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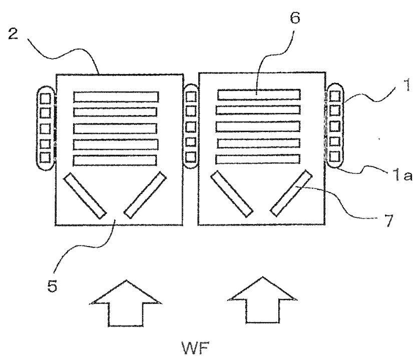
(54) HEAT EXCHANGER AND AIR CONDITIONER

(57) Provided is a heat exchanger, including a plurality of flat tubes arranged in a right-and-left direction orthogonal to a front-and-back direction, the front-and-back direction being an airflow direction of the heat exchanger, a corrugated fin sandwiched by adjacent ones of the plurality of flat tubes and thermally connected to the adjacent ones of the plurality of flat tubes at each of apexes of the corrugated fin, an inlet header connected to one end of each of the plurality of flat tubes, and an outlet header connected to the other end of each of the plurality of flat tubes, the plurality of flat tubes extending along an up-and-down direction of the heat exchanger, the corrugated fin including a protruding portion protruding to a front side with respect to a front-side end portion of each of the plurality of flat tubes, the protruding portion including a first lug portion oriented obliquely to the front-and-back direction, the corrugated fin further including a second lug portion formed in the right-and-left direction at a part sandwiched by the adjacent ones of the plurality of flat tubes.

FIG. 3



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Description

Technical Field

[0001] The present invention relates to a heat exchanger that is to be used in air-conditioning apparatuses such as a room air-conditioning apparatus and a package air-conditioning apparatus, and to an air-conditioning apparatus including the heat exchanger.

Background Art

[0002] There has been the following problem in a related-art corrugated-fin heat exchanger mounted to an outdoor unit of an air-conditioning apparatus. During a heating operation, heat of air flowing through air passages is removed by flat tubes through corrugated fins, so that water vapor in the air is brought into a supersaturated state. When surface temperatures of the flat tubes and the corrugated fins are 0 °C or less, the supersaturated water vapor turns into ice, and frost is formed on surfaces of the flat tubes and the corrugated fins. When the frost formation proceeds, spaces formed by each fin are closed, with the result that airflow resistance increases to degrade heating performance.

[0003] To solve this problem, there has been proposed a corrugated-fin heat exchanger in which the corrugated fins partially protrude to a windward side with respect to windward-side end portions of the flat tubes (see, for example, Patent Literature 1).

[0004] In the corrugated-fin heat exchanger disclosed in Patent Literature 1, the protruding portions of the corrugated fins, which protrude to the windward side with respect to the windward-side end portions of the flat tubes, have a large heat-transfer distance from the flat tubes. Consequently, the fin efficiency (thermal conductivity in the fins) is lowered, so that the surface temperature of the corrugated fins is less likely to be lowered. Thus, the amount of formed frost is reduced, thereby being capable of preventing the spaces formed by each fin from being closed.

List of Citations

Patent Literature

[0005]

Patent Literature 1: Japanese Unexamined Patent Application Publication JP 6-147 785 A

Summary of the Invention

Technical Problem

[0006] In the related-art corrugated-fin heat exchanger as disclosed in Patent Literature 1, when lug portions formed in an airflow orthogonal direction are provided on the protruding portions of the corrugated fins to promote heat transfer (promote heat transfer between the fins and air), the fin efficiency is further lowered, thereby preventing frost formation on the lug portions.

[0007] However, there has been a problem in that, in a case where frost is once formed on the protruding portions or the lug portions of the corrugated fins, when the frost is melted by refrigerant heat during a defrosting operation, heat is less likely to be transferred from the flat tubes to the frost through the corrugated fins, with the result that the defrosting performance is degraded.

[0008] The present invention has been made to solve the above-mentioned problem and has an object to provide a heat exchanger and an air-conditioning apparatus that are capable of preventing degradation of defrosting performance while promoting heat transfer.

Solution to Problem

[0009] According to one embodiment of the present invention, there is provided a heat exchanger, including a plurality of flat tubes arranged in a right-and-left direction orthogonal to a front-and-back direction, the front-and-back direction being an airflow direction of the heat exchanger, a corrugated fin sandwiched by adjacent ones of the plurality of flat tubes and thermally connected to the adjacent ones of the plurality of flat tubes at each of apexes of the corrugated fin, an inlet header connected to one end of each of the plurality of flat tubes, and an outlet header connected to the other end of each of the plurality of flat tubes, the plurality of flat tubes extending along an up-and-down direction of the heat exchanger, the corrugated fin including a protruding portion protruding to a front side with respect to a front-side end portion of each of the plurality of flat tubes, the protruding portion including a first lug portion oriented obliquely to the front-and-back direction, the corrugated fin further including a second lug portion formed in the right-and-left direction at a part sandwiched by the adjacent ones of the plurality of flat tubes.

Advantageous Effects of Invention

[0010] In the heat exchanger of one embodiment of the present invention, the corrugated fin includes the protruding portion protruding to the front side with respect to the front-side end portion of each of the flat tubes. The protruding portion includes the (first) lug portion to promote heat transfer. The lug portion is oriented obliquely to the front-and-back direction that is the airflow direction.

[0011] Consequently, a heat transfer passage is less likely to be divided by the lug portion during a defrosting operation as compared to a case where the lug portion is formed in the airflow orthogonal direction. As a result, heat can sufficiently be transferred to the protruding portion and the lug portion of the corrugated fin, thereby being capable of preventing the degradation of the defrosting performance.

Brief Description of Drawings

[0012]

FIG. 1 is a perspective view for illustrating a corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIG. 2 is an enlarged front view of flat tubes and corrugated fins of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIG. 3 is a sectional view taken along the line A-A of FIG. 2.

FIG. 4 is a schematic view for illustrating an outdoor unit (side-flow type) of an air-conditioning apparatus according to Embodiment 1 of the present invention.

FIG. 5 is a schematic view for illustrating an outdoor unit (top-flow type) of the air-conditioning apparatus according to Embodiment 1 of the present invention.

FIGS. 6 are views for illustrating first lug portions of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIG. 7 is a perspective view for illustrating drainage passages of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIG. 8 is a view for illustrating a modification example of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIGS. 9 are views for illustrating a first modification example of the first lug portions of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIGS. 10 are views for illustrating a second modification example of the first lug portions of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIGS. 11 are views for illustrating a third modification example of the first lug portions of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIGS. 12 are views for illustrating a fourth modification example of the first lug portions of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIG. 13 is a view for illustrating a fifth modification example of the first lug portions of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIGS. 14 are enlarged front views of the flat tubes and the corrugated fins, for illustrating a modification example of the corrugated fins of the corrugated-fin heat exchanger according to Embodiment 1 of the present invention.

FIG. 15 is a perspective view for illustrating a corrugated-fin heat exchanger according to Embodiment 2 of the present invention.

FIG. 16 is an enlarged front view of the flat tubes and the corrugated fins of the corrugated-fin heat exchanger according to Embodiment 2 of the present invention.

FIG. 17 is a sectional view taken along the line C-C of FIG. 16.

FIG. 18 is a view for illustrating a state of frost formation on the flat tubes and the corrugated fins during a heating operation in the corrugated-fin heat exchanger according to Embodiment 2 of the present invention.

FIG. 19 is a view for illustrating a state of frost formation on the flat tubes and the corrugated fins during the defrosting operation in the corrugated-fin heat exchanger according to Embodiment 2 of the present invention.

FIG. 20 is a perspective view for illustrating drainage passages of the corrugated-fin heat exchanger according to Embodiment 2 of the present invention.

FIG. 21 is a sectional view taken along the line D-D of FIG. 17.

Description of Embodiments

[0013] Embodiments of the present invention are described below with reference to the drawings. The present invention is not limited to Embodiments described below. Moreover, in the drawings referred to below, the size relationship of components may be different from the actual size relationship in some cases.

Embodiment 1

[0014] FIG. 1 is a perspective view for illustrating a corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. Further, FIG. 2 is an enlarged front view of flat tubes 1 and corrugated fins 2 of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. The arrow WF in FIG. 1 indicates a flow of air (airflow direction) generated by a fan 31 (see FIG. 4 and FIG. 5 described later) or other units, and the arrow RF indicates a flow of refrigerant. The same arrows are used in the drawings described later. Further, the expressions "up", "down", "left", "right", "front", and "back" used in Embodiment 1 indicate directions that are given when the corrugated-fin heat exchanger 10 is viewed from the front side unless otherwise noted.

[0015] As illustrated in FIG. 1 and FIG. 2, the corrugated-fin heat exchanger 10 according to Embodiment 1 includes the plurality of flat tubes 1 arranged in an airflow orthogonal direction (right-and-left direction) orthogonal to the airflow direction (front-and-back direction) indicated by the arrow WF, the meandering corrugated fins 2 each sandwiched by the adjacent flat tubes 1 and thermally connected to the flat tubes 1 at each apex 2a, an inlet header 3 connected to one end (lower end) of each flat tube 1, and an outlet header 4 connected to the other end (upper end) of each flat tube 1.

[0016] The corrugated-fin heat exchanger 10 exchanges heat between refrigerant flowing through the flat tubes 1 and air flowing through spaces each surrounded by the adjacent flat tubes 1 and the corrugated fin 2 (hereinafter referred to as "heat-exchanger air passages"). Each flat tube 1 extends along an up-and-down direction.

[0017] The corrugated fins 2 are each a metal thin plate shaped to have peaks and troughs that are apexes 2a alternately as viewed from one side. The peaks of the corrugated fin 2 are joined to a surface of one flat tube 1 of the two flat tubes 1 adjacent in the airflow orthogonal direction (right-and-left direction), and the troughs of the corrugated fin 2 are joined to a surface of the other flat tube 1. The peaks and the troughs of the corrugated fin 2 have a shape extending in the airflow direction (front-and-back direction).

[0018] Consequently, joined portions between the corrugated fin 2 and the flat tube 1 each have a linear shape being continuous in the airflow direction (front-and-back direction). The joined portions each have a width enough for the joining. Further, when the peaks and the troughs have flat surfaces, and the flat surfaces are joined to the flat tubes 1, the joined portions between the corrugated fins 2 and the flat tubes 1 each have a wide linear shape.

[0019] FIG. 3 is a sectional view of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention that is taken along the line A-A of FIG. 2. Further, FIGS. 6 are views for illustrating first lug portions 7 of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. In FIGS. 6, a part (a) is a perspective view of the first lug portions 7, and a part (b) is a sectional view taken along the line B-B of the part (a).

[0020] As illustrated in FIG. 3, on a windward side (front side) of each of the corrugated fins 2, there is formed a protruding portion 5 protruding to a windward side (front side) with respect to windward-side end portions (front-side end portions) 1a of the flat tubes 1. Further, a plurality of lug portions are formed in the corrugated fin 2 to promote heat transfer (promote heat transfer between fin and air).

[0021] The first lug portions 7 are formed in the protruding portion 5 in a radial direction extending from the flat tubes 1 toward a center portion of a windward-side end portion (front-side end portion) of the protruding portion 5. Those first lug portions 7 formed to be inclined (oblique) to the airflow direction (front-and-back direction) are provided such that the two first lug portions 7 are arranged in a bilaterally symmetrical manner.

[0022] As illustrated in FIGS. 6, the first lug portions 7 are each of a louver type in which two slits (cut lines) are formed in the surface of the protruding portion 5 (hereinafter referred to as "protruding surface") of the corrugated fin 2, and the first lug portions 7 are each lugged from the two slits in the protruding surface of the corrugated fin 2 in both the up and down directions.

[0023] Further, on a part of the corrugated fin 2 other than the protruding portion 5, that is, the part sandwiched by the adjacent flat tubes 1, there are provided second lug portions 6 formed in the airflow orthogonal direction (right-and-left direction), and the five second lug portions 6 are formed to be arrayed in the airflow direction (front-and-back direction).

[0024] FIG. 4 is a schematic view for illustrating an outdoor unit (side-flow type) of an air-conditioning apparatus according to Embodiment 1 of the present invention. Further, FIG. 5 is a schematic view for illustrating an outdoor unit (top-flow type) of the air-conditioning apparatus according to Embodiment 1 of the present invention. FIG. 4 and FIG. 5 are also referred to in Embodiment 2 described later.

[0025] As illustrated in FIG. 4 and FIG. 5, the corrugated-fin heat exchanger 10 is mounted to the outdoor unit of the air-conditioning apparatus including the fan 31, thereby constructing a refrigeration cycle for circulating refrigerant between the outdoor unit and an indoor unit connected to the outdoor unit by pipes.

[0026] As the outdoor unit in which the corrugated-fin heat exchanger 10 is mounted, a side-flow type illustrated in FIG. 4 and a top-flow type illustrated in FIG. 5 are given.

[0027] In the outdoor unit of the side-flow type, as illustrated in FIG. 4, an air outlet 32a is provided in a side surface of an outdoor-unit main body 30a on a front surface side. Further, a corrugated-fin heat exchanger 10a having an L-shape in plan view is mounted to the outdoor unit, and air inlets 33a are provided in side surfaces of the outdoor-unit main body 30a that are opposed to the corrugated-fin heat exchanger 10a.

[0028] With a flow of air that is generated by the fan 31, the air is sucked into the outdoor-unit main body 30a through the air inlets 33a, and flows through the corrugated-fin heat exchanger 10a. At this time, heat is exchanged between the air and refrigerant sent from the indoor unit (not shown), compressed in a compressor 34, and then flowing through the flat tubes of the corrugated-fin heat exchanger 10a. Subsequently, the air is blown out through the air outlet 32a to the outside of the outdoor-unit main body 30a.

[0029] Further, in the outdoor unit of the top-flow type, as illustrated in FIG. 5, an air outlet 32b is provided in an upper surface of an outdoor-unit main body 30b. Further, a corrugated-fin heat exchanger 10b having a U-shape in plan view is mounted to the outdoor unit, and air inlets 33b are provided in side surfaces of the outdoor-unit main body 30b that are opposed to the corrugated-fin heat exchanger 10b.

[0030] With a flow of air that is generated by the fan 31, the air is sucked into the outdoor-unit main body 30b through the air inlets 33b, and flows through the corrugated-fin heat exchanger 10b. At this time, heat is exchanged between the air and refrigerant sent from the indoor unit (not shown), compressed in the compressor 34, and then flowing through the flat tubes of the corrugated-fin heat exchanger 10b. Subsequently, the air is blown out through the air outlet 32b to the outside of the outdoor-unit main body 30b.

[0031] Next, an operation of the corrugated-fin heat exchanger 10 according to Embodiment 1 is described.

[0032] As illustrated in FIG. 1, with the flow of air that is generated by the fan 31, the air flows into the corrugated-fin heat exchanger 10, exchanges heat with the refrigerant flowing through the flat tubes 1 when the air flows through the heat-exchanger air passages, and flows out from the corrugated-fin heat exchanger 10.

[0033] Next, the flow of the refrigerant is described.

[0034] During a heating operation, refrigerant that is returned after exchanging heat with air in the indoor unit to transfer heat to be liquefied and then being decompressed into a low-temperature and low-pressure two-phase gas-liquid state flows into the corrugated-fin heat exchanger 10 serving as an evaporator, which is mounted to the outdoor unit, through the inlet header 3.

[0035] Then, the refrigerant flows through the flat tubes 1, exchanges heat with air flowing through the heat-exchanger air passages to receive heat to be evaporated, then flows out through the outlet header 4, and flows into the indoor unit again. In this manner, the refrigerant circulates in the refrigeration circuit.

[0036] During the heating operation, the heat of the air flowing through the heat-exchanger air passages is removed by the flat tubes 1 through the corrugated fins 2, and water vapor in the air is brought into a supersaturated state. Then, the supersaturated water vapor is condensed on surfaces of the flat tubes 1 and the corrugated fins 2 to turn into water.

[0037] Part of this water flows along the surfaces of the flat tubes 1, and part of this water flows through the slits formed in the protruding surface of the corrugated fin 2, to be drained to a lower part of the corrugated-fin heat exchanger 10. In this case, when the amount of condensed dew is large, or the drainage performance is poor, water stagnates in spaces formed by the fin of the corrugated fin 2, so that the heat-exchanger air passages are closed.

[0038] As a result, the performance of the corrugated-fin heat exchanger 10 is degraded, thereby leading to degradation of heating performance. To solve this problem, in the corrugated-fin heat exchanger 10 according to Embodiment 1, the first lug portions 7 are formed in the radial direction extending from the flat tubes 1 toward the center of the windward-side end portion (front-side end portion) of the protruding portion 5.

[0039] FIG. 7 is a perspective view for illustrating drainage passages of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. The arrows DFa and DFb in FIG. 7 indicate flows of water in a drainage process.

[0040] As illustrated in FIG. 7, the corrugated-fin heat exchanger 10 has two drainage passages. The first passage is a passage for water flowing through the slits, which are formed in the protruding surface of the corrugated fin 2 in the course of forming the first lug portions 7, as indicated by the arrows DFb. The second passage is a passage for water flowing from the protruding portion 5 through the vicinity of the apex 2a of the corrugated fin 2 along the flat tube 1, as indicated by the arrows DFa.

[0041] In the second passage, the first lug portions 7 are formed in the radial direction extending from the flat tubes 1 toward the center of the windward-side end portion (front-side end portion) of the protruding portion 5. Thus, drainage of water flowing along the flat tubes 1 is promoted by the air guiding action of the first lug portions 7.

[0042] Further, when the surface temperatures of the flat tubes 1 and the corrugated fins 2 are 0 °C or less, supersaturated water vapor turns into ice, so that frost is formed on the surfaces. In particular, the effect of promoting the heat transfer is significant at the lug portions, and hence the amount of formed frost is large at the lug portions.

[0043] Next, when the performance of the corrugated-fin heat exchanger 10 is degraded due to closure of the heat-exchanger air passages caused by frost formation in the corrugated-fin heat exchanger 10 or due to other factors, and the heating performance is degraded, a defrosting operation is started.

[0044] During the defrosting operation, normally, the fan 31 is stopped and the refrigeration cycle is switched to a cooling operation, or other measures are taken so that high-temperature refrigerant is caused to flow into the corrugated-fin heat exchanger 10. In this manner, the frost adhering to each of the surfaces of the flat tubes 1 and the corrugated fins 2 is melted.

[0045] Then, the melted frost turns into water and flows along the surfaces of the flat tubes 1. Further, the water flows through the slits, which are formed in the protruding surface of the corrugated fin 2 in the course of forming the first lug portions 7, to thereby be drained to the lower part of the corrugated-fin heat exchanger 10. After the defrosting is completed, the heating operation is started again.

[0046] In this case, when the lug portions are formed in the corrugated fins 2, the lug portions, specifically, the slits formed in the course of forming the lug portions divide heat transfer passages from a leeward side (back side) that is a side at the position of the flat tube 1, through which the refrigerant flows, to the windward side (front side), with the result that the fin efficiency (thermal conductivity in the fins) is lowered.

[0047] As a result, during the defrosting operation, heat from the refrigerant cannot sufficiently be transferred to the windward-side end portion (front-side end portion) of the protruding portion 5 and the lug portions, with the result that a time period required for the defrosting is prolonged. Meanwhile, when the heat-exchanger air passages are closed due to the frost formation, the heating performance is degraded.

[0048] To solve this problem, in the corrugated-fin heat exchanger 10 according to Embodiment 1, the first lug portions 7 are formed in the protruding portion 5 in the radial direction extending from the flat tubes 1 toward the center portion of the windward-side end portion (front-side end portion) of the protruding portion 5. Consequently, the heat transfer passages are less likely to be divided by the lug portions as compared to the case where the lug portions are formed in the airflow orthogonal direction (right-and-left direction).

[0049] As a result, during the defrosting operation, heat can sufficiently be transferred to the windward-side end portion (front-side end portion) of the protruding portion 5 and the first lug portions 7, thereby being capable of preventing the degradation of the defrosting performance. That is, the time period required for the defrosting can be prevented from being prolonged.

[0050] Further, an interval is secured between the right and left first lug portions 7. Thus, even when frost is formed on the first lug portions 7 during the defrosting operation, the heat-exchanger air passages can be secured, thereby being capable of preventing the degradation of the heating performance.

[0051] In the corrugated-fin heat exchanger 10 of Embodiment 1, it is unnecessary to take a measure of, for example, increasing pitches of the corrugated fins 2 (interval between the adjacent apexes 2a) by sacrificing the performance during the normal operation, to achieve the above-mentioned effect.

[0052] FIG. 8 is a view for illustrating a modification example of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. FIG. 8 is a sectional view taken along the line A-A of FIG. 2 similarly to FIG. 3.

[0053] In Embodiment 1, the number of the first lug portions 7 is two. However, the number of the first lug portions 7 is not limited to two, and the number of the first lug portions 7 may be one. Further, as illustrated in FIG. 8, three or more first lug portions 7 may be formed in the radial direction extending from the flat tubes 1 toward the center portion of the windward-side end portion (front-side end portion) of the protruding portion 5.

[0054] When a large number of first lug portions 7 are formed in this manner, the drainage performance is enhanced with the action of guiding air to the flat tubes 1 serving as the drainage passages during the heating operation. Further, the heat transfer is promoted during the normal operation by the effect of front edges of the lug portions without degrading the defrosting performance during the defrosting operation, thereby being capable of enhancing the heating performance.

[0055] FIGS. 9 are views for illustrating a first modification example of the first lug portions 7 of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. Further, FIGS. 10 are views for illustrating a second modification example of the first lug portions 7 of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. Further, FIGS. 11 are views for illustrating a third modification example of the first lug portions 7 of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention.

[0056] Further, FIGS. 12 are views for illustrating a fourth modification example of the first lug portions 7 of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. In each of FIGS. 9 to FIGS. 12, a part (a) is a perspective view of a modification example of the first lug portions 7, and a part (b) is a sectional view taken along the line B-B of the part (a).

[0057] As illustrated in FIGS. 9, the first modification example of the first lug portions 7 according to Embodiment 1 (first lug portions 7a) is of a slit type of being lugged (raised) in one direction (upward direction) from the protruding surface of the corrugated fin 2.

[0058] In the first modification example, the heat transfer performance is degraded as compared to the louver type illustrated in FIGS. 6. However, there are obtained effects of increasing the area of the raised portions of the slits (heat transfer area for promoting heat transfer) and increasing the strength of the fins.

[0059] Further, as illustrated in FIGS. 10, the second modification example of the first lug portions 7 according to Embodiment 1 (first lug portions 7b) is of a type of being simply folded back in in one direction (upward direction) from the protruding surface of the corrugated fin 2 and lugged into a rectangular shape in plan view.

[0060] In the second modification example, the heat transfer performance is degraded as compared to the louver type illustrated in FIGS. 6 and the slit type illustrated in FIGS. 9. However, the slits can be formed relatively easily, thereby attaining simplification of manufacture.

[0061] Further, as illustrated in FIGS. 11, the third modification example of the first lug portions 7 according to Embodiment 1 (first lug portions 7c) is of a type of being folded back in the one direction (upward direction) from the protruding surface of the corrugated fin 2 and lugged into a triangular shape in plan view, in which the lugged portions are reduced in height toward the windward-side end portion (front-side end portion) of the protruding portion 5.

[0062] As compared to the first lug portions 7b illustrated in FIGS. 10, the first lug portions 7c illustrated in FIGS. 11 are increased in area to promote heat transfer by the effect of the front edges of the lug portions, that is, the first lug portions. Consequently, in the third modification example, the effect of promoting the heat transfer by the lug portions can be obtained more than the second modification example.

[0063] Further, as illustrated in FIGS. 12, the fourth modification example of the first lug portions 7 according to Embodiment 1 (first lug portions 7d) is of a slit type in which one slit is formed in the protruding surface of the corrugated fin 2, and the protruding surface of the corrugated fin 2 is not raised with the slit or is raised with the slit to a small extent to form a cutout.

[0064] The first lug portions 7d illustrated in FIGS. 12 are small lug portions, and hence the effect of the heat transfer promotion by the lug portions is small. However, intervals formed by the fin can be prevented from being small, thereby being capable of preventing the degradation of the heating performance due to closure of the heat-exchanger air passages caused by the frost formation.

[0065] Further, water generated during the defrosting operation can be drained to the lower part of the corrugated-fin heat exchanger 20 through the slits that are formed in the protruding surface of the corrugated fin 2 in the course of forming the first lug portions 7d. That is, drainage passages for water to be drained can be secured with the slits.

[0066] Further, the slits of the first lug portions 7d are small, and hence the heat transfer passages are less likely to be divided. As a result, heat can sufficiently be transferred to the windward-side end portion (front-side end portion) of the protruding portion 5 and the first lug portions 7d during the defrosting operation, thereby being capable of preventing the degradation of the defrosting performance. That is, the time period required for the defrosting can be prevented from being prolonged.

[0067] FIG. 13 is a view for illustrating a fifth modification example of the first lug portions 7 of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. Further, FIGS. 14 are enlarged front views of the flat tubes 1 and the corrugated fins 2, for illustrating a modification example of the corrugated fins 2 of the corrugated-fin heat exchanger 10 according to Embodiment 1 of the present invention. FIG. 13 is a front view of the corrugated fin 2 and the first lug portions 7 of the corrugated-fin heat exchanger 10.

[0068] The corrugated fins 2 are each sandwiched by the adjacent flat tubes 1 and thermally connected to the flat tubes 1 at each apex 2a.

[0069] As illustrated in FIG. 13, the fifth modification example of the first lug portions 7 according to Embodiment 1 (first lug portions 7e) corresponds to the two first lug portions 7e formed on the right and left sides of the center portion (of the protruding portion 5) of the corrugated fin 2 in the airflow orthogonal direction (right-and-left direction).

[0070] The first lug portion 7e1 on the left side is lugged from the surface of the corrugated fin 2 in the downward direction, and the first lug portion 7e2 on the right side is lugged from the surface of the corrugated fin 2 in the upward direction. That is, the first lug portions 7e are lugged toward an outer peripheral side at the vicinity of each apex 2a of the corrugated fin 2.

[0071] In the corrugated fins 2, the intervals formed by the fin are smaller on the inner peripheral side at the vicinity of each apex 2a. However, as illustrated in FIG. 13, the first lug portions 7e are lugged toward the outer peripheral side on which the intervals formed by the fin are larger, so that air flows satisfactorily at portions at which the first lug portions 7e are formed. That is, by forming the first lug portions 7e toward the outer peripheral side at the vicinity of each apex 2a of the corrugated fin 2, increase in airflow resistance can be prevented as compared to a case where the first lug portions 7e are formed toward the inner peripheral side, thereby being capable of preventing the degradation of the heating performance.

[0072] Further, an interval is secured between the right and left first lug portions 7e. Thus, even when frost is formed on the first lug portions 7e during the defrosting operation, the heat-exchanger air passages can be secured, thereby being capable of preventing the degradation of the heating performance.

[0073] As described above, in the corrugated-fin heat exchanger 10 of Embodiment 1, the two first lug portions 7 are formed in the protruding portion 5 on the right and left sides to promote heat transfer. Further, the first lug portions 7 are formed in the radial direction extending from the flat tubes 1 toward the center portion of the windward-side end portion (front-side end portion) of the protruding portion 5.

[0074] That is, the first lug portions 7 are oriented obliquely to the airflow direction (front-and-back direction). With this configuration, as compared to a case where the lug portions are formed in the airflow orthogonal direction (right-and-left direction), water is easily drained with the action of guiding air to the flat tubes 1 serving as the drainage passages, and further, the heat transfer passages are less likely to be divided by the lug portions. As a result, the drainage performance is enhanced during the heating operation.

[0075] Further, during the defrosting operation, heat can sufficiently be transferred to the windward-side end portion (front-side end portion) of the protruding portion 5 and the first lug portions 7, thereby being capable of preventing the degradation of the defrosting performance. That is, the time period required for the defrosting can be prevented from being prolonged.

[0076] Further, an interval is secured between the right and left first lug portions 7. Thus, even when dew condensation or frost formation occurs on the first lug portions 7 during the defrosting operation, the heat-exchanger air passages can be secured, thereby being capable of preventing the degradation of the heating performance.

[0077] As basic configurations of the flat tubes 1 and the corrugated fins 2 of the corrugated-fin heat exchanger 10 according to Embodiment 1, there are provided the flat tubes 1 serving as the drainage passages extending in the up-and-down direction and the meandering corrugated fins 2 each sandwiched by the adjacent flat tubes 1 and thermally joined to the flat tubes 1. In FIG. 2, the shape of each of the apexes of the corrugated fins 2 that are joined to the flat tubes 1 is an arc shape.

[0078] However, as illustrated in FIG. 14(a), the shape may be a flat shape, and in this case, the joined area is increased to promote thermal conduction. Further, as illustrated in FIG. 14(b), the corrugated fins 2 may each have a shape having surfaces perpendicular to the flat tubes 1, that is, a shape having the surfaces perpendicular to the flat tubes 1 and parallel to one another. With this shape, the pitches of the corrugated fins 2 (interval between the adjacent apexes 2a) can be reduced to increase the mounting area, thereby enhancing the heat exchange performance.

[0079] Effects similar to those described above can be obtained also in an air-conditioning apparatus including the corrugated-fin heat exchanger 10 according to Embodiment 1.

Embodiment 2

[0080] Embodiment 2 of the present invention is described below. Description of the same components as those of Embodiment 1 is omitted or partly omitted. The parts same as or corresponding to those of Embodiment 1 are denoted by the same reference signs.

[0081] FIG. 15 is a perspective view for illustrating a corrugated-fin heat exchanger 20 according to Embodiment 2 of the present invention. Further, FIG. 16 is an enlarged front view of the flat tubes 1 and the corrugated fins 2 of the corrugated-fin heat exchanger 20 according to Embodiment 2 of the present invention. Further, FIG. 17 is a sectional view taken along the line C-C of FIG. 16.

[0082] As illustrated in FIG. 15 and FIG. 16, in the corrugated-fin heat exchanger 10 according to Embodiment 2, the plurality of flat tubes 1 that are arranged in the airflow orthogonal direction (right-and-left direction) orthogonal to the airflow direction (front-and-back direction) indicated by the arrow WF are provided in two rows in the airflow direction (front-and-back direction). Each flat tube 1 extends along the up-and-down direction. Further, there are provided the meandering corrugated fins 2 each sandwiched by the adjacent flat tubes 1 in the airflow orthogonal direction (right-and-left direction) and thermally connected to the flat tubes 1 at each apex 2a.

[0083] Further, the inlet header 3 is connected to one end (lower end) of each flat tube 1 on the windward side (front side), and the outlet header 4 is connected to one end (lower end) of each flat tube 1 on the leeward side (back side). An intermediate header 11 is connected to the other end (upper end) of each flat tube 1 on the windward side (front side) and the other end (upper end) of each flat tube 1 on the leeward side (back side). Heat is exchanged between refrigerant flowing through the flat tubes 1 and air flowing through the spaces in each of the fins of the corrugated fins 2.

[0084] As illustrated in FIG. 17, on the windward side (front side) of each of the corrugated fins 2, there is formed the protruding portion 5 protruding to the windward side (front side) with respect to the windward-side end portions (front-side end portions) 1a of the flat tubes 1. Further, the plurality of lug portions are formed in the corrugated fin 2 to promote heat transfer.

[0085] In the protruding portion 5, the two first lug portions 7 that are formed to be inclined (oblique) to the airflow direction (front-and-back direction) are provided on the right and left sides. The first lug portions 7 are oriented obliquely in the same direction with respect to the airflow direction (front-and-back direction).

[0086] Further, on the part of the corrugated fin 2 other than the protruding portion 5, that is, the part sandwiched by the adjacent flat tubes 1, there are provided the second lug portions 6 formed in the airflow orthogonal direction (right-and-left direction), and the five second lug portions 6 are formed to be arrayed in the airflow direction (front-and-back direction).

[0087] As illustrated in FIG. 4 and FIG. 5, the corrugated-fin heat exchanger 20 is mounted to the outdoor unit of the air-conditioning apparatus including the fan 31, thereby constructing a refrigeration cycle for circulating refrigerant between the outdoor unit and an indoor unit connected to the outdoor unit by pipes.

[0088] Next, an operation of the corrugated-fin heat exchanger 20 according to Embodiment 2 is described.

[0089] As illustrated in FIG. 15, with the flow of air that is generated by the fan 31, the air flows into the corrugated-fin heat exchanger 20, exchanges heat with the refrigerant flowing through the flat tubes 1 when the air flows through the heat-exchanger air passages, and flows out from the corrugated-fin heat exchanger 20.

[0090] Next, the flow of the refrigerant is described.

[0091] During the heating operation, refrigerant that is returned after exchanging heat with air in the indoor unit to transfer heat to be liquefied and then being decompressed into a low-temperature and low-pressure two-phase gas-liquid state flows into the corrugated-fin heat exchanger 20 serving as an evaporator, which is mounted to the outdoor unit, through the inlet header 3.

[0092] Then, the refrigerant flows through the flat tubes 1 on the windward side (front side), flows through the flat tubes 1 on the leeward side (back side) through the intermediate header 11, exchanges heat with air flowing through the heat-exchanger air passages to receive heat to be evaporated, then flows out through the outlet header 4, and flows into the indoor unit again. In this manner, the refrigerant circulates in the refrigeration circuit.

[0093] Other operations are similar to those in Embodiment 1, and hence description of the operations is omitted.

[0094] FIG. 18 is a view for illustrating a state of frost formation on the flat tubes 1 and the corrugated fins 2 during the heating operation in the corrugated-fin heat exchanger 20 according to Embodiment 2 of the present invention. Further, FIG. 19 is a view for illustrating a state of frost formation on the flat tubes 1 and the corrugated fins 2 during the defrosting operation in the corrugated-fin heat exchanger 20 according to Embodiment 2 of the present invention.

[0095] Further, FIG. 20 is a perspective view for illustrating drainage passages of the corrugated-fin heat exchanger 20 according to Embodiment 2 of the present invention. FIG. 18 and FIG. 19 are sectional views taken along the line C-C of FIG. 16 similarly to FIG. 17. Further, the arrows DFa, DFb, DFc, and DFd of FIG. 20 indicate the flows of water during the defrosting operation.

[0096] The amount of formed frost is small at a portion on the corrugated fin 2 at which the airflow velocity is low in the airflow velocity distribution, and the amount of formed frost is large at a portion on the corrugated fin 2 at which the airflow velocity is high in the airflow velocity distribution. As illustrated in FIG. 18 and FIG. 19, in Embodiment 2, the airflow velocity distribution is formed in a direction to which an airflow direction is slightly bent toward the airflow orthogonal direction (right-and-left direction) with the air guiding action by the first lug portions 7.

[0097] Then, as in a frost formation portion (portion at which frost is formed) 40 illustrated in FIG. 18, frost is formed to be dispersed in the front-and-back direction (airflow direction). Thus, as compared to a case where frost is formed to be concentrated at the windward-side end portion (front-side end portion) of the protruding portion 5, the amount of formed frost is small.

[0098] Consequently, a portion at which the amount of formed frost is small, that is, a portion at which the airflow resistance is relatively small is secured easily, thereby being capable of obtaining a configuration in which the entire front surface side (windward side) of the corrugated-fin heat exchanger 20 is less likely to be closed.

[0099] As illustrated in FIG. 20, the first lug portions 7 are inclined to the airflow direction (front-and-back direction) and extend along with an inclination direction of each surface of the meandering corrugated fin 2, and the first lug portions 7 are alternately inclined to directions horizontally opposite to each other in the up-and-down direction. That is, a first lug portion 7α that is inclined in the left direction from the windward side (front side) to the leeward side (back side) is formed in a surface of the corrugated fin 2 that is inclined from the right side to the left side. Further, a first lug portion 7β that is inclined in the right direction from the windward side (front side) to the leeward side (back side) is formed in a surface of the corrugated fin 2 that is inclined from the left side to the right side.

[0100] The frost on the frost formation portion 40 illustrated in FIG. 18 is melted into water during the defrosting operation. Consequently, to drain the water to the lower part of the corrugated-fin heat exchanger 10, the drainage passages are formed in the corrugated-fin heat exchanger 20 as illustrated in FIG. 20. The two drainage passages are provided. The first passage is a passage for water flowing through the slits formed in the protruding surface of the corrugated fin 2 in the course of forming the first lug portions 7, as indicated by the arrow DFc and the arrow DFd.

[0101] The second passage is a passage for water flowing from the protruding portion 5 to the vicinity of the apex 2a of the corrugated fin 2 and flowing through a part between the flat tube 1 on the windward side (front side) and the flat tube 1 on the leeward side (back side), as indicated by the arrow DFa and the arrow DFb.

[0102] In the second passage, the first lug portions 7 are provided to be inclined to the airflow direction (front-and-back direction) and to extend along with the inclination direction of the meandering corrugated fin 2. Thus, with use of the gravity, water is easily guided to the part between the flat tube 1 on the windward side (front side) and the flat tube 1 on the leeward side (back side).

[0103] As described above, in Embodiment 2, the flat tubes 1 are provided in two rows in the airflow direction (front-and-back direction). Consequently, in addition to the passage for water flowing through the slits and the passage for water flowing along the flat tube 1, there is formed the passage for water flowing through the part between the flat tube 1 on the windward side (front side) and the flat tube 1 on the leeward side (back side).

[0104] Consequently, not only water flows along the flat tube 1 to be drained due to the gravity when the flat tubes 1 are provided in only one row, but also the water is sucked by a capillary force of a gap formed between the flat tube 1 on the windward side (front side) and the flat tube 1 on the leeward side (back side), so that the water is easily drained to the lower part of the corrugated-fin heat exchanger 10, thereby enhancing the drainage performance.

[0105] Further, when air is caused to flow after the defrosting, the drainage performance can further be enhanced with the above-mentioned air guiding action. The enhancement of the drainage performance with the air guiding action exerts the effect to promote drainage of water to the flat tubes 1 not only during the defrosting operation but also during the normal heating operation even in a case where dew condensation occurs on the surfaces of the flat tubes 1 or the corrugated fins 2.

[0106] When the two first lug portions 7 that are oriented obliquely in the same direction with respect to the airflow direction (front-and-back direction) are formed on the right and left sides on the protruding portion 5 of the corrugated fin 2, one first lug portion 7 is not formed at a position in the radial direction extending from the flat tubes 1, and hence the defrosting performance is degraded as compared to Embodiment 1.

[0107] However, in the protruding portion 5 of the corrugated fin 2, in which the first lug portions 7 are formed, the amount of formed frost is relatively small, and hence the influence of the degradation of the defrosting performance is small. Further, the air guiding action is promoted as compared to Embodiment 1, and an effect of being capable of prolonging a time period until the defrosting operation is performed is more significant.

[0108] FIG. 21 is a sectional view taken along the line D-D of FIG. 17.

[0109] As illustrated in FIG. 21, the thickness of the center portion of the corrugated fin 2 in the airflow orthogonal direction (right-and-left direction) is formed larger than those of other portions (both right and left end portions). With this configuration, when frost is formed on the windward-side end portion (front-side end portion) of the protruding portion 5, during the defrosting operation, the fin efficiency can be enhanced substantially equally to that in a case where the entire thickness of the fin is increased.

[0110] Consequently, heat can sufficiently be transferred to the windward-side end portion (front-side end portion) of the protruding portion 5 and the first lug portions 7, thereby being capable of preventing the degradation of the defrosting performance. That is, the time period required for the defrosting can be prevented from being prolonged.

[0111] The case where the thickness of the corrugated fin 2 is varied only at the windward-side end portion (front-side end portion) of the protruding portion 5 as described above is most efficient. However, the thickness of the corrugated fin 2 may be entirely varied in the same manner in the airflow direction (front-and-back direction). In this case, also when frost is formed on a part of the corrugated fin 2 on the leeward side (back side), the defrosting performance can be enhanced.

[0112] As described above, in the corrugated-fin heat exchanger 20 of Embodiment 2, the two first lug portions 7 are formed in the protruding portion 5 on the right and left sides to promote heat transfer. The first lug portions 7 are oriented obliquely in the same direction with respect to the airflow direction (front-and-back direction). Thus, the air guiding action is promoted as compared to Embodiment 1, thereby being capable of prolonging the time period until the defrosting operation is performed.

[0113] Further, the flat tubes 1 are provided in two rows in the airflow direction (front-and-back direction). Thus, in addition to the passage for water flowing through the slits, the passage for water flowing through the part between the flat tube 1 on the windward side (front side) and the flat tube 1 on the leeward side (back side) is formed.

[0114] Consequently, as compared to the case where the flat tubes 1 are provided in only one row, water is easily drained to the lower part of the corrugated-fin heat exchanger 10, thereby enhancing the drainage performance. Further, when air is caused to flow after the defrosting, the drainage performance can be further enhanced with the above-mentioned air guiding action.

[0115] Further, the thickness of the center portion of the corrugated fin 2 in the airflow orthogonal direction (right-and-left direction) is formed larger than those of other portions (both right and left end portions), and hence, during the defrosting operation, the fin efficiency can be enhanced substantially equally to that in the case where the entire thickness of the fin is increased. Consequently, heat can sufficiently be transferred to the windward-side end portion (front-side end portion) of the protruding portion 5 and the first lug portions 7, thereby being capable of preventing the degradation of the defrosting performance. That is, the time period required for the defrosting can be prevented from being prolonged.

[0116] Effects similar to those described above can be obtained also in an air-conditioning apparatus including the corrugated-fin heat exchanger 20 according to Embodiment 2.

List of Reference Signs

[0117]

1	flat tube
2	corrugated fin
2a	apex
3	inlet header
4	outlet header
5	protruding portion
6	second lug portion
7	first lug portion
7a	first lug portion
7b	first lug portion
7c	first lug portion
7d	first lug portion
7e	first lug portion
7e1	first lug portion
7e2	first lug portion
7α	first lug portion
7β	first lug portion
10	corrugated-fin heat exchanger
10a	corrugated-fin heat exchanger
10b	corrugated-fin heat exchanger
11	intermediate header
20	corrugated-fin heat exchanger
30a	outdoor-unit main body
30b	outdoor-unit main body
31	fan
32a	air outlet
32b	air outlet
33a	air inlet
33b	air inlet
34	compressor
40	frost formation portion

Claims

1. A heat exchanger, comprising:

- a plurality of flat tubes arranged in a right-and-left direction orthogonal to a front-and-back direction, the front-and-back direction being an airflow direction of the heat exchanger;
- a corrugated fin sandwiched by adjacent ones of the plurality of flat tubes and thermally connected to the adjacent ones of the plurality of flat tubes at each of apexes of the corrugated fin;
- an inlet header connected to one end of each of the plurality of flat tubes; and
- an outlet header connected to an other end of each of the plurality of flat tubes,
- the plurality of flat tubes extending along an up-and-down direction of the heat exchanger,
- the corrugated fin including a protruding portion protruding to a front side with respect to a front-side end portion of each of the plurality of flat

tubes,
- the protruding portion including at least one first lug portion oriented obliquely to the front-and-back direction,
- the corrugated fin further including a second lug portion formed in the right-and-left direction at a part sandwiched by the adjacent ones of the plurality of flat tubes.

2. The heat exchanger of claim 1, wherein the at least one first lug portion comprises a plurality of first lug portions.

3. The heat exchanger of claim 2, wherein the plurality of first lug portions are formed in a radial direction extending from each of the plurality of flat tubes toward a center portion of a front-side end portion of the protruding portion.

4. The heat exchanger of claim 2, wherein all of the plurality of first lug portions are oriented obliquely in the same direction with respect to the front-and-back direction.

5. The heat exchanger of claim 4, wherein the plurality of first lug portions are formed to be inclined in an inclination direction of each of surfaces of the corrugated fin from the front side to a back side.

6. The heat exchanger of any one of claims 1 to 4, wherein the plurality of flat tubes are provided in two rows in the front-and-back direction.

7. The heat exchanger of any one of claims 1 to 6, wherein a thickness of a center portion of the corrugated fin in the right-and-left direction is formed larger than thicknesses of other portions of the corrugated fin.

8. The heat exchanger of any one of claims 1 to 7, wherein the at least one first lug portion is formed by forming the one slit in the protruding portion.

9. An air-conditioning apparatus, comprising:

- the heat exchanger of any one of claims 1 to 8; and
- a fan configured to send air to the heat exchanger;
- the heat exchanger including the protruding portion arranged on a windward side of the heat exchanger.

FIG. 1

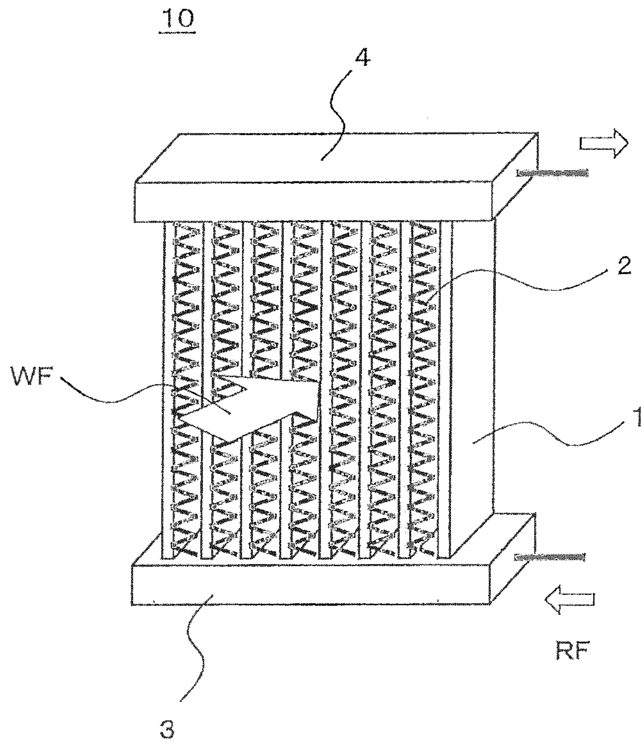


FIG. 2

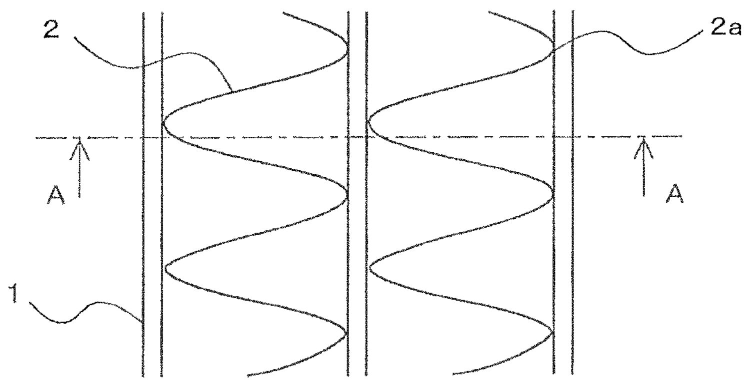


FIG. 3

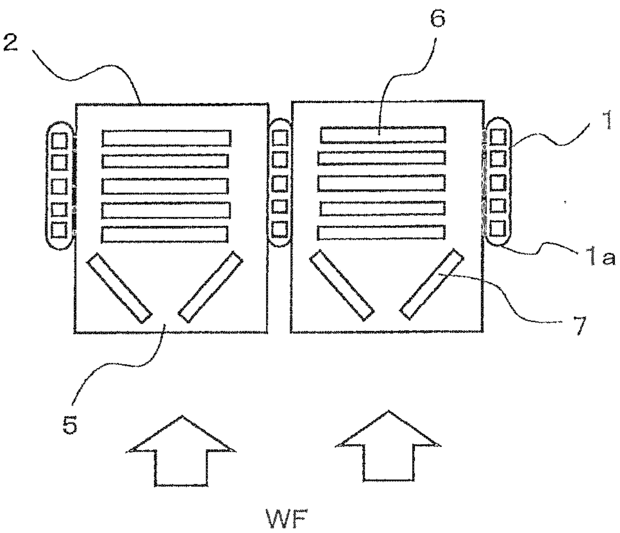


FIG. 4

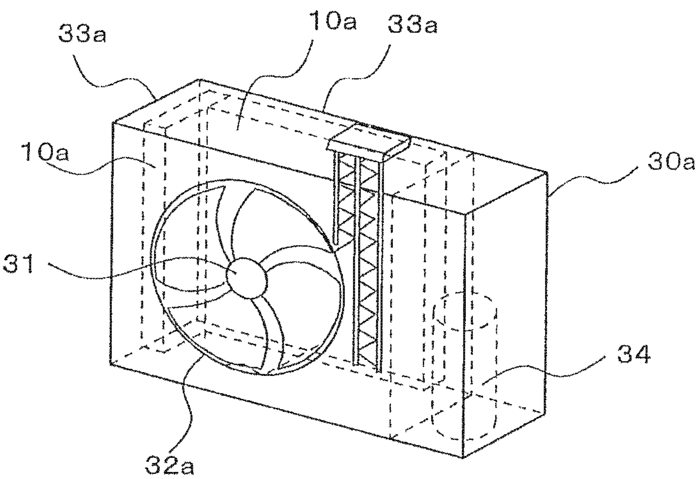


FIG. 5

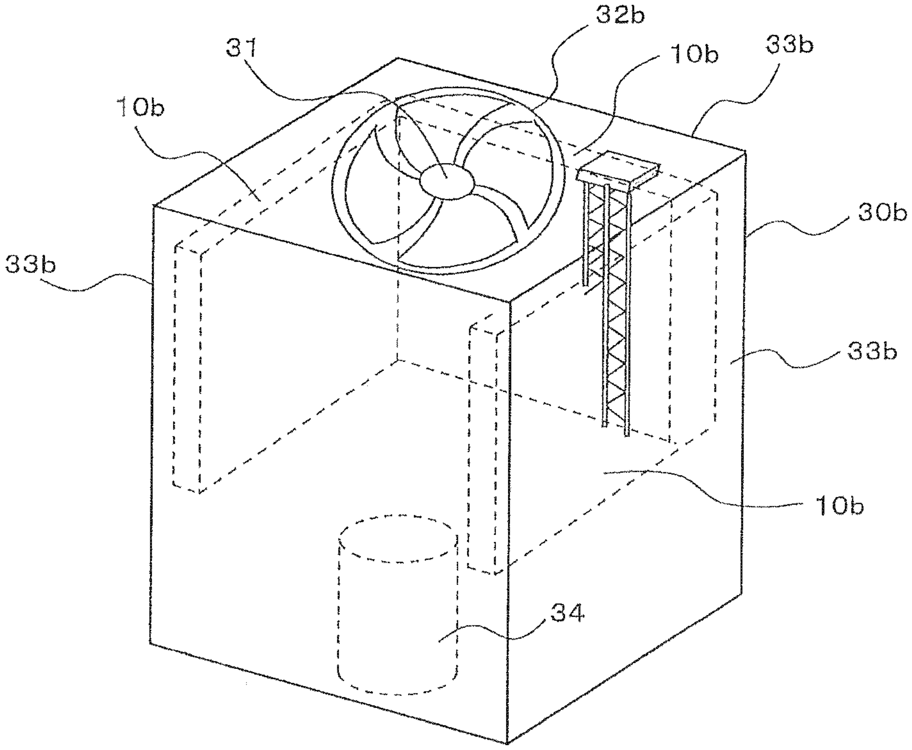


FIG. 6

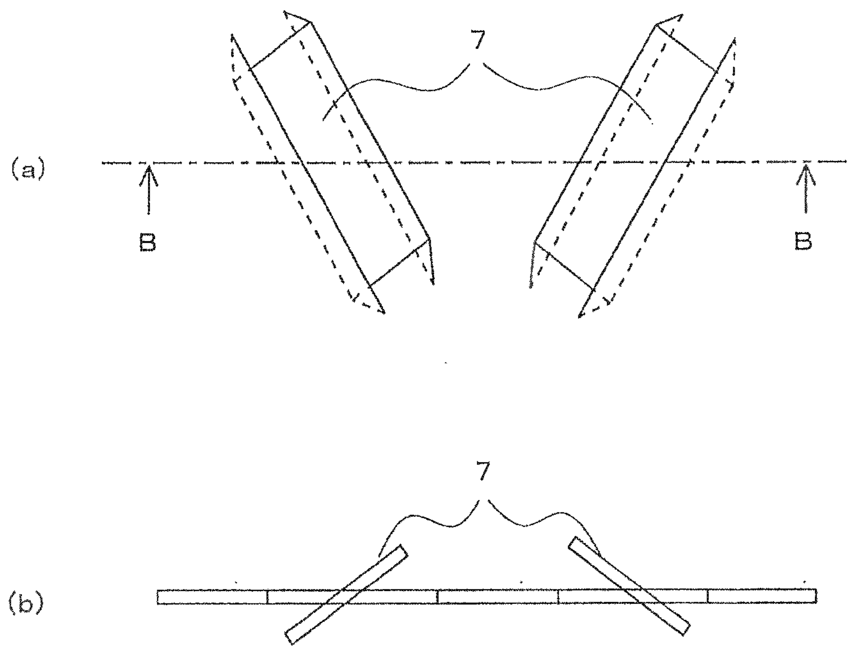


FIG. 7

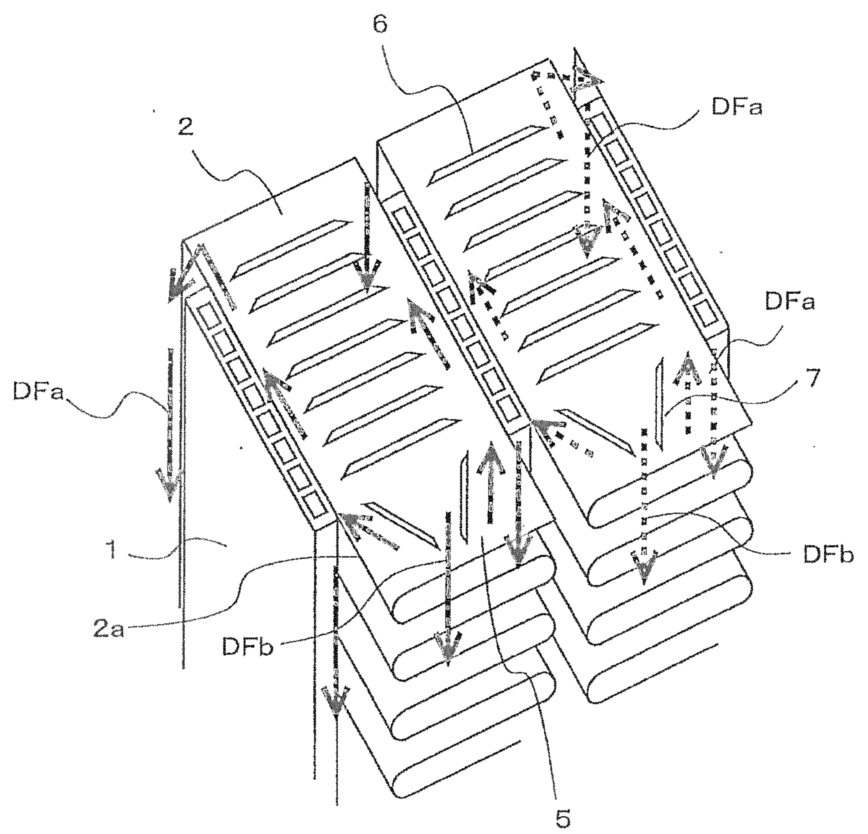


FIG. 8

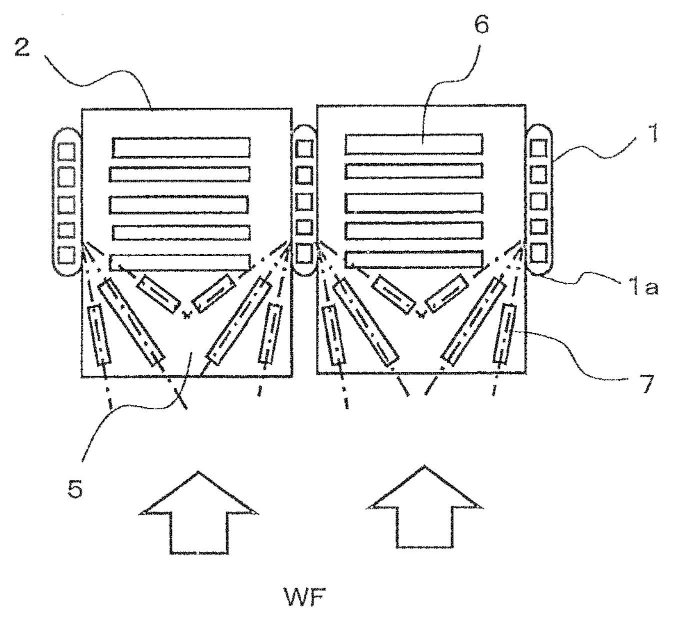
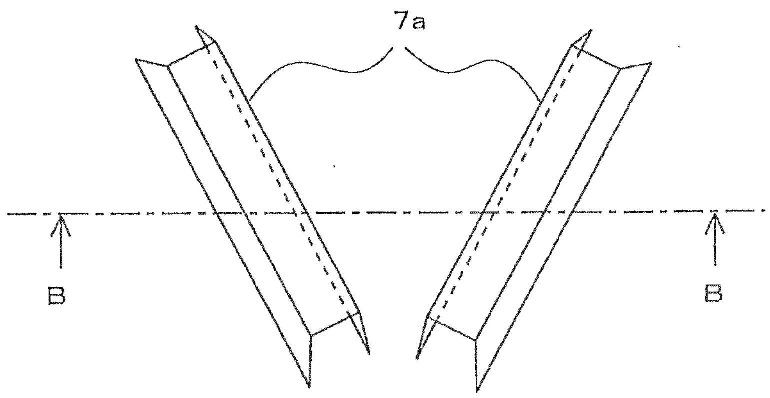


FIG. 9

(a)



(b)

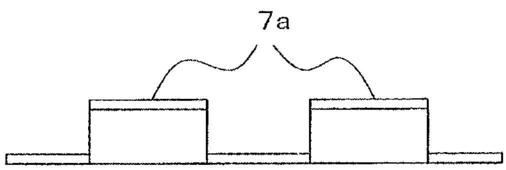


FIG. 10

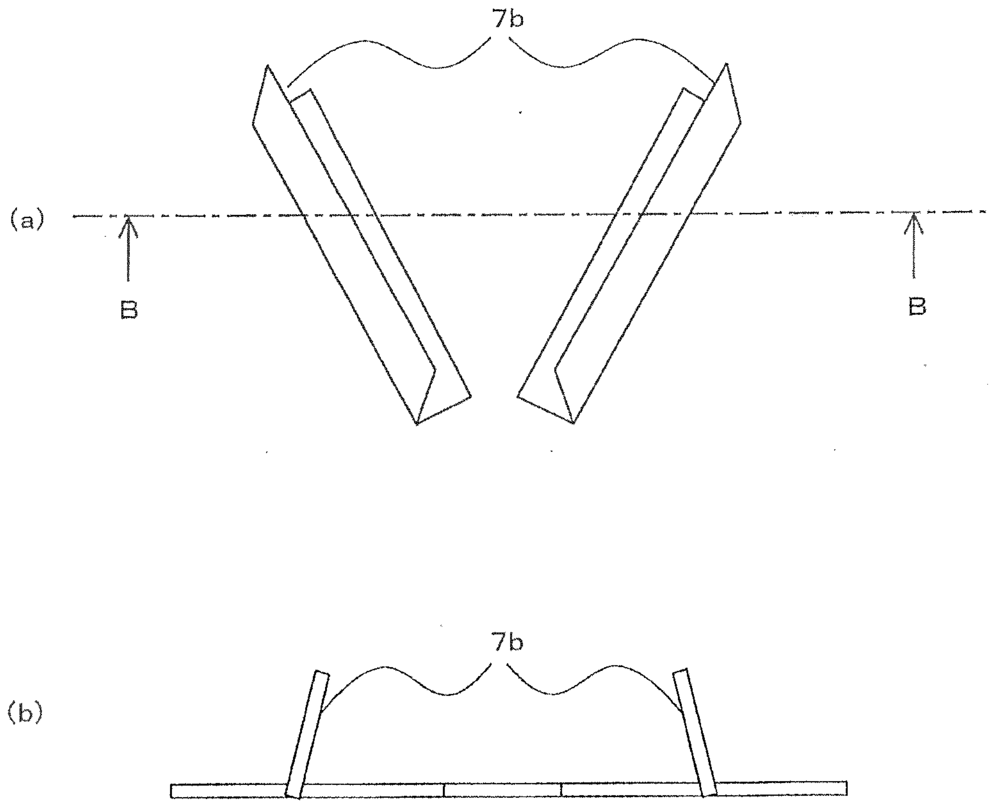
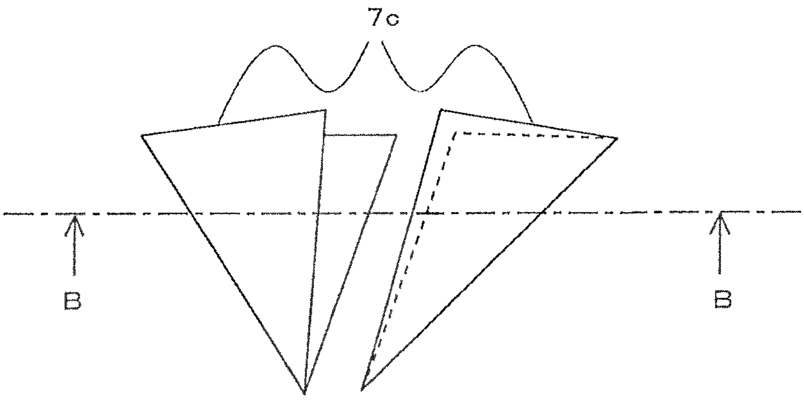


FIG. 11

(a)



(b)

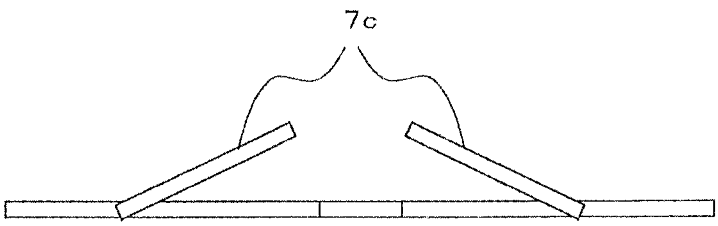


FIG. 12

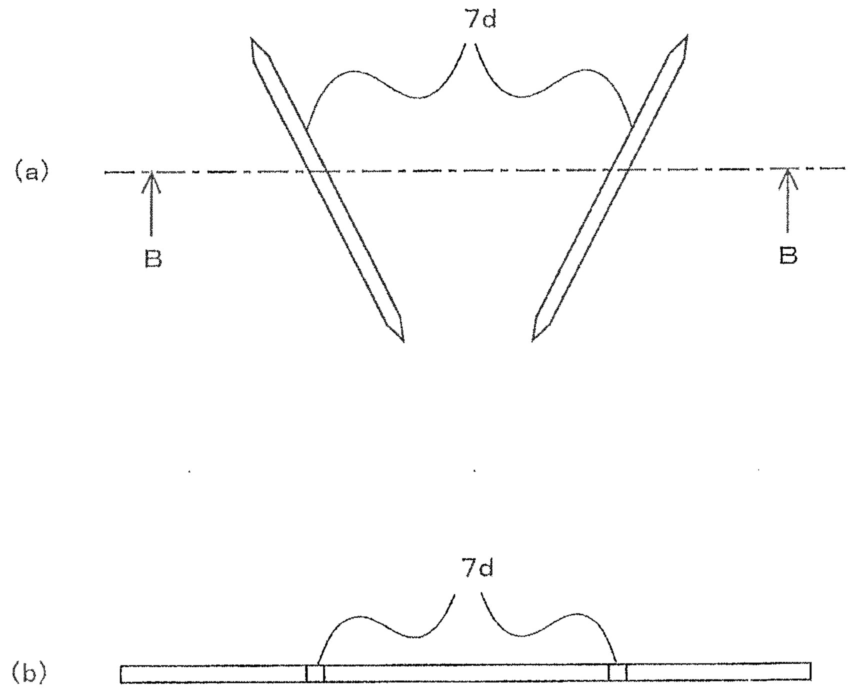


FIG. 13

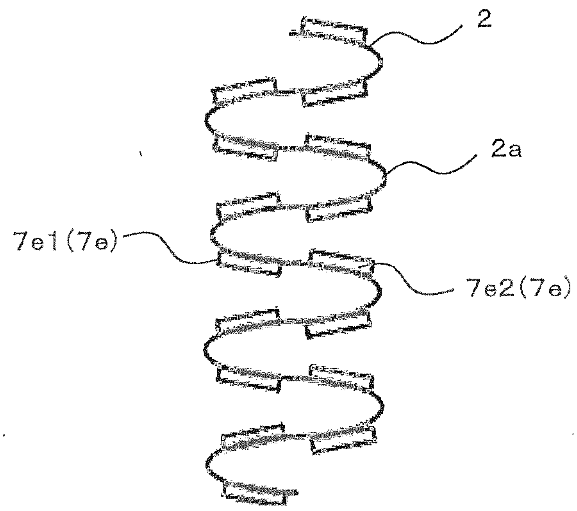


FIG. 14

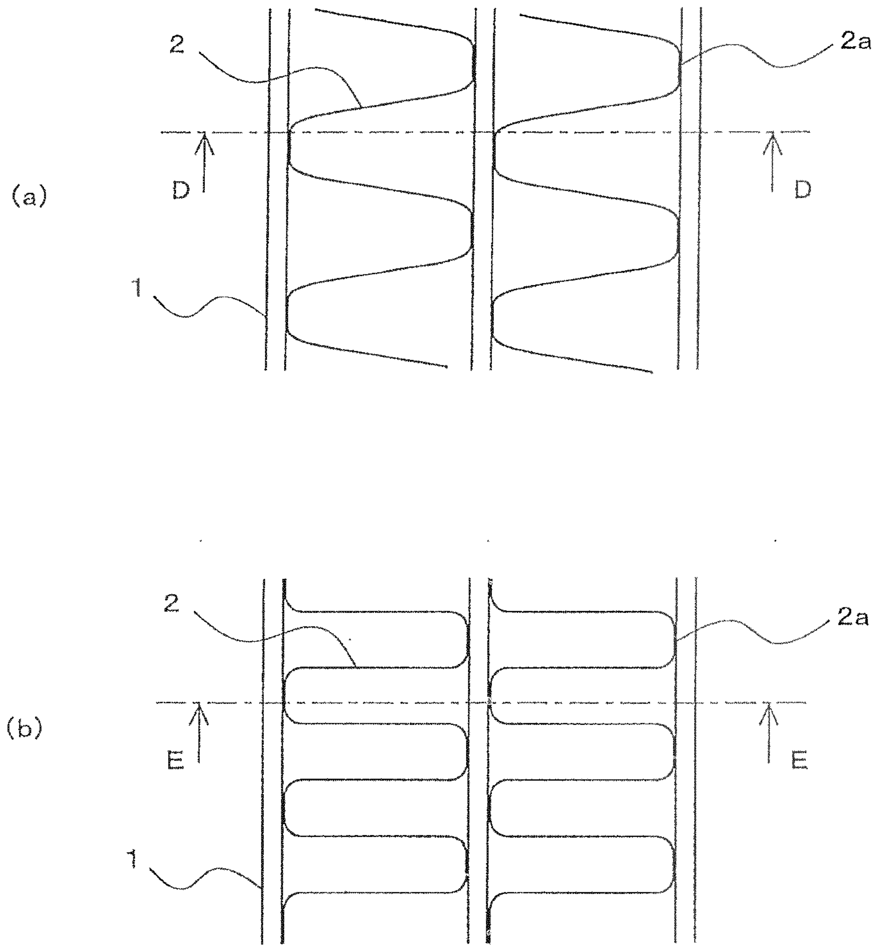


FIG. 15

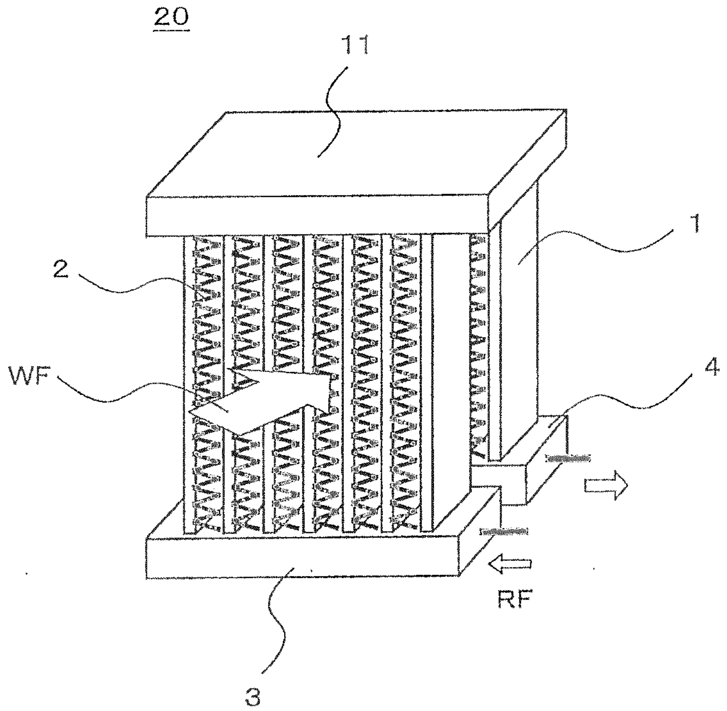


FIG. 16

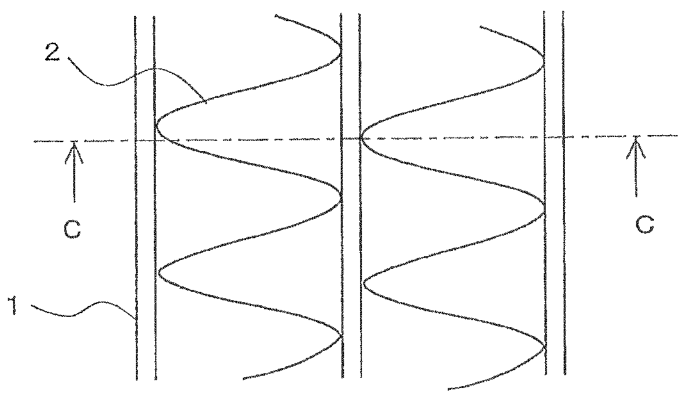


FIG. 17

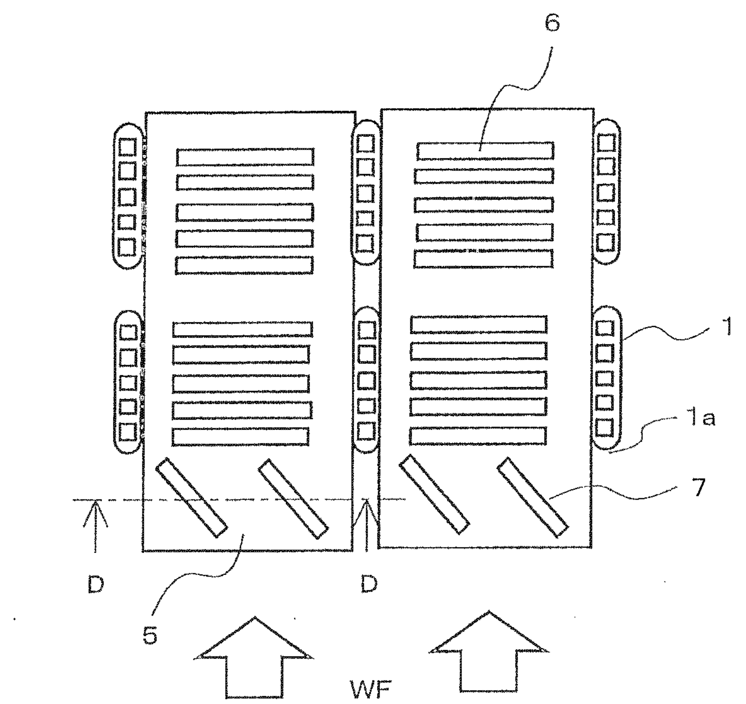


FIG. 18

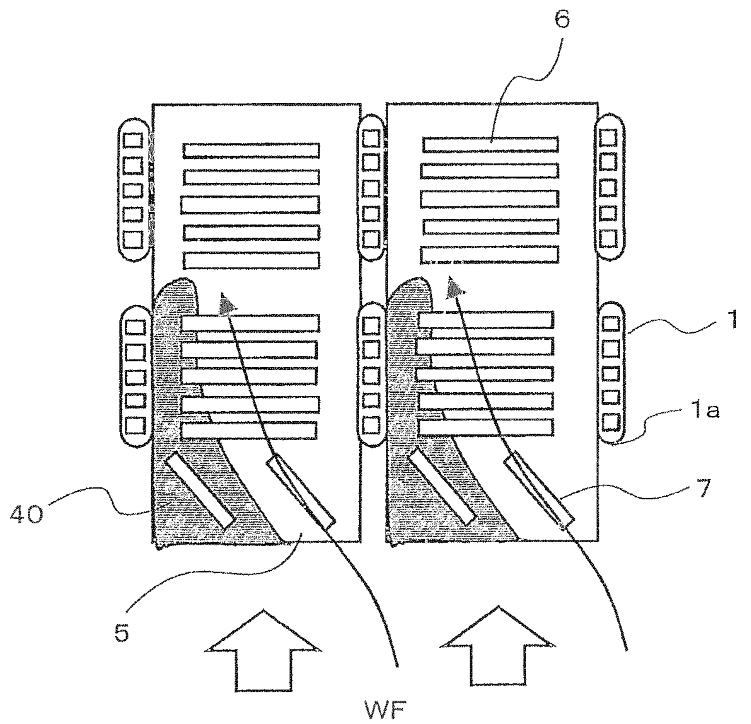


FIG. 19

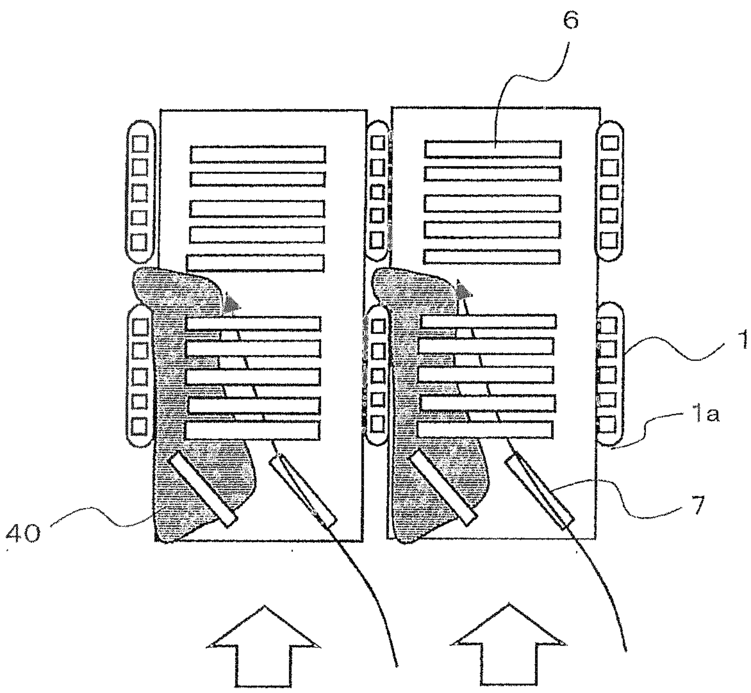


FIG. 20

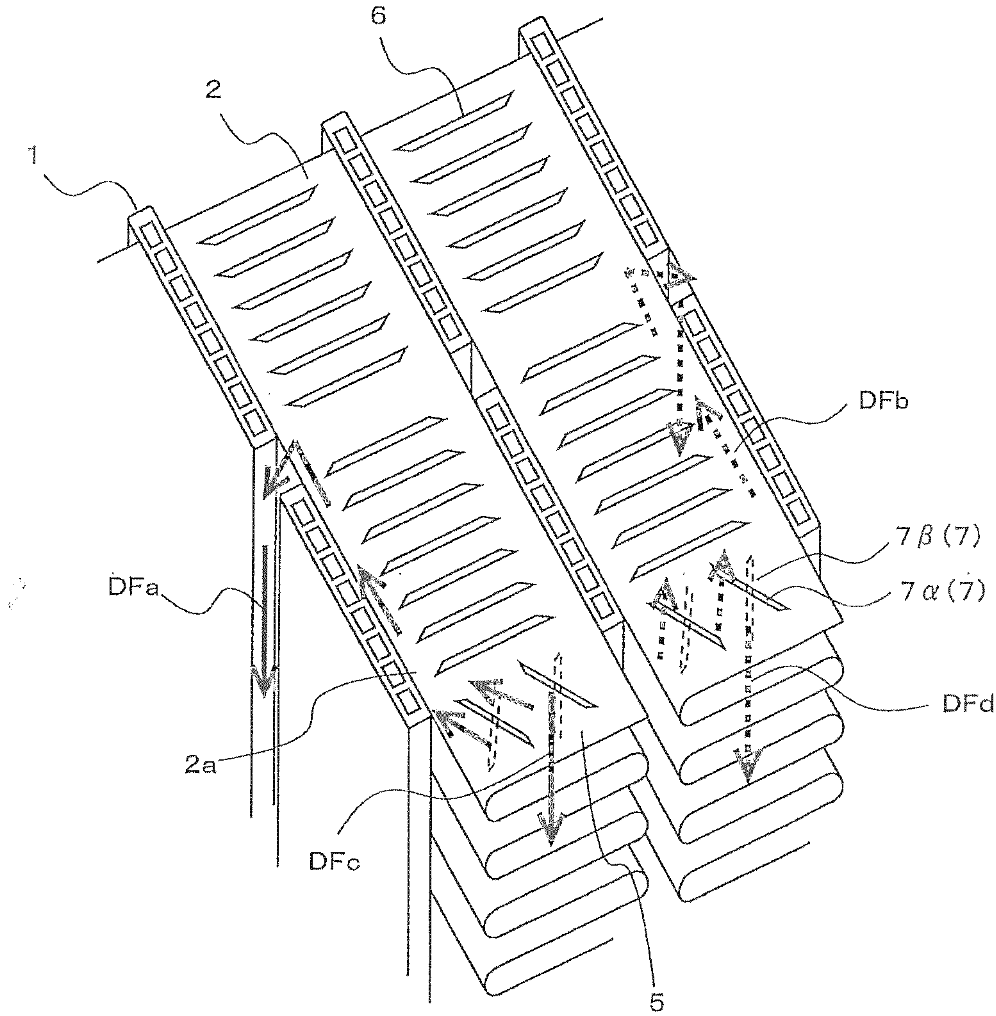
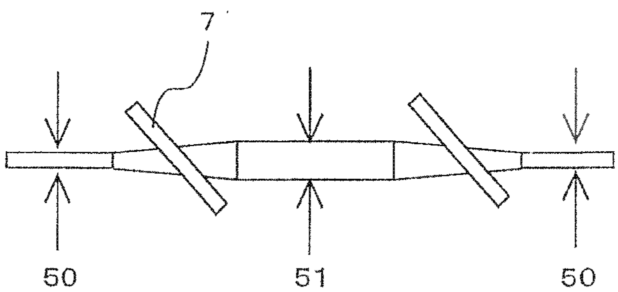


FIG. 21



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/056675

A. CLASSIFICATION OF SUBJECT MATTER
F28F1/30(2006.01)i, *F24F1/18*(2011.01)i, *F25B39/02*(2006.01)i, *F28D1/053*(2006.01)i, *F28F1/32*(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)
F28F1/30, F24F1/18, F25B39/02, F28D1/053, F28F1/32

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-232246 A (Denso Corp.), 13 September 2007 (13.09.2007), paragraphs [0028] to [0059], [0083] to [0089]; fig. 1, 3 to 4, 14 & US 2007/0199686 A1 paragraphs [0030] to [0060]; fig. 1, 3 to 4A, 14 & DE 102007009535 A & CN 101029807 A	1-9
Y	JP 2004-271113 A (Matsushita Electric Industrial Co., Ltd.), 30 September 2004 (30.09.2004), paragraphs [0013], [0023] to [0025]; fig. 3 to 4 (Family: none)	1-9

☒ 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	Date of mailing of the international search report
18 May 2016 (18.05.16)	31 May 2016 (31.05.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/056675

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	JP 2010-25476 A (Daikin Industries, Ltd.), 04 February 2010 (04.02.2010), paragraphs [0010], [0064] to [0070]; fig. 3 to 5 (Family: none)	4-5,9
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Y	JP 60-144579 A (Nissan Motor Co., Ltd.), 30 July 1985 (30.07.1985), specification, page 1, lower left column, line 13 to page 3, upper right column, line 6; fig. 2, 4 to 7 (Family: none)	8
A	JP 2012-154492 A (Daikin Industries, Ltd.), 16 August 2012 (16.08.2012), paragraph [0078]; fig. 7 to 8 (Family: none)	1-9
A	JP 2006-297472 A (Valeo Thermal Systems Japan Corp.), 02 November 2006 (02.11.2006), paragraphs [0026] to [0027]; fig. 10 (Family: none)	1-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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