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(54) **REFRIGERANT DISTRIBUTING DEVICE AND HEAT EXCHANGER WITH THE SAME**

(57) A refrigerant distributing device and a heat exchanger comprising the refrigerant distributing device are provided. The refrigerant distributing device comprises a distributing tube (1) defining a first end and a second end in a length direction thereof, and a plurality of nozzles (2) disposed on the distributing tube (1) along the length direction of the distributing tube, each nozzle having a predetermined length and being formed with a through

hole (21) communicating an interior of the distributing tube and an exterior of the distributing tube. By provision of the nozzles, the flow resistance is increased, the refrigerant flow rate is more uniform along the length direction of the distributing tube. In addition, the refrigerant can be ejected along the radial direction, the axial direction, the circumferential direction and other directions, so that the uniformity of the refrigerant in the space outside the distributing tube is improved.

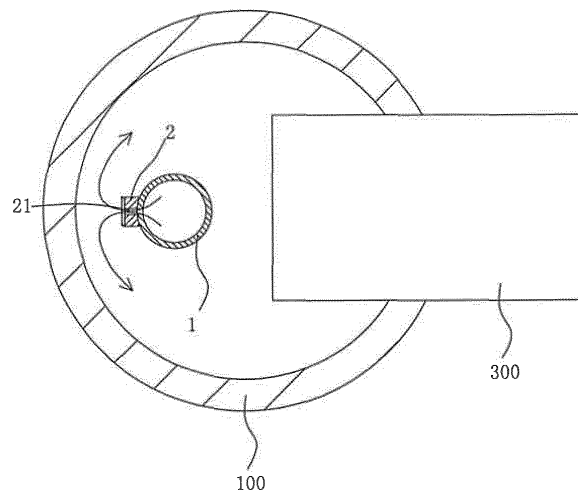


Fig. 25

Description

FIELD

[0001] The present disclosure relates to a refrigerant distributing device of a heat exchanger and a heat exchanger comprising the same.

BACKGROUND

[0002] A distributing tube is generally inserted into a header of the heat exchanger in order to ensure uniform distribution of a refrigerant in the heat exchange tubes of the heat exchanger. The distributing tube is formed with openings through which the refrigerant enters into the header from the distributing tube so as to be distributed to individual heat exchange tubes.

[0003] The conventional distributing tube has disadvantages. For example, in use, a refrigerant at an inlet of a heat exchanger is in a gaseous-liquid two phase state, and the density difference between the gaseous refrigerant and the liquid refrigerant is large, which may cause gas-liquid separation, thus affecting the refrigerant distribution uniformity. The gaseous-liquid refrigerant directly flows into the header through openings of the distributing tube, and the gas-liquid separation tends to occur when the gaseous-liquid refrigerant leaves the openings, thus affecting the refrigerant distribution uniformity. Pressures at individual openings are not balanced in a refrigerant flow direction, thus causing flow rate imbalance between individual openings in a length direction of the distributing tube. The machining of the openings is difficult due to the increased amount or different types of the openings, and the distributing tube is difficult to clean due to the burrs on machining surfaces of the openings.

SUMMARY

[0004] The present disclosure seek to solve at least one of the problems existing in the prior art.

[0005] Accordingly, an object of a first aspect of the present disclosure is to provide a refrigerant distributing device capable of improving the refrigerant distribution uniformity.

[0006] An object of a second aspect of the present disclosure is to provide a heat exchanger comprising the refrigerant distributing device according to the first aspect of the present disclosure which may have improved heat exchange performance.

[0007] Embodiments of the first aspect of the present disclosure provide a refrigerant distributing device comprising: a distributing tube defining a first end and a second end in a length direction thereof; and a plurality of nozzles disposed on the distributing tube along the length direction of the distributing tube, each nozzle having a predetermined length and being formed with a through hole communicating an interior of the distributing tube

and an exterior of the distributing tube.

[0008] The refrigerant distributing device according to embodiments of the present disclosure is capable of improving the flow rate balance. The flow resistance is increased because of the nozzles, the pressures at individual nozzles may be balanced, and the pressure imbalance between individual nozzles may be reduced greatly, so that the refrigerant flow rate along the length direction of the distributing tube is more balanced.

[0009] The refrigerant distributing device according to embodiments of the present disclosure can control and adjust the flow direction of the refrigerant. The gaseous-liquid refrigerant may be ejected out of the nozzles along the radial direction, the axial direction, the circumferential direction and other directions of the distributing tube, so that the refrigerant distribution uniformity in the exterior of the distributing tube is improved greatly.

[0010] In some embodiments, the plurality of nozzles are arranged in a plurality of rows in a circumferential direction of the distributing tube, and the nozzles in each row are arranged spirally.

[0011] In some embodiments, the through hole is a circular hole and passes through inner and outer end surfaces of the nozzle, and a length of the through hole is 0.125-250 times as large as a hydraulic diameter of the through hole.

[0012] In some embodiments, the through hole passes through inner and outer end surfaces of the nozzle, and an axial direction of the through hole is inclined relative to an axial direction of the nozzle.

[0013] In some embodiments, the through hole has a rectangular or cross-shaped cross section.

[0014] In some embodiments, the through hole comprises a first through hole segment extending in a radial direction of the nozzle and a second through hole segment extending in an axial direction of the nozzle, an inner end of the second through hole segment is communicated with the interior of the distributing tube, and an outer end of the second through hole segment is closed, the first through hole segment communicates the second through hole segment with the exterior of the distributing tube.

[0015] In some embodiments, a plurality of the first through hole segments are formed and arranged in a circumferential direction of the second through hole segment.

[0016] In some embodiments, the through hole comprises a first through hole segment and a second through hole segment extending in an axial direction of the nozzle, an inner end of the second through hole segment is communicated with the interior of the distributing tube, and an outer end of the second through hole segment is closed, the first through hole segment communicates the second through hole segment with the exterior of the distributing tube, and an axial direction of the first through hole segment is deviated from a radial direction of the nozzle.

[0017] In some embodiments, an inner end of each

nozzle is extended into the interior of the distributing tube by a predetermined length.

[0018] In some embodiments, the inner end of the each nozzle is formed with a bent portion.

[0019] In some embodiments, an inner end of each nozzle is flush with an inner wall surface or an outer wall surface of the distributing tube.

[0020] In some embodiments, the through hole passes through inner and outer end surfaces of the nozzle, an axial direction of the through hole is parallel to an axial direction of the nozzle, the distributing tube has a circular cross-section, a ratio H/D of a length H of the through hole to a hydraulic diameter D of the distributing tube is in a range of 0.027 to 25, and a ratio H/L of the length H of the through hole to a length L of the distributing tube is in a range of 3.3×10^{-4} to 0.125.

[0021] In some embodiments, a sum of cross-sectional areas of the through holes of the nozzles is 0.01 % to 40% of a circumferential surface area of the distributing tube.

[0022] Embodiments according to the second aspect of the present disclosure provide a heat exchanger comprising: an inlet header; an outlet header; a plurality of heat exchange tubes each having two ends connected with the inlet header and the outlet header respectively to communicate the inlet header and the outlet header; a plurality of fins disposed between adjacent heat exchange tubes respectively; and a refrigerant distributing device according to embodiments of the first aspect of the present disclosure disposed in the inlet header.

[0023] Additional aspects and advantages of embodiments of present disclosure will be given in part in the following descriptions, become apparent in part from the following descriptions, or be learned from the practice of the embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWING

[0024] These and other aspects and advantages of embodiments of the present disclosure will become apparent and more readily appreciated from the following descriptions made with reference to the accompanying drawings, in which:

Fig. 1 is a schematic view of a refrigerant distributing device according to a first embodiment of the present disclosure;

Fig. 2 is a top view of the refrigerant distributing device shown in Fig. 1;

Fig. 3 is a schematic cross-sectional view of the refrigerant distributing device shown in Fig. 1;

Fig. 4 is a partial sectional view of a refrigerant distributing device according to a second embodiment of the present disclosure;

Fig. 5 is a top view of the refrigerant distributing device shown in Fig. 4;

Fig. 6 is a partial sectional view of a refrigerant distributing device according to a third embodiment of

the present disclosure;

Fig. 7 is a top view of the refrigerant distributing device shown in Fig. 6;

Fig. 8 is a schematic cross-sectional view of the refrigerant distributing device shown in Fig. 6;

Fig. 9 is a partial sectional view of a refrigerant distributing device according to a fourth embodiment of the present disclosure;

Fig. 10 is a top view of the refrigerant distributing device shown in Fig. 9;

Fig. 11 is a schematic cross-sectional view of the refrigerant distributing device shown in Fig. 9;

Fig. 12 is a partial sectional view of a refrigerant distributing device according to a fifth embodiment of the present disclosure;

Fig. 13 is a top view of the refrigerant distributing device shown in Fig. 12;

Fig. 14 is a schematic cross-sectional view of the refrigerant distributing device shown in Fig. 12;

Fig. 15 is a schematic view of a refrigerant distributing device according to a sixth embodiment of the present disclosure;

Fig. 16 is a top view of the refrigerant distributing device shown in Fig. 15;

Fig. 17 is a schematic cross-sectional view of the refrigerant distributing device shown in Fig. 15;

Fig. 18 is a schematic view of a refrigerant distributing device according to a seventh embodiment of the present disclosure;

Fig. 19 is a top view of the refrigerant distributing device shown in Fig. 18;

Fig. 20 is a schematic cross-sectional view of the refrigerant distributing device shown in Fig. 18;

Fig. 21 is a schematic view of a refrigerant distributing device according to an eighth embodiment of the present disclosure;

Fig. 22 is a top view of the refrigerant distributing device shown in Fig. 21;

Fig. 23 is a schematic cross-sectional view of the refrigerant distributing device shown in Fig. 21;

Fig. 24 is a schematic view of a heat exchanger according to an embodiment of the present disclosure;

Fig. 25 is a schematic partial cross-sectional view of an inlet header of the heat exchanger shown in Fig. 24; and

Fig. 26 is a graph illustrating a comparison between a refrigerant distribution effect of a refrigerant distributing device according to an embodiment of the present disclosure and a refrigerant distribution effect of a conventional distributing tube.

DETAILED DESCRIPTION

[0025] Reference will be made in detail to embodiments of the present disclosure. The embodiments described herein with reference to drawings are explanatory, illustrative, and used to generally understand the present disclosure. The embodiments shall not be con-

strued to limit the present disclosure. The same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions.

[0026] In the specification, unless specified or limited otherwise, relative terms such as "length direction", "lateral", "axial direction", "upper", "lower", "front", "rear", "left", "right", "vertical", "horizontal", "top", "bottom", "inner", "outer", as well as derivative thereof (e.g., "horizontally", "downwardly", "upwardly", etc.) should be construed to refer to the orientation as then described or as shown in the drawings under discussion. These relative terms are for convenience of description and do not require that the present disclosure be constructed or operated in a particular orientation.

[0027] The refrigerant distributing device according to embodiments of the present disclosure will be described below with reference to the drawings.

[0028] As shown in Figs. 1-23, the refrigerant distributing device according to embodiments of the present disclosure comprises a distributing tube 1 having a first end (i.e. the left end in Fig. 1) and a second end (i.e. the right end in Fig. 1) in a length direction (i.e. the left and right direction in Fig. 1) thereof. A plurality of nozzles 2 are disposed on the distributing tube 1 along the length direction of the distributing tube 1, and each nozzle 2 has a predetermined length and is formed with a through hole 21 communicating an interior of the distributing tube 1 and an exterior of the distributing tube 1. Here, a person having ordinary skill in the art will appreciate that the exterior of the distributing tube 1 means an interior of a header when the refrigerant distributing device is mounted into the header of a heat exchanger.

[0029] In an example, as shown in Fig. 1, the first end of the distributing tube 1 is open, and the second end of the distributing tube 1 is closed. However, a person having ordinary skill in the art will appreciate that the second end of the distributing tube 1 may be open, and then closed by an end wall of the header when the refrigerant distributing device is mounted into the header of the heat exchanger. In order to facilitate description, hereinafter, the left end of the distributing tube 1 is referred as an inlet end of the distributing tube 1, that is, the left end opening of the distributing tube 1 is used as the refrigerant inlet of the distributing tube 1.

[0030] With the refrigerant distributing device according to embodiments of the present disclosure, the plurality of nozzles 2 are mounted on the distributing tube 1 along the length direction of the distributing tube 1, the pumping effect may be generated in the nozzles 2 under the same pressure as that in the related art, such that the flow rate in the nozzles 2 is larger than that in openings of a conventional distributing tube when the hydraulic diameter of the nozzle 2 is identical with that of the opening of the conventional distributing tube.

[0031] In addition, the gaseous refrigerant and the liquid refrigerant may be mixed again when flowing in the through holes 21 of the nozzles 2, thus further reducing

the gas-liquid separation. Moreover, the through holes 21 of the nozzles 2 may increase the length of the refrigerant ejection passage so as to increase the refrigerant distribution pressure difference, such that the refrigerant flow rate distribution is more uniform along the entire length direction of the distributing tube 1, thus improving the heat exchange performance of the heat exchanger.

[0032] By comparison to the conventional distributing tube having distributing openings formed in a wall thereof, with the refrigerant distributing device according to embodiments of the present disclosure, the nozzles 2 each having a predetermined length are disposed on the distributing tube 1. The refrigerant flow rate Q follows a

formula: $Q = \mu_0 A \sqrt{2gH}$, where A is a cross-sectional area of the through hole 21 of the nozzle 2, H is a pressure head, g is the gravity acceleration, and μ_0 is a flow rate coefficient. Because the flow rate coefficient μ_0 of the nozzle 2 is 0.82 and the flow rate coefficient μ_0 of the opening in the conventional distributing tube is 0.62, the flow rate in the nozzle 2 is larger than that in the opening in the conventional distributing tube when the hydraulic diameter of the nozzle 2 is identical with that of the opening in the conventional distributing tube.

[0033] In addition, with the conventional distributing tube, the refrigerant flows out of the distributing tube through individual openings formed in the wall of the distributing tube, the pressure drops in the individual openings are unequal, and a pressure difference between the refrigerant inlet and the opening furthest from the refrigerant inlet (i.e., the last opening) differs greatly from that between the refrigerant inlet and the opening nearest to the refrigerant inlet (i.e. the first opening), such that the refrigerant flow rate distribution along a length direction of the distributing tube is non-uniform, that is, the flow rate in the first opening is much larger than that in the last opening. In contrast, with the refrigerant distributing device according to embodiments of the present disclosure, because the nozzles 2 each having a predetermined length are disposed on the distributing tube 1, the refrigerant flow passage in each nozzle 2 is lengthened, and the refrigerant distribution pressure drop in the nozzles 2 is larger than that in the openings in the conventional distributing tube, such that a pressure difference between the refrigerant inlet and the first nozzle 2 (for example, the leftmost nozzle in Fig. 1) is substantially identical with a pressure difference between the refrigerant inlet and the last nozzle 2 (for example, the rightmost nozzle in Fig. 1). Therefore, the refrigerant distribution along the length direction of the distributing tube 1 is more uniform, as shown in Fig. 26. In Fig. 26, the abscissas s represent a distance from each opening in the conventional distributing tube to the refrigerant inlet and a distance from each nozzle 2 in the refrigerant distributing device according to embodiments of the present disclosure to the refrigerant inlet, and the ordinates m represent a refrigerant flow rate in each opening and a

refrigerant flow rate in each nozzle 2.

[0034] The refrigerant distributing device according to a first embodiment of the present disclosure will be described below with reference to Figs. 1-3, As shown in Figs. 1-3, with the refrigerant distributing device according to the first embodiment of the present disclosure, the plurality of nozzles 2 are disposed on the distributing tube 1 along the length direction (i.e. the left and right direction in Fig. 1) of the distributing tube 1, and arranged on the distributing tube 1 in a straight line. Preferably, the distributing tube 1 is formed with a plurality of mounting holes 11, and each nozzle 2 is fitted and mounted in one mounting hole 11.

[0035] In the embodiment shown in Figs. 1-3, each nozzle 2 is cylindrical, the through hole 21 is a circular hole and passes through an inner end surface (e.g. the lower end surface in Fig. 1) and an outer end surface (e.g. the upper end surface in Fig. 1) of the nozzle 2. A length of the through hole 21 is 0.125-250 times as large as a hydraulic diameter of the through hole 21. It should be noted that if the length of the through hole 21 of the nozzle 2 is too large, the flow resistance of the refrigerant in the nozzle 2 will be increased; and if the length of the through hole 21 of the nozzle 2 is too small, the pumping effect will be weakened. Therefore, it has been found by the applicant through lots of efforts and experiments that the balance between reducing the resistance and maintaining the pumping effect may be achieved by controlling the length of the through hole 21 to be 0.125-250 times as large as the hydraulic diameter of the through hole 21.

[0036] As shown in Figs. 1-3, in some specific examples, an outer end (i.e. the upper end in Fig. 1) of the through hole 21 has an enlarged segment 22, thus facilitating the machining of the through hole 21.

[0037] As shown in Figs. 1-2, in some examples, the plurality of nozzles 2 are spaced apart from each other at equal intervals in the length direction of the distributing tube 1. However, the present disclosure is not limited to this. For example, the plurality of nozzles 2 may be spaced apart from each other at unequal intervals.

[0038] As shown in Fig. 3, in one example, an axial direction of the through hole 21 is consistent with an axial direction of the nozzle 2.

[0039] In other examples, an inner end (i.e. the end of each nozzle 2 close to the distributing tube 1) of each nozzle 2 is extended into the interior of the distributing tube 1 by a predetermined length. Because the nozzle 2 is inserted into the interior of the distributing tube 1, the refrigerant is agitated when flowing in the distributing tube 1 along the axial direction of the distributing tube 1, and the gaseous refrigerant and the liquid refrigerant are separated from and then remixed with each other continuously, such that the gaseous refrigerant and the liquid refrigerant may be still mixed uniformly when flowing to a region in the distributing tube 1 away from the refrigerant inlet of the distributing tube 1. Alternatively, the inner end of each nozzle 2 is flush with the inner wall surface or the outer wall surface of the distributing tube 1.

[0040] In some embodiments, the through hole 21 passes through the inner end surface and the outer end surface of the nozzle 2, and the axial direction of the through hole 21 is parallel to the axial direction of the nozzle 2. The distributing tube 1 is a circular tube, a ratio H/D of a length H of the through hole 21 to a hydraulic diameter D of the distributing tube 1 is in a range of 0.027 to 25, and a ratio H/L of the length H of the through hole 21 to a length L of the distributing tube 1 is in a range of 3.3×10^{-4} to 0.125.

[0041] According to some embodiments of the present disclosure, if the local pressure drop is not considered, according to a formula of the frictional resistance (i.e. frictional drag) in the distributing tube:

$$\Delta P = \lambda (1/d) \rho \mu^2 / 2$$

the resistance in a single nozzle is:

$$\Delta P_{\text{nozzle}} = \lambda_1 (H/d) \rho \mu^2 / 2$$

the frictional resistance in the distributing tube is:

$$\Delta P_{\text{tube}} = \lambda_2 (L/D) \rho \mu^2 / 2$$

when ΔP_{nozzle} is larger than ΔP_{tube} , the optimization of the flow rate in the nozzle may be realized.

[0042] Therefore, when the ratio H/D of the length H of the through hole 21 to the hydraulic diameter D of the distributing tube 1 is in a range of 0.027 to 25 and the ratio H/L of the length H of the through hole 21 to the length L of the distributing tube 1 is in a range of 3.3×10^{-4} to 0.125, the flow rate distribution between individual nozzles 2 of the distributing tube 1 may be optimized. For example, in a specific example, $H = 1-25$ millimeters, $d = 0.1-8$ millimeters, $D = 1-36$ millimeters, $L = 0.2-3$ meters.

[0043] Likewise, based on the above analysis, when a sum of cross-sectional areas of the through holes 21 of the nozzle 2 is 0.01% to 40% of a circumferential surface area of the distributing tube 1, the flow rate distribution between individual nozzles 2 of the distributing tube 1 may be optimized.

[0044] In the embodiment shown in Figs. 1-3, the distributing tube 1 has a circular cross section, and the through hole 21 in the nozzle 2 is a circular hole (i.e. the through hole has a circular cross section). However, the present disclosure is not limited to this. For example, in other embodiments, the distributing tube 1 may have a rectangular cross section, and the cross section of the through hole 21 may have a square shape or any other suitable shape.

[0045] The refrigerant distributing device according to a second embodiment of the present disclosure will be described below with reference to Figs. 4-5. In the second embodiment shown in Figs. 4-5, the nozzle 2 is cylindrical, the through hole 21 has a circular cross section, the through hole 21 passes through an inner end surface (i.e., a lower end surface in Fig. 4) and an outer end surface (i.e., an upper end surface in Fig. 4) of the nozzle 2, and the axial direction of the through hole 21 is inclined at a predetermined angle α of, for example, about 0-90 degrees, preferably 0-60 degrees, relative to the axial direction of the nozzle 2. By controlling the axial direction of the through hole 21 to be inclined relative to the axial direction of the nozzle 2, the length of the through hole 21 may be increased without changing the length of the nozzle 2. Therefore, the length of the refrigerant flow passage may be increased so as to enhance the mixing effect of the gaseous refrigerant and the liquid refrigerant, and the direction of the refrigerant flow passage may be changed, so that the refrigerant is ejected out of the distributing tube 1 at a particular angle so as to improve the distribution effect.

[0046] The refrigerant distributing device according to a third embodiment of the present disclosure will be described below with reference to Figs. 6-8. In the third embodiment shown in Figs. 6-8, the nozzle 2 is cylindrical, the through hole 21 passes through an inner end surface and an outer end surface of the nozzle 2, and the through hole 21 has a cross-shaped cross section. However, the present disclosure is not limited to this. For example, the through hole 21 may have a rectangular cross section. Since the through hole 21 has a non-circular cross section, the pumping effect and the ejection effect may be further enhanced, and the gas-liquid separation may be eliminated.

[0047] The refrigerant distributing device according to a fourth embodiment of the present disclosure will be described below with reference to Figs. 9-11. In the fourth embodiment shown in Figs. 9-11, the inner end of each nozzle 2 is extended into the interior of the distributing tube 1 by a predetermined length, and the inner end of the each nozzle 2 is formed with a bent portion. In other words, the nozzle 2 may be of a bent cylinder. An angle β between the bent portion and the main body of the nozzle 2 may be in a range of about 45 degrees to 180 degrees. By forming the bent portion at the inner end of the nozzle 2, the gaseous refrigerant and the liquid refrigerant may be guided, and the agitation effect on the refrigerant in the distributing tube 1 may be further enhanced.

[0048] The refrigerant distributing device according to a fifth embodiment of the present disclosure will be described below with reference to Figs. 12-14. In the fifth embodiment shown in Figs. 12-14, the through hole 21 comprises a first through hole segment 212 extending in a radial direction of the nozzle 2 and a second through hole segment 211 extending in an axial direction of the nozzle 2. The inner end (the lower end in Fig. 12) of the

second through hole segment 211 is communicated with the interior of the distributing tube 1, and the outer end (the upper end in Fig. 12) of the second through hole segment 211 is closed. The first through hole segment 212 communicates the second through hole segment 211 with the exterior of the distributing tube 1. In other words, the inner end of the first through hole segment 212 is communicated with the second through hole segment 211, and the outer end of the first through hole segment 212 is communicated with the exterior of the distributing tube 1. In a specific example, a plurality of the first through hole segments 212, for example, 2-12 first through hole segments 212, are formed and arranged in the circumferential direction of the second through hole segment 211. Since the first through hole segment 212 is extended in the radial direction of the nozzle 2, the refrigerant is easy to control to be ejected out of the nozzle 2 along various radial directions of the nozzle 2, but may not be ejected along the radial direction of the distributing tube 1, thus improving the distribution uniformity of the refrigerant in the exterior of the distributing tube 1. Therefore, the refrigerant may be distributed in the exterior of the distributing tube 1 more uniformly.

[0049] The refrigerant distributing device according to a sixth embodiment of the present disclosure will be described below with reference to Figs. 15-17. In the sixth embodiment shown in Figs. 15-17, the through hole 21 comprises a plurality of first through hole segments 212 and a second through hole segment 211 extending in an axial direction of the nozzle 2. The inner end of the second through hole segment 211 is communicated with the interior of the distributing tube 1, and the outer end of the second through hole segment 211 is closed. The first through hole segments 212 communicate the second through hole segment 211 with the exterior of the distributing tube 1. In the embodiment shown in Figs. 15-17, the first through hole segments 212 and the second through hole segment 211 have circular cross sections, and the axial direction of the first through hole segment 212 is deviated from the radial direction of the nozzle 2, for example, the axial direction of the first through hole segment 212 is consistent with a tangential direction of the second through hole segment 211. Therefore, the refrigerant passing through the first through hole segment 212 is ejected along a direction deviated from the radial direction of the nozzle 2, and consequently the rotation of the refrigerant after being ejected into the second through hole segment 212 is enhanced, thus improving the distribution uniformity of the refrigerant in the exterior of the distributing tube 1. Therefore, the gaseous refrigerant and the liquid refrigerant may be distributed in the exterior of the distributing tube 1 more uniformly.

[0050] The refrigerant distributing device according to a seventh embodiment of the present disclosure will be described below with reference to Figs. 18-20. In the seventh embodiment shown in Figs. 18-20, the through hole 21 comprises a first through hole segment 212 and a second through hole segment 211 extending in an axial

direction of the nozzle 2. The first through hole segment 212 and the second through hole segment 211 have rectangular cross sections. Alternatively, a plurality of first through hole segments 212 may be formed, and extended in the radial direction of the nozzle 2 or a direction deviated from the radial direction of the nozzle 2.

[0051] The refrigerant distributing device according to an eighth embodiment of the present disclosure will be described below with reference to Figs. 21-23. In the eighth embodiment shown in Figs. 21-23, the plurality of nozzles 2 are spirally arranged in the length direction of the distributing tube 1. Therefore, the gaseous refrigerant and the liquid refrigerant may be spirally ejected along the length direction of the distributing tube 1, so that the gaseous refrigerant and the liquid refrigerant may be uniformly distributed in the exterior of the distributing tube 1.

[0052] In the above embodiments, the plurality of nozzles 2 are arranged in one row. However, it should be appreciated that the plurality of nozzles 2 may be arranged in a plurality of rows in a circumferential direction of the distributing tube 1, and the nozzle 2 in each row may be arranged spirally or linearly.

[0053] In the above embodiments, the nozzles 2 are cylindrical. However, the present disclosure is not limited to this. For example, the nozzles 2 may be of a prism having a rectangular cross section or a cross section of other shapes.

[0054] In some embodiments, the nozzles 2 may be manufactured separately and mounted onto the distributing tube 1. Alternatively, the nozzles 2 and the distributing tube 1 may be integrally manufactured, for example, the nozzles 2 and the distributing tube 1 are integrally cast.

[0055] With the refrigerant distributing device according to embodiments of the present disclosure, because the nozzles 2 are disposed on the distributing tube 1, the distribution effect may be improved, and the separation of the gaseous refrigerant and the liquid refrigerant may be reduced, thus improving the heat exchange effect.

[0056] The heat exchanger according to an embodiment of the present disclosure will be described below with reference to Figs. 24-25. As shown in Figs. 24-25, the heat exchanger according to an embodiment of the present disclosure comprises an inlet header 100, an outlet header 200, a plurality of heat exchange tubes 300, a plurality of fins 400, and a refrigerant distributing device described with reference to embodiments of the present disclosure.

[0057] Two ends of each heat exchange tube 300 are connected with the inlet header 100 and the outlet header 200 respectively to communicate the inlet header 100 and the outlet header 200. The plurality of fins 400 are disposed between adjacent heat exchange tubes 300 respectively. The refrigerant distributing device is disposed in the inlet header 100. As shown in Figs. 24-25, one end (i.e., a right end in Fig. 24) of the distributing tube 1 of the refrigerant distributing device is inserted into the inlet header 100 along a length direction of the

inlet header 100. For example, the one end of the distributing tube 1 may be closed by a separate end cap or the right end wall of the inlet header 100. The other end (i.e., a left end in Fig. 24) of the distributing tube 1 may be exposed out of the inlet header 100 and used as a refrigerant inlet of the heat exchanger. With the heat exchanger according to an embodiment of the present disclosure, the refrigerant distribution effect and the heat exchange performance are good.

[0058] It should be appreciated that, in some embodiments, the refrigerant distributing device according to an embodiment of the present disclosure may also be disposed in the outlet header 200. In this case, the refrigerant distributing device is used as a refrigerant collecting device. Alternatively, the refrigerant distributing device according to an embodiment of the present disclosure may be disposed in the inlet header 100 and the outlet header 200 simultaneously.

[0059] In conclusion, the refrigerant distributing device and the heat exchanger according to embodiments of the present disclosure are capable of improving the flow rate balance. Since the flow resistance is increased by means of the through holes of the nozzles, the pressure difference between individual nozzles may be balanced, and the pressure imbalance between individual nozzles may be reduced largely, so that the refrigerant flow rate along the length direction of the distributing tube may be more balanced.

[0060] The refrigerant distributing device and the heat exchanger according to embodiments of the present disclosure are capable of controlling and adjusting the direction of the refrigerant. The gaseous refrigerant and the liquid refrigerant may be ejected out of the nozzles not only along the radial direction of the distributing tube, but also along the axial direction, the circumferential direction or other directions of the distributing tube, so that the refrigerant distribution uniformity in the exterior of the distributing tube may be improved largely.

[0061] Reference throughout this specification to "a first embodiment", "a second embodiment", "some embodiments", "an example", "a specific example", or "some examples" means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present disclosure. Thus, the appearances of the above phrases in various places throughout this specification are not necessarily referring to the same embodiment or example of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples.

[0062] Although explanatory embodiments have been shown and described, it would be appreciated by those skilled in the art that the above embodiments can not be construed to limit the present disclosure, and changes, alternatives, and modifications can be made in the embodiments without departing from spirit, principles and

scope of the present disclosure.

Claims

1. A refrigerant distributing device, comprising:

a distributing tube defining a first end and a second end in a length direction thereof; and a plurality of nozzles disposed on the distributing tube along the length direction of the distributing tube, each nozzle having a predetermined length and being formed with a through hole communicating an interior of the distributing tube and an exterior of the distributing tube.

2. The refrigerant distributing device according to claim 1, wherein the plurality of nozzles are arranged in a plurality of rows in a circumferential direction of the distributing tube, and the nozzles in each row are arranged spirally.

3. The refrigerant distributing device according to claim 1, wherein the through hole is a circular hole and passes through inner and outer end surfaces of the nozzle, and a length of the through hole is 0.125-250 times as large as a hydraulic diameter of the through hole.

4. The refrigerant distributing device according to claim 1, wherein the through hole passes through inner and outer end surfaces of the nozzle, and an axial direction of the through hole is inclined relative to an axial direction of the nozzle.

5. The refrigerant distributing device according to claim 1, wherein the through hole has a rectangular or cross-shaped cross section.

6. The refrigerant distributing device according to claim 1, wherein the through hole comprises a first through hole segment extending in a radial direction of the nozzle and a second through hole segment extending in an axial direction of the nozzle, wherein an inner end of the second through hole segment is communicated with the interior of the distributing tube, and an outer end of the second through hole segment is closed, wherein the first through hole segment communicates the second through hole segment with the exterior of the distributing tube.

7. The refrigerant distributing device according to claim 6, wherein a plurality of the first through hole segments are formed and arranged in a circumferential direction of the second through hole segment.

8. The refrigerant distributing device according to claim

1, wherein the through hole comprises a first through hole segment and a second through hole segment extending in an axial direction of the nozzle, wherein an inner end of the second through hole segment is communicated with the interior of the distributing tube, and an outer end of the second through hole segment is closed, wherein the first through hole segment communicates the second through hole segment with the exterior of the distributing tube, and an axial direction of the first through hole segment is deviated from a radial direction of the nozzle.

9. The refrigerant distributing device according to any one of claims 1-8, wherein an inner end of each nozzle is extended into the interior of the distributing tube by a predetermined length.

10. The refrigerant distributing device according to claim 9, wherein the inner end of the nozzle is formed with a bent portion.

11. The refrigerant distributing device according to any one of claims 1-8, wherein an inner end of each nozzle is flush with an inner wall surface or an outer wall surface of the distributing tube.

12. The refrigerant distributing device according to claim 1, wherein the through hole passes through inner and outer end surfaces of the nozzle, wherein an axial direction of the through hole is parallel to an axial direction of the nozzle, the distributing tube has a circular cross-section, wherein a ratio H/D of a length H of the through hole to a hydraulic diameter D of the distributing tube is in a range of 0.027 to 25, and a ratio H/L of the length H of the through hole to a length L of the distributing tube is in a range of 3.3×10^{-4} to 0.125.

13. The refrigerant distributing device according to claim 1, wherein a sum of cross-sectional areas of the through holes of the nozzles is 0.01% to 40% of a circumferential surface area of the distributing tube.

14. A heat exchanger, comprising:

an inlet header;
an outlet header;
a plurality of heat exchange tubes each having two ends connected with the inlet header and the outlet header respectively to communicate the inlet header and the outlet header;
a plurality of fins disposed between adjacent heat exchange tubes respectively; and
a refrigerant distributing device according to any one of claims 1-13 disposed in the inlet header.

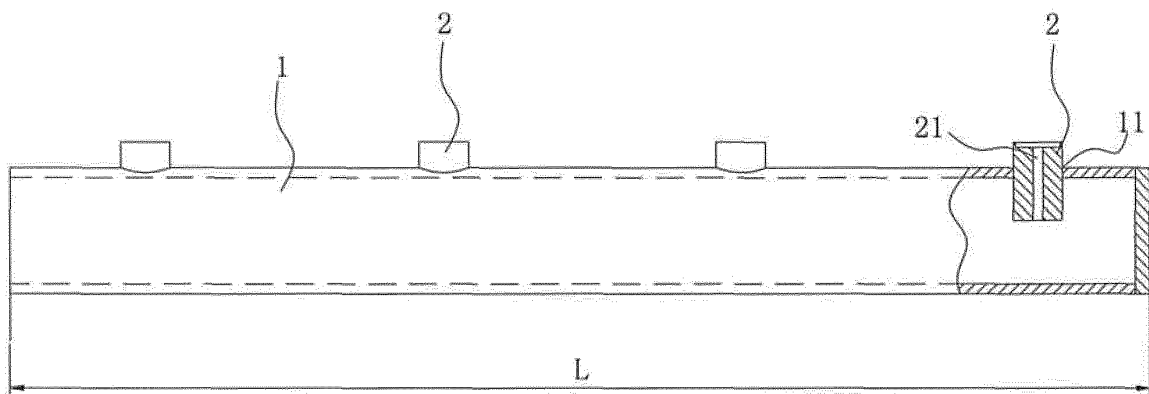


Fig. 1

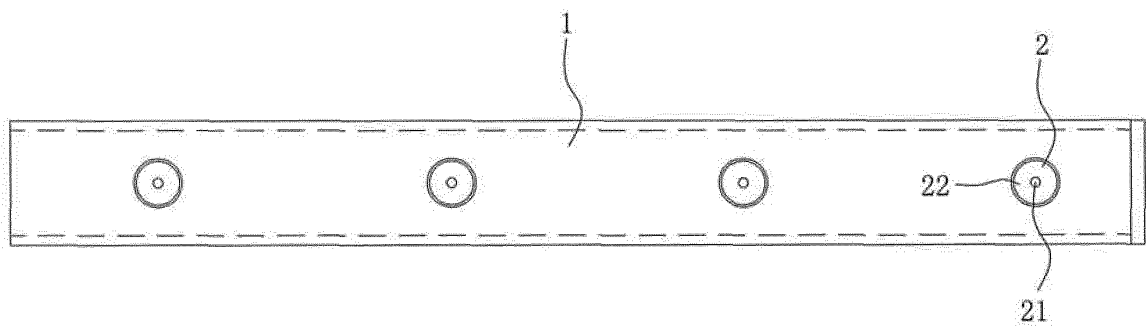


Fig. 2

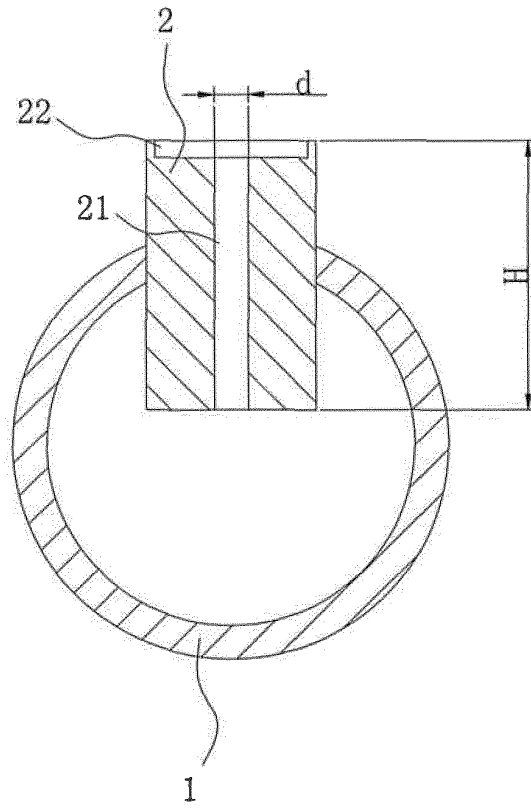


Fig. 3

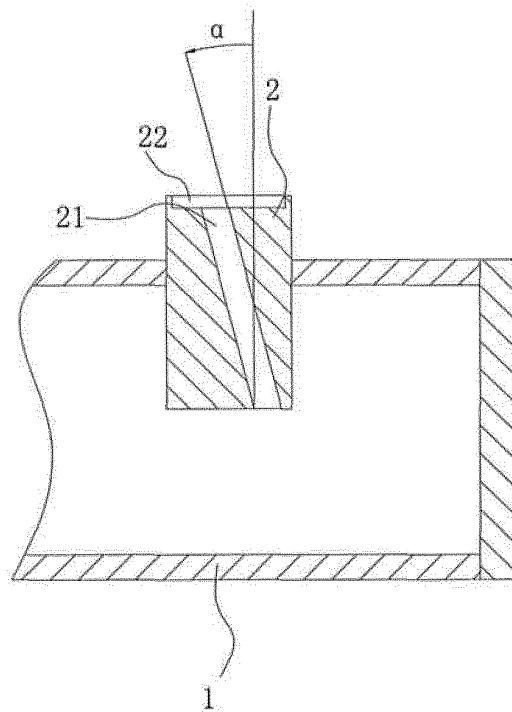


Fig. 4

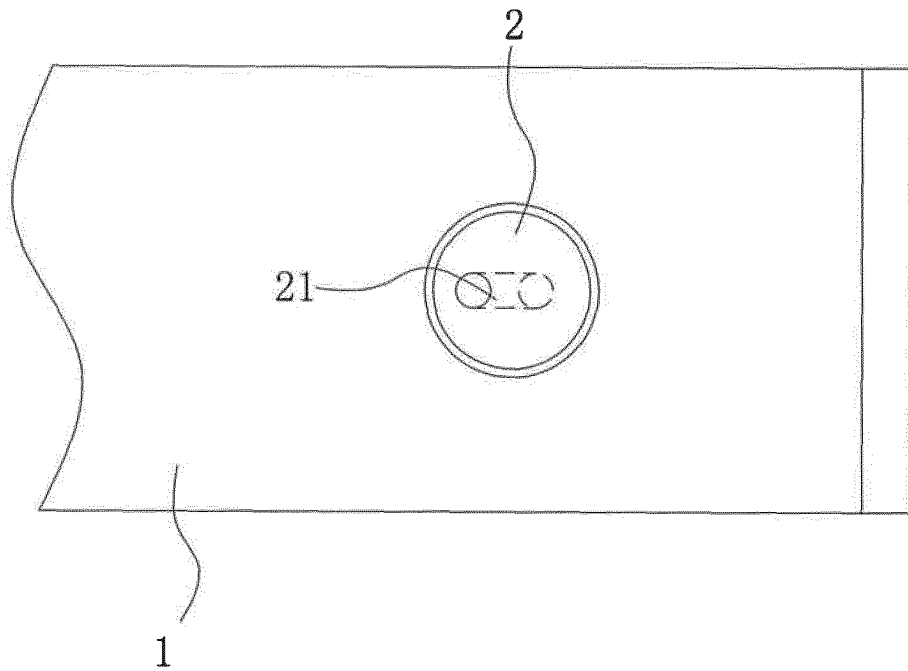


Fig. 5

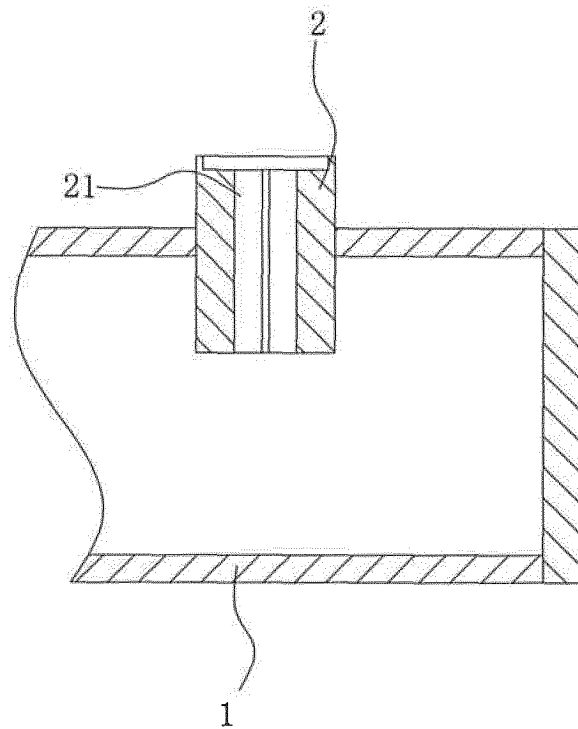


Fig. 6

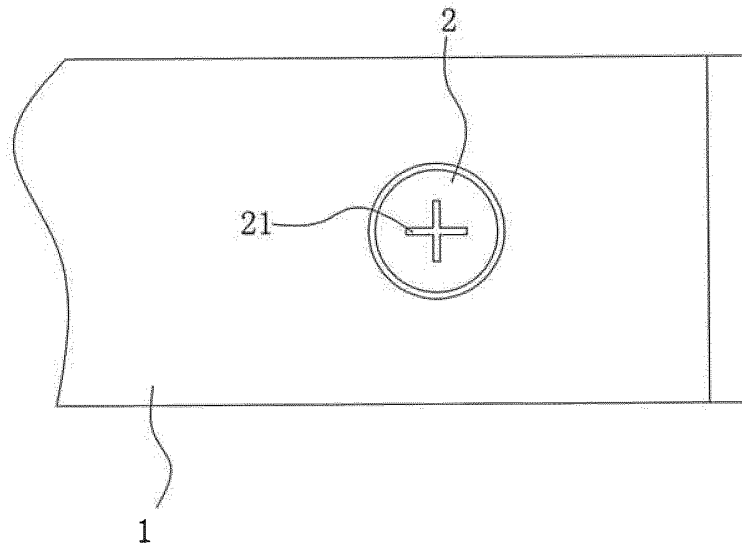


Fig. 7

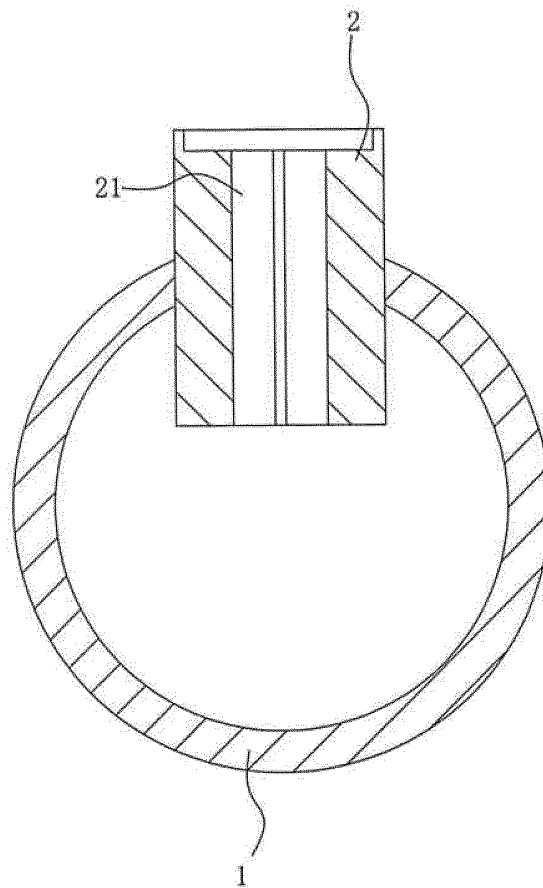


Fig. 8

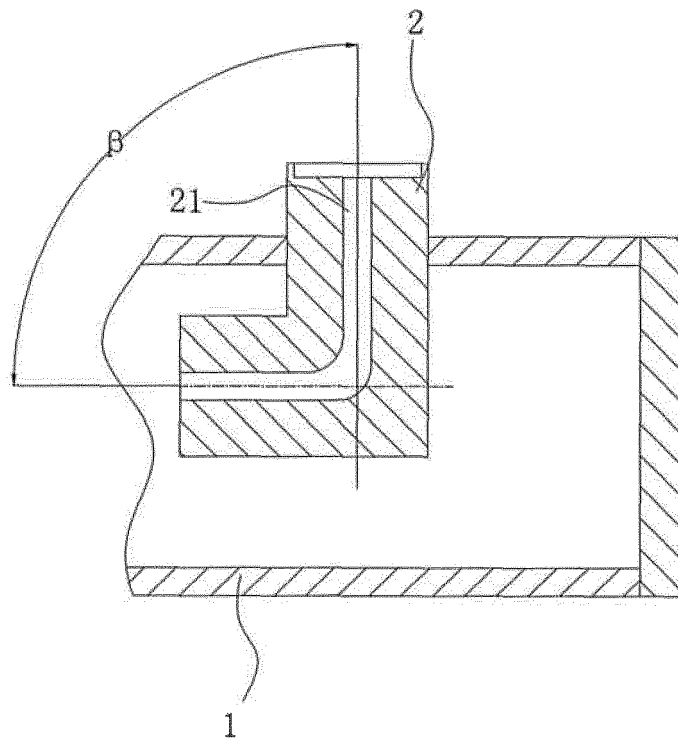


Fig. 9

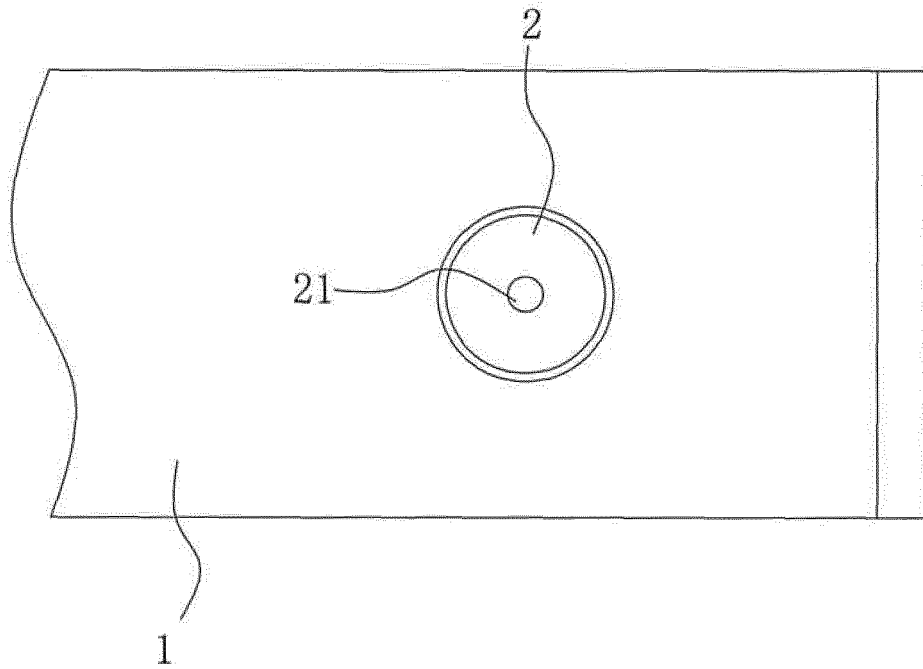


Fig. 10

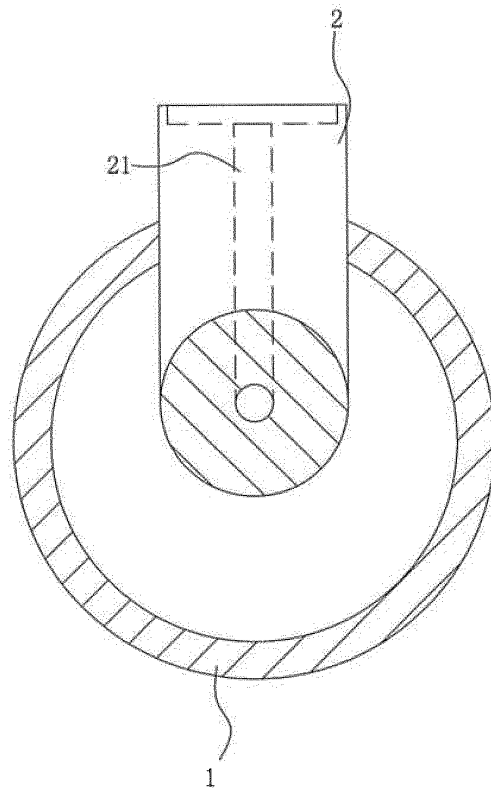


Fig. 11

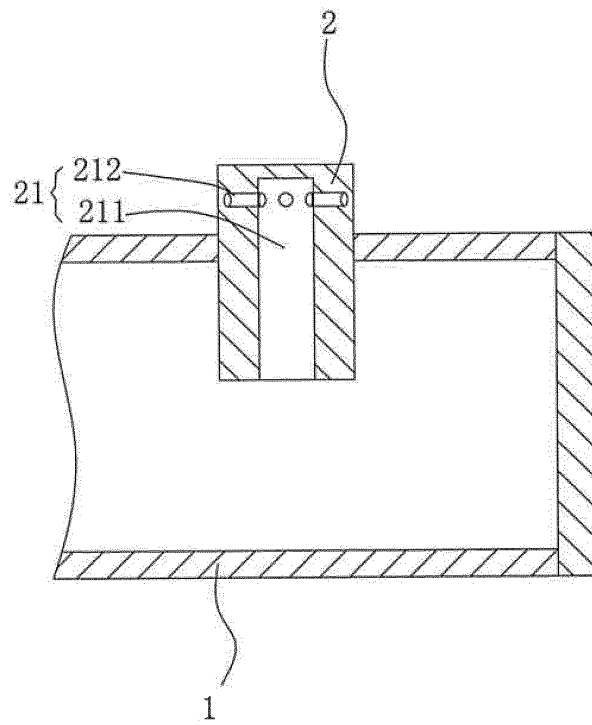


Fig. 12

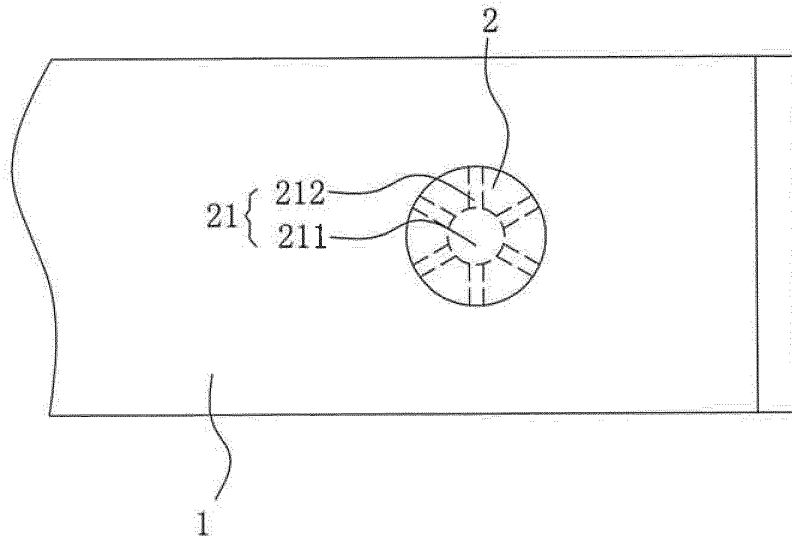


Fig. 13

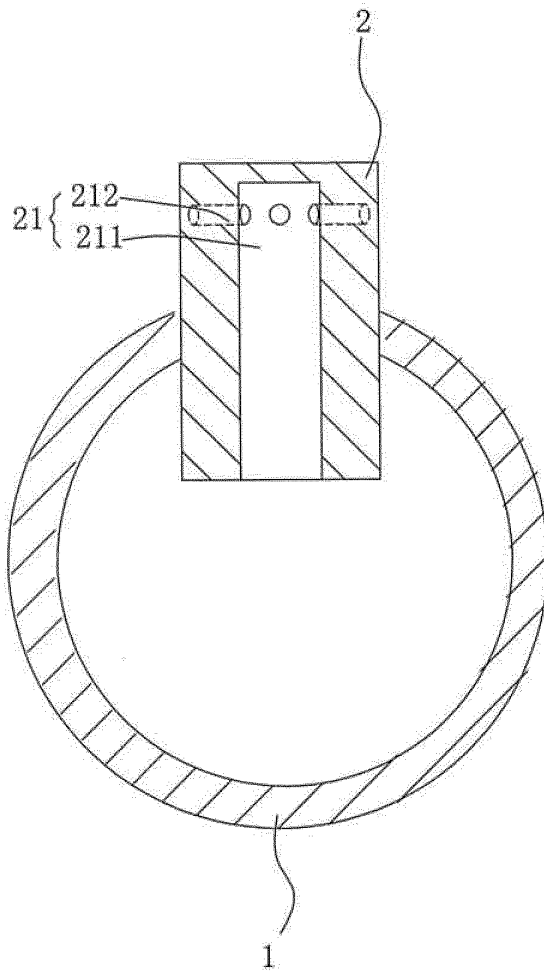


Fig. 14

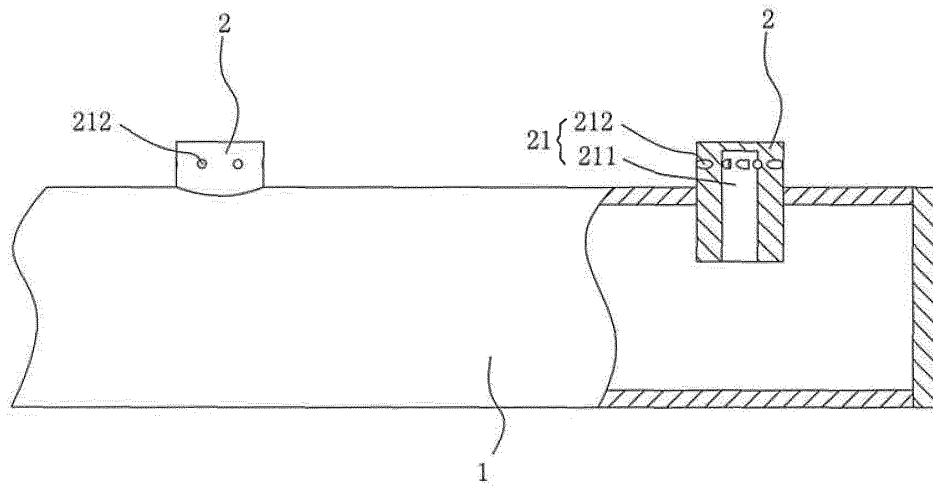


Fig. 15

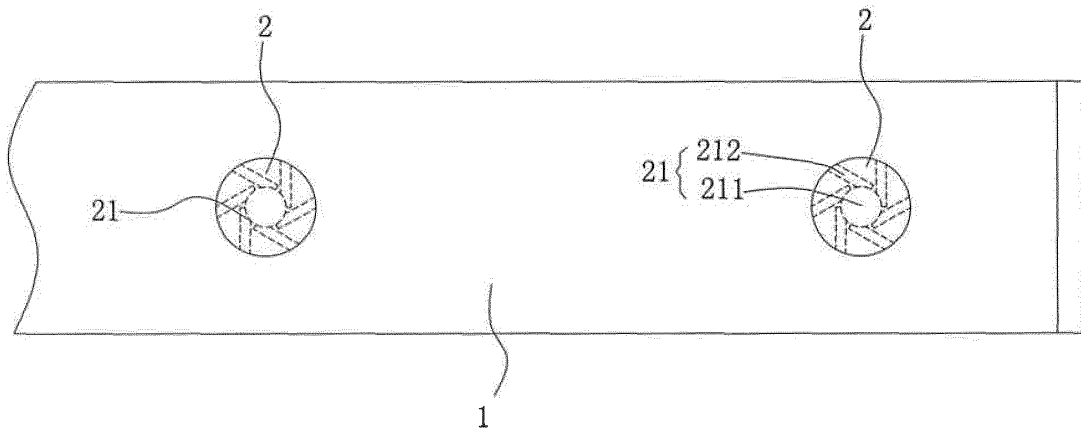


Fig. 16

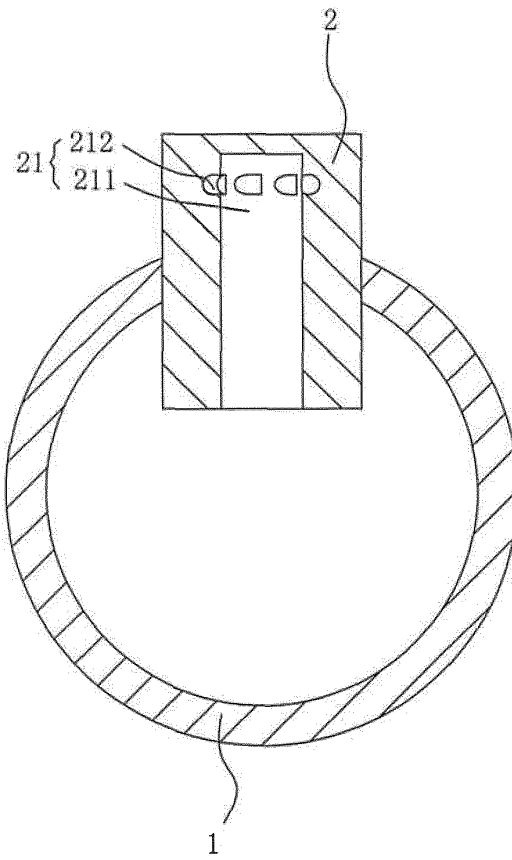


Fig. 17

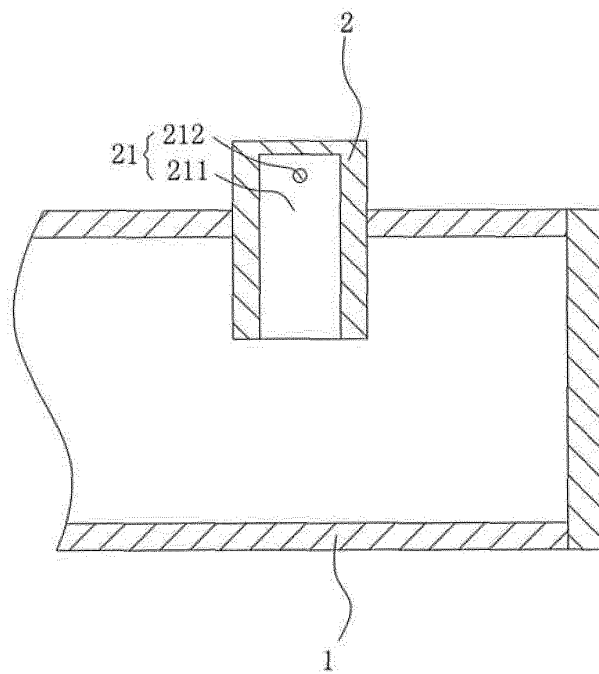


Fig. 18

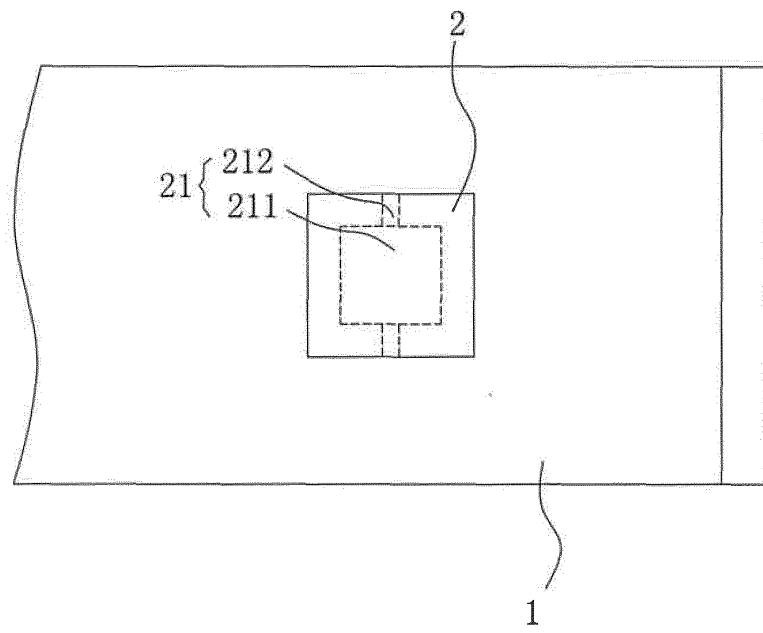


Fig. 19

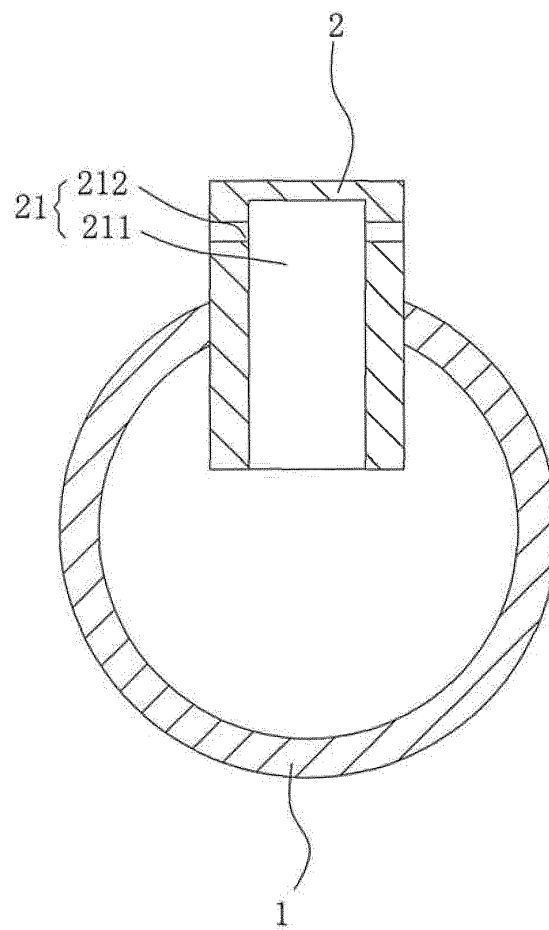


Fig. 20

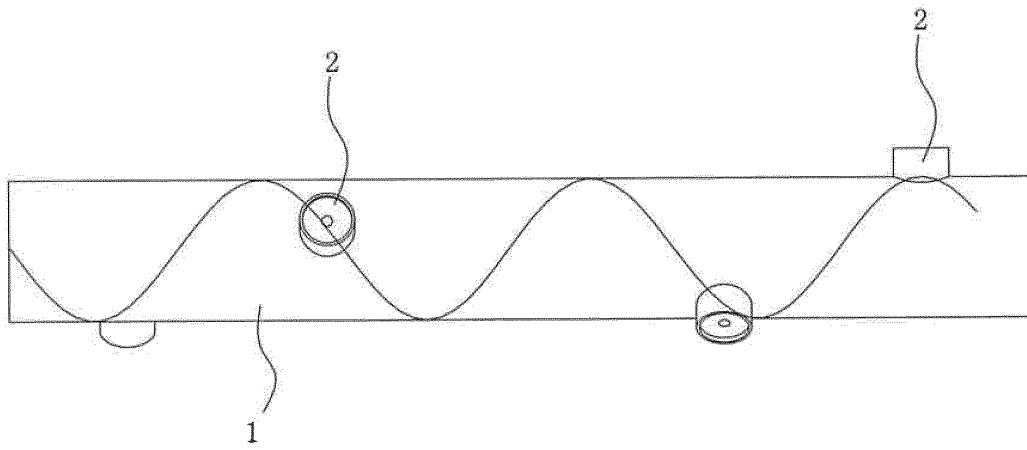


Fig. 21

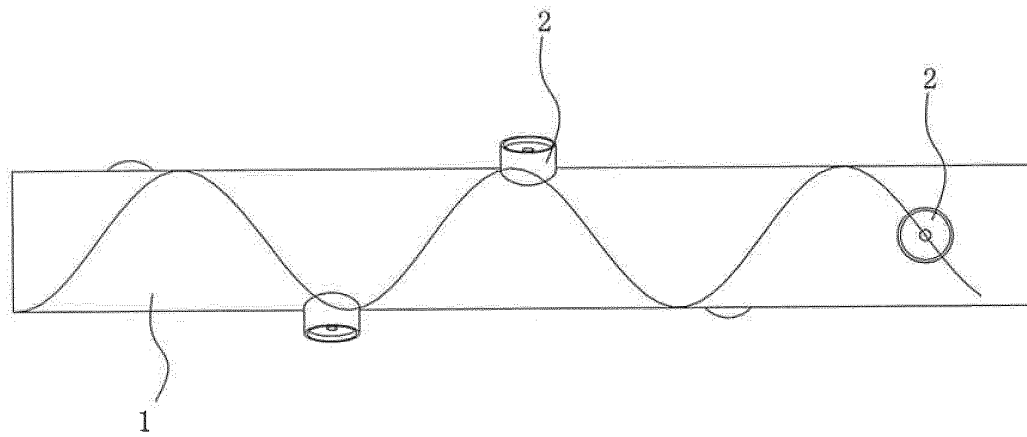


Fig. 22

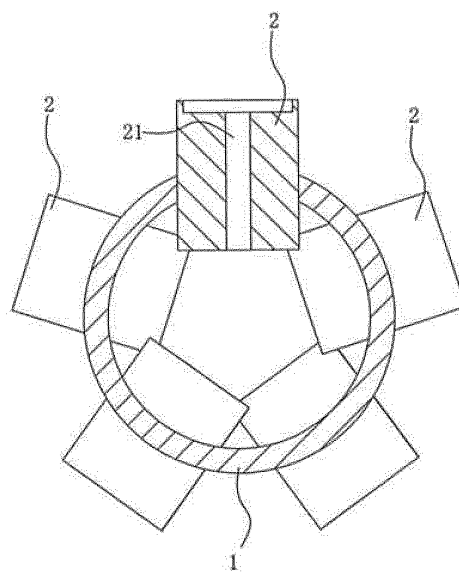


Fig. 23

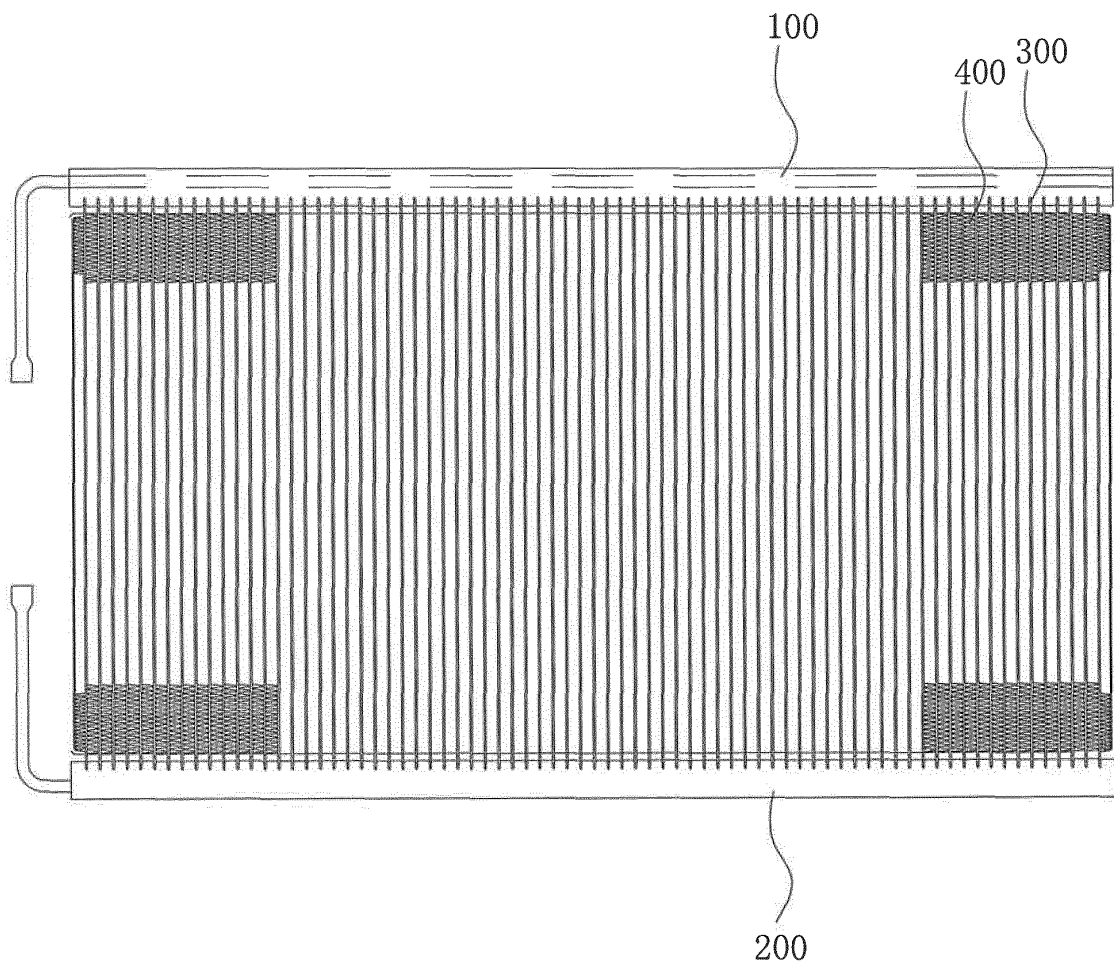


Fig. 24

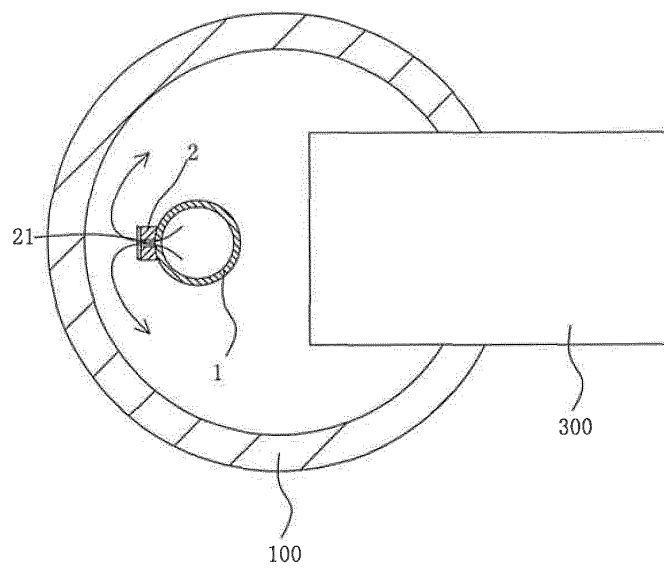


Fig. 25

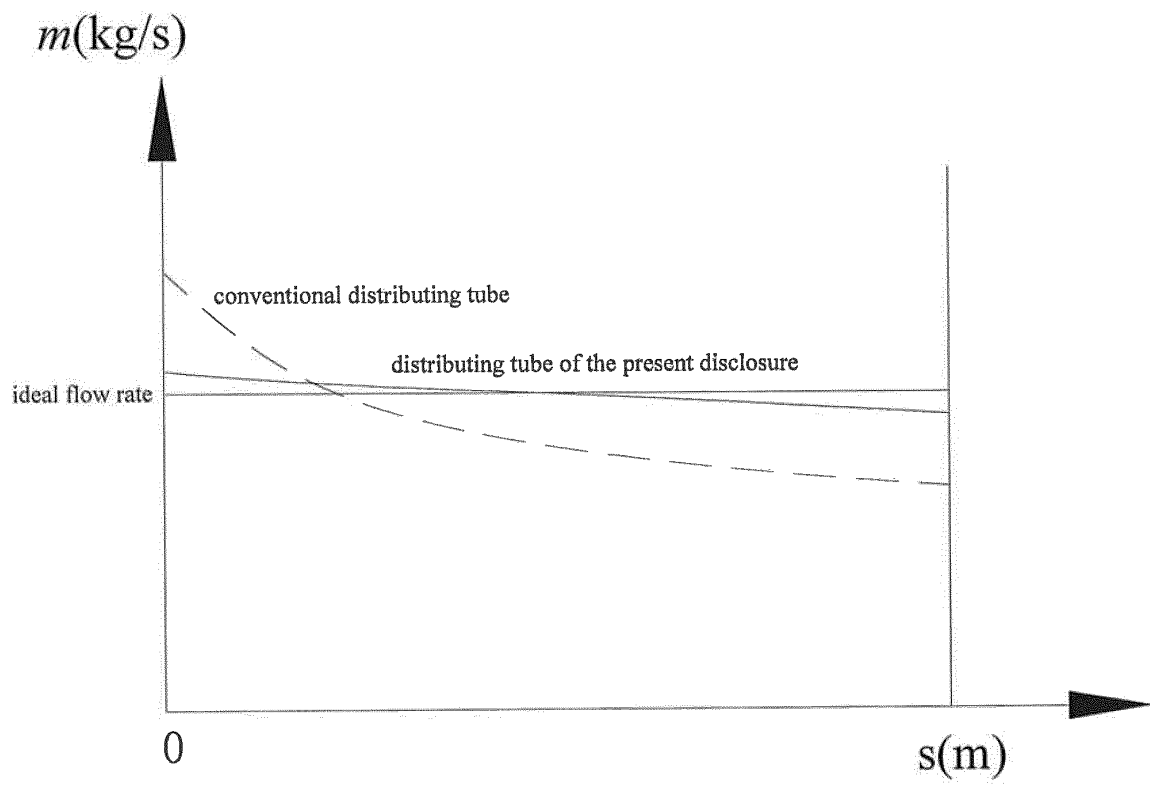


Fig. 26

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/073846

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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: F28F1; F28F9; F25B39; F28D1; F28D3; F28D5; F28D7; F28D15; F17D1; F17D3

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)

CNPAT; CNKI; WPI; EPODOC: distribut+, spread+, scatter+, nozzle?, hole?, opening?, aperture?, branch??. project+, protrud+, pipe?, tube?, header?, manifold?, collect+, heat w exchanger?, refrigera+, cool+, air, gas+, liquid, fluid

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO2006039148A2 (ADVANCED HEAT TRANSFER LLC et al.) 13 Apr. 2006 (13.04.2006) description page 6 line 14 to page 10 line 18, figures 2-5	1, 3, 9, 12-14
Y		2, 4, 5, 10, 11
X	CN101660870A (DANFOSS SANHUA HANGZHOU MICRO CHANNEL HE) 03 Mar. 2010 (03.03.2010) description page 3 lines 17-27, page 5 lines 17-21, figures 1, 5	1, 9, 14
X	WO2006039086A2 (ADVANCED HEAT TRANSFER LLC et al.) 13 Apr. 2006 (13.04.2006) description page 5 line 13 to page 8 line 16, figures 2-3	1, 9, 14
PX	CN201757545U (ZHAO, Min) 09 Mar. 2011 (09.03.2011) description paragraphs 0015-0018, figures 1-4	1, 4, 14

☒ 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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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
26 Jul.2011 (26.07.2011)Date of mailing of the international search report
15 Sep. 2011 (15.09.2011)Name and mailing address of the ISA/CN
The State Intellectual Property Office, the P.R.China
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/073846

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	CN102072684A (DANFOSS SANHUA HANGZHOU MICRO CHANNEL HE) 25 May 2011 (25.05.2011) description paragraphs 0033-0062, figures 1-9	1, 9, 14
Y	CN101839590A (DANFOSS SANHUA HANGZHOU MICRO CHANNEL HE) 22 Sep. 2010 (22.09.2010) description paragraphs 0045-0080, figures 1A-3j	2, 4, 5
Y	CN1920369A (UNIV ZHEJIANG) 28 Feb.2007 (28.02.2007) description page 3 line 19 to page 4 line 6, figures 1-4	10, 11
A	WO2008060270A1 (CARRIER CORP et al.) 22 May 2008 (22.05.2008) the whole document	1-14
A	JP2004278935A (CALSONIC CORP) 07 Oct. 2004 (07.10.2004) the whole document	1-14

Form PCT/ISA /210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2011/073846

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO2006039148A2	13.04.2006	WO2006039148A3	19.04.2007
		US2006070399A1	06.04.2006
		US7331195A1	12.02.2008
		CA2582377A1	13.04.2006
		EP1797378A2	20.06.2007
		AU2005292468A1	13.04.2006
		CN101031762A	05.09.2007
		US7331195B2	19.02.2008
		MXPA07003876A	01.10.2007
		CN100549567C	14.10.2009
		AU2005292468B2	17.02.2011
		MX283882B	09.02.2011
		MX2007003876A	03.10.2007
CN101660870A	03.03.2010	US2011061844A1	17.03.2011
		EP2299224A2	23.03.2011
WO2006039086A2	13.04.2006	WO2006039086A3	12.10.2006
		US2006070401A1	06.04.2006
		US7086249B2	08.08.2006
		EP1794513A2	13.06.2007
		AU2005292493A1	13.04.2006
		CN101076698A	21.11.2007
		MXPA07003560A	01.01.2008
		CN100476319C	08.04.2009
		AU2005292493B2	03.12.2009
		MX277813B	03.08.2010
		CA2589384A1	27.06.2007
		MX2007003560A	16.01.2008
CN201757545U	09.03.2011	None	
CN102072684A	25.05.2011	None	
CN101839590A	22.09.2010	None	
CN1920369A	28.02.2007	CN100435928C	26.11.2008
WO2008060270A1	22.05.2008	EP2082181A1	29.07.2009
		CN101568792A	28.10.2009
		US2010282454A1	11.11.2010
JP2004278935A	07.10.2004	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/073846

Continuation of : CLASSIFICATION OF SUBJECT MATTER

F28F 9/02 (2006.01) i

F28F 1/00 (2006.01) i