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(71) Applicant: **Samsung Electronics Co., Ltd.**
Suwon-si, Gyeonggi-do 506-762 (KR)

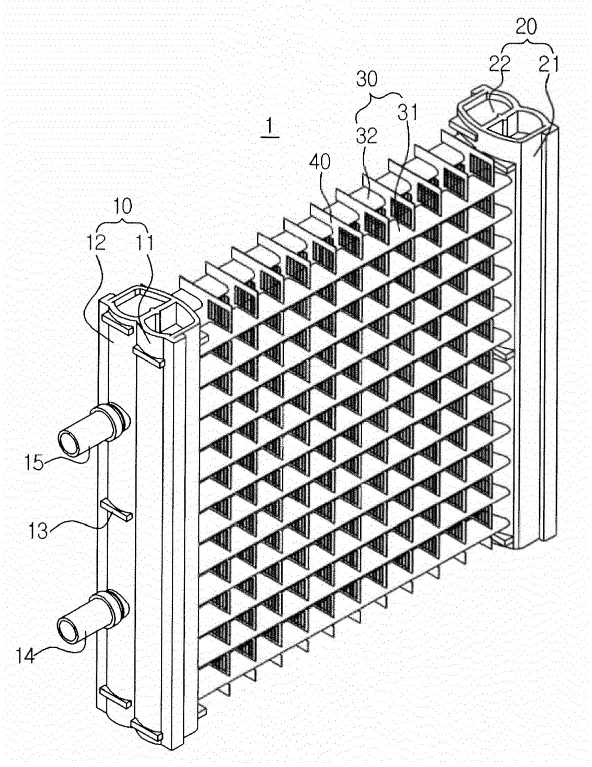
(72) Inventors:
- **Kim, Young Min**
  Gyeonggi-do (KR)
- **Gaku, Hayase**
  Gyeonggi-do (KR)
- **Kim, Dong Hyun**
  Incheon (KR)

(74) Representative: **Grünecker, Kinkeldey, Stockmair & Schwanhäusser**
Leopoldstrasse 4
80802 München (DE)

(54) **Heat Exchanger and Micro-Channel Tube Thereof**

(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 extending vertically and 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, and a plurality of flat micro-channel tubes arranged horizontally while being vertically spaced apart from one another by a desired clearance and arranged in a front row and a rear row between the first header and the second header. Micro-channels are formed in each of the micro-channel tubes.

FIG. 1



EP 2 447 660 A2

Description

BACKGROUND

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.

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 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, 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, 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 extending vertically and 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, and a plurality of flat micro-channel tubes arranged horizontally while being vertically spaced apart from one another by a desired clearance and arranged in a front row and a rear row between the first header and the second header, and micro-channels are formed in each of the micro-channel tubes.

[0010] The front row and rear row micro-channel tubes may be alternately arranged in a zigzag formation.

[0011] The front row and rear row micro-channel tubes may be arranged to be horizontally aligned with each other.

[0012] The micro-channel tubes may have a pitch Tp satisfying a range of about $7mm \leq Tp \leq 11mm$.

[0013] A thickness Tt of each micro-channel tube may satisfy a range of about $2mm \leq Tt \leq 3.5mm$.

[0014] A wall thickness Tow of each micro-channel tube may satisfy a range of about $0.1mm \leq Tow \leq 0.35mm$.

[0015] A width Wc of each micro-channel may satisfy a range of about $0.5mm \leq Wc \leq 1.5mm$.

[0016] The inflow tube may be connected to a lower side of the first header, whereas the outflow tube may be connected to an upper side of the first header.

[0017] The first and second headers may include respective front tanks and respective rear tanks.

[0018] In accordance with another aspect of the present disclosure, a micro-channel tube assembly for a heat exchanger including a plurality of micro-channel tubes, wherein the micro-channel tubes are arranged horizontally while being vertically spaced apart from one another by a desired clearance and are arranged in a front row and a rear row between the first header and the second header extending vertically, and a thickness Tt of each micro-channel tube satisfies a range of about $2mm \leq Tt \leq 3.5mm$.

[0019] In accordance with another aspect of the present disclosure, a micro-channel tube assembly for a heat exchanger including a plurality of micro-channel tubes, wherein the micro-channel tubes are arranged horizontally while being vertically spaced apart from one another by a desired clearance and are arranged in a front row and a rear row between the first header and the second header extending vertically, and a wall thickness Tow of each micro-channel tube satisfies a range of about $0.1mm \leq Tow \leq 0.35mm$.

[0020] In accordance with another aspect of the present disclosure, a micro-channel tube assembly for a heat exchanger comprising a plurality of micro-channel tubes, wherein the micro-channel tubes are arranged horizontally while being vertically spaced apart from one another by a desired clearance and are arranged in a front row and a rear row between the first header and the second header extending vertically, and a width Wc of each micro-channel tube satisfies a range of about $0.5mm \leq Wc \leq 1.5mm$.

[0021] The front row and rear row micro-channel tubes may be alternately arranged in a zigzag formation.

[0022] The front row and rear row micro-channel tubes may be arranged to be horizontally aligned with each other.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] 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:

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 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;

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

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;

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;

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 quantity of heat according to the thickness of each micro-channel tube;

FIG. 13 is a graph illustrating variation in quantity of heat according to the pitch of the adjacent micro-channel tubes;

FIG. 14 is a graph illustrating variation in quantity of heat according to the wall thickness of each micro-channel tube; and

FIG. 15 is a graph illustrating variation in quantity of heat according to the width of each micro-channel.

DETAILED DESCRIPTION

[0024] 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.

[0025] Hereinafter, exemplary embodiments of the present disclosure will be described with reference to the accompanying drawings.

[0026] FIG. 1 is a perspective view illustrating an external appearance of a heat exchanger according to an exemplary embodiment of the present disclosure.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] FIG. 2 is a 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.

[0035] 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 and height. The fin body 43 may be a rectangular thin plate.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] In each fin 40, front row and rear row louvers 41 and 42 or front row and rear row slits 46a and 46b 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. Of course, the louvers 41 and 42 and the slits 46a and 46b may also be formed together. Each of the louvers 41 and slits 46a are formed between the vertically adjacent front row slots 44, and each of the louvers 42 and slits 46b are formed between the vertically adjacent rear row slots 45.

[0043] 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.

[0044] 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.

[0045] As described above, in each fin 40 for the heat exchanger, slits 46a may be formed between vertically adjacent slots 44 and, similarly, slits 46b may be formed between vertically adjacent 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.

[0046] 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.

[0047] 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.

[0048] 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.

[0049] 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.

[0050] 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.

[0051] FIGS. 12 to 15 are graphs illustrating variations in quantity of heat according to the thickness of each micro-channel tube, the pitch of the adjacent micro-channel tubes, the wall thickness of each micro-channel tube, and the width of each micro-channel, respectively.

[0052] In the heat exchanger having the structure as described above, performance of the heat exchanger may vary depending on the thickness Tt of each micro-channel tube 30, the pitch Tp of the adjacent micro-channel tubes 30, the wall thickness Tow of each micro-channel tube 30, and the width Wc of each micro-channel 33.

[0053] As shown in FIG. 12, it may be found that the quantity of heat Q increases as the thickness Tt of each micro-channel tube 30 increases. However, considering an increase in manufacturing costs of the micro-channel tubes 30, the thickness Tt of each micro-channel tube 30 may be determined in a range of 2mm $\leq$ Tt $\leq$ 3.5mm.

[0054] Similarly, as shown in FIG. 13, the pitch Tp of the adjacent micro-channel tubes 30 may be determined in a range of 7mm $\leq$ Tp $\leq$ 11 mm. In general, although the quantity of heat Q has an increasing tendency as the pitch Tp of the adjacent micro-channel tubes 30 reduces, the quantity of heat Q may converge upon a maximum value if the pitch Tp of the adjacent micro-channel tubes 30 approaches approximately 7mm.

[0055] As shown in FIG. 14, although the quantity of heat Q increases as the wall thickness Tow of each micro-channel tube 30 decreases, the quantity of heat Q converges upon a maximum value if the wall thickness Tow of each micro-channel tube 30 approaches approximately 0.1mm.

[0056] As shown in FIG. 15, the quantity of heat Q increases as the width Wc of each micro-channel 33 increases, the quantity of heat Q subsequently has a maximum value when the width Wc is in a range of approximately 0.5mm $\leq$ Wc $\leq$ 1.5mm, and then the quantity of heat Q reduces again.

[0057] As described above, in the heat exchanger including the micro-channel tubes 30, which are horizontally arranged while being vertically spaced apart from one another by a desired clearance and are arranged in the front row and the rear row between the first header and the second header extending vertically, when the thickness Tt of each micro-channel tube 30, the pitch Tp of the adjacent micro-channel tubes 30, the wall thickness Tow of each micro-channel tube 30, and the width Wc of each micro-channel 33 satisfy the above-described ranges respectively, the heat exchanger may simultaneously realize optimal performance while securing drainage performance.

[0058] 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.

[0059] 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 extending vertically and connected with an inflow pipe and an outflow pipe;
    a second header spaced apart from the first header by a defined distance and arranged parallel to the first header; and
    a plurality of micro-channel tubes arranged horizontally while being vertically spaced apart from one another by a defined clearance and 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.

2. The heat exchanger according to claim 1, wherein the front row and rear row micro-channel tubes are alternately arranged in a zigzag formation.

3. The heat exchanger according to claim 1, wherein the front row and rear row micro-channel tubes are arranged to be horizontally aligned with each other.

4. The heat exchanger according to claim 1, wherein the micro-channel tubes have a pitch Tp satisfying a range of about 7mm $\leq$ Tp $\leq$ 11mm.

5. The heat exchanger according to claim 1, wherein a thickness Tt of each micro-channel tube satisfies a range of about 2mm $\leq$ Tt $\leq$ 3.5mm.

6. The heat exchanger according to claim 1, wherein a wall thickness Tow of each micro-channel tube satisfies a range of about 0.1mm $\leq$ Tow $\leq$ 0.35mm.

7. The heat exchanger according to claim 1, wherein a width Wc of each micro-channel satisfies a range of about 0.5mm $\leq$ Wc $\leq$ 1.5mm.

8. The heat exchanger according to claim 1, wherein the inflow pipe is connected to a lower side of the first header, whereas the outflow pipe is connected to an upper side of the first header.

9. The heat exchanger according to claim 1, wherein the first and second headers comprise respective

front tanks and respective rear tanks.

10. The heat exchanger according to claim 1, further comprising a plurality of fins corresponding to the plurality of micro-channel tubes, each fin comprising a rectangular plate.

11. The heat exchanger according to claim 10, wherein each fin comprises:

front row slots and rear row slots so that the front row and rear row micro-channel tubes are fitted into the front row slots and the rear row slots, respectively, and
collars perpendicular to the fin body.

FIG. 1

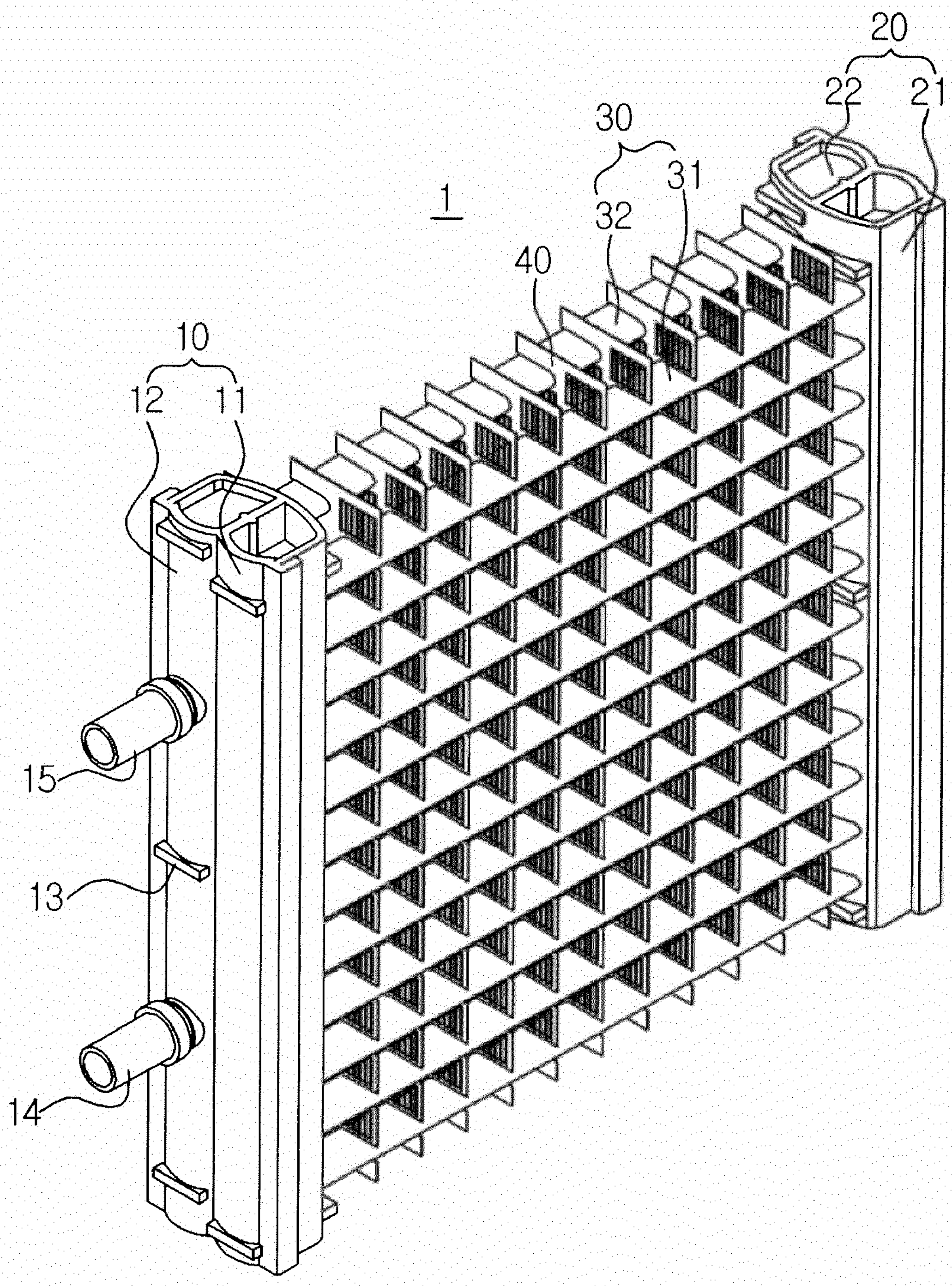


FIG. 2

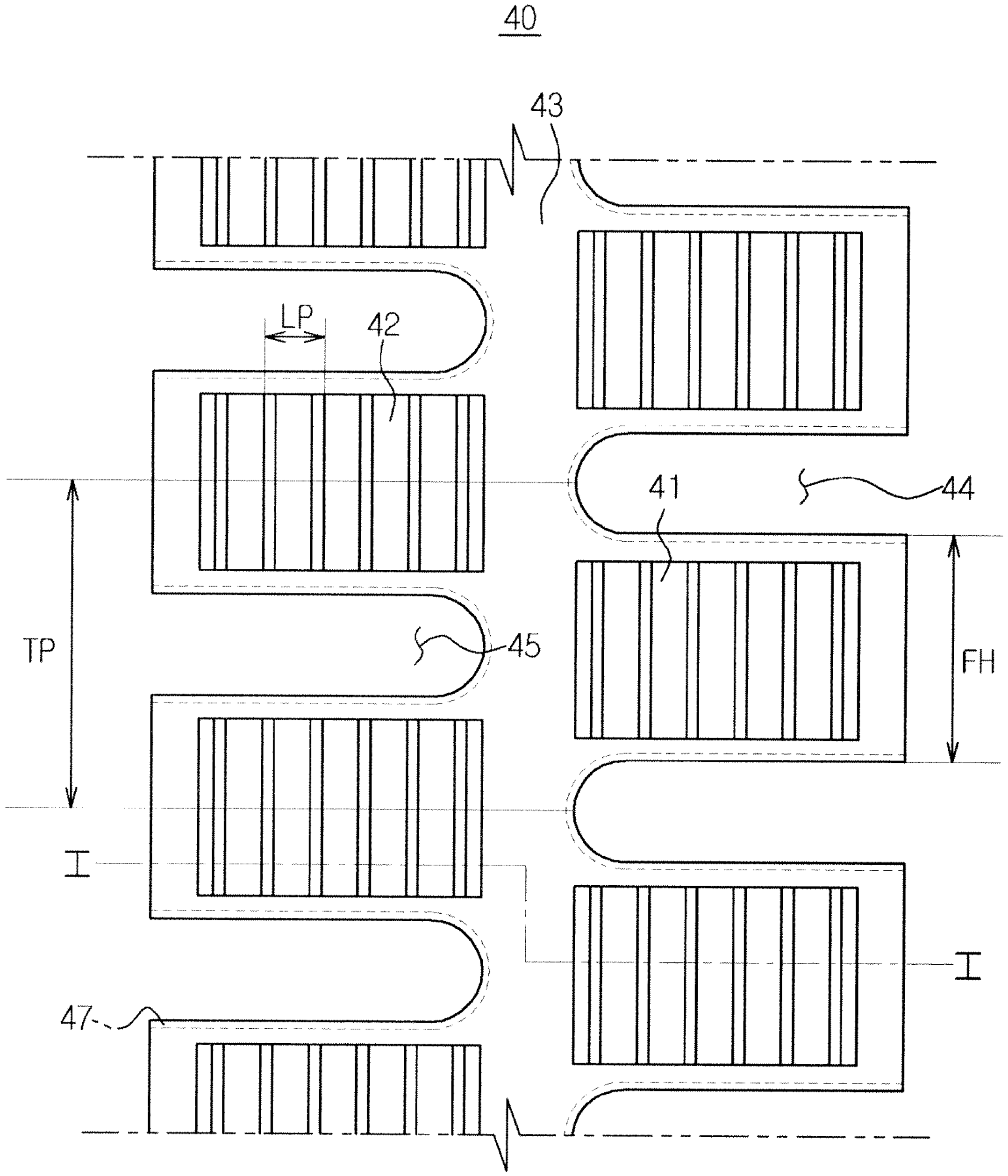


FIG. 3

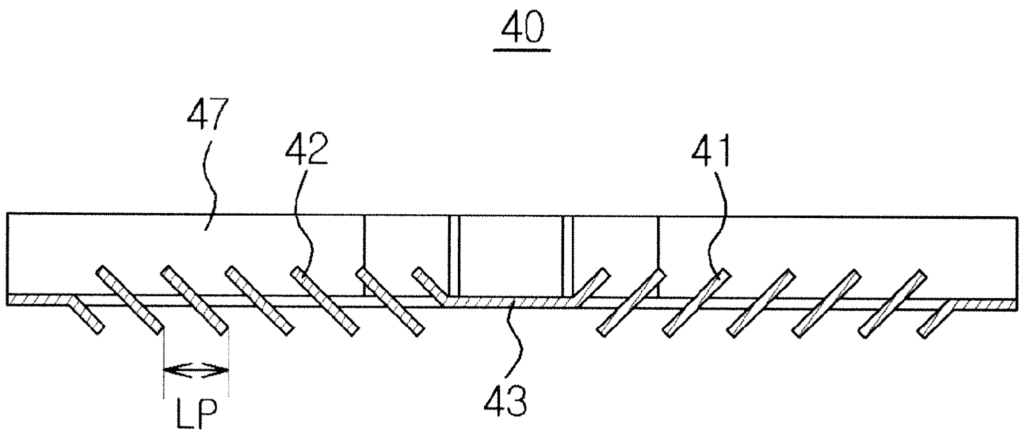


FIG. 4

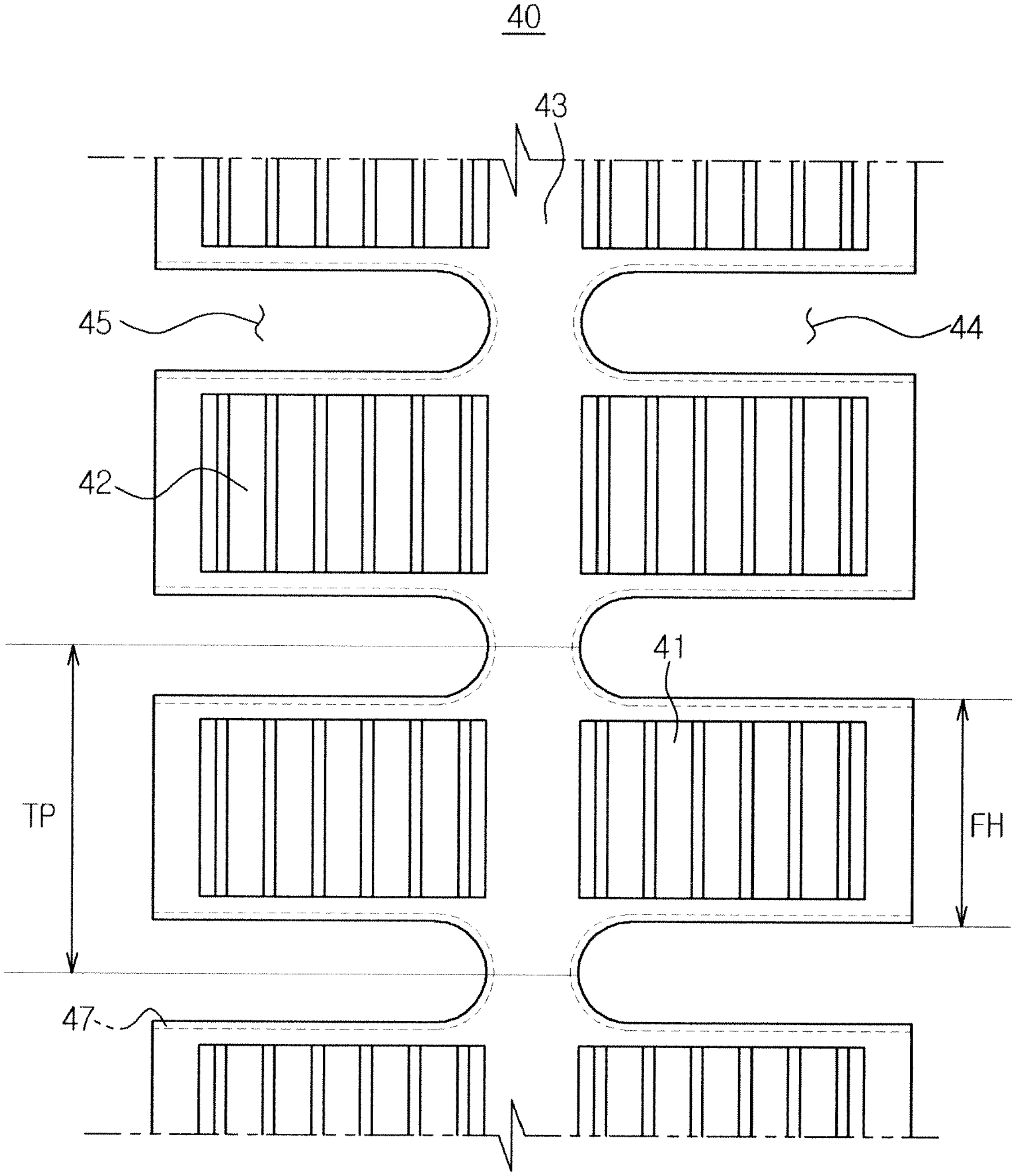


FIG. 5

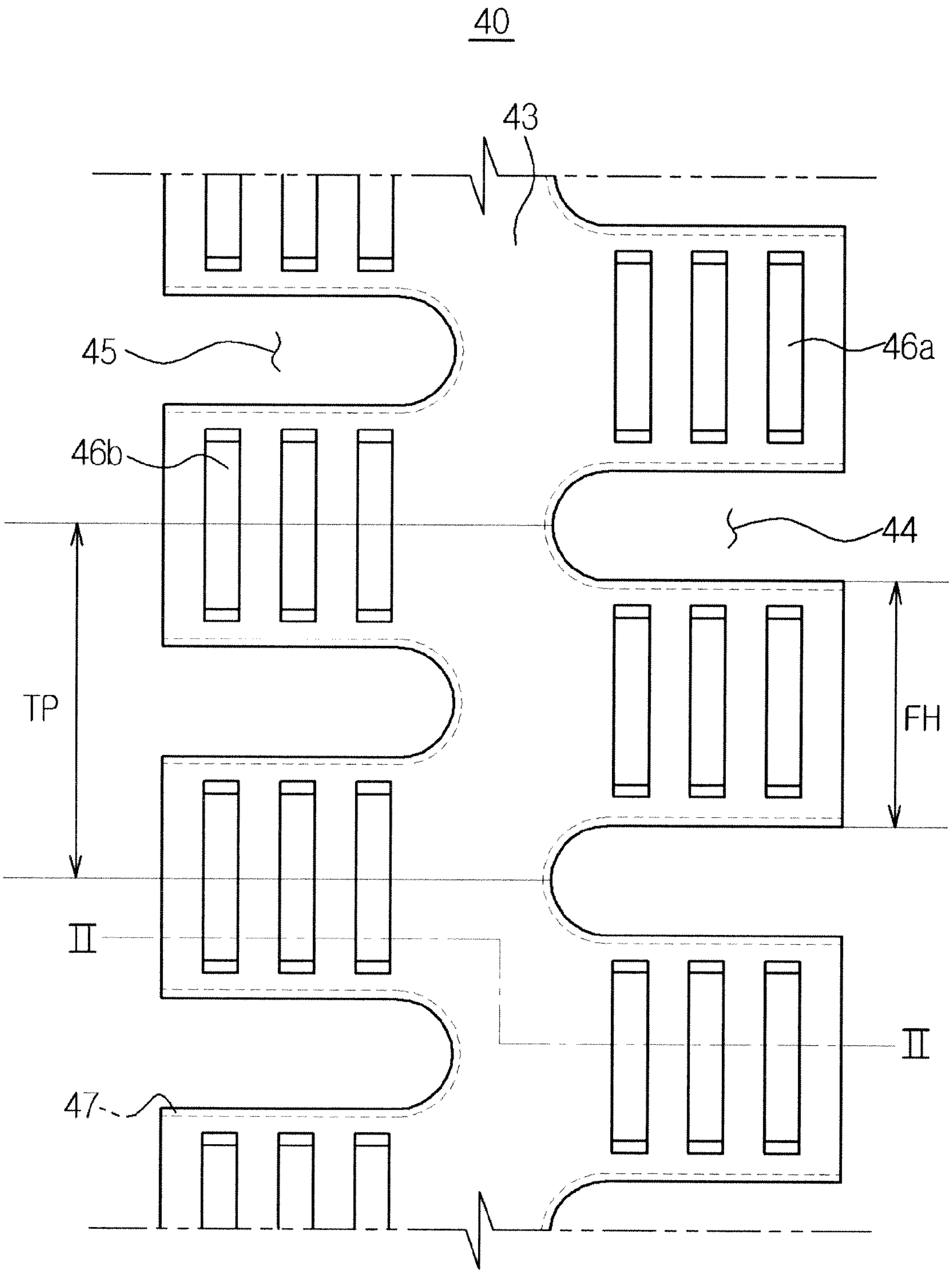


FIG. 6

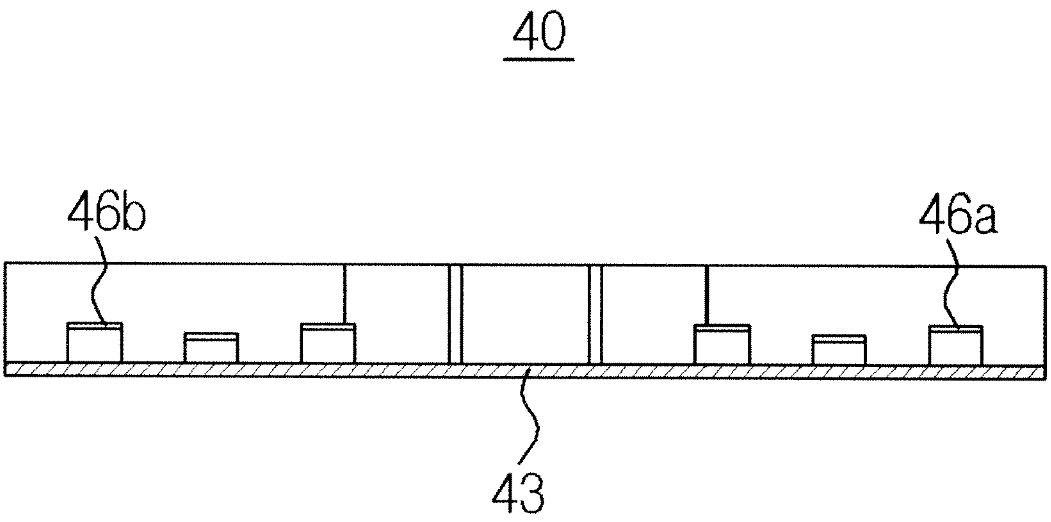


FIG. 7

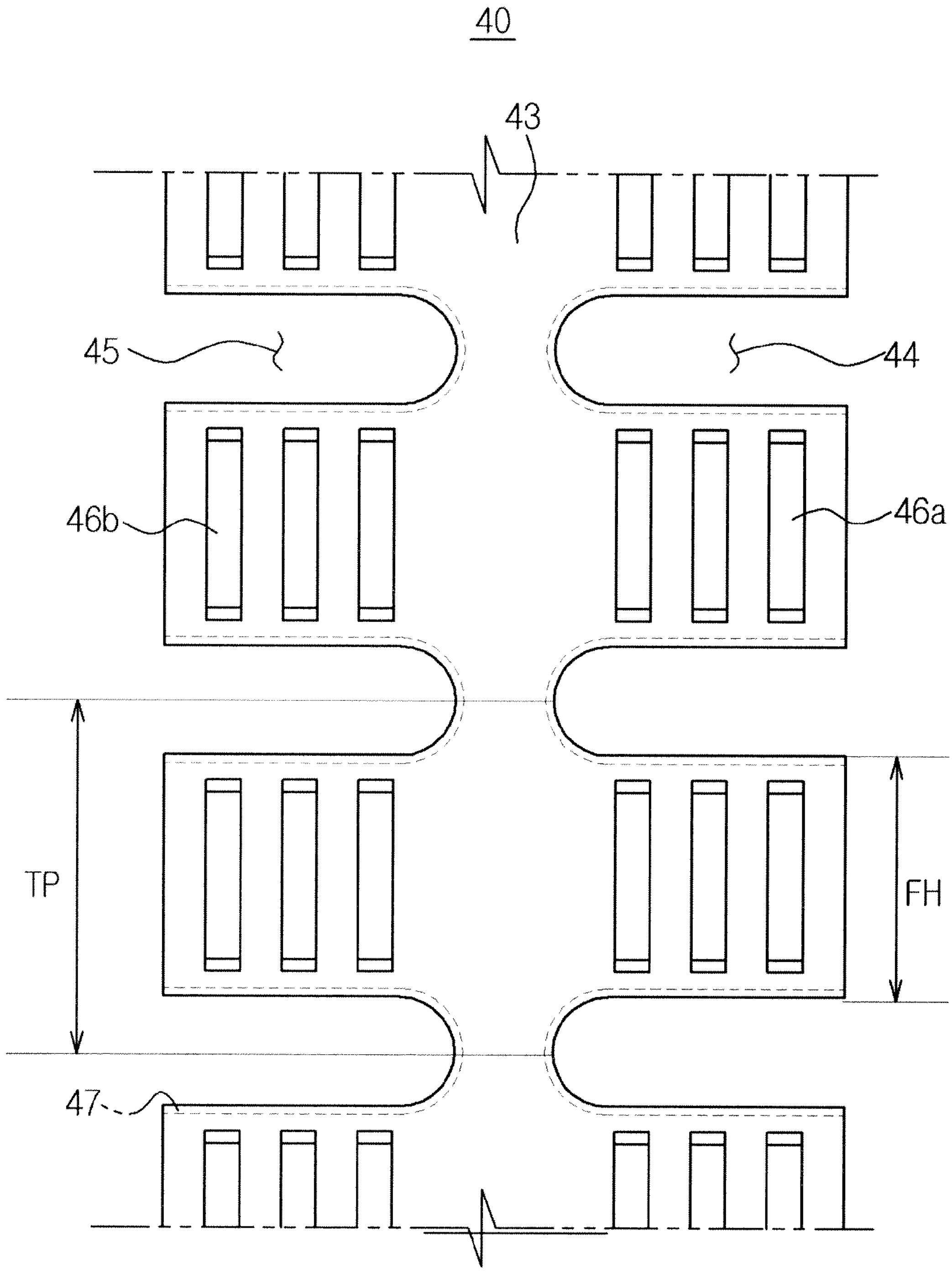


FIG. 8

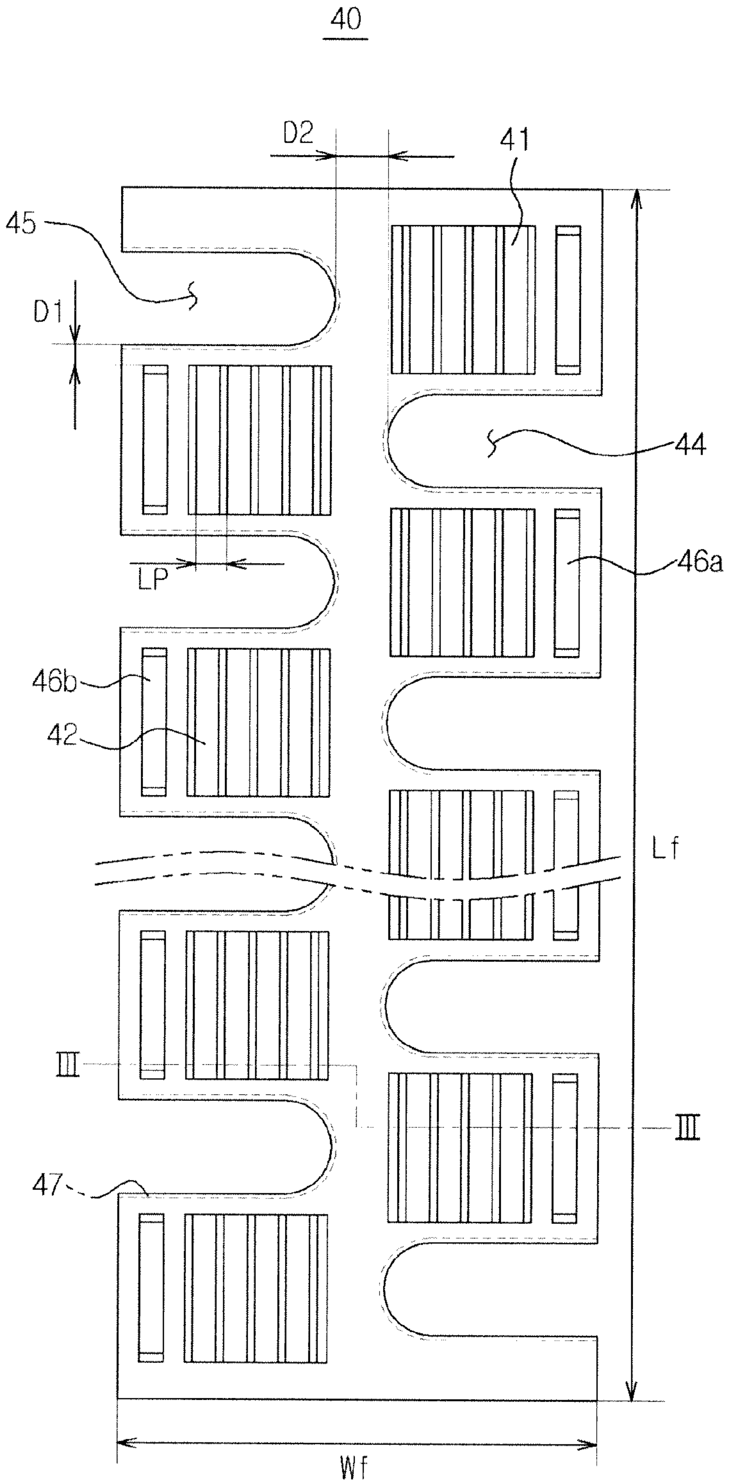


FIG. 9

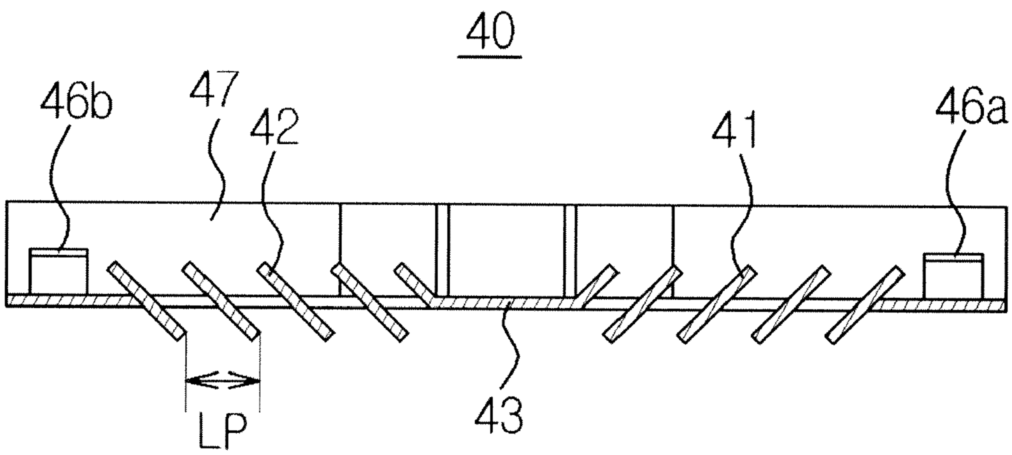


FIG. 10

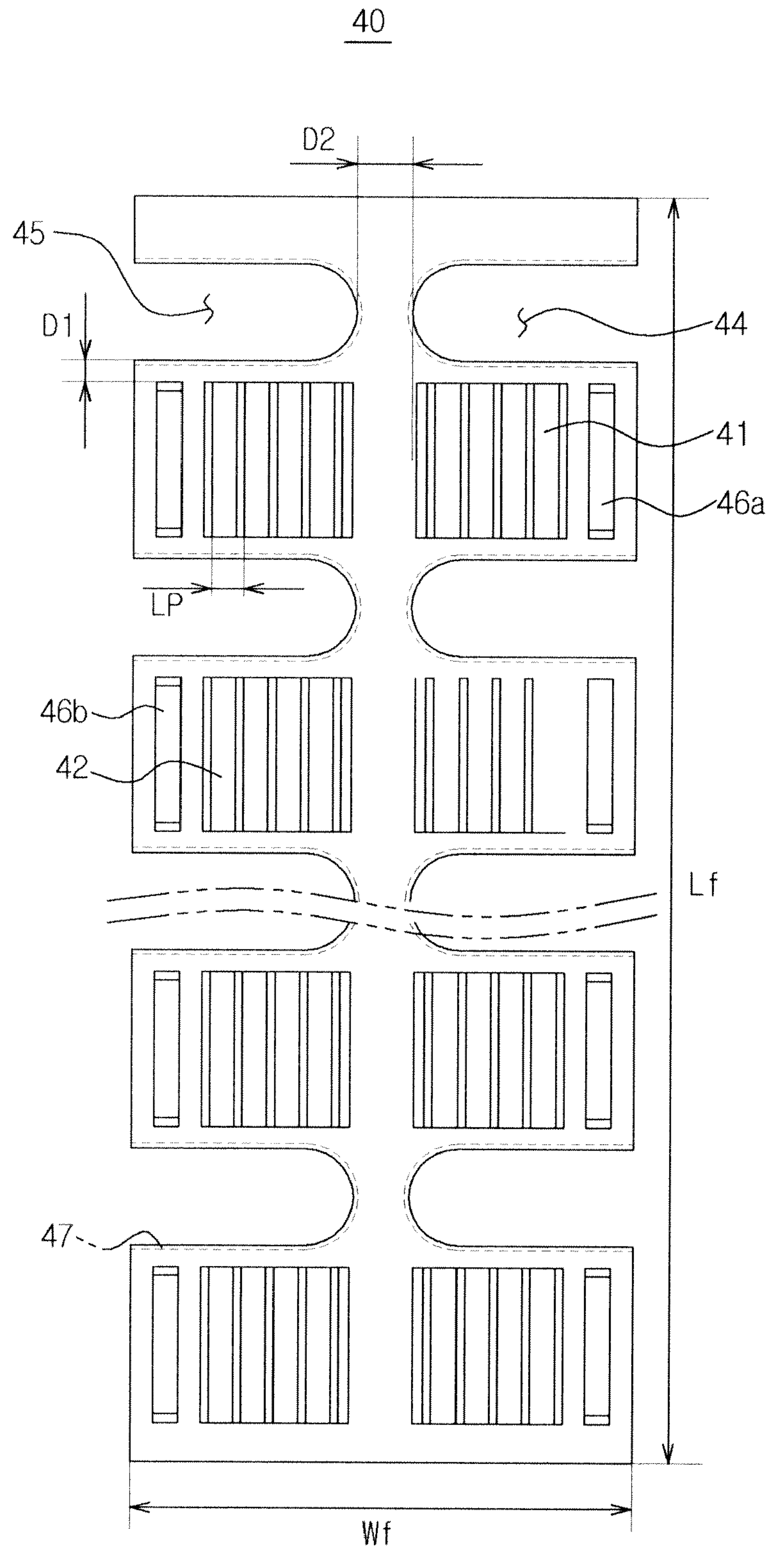


FIG. 11

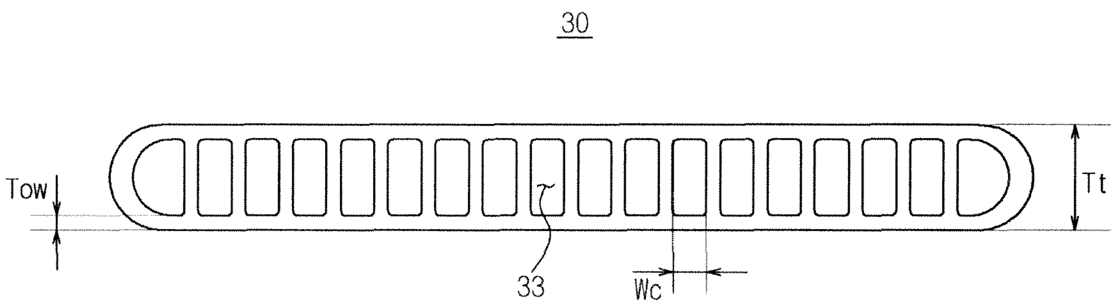


FIG. 12

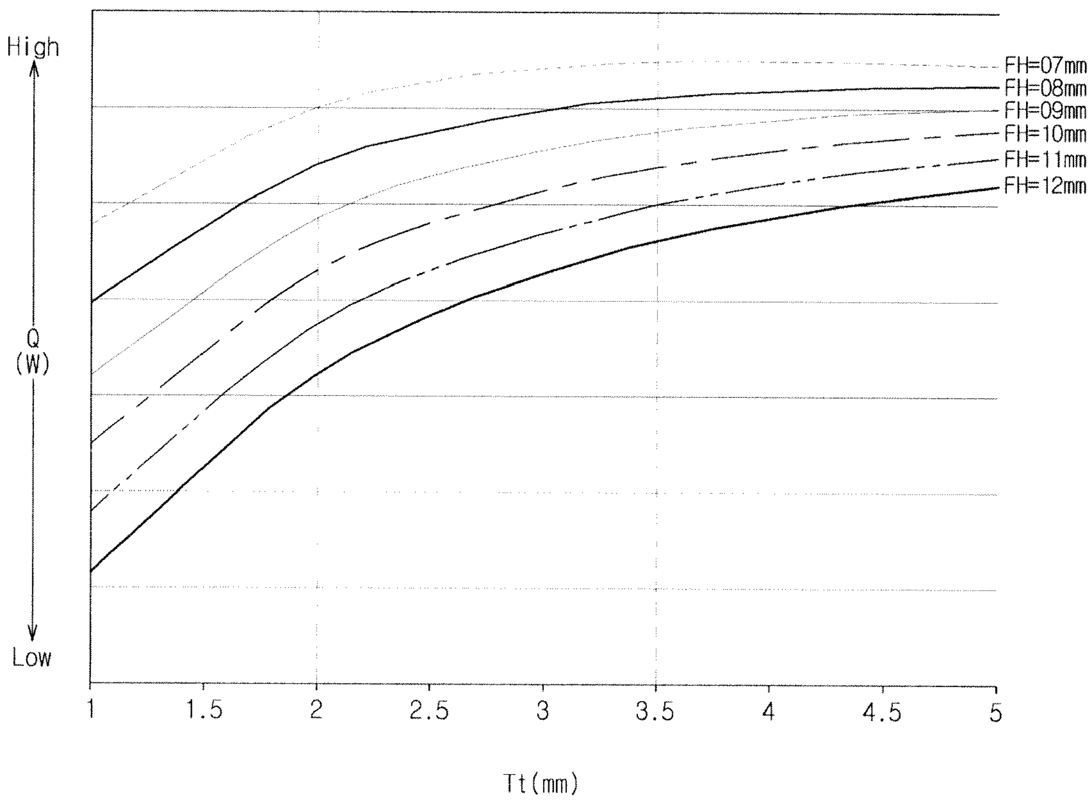
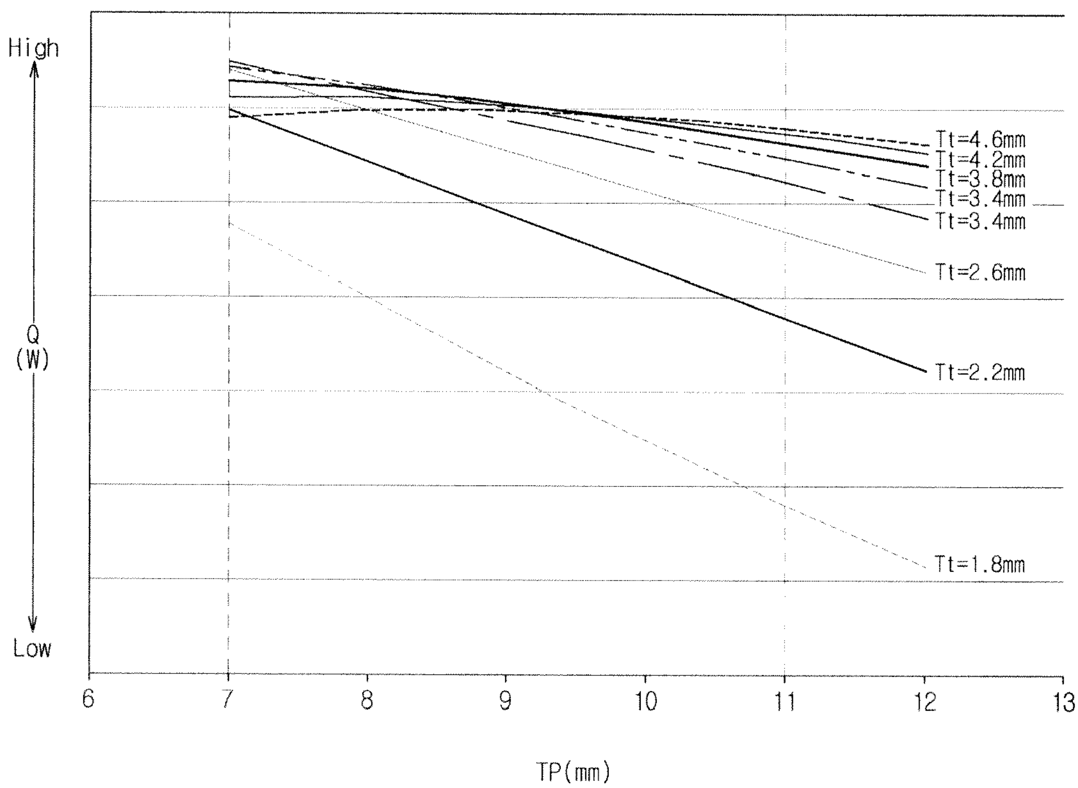

High
Q
(W)
Low
FH=07mm
FH=08mm
FH=09mm
FH=10mm
FH=11mm
FH=12mm
1
1.5
2
2.5
3
3.5
4
4.5
5
Tt(mm)

FIG. 13


High
Q
(W)
Low
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Tt=4.2mm
Tt=3.8mm
Tt=3.4mm
Tt=3.4mm
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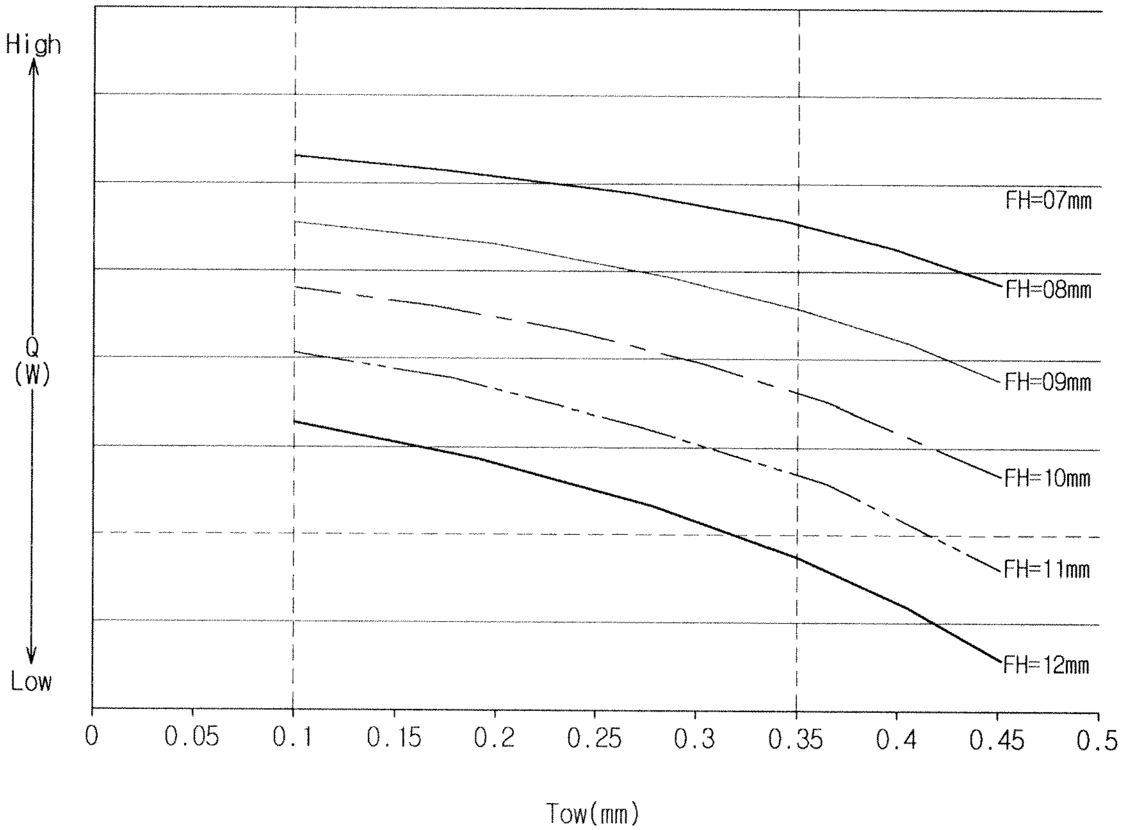
Tt=1.8mm
6
7
8
9
10
11
12
13
TP(mm)

FIG. 14


High
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(W)
Low
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FH=11mm
FH=12mm
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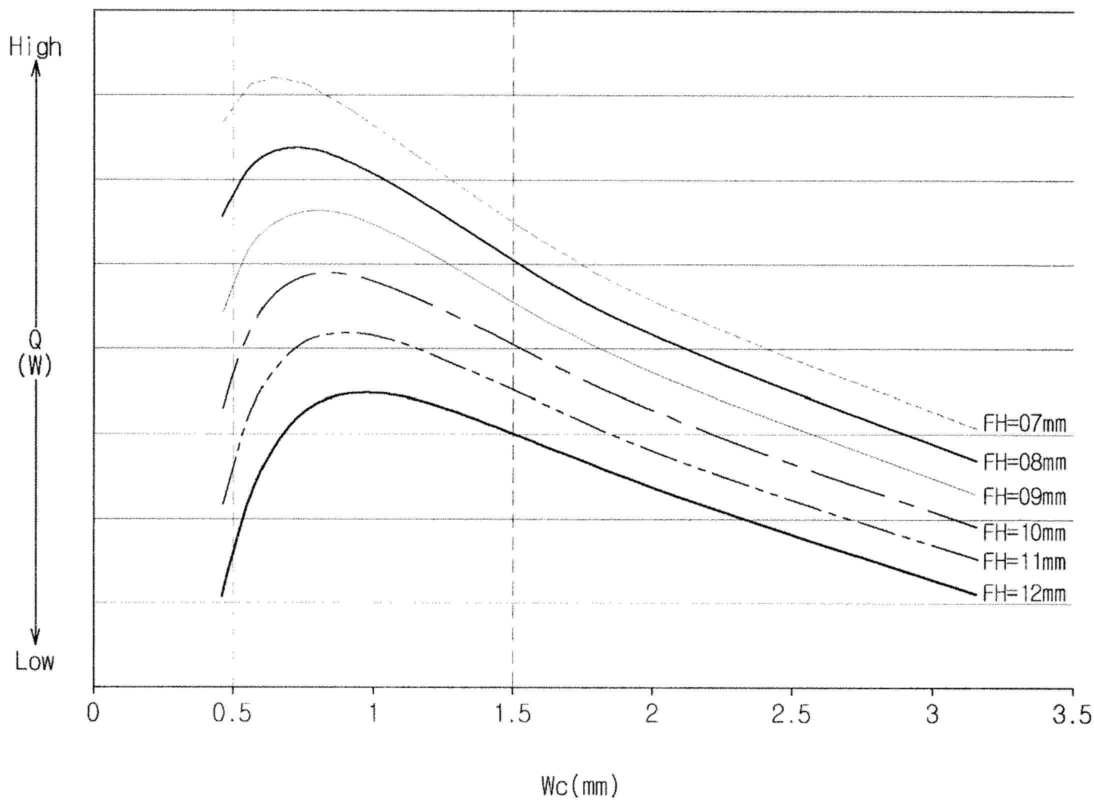
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Tow(mm)

FIG. 15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