



(11)

EP 4 818 628 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
07.10.2026 Bulletin 2026/41

(21) Application number: **24896687.1**

(22) Date of filing: **29.11.2024**

(51) International Patent Classification (IPC):
F28F 25/08 ^(2006.01) **F28F 25/10** ^(2006.01)
F28C 1/00 ^(2006.01)

(52) Cooperative Patent Classification (CPC):
F28C 1/00; F28C 1/16; F28F 25/08; F28F 25/10

(86) International application number:
PCT/CN2024/135470

(87) International publication number:
WO 2025/113603 (05.06.2025 Gazette 2025/23)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **01.12.2023 CN 202311642492**
29.01.2024 CN 202420210190 U
19.07.2024 CN 202410975755

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(54) **FILLER MODULE AND COOLING TOWER**

(57) The present disclosure relates to a packing module. The packing module includes a plurality of packing sheets arranged in a stacked manner. The packing sheet is configured such that a first offset part offset toward a rear side is provided on a left side of an upper end portion, a second offset part offset toward a front side is provided on a right side of the upper end portion, a third offset part offset toward the rear side is provided on a left side of a lower end portion, and a fourth offset part offset toward the front side is provided on a right side of the lower end portion. Adjacent packing sheets are arranged in such a way as to be rotated by 180° about a horizontal axis of a body part of the packing sheet. According to the present disclosure, the manufacturing cost of the packing module can be significantly reduced, and the packing module can be easily assembled using the packing sheets.

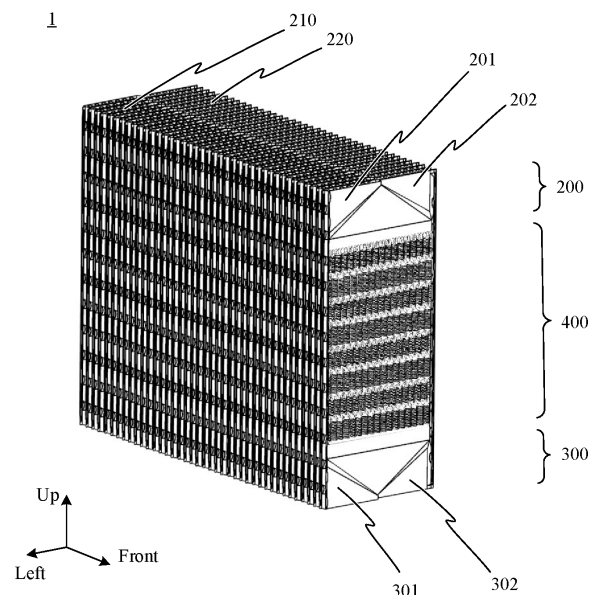


FIG. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to modules for a cooling tower, and in particular, to a packing module in a cooling tower.

BACKGROUND

[0002] As a heat exchange packing sheet technology for a cooling tower, the applicant previously disclosed, in Patent Application No. 201910877463.9 filed on July 15, 2019, a packing module in which a downward hot water flow path is separated from an upward cold air flow path. In the packing module, hot water flows in from an opening formed at an upper end of the packing module, which occupies a portion of the width of the upper end, and air flows in through an opening formed in another portion of the width of the upper end of the packing module. Manufacture of the packing module requires four types of packing sheets A, B, C, and D, and it has been found that the packing module exhibits excellent cooling performance for hot water.

[0003] In order to further simplify the structure, facilitate mounting, and reduce the cost, the present disclosure provides a packing module.

SUMMARY

[0004] In view of the above prior art, the present disclosure provides a packing module, characterized in that: the packing module includes a plurality of packing sheets arranged in a stacked manner; the packing sheet is configured such that a first offset part offset toward a rear side is provided on a left side of an upper end portion, a second offset part offset toward a front side is provided on a right side of the upper end portion, a third offset part offset toward the rear side is provided on a left side of a lower end portion, and a fourth offset part offset toward the front side is provided on a right side of the lower end portion; adjacent packing sheets are arranged in such a way as to be rotated by 180° about a horizontal axis of a body part of the packing sheet.

[0005] Preferably, the second offset part of the packing sheet is brought into contact with a fourth offset part of a front-side flipped packing sheet located on a front side in a stacking direction, and the fourth offset part of the packing sheet is brought into contact with a second offset part of the front-side flipped packing sheet, such that a first upper-end opening is formed between the first offset part of the packing sheet and a third offset part of the front-side flipped packing sheet, and a first lower-end opening is formed between the third offset part of the packing sheet and a first offset part of the front-side flipped packing sheet. The first upper-end opening and the first lower-end opening are in communication with a first heat exchange part formed between the body part of the

packing sheet and a body part of the front-side flipped packing sheet on an upper side and a lower side in a vertical direction, respectively, thereby forming a first flow path.

5 [0006] Preferably, the first offset part of the packing sheet is brought into contact with a third offset part of a rear-side flipped packing sheet located on a rear side in the stacking direction, and the third offset part of the packing sheet is brought into contact with a first offset
10 part of the rear-side flipped packing sheet, such that a second upper-end opening is formed between the second offset part of the packing sheet and a fourth offset part of the rear-side flipped packing sheet, and a second lower-end opening is formed between the fourth offset
15 part of the packing sheet and a second offset part of the rear-side flipped packing sheet. The second upper-end opening and the second lower-end opening are in communication with a second heat exchange part formed between the body part of the packing sheet and a body
20 part of the rear-side flipped packing sheet on the upper side and the lower side in the vertical direction, respectively, thereby forming a second flow path.

[0007] Further preferably, a first flow straightening plate that gradually increases in width and gradually
25 decreases in thickness from the first upper-end opening to the first heat exchange part is disposed between the first offset part of the packing sheet and the third offset part of the front-side flipped packing sheet.

[0008] Preferably, a third flow straightening plate that
30 gradually increases in width and gradually decreases in thickness from the first lower-end opening to the first heat exchange part is disposed between the third offset part of the packing sheet and the first offset part of the front-side flipped packing sheet.

35 [0009] In addition, a second flow straightening plate that gradually increases in width and gradually decreases in thickness from the second upper-end opening to the second heat exchange part is disposed between the second offset part of the packing sheet and the fourth
40 offset part of the rear-side flipped packing sheet.

a fourth flow straightening plate that gradually increases in width and gradually decreases in thickness from the second lower-end opening to the second heat exchange part is disposed between the fourth offset part of the
45 packing sheet and the second offset part of the rear-side flipped packing sheet.

[0010] Further preferably, a left side edge of each of the packing sheets is offset toward the front side to form a linear sealing edge part, and the sealing edge part of the
50 packing sheet is brought into contact with a sealing edge part of the front-side flipped packing sheet located on the front side in the stacking direction.

[0011] The sealing edge part of the packing sheet is brought into contact with the sealing edge part of the
55 front-side flipped packing sheet located on the front side in the stacking direction, and the two are joined by welding.

[0012] In addition, the present disclosure provides a

cooling tower including the packing module described above. The packing module according to the present disclosure can further simplify the structure, facilitate mounting, and reduce the cost.

[0013] In addition, the present disclosure provides a packing module for a cooling tower. The packing module includes rectangular packing sheets A and B alternately stacked at predetermined intervals. The rectangular packing sheets A and B form first and second flow paths that are alternately arranged. An upper-section guide part and a lower-section guide part are disposed in an upper section and a lower section of the packing module, respectively. The upper-section guide part includes a plurality of first upper-end openings and second upper-end openings provided in an upper surface of the packing module. The first upper-end openings are located on one side perpendicular to a stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths. The second upper-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths. The lower-section guide part includes a plurality of first lower-end openings and second lower-end openings provided in a lower surface of the packing module. The first lower-end openings are located on the one side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths. The second lower-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths.

[0014] Further, the packing module according to the present disclosure is preferably configured such that a heat exchange part is disposed between the upper-section guide part and the lower-section guide part. The heat exchange part includes: first heat exchange parts in a form of a flat cavity formed between the packing sheets B-A; and second heat exchange parts in a form of a flat cavity formed between the packing sheets A-B, where the first heat exchange parts and the second heat exchange parts are alternately stacked in a stacking direction.

[0015] Further, the packing module according to the present disclosure is preferably configured such that a total dimension of the first upper-end openings, the second upper-end openings, the first lower-end openings, and the second lower-end openings in the stacking direction is substantially equal to a stacking thickness of the packing module. Further, the packing module according to the present disclosure is preferably configured such that flow straightening plates are disposed between each of the upper-end openings and the heat exchange part, as well as between each of the lower-end openings and the heat exchange part. Each of the flow straightening plates has a corrugated transverse cross-section, and opposite sides of the corrugated shape abut against the packing sheets, respectively.

[0016] Further, the packing module according to the present disclosure is preferably configured such that a distance between the packing sheet A and the packing sheet B is d ; each flow straightening plate has a large corrugation amplitude and a small corrugation pitch at an upper-end opening and a lower-end opening thereof, and during extension of the flow straightening plate toward the heat exchange part, the corrugation amplitude gradually decreases while the corrugation pitch gradually increases.

[0017] Further, the packing module according to the present disclosure is preferably configured such that, at the upper-section guide part, an upper end portion of the packing sheet A on one side in the stacking direction is offset toward one side in the stacking direction, and an upper end portion of the packing sheet B on the one side in the stacking direction is offset toward the other side in the stacking direction, such that at corresponding regions, the packing sheet A and the packing sheet B are in close contact with each other on one side in the stacking direction, and the packing sheet B and the packing sheet A are spaced apart from each other on an opposite side in the stacking direction, thereby forming the first upper-end opening; and an upper end portion of the packing sheet B on the other side in the stacking direction is offset toward one side in the stacking direction, and an upper end portion of the packing sheet A on the other side in the stacking direction is offset toward the other side in the stacking direction, such that at corresponding regions, the packing sheet B and the packing sheet A are in close contact with each other on one side in the stacking direction, and the packing sheet A and the packing sheet B are spaced apart from each other on an opposite side in the stacking direction, thereby forming the second upper-end opening. At the lower-section guide part, a lower end portion of the packing sheet A on one side in the stacking direction is offset toward one side in the stacking direction, and a lower end portion of the packing sheet B on the one side in the stacking direction is offset toward the other side in the stacking direction, such that at corresponding regions, the packing sheet A and the packing sheet B are in close contact with each other on one side in the stacking direction, and the packing sheet B and the packing sheet A are spaced apart from each other on an opposite side in the stacking direction, thereby forming the first lower-end opening; and a lower end portion of the packing sheet B on the other side in the stacking direction is offset toward one side in the stacking direction, and the lower end portion of the packing sheet A on the other side in the stacking direction is offset toward the other side in the stacking direction, such that at corresponding regions, the packing sheet B and the packing sheet A are in close contact with each other on one side in the stacking direction, and the packing sheet A and the packing sheet B are spaced apart from each other on an opposite side in the stacking direction, thereby forming the second lower-end opening.

[0018] Further, the packing module according to the present disclosure is preferably configured such that, at the upper-section guide part, the upper-section guide parts of the packing sheet A and the packing sheet B are configured such that portions thereof on opposite sides in the stacking direction are respectively offset in opposite directions in the stacking direction; and at the lower-section guide part, the lower-section guide parts of the packing sheet A and the packing sheet B are configured such that portions thereof on the opposite sides in the stacking direction are respectively offset in the opposite directions in the stacking direction.

[0019] Further, the packing module according to the present disclosure is preferably configured such that portions, on the opposite sides in the stacking direction, of at least one of the upper-section guide part of the packing sheet A and the upper-section guide part of the packing sheet B are offset in the opposite directions in the stacking direction by non-zero amounts; and portions, on the opposite sides in the stacking direction, of at least one of the lower-section guide part of the packing sheet A and the lower-section guide part of the packing sheet B are offset in the opposite directions in the stacking direction by non-zero amounts.

[0020] Further, the packing module according to the present disclosure is preferably configured such that the upper-section guide part of the packing sheet A and the upper-section guide part of the packing sheet B have different offset amounts on the opposite sides in the stacking direction; and the lower-section guide part of the packing sheet A and the lower-section guide part of the packing sheet B have different offset amounts on the opposite sides in the stacking direction.

[0021] Further, the packing module according to the present disclosure is preferably configured such that widths of the first upper-end opening and the second upper-end opening on opposite sides perpendicular to the stacking direction are equal to widths of the first lower-end opening and the second lower-end opening on opposite sides in the stacking direction, and the flow straightening plates disposed between each of the upper-end openings and the first heat exchange part, as well as between each of the lower-end openings and the first heat exchange part, are a same component.

[0022] In addition, the present disclosure further provides a low airflow-resistance packing module. The low airflow-resistance packing module includes rectangular packing sheets A and B alternately stacked at predetermined intervals. The rectangular packing sheets A and B form first flow paths and second flow paths that are alternately arranged. An upper-section guide part and a lower-section guide part are disposed in an upper section and a lower section of the packing module, respectively. A heat exchange part is disposed between the upper-section guide part and the lower-section guide part. The heat exchange part includes: first heat exchange parts in a form of a flat cavity formed between the packing sheets B-A; and second heat exchange parts

in a form of a flat cavity formed between the packing sheets A-B, where the first heat exchange parts and the second heat exchange parts are alternately stacked in a stacking direction. The first flow path serves as a water spraying channel, and the second flow path serves as an air intake channel. The upper-section guide part includes a plurality of first upper-end openings and second upper-end openings provided in an upper surface of the packing module. The first upper-end openings are located on one side perpendicular to a stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths. The second upper-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths. The lower-section guide part includes a plurality of first lower-end openings and second lower-end openings provided in a lower surface of the packing module. The first lower-end openings are located on one side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths. The second lower-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths. At the upper-section guide part, a first flow straightening plate is provided only in the first upper-end opening, the first flow straightening plate guiding spray water from the first upper-end opening to the first heat exchange part having substantially an entire width of the packing module.

[0023] Preferably, the low airflow-resistance packing module according to the present disclosure is characterized in that: at the lower-section guide part, a second flow straightening plate is provided only in the first lower-end opening, the second flow straightening plate guiding the spray water to the first lower-end opening from the first heat exchange part having substantially an entire width of the packing module.

[0024] Preferably, the low airflow-resistance packing module according to the present disclosure is characterized in that: a width of the first upper-end opening is substantially equal to a width of the second upper-end opening, a width of the first lower-end opening is substantially equal to a width of the second lower-end opening, and the first flow straightening plate and the second flow straightening plate are a same component.

[0025] Preferably, the low airflow-resistance packing module according to the present disclosure is characterized in that: the first upper-end opening and the first lower-end opening are located on a same side of the packing module, and the first flow straightening plate and the second flow straightening plate are a same component.

[0026] Preferably, the low airflow-resistance packing module according to the present disclosure is characterized in that: the first upper-end opening and the first lower-end opening are located on a same side of the packing module, and a sealing edge part is formed on an

edge of an outer side of the first upper-end opening in a width direction of the packing module.

[0027] Preferably, the low airflow-resistance packing module according to the present disclosure is characterized in that: the sealing edge part is configured such that an upper end portion of the packing sheet A is offset toward a rear side at the first upper-end opening and offset toward a front side at an edge; the packing sheet B on a front side in the stacking direction is offset toward the front side at the first upper-end opening to be brought into contact with a first upper-end opening of another packing sheet A on the front side, and offset toward the rear side at an edge to be brought into contact with an edge of the packing sheet A.

[0028] Preferably, the low airflow-resistance packing module according to the present disclosure is characterized in that: each of the first and second flow straightening plates has a corrugated transverse cross-section, and opposite sides of the corrugated shape abut against the packing sheets, respectively.

[0029] Preferably, the low airflow-resistance packing module according to the present disclosure is characterized in that: a distance between the packing sheet A and the packing sheet B is d ; each of the first and second flow straightening plates has a large corrugation amplitude and a small corrugation pitch at an upper-end opening and a lower-end opening thereof, and during extension of the flow straightening plate toward the heat exchange part, the corrugation amplitude gradually decreases while the corrugation pitch gradually increases.

[0030] In addition, the present disclosure provides a cooling tower. The cooling tower includes the above-described low airflow-resistance packing module, characterized in that: in the first flow path, the sprayed hot water flows in through the first upper-end opening formed at a portion of the packing module in the width direction, undergoes heat exchange in the first heat exchange part having substantially the entire width, through the packing sheets A and B, with cold air in the second heat exchange part of the adjacent second flow path, and flows out through the first lower-end opening formed at a portion in the width direction. In the second flow path, cold air is introduced into the second heat exchange part only through the first lower-end opening formed at a portion in the width direction, exchanges heat at the second heat exchange part having substantially the entire width, and then is led out through the second upper-end opening formed at a portion in the width direction.

[0031] According to the present disclosure, the structure of the packing module can be significantly simplified, the cost can be reduced on the premise of ensuring the heat exchange efficiency, and the airflow resistance for drawing cold air is extremely small.

[0032] In addition, the present disclosure provides a packing module having a watertight sealing edge. The packing module having a watertight sealing edge includes rectangular packing sheets A and B alternately stacked at predetermined intervals, the rectangular pack-

ing sheets A and B forming first flow paths and second flow paths that are alternately arranged, where the packing module includes an upper-section guide part located in an upper section and a heat exchange part located below the upper-section guide part. The heat exchange part includes: first heat exchange parts in a form of a flat cavity formed between the packing sheets B-A; and second heat exchange parts in a form of a flat cavity formed between the packing sheets A-B, where the first heat exchange parts and the second heat exchange parts are alternately stacked in a stacking direction from front to rear. At the upper-section guide part, the packing sheet A is configured such that a first upper-section guide part on one side in a horizontal direction is offset toward a rear side in the stacking direction, and a second upper-section guide part on the other side is offset toward a front side in the stacking direction; and one side edge of the packing sheet A is offset as a whole toward the front side to form a first sealing edge part. At the upper-section guide part, the packing sheet B is configured such that a third upper-section guide part on one side in the horizontal direction is offset toward the front side in the stacking direction, and a fourth upper-section guide part on the other side is offset toward the rear side in the stacking direction; and one side edge of the packing sheet B is offset toward the rear side to form a second sealing edge part. When the packing sheets A and B are stacked from rear to front in the stacking direction, the first sealing edge part of the packing sheet A is brought into contact with the second sealing edge part of the packing sheet B adjacent to the front side to form a sealing edge.

[0033] Preferably, the sealing edge is formed by welding the first sealing edge part and the second sealing edge part to each other.

[0034] In addition, preferably, the first upper-section guide part of the packing sheet A and the third upper-section guide part of the packing sheet B on the rear side in the stacking direction are brought into contact with each other at least at upper end portions, and the second upper-section guide part of the packing sheet A and the fourth upper-section guide part of the packing sheet B on the front side in the stacking direction are brought into contact with each other at least at upper end portions.

[0035] In addition, preferably, between adjacent packing sheets B-A in the stacking direction from front to rear, a first upper-end opening located on one side in the horizontal direction is formed by upper-end edges of the first upper-section guide part of the packing sheet A and the third upper-section guide part of the packing sheet B, and the width of the first upper-end opening gradually increases downward, thereby communicating with the first heat exchange part to form the first flow path. An edge of the first flow path on one side in a horizontal direction is sealed by the sealing edge.

[0036] In addition, preferably, between adjacent packing sheets A-B in the stacking direction from front to rear, a second upper-end opening located on the other side in the horizontal direction is formed by upper-end edges of

the fourth upper-section guide part of the packing sheet B and the second upper-section guide part of the packing sheet A, and the width of the second upper-end opening gradually increases downward, thereby communicating with the second heat exchange part.

[0037] In addition, preferably, the alternately stacked packing sheets A and B further include lower-section guide parts located below the heat exchange part; a lower-section guide part of the packing sheet A is configured such that a first lower-section guide part on one side in the horizontal direction is offset toward the rear side in the stacking direction, and a second lower-section guide part on the other side is offset toward the front side in the stacking direction; and a lower-section guide part of the packing sheet B is configured such that a third lower-section guide part on one side in the horizontal direction is offset toward the front side in the stacking direction, and a fourth lower-section guide part on the other side is offset toward the rear side in the stacking direction.

[0038] In addition, preferably, the first lower-section guide part of the packing sheet A and the third lower-section guide part of the packing sheet B on the rear side in the stacking direction are brought into contact with each other at least at lower end portions, and the second lower-section guide part of the packing sheet A and the fourth lower-section guide part of the packing sheet B on the front side in the stacking direction are brought into contact with each other at least at lower end portions.

[0039] In addition, preferably, between adjacent packing sheets B-A in the stacking direction from front to rear, a first lower-end opening located on one side in the horizontal direction is formed by lower-end edges of the first lower-section guide part of the packing sheet A and the third lower-section guide part of the packing sheet B, and a width of the first lower-end opening gradually increases upward, thereby communicating with the first heat exchange part to form a lower-section portion of the first flow path. An edge of the first flow path on one side in a horizontal direction is sealed by the sealing edge.

[0040] Further preferably, between adjacent packing sheets A-B in the stacking direction from front to rear, a second lower-end opening located on the other side in the horizontal direction is formed by lower-end edges of the fourth lower-section guide part of the packing sheet B and the second lower-section guide part of the packing sheet A, and a width of the second lower-end opening gradually increases upward, thereby communicating with the second heat exchange part.

[0041] In addition, the present disclosure further provides a cooling tower. The cooling tower includes the packing module having a watertight sealing edge according to any one of claims 1 to 9, and hot water is sprayed from top to bottom in the first flow path, and cold air is introduced from bottom to top in the second flow path.

[0042] According to the present disclosure, the structure of the packing module can be significantly simplified, the cost can be reduced on the premise of ensuring the

heat exchange efficiency, and the airflow resistance for drawing cold air is extremely small. The packing module can further simplify the structure, facilitate the mounting, and reduce costs without reducing the heat exchange efficiency, thereby avoiding the problem of excessive increase in air humidity caused by hot water entering the air flow path.

[0043] Furthermore, the present disclosure provides a packing module having a watertight sealing edge. The packing module having a watertight sealing edge includes: rectangular packing sheets A and B alternately stacked at predetermined intervals, the rectangular packing sheets A and B forming first flow paths and second flow paths that are alternately arranged, where the packing module includes an upper-section guide part located in an upper section and a heat exchange part located below the upper-section guide part. The heat exchange part includes: first heat exchange parts in a form of a flat cavity formed between the packing sheets B-A; and second heat exchange parts in a form of a flat cavity formed between the packing sheets A-B, where the first heat exchange parts and the second heat exchange parts are alternately stacked in a stacking direction from front to rear. At the upper-section guide part, the packing sheet A is configured such that a first upper-section guide part on one side in a horizontal direction is offset toward a rear side in the stacking direction, and a second upper-section guide part on the other side is offset toward a front side in the stacking direction; and at the upper-section guide part, the packing sheet B is configured such that a third upper-section guide part on one side in the horizontal direction is offset toward the front side in the stacking direction, and a fourth upper-section guide part on the other side is offset toward the rear side in the stacking direction. In this way, between the packing sheets A-B arranged in a stacked manner, upper-section guide parts thereof on one side are brought into contact with each other to form a portion of an edge of a first upper-end opening of the first flow path; and between the packing sheets B-A arranged in a stacked manner, upper-section guide parts thereof on the other side are brought into contact with each other to form a portion of an edge of a second upper-end opening of the second flow path. A first flow straightening plate is provided at least in the first upper-end opening, the first flow straightening plate guiding a fluid entering through a portion of the packing module in the width direction to the first heat exchange part having substantially an entire width of the packing module. The first flow straightening plate is in a corrugated shape in the horizontal direction, and an end portion on a side of the first upper-end opening is spaced apart from an upper-end edge of the first upper-end opening by a predetermined distance, thereby forming a clearance region inside the first upper-end opening. In the clearance region, upper-end edges on one side of the packing sheets A-B that are brought into contact are joined by welding. Preferably, one side edge of the packing sheet A is offset as a whole toward the front side to

form a first sealing edge part; one side edge of the packing sheet B is offset as a whole toward the rear side to form a second sealing edge part; and when the packing sheets A and B are stacked from rear to front in the stacking direction, the first sealing edge part of the packing sheet A is brought into contact with the second sealing edge part of the packing sheet B adjacent to the front side to form a sealing edge.

[0044] Further preferably, the sealing edge is formed by welding the first sealing edge part and the second sealing edge part to each other.

[0045] In addition, preferably, the first upper-section guide part of the packing sheet A and the third upper-section guide part of the packing sheet B on the rear side in the stacking direction are brought into contact with each other at least at upper end portions, and the second upper-section guide part of the packing sheet A and the fourth upper-section guide part of the packing sheet B on the front side in the stacking direction are brought into contact with each other at least at upper end portions.

[0046] Further preferably, between adjacent packing sheets B-A in the stacking direction from front to rear, a first upper-end opening located on one side in the horizontal direction is formed by upper-end edges of the first upper-section guide part of the packing sheet A and the third upper-section guide part of the packing sheet B, and the width of the first upper-end opening gradually increases downward, thereby communicating with the first heat exchange part to form the first flow path. An edge of the first flow path on one side in a horizontal direction is sealed by the sealing edge.

[0047] Further preferably, between adjacent packing sheets A-B in the stacking direction from front to rear, a second upper-end opening located on the other side in the horizontal direction is formed by upper-end edges of the fourth upper-section guide part of the packing sheet B and the second upper-section guide part of the packing sheet A, and the width of the second upper-end opening gradually increases downward, thereby communicating with the second heat exchange part.

[0048] Further preferably, the alternately stacked packing sheets A and B further include lower-section guide parts located below the heat exchange part; a lower-section guide part of the packing sheet A is configured such that a first lower-section guide part on one side in the horizontal direction is offset toward the rear side in the stacking direction, and a second lower-section guide part on the other side is offset toward the front side in the stacking direction; and a lower-section guide part of the packing sheet B is configured such that a third lower-section guide part on one side in the horizontal direction is offset toward the front side in the stacking direction, and a fourth lower-section guide part on the other side is offset toward the rear side in the stacking direction.

[0049] Furthermore, preferably, the first lower-section guide part of the packing sheet A and the third lower-section guide part of the packing sheet B on the rear side in the stacking direction are brought into contact with

each other at least at lower end portions, and the second lower-section guide part of the packing sheet A and the fourth lower-section guide part of the packing sheet B on the front side in the stacking direction are brought into contact with each other at least at lower end portions.

[0050] In the present disclosure, preferably, the first flow path is used as a hot spray water flow path, and the second flow path is used as an air flow path.

[0051] In addition, the present disclosure provides a cooling tower. The cooling tower includes the packing module having a watertight sealing edge described above, and hot water is sprayed from top to bottom in the first flow path, and cold air is introduced from bottom to top in the second flow path.

[0052] In addition, the present disclosure provides a packing assembly. The packing assembly includes a packing module and a packing frame surrounding an outer side of the packing module, where the packing module includes rectangular packing sheets A and B alternately stacked at predetermined intervals, the rectangular packing sheets A and B forming first and second flow paths that are alternately arranged, where an upper-section guide part and a lower-section guide part are disposed in an upper section and a lower section of the packing module, respectively;

the upper-section guide part includes a plurality of first upper-end openings and second upper-end openings provided in an upper surface of the packing module, where

the first upper-end openings are located on one side perpendicular to a stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths; and

the second upper-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths;

the lower-section guide part includes a plurality of first lower-end openings and second lower-end openings provided in a lower surface of the packing module, where

the first lower-end openings are located on the one side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths; and

the second lower-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths.

[0053] Preferably, the present disclosure further provides a cooling tower. The cooling tower includes: the packing assembly described above, where a length of the packing assembly in the stacking direction is approximately 1/2 of a length of an inner cavity of the cooling tower in a corresponding direction.

[0054] According to the present disclosure, the struc-

ture of the packing module can be significantly simplified, the cost can be reduced on the premise of ensuring the heat exchange efficiency, and the airflow resistance for drawing cold air is extremely small. The packing module can further simplify the structure, facilitate the mounting, and reduce costs without reducing the heat exchange efficiency, thereby avoiding the problem of excessive increase in air humidity caused by hot water entering the air flow path, and significantly improving the mechanical strength of the upper and lower ends of the packing module.

DESCRIPTION OF THE DRAWINGS

[0055]

FIG. 1 is a structural diagram of a packing module according to Embodiment 1 of the present disclosure;

FIG. 2 is an exploded view of a packing module according to Embodiment 1 of the present disclosure;

FIG. 3 is a perspective view of a packing sheet A according to Embodiment 1 of the present disclosure;

FIG. 4 is a perspective view of a packing sheet B according to Embodiment 1 of the present disclosure;

FIG. 5 is a perspective view of a flow straightening plate according to Embodiment 1 of the present disclosure;

FIG. 6 is a perspective view of a flow straightening plate stacked on a front side of a packing sheet A according to Embodiment 1 of the present disclosure;

FIG. 7 is a perspective view in which a packing sheet B and a flow straightening plate are further stacked on the front side on the basis of FIG. 6.

FIG. 8 is a top exploded view of a packing module according to Embodiment 1 of the present disclosure;

FIG. 9 is a top view of a packing module according to Embodiment 1 of the present disclosure;

FIG. 10 is an exploded view of a packing module according to Embodiment 2 of the present disclosure;

FIG. 11 is a top exploded view of a packing module according to Embodiment 2 of the present disclosure;

FIG. 12 is a top view of a packing module according to Embodiment 2 of the present disclosure;

FIG. 13 is a three-dimensional exploded view according to Embodiment 3 of the present disclosure;

FIG. 14 is a partial enlarged view of FIG. 13;

FIG. 15 is one embodiment of a cooling tower employing the packing module according to the present disclosure;

FIG. 16 is another embodiment of a cooling tower

employing the packing module according to the present disclosure;

FIG. 17 is a view of the packing assembly according to the present disclosure;

FIG. 18 is a view from another perspective of the packing assembly according to the present disclosure;

FIG. 19 is a view of a cooling tower employing the packing assembly according to the present disclosure; and

FIG. 20 is another view of a cooling tower employing the packing assembly according to the present disclosure.

15 DETAILED DESCRIPTION

[0056] Preferred embodiments of the present disclosure will be described in detail below with reference to the accompanying drawings.

[Embodiment 1]

[0057] A packing module 1 according to Embodiment 1 of the present disclosure will be described in detail below.

[Packing Module 1]

[0058] In this embodiment, the packing module 1 includes packing sheets A and packing sheets B alternately stacked at a predetermined interval d , and the stacked packing sheets A and B form a first flow path R1 and a second flow path R2 that are alternately arranged in the packing module 1.

[0059] An upper-section guide part 200 and a lower-section guide part 300 are respectively formed at the upper and lower sections of the packing module 1, and a heat exchange part 400 is formed at the middle section.

[Upper-Section Guide Part 200]

[0060] At the upper end of the upper-section guide part 200, guide openings are formed by the alternately arranged upper end portions of rectangular packing sheets A and B, as specifically described below.

[0061] On one side perpendicular to the stacking direction (left side in the figure), the upper end portion of the packing sheet A is offset toward one side in the stacking direction (back side in the figure), and the upper end portion of the packing sheet B is offset toward the opposite direction (front side in the figure), such that in the stacking direction from the front side to the rear side in the figure, the left-side upper end portions of packing sheets A-B are attached to each other, and the left-side upper end portions of packing sheets B-A are spaced apart from each other to form a first upper-end opening 210. For the packing module 1, a plurality of first upper-end openings 210 are arranged in parallel in the stacking direction. Thus, the first upper-end opening 210 is in communica-

tion with the first flow path R1 formed between the packing sheets B-A.

[0062] On the other side perpendicular to the stacking direction (right side in the figure), the upper end portion of the packing sheet A is offset toward the other side of the stacking direction (front side in the figure), and the upper end portion of the packing sheet B is offset toward the opposite direction (rear side in the figure), such that in the stacking direction from the front side to the rear side in the figure, the right-side upper end portions of the packing sheets B-A are attached to each other, and the right-side upper end portions of the packing sheets A-B are spaced apart from each other to form a second upper-end opening 220. For the packing module 1, a plurality of second upper-end openings 220 are arranged in parallel in the stacking direction. Thus, the first upper-end opening 220 is in communication with the first flow path R2 formed between the packing sheets A-B.

[0063] In the upper-section guide part 200, an upper-left-path flow straightening plate 230 is provided in the first flow path R1 between the first upper-end opening 210 formed by the packing sheets B-A and the heat exchange part 400 enclosed by the packing sheets B-A. The upper end of the upper-left-path flow straightening plate 230 matches the width of the first upper-end opening 210, and the width gradually increases from top to bottom. The lower end of the upper-left-path flow straightening plate corresponds to the width of the heat exchange part 400 (a first heat exchange part 401 of the first flow path).

[0064] In this embodiment, the upper-left-path flow straightening plate 230 has a corrugated transverse cross-section in a direction perpendicular to the stacking direction, and on two sides of the corrugated shape in the stacking direction, the back side abuts against the front surface of the packing sheet A sandwiching the upper-left-path flow straightening plate, and the front side abuts against the rear surface of the packing sheet B sandwiching the upper-left-path flow straightening plate. Thus, in the first flow path R1 that is formed between the first upper-end opening 210 and the heat exchange part 400 and approximates a right trapezoid, a guide part is formed for guiding the width of the first upper-end opening 210 to the entire width of the heat exchange part 400, which is substantially equal to the widths of the packing sheets A and B.

[0065] In the upper-section guide part 200, an upper-right-path flow straightening plate 240 is provided in the second flow path R2 between the second upper-end opening 220 formed by the packing sheets A-B and the heat exchange part 400 enclosed by the packing sheets A-B. The upper end of the upper-right-path flow straightening plate 240 matches the width of the second upper-end opening 220, and the width gradually increases from top to bottom. The lower end of the upper-right-path flow straightening plate corresponds to the width of the heat exchange part 400 (a first heat exchange part 402 of the second flow path).

[0066] In this embodiment, the upper-right-path flow straightening plate 240 has a corrugated transverse cross-section in the direction perpendicular to the stacking direction, and on two sides of the corrugated shape in the stacking direction, the back side abuts against the front surface of the packing sheet B sandwiching the upper-right-path flow straightening plate, and the front side abuts against the rear surface of the packing sheet A sandwiching the upper-right-path flow straightening plate. Thus, in the second flow path R2 that is formed between the second upper-end opening 220 and the heat exchange part 400 and approximates a right trapezoid, a guide part is formed for guiding the width of the second upper-end opening 220 to the entire width of the heat exchange part 400, which is substantially equal to the widths of the packing sheets A and B.

[Lower-Section Guide Part 300]

[0067] At the lower end of the lower-section guide part 300, guide openings are formed by the alternately arranged lower end portions of the packing sheets A and B, as specifically described below.

[0068] On one side perpendicular to the stacking direction (left side in the figure), the lower end portion of the packing sheet A is offset toward one side in the stacking direction (back side in the figure), and the lower end portion of the packing sheet B is offset toward the opposite direction (front side in the figure), such that in the stacking direction from the front side to the rear side in the figure, the left-side lower end portions of the packing sheets A-B are attached to each other, and the left-side lower end portions of the packing sheets B-A are spaced apart from each other to form a first lower-end opening 310. Thus, the first lower-end opening 310 is in communication with the first flow path R1 formed between the packing sheets B-A.

[0069] On the other side perpendicular to the stacking direction (right side in the figure), the lower end portion of the packing sheet A is offset toward the other side in the stacking direction (front side in the figure), and the lower end portion of the packing sheet B is offset toward the opposite direction (rear side in the figure), such that in the stacking direction from the front side to the rear side in the figure, the left-side lower end portions of the packing sheets B-A are attached to each other, and the left-side lower end portions of the packing sheets A-B are spaced apart from each other to form a second lower-end opening 320. Thus, the second lower-end opening 320 is in communication with the first flow path R2 formed between the packing sheets A-B.

[0070] In the lower-section guide part 300, a lower-left-path flow straightening plate 330 is provided in the first flow path R1 between the first lower-end opening 310 formed by the packing sheets B-A and the heat exchange part 400 enclosed by the packing sheets B-A. The lower end of the lower-left-path flow straightening plate 330 matches the width of the first lower-end opening 310, and

the width of the lower-left-path flow straightening plate gradually increases from bottom to top. The upper end of the lower-left-path flow straightening plate corresponds to the width of the heat exchange part 400.

[0071] In this embodiment, the lower-left-path flow straightening plate 330 has a corrugated transverse cross-section in the direction perpendicular to the stacking direction, the back side of the corrugated shape abuts against the front surface of the packing sheet A, and the front side abuts against the rear surface of the packing sheet B. Thus, in the first flow path R1 that is formed between the first lower-end opening 310 and the heat exchange part 400 and approximates an inverted right trapezoid, a guide part is formed for guiding the width of the first lower-end opening 310 to the entire width of the heat exchange part 400, which is substantially equal to the widths of the packing sheets A and B.

[0072] In the lower-section guide part 300, a lower-right-path flow straightening plate 340 is provided in the second flow path R2 between the second lower-end opening 320 formed by the packing sheets A-B and the heat exchange part 400 enclosed by the packing sheets A-B. The lower end of the lower-right-path flow straightening plate 340 matches the width of the second lower-end opening 320, and the width of the lower-right-path flow straightening plate gradually increases from top to bottom. The lower end of the lower-right-path flow straightening plate corresponds to the width of the heat exchange part 400.

[0073] In this embodiment, the lower-right-path flow straightening plate 340 has a corrugated transverse cross-section in the direction perpendicular to the stacking direction, the back side of the corrugated shape abuts against the front surface of the packing sheet B, and the front side abuts against the rear surface of the packing sheet A. Thus, in the second flow path R2 that is formed between the second lower-end opening 320 and the heat exchange part 400 and approximates an inverted right trapezoid, a guide part is formed for guiding the width of the second lower-end opening 320 to the entire width of the heat exchange part 400, which is substantially equal to the widths of the packing sheets A and B.

[0074] By alternately stacking the packing sheets A and the packing sheets B to form the packing module 1, the first flow path R1 and the second flow path R2 that are isolated from each other and alternately stacked are formed within the packing module 1. The configuration of the first flow path R1 and the second flow path R2 will be described in detail below.

[Unit of First Flow Path R1]

[0075] In this embodiment, for the packing module 1, in the stacking direction from the front side to the rear side in the figure, a unit of the first flow path R1 is formed between an adjacent packing sheet B and the packing sheet A located behind the packing sheet B, namely, between the packing sheets B-A.

[0076] As shown in the figure, the first flow path R1 includes the following from top to bottom: a first upper-end opening 210 located on the left side of the upper end of the packing module 1; a left upper-section guide part 201 of the upper-section guide part 200 filled and supported between the packing sheets B and A by the upper-left-path flow straightening plate 230; a first heat exchange part 401 in the form of a flat cavity formed between the packing sheets B-A in the stacking direction of the heat exchange part 400; a left lower-section guide part 301 of the lower-section guide part 300 filled and supported between the packing sheets B and A by the lower-left-path flow straightening plate 330; and a first lower-end opening 310 located on the left side of the lower end of the packing module 1.

[0077] Thus, in this embodiment, one unit of the first flow path R1 in the form of a flat cavity is formed between the adjacent packing sheets B and A, and the first upper-end opening 210 serving as the upper-end opening of the unit and the first lower-end opening 310 serving as the lower-end opening of the unit are located on the same side perpendicular to the stacking direction.

[Unit of Second Flow Path R2]

[0078] In this embodiment, for the packing module 1, in the stacking direction from the front side to the rear side in the figure, a unit of the second flow path R2 is formed between an adjacent packing sheet A and the packing sheet B located behind the packing sheet A, namely, between the packing sheets A-B.

[0079] As shown in the figure, the second flow path R2 includes the following from top to bottom: a second upper-end opening 220 located on the right side of the upper end of the packing module 1; a right upper-section guide part 202 of the upper-section guide part 200 filled and supported between the packing sheets A and B by the upper-right-path flow straightening plate 240; a second heat exchange part 402 in the form of a flat cavity formed between the packing sheets A-B in the stacking direction of the heat exchange part 400; a right lower-section guide part 302 of the lower-section guide part 300 filled and supported between the packing sheets A and B by the lower-right-path flow straightening plate 340; and a second lower-end opening 320 located on the right side of the lower end of the packing module 1.

[0080] Thus, in this embodiment, one unit of the first flow path R1 in the form of a flat cavity is formed between the adjacent packing sheets A and B, and the second upper-end opening 220 serving as the upper-end opening of the unit and the second lower-end opening 320 serving as the lower-end opening of the unit are located on the same side perpendicular to the stacking direction.

[Heat Exchange Part 400]

[0081] The first heat exchange parts 401 and the second heat exchange parts 402 are alternately stacked to

form the heat exchange part 400, in which the first flow path R1 and the second flow path R2 are alternately stacked with each other for indirect heat exchange.

[Upper-end and Lower-end Openings of Flow Path]

[0082] As described above, in the stacking direction of the packing sheets A and B, the first flow path R1 and the second flow path R2 in the form of a flat cavity are formed between the packing sheets B-A and the packing sheets A-B, respectively, such that the first flow path R1 and the second flow path R2 are alternately stacked. Therefore, for the packing module 1, first and second upper-end openings 210, 220 that are arranged in parallel in the direction perpendicular to the stacking direction are formed on the upper-end edge.

[0083] In this embodiment, as shown in the figure, the first upper-end opening 210 is formed on the left side. Since the left-side upper end portion of the packing sheet A is offset toward the back side in the figure and the left-side upper end portion of the packing sheet B is offset toward the opposite front side in the figure, the left-side upper end portions of the packing sheets A-B are attached to each other, and the left-side upper end portions of the packing sheets B-A are spaced apart from each other. Thus, strip-shaped openings are formed by the left-side upper end portions of the packing sheets B-A being spaced apart from each other and are arranged in parallel in the stacking direction via the left-side upper end portions of the attached packing sheets A-B, forming a complete first upper-end opening 210. When the thickness of the packing sheet is not taken into account, it is equivalent to forming an open first upper-end opening 210 over the entire region on one side (left side in the figure) perpendicular to the stacking direction at the upper end of the packing module 1.

[0084] Similarly, the second upper-end opening 220 is formed on the right side, opposite to the first upper-end opening 210, the right-side upper end portion of the packing sheet B is offset toward the back side in the figure, and the right-side upper end portion of the packing sheet A is offset toward the opposite front side in the figure, such that the right-side upper end portions of the packing sheets B-A are attached to each other, and the right-side upper end portions of the packing sheets A-B are spaced apart from each other. Thus, strip-shaped openings are formed by the right-side upper end portions of the packing sheets A-B being spaced apart from each other and are arranged in parallel in the stacking direction via the right-side upper end portions of the attached packing sheets B-A, forming a complete second upper-end opening 220. When the thickness of the packing sheet is not taken into account, it is equivalent to forming an open second upper-end opening 220 over the entire region on the other side (right side in the figure) perpendicular to the stacking direction at the upper end of the packing module 1.

[0085] In another aspect, the first upper-end opening

210 and the second upper-end opening 220 that are arranged in parallel in the direction perpendicular to the stacking direction are formed on the lower-end edge.

[0086] In this embodiment, as shown in the figure, the first lower-end opening 310 is formed on the left side. Since the left-side lower end portion of the packing sheet A is offset toward the back side in the figure and the left-side lower end portion of the packing sheet B is offset toward the opposite front side in the figure, the left-side lower end portions of the packing sheets A-B are attached to each other, and the left-side lower end portions of the packing sheets B-A are spaced apart from each other. Thus, strip-shaped openings are formed by the left-side lower end portions of the packing sheets B-A being spaced apart from each other and are arranged in parallel in the stacking direction via the left-side lower end portions of the attached packing sheets A-B, forming a complete first lower-end opening 310. When the thickness of the packing sheet is not taken into account, it is equivalent to forming an open first lower-end opening 310 over the entire region on one side (left side in the figure) perpendicular to the stacking direction at the lower end of the packing module 1.

[0087] Similarly, the second lower-end opening 320 is formed on the right side, opposite to the first lower-end opening 310, the right-side lower end portion of the packing sheet B is offset toward the back side in the figure, and the right-side lower end portion of the packing sheet A is offset toward the opposite front side in the figure, such that the right-side lower end portions of the packing sheets B-A are attached to each other, and the right-side lower end portions of the packing sheets A-B are spaced apart from each other. Thus, strip-shaped openings are formed by the right-side lower end portions of the packing sheets A-B being spaced apart from each other and are arranged in parallel in the stacking direction via the right-side lower end portions of the attached packing sheets B-A, forming a complete second lower-end opening 320. When the thickness of the packing sheet is not taken into account, it is equivalent to forming an open second lower-end opening 320 over the entire region on the other side (right side in the figure) perpendicular to the stacking direction at the lower end of the packing module 1.

[Opening of Flow Path]

[0088] The first flow path R1 will be described in further detail in a direction from top to bottom.

[0089] As described above, the first flow path R1 is formed at the upper end of the packing module 1, which is equivalent to forming the first upper-end opening 210 over the entire region on the left side perpendicular to the stacking direction. In addition, at the first upper-end opening 210, the first flow path is divided into a plurality of units by the portion where the left-side upper end portions of the packing sheets A-B are attached to each other. In the left upper-section guide part 201, after

passing downward through the portion where the left-side upper end portions of the packing sheets A-B are attached to each other, the units of the first flow path R1 separate from each other in the stacking direction. In one aspect, the dimension in the stacking direction gradually decreases, and in another aspect, the dimension in the direction perpendicular to the stacking direction gradually increases to substantially the width of the packing sheets A and B, forming a flat shape; that is, the thickness decreases while the width increases. The units enter, from the upper-section guide part 200, into the first heat exchange part 401 of the heat exchange part 400, which is a flat heat exchange space defined by the packing sheets B-A.

[0090] As the heat exchange part 400 continues downward to the lower-section guide part 300, contrary to the situation in the upper-section guide part 200, the units of the first flow path R1 extend downward from a flat shape having a width substantially equal to the width of the packing sheets A and B. In one aspect, the dimension in the stacking direction gradually increases, and in another aspect, the dimension in the direction perpendicular to the stacking direction gradually decreases to the width of the second lower-end opening 320; that is, the thickness increases while the width decreases. In the left lower-section guide part 301, the units merge at the portion where the left-side lower end portions of the packing sheets A-B are attached to each other and reach the first lower-end opening 310. Thus, in the first flow path R1, theoretically, the cross-sectional area of the flow path remains substantially unchanged throughout the entire flow path from the first upper-end opening 210, through the upper-section guide part 200, the heat exchange part 400, and the lower-section guide part 300, to the first lower-end opening 310.

[0091] The second flow path R2 is configured rotationally symmetrical to the first flow path R1, which will be described in further detail below.

[0092] As described above, the second flow path R2 is formed at the upper end of the packing module 1, which is equivalent to forming the second upper-end opening 220 over the entire region on the right side perpendicular to the stacking direction. In addition, at the second upper-end opening 220, the second flow path is divided into a plurality of units by the portion where the right-side upper end portions of the packing sheets B-A are attached to each other. In the right upper-section guide part 202, after passing downward through the portion where the right-side upper end portions of the packing sheets B-A are attached to each other, the units of the first flow path R1 separate from each other in the stacking direction. In one aspect, the dimension in the stacking direction gradually decreases, and in another aspect, the dimension in the direction perpendicular to the stacking direction gradually increases to substantially the width of the packing sheets A and B, forming a flat shape; that is, the thickness decreases while the width increases. The units enter, from the upper-section guide part 200, into the second

heat exchange part 402 of the heat exchange part 400, which is a flat heat exchange space defined by the packing sheets A-B.

[0093] As the heat exchange part 400 continues downward to the lower-section guide part 300, contrary to the situation in the upper-section guide part 200, the units of the second flow path R2 extend downward from a flat shape having a width substantially equal to the width of the packing sheets A and B. In one aspect, the dimension in the stacking direction gradually increases, and in another aspect, the dimension in the direction perpendicular to the stacking direction gradually decreases to the width of the second lower-end opening 320; that is, the thickness increases while the width decreases. In the right lower-section guide part 302, the units merge at the portion where the right-side lower end portions of the packing sheets B-A are attached to each other and reach the second lower-end opening 320.

[0094] Thus, in the second flow path R2, theoretically, the cross-sectional area of the flow path remains substantially unchanged throughout the entire flow path from the second upper-end opening 220, through the upper-section guide part 200, the heat exchange part 400, and the lower-section guide part 300, to the second lower-end opening 320.

[0095] As described above, in this embodiment, the total opening area of the first upper-end opening 210 and the second upper-end opening 220, serving as the upper-end openings of the first flow path R1 and the second flow path R2, is consistent with the total flow-path cross-sectional area of the respective portions from top to bottom. Similarly, the total opening area of the first and second lower-end openings 310, 320, which serve as the lower-end openings of the first flow path R1 and the second flow path R2, is consistent with the total flow-path cross-sectional area of the respective portions from top to bottom. That is, the opening area of the upper and lower ends of the packing module 1 is consistent with the horizontal cross-sectional area of the packing module 1, such that the fluid throughput and the passage efficiency of all flow paths R1, R2 can be greatly increased, and the resistance of the packing module 1 can be reduced, which will be described in further detail below.

[Flow Straightening Plate]

[0096] In this way, when the flow straightening plates 230, 240, 330, 340 are provided in the guide parts 201, 202, 301, 302, that is, when the flow straightening plates 230, 240, 330, 340 are provided in the respective first and second flow paths R1, R2, the flow straightening plates 230, 240, 330, 340 are formed in a corrugated shape, the extension direction of the corrugated protrusions corresponds to the extension paths of the first and second flow paths R1, R2, and the thicknesses of the flow straightening plates 230, 240, 330, 340 are far different from the flow-path cross-sectional area of the first and second flow path R1, R2, and thus the passage efficiency of the first

and second flow paths R1, R2 is not affected.

[0097] In addition, in this embodiment, the first upper-end opening 210 and the second upper-end opening 220, which serve as the upper-end openings of the first and second flow paths R1, R2, are arranged in parallel in the direction perpendicular to the stacking direction and have substantially the same width, such that the upper-left-path flow straightening plate 230 and the upper-right-path flow straightening plate 240, which are respectively located in the left upper-section guide part 201 and the right upper-section guide part 202, have substantially identical accommodating space configurations and are arranged in a rotationally symmetric manner. Therefore, the upper-left-path flow straightening plate 230 and the upper-right-path flow straightening plate 240 can be configured using the same components.

[0098] Similarly, the first lower-end opening 310 and the second lower-end opening 320, which serve as the lower-end openings of the first and second flow paths R1, R2, are arranged in parallel in the direction perpendicular to the stacking direction and have substantially the same width, such that the lower-left-path flow straightening plate 330 and the lower-right-path flow straightening plate 340, which are respectively located in the left lower-section guide part 301 and the right lower-section guide part 302, have substantially identical accommodating space configurations and are arranged in a rotationally symmetric manner. Therefore, the lower-left-path flow straightening plate 330 and the lower-right-path flow straightening plate 340 can be configured using the same components.

[0099] Further, in this embodiment, by making the heights of the upper-section guide part 200 and the lower-section guide part 300 substantially the same, and making the configurations of the accommodating spaces for the flow straightening plates 230, 240, 330, 340 substantially the same, the upper-left-path flow straightening plate 230, the upper-right-path flow straightening plate 240, the lower-left-path flow straightening plate 330, and the lower-right-path flow straightening plate 340 can be configured using the same components. In this way, when the packing module 1 is manufactured, only the packing sheet A, the packing sheet B, and the shared flow straightening plate are required, thereby significantly reducing the production cost of the packing module 1, and significantly improving the assembly efficiency.

[0100] In this embodiment, the same packing sheets A and B as in Embodiment 1 may be used. In Embodiment 1, the left upper-section guide part 201, the right upper-section guide part 202, the left lower-section guide part 301, and the right lower-section guide part 302 are provided with the upper-left-path flow straightening plate 230, the upper-right-path flow straightening plate 240, the lower-left-path flow straightening plate 330, and the lower-right-path flow straightening plate 340, respectively. The left upper-section guide part 201 and the left lower-section guide part 301 are both located on the same side of the packing module 1 (the left side in

Embodiment 1), and the right upper-section guide part 202 and the right lower-section guide part 302 are both located on the other same side of the packing module 1 (the right side in Embodiment 1). That is, the fluid flowing into/introduced into the packing module 1 from one side (the left side) of the packing module 1 in the width direction forms a flow path R1 extending over substantially the entire width of the packing module 1 in the heat exchange part 400. The fluid flowing into/introduced into the packing module 1 from the other side (the right side) of the packing module 1 in the width direction forms a flow path R2 extending over substantially the entire width of the packing module 1 in the heat exchange part 400. The thicknesses of R1 and R2 in the stacking direction are half of the thicknesses of the openings in the stacking direction, and the sum of the respective thicknesses of R1 and R2 is equivalent to half of the thickness of the packing module 1 in the stacking direction. Therefore, a state where inflow and outflow occur on the same side is formed; that is, if hot water flows in from the first upper-end opening 210 at the upper left end, the packing module 1 flows out through the first lower-end opening 310 at the lower left end, and if cold air is introduced from the first lower-end opening 310 at the lower left end, the packing module 1 flows out through the first upper-end opening 210 at the upper left end, forming the first flow path R1. The same applies to the second upper-end opening 220 and the second lower-end opening 320 serving as the upper and lower end openings on the right side, except that the fluid flowing therethrough is different from that on the left side, forming the second flow path R2. Certainly, the packing module 1 may also be configured in the same manner as conventional packing modules, in which hot water is simultaneously sprayed into the first and second upper-end openings 210, 220, and cold air is simultaneously drawn from the first and second lower-end openings 310, 320, such that the hot water and the cold air in the flow path move in opposite directions and are brought into direct contact for heat exchange. However, when different fluids flow into the first flow path R1 and the second flow path R2, the conventional method cannot achieve the low saturated humidity of the discharged hot air as in the above-described configuration, and therefore cannot avoid plume formation.

[0101] Certainly, the first upper-end opening 210 and the first lower-end opening 310, which serve as the upper and lower end openings of the first flow path R1, may also be respectively arranged on different sides of the left and right sides of the packing module. Similarly, the second upper-end opening 220 and the second lower-end opening 320, which serve as the upper and lower-end openings of the second flow path R2, are also respectively arranged on different sides of the left and right sides of the packing module. This does not have a substantial effect on the function of the packing module 1 that is provided with the two flow paths R1, R2 arranged through the packing sheets A and B and the openings at the upper and lower ends, and falls within an embodiment equivalent

lent to Embodiment 1 described above.

[Embodiment 2]

[0102] A packing module 1' according to Embodiment 2, which is a preferred embodiment of the present disclosure, differs from the packing module 1 according to Embodiment 1 in that flow straightening plates are provided only in the first flow path R1, namely, the upper-left-path flow straightening plate 230 provided in the left upper-section guide part 201 of the first flow path R1 and the lower-left-path flow straightening plate 330 provided in the left lower-section guide part 301 of the first flow path R1, while no flow straightening plate is provided in the second flow path R2. Therefore, in this embodiment, the first flow path R1 is used as a water spraying channel, and the second flow path R2 is used as an air intake channel.

[0103] As shown in FIGs. 10 to 12, by providing the flow straightening plates 230, 330 only in the first flow path R1, in the first flow path R1, the spray water flows into the packing module 1' through the first upper-end openings 210, which are arranged in parallel in the stacking direction on the left side of the arrow shown in the drawing of the packing module 1', that is, through a portion of the width of the upper opening. And the spray water is guided to the substantially entire width range of the first heat exchange part 401 by the flow straightening plate 230 in the left upper-section guide part 201, thereby effectively forming water films on the wall surfaces of the packing sheets A and B on both sides of the first flow path R1. Then, the spray water is guided by the flow straightening plate 330 in the left lower-section guide part 301 to the first lower-end openings 310 arranged in parallel in the stacking direction on the left side of the arrow shown in the drawing of the packing module 1', and then flows out through a portion of the width of the lower opening of the packing module 1'.

[0104] In another aspect, cold air is introduced into the packing module 1', via the second flow path R2, from the second lower-end opening 320 arranged in the stacking direction on the right side indicated by the arrow in the drawing of the packing module 1', namely, a portion of the width of the lower opening, and then enters the right lower-section guide part 302. After that, based on the flow properties inherent to the gaseous fluid, the thickness of the flow path is gradually limited in the stacking direction by the lower-section guide part 302, and the width of the flow path is gradually increased to substantially the entire width of the second heat exchange part 402, thereby effectively exchanging heat, through the packing sheets A and B, with hot water attached to the wall portion of the first heat exchange part 401. Then, in the right upper-section guide part 202, the width of the flow path is gradually limited to the second upper-end opening 220 arranged in the stacking direction, that is, a portion of the width of the upper opening, and the thickness of the flow path in the stacking direction is gradually

increased to 2d, such that the cold air is led out through the second upper-end opening of the packing module 1'.

[0105] It can be seen that, compared with the packing module 1 according to Embodiment 1 of the present disclosure, in this embodiment, by removing the flow straightening plates located at the right upper-section guide part 202 and the right lower-section guide part 302 of the second flow path R2 and using the second flow path R2 only as a cold air flow path, the cold air drawn into the second flow path R2 can achieve the smallest possible airflow resistance. In addition, since air flow is not affected by gravity in the same manner as water flow, substantially the same cooling efficiency as that of the packing module 1 according to Embodiment 1 can be obtained even without providing the flow straightening plate, while ensuring the same air flow rate through the second flow path R2 as that in Embodiment 1 described above. However, in this case, since the flow straightening plate is not provided in the second flow path R2, the airflow resistance of the air introduced into the packing module 1' is smaller. When an active exhaust cooling tower is used, the fan at the top of the cooling tower requires lower power, which can effectively save electric energy. In addition, since the packing module 1' according to this embodiment can achieve smaller airflow resistance, it is more suitable for cooling towers that do not employ a fan but instead draw air in a passive manner, such as a hyperbolic cooling tower.

[0106] In this embodiment, preferably, the upper and lower end openings of the first flow path R1 and the second flow path R2 are located on the same side in the width direction of the packing module, such that a good water barrier structure can be formed through the arrangement of the packing sheets A and B, thereby preventing the water in the first flow path R1 provided with the upper-left-path flow straightening plate 230 and the lower-left-path flow straightening plate 330 from intruding into the air flow path of the second flow path R2 through the gap. A detailed explanation is provided hereinafter.

[0107] Further, in this embodiment, as shown in FIG. 11, at the upper end portion of the packing sheet A of the packing module 1', the rear half portion of the first upper-end opening 210 formed by the packing sheet A is formed by offsetting the left side of the portion where the first upper-end opening 210 is connected to the second upper-end opening 220, namely, the first upper-end opening 210 side, by a distance of $d/2$ toward the rear side from the base position O_A of the heat exchange part 400 of the packing sheet A. Furthermore, on the left-end edge of the packing sheet A, a left sealing edge part 215A is formed by offsetting the rear half portion of the first upper-end opening 210 toward the front side by a distance of d , that is, offsetting the base position O_A of the heat exchange part 400 of the packing sheet A toward the front side by a distance of $d/2$. The left sealing edge part 215A extends linearly in the vertical direction.

[0108] Furthermore, at the upper end portion of the

packing sheet A, the front half portion of the second upper-end opening 220 of the second flow path R2 on the rear side, which is formed by the packing sheet A, is formed by offsetting the right side of the portion where the first upper-end opening 210 is connected to the second upper-end opening 220, namely, the second upper-end opening 220 side, toward the front side by a distance of $d/2$.

[0109] Further, at the upper end portion of the packing sheet B adjacent to the packing sheet A on the front side in the stacking direction, the front half portion of the first upper-end opening 210 formed by the packing sheet B is formed by offsetting the left side of the portion where the first upper-end opening 210 is connected to the second upper-end opening 220, namely, the first upper-end opening 210 side, by a distance of $d/2$ toward the front side from the base position O_B of the heat exchange part 400 of the packing sheet B. Furthermore, on the left-end edge of the packing sheet B, a left sealing edge part 215B is formed by offsetting the front half portion of the first upper-end opening 210 toward the rear side by a distance of d , that is, offsetting the base position O_B of the heat exchange part 400 of the packing sheet B toward the rear side by a distance of $d/2$. The left sealing edge part 215B extends linearly in the vertical direction.

[0110] Furthermore, at the upper end portion of the packing sheet B, the rear half portion of the second upper-end opening 220 of the front-side second flow path R2 formed by the packing sheet B is formed by offsetting the right side of the portion where the first upper-end opening 210 is connected to the second upper-end opening 220, that is, the second upper-end opening 220 side, by a distance of $d/2$ toward the rear side.

[0111] Thus, when the packing sheet A and the packing sheet B adjacent thereto on the front side are assembled in contact with each other, the complete first upper-end opening 210 is defined, at the upper-end edges of the left-side portions of the packing sheet A and the packing sheet B, by the rear half portion of the first upper-end opening 210 of the packing sheet A and the front half portion of the first upper-end opening 210 of the packing sheet B adjacent to the front side. In addition, on the left side of the first upper-end opening 210, the left sealing edge part 215A of the packing sheet A and the left sealing edge part 215B of the packing sheet B are brought into contact with each other from top to bottom.

[0112] Thus, the first flow path R1 formed by the packing sheet A and the packing sheet B adjacent thereto on the front side is provided with an inflow opening having a thickness of $2d$, namely, the first upper-end opening 210, and the left sealing edge 215 of the first flow path R1 is formed by combining the left sealing edge part 215A and the left sealing edge part 215B, which are offset relative to each other and then brought into contact with each other. The left sealing edge 215 thereof can easily form a sealing structure during joint sealing. When the first flow path R1 is used as a flow path for hot spray water, since the hot water enters from the first upper-end opening 210

arranged in the front-rear direction on the left side of the packing module 1', the hot water is less likely to seep out from the left sealing edge 215 when the hot water is guided into the heat exchange part 400.

[0113] In another aspect, after the hot water is guided from the first upper-end opening 210 to the heat exchange part 400, the water overflows, under the action of its own gravity, along the rear wall surface of the packing sheet B and the front wall surface of the packing sheet A on the front and rear sides within the heat exchange part 400, and does not easily intrude into the right sealing edge of the packing module 1'. Therefore, the sealing performance requirement for the right sealing edge is significantly reduced.

[0114] Specifically, in this embodiment, for the lower-section guide part 300, if the lower-section guide part 300 is rotated by 180° about the horizontal axis perpendicular to the stacking direction, the structure thereof is the same as the configuration of the upper-section guide part 200. For the lower-section guide part 300, similarly to the configuration of the upper-section guide part 200, the lower-end edges of the packing sheet A and the packing sheet B adjacent to the front side thereof are offset, such that the continuous left sealing edge parts 215A, 215B are formed from top to bottom at the left-side edges of the packing sheet A and the packing sheet B, including the left-side edge of the heat exchange part 400, thereby effectively preventing water from seeping out from the left sealing edge 215, particularly preventing water from seeping out from the left sealing edge 215 at portions of the upper-section guide part 200 and the lower-section guide part 300.

[0115] Furthermore, in this embodiment, any joining method may be used for the sealing edge parts 215 formed by the left sealing edge parts 215A, 215B. However, from the perspective of assembly convenience, pressure welding is preferred for joining the sealing edge part 215. This is because, when the packing sheets A and B and the flow straightening plates 230, 330 are assembled by using the device, the welding operation of the packing sheets B-A can be completed by simply aligning the adjacent packing sheets B in the front-to-rear direction. In this case, since the packing sheets A and B are offset to be brought into contact with each other on the right-side portions of the upper and lower end edges, the pressure welding device is operated to weld the sealing edge part 215 and the right-side portions of the upper and lower end edges of the packing sheets B-A.

[0116] Therefore, by inserting the flow straightening plates 230, 330 between the packing sheets B-A and welding the sealing edge part 215 and the right-side portions of the upper and lower end edges of the packing sheets B-A, the packing sheets B-A located at the front and rear in the stacking direction can form a module with extremely high structural stability, and then a plurality of modules formed by the packing sheets B-A are combined and bonded together in the stacking direction. Since each individual module has good strength and stability, the

difficulty in module assembly can be greatly reduced, and the efficiency of assembling the modules of the packing sheets B-A into the packing module 1' can be improved.

[0117] In the drawings of this embodiment, from the perspective of assembly process and processing convenience, the right sealing edge is not provided with the same structure as that of the left sealing edge 215. However, this does not constitute a limitation on the configuration of the right sealing edge, and certainly, a structure that is the same as that of the left sealing edge 215 may also be applied to the right sealing edge.

[Embodiment 3]

[0118] A packing module 1" according to Embodiment 3, which is a preferred embodiment of the present disclosure, as shown in FIGs. 13 and 14, differs from the packing module 1 according to Embodiment 1 described above in the configuration and assembly method of the upper-left-path flow straightening plate 230, the upper-right-path flow straightening plate 240, the lower-left-path flow straightening plate 330, and the lower-right-path flow straightening plate 340, and their corresponding first upper-end opening 210, second upper-end opening 220, first lower-end opening 310, and second lower-end opening 320.

[0119] In this embodiment, the upper-end edges of the upper-left-path flow straightening plate 230 and the upper-right-path flow straightening plate 240 are respectively lower than the first upper-end opening 210 and the second upper-end opening 220; that is, the upper-end edges of the upper-left-path flow straightening plate 230 and the upper-right-path flow straightening plate 240 are respectively positioned inside the first upper-end opening 210 and the second upper-end opening 220.

[0120] Similarly, the upper-end edges of the lower-left-path flow straightening plate 330 and the lower-right-path flow straightening plate 340 are respectively higher than the first lower-end opening 310 and the second lower-end opening 320; that is, the lower-end edges of the lower-left-path flow straightening plate 330 and the lower-right-path flow straightening plate 340 are respectively positioned inside the first lower-end opening 310 and the second lower-end opening 320.

[0121] In other words, in this embodiment, the opening-side end portions of the flow straightening plates 230, 240, 330, 340 are respectively positioned within the corresponding upper and lower end openings 210, 220, 310, 320 by a predetermined distance h. In FIGs. 13 and 14, only the upper-left-path flow straightening plate 230 is shown as an example, and other flow straightening plates 240, 330, 340 may be provided in the same manner.

[0122] When the packing sheets A and B are stacked, at the left upper-section guide part 201, since the packing sheet A is offset toward the rear side in the stacking direction and the packing sheet B is offset toward the front side in the stacking direction, the left upper-end

edges of the packing sheet A and the packing sheet B are brought into contact with each other at the edge of the first upper-end opening 210.

[0123] Since the flow straightening plate 230 provided in the left upper-section guide part 201 is located inside the first upper-end opening 210, the upper-end edge of the packing sheets A-B at the first upper-end opening 210 in the stacking direction is avoided, and the distance of h is maintained. Thus, a welding process can be performed on this clearance region using a heating fixture, thereby forming a welding trace L.

[0124] In Embodiments 1 and 2, the flow straightening plate 230 is not retracted into the first upper-end opening 210. During the welding process, due to the interference from the flow straightening plate arranged to be corrugated at the end surface of the first upper-end opening 210, only intermittent welds can be formed to accommodate the corrugated arrangement of the flow straightening plate 230. The left upper-end edge of the packing sheets A-B can only be sealed by applying adhesive after being brought into contact with each other.

[0125] In contrast, in this embodiment, by retracting the flow straightening plate into the first upper-end opening 210, this clearance region can be utilized to perform continuous pressure welding on the left upper-end edge of the packing sheets A-B.

[0126] In this way, in one aspect, the connection strength of the left upper-end edge of the packing sheets A-B is improved, such that the overall strength of the packing module 1" can be significantly improved even after the packing sheets A and B are stacked in a plurality of layers.

[0127] In another aspect, more importantly, in the case where the first flow path R1 on the left side serves as a hot spray water flow path and the second flow path R2 on the right side serves as an air flow path, the inner side of the left upper-end seam of the packing sheets A-B forming the first upper-end opening 210 is in communication with the second flow path R2. By joining the seam by welding, the water tightness performance can be effectively improved, thereby preventing the occurrence of water leakage due to adhesive failure caused by aging over time. Furthermore, in this embodiment, as shown in Embodiment 2, by positioning the first lower-end opening also on the left side of the packing module 1" and forming the continuous sealing edge parts 215A, 215B on the left-side edges of the packing sheets A and B, respectively, the probability of leakage from the upper end of the first flow path R1 to the second flow path can be minimized when the first flow path R1 serves as the hot spray water flow path; additionally, the left side can also be sealed by welding, thereby preventing leakage.

[0128] For the right side, since the first flow path R1 guides the hot water from a portion of the width on the left side to substantially the entire width of the heat exchange part and then back to a portion of the width on the left side to flow out from the first lower-end opening 310, the hot water, under the action of gravity, is difficult to overflow

from the right-side edge. Therefore, a simple convex-concave engagement may be used for the right-side sealing edge, such as fitting connection, adhesive bonding, or spot welding.

[0129] Certainly, without considering a small increase in the cost, the method corresponding to the left-side sealing edge may also be used for the right-side sealing edge. Certainly, the right sealing edge may also be formed by offsetting the right-side edge of the heat exchange part 400 of the packing sheets A and B in the same direction as the left-side edge. Therefore, the first flow path can be completely sealed.

[0130] In this embodiment, as an example, only the configuration of the upper-left-path flow straightening plate 230 and the first upper-end opening 210 in the left upper-section guide part 201 is described, and the same configuration may be adopted for other second upper-end openings 220, first lower-end openings 310, and second lower-end openings 320, and the corresponding flow straightening plates 240, 330, 340. Therefore, the overall strength of the packing module 1" can be improved. In particular, for the upper and lower end surfaces of the packing module 1" having the upper and lower end openings 210, 220, 310, 320 arranged in parallel, the strength will be significantly enhanced. In this way, the firmness, reliability, and durability will be significantly improved during the transportation, handling, mounting, and daily operation of the packing module 1".

[Embodiment 4]

[0131] In Embodiment 1, the first upper-end opening 210 and the first lower-end opening 310 may both be located on the left side of the packing module and have the same width, and the second upper-end opening 220 and the second lower-end opening 320 may both be located on the right side of the packing module and have the same width. This is referred to as the same-side and same-width configuration. Therefore, the packing sheet A and the packing sheet B can be made of the same components, thereby reducing the manufacturing cost of the packing module. That is, the packing sheet B (i.e., the flipped packing sheet A) may be rotated 180° about the horizontal axis relative to the packing sheet A. Therefore, in this embodiment, the description of the packing sheet B is made based on the position of the packing sheet A before being rotated.

[0132] The packing sheet A is configured such that an upper left offset part offset toward the rear side is provided on the left side of the upper end portion, an upper right offset part offset toward the front side is provided on the right side of the upper end portion, a lower left offset part offset toward the rear side is provided on the left side of the lower end portion, and a lower right offset part offset toward the front side is provided on the right side of the lower end portion. The adjacent packing sheets B may be arranged in such a way as to be rotated 180° about the horizontal axis of the body part of the packing sheet A.

[0133] Thus, the upper right offset part of the packing sheet A is brought into contact with the lower right offset part of the packing sheet B located on the front side in the stacking direction; the lower right offset part of the packing sheet A is brought into contact with the upper right offset part of the packing sheet B, such that the first upper-end opening 210 is formed between the upper left offset part of the packing sheet A and the lower left offset part of the packing sheet B, and the first lower-end opening 310 is formed between the lower left offset part of the packing sheet A and the upper left offset part of the packing sheet B. The first upper-end opening 210 and the first lower-end opening 310 are in communication with the first heat exchange part 401 formed between the body part of the packing sheet A and the body part of the packing sheet B on the upper side and the lower side in the vertical direction, respectively, thereby forming the first flow path R1.

[0134] The upper left offset part of the packing sheet A is brought into contact with the lower left offset part of the packing sheet B located on the rear side in the stacking direction; the lower left offset part of the packing sheet A is brought into contact with the upper left offset part of the packing sheet B, such that a second upper-end opening 220 is formed between the upper right offset part of the packing sheet A and the lower right offset part of the packing sheet B, and a second lower-end opening 320 is formed between the lower right offset part of the packing sheet A and the upper right offset part of the packing sheet B. The second upper-end opening 220 and the second lower-end opening 320 are in communication with the second heat exchange part 402 formed between the body part of the packing sheet A and the body part of the packing sheet B on the upper side and the lower side in the vertical direction, respectively, thereby forming the second flow path R2.

[0135] Furthermore, an upper-left-path flow straightening plate 230 that gradually increases in width and gradually decreases in thickness from the first upper-end opening 310 to the first heat exchange part 401 is disposed between the upper left offset part of the packing sheet A and the lower left offset part of the packing sheet B.

[0136] A lower-left-path flow straightening plate 330 that gradually increases in width and gradually decreases in thickness from the first lower-end opening 310 to the first heat exchange part 401 is disposed between the lower left offset part of the packing sheet A and the upper left offset part of the packing sheet B.

[0137] Similarly, an upper-right-path flow straightening plate 240 that gradually increases in width and gradually decreases in thickness from the second upper-end opening 220 to the second heat exchange part 402 is provided between the upper right offset part of the packing sheet A and the lower right offset part of the packing sheet B.

[0138] A lower-right-path flow straightening plate 340 that gradually increases in width and gradually decreases in thickness from the second lower-end opening

320 to the second heat exchange part 402 is disposed between the lower right offset part of the packing sheet A and the upper right offset part of the packing sheet B.

[0139] On this basis, as in Embodiment 2, the left-side edge of each packing sheet A is offset toward the front side to form a linear sealing edge part 215A, and the sealing edge part of the packing sheet A is brought into contact with the sealing edge part 215B of the packing sheet B located on the front side in the stacking direction.

[0140] The sealing edge part 215A of the packing sheet A is brought into contact with the sealing edge part 215B of the packing sheet B located on the front side in the stacking direction, and the two are joined by welding, forming a left sealing edge 215.

[0141] Thus, according to this embodiment, the number of components can be further reduced, and when the packing module is assembled using the packing sheets, it is only necessary to sequentially stack the non-flipped packing sheet A and the packing sheet B that has been rotated by 180°.

[Cooling Tower 1]

[0142] FIG. 10 is a schematic diagram of a cooling tower manufactured based on the packing module 1 according to this embodiment.

[0143] The bottom layer of the cooling tower 10 is an air inlet layer 101, and a plurality of air dampers 102 are disposed around the periphery of the air inlet layer 101. A packing layer 103 is disposed above the air inlet layer 101, and the packing layer 103 is formed by arranging a plurality of packing modules 1 in a matrix pattern on a horizontal plane. A spray part 104 is disposed above the packing layer 103, and the spray part 104 sprays hot water to be treated onto each packing module 1 of the packing layer 103. A partition plate 105 extending in the stacking direction of the packing module 1 is substantially vertically disposed in a region between the spray part 104 and the packing layer 103. A plurality of partitioned spaces 105a, 105b are defined by the partition plates 105 and the top surfaces of the packing modules 1. The partitioned space 105a serves as a spray space for spraying hot water, and the partitioned space 105b serves as an air intake space for drawing air from bottom to top. The spray space 105a and the air intake space 105b are alternately arranged in the direction perpendicular to the stacking direction within the matrix formed by the packing modules 1, and each partition plate 105 is disposed at the junction position of the first upper-end opening 210 and the second upper-end opening 220 of the packing module 1, thereby separating the first flow path R1 and the second flow path R2 that are in communication with the first upper-end opening 210 and the second upper-end opening 220.

[0144] Above the spray part 104 is an exhaust layer 106, and above the exhaust layer 106 is an exhaust outlet 108 provided with a fan 107. The fan 107 draws air upward, causing cold air to enter the air inlet layer 101

from the air damper 102 at the lower layer of the cooling tower 10, move upward through each packing module 1 of the packing layer 103, and pass through the spray space 105a and the air intake space 105b. After being further mixed in the exhaust layer 106, the cold air is discharged upward through the exhaust outlet 108.

[0145] In another aspect, the hot water to be treated, which is sprayed from the spray part 104 onto each packing module 1 of the packing layer 103, falls to the bottom surface of the air inlet layer 101 after being cooled through the packing modules 1, and the cooled water is recycled by a collection device for reuse in the factory.

Operating State 1:

[0146] As described above, the cooling tower 10 is set to a winter operating state. In this case, the hot water to be treated, which is sprayed from the spray part 104, is confined within the spray space 105a and enters one of the two flow paths of the packing module 1. In this embodiment, since the partition plate 105 is disposed at the junction position between the first upper-end opening 210 and the second upper-end opening 220 relative to the packing module 1, the first and second flow paths R1, R2 that are adjacent to each other between two adjacent packing modules 1 each form a water flow path, while the flow paths R1, R2 on the outer side are adjacent to the second and first flow paths that are adjacent thereto on both sides, respectively, and both form air flow paths.

[0147] In the water flow path, the sprayed water flows into the packing module 1, passes through the upper-section guide part 200, and is formed in the heat exchange part 400 as a water film that is distributed over a flat space of substantially the entire width of the packing module 1 and attached to the wall surfaces on both sides in the stacking direction of the flat space. The adjacent flow paths on both sides in the stacking direction serve as air flow paths, and heat exchange is performed with the hot water in the water flow paths through the wall surfaces of the packing sheets A and B.

[0148] When the cooling tower 10 operates in winter, the air drawn into the air flow path from below the packing module 1 is dry cold air, with low temperature and low moisture content. During heat exchange with hot water in the air flow path of the packing module 1, since the heat exchange is completed in an independent flow path completely separated by the packing sheets A and B, the temperature of the air rises when the air is discharged from above the packing module 1, but the moisture content at this point remains unchanged; that is, hot dry air is formed.

[0149] In another aspect, since hot water is sprayed from the spray part 104 above in the water flow path, the air drawn by the fan 107 in the water flow path is subjected to a large resistance. As a result, the air flow passing through the water flow path is very small compared to that passing through the air flow path, typically only a fraction thereof. The air passing through the air flow path be-

comes hot saturated air, i.e., humid hot air.

[0150] The hot dry air passing through the air flow path and the humid hot air passing through the water flow path are mixed in the exhaust layer 106. Due to the small amount of humid hot air, the resulting mixture forms unsaturated hot air after mixing with the hot dry air. After being discharged to the atmosphere through the fan 107 and the exhaust outlet 108, the unsaturated hot air is gradually cooled, and a small amount of moisture is precipitated, thereby significantly reducing plume formation.

[0151] In this embodiment, by switching the spray part 104, the spray space 105a and the air intake space 105b can be flexibly switched; that is, the spraying of hot water into the spray space 105a is stopped, while hot water is sprayed into the air intake space 105b. In this way, the functions of the spray space 105a and the air intake space 105b can be exchanged. In one aspect, the normal operation of the cooling tower 10 can be ensured, and in another aspect, the flow path R1 or R2 of the packing module 1 in communication with the air intake space 105b can be effectively cleaned and maintained, such that the cleaning and maintenance work on the cooling tower 10 does not affect the normal operation of the cooling tower 10.

Operating State 2:

[0152] In a summer operating state, by adjusting the spray part 104, the air intake space 105b can be sprayed with hot water in the same way as the spray space 105a. This can ensure that the heat exchange efficiency of the cooling tower 10 can be maximized without plume formation in summer.

[Cooling Tower 20]

[0153] In this embodiment, the above-described packing module 1 is still used. However, for the cooling tower 20, only the differences from the cooling tower 10 will be described in detail, and the same configuration will not be repeated. The cooling tower 20 according to this embodiment differs from the above-described cooling tower 10 in that, for each spray space 105a, a cover plate 109 in the stacking direction of the packing module 1 is further provided substantially horizontally above the partition plate 105. The cover plate 109, the partition plate 105, and the packing module 1 are provided to define a plurality of partitioned spaces 205a, 205b. In this embodiment, the cover plate 109 is only disposed in the spray space 205a for spraying hot water, while no cover plate 109 is disposed in the air intake space 205b for air exhaust. Certainly, the cover plate 109 may also be disposed in both the spray space 105a and the air intake space 205b, and the cover plate 109 is configured as a continuous plate or may be formed by combining a plurality of plates, and the cover plate 109 may be flipped or flipped in a bi-parting manner along one or both sides of

the partition wall 105 to form a detachable or openable mode, such that the spray space 205a and the air intake space 205b can be switched.

5 Operating State 1:

[0154] This operating state is particularly suitable for winter in northern China. In this state, the operating process of the cooling tower 20 is similar to that of the above-described cooling tower 10, except that since the cover plate 109 is disposed above the spray space 205a, the spray space 205a does not function as an air intake space in principle, and only the hot water flows downward through the flow path R1 or R2 of the packing module corresponding to the spray space 205a. Therefore, in the exhaust layer 106 of the cooling tower 20, only the hot dry air from the air intake space 205b is present.

[0155] Therefore, in the cooling tower 20, only hot dry air is drawn by the fan 107 and discharged from the exhaust outlet 108, such that the moisture in the hot air discharged by the cooling tower 20 is minimized, thereby further improving the plume reduction capacity of the cooling tower 20 in winter. In addition, since the discharged air is only hot dry air, the amount of water discharged from the cooling tower 20 is also reduced, which is more conducive to saving water.

[0156] In the case where the spray space 205a and the air intake space 205b are each provided with an openable and closable (side-opening, double-opening, or removable) cover plate 109, by opening the cover plate above the spray space 205a and closing the cover plate above the air intake space 205b, and adjusting the spray part 104, the functions of the spray space 205a and the air intake space 205b can be exchanged in the same manner as in the above-described cooling tower 10, thereby cleaning the flow path R1 or R2 of the packing module 1 corresponding to the original air intake space 205b and avoiding the shutdown of the cooling tower 20.

[0157] Certainly, by opening only the cover plate 109, the same operating state as that of the above-described cooling tower 10 can be achieved, and their operating efficiency and operating results are also substantially the same.

45 Operating State 2:

[0158] In the summer operating state, by removing or opening the cover plate 109 above the spray space 205a and adjusting the spray part 104, hot water is sprayed into the air intake space 205b in the same manner as into the spray space 205a, such that the cooling tower 20 and the above-described cooling tower 10 achieve the operating state of improving the heat exchange efficiency in summer in the same manner.

[0159] In the cooling tower 20 according to this embodiment, the cover plate 109 disposed above the partitioned spaces 205a, 205b is a flat plate, but is not limited thereto. The cover plate may also be a plate extending

from the partition plates 105 on both sides of the partitioned spaces 205a, 205b toward the center in the stacking direction of the packing module 1, overlapping to seal the partitioned spaces 205a, 205b, and forming an upward or downward vertex angle at the overlapping position. That is, as long as the upper portions of the partitioned spaces 205a, 205b can be sealed, the configuration of the cover plate 109 is not limited.

[0160] In the above embodiment, the flow straightening plate 230 is disposed in the left upper-section guide part 201, formed between the packing sheets B-A in the stacking direction of the packing module 1, of the upper-section guide part 200 of the first flow path R1.

[0161] Furthermore, the flow straightening plate 240 is disposed in the right upper-section guide part 202, formed between the packing sheets A-B in the stacking direction, of the upper-section guide part 200 of the second flow path R2.

[0162] In another aspect, the flow straightening plate 330 is disposed in the left lower-section guide part 301, formed between the packing sheets B-A in the stacking direction, of the lower-section guide part 300 of the first flow path R1.

[0163] Furthermore, the flow straightening plate 340 is disposed in the right upper-section guide part 202, formed between the packing sheets A-B in the stacking direction, of the lower-section guide part 300 of the second flow path R2. Since the first upper-end opening 210 and the second upper-end opening 220 each occupy substantially half of the width of the packing module 1, in practice, the flow straightening plate 230 is provided in a substantially right trapezoidal region. This region is defined by: starting from substantially the middle portion of the upper edge of the packing sheets B-A, extending downward through the left-side edge of the upper-section guide part 200, then moving rightward along the lower end line of the upper-section guide part 200 to the right-side edge of the upper-section guide part 200, and then turning obliquely upward toward substantially the middle portion of the upper edge of the packing sheet A (B). The packing sheet A is offset toward the rear side at the right trapezoid region, and conversely, the packing sheet B is offset toward the front side. As a result, in the stacking direction, the packing sheet A on the front side and the packing sheet B on the rear side, namely, the packing sheets A-B, are brought into close contact with each other at the periphery of the first upper-end opening 210. Consequently, at the first upper-end opening 210, the opening width in the stacking direction between the packing sheet B on the front side and the packing sheet A on the rear side, that is, between the packing sheets B-A, is 2d. That is, in this right trapezoid region, the distance in the stacking direction at the first upper-end opening 210 of the upper end is approximately 2d, while the distance in the stacking direction at the portion where the lower end is connected to the heat exchange part 400 is the interval d between the packing sheets A and B, thereby forming the space of the left upper-section guide part 201.

[0164] In the horizontal direction, the flow straightening plate 230 has a corrugated cross-section extending perpendicular to the stacking direction. At the upper portion near the first upper-end opening 210, the corrugation amplitude is large while the corrugation pitch is small. As the flow straightening plate extends from top to bottom toward the heat exchange part 400, the corrugation amplitude gradually decreases, and the corrugation pitch gradually increases, thereby filling the space of the left upper-section guide part 201. By allowing the flow straightening plate 230 to be corrugated in the horizontal direction, a plurality of guide flow paths are formed from the first upper-end opening 210 to the heat exchange part 400. Each guide flow path has an upper end with a large thickness in the stacking direction and a small width in the horizontal direction, and a lower end with a small thickness and a large width. This enables the hot water flowing in from the first upper-end opening 210, which has substantially half the width of the packing module 1, to be effectively and uniformly guided to the heat exchange part 400, which has substantially the entire width of the packing module 1. Moreover, regardless of the individual guide flow path or the entire guide flow path, the change in the cross-sectional area of the guide flow path from top to bottom is minimized, thereby reducing fluid resistance. Good passage efficiency can be achieved for both the hot water sprayed from above and the air drawn in from bottom to top.

[0165] The same configuration is applied to the flow straightening plate 240 located in the space of the right upper-section guide part 202, except that the arrangement position thereof is rotationally symmetrical to that of the flow straightening plate 240 in the horizontal direction.

[0166] Similarly to the left upper-section guide part 201 and the right upper-section guide part 202 located in the upper-section guide part 200, the flow straightening plates 330, 340 are respectively provided in the left lower-section guide part 301 and the right lower-section guide part 302. The left lower-section guide part is formed by offsetting, toward the outer side in the stacking direction, an inverted right trapezoid region of the packing sheets B-A at the lower-section guide part 300, and the right lower-section guide part is formed by offsetting, toward the outer side in the stacking direction, an inverted right trapezoid region of the packing sheets A-B at the lower-section guide part 300. The flow straightening plates 330, 340 form, in the left lower-section guide part 301 and the right lower-section guide part 302, a plurality of flow paths that have an upper end with a small thickness in the stacking direction and a large width in the horizontal direction, and a lower end with a large thickness and a small width. Thus, this can guide the water from the heat exchange parts 400 having substantially the entire width of the first and second flow paths R1, R2 of the packing module 1 to the first and second lower-end openings 310, 320 having substantially half the width.

[0167] That is, the flow straightening plates 330, 340

have an inverted configuration in which the corrugation amplitude is large and the corrugation pitch is small at the first and second lower-end openings 310, 320. As the flow straightening plate extends from bottom to top toward the heat exchange part 400, the corrugation amplitude gradually decreases and the corrugation pitch gradually increases.

[0168] Similarly, the flow straightening plate 330 located in the space of the left lower-section guide part 301 and the flow straightening plate 340 located in the space of the right lower-section guide part 302 are rotationally symmetric in the horizontal direction.

[0169] Therefore, in the case where the first and second upper-end openings 210, 220 and the first and second lower-end openings 310, 320 are each substantially half the width of the packing module 1, if the vertical lengths of the upper-section and lower-section guide parts 200, 300 are the same, the left upper-section guide part 201, the right upper-section guide part 202, the left lower-section guide part 301, and the right lower-section guide part 302 may form a rotationally symmetric structure. Therefore, the flow straightening plates 230, 240, 330, 340 may be configured as the same component, such that only three types of components are required during the manufacturing of the packing module 1, namely, the packing sheet A, the packing sheet B, and a common flow straightening plate. In this way, not only the mold costs and the production costs of components for manufacturing the packing module 1 are significantly reduced, but also the model differences of the flow straightening plates do not need to be considered during assembly of the packing sheet A, the packing sheet B, and the flow straightening plate, which facilitates the assembly and significantly reduces the overall production cost of the packing module 1.

[0170] According to the above preferred embodiment, by respectively offsetting and attaching the packing sheet A and the packing sheet B at the upper-section guide part and the lower-section guide part, the first upper-end opening, the second upper-end opening, the first lower-end opening, and the second lower-end opening are each stacked in the stacking direction. Without considering the thicknesses of the packing sheets A and B, the total dimension of the openings in the stacking direction is substantially equal to the stacking thickness of the packing module in the stacking direction.

[Packing Assembly 350]

[0171] As described above, during the mounting of the packing module 1, the packing module 1 is typically divided and stacked only to a predetermined thickness (e.g., 1 m to 3 m) to form units of the packing module 1. The units are then arranged in a straight line and close to each other in the stacking direction of the packing module 1, thereby forming the packing module 1 as a complete row. Therefore, during the mounting of the cooling tower 30, to ensure minimal air leakage and water leakage from

the cooling tower 30, it is necessary to ensure that the units of the packing module 1 are mounted in a straight line. However, when the packing modules 1 are mounted at the mounting site, since the work is performed inside the cooling tower, the packing modules 1 often need to be manually positioned in place, which makes the operation difficult. In addition, due to inevitable factors such as tolerances and deformations of the packing modules 1, the connection surfaces between two adjacent packing modules 1 in the stacking direction of the packing sheets are not in close contact, which may easily cause leakage. In cold winter conditions, water leaking into the air flow path may freeze into ice, causing blockage of the air flow path and even damage to the equipment.

[0172] To solve the above problem, as shown in FIGs. 17 and 18, this embodiment provides a packing assembly 350, which includes a packing module 1 and a packing frame 351 surrounding the outer side of the packing module. In addition, the length of the packing assembly 350 in the stacking direction of the packing sheets is greater than the width of the packing assembly 350. In practical engineering applications, the packing module 1 may be manufactured in the factory, and the above-described packing frame 350 is mounted on the outer side of the packing module.

[0173] For example, the length of the packing assembly 350 in the stacking direction of the packing sheets is approximately equal to 1/2 of the length in the corresponding direction within the internal space of the cooling tower. Thus, as shown in FIGs. 19 and 20, the packing assembly 350 and the packing assembly 350' each occupy half of the length of the cooling tower in the corresponding direction. The packing assembly 350 is mounted into the cooling tower by using a hoisting device or a tool from the left side in FIG. 20, and the packing assembly 350' is mounted into the cooling tower by using a hoisting device or a tool from the right side in FIG. 20. By adopting the above method, during construction of the cooling tower, each of the packing assemblies 350, 350' can be quickly mounted into the cooling tower, which greatly increases the speed of mounting the packing layer in the cooling tower and reduces the probability of leakage at the connection surface between the packing modules.

[0174] In some embodiments, the above-described packing frame 350 may be made of a profile such as a square tube or an angle iron by welding, screw connection, or the like. The members forming the above-described packing frame 350 may be located at various corners of the packing module 1. In order to improve the strength of the packing frame 350, at least one of horizontal, vertical, and inclined braces 3511 may further be provided.

[0175] As shown in FIGs. 17 and 18, the packing assembly 350 can further include an upper frame 352, and the upper frame 352 is fixed to the upper side of the packing frame 351. The upper frame 352 may be configured to serve as a support structure for the spray part

104. A spray pipe 1042 of the spray part 104 may be fixed to the top of the upper frame 352, and a spray head 1041 may be mounted at an appropriate position.

[0176] In addition, the above-described upper frame 352 may be of a split structure; that is, the upper frame 352 is formed by assembling a plurality of split bodies of the upper frame 352, and the upper frame 352 is mounted on the upper side of the packing frame 351, thereby reducing the weight of a single split body and facilitating the transportation and assembly.

[0177] As shown in FIG. 19, by arranging the above-described packing frame 351 and the upper frame 352, support for the mounting of the partition plate 105 and the partition plate 105' can be provided, without additionally constructing cross beams inside the cooling tower, thereby improving the convenience of the mounting and the sealing performance of the partition plates 105, 105'.

[0178] The packing module and the cooling tower with the packing module according to the preferred embodiments of the present disclosure have been described in detail above. However, those skilled in the art can make various modifications, changes, combinations, etc. on this basis, and all such modifications, changes, and combinations fall within the protection scope of the claims of the present application.

Claims

1. A packing module, comprising
 - a plurality of packing sheets arranged in a stacked manner, wherein the packing sheet is configured such that a first offset part offset toward a rear side is provided on a left side of an upper end portion; a second offset part offset toward a front side is provided on a right side of the upper end portion; a third offset part offset toward the rear side is provided on a left side of a lower end portion; a fourth offset part offset toward the front side is provided on a right side of the lower end portion; and adjacent packing sheets are arranged in such a way as to be rotated by 180° about a horizontal axis of a body part of the packing sheet.
2. The packing module according to claim 1, wherein
 - the second offset part of the packing sheet is brought into contact with a fourth offset part of a front-side flipped packing sheet located on a front side in a stacking direction, and the fourth offset part of the packing sheet is brought into contact with a second offset part of the front-side flipped packing sheet, such that a first upper-end opening is formed between the first offset part of the packing sheet and a third

offset part of the front-side flipped packing sheet, and

a first lower-end opening is formed between the third offset part of the packing sheet and a first offset part of the front-side flipped packing sheet, wherein

the first upper-end opening and the first lower-end opening are in communication with a first heat exchange part formed between the body part of the packing sheet and a body part of the front-side flipped packing sheet on an upper side and a lower side in a vertical direction, respectively, thereby forming a first flow path.

3. The packing module according to claim 2, wherein
 - the first offset part of the packing sheet is brought into contact with a third offset part of a rear-side flipped packing sheet located on a rear side in the stacking direction, and the third offset part of the packing sheet is brought into contact with a first offset part of the rear-side flipped packing sheet, such that a second upper-end opening is formed between the second offset part of the packing sheet and a fourth offset part of the rear-side flipped packing sheet, and a second lower-end opening is formed between the fourth offset part of the packing sheet and a second offset part of the rear-side flipped packing sheet, wherein the second upper-end opening and the second lower-end opening are in communication with a second heat exchange part formed between the body part of the packing sheet and a body part of the rear-side flipped packing sheet on the upper side and the lower side in the vertical direction, respectively, thereby forming a second flow path.
4. The packing module according to claim 2, wherein a first flow straightening plate that gradually increases in width and gradually decreases in thickness from the first upper-end opening to the first heat exchange part is disposed between the first offset part of the packing sheet and the third offset part of the front-side flipped packing sheet.
5. The packing module according to claim 4, wherein a third flow straightening plate that gradually increases in width and gradually decreases in thickness from the first lower-end opening to the first heat exchange part is disposed between the third offset part of the packing sheet and the first offset part of the front-side flipped packing sheet.
6. The packing module according to claim 3, wherein a second flow straightening plate that gradually in-

creases in width and gradually decreases in thickness from the second upper-end opening to the second heat exchange part is disposed between the second offset part of the packing sheet and the fourth offset part of the rear-side flipped packing sheet.

7. The packing module according to claim 6, wherein a fourth flow straightening plate that gradually increases in width and gradually decreases in thickness from the second lower-end opening to the second heat exchange part is disposed between the fourth offset part of the packing sheet and the second offset part of the rear-side flipped packing sheet.

8. The packing module according to any one of claims 1 to 7, wherein a left side edge of each of the packing sheets is offset toward the front side to form a linear sealing edge part, and the sealing edge part of the packing sheet is brought into contact with a sealing edge part of the front-side flipped packing sheet located on the front side in the stacking direction.

9. The packing module according to claim 8, wherein the sealing edge part of the packing sheet is brought into contact with the sealing edge part of the front-side flipped packing sheet located on the front side in the stacking direction, and the two are joined by welding.

10. A cooling tower, comprising:
the packing module according to any one of claims 1 to 9.

11. A packing module for a cooling tower, comprising

rectangular packing sheets A and B alternately stacked at predetermined intervals, the rectangular packing sheets A and B forming first and second flow paths that are alternately arranged, wherein an upper-section guide part and a lower-section guide part are disposed in an upper section and a lower section of the packing module, respectively; the upper-section guide part comprises a plurality of first upper-end openings and second upper-end openings provided in an upper surface of the packing module, wherein the first upper-end openings are located on one side perpendicular to a stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths; and the second upper-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths;

the lower-section guide part comprises a plurality of first lower-end openings and second lower-end openings provided in a lower surface of the packing module, wherein

the first lower-end openings are located on the one side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths; and the second lower-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths.

12. The packing module according to claim 11, wherein a heat exchange part is disposed between the upper-section guide part and the lower-section guide part, the heat exchange part comprising:

first heat exchange parts in a form of a flat cavity formed between the packing sheets B-A; and second heat exchange parts in a form of a flat cavity formed between the packing sheets A-B, wherein the first heat exchange parts and the second heat exchange parts are alternately stacked in the stacking direction.

13. The packing module according to claim 11, wherein a total dimension of the first upper-end openings, the second upper-end openings, the first lower-end openings, and the second lower-end openings in the stacking direction is substantially equal to a stacking thickness of the packing module.

14. The packing module according to claim 13, wherein

flow straightening plates are disposed between each of the upper-end openings and the heat exchange part, as well as between each of the lower-end openings and the heat exchange part; each of the flow straightening plates has a corrugated transverse cross-section, and opposite sides of the corrugated shape abut against the packing sheets, respectively.

15. The packing module according to claim 14, wherein

a distance between the packing sheet A and the packing sheet B is d ; each flow straightening plate has a large corrugation amplitude and a small corrugation pitch at an upper-end opening and a lower-end opening thereof, and during extension of the flow straightening plate toward the heat exchange part, the corrugation amplitude gradually decreases while the corrugation pitch gradually increases.

16. The packing module according to any one of claims 11 to 15, wherein

at the upper-section guide part,
 an upper end portion of the packing sheet A on
 one side in the stacking direction is offset toward
 one side in the stacking direction, and an upper
 end portion of the packing sheet B on the one
 side in the stacking direction is offset toward the
 other side in the stacking direction, such that at
 corresponding regions, the packing sheet A and
 the packing sheet B are in close contact with
 each other on one side in the stacking direction,
 and the packing sheet B and the packing sheet A
 are spaced apart from each other on an opposite
 side in the stacking direction, thereby forming
 the first upper-end opening; and
 an upper end portion of the packing sheet B on
 the other side in the stacking direction is offset
 toward one side in the stacking direction, and an
 upper end portion of the packing sheet A on the
 other side in the stacking direction is offset to-
 ward the other side in the stacking direction,
 such that at corresponding regions, the packing
 sheet B and the packing sheet A are in close
 contact with each other on one side in the stack-
 ing direction, and the packing sheet A and the
 packing sheet B are spaced apart from each
 other on an opposite side in the stacking direc-
 tion, thereby forming the second upper-end
 opening;
 at the lower-section guide part,
 a lower end portion of the packing sheet A on
 one side in the stacking direction is offset toward
 one side in the stacking direction, and a lower
 end portion of the packing sheet B on the one
 side in the stacking direction is offset toward the
 other side in the stacking direction, such that at
 corresponding regions, the packing sheet A and
 the packing sheet B are in close contact with
 each other on one side in the stacking direction,
 and the packing sheet B and the packing sheet A
 are spaced apart from each other on an opposite
 side in the stacking direction, thereby forming
 the first lower-end opening; and
 a lower end portion of the packing sheet B on the
 other side in the stacking direction is offset to-
 ward one side in the stacking direction, and a
 lower end portion of the packing sheet A on the
 other side in the stacking direction is offset to-
 ward the other side in the stacking direction,
 such that at corresponding regions, the packing
 sheet B and the packing sheet A are in close
 contact with each other on one side in the stack-
 ing direction, and the packing sheet A and the
 packing sheet B are spaced apart from each
 other on an opposite side in the stacking direc-
 tion, thereby forming the second lower-end

opening.

17. The packing module according to claim 11, wherein

at the upper-section guide part,
 the upper-section guide parts of the packing
 sheet A and the packing sheet B are configured
 such that portions thereof on opposite sides in
 the stacking direction are respectively offset in
 opposite directions in the stacking direction; and
 at the lower-section guide part,
 the lower-section guide parts of the packing
 sheet A and the packing sheet B are configured
 such that portions thereof on the opposite sides
 in the stacking direction are respectively offset in
 the opposite directions in the stacking direction.

18. The packing module according to claim 17, wherein

portions, on the opposite sides in the stacking
 direction, of at least one of the upper-section
 guide part of the packing sheet A and the upper-
 section guide part of the packing sheet B are
 offset in the opposite directions in the stacking
 direction by non-zero amounts;
 portions, on the opposite sides in the stacking
 direction, of at least one of the lower-section
 guide part of the packing sheet A and the low-
 er-section guide part of the packing sheet B are
 offset in the opposite directions in the stacking
 direction by non-zero amounts.

19. The packing module according to claim 17, wherein

the upper-section guide part of the packing
 sheet A and the upper-section guide part of
 the packing sheet B have different offset
 amounts on the opposite sides in the stacking
 direction;
 the lower-section guide part of the packing sheet
 A and the lower-section guide part of the packing
 sheet B have different offset amounts on the
 opposite sides in the stacking direction.

20. The packing module according to claim 14, wherein

widths of the first upper-end opening and the
 second upper-end opening on opposite sides
 perpendicular to the stacking direction are equal
 to widths of the first lower-end opening and the
 second lower-end opening on opposite sides
 perpendicular to the stacking direction, and
 the flow straightening plates disposed between
 each of the upper-end openings and the first
 heat exchange part, as well as between each
 of the lower-end openings and the first heat
 exchange part, are a same component.

- 21.** A packing module having a watertight sealing edge, comprising:

rectangular packing sheets A and B alternately stacked at predetermined intervals, the rectangular packing sheets A and B forming first flow paths and second flow paths that are alternately arranged, wherein the packing module comprises an upper-section guide part located in an upper section and a heat exchange part located below the upper-section guide part, the heat exchange part comprises: first heat exchange parts in a form of a flat cavity formed between the packing sheets B-A; and second heat exchange parts in a form of a flat cavity formed between the packing sheets A-B, wherein the first heat exchange parts and the second heat exchange parts are alternately stacked in a stacking direction from front to rear; at the upper-section guide part, the packing sheet A is configured such that a first upper-section guide part on one side in a horizontal direction is offset toward a rear side in the stacking direction, and a second upper-section guide part on the other side is offset toward a front side in the stacking direction; and one side edge of the packing sheet A is offset as a whole toward the front side to form a first sealing edge part; at the upper-section guide part, the packing sheet B is configured such that a third upper-section guide part on one side in the horizontal direction is offset toward the front side in the stacking direction, and a fourth upper-section guide part on the other side is offset toward the rear side in the stacking direction; and one side edge of the packing sheet B is offset toward the rear side to form a second sealing edge part; when the packing sheets A and B are stacked from rear to front in the stacking direction, the first sealing edge part of the packing sheet A is brought into contact with the second sealing edge part of the packing sheet B adjacent to the front side to form a sealing edge.

- 22.** The packing module having a watertight sealing edge according to claim 21, wherein the sealing edge is formed by welding the first sealing edge part and the second sealing edge part to each other.

- 23.** The packing module having a watertight sealing edge according to claim 21, wherein the first upper-section guide part of the packing sheet A and the third upper-section guide part of the packing sheet B on the rear side in the stacking direction are brought into contact with each other at least at

upper end portions, and the second upper-section guide part of the packing sheet A and the fourth upper-section guide part of the packing sheet B on the front side in the stacking direction are brought into contact with each other at least at upper end portions.

- 24.** The packing module having a watertight sealing edge according to claim 21, wherein

between adjacent packing sheets B-A in the stacking direction from front to rear, a first upper-end opening located on one side in the horizontal direction is formed by upper-end edges of the first upper-section guide part of the packing sheet A and the third upper-section guide part of the packing sheet B, and a width of the first upper-end opening gradually increases downward, thereby communicating with the first heat exchange part to form the first flow path, wherein an edge of the first flow path on one side in a horizontal direction is sealed by the sealing edge.

- 25.** The packing module having a watertight sealing edge according to claim 24, wherein

between adjacent packing sheets A-B in the stacking direction from front to rear, a second upper-end opening located on the other side in the horizontal direction is formed by upper-end edges of the fourth upper-section guide part of the packing sheet B and the second upper-section guide part of the packing sheet A, and a width of the second upper-end opening gradually increases downward, thereby communicating with the second heat exchange part.

- 26.** The packing module having a watertight sealing edge according to claim 24 or 25, wherein

the alternately stacked packing sheets A and B further comprise lower-section guide parts located below the heat exchange part; a lower-section guide part of the packing sheet A is configured such that a first lower-section guide part on one side in the horizontal direction is offset toward the rear side in the stacking direction, and a second lower-section guide part on the other side is offset toward the front side in the stacking direction; a lower-section guide part of the packing sheet B is configured such that a third lower-section guide part on one side in the horizontal direction is offset toward the front side in the stacking direction, and a fourth lower-section guide part on the other side is offset toward the rear side in the stacking direction.

27. The packing module having a watertight sealing edge according to claim 26, wherein the first lower-section guide part of the packing sheet A and the third lower-section guide part of the packing sheet B on the rear side in the stacking direction are brought into contact with each other at least at lower end portions, and the second lower-section guide part of the packing sheet A and the fourth lower-section guide part of the packing sheet B on the front side in the stacking direction are brought into contact with each other at least at lower end portions. 5 10
28. The packing module having a watertight sealing edge according to claim 26, wherein 15
- between adjacent packing sheets B-A in the stacking direction from front to rear, a first lower-end opening located on one side in the horizontal direction is formed by lower-end edges of the first lower-section guide part of the packing sheet A and the third lower-section guide part of the packing sheet B, and a width of the first lower-end opening gradually increases upward, thereby communicating with the first heat exchange part to form a lower-section portion of the first flow path, wherein an edge of the first flow path on one side in a horizontal direction is sealed by the sealing edge. 20 25 30
29. The packing module having a watertight sealing edge according to claim 28, wherein 35
- between adjacent packing sheets A-B in the stacking direction from front to rear, a second lower-end opening located on the other side in the horizontal direction is formed by lower-end edges of the fourth lower-section guide part of the packing sheet B and the second lower-section guide part of the packing sheet A, and a width of the second lower-end opening gradually increases upward, thereby communicating with the second heat exchange part. 40 45
30. A cooling tower, comprising
- the cooling tower comprises the packing module having a watertight sealing edge according to any one of claims 11 to 29, wherein hot water is sprayed from top to bottom in the first flow path, and cold air is introduced from bottom to top in the second flow path. 50
31. A packing module having a watertight sealing edge, comprising: 55
- rectangular packing sheets A and B alternately

stacked at predetermined intervals, the rectangular packing sheets A and B forming first flow paths and second flow paths that are alternately arranged, wherein the packing module comprises an upper-section guide part located in an upper section and a heat exchange part located below the upper-section guide part the heat exchange part comprises: first heat exchange parts in a form of a flat cavity formed between the packing sheets B-A; and second heat exchange parts in a form of a flat cavity formed between the packing sheets A-B, wherein the first heat exchange parts and the second heat exchange parts are alternately stacked in a stacking direction from front to rear; at the upper-section guide part, the packing sheet A is configured such that a first upper-section guide part on one side in a horizontal direction is offset toward a rear side in the stacking direction, and a second upper-section guide part on the other side is offset toward a front side in the stacking direction; and at the upper-section guide part, the packing sheet B is configured such that a third upper-section guide part on one side in the horizontal direction is offset toward the front side in the stacking direction, and a fourth upper-section guide part on the other side is offset toward the rear side in the stacking direction; in this way between the packing sheets A-B arranged in a stacked manner, upper-section guide parts thereof on one side are brought into contact with each other to form a portion of an edge of a first upper-end opening of the first flow path; and between the packing sheets B-A arranged in a stacked manner, upper-section guide parts thereof on the other side are brought into contact with each other to form a portion of an edge of a second upper-end opening of the second flow path; a first flow straightening plate is provided at least in the first upper-end opening, the first flow straightening plate guiding a fluid entering through a portion of the packing module in the width direction to the first heat exchange part having substantially an entire width of the packing module; the first flow straightening plate is in a corrugated shape in the horizontal direction, and an end portion on a side of the first upper-end opening is spaced apart from an upper-end edge of the first upper-end opening by a predetermined distance, thereby forming a clearance region inside the first upper-end opening, wherein in the clearance region, upper-end edges on one side of the packing sheets A-B that are brought into contact are joined by welding.

- 32.** The packing module having a watertight sealing edge according to claim 31, wherein

one side edge of the packing sheet A is offset as a whole toward the front side to form a first sealing edge part; 5
 one side edge of the packing sheet B is offset toward the rear side to form a second sealing edge part;
 when the packing sheets A and B are stacked from rear to front in the stacking direction, the first sealing edge part of the packing sheet A is brought into contact with the second sealing edge part of the packing sheet B adjacent to the front side to form a sealing edge. 10 15

- 33.** The packing module having a watertight sealing edge according to claim 31, wherein the sealing edge is formed by welding the first sealing edge part and the second sealing edge part to each other. 20

- 34.** The packing module having a watertight sealing edge according to claim 31, wherein the first upper-section guide part of the packing sheet A and the third upper-section guide part of the packing sheet B on the rear side in the stacking direction are brought into contact with each other at least at upper end portions, and the second upper-section guide part of the packing sheet A and the fourth upper-section guide part of the packing sheet B on the front side in the stacking direction are brought into contact with each other at least at upper end portions. 25 30

- 35.** The packing module having a watertight sealing edge according to claim 31, wherein

between adjacent packing sheets B-A in the stacking direction from front to rear, a first upper-end opening located on one side in the horizontal direction is formed by upper-end edges of the first upper-section guide part of the packing sheet A and the third upper-section guide part of the packing sheet B, 40 45
 and a width of the first upper-end opening gradually increases downward, thereby communicating with the first heat exchange part to form the first flow path, wherein an edge of the first flow path on one side in a horizontal direction is sealed by the sealing edge. 50

- 36.** The packing module having a watertight sealing edge according to claim 34, wherein

between adjacent packing sheets A-B in the stacking direction from front to rear, a second upper-end opening located on the 55

other side in the horizontal direction is formed by upper-end edges of the fourth upper-section guide part of the packing sheet B and the second upper-section guide part of the packing sheet A, and a width of the second upper-end opening gradually increases downward, thereby communicating with the second heat exchange part.

- 37.** The packing module having a watertight sealing edge according to claim 35, wherein

the alternately stacked packing sheets A and B further comprise lower-section guide parts located below the heat exchange part; a lower-section guide part of the packing sheet A is configured such that a first lower-section guide part on one side in the horizontal direction is offset toward the rear side in the stacking direction, and a second lower-section guide part on the other side is offset toward the front side in the stacking direction; a lower-section guide part of the packing sheet B is configured such that a third lower-section guide part on one side in the horizontal direction is offset toward the front side in the stacking direction, and a fourth lower-section guide part on the other side is offset toward the rear side in the stacking direction.

- 38.** The packing module having a watertight sealing edge according to claim 37, wherein the first lower-section guide part of the packing sheet A and the third lower-section guide part of the packing sheet B on the rear side in the stacking direction are brought into contact with each other at least at lower end portions, and the second lower-section guide part of the packing sheet A and the fourth lower-section guide part of the packing sheet B on the front side in the stacking direction are brought into contact with each other at least at lower end portions. 35 40

- 39.** The packing module having a watertight sealing edge according to claims 31 to 38, wherein the first flow path is used as a hot spray water flow path, and the second flow path is used as an air flow path.

- 40.** A cooling tower, comprising

the cooling tower comprises the packing module having a watertight sealing edge according to any one of claims 31 to 39, wherein hot water is sprayed from top to bottom in the first flow path.

- 41.** A low airflow-resistance packing module, comprising

rectangular packing sheets A and B alternately stacked at predetermined intervals, the rectangular packing sheets A and B forming first flow paths and second flow paths that are alternately arranged, wherein an upper-section guide part and a lower-section guide part are disposed in an upper section and a lower section of the packing module, respectively;

a heat exchange part is disposed between the upper-section guide part and the lower-section guide part, the heat exchange part comprising: first heat exchange parts in a form of a flat cavity formed between the packing sheets B-A; and second heat exchange parts in a form of a flat cavity formed between the packing sheets A-B, wherein the first heat exchange parts and the second heat exchange parts are alternately stacked in a stacking direction;

the first flow path serves as a water spraying channel, and the second flow path serves as an air intake channel;

the upper-section guide part comprises a plurality of first upper-end openings and second upper-end openings provided in an upper surface of the packing module, wherein the first upper-end openings are located on one side perpendicular to a stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths; and the second upper-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths;

the lower-section guide part comprises a plurality of first lower-end openings and second lower-end openings provided in a lower surface of the packing module, wherein the first lower-end openings are located on the one side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths; and the second lower-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths;

substantially right-trapezoidal flow path spaces are respectively formed between the first upper-end opening and the first heat exchange part and between the second upper-end opening and the second heat exchange part; substantially inverted right-trapezoidal flow path spaces are respectively formed between the first lower-end opening and the first heat exchange part and between the second lower-end opening and the second heat exchange part;

at the upper-section guide part, a first flow

straightening plate is provided only in the first upper-end opening, the first flow straightening plate guiding spray water from the first upper-end opening to the first heat exchange part having substantially an entire width of the packing module.

42. The low airflow-resistance packing module according to claim 41, wherein
at the lower-section guide part, a second flow straightening plate is provided only in the first lower-end opening, the second flow straightening plate guiding the spray water to the first lower-end opening from the first heat exchange part having substantially an entire width of the packing module.
43. The low airflow-resistance packing module according to claim 42, wherein
a width of the first upper-end opening is substantially equal to a width of the second upper-end opening,
a width of the first lower-end opening is substantially equal to a width of the second lower-end opening, and
the first flow straightening plate and the second flow straightening plate are a same component.
44. The low airflow-resistance packing module according to claim 42, wherein
the first upper-end opening and the first lower-end opening are located on a same side of the packing module, and the first flow straightening plate and the second flow straightening plate are a same component.
45. The low airflow-resistance packing module according to claim 41 or 42, wherein
the first upper-end opening and the first lower-end opening are located on a same side of the packing module, and
a sealing edge part is formed on an edge of an outer side of the first upper-end opening in a width direction of the packing module.
46. The low airflow-resistance packing module according to claim 45, wherein
the sealing edge part is configured such that an upper end portion of the packing sheet A is offset toward a rear side at the first upper-end opening and offset toward a front side at an edge;
the packing sheet B on a front side in the stacking direction
is offset toward the front side at the first upper-end opening to be brought into contact with a first

upper-end opening of a packing sheet A on the front side, and
offset toward the rear side at an edge to be brought into contact with an edge of the packing sheet A.

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- 47.** The low airflow-resistance packing module according to claim 41, wherein
each of the first and second flow straightening plates has a corrugated transverse cross-section, and opposite sides of the corrugated shape abut against the packing sheets, respectively.

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- 48.** The low airflow-resistance packing module according to claim 47, wherein

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a distance between the packing sheet A and the packing sheet B is d;
each of the first and second flow straightening plates has a large corrugation amplitude and a small corrugation pitch at an upper-end opening and a lower-end opening thereof, and during extension of the flow straightening plate toward the heat exchange part, the corrugation amplitude gradually decreases while the corrugation pitch gradually increases.

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- 49.** A cooling tower, comprising

the low airflow-resistance packing module according to any one of claims 41 to 48, wherein hot water is sprayed in the first flow path, flows in through the first upper-end opening formed at a portion of the packing module in the width direction, undergoes heat exchange in the first heat exchange part having substantially the entire width, through the packing sheets A and B, with cold air in a second heat exchange part of an adjacent second flow path, and flows out through the first lower-end opening formed at a portion in the width direction;
in the second flow path, cold air is introduced into the second heat exchange part only through the first lower-end opening formed at a portion in the width direction, exchanges heat in a second heat exchange part having substantially an entire width, and then is led out through the second upper-end opening formed at a portion in the width direction.

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- 50.** A packing assembly, comprising

a packing module and a packing frame surrounding an outer side of the packing module, wherein
the packing module comprises rectangular packing sheets A and B alternately stacked at predetermined intervals, the rectangular pack-

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ing sheets A and B forming first and second flow paths that are alternately arranged, wherein an upper-section guide part and a lower-section guide part are disposed in an upper section and a lower section of the packing module, respectively;

the upper-section guide part comprises a plurality of first upper-end openings and second upper-end openings provided in an upper surface of the packing module, wherein
the first upper-end openings are located on one side perpendicular to a stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths; and
the second upper-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths;

the lower-section guide part comprises a plurality of first lower-end openings and second lower-end openings provided in a lower surface of the packing module, wherein
the first lower-end openings are located on the one side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the first flow paths; and
the second lower-end openings are located on the other side perpendicular to the stacking direction, arranged in parallel in the stacking direction, and in communication with the second flow paths.

- 51.** A cooling tower, comprising:

the packing assembly according to claim 50, wherein a length of the packing assembly in the stacking direction is approximately 1/2 of a length of an inner cavity of the cooling tower in a corresponding direction.

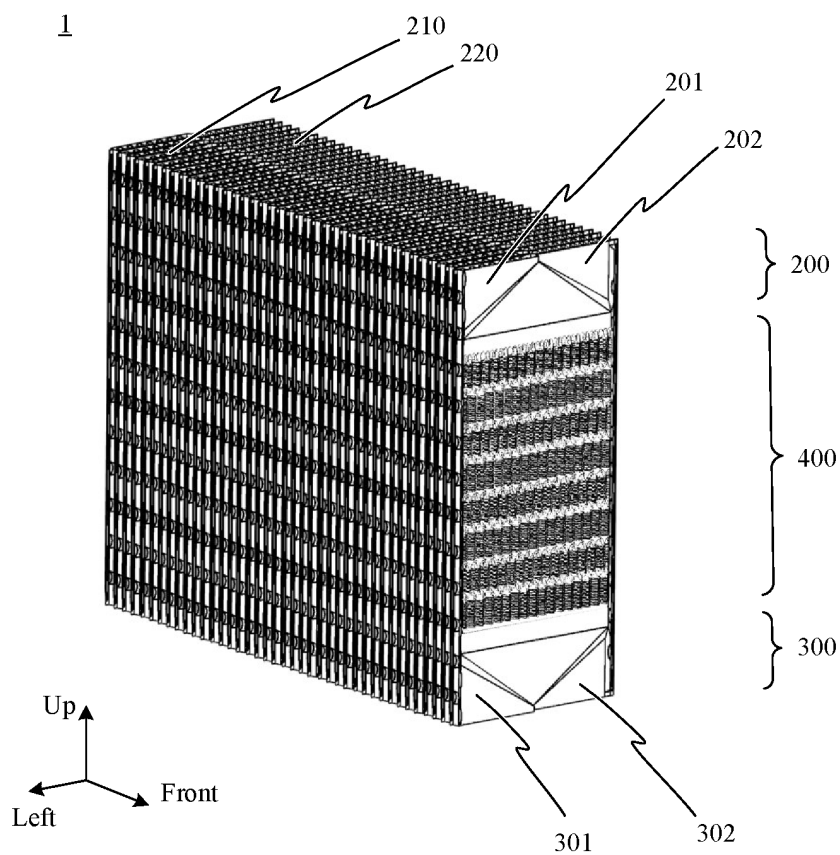


FIG. 1

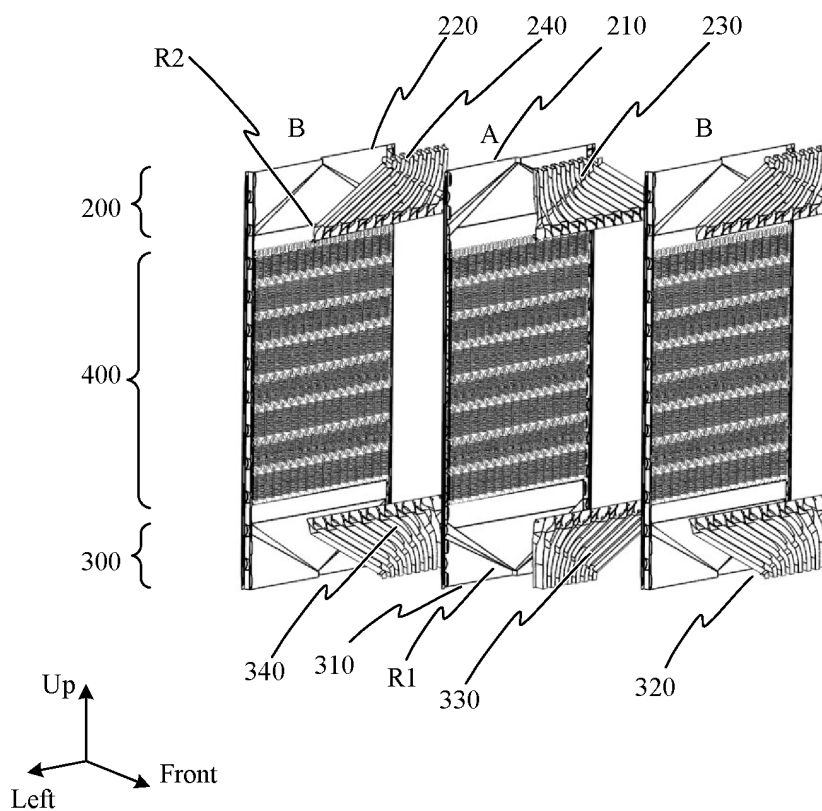


FIG. 2

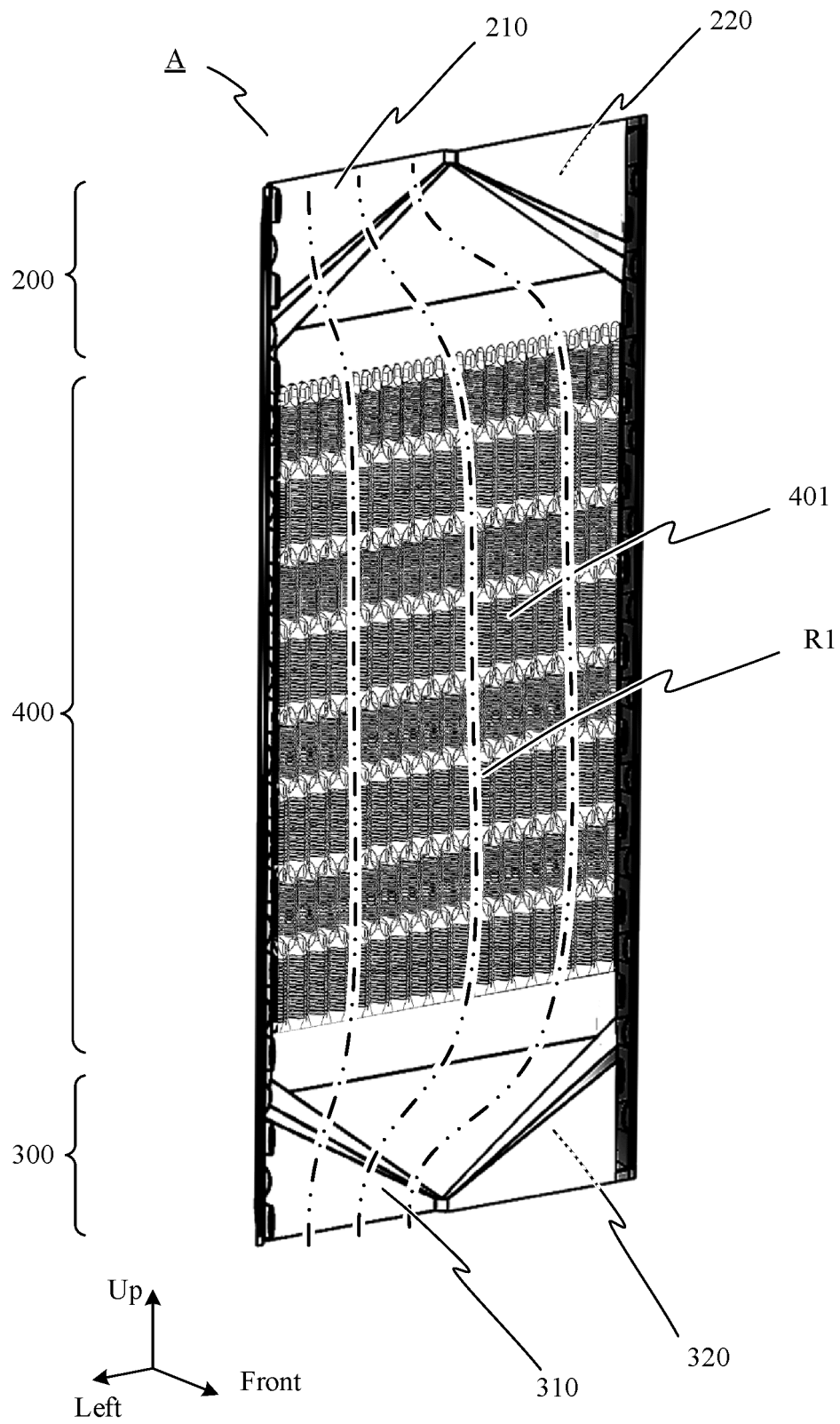


FIG. 3

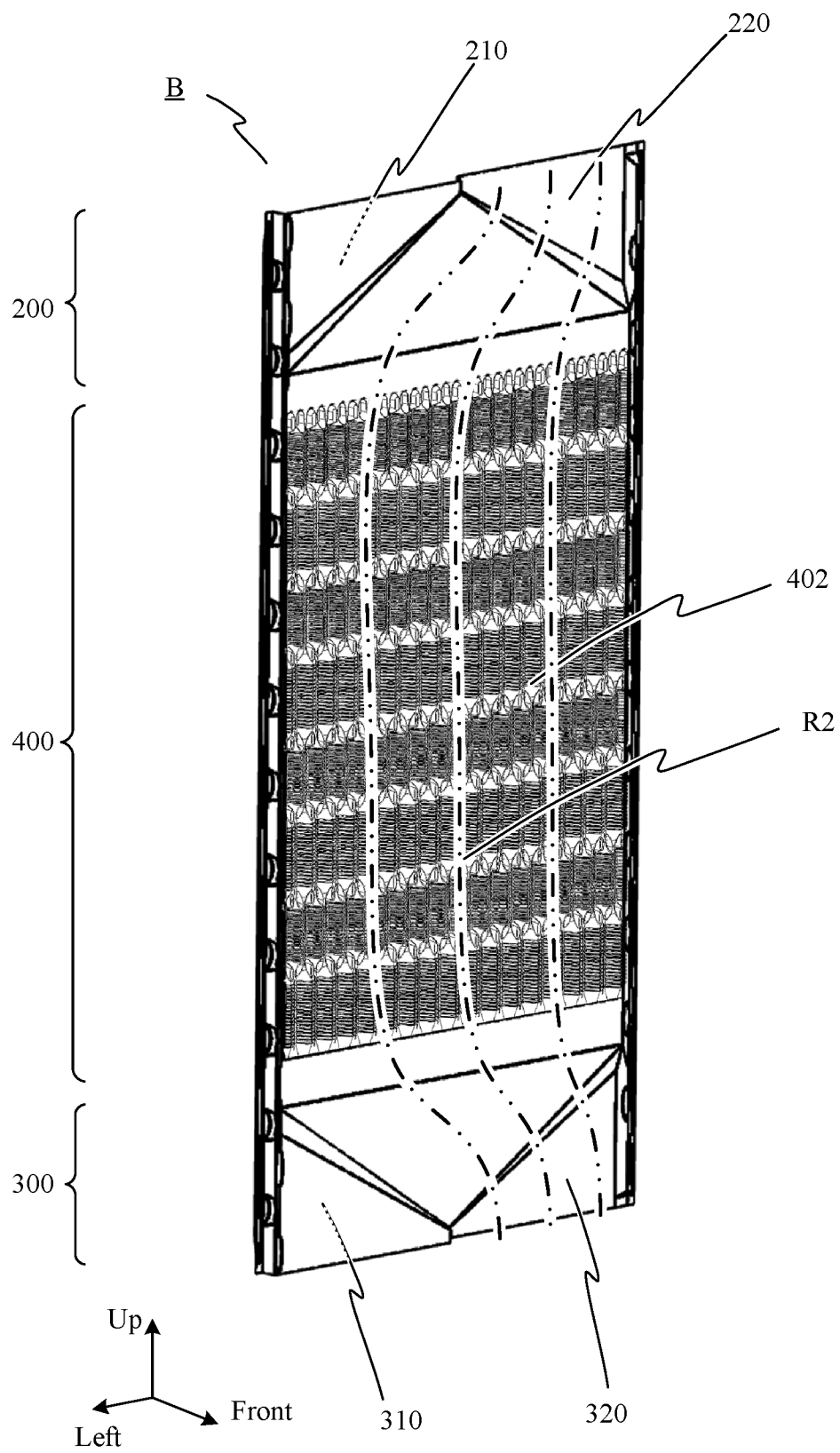


FIG. 4

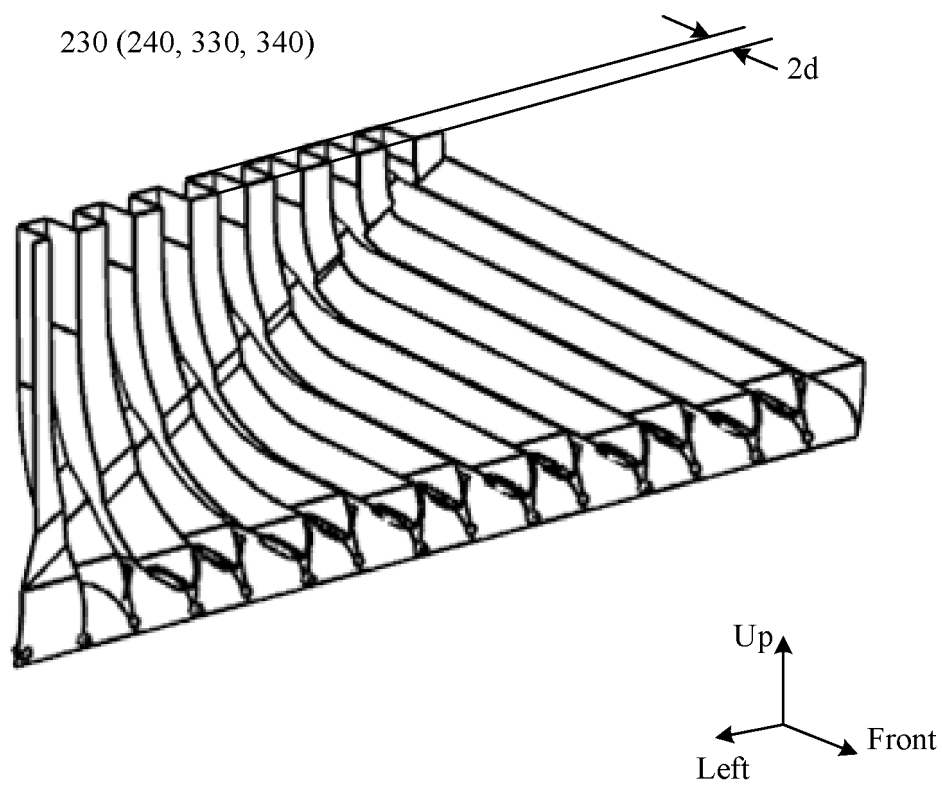


FIG. 5

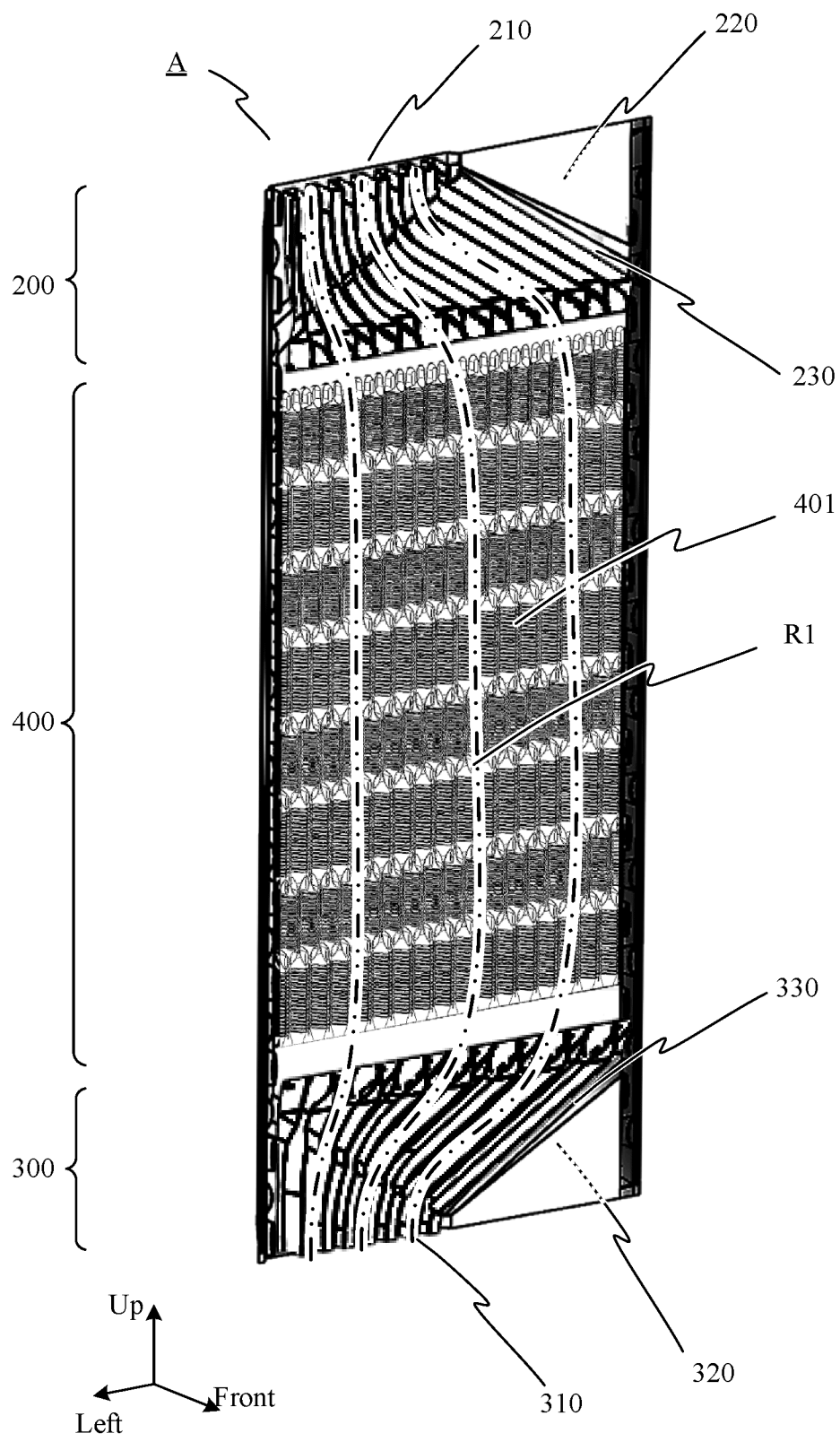


FIG. 6

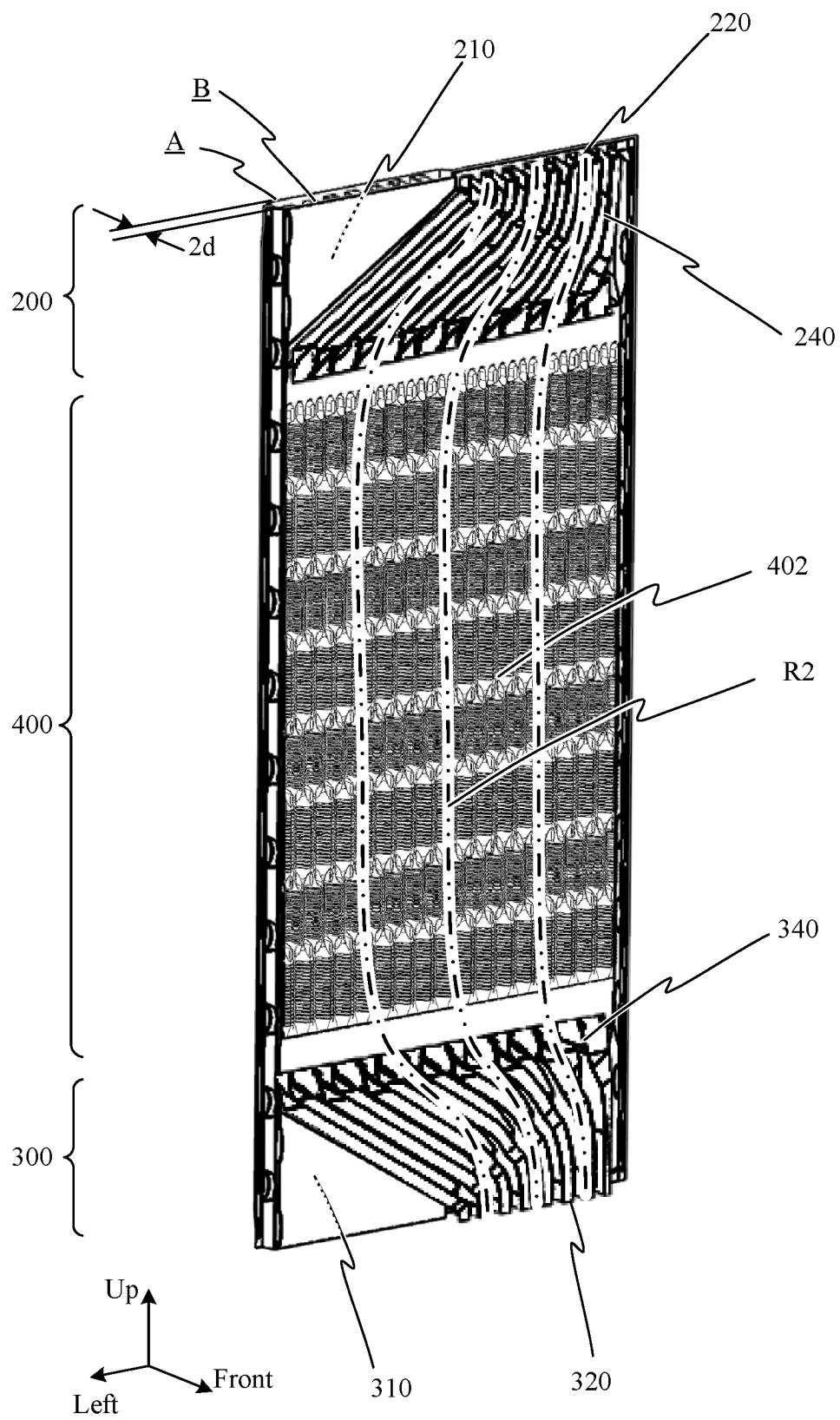


FIG. 7

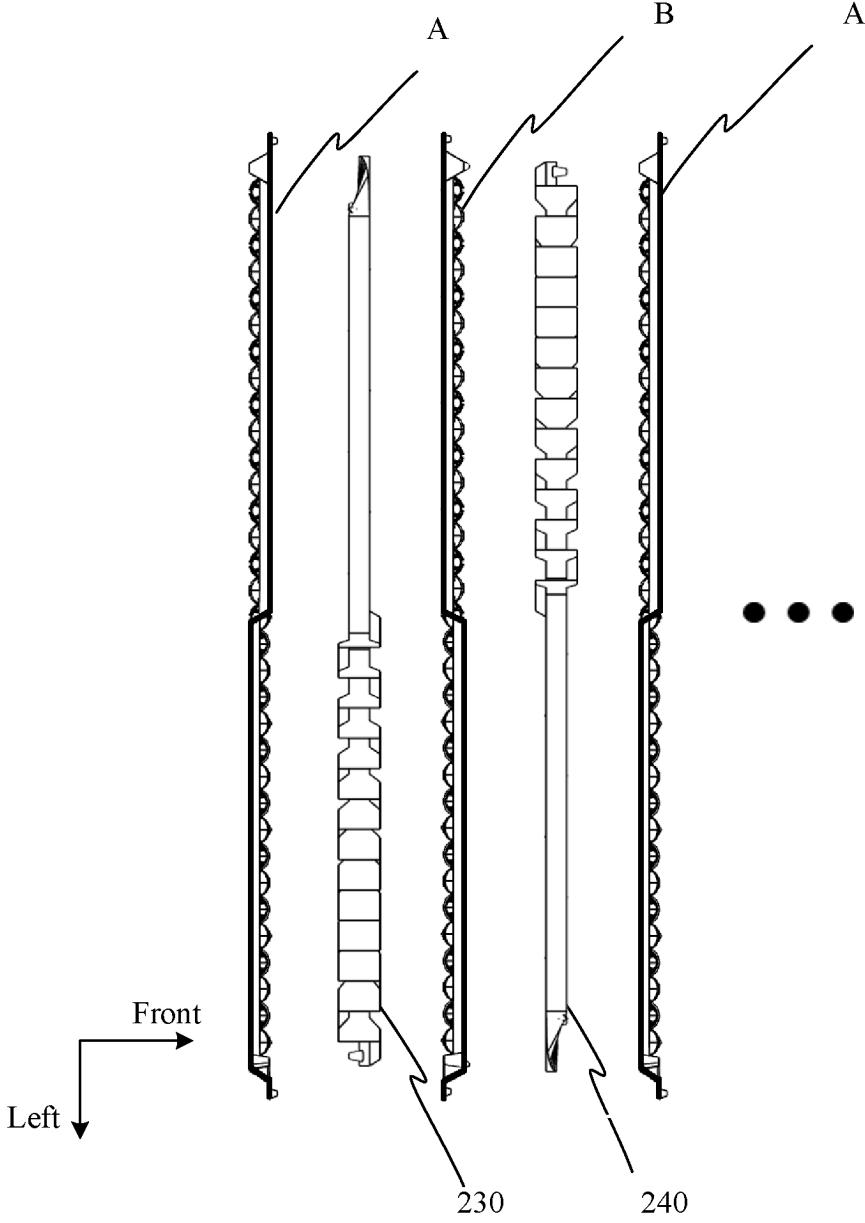


FIG. 8

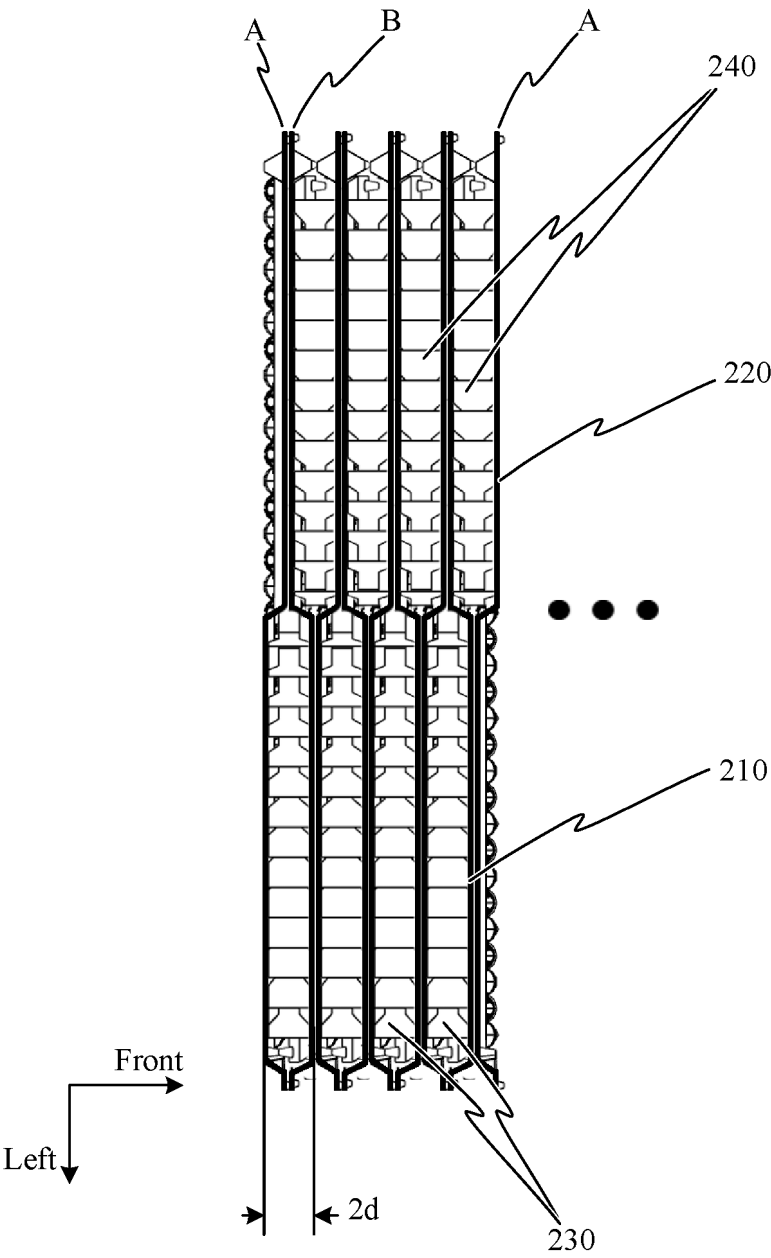


FIG. 9

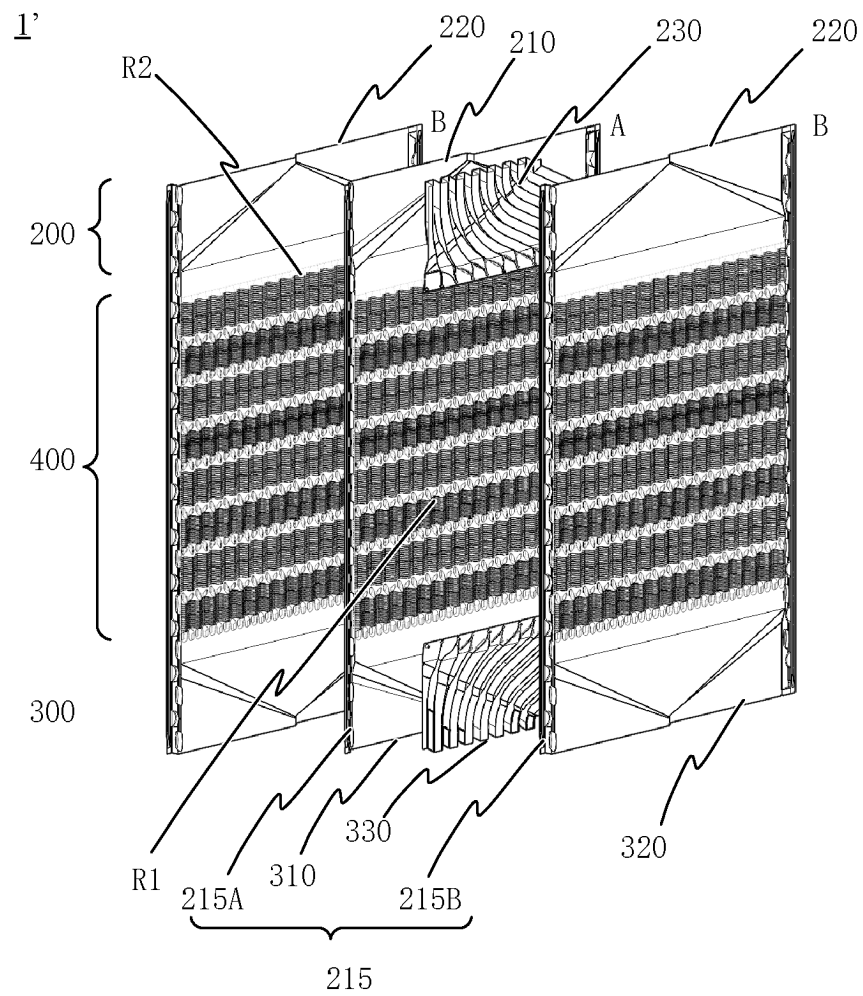


FIG. 10

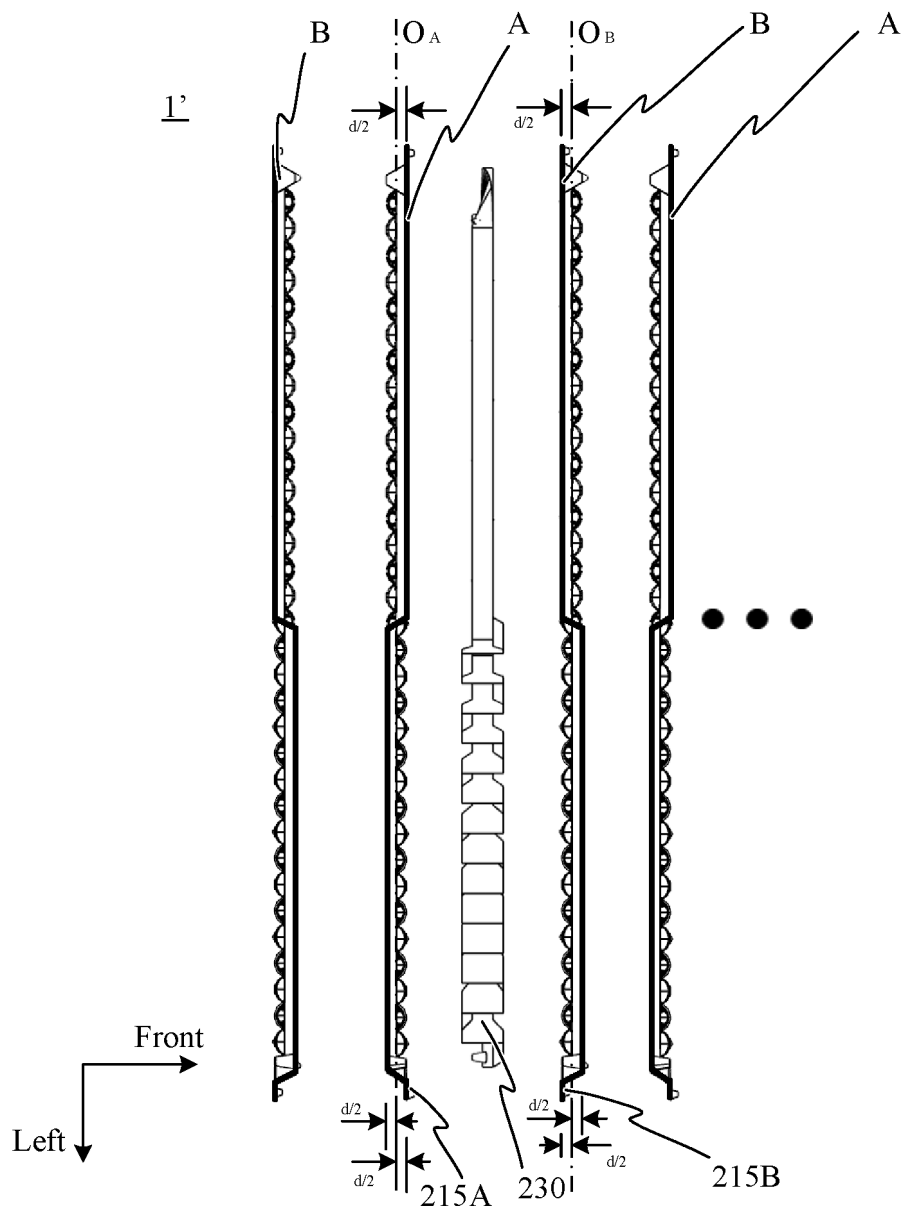


FIG. 11

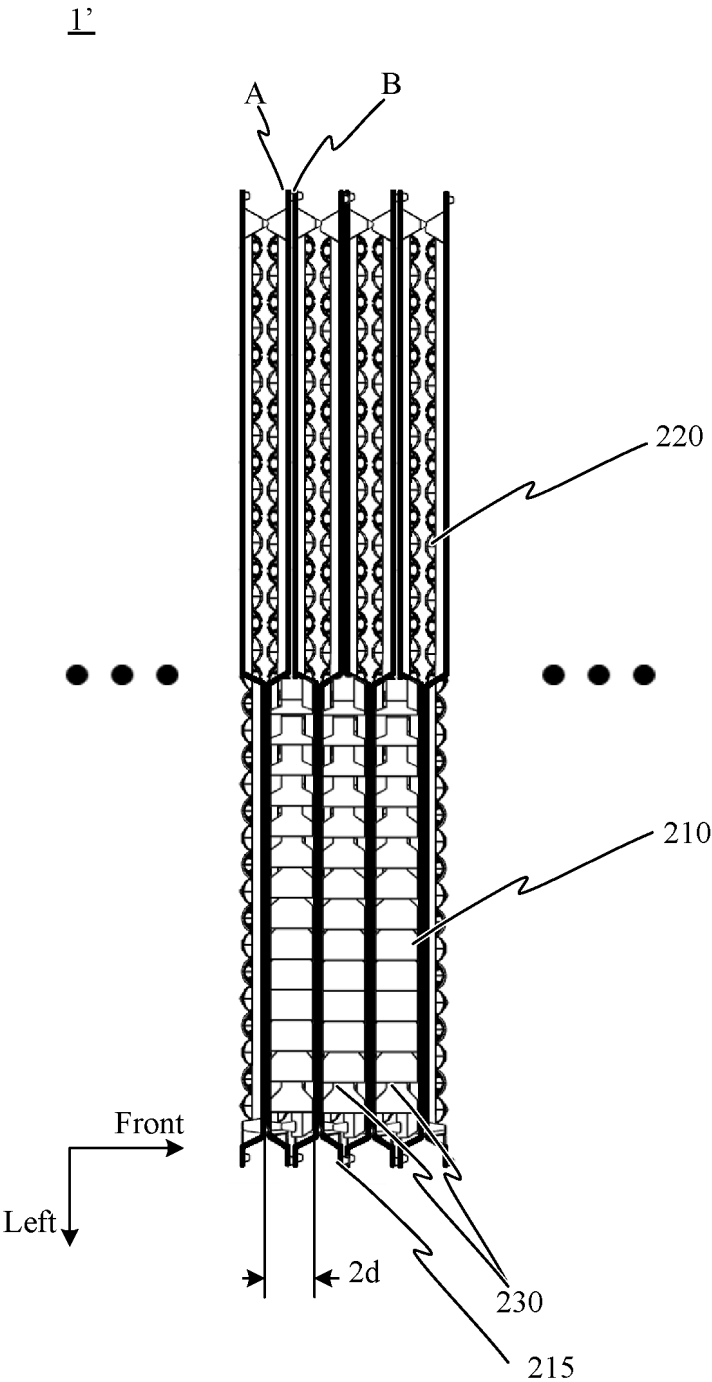


FIG. 12

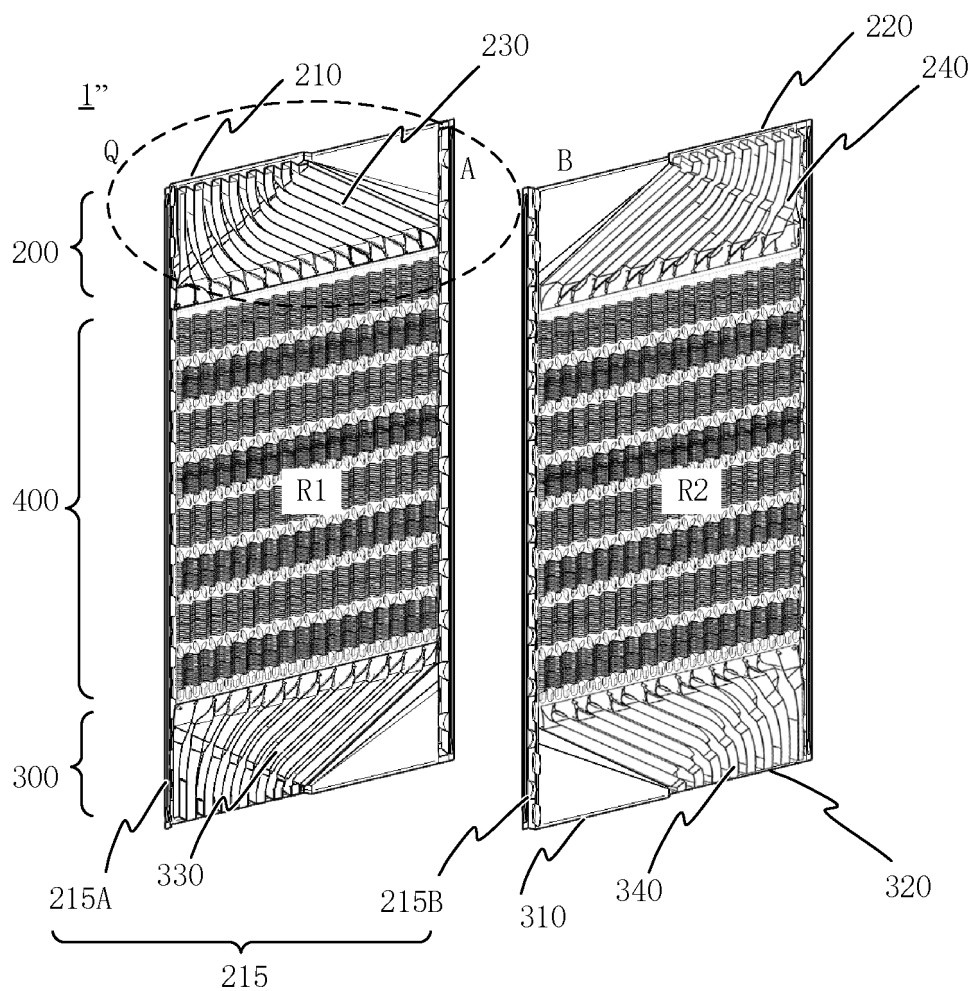


FIG. 13

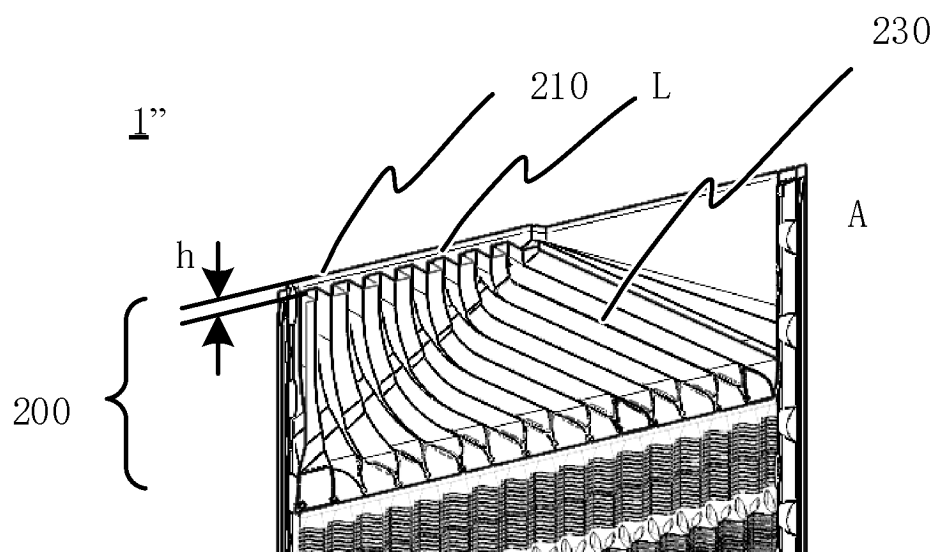


FIG. 14

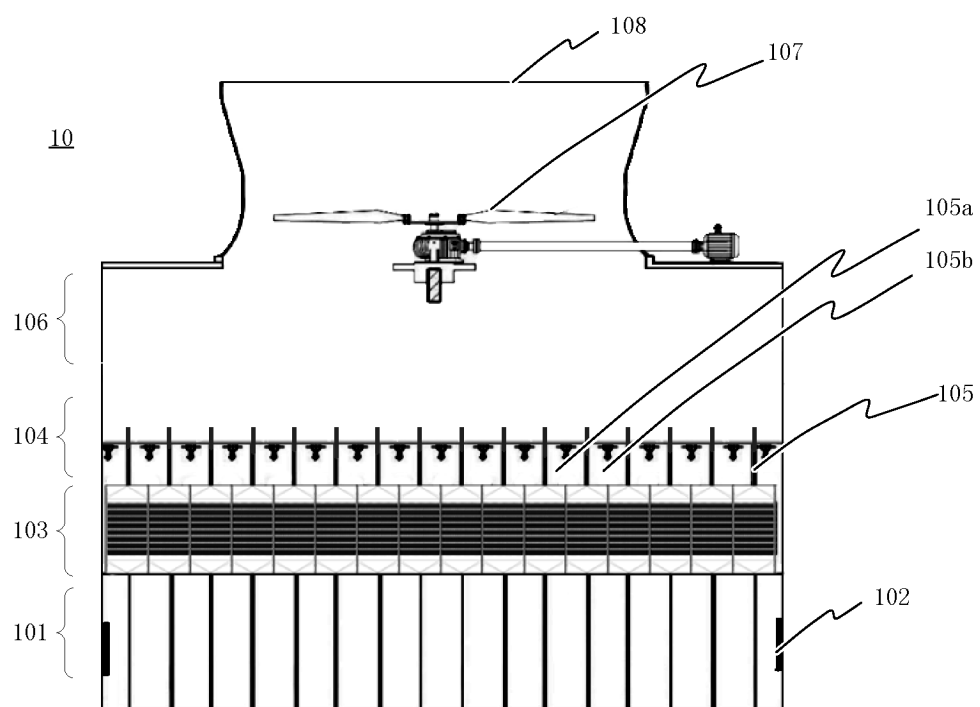


FIG. 15

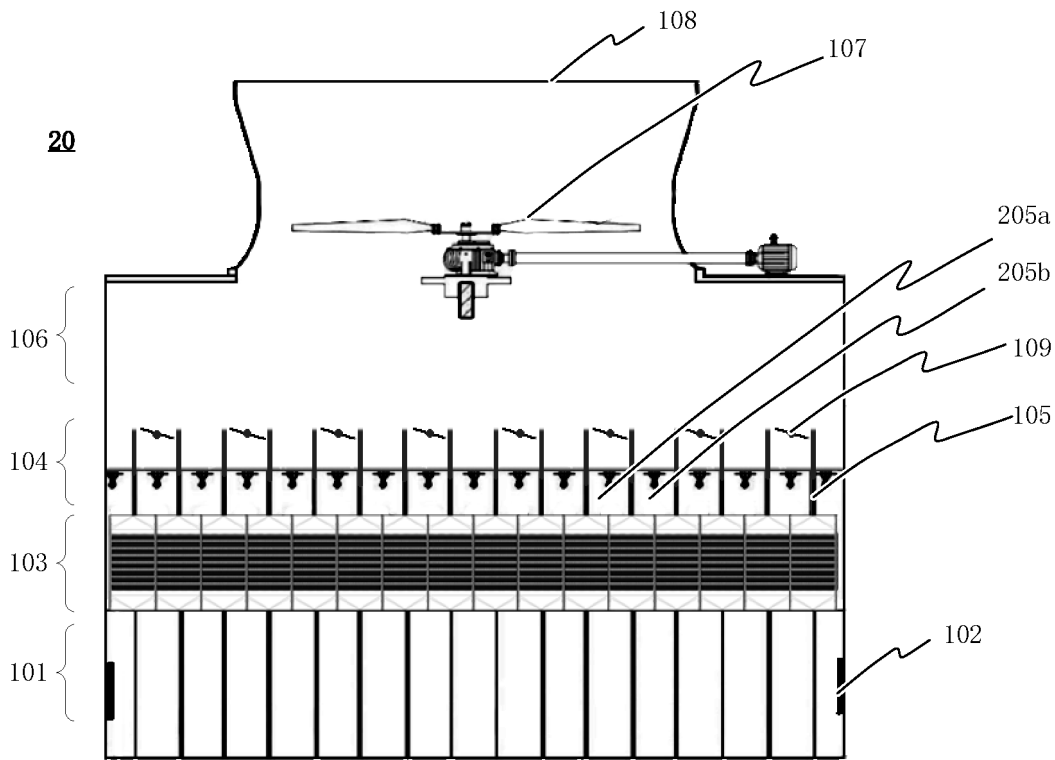


FIG. 16

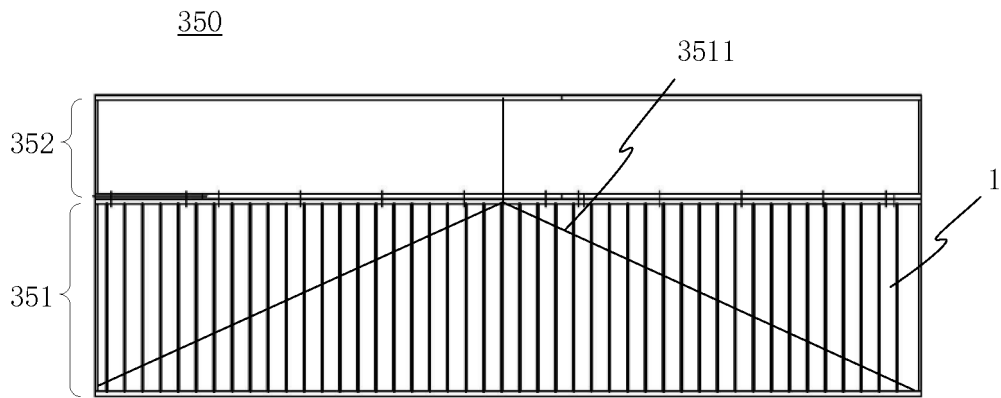


FIG. 17

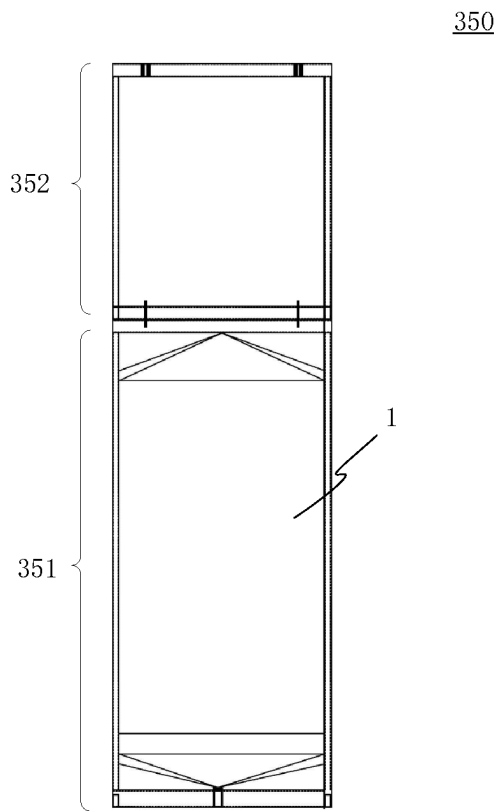


FIG. 18

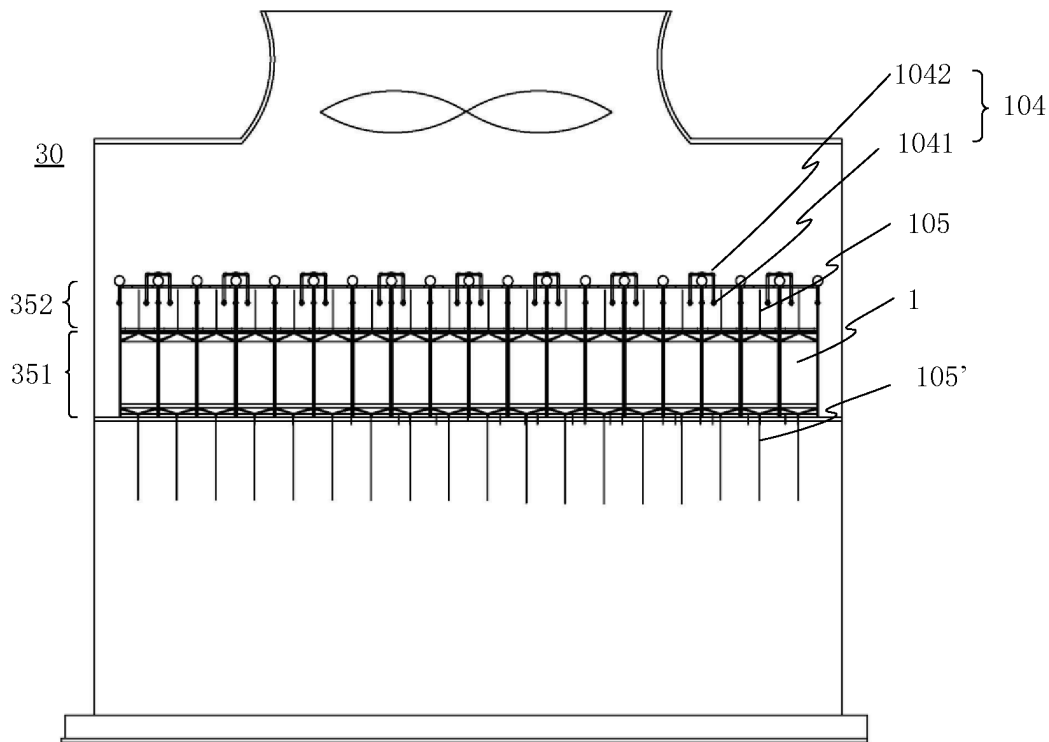


FIG. 19

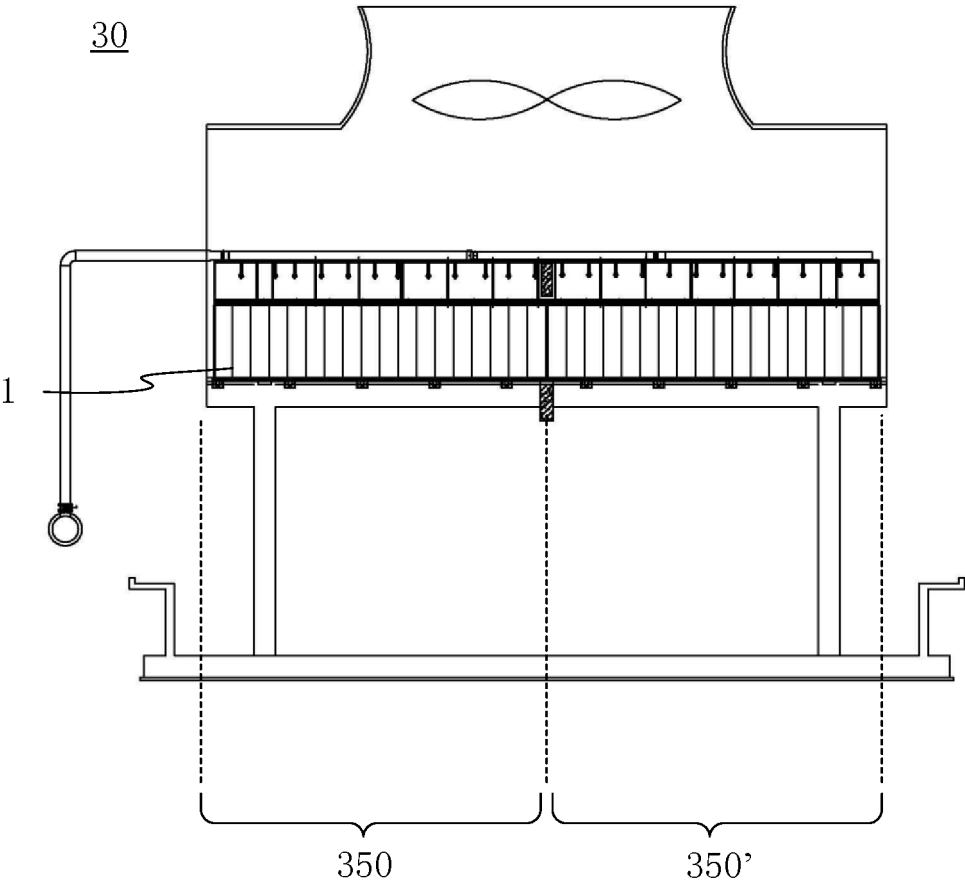


FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/135470

A. CLASSIFICATION OF SUBJECT MATTER

F28F25/08(2006.01)i; F28F25/10(2006.01)i; F28C1/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:F28F25/-,F28C1/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT, ENTXT, ENTXTC, VCN, DWPI, CNKI: 贝诺, 李金鹏, 许玉芝, 高金城, 岳桂岭, 郑嘉斌, 降温, 冷却, 填料, 片, 偏移, 偏置, 通道, 通路, 层叠, 叠放, 叠置, 整流片, 水, 空气, 气体, 冷却塔, 框架, cool+, tower+, pack+, stack+, passage?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 107270735 A (GUANGZHOU LAXUN TECHNOLOGY EXPLOIT CO., LTD.) 20 October 2017 (2017-10-20) description, paragraphs 23-35, and figures 1-4	1-40, 50-51
X	CN 102865770 A (CHINA NUCLEAR POWER ENGINEERING CO., LTD.) 09 January 2013 (2013-01-09) description, paragraphs 41-69	1-40, 50-51
PX	CN 117647150 A (SHANDONG BENO COOLING EQUIPMENT CO., LTD.) 05 March 2024 (2024-03-05) entire document	41-49
PX	CN 117647149 A (SHANDONG BENO COOLING EQUIPMENT CO., LTD.) 05 March 2024 (2024-03-05) entire document	1-20
PX	CN 117647151 A (SHANDONG BENO COOLING EQUIPMENT CO., LTD.) 05 March 2024 (2024-03-05) entire document	21-49

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 14 February 2025	Date of mailing of the international search report 17 February 2025
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088	Authorized officer Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/135470

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 117781765 A (SHANDONG BENO COOLING EQUIPMENT CO., LTD.) 29 March 2024 (2024-03-29) entire document	21-49
A	KR 20200109750 A (KIM YOUNG CHUL) 23 September 2020 (2020-09-23) entire document	1-51

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2024/135470

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	107270735	A	20 October 2017	None			
CN	102865770	A	09 January 2013	CN	102865770	B	05 November 2014
CN	117647150	A	05 March 2024	None			
CN	117647149	A	05 March 2024	CN	117647149	B	23 April 2024
CN	117647151	A	05 March 2024	CN	117647151	B	19 April 2024
CN	117781765	A	29 March 2024	None			
KR	20200109750	A	23 September 2020	KR	102162553	B1	07 October 2020

REFERENCES CITED IN THE DESCRIPTION

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