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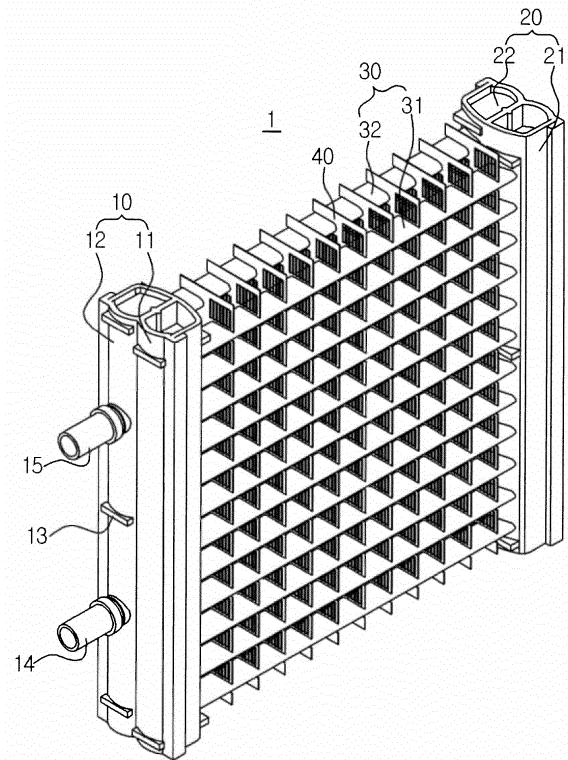
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(54) Heat exchanger and fin for the same

(57) A heat exchanger having a structure in which micro-channel tubes are respectively fitted into both sides of corresponding flat fins for heat exchange, thereby achieving enhancements in drainage and heat transfer performance. The heat exchanger includes a first header connected with an inflow tube and an outflow tube, a second header spaced apart from the first header by a desired distance and arranged parallel to the first header, a plurality of flat micro-channel tubes arranged in a front row and a rear row between the first header and the second header, and a plurality of plate type fins. Each of the micro-channel tubes includes micro-channels. Each of the fins includes slots arranged in a front row and a rear row to respectively fit the front row and rear row micro-channel tubes into the slots.

FIG. 1



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Description

BACKGROUND

5 1. Field

[0001] Embodiments of the present disclosure relate to a heat exchanger of an air conditioner having a structure capable of achieving enhancements in drainage and heat transfer performance.

10 2. Description of the Related Art

[0002] Heat exchangers, which implement one part of the refrigeration cycle, are used in equipment such as air conditioners and refrigerators. Heat exchangers include a plurality of fins for heat exchange arranged to be spaced apart from one another, and a plurality of refrigerant tubes, which is installed to come into contact with the plural fins for heat exchange, to guide refrigerant. In such a heat exchanger, air flowing into the heat exchanger from the outside undergoes heat exchange while passing through the fins for heat exchange, so that cooling operation or heating operation is achieved.

[0003] Heat exchangers are classified into fin & tube type and parallel flow type heat exchangers in accordance with shapes of the fin and tube and coupling relations therebetween.

[0004] Conventionally, the fin & tube type heat exchanger has a structure in which press-worked fins are layered, and a plurality of circular tubes is then fitted between adjacent ones of the layered fins through a press-fit process. On the other hand, the parallel flow type heat exchanger has a structure in which a fin having a corrugated shape is joined between flat elliptical tubes through a brazing process.

[0005] In general, the parallel flow type heat exchanger is superior in terms of heat exchange efficiency, as compared to the fin & tube type heat exchanger. However, drainage of condensed water from the parallel flow type heat exchanger may be troublesome.

SUMMARY

[0006] Therefore, it is an aspect of the present disclosure to provide a fin micro-channel heat exchanger (FMC) having a structure capable of achieving enhancements in drainage and heat transfer performance.

[0007] It is another aspect of the present disclosure to provide a model capable of achieving an optimal design of FMC.

[0008] Additional aspects of the disclosure will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

[0009] In accordance with one aspect of the present disclosure, a heat exchanger includes a first header connected with an inflow tube and an outflow tube, a second header spaced apart from the first header by a desired distance and arranged parallel to the first header, a plurality of flat micro-channel tubes arranged in a front row and a rear row between the first header and the second header, and a plurality of plate type fins, each of the micro-channel tubes includes micro-channels, and each of the fins includes slots arranged in a front row and a rear row to respectively fit the front row and rear row micro-channel tubes into the slots.

[0010] Louvers or slits may be formed between vertically adjacent ones of the slots in each of the fins.

[0011] The louvers may have a pitch LP satisfying a range of about $0.8\text{mm} \leq \text{Lip} \leq 1.2\text{mm}$.

[0012] A clearance D1 between each slot and each louver or slit adjacent to each other may satisfy a range of about $0\text{mm} < \text{D1} \leq 1\text{mm}$.

[0013] A clearance D2 between the front row and rear row slots may satisfy a range of about $\text{D2} \geq 2\text{mm}$.

[0014] A ratio R between an air-side heat transfer area A and a refrigerant-side heat transfer area C defined by equations below may satisfy a range of about $2.5\text{mm} \leq R \leq 3.5\text{mm}$:

50
$$A = ((L_f \times W_f) - (\text{sum of slot areas per fin})) \times 2 \times \text{total number of fins},$$

55
$$C = (W_c + H_c) \times 2 \times L_t \times (\text{total number of micro-channels per micro-channel tube}) \times (\text{total number of micro-channel tubes}), \text{ and}$$

$$R = A / C,$$

5 where "Lf" represents an overall height of each fin, "Wf" represents a width of each fin, "Wc" represents a width of each micro-channel, "Hc" represents a height of each micro-channel, and "Lt" represents a length of each micro-channel tube.

[0015] Openings arranged in the form of a lattice between vertically adjacent ones of the slots may be formed at each of the fins.

[0016] Each of the openings may have a square shape.

10 [0017] The first and second headers may extend vertically.

[0018] In accordance with another aspect of the present disclosure, a fin assembly for a heat exchanger including a plurality of plate type fins into which flat micro-channel tubes are fitted, wherein each of the fins may include slots arranged in a front row and a rear row to receive the micro-channel tubes, respectively, and louvers or slits formed between vertically adjacent ones of the slots.

15 [0019] The louvers may have a pitch LP satisfying a range of about $0.8\text{mm} \leq \text{Lip} \leq 1.2\text{mm}$.

[0020] A clearance D1 between each slot and each louver or slit adjacent to each other may satisfy a range of about $0\text{mm} < D1 \leq 1\text{mm}$.

[0021] A clearance D2 between the front row and rear row slots may satisfy a range of about $D2 \leq 2\text{mm}$.

20 [0022] In accordance with another aspect of the present disclosure, a fin assembly for a heat exchanger including a plurality of plate type fins into which flat micro-channel tubes are fitted, wherein each of the fins may include slots arranged in a front row and a rear row to receive the micro-channel tubes, respectively, and openings arranged in a lattice form between the vertically adjacent ones of the slots.

[0023] Each of the openings may have a square shape.

25 BRIEF DESCRIPTION OF THE DRAWINGS

[0024] These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

30 FIG. 1 is a perspective view illustrating an external appearance of a heat exchanger according to an exemplary embodiment of the present disclosure;

FIG. 2 is a top view schematically illustrating a fin structure of the heat exchanger according to an exemplary embodiment of the present disclosure;

35 FIG. 3 is a sectional view taken along line I - I of FIG. 2;

FIG. 4 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure;

40 FIG. 5 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure;

FIG. 6 is a sectional view taken along line II - II of FIG. 5;

45 FIG. 7 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure;

FIG. 8 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure;

50 FIG. 9 is a sectional view taken along line III - III of FIG. 8;

FIG. 10 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure;

55 FIG. 11 is a sectional view illustrating a cross section of a micro-channel tube included in the heat exchanger according to an exemplary embodiment of the present disclosure;

FIG. 12 is a graph illustrating variation in heat exchange performance according to a ratio between an air-side heat transfer area and a refrigerant-side heat transfer area;

FIGS. 13 and 14 are views explaining a method of joining the tubes and fins for the heat exchanger according to an exemplary embodiment of the present disclosure, respectively; and

FIG. 15 is a perspective view illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure.

DETAILED DESCRIPTION

[0025] Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0026] Hereinafter, exemplary embodiments of the present disclosure will be described with reference to the accompanying drawings.

[0027] FIG. 1 is a perspective view illustrating an external appearance of a heat exchanger according to an exemplary embodiment of the present disclosure.

[0028] Referring to FIG. 1, the heat exchanger 1 according to the exemplary embodiment of the present disclosure includes a first header 10, a second header 20, micro-channel tubes 30, and fins 40.

[0029] The first header 10 and the second header 20 extend vertically while being spaced apart from each other by a desired distance. Tube coupling portions (not shown) are formed at facing walls of the first and second headers 10 and 20. Each tube coupling portion is formed by cutting the corresponding header wall to a size in accordance with a cross section of the corresponding micro-channel tube 30 to couple the micro-channel tube 30 to the tube coupling portion.

[0030] The first header 10 and the second header 20 include respective front tanks 11 and 21 and respective rear tanks 12 and 22. The front tanks 11 and 21 and the rear tanks 12 and 22 are partitioned by partition walls, respectively. Each of the front tanks 11 and 21 and the rear tanks 12 and 22 may be further vertically partitioned by baffles 13.

[0031] The micro-channel tubes 30 are installed between the first and second headers 10 and 20, to guide refrigerant by communicating the first header 10 with the second header 20.

[0032] Each of the micro-channel tubes 30 is a path through which refrigerant passes. Refrigerant is compressed or expanded while circulating in an air conditioner (not shown), so that cooling and heating may be achieved.

[0033] The micro-channel tubes 30, which are vertically spaced apart from one another by a desired clearance, are arranged in two rows, namely, a front row and a rear row. That is, the micro-channel tubes 30 include front row micro-channel tubes 31 and rear row micro-channel tubes 32. Here, the front row and rear row micro-channel tubes 31 and 32 are alternately arranged in a zigzag formation. However, the front row and rear row micro-channel tubes 31 and 32 may be arranged to be horizontally aligned with each other, as shown in FIG. 4.

[0034] Meanwhile, an inflow tube 14 into which refrigerant flows and an outflow tube 15 from which heat-exchanged refrigerant while passing through the micro-channel tubes 30 is discharged are connected to the first header 10. The inflow and outflow tubes 14 and 15 may be respectively connected to lower and upper sides of the first header 10, in order to prevent accumulation of refrigerant droplets caused by gravity, even if refrigerant flowing into the first header 10 has both a gas phase and a liquid phase.

[0035] FIG. 2 is a top view schematically illustrating a fin structure of the heat exchanger according to an exemplary embodiment of the present disclosure. FIG. 3 is a sectional view taken along line I - I of FIG. 2.

[0036] A structure of fins and tubes for the heat exchanger according to the exemplary embodiments of the present disclosure will be described with reference to FIGS. 2 and 3.

[0037] Referring to FIGS. 2 and 3, a fin body 43 in each fin 40 is formed to have a plate shape with a certain width W_f and height H_f . The fin body 43 may be a rectangular thin plate.

[0038] Each fin 40 is installed to come into contact with the corresponding micro-channel tubes 30, and may be formed as widely as possible so that the section thereof to radiate or absorb heat becomes wider.

[0039] Heat of refrigerant flowing inside the micro-channel tubes 30 is transferred to air flowing around the fins 40 via the micro-channel tubes 30 and fins 40, thereby easily radiating heat to the outside.

[0040] On the contrary, even when heat of air flowing around the fins 40 is transferred to refrigerant via the fins 40 and micro-channel tubes 30, the heat is also radiated to the outside in the same way as described above.

[0041] Meanwhile, front row slots 44 and rear row slots 45 are formed at each of the fins 40 so that the front row and rear row micro-channel tubes 31 and 32 are fitted into the front row slots 44 and the rear row slots 45, respectively. In each fin 40, collars 47 perpendicular to the fin body 43 are formed respectively at peripheral areas of the front row and rear row slots 44 and 45 to easily fit the front row and rear row micro-channel tubes 31 and 32 into the corresponding front row and rear row slots 44 and 45 respectively, thereby securing a desired joining force.

[0042] The fins 40 are arranged to be evenly spaced in parallel with a flow direction of air. Thus, air may execute heat

exchange while naturally flowing along surfaces of the fins 40 without greatly undergoing resistance caused by the fins 40.

[0043] When the front row and rear row micro-channel tubes 31 and 32 are arranged in a zigzag formation, the front row and rear row slots 44 and 45 of each fin 40 are also arranged in a zigzag formation. However, when the front row and rear row micro-channel tubes 31 and 32 are arranged to be horizontally aligned with each other, as shown in FIG. 4, the front row and rear row slots 44 and 45 of each fin 40 are also arranged to be horizontally aligned with each other, of course.

[0044] In each fin 40, front row and rear row louvers 41 and 42 are formed between the vertically adjacent slots 44 and between the vertically adjacent slots 45 respectively, to enhance heat transfer efficiency by increasing a contact area with air.

[0045] The louvers 41 are formed between the vertically adjacent front row slots 44, and the louvers 42 are formed between the vertically adjacent rear row slots 45.

[0046] In each fin 40, the front row louvers 41 and the rear row louvers 42 are symmetrically arranged in a width direction of the fin 40, and each of the front row louvers 41 and the rear row louvers 42 is formed so that a portion of the fin body 43 is slightly bent from a plane of the fin 40 in an upward or downward direction to be inclined at a desired angle. Accordingly, air flowing along the fins 40 is dispersed by the louvers 41 and 42, and growth of a boundary layer is restrained, so that heat exchange efficiency may be enhanced.

[0047] In each fin 40, the clearance D1 between each slot 44 or 45 and each louver 41 or 42 may be 1 mm or less, in order to prevent an increase in air-side pressure loss and a deterioration in heat transfer performance due to formation of water droplets at lower ends of the micro-channel tubes 30. In accordance with such a structure, condensed water may be smoothly drained to lower ends of the fins 40 by capillary action.

[0048] In each fin 40, drainage performance may be enhanced when the clearance D2 between the front row slots 44 into which the front row micro-channel tubes 31 are respectively fitted and the rear row slots 45 into which the rear row micro-channel tubes 32 are respectively fitted may be 2mm or more.

[0049] Drainage performance may be enhanced when the pitch LP of the louvers 41 and 42 satisfies a range of $0.8\text{mm} \leq \text{Lip} \leq 1.2\text{mm}$.

[0050] FIG. 5 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure. FIG. 6 is a sectional view taken along line II - II of FIG. 5. FIG. 7 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure.

[0051] In each fin 40 for the heat exchanger, instead of the louvers 41 and 42, slits 46a and 46b may be formed between vertically adjacent slots 44 and between vertically adjacent slots 45, respectively. The slits 46a are formed between the vertically adjacent front row slots 44, and the slits 46b are formed between the vertically adjacent rear row slots 45. Air is changed into turbulent air while flowing into openings of the slits 46a and 46b, and the turbulent air circulates around the micro-channel tubes 30, and thus heat exchange efficiency may be improved.

[0052] In the present embodiments, front row slots 44 and rear row slots 45 of each fin 40 may be arranged in a zigzag formation or to be horizontally aligned with each other.

[0053] FIG. 8 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure. FIG. 9 is a sectional view taken along line III - III of FIG. 8. FIG. 10 is a view schematically illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure.

[0054] As shown in FIGS. 8 to 10, louvers 41 and 42 and slits 46a and 46b in each fin 40 may also be formed together, and front row slots 44 and rear row slots 45 in each fin 40 may be arranged in a zigzag formation or to be horizontally aligned with each other. Since the remaining components are the same as those according to another exemplary embodiment of the present disclosure, no description will be given.

[0055] Meanwhile, as shown in FIG. 11, each of the micro-channel tubes 30 has a flat shape, and a plurality of micro-channels 33 is formed in the micro-channel tube 30 to guide refrigerant in the micro-channel tube 30.

[0056] Although each of the micro-channel tubes 30 may have a circular shape in a cross section, the micro-channel tube 30 may have a flat shape to expand a heat transfer area.

[0057] FIG. 12 is a graph illustrating variation in heat exchange performance according to a ratio between an air-side heat transfer area and a refrigerant-side heat transfer area. In the graph, the x-axis refers to the ratio R between the air-side heat transfer area A and the refrigerant-side heat transfer area C, whereas the y-axis refers to the quantity of heat per frontal area Q/FA, heat transfer capacity per frontal area HA/FA, and pressure loss per unit length dP/L (however, numerical values of the y-axis are relative values).

[0058] In the heat exchanger including the fins 40 and micro-channel tubes 30 having the structure as described above, performance characteristics according to the ratio R between the air-side heat transfer area A and the refrigerant-side heat transfer area C may be varied.

[0059] The air-side heat transfer area A is defined by $A = ((L_f \times W_f) - (\text{sum of slot areas per fin})) \times 2 \times \text{total number of fins}$, where "L_f" represents the length (or height) of each fin 40, and "W_f" represents the width of each fin 40. On the

other hand, the refrigerant-side heat transfer area C is defined by $C = (W_c + H_c) \times 2 \times L_t \times$ (total number of micro-channels per micro-channel tube) \times (total number of micro-channel tubes), where "Wc" represents the width of each micro-channel, "Hc" represents the height of each micro-channel, and "Lt" represents the length of each micro-channel tube. The ratio R is defined by $R = \text{air-side heat transfer area A} / \text{refrigerant-side heat transfer area C}$.

[0060] As shown in FIG. 12, pressure loss increases as the ratio R between the air-side heat transfer area A and the refrigerant-side heat transfer area C increases. Therefore, when the ratio R satisfies a range of about $2.5 \leq R \leq 3.5$, overall performance characteristics may be optimized.

[0061] Conventionally, the ratio R between the air-side heat transfer area A and the refrigerant-side heat transfer area C is $10 \leq R \leq 20$ in the case of the fin & tube type heat exchanger, whereas the ratio R is $3 \leq R \leq 4$ in the case of the parallel flow type heat exchanger.

[0062] Accordingly, the refrigerant-side heat transfer area C may be increased, in order to obtain an optimal performance characteristic.

[0063] FIGS. 13 and 14 are views explaining a method of joining the tubes and fins for the heat exchanger according to an exemplary embodiment of the present disclosure, respectively.

[0064] The joining of the micro-channel tubes 30 and fins 40 as described above may be achieved by welding wires 50, in addition to a brazing process conventionally used to join aluminum clad fins and tubes.

[0065] When the welding wires 50 are respectively installed at inner sides of the slots 44 and 45 in each fin 40 so that the front row and rear row micro-channel tubes 31 and 32, which are respectively fitted into the corresponding slots 44 and 45, are welded to the slots 44 and 45 by the welding wires 50, as shown in FIG. 13, the fin 40 and the front row and rear row micro-channel tubes 31 and 32 may be welded and joined together while the melted welding wires flow into the gaps between the micro-channel tubes and the corresponding slots, as shown in FIG. 14. In accordance with such a method, joining defects may be greatly resolved in addition to easy welding.

[0066] FIG. 15 is a perspective view illustrating a fin structure of the heat exchanger according to another exemplary embodiment of the present disclosure.

[0067] In each plate type fin 140 for the heat exchanger into which the flat micro-channel tubes are fitted, the fin 140 may include a fin body 143, slots 145 alternatively arranged in a zigzag formation to respectively fit the micro-channel tubes, and a plurality of openings 148 arranged in a lattice form between the vertically adjacent slots 145. Collars 147 may be formed respectively around the slots 145 so as to easily attach the micro-channel tubes to the slots 145 by fitting the micro-channel tubes into the slots 145.

[0068] As shown in FIG. 15, air F flowing in a thickness direction of the fins 140 may pass between a front surface and a rear surface of each fin 140 through the openings 148 while flowing between the fins 140. Further, since a plurality of fins 140 is layered, the openings 148 arranged at corresponding positions between the layered fins 140 may form a channel. Thus, a reduction in air-side pressure loss and an enhancement in heat transfer performance may be achieved.

[0069] As is apparent from the above description, in accordance with aspects of the present disclosure, it may be possible to provide a fin micro-channel heat exchanger having a structure capable of achieving enhancements in drainage and heat transfer performance.

[0070] Although a few embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. A heat exchanger comprising:

a first header connected with an inflow tube and an outflow tube;
 a second header spaced apart from the first header by a defined distance and arranged parallel to the first header;
 a plurality of micro-channel tubes arranged in a front row and a rear row between the first header and the second header, each of the micro-channel tubes comprising a plurality of micro-channels; and
 a plurality of plate type fins, each of the plate type fins comprising slots arranged in a front row and a rear row to respectively receive the front row and rear row of the micro-channel tubes.

2. The heat exchanger according to claim 1, wherein each of the plate type fins comprises louvers or slits formed between vertically adjacent ones of the slots.

3. The heat exchanger according to claim 2, wherein the louvers have a pitch LP satisfying a range of about $0.8\text{mm} \leq L_p \leq 1.2\text{mm}$.

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4. The heat exchanger according to claim 2, wherein a clearance D1 between each slot and each louver or slit adjacent to each other satisfies a range of about $0\text{mm} < D1 \leq 1\text{ mm}$.
5. The heat exchanger according to claim 2, wherein a clearance D2 between the front row and rear row slots satisfies a range of about $D2 \leq 2\text{mm}$.
6. The heat exchanger according to claim 2, wherein a ratio R between an air-side heat transfer area A and a refrigerant-side heat transfer area C defined by equations below satisfies a range of about $2.5\text{mm} \leq R \leq 3.5\text{mm}$:

$$A = ((L_f \times W_f) - (\text{sum of slot areas per fin})) \times 2 \times \text{total number of fins},$$

$$C = (W_c + H_c) \times 2 \times L_t \times (\text{total number of micro-channels per micro-channel tube}) \times (\text{total number of micro-channel tubes}), \text{ and}$$

$$R = A / C,$$

where "L_f" represents an overall height of each fin, "W_f" represents a width of each fin, "W_c" represents a width of each micro-channel, "H_c" represents a height of each micro-channel, and "L_t" represents a length of each micro-channel tube.

7. The heat exchanger according to claim 1, wherein welding material, provided at inner sides of the slots arranged in each of the first row and rear row in each fins, is used to permanently attach the micro-channel tubes to the corresponding slots.
8. The heat exchanger according to claim 1, wherein openings arranged in the form of a lattice between vertically adjacent ones of the slots are formed at each of the fins.
9. The heat exchanger according to claim 8, wherein each of the openings has a square shape.
10. The heat exchanger according to claim 1, wherein the first and second headers extend vertically.

FIG. 1

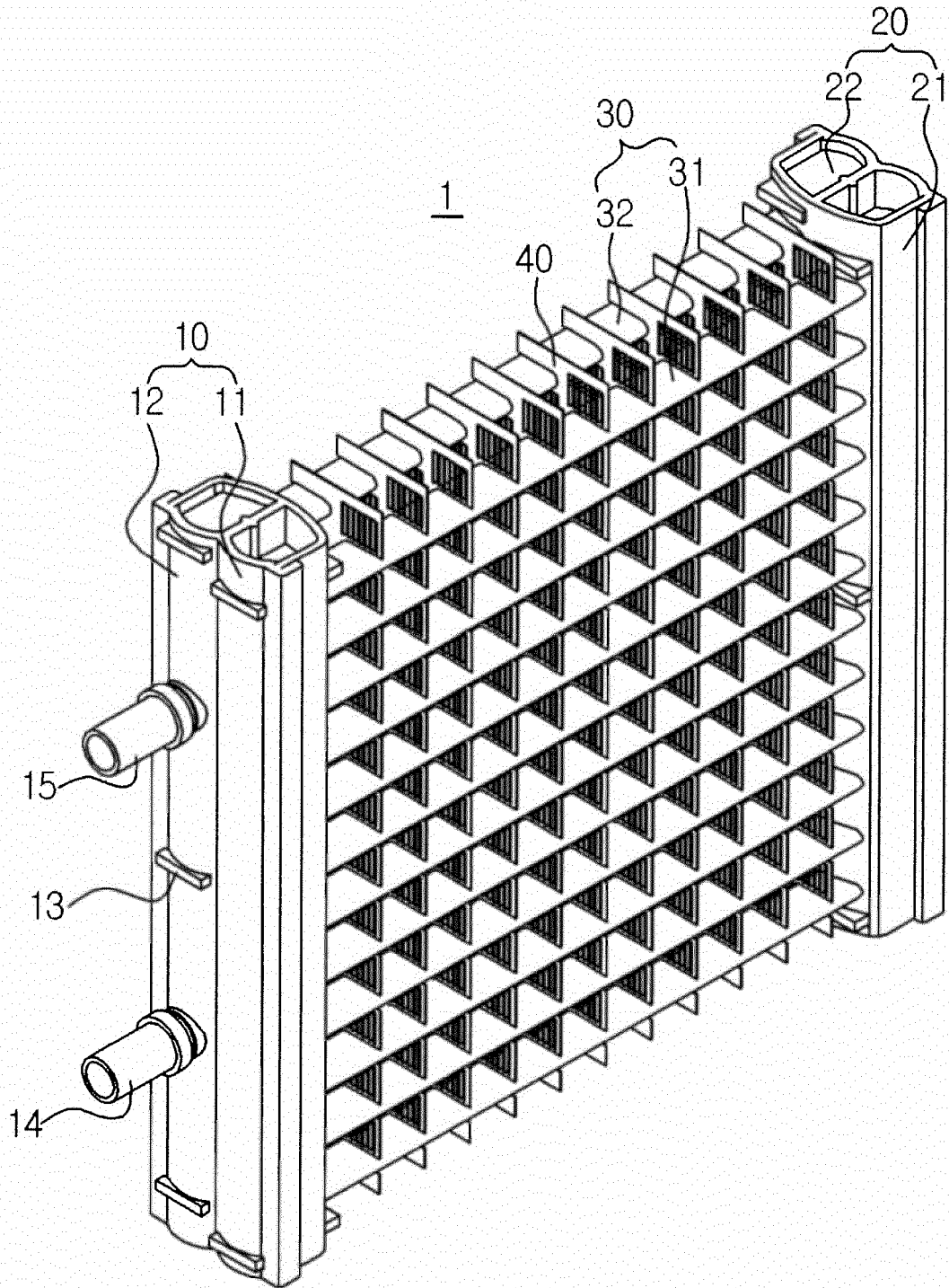


FIG. 2

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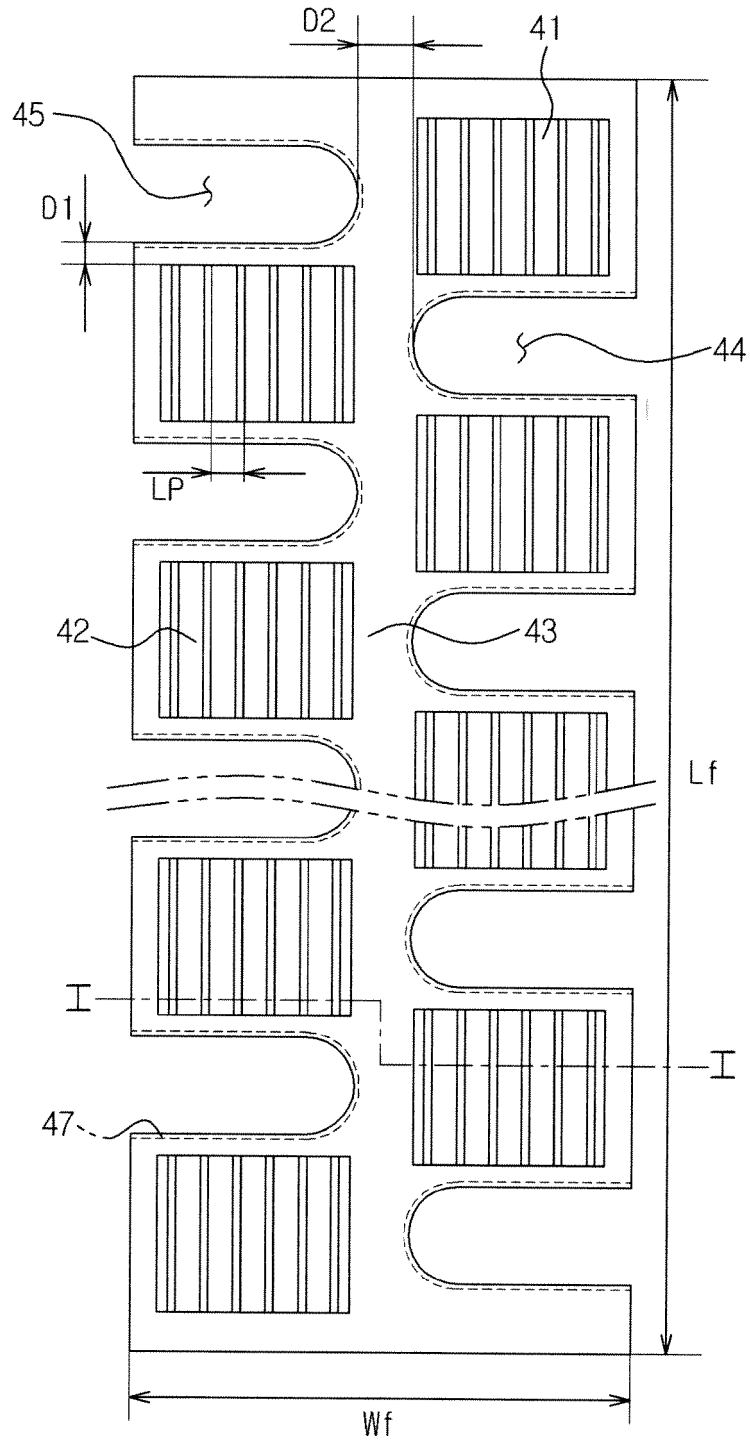


FIG. 3

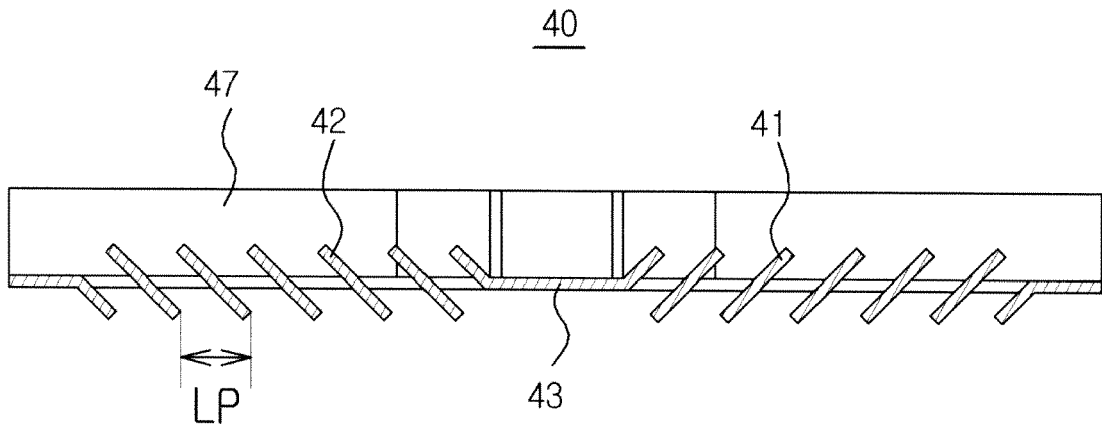


FIG. 4

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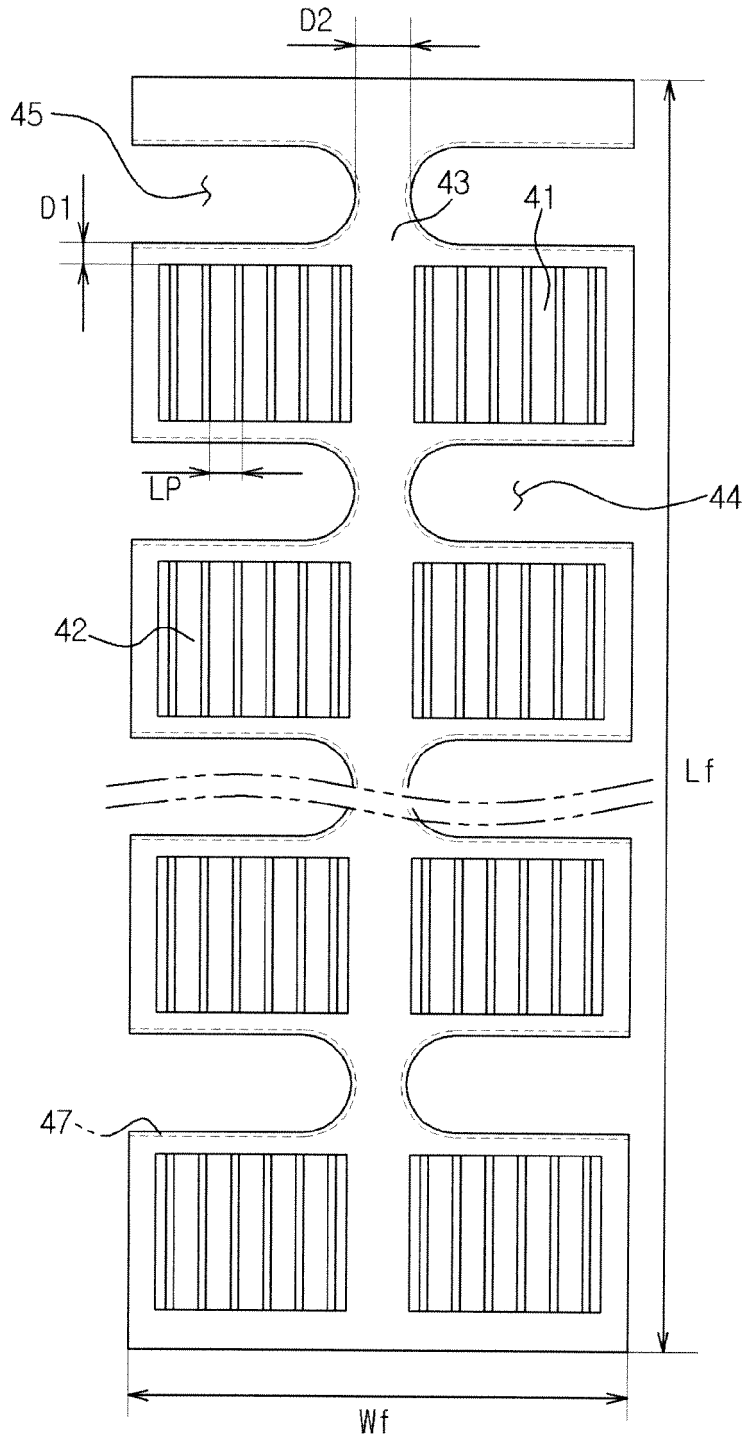


FIG. 5
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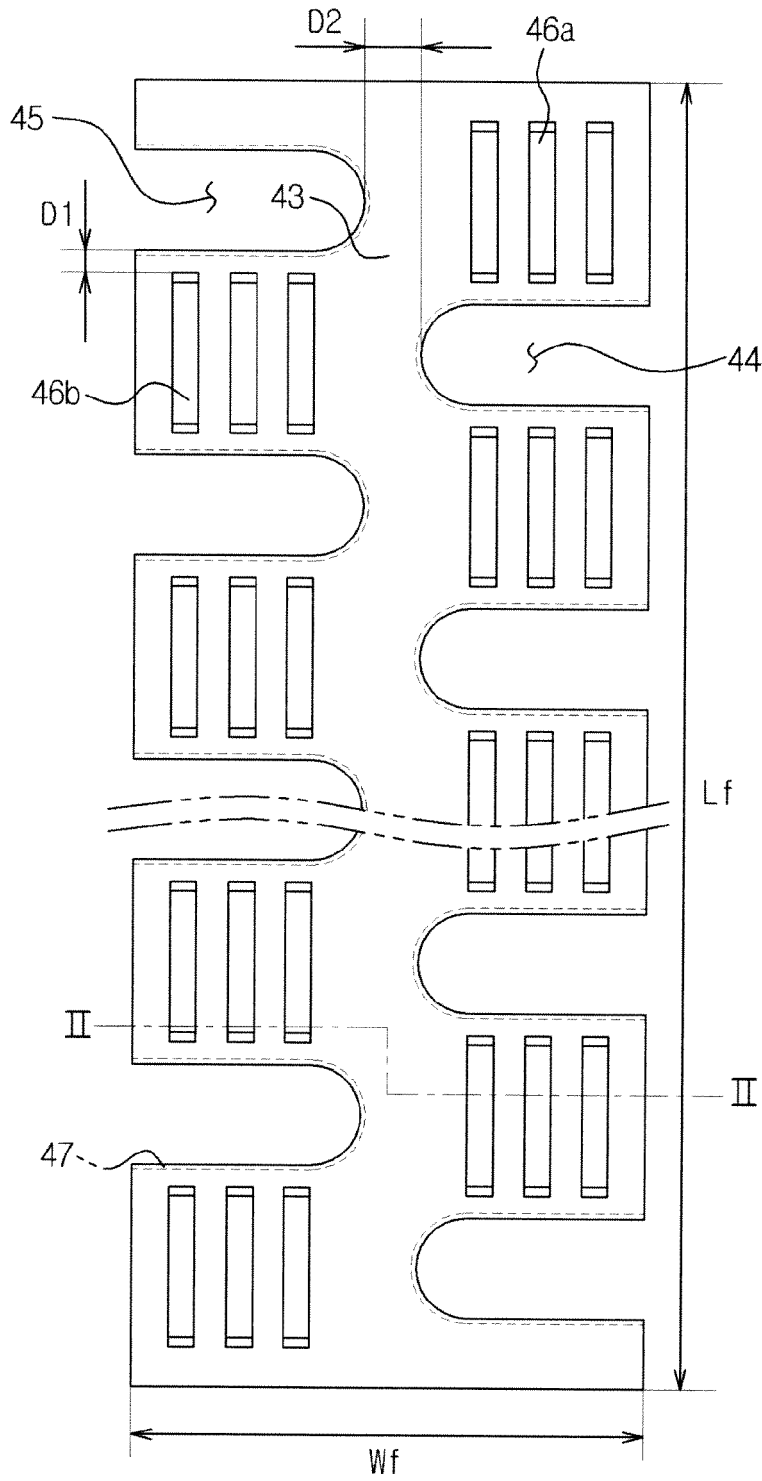


FIG. 6

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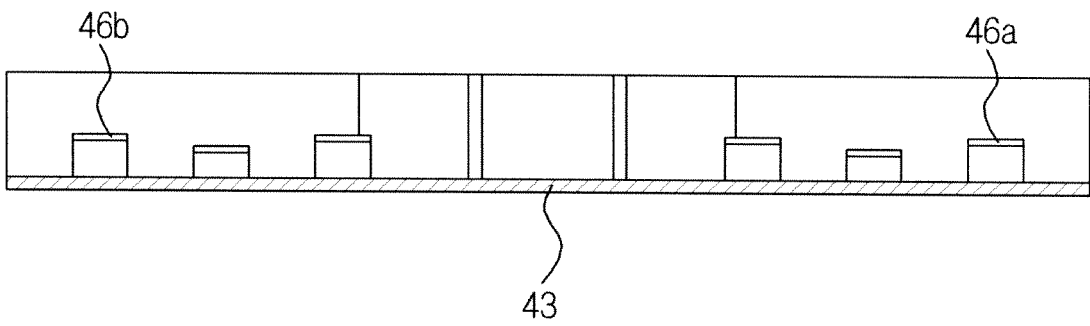


FIG. 7

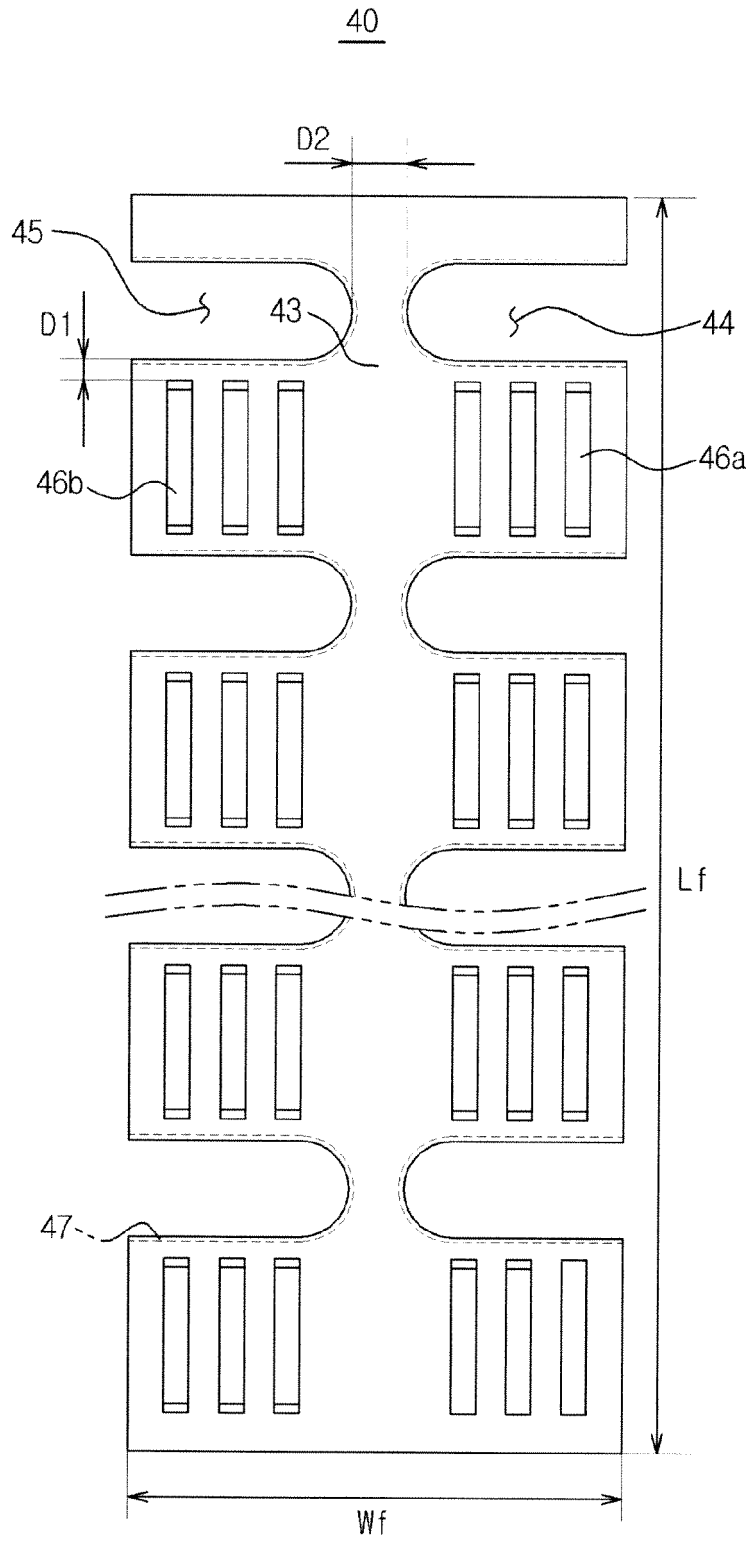


FIG. 8

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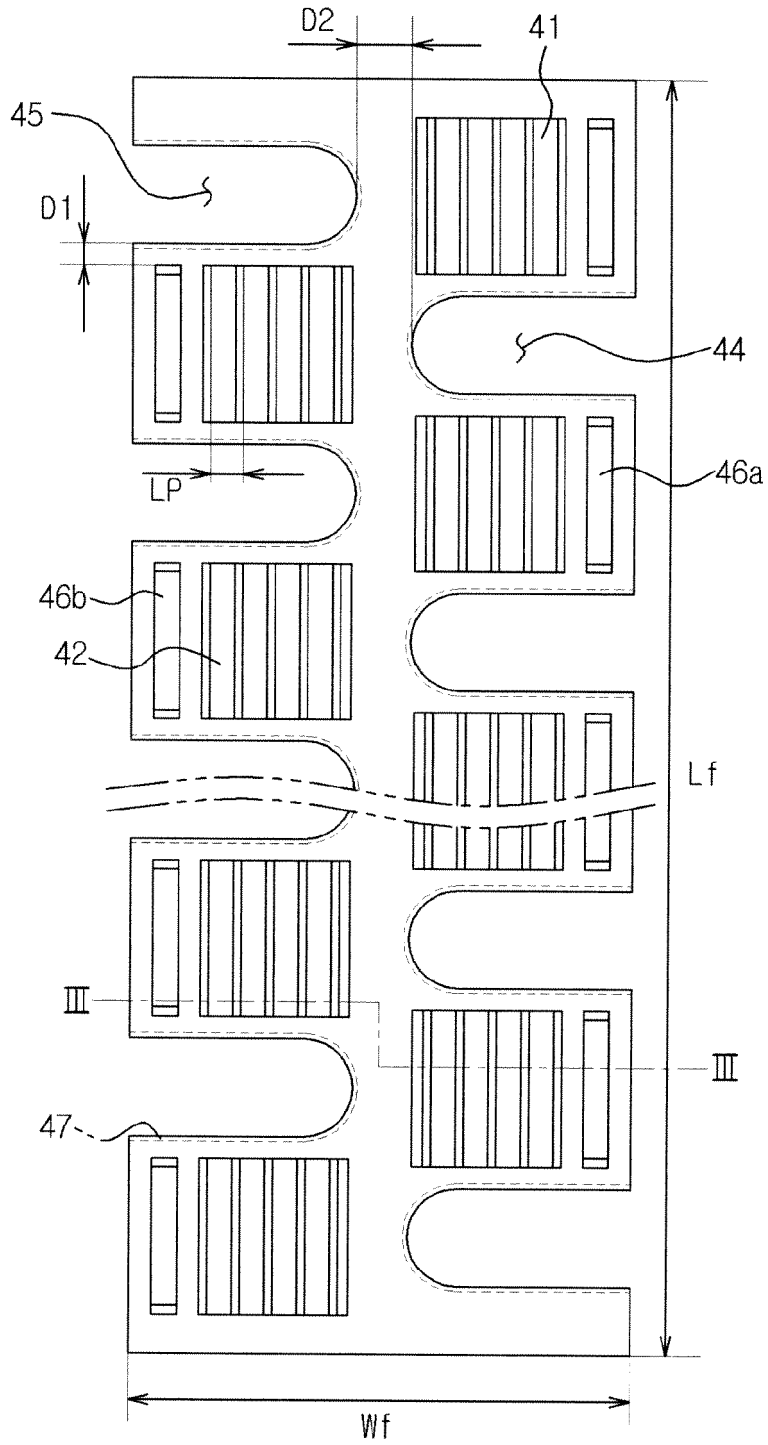


FIG. 9

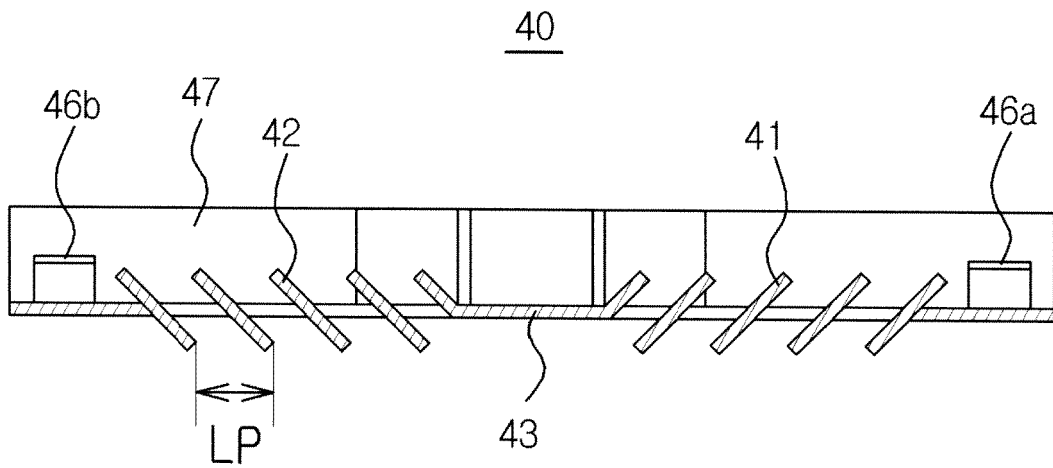


FIG. 10

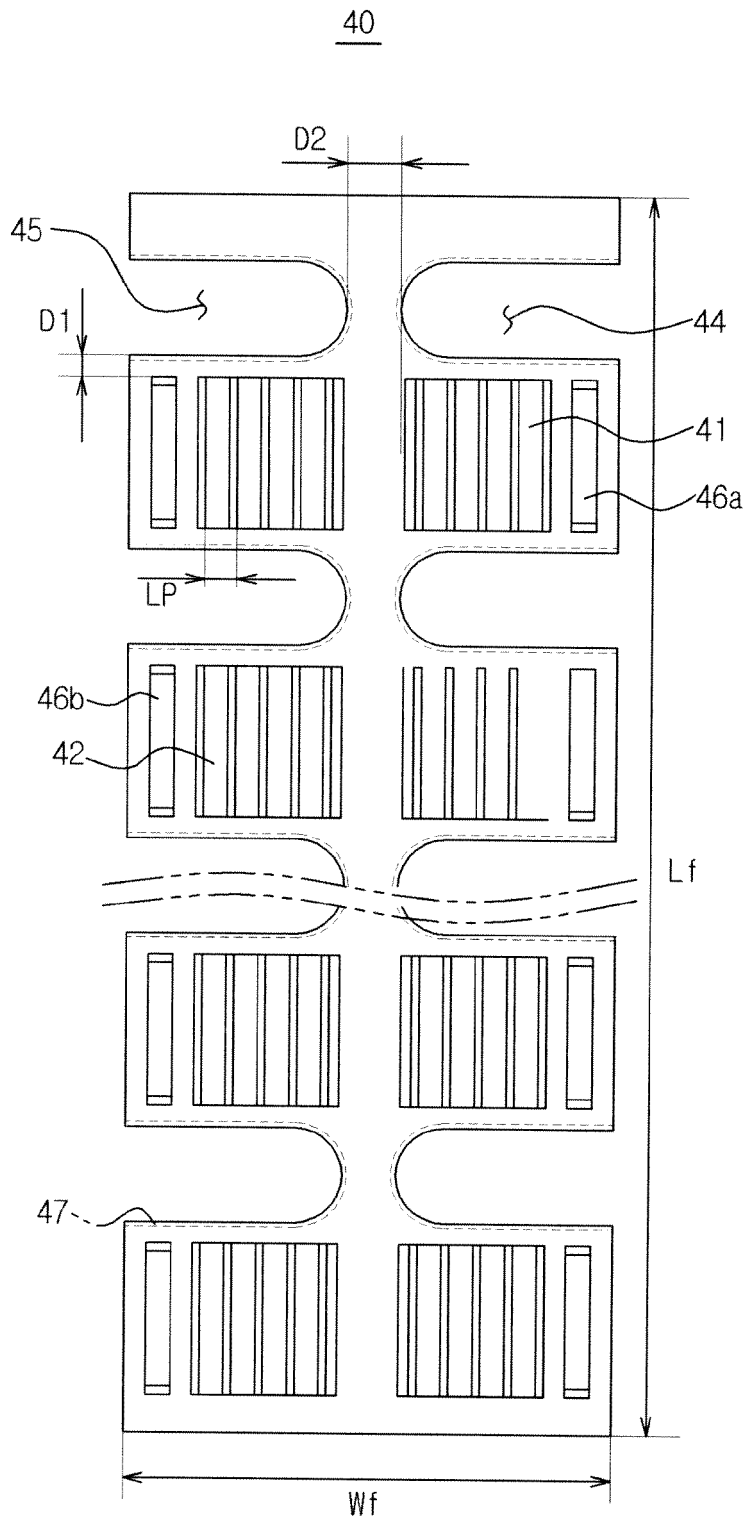


FIG. 11

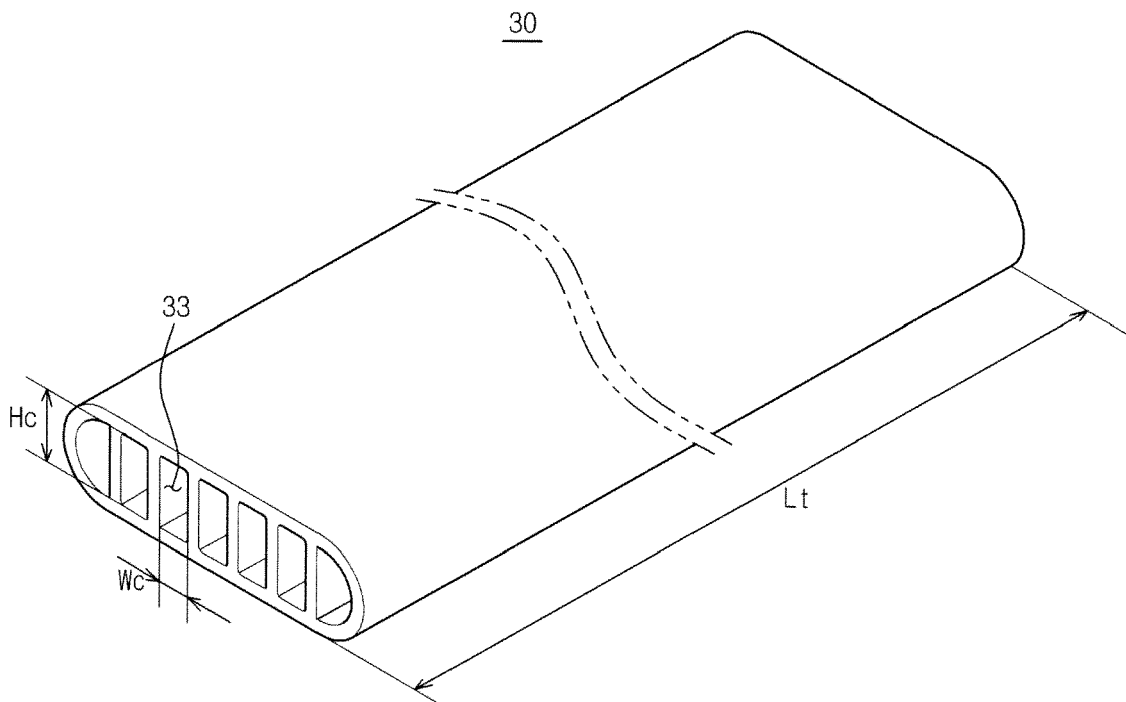


FIG. 12

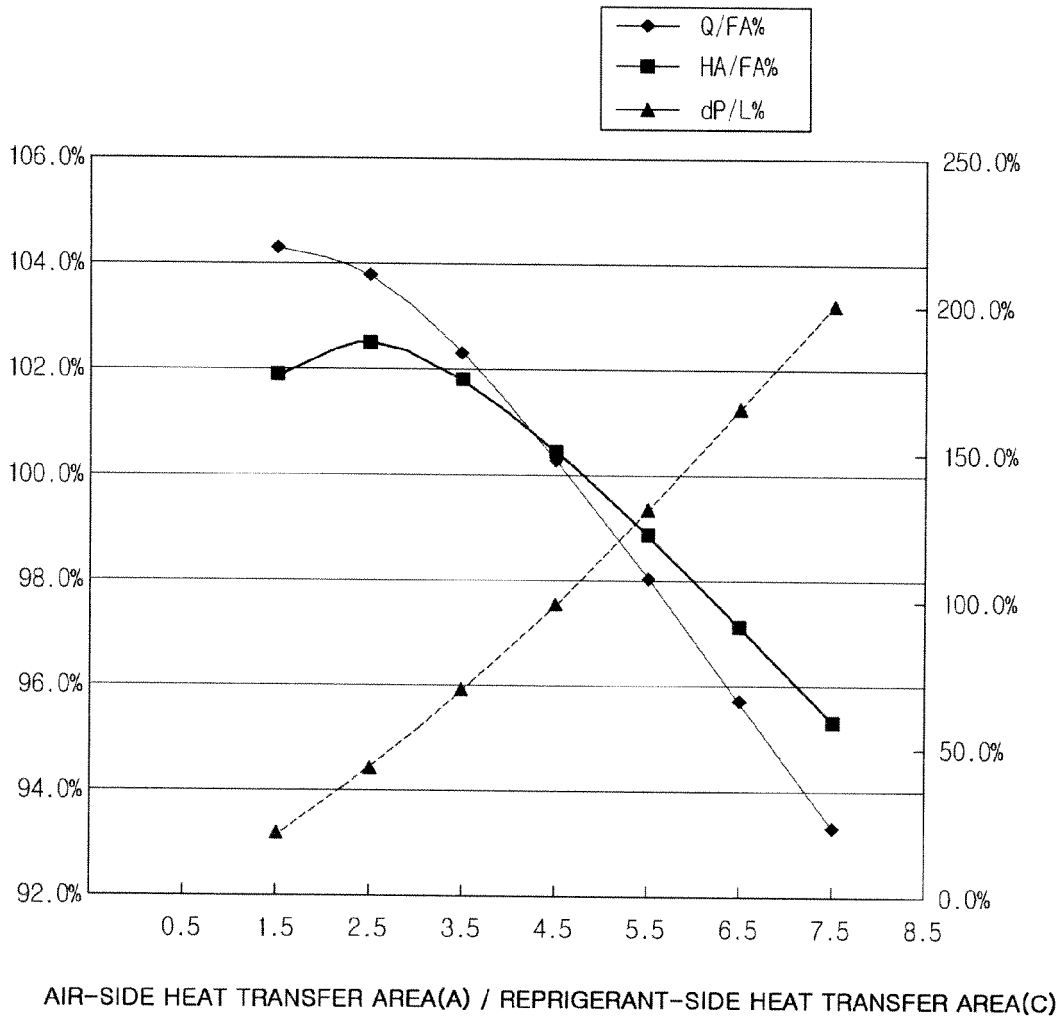


FIG. 13

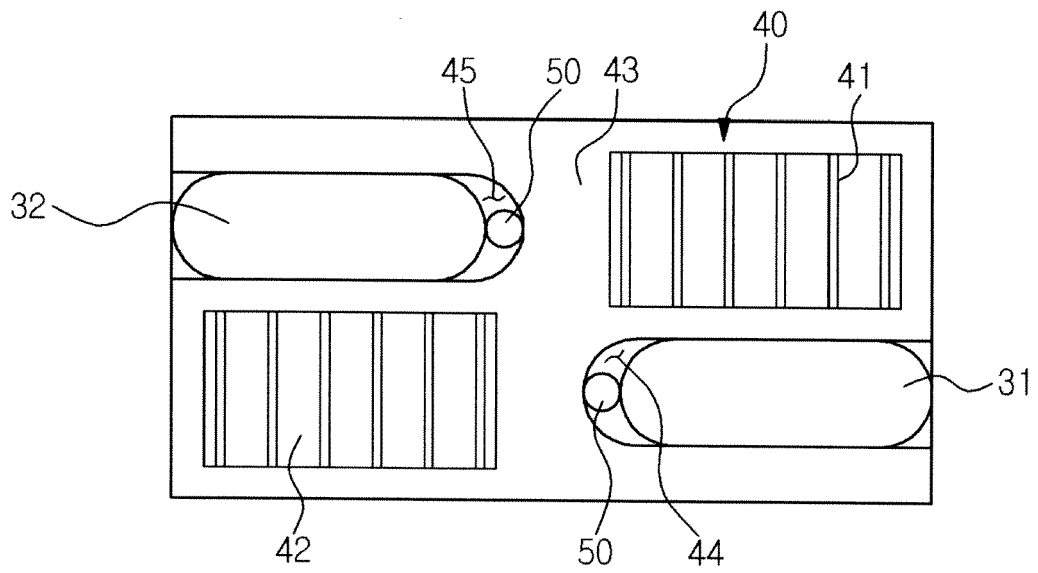


FIG. 14

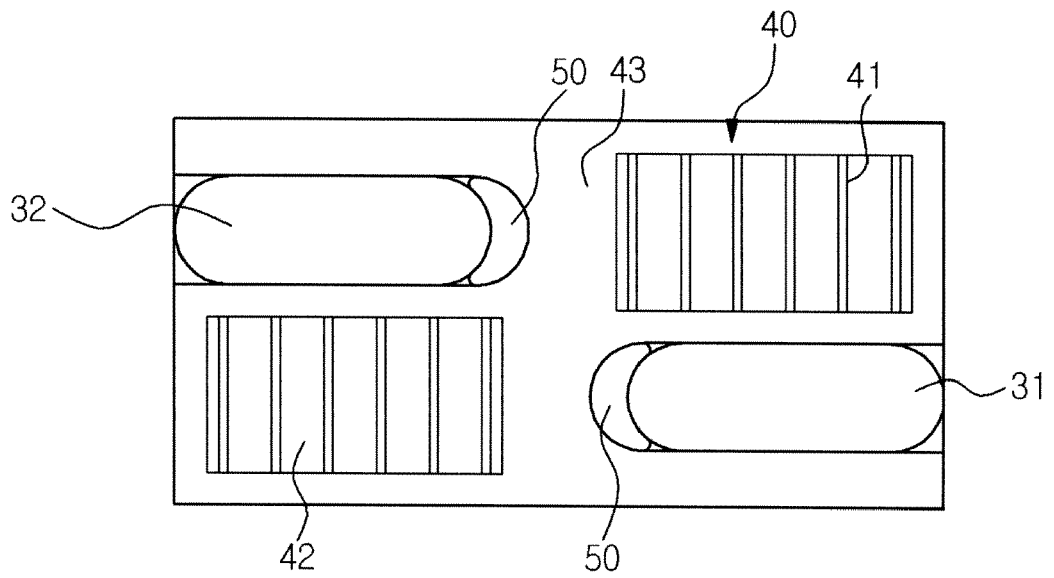


FIG. 15

