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(54) HEAT EXCHANGER AND AIR CONDITIONING SYSTEM

(57) Embodiments of the present invention relate to a heat exchanger and an air conditioning system having the same. The heat exchanger includes a plurality of fins and a row of heat transfer tubes. The fin includes a fin body and a plurality of columns of heat exchange tube slots formed in the fin body. The column of heat exchange tube slots includes a plurality of heat exchange tube slots arranged in a first direction, the plurality of fins being arranged in a second direction perpendicular to the first direction, and the plurality of columns of heat exchange tube slots being arranged in a third direction perpendicular to the first direction and the second direction. The row of heat exchange tubes is provided in the heat exchange tube slot of the column of heat exchange tube slots, and the row of heat exchange tubes includes one heat exchange tube or a plurality of heat exchange tubes. A length of at least one heat exchange tube slot in the third direction is greater than a heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction. Therefore, the performance of the heat exchanger and the air conditioning system can be improved.

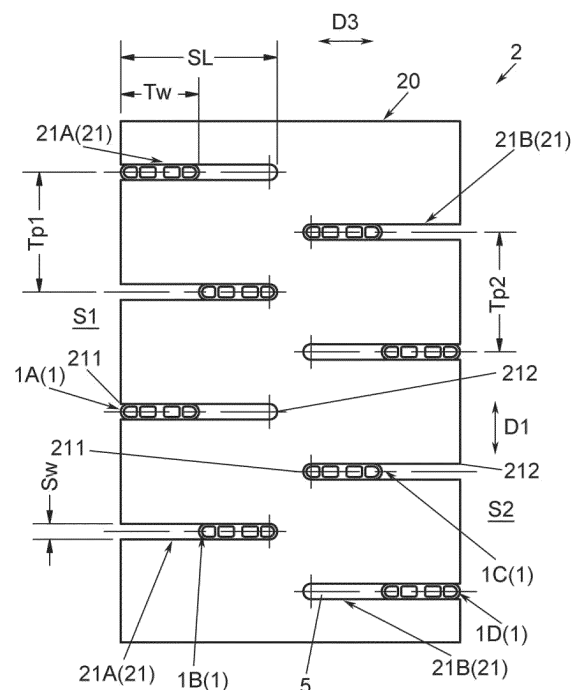


Fig. 15

Description

TECHNICAL FIELD

[0001] Embodiments of the present invention relate to a heat exchanger and an air conditioning system having the same.

BACKGROUND

[0002] A heat exchanger includes heat exchange tubes and fins having heat exchange tube slots. The heat exchange tube slots have openings on a side of the heat exchanger, or the heat exchange tube slots have no opening. The heat exchange tubes are inserted into the heat exchange tube slots of the fins.

SUMMARY

[0003] An object of embodiments of the present invention is to provide a heat exchanger and an air conditioning system having the same, thereby, for example, improving the performance of the heat exchanger.

[0004] Embodiments of the present invention provide a heat exchanger including: a plurality of fins, each of the plurality of fins including a fin body and a plurality of columns of heat exchange tube slots formed in the fin body, each of the plurality of columns of heat exchange tube slots including a plurality of heat exchange tube slots arranged in a first direction, the plurality of fins being arranged in a second direction perpendicular to the first direction, and the plurality of columns of heat exchange tube slots of each of the plurality of fins being arranged in a third direction perpendicular to the first direction and the second direction; and a row of heat exchange tubes provided in each heat exchange tube slot of the plurality of heat exchange tube slots of each column of heat exchange tube slots of the plurality of columns of heat exchange tube slots, the row of heat exchange tubes including one heat exchange tube or a plurality of heat exchange tubes, wherein a length of at least one heat exchange tube slot of the plurality of heat exchange tube slots of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of at least one fin of the plurality of fins in the third direction is greater than a heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction, in the case that the row of heat exchange tubes includes the one heat exchange tube, the heat exchange tube size is a size of the one heat exchange tube in the third direction, and in the case that the row of heat exchange tubes includes the plurality of heat exchange tubes, the heat exchange tube size is a sum of sizes of the plurality of heat exchange tubes in the third direction.

[0005] According to embodiments of the present invention, the plurality of fins and the heat exchange tubes of the rows of heat exchange tubes provided in the heat

exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins constitute a heat exchanger core, the heat exchanger core including a first core portion and a second core portion, the first core portion and the second core portion being positioned on both sides of a plane passing through a geometric center of the fin bodies and perpendicular to the third direction, respectively, the first core portion being positioned on a first side of the heat exchanger in the third direction, and the second core portion being positioned on a second side of the heat exchanger opposite to the first side in the third direction, wherein a heat exchange efficiency of the first core portion is lower than that of the second core portion.

[0006] According to embodiments of the present invention, the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of at least one fin of the plurality of fins and the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the at least one fin of the plurality of fins are arranged alternately in the first direction.

[0007] According to embodiments of the present invention, a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins and the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins have the same number and size of the heat exchange tubes.

[0008] According to embodiments of the present invention, a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins and a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins have different numbers and/or sizes of the heat exchange tubes.

[0009] According to embodiments of the present invention, a sum of the heat exchange tube sizes of a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least one column of heat

exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins is smaller than a sum of heat exchange tube sizes of a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins.

[0010] According to embodiments of the present invention, a heat transfer coefficient of the one heat exchange tube, (or a heat transfer coefficient of at least one heat exchange tube of a plurality of heat exchange tubes), of at least one row of heat exchange tubes of the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins is less than that of the one heat exchange tube, (or that of at least one heat exchange tube of the plurality of heat exchange tubes), of at least one row of heat exchange tubes of a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins.

[0011] According to embodiments of the present invention, the length SL of at least one heat exchange tube slot of the plurality of heat exchange tube slots of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of at least one fin of the plurality of fins in the third direction and the size Tw of the heat exchange tubes of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction satisfy the following relationship: $SL = n \cdot Tw$, where n is a positive integer.

[0012] According to embodiments of the present invention, n is greater than or equal to 2.

[0013] According to embodiments of the present invention, spacing between the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins is different from spacing between the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins.

[0014] According to embodiments of the present invention, spacing between the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat

exchange tube slots of the plurality of fins is greater than spacing between the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins.

[0015] According to embodiments of the present invention, at least one heat exchange tube slot of the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins and at least one heat exchange tube slot of the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins are displaced from each other in the first direction and, when viewed in the first direction, partially overlap.

[0016] According to embodiments of the present invention, the heat exchange tube slot of the column of heat exchange tube slots of the fin has a first slot edge and a second slot edge, the first slot edge and the second slot edge being respectively positioned on the outermost sides of the heat exchange tube slot in the third direction, and the first slot edge of the heat exchange tube slot of the fin being closer to the first side of the heat exchanger in the third direction than the second slot edge of the heat exchange tube slot of the fin; and the first slot edges of the plurality of heat exchange tube slots of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction, and/or the second slot edges of the plurality of heat exchange tube slots of the at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction.

[0017] According to embodiments of the present invention, the plurality of heat exchange tube slots of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins have substantially the same size in the third direction.

[0018] According to embodiments of the present invention, the fin body of the fin has a substantially flat shape.

[0019] According to embodiments of the present invention, the fin body of the fin includes a first fin body portion positioned on a first side of the heat exchanger in the third direction and a second fin body portion positioned on a second side of the heat exchanger opposite to the first side in the third direction, the first fin body portion being inclined relative to a plane defined by the first direction and the third direction, and a first angle being formed between the first fin body portion and the plane

defined by the first direction and the third direction; the second fin body portion being inclined relative to the plane defined by the first direction and the third direction, and a second angle being formed between the second fin body portion and the plane defined by the first direction and the third direction, wherein the first angle is different from the second angle.

[0020] According to embodiments of the present invention, the first angle is greater than the second angle.

[0021] According to embodiments of the present invention, the fin body of the fin is inclined relative to a plane defined by the first direction and the third direction.

[0022] According to embodiments of the present invention, an angle between the fin body of the fin and the plane defined by the first direction and the third direction is less than or equal to 45 degrees.

[0023] According to embodiments of the present invention, the fin body of the plurality of fins includes a first fin body portion positioned on a first side of the heat exchanger in the third direction and a second fin body portion positioned on a second side of the heat exchanger opposite to the first side in the third direction, and the fin includes a first louver provided on the first fin body portion, and a second louver provided on the second fin body portion, wherein the heat exchange efficiency of the first louver is lower than that of the second louver.

[0024] According to embodiments of the present invention, the plurality of columns of heat exchange tube slots of the plurality of fins include a first column of heat exchange tube slots and a second column of heat exchange tube slots positioned on a first side and a second side of the heat exchanger opposite to each other in the third direction, respectively.

[0025] According to embodiments of the present invention, the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins have an opening towards the first side of the heat exchanger, and the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins have an opening towards the second side of the heat exchanger.

[0026] According to embodiments of the present invention, the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins and the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins have the same length in the third direction.

[0027] According to embodiments of the present invention, the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction, and/or the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction.

[0028] According to embodiments of the present invention, at least one of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the

plurality of fins and at least one of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins are displaced from each other in the first direction.

[0029] According to embodiments of the present invention, a length of at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins in the third direction is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction, and a length of at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins in the third direction is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction.

[0030] According to embodiments of the present invention, a length of at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins in the third direction is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction, and a length of at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins in the third direction is substantially equal to the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction.

[0031] According to embodiments of the present invention, the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins partially overlaps with the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins when viewed in the first direction.

[0032] According to embodiments of the present invention, a center of the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins in the third direction overlaps with the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins when viewed in the first direction, and/or, the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins overlaps with a center of the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins in the third direction when viewed in the first direction.

[0033] According to embodiments of the present invention, the heat exchange tube slot of the column of heat exchange tube slots of the fin has a first slot edge and a second slot edge, the first slot edge and the second slot

edge being respectively positioned on the outermost sides of the heat exchange tube slot in the third direction, and the first slot edge of the heat exchange tube slot of the fin being closer to the first side of the heat exchanger in the third direction than the second slot edge of the heat exchange tube slot of the fin; and the second slot edges of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction, and/or, the first slot edges of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction.

[0034] According to embodiments of the present invention, the heat exchange tubes of the rows of heat exchange tubes provided in the heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins include a plurality of columns of heat exchange tubes arranged in the third direction, each column of heat exchange tubes of the plurality of columns of heat exchange tubes including a plurality of heat exchange tubes arranged in the first direction.

[0035] According to embodiments of the present invention, the heat exchange tube of the plurality of columns of heat exchange tubes includes a first end positioned on one side of the heat exchange tube in the second direction and a second end positioned on the other side of the heat exchange tube in the second direction; and the heat exchanger further includes: a first header connected and fluidly communicated with the first end of the heat exchange tube; and a second header connected and fluidly communicated with the second end of the heat exchange tube.

[0036] According to embodiments of the present invention, the heat exchange tube of the plurality of columns of heat exchange tubes includes a first end positioned on one side of the heat exchange tube in the second direction and a second end positioned on the other side of the heat exchange tube in the second direction; and the heat exchanger further includes: a first header connected and fluidly communicated with the first ends of the heat exchange tubes of the plurality columns of heat exchange tubes; and two second headers, one of the two second headers being connected and fluidly communicated with the second ends of the heat exchange tubes of at least one column of heat exchange tubes of the plurality of columns of heat exchange tubes, and the other of the two second headers being connected and fluidly communicated with the second ends of the heat exchange tubes of at least another column of heat exchange tubes of the plurality of columns of heat exchange tubes.

[0037] According to embodiments of the present invention, the heat exchange tube of the plurality of columns of heat exchange tubes includes a first end positioned on one side of the heat exchange tube in the second direction and a second end positioned on the other side of the heat exchange tube in the second

direction; and the heat exchanger further includes: a connection portion, by which the first ends of the heat exchange tubes of one column of heat exchange tubes of the plurality columns of heat exchange tubes and the first ends of the heat exchange tubes of another column of heat exchange tubes of the plurality columns of heat exchange tubes are connected and fluidly communicated with each other; and two second headers, one of the two second headers being connected and fluidly communicated with the second ends of the heat exchange tubes of the one column of heat exchange tubes, and the other of the two second headers being connected and fluidly communicated with the second ends of the heat exchange tubes of the another column of heat exchange tubes.

[0038] According to embodiments of the present invention, the connection portion includes a plurality of connection tubes, by which the first ends of the heat exchange tubes of the one column of heat exchange tubes are connected and fluidly communicated with the first ends of the heat exchange tubes of the another column of heat exchange tubes of the plurality of connection tubes, respectively.

[0039] According to embodiments of the present invention, the heat exchange tube of the one column of heat exchange tubes, the connection tube, and the heat exchange tube of the another column of heat exchange tubes, which are connected with each other, are formed by bending one tube.

[0040] According to embodiments of the present invention, the heat exchange tube of the plurality of columns of heat exchange tubes includes a first end positioned on one side of the heat exchange tube in the second direction and a second end positioned on the other side of the heat exchange tube in the second direction; and the heat exchanger further includes: two first headers and two second headers, one of the two first headers and one of the two second headers being connected and fluidly communicated with the first ends and the second ends of the heat exchange tubes of at least one column of heat exchange tubes of the plurality of columns of heat exchange tubes, respectively, and the other of the two first headers and the other of the two second headers being connected and fluidly communicated with the first ends and the second ends of the heat exchange tubes of at least another column of heat exchange tubes of the plurality of columns of heat exchange tubes, respectively.

[0041] According to embodiments of the present invention, in use, at least a portion of the heat exchange tube extends substantially vertically.

[0042] According to embodiments of the present invention, each of at least some fins is formed by one plate.

[0043] Embodiments of the present invention further provide an air conditioning system including the above-mentioned heater exchanger.

[0044] With the heat exchanger and the air conditioning system having the same according to the embodi-

ments of the present invention, for example, the performance of the heat exchanger may be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045]

Fig. 1 is a schematic front view of a heat exchanger according to an embodiment of the present invention;

Fig. 2 is a schematic left view of the heat exchanger shown in Fig. 1;

Fig. 3 is a schematic front view of a heat exchanger according to an embodiment of the present invention;

Fig. 4 is a schematic left view of the heat exchanger shown in Fig. 3;

Fig. 5 is a schematic front view of a heat exchanger according to an embodiment of the present invention;

Fig. 6 is a schematic left view of the heat exchanger shown in Fig. 5;

Fig. 7 is a schematic top view of a fin of a heat exchanger according to an embodiment of the present invention;

Fig. 8 is a schematic top view of a fin of a heat exchanger according to an embodiment of the present invention;

Fig. 9 is a schematic top view of a fin of a heat exchanger according to an embodiment of the present invention;

Fig. 10 is a schematic top view of a fin of a heat exchanger according to an embodiment of the present invention;

Fig. 11 is a schematic top view of a fin of a heat exchanger according to an embodiment of the present invention;

Fig. 12 is a schematic front view of the fin of the heat exchanger shown in Fig. 11;

Fig. 13 is a schematic top view of a fin of a heat exchanger according to an embodiment of the present invention;

Fig. 14 is a schematic front view of the fin of the heat exchanger shown in Fig. 13;

Fig. 15 is a schematic top view showing a fitting relationship between a fin and a heat exchange tube of a heat exchanger according to an embodiment of the present invention;

Fig. 16 is a schematic top view showing a fitting relationship between a fin and a heat exchange tube of a heat exchanger according to an embodiment of the present invention;

Fig. 17 is a schematic top view showing a fitting relationship between a fin and a heat exchange tube of a heat exchanger according to an embodiment of the present invention;

Fig. 18 is a schematic top view showing a fitting relationship between a fin and a heat exchange tube

of a heat exchanger according to an embodiment of the present invention;

Fig. 19 is a schematic top view showing a fitting relationship between a fin and a heat exchange tube of a heat exchanger according to an embodiment of the present invention; and

Fig. 20 is a schematic front view showing the fitting relationship between the fin and the heat exchange tube of the heat exchanger shown in Fig. 19.

DETAILED DESCRIPTION OF EMBODIMENTS

[0046] The present invention is further explained below by means of specific embodiments in conjunction with the drawings.

[0047] Referring to Figs. 1-20, a heat exchanger 100 according to an embodiment of the present invention includes: a plurality of fins 2 and rows of heat exchange tubes. Each of the plurality of fins 2 includes a fin body 20 and a plurality of columns of heat exchange tube slots formed in the fin body 20, for example, Figs. 7-11, 13 and 15-19 show a first column of heat exchange tube slots including a plurality of heat exchange tube slots 21A and a second column of heat exchange tube slots including a plurality of heat exchange tube slots 21B, the first column of heat exchange tube slots and the second column of heat exchange tube slots being positioned on a first side S1 and a second side S2 of the heat exchanger 100 opposite to each other in a third direction D3, respectively. In addition, the fin 2 may include three or more columns of heat exchange tube slots. Each of the plurality of columns of heat exchange tube slots includes a plurality of heat exchange tube slots 21 arranged in a first direction D1, the plurality of fins 2 being arranged in a second direction D2 perpendicular to the first direction D1, and the plurality of columns of heat exchange tube slots of each of the plurality of fins 2 being arranged in a third direction D3 perpendicular to the first direction D1 and the second direction D2. The row of heat exchange tubes is arranged in each heat exchange tube slot 21 of the plurality of heat exchange tube slots 21 of each column of heat exchange tube slots of the plurality of columns of heat exchange tube slots, and the row of heat exchange tubes is composed of one heat exchange tubes 1 or a plurality of heat exchange tubes 1. Referring to Figs. 15 to 19, a length of at least one heat exchange tube slot 21 of the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of at least one fin 2 of the plurality of fins 2 in the third direction D3 is greater than a heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction D3. In the case that the row of heat exchange tubes is composed of the one heat exchange tube 1, the heat exchange tube size is a size of the one heat exchange tube 1 in the third direction, and in the case that the row of heat exchange tubes is composed of the plurality of heat exchange tubes

1, the heat exchange tube size is a sum of sizes of the plurality of heat exchange tubes 1 in the third direction. According to the embodiments of the present invention, the length of at least one heat exchange tube slot 21 of the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of at least one fin 2 of the plurality of fins 2 in the third direction D3 is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction D3, which may allow a gap 5 for passage of water to be formed in the at least one heat exchange tube slot 21. For example, the gap 5 forms a drainage passage through which defrosting water may quickly flow away, thereby improving the performance of the heat exchanger under frosting conditions.

[0048] Referring to Figs. 7, 9, 11, 13, 15-17 and 19, in some embodiments of the present invention, the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger 100 in the third direction D3, of the plurality of columns of heat exchange tube slots of at least one fin 2 of the plurality of fins 2 and the plurality of heat exchange tube slots 21 of at least another column of heat exchange tube slots, positioned on a second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots 21 of at least one fin 2 of the plurality of fins 2 are arranged alternately in the first direction D1. Therefore, it is convenient to adjust heat exchange efficiency of various regions of the heat exchanger 100 in the third direction D3. According to the examples of the present invention, as shown in Figs. 9 and 17, at least one heat exchange tube slot 21 of the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger 100 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 and at least one heat exchange tube slot 21 of the plurality of heat exchange tube slots 21 of at least another column of heat exchange tube slots, positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 are displaced from each other in the first direction D1 and, when viewed in the first direction D1, partially overlap. Therefore, it is convenient to adjust the heat exchange efficiency of the various regions of the heat exchanger 100 in the third direction D3.

[0049] Referring to Fig. 8, in some other embodiments of the present invention, at least one heat exchange tube slot 21 of the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger 100 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 and at least one heat exchange tube slot 21 of the plurality of heat exchange

tube slots 21 of at least another column of heat exchange tube slots, positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 are substantially aligned with each other in the first direction D1.

[0050] Referring to Figs. 10 and 18, in some embodiments of the present invention, spacing between the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger 100 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 is different from spacing between the plurality of heat exchange tube slots 21 of at least another column of heat exchange tube slots, positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2. For example, the spacing between the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger 100 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 is greater than the spacing between the plurality of heat exchange tube slots 21 of at least another column of heat exchange tube slots, positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2. Therefore, it is convenient to adjust the heat exchange efficiency of the various regions of the heat exchanger 100 in the third direction D3.

[0051] Referring to Figs. 7-11, 13 and 15-19, in the embodiments of the present invention, the heat exchange tube slot 21 of the column of heat exchange tube slots of the fin 2 has a first slot edge 211 and a second slot edge 212, the first slot edge 211 and the second slot edge 212 being respectively positioned on outermost sides of the heat exchange tube slot 21 in the third direction D3, and the first slot edge 211 of the heat exchange tube slot 21 of the fin 2 being closer to the first side S1 of the heat exchanger 100 in the third direction D3 than the second slot edge 212 of the heat exchange tube slot 21 of the fin 2 in the third direction D3. The first slot edges 211 of the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins 2 are substantially aligned with each other in the third direction D3, and/or the second slot edges 212 of the plurality of heat exchange tube slots 21 of the at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins 2 are substantially aligned with each other in the third direction D3. For example, the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins 2 may have substantially the same size in the third direction D3.

[0052] Referring to Figs. 1-10 and 13-18, in some embodiments of the present invention, the fin body 20 of the fin 2 may have a substantially flat shape. The fin body 20 of the fin 2 may be inclined relative to a plane defined by the first direction D1 and the third direction D3. For example, an angle between the fin body 20 of the fin 2 and the plane defined by the first direction D1 and the third direction D3 is less than or equal to 45 degrees.

[0053] Referring to Figs. 11-12 and 19-20, in some embodiments of the present invention, the fin body 20 of the fin 2 includes a first fin body portion 20A positioned on the first side S1 of the heat exchanger 100 in the third direction D3, and a second fin body portion 20B positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, wherein the first fin body portion 20A and the second fin body portion 20B may have a substantially flat shape. The first fin body portion 20A is inclined relative to the plane defined by the first direction D1 and the third direction D3, and a first angle α is formed between the first fin body portion 20A and the plane defined by the first direction D1 and the third direction D3. The second fin body portion 20B is inclined relative to the plane defined by the first direction D1 and the third direction D3, and a second angle β is formed between the second fin body portion 20B and the plane defined by the first direction D1 and the third direction D3, wherein the first angle α is different from the second angle β . For example, the first angle α is greater than the second angle β . Therefore, it is beneficial for discharge of the condensate water.

[0054] Referring to Figs. 7-11, 13 and 15-19, in the embodiments of the present invention, the plurality of columns of heat exchange tube slots of the plurality of fins 2 include a first column of heat exchange tube slots and a second column of heat exchange tube slots positioned the first side S1 and the second side S2 of the heat exchanger 100 opposite to each other in the third direction D3, respectively. For example, the first column of heat exchange tube slots is positioned on a windward side of the heat exchanger, and the second column of heat exchange tube slots is positioned on a leeward side of the heat exchanger. The first column of heat exchange tube slots includes a plurality of heat exchange tube slots 21A, and the second column of heat exchange tube slots includes a plurality of heat exchange tube slots 21B. The plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 have an opening towards the first side S1 of the heat exchanger 100, and the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 have an opening towards the second side S2 of the heat exchanger 100. The heat exchange tube slots 21 of the plurality of fins 2 may have no opening and are closed heat exchange tube slots. The plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 and the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plur-

ality of fins 2 may have the same length in the third direction D3. The plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 may be substantially aligned with each other in the third direction D3, and/or the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 may be substantially aligned with each other in the third direction D3.

[0055] Referring to Fig. 8, in the embodiments of the present invention, the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 and the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 may be substantially aligned with each other in the first direction D1.

[0056] Referring to Figs. 7, 9, 11, 13, 15-17 and 19, in the embodiments of the present invention, at least one of the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 and at least one of the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 may be displaced from each other in the first direction D1. The plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 and the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 may be displaced from each other in the first direction D1. Referring to Figs. 9 and 17, in the embodiments of the present invention, at least one of the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 partially overlaps with at least one of the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 when viewed in the first direction D1. According to the examples of the present invention, a center of the at least one of the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 in the third direction D3 and the at least one of the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 overlap with each other when viewed in the first direction D1, and/or, the at least one of the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 and a center of the at least one of the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 in the third direction D3 overlap with each other when viewed in the first direction D1. Therefore, it is convenient to adjust the heat exchange efficiency of the various regions of the heat exchanger 100 in the third direction D3.

[0057] Referring to Figs. 15 and 17-19, in some embodiments of the present invention, a length of at least one of the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins

2 in the third direction D3 is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction D3, and a length of at least one of the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 in the third direction D3 is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction D3. Referring to Fig. 16, in some other embodiments of the present invention, the length of at least one of the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 in the third direction D3 is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction D3, and a length of at least one of the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 in the third direction D3 is substantially equal to the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction D3.

[0058] Referring to Figs. 7-11, 13 and 15-19, in the embodiments of the present invention, the second slot edges 212 of the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots of the plurality of fins 2 are substantially aligned with each other in the third direction D3, and/or, the first slot edges 211 of the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots of the plurality of fins 2 are substantially aligned with each other in the third direction D3.

[0059] Referring to Figs. 1, 3 and 5, in the embodiments of the present invention, the plurality of fins 2 and the heat exchange tubes 1 of the rows of heat exchange tubes 1 provided in the heat exchange tube slots 21 of the plurality of columns of heat exchange tube slots of the plurality of fins 2 constitute a heat exchanger core 8, the heat exchanger core 8 including a first core portion 81 and a second core portion 82. The first core portion 81 and the second core portion 82 are positioned on both sides of a plane passing through a geometric center of the fin bodies 20 and perpendicular to the third direction D3, respectively, the first core portion 81 being positioned on the first side S1 of the heat exchanger 100 in the third direction D3, and the second core portion 82 being positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, wherein the heat exchange efficiency of the first core portion 81 is lower than that of the second core portion 82. The heat exchange efficiency refers to a measurement of efficiency of the heat transfer between air and other fluid media after the air flows through the heat exchanger. Given the same atmospheric environment, the same dry bulb temperature, the same wet bulb temperature, the same atmospheric pressure, the same fluid, the same inlet temperature, and the same flow rate, the average

temperatures at the air outlet are compared to obtain the difference of temperature change before and after the air flows through the heat exchanger. Greater temperature change means higher heat exchange efficiency. According to the embodiments of the present invention, in the case that the first core portion 81 is positioned on the windward side of the heat exchanger and the second core portion 82 is positioned on the leeward side of the heat exchanger, the utilization efficiency of the first core portion 81 may be balanced and the second core portion 82 may be fully utilized by adjusting the heat exchange efficiencies of the first core portion 81 and the second core portion 82. In addition, it may potentially reduce an amount of the generated condensate water at the first core portion 81, reduce the heat transfer resistance caused by the condensate water, and instead improve the overall heat exchange efficiency of the heat exchanger.

[0060] Referring to Figs. 13 and 14, in the embodiments of the present invention, the fin body 20 of the plurality of fins 2 includes a first fin body portion 20A positioned on the first side S1 of the heat exchanger 100 in the third direction D3 and a second fin body portion 20B positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3. The fin 2 includes first louver(s) 22A provided in the first fin body portion 20A, and second louver(s) 22B provided in the second fin body portion 20B, the heat exchange efficiency of the first louver(s) 22A being lower than that of the second louver(s) 22B. Therefore, it is convenient to adjust the heat exchange efficiency of the various regions of the heat exchanger 100 in the third direction D3. For example, a number of the first louver(s) 22A is smaller than that of the second louver(s) 22B, a range in which the first louver(s) 22A is provided in the third direction D3 is smaller than a range in which the second louver(s) 22B is provided in the third direction D3, spacing between adjacent first louvers 22A is greater than spacing between adjacent second louvers 22B, and an inclination angle of the first louver(s) 22A relative to the first fin body portion 20A is smaller than that of the second louver(s) 22B relative to the second body portion 20B. For example, as shown in Fig. 14, the spacing between the adjacent first louvers 22A is 3mm, the inclination angle of the first louver(s) 22A relative to the first fin body portion 20A is 25 degrees, the spacing between the adjacent second louvers 22B is 2mm, and the inclination angle of the second louver(s) 22B relative to the second fin body portion 20B is 30 degrees. According to another example of the present invention, the fin 2 includes the second louver(s) 22B provided on the second fin body portion 20B, and there is no louver on the first fin body portion 20A.

[0061] Referring to Figs. 16 and 18, in the embodiments of the present invention, the sum of the heat exchange tube sizes of the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger

100 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 is less than the sum of the heat exchange tube sizes of the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots 21 of at least another column of heat exchange tube slots, positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2.

[0062] Referring to Figs. 1, 3, 5 and 15-20, in the embodiments of the present invention, a heat transfer coefficient of the one heat exchange tube 1 or at least one heat exchange tube 1 of the plurality of heat exchange tubes 1 of at least one row of heat exchange tubes of the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger 100 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 is smaller than that of the one heat exchange tube 1 or at least one heat exchange tube 1 of the plurality of heat exchange tubes 1 of at least one row of heat exchange tubes of the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots 21 of at least another column of heat exchange tube slots, positioned on second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2. Therefore, it is convenient to adjust the heat exchange efficiency of the various regions of the heat exchanger 100 in the third direction D3.

[0063] Referring to Figs. 15, 17, 18 and 19, in some embodiments of the present invention, the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger 100 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 and the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots 21 of at least another column of heat exchange tube slots, positioned on the second side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 have the same number and size of the heat exchange tubes 1, thereby reducing the complexity of the production and processing process, and reducing the probability of misusing the heat exchange tubes.

[0064] Referring to Fig. 16, in some embodiments of the present invention, the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots, positioned on the first side S1 of the heat exchanger 100 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 and the plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots 21 of at least another column of heat exchange tube slots, positioned on the second

side S2 of the heat exchanger 100 opposite to the first side S1 in the third direction D3, of the plurality of columns of heat exchange tube slots of the plurality of fins 2 have different numbers and sizes of the heat exchange tubes 1. Therefore, it is convenient to adjust the heat exchange efficiency of the various regions of the heat exchanger 100 in the third direction D3.

[0065] Referring to Figs. 15-19, in the embodiments of the present invention, a length SL of at least one heat exchange tube slot 21 of the plurality of heat exchange tube slots 21 of at least one column of heat exchange tube slots 21 of the plurality of columns of heat exchange tube slots of at least one fin 2 of the plurality of fins 2 in the third direction D3 and a size Tw of the heat exchange tube(s) of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction D3 satisfy the following relationship of: $SL = n * Tw$, where n is a positive integer. n may be greater than or equal to 2. For example, the length of the heat exchange tube slot 21 of the plurality of columns of heat exchange tube slots in the third direction D3 is related to the size of the heat exchange tube in the third direction D3 in an integral multiple. Therefore, the complexity of the production process is reduced and the utilization rate of inefficient heat transfer area is reduced.

[0066] Referring to Figs. 1, 3, 5 and 15-20, in the embodiments of the present invention, the heat exchange tubes 1 of the row of heat exchange tubes arranged in the heat exchange tube slot 21 of the plurality of columns of heat exchange tube slots of the plurality of fins 2 includes a plurality of columns of heat exchange tubes arranged in the third direction D3, each column of heat exchange tubes of the plurality of columns of heat exchange tubes includes a plurality of heat exchange tubes arranged in the first direction D1. For example, a first column of heat exchange tubes includes a plurality of heat exchange tubes 1A, a second column of heat exchange tubes includes a plurality of heat exchange tubes 1B, a third column of heat exchange tubes includes a plurality of heat exchange tubes 1C, a fourth column of heat exchange tubes includes a plurality of heat exchange tubes 1D, and so on. Referring to Figs. 1, 3 and 5, in the embodiments of the present invention, the heat exchange tube 1 of the plurality of columns of heat exchange tubes includes a first end 18 positioned on one side of the heat exchange tube 1 in the second direction D2 and a second end 19 positioned on the other side of the heat exchange tube 1 in the second direction D2. In one example, the heat exchanger 100 further includes: a first header 31 connected and fluid communicated with the first ends 18 of the heat exchange tubes 1; and a second header 32 connected and fluid communicated with the second ends 19 of the heat exchange tubes 1. In another example, the heat exchanger 100 further includes: a first header 31 connected and fluid communicated with the first ends 18 of the heat exchange tubes 1 of the plurality of columns of heat exchange tubes; and two second headers 32, one of the two second

headers 32 being connected and fluid communicated with the second ends 19 of the heat exchange tubes 1 of at least one column of heat exchange tubes of the plurality of columns of heat exchange tubes, and the other of the two second headers 32 being connected and fluid communicated with the second ends 19 of the heat exchange tubes 1 of at least another column of heat exchange tubes of the plurality of columns of heat exchange tubes. In further another example, referring to Figs. 5 and 6, the heat exchanger 100 further includes a connecting portion 6, by which the first ends 18 of the heat exchange tubes 1 of one column of heat exchange tubes of the plurality of columns of heat exchange tubes are connected and fluid communicated with the first ends 18 of the heat exchange tubes 1 of another column of heat exchange tubes of the plurality of columns of heat exchange tubes, respectively; and two second headers 32, one of the two second headers 32 being connected and fluid communicated with the second ends 19 of the heat exchange tubes 1 of the one column of heat exchange tubes, and the other of the two second headers 32 being connected and fluid communicated with the second ends 19 of the heat exchange tubes 1 of the another column of heat exchange tubes. The connection portion 6 may be a plurality of connection tubes 60, by which the first ends 18 of the heat exchange tubes 1 of the one column of heat exchange tubes are connected and fluidly communicated with the first ends 18 of the heat exchange tubes 1 of the another column of heat exchange tubes, respectively. The connection portion 6 may also enable the first ends 18 of the heat exchange tubes 1 of the one column of heat exchange tubes to be connected and fluidly communicated with the first ends 18 of the heat exchange tubes 1 of the another column of heat exchange tubes, but not being in one-to-one correspondence relationship. The heat exchange tube 1 of the one column of heat exchange tubes, the connection tubes 60, and the heat exchange tube 1 of the another column of heat exchange tubes, which are connected with each other, may be formed by bending one tube. In the examples shown in Figs. 5 and 6, the first ends 18 of the heat exchange tubes 1 of two columns of heat exchange tubes of the plurality of columns of heat exchange tubes are connected and fluidly communicated with the first ends 18 of the heat exchange tubes 1 of another two columns of heat exchange tubes of the plurality of columns of heat exchange tubes, respectively, one of the two second headers 32 is connected and fluidly communicated with the second ends 19 of the heat exchange tubes 1 of the two columns of heat exchange tubes, and the other of the two second headers 32 is connected and fluidly communicated with the second ends 19 of the heat exchange tubes 1 of the another two columns of heat exchange tubes. In further examples, referring to Figs. 1 and 3, the heat exchanger 100 further includes: two first headers 31 and two second headers 32, one of the two first headers 31 and one of the two second headers 32 being connected and fluidly communicated with the first ends 18 and the second ends

19 of the heat exchange tubes 1 of at least one column of the heat exchange tubes of the plurality of columns of heat exchange tubes, respectively, and the other of the two first headers 31 and the other of the two second headers 32 being connected and fluidly communicated with the first ends 18 and the second ends 19 of the heat exchange tubes 1 of at least another column of the heat exchange tubes of the plurality of columns of heat exchange tubes, respectively. In the examples shown in Figs. 1 and 3, each first header 31 is connected and fluidly communicated with the first ends 18 of the heat exchange tubes 1 of two columns of heat exchange tubes of the plurality of columns of heat exchange tubes, and each second header 32 is connected and fluidly communicated with the second ends 19 of the heat exchange tubes 1 of two columns of heat exchange tubes of the plurality of columns of heat exchange tubes.

[0067] Referring to Figs. 1 to 6, in the embodiments of the present invention, in use, at least a portion of the heat exchange tube 1 extends substantially vertically. For example, the heat exchange tube 1 extends substantially vertically. In addition, at least a portion of the heat exchange tube 1 may also extend substantially horizontally or obliquely, for example, the heat exchange tube 1 may extend substantially horizontally or obliquely. Referring to Figs. 1-20, in the embodiments of the present invention, each of at least some fins 2 is formed by one plate. For example, the fin 2 is formed by one plate.

[0068] In the example shown in Fig. 15, the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots have an opening towards the first side S1 of the heat exchanger 100, and the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots have an opening towards the second side S2 of the heat exchanger 100. The sizes T_w of the heat exchange tubes 1 in the third direction D3 are substantially the same, and the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots and the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots are displaced from each other in the first direction D1. The length of the heat exchange tube slot 21 in the third direction D3 is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the heat exchange tube slot 21 in the third direction D3. Spacing TP1 between the plurality of heat exchange tube slots 21A of the first column of heat exchange tube slots is substantially the same as spacing TP2 between the plurality of heat exchange tube slots 21B of the second column of heat exchange tube slots. A width S_w of the heat exchange tube slot 21 in the first direction are substantially the same.

[0069] In the example shown in Fig. 16, the lengths of the heat exchange tube slots 21A of the first column of heat exchange tube slots in the third direction D3 are greater than the heat exchange tube sizes of the rows of heat exchange tubes inserted in the heat exchange tube slots 21A in the third direction D3, and the lengths of the

heat exchange tube slots 21B of the second column of heat exchange tube slots in the third direction D3 are substantially equal to the heat exchange tube sizes of the rows of heat exchange tubes inserted in the heat exchange tube slots 21B in the third direction D3. In order to improve the heat exchange efficiency, the rows of heat exchange tubes with the larger heat exchange tube sizes or the heat exchange tubes with the higher efficiency (with the higher heat transfer efficiency) may be placed in the heat exchange tube slots 21B of the second column of heat exchange tube slots.

[0070] In the embodiments of the present invention, the heat exchange tube 1 may be a flat tube or any heat exchange tube having two planes which are substantially parallel to each other.

[0071] An air conditioning system according to an embodiment of the present invention includes: the above-mentioned heat exchanger 100. More specifically, the air conditioning system includes: a compressor, a condenser, an evaporator, an expansion valve, etc.. At least one of the condenser and the evaporator may be the above-mentioned heat exchanger 100.

[0072] With the heat exchanger and the air conditioning system having the same according to the embodiments of the present invention, for example, the performance of the heat exchanger and the air conditioning system can be improved.

[0073] According to the embodiments of the present invention, the temperature of the various regions of the heat exchanger in the third direction may be flexibly controlled, thereby avoiding the phenomenon of the condensation water being concentrated on the windward side due to overly efficient heat exchange on the windward side of the heat exchanger, furthermore, the leeward side of the heat exchanger may also be fully utilized, this not only effectively reduces wind resistance (due to the accumulation of the less condensation water), but also balances the heat exchange efficiencies on the windward and leeward sides of the heat exchanger, thereby achieving the overall improvement of the heat exchanger efficiency.

[0074] Although the above embodiments are described, some features of the above embodiments and/or some of the above embodiments may be combined to form new embodiments.

Claims

1. A heat exchanger comprising:

a plurality of fins, each of the plurality of fins comprising a fin body and a plurality of columns of heat exchange tube slots formed in the fin body, each of the plurality of columns of heat exchange tube slots comprising a plurality of heat exchange tube slots arranged in a first direction, the plurality of fins being arranged in

a second direction perpendicular to the first direction, and the plurality of columns of heat exchange tube slots of each of the plurality of fins being arranged in a third direction perpendicular to the first direction and the second direction; and

a row of heat exchange tubes provided in each heat exchange tube slot of the plurality of heat exchange tube slots of each column of heat exchange tube slots of the plurality of columns of heat exchange tube slots, the row of heat exchange tubes comprising one heat exchange tube or a plurality of heat exchange tubes, wherein

a length of at least one heat exchange tube slot of the plurality of heat exchange tube slots of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of at least one fin of the plurality of fins in the third direction is greater than a heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction, in the case that the row of heat exchange tubes comprises the one heat exchange tube, the heat exchange tube size is a size of the one heat exchange tube in the third direction, and in the case that the row of heat exchange tubes comprises the plurality of heat exchange tubes, the heat exchange tube size is a sum of sizes of the plurality of heat exchange tubes in the third direction.

2. The heat exchanger according to claim 1, wherein the plurality of fins and the heat exchange tubes of the rows of heat exchange tubes provided in the heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins constitute a heat exchanger core, the heat exchanger core comprising a first core portion and a second core portion, the first core portion and the second core portion being positioned on both sides of a plane passing through a geometric center of the fin bodies and perpendicular to the third direction, respectively, the first core portion being positioned on a first side of the heat exchanger in the third direction, and the second core portion being positioned on a second side of the heat exchanger opposite to the first side in the third direction, wherein a heat exchange efficiency of the first core portion is lower than that of the second core portion.

3. The heat exchanger according to claim 1, wherein the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of at least one fin of the plurality of fins and the plurality of heat exchange tube slots of

at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the at least one fin of the plurality of fins are arranged alternately in the first direction.

4. The heat exchanger according to claim 1, wherein a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins and a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins have the same number and size of the heat exchange tubes.

5. The heat exchanger according to claim 1, wherein a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins and a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins have different numbers and/or sizes of the heat exchange tubes.

6. The heat exchanger according to claim 1, wherein a sum of heat exchange tube sizes of a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins is smaller than a sum of heat exchange tube sizes of a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins.

7. The heat exchanger according to claim 1, wherein a heat transfer coefficient of the one heat exchange tube, or a heat transfer coefficient of at least one heat exchange tube of the plurality of heat exchange

tubes, of at least one row of heat exchange tubes of a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins is less than that of the one heat exchange tube, or that of at least one heat exchange tube of the plurality of heat exchange tubes, of at least one row of heat exchange tubes of a plurality of rows of heat exchange tubes in the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins.

8. The heat exchanger according to claim 1, wherein

the length SL of at least one heat exchange tube slot of the plurality of heat exchange tube slots of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of at least one fin of the plurality of fins in the third direction and the size Tw of the heat exchange tubes of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction satisfy the following relationship of:

$$SL=n*Tw,$$

where, n is a positive integer.

9. The heat exchanger according to claim 8, wherein n is greater than or equal to 2.

10. The heat exchanger according to claim 1, wherein spacing between the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins is different from spacing between the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins.

11. The heat exchanger according to claim 1, wherein at least one heat exchange tube slot of the plurality of heat exchange tube slots of at least one column of heat exchange tube slots, positioned on a first side of the heat exchanger in the third direction, of the plurality of columns of heat exchange tube slots of

the plurality of fins and at least one heat exchange tube slot of the plurality of heat exchange tube slots of at least another column of heat exchange tube slots, positioned on a second side of the heat exchanger opposite to the first side in the third direction, of the plurality of columns of heat exchange tube slots of the plurality of fins are displaced from each other in the first direction and, when viewed in the first direction, partially overlap.

12. The heat exchanger according to claim 1, wherein

the heat exchange tube slot of the column of heat exchange tube slots of the fin has a first slot edge and a second slot edge, the first slot edge and the second slot edge being respectively positioned on outermost sides of the heat exchange tube slot in the third direction, and the first slot edge of the heat exchange tube slot of the fin being closer to the first side of the heat exchanger in the third direction than the second slot edge of the heat exchange tube slot of the fin; and

the first slot edges of the plurality of heat exchange tube slots of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction, and/or the second slot edges of the plurality of heat exchange tube slots of the at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction.

13. The heat exchanger according to claim 1, wherein the plurality of heat exchange tube slots of at least one column of heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins have substantially the same size in the third direction.

14. The heat exchanger according to claim 1, wherein the fin body of the fin comprises a first fin body portion positioned on a first side of the heat exchanger in the third direction and a second fin body portion positioned on a second side of the heat exchanger opposite to a first side in the third direction, the first fin body portion being inclined relative to a plane defined by the first direction and the third direction, and a first angle being formed between the first fin body portion and the plane defined by the first direction and the third direction; the second fin body portion being inclined relative to the plane defined by the first direction and the third direction, and a second angle being formed between the second fin body portion and the plane defined by the first direction and the third direction, wherein the first angle is different from

the second angle.

15. The heat exchanger according to claim 1, wherein the fin body of the fin is inclined relative to a plane defined by the first direction and the third direction.

16. The heat exchanger according to claim 1, wherein The fin body of the plurality of fins comprises a first fin body portion positioned on a first side of the heat exchanger in the third direction and a second fin body portion positioned on a second side of the heat exchanger opposite to the first side in the third direction, and the fin comprises a first louver provided on the first fin body portion, and a second louver provided on the second fin body portion, wherein the heat exchange efficiency of the first louver is lower than that of the second louver.

17. The heat exchanger according to claim 1, wherein the plurality of columns of heat exchange tube slots of the plurality of fins comprise a first column of heat exchange tube slots and a second column of heat exchange tube slots positioned on a first side and a second side of the heat exchanger opposite to each other in the third direction, respectively.

18. The heat exchanger according to claim 17, wherein the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins have an opening towards the first side of the heat exchanger, and the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins have an opening towards the second side of the heat exchanger.

19. The heat exchanger according to claim 17, wherein the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins and the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins have the same length in the third direction.

20. The heat exchanger according to claim 19, wherein the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction, and/or the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction.

21. The heat exchanger according to claim 17, wherein at least one of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins and at least one of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins are

displaced from each other in the first direction.

- 22.** The heat exchanger according to claim 21, wherein a length of at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins in the third direction is greater than the heat exchange tube size of the row of heat exchange tubes inserted in the at least one heat exchange tube slot in the third direction, and a length of at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins in the third direction is greater than or substantially equal to the heat exchange tube size of the row of heat exchange tubes inserted in the heat exchange tube slot in the third direction.
- 23.** The heat exchanger according to claim 21, wherein the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins partially overlaps with the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins when viewed in the first direction.
- 24.** The heat exchanger according to claim 23, wherein a center of the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins in the third direction overlaps with the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins when viewed in the first direction, and/or, the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins overlaps with a center of the at least one heat exchange tube slot of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins in the third direction when viewed in the first direction.
- 25.** The heat exchanger according to claim 17, wherein the heat exchange tube slot of the column of heat exchange tube slots of the fin has a first slot edge and a second slot edge, the first slot edge and the second slot edge being respectively positioned on outermost sides of the heat exchange tube slot in the third direction, and the first slot edge of the heat exchange tube slot of the fin being closer to the first side of the heat exchanger in the third direction than the second slot edge of the heat exchange tube slot of the

fin; and

the second slot edges of the plurality of heat exchange tube slots of the first column of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction, and/or, the first slot edges of the plurality of heat exchange tube slots of the second column of heat exchange tube slots of the plurality of fins are substantially aligned with each other in the third direction.

- 26.** The heat exchanger according to claim 1, wherein the heat exchange tubes of the rows of heat exchange tubes provided in the heat exchange tube slots of the plurality of columns of heat exchange tube slots of the plurality of fins comprise a plurality of columns of heat exchange tubes arranged in the third direction, each column of heat exchange tubes of the plurality of columns of heat exchange tubes comprising a plurality of heat exchange tubes arranged in the first direction.
- 27.** The heat exchanger according to claim 26, wherein the heat exchange tube of the plurality of columns of heat exchange tubes comprises a first end positioned on one side of the heat exchange tube in the second direction and a second end positioned on the other side of the heat exchange tube in the second direction; and the heat exchanger further comprises: a first header connected and fluidly communicated with the first end of the heat exchange tube; and a second header connected and fluidly communicated with the second end of the heat exchange tube.
- 28.** The heat exchanger according to claim 26, wherein the heat exchange tube of the plurality of columns of heat exchange tubes comprises a first end positioned on one side of the heat exchange tube in the second direction and a second end positioned on the other side of the heat exchange tube in the second direction; and the heat exchanger further comprises: a first header connected and fluidly communicated with the first ends of the heat exchange tubes of the plurality of columns of heat exchange tubes; and two second headers, one of the two second headers being connected and fluidly communicated with the second ends of the heat exchange tubes of at least one column of heat exchange tubes of the plurality of columns of heat exchange tubes, and the other of the two second headers being connected and fluidly communicated with the second ends of the heat exchange tubes of at least another column of

heat exchange tubes of the plurality of columns of heat exchange tubes.

29. The heat exchanger according to claim 26, wherein

the heat exchange tube of the plurality of columns of heat exchange tubes comprises a first end positioned on one side of the heat exchange tube in the second direction and a second end positioned on the other side of the heat exchange tube in the second direction; and the heat exchanger further comprises: a connection portion, by which the first ends of the heat exchange tubes of one column of heat exchange tubes of the plurality of columns of heat exchange tubes and the first ends of the heat exchange tubes of another column of heat exchange tubes of the plurality of columns of heat exchange tubes are connected and fluidly communicated with each other; and two second headers, one of the two second headers being connected and fluidly communicated with the second ends of the heat exchange tubes of the one column of heat exchange tubes, and the other of the two second headers being connected and fluidly communicated with the second ends of the heat exchange tubes of the another column of heat exchange tubes.

30. The heat exchanger according to claim 29, wherein

the connection portion comprises a plurality of connection tubes, by which the first ends of the heat exchange tubes of the one column of heat exchange tubes are connected and fluidly communicated with the first ends of the heat exchange tubes of the another column of heat exchange tubes of the plurality of connection tubes, respectively, wherein the heat exchange tube of the one column of heat exchange tubes, the connection tube, and the heat exchange tube of the another column of heat exchange tubes, which are connected with each other, are formed by bending one tube.

31. The heat exchanger according to claim 26, wherein

the heat exchange tube of the plurality of columns of heat exchange tubes comprises a first end positioned on one side of the heat exchange tube in the second direction and a second end positioned on the other side of the heat exchange tube in the second direction; and the heat exchanger further comprises: two first headers and two second headers, one of the two first headers and one of the two second headers being connected and fluidly communicated with the first ends and the second ends of the heat

exchange tubes of at least one column of heat exchange tubes of the plurality of columns of heat exchange tubes, respectively, and the other of the two first headers and the other of the two second headers being connected and fluidly communicated with the first ends and the second ends of the heat exchange tubes of at least another column of heat exchange tubes of the plurality of columns of heat exchange tubes, respectively.

32. An air conditioning system comprising: the heat exchanger according to any one of claims 1 to 31.

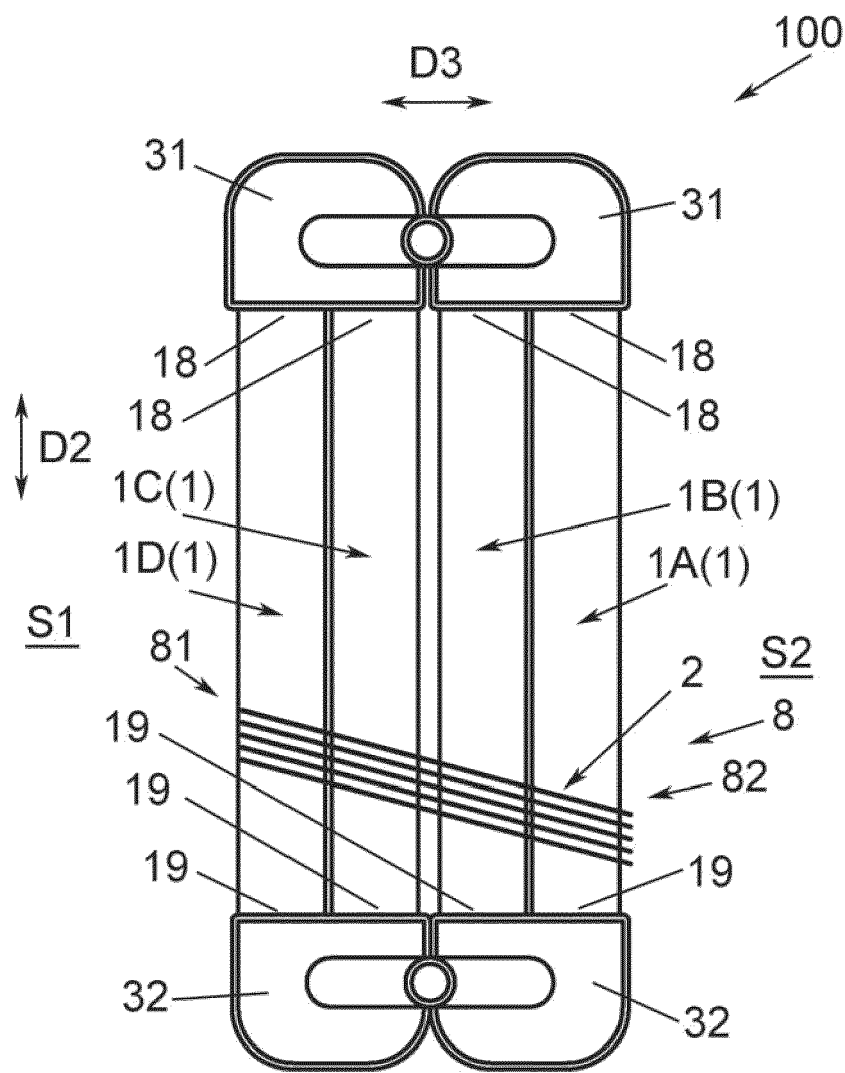


Fig. 1

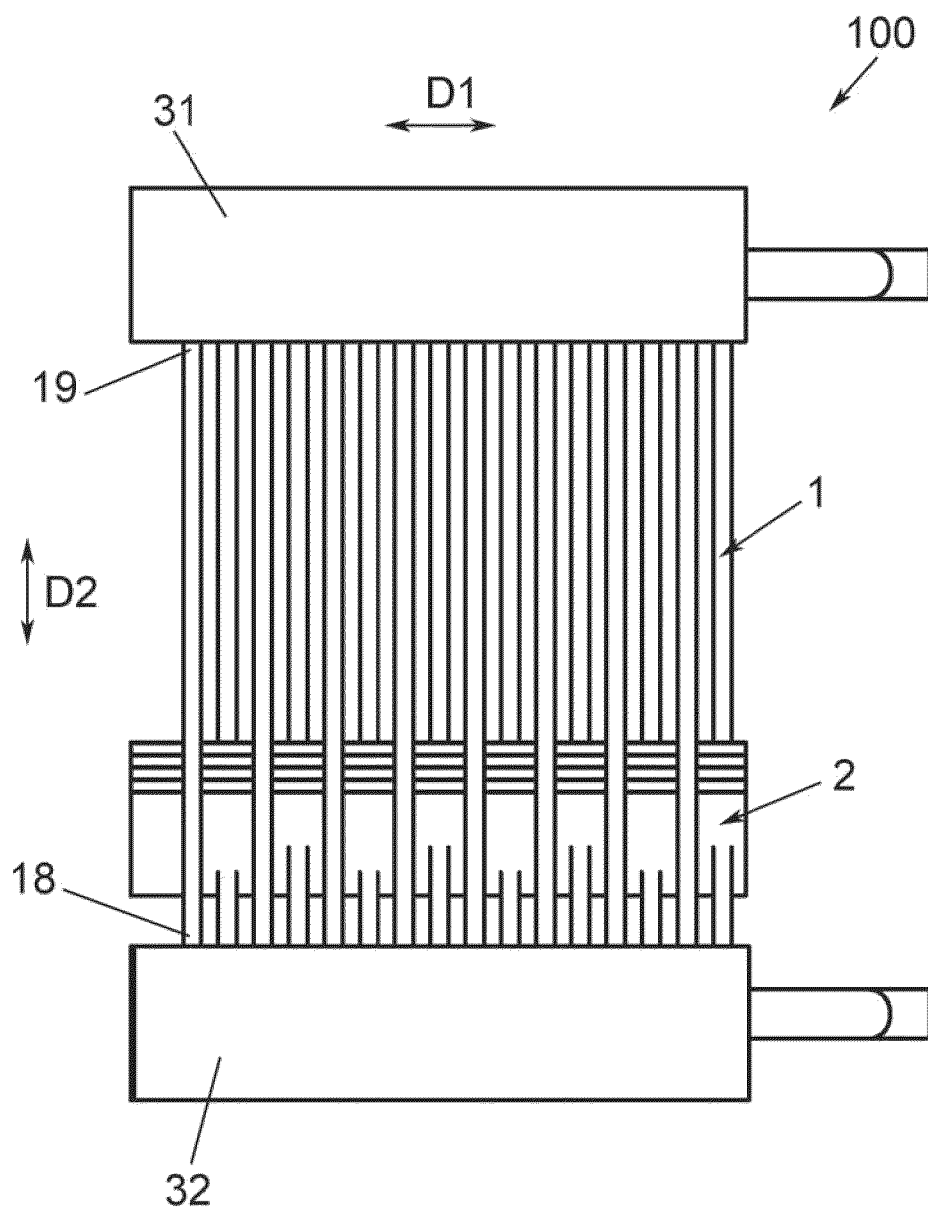


Fig. 2

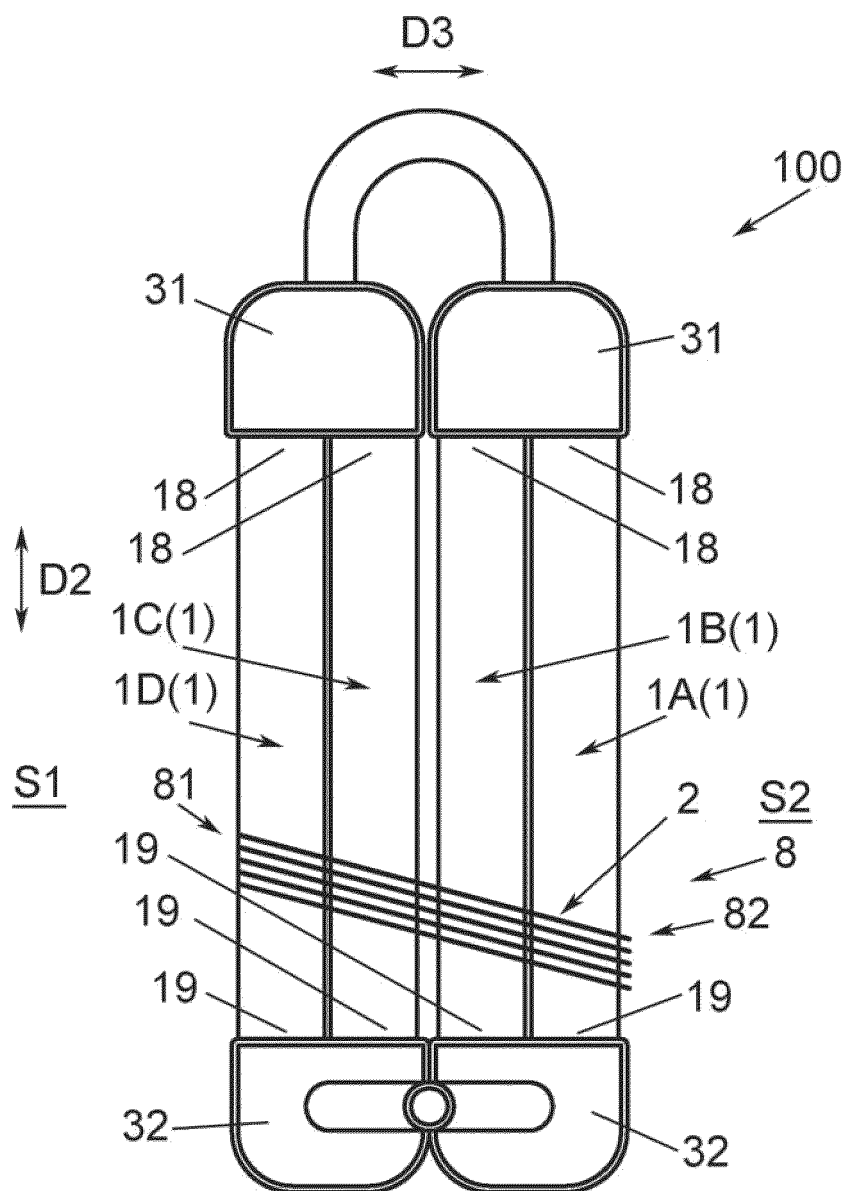


Fig. 3

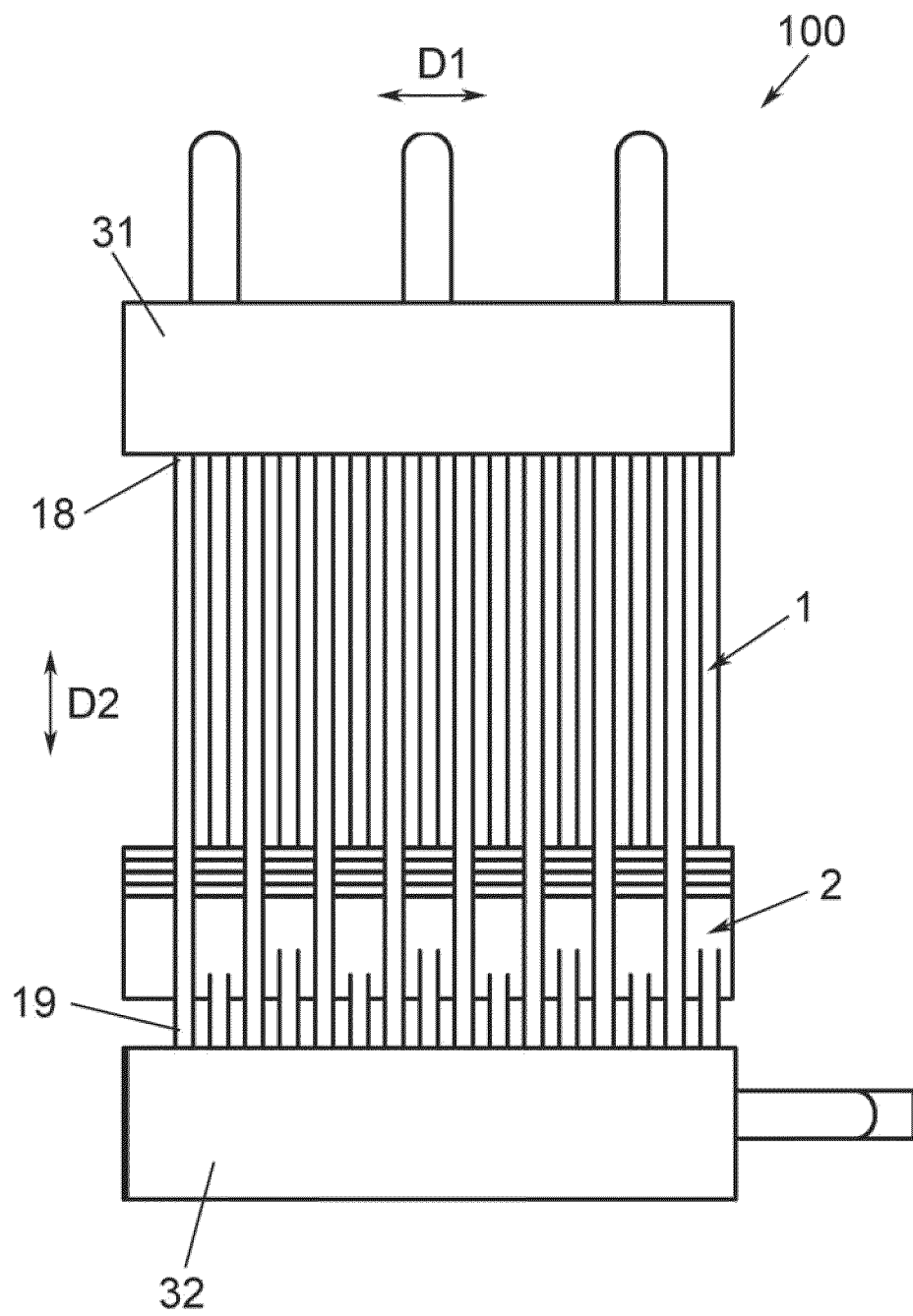


Fig. 4

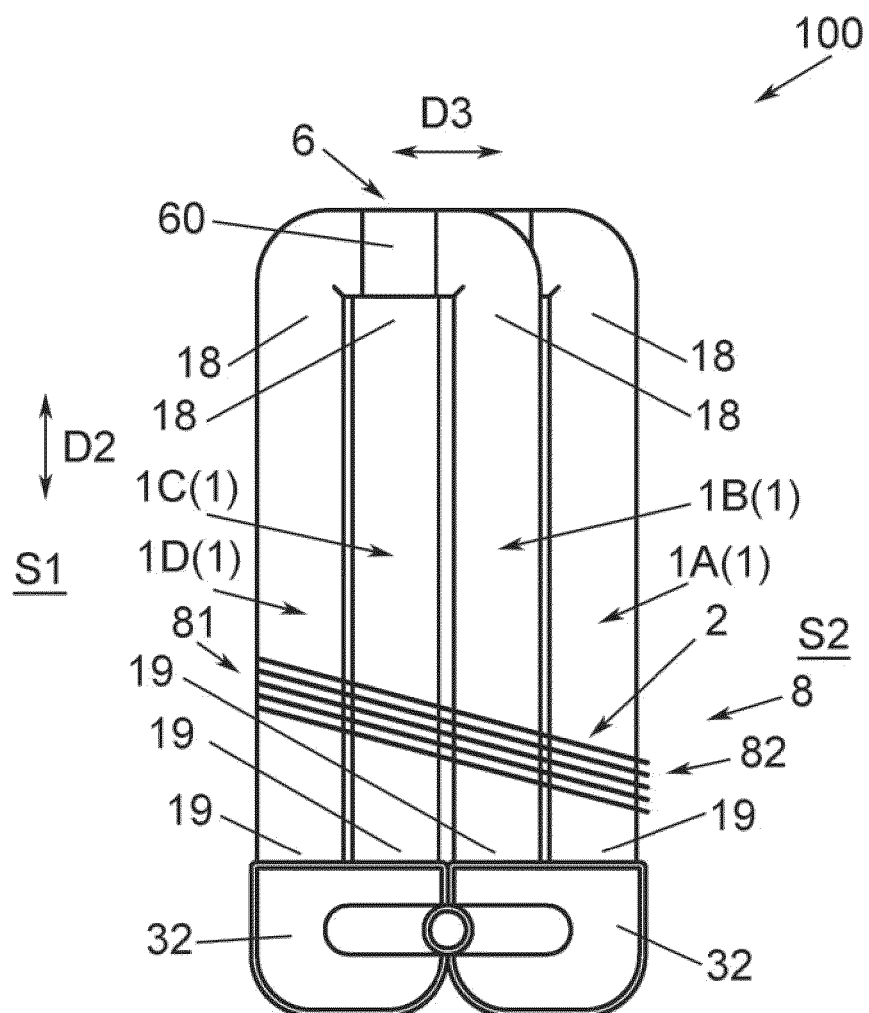


Fig. 5

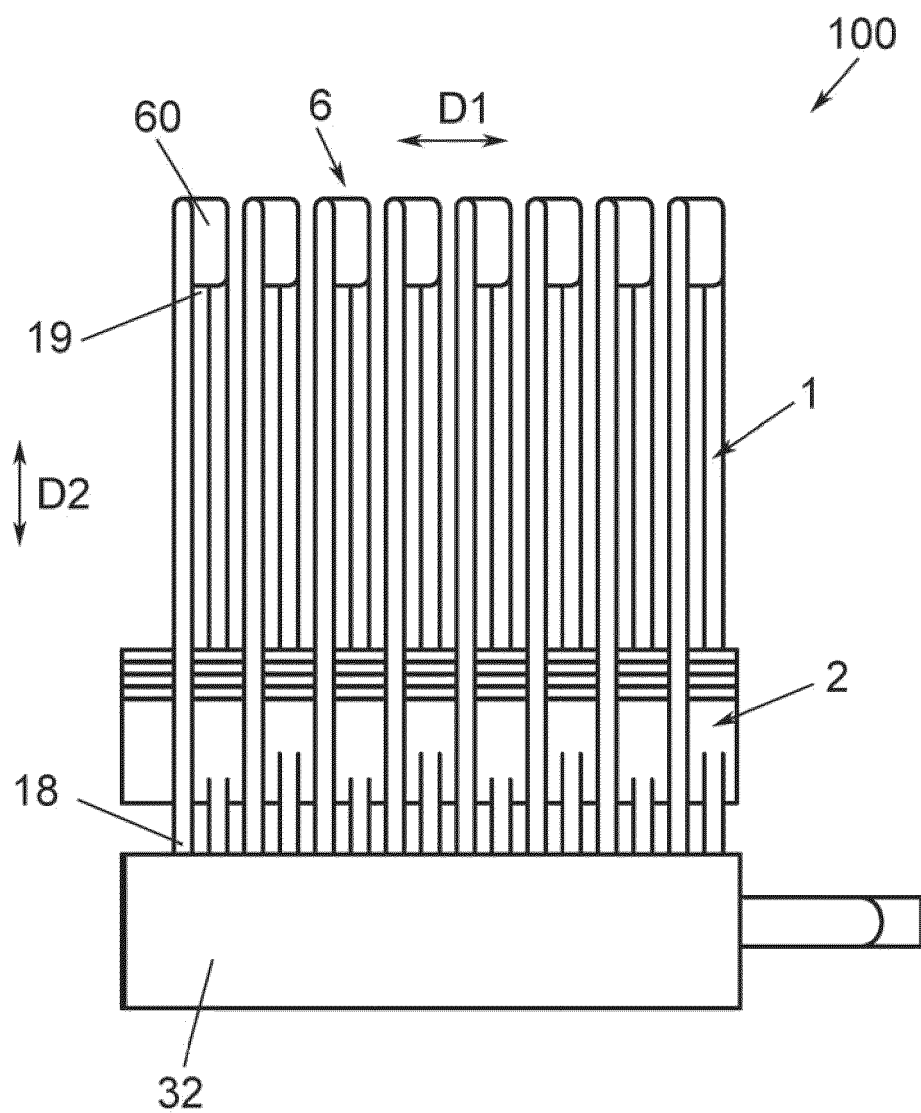


Fig. 6

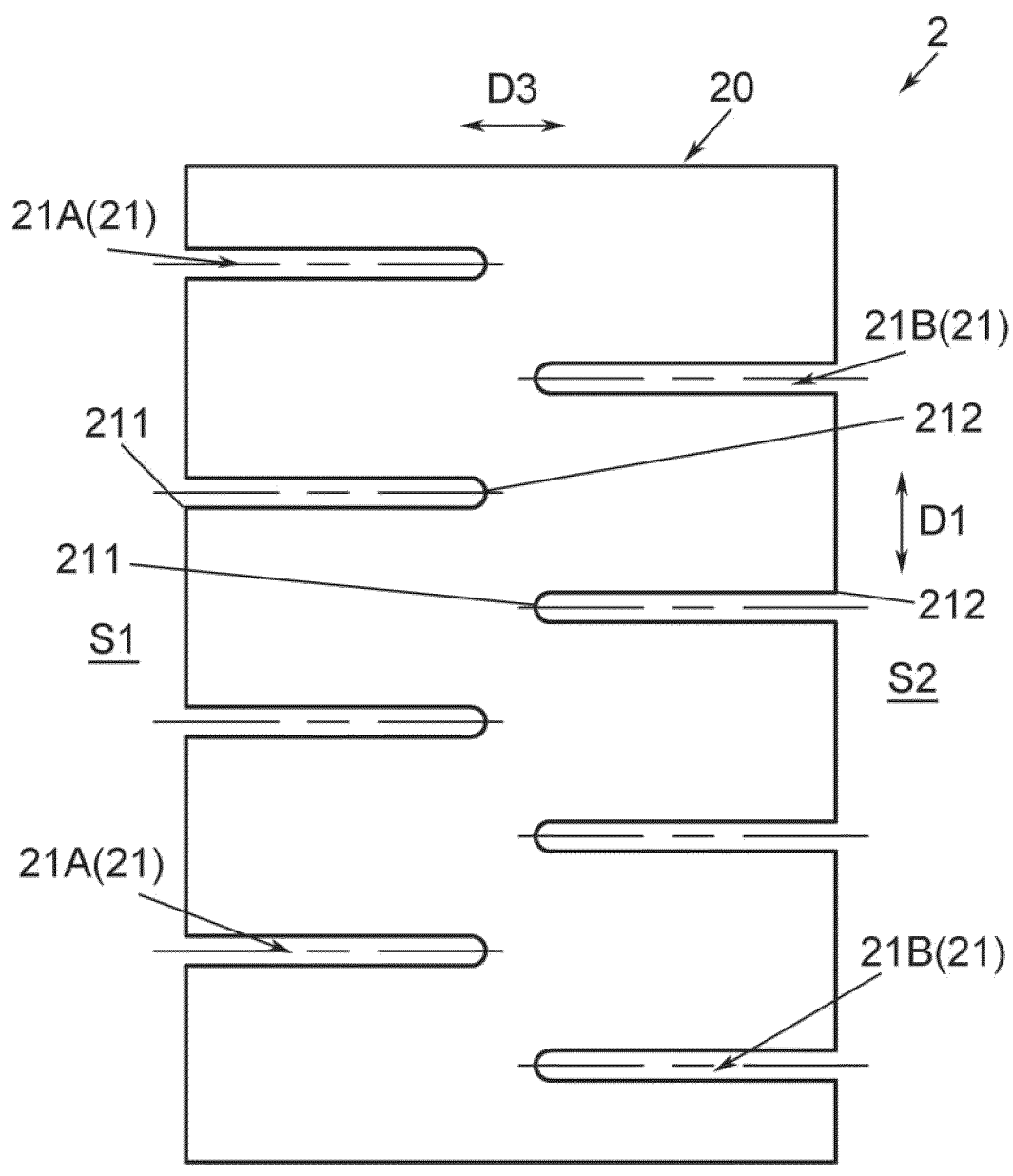


Fig. 7

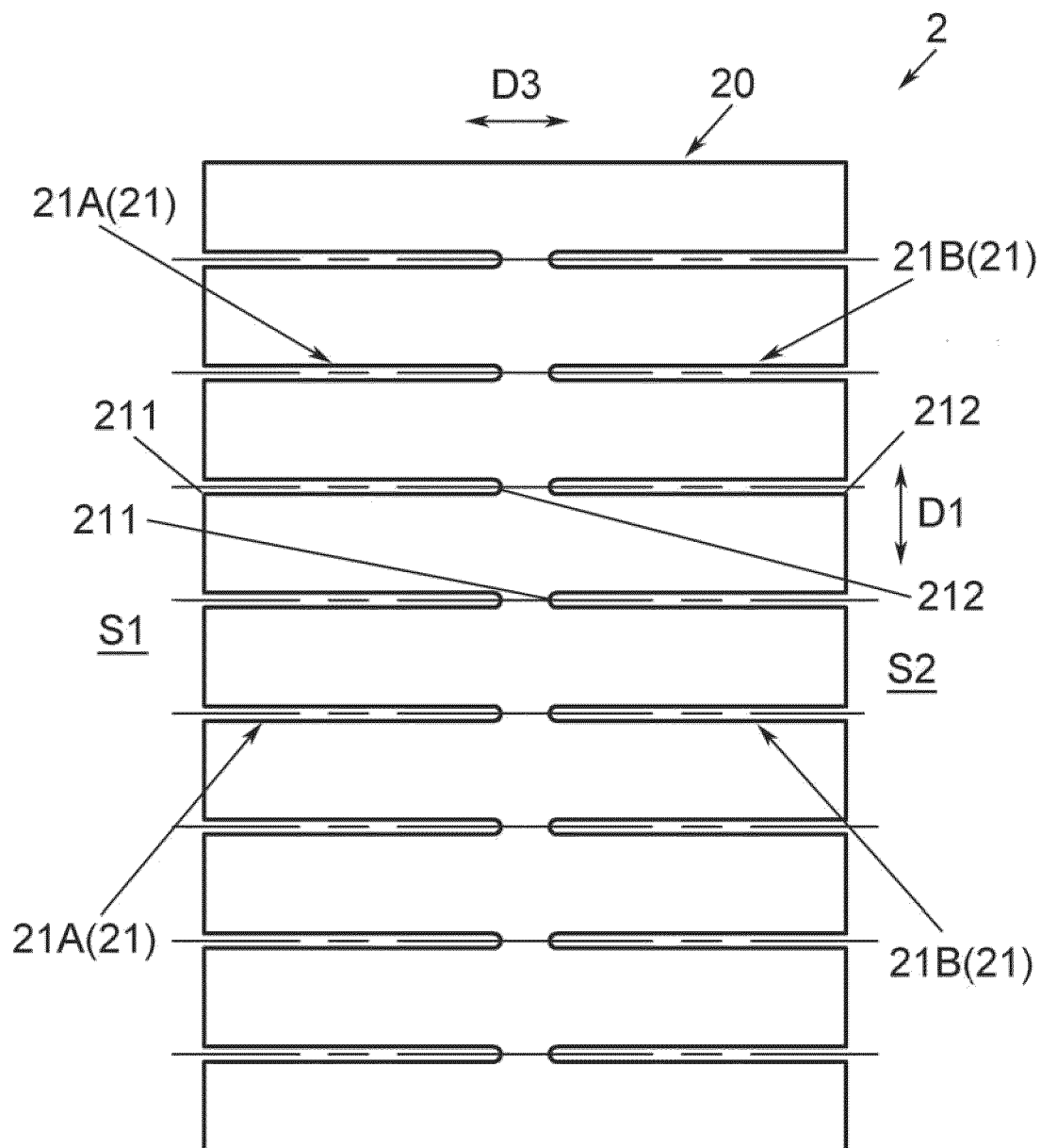


Fig. 8

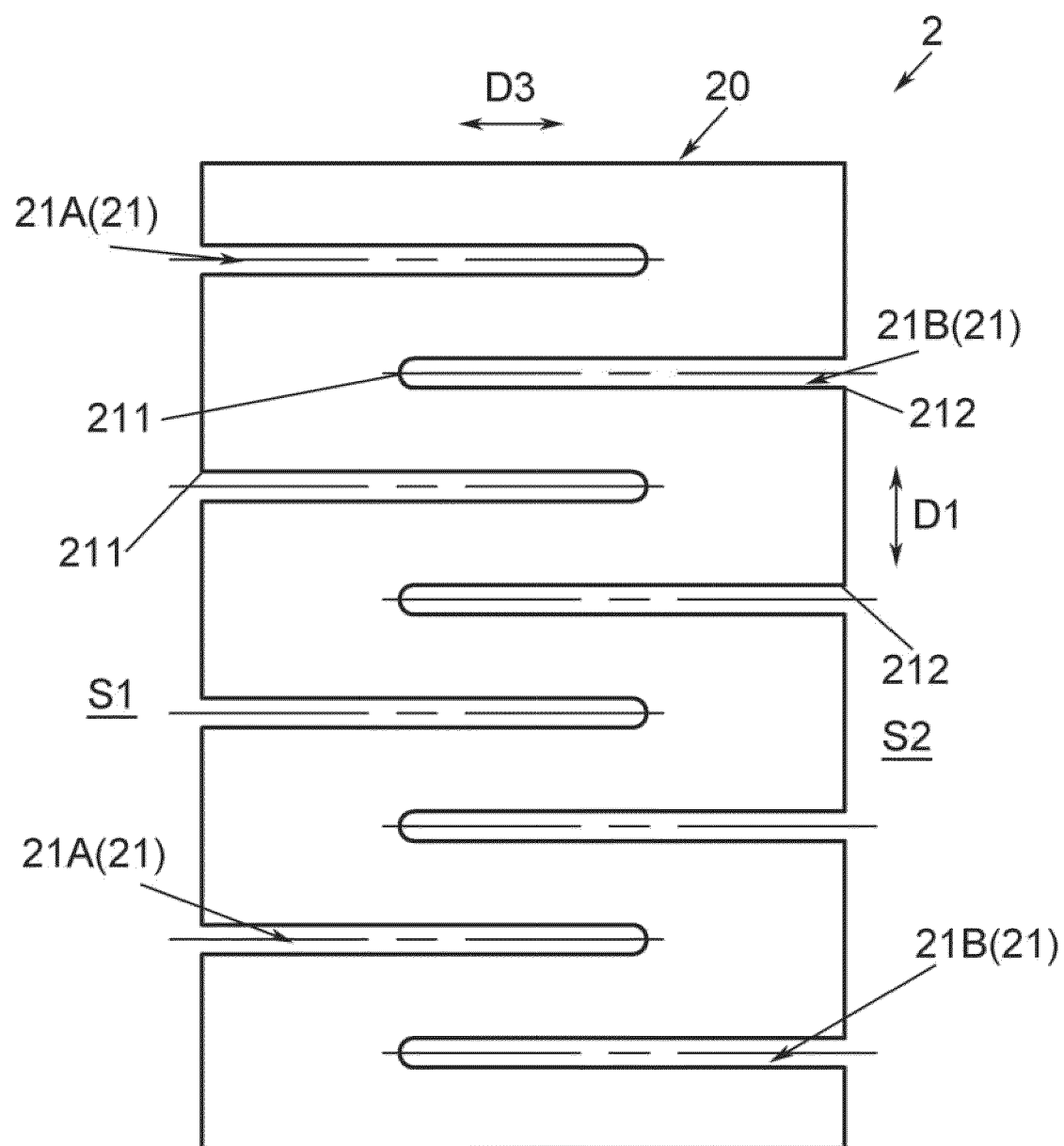


Fig. 9

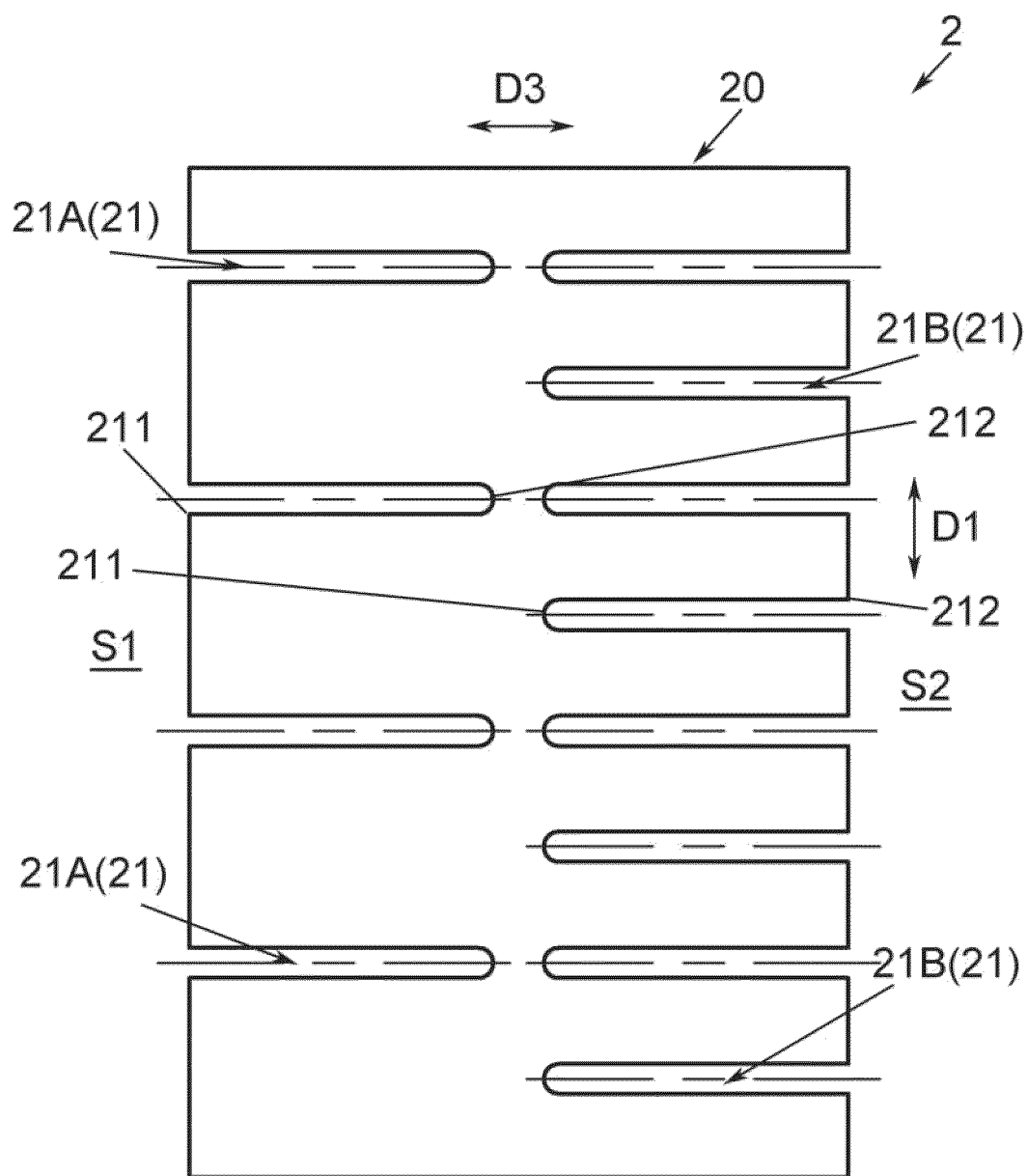


Fig. 10

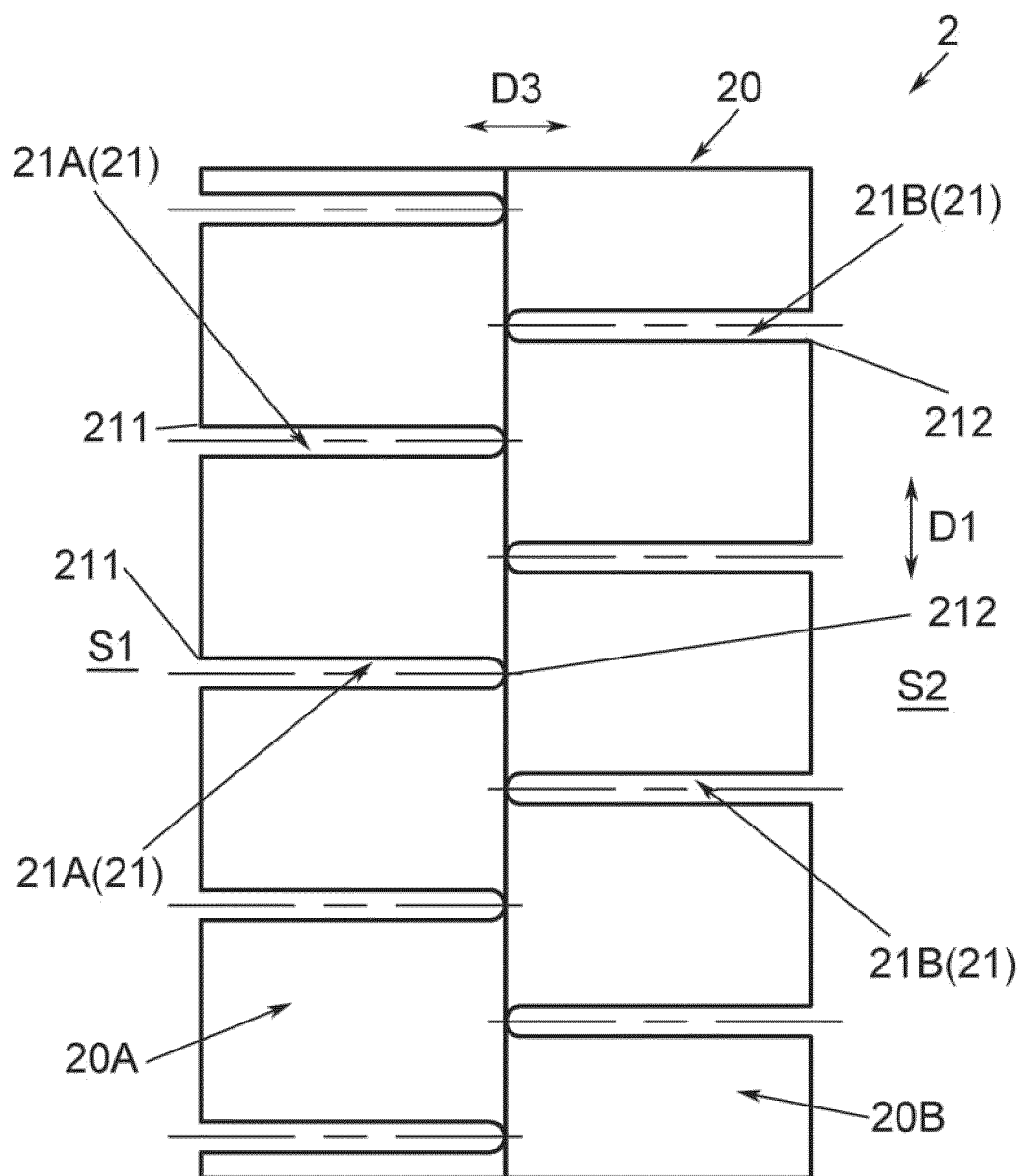


Fig. 11

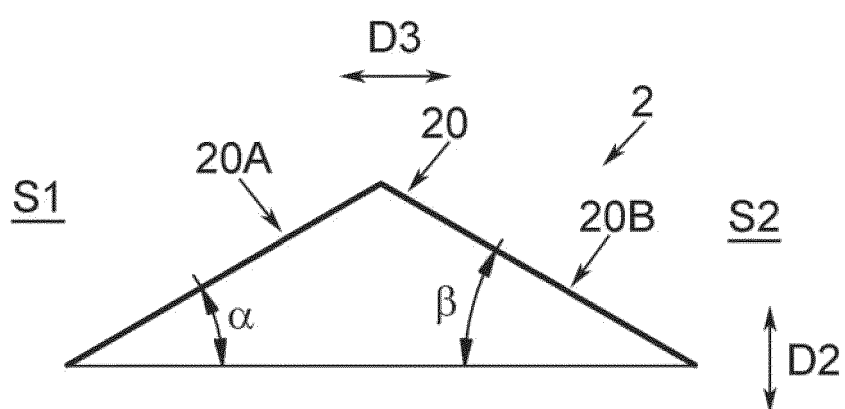


Fig. 12

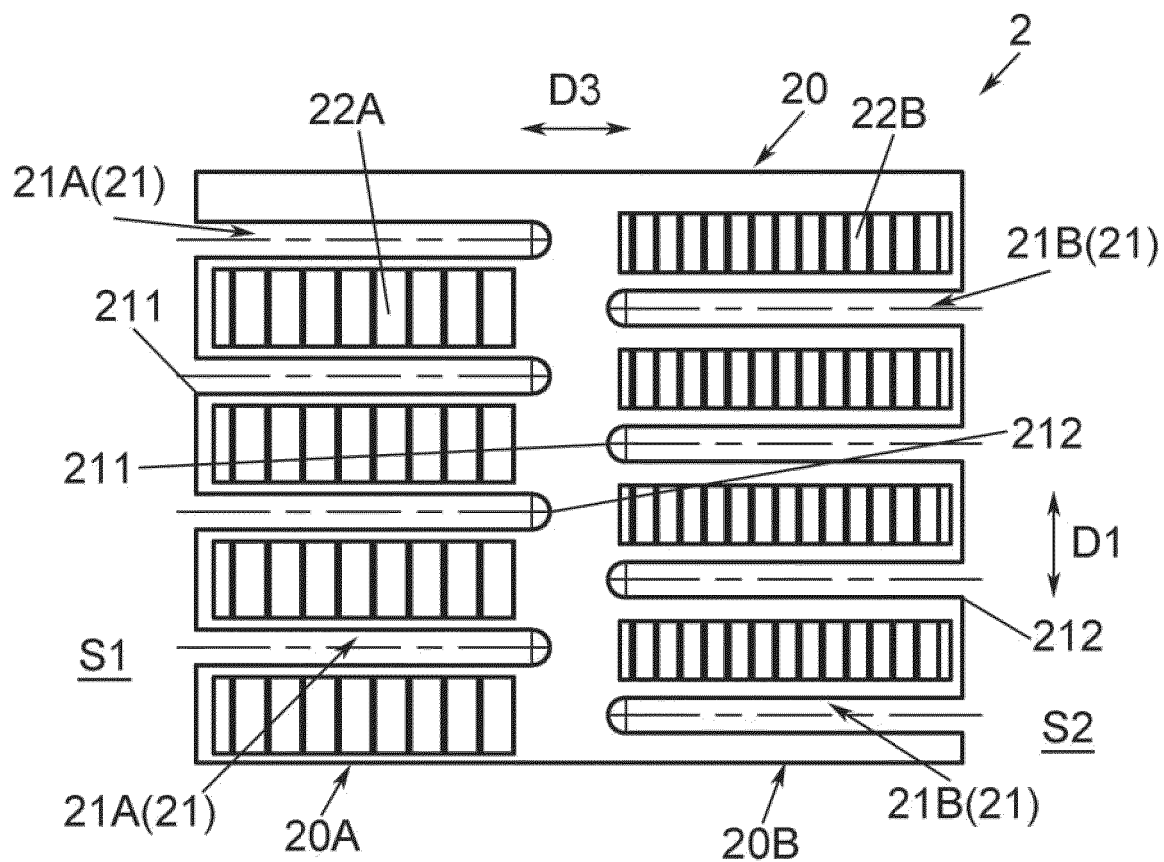


Fig. 13

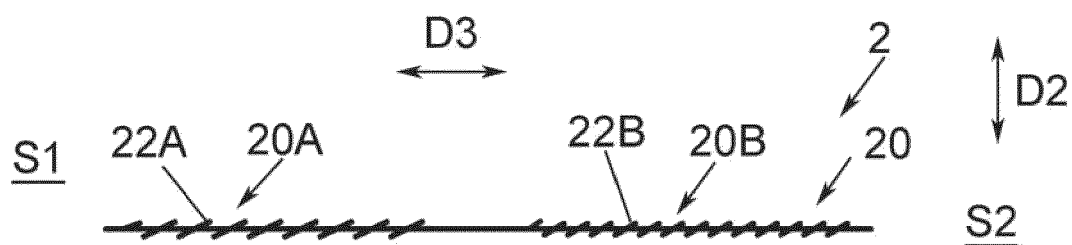


Fig. 14

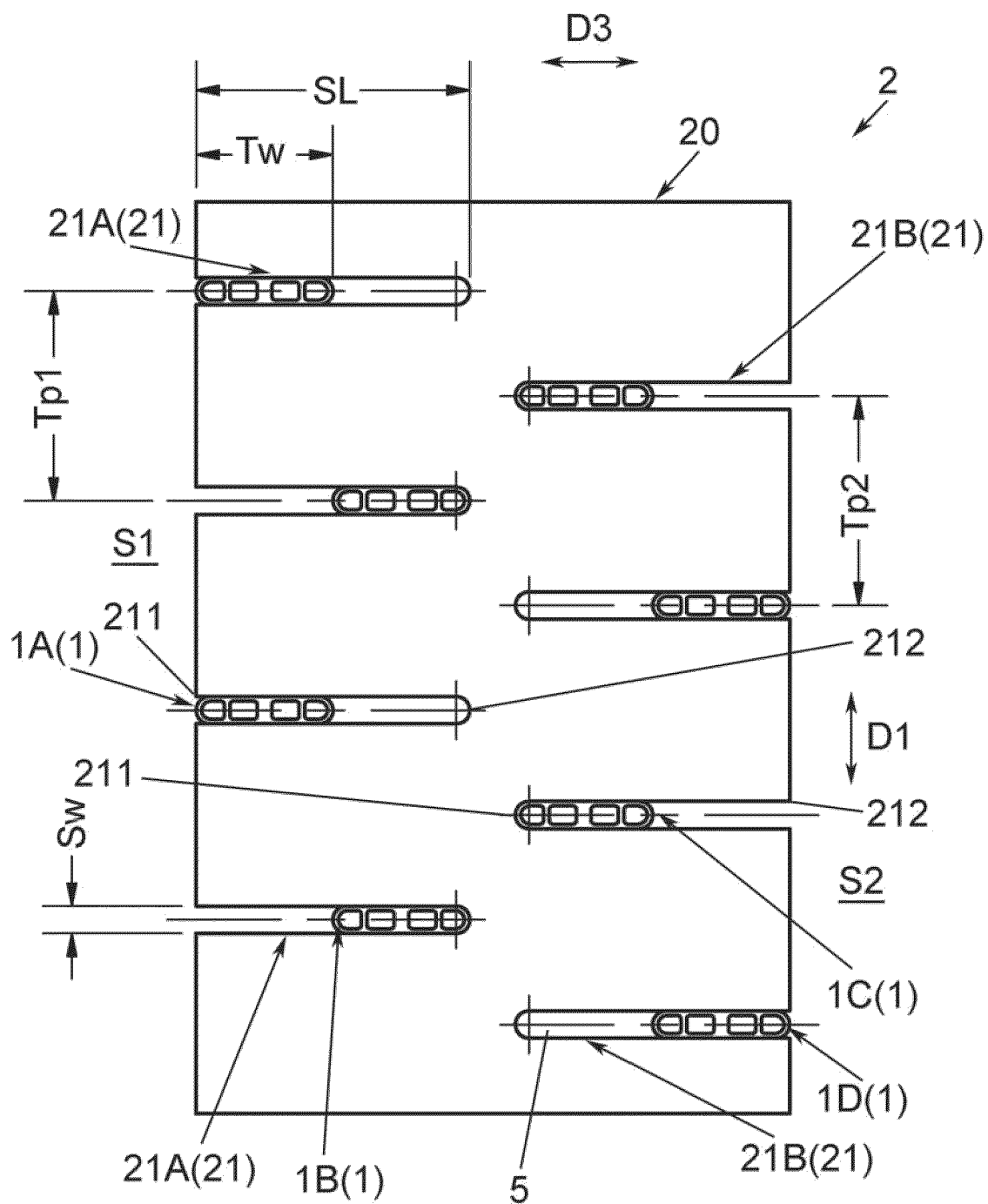


Fig. 15

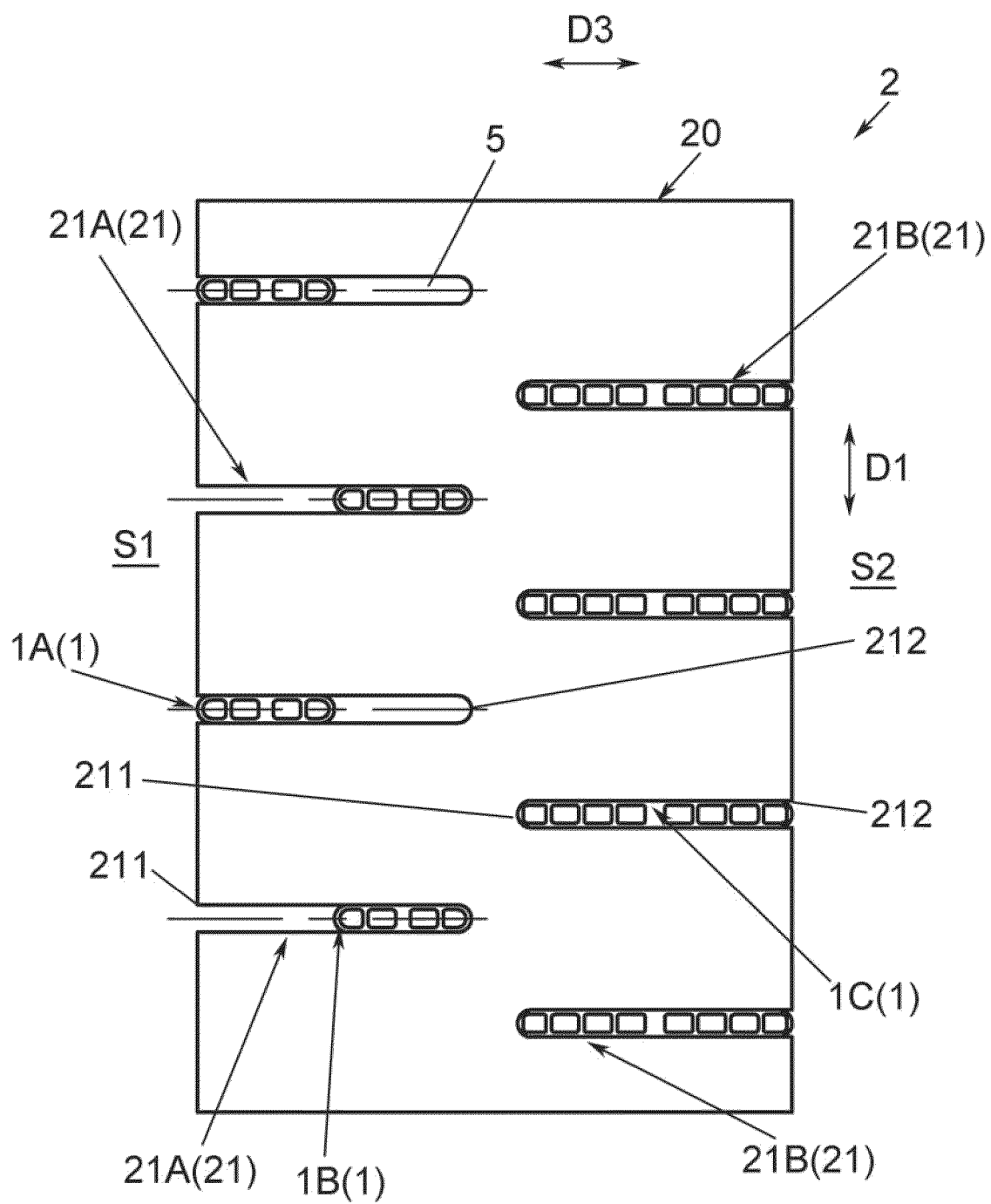


Fig. 16

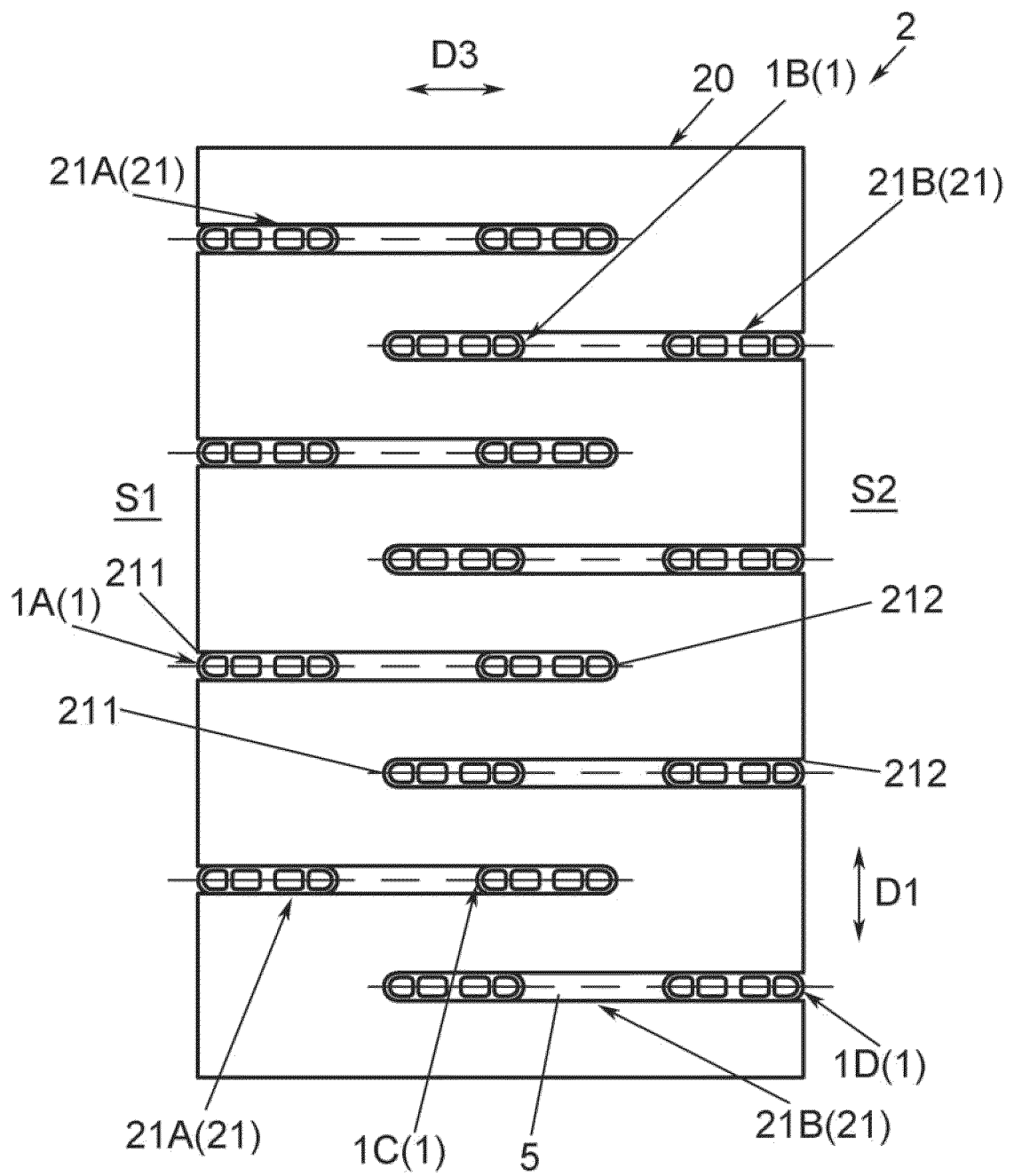


Fig. 17

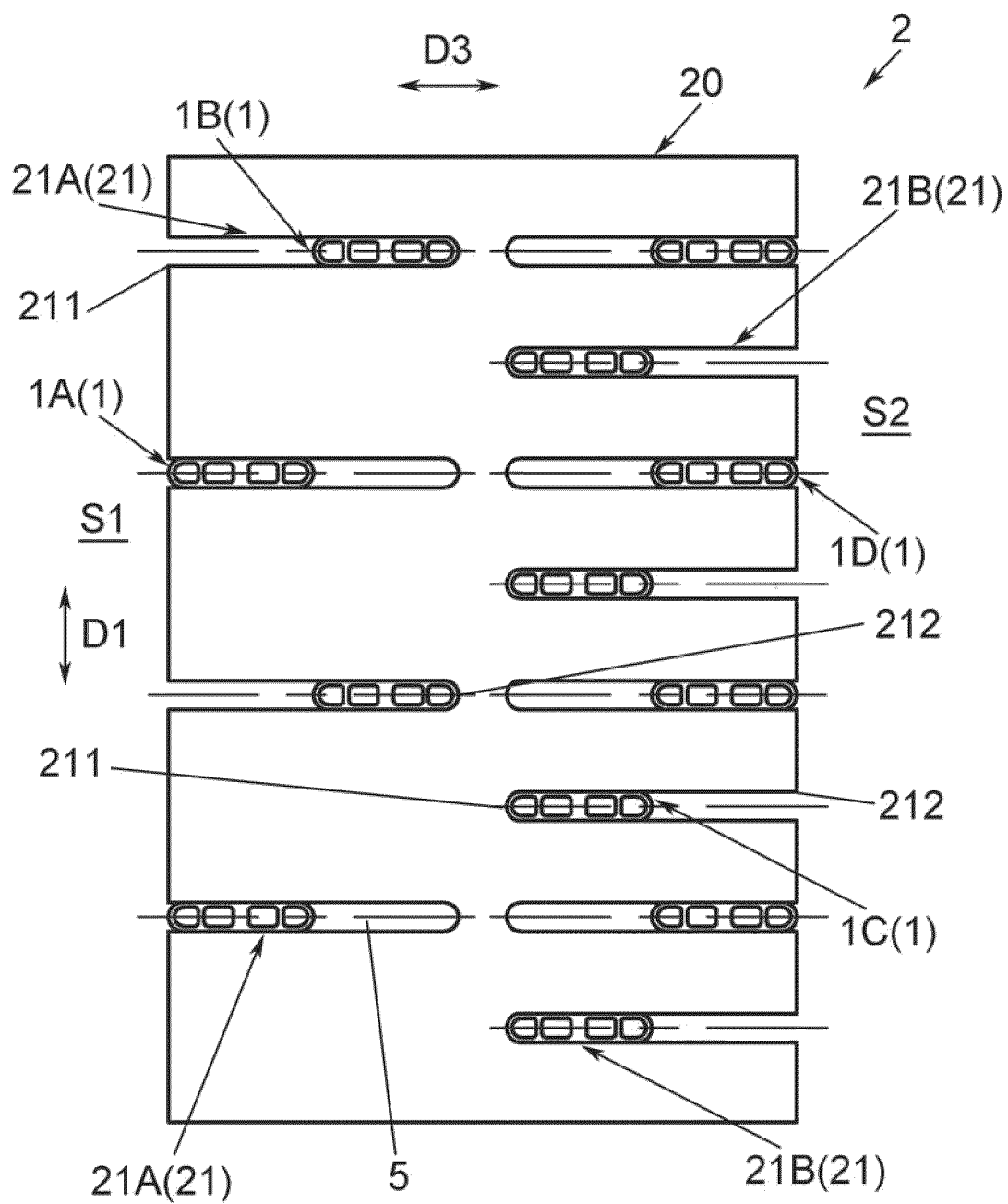


Fig. 18

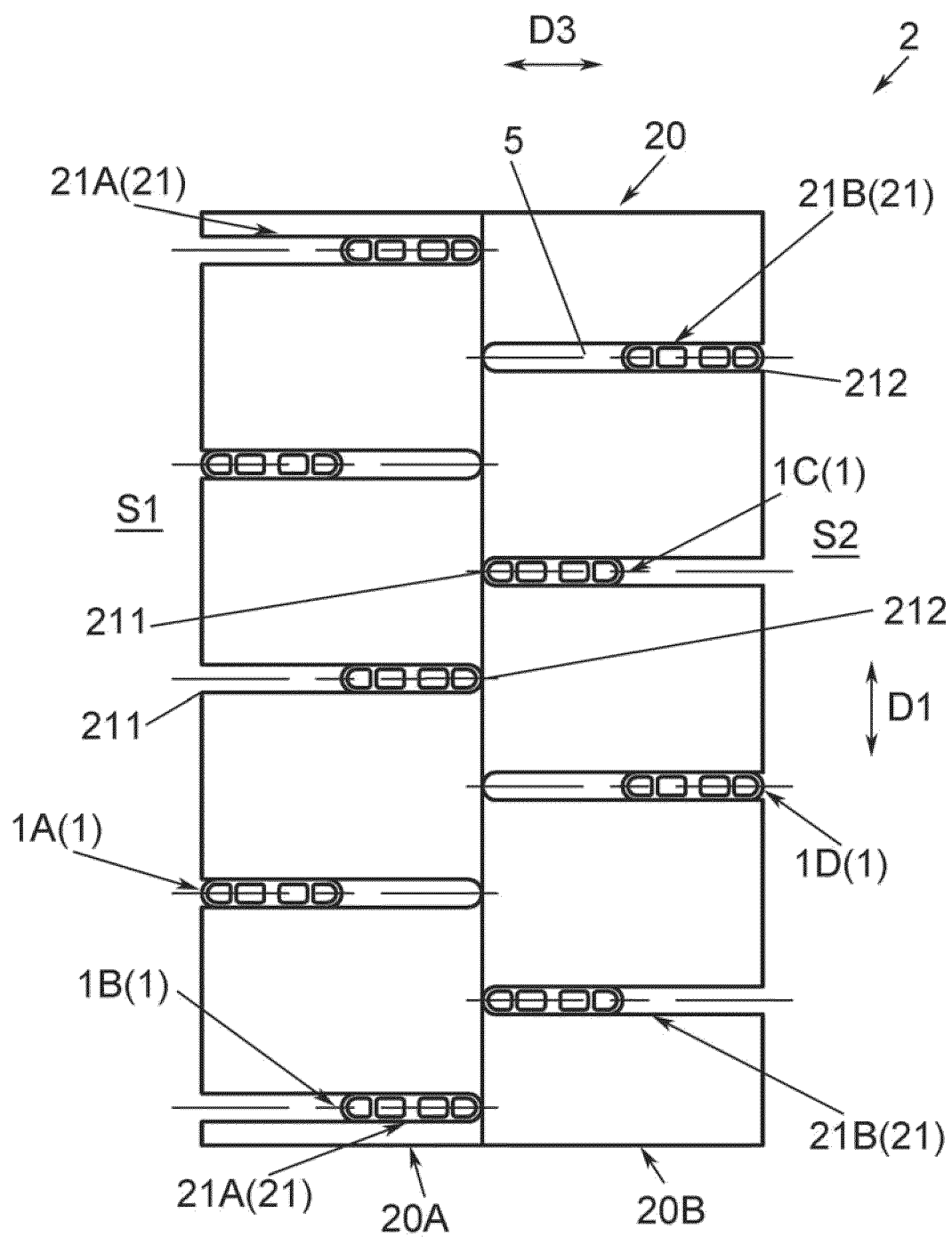


Fig. 19

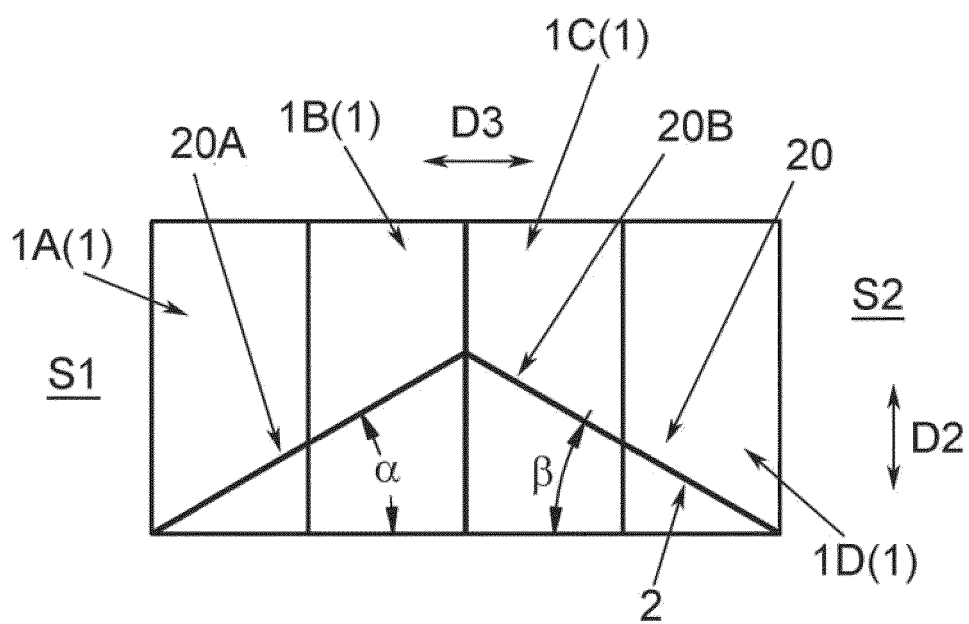


Fig. 20



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Application Number

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Place of search Munich		Date of completion of the search 24 January 2025	Examiner Vassoille, Bruno
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