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(54) **Stacked pipe heat exchanger with guide members**

(57) A heat exchanger (1) includes a heat transmitting structure (2) for heat exchange and a guide member (3). The heat exchanger (1) is configured to exchange heat between external fluid flowing outside the heat transmitting structure (2) and the heat transmitting structure (2). The heat transmitting structure (2) includes a plurality of heat transmitting members (2a-2h) for heat

exchange. The heat transmitting members (2a-2h) are arranged side by side in such a manner as to have intervals between the adjacent heat transmitting members (2a-2h). The guide member (3) is arranged in the intervals between the heat transmitting members (2a-2h) so as to change a direction of the external fluid flowing outside the heat transmitting structure (2).

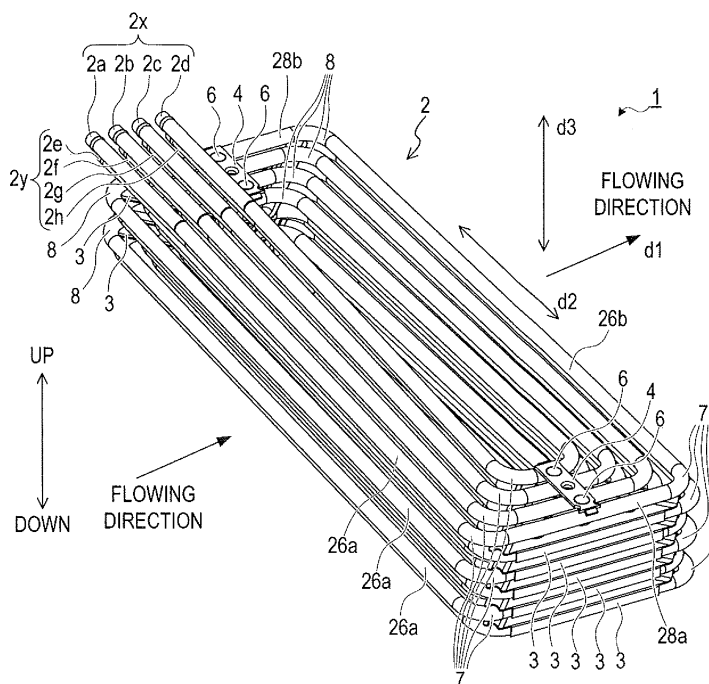


FIG.1

## Description

### BACKGROUND

**[0001]** The present invention relates to a heat exchanger that exchanges heat between external fluid introduced from outside and heat transmitting members for heat exchange.

**[0002]** In the heat exchanger of this type disclosed, for example, in Unexamined Japanese Patent Publication Nos. 2008-025976 and 2008-032252, the pipes are stacked in the housing space to form a pipe group. Each pipe at least includes cross pipes which are pipes arranged in a direction crossing a flowing direction of the external fluid. Each pipe is stacked in a direction crossing a plane defined by a longitudinal direction of the cross pipes and the flowing direction. Each pipe is stacked in such a manner that the pipes adjacent in the stacking direction, as well as the cross pipes adjacent in the stacking direction, are not brought into contact with each other.

### SUMMARY

**[0003]** As noted above, since the pipes are stacked so as not to be brought into contact with each other in the heat exchangers of this type, the external fluid is easy to flow between the pipes adjacent to each other in the stacking direction. The faster the flow of the external fluid between the pipes is, however, the more unlikely sufficient heat exchange is to be achieved between the external fluid and internal fluid inside the pipes. For example, the external fluid may pass through between the pipes before sufficient heat exchange is achieved. Or, some part of the external fluid may pass through between the pipes without being brought into contact with the pipes. In such cases, heat exchange efficiency may be hard to increase.

**[0004]** In one aspect of the invention, it is preferable to be able to enhance heat exchange efficiency of a heat exchanger.

**[0005]** A heat exchanger of the invention includes a heat transmitting structure for heat exchange and a guide member. The heat exchanger is configured to exchange heat between external fluid flowing outside the heat transmitting structure and the heat transmitting structure. The heat transmitting structure includes a plurality of heat transmitting members for heat exchange. The heat transmitting members are arranged side by side in such a manner as to have intervals between the adjacent heat transmitting members. The guide member is arranged in the intervals between the adjacent heat transmitting members so as to change a direction of the external fluid flowing outside the heat transmitting structure.

**[0006]** According to the heat exchanger configured as such, since the guide member changes the direction of the external fluid passing through the intervals, the external fluid is difficult to pass by between the heat transmitting members and then easy to be brought into contact

with the heat transmitting members. Consequently, heat exchange efficiency can be enhanced. The guide member may be arranged in at least a section in the intervals formed between the adjacent heat transmitting members.

**[0007]** In the heat exchanger of the present invention, the heat transmitting members may include pipes inside which internal fluid for heat exchange can flow. Heat may be exchanged between the external fluid flowing outside the heat transmitting members and the internal fluid flowing inside the heat transmitting members. Also, in the present heat exchanger, the heat transmitting members may be arranged to extend in a direction crossing the flowing direction of the external fluid (a direction, for example, orthogonal to the flowing direction of the external fluid on a plane including the flowing direction). The heat transmitting members may be arranged side by side in a direction crossing a plane defined by a longitudinal direction of the heat transmitting members and the flowing direction.

**[0008]** Moreover, in the heat exchanger of the present invention, at least two of the heat transmitting members may be arranged to be in parallel to each other. The heat exchanger of the present invention may include a housing space for housing the heat transmitting structure. The external fluid may flow through the housing space.

**[0009]** The heat transmitting members may be formed into a spiral shape. The spiral shape can also be described as helical shape. Particularly, the heat transmitting members extend in a spiral manner. The spiral transmitting members may include crossing members and connecting members. The crossing members are arranged to extend in the direction crossing the flowing direction of the external fluid. The connecting members connect upstream members which are the crossing members located upstream in the flowing direction and downstream members which are the crossing members located downstream in the flowing direction. The heat transmitting members may be housed in the housing space in such spiral state.

**[0010]** With the above constitution, the heat exchanger including the heat transmitting members having the intervals therebetween as above (i.e., the heat transmitting members not in contact with each other) can be achieved by the spiral heat transmitting members.

**[0011]** One example of the constitution in which the guide member is arranged in at least a section in the intervals formed between the spiral heat transmitting members is as follows. Particularly, the guide member may be arranged in one or both of between first connecting members (more particularly, between the adjacent first connecting members) which are the connecting members located on one end sides of the crossing members and between second connecting members (more particularly, between the adjacent second connecting members) which are the connecting members located on the other end sides of the crossing members. Such constitution allows the guide member to change the di-

rection of the external fluid passing between the adjacent connecting members.

**[0012]** Each of the connecting members connecting the crossing members contacts the external fluid flowing through the intervals between the connecting members. Then, heat is exchanged between the external fluid and the connecting members. If the contact angle upon contact between the connecting members and the external fluid is small, thermal boundary layers generated in the connecting members are difficult to be separated from surface of the connecting member. In this case, heat is not efficiently exchanged. The thermal boundary layer herein indicates a layer having a predetermined thickness, which is brought into contact with a surface of the heat transmitting member. The thermal boundary layer has a different temperature than a surrounding area outside the thermal boundary layer. If the thermal boundary layer exists, direct heat transmission between the external fluid and the heat transmitting member is blocked. Thus, thermal conversion efficiency is reduced.

**[0013]** However, if the guide member is arranged in the intervals between the connecting members as in the above-described constitution, the direction of the external fluid flowing through the intervals can be changed. Separation of the thermal boundary layers generated in the connecting members can be promoted. In this manner, heat exchange efficiency between the connecting members and the external fluid upon contact between the connecting members and the external fluid can be enhanced.

**[0014]** Also, since such change in the direction of the external fluid can promote separation of the thermal boundary layers in end areas of the crossing members, heat exchange efficiency in the whole heat exchanger can be also enhanced.

**[0015]** Particulars of the guide member in the above-described respective constitutions are not specifically limited as long as the direction of the external fluid flowing along a flowing direction can be changed after the external fluid reaches the guide member. For example, the guide member may be configured as below.

**[0016]** Particularly, the guide member may include a plate-like portion interposed between the adjacent heat transmitting members, and a protruding portion protruding from a plane of the plate-like portion. In this constitution, since the protruding portion protrudes from the plane of the plate-like portion of the guide member, the direction of the external fluid flowing along the flowing direction can be changed. For example, contact of the external fluid with the protruding portion can change the direction of the external fluid to a direction toward the adjacent heat transmitting members forming the interval including the plate-like portion.

**[0017]** In the above-described constitution, the protruding portion of the guide member may only protrude from the plate-like portion. There is no limitation in where on the plate-like portion the protruding portion is provided. However, it is preferable that the protruding portion

protrudes from the plate-like portion over as broad a range as possible in the plate-like portion so that the external fluid can be guided toward the heat transmitting members in a broader range.

**[0018]** Specifically, it is preferable that the protruding portion may be arranged over the maximum possible range in the plate-like portion. The protruding portion may be also arranged to extend in the direction crossing the flowing direction of the external fluid. In other words, the protruding portion may be arranged such that the external fluid flowing along the flowing direction of the external fluid can hit the protruding portion.

**[0019]** In the above-described constitution, owing to the protruding portion extending in the direction crossing the flowing direction of the external fluid, the external fluid flowing through the intervals between the adjacent heat transmitting members abuts on the protruding portion and is then guided toward the respective adjacent heat transmitting members forming the interval including the plate-like portion. In other words, the direction of the external fluid flowing along the flowing direction is changed.

**[0020]** Other constitutions may be described as follows. Particularly, the protruding portion of the guide member protrudes obliquely toward one of the two adjacent heat transmitting members of the heat transmitting members forming the interval including the plate-like portion of the guide member.

**[0021]** In the above-described constitution, the external fluid flowing through the intervals between the heat transmitting members can be obliquely guided toward one of the two adjacent heat transmitting members of the heat transmitting members forming the interval including the plate-like portion of the guide member. In other words, the direction of the external fluid flowing along the flowing direction can be changed. In this case, an angle at which the external fluid abuts on the protruding portion becomes smaller than a right angle. Thus, the protruding portion does not largely obstruct the downstream flow of the external fluid. As a result, the protruding portion can guide the external fluid toward one of the two adjacent heat transmitting members of the heat transmitting members forming the interval including the plate-like portion of the guide member, without largely obstructing the flow of the external fluid. Opportunities to bring the external fluid into contact with the heat transmitting members can be increased. In this case, heat exchange efficiency can be enhanced.

**[0022]** The protruding portion of the guide member in the above-described respective constitutions only has to protrude from the plane of the plate-like portion. For example, the protruding portion may be a member attached to the plate-like portion, a member formed by cutting and raising the plate-like portion, or a member integrally formed with the plate-like portion.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0023]** The present invention will be described herein-

after by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of appearance of a heat exchanger 1;  
 FIG. 2 is a diagram showing a heat transmitting pipe group 2 viewed in a flowing direction d1 of external fluid;  
 FIG. 3A is a plan view of a guide member 3;  
 FIG. 3B is a side view of the guide member 3;  
 FIG. 4 is a perspective view showing a state of assembling the heat exchanger 1;  
 FIG. 5 is diagram showing an example of the heat exchanger 1 being used; and  
 FIG. 6 is an enlarged view showing a protruding portion 37.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

### (1) Overall constitution

**[0024]** Referring to FIG. 5, a heat exchanger 1 passes and discharges external fluid (not shown) introduced from outside through a housing space (space inside a casing 10) 11 which houses a heat transmitting pipe group 2 so as to exchange heat between the external fluid and internal fluid flowing inside pipes 2a to 2h (see FIG. 1) constituting the heat transmitting pipe group 2. The heat transmitting pipe group 2, as shown in FIG. 1, includes a first pipe set 2x and a second pipe set 2y. The first pipe set 2x includes the pipes 2a, 2b, 2c and 2d. The second pipe set 2y includes the pipes 2e, 2f, 2g and 2h.

**[0025]** In the housing space 11, the pipe 2a spirally extends so as to form a near rectangle. The same applies to the other pipes 2b to 2h. The pipes 2a to 2h (in other words, the whole heat transmitting pipe group 2) form a near parallelepiped. The first pipe set 2x and the second pipe set 2y are slightly shifted from one another along a flowing direction d1 of the external fluid while being stacked along a stacking direction d3. The stacking direction d3 is understood as a direction orthogonal to an arrangement direction of the pipes 2a to 2d, or an arrangement direction of the pipes 2e to 2h (which is the same direction as the flowing direction d1 of the external fluid) (see FIG. 1).

**[0026]** Now, constitutions of the pipes 2a to 2h will be explained. Hereinafter, description on the pipe 2a will be given and description on the other pipes 2b to 2h will be omitted, since the pipes 2b to 2h are constituted in the same manner as the pipe 2a.

**[0027]** The pipe 2a includes an upstream pipe 26a, a downstream pipe 26b and connecting pipes 28a and 28b. The upstream pipe 26a is part of the pipe 2a that is arranged along a direction d2 crossing the flowing direction d1 of the external fluid on an upstream side of the flowing direction d1 of the external fluid. The downstream pipe 26b is part of the pipe 2a that is arranged along the di-

rection d2 crossing the flowing direction d1 of the external fluid on a downstream side of the flowing direction d1 of the external fluid. The connecting pipes 28a and 28b are parts of the pipe 2a that connects the upstream pipe 26a and the downstream pipe 26b. Hereinafter, description on the upstream pipes, the downstream pipes and the connecting pipes of the pipes 2b to 2h is omitted. However, it is easily understood by those skilled in the art that the pipes 2b to 2h have the same constitution as the pipe 2a.

**[0028]** In FIG. 1, three upstream pipes 26a can be seen regarding the pipe 2a. In FIG. 2, two upstream pipes 26a are shown regarding the pipe 2a. As shown in FIGS. 1 and 2, the adjacent upstream pipes 26a are positioned at regular intervals along the stacking direction d3. The same applies to the downstream pipes 26b. Also, the upstream pipes 26a and the downstream pipes 26b slope with respect to a horizontal plane in a state where the heat exchanger 1 is installed for use (see FIG. 2).

**[0029]** Between the first pipe set 2x and the second pipe set 2y, interspaces 12 (see FIG. 2) are formed which extend along a longitudinal direction of the pipes 2a to 2h. In each of the interspaces 12, a guide member 3 is provided to change the direction of the external fluid flowing along the flowing direction d1. More particularly, in the present embodiment, the guide member 3 (see FIG. 2) is arranged in both interspaces 12a (see FIG. 2) which are the interspaces 12 formed between the adjacent connecting pipes (between the connecting pipe 28a and another connecting pipe adjacent thereto) and interspaces 12b (see FIG. 2) which are the interspaces 12 formed between the adjacent connecting pipes (between the connecting pipe 28b and another connecting pipe adjacent thereto).

**[0030]** The guide member 3 is, as shown in FIGS. 3A and 3B, includes a plate-like portion 33 spreading out to form a near triangle, and a protruding portion 37 that protrudes from the plate-like portion 33. The protruding portion 37 is formed all along sides 35 and 36 other than a base 34 of the plate-like portion 33. Particularly, the protruding portion 37 has a shape convexly bent upward (in particular, orthogonally upward; see FIGS. 3A and 3B), with the guide member 3 interposed in the interspace 12 and the heat exchanger 1 arranged in a state of use. Specifically, the protruding portion 37 protrudes obliquely toward the pipes 2a to 2d or the pipes 2e to 2h (i.e., the pipes forming the interspaces 12a and 12b including the plate-like portions 33). Particularly, a portion R1 (see FIG. 6) corresponds to the portion "protruding obliquely upward". The portion R1 can be understood as a portion which is raised upward from an upstream side toward a downstream side of the convexly bent portion of the protruding portion 37 when the guide members 3 are arranged in the interspaces 12a and 12b.

**[0031]** The guide member 3 is interposed between the adjacent connecting pipes so that the protruding portion 37 abuts on spots near connection points 7 between the connecting pipe 28a and the upstream pipe 26a and be-

tween the connecting pipe 28a and the downstream pipe 26b, and spots near connection points 8 between the connecting pipes 28b and the upstream pipes 26a and between the connecting pipes 28b and the downstream pipes 26b. Also, in the plate-like portion 33 of the guide member 3, a plurality of through holes 39 are formed which penetrate the plate-like portion 33 in its thickness direction.

**[0032]** As shown in FIG. 4, the guide member 3 is fixed to the first pipe set 2x or the second pipe set 2y by clamping members 4 and 5 and bar-like connecting members 6. The clamping members 4 and 5 are provided to clamp the first pipe set 2x or the second pipe set 2y. The connecting members 6 connect the clamping members 4 and 5.

## (2) Operation and effect

**[0033]** In the heat exchanger 1 constituted as such, the protruding portion 37 of the guide member 3 can change the direction of the external fluid flowing along the flowing direction d1 in the midst of a flow passage of the external fluid. As a result, it is difficult for the external fluid to pass by between the first pipe set 2x and the second pipe set 2y. It becomes easy for the external fluid to be brought into contact with the first pipe set 2x and the second pipe set 2y (more particularly, the pipes 2a to 2h) forming the interspaces 12a and 12b including the guide members 3. Therefore, heat exchange efficiency can be enhanced.

**[0034]** Also in the above-described embodiment, the guide member 3 is arranged in the respective interspaces 12a and 12b, of the interspaces 12 (see FIG. 2). Therefore, the direction of the external fluid flowing along the flowing direction d1 passing between the interspaces 12a and 12b can be changed.

**[0035]** If the guide member 3 is arranged in the interspaces 12a and the interspaces 12b as such, the direction of the external fluid flowing along the flowing direction d1 flowing through the interspaces 12a and 12b can be changed. Also, exfoliation of the thermal boundary layers generated in the connecting pipes 28a and 28b can be facilitated. Thus, heat exchange efficiency by contact between the connecting pipes 28a, 28b and the external fluid can be enhanced. The thermal boundary layers are layers having a predetermined thickness and in contact with surfaces of the pipes 2a to 2h. The thermal boundary layers have a different temperature than a surrounding area outside the thermal boundary layers.

**[0036]** The change in the direction of the external fluid flowing along the flowing direction d1 as such can facilitate exfoliation of the thermal boundary layers at end portions of the upstream pipes 26a and the downstream pipes 26b, thereby contributing to enhancement of heat exchange efficiency in the whole heat exchanger 1.

**[0037]** In the above-described embodiment, the protruding portion 37 protrudes from the plane of the plate-like portion 33 in the guide member 3. Thus, the external

fluid which abuts on the protruding portion 37 can flow toward the first pipe set 2x and the second pipe set 2y forming the interspaces 12a and 12b including the plate-like portions 33.

**[0038]** In the above-described embodiment, the external fluid can be guided toward the downstream pipes 26b located downstream without largely obstructing the flow of the external fluid. Particularly, as shown in FIG. 6, the protruding portion 37 does not largely obstruct downstream flow of the external fluid since an angle  $\alpha$  at which the external fluid abuts on the protruding portion 37 becomes smaller than a right angle. As a result, the flow of the external fluid can be adjusted to be brought into contact with the pipes 2a to 2h (more particularly, the downstream pipes 26b or the connecting pipes 28a and 28b) at a predetermined angle over a broad range. Thereby, heat exchange efficiency can be enhanced. As above, in the present embodiment, the protruding portion 37 has to at least have a surface with which the external fluid is brought into contact at the angle  $\alpha$  (see FIG. 6) smaller than a right angle. The protruding portion 37 can take any form as long as a surface is provided with which the external fluid is brought into contact at the angle  $\alpha$  smaller than a right angle.

**[0039]** In the above-described embodiment, the protruding portion 37 can be formed by easy processing such as bending an edge side of the plate-like portion 33. Thus, the guide member 3 can be easily formed from a mere plate-like member. Moreover, by bending the edge side of the plate-like portion 33, bending strength of the guide member 3 can be improved.

**[0040]** When the guide member 3 is arranged between the adjacent connecting pipes, the protruding portion 37 abuts on the spot near the connection points 7 between the connecting pipe 28a and the upstream pipe 26a and between the connecting pipe 28a and the downstream pipe 26b, or the connection points 8 between the connecting pipe 28b and the upstream pipe 26a and between the connecting pipe 28b and the downstream pipe 26b. Thus, backlash in the pipes 2a to 2h in the stacking direction d3 can be inhibited.

**[0041]** In the above-described embodiment, the through holes 39 are formed in the plate-like portion 33 of the guide member 3. Thus, fluid such as ambient air and moisture can flow through the through holes 39. As a result, retention of the fluid around the guide member 3 can be avoided.

**[0042]** In the above-described embodiment, the heat transmitting pipe group 2 is an example of the heat transmitting structure. The pipes 2a to 2h is an example of the heat transmitting members and pipes. The flowing direction d1 is an example of the "flowing direction of the external fluid". The direction d2 is an example of the "direction crossing the flowing direction of the external fluid". The direction d3 is an example of the "direction crossing the surface defined by the longitudinal direction of the heat transmitting members and the flowing direction". The upstream pipes 26a and the downstream pipes 26b

are examples of the crossing members, in which the upstream pipes 26a correspond to the upstream members and the downstream pipes 26b correspond to the downstream members. The connecting pipes 28a and 28b are examples of the connecting members. For example, the connecting member 28a corresponds to the first connecting member, and the connecting member 28b corresponds to the second connecting member.

### (3) Variations

**[0043]** In the above, an embodiment of the invention has been described. It goes without saying, however, that the present invention is not limited to the above-described embodiment, and can take various modes within the technical scope of the invention.

**[0044]** For example, the pipes 2a to 2h may only include sections (the upstream pipe 26a and the downstream pipe 26b) arranged along the direction d2 crossing the flowing direction d1 of the external fluid on upstream and downstream sides. The upstream pipe 26a and the downstream pipe 26b may be formed by individual pipes.

**[0045]** The particular constitution of the guide member 3 is not limited to that of the above-described embodiment, as long as the guide member 3 can change the direction of the external fluid flowing along the flowing direction after the external fluid reaches the guide member 3.

**[0046]** In the above-described embodiment, the protruding portion 37 may only protrude from part of the plate-like portion 33.

**[0047]** In the above-described embodiment, the protruding portion 37 of the guide member 3 may only have to protrude from the plane of the plate-like portion 33. For example, the protruding portion 37 may be a member attached to the plate-like portion 33, a member formed by cutting and raising the plate-like portion 33, or a member integrally formed with the plate-like portion 33.

**[0048]** In the above-described embodiment, the protruding portion 37 may protrude downward (perpendicularly downward) when the guide member 3 is interposed between the first pipe set 2x and the second pipe set 2y in a state of use of the heat exchanger 1. Or, the protruding portion 37 may protrude on both the upper surface side and lower surface side.

**[0049]** In the above-described embodiment, the guide member 3 may be arranged in only one of the interspaces 12a and the interspaces 12b. Also, one or more guide members 3 may be provided in the interspaces between the adjacent upstream pipes 26a.

### Claims

1. A heat exchanger (1) comprising a heat transmitting structure (2) for heat exchange and a guide member (3), the heat exchanger (1) being configured to ex-

change heat between external fluid flowing outside the heat transmitting structure (2) and the heat transmitting structure (2),

the heat transmitting structure (2) including a plurality of heat transmitting members (2a-2h) for heat exchange, the heat transmitting members (2a-2h) being arranged side by side in such a manner as to have intervals between the adjacent heat transmitting members (2a-2h),

the guide member (3) being arranged in the intervals between the adjacent heat transmitting members (2a-2h) so as to change a direction of the external fluid flowing outside the heat transmitting structure (2).

2. The heat exchanger (1) according to claim 1, wherein the heat transmitting members (2a-2h) include pipes (2a-2h) inside which internal fluid for heat exchange can flow, and

heat is exchanged between the external fluid flowing outside the heat transmitting member (2a-2h) and the internal fluid flowing inside the heat transmitting member (2a-2h).

3. The heat exchanger (1) according to claim 1 or 2, wherein

the heat transmitting members (2a-2h) are arranged to extend in a direction crossing the flowing direction of the external fluid, and arranged side by side in a direction crossing a plane defined by a longitudinal direction of the heat transmitting members (2a-2h) and the flowing direction.

4. The heat exchanger (1) according to one of claims 1 to 3, wherein at least two of the heat transmitting members (2a-2h) are arranged to be in parallel to each other.

5. The heat exchanger (1) according to one of claims 1 to 4, further comprising a housing space (11) for housing the heat transmitting structure (2), and the external fluid flows through the housing space (11).

6. The heat exchanger (1) according to one of claims 1 to 5, wherein

the heat transmitting members (2a-2h) extend in a spiral manner, and include crossing members (26a, 26b) that are arranged to extend in the direction crossing the flowing direction of the external fluid and connecting members (28a, 28b) that connect upstream crossing members (26a) which are the crossing members (26a, 26b) located upstream in the flowing direction and downstream crossing members (26b) which are the crossing members (26a, 26b) located downstream in the flowing direction.

7. The heat exchanger (1) according to claim 6, wherein the guide member (3) is arranged in one or both of

between adjacent first connecting members (28a) which are the connecting members (28a,28b) located on one end sides of the crossing members (26a. 26b) and between adjacent second connecting members (28b) which are the connecting members (28a,28b) located on the other end sides of the crossing members (26a.26b). 5

8. The heat exchanger (1) according to one of claims 1 to 7, wherein 10  
the heat transmitting members (2a-2h) are arranged side by side in such a manner as to have intervals between the adjacent heat transmitting members (2a-2h). 15

9. The heat exchanger (1) according to one of claims 1 to 8,  
the guide member (3) includes a plate-like portion (33) interposed between the heat transmitting members (2a-2h), and a protruding portion (37) protruding 20  
from a plane of the plate-like portion (33).

10. The heat exchanger (1) according to claim 9, wherein 25  
the protruding portion (37) of the guide member (3) protrudes obliquely toward the heat transmitting members (2a-2h) forming an interval including the plate-like portion (33). 30

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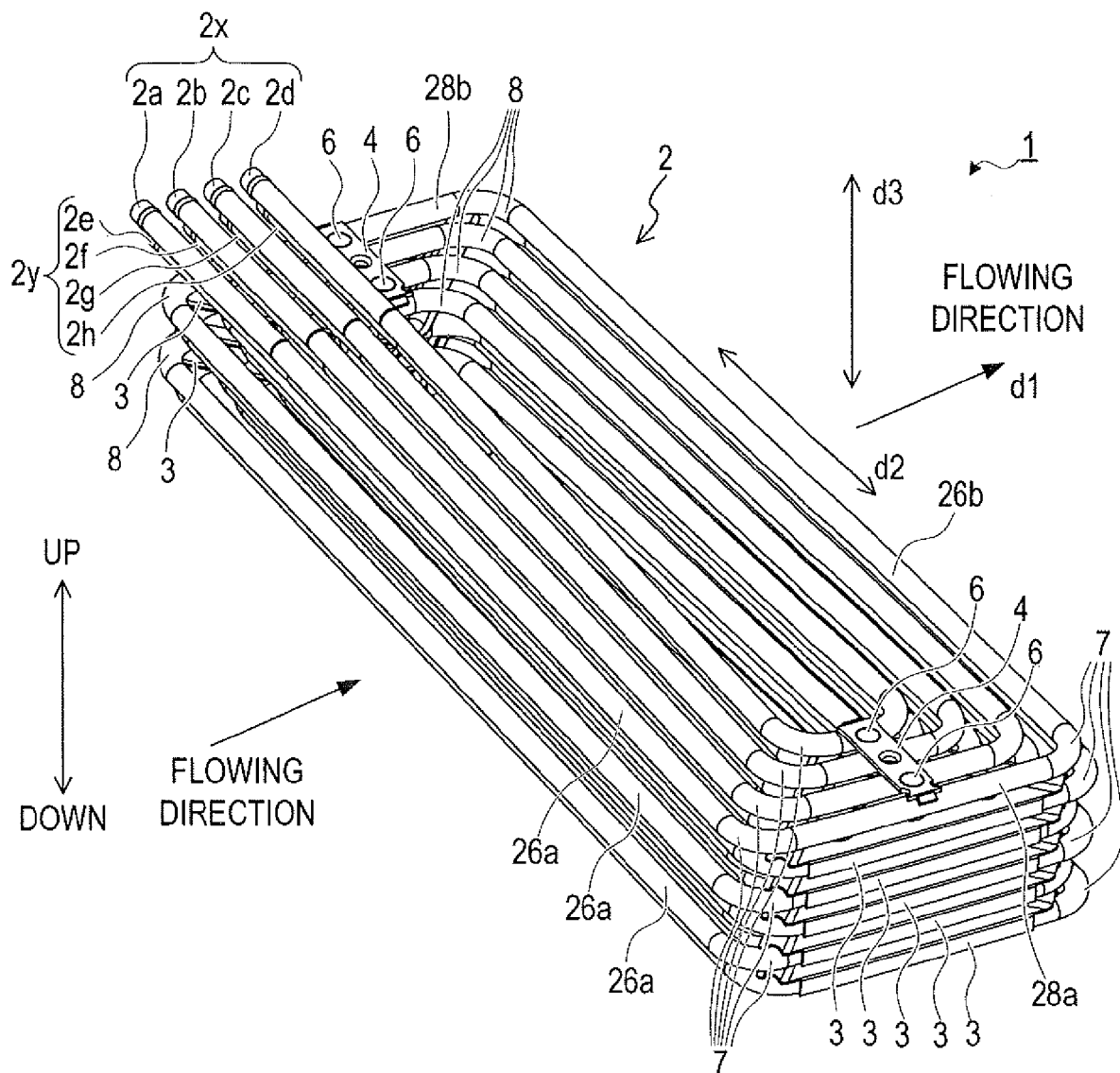


FIG.1



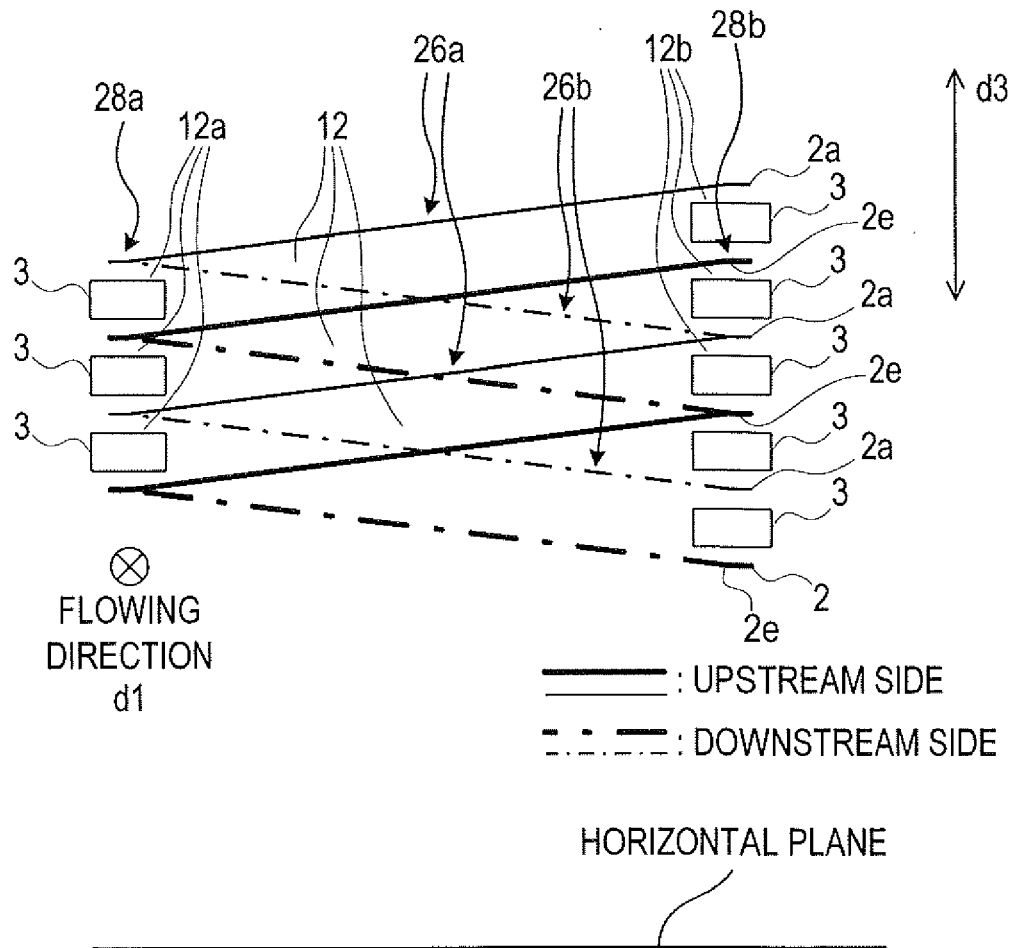


FIG.2

FIG.3A

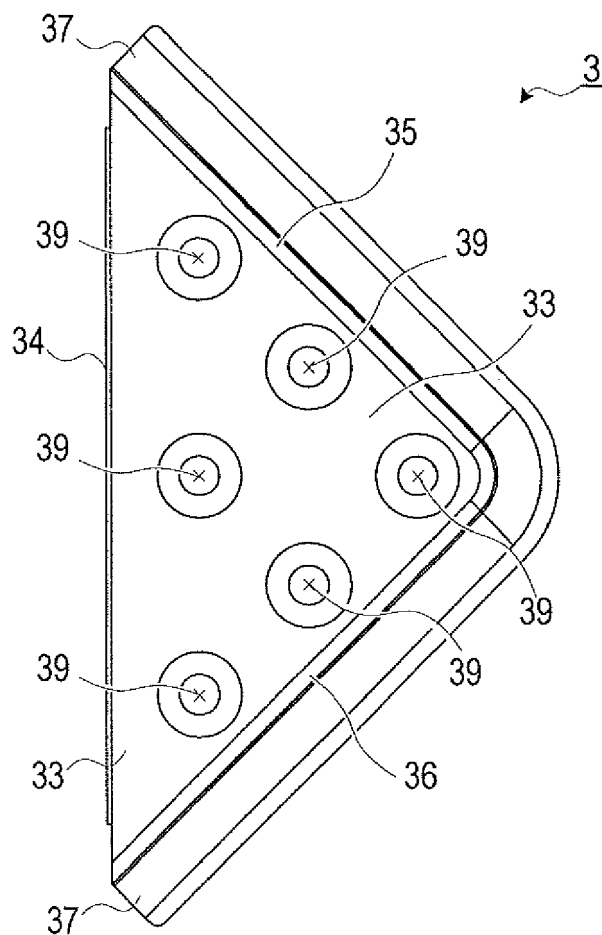
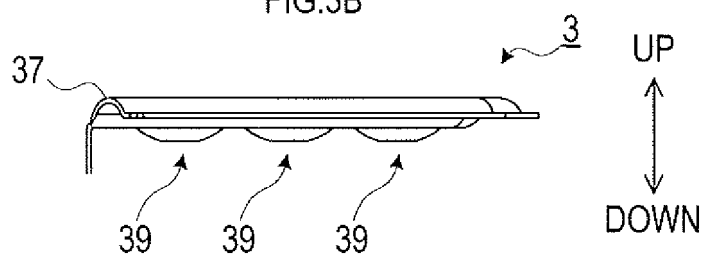


FIG.3B



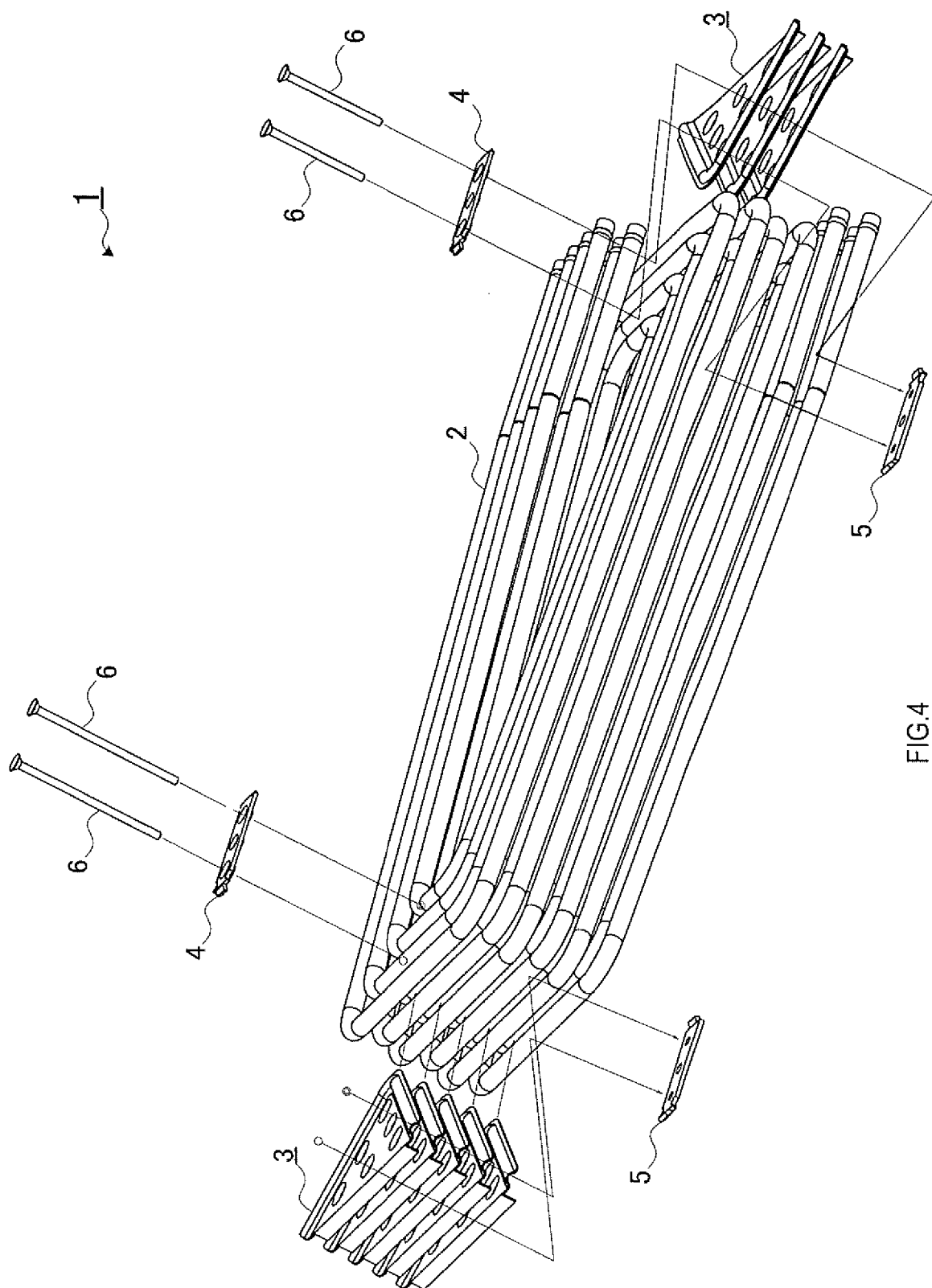


FIG.4

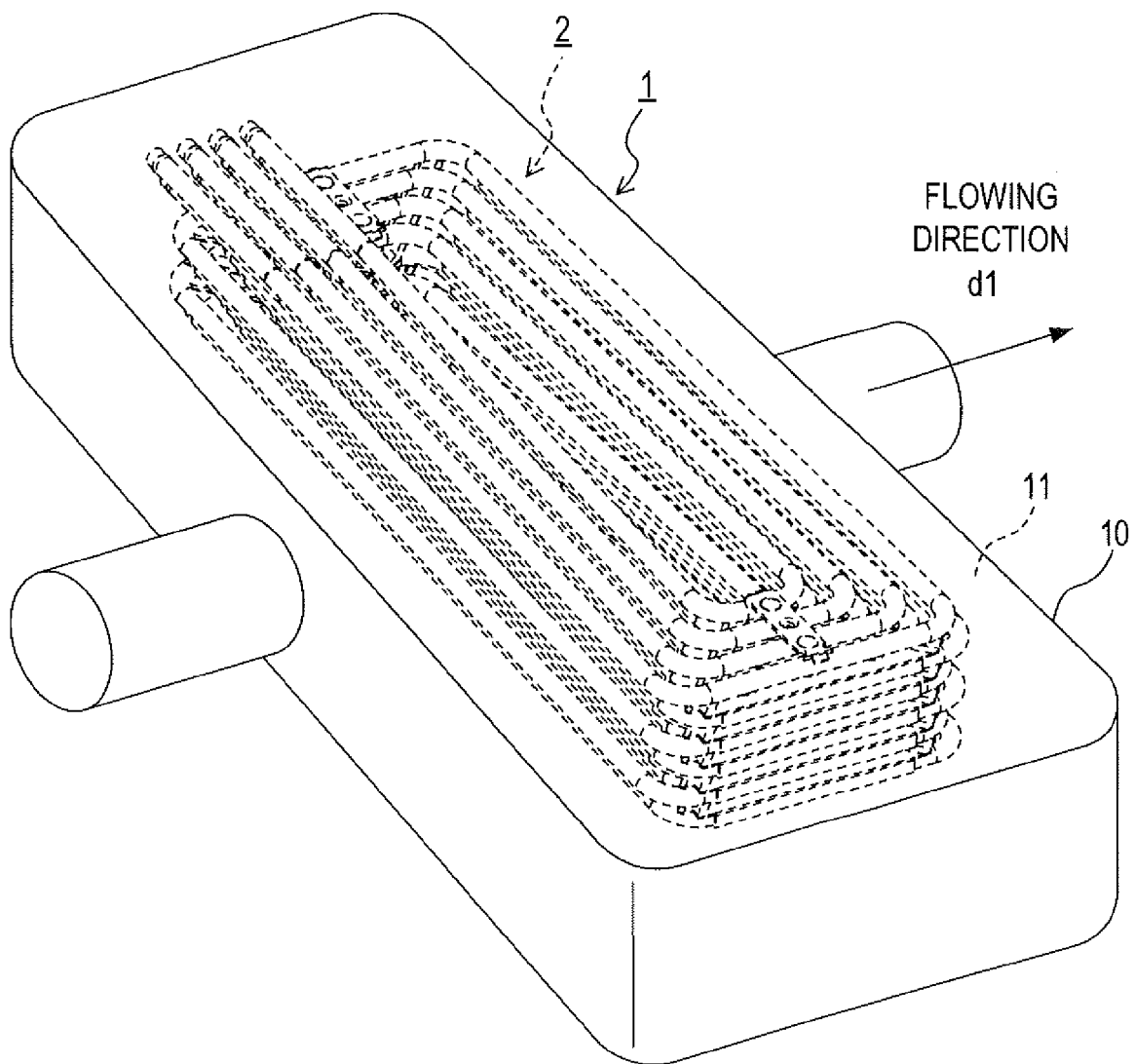


FIG.5

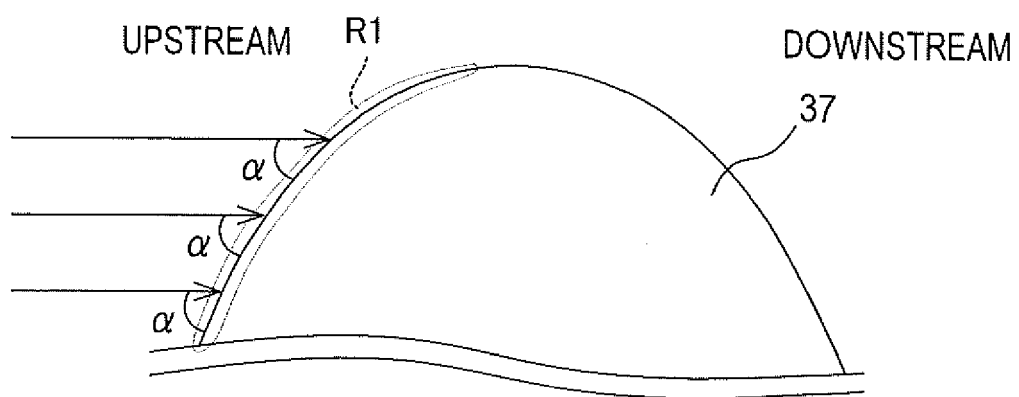


FIG.6

**REFERENCES CITED IN THE DESCRIPTION**

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