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(71) Applicant: **Panasonic Intellectual Property Management Co., Ltd.**
Osaka-shi, Osaka 540-6207 (JP)

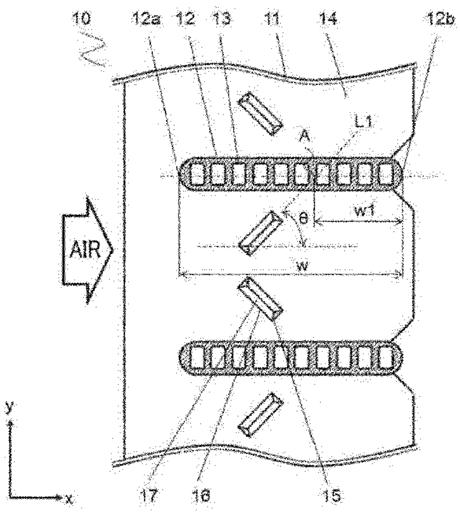
(72) Inventors:
- **KAWABATA, Ryuji**
Osaka 540-6207 (JP)
- **HASEGAWA, Hiroshi**
Osaka 540-6207 (JP)

(74) Representative: **Eisenführ Speiser**
Patentanwälte Rechtsanwälte PartGmbB
Postfach 31 02 60
80102 München (DE)

(54) **HEAT EXCHANGER**

(57) A fin 11 includes a flat part 14 and a heat transfer promoting part 15 raised from the flat part 14, the heat transfer promoting part 15 is formed between adjacent flat pipes 12 and between a front edge part 12a of the flat pipe 12 and a rear edge part 12b of the flat pipe 12, and a boundary line 16 of boundary lines formed by the heat transfer promoting part 15 and the flat part 14 that is located on an upstream side of air flow extends from the upstream side to the downstream side of air flow and is inclined to come closer to the flat pipe 14.

FIG.2



10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
16 BOUNDARY LINE
17 HEAT TRANSFER PROMOTING SURFACE

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a heat exchanger that is formed by a plurality of plate-shaped fins and a plurality of flat pipes each having a plurality of coolant flow channels, and exchanges heat between air flowing between the plurality of fins and a coolant flowing in the coolant flow channels of the plurality of flat pipes.

Description of the Related Art

[0002] Conventional heat exchangers are known which are formed by a plurality of plate-shaped fins that are arranged at predetermined intervals and a plurality of flat pipes having a plurality of coolant flow channels that are perpendicularly inserted into the fins.

[0003] As the heat exchanger of this type, a heat exchanger that has a plurality of cut-and-raised parts on each fin is disclosed (see Patent Literature 1, for example).

[0004] FIG. 24 is a plan view of fins of the conventional heat exchanger described in Patent Literature 1 in the x-y plane, in which the x direction is the direction of air flow, and the y direction is the direction of arrangement of flat pipes.

[0005] As shown in FIG 24, a heat exchanger 1 is formed by plate-shaped fins 2 and a plurality of flat pipes 4 having a plurality of coolant flow channels 3 that are perpendicularly inserted into the fins 2, and the rear edge part of a cut-and-raised part of a plurality of cut-and-raised parts 5 provided on the fins 2 that is located on the downstream side of the air flow (in the +x direction) is located downstream from the rear edge part of the flat pipe 4 in the direction of the air flow (in the +x direction).

[0006] As a result, the dead water region of the flat pipe on the downstream side of the air flow (in the +x direction) is reduced, and the ventilation resistance can be reduced.

[0007] Patent literature 1: Japanese Patent Laid-Open No. 2010-54060

SUMMARY OF THE INVENTION

[0008] However, the conventional configuration has a problem that the boundary layer formed from the front rear edge of the flat pipe increases in thickness as air flows to the downstream side (in the +x direction), and heat transfer on other side surfaces of the flat pipe than the front edge part is suppressed, so that of the plurality of coolant flow channels formed in the flat pipe, the amount of heat exchanged with the coolant flowing in coolant flow channels in other parts than the front edge part decreases, and the heat exchange capability decreases.

[0009] The present invention has been devised to solve the problem of the prior art described above, and an object of the present invention is to provide a heat exchanger using a flat pipe, in which heat transfer on other side surfaces of the flat pipe than a front edge part of the flat pipe is promoted to increase the amount of heat exchanged with a coolant flowing in coolant flow channels in other parts than the front edge part of a plurality of coolant flow channels formed in the flat pipe and improve a heat exchange capability.

[0010] To solve the problem of the prior art described above, a heat exchanger according to the present invention includes: a plurality of plate-shaped fins arranged at predetermined intervals; and a plurality of flat pipes that are arranged in parallel with each other, that are perpendicularly inserted into the fins and that have a plurality of coolant flow channels, the fin includes a flat part and a heat transfer promoting part raised from the flat part, the heat transfer promoting part is formed between adjacent flat pipes and between a front edge part of the flat pipe and a rear edge part of the flat pipe, and of boundary lines formed by the heat transfer promoting part and the flat part, a boundary line located on an upstream side of air flow extends from the upstream side to a downstream side of the air flow and is inclined to come closer to the flat pipe.

[0011] With such a configuration, the air passing through the gaps between the plurality of adjacent flat pipes collides with a surface of the heat transfer promoting part raised from the boundary line to form a flow toward a side surface of the flat pipe, so that the boundary layer on the side surface of the flat pipe is reduced in thickness.

[0012] The heat exchanger according to the present invention can promote heat transfer on the other side surfaces of the flat pipe than the front edge part, so that the amount of heat exchanged with the coolant flowing in coolant flow channels in the other parts than the front edge parts of the plurality of coolant flow channels formed in the flat pipes increases, and the heat exchange capability can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 is a perspective view of a heat exchanger according to a first embodiment of the present invention.

FIG. 2 is a plan view of fins of the heat exchanger according to the first embodiment of the present invention in an x-y plane.

FIG. 3 is a side view of fins of the heat exchanger according to the first embodiment of the present invention in a z-y plane viewed in the x direction.

FIG. 4 is a characteristic diagram showing a relationship between an air-side heat transfer rate k and w1/w according to the first embodiment of the present invention.

FIG. 5 is a characteristic diagram showing a relationship between the air-side heat transfer rate k and a ventilation resistance ΔP and h1/h according to the first embodiment of the present invention.

FIG. 6 is a characteristic diagram showing a relationship between the air-side heat transfer rate k and the ventilation resistance ΔP and θ according to the first embodiment of the present invention.

FIG. 7 is a plan view of fins of a heat exchanger according to a first modification of the first embodiment of the present invention in the x-y plane.

FIG. 8 is a plan view of fins of a heat exchanger according to a second modification of the first embodiment of the present invention in the x-y plane.

FIG. 9 is a side view of fins of the heat exchanger according to the second modification of the first embodiment of the present invention in the z-y plane viewed in the x direction.

FIG. 10 is a plan view of fins of a heat exchanger according to a third modification of the first embodiment of the present invention in the x-y plane.

FIG. 11 is a plan view of fins of a heat exchanger according to a fourth modification of the first embodiment of the present invention in the x-y plane.

FIG. 12 is a side view of fins of the heat exchanger according to the fourth modification of the first embodiment of the present invention in the z-y plane viewed in the x direction.

FIG. 13 is a side view of fins of a heat exchanger according to a fifth modification of the first embodiment of the present invention in the z-y plane viewed in the x direction.

FIG. 14 is a plan view of fins of a heat exchanger according to a second embodiment of the present invention in the x-y plane.

FIG. 15 is a side view of fins of the heat exchanger according to the second embodiment of the present invention in the z-y plane viewed in the x direction.

FIG. 16 is a cross-sectional view of the heat exchanger according to the second embodiment of the present invention taken along the line indicated by the arrows A.

FIG. 17 is a characteristic diagram showing a relationship between the air-side heat transfer rate k and the ventilation resistance ΔP and α according to the second embodiment of the present invention.

FIG. 18 is a plan view of fins of a heat exchanger according to a first modification of the second embodiment of the present invention in the x-y plane.

FIG. 19 is a side view of fins of the heat exchanger according to the first modification of the second embodiment in the z-y plane viewed in the x direction.

FIG. 20 is a plan view of fins of a heat exchanger according to a second modification of the second embodiment of the present invention in the x-y plane.

FIG. 21 is a side view of fins of the heat exchanger according to the second modification of the second embodiment of the present invention in the z-y plane viewed in the x direction.

FIG. 22 is a characteristic diagram showing a relationship between the air-side heat transfer rate k and the ventilation resistance ΔP and I1/I according to the second modification of the second embodiment of the present invention.

FIG. 23 is a side view of fins of a heat exchanger according to a third modification of the second embodiment of the present invention in the z-y plane viewed in the x direction.

FIG. 24 is a plan view of fins of a conventional heat exchanger in an x-y plane.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] A first invention is a heat exchanger, comprising: a plurality of plate-shaped fins arranged at predetermined intervals; and a plurality of flat pipes that are arranged in parallel with each other, that are perpendicularly inserted into the fins and that have a plurality of coolant flow channels, wherein the fin includes a flat part and a heat transfer promoting part raised from the flat part, the heat transfer promoting part is formed between adjacent flat pipes and between a front edge part of the flat pipe and a rear edge part of the flat pipe, and of boundary lines formed by the heat transfer promoting part and the flat part, a boundary line located on an upstream side of air flow extends from the upstream side to a downstream side of the air flow and is inclined to come closer to the flat pipe.

[0015] With such a configuration, the air passing through the gaps between the plurality of adjacent flat pipes collides with a surface of the heat transfer promoting part raised from the boundary line to form a flow toward a side surface of the flat pipe, so that the boundary layer on the side surface of the flat pipe is reduced in thickness.

[0016] Therefore, heat transfer on the other side surfaces of the flat pipe than the front edge part can be promoted, so that the amount of heat exchanged with the coolant flowing in coolant flow channels in the other parts than the front edge parts of the plurality of coolant flow channels formed in the flat pipe increases, and the heat exchange capability can be improved.

[0017] According to a second invention, the heat transfer promoting part has a shape such that the flat part is cut, and a cut part of the flat part is raised along the boundary line.

[0018] By providing the cut-and-raised part as described above, the rise angle of the heat transfer promoting part from the flat part can be increased.

[0019] The air colliding with the surface of the heat transfer promoting part raised from the boundary line is prevented from getting over the heat transfer promoting part, and an air flow toward the side surface of the flat pipe is formed with reliability, so that the boundary layer at the side surface of the flat pipe is further reduced in thickness.

[0020] Therefore, even in a high capacity operation in which the speed of the airflow is higher, heat transfer on the other side surfaces of the flat pipe than the front edge part can be promoted, so that the amount of heat exchanged with the coolant flowing in coolant flow channels in other parts than the front edge parts of the plurality of coolant flow channels formed in the flat pipe increases, and the heat exchange capability can be improved.

[0021] In the following, embodiments of the present invention will be described with reference to the drawings. Note that the present invention is not limited to these embodiments.

(First Embodiment)

[0022] FIG. 1 is a perspective view of a heat exchanger according to a first embodiment of the present invention. An x direction is an air flow direction, a y direction is a direction of arrangement of flat pipes, and a z direction is a direction of arrangement of fins.

[0023] In FIG. 1, a heat exchanger 10 includes a plurality of plate-shaped fins 11 arranged at predetermined intervals and a plurality of flat pipes 12 arranged in parallel with each other and perpendicularly inserted into the plurality of fins 11, and exchanges heat between air flowing between the plurality of fins 11 and a coolant flowing in a plurality of coolant flow channels 13 formed in the plurality of flat pipes 12.

[0024] As the coolant, R410A, R32 or a mixture coolant containing R32 is used, for example. The flat pipes 12 may be connected to form a single pipe or may be separate pipes. Each of the flat pipes 12 may have a plurality of inlet ports or outlet ports.

[0025] FIG. 2 is a plan view of fins of the heat exchanger according to the first embodiment of the present invention in an x-y plane, and FIG. 3 is a side view of fins of the heat exchanger according to the first embodiment of the present invention in a z-y plane viewed in the x direction.

[0026] A y-direction side surface of the flat pipe 12 located on an upstream side of the air flow (in the -x direction) forms a front edge part 12a, and a y-direction side surface of the flat pipe 12 located on a downstream side of the air flow (in the +x direction) forms a rear edge part 12b.

[0027] The fin 11 is formed by a flat part 14 and a heat transfer promoting part 15 that rises from the flat part 14 to the side of a passage of the air flow (in the +z direction).

[0028] The heat transfer promoting part 15 has a V-shape and extends obliquely with respect to the air flow direction (x direction). A part of the heat transfer promoting part 15 is provided between adjacent flat pipes 12 and between the front edge part 12a and the rear edge part 12b of each flat pipe 12.

[0029] Of boundary lines formed by the heat transfer promoting part 15 and the flat part 14, a boundary line 16 that is substantially in parallel with a ridge of the heat transfer promoting part 15 and located on the upstream side of the air flow and has a greater dimension extends from the upstream side to the downstream side of the air flow and is inclined to come closer to the flat pipe 12.

[0030] The heat transfer promoting part 15 further has a heat transfer promoting surface 17 that rises from the boundary line 16 with which the air collides.

[0031] An end part of the boundary line 16 on the downstream side of the air flow (in the +x direction) is located upstream from the rear edge part 12b of the flat pipe 12 in the direction of the air flow (in the -x direction). A line L1, which is an extension of the ridge of the heat transfer promoting part 15 on the downstream side of the air flow (in the +x direction), is inclined $\theta°$ with respect to the direction of the air flow (the +x direction) and intersects with the flat pipe 12 at a point upstream from the rear edge part 12b of the flat pipe 12 in the direction of the air flow (in the -x direction).

[0032] Next, the air flow will be described.

[0033] A part of the air flowing into gaps between the fins 11 collides with the front edge parts 12a of the flat pipes 12, and another part of the air does not collide with the flat pipes 12 but passes through the plurality of adjacent flat pipes 12.

[0034] At the front edge part 12a of the flat pipe 12 with which the air collides, a boundary layer is reduced in thickness, so that the heat transfer rate is highest in the flat pipe 12. The boundary layer around the flat pipe 12 increases in thickness and the heat transfer rate of the flat pipe 12 decreases as it goes toward the downstream side of the air flow (in the +x direction)

[0035] The air having collided with the front edge part 12a of each flat pipe 12 exchanges heat with the coolant flowing in a coolant flow channel 13 on the side of the front edge part 12a of the flat pipe 12 and then passes through the gaps between the adjacent flat pipes 12.

[0036] The air passing through the gaps between the adjacent flat pipes 12 collides with the heat transfer promoting surfaces 17 of the heat transfer promoting parts 15 provided on the fins 11, which promotes the heat transfer with the fins 11.

[0037] As the air experiences heat exchange on the upstream side of the air flow, the temperature of the air comes closer to the temperature of the coolant flowing in each coolant flow channel 13 of the flat pipe 12. Thus, the difference in temperature between the air and the coolant decreases as the air flows to the downstream side of the air flow.

[0038] With the heat exchanger configured as described above, the air flowing between the plurality of adjacent flat pipes 12 collides with the heat transfer promoting surface 17 of each heat transfer promoting part 15 and then is guided along the heat transfer promoting surface 17 toward a side surface of the flat pipe 12, so that the boundary layer at the side surface of the flat pipe 12 is reduced in thickness.

[0039] As a result, heat transfer on other side surfaces of each flat pipe 12 than the front edge part 12a can be promoted, and therefore, the amount of heat exchanged with the coolant flowing in coolant flow channels 13 formed in other parts of each flat pipe 12 than the front edge part 12a can be increased, and the heat exchange capability can be improved.

[0040] A length of the flat pipe 12 in a longer-side direction (the x direction) is denoted by w, a distance from an intersection A between the line L1 and a line that extends in the direction of the air flow (the x direction) and passes through a center of the flat pipe 12 in a shorter-side direction (the y direction) to the rear edge part 12b of the flat pipe 12 is denoted by W1, a distance between adjacent fins 11 is denoted by h, and a height of the heat transfer promoting part 15 in the +z direction is denoted by h1. FIG. 4 is a characteristic diagram showing a relationship between an air-side heat transfer rate k and w1/w, FIG. 5 is a characteristic diagram showing a relationship between the air-side heat transfer rate k and a ventilation resistance ΔP and h1/h, and FIG. 6 is a characteristic diagram showing a relationship between the air-side heat transfer rate k and the ventilation resistance ΔP and the angle θ. In the first embodiment, the length w in the longer-side direction (the x direction) of the flat pipe 12 is 16 mm (w = 16 mm), and the distance h between adjacent fins 11 is 1.3 mm (h = 1.3 mm).

[0041] As shown in FIG. 4, as w1 decreases, k increases, and the heat exchange capability improves. If the heat transfer promoting part 15 is arranged so that $w1 \leq 0.45w$, the heat exchanger can have a high heat transfer capability. Therefore, the heat transfer promoting part 15 is desirably arranged so that $w1 \leq 7.2$ mm, since w = 16 mm. By setting $w1 \leq 7.2$ mm, the boundary layer around the flat pipe 12, which increases in thickness as it goes to the downstream side of the air flow (in the +x direction), can be reduced in thickness, so that heat transfer can be promoted on the other side surfaces than the front edge part 12a of the flat pipe 12, and the heat exchange capability can be improved.

[0042] In particular, if w1 = 0 mm, the line L1 intersects with the rear edge part 12b of the flat pipe 12, so that the air flow is more likely to be guided to the side surfaces of the flat pipe 12 closer to the rear edge part 12b, at which the difference in temperature between the air and the coolant is small and heat exchange is less likely to occur, and the heat transfer on the side surfaces of the flat pipe 12 closer to the rear edge part 12b can be promoted. As a result, sufficient heat exchange occurs on the entire flat pipe 12, and the heat exchange capability can be improved even in a high capacity operation in which the total coolant circulation amount is high.

[0043] As shown in FIG. 5, as h1 increases, k increases, and the heat exchange capability improves. In addition, ΔP increases, and an input to an air blower increases. In particular, if the heat transfer promoting part 15 is arranged so that $h1 \leq 0.60h$, the heat exchanger can have a high heat exchange capability. Therefore, the heat transfer promoting part 15 is desirably arranged so that $h1 \leq 7.8$ mm, since h = 1.3 mm.

[0044] With such a configuration, the air flow is more likely to be guided to the side surfaces of the flat pipe 12 closer to the rear edge part 12b, and the heat transfer on the side surfaces of the flat pipe 12 closer to the rear edge part 12b can be promoted, while reducing an increase of the ventilation resistance ΔP, which is due to inhibition of the air flow (in the +x direction) so that the ventilation resistance ΔP is equal to or less than an allowable value, so that the heat exchange capability can be improved.

[0045] As shown in FIG. 6, as θ increases, k increases, and the heat exchange capability improves. In addition, ΔP increases, and the input to the air blower increases. In particular, the heat transfer promoting part 15 is desirably arranged so that $\theta \leq 60°$.

[0046] With such a configuration, the air flow is more likely to be guided to the side surfaces of the flat pipe 12 closer to the rear edge part 12b, and the heat transfer on the side surfaces of the flat pipe 12 closer to the rear edge part 12b can be promoted, while reducing an increase of the ventilation resistance ΔP, which is due to contraction of the air flow that occurs when the air passes through the heat transfer promoting part 15 so that the ventilation resistance ΔP is equal to or less than an allowable value, so that the heat exchange capability can be improved.

[0047] In this example, two heat transfer promoting parts 15 are arranged symmetrically with respect to a center line between the adjacent flat pipes 12. However, the heat transfer promoting parts 15 may not be arranged symmetrically with respect to the center line, or the number of heat transfer promoting parts may be one, three or more. Furthermore, although the boundary line 16 is showed as a straight line, of course, the same effects can be achieved if the boundary line is curved in a parabola and extends from the upstream side to downstream side of the air flow to come closer to the flat pipe 12.

[0048] FIG. 7 is a plan view of fins of a heat exchanger according to a first modification of the first embodiment of the present invention in the x-y plane.

[0049] As shown in FIG. 7, at least one heat transfer promoting part 15 is arranged downstream, in the direction of the airflow (in the +x direction), from a central part in the width direction of the flat pipe 12 in the longer-side direction (the x direction).

[0050] With such a configuration, the air passing through the gaps between the adjacent flat pipes 12 collides with the heat transfer promoting surface 17 of the heat transfer promoting part 15 raised from the boundary line 16 at a point downstream in the direction of the air flow (in the +x direction) from the central part in the width direction of the flat pipe 12 in the longer-side direction (the x direction). Therefore, on the downstream side of the air flow (in the +x direction), at which the difference in temperature between the air and the coolant is small and heat exchange is less likely to occur, the heat transfer promoting surface 17 of the heat transfer promoting part

15 disturbs the airflow to promote heat transfer between the air and the fin 11, so that the heat exchange capability can be improved even in a low capacity operation in which the speed of the air flow is low.

[0051] FIG. 8 is a plan view of fins of a heat exchanger according to a second modification of the first embodiment of the present invention in the x-y plane, FIG. 9 is a side view of fins of the heat exchanger according to the second modification of the first embodiment of the present invention in the z-y plane viewed in the x direction, and FIG. 10 is a plan view of fins of a heat exchanger according to a third modification of the first embodiment of the present invention in the x-y plane.

[0052] As shown in FIGS. 8 and 9, the heat transfer promoting part 15 has the shape of a triangular pyramid, and the heat transfer promoting part 15 and the flat part 14 form two boundary lines 16 on the upstream side of the air flow. Thus, a single heat transfer promoting part 15 has two heat transfer promoting surfaces 17.

[0053] The two boundary lines 16 extend from the upstream side to the downstream side of the air flow in such a manner that the boundary lines 16 are inclined toward the respective closer flat pipes 12. The heat transfer promoting surfaces 17 raised from the respective boundary lines 16 with which the air collides are arranged in the x-y plane in such a manner that lines L2 and L3 do not intersect with each other, provided that the line L2 is a straight line that connects an apex of the heat transfer promoting part 15 in the height direction (the +z direction) and the rear edge part 12b of the flat pipe 12 to each other and the line L3 is an extension of the boundary line 16 toward the flat pipe from the upstream side to the downstream side of the airflow.

[0054] With the heat exchanger configured as described above, a plurality of heat transfer promoting parts 15 are not provided for each fin, and the air flow can be guided to the side surfaces of the plurality of adjacent flat pipes 12 by a reduced number of heat transfer promoting parts 15. Therefore, the possibility of a break or creasing of the fins can be prevented from increasing due to providing a plurality of heat transfer promoting parts 15 for each fin.

[0055] If the heat transfer promoting part 15 is arranged so that the lines L2 and L3 are in parallel with each other, the air flow is more likely to be guided to the side surfaces of the flat pipe 12 closer to the rear edge part 12b, at which the difference in temperature between the air and the coolant is smallest and heat exchange is less likely to occur, and the heat transfer on the side surfaces of the flat pipe 12 closer to the rear edge part 12b can be promoted. As a result, sufficient heat exchange occurs on the entire flat pipe 12, and the heat exchange capability can be improved even in a high capacity operation in which the total coolant circulation amount is high.

[0056] Although the heat transfer promoting part 15 has the shape of a triangular pyramid in this example, of course, the same effects can be achieved even if the heat transfer promoting part 15 has a quadrangular pyramid as shown in FIG. 10.

[0057] FIG. 11 is a plan view of fins of a heat exchanger according to a fourth modification of the first embodiment of the present invention in the x-y plane, FIG. 12 is a side view of fins of the heat exchanger according to the fourth modification of the first embodiment of the present invention in the z-y plane viewed in the x direction, and FIG. 13 is a plan view of fins of a heat exchanger according to a fifth modification of the first embodiment of the present invention in the x-y plane.

[0058] As shown in FIGS. 11 and 12, a plurality of heat transfer promoting parts 15a, 15b and 15c are provided on each fin 11. The heat transfer promoting parts 15a and 15b have a V-shape and extend obliquely with respect to the airflow direction (the x direction). The heat transfer promoting part 15c has the shape of a triangular pyramid and is arranged downstream in the direction of the airflow (the +x direction) from the heat transfer promoting parts 15a and 15b.

[0059] With such a configuration, the air passing through the gaps between the heat transfer promoting parts 15a and 15b is likely to be guided to the side surfaces of the flat pipes 12 by the heat transfer promoting part 15c arranged on the downstream side of the air flow (in the +x direction), and the heat transfer can be promoted on the entire side surfaces of the flat pipes 12, so that the heat exchange capability can be improved.

[0060] Although the plurality of heat transfer promoting parts 15a, 15b and 15c are shown as being raised to the same height in the +z direction, of course, the same effects can be achieved even if the plurality of heat transfer promoting parts 15a, 15b and 15c are raised to different heights in the +z direction.

[0061] Although the plurality of heat transfer promoting parts 15a, 15b and 15c are raised into the air flow passage on the same side (in the +z direction) in this example, of course, the same effects can be achieved even if the plurality of heat transfer promoting parts are raised into the air flow passages on the different sides, for example, the heat transfer promoting parts 15a and 15b are raised in the +z direction and the heat transfer promoting part 15c is raised in the -z direction, as shown in FIG. 13.

[0062] Furthermore, although the heat transfer promoting parts 15a and 15b are shown as having a V-shape, and the heat transfer promoting part 15c is shown as having the shape of a triangular pyramid, of course, the same effects can be achieved even if different combinations of the shapes of the heat transfer promoting parts are adopted, for example, the heat transfer promoting parts 15a and 15b have a V-shape, and the heat transfer promoting part 15c has the shape of a quadrangular pyramid, or even if combinations of three or more shapes are adopted, for example, the heat transfer promoting part 15a has a V-shape, the heat transfer promoting part 15b has the shape of a triangular pyramid, and the heat transfer promoting part 15c has the shape of a quadrangular pyramid.

(Second Embodiment)

[0063] FIG. 14 is a plan view of fins of a heat exchanger according to a second embodiment of the present invention in the x-y plane, FIG. 15 is a side view of fins of the heat exchanger according to the second embodiment of the present invention in the z-y plane viewed in the x direction, and FIG. 16 is a cross-sectional view taken along the line indicated by the arrows A.

[0064] As shown in FIGS. 14, 15 and 16, the heat transfer promoting part 15 has a shape such that the flat part 14 is cut, and a cut part of the flat part 14 is raised along the boundary line 14 in the +z direction.

[0065] Thus, the heat transfer promoting surface 17 of the heat transfer promoting part 15 is formed by cutting and raising, so that the rise angle α from the flat part 14 can be increased.

[0066] The heat transfer promoting part 15 is arranged so that a line L4, which is an extension of the upper side in the +z direction of the heat transfer promoting surface 17 to the downstream side of the air flow (in the +x direction), intersects with the flat pipe 12 at a point upstream from the rear edge part 12b of the flat pipe 12 in the direction of the air flow (in the -x direction).

[0067] As a result, the air colliding with the heat transfer promoting surface 17 of the heat transfer promoting part 15 raised from the boundary line 16 is prevented from flowing in the +z direction to get over the heat transfer promoting surface 17, and the air flow toward the side surface of the flat pipe 12 is formed with reliability, so that the boundary layer at the side surface of the flat pipe 12 is further reduced in thickness.

[0068] Therefore, even in a high capacity operation in which the speed of the airflow is high, heat transfer on other side surfaces of each flat pipe 12 than the front edge part 12a can be promoted, and therefore, the amount of heat exchanged with the coolant flowing in the coolant flow channels 13 formed in other parts of each flat pipe 12 than the front edge part 12a can be increased, and the heat exchange capability can be improved.

[0069] If the heat transfer promoting part 15 is arranged so that the line L4 intersects with the rear edge part 12b of the flat pipe 12, the air flow is more likely to be guided to the side surfaces of the flat pipe 12 closer to the rear edge part 12b, at which the difference in temperature between the air and the coolant is smallest and heat exchange is less likely to occur, and the heat transfer on the side surfaces of the flat pipe 12 closer to the rear edge part 12b can be promoted. As a result, sufficient heat exchange occurs on the entire flat pipe 12, and the heat exchange capability can be improved even in a high capacity operation in which the total coolant circulation amount is high.

[0070] FIG. 17 is a characteristic diagram showing a relationship between the air-side heat transfer rate k and the ventilation resistance ΔP and the rise angle α. As α increases, k increases, and the heat exchange capability improves. In addition, ΔP increases, and the input to the air blower increases. In particular, the heat transfer promoting part 15 is desirably arranged so that $60° \leq \alpha \leq 90°$.

[0071] With such a configuration, an effect of disturbing the air flow to promote the heat transfer between the air and the fins 11 due to the air having passed through the gaps between the adjacent flat pipes 12 colliding with the heat transfer promoting surface 17 of the heat transfer promoting part 15 raised from the boundary line 16 and an effect of forming the air flow toward the side surfaces of the flat pipes 12 to reduce the thickness of the boundary layers at the side surfaces of the flat pipes 12, thereby promoting the heat transfer between the air and the flat pipes 12 can be achieved, while reducing an increase of the ventilation resistance ΔP so that the ventilation resistance ΔP is equal to or less than an allowable value.

[0072] Furthermore, even if the speed of the air flow is high, the air flow is prevented from flowing in the +z direction to get over the heat transfer promoting surface 17, and the air flow is guided to the side surfaces of the flat pipes 12 with reliability. Therefore, even in a maximum capacity operation in which the speed of the airflow is still higher, the heat exchange capability can be improved.

[0073] FIG. 18 is a plan view of fins of a heat exchanger according to a first modification of the second embodiment of the present invention in the x-y plane, and FIG. 19 is a side view of fins of the heat exchanger according to the first modification of the second embodiment in the z-y plane viewed in the x direction.

[0074] Of course, the same effects can be achieved even if a single heat transfer promoting part 15 is formed by a plurality of cut-and-raised parts as shown in FIGS. 18 and 19.

[0075] FIG. 20 is a plan view of fins of a heat exchanger according to a second modification of the second embodiment of the present invention in the x-y plane, FIG. 21 is a side view of fins of the heat exchanger according to the second modification of the second embodiment of the present invention in the z-y plane viewed in the x direction, and FIG. 23 is a side view of fins of a heat exchanger according to a third modification of the second embodiment of the present invention in the z-y plane viewed in the x direction.

[0076] As shown in FIGS. 20 and 21, a plurality of heat transfer promoting parts 15a, 15b and 15c are provided for each fin 11, the heat transfer promoting parts 15a and 15b are formed by cutting and raising, and the heat transfer promoting part 15c has the shape of a triangular pyramid and is arranged downstream from the heat transfer promoting parts 15a and 15b in the direction of the air flow (in the +x direction).

[0077] With such a configuration, the air passing through the gaps between the heat transfer promoting parts 15a and 15b is likely to be guided to the side surfaces of the flat pipes 12 by the heat transfer promoting part 15c arranged on the downstream side of the air flow (in the +x direction), and the heat transfer can be promoted on the entire flat pipes 12, so that the heat exchange capability can be improved.

[0078] Although the plurality of heat transfer promoting parts 15a, 15b and 15c are shown as being raised to the same height in the +z direction, of course, the same effects can be achieved even if the plurality of heat transfer promoting parts 15a, 15b and 15c are raised to different heights in the +z direction.

[0079] Provided that the distance between the plurality of adjacent flat pipes 12 is denoted by l, and the length in the y direction of the heat transfer promoting surfaces 17a, 17b and 17c of the heat transfer promoting parts 15a, 15b and 15c projected onto the downstream side of the air flow (in the +x direction) is denoted by l1, FIG. 22 is a characteristic diagram showing a relationship between the air-side heat transfer rate k and the ventilation resistance ΔP and l1/l. In the second embodiment, the distance l between the plurality of adjacent flat pipes 12 is 8.4 mm (l = 8.4 mm).

[0080] As shown in FIG. 22, as l1 increases, k increases, and the heat exchange capability improves. In addition, ΔP increases, and the input to the air blower increases. In particular, if the heat transfer promoting part 15 is arranged so that $l1 \leq 0.65l$, the heat exchanger can have a high heat exchange capability. Therefore, the heat transfer promoting part 15 is desirably arranged so that $l1 \leq 5.4$ mm, since l = 8.4 mm.

[0081] With such a configuration, the air flow is more likely to be guided to the side surfaces of the flat pipe 12 closer to the rear edge part 12b, and the heat transfer on the side surfaces of the flat pipe 12 closer to the rear edge part 12b can be promoted, while reducing an increase of the ventilation resistance ΔP so that the ventilation resistance ΔP is equal to or less than an allowable value, so that the heat exchange capability can be improved.

[0082] Although the plurality of heat transfer promoting parts 15a, 15b and 15c are raised into the air flow passage on the same side (in the +z direction) in this example, of course, the same effects can be achieved even if the plurality of heat transfer promoting parts are raised into the airflow passages on the different sides, for example, the heat transfer promoting parts 15a and 15b are raised in the +z direction and the heat transfer promoting part 15c is raised in the -z direction, as shown in FIG. 23.

[0083] Furthermore, although the heat transfer promoting parts 15a and 15b are shown as having the cut-and-raised shape, and the heat transfer promoting part 15c is shown as having the shape of a triangular pyramid, of course, the same effects can be achieved even if different combinations of the shapes of the heat transfer promoting parts are adopted, for example, the heat transfer promoting parts 15a and 15b have the cut-and-raised shape, and the heat transfer promoting part 15c has shape of a quadrangular pyramid.

Industrial Applicability

[0084] The present invention is a heat exchanger using a flat pipe that is improved in heat exchange capability by promoting heat transfer on the flat pipe on the downstream side of air flow and can be used in applications, such as a freezer, an air conditioner or an air conditioning and hot water supply complex system.

Reference Signs List

[0085]

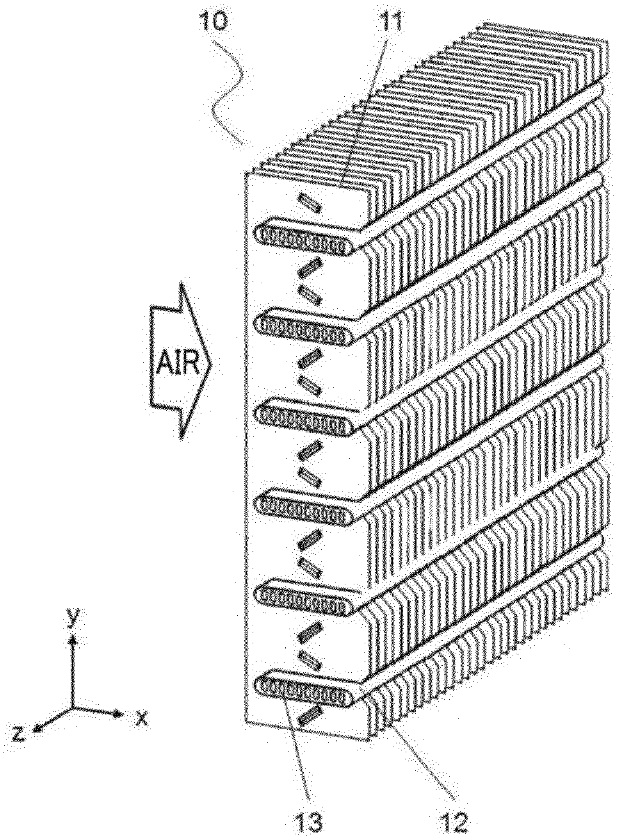
1 heat exchanger
2 fin
3 coolant flow channel
4 flat pipe
5 cut-and-raised part
10 heat exchanger
11 fin
12 flat pipe
12a front edge part
12b rear edge part
13 coolant flow channel
14 flat part
15, 15a, 15b, 15c heat transfer promoting part
16 boundary line
17, 17a, 17b, 17c heat transfer promoting surface

Claims

1. A heat exchanger, comprising: a plurality of plate-shaped fins (2) arranged at predetermined intervals; and a plurality of flat pipes (4) that are arranged in parallel with each other, that perpendicularly inserted into the fins, and that have a plurality of coolant flow channels (3), **characterized in that** the fin includes a flat part (14) and a heat transfer promoting part (15, 15a, 15b, 15c, 17, 17a, 17b, 17c) raised from the flat part, the heat transfer promoting part is formed between adjacent flat pipes and between a front edge part (12a) of the flat pipe and a rear edge part (12b) of the flat pipe, and of boundary lines formed by the heat transfer promoting part and the flat part, a boundary line (16) located on an upstream side of air flow extends from the upstream side to a downstream side of the air flow and is inclined to come closer to the flat pipe.

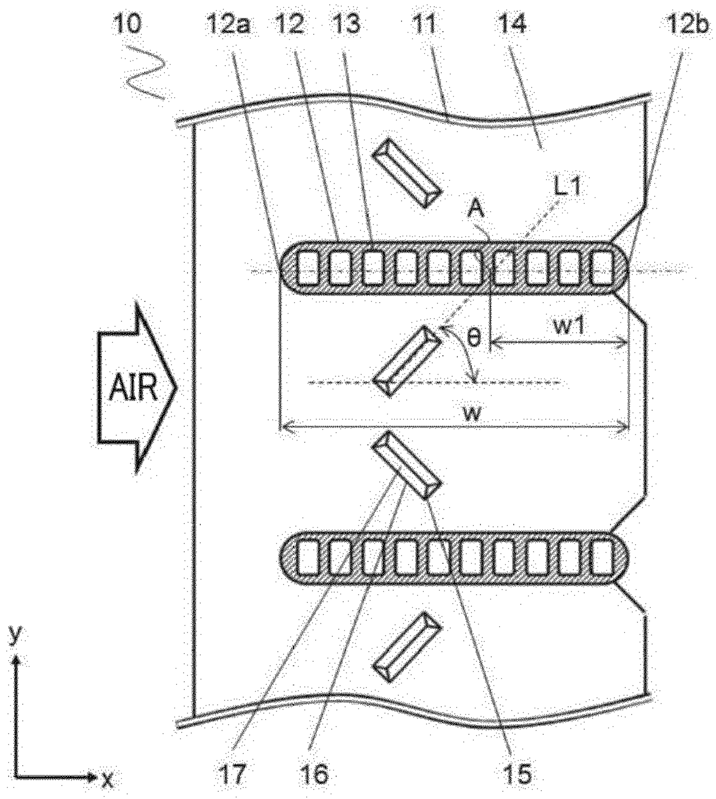
2. The heat exchanger according to claim 1, wherein the heat transfer promoting part has a shape such that the flat part is cut, and a cut part of the flat part is raised along the boundary line.

FIG.1



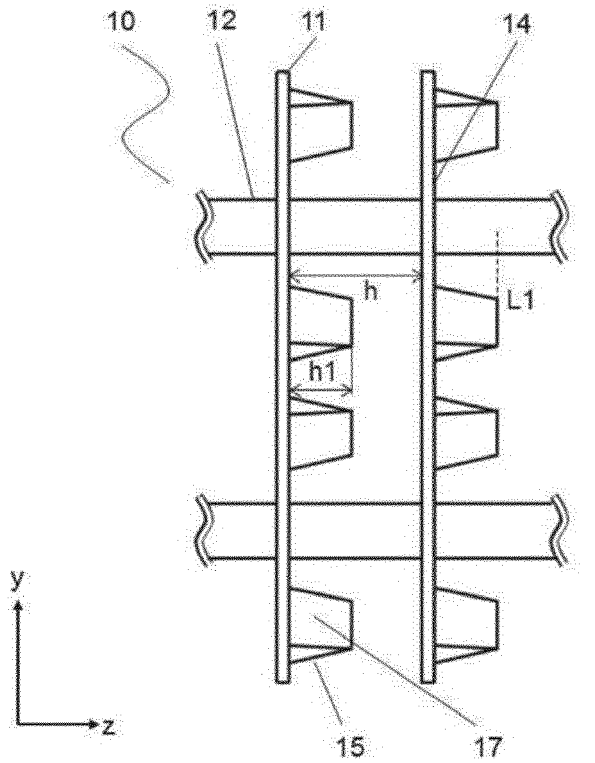
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
13 COOLANT FLOW CHANNEL

FIG.2



10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
16 BOUNDARY LINE
17 HEAT TRANSFER PROMOTING SURFACE

FIG.3



10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
17 HEAT TRANSFER PROMOTING SURFACE

FIG.4

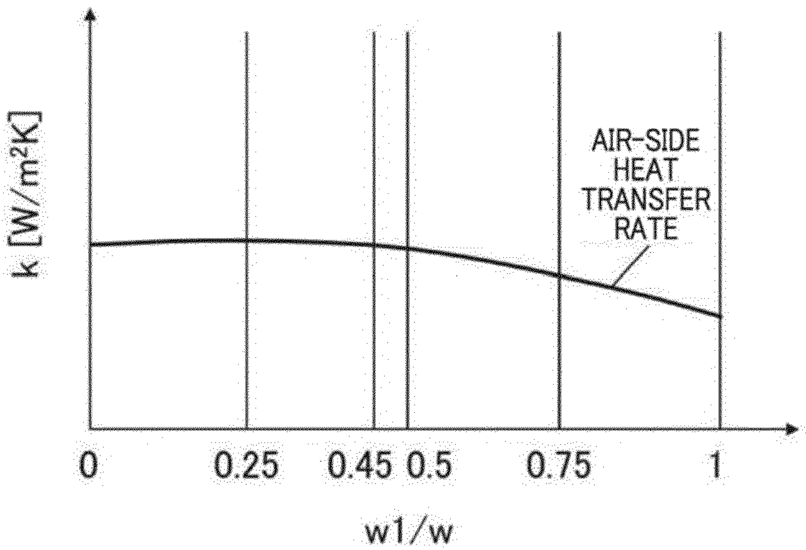


FIG.5

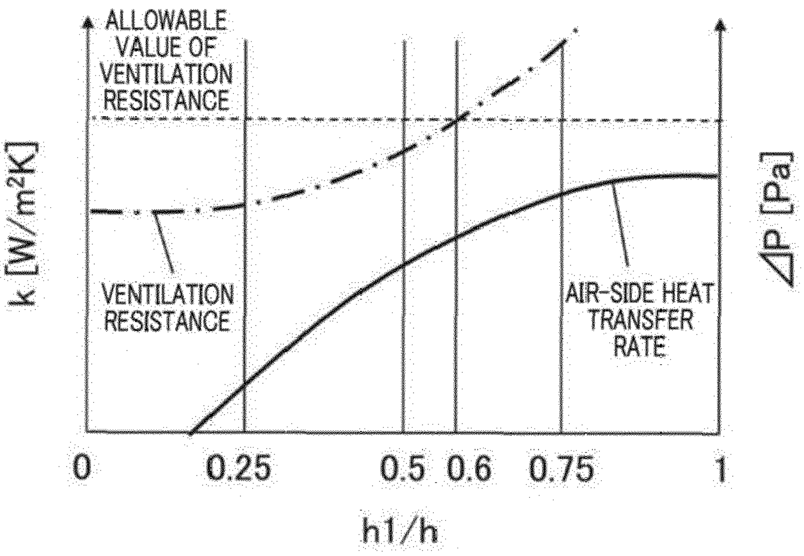

ALLOWABLE
VALUE OF
VENTILATION
RESISTANCE
k [W/m²K]
ΔP [Pa]
VENTILATION
RESISTANCE
AIR-SIDE HEAT
TRANSFER
RATE
0
0.25
0.5
0.6
0.75
1
h1/h

FIG.6

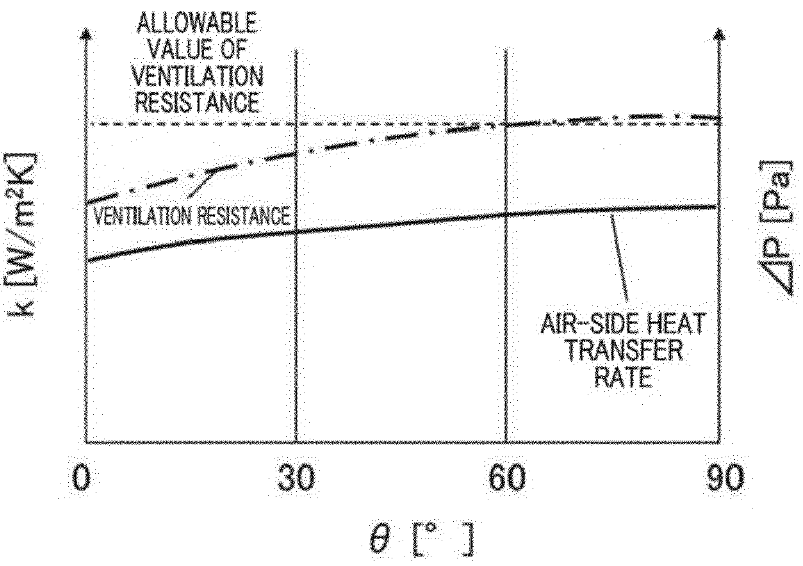
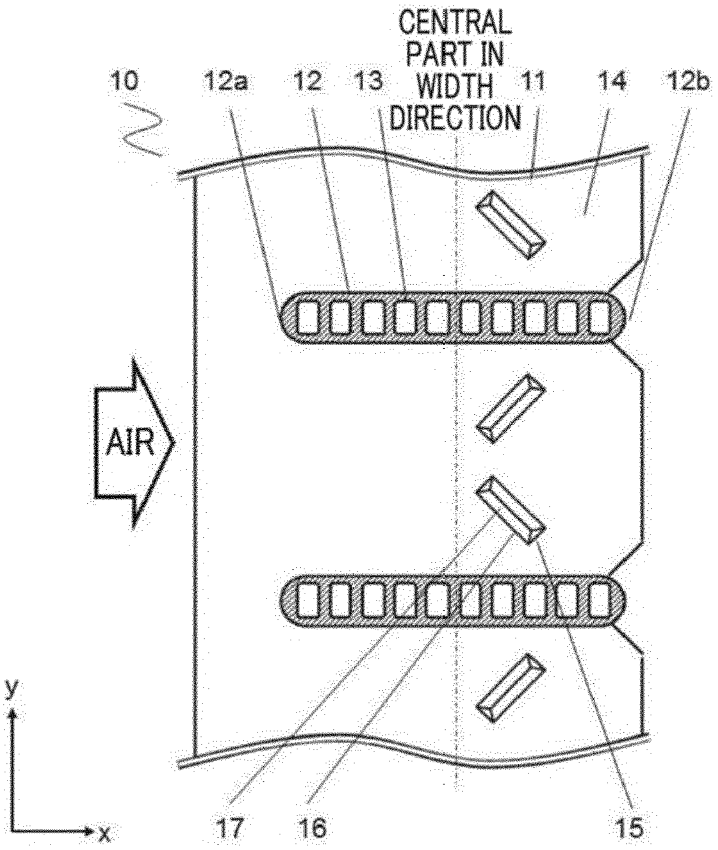
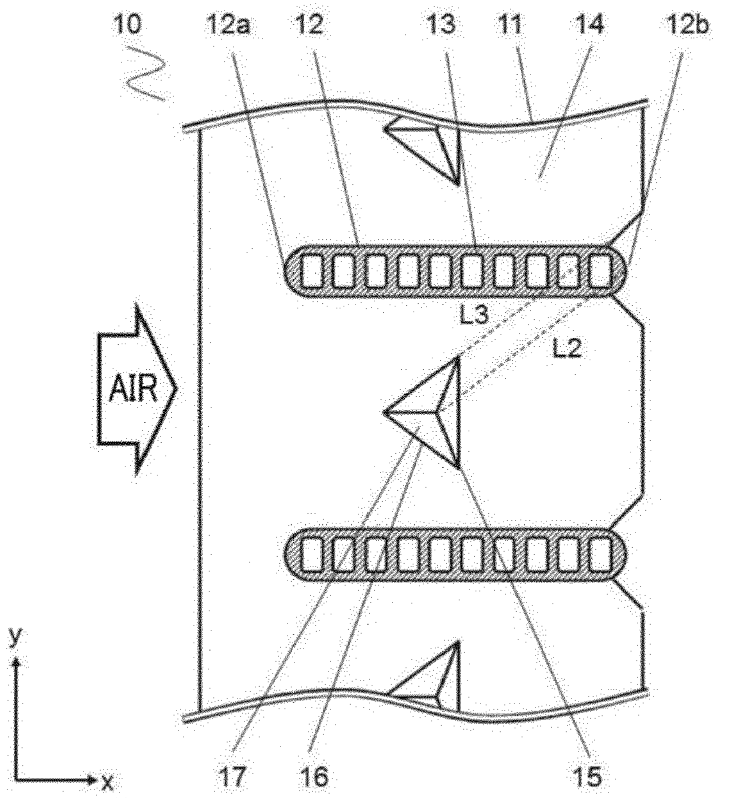

ALLOWABLE VALUE OF VENTILATION RESISTANCE
VENTILATION RESISTANCE
AIR-SIDE HEAT TRANSFER RATE
k [W/m2K]
⊿P [Pa]
0
30
60
90
θ [°]

FIG.7



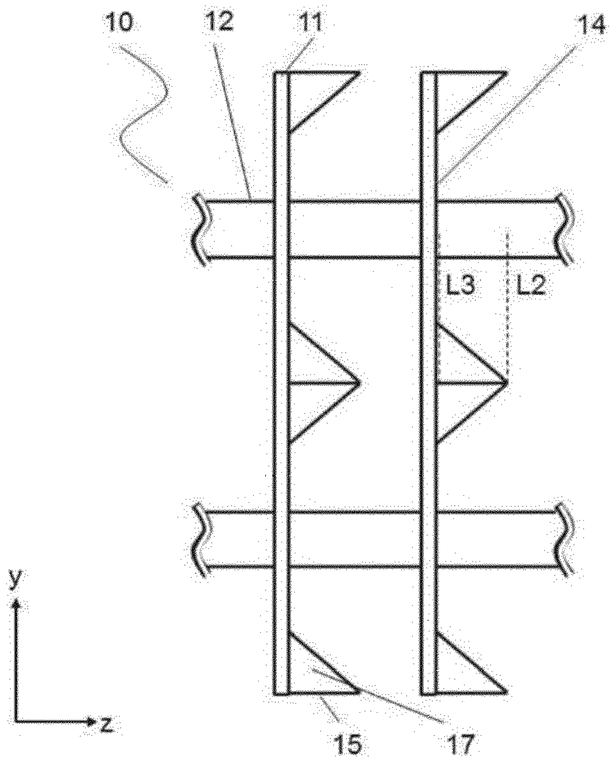
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
16 BOUNDARY LINE
17 HEAT TRANSFER PROMOTING SURFACE

FIG.8



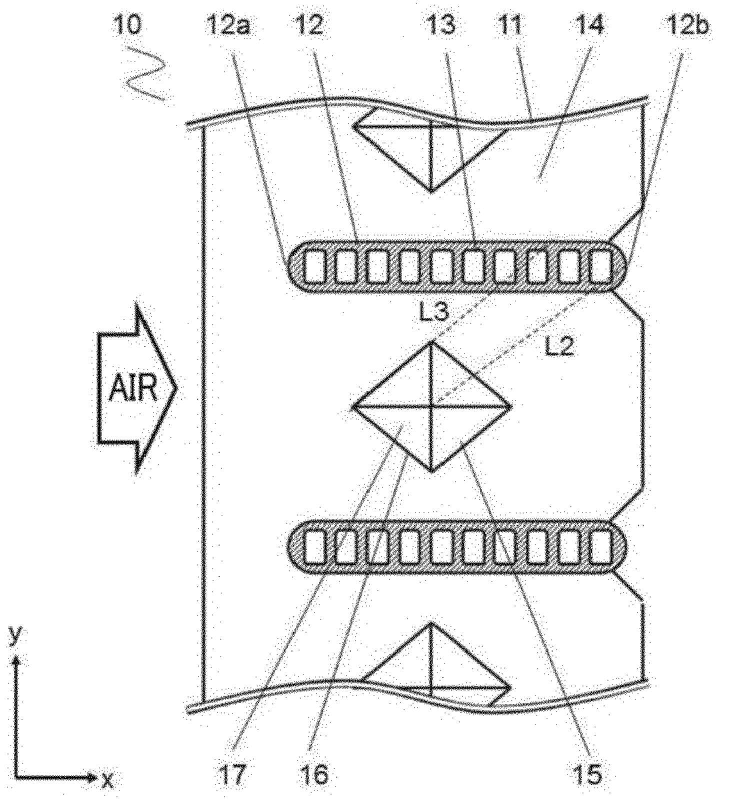
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
16 BOUNDARY LINE
17 HEAT TRANSFER PROMOTING SURFACE

FIG.9



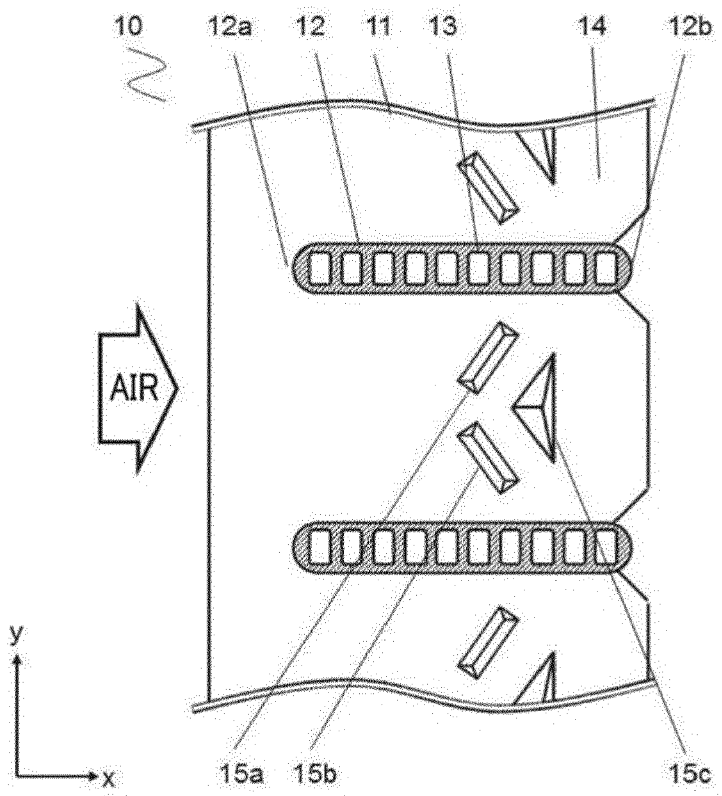
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
17 HEAT TRANSFER PROMOTING SURFACE

FIG.10



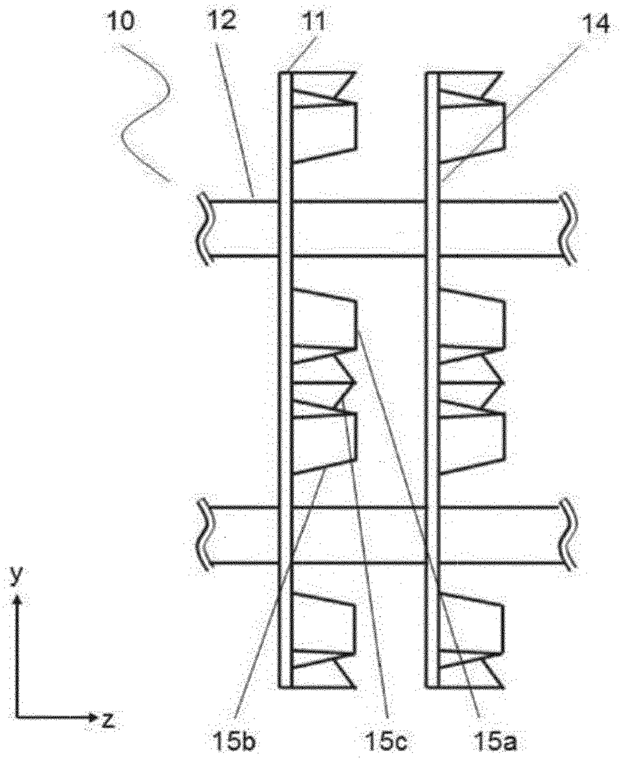
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
16 BOUNDARY LINE
17 HEAT TRANSFER PROMOTING SURFACE

FIG.11



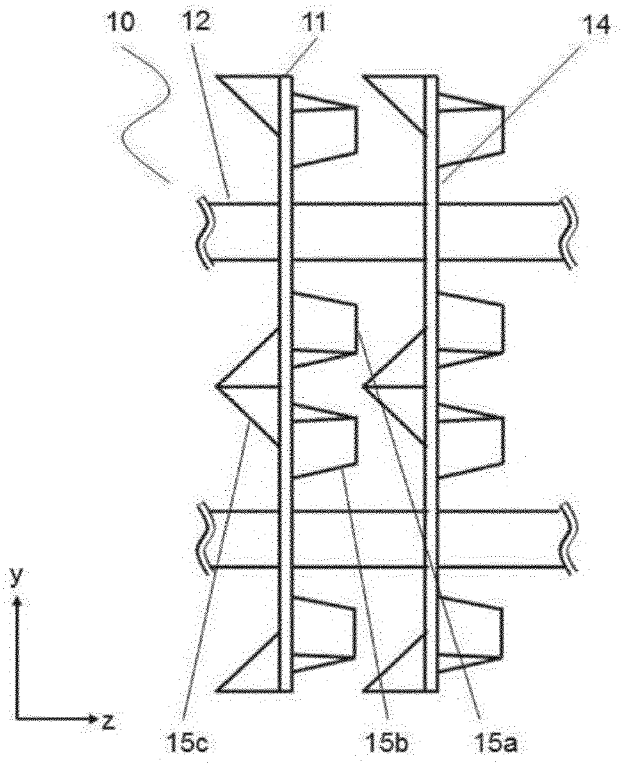
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15a, 15b, 15c HEAT TRANSFER PROMOTING PART

FIG.12



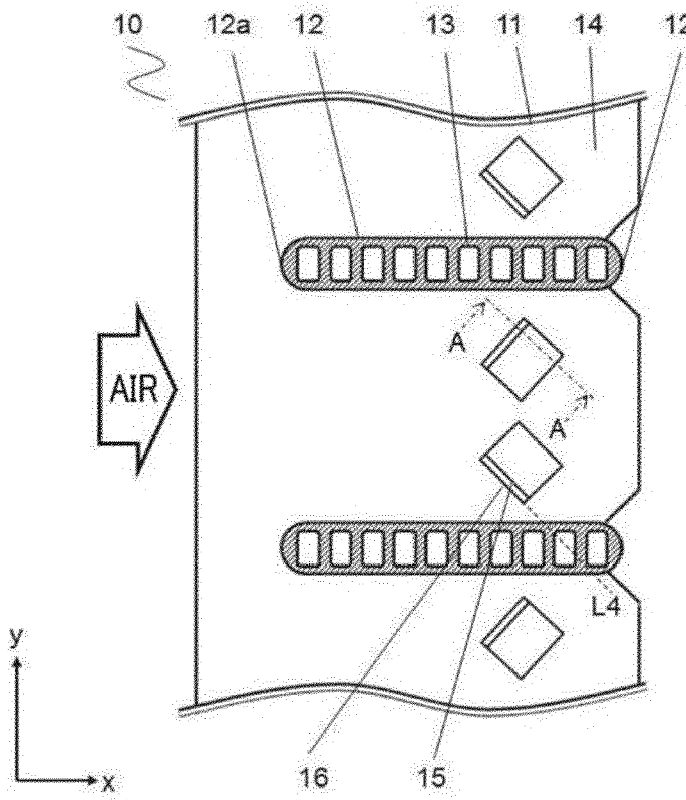
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
14 FLAT PART
15a, 15b, 15c HEAT TRANSFER PROMOTING PART

FIG.13



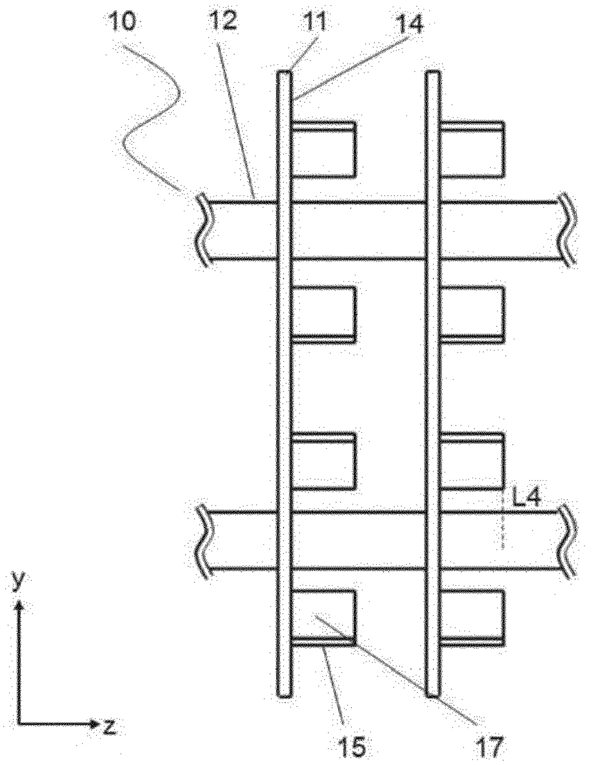
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
14 FLAT PART
15a, 15b, 15c HEAT TRANSFER PROMOTING PART

FIG.14



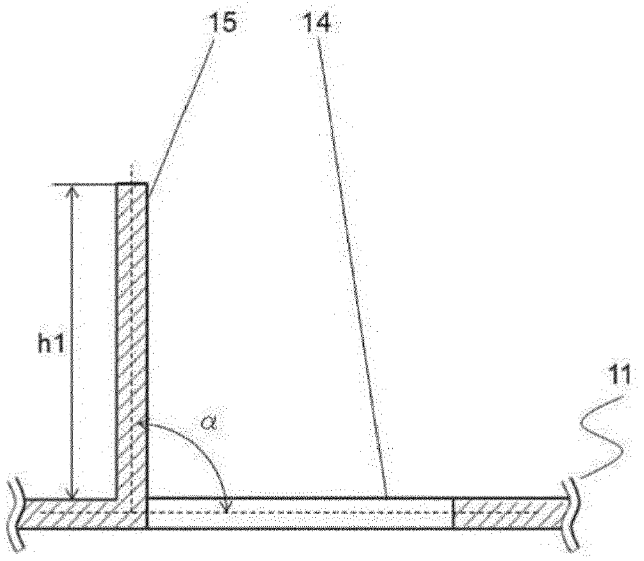
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
16 BOUNDARY LINE

FIG.15



10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
17 HEAT TRANSFER PROMOTING SURFACE

FIG.16



11 FIN
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART

FIG.17

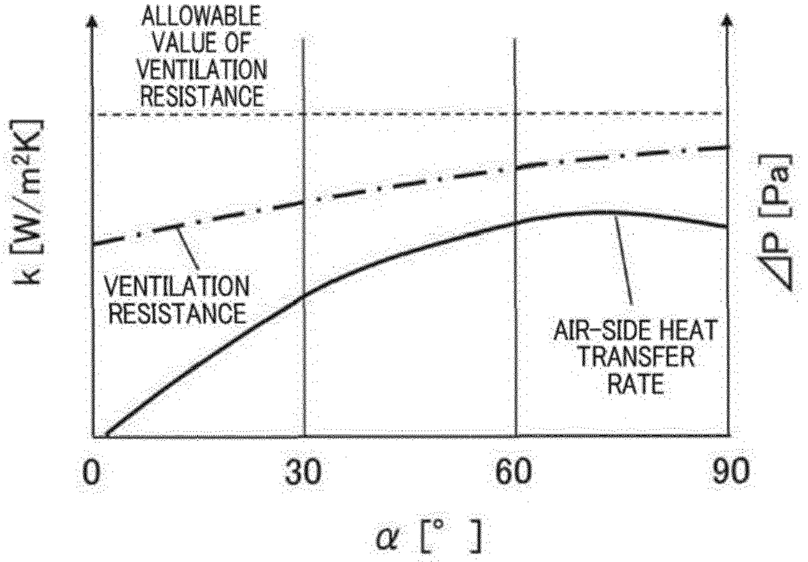
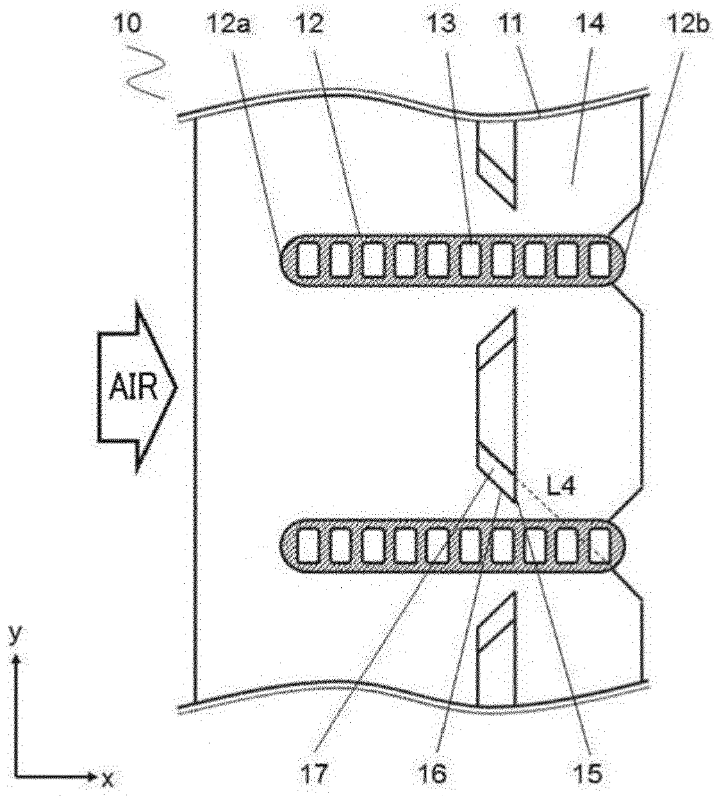
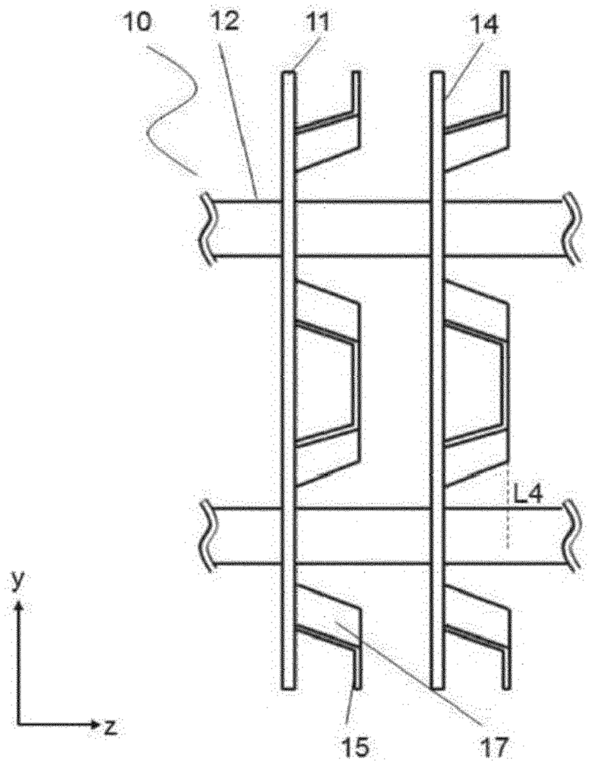

ALLOWABLE VALUE OF VENTILATION RESISTANCE
k [W/m²K]
ΔP [Pa]
VENTILATION RESISTANCE
AIR-SIDE HEAT TRANSFER RATE
0
30
60
90
α [°]

FIG.18



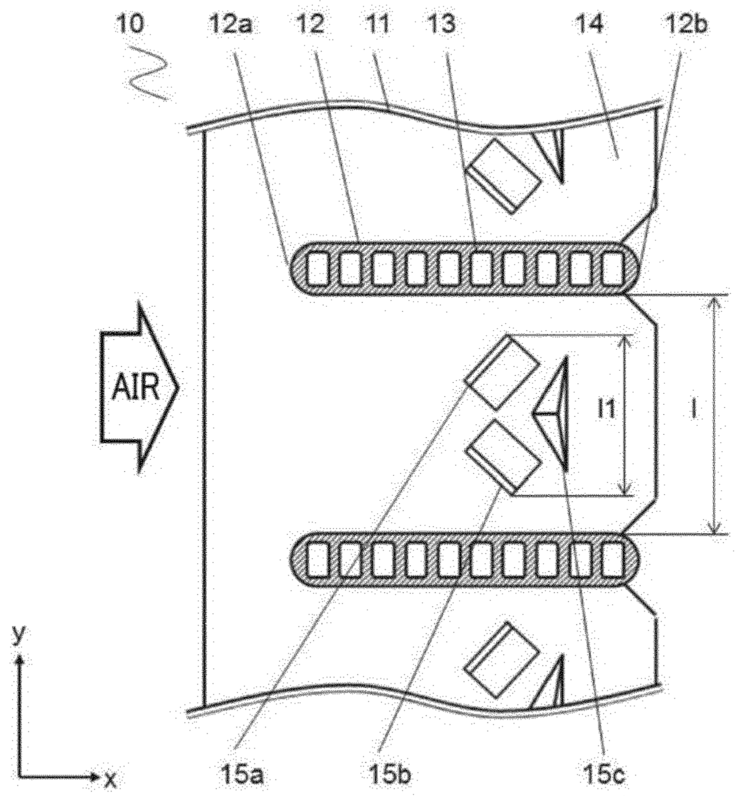
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
16 BOUNDARY LINE
17 HEAT TRANSFER PROMOTING SURFACE

FIG.19



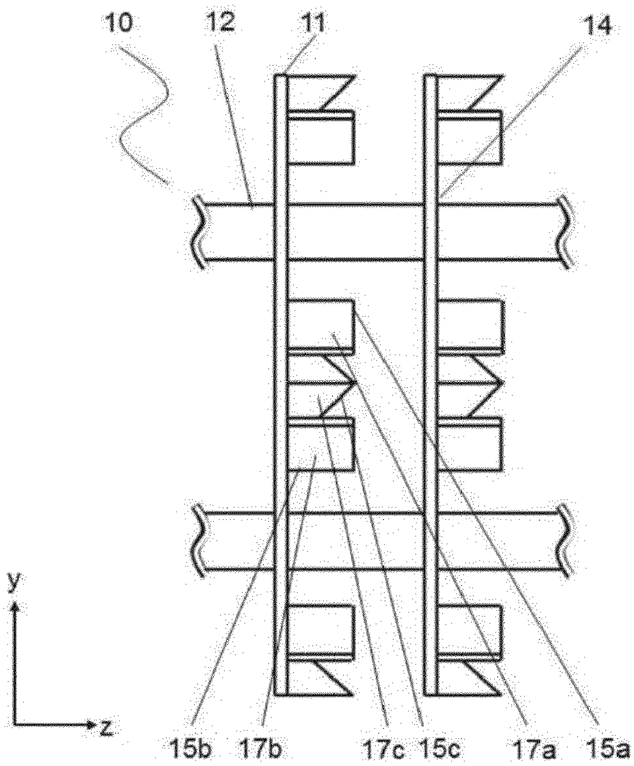
10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
14 FLAT PART
15 HEAT TRANSFER PROMOTING PART
17 HEAT TRANSFER PROMOTING SURFACE

FIG.20



10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
12a FRONT EDGE PART
12b REAR EDGE PART
13 COOLANT FLOW CHANNEL
14 FLAT PART
15a, 15b, 15c HEAT TRANSFER PROMOTING PART

FIG.21



10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
14 FLAT PART
15a, 15b, 15c HEAT TRANSFER PROMOTING PART
17a, 17b, 17c HEAT TRANSFER PROMOTING SURFACE

FIG.22

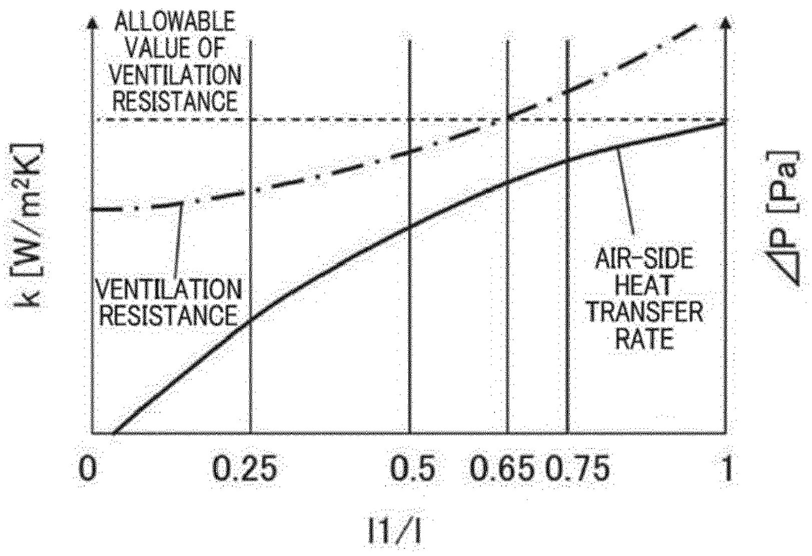
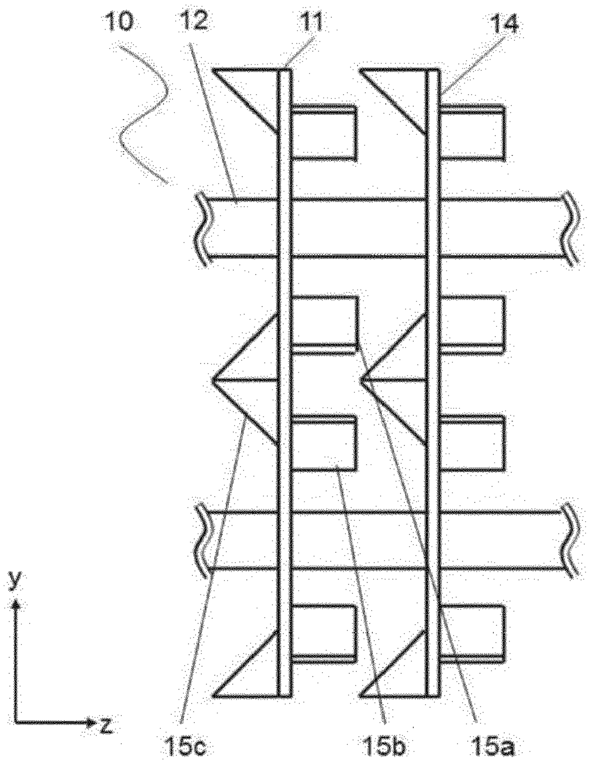
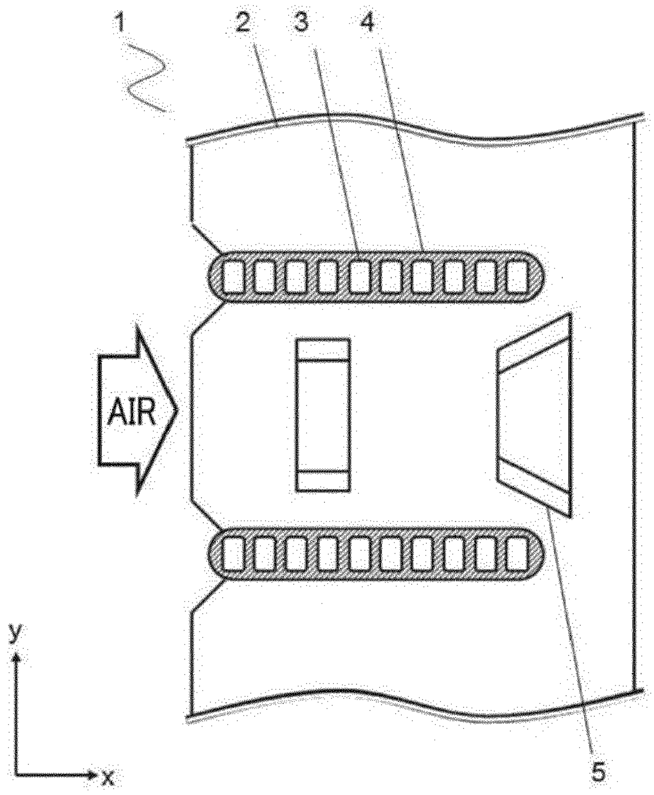

ALLOWABLE VALUE OF VENTILATION RESISTANCE
k [W/m2K]
ΔP [Pa]
VENTILATION RESISTANCE
AIR-SIDE HEAT TRANSFER RATE
0
0.25
0.5
0.65
0.75
1
l1/l

FIG.23



10 HEAT EXCHANGER
11 FIN
12 FLAT PIPE
14 FLAT PART
15a, 15b, 15c HEAT TRANSFER PROMOTING PART

FIG.24



1 HEAT EXCHANGER
2 FIN
3 COOLANT FLOW CHANNEL
4 FLAT PIPE
5 CUT-AND-RAISED PART

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EUROPEAN SEARCH REPORT

Application Number
EP 18 18 8111

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X	JP 2005 201492 A (MATSUSHITA ELECTRIC IND CO LTD) 28 July 2005 (2005-07-28) * figures 4,5 *	1	
X	EP 2 667 139 A1 (DAIKIN IND LTD [JP]) 27 November 2013 (2013-11-27) * figure 9 *	1	
X	JP S61 237995 A (MATSUSHITA ELECTRIC IND CO LTD) 23 October 1986 (1986-10-23) * pages 1,2; figure 3 *	1	

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F28F
F28D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
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