heat exchanging part 20 is positioned to have the same inclination as the upper surface 25a of each of Embodiment 1 to Embodiment 3. Thereby, the drainage performance can be improved in the same manner as in Embodiment 1 to Embodiment 3.

[0098] That is, the tangent plane 17, 27 of the heat transfer tube 15, 25 is only required to be inclined downward from the downstream end 11d, 21d toward the upstream end 11c, 21c of the fin 11, 21. The upper end (a point C in Fig. 14) of the heat transfer tube 25 is only required to be positioned higher than the lower surface 15c of the heat transfer tube 15 laterally adjacent to the heat transfer tube 25. An intersecting point A at which the tangent plane 27 of the heat transfer tube 25 and the extension line of the lower surface 15c of the heat transfer tube 15 intersect is only required to coincide with an intersecting point B at which the tangent plane 27 and the extension line of the lower surface 25c of the heat transfer tube 25 intersect, or is located closer to the heat transfer tube 25 than is the intersecting point B.

[0099] Such a configuration enables the arrangement positions of the heat transfer tubes 15 and 25 to be similar to those of Embodiment 1 to Embodiment 3. The air flow in the first heat exchanging part 10 and the second heat exchanging part 20 can also be similar to that in Embodiment 1 to Embodiment 3. More specifically, the air supplied from the fan 501 into the first heat exchanging part 10 in the substantially horizontal direction flows in the substantially horizontal direction along the lower surface 15c in the vicinity of the lower surface 15c of the heat transfer tube 15 positioned substantially horizontally. The air flows more upward than the horizontal direction in the vicinity of the upper surface 15a at a portion that is upstream of the lateral center position in the air flow. Consequently, the air flowing into gaps between the heat transfer tubes 15 adjacent to each other in the up-down direction flows more upward than the horizontal direction as in Embodiment 1 to Embodiment 3. Thus, the air flowing into gaps between the fins 21 of the second heat exchanging part 20 flows more upward than the horizontal direction, and reaches the upstream ends 25b of the respective heat transfer tubes 25. As in Embodiment 1 to Embodiment 3, the sufficient amount of air can flow in the vicinity of the upper surface 25a of the heat transfer tube 25 located at a position behind the dead water region. In the case of an existing art, the air velocity is reduced in the vicinity of the upper surface 25a of the heat transfer tube 25, which is located behind the dead water region. This air flow can facilitate heat exchange between the air and the upper surface 25a.

Reference Signs List

[0100] 1 Heat exchanger, 10 First heat exchanging part, 11 Fin, 11a First area, 11b Second area, 11c Upstream end, 11d Downstream end, 12 Notch, 12a Upstream end, 12b Opening, 13 Through hole, 13a Upstream end, 13b Downstream end, 15 Heat transfer tube, 15a Upper surface, 15b Upstream end, 15cLower surface, 15d Downstream end, 16 Refrigerant passage, 17 Tangent plane, 20 Second heat exchanging part, 21 Fin, 21a First area, 21b Second area, 21c Upstream end, 21d Downstream end, 22 Notch, 22a Upstream end, 22b Opening, 23 Through hole, 23a Upstream end, 23b Downstream end, 25 Heat transfer tube, 25a Upper surface, 25b Upstream end, 25cLower surface, 25d Downstream end, 26 Refrigerant passage, 27 Tangent plane, 100 Refrigeration cycle apparatus, 200 Compressor, 300 Condenser, 301 Fan, 400 Expansion mechanism, 500 Evaporator, 501 Fan

Claims

1. A heat exchanger (1), comprising:

    a first fin (11) having a first end (11c) and a second end (11d) in a lateral direction;
    a second fin (21) having a third end (21c) and a fourth end (21d) in the lateral direction, the third end (21c) being positioned to face the second end (11d);
    a first heat transfer tube (15) positioned away from the first end (11c) by a first predetermined interval and passing through the first fin (11); and
    a second heat transfer tube (25) positioned away from the third end (21c) by a second predetermined interval and passing through the second fin (21),
    the first heat transfer tube (15) having a planar or curved first upper surface (15a) and a planar first lower surface (15c),
    the second heat transfer tube (25) having a planar or curved second upper surface (25a) and a planar second lower surface (25c), and
    the heat exchanger being **characterized in that**:
    when the first upper surface (15a) is defined as a first surface in a case where the first upper surface (15a) has a planar shape, a tangent plane (17) of the first upper surface (15a) is defined as a first surface in a case where the first upper surface (15a) has a curved shape, the second upper surface (25a) is defined as a second surface in a case where the second upper surface (25a) has a planar shape, and a tangent plane (27) of the second upper surface (25a) is defined as a second surface in a case where the second upper surface (25a) has a curved shape, and
    when the first heat transfer tube (15) and the second heat transfer tube (25) are viewed in such a manner that the first lower surface (15c) is horizontal,
    in a vertical cross section perpendicular to a direction in which the first heat transfer tube (15) passes through the first fin (11),
    the first surface being inclined downward toward the first end (11c),
    the second surface being inclined downward toward the third end (21c),
    an upper end of the second heat transfer tube (25) being located higher than the first lower surface (15c),
    an intersecting point A at which the second surface or an extension line of the second surface and an extension line of the first lower surface (15c) intersect being located closer to the second heat transfer tube (25) than is an intersecting point B at which the second surface or the extension line of the second surface and an extension line of the second lower surface (25c) intersect.

2. The heat exchanger (1) of claim 1, wherein when the first heat transfer tube (15) and the second heat transfer tube (25) are viewed in such a manner that the first lower surface (15c) is horizontal, the second lower surface (25c) is inclined downward toward the third end (21c).

3. A refrigeration cycle apparatus (100), comprising:

    the heat exchanger (1) of claim 1 or 2; and
    a fan (501) configured to supply air to the heat exchanger (1) from the first end (11c) along the first lower surface (15c),
    the heat exchanger (1) being installed in such a manner that the first surface is inclined downward toward the first end (11c), and the second surface is inclined downward toward the third end (21c).

4. The refrigeration cycle apparatus (100) of claim 3, wherein the heat exchanger (1) is installed in such a manner that the first lower surface (15c) is horizontal or is inclined downward toward the first end (11c).

Patentansprüche

1. Wärmetauscher (1), umfassend:

eine erste Lamelle (11c), aufweisend ein erstes Ende (11c) und ein zweites Ende (11d) in einer lateralen Richtung;
eine zweite Lamelle (21), aufweisend ein drittes Ende (21c) und ein viertes Ende (21d) in der lateralen Richtung, wobei das dritte Ende (21c) positioniert ist, um dem zweiten Ende (11d) zugewandt zu sein;
eine erste Wärmeübertragungsleitung (15), die von dem ersten Ende (11c) um einen ersten vorherbestimmten Abstand entfernt positioniert ist und durch die erste Lamelle (11) hindurch verläuft; und
eine zweite Wärmeübertragungsleitung (25), die von dem dritten Ende (21c) um einen zweiten vorherbestimmten Abstand entfernt positioniert ist und durch die zweite Lamelle (21) hindurch verläuft,
wobei die erste Wärmeübertragungsleitung (15) eine planare oder gekrümmte erste obere Oberfläche (15a) und eine planare erste untere Oberfläche (15c) aufweist,
wobei die zweite Wärmeübertragungsleitung (25) eine planare oder gekrümmte zweite obere Oberfläche (25a) und eine planare zweite untere Oberfläche (25c) aufweist, und
der Wärmetauscher **dadurch gekennzeichnet ist, dass**:

wenn die erste obere Oberfläche (15a) als eine erste Oberfläche in einen Fall definiert ist, in welchem die erste obere Oberfläche (15a) eine planare Form aufweist, eine Tangentialebene (17) der ersten oberen Oberfläche (15a) als eine erste Oberfläche in einem Fall definiert ist, in welchem die erste obere Oberfläche (15a) eine gekrümmte Form aufweist, die zweite obere Oberfläche (25a) als eine zweite Oberfläche in einem Fall definiert ist, in welchem die zweite obere Oberfläche (25a) eine planare Form aufweist, und eine Tangentialebene (27) der zweiten oberen Oberfläche (25a) als eine zweite Oberfläche in einem Fall definiert ist, in welchem die zweite obere Oberfläche (25a) eine gekrümmte Form aufweist, und wenn die erste Wärmeübertragungsleitung (15) und die zweite Wärmeübertragungsleitung (25) in einer solchen Weise betrachtet werden, dass die erste untere Oberfläche (15c) horizontal ist,
in einem vertikalen Querschnitt senkrecht zu einer Richtung, in der die erste Wärmeübertragungsleitung (15) durch die erste Lamelle (11) hindurch verläuft,
die erste Oberfläche zu dem ersten Ende (11c) hin nach unten geneigt ist,
die zweite Oberfläche zu dem dritten Ende (21c) hin nach unten geneigt ist,
ein oberes Ende der zweiten Wärmeübertragungsleitung (25) höher angeordnet ist als die erste untere Oberfläche (15c),
ein Schnittpunkt A, an dem sich die zweite Oberfläche oder eine Verlängerungslinie der zweiten Oberfläche und eine Verlängerungslinie der ersten unteren Oberfläche (15c) schneiden, näher an der zweiten Wärmeübertragungsleitung (25) liegt als ein Schnittpunkt B, an dem sich die zweite Oberfläche oder die Verlängerungslinie der zweiten Oberfläche und eine Verlängerungslinie der zweiten unteren Oberfläche (25c) schneiden.

2. Wärmetauscher (1) nach Anspruch 1, wobei, wenn die erste Wärmeübertragungsleitung (15) und die zweite Wärmeübertragungsleitung (25) in einer solchen Weise betrachtet werden, dass die erste untere Oberfläche (15c) horizontal ist, die zweite untere Oberfläche (25c) zu dem dritten Ende (21c) hin nach unten geneigt ist.

3. Kältekreislaufvorrichtung (100), umfassend:

den Wärmetauscher (1) nach Anspruch 1 oder 2; und
einen Lüfter (501), der eingerichtet ist, dem Wärmetauscher (1) von dem ersten Ende (11c) entlang der ersten unteren Oberfläche (15c) Luft zuzuführen,
wobei der Wärmetauscher (1) derart installiert ist, dass die erste Oberfläche zu dem ersten Ende (11c) hin nach unten geneigt ist und die zweite Oberfläche zu dem dritten Ende (21c) hin nach unten geneigt ist.

4. Kältekreislaufvorrichtung (100) nach Anspruch 3, wobei der Wärmetauscher (1) derart installiert ist, dass die erste untere Oberfläche (15c) horizontal ist oder zu dem ersten Ende (11c) hin nach unten geneigt ist.

Revendications

1. Échangeur de chaleur (1), comprenant :

une première ailette (11) présentant une première extrémité (11c) et une deuxième extrémité (11d) dans une direction latérale ;
une deuxième ailette (21) présentant une troisième extrémité (21c) et une quatrième extré-

mité (21d) dans la direction latérale, la troisième extrémité (21c) étant positionnée afin de faire face à la deuxième extrémité (11d) ;
un premier tube de transfert de la chaleur (15) positionné distant de la première extrémité (11c) d'un premier intervalle prédéterminé et passant à travers la première ailette (11) ; et
un deuxième tube de transfert de la chaleur (25) positionné distant de la troisième extrémité (21c) d'un second intervalle prédéterminé et passant à travers la deuxième ailette (21) ;
le premier tube de transfert de la chaleur (15) présentant une première surface supérieure plane ou incurvée (15a) et une première surface inférieure plane (15c),
le second tube de transfert de la chaleur (25) présentant une seconde surface supérieure plane ou incurvée (25a) et une seconde surface inférieure plane (25c), et
l'échangeur de chaleur étant **caractérisé en ce que** :

lorsque la première surface supérieure (15a) est définie en tant que première surface dans un cas où la première surface supérieure (15a) présente une forme plane, un plan tangent (17) de la première surface supérieure (15a) est défini en tant que première surface dans un cas où la première surface supérieure (15a) présente une forme incurvée, la seconde surface supérieure (25a) est définie en tant que seconde surface dans un cas où la seconde surface supérieure (25a) présente une forme plane, et un plan tangent (27) de la seconde surface supérieure (25a) est défini en tant que seconde surface dans un cas où la seconde surface supérieure (25a) présente une forme incurvée, et
lorsque le premier tube de transfert de la chaleur (15) et le second tube de transfert de la chaleur (25) sont vus de telle manière que la première surface inférieure (15c) soit horizontale,
dans une section en coupe verticale perpendiculaire à la direction dans laquelle le premier tube de transfert de la chaleur (15) passe à travers la première ailette (11),
la première surface étant inclinée vers le bas vers la première extrémité (11c),
la seconde surface étant inclinée vers le bas vers la troisième extrémité (21c),
une extrémité supérieure du second tube de transfert de la chaleur (25) se situant plus haute que la première surface inférieure (15c),
un point d'intersection A où la seconde surface ou une ligne d'extension de la seconde surface et une ligne d'extension de la première surface inférieure (15c) se coupent, se situant plus près du second tube de transfert de chaleur (25) qu'un point d'intersection B où la seconde surface ou la ligne d'extension de la seconde surface et une ligne d'extension de la seconde surface inférieure (25c) se coupent.

2. Échangeur de chaleur (1) selon la revendication 1, dans lequel, lorsque le premier tube de transfert de la chaleur (15) et le second tube de transfert de la chaleur (25) sont vus de telle manière que lorsque la première surface inférieure (15c) est horizontale, la seconde surface inférieure (25c) soit inclinée vers le bas vers la troisième extrémité (21c).

3. Appareil à cycle de réfrigération (100), comprenant :

l'échangeur de chaleur (1) selon la revendication 1 ou 2 ; et
une soufflante (501) configurée pour fournir l'air à l'échangeur de chaleur (1) à partir de la première extrémité (11c) le long de la première surface inférieure (15c),
l'échangeur de chaleur (1) étant installé de telle manière que la première surface soit inclinée vers le bas vers la première extrémité (11c), et que la seconde surface soit inclinée vers le bas vers la troisième extrémité (21c).

4. Appareil à cycle de réfrigération (100) selon la revendication 3, dans lequel l'échangeur de chaleur (1) est installé de telle manière que la première surface inférieure (15c) soit horizontale, ou soit inclinée vers le bas vers la première extrémité (11c).

FIG. 1

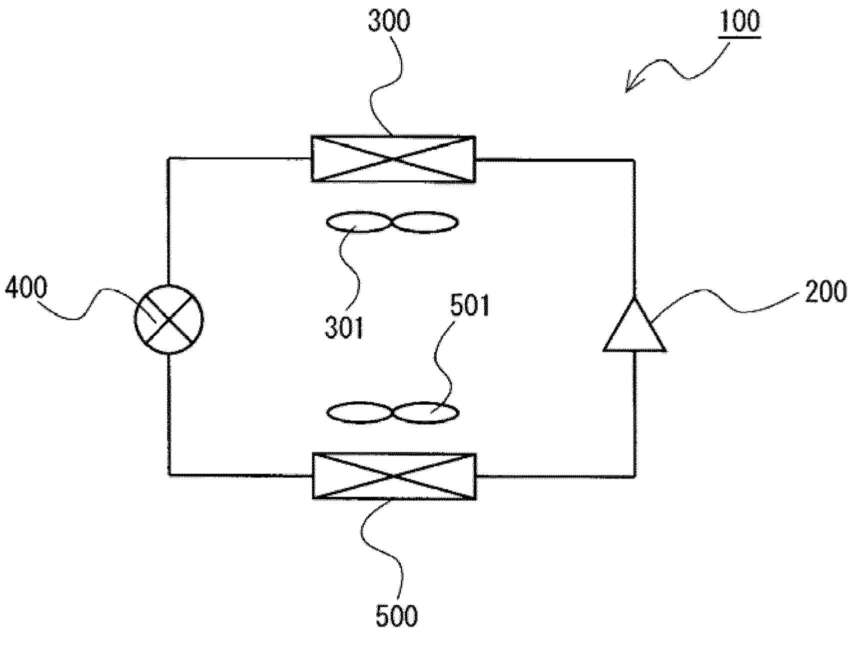


FIG. 2

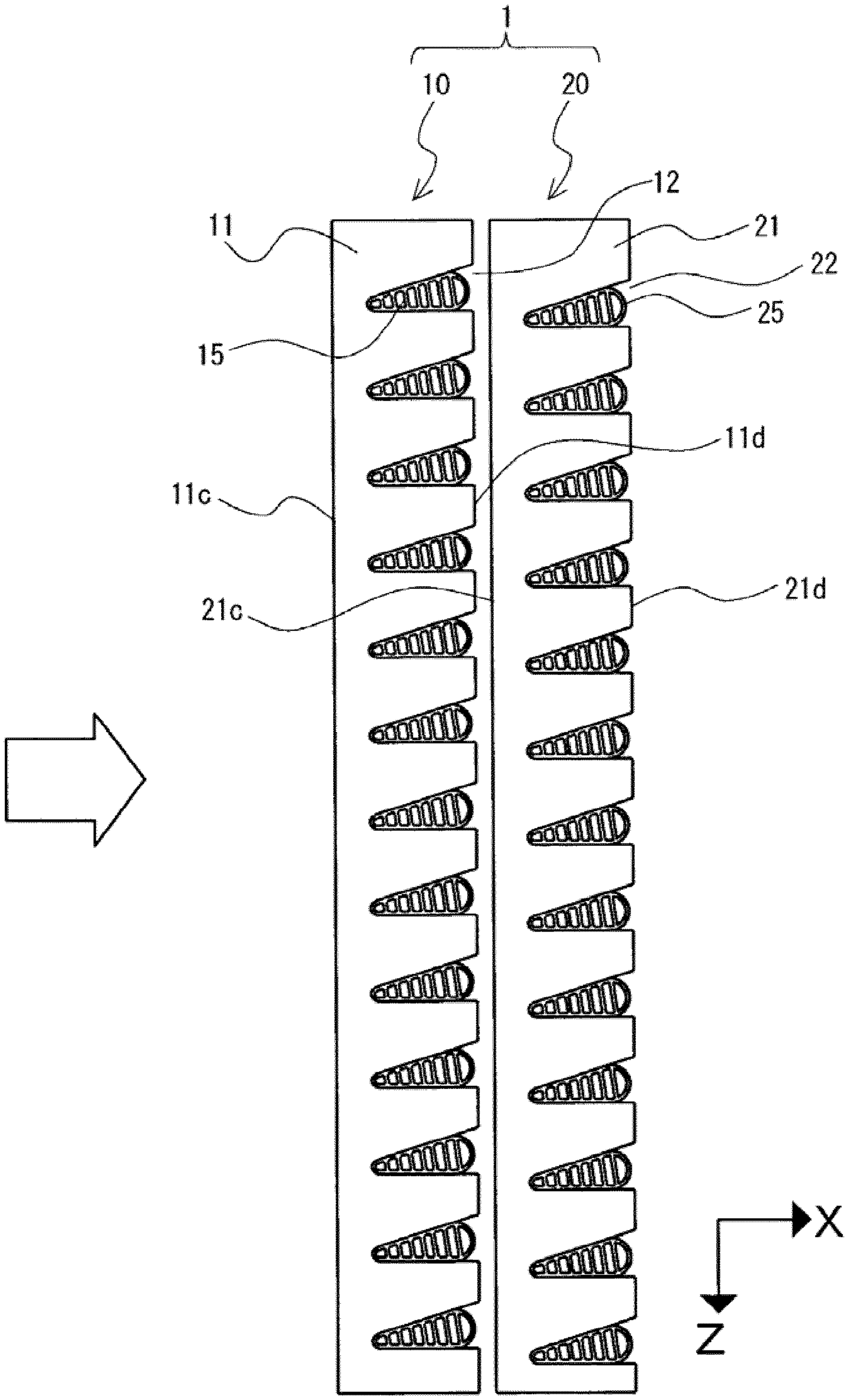
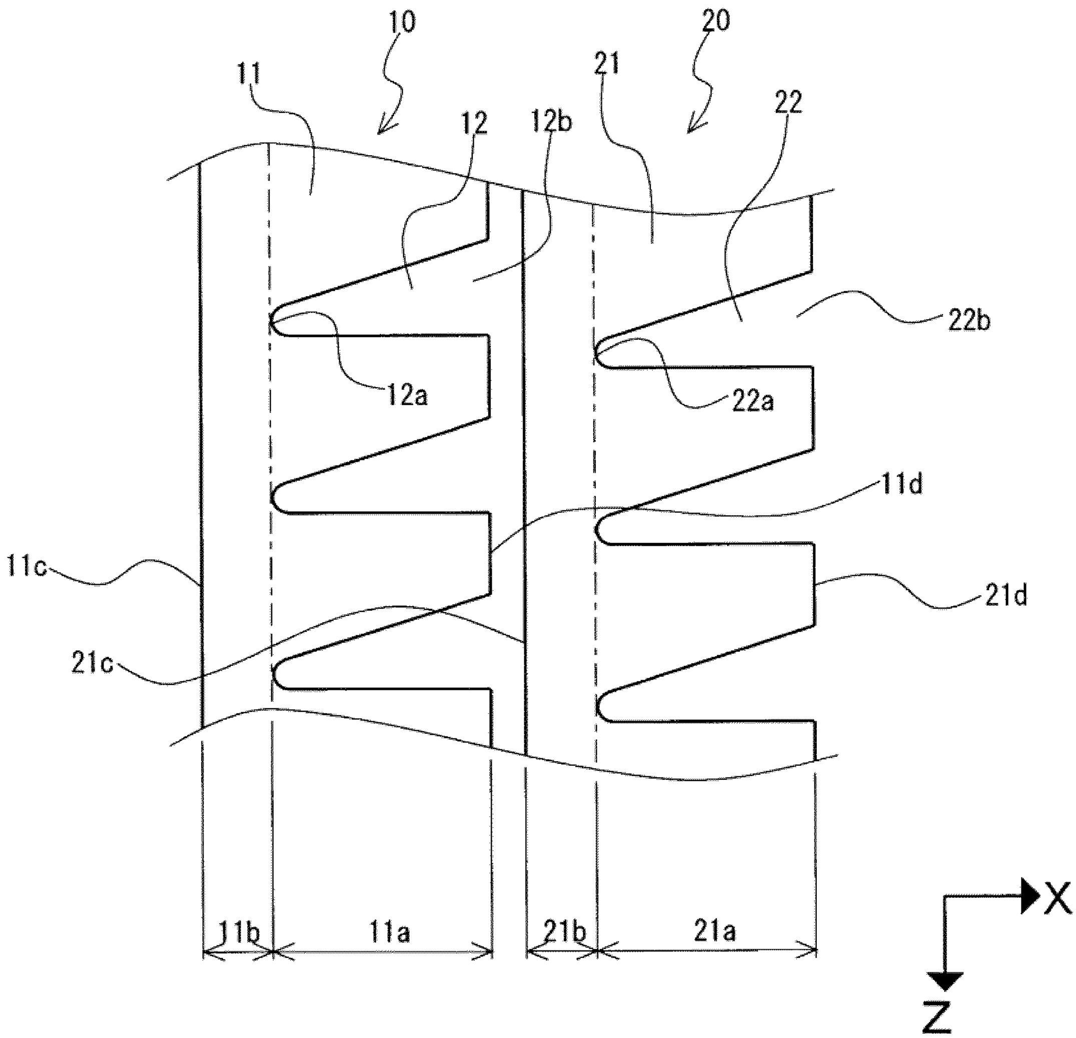


FIG. 3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22b
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22a
11d
11c
21d
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11a
21b
21a
X
Z

FIG. 4

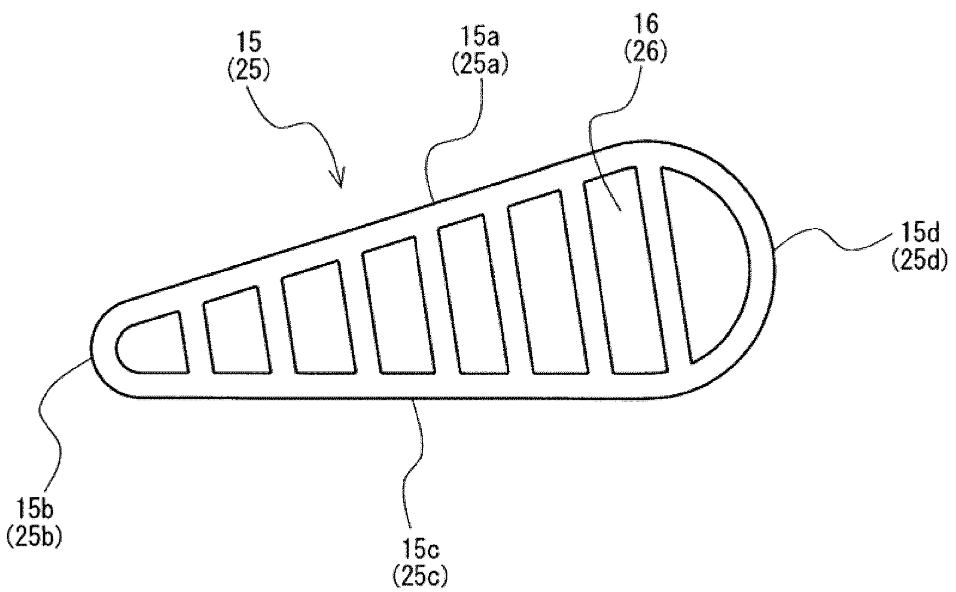
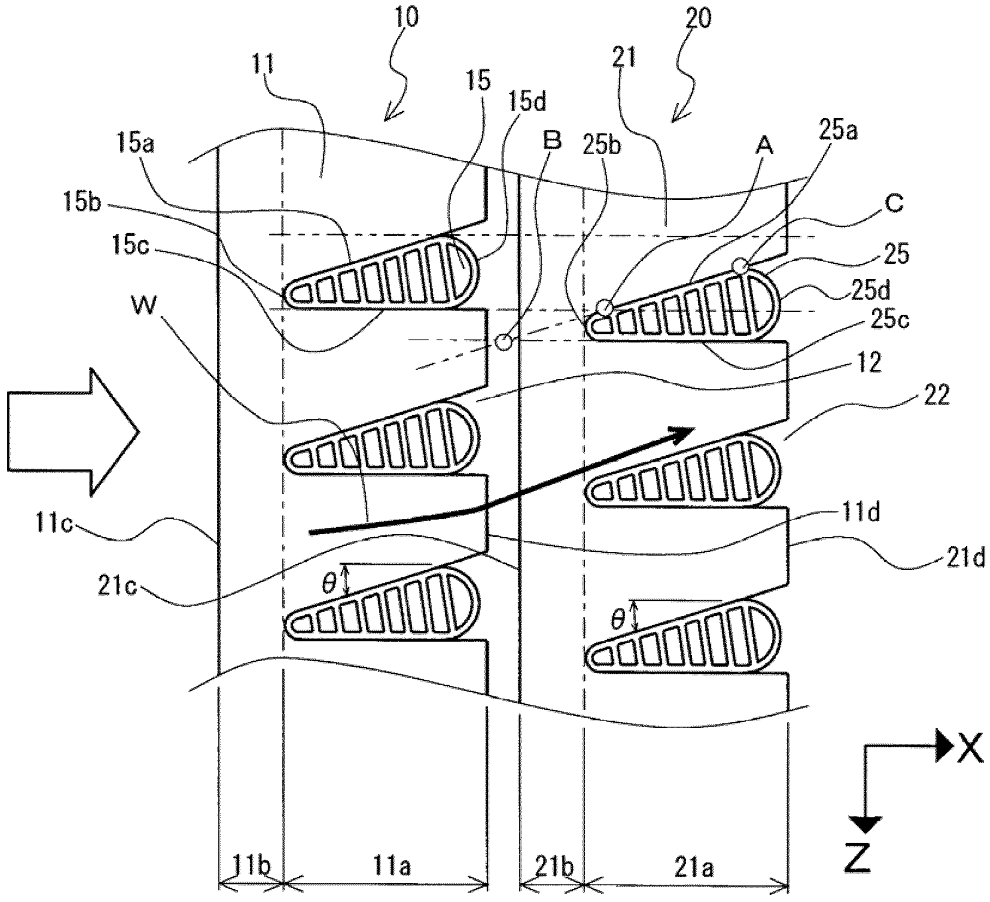

15
(25)
15a
(25a)
16
(26)
15d
(25d)
15b
(25b)
15c
(25c)

FIG. 5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21c
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11a
21b
21a

FIG. 6

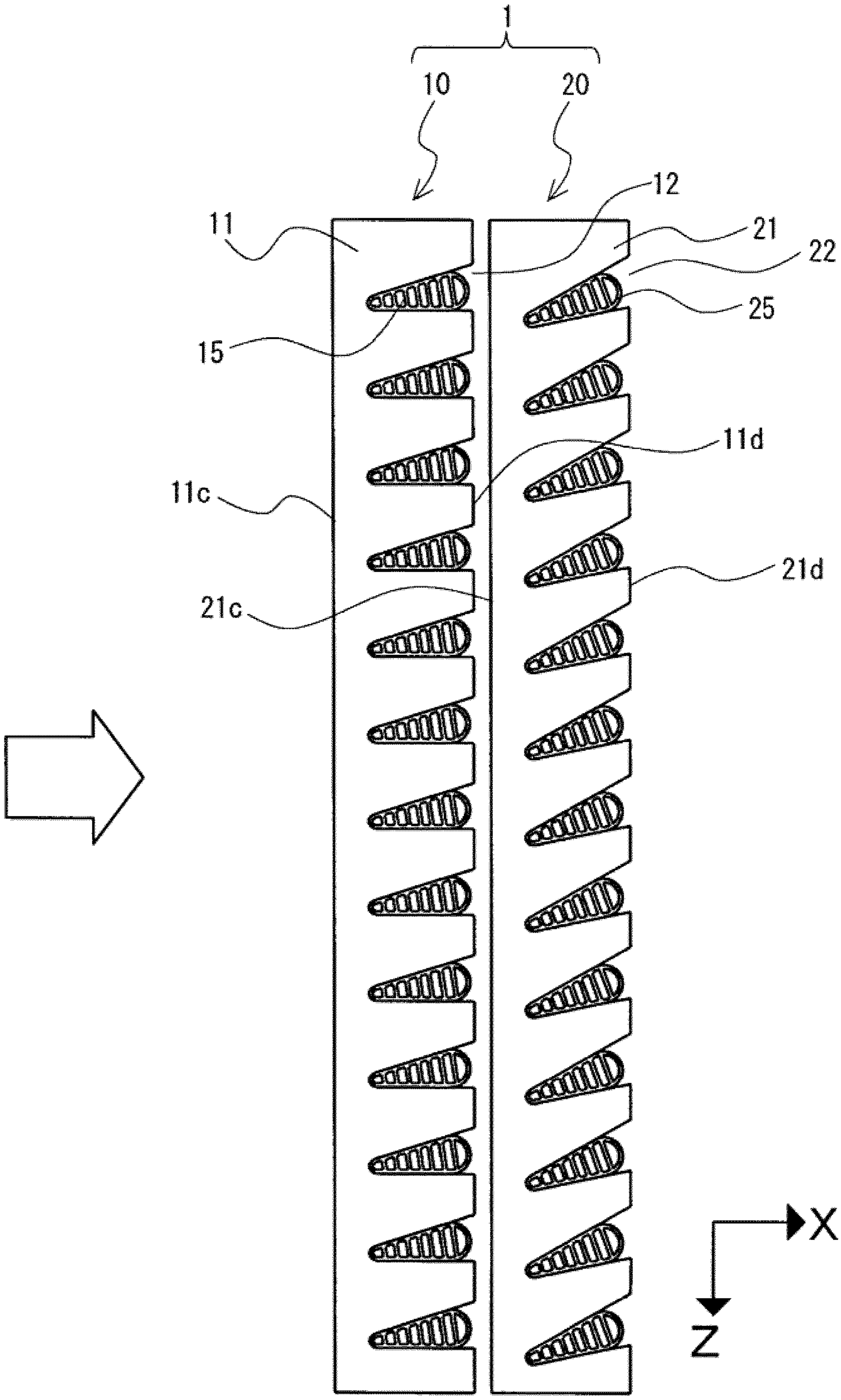
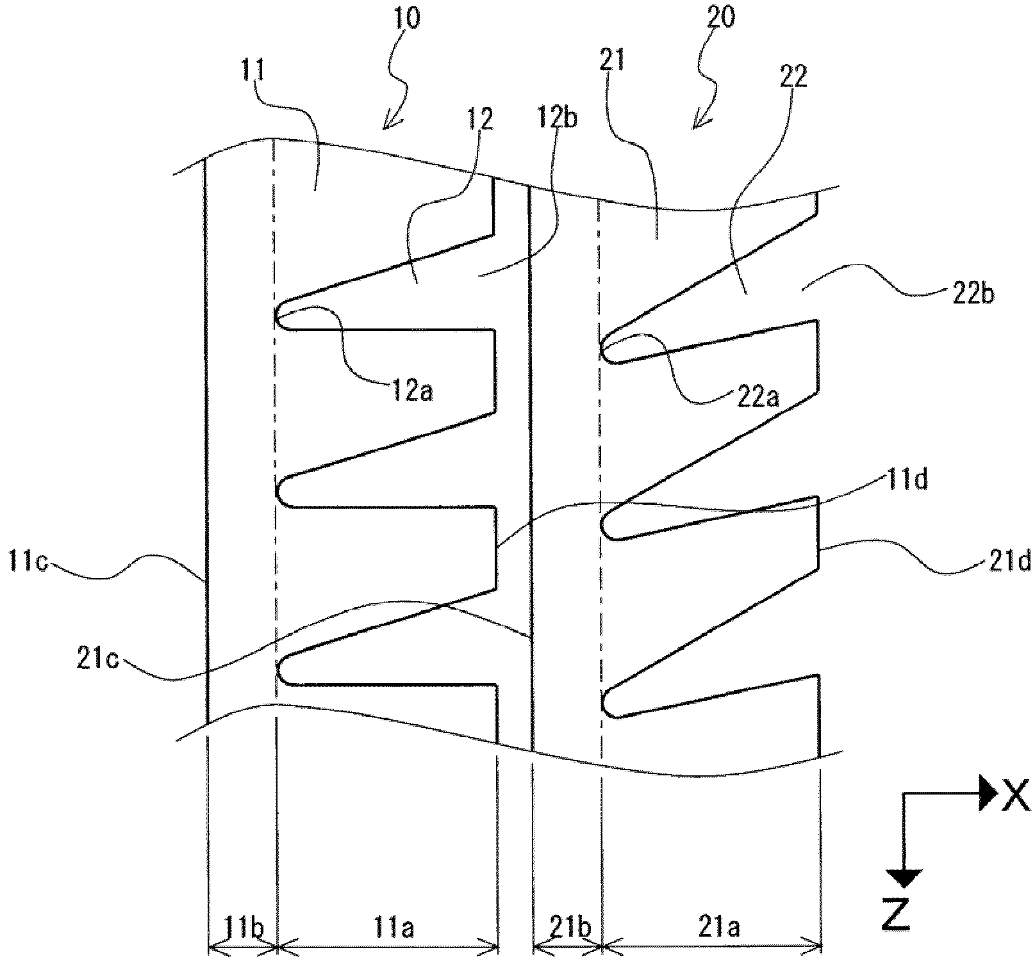


FIG. 7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22a
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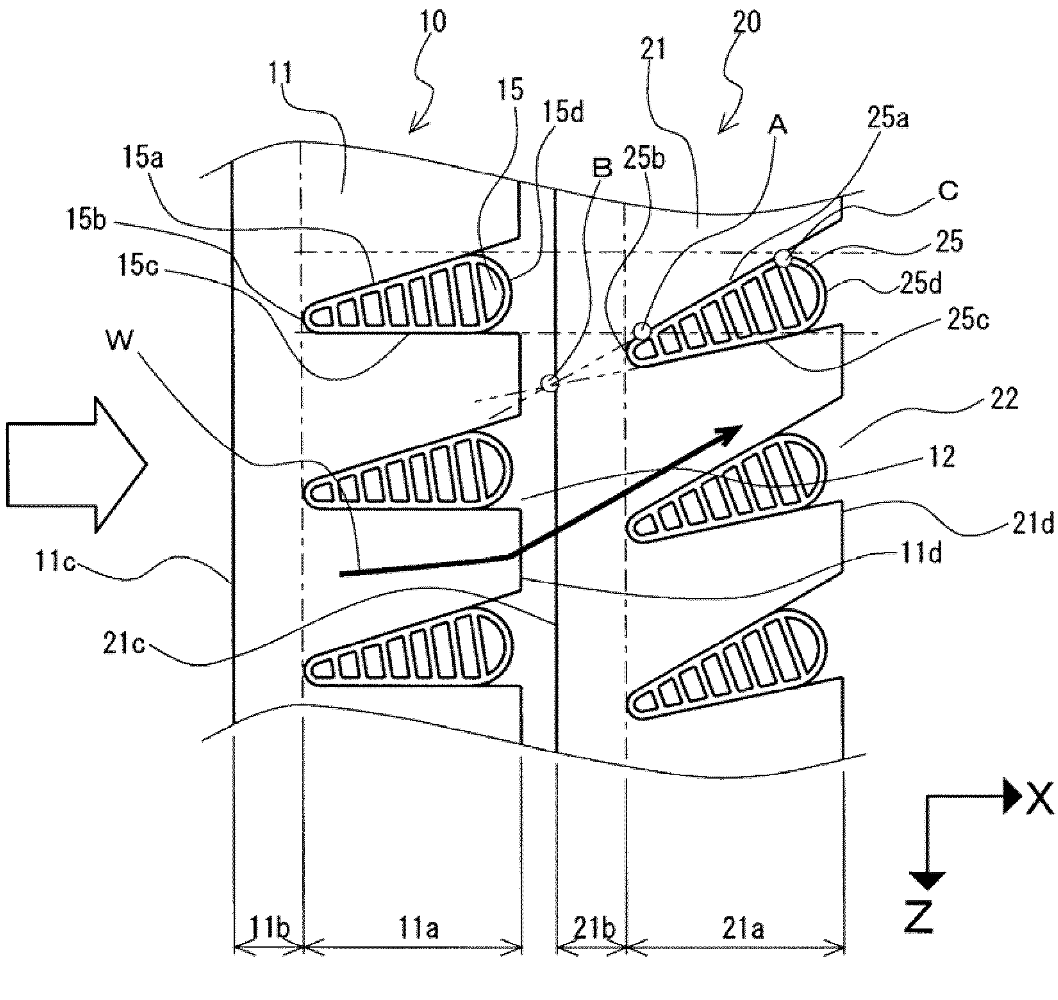
11c
21d
21c
X
Z
11b
11a
21b
21a

FIG. 8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C
15b
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11c
11d
21c
X
Z
11b
11a
21b
21a

FIG. 9

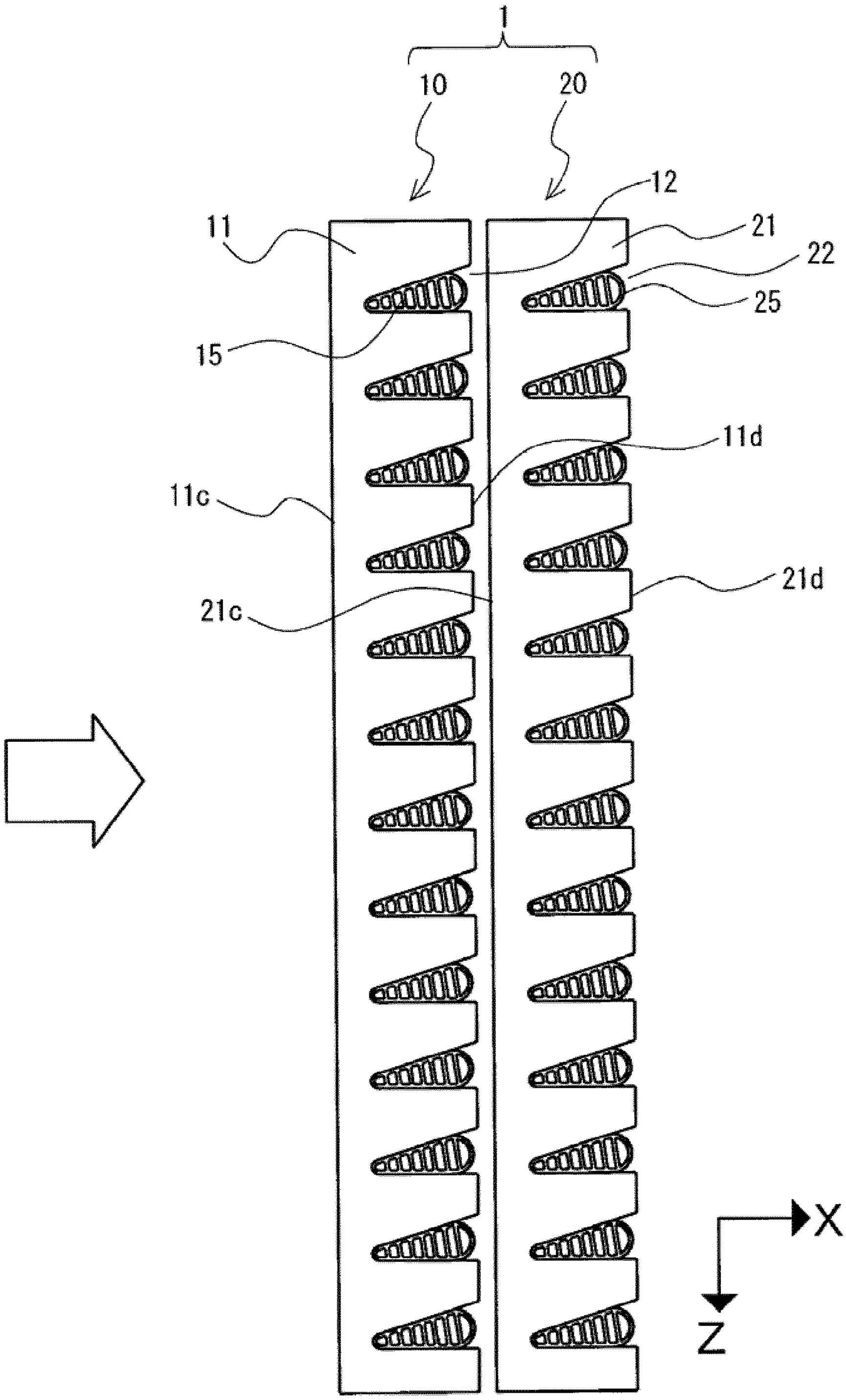
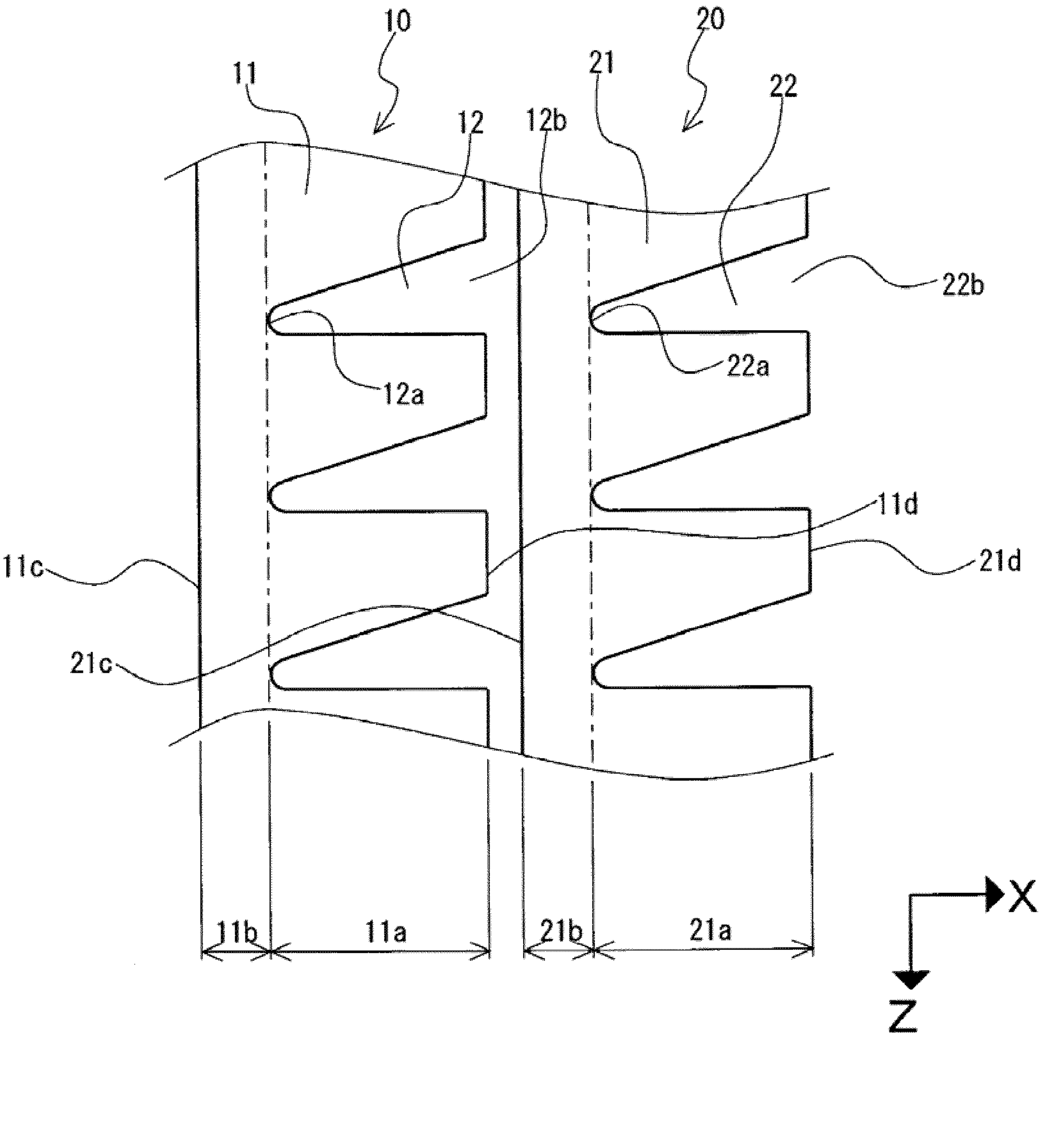


FIG. 10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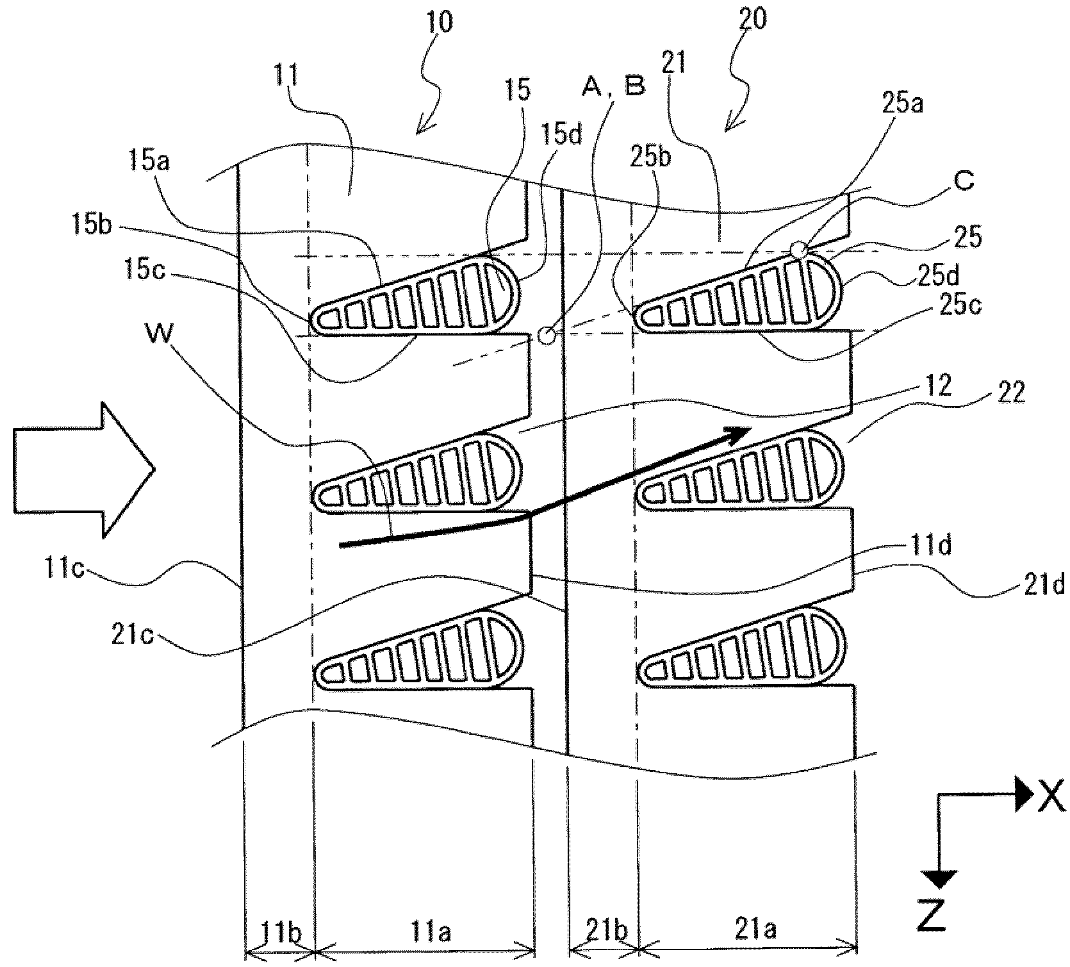
11a
21b
21a
X
Z

FIG. 11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15c
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11a
21b
21a

FIG. 12

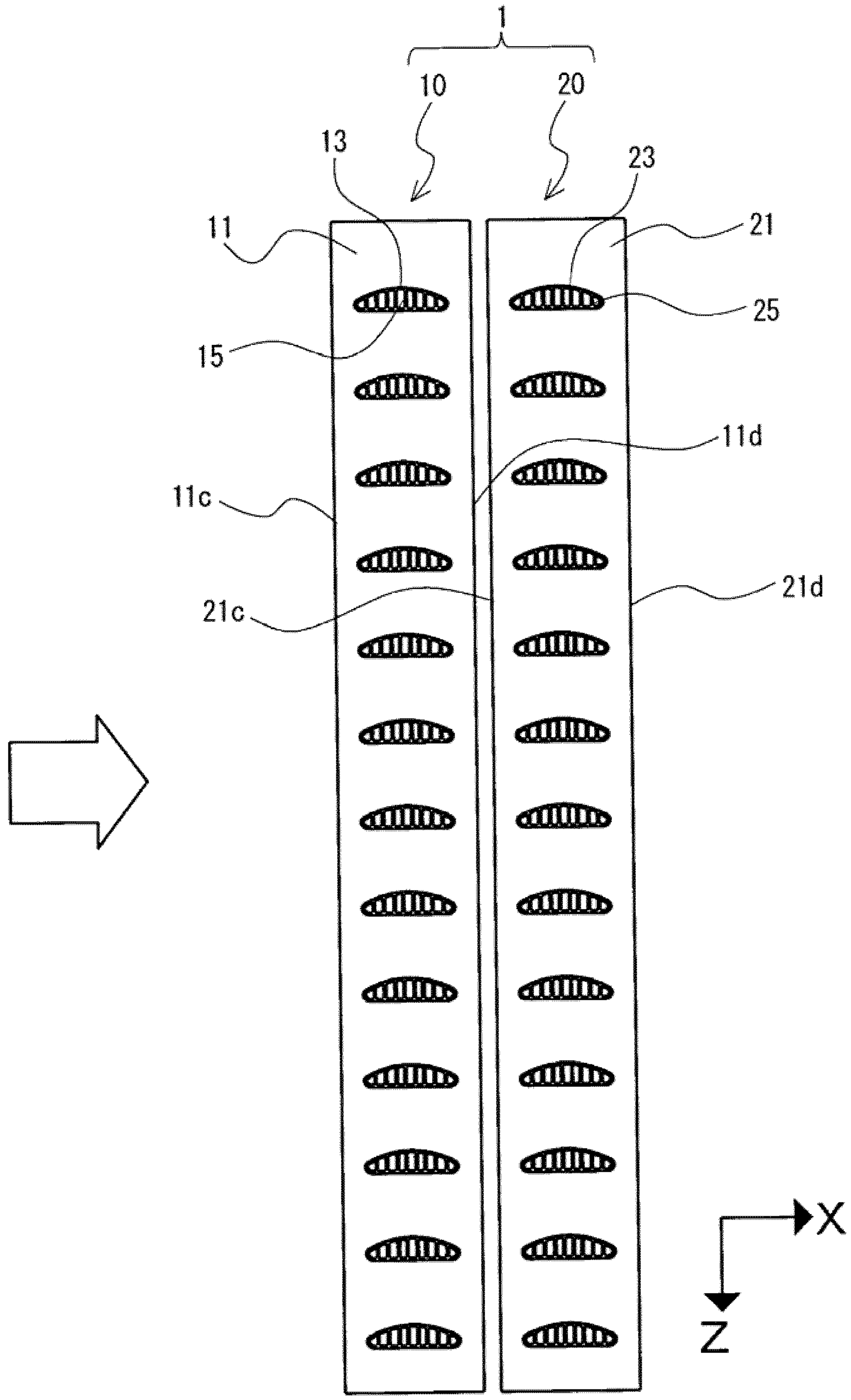
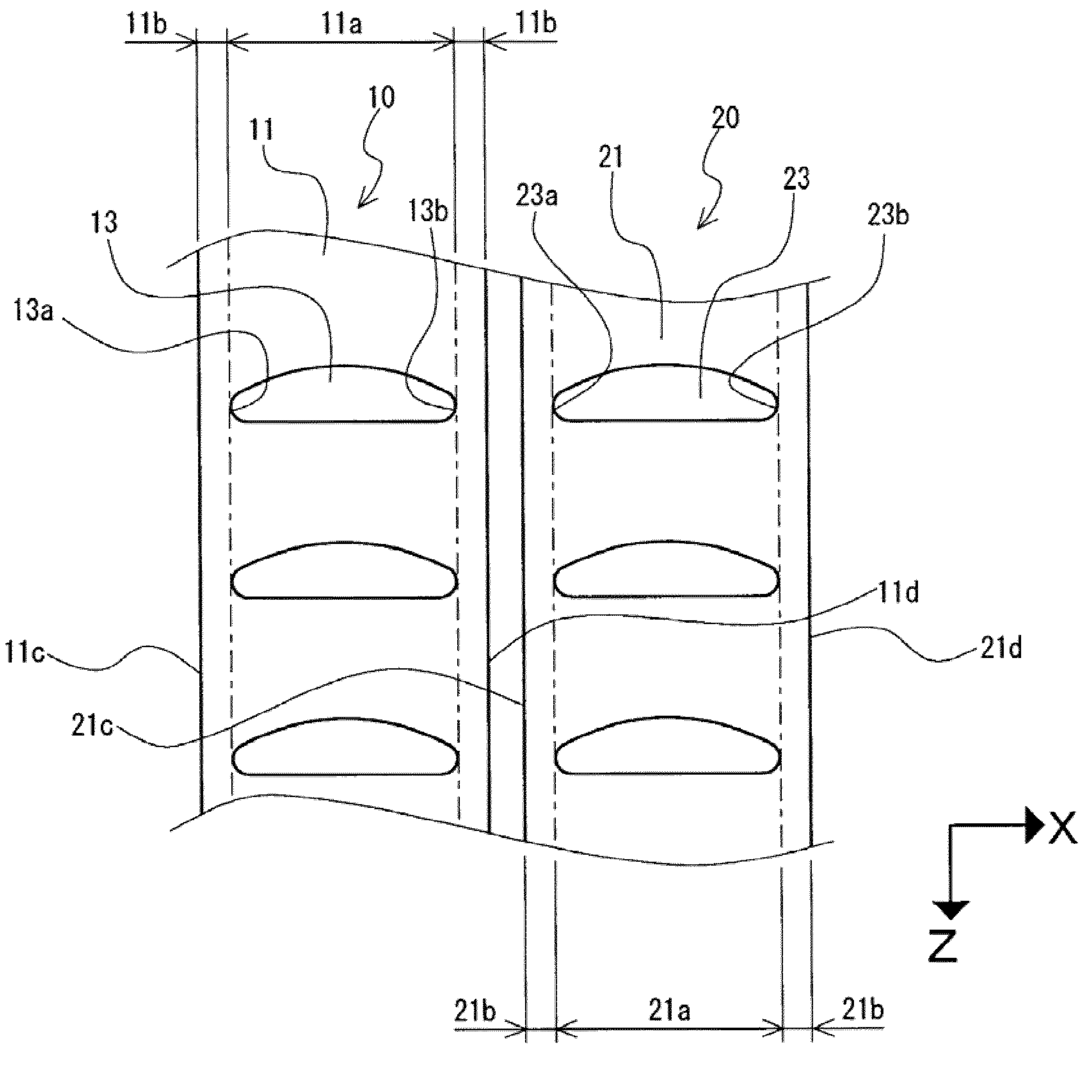


FIG. 13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23b
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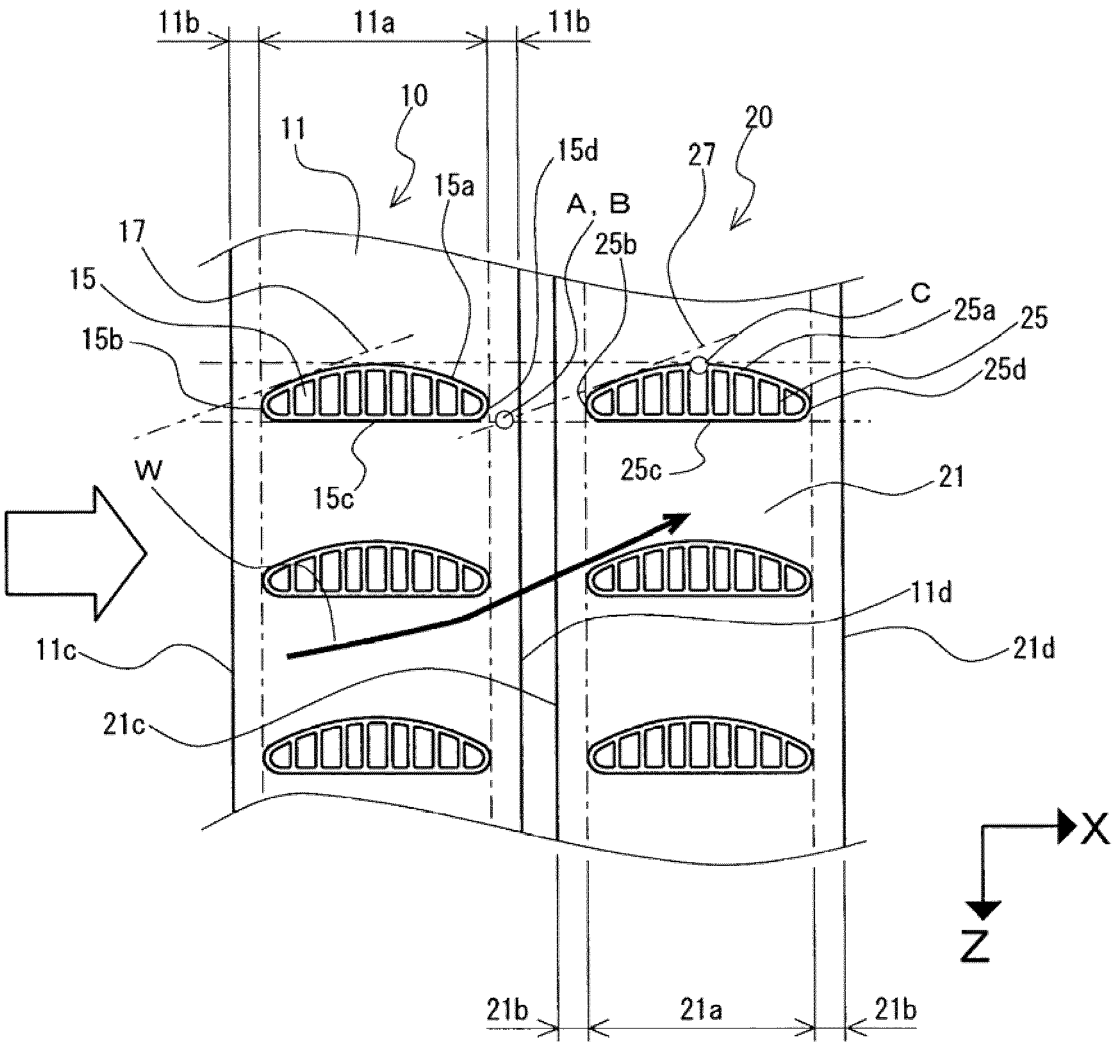
11d
11c
21d
21c
X
Z
21b
21a
21b

FIG. 14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25b
17
15
C
25a
25
15b
25d
W
15c
25c
21
11d
11c
21d
21c
X
Z
21b
21a
21b

REFERENCES CITED IN THE DESCRIPTION

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- JP 2005114308 B **[0006]**
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- WO 2014091536 A **[0007]**