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(54) LIQUID DISTRIBUTOR AND HEAT EXCHANGER

(57) A liquid distributor (10) and a heat exchanger (100) are provided. The liquid distributor (10) includes a sleeve (11), a distribution structure (12), and a turbulence plate (15). The sleeve (11) is penetrated by a plurality of heat exchange tubes (20). The distribution structure (12) is located inside the sleeve (11) and connected to the sleeve (11), and the distribution structure (12) can divide the interior of the sleeve (11) into at least a first chamber (13) and a second chamber (14) which are in communication with each other. The first chamber (13) is located at a side of the distribution structure (12) away from the heat exchange tubes (20), and the second chamber (14) is located at a side of the distribution structure (12) proximal to the heat exchange tubes (20). The turbulence plate (15) is located in the second chamber (14), connected to the sleeve (11), and spaced apart from the distribution structure (12). The heat exchange tubes (20) are partly inserted into the turbulence plate (15) and are in communication with the second chamber (14).

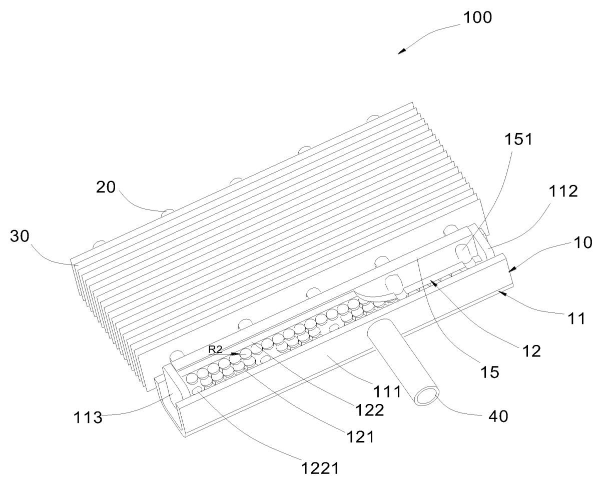

FIG. 6

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese patent applications No. 202221486490.7, filed on June 14, 2022, and titled "LIQUID DISTRIBUTOR AND HEAT EXCHANGER", and No. 202210669534.8, filed on June 14, 2022, and titled "LIQUID DISTRIBUTOR AND HEAT EXCHANGER". The contents of the above identified applications are hereby incorporated herein in their entireties by reference.

TECHNICAL FIELD

[0002] The present invention relates to the field of heat exchange technology, in particular, to a liquid distributor and a heat exchanger.

BACKGROUND

[0003] Main components of an air conditioning system include a compressor, a condenser, a throttle apparatus, and a heat exchanger. The heat exchanger performs heat exchange with the outside. The heat exchanger includes a fin, a heat exchange tube, a manifold, and a liquid distributor. The liquid distributor mainly functions to evenly distribute medium.

[0004] In the related art, the liquid distributor includes a sleeve and a distribution plate. An end of the heat exchange tube is inserted into the sleeve and in communication with interior of the sleeve. The distribution plate is mounted in the sleeve and provided with multiple distribution holes. The medium enters the liquid distributor, and is distributed through the distribution holes into the heat exchange tube, so as to achieve a uniform distribution effect.

[0005] However, the medium that enters the liquid distributor is usually in a gas-liquid two-phase form. Due to application conditions and complexity of gas-liquid two-phase flow, it is difficult for the distribution plate to implement uniform distribution of the medium. In many cases, when a gas-liquid two-phase medium enters the liquid distributor, a splitting phenomenon may occur since a flow rate of a gas and a liquid is different, resulting in that the medium is mixed non-uniformly into the heat exchange tube, thereby greatly affecting overall performance of the heat exchanger.

SUMMARY

[0006] According to various embodiments of the present invention, a liquid distributor and a heat exchanger are provided, which are capable of improving media uniformity and heat exchange efficiency of the heat exchanger.

[0007] A liquid distributor includes a sleeve, a distribution structure, and a turbulence plate. The sleeve is penetrated by a plurality of heat exchange tubes. The distribution structure is located inside the sleeve and is connected to the sleeve, the distribution structure is capable of dividing the interior of the sleeve into at least a first chamber and a second chamber in communication with each other, the first chamber is located at a side of the distribution structure away from the plurality of heat exchange tubes, and the second chamber is located at a side of the distribution structure proximal to the plurality of heat exchange tubes. The turbulence plate is located in the second chamber and is connected to the sleeve, the turbulence plate is spaced apart from the distribution structure, and the plurality of heat exchange tubes are partly inserted into the turbulence plate and are in communication with the second chamber.

[0008] It should be understood that the turbulence plate is disposed to fill a gap between two adjacent heat exchange tubes, so as to avoid a medium flowing into the gap, reduce separation space of a gas-liquid two-phase medium, and then cooperate with the distribution structure to mix the medium uniformly and distribute the media uniformly, so that the gas-liquid two-phase medium may be mixed more uniformly, and heat exchange efficiency of the heat exchanger may be improved.

[0009] In an embodiment, the turbulence plate is provided with a plurality of turbulence holes matched with shapes of the plurality of heat exchange tubes, each of the plurality of heat exchange tubes extends into corresponding one of the plurality of turbulence holes, and a length of each of the plurality of heat exchange tubes that extends into the corresponding one of the plurality of turbulence holes is less than a depth of the turbulence hole. Alternatively, an end of each of the plurality of heat exchange tubes that extends into the corresponding one of the plurality of turbulence holes is flush with a side surface of the turbulence plate proximal to the distribution structure.

[0010] In this way, the separation space of the gas-liquid two-phase medium may be reduced, thereby improving mixing uniformity of the medium.

[0011] In an embodiment, a shape of the distribution structure is a plate, and the distribution structure is provided with a plurality of distribution holes for communicating the first chamber with the second chamber.

[0012] In this way, the medium may be uniformly distributed.

[0013] In an embodiment, the plurality of distribution holes are spaced along a length direction of the distribution structure, or the plurality of distribution holes are arranged in a matrix manner.

[0014] In this way, the mixing uniformity of the medium may be further improved.

[0015] In an embodiment, each of the plurality of distribution holes are in a circular shape or a polygonal shape.

[0016] In this way, it facilitates circulation of the medium.

[0017] In an embodiment, each of the plurality of distribution holes are in a circular shape, and a radius of each of the plurality of distribution holes is defined as R1, and the radius R1 of each of the plurality of distribution holes satisfies a following formula: 0.5 mm $\leq$ R1 $\leq$ 2 mm.

[0018] In this way, it may balance uniformity and flow resistance of the medium.

[0019] In an embodiment, the distribution structure includes a plurality of padding members. The plurality of padding members are distributed sequentially along a length direction and a width direction of the turbulence plate, and adjacent two of the plurality of padding members are connected with each other, so that a plate structure is defined by the plurality of padding members. At least one liquid homogenizing hole for communicating the first chamber with the second chamber is formed among the plurality of padding members.

[0020] In this way, the mixing uniformity of the medium may be improved.

[0021] In an embodiment, the plurality of padding members are arranged in a matrix manner. Alternatively, along the length direction of the turbulence plate, the plurality of padding members are divided into multiple rows, and the plurality of padding members in adjacent two of multiple rows are arranged in a staggered manner.

[0022] In this way, the mixing uniformity of the medium may be further improved.

[0023] In an embodiment, each of the plurality of padding members is a rotating body or a polyhedron.

[0024] In this way, a contact area of the medium may be increased, thereby improving the mixing uniformity of the medium.

[0025] In an embodiment, the plurality of padding members are in a spherical shape, and a radius of each of the plurality of padding members is defined as R2, and the radius R2 of each of the plurality of padding members satisfies a following formula: 0.5 mm $\leq$ R2 $\leq$ 3 mm.

[0026] In this way, it may balance uniformity and flow resistance of the medium.

[0027] In an embodiment, the distribution structure includes a distribution plate and a plurality of padding members. The distribution plate is provided with a plurality of distribution holes for communicating the first chamber with the second chamber. The plurality of padding members are located in either or both of the first chamber and the second chamber, and the plurality of padding members are connected to the distribution plate.

[0028] In this way, the mixing uniformity of the medium may be improved.

[0029] In an embodiment, the plurality of padding members are distributed sequentially along a length direction and a width direction of the distribution plate, and adjacent two of the plurality of padding members are connected with each other, so that a plate structure is defined by the plurality of padding members. At least one liquid homogenizing hole is formed among the plurality of padding members.

[0030] In this way, the mixing uniformity of the medium may be improved, and the structural stability of the liquid distributor may be increased.

[0031] In an embodiment, the plurality of padding members are arranged in a matrix manner. Alternatively, along the length direction of the distribution plate, the plurality of padding members are divided into multiple rows, and the plurality of padding members in adjacent two of multiple rows are arranged in a staggered manner.

[0032] In this way, the mixing uniformity of the medium may be further improved.

[0033] In an embodiment, the turbulence plate is provided with a plurality of turbulence holes matched with shapes of the plurality of heat exchange tubes, the plurality of turbulence holes are disposed at intervals along a length direction of the turbulence plate, the plurality of distribution holes are disposed at intervals along a length direction of the distribution plate, and an axis of each of the plurality of turbulence holes is overlapped with an axis of each of the plurality of distribution holes, respectively.

[0034] In this way, it facilitates circulation of the medium.

[0035] In an embodiment, the turbulence plate is provided with a plurality of turbulence holes matched with shapes of the plurality of heat exchange tubes, and a cross-sectional area of each of the plurality of turbulence holes is greater than that of each of the plurality of distribution holes.

[0036] In this way, the mixing uniformity of the medium may be improved.

[0037] A heat exchanger is further provided in the present invention, including any one of the above liquid distributors, a plurality of fins, and the plurality of heat exchange tubes. The plurality of fins are disposed at intervals and in parallel. The plurality of heat exchange tubes penetrate the plurality of fins, respectively, and an end of each of the plurality of heat exchange tubes is in communication with the liquid distributor.

[0038] Compared with the related art, the heat exchanger provided in the present invention may improve uniformity of the medium and heat exchange efficiency of the heat exchanger by a joint function of the distribution structure and the turbulence plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] To describe the technical solutions in the embodiments or in the related art more clearly, the following briefly describes the accompanying drawings required for describing the embodiments or the related art. Apparently, the accompanying drawings in the following description show only some embodiments of the present invention, and one skilled in the art may still derive other drawings from these accompanying drawings without creative labor.

FIG. 1 is a sectional schematic diagram of a liquid distributor in a first embodiment of the present invention.

FIG. 2 is a schematic diagram of a distribution structure in the first embodiment of the present invention.

FIG. 3 is a sectional schematic diagram of another distribution structure in the first embodiment of the present invention.

FIG. 4 is a front diagram of a distribution structure in a second embodiment of the present invention.

FIG. 5 is a front diagram of another distribution structure in the second embodiment of the present invention.

FIG. 6 is a sectional schematic diagram of a liquid distributor in a third embodiment of the present invention.

FIG. 7 is a sectional schematic diagram of a liquid distributor in an embodiment of the present invention.

FIG. 8 is a sectional schematic diagram of a liquid distributor unit in the present invention.

FIG. 9 is a sectional schematic diagram of a heat exchanger in the present invention.

[0040] In the figures, 100 represents a heat exchanger, 10 represents a liquid distributor, 11 represents a sleeve, 111 represents a main body, 112 represents a first end cap, 113 represents a second end cap, 12 represents a distribution structure, 121 represents a padding member, 1211 represents a liquid homogenizing hole, 122 represents a distribution plate, 1221 represents a distribution hole, 13 represents a first chamber, 14 represents a second chamber, 15 represents a turbulence plate, 151 represents a turbulence hole, 20 represents a heat exchange tube, 30 represents a fin, 40 represents an inlet nozzle, 50 represents a nozzle base, and 60 represents a liquid distributor unit.

DETAILED DESCRIPTION

[0041] The technical solutions in the embodiments of the present invention will be described clearly and completely in the following in conjunction with the accompanying drawings in the embodiments of the present invention, and it is obvious that the described embodiments are only a part of the embodiments of the present invention, but not all of the embodiments. Based on the embodiments in the present invention, all other embodiments obtained by one skilled in the art without making creative labor fall within the scope of protection of the present invention.

[0042] It should be noted that when an assembly is considered to be "fixed to" or "disposed on" another assembly, it may be directly disposed to another assembly, or there can be a centered assembly. When an assembly is considered to be "connected to" another assembly, it may be directly connected to another assembly, or there can be a centered assembly at the same time. The terms "vertical", "horizontal", "upper", "lower", "left", "right", and the like used in the description of the present invention are for a purpose of description only, and are not intended to represent the only implementation.

[0043] In addition, the terms "first" and "second" are used only for the purpose of description, and cannot be understood to indicate or imply relative importance or implicitly indicate the quantity of indicated technical features. Therefore, a feature defined with "first" and "second" may explicitly or implicitly include at least one feature. In the description of the present invention, "a plurality of" means at least two, for example, two, three, and the like, unless otherwise specifically limited.

[0044] In the present invention, unless otherwise specified and limited, a first feature is "on" or "under" a second feature, which means that the first feature is in direct contact with the second feature, or the first feature is in indirect contact with the second feature by an intermediate medium. In addition, the first feature is "above", "over", and "on" the second feature, which means that the first feature is directly above or obliquely above the second feature, or only indicates that a level height of the first feature is higher than that of the second feature. The first feature is "below", "under", "beneath" the second feature, which means that the first feature is directly below or obliquely below the second feature, or only indicates that the level height of the first feature is less than that of the second feature.

[0045] Unless defined otherwise, technical terms or scientific terms involved in the description of the present invention have the same meanings as generally understood by one skilled in the technical field of the present invention. The terms used in the description of the present invention are merely intended to describe specific embodiments, and are not intended to limit the present invention. The term "and/or" as used herein includes any and all combinations of one or more associated listed items.

[0046] Referring to FIG. 1, a liquid distributor 10 is provided in the present invention. The liquid distributor 10 is applied to a heat exchanger 100.

[0047] Main components of an air conditioning system include a compressor, a condenser, a throttle apparatus, and a heat exchanger. The heat exchanger performs heat exchange with the outside. The heat exchanger includes a fin, a heat exchange tube, a manifold, and a liquid distributor. The liquid distributor mainly functions to evenly distribute medium.

[0048] In the related art, the liquid distributor includes a sleeve and a distribution plate. An end of the heat exchange tube is inserted into the sleeve and in communication with the interior of the sleeve. The distribution plate is mounted in the sleeve and provided with multiple distribution holes. The medium enters the liquid distributor and is distributed through the distribution holes into the heat exchange tube, so as to achieve a uniform distribution effect. However, the medium that enters the liquid distributor is usually in a gas-liquid two-phase form. Due to application conditions and complexity of gas-liquid two-phase flow, it is difficult for the distribution plate to implement uniform distribution of the medium. In many cases, when a gas-liquid two-phase medium enters the liquid distributor, a splitting phenomenon may occur since a flow rate of a gas and a liquid is different, resulting in that the medium is mixed non-uniformly into the heat exchange tube, thereby greatly affecting overall performance of the heat exchanger.

[0049] To resolve the foregoing problem, referring to FIG. 1 and FIG. 6, a liquid distributor 10 is provided in the present invention. The liquid distributor 10 includes a sleeve 11, a distribution structure 12, and a turbulence plate 15, and the sleeve 11 is penetrated by a plurality of heat exchange tubes 20. The distribution structure 12 is located inside the sleeve 11 and is connected to the sleeve 11, and the distribution structure 12 is capable of dividing the interior of the sleeve 11 into at least a first chamber 13 and a second chamber 14 in communication with each other. The first chamber 13 is located at a side of the distribution structure 12 away from the plurality of heat exchange tubes 20, and the second chamber 14 is located at a side of the distribution structure 12 proximal to the plurality of heat exchange tubes 20. The turbulence plate 15 is located in the second chamber 14 and is connected to the sleeve 11, and the turbulence plate 15 is spaced apart from the distribution structure 12. The plurality of heat exchange tubes 20 are partly inserted into the turbulence plate 15 and are in communication with the second chamber 14.

[0050] Specifically, an end surface of the turbulence plate 15 proximal to the sleeve 11 may be fully attached to the sleeve 11, and a specific setting manner of the turbulence plate 15 and the sleeve 11 is not limited. In the present embodiment, the turbulence plate 15 and the sleeve 11 may be disposed separately, and the turbulence plate 15 and the sleeve 11 may be welded to fully attached. In other embodiments, the turbulence plate 15 and the sleeve 11 may be integrally formed, thereby simplifying a structure of the liquid distributor 10.

[0051] In an operation process, the gas-liquid two-phase medium enters the liquid distributor 10. The gas-liquid two-phase medium enters the first chamber 13 first, and enters the second chamber 14 after being mixed and distributed uniformly by the distribution structure 12. The turbulence plate 15 is disposed in the second chamber 14. If the turbulence plate 15 is not mounted, a gap exists between adjacent two of the plurality of heat exchange tubes 20 that are in communication with the second chamber 14, so that most of the medium fills the gap after the medium enters the second chamber 14, resulting in decreasing a utilization rate and a flow rate of the medium. It may be understood that the turbulence plate 15 may avoid the medium flowing into the gap, so that the medium may flow into the heat exchange tube 20 completely, and utilization rate of the medium may be improved. In addition, separation space of the gas-liquid two-phase medium may be reduced, so that the gas-liquid two-phase medium may be mixed more uniformly, and heat exchange efficiency of the heat exchanger 100 may be improved.

[0052] The turbulence plate 15 may be provided with a plurality of turbulence holes 151 matched with shapes of the plurality of heat exchange tubes 20, and each of the plurality of heat exchange tubes 20 may extend into corresponding one of the plurality of turbulence holes 151. The plurality of heat exchange tubes 20 may be inserted into the turbulence hole 151 and be fixedly connected to the turbulence plate 15, so that connection strength between the plurality of heat exchange tubes 20 and the turbulence plate 15 may be further improved, thereby improving structural stability of the heat exchanger 100.

[0053] In an embodiment, a length of each of the plurality of heat exchange tubes 20 that extends into the corresponding one of the plurality of turbulence holes 151 may be less than a depth of the turbulence hole 151. In this way, the medium may enter the plurality of heat exchange tubes 20 through the plurality of turbulence holes 151 completely, and the medium may not flow into the gap between adjacent two of the plurality of heat exchange tubes 20, so as to reduce the separation space of the gas-liquid two-phase medium, keep a relatively high flow rate of the medium, and improve mixing uniformity and utilization rate of the medium.

[0054] In another embodiment, an end of each of the plurality of heat exchange tube 20 that extends into the corresponding one of the plurality of turbulence holes 151 may be flush with a side surface of the turbulence plate 15 proximal to the distribution structure 12. In this way, it may be avoided that the medium flows into the gap between adjacent two of the plurality of heat exchange tubes 20, and a part of the medium may also be prevented from being filled in the plurality of turbulence holes 151. The media may directly flow into the plurality of heat exchange tubes 20 completely, and in addition, the media may keep the relatively high flow rate, thereby improving mixing uniformity and utilization rate of the medium.

A first embodiment

[0055] Referring to FIG. 1 to FIG. 3, a shape of the distribution structure 12 may be a plate, and the distribution structure 12 may be provided with a plurality of distribution holes 1221 for communicating the first chamber 13 with the second chamber 14. In an operation process, after the gas-liquid two-phase medium enters the first chamber 13 and impacts on a plate surface of the distribution structure 12, the medium may diffuse around and flow into a nearby distribution hole 1221. In this period, the medium with different flow directions may be doped with each other, so that a mixing scale in the medium may become smaller, gas-liquid mixing may be more uniform, and then the medium may flow into the second chamber 14 with the relatively high flow rate by throttling effect of the plurality of distribution holes 1221, thereby further improving distribution uniformity of the media and heat exchange efficiency of the heat exchanger 100.

[0056] In an embodiment, referring to FIG. 1, the plurality of distribution holes 1221 may be spaced along a length direction of the distribution structure 12. The plurality of turbulence holes 151 may be spaced along a length direction of the turbulence plate 15, and the plurality of turbulence holes 151 may be disposed in a one-to-one correspondence with the plurality of distribution holes 1221. Specifically, an axis of each of the plurality of turbulence holes 151 may be overlapped with an axis of each of the plurality of distribution holes 1221, respectively, so as to facilitate circulation of the medium, and the uniformly distributed medium may quickly enter the plurality of heat exchange tubes 20, thereby improving heat exchange efficiency of the heat exchanger 100.

[0057] Furthermore, a cross-sectional area of each of the plurality of turbulence holes 151 may be greater than that of each of the plurality of distribution holes 1221. When the medium passes through the plurality of distribution holes 1221, the flow rate of the medium may be accelerated, so that the medium may further be mixed uniformly, and heat exchange efficiency of the heat exchanger 100 may be improved.

[0058] In another embodiment, referring to FIG. 2 and FIG. 3, the plurality of distribution holes 1221 may be arranged in a matrix manner. That is, the plurality of distribution holes 1221 may be arranged in multiple rows and multiple columns, and the plurality of distribution holes 1221 may be arranged at a uniform interval, so that the gas-liquid two-phase medium may further be mixed uniformly.

[0059] Furthermore, each of the plurality of distribution holes 1221 may be in a circular shape or a polygonal shape. In this way, the plurality of distribution holes 1221 may be easily processed and facilitate circulation of the medium. In other embodiments, the plurality of distribution holes 1221 may be in a triangle shape, a square shape, an octagon shape, or other shapes, as long as the same effect may be achieved.

[0060] In an embodiment, each of the plurality of distribution holes 1221 may be in a circular shape, and a radius of each of the plurality of distribution holes 1221 may be defined as R1, which satisfies the following formula: $0.5 \text{ mm} \leq R1 \leq 2 \text{ mm}$. By reasonably setting a size of the plurality of distribution holes 1221, the uniformity and the flow resistance of the medium may be balanced. If $R1 < 0.5$ mm, the plurality of distribution hole 1221 may be too small, and the flow resistance of the medium may be increased, so that energy consumption of the heat exchanger 100 may increase. If $R1 > 2$ mm, the plurality of distribution holes 1221 may be excessively large, and the flow rate of the medium may be decreased, resulting in non-uniform mixing of the medium. For example, the radius R1 of each of the plurality of distribution holes 1221 may be 1 mm, 1.2 mm, or 1.5 mm.

A second embodiment

[0061] Referring to FIG. 4, the distribution structure 12 may include a plurality of padding members 121. The plurality of padding members 121 may be distributed sequentially along a length direction and a width direction of the turbulence plate 15, and adjacent two of the plurality of padding members 121 may be connected with each other, so that a plate structure may be defined by the plurality of padding members. At least one liquid homogenizing hole 1211 for communicating the first chamber 13 with the second chamber 14 may be formed among the plurality of padding members 121. In an operation process, after the gas-liquid two-phase medium enters the first chamber 13, and impacts on a surface of the plurality of padding members 121, the medium may diffuse around and flow into a nearby liquid homogenizing hole 1211, and flow into the second chamber 14 by the liquid homogenizing hole 1211. In this period, the medium with different flow directions may be doped with each other, so that a mixing scale in the media becomes smaller, gas-liquid mixing may be more uniform, and then the medium may keep the relatively high flow rate by throttling effect of the liquid homogenizing hole 1211, thereby further improving mixing uniformity of the medium and heat exchange efficiency of the heat exchanger 100. In addition, the plurality of padding members 121 may improve impact frequency of the medium, thereby enhancing effect of gas-liquid mixing of the medium.

[0062] In an embodiment, referring to FIG. 4, the plurality of padding members 121 may be arranged in a matrix manner. That is, the plurality of padding members 121 may be disposed in multiple rows and multiple columns. The plurality of padding members 121 that are arranged at a uniform interval may further perform a function of uniformly mixing the gas-liquid two-phase medium.

[0063] In another embodiment, referring to FIG. 5, the plurality of padding members 121 may be divided into multiple rows along the length direction of the turbulence plate 15. The plurality of padding members 121 in adjacent two of multiple rows may be arranged in a staggered manner. In this way, a size of the at least one liquid homogenizing hole 1211 surrounded by the plurality of padding members 121 may be decreased, and the medium may keep a higher flow rate when the medium flows into the at least one liquid homogenizing hole 1211, thereby improving mixing uniformity of the medium.

[0064] Furthermore, each of the plurality of padding members 121 may be a rotating body or a polyhedron. The rotating body may refer to a three-dimensional structure defined by rotating a plane curve by using a straight line in the same plane as a rotation axis. For example, the plurality of padding members 121 may include a cylinder or a cone. The polyhedron may refer to a three-dimensional structure surrounded by four or more polygons. For example, the plurality of padding members 121 may include a cube, a pyramid, or a prism. In this way, a contact area between the plurality of padding members 121 and the gas-liquid two-phase medium may be increased, and collision in the gas-liquid two-phase medium may be enhanced, thereby improving mixing uniformity of the medium.

[0065] In an embodiment, the plurality of padding members 121 may be in a spherical shape, and an impact frequency with the medium may be improved due to a shape characteristic of a spherical surface, thereby enhancing effect of gas-liquid mixing of the medium. In addition, a radius of each of the plurality of padding members 121 may be defined as R2, which may satisfy the following formula: 0.5 mm ≤ R2 ≤ 3 mm. By reasonably setting a size of the plurality of padding members 121, the uniformity and the flow resistance of the medium may be balanced. If R2 < 0.5 mm, a size of the at least one liquid homogenizing hole 1211 surrounded by adjacent two of the plurality of padding members 121 may be too small, and the resistance may be increased when the medium passes through the at least one liquid homogenizing hole 1211, resulting in increasing energy consumption of the heat exchanger 100. If R2 > 3 mm, the size of the at least one liquid homogenizing hole 1211 surrounded by adjacent two of the plurality of padding members 121 may be excessively large, and the flow rate of the medium may be decreased, resulting in non-uniform mixing of the medium. For example, the radius R1 of each of the at least one liquid homogenizing hole 1211 may be 1 mm, 1.2 mm, or 1.5 mm. In other embodiments, a suitable size of the at least one liquid homogenizing hole 1211 may further be selected according to the flow of the medium in practical application, and the size of the at least one liquid homogenizing hole 1211 may be increased as the flow increases.

A third embodiment

[0066] Referring to FIG. 6, the distribution structure 12 may include a distribution plate 122 and a plurality of padding members 121.

[0067] The distribution plate 122 may be provided with a plurality of distribution holes 1221 for communicating the first chamber 13 with the second chamber 14. The plurality of distribution holes 1221 may have throttling effect, and there is a certain resistance when the medium passes through the plurality of distribution holes 1221. Since gas-liquid mixing ratios are different, the resistance generated when the medium passes through the plurality of distribution holes 1221 may be different. The gas-liquid two-phase medium may be fully mixed by different resistance, so that uniform liquid distribution may be performed initially. In addition, the flow rate of the medium may be increased.

[0068] The plurality of padding members 121 may perform a function of uniformly mixing the medium and occupying internal space of the liquid distributor 10. When the gas-liquid two-phase medium flows into the liquid distributor 10, since a certain gap exists among the plurality of padding members 121, the gas-liquid two-phase medium may keep the relatively high flow rate, and may be interfered by the plurality of padding members 121, and collision interference may continue to occur on the gas-liquid two-phase medium, so that a mixing scale in the medium may become smaller, i.e., mixing uniformity of the gas-liquid two-phase medium may be improved, thereby improving heat exchange efficiency of the heat exchanger 100.

[0069] In an embodiment, the plurality of padding members 121 may be located in the first chamber 13 and be connected to the distribution plate 122. After the medium enters the first chamber 13, the gas-liquid two-phase medium may be uniformly mixed by the plurality of padding members 121 first, be uniformly distributed into the second chamber 14 by the plurality of distribution holes 1221, and then flow into the plurality of heat exchange tubes 20 for heat exchange, thereby further improving mixing uniformity of the medium.

[0070] In another embodiment, the plurality of padding members 121 may be located in the second chamber 14 and be connected to the distribution plate 122. After the medium enters the first chamber 13, the gas-liquid two-phase medium may be uniformly distributed into the second chamber 14 by the plurality of distribution holes 1221, further be uniformly mixed by the plurality of padding members 121, and then flow into the plurality of heat exchange tubes 20 for heat exchange, thereby further improving mixing uniformity of the medium.

[0071] In another embodiment, the plurality of padding members 121 may be located in the first chamber 13 and the second chamber 14, respectively, and be connected to the distribution plate 122, respectively. After the medium enters the first chamber 13, the gas-liquid two-phase medium may be uniformly mixed by the plurality of padding members 121 first, be uniformly distributed into the second chamber 14 by the plurality of distribution holes 1221, further be uniformly mixed by the plurality of padding members 121 in the second chamber 14, and then flow into the plurality of heat exchange tubes 20 for heat exchange, thereby further improving mixing uniformity of the medium.

[0072] Referring to FIG. 4 and FIG. 5, the plurality of padding members 121 may be distributed sequentially along a length direction and a width direction of the distribution plate 122, and adjacent two of the plurality of padding members 121 may be connected with each other, so that a plate structure may be defined by the plurality of padding members 121. At least one liquid homogenizing hole 1211 may be formed among the plurality of padding members 121. Adj acent two of the plurality of padding members 121 may mutually abut against each other and be connected with each other, so that a size of a gap between adj acent two of the plurality of padding members 121 may be reduced, and the flow rate of the medium may be improved, thereby improving mixing uniformity of the gas-liquid two-phase medium. On the other hand, connection strength among the plurality of padding members 121 may be improved, and structural stability of the liquid distributor 10 may be increased.

[0073] In an embodiment, the plate structure defined by the plurality of padding members 121 may be located in the first chamber 13 and be connected to the distribution plate 122. After the medium enters the first chamber 13, the medium may impact on the surface of the plurality of padding members 121, flow into a nearby liquid homogenizing hole 1211 for a first uniform distribution, flow through the liquid homogenizing hole 1211 to the plurality of distribution holes 1221, pass through the plurality of distribution holes 1221 for a second uniform distribution, enter the second chamber 14, and then flow into the plurality of heat exchange tubes 20 for heat exchange. Under a joint action of the plurality of padding members 121 and the plurality of distribution holes 1221, the gas-liquid two-phase medium may be mixed more uniformly, and uniform distribution may be implemented. In this way, the heat exchange efficiency of the heat exchanger 100 may further be improved.

[0074] In another embodiment, the plate structure defined by the plurality of padding members 121 may be located in the second chamber 14 and be connected to the distribution plate 122. After the medium enters the first chamber 13, the medium may pass through plurality of distribution holes 1221 for a first uniform distribution, enter the second chamber 14, impact on the surface of the plurality of padding members 121, flow out from a nearby liquid homogenizing hole 1211 for a second uniform distribution, and then flow into the plurality of heat exchange tubes 20 for heat exchange. Under a joint action of the plurality of padding members 121 and the plurality of distribution holes 1221, the gas-liquid two-phase medium may be mixed more uniformly, and uniform distribution may be implemented. In this way, the heat exchange efficiency of the heat exchanger 100 may further be improved.

[0075] In another embodiment, both the first chamber 13 and the second chamber 14 may be provided with the plate structure defined by the plurality of padding members 121, and connected to the distribution plate 122, respectively. After the medium enters the first chamber 13, the medium may impact on the surface of the plurality of padding members 121, flow into a nearby liquid homogenizing hole 1211 for a first uniform distribution, flow to the plurality of distribution hole 1221 for a second uniform distribution, and then enter the second chamber 14. In the second chamber 14, the medium may impact on the surface of the plurality of padding members 121, flow out from a nearby liquid homogenizing hole 1211 for a third uniform distribution, and then flow into the plurality of heat exchange tubes 20 for heat exchange. Under a joint action of the plurality of padding members 121 and the plurality of distribution holes 1221, the gas-liquid two-phase medium may be mixed more uniformly, and uniform distribution may be implemented. In this way, the heat exchange efficiency of the heat exchanger 100 may further be improved.

[0076] In an embodiment, referring to FIG. 4, the plurality of padding members 121 may be arranged in a matrix manner. The plurality of padding members 121 that are arranged at a uniform interval may further perform a function of uniformly mixing the gas-liquid two-phase medium.

[0077] In another embodiment, referring to FIG. 5, the plurality of padding members 121 may be divided into multiple rows along the length direction of the distribution plate 122. The plurality of padding members 121 in adjacent two of multiple rows may be arranged in staggered manner. In this way, the size of the at least one liquid homogenizing hole 1211 surrounded by the plurality of padding members 121 may further be decreased, and the medium may keep a higher flow rate when the medium flows into the at least one liquid homogenizing hole 1211, thereby improving mixing uniformity of the medium. In other embodiments, each of the plurality of padding members 121 may also be disposed in a circular shape on the distribution plate 122, as long as the same effect may be met.

[0078] Referring to FIG. 6, the turbulence plate 15 may be provided with a plurality of turbulence holes 151 matched with shapes of the plurality of heat exchange tubes 20. The plurality of turbulence holes 151 may be disposed at intervals along a length direction of the turbulence plate 15, the plurality of distribution holes 1221 may be disposed at intervals along a length direction of the distribution plate 122, and the axis of each of the plurality of turbulence holes 151 may be overlapped with the axis of each of the plurality of distribution holes 1221, respectively. It may be understood that, after entering the first chamber 13, the medium may quickly flow into the second chamber 14 by the plurality of distribution holes 1221 on the distribution plate 122. Since the axis of each of the plurality of turbulence holes 151 is overlapped with the axis of each of the plurality of distribution holes 1221, respectively, i.e., the plurality of distribution holes 1221 are facing the plurality of turbulence holes 151, which facilitates circulation of the medium, the medium after uniform distribution may directly flow into the plurality of heat exchange tubes 20, thereby improving heat exchange performance of the heat exchanger 100.

[0079] Furthermore, the turbulence plate 15 may be provided with a plurality of turbulence holes 151 matched with shapes of the plurality of heat exchange tubes 20, and a cross-sectional area of each of the plurality of turbulence holes 151 may be greater than that of each of the plurality of distribution holes 1221. When the medium passes through the plurality of distribution holes 1221, the flow rate of the medium may be accelerated, so that the medium may further be mixed uniformly, and the heat exchange efficiency of the heat exchanger 100 may be improved.

[0080] Referring to FIG. 1, FIG. 6, and FIG. 7, the sleeve 11 provided in the present invention includes a body 111, a first end cap 112, and a second end cap 113. The first end cap 112 may be blocked at an end of the body 111. The second end cap 113 may be blocked at an end of the body 111 away from the first end cap 112. In this way, the sleeve 11 may be closed, so that the medium may circulate according to a planned circulation path, thereby avoiding leakage. In addition, the first end cap 112 and the second end cap 113 may facilitate assembly and positioning of the distribution plate 122 and the turbulence plate 15, thereby improving assembly efficiency of the heat exchanger 100.

[0081] An inlet nozzle 40 may penetrate a sidewall of the sleeve 11 opposite to the heat exchange tubes 20.

[0082] Referring to FIG. 6, in an embodiment, the sleeve 11 may be a cube, and the sleeve 11 disposed in a square may facilitate being welded to the plurality of heat exchange tubes 20 and the inlet nozzle 40, thereby improving production efficiency of the heat exchanger 100.

[0083] Referring to FIG. 7, in another embodiment, the sleeve 11 may be a cylindrical body, the sleeve 11 with the cylindrical body may be connected to the inlet nozzle 40 by a nozzle base 50, and a side of the nozzle base 50 proximal to the sleeve 11 may include a surface that is matched with a side surface of the sleeve 11, which facilitates being welded and fixed to the sleeve 11. A side of the nozzle base 50 away from the sleeve 11 may include a plane, which facilitates being connected to the inlet nozzle 40.

[0084] A heat exchanger 100 is further provided in the present invention, including the liquid distributor 10, a plurality of fins 30, and the plurality of heat exchanger tubes 20. The plurality of fins 30 are disposed at intervals and in parallel. The plurality of heat exchange tubes 20 penetrate the plurality of fins 30, respectively, and an end of each of the plurality of heat exchange tubes 20 is in communication with the liquid distributor 10. The heat exchanger 100 further includes a manifold (not shown in the figures), and the manifold is configured to aggregate the medium after heat exchange.

[0085] In an embodiment, the plurality of heat exchange tubes 20 may be arranged at intervals along a height direction of the heat exchanger 100 to form a column. In other embodiments, the plurality of heat exchange tubes 20 may be arranged at intervals along a width direction of the heat exchanger 100 to form a plurality of columns, and heat exchange tubes 20 in adjacent columns may be connected by a bent tube. When the number of columns of the plurality of heat exchange tubes 20 is an odd number, the manifold may be located at a side of the heat exchanger 100 away from the liquid distributor 10. When the number of columns of the plurality of heat exchange tubes 20 is an even number, the manifold may be located at the same side of the heat exchanger 100 as the liquid distributor 10.

[0086] Furthermore, the heat exchanger 100 may further include a dispenser (not shown in the figures), and an end of the dispenser may be connected to the liquid distributor 10. The dispenser may include a capillary tube in communication with the inlet nozzle 40.

[0087] In a practical application, the liquid distributor 10 may be set vertically. When the heat exchanger 100 is in operation, the medium enters the inlet nozzle 40 from the capillary tube, enters the liquid distributor 10, enters the plurality of heat exchange tubes 20 after uniform distribution of the distribution structure 12 and the turbulence plate 15, and performs heat exchange with the outside by the plurality of fins 30. The medium after heat exchange is converged to the manifold to flow out.

[0088] Furthermore, referring to FIG. 9, the heat exchanger 100 may include a plurality of liquid distributors 10, and the plurality of liquid distributors 10 may be distributed at intervals along the height direction of the heat exchanger 100. The dispenser may include a plurality of capillary tubes, and the plurality of capillary tubes may be connected to corresponding inlet nozzles 40, respectively.

[0089] In other embodiments, the quantity of the liquid distributors 10 and the quantity of the capillary tubes on the heat exchanger 100 may be changed as required. For example, both the quantity of the liquid distributors 10 and the quantity of the capillary tubes may be one, two, or three, as long as the quantity of the liquid distributors 10 is consistent with the quantity of the capillary tubes.

[0090] Furthermore, referring to FIG. 8 and FIG. 9, in the present invention, a single liquid distributor 10 may be connected to the inlet nozzle 40 and the plurality of heat exchange tubes 20 to form a liquid distributor unit 60. In this way, production efficiency of the heat exchanger 100 may be improved by facilitating modular production.

[0091] The various technical features of the above-described embodiments may be combined arbitrarily, and all possible combinations of the various technical features of the above-described embodiments have not been described for the sake of brevity of description. However, as long as there is no contradiction in the combination of these technical features, they should be considered to be within the scope of this description.

[0092] The foregoing embodiments represent only several implementation manners of the present invention, and descriptions thereof are relatively specific and detailed, but may not be construed as a limitation on the scope of the present invention. It should be noted that one skilled in the art may make some modifications and improvements without departing from the concept of the present invention, which are within the protection scope of the present invention. Therefore, the protection scope of the present invention shall be subject to the appended claims.

Claims

1. A liquid distributor, **characterized by** comprising a sleeve, a distribution structure, and a turbulence plate,

   wherein the sleeve is penetrated by a plurality of heat exchange tubes;
   the distribution structure is located inside the

sleeve and is connected to the sleeve, the distribution structure is capable of dividing the interior of the sleeve into at least a first chamber and a second chamber in communication with each other, the first chamber is located at a side of the distribution structure away from the plurality of heat exchange tubes, and the second chamber is located at a side of the distribution structure proximal to the plurality of heat exchange tubes; and

the turbulence plate is located in the second chamber and is connected to the sleeve, the turbulence plate is spaced apart from the distribution structure, and the plurality of heat exchange tubes are partly inserted into the turbulence plate and are in communication with the second chamber.

2. The liquid distributor of claim 1, wherein the turbulence plate is provided with a plurality of turbulence holes matched with shapes of the plurality of heat exchange tubes, each of the plurality of heat exchange tubes extends into corresponding one of the plurality of turbulence holes, and a length of each of the plurality of heat exchange tubes that extends into the corresponding one of the plurality of turbulence holes is less than a depth of the turbulence hole; or, an end of each of the plurality of heat exchange tubes that extends into the corresponding one of the plurality of turbulence holes is flush with a side surface of the turbulence plate proximal to the distribution structure.

3. The liquid distributor of claim 1, wherein a shape of the distribution structure is a plate, and the distribution structure is provided with a plurality of distribution holes for communicating the first chamber with the second chamber.

4. The liquid distributor of claim 3, wherein the plurality of distribution holes are spaced along a length direction of the distribution structure, or the plurality of distribution holes are arranged in a matrix manner.

5. The liquid distributor of claim 3, wherein each of the plurality of distribution holes are in a circular shape or a polygonal shape.

6. The liquid distributor of claim 3, wherein each of the plurality of distribution holes are in a circular shape, and a radius of each of the plurality of distribution holes is defined as R1, and the radius R1 of each of the plurality of distribution holes satisfies a following formula: $0.5 \text{ mm} \leq R1 \leq 2 \text{ mm}$.

7. The liquid distributor of claim 1, wherein the distribution structure comprises a plurality of padding members, the plurality of padding members are distributed sequentially along a length direction and a width direction of the turbulence plate, and adjacent two of the plurality of padding members are connected with each other, so that a plate structure is defined by the plurality of padding members; and

at least one liquid homogenizing hole for communicating the first chamber with the second chamber is formed among the plurality of padding members.

8. The liquid distributor of claim 7, wherein the plurality of padding members are arranged in a matrix manner; or

along the length direction of the turbulence plate, the plurality of padding members are divided into multiple rows, and the plurality of padding members in adjacent two of multiple rows are arranged in a staggered manner.

9. The liquid distributor of claim 7, wherein each of the plurality of padding members is a rotating body or a polyhedron.

10. The liquid distributor of claim 9, wherein the plurality of padding members are in a spherical shape, and a radius of each of the plurality of padding members is defined as R2, and the radius R2 of each of the plurality of padding members satisfies a following formula: $0.5 \text{ mm} \leq R2 \leq 3 \text{ mm}$.

11. The liquid distributor of claim 1, wherein the distribution structure comprises a distribution plate and a plurality of padding members,

the distribution plate is provided with a plurality of distribution holes for communicating the first chamber with the second chamber; and

the plurality of padding members are located in either or both of the first chamber and the second chamber, and the plurality of padding members are connected to the distribution plate.

12. The liquid distributor of claim 11, wherein the plurality of padding members are distributed sequentially along a length direction and a width direction of the distribution plate, and adj acent two of the plurality of padding members are connected with each other, so that a plate structure is defined by the plurality of padding members; and

at least one liquid homogenizing hole is formed among the plurality of padding members.

13. The liquid distributor of claim 12, wherein the plurality of padding members are arranged in a matrix manner; or

along the length direction of the distribution plate, the plurality of padding members are divided into multiple rows, and the plurality of padding members in adjacent two of multiple rows are arranged in a staggered manner.

14. The liquid distributor of claim 11, wherein the turbulence plate is provided with a plurality of turbulence holes matched with shapes of the plurality of heat exchange tubes, the plurality of turbulence holes are disposed at intervals along a length direction of the turbulence plate, the plurality of distribution holes are disposed at intervals along a length direction of the distribution plate, and an axis of each of the plurality of turbulence holes is overlapped with an axis of each of the plurality of distribution holes, respectively.

15. The liquid distributor of claim 11, wherein the turbulence plate is provided with a plurality of turbulence holes matched with shapes of the plurality of heat exchange tubes, and a cross-sectional area of each of the plurality of turbulence holes is greater than that of each of the plurality of distribution holes.

16. A heat exchanger, **characterized by** comprising the liquid distributor of any one of claims 1 to 15, a plurality of fins, and the plurality of heat exchange tubes,

wherein the plurality of fins are disposed at intervals and in parallel; and
the plurality of heat exchange tubes penetrate the plurality of fins, respectively, and an end of each of the plurality of heat exchange tubes is in communication with the liquid distributor.

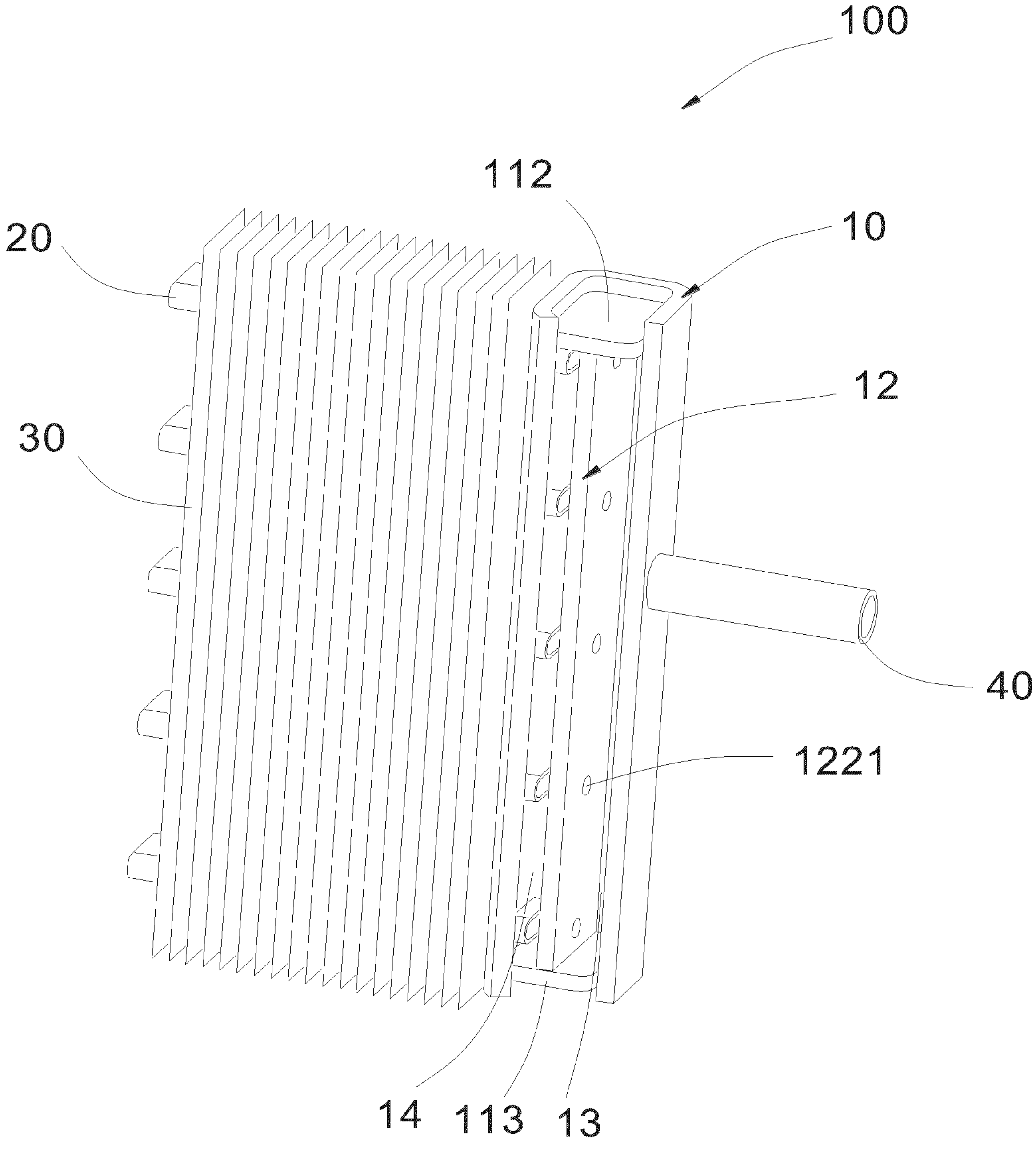

FIG. 1

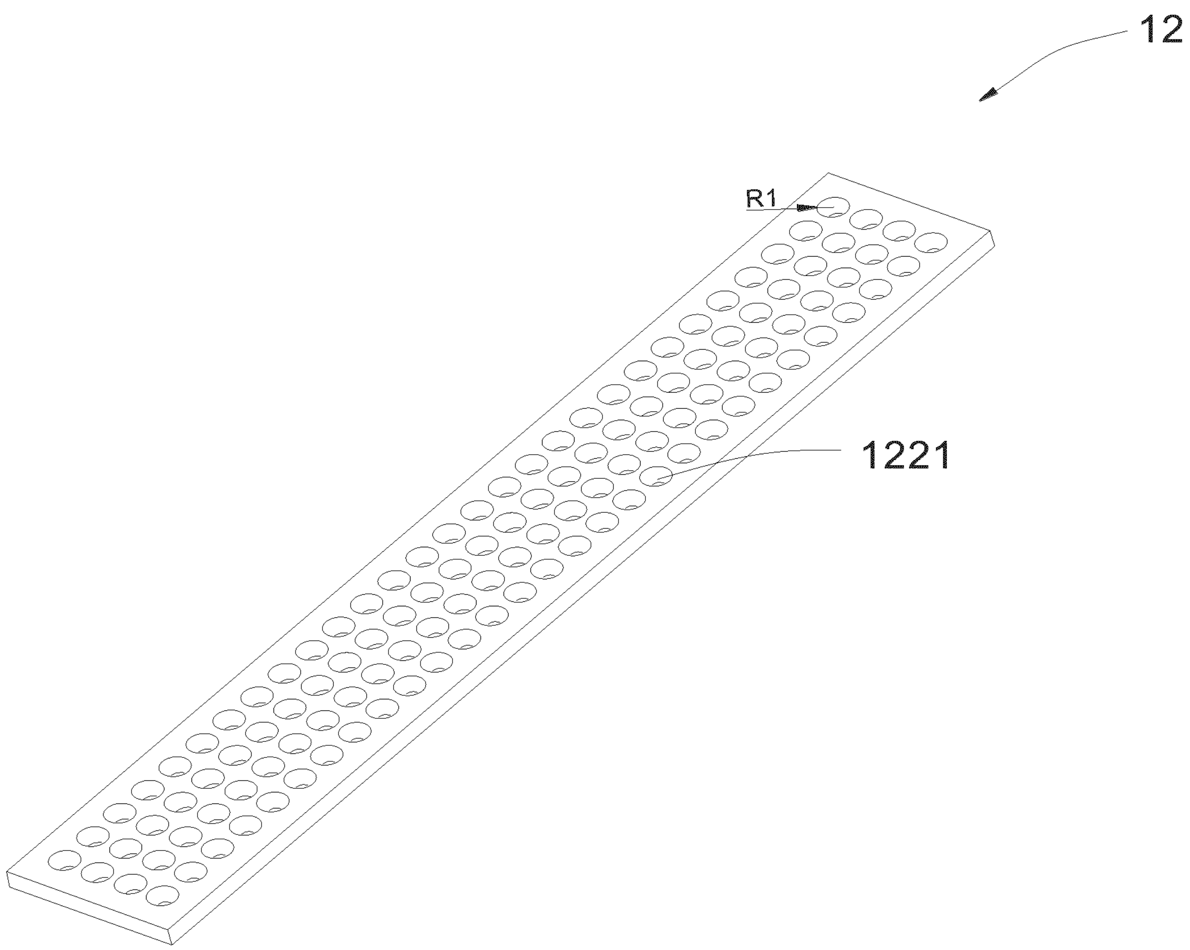

FIG. 2

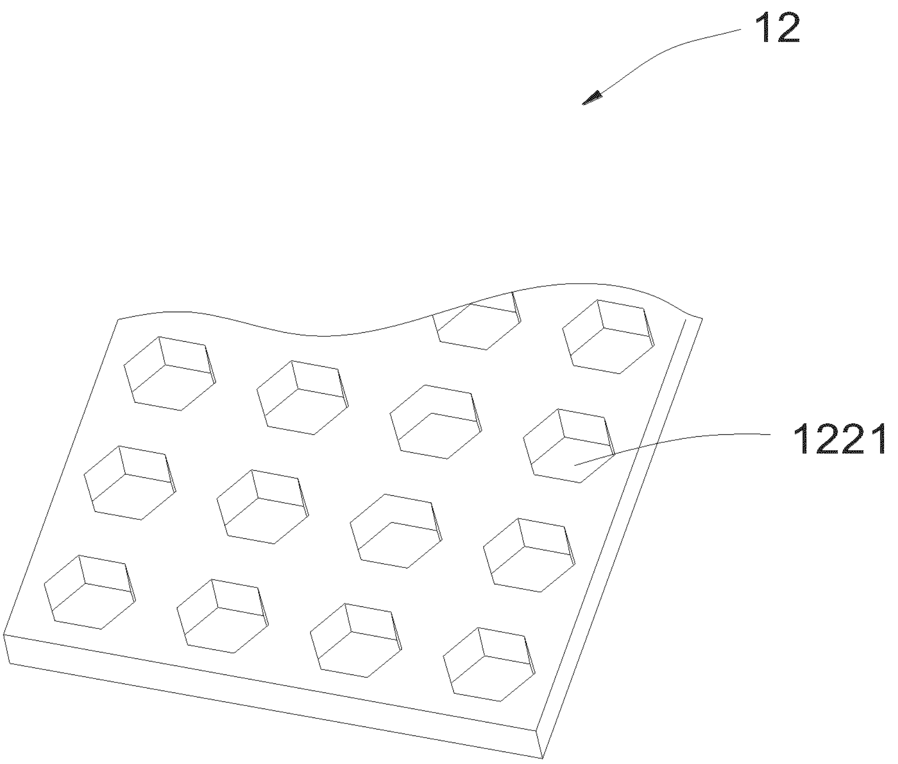

FIG. 3

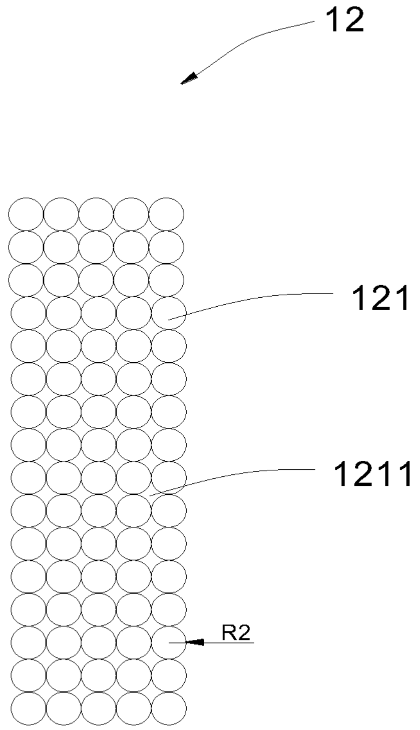

FIG. 4

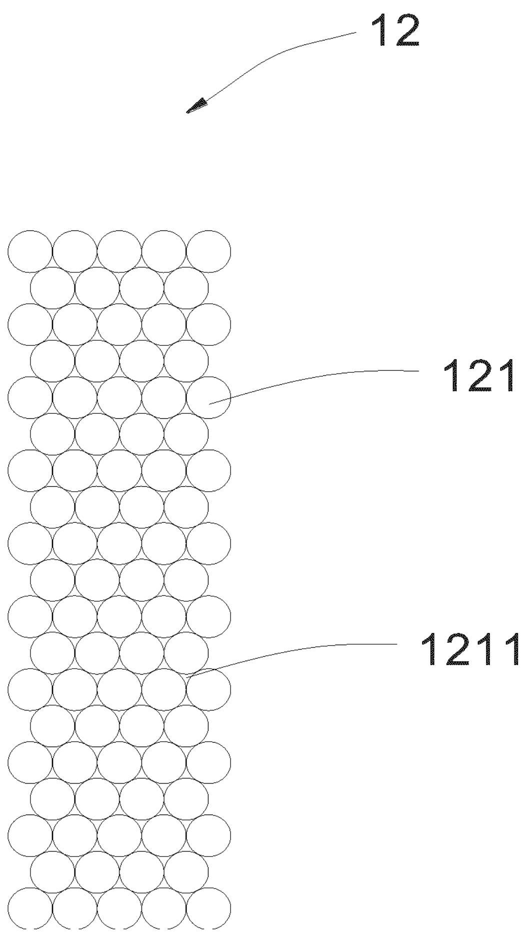

FIG. 5

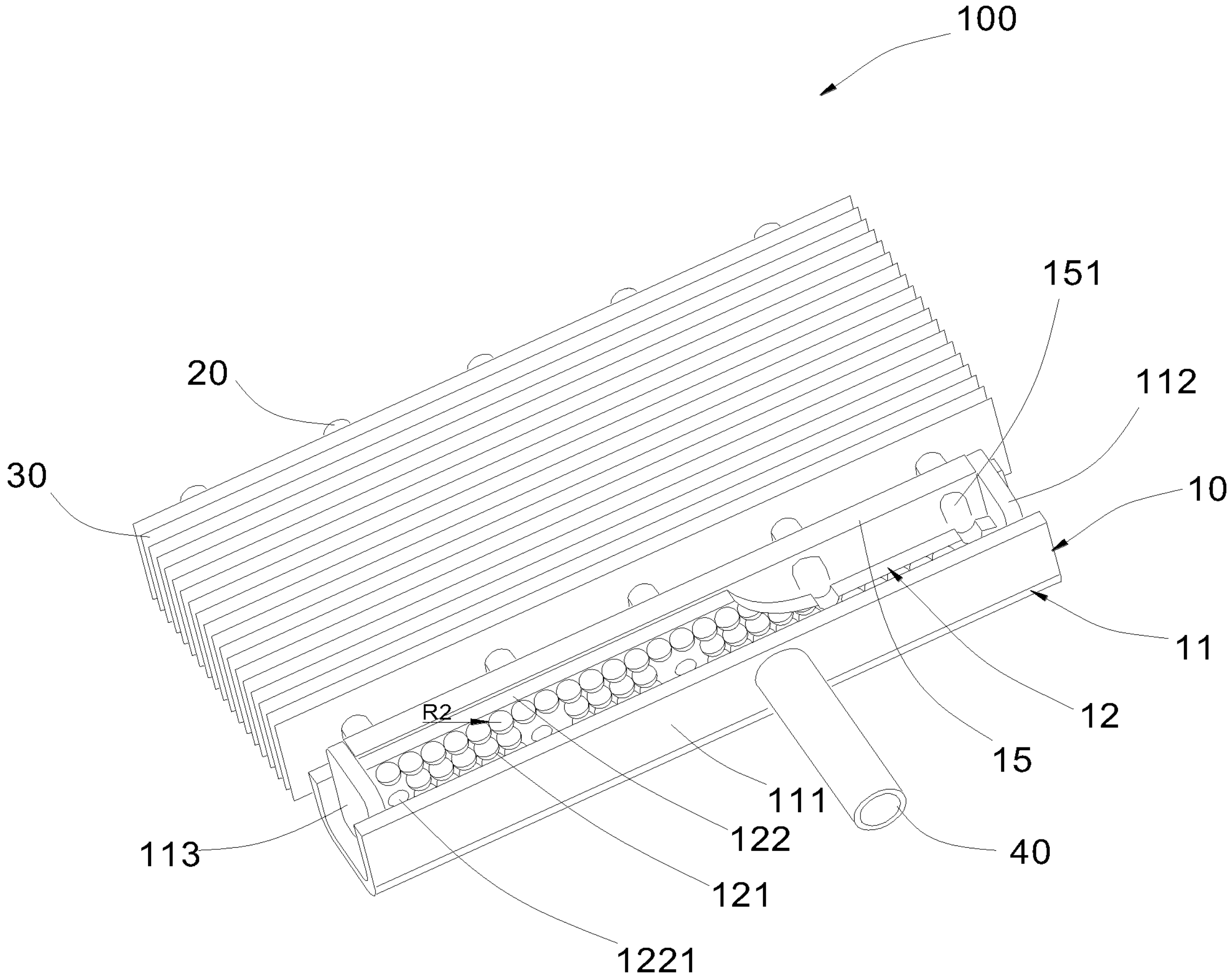

FIG. 6

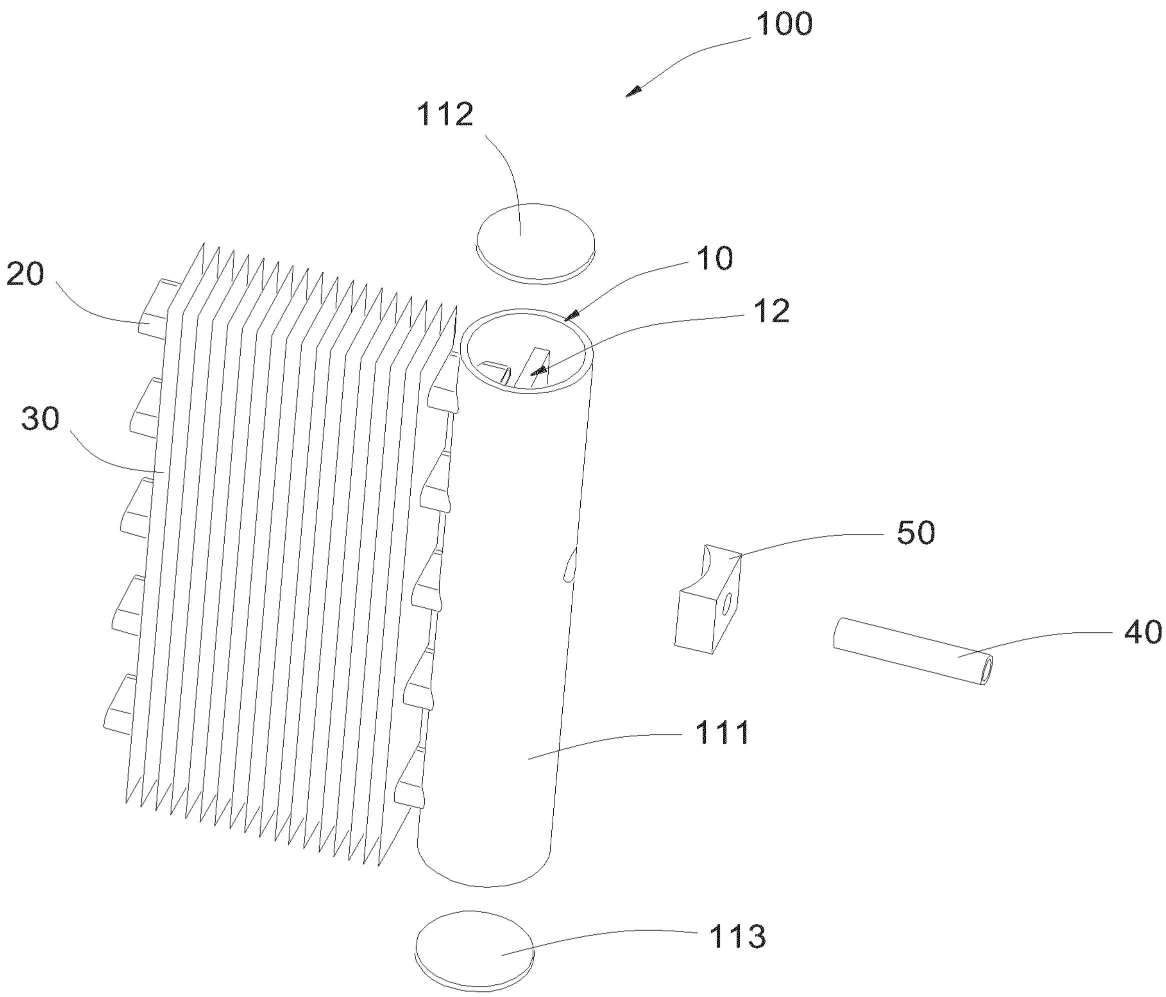

FIG. 7

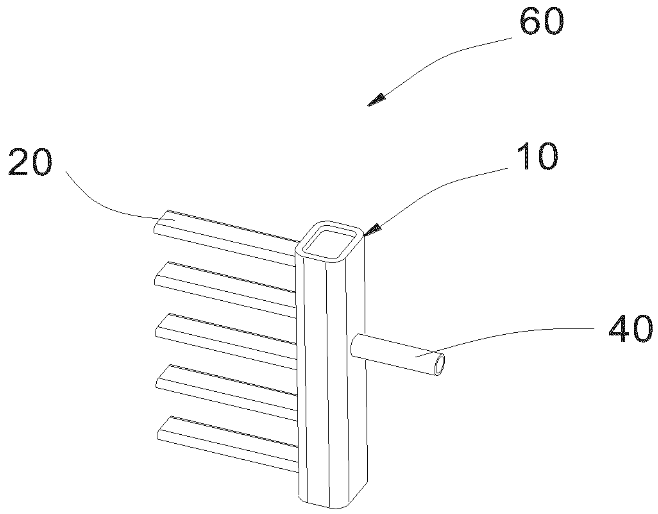

FIG. 8

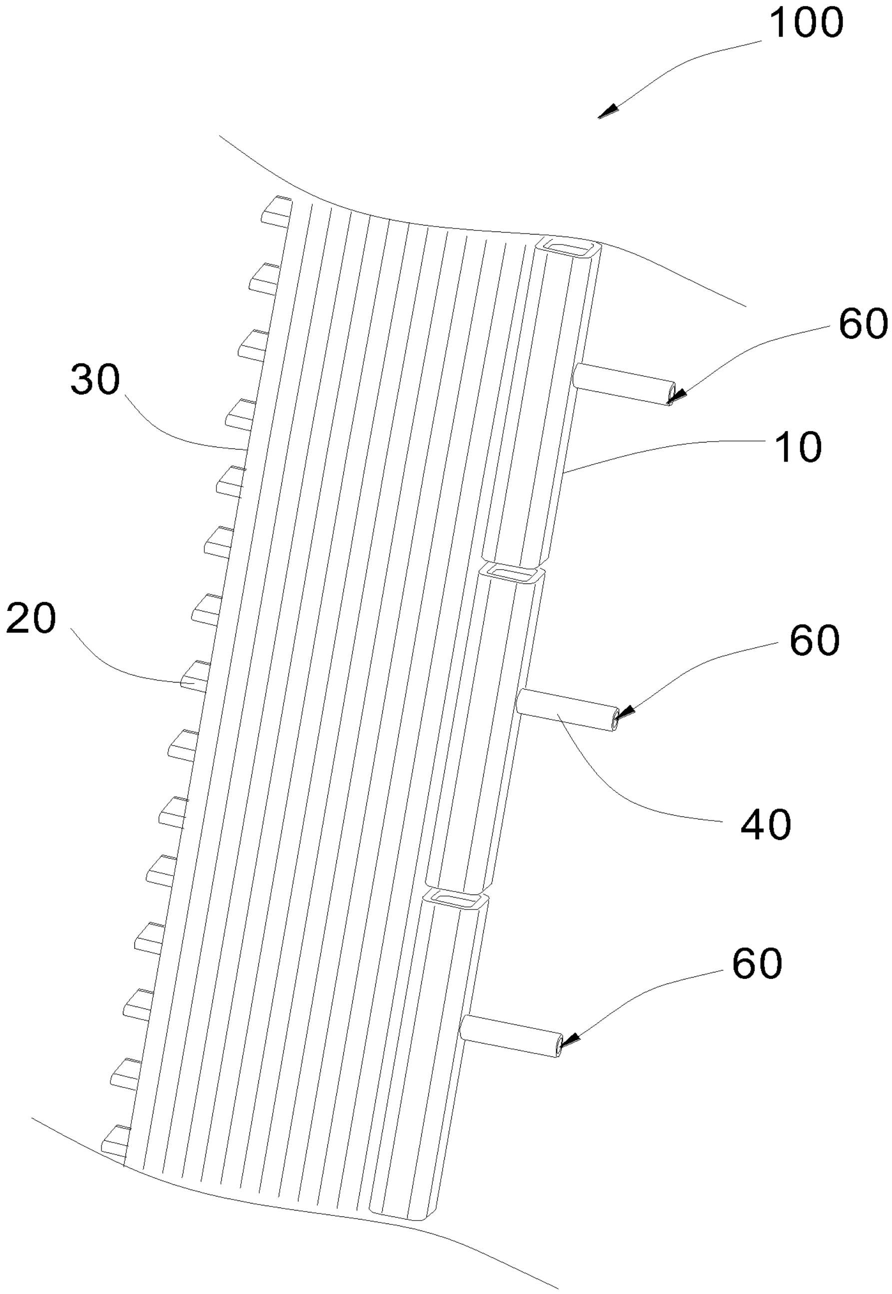

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/096861

A. CLASSIFICATION OF SUBJECT MATTER

F28F9/02(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: F28F1 F28F9 F25B

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, ENTXTC, VEN, WPABS, CNKI: 集管 集流管 分配 分流 分液 板紊流 湍流 齐平 header tube pipe conduit distribut + divid+ plate panel board turbulen+ flush

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 217979382 U (ZHEJIANG DUNAN THERMAL TECHNOLOGY CO., LTD.) 06 December 2022 (2022-12-06) entire document	1-16
Y	CN 203132410 U (SANHUA (HANGZHOU) MICRO CHANNEL HEAT EXCHANGER CO., LTD.) 14 August 2013 (2013-08-14) description, paragraphs [0032]-[0065], and figures 1-6	1-6, 16
Y	US 2017074601 A1 (VALEO SYSTEMES THERMIQUES) 16 March 2017 (2017-03-16) description, paragraphs [0029]-[0040], and figure 1	1-6, 16
A	CN 215064000 U (ZHEJIANG DUNAN THERMAL TECHNOLOGY CO., LTD.) 07 December 2021 (2021-12-07) entire document	1-16
A	US 2017092382 A1 (GE HITACHI NUCLEAR ENERGY AMERICAS LLC.) 30 March 2017 (2017-03-30) entire document	1-16

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
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- "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
- "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
- "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
- "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
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 August 2023	**15 August 2023**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/096861

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	217979382	U	06 December 2022	None			
CN	203132410	U	14 August 2013	None			
US	2017074601	A1	16 March 2017	US	10180290	B2	15 January 2019
				KR	20160145137	A	19 December 2016
				WO	2015169807	A1	12 November 2015
				MX	2016014497	A	23 May 2017
				JP	2017515086	A	08 June 2017
				EP	3140604	A1	15 March 2017
				EP	3140604	B1	05 July 2023
				FR	3020671	A1	06 November 2015
				FR	3020671	B1	10 June 2016
CN	215064000	U	07 December 2021	None			
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				US	11322266	B2	03 May 2022
				WO	2017058861	A1	06 April 2017
				US	10553322	B2	04 February 2020

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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- CN 202210669534 **[0001]**