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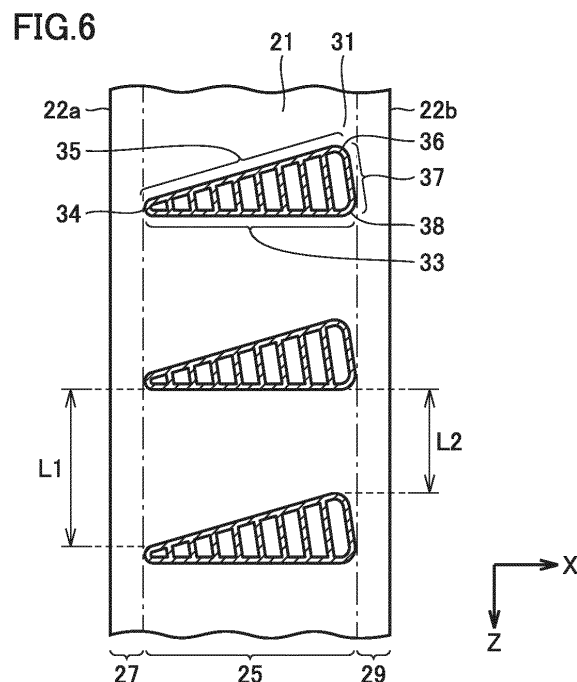
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(54) **HEAT EXCHANGER AND REFRIGERATION CYCLE APPARATUS PROVIDED WITH SAME**

(57) In an outdoor heat exchanger (17), a longitudinal direction of a fin (21) is in parallel to an orientation of the gravity (YG). A first drain region (27) is provided on a side of an end portion (22a) of the fin (21), and a second drain region (29) is provided on a side of an end portion (22b). An outer wall lower surface (33) of a heat transfer tube (31) is located substantially horizontally. A first outer wall upper surface (35) of the heat transfer tube (31) slopes down at a first angle of inclination (θ_1) from an end portion (36) toward the first drain region (27). A second outer wall upper surface (37) of the heat transfer tube (31) slopes down at a second angle of inclination (θ_2) from the end portion (36) toward the second drain region (29).



Description

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger and a refrigeration cycle apparatus comprising the same, and particularly to a heat exchanger comprising a fin-and-tube type heat exchanger and a refrigeration cycle apparatus comprising the heat exchanger.

BACKGROUND ART

[0002] A fin-and-tube type heat exchanger has conventionally been known as a heat exchanger of an air conditioning apparatus. In an outdoor heat exchanger of this type, a heat transfer tube is arranged to penetrate a plurality of plate-shaped fins. For example, a flat tube of which cross-sectional shape is of a flat profile is employed as the heat transfer tube. Heat is exchanged between a heat exchanging fluid such as air which flows between fins and a heat exchanged fluid such as refrigerant which flows through the heat transfer tube.

[0003] In a heat exchanger to which a flat tube is applied, a larger heat transfer area of the heat transfer tube can be secured than in a heat exchanger to which an annular tube is applied. In addition, in the heat exchanger to which the flat tube is applied, a flow resistance of the heat exchanging fluid can be suppressed. Therefore, heat transfer performance can be improved.

[0004] In an example in which the heat exchanger to which the flat tube is applied functions as an evaporator, it is poorer in drainage than the heat exchanger to which the annular tube is applied. Specifically, droplets of water tend to remain on an outer wall surface of the flat tube due to the cross-sectional shape of the heat transfer tube. When the heat exchanger to which the flat tube is applied is employed, for example, as an outdoor heat exchanger of an air conditioning apparatus, the outdoor heat exchanger functions as an evaporator during a heating operation.

[0005] Moisture contained in air as the heat exchanging fluid condenses at a surface of the outdoor heat exchanger and adheres thereto as frost. For example, as the frost adheres between fins, a flow resistance of air which passes through the outdoor heat exchanger increases. As the frost adheres to the outdoor heat exchanger, heat is not efficiently exchanged between air and refrigerant and heat transfer performance lowers. Furthermore, with growth of the frost, the heat exchanger may suffer damage.

[0006] In order to prevent such an unfavorable condition, the air conditioning apparatus is provided with a defrosting mode for removing frost which adheres to the outdoor heat exchanger as an operation mode. Droplets of water, however, may remain in spite of the operation in the defrosting mode. In such a case, remaining droplets of water are again frozen and grow to greater frost. In order to avoid this situation, a time period for operations

in the defrosting mode should be extended. Consequently, a temperature in a heated room lowers, comfortableness in the room lowers, or average heating capability lowers.

[0007] Measures for overcoming such an unfavorable condition have been taken. For example, in PTL 1, a heat exchanger in which a notch is provided on a downstream side in a flow of air between fins and a flat tube is inserted in the notch so as to provide an up slope with respect to the flow of air has been proposed.

CITATION LIST

PATENT LITERATURE

[0008] PTL 1: Japanese Patent Laying-Open No. 07-91873

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0009] In an air conditioning apparatus, in order to improve drainage in removing frost which adheres to an outdoor heat exchanger during a heating operation, various measures have conventionally been proposed.

[0010] The present invention was made as a part of such development, and one object thereof is to provide a heat exchanger which achieves improved drainage and another object is to provide a refrigeration cycle apparatus comprising such a heat exchanger.

SOLUTION TO PROBLEM

[0011] A heat exchanger according to the present invention comprises a plate-shaped fin having a width and a heat transfer tube. The heat transfer tube is arranged to penetrate the fin. The fin has a first end portion and a second end portion opposed to each other with the width being interposed. In a direction of width of the fin, a first region, a second region, and a third region are located. In the first region, the heat transfer tube is arranged. The second region is arranged on a side of the first end portion relative to the first region. The third region is arranged on a side of the second end portion relative to the first region. The heat transfer tube comprises an outer wall lower surface, a first outer wall upper surface, and a second outer wall upper surface. The outer wall lower surface is located along the direction of width. The first outer wall upper surface is connected to the outer wall lower surface and inclined from the side of the first end portion toward the second end portion as being away from the outer wall lower surface. The second outer wall upper surface is connected to the first outer wall upper surface, inclined from the first outer wall upper surface toward the second end portion as being closer to the outer wall lower surface, and connected to the outer wall lower surface. A first angle of inclination at which the first outer wall upper

surface is inclined with respect to the outer wall lower surface is smaller than a second angle of inclination at which the second outer wall upper surface is inclined with respect to the outer wall lower surface.

ADVANTAGEOUS EFFECTS OF INVENTION

[0012] According to the heat exchanger in the present invention, the second region is provided on the side of the first end portion in the fin and the third region is provided on the side of the second end portion. The heat transfer tube comprises the first outer wall upper surface and the second outer wall upper surface inclined with respect to the outer wall lower surface. Droplets of water produced in the outdoor heat exchanger thus flow from the first outer wall upper surface and the like into the second region and the like and are guided to a lower portion of the outdoor heat exchanger. Consequently, drainage can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0013]

Fig. 1 is a diagram showing a refrigerant circuit of a refrigeration cycle apparatus comprising an outdoor heat exchanger according to each embodiment.

Fig. 2 is a side view of an outdoor heat exchanger according to a first embodiment.

Fig. 3 is a front view of the outdoor heat exchanger in the first embodiment.

Fig. 4 is a partially enlarged cross-sectional perspective view for illustrating a structure of a heat transfer tube applied to the outdoor heat exchanger in the first embodiment.

Fig. 5 is a partially enlarged side view for illustrating a structure of a fin applied to the outdoor heat exchanger in the first embodiment.

Fig. 6 is a partially enlarged side view showing a state of attachment of the heat transfer tube to the fin in the first embodiment.

Fig. 7 is a diagram showing a flow of refrigerant in a refrigerant circuit for illustrating an operation by the refrigeration cycle apparatus in the first embodiment.

Fig. 8 is a partially enlarged side view for illustrating a flow of outdoor air which passes through the outdoor heat exchanger in the first embodiment.

Fig. 9 is a partially enlarged side view for illustrating a flow of droplets of water produced in the outdoor heat exchanger in the first embodiment.

Fig. 10 is a diagram showing relation between an amount of remaining water in the heat transfer tube and the like and an angle of inclination of a first outer wall upper surface of the heat transfer tube in the first embodiment.

Fig. 11 is a side view of the outdoor heat exchanger according to a second embodiment.

Fig. 12 is a partially enlarged side view showing a

state of attachment of the heat transfer tube to the fin in the second embodiment.

Fig. 13 is a partially enlarged side view for illustrating a flow of outdoor air which passes through the outdoor heat exchanger in the second embodiment.

Fig. 14 is a partially enlarged side view for illustrating a flow of droplets of water produced in the outdoor heat exchanger in the second embodiment.

DESCRIPTION OF EMBODIMENTS

First Embodiment.

[0014] A construction of the entire air conditioning apparatus as a refrigeration cycle apparatus to which a heat exchanger is applied (a refrigerant circuit) will initially be described.

[0015] As shown in Fig. 1, an air conditioning apparatus 1 comprises a compressor 3, a four-way valve 5, an indoor unit 7, an indoor heat exchanger 9, an indoor fan 11, a throttle device 13, an outdoor unit 15, an outdoor heat exchanger 17, and an outdoor fan 19. Indoor heat exchanger 9 and indoor fan 11 are arranged in indoor unit 7. Outdoor heat exchanger 17 and outdoor fan 19 are arranged in outdoor unit 15. Compressor 3, four-way valve 5, indoor heat exchanger 9, throttle device 13, and outdoor heat exchanger 17 are connected to one another through a refrigerant pipe.

[0016] Outdoor heat exchanger 17 arranged in outdoor unit 15 will now be described. As shown in Figs. 2 and 3, outdoor heat exchanger 17 is constituted of a plurality of fins 21 and a plurality of heat transfer tubes 31. The plurality of heat transfer tubes 31 are arranged to penetrate the plurality of fins 21. The plurality of fins 21 are arranged such that a longitudinal direction of fin 21 is in parallel to an orientation of the gravity YG. Outdoor fan 19 is arranged to be opposed to outdoor heat exchanger 17.

[0017] A structure of heat transfer tube 31 will now be described. As shown in Fig. 4, the heat transfer tube has such a cross-sectional shape that a length (width) in an X direction is longer than a length (width) in a Z direction. In heat transfer tube 31, a plurality of flow paths 39 are provided as flow paths through which refrigerant flows. Heat transfer tube 31 is formed, for example, of aluminum or an aluminum alloy. Heat transfer tube 31 may be formed, for example, by forming aluminum to have an oblong cross-sectional shape through extrusion and thereafter further working the formed aluminum to have a final cross-sectional shape. Heat transfer tube 31 may have a groove formed in an inner wall surface.

[0018] Heat transfer tube 31 comprises an outer wall lower surface 33, a first outer wall upper surface, 35, and a second outer wall upper surface 37. First outer wall upper surface 35 is connected to the outer wall lower surface. First outer wall upper surface 35 is inclined at a first angle of inclination $\theta 1$ with respect to outer wall lower surface 33. An end portion 34 where outer wall lower

surface 33 and first outer wall upper surface 35 are connected to each other is rounded so that outer wall lower surface 33 and first outer wall upper surface 35 are smoothly connected to each other.

[0019] Second outer wall upper surface 37 is connected to first outer wall upper surface 35 and outer wall lower surface 33. Second outer wall upper surface 37 is inclined at a second angle of inclination θ_2 with respect to outer wall lower surface 33. An end portion 36 where first outer wall upper surface 35 and second outer wall upper surface 37 are connected to each other is rounded so that first outer wall upper surface 35 and second outer wall upper surface 37 are smoothly connected to each other. An end portion 38 where second outer wall upper surface 37 and outer wall lower surface 33 are connected to each other is rounded so that second outer wall upper surface 37 and outer wall lower surface 33 are smoothly connected to each other.

[0020] Roundness (R) of end portion 34 is less than roundness (R) of end portions 36 and 38. End portion 36 is substantially equal in roundness (R) to end portion 38. A cross-sectional shape (contour) of heat transfer tube 31 is substantially in symmetry with respect to a bisector of first angle of inclination θ_1 at end portion 34.

[0021] Fin 21 will now be described. As shown in Fig. 5, fin 21 has a width in the X direction and extends like a band in the Z direction with the width being maintained. Fin 21 is formed, for example, of aluminum or an aluminum alloy. A through hole 23 through which the heat transfer tube passes is provided in fin 21. Through hole 23 is formed into a shape corresponding to the cross-sectional shape (contour) of heat transfer tube 31. An end of fin 21 which is in contact with outer wall lower surface 33 of heat transfer tube 31 extends in the X direction. Corner portions 23a, 23b, and 23c of through hole 23 are rounded in correspondence with end portions 34, 36, and 38 of heat transfer tube 31. Through holes 23 are provided at a pitch D.

[0022] Corner portion 23a of through hole 23 is at a distance (a length A) from one end portion 22a (a first end portion) in the direction of width of fin 21. Corner portion 23b of through hole 23 is at a distance (a length B) from the other end portion 22b (a second end portion) in the direction of width of fin 21. Therefore, no through hole 23 is located in a region from end portion 22a of fin 21 over length A. On the side of end portion 22a, a portion of plate-shaped fin 21 is located as being continuous along the Z direction. No through hole 23 is located in a region from end portion 22b of fin 21 over length B. On the side of end portion 22b, a portion of plate-shaped fin 21 is located as being continuous along the Z direction.

[0023] A portion of plate-shaped fin 21 located as being continuous on the side of end portion 22a is defined as a first drain region 27 (a second region). A portion of plate-shaped fin 21 located as being continuous on the side of end portion 22b is defined as a second drain region 29 (a third region). As will be described later, first drain region 27 and second drain region 29 are regions for

draining droplets of water (condensation) produced in outdoor heat exchanger 17. An insertion region 25 (a first region) through which heat transfer tube 31 passes is located between first drain region 27 and second drain region 29.

[0024] A state of attachment of heat transfer tube 31 to fin 21 will now be described. As shown in Fig. 6, outer wall lower surface 33 of heat transfer tube 31 is located in parallel to the direction of width (the X direction) of fin 21. Outer wall lower surface 33 is located substantially horizontally. First outer wall upper surface 35 of heat transfer tube 31 slopes down at first angle of inclination θ_1 from end portion 36 toward first drain region 27.

[0025] Second outer wall upper surface 37 of heat transfer tube 31 slopes down at second angle of inclination θ_2 from end portion 36 toward second drain region 29. End portion 36 of heat transfer tube 31 is located on the side of second drain region 29 relative to the center in the direction of width of fin 21.

[0026] In a space defined between one heat transfer tube 31 and another heat transfer tube 31 adjacent in the vertical direction, a distance L2 between outer wall lower surface 33 of one heat transfer tube 31 and end portion 36 of another heat transfer tube 31 is shorter than a distance L1 between end portion 34 of one heat transfer tube 31 and end portion 34 of another heat transfer tube 31.

[0027] An operation by air conditioning apparatus 1 comprising outdoor unit 15 (see Fig. 1) having outdoor heat exchanger 17 described above in a cooling operation will now initially be described.

[0028] As shown in Fig. 7, as compressor 3 is driven, refrigerant in a gaseous state at a high temperature and a high pressure is discharged from compressor 3. Subsequently, the refrigerant flows along a dotted arrow. The discharged gas refrigerant (single phase) at the high temperature and the high pressure flows into outdoor heat exchanger 17 of outdoor unit 15 through four-way valve 5. In outdoor heat exchanger 17, heat is exchanged between the refrigerant that flows in and outdoor air (air) supplied by outdoor fan 19. The gas refrigerant at the high temperature and the high pressure is condensed and becomes liquid refrigerant (single phase) at a high pressure.

[0029] The liquid refrigerant at the high pressure sent from outdoor heat exchanger 17 is turned into refrigerant in a state of two phases of gas refrigerant at a low pressure and liquid refrigerant at a low pressure by throttle device 13. The refrigerant in the two-phase state flows into indoor heat exchanger 9 of indoor unit 7. In indoor heat exchanger 9, heat is exchanged between the refrigerant in the two-phase state which flows in and air supplied by indoor fan 11. The refrigerant in the two-phase state is turned into gas refrigerant (single phase) at a low pressure as liquid refrigerant evaporates therefrom. As a result of this heat exchange, the room is cooled. The gas refrigerant at the low pressure sent from indoor heat exchanger 9 flows into compressor 3 through four-way

valve 5, is compressed to be gas refrigerant at a high temperature and a high pressure, and is discharged again from compressor 3. This cycle is subsequently repeated.

[0030] A heating operation will now be described. As shown in Fig. 7, as compressor 3 is driven, refrigerant in a gaseous state at a high temperature and a high pressure is discharged from compressor 3. The refrigerant subsequently flows along a solid arrow. The discharged gas refrigerant (single phase) at the high temperature and the high pressure flows into indoor heat exchanger 9 through four-way valve 5. In indoor heat exchanger 9, heat is exchanged between the gas refrigerant which flows in and air supplied by indoor fan 11, and the gas refrigerant at the high temperature and the high pressure is condensed to be liquid refrigerant (single phase) at a high pressure. As a result of this heat exchange, the room is heated. The liquid refrigerant at the high pressure sent from indoor heat exchanger 9 is turned into refrigerant in a state of two phases of gas refrigerant at a low pressure and liquid refrigerant at a low pressure by throttle device 13.

[0031] The refrigerant in the two-phase state flows into outdoor heat exchanger 17. In outdoor heat exchanger 17, heat is exchanged between the refrigerant in the two-phase state which flows in and outdoor air (air) supplied by outdoor fan 19, and the refrigerant in the two-phase state is turned into gas refrigerant (single phase) at a low pressure as liquid refrigerant evaporates therefrom. The gas refrigerant at a low pressure sent from outdoor heat exchanger 17 flows into compressor 3 through four-way valve 5, is compressed to be gas refrigerant at a high temperature and a high pressure, and is discharged again from compressor 3. This cycle is subsequently repeated.

[0032] A flow and the like of outdoor air sent into outdoor unit 15 will now be described. In outdoor unit 15, fin 21 is arranged such that its longitudinal direction is in the orientation of the gravity (arrow YG and the Z direction). A rotation shaft of outdoor fan 19 is arranged in the horizontal direction (X direction) substantially orthogonal to the orientation of the gravity.

[0033] As shown in Fig. 8, with rotation of outdoor fan 19, outdoor air supplied to outdoor unit 15 flows into outdoor heat exchanger 17 substantially horizontally from the side of end portion 22a of fin 21 toward end portion 22b. Outdoor air which passes through outdoor heat exchanger 17 is sent out of outdoor unit 15. Outdoor air which reaches end portion 34 of heat transfer tube 31 (a streamline SL) is divided into outdoor air which flows along outer wall lower surface 33 and outdoor air which flows along first outer wall upper surface 35.

[0034] A flow of outdoor air over first outer wall upper surface 35 will now be described. First outer wall upper surface 35 is inclined at first angle of inclination θ_1 with respect to outer wall lower surface 33 arranged substantially horizontally (see Fig. 4). Therefore, outdoor air which flows into outdoor heat exchanger 17 substantially

horizontally flows along first outer wall upper surface 35 as it receives drag from first outer wall upper surface 35. Since end portion 34 where first outer wall upper surface 35 and outer wall lower surface 33 are connected to each other is rounded, great separation of outdoor air can be suppressed. Heat exchange between outdoor air and refrigerant which flows through heat transfer tube 31 can thus be promoted at first outer wall upper surface 35.

[0035] Since outer wall lower surface 33 is arranged substantially horizontally, outdoor air which flows into outdoor heat exchanger 17 substantially horizontally flows along outer wall lower surface 33 without substantially receiving drag from outer wall lower surface 33. Heat exchange between outdoor air and refrigerant which flows through heat transfer tube 31 can thus be promoted at outer wall lower surface 33 while a flow resistance is lessened.

[0036] As described above, between one heat transfer tube 31 and another heat transfer tube 31 adjacent in the vertical direction, distance L2 is shorter than distance L1 (see Fig. 6). Therefore, a vertical length of the space defined between one heat transfer tube 31 and another heat transfer tube 31 is narrowed along the direction of flow of outdoor air. Creation of a low wind velocity region (a dead water region) due to expansion of a region where outdoor air flows can thus be suppressed, and heat exchange between outdoor air and refrigerant which flows through heat transfer tube 31 can be promoted.

[0037] A process of draining droplets of water produced in outdoor heat exchanger 17 will now be described. As described above, in the heating operation by air conditioning apparatus 1, outdoor heat exchanger 17 functions as an evaporator. Moisture contained in outdoor air becomes droplets of water and adheres to the surface of fin 21 and the like of outdoor heat exchanger 17.

[0038] As droplets of water which adhere to a portion of fin 21 around heat transfer tube 31 grow, they run down along fin 21 due to the gravity and reach first outer wall upper surface 35 or second outer wall upper surface 37 of heat transfer tube 31. As shown in Fig. 9, droplets of water which reach first outer wall upper surface 35 flow along first outer wall upper surface 35 due to the gravity. Most of droplets of water flow into first drain region 27 owing to inertia of that flow, run down along fin 21, and reach a lower portion of outdoor heat exchanger 17.

[0039] In first drain region 27, heat transfer tube 31 is not located but a portion of plate-shaped fin 21 is continuously located. Droplets of water which flow into first drain region 27 thus reach the lower portion of outdoor heat exchanger 17 at once and are drained.

[0040] Similarly, droplets of water which reach second outer wall upper surface 37 flow along second outer wall upper surface 37, flow into second drain region 29 owing to inertia of that flow, run down along fin 21, and reach the lower portion of outdoor heat exchanger 17 at once. By providing first drain region 27 and second drain region 29 at opposing ends (end portion 22a and end portion

22b) of fin 21, drainage can be enhanced as compared with an example in which a drain region is formed only in one of them.

[0041] Some of droplets of water which did not flow from first outer wall upper surface 35 into first drain region 27 goes around end portion 34 to reach outer wall lower surface 33. Droplets of water which did not flow from second outer wall upper surface 37 into second drain region 29 go around end portion 38 to reach outer wall lower surface 33.

[0042] Droplets of water which reach outer wall lower surface 33 stay on outer wall lower surface 33 with surface tension, gravity, and static frictional force being balanced, and grow thereon. The droplets of water expand downward with growth thereof and are affected more by the gravity. When the droplets of water further grow and the gravity applied thereto is greater than force in an orientation opposite to the orientation of the gravity such as surface tension, the droplets of water leave outer wall lower surface 33.

[0043] The droplets of water which left outer wall lower surface 33 fall downward along fin 21 and reach first outer wall upper surface 35 or second outer wall upper surface 37 of heat transfer tube 31 located directly below. As described above, the droplets of water which reach first outer wall upper surface 35 flow along first outer wall upper surface 35, thereafter flow into first drain region 27, run down along fin 21, and reach the lower portion of outdoor heat exchanger 17 at once. Droplets of water which reach second outer wall upper surface 37 flow along second outer wall upper surface 37, thereafter flow into second drain region 29, run down along fin 21, and reach the lower portion of outdoor heat exchanger 17 at once. Such a flow of droplets of water is repeated and the droplets of water are finally drained to below outdoor heat exchanger 17.

[0044] First angle of inclination θ_1 of first outer wall upper surface 35 will now be described. First angle of inclination θ_1 refers to an angle formed with respect to outer wall lower surface 33 and represents an angle of inclination with respect to the horizontal direction. Fig. 10 shows a graph representing relation between an amount of remaining water on outer wall lower surface 33 and the like of heat transfer tube 31 and first angle of inclination θ_1 . The abscissa represents first angle of inclination θ_1 and the ordinate represents an amount of remaining water. As shown in Fig. 10, it can be seen that the amount of remaining water abruptly decreases in a range of first angle of inclination θ_1 from 0° to 20° .

[0045] When first angle of inclination θ_1 exceeds 20° , however, the amount of remaining water does not much vary and significant improvement in drainage may not be expected. When first angle of inclination θ_1 is increased, in two heat transfer tubes 31 adjacent in the vertical direction, first outer wall upper surface 35 of heat transfer tube 31 located below comes closer to outer wall lower surface 33 of heat transfer tube 31 located above. Therefore, a distance between heat transfer tube 31 located

below and heat transfer tube 31 located above decreases, and a flow resistance when outdoor air flows increases. Therefore, first angle of inclination θ_1 is desirably set to 20° or smaller. Second angle of inclination θ_2 formed between second outer wall upper surface 37 and outer wall lower surface 33 is greater than 20° .

[0046] Thus, in the outdoor heat exchanger described above, droplets of water which adhere to outer wall lower surface 33 and the like of heat transfer tube 31 flow positively through first drain region 27 or second drain region 29 and are drained to below outdoor heat exchanger 17. Consequently, drainage can be improved. In a heat transfer tube having an annular cross-sectional shape which has conventionally been employed as the heat transfer tube, droplets of water which adhere to an outer wall surface of the heat transfer tube tend to flow toward a lower portion of the outer wall surface of the heat transfer tube. Therefore, an amount of droplets of water which flow along an end of a fin is small and drainage tends to become poor.

[0047] In outdoor heat exchanger 17 described above, first drain region 27 is arranged windward. No heat transfer tube 31 is arranged in first drain region 27 and first drain region 27 is distant from heat transfer tube 31. Therefore, when outdoor heat exchanger 17 functions as an evaporator, first drain region 27 is higher in temperature than insertion region 25 where heat transfer tube 31 is arranged. Thus, adhesion of frost to a windward portion of outdoor heat exchanger 17 can be suppressed and resultant blocking of an air passage path can be suppressed. Consequently, a rate of heat exchange between refrigerant and outdoor air can be enhanced.

Second Embodiment.

[0048] An example in which fin 21 is arranged such that the longitudinal direction of fin 21 is in parallel to the orientation of the gravity in outdoor heat exchanger 17 has been described previously. An outdoor heat exchanger in which a fin is arranged such that the longitudinal direction of the fin is inclined with respect to the orientation of the gravity will be described.

[0049] As shown in Figs. 11 and 12, in outdoor heat exchanger 17, the longitudinal direction of fin 21 is inclined by an angle ϕ (a third angle of inclination) with respect to orientation of the gravity YG. In this case, fin 21 having an end portion 22c (a third end portion) and an end portion 22d (a fourth end portion) in the longitudinal direction is arranged such that end portion 22c is inclined toward end portion 22a. Namely, fin 21 is arranged such that end portion 22c is inclined windward.

[0050] Angle (first angle of inclination) θ_1 is formed between outer wall lower surface 33 and first outer wall upper surface 35. An angle $\phi + \theta_1$ is formed between first outer wall upper surface 35 and the horizontal direction. Angle ϕ is formed between outer wall lower surface 33 and the horizontal direction. Angle ϕ is set to be smaller than first angle of inclination θ_1 . Since features are oth-

erwise the same as in outdoor heat exchanger 17 shown in Fig. 2 and the like, the same member has the same reference character allotted and description thereof will not be repeated unless it is necessary.

[0051] An operation by air conditioning apparatus 1 comprising outdoor unit 15 (see Fig. 1) having outdoor heat exchanger 17 described above will now be described. A basic operation is similar to the operation by air conditioning apparatus 1 described previously.

[0052] Initially, in a cooling operation, in particular in outdoor heat exchanger 17, heat is exchanged between refrigerant which flows in and outdoor air (air) supplied by outdoor fan 19. Gas refrigerant at a high temperature and a high pressure is condensed to be liquid refrigerant (single phase) at a high pressure. In a heating operation, in particular in outdoor heat exchanger 17, heat is exchanged between refrigerant in a two-phase state which flows in and outdoor air (air) supplied by outdoor fan 19. The refrigerant in the two-phase state is turned into gas refrigerant (single phase) at a low pressure as liquid refrigerant evaporates therefrom.

[0053] A flow of outdoor air sent into outdoor unit 15 will now be described. As shown in Fig. 13, outdoor air (an arrow YW) supplied into outdoor unit 15 with rotation of outdoor fan 19 flows from the side of end portion 22a of fin 21 into outdoor heat exchanger 17 substantially horizontally. Outdoor air (streamline SL) which reaches end portion 34 of heat transfer tube 31 is divided into outdoor air which flows along outer wall lower surface 33 and outdoor air which flows along first outer wall upper surface 35.

[0054] A flow of outdoor air over first outer wall upper surface 35 will now be described. First outer wall upper surface 35 is inclined at angle $\theta_1 + \phi$ with respect to the horizontal direction (see Fig. 11). Therefore, outdoor air which flows into outdoor heat exchanger 17 substantially horizontally flows along first outer wall upper surface 35 without causing great separation by receiving drag from first outer wall upper surface 35. Heat exchange between outdoor air and refrigerant (first outer wall upper surface 35 of heat transfer tube 31) can thus be promoted. A flow resistance can be lessened.

[0055] Outer wall lower surface 33 is inclined at angle ϕ with respect to the horizontal direction (see Fig. 11). In this case, outer wall lower surface 33 is inclined such that outdoor air which horizontally flows into outdoor heat exchanger 17 does not receive drag from outer wall lower surface 33. That angle ϕ , however, is relatively small, and occurrence of great separation can be suppressed.

[0056] A vertical length of the space defined between one heat transfer tube 31 and another heat transfer tube 31 adjacent in the vertical direction is made smaller along a direction of flow of outdoor air. Creation of a low wind velocity region (a dead water region) due to expansion of a region where outdoor air flows can thus be suppressed, and heat exchange between outdoor air and refrigerant which flows through heat transfer tube 31 can be promoted.

[0057] In outdoor heat exchanger 17 in which fin 21 is inclined described above, a direction of flow of outdoor air sent into outdoor heat exchanger 17 is slightly bent as compared with that in outdoor heat exchanger 17 in which fin 21 is not inclined. That angle ϕ , however, is set to be relatively small, and significant increase in flow resistance can be avoided.

[0058] A process of draining droplets of water produced in outdoor heat exchanger 17 will now be described. As described previously, during a heating operation by an air conditioning apparatus, outdoor heat exchanger 17 functions as an evaporator. Moisture contained in outdoor air becomes droplets of water and adheres to a surface of fin 21 of outdoor heat exchanger 17.

[0059] As droplets of water which adhere to a portion of fin 21 around heat transfer tube 31 grow, they run down along fin 21 due to the gravity and reach first outer wall upper surface 35 and the like of heat transfer tube 31. As shown in Fig. 14, droplets of water which reach first outer wall upper surface 35 flow over first outer wall upper surface 35 due to the gravity, and most of droplets of water flow into first drain region 27 owing to inertia of the flow, run down along fin 21, and reach the lower portion of outdoor heat exchanger 17. In particular, first outer wall upper surface 35 is inclined at angle $\theta_1 + \phi$ with respect to the horizontal direction so that a component of the gravity applied to the droplets of water along first outer wall upper surface 35 increases and the droplets of water are more likely to flow into first drain region 27.

[0060] In first drain region 27, heat transfer tube 31 is not located but a portion of plate-shaped fin 21 is continuously located. Thus, droplets of water which flow into first drain region 27 reach the lower portion of outdoor heat exchanger 17 at once and are drained.

[0061] Since outer wall lower surface 33 is inclined at angle ϕ with respect to the horizontal direction, some of droplets of water which did not flow into first drain region 27 from first outer wall upper surface 35 tends to stay at end portion 34 without reaching outer wall lower surface 33. The droplets of water which stay grow with surface tension, gravity, and static frictional force being balanced.

[0062] The droplets of water expand downward with growth thereof and are affected more by the gravity. When the droplets of water further grow and the gravity applied to the droplets of water is greater than force in an orientation opposite to the orientation of the gravity such as surface tension, the droplets of water leave end portion 34. The droplets of water which left end portion 34 flow into first drain region 27, run down along fin 21, and reach the lower portion of outdoor heat exchanger 17 at once. The droplets of water are thus drained to below outdoor heat exchanger 17.

[0063] Outdoor heat exchanger 17 described above and an outdoor heat exchanger (an outdoor heat exchanger A) in which an outer wall surface is not inclined but a fin is inclined are compared with each other. In order to obtain the same draining effect, angle ϕ at which the fin is inclined may be smaller in the outdoor heat exchanger

er described above than in outdoor heat exchanger A.

[0064] Creation of a dead water region in the vicinity of outer wall lower surface 33 can thus be suppressed and heat transfer performance can be improved. A space in a depth direction of outdoor heat exchanger 17 in installation in outdoor unit 15 can be reduced, which contributes to reduction in size of outdoor unit 15.

[0065] Outdoor heat exchangers comprising fins described in embodiments can variously be combined as necessary.

[0066] The embodiments disclosed herein are illustrative and restriction thereto is not intended. The present invention is defined by the terms of the claims rather than the description above and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

INDUSTRIAL APPLICABILITY

[0067] The present invention is effectively used for a refrigeration cycle apparatus comprising a fin-and-tube type heat exchanger.

REFERENCE SIGNS LIST

[0068] 1 air conditioning apparatus; 3 compressor; 5 four-way valve; 7 indoor unit; 9 indoor heat exchanger; 11 indoor fan; 13 throttle device; 15 outdoor unit; 17 outdoor heat exchanger; 19 outdoor fan; 21 fin; 22a, 22b, 22c, 22d end portion; 23 through hole; 23a, 23b, 23c corner portion; 25 insertion region; 27 first drain region; 29 second drain region; 31 heat transfer tube; 33 outer wall lower surface; 35 first outer wall upper surface; 37 second outer wall upper surface; 34, 36, 38 end portion; 39 flow path; YW arrow; YG orientation; and SL streamline

Claims

1. A heat exchanger comprising:

a plate-shaped fin having a width; and
a heat transfer tube arranged to penetrate the fin,
the fin having a first end portion and a second end portion opposed to each other with the width being interposed,
in a direction of the width of the fin,
a first region where the heat transfer tube is arranged,
a second region arranged on a side of the first end portion relative to the first region, and
a third region arranged on a side of the second end portion relative to the first region being located,
the heat transfer tube comprising
an outer wall lower surface located along the

direction of the width,

a first outer wall upper surface connected to the outer wall lower surface and inclined from the side of the first end portion toward the second end portion as being away from the outer wall lower surface, and

a second outer wall upper surface connected to the first outer wall upper surface, inclined from the first outer wall upper surface toward the second end portion as being closer to the outer wall lower surface, and connected to the outer wall lower surface,

a first angle of inclination at which the first outer wall upper surface is inclined with respect to the outer wall lower surface being smaller than a second angle of inclination at which the second outer wall upper surface is inclined with respect to the outer wall lower surface.

2. The heat exchanger according to claim 1, wherein the fin is arranged such that a direction intersecting with the direction of the width is in parallel to an orientation of gravity.

3. The heat exchanger according to claim 2, wherein the first angle of inclination is set to 20° or smaller.

4. The heat exchanger according to claim 1, wherein the fin comprises a third end portion and a fourth end portion opposed to each other at a distance from each other in a direction intersecting with the direction of the width, and the fin is arranged such that the third end portion located in a direction opposite to an orientation of gravity is inclined toward the first end portion.

5. The heat exchanger according to claim 4, wherein a third angle of inclination at which the third end portion is inclined toward the first end portion is set to an angle smaller than the first angle of inclination.

6. A refrigeration cycle apparatus comprising:

the heat exchanger according to any one of claims 1 to 5,
the heat exchanger being applied as an outdoor heat exchanger, and
outdoor air being sent horizontally to the outdoor heat exchanger.

FIG.1

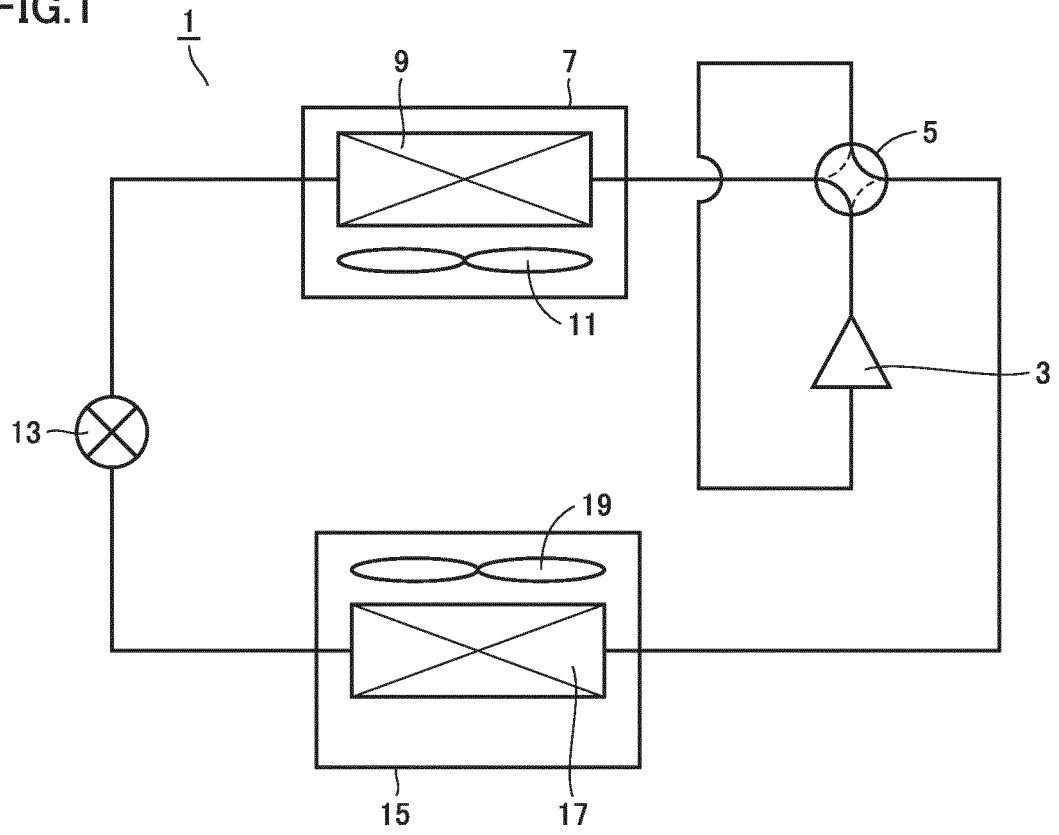
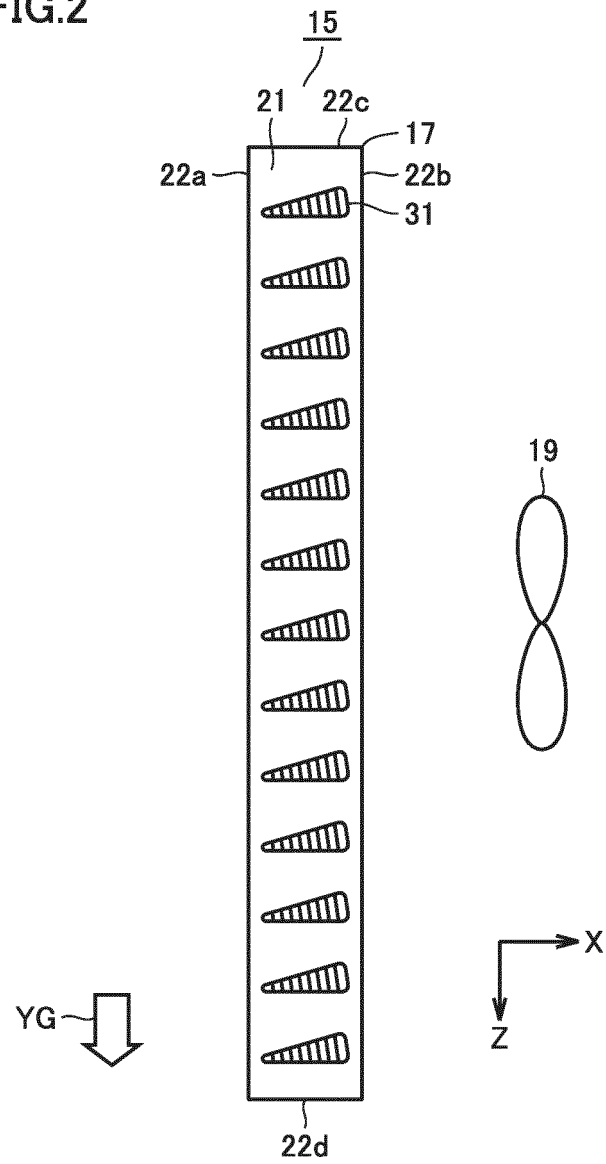


FIG.2



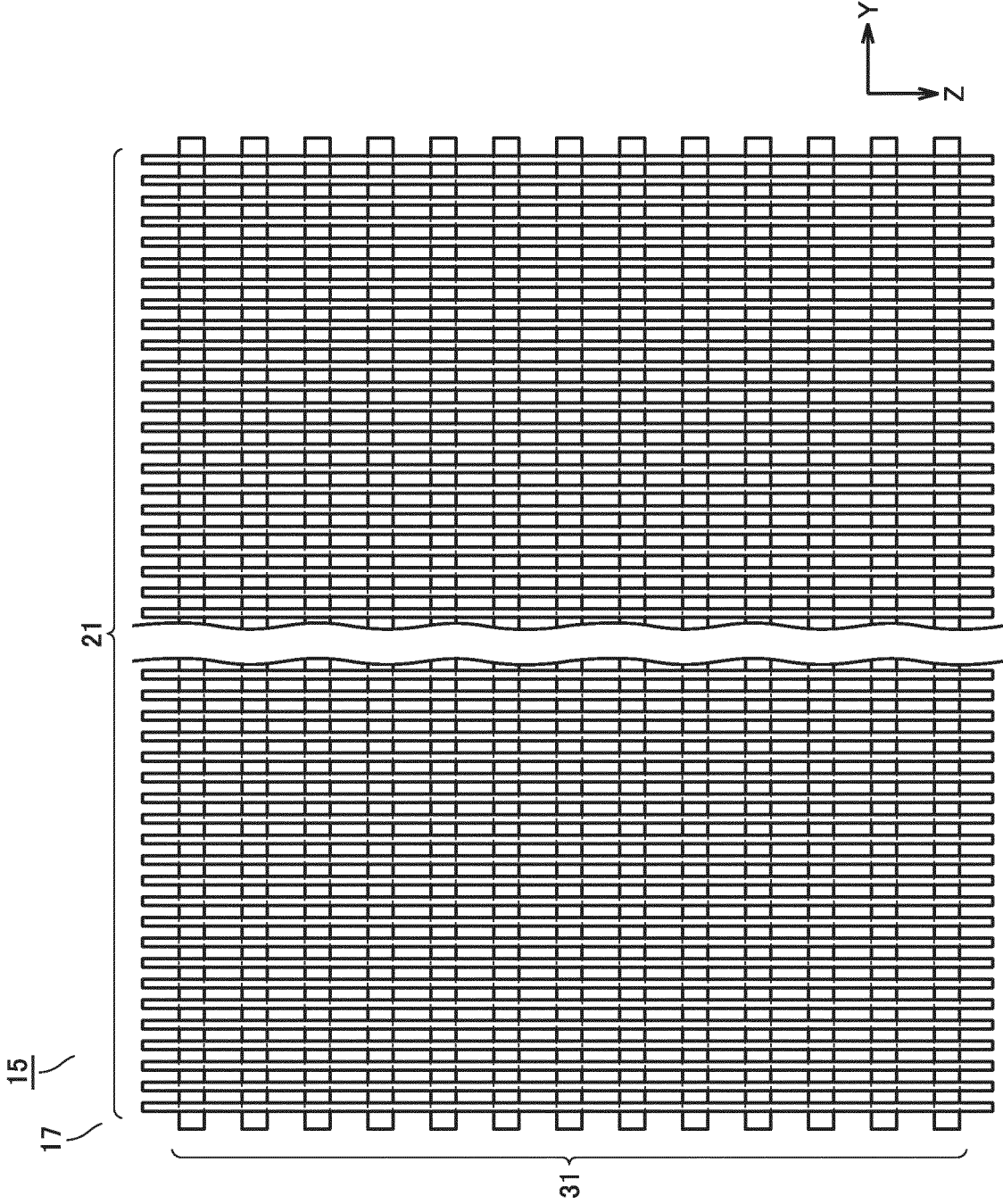


FIG.3

FIG.4

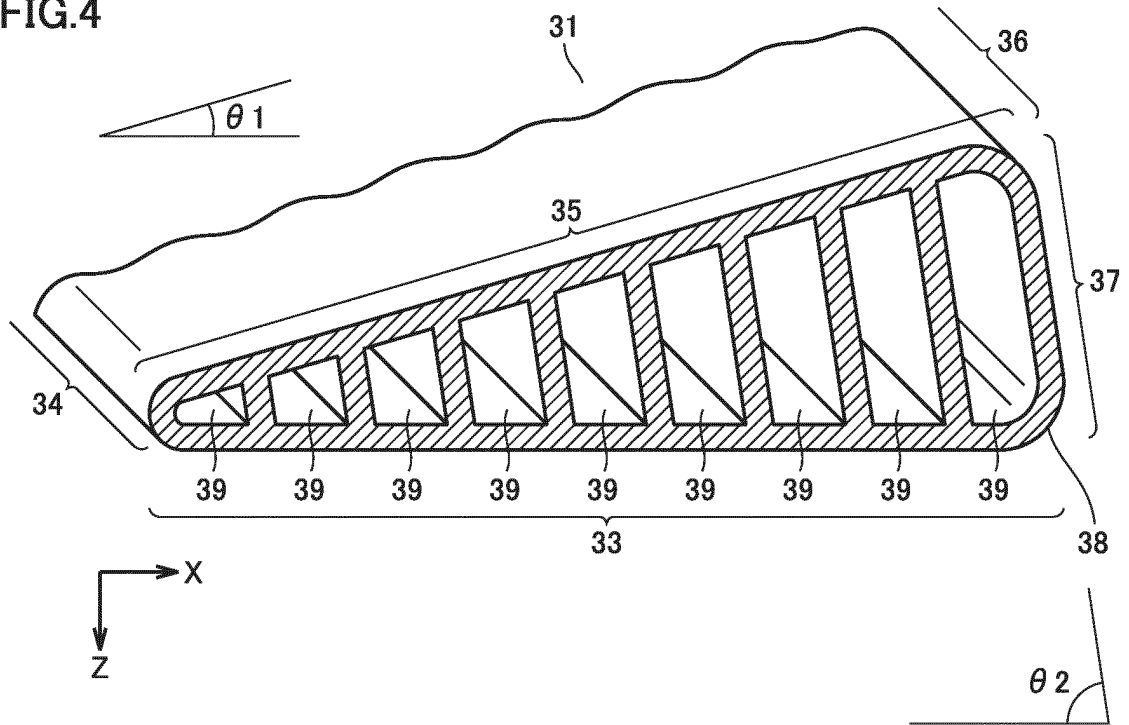


FIG.5

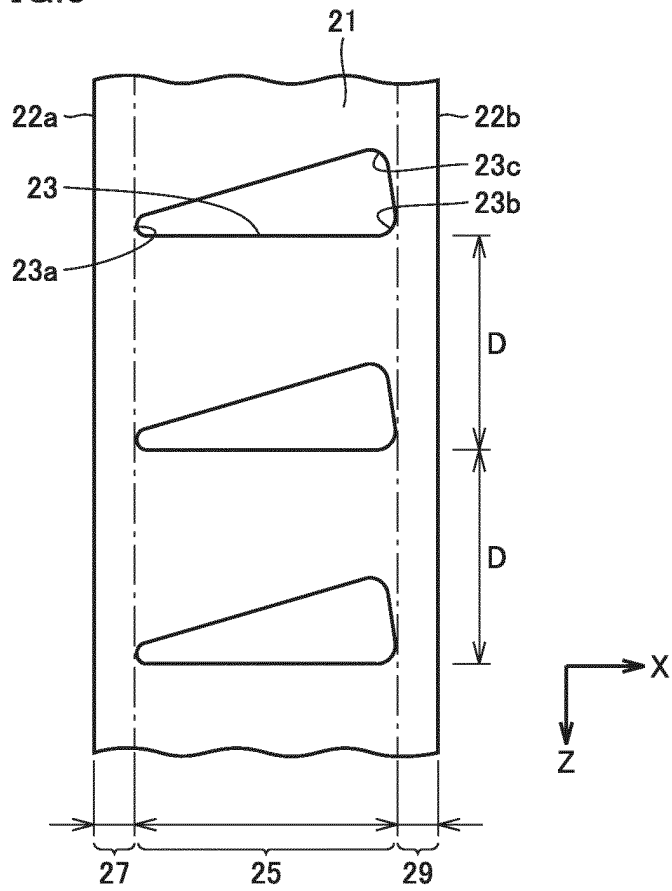


FIG.6

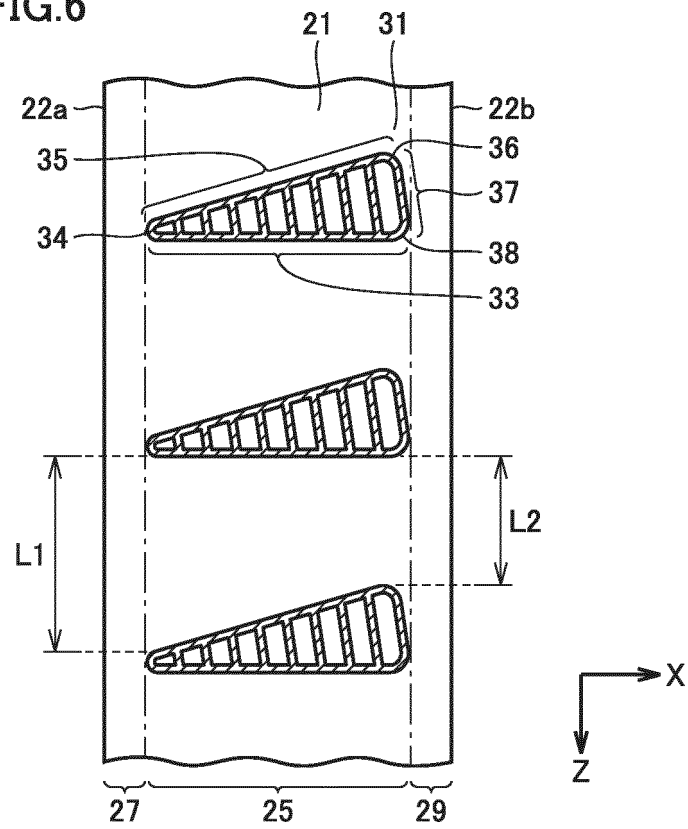


FIG. 7

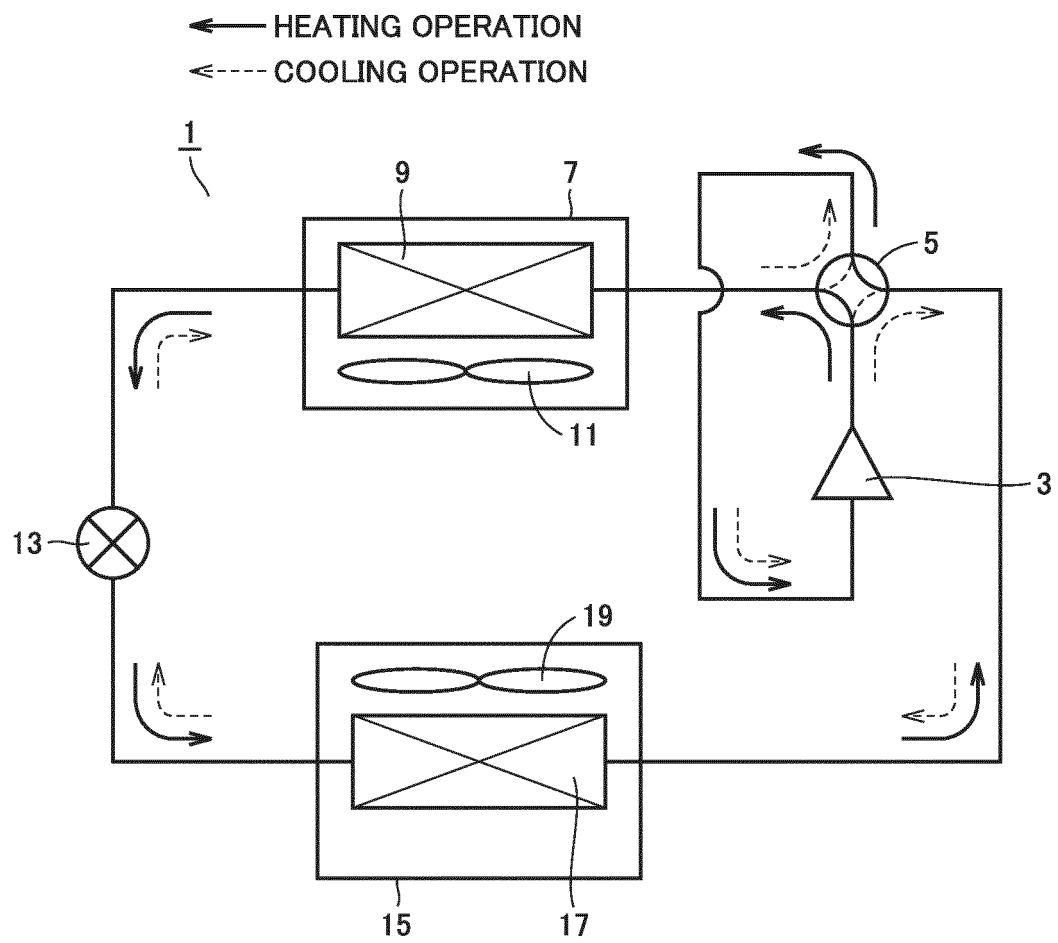


FIG.8

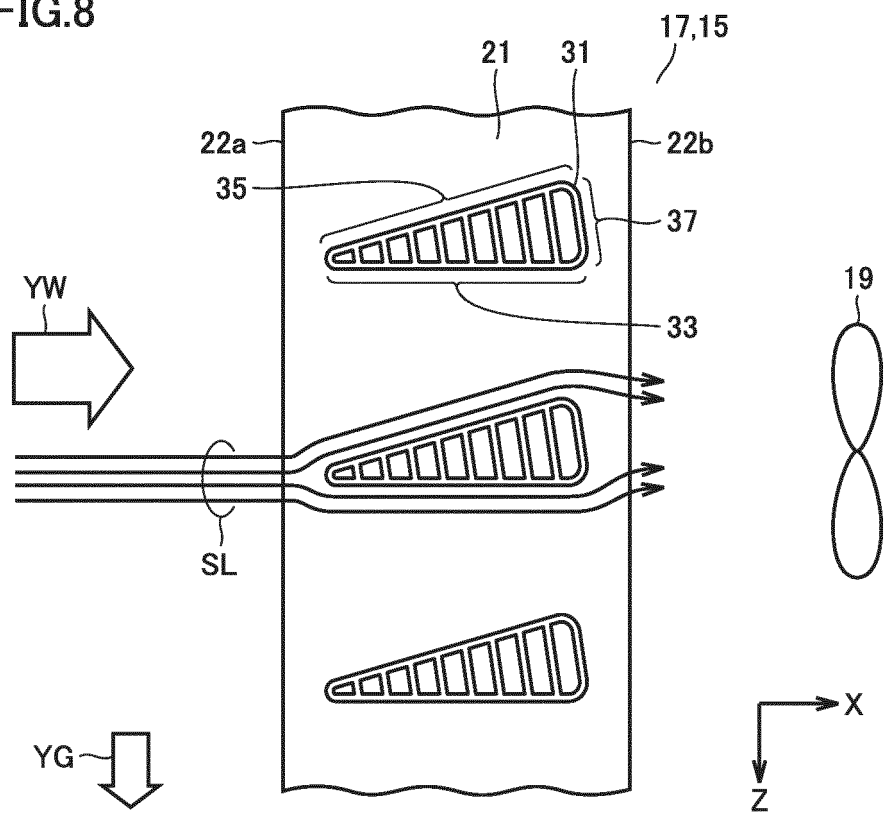


FIG.9

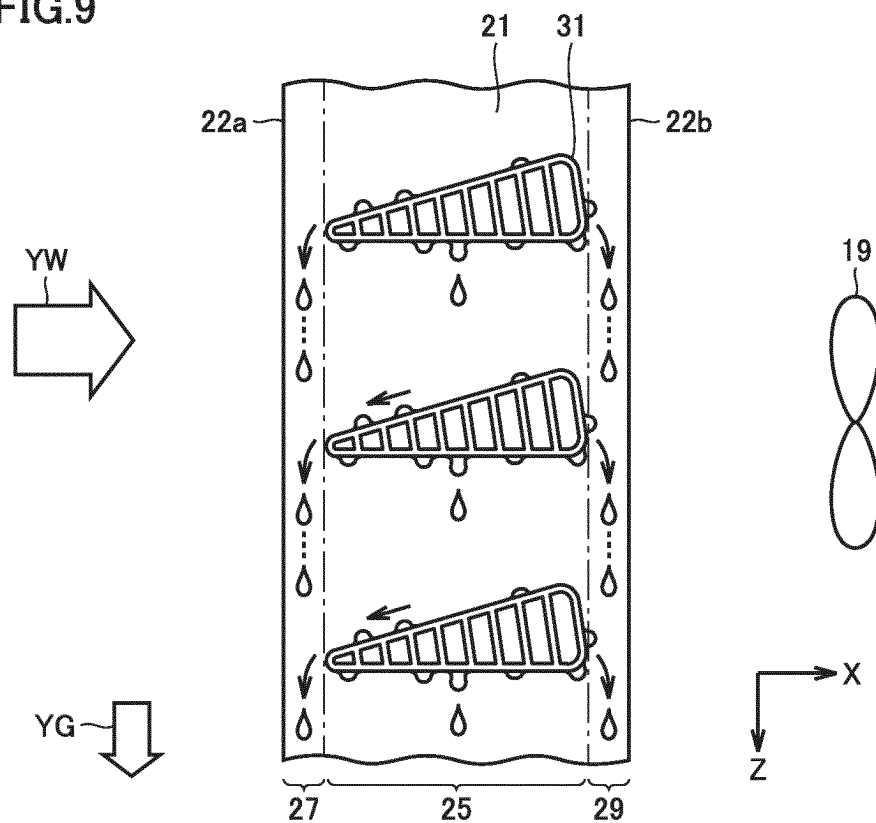


FIG.10

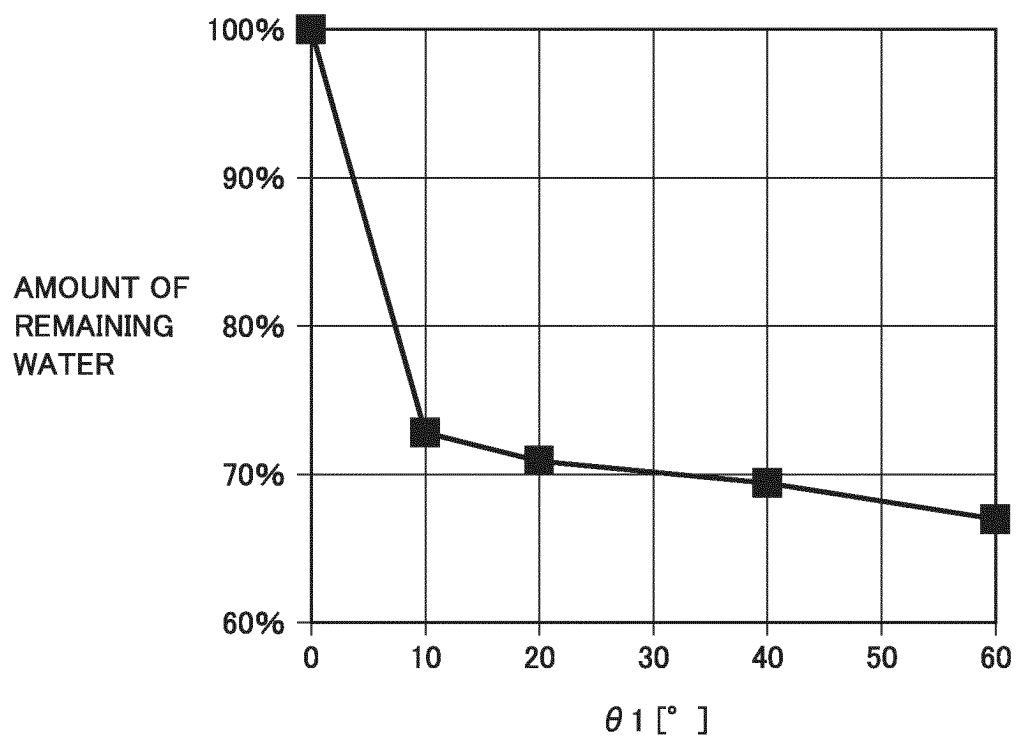


FIG.11

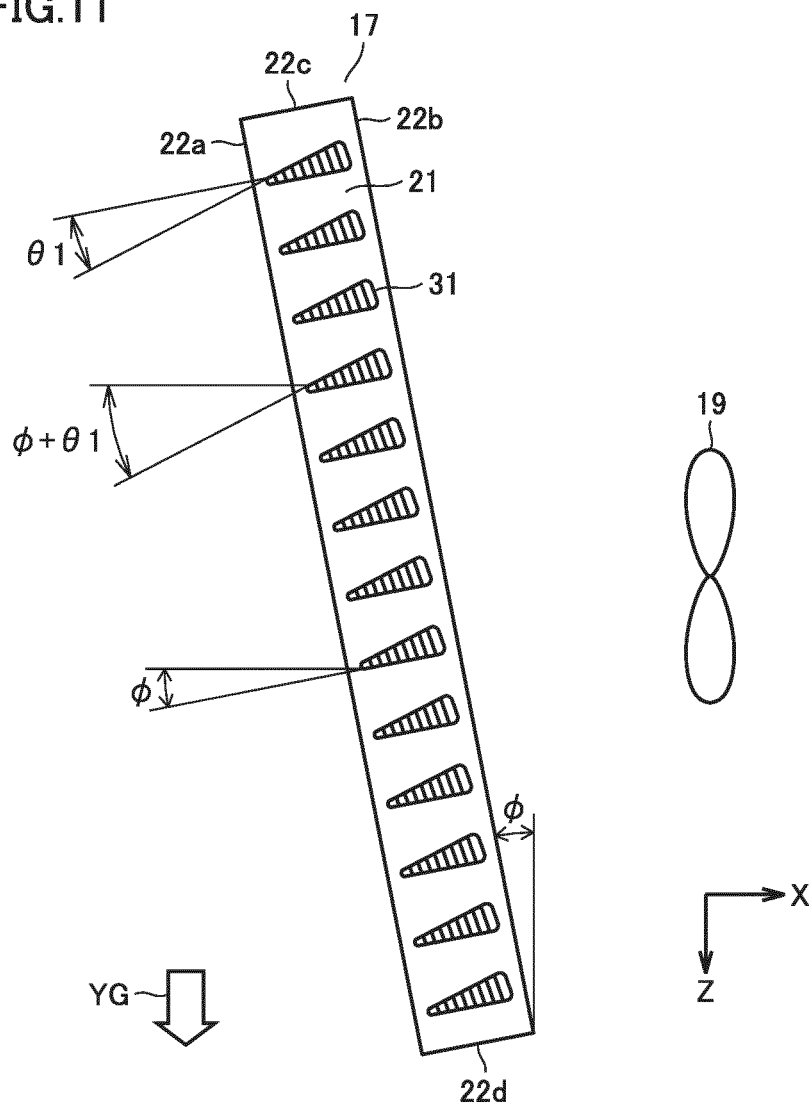


FIG.12

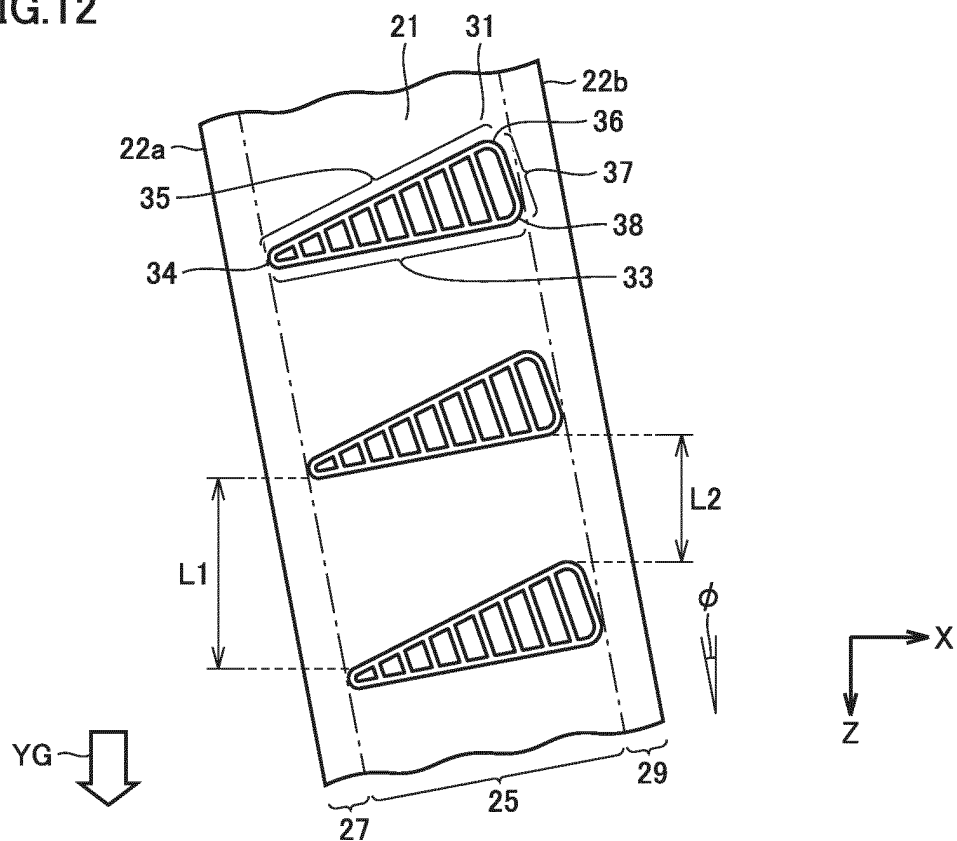


FIG.13

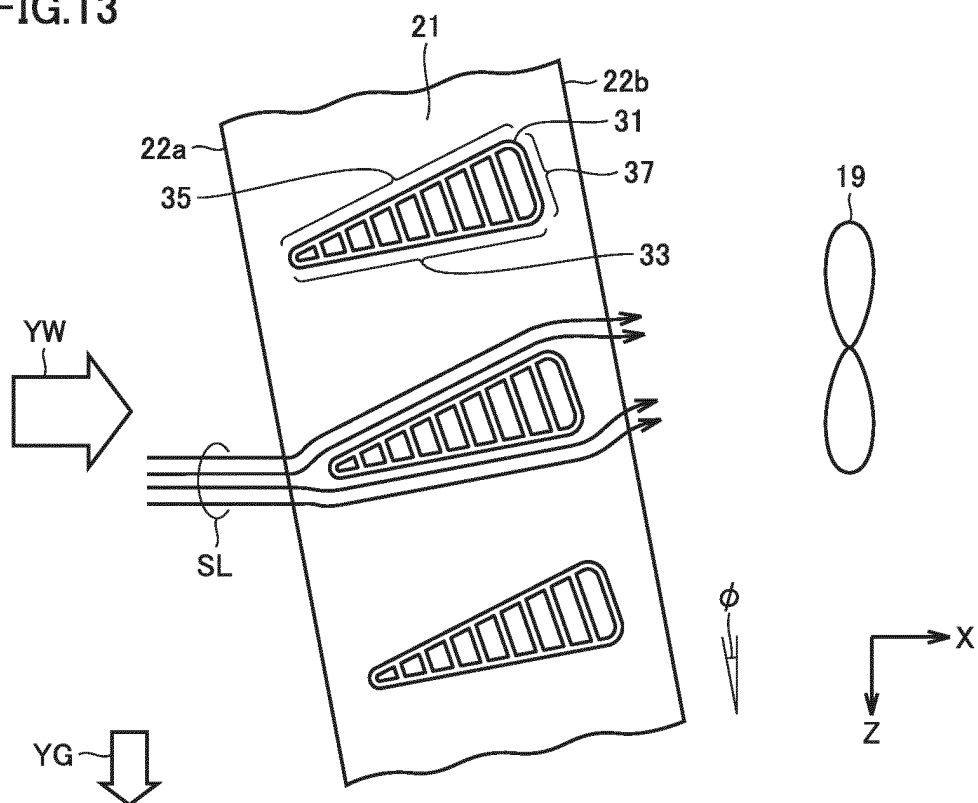
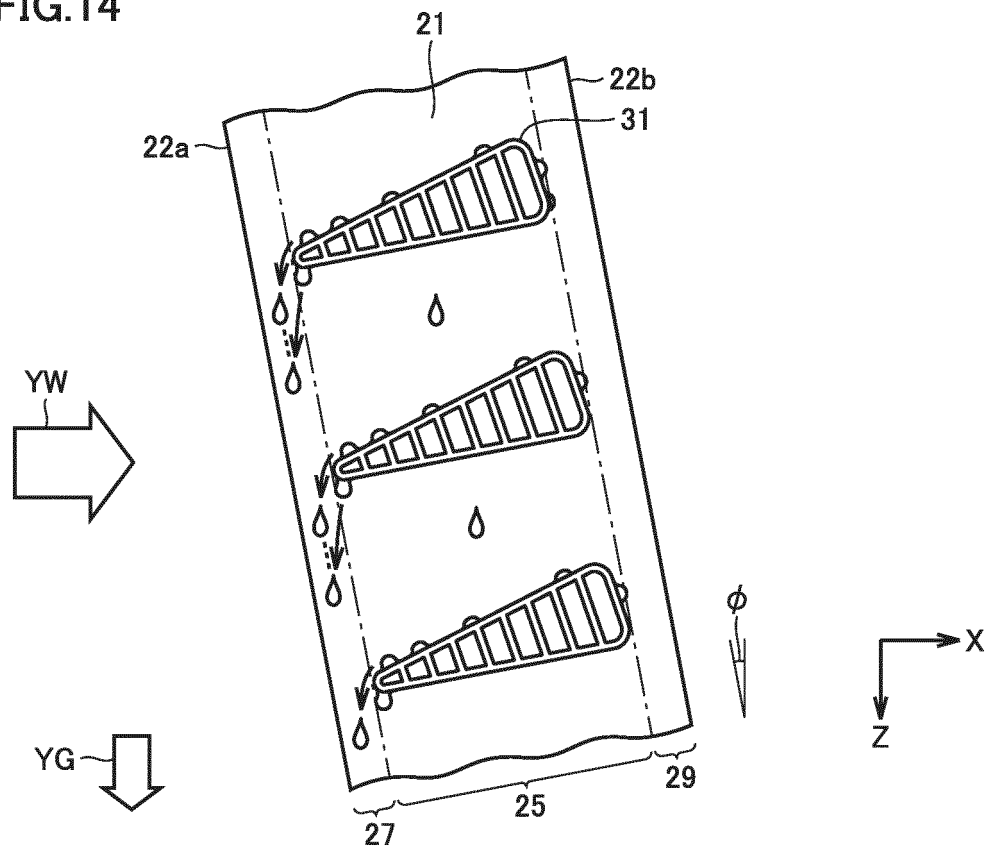


FIG.14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/069530

A. CLASSIFICATION OF SUBJECT MATTER

F28F1/32(2006.01)i, F25B39/02(2006.01)i, F28F1/02(2006.01)i, F28F1/04(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)

F28F1/32, F25B39/02, F28F1/02, F28F1/04

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.
X	JP 10-62086 A (Nippon Light Metal Co., Ltd.),	1-2
Y	06 March 1998 (06.03.1998), paragraphs [0011], [0028] to [0030]; fig. 3, 8, 11 (Family: none)	1-6
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 73147/1991(Laid-open No. 25173/1993) (Mitsubishi Heavy Industries, Ltd.), 02 April 1993 (02.04.1993), paragraphs [0008], [0009]; fig. 1, 4 (Family: none)	1-6

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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Date of the actual completion of the international search
12 September 2016 (12.09.16)Date of mailing of the international search report
20 September 2016 (20.09.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/069530

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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	JP 2013-200119 A (Mitsubishi Electric Corp.), 03 October 2013 (03.10.2013), paragraphs [0022], [0023]; fig. 6 (Family: none)	4-6
A	JP 2005-114308 A (Matsushita Electric Industrial Co., Ltd.), 28 April 2005 (28.04.2005), fig. 2 (Family: none)	1-6

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 7091873 A [0008]