



(12)

EUROPEAN PATENT APPLICATION

- (43)

Date of publication:
26.06.2024 Bulletin 2024/26

(51)

International Patent Classification (IPC):
F28D 1/04 (2006.01) F28D 1/053 (2006.01)
F28D 3/02 (2006.01) F28F 1/02 (2006.01)
- (21)

Application number: 23219784.8

(52)

Cooperative Patent Classification (CPC):
F28D 1/05383; F28D 1/0443; F28D 3/02;
F28F 1/025; F28F 9/0282; F28F 1/022
- (22)

Date of filing: 22.12.2023

(84) Designated Contracting States: AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR Designated Extension States: BA Designated Validation States: KH MA MD TN	(71) Applicant: Carrier Corporation Palm Beach Gardens, FL 33418 (US) (72) Inventor: JOARDAR, Arindom East Syracuse, New York 13057 (US) (74) Representative: Dehns St. Bride's House 10 Salisbury Square London EC4Y 8JD (GB)
(30) Priority: 23.12.2022 US 202263477124 P	

(54)

MICROCHANNEL TUBE FOR EVAPORATORS

(57) A microchannel tube for an inlet manifold of an evaporator having a downward flow configuration is disclosed. The tube is a hollow member comprising a plurality of channels configured therewithin and extending parallelly between opposite ends of the tube. One end of the tube is adapted to be disposed of within the inlet manifold such that a first section of the tube remains disposed of within the manifold and the tube protrudes at a predefined angle in a downward direction from the inlet manifold. Further, a predetermined area of a first wall and/or a second wall of the first section of the tube, at a bottom end of the first section, is removed such that the plurality of channels of the tube are exposed to a fluid present in the manifold via the predetermined removed area.

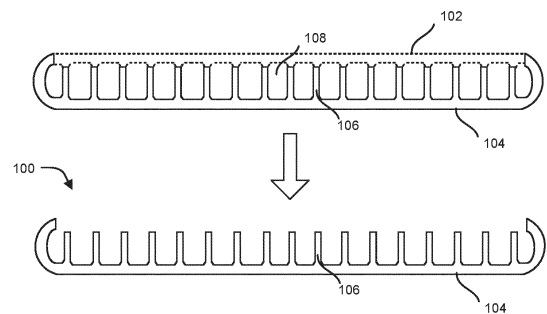


FIG. 1A

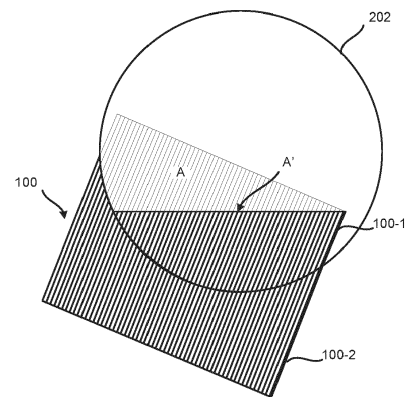


FIG. 1B

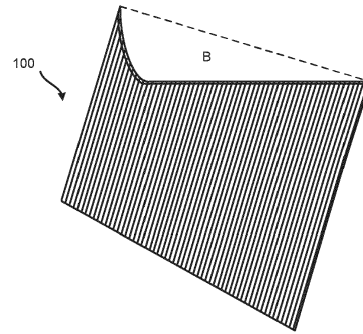


FIG. 1C

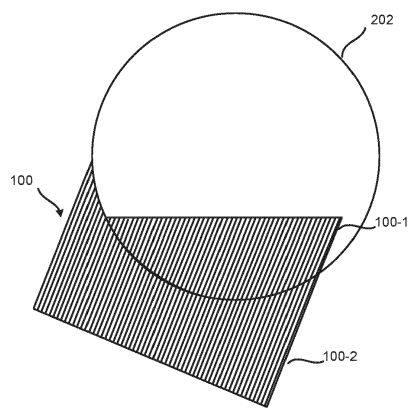


FIG. 1D

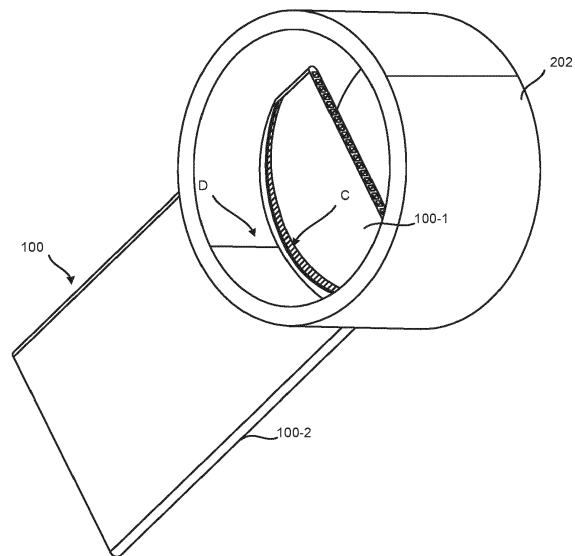


FIG. 1E

Description

[0001] This patent application claims the benefit of US Provisional Patent Application No. 63/477,124, filed on Dec 23, 2022, which is incorporated by reference herein in its entirety.

[0002] This invention relates to the field of evaporators, and more particularly, a microchannel tube for the inlet manifold of evaporators.

[0003] Existing evaporators having a downward flow configuration generally have an inlet manifold (header) that allows a fluid (refrigerant) associated with the evaporator to flow out of the inlet manifold in a downward direction. These evaporators generally include inclined multichannel tubes having one end of the tubes within the inlet manifold and another end of the tubes protruding from the inlet manifold in the downward direction and further connected to an outlet manifold. Even distribution of the fluid (refrigerant) in the multichannel tubes results in more efficient operation but may be difficult to achieve.

[0004] There is, therefore, a need to enable even distribution of fluid or refrigerant within the inlet manifold of the evaporator.

[0005] According to a first aspect of the invention there is provided a microchannel tube for a manifold of an evaporator having a V-coil configuration. The microchannel tube comprises a hollow member defining a shape of the tube and comprising a plurality of channels configured therewithin and extending parallelly between a first end and a second end of the hollow member, wherein, the first end of the tube is adapted to be disposed within the manifold such that a first section of the tube at the first end remains disposed of within the manifold and the tubes protrude at a predefined angle in a downward direction from the inlet manifold, wherein a predetermined area of a first wall and/or a second wall of the first section of the tube, at a bottom end of the first section, is removed such that the plurality of channels of the tube are exposed to a fluid present in the manifold via the predetermined removed area.

[0006] Optionally, the manifold is a hollow cylinder, wherein the predetermined removed area is adjacent to an inner-bottom curved surface of the manifold within the manifold.

[0007] Optionally, the predetermined removed area has a curved profile corresponding to profile of the inner-bottom curved surface of the manifold.

[0008] Optionally, at least a portion of the first end of the tube is trimmed off such that a top edge of the trimmed tube is oriented horizontally, which laterally exposes the inlet ports to the fluid within the manifold.

[0009] Optionally, the microchannel tube has a flat profile, wherein the first wall and the second wall are flat.

[0010] Optionally, the tube comprises one or more partition walls extending between two the first wall and the second wall of the tube, such that the plurality of channels is created between the adjacent partition walls within the tube.

[0011] Optionally, the tube is inclined at the predefined angle from a longitudinal axis of the manifold and protrudes at the predefined angle in a downward direction from the manifold, and wherein the first wall of the tube faces a fluid inlet side of the inlet manifold and the second wall of the tube faces a side opposite to the fluid inlet side of the inlet manifold.

[0012] The invention may provide a manifold comprising the microchannel tube as recited herein with reference to the first aspect of the invention. The invention may provide an evaporator (e.g. having a V-coil configuration) comprising a manifold comprising the microchannel tube as recited herein with reference to the first aspect of the invention.

[0013] According to a second aspect of the invention, there is provided a downward flow configuration evaporator comprising an inlet manifold, an outlet manifold, and a plurality of microchannel tubes fluidically configured between the inlet manifold and the outlet manifold in a downward flow configuration such that the tubes protrude at a predefined angle in a downward direction from the inlet manifold, wherein each of the tubes is a hollow member comprising a plurality of channels configured therewithin and extending parallelly between opposite ends within the hollow member; wherein, a first end of each of the tubes is adapted to be disposed of within the inlet manifold such that a first section of each of the tube at the first end remains disposed of within the inlet manifold, and a predetermined area of a first wall of the first section of the tube, at a bottom end of the first section, is removed such that the plurality of channels of each of the tubes are exposed to a fluid present in the manifold via the predetermined removed area.

[0014] Optionally, the evaporator is in a downward fluid flow configuration having a V-Coil arrangement.

[0015] Optionally, the manifold is a hollow cylinder, wherein the predetermined removed area is adjacent to an inner-bottom curved surface of the manifold within the manifold.

[0016] Optionally, at least a portion of the first end of each of the tubes is trimmed off to laterally expose the inlet ports associated with each of the tubes to the fluid of the inlet manifold.

[0017] Optionally, the evaporator comprises a plurality of heat dissipating fins extending between adjacent tubes among the plurality of tubes.

[0018] Optionally, the plurality of tubes are spaced apart by a predefined distance along a length of the inlet manifold.

[0019] Optionally, the microchannel tube is a flat tube, and wherein the first wall of the tube faces a fluid inlet side of the inlet manifold, and the second wall of the tube faces a side opposite to the inlet side of the inlet manifold.

[0020] Optionally, the inlet manifold is a cylindrical housing having an opening at fluid inlet side of the cylindrical housing, wherein the inlet manifold is configured to receive the fluid via the opening.

[0021] Optionally, the flat wall of each of the tubes is

oriented perpendicular to a longitudinal axis of the inlet manifold.

[0022] Each of the plurality of microchannel tubes of the second aspect of the invention may be a microchannel tube as recited herein with reference to the first aspect of the invention, and hence may comprise any of the features recited herein.

[0023] According to a third aspect of the invention, there is provided a method for enabling even distribution of a fluid across inlet ports of tubes within an inlet manifold of an evaporator having a downward flow configuration. The method comprising the steps of removing a predetermined area of a first wall and/or a second wall of each of the tubes, wherein the predetermined removed area is at a predefined distance below a first end of the tubes" and disposing the first end of the tubes within the inlet manifold of the evaporator such that a first section of the tubes at the first end remain within the inlet manifold and the tubes protrude from the inlet manifold in a downward direction making a predefined angle from a plane of the inlet manifold, wherein the first end of each of the tubes is disposed within the inlet manifold such that the predetermined removed area remains within the manifold at a bottom end of the first section of the tubes to expose the plurality of channels of the tubes to a fluid present in the manifold via the predetermined removed area.

[0024] Optionally, the manifold is a hollow cylinder, wherein the predetermined area of the first wall and/or the second wall of the first section of the tubes, adjacent to an inner-bottom curved surface of the manifold.

[0025] Optionally, predetermined removed area has a curved profile corresponding to profile of the inner-bottom curved surface of the manifold.

[0026] Optionally, the method comprises the step of laterally exposing the inlet ports of the tubes by trimming off at least a portion of the first end of each of the tubes such that a top edge of the trimmed tubes is oriented horizontally.

[0027] The method may comprise providing, arranging, and/or using the microchannel tube as recited herein with reference to the first aspect of the invention, and/or the evaporator as recited herein with reference to the second aspect of the invention.

[0028] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, features, and techniques of the invention will become more apparent from the following description taken in conjunction with the drawings.

[0029] The accompanying drawings are included by way of example only to provide a further understanding of the subject disclosure of this invention and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the subject disclosure and, together with the description, serve to explain the principles of the subject disclosure.

[0030] In the drawings, similar components and/or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label with a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

[0031] FIG. 1A is a schematic diagram illustrating a top view of an exemplary embodiment of the microchannel tube where one of the flat walls of a section of the tube is shaved off in accordance with one or more embodiments of the invention.

[0032] FIG. 1B is a schematic diagram illustrating the microchannel tube of FIG. 1A disposed within the inlet manifold of an evaporator in accordance with one or more embodiments of the invention.

[0033] FIG. 1C is a schematic diagram illustrating a side view of another exemplary embodiment of the microchannel tube where a top portion of the tube is trimmed off in accordance with one or more embodiments of the invention.

[0034] FIG. 1D is a schematic diagram illustrating the microchannel tube of FIG. 1C being disposed of within the inlet manifold of an evaporator in accordance with one or more embodiments of the invention.

[0035] FIG. 1E is a schematic diagram illustrating the isometric view of the microchannel tube having an area of the first wall at a bottom end of the first section being removed and the first section disposed of within the inlet manifold of an evaporator in accordance with one or more embodiments of the invention.

[0036] FIG. 2 is a schematic diagram illustrating an isometric view of an exemplary embodiment of the evaporator having a downward fluid flow configuration in accordance with one or more embodiments of the invention.

[0037] FIG. 3 is an enlarged view of FIG. 2 depicting the inlet manifold and the tubes being disposed of in the inlet manifold in accordance with one or more embodiments of the invention.

[0038] FIG. 4 is a flow diagram illustrating the steps involved in the method for enabling even distribution of fluid across inlet ports of the tubes within the inlet manifold of the evaporator in accordance with one or more embodiments of the invention

[0039] The following is a detailed description of embodiments of the disclosure depicted in the accompanying drawings. The embodiments are in such detail as to clearly communicate the disclosure. However, the amount of detail offered is not intended to limit the anticipated variations of embodiments; on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the subject disclosure as defined by the appended claims.

[0040] Various terms are used herein. To the extent a term used in a claim is not defined below, it should be given the broadest definition persons in the pertinent art

have given that term as reflected in printed publications and issued patents at the time of filing.

[0041] In the specification, reference may be made to the spatial relationships between various components and to the spatial orientation of various aspects of components as the devices are depicted in the attached drawings. However, as will be recognized by those skilled in the art after a complete reading of the subject disclosure, the components of this invention, described herein may be positioned in any desired orientation. Thus, the use of terms such as "above," "below," "upper," "lower," "first," "second" or other like terms to describe a spatial relationship between various components or to describe the spatial orientation of aspects of such components should be understood to describe a relative relationship between the components or a spatial orientation of aspects of such components, respectively, as the multichannel tube, manifold, evaporator, and corresponding components, described herein may be oriented in any desired direction.

[0042] Evaporators generally include inclined multichannel tubes having one end of the tubes within the inlet manifold and another end of the tubes protruding from the inlet manifold in the downward direction and further connected to an outlet manifold. Even distribution of the fluid (refrigerant) in the multichannel tubes results in more efficient operation but may be difficult to achieve. Due to the inclination of the tubes, the fluid column inside the inlet manifold feeds more fluid to some of the ports of the tubes, which are at a lower elevation relative to the fluid-free surface. Additionally, there may be uneven distribution from one end of the manifold to the other due at least, in part, to uneven flow into ports of the tubes. This uneven distribution or mal-distribution of fluid across the ports of the tubes may lead to the formation of a pool of fluid within the inlet manifold, which is highly undesirable as it may affect the overall performance of the evaporator and may also damage the evaporator in the worst case.

[0043] Referring to FIG. 1A to 1D, an exemplary embodiment of the microchannel tube 100 (also referred to as "tube 100") is illustrated. The tube 100 includes a hollow member which may preferably have a flat profile having opposite flat walls 102, 104 (first wall 102, and second wall 104), however, the tube 100 may also have other profiles without any limitations and all such embodiments are well within the scope of the invention. Further, tube 100 includes multiple channels 108 configured along a longitudinal axis of the tube 100 therewithin and extending parallelly between a first end (top end) and a second end (bottom end) of the hollow member such that multiple fluid flow paths (also designated as 108, herein) of a predefined radius (for example, generally in the range of millimeters) are created between the first end and second end of the tube 100, which allows fluid such as refrigerant to flow from inlet ports of channels 108 to the outlet ports of the channels 108 at the second end of the tube 100.

[0044] In some embodiments, multiple flat partition walls 106 extend parallelly between two opposite flat

walls 102, 104 of the tube 100, which may be separated equidistantly, such that square-shaped or rectangular-shaped channels 108 are created between the adjacent partition walls 106. In other embodiments (not shown), flat partition walls 106 may also be inclined at a non-perpendicular angle between two opposite flat walls 102, 104 of the tube 100 such that triangular-shaped, W-shaped, or N-shaped partition walls are created between the adjacent partition walls of the tube 100. In other embodiments (not shown), multiple curved partition walls 106 may extend parallelly between two opposite flat walls 102, 104 of the tube 100, which may be separated equidistantly, such that barrel-shaped or cylindrical-shaped channels 108 are created between the adjacent partition walls of the tube 100. In another embodiment, a flat sheet, preferably made of the same material of the hollow walls, may be machined or profiled in a step profile or zig-zag profile or sinewave profile, and the like. The step profiled sheet or zig-zag profiled sheet or sinewave profiles sheet may then be configured inside the hollow member of the tubes 100, to create multiple channels 108 within tube 100. Tube 100 is preferentially made of a lightweight, thermally conductive, and chemical-resistant material, however, the tube 100 may also be made of other materials as well. In one embodiment, tube 100 may be made of extruded aluminum.

[0045] The tubes 100 are shown in drawings hereof, for ease and clarity of illustration, as having a fixed number of channels 108 defining flow paths having a square cross-section. However, it is to be understood that in commercial applications, such as for example refrigerant vapor compression systems, each multichannel tube 100 may typically have about ten to twenty flow channels 108, but may have a greater or a lesser multiplicity of channels 108, as desired.

[0046] The first end of the tube 100 is adapted to be disposed of within the inlet manifold 202 of an evaporator 200 or heat exchanger using the brazing technique, 2-D printing technique, and other known techniques known in the art, such that the tube 100 remains inclined at a predefined angle from a horizontal planar axis of the manifold 202, with a certain section 100-1 (first section) of the tube 100 near the first end of the tube 100 disposed of within the inlet manifold 202 and another section 100-2 (second section) of the tube 100 protruding out of the inlet manifold 202 in the downward direction. Also, tube 100 is disposed within the manifold such that the flat wall or opposite walls 102, 104 of the tube 100 orients perpendicular to a longitudinal axis of the inlet manifold 202 in the direction of the incoming fluid within the manifold 202. Further, at least a portion of one wall 102 of tube 100, which is within the inlet manifold 202, is removed as shown in FIG. 1A or a top portion (B) of the first section 100-1 of the tube trimmed off as shown in FIG. 1C or a predetermined area (C) of the wall at the bottom end of the first section 100-1 of tube 100 is removed as shown in FIG. 1E such that the plurality of channels of each tube 100 are exposed to the fluid within the inlet manifold

202 via the inlet ports, the predetermined removed area (C) or both. This exposure of the inlet ports or plurality of channels enables the even distribution of fluid across the inlet ports of each tube 100 and prevents the formation of a pool of fluid within the inlet manifold 202. In one or more embodiments, the wall 102 may be shaved off as shown in FIG. 1A and 1B, prior to disposing of the first end of tube 100 within the inlet manifold 202, such that the wall 102 (first wall) has a varying height and has portions with a height that is less than the height of wall 104 (second wall). In one or more embodiments, the top portion B of tube 100 may be trimmed off as shown in FIG. 1C and 1D, prior to disposing of the first end of tube 100 within the inlet manifold 202, such that the inlet ports associated with each tube 100 are exposed laterally to the fluid within the inlet manifold 202. In one or more embodiments, the predetermined area C of the wall (first wall and/or second wall) at a bottom of the first section 100-1 of the tube 100 may be removed or kept uncovered as shown in FIG. 1E, such that the plurality of channels associated with tube 100 are exposed to the fluid through the removed or uncovered area C of the tube 100. As illustrated in FIG. 1E, the manifold 100 may be a hollow cylinder and predetermined removed area C of the tube 102 may be adjacent to an inner-bottom curved surface (D) of the manifold 100. Further, the predetermined removed area C may have a curved profile corresponding to a profile of the inner-bottom curved surface D of the manifold 100.

[0047] Referring to FIGs. 1A and 1B, one of the flat walls 102 of the first section 100-1 of the tube 100 within the manifold are at least partially removed such that the wall 102 has a varying height across the width of tube 100 and has portions with a height that is less than the height of wall 104, thereby laterally exposing the inlet ports associated with the channels 108 within the manifold to the fluid of the manifold. As illustrated in FIG. 1B, a predetermined area (A) of the wall of the first section 100-1 of the tube 100 is removed such that the bottom base A' of the predetermined area A remains horizontally oriented with respect to the manifold and the portion of the flat wall 102 above the bottom base is removed, exposing each of the inlet ports laterally to the fluid of the manifold. In some embodiments (not shown), both flat walls 102, 104 of the first section 100-1 of the tube 100 within the manifold can be removed or shaved off to laterally expose the inlet ports to the fluid within the inlet manifold 202.

[0048] Referring to FIGs. 1C and 1D, a top portion B of the first section 100-1 of the tube 100 within the manifold is trimmed off such that a top edge of the trimmed tube 100 is oriented substantially along a horizontal axis, which laterally exposes the inlet ports associated with the channels 108 within the manifold 202 to the fluid of the manifold 202. As illustrated in FIG. 1D, a predetermined portion B of the first section 100-1 of the tube 100 is trimmed off such that the top edge of the trimmed tube 100 is substantially horizontally oriented with respect to

the manifold, and the remaining portion 100-2 of the tube 100 below the flat top edge remains untouched, which exposes each of the inlet ports laterally to the fluid of the manifold 202.

[0049] Referring to FIGs. 2 and 3, an exemplary embodiment of the evaporator 200 having a downward fluid flow configuration is illustrated. The evaporator 200 includes an inlet manifold 202 (also known as inlet header) and an outlet manifold 204 (also known as outlet header), which may preferably be configured horizontally over a support structure 206 at the same elevation, however, in other embodiments, the inlet manifold 202 may also be positioned at an elevated height above the outlet manifold 204. Further, the evaporator 200 includes a plurality of tubes 100 that are already described in detail in connection with FIGs. 1A to 1D, which are in fluidic communication with the inlet manifold 202 and the outlet manifold 204. The tubes 100 may be equally spaced. The tubes 100 extend parallelly, with one end (first end) of the tube 100 disposed of within the inlet manifold 202 and the other end extending out of the inlet manifold 202 at a predefined angle and further connected to and disposed in the outlet manifold 204.

[0050] Referring to FIG. 1E, a predetermined area C of the wall (first wall and/or second wall) at the bottom end of the first section 100-1 of the tube 100 may be removed or kept uncovered as shown in FIG. 1E, such that the plurality of channels associated with tube 100 is exposed to the fluid through the removed or uncovered area C of the tube 100. The predetermined removed area C may be adjacent to an inner-bottom curved surface (D) within the manifold 100. Further, the predetermined area C may have a curved profile corresponding to the profile of the inner-bottom curved surface D of the manifold 100.

[0051] The manifolds 202, 204 are preferably made up of cylindrical, aluminum tubing/housing having aluminum braze cladding on its exterior surface, however, the manifolds may also have a square, rectangular, hexagonal, octagonal, or other polygonal cross-section. On their facing sides, the manifolds 202, 204 are provided with a series of generally parallel slots or openings for the receipt of the corresponding first ends of the tubes 100, such that a first end or a first section 100-1 as shown in FIG. 1B to 1E are located within the manifolds 202, 204. The tubes 100 are preferably formed of extruded aluminum. The manifolds 202, 204 are preferably welded or brazed with the tubes 100. Further, each of the manifolds 202, 204 is provided with substantially spherical domes between adjacent tubes 100 to improve the pressure resistance of the manifolds. The manifold has opposite ends closed by caps brazed or welded thereto. The various components may be brazed together, and accordingly, in the usual case, brazing is employed to fasten the caps on opposite ends of the manifold. Similarly, fittings such as a vapor inlet/outlet fitting 212 may also be brazed to one end of the 202, 204 manifold.

[0052] Further, the evaporator 200 includes heat dissipating fins 214 of brazed clad aluminum extending par-

ally between adjacent tubes 100. The fins 214 facilitate the exchange of heat between the fluid flowing through the tubes 100 and air flowing across the tubes 100 of the evaporator 200. Besides, the fins 214 also provide structural support and rigidity to the tubes 100 as well as the evaporator 200.

[0053] In one embodiment, as shown in FIG. 2, the evaporator 200 is a V-coil arrangement evaporator 200 having the inlet manifold 202 and the outlet manifold 204 oriented horizontally in the same plane over the support structure 206. Further, tubes 100 protrude from the inlet manifold 202 making an acute angle from the plane of the inlet manifold 202 in a downward direction and further extending in an upward direction at the same acute angle into the outlet manifold 204, such that the V-coil arrangement of the tubes 100 having a bend at bottom mid-point of the tubes 100 is formed. The bend at the bottom of tube 100 results in the formation of an apex at the approximate midpoint of the V-shaped tubes 100. The apex is below the plane defined by the manifolds. Further, a condensate trough 208 is attached along the apex or bend of the tubes 100 by fasteners, extending along an axis parallel to the longitudinal axis of the manifolds 202, 204. Trough 208 is configured to collect condensate formed in the tubes 100 and the V-coil arrangement facilitates an easier flow of condensate towards the bottom trough 208. The trough 208 may be further provided with one or more condensate outlet fittings 216 to remove the collected condensate.

[0054] During operation, a compressor associated with the evaporator 200 circulates hot, high-pressure refrigerant vapor through a refrigerant line into the inlet manifold 202 of the evaporator 200, and thence through the tubes 100 of the evaporator 200 where the hot refrigerant vapor condenses to a liquid as it passes in a heat exchange relationship with a cooling fluid, such as ambient air which is passed over the by a fan (not shown). The high-pressure, liquid refrigerant collects in the outlet manifold 204 of evaporator 200 and is then supplied back through the refrigerant line into the inlet manifold 202 of evaporator 200. As the high-pressure condensed refrigerant liquid passes through the refrigerant line from the outlet manifold 204 of the evaporator 200 to the inlet manifold 202 of the evaporator 200, it traverses through a thermostatic expansion valve (TXV) 210. In the TXV 210, the high-pressure, liquid refrigerant is partially expanded either to lower pressure, liquid refrigerant, or, more commonly, to a low-pressure liquid/vapor refrigerant mixture. The vapor phase refrigerant, being less dense than the liquid phase refrigerant, naturally tend to separate and migrate upwardly within the inlet manifold 202 and collect above the level of the liquid phase refrigerant within the inlet manifold 202. Because the first end or inlet ports of tubes 100 open into the inlet manifold 202 through the bottom, therefore, the inlet ports of channels 108 of the tubes 100 will open beneath the surface of the liquid phase refrigerant. Therefore, gravity assists in evenly distributing the liquid refrigerant collected within the inlet

manifold 202 amongst the multiple channels 108 of the plurality of tubes 100 disposed within the inlet manifold 202. Besides, as all the inlet ports of each tube 100 are exposed laterally to liquid refrigerant within the inlet manifold 202, the refrigerant is evenly received by all the channels 108 of the tubes 100.

[0055] It should be obvious to a person skilled in the art that while FIG. 2 and some embodiments have been elaborated for the V-coil arrangement evaporator for the sake of simplicity and better explanation purpose, however, the teachings are equally applicable for other evaporators having downward fluid flow configuration such as N-coil evaporator, J-coil evaporator, U-coil evaporator, and the like, and all such embodiments are well within the scope of the invention.

[0056] Referring to FIG. 4, method 400 for enabling even distribution of fluid across inlet ports of tubes within an inlet manifold of an evaporator is illustrated. Method 400 comprises step 402 of removing a predetermined area of a first wall and/or a second wall of each of the tubes, where the predetermined removed area is at a predefined distance below a first end of the tubes and adjacent to an inner-bottom surface of the manifold. Method 400 further comprises step 404 of disposing the first end of the tubes within the inlet manifold such that a first section of each of the tubes at the first end as well as the removed area remains disposed of within the inlet manifold. The first end of the tube is disposed of within the manifold such that the flat wall or opposite walls of the tube orients perpendicular to a longitudinal axis of the inlet manifold in the direction of the incoming fluid within the manifold. In one or more embodiments, at step 402, the predetermined area of the first wall and/or second wall of the tube at a bottom end the first section of the tube may be removed as shown in FIG. 1E, prior to disposing of the first section of the tube within the inlet manifold such that the predetermined removed area remains within the manifold at the bottom end of the first section of the tubes, adjacent to the inner-bottom surface of the manifold, to expose the plurality of channels of the tubes to a fluid present in the manifold via the predetermined removed area. In one or more embodiments, at step 406, the top portion of tube may be trimmed off as shown in FIG. 1C and 1D, prior to disposing of the first end of tube within the inlet manifold, such that the inlet ports associated with each tube are exposed laterally to the fluid within the inlet manifold.

[0057] It should be obvious for a person skilled in the art that step 404 of disposing the first section of the tubes of the evaporator within the inlet manifold may also be done prior to step 402 of removing predetermined area of the wall of each tube, however, it is preferable to perform the step 402 of removing the predetermined area to expose the channels of each tube, followed by step 403 of disposing the first section of the tubes of the evaporator within the inlet manifold.

[0058] In one embodiment, method 400 may comprise step of laterally exposing the inlet ports of the tubes by

at least partially removing at least one wall of the first section of each of the tubes. A predetermined area (area 'A' of FIG. 1B) of the wall of the first section of the tube is removed tube such that the bottom of the predetermined area remains horizontally oriented and rest portion of the flat wall above the bottom is removed, which exposes each of the inlet ports laterally to the fluid of the manifold.

[0059] Thus, the tube, evaporator, and method disclosed herein overcomes the drawbacks, limitations, and shortcomings associated with existing technologies by enabling even distribution of fluid or refrigerant across ports of the tubes within the inlet manifold of downward fluid flow evaporators, thereby preventing the formation of a pool of fluid within the inlet manifold.

[0060] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention as defined by the appended claims. Modifications may be made to adopt a particular situation or material to the teachings of the invention without departing from the scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed, but that the invention includes all embodiments falling within the scope of the invention as defined by the appended claims.

[0061] In interpreting the specification, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced. Where the specification claims refer to at least one of something selected from the group consisting of A, B, Cand N, the text should be interpreted as requiring only one element from the group, not A plus N, or B plus N, etc.

Claims

1. A microchannel tube for a manifold of an evaporator having a V-coil configuration, the microchannel tube comprising:

a hollow member defining a shape of the tube and comprising a plurality of channels therewithin and extending parallelly between a first end and a second end of the hollow member; wherein,
the first end of the tube is adapted to be disposed of within the manifold such that a first section of the tube at the first end remains disposed of within the manifold and the tube protrudes at a pre-

defined angle in a downward direction from the inlet manifold, and

a predetermined area of a first wall and/or a second wall of the first section of the tube, at a bottom end of the first section, is removed such that the plurality of channels of the tube are exposed to a fluid present in the manifold via the predetermined removed area.

2. The microchannel tube of claim 1, wherein the manifold is a hollow cylinder, wherein the predetermined removed area is adjacent to an inner-bottom curved surface of the manifold; and/or wherein the predetermined removed area has a curved profile corresponding to profile of the inner-bottom curved surface of the manifold.
3. The microchannel tube of claim 1 or 2, wherein at least a portion of the first end of the tube is trimmed off such that a top edge of the trimmed tube is oriented horizontally, which laterally exposes the inlet ports to the fluid within the manifold.
4. The microchannel tube of claim 1, 2 or 3, wherein the microchannel tube has a flat profile, wherein the first wall and the second wall of the tube are flat.
5. The microchannel tube of any preceding claim, wherein the tube comprises one or more partition walls extending between the first wall and the second wall of the tube, such that the plurality of channels is created between the adjacent partition walls within the tube.
6. The microchannel tube of any preceding claim, wherein the tube is inclined at the predefined angle from a longitudinal axis of the manifold, and wherein the first wall of the tube faces a fluid inlet side of the inlet manifold and the second wall of the faces a side opposite to the fluid inlet side of the inlet manifold.
7. A downward flow configuration evaporator comprising:

an inlet manifold;
an outlet manifold; and
a plurality of microchannel tubes fluidically configured between the inlet manifold and the outlet manifold in a downward flow configuration such that the tubes protrude at a predefined angle in a downward direction from the inlet manifold, wherein each of the tubes is a hollow member comprising a plurality of channels therewithin and extending parallelly between opposite ends within the hollow member;
wherein,
a first end of each of the tubes is adapted to be disposed of within the inlet manifold such that a

- first section of each of the tube at the first end remains disposed of within the inlet manifold, and
 a predetermined area of a first wall of the first section of the tube, at a bottom end of the first section, is removed such that the plurality of channels of each of the tubes are exposed to a fluid present in the manifold via the predetermined removed area.
8. The evaporator of claim 7, wherein the evaporator is in a downward fluid flow configuration having a V-coil arrangement.
9. The evaporator of claim 7 or 8, wherein the manifold is a hollow cylinder, wherein the predetermined removed area is adjacent to an inner-bottom curved surface of the manifold; and/or wherein at least a portion of the first end of each of the tubes is trimmed off to laterally expose the inlet ports associated with each of the tubes to the fluid of the inlet manifold.
10. The evaporator of claim 7, 8 or 9, wherein the evaporator comprises a plurality of heat dissipating fins extending between adjacent tubes among the plurality of tubes; and/or wherein the plurality of tubes are spaced apart by a predefined distance along a length of the inlet manifold.
11. The evaporator of any of claims 7 to 10, wherein the microchannel tube is a flat tube, and wherein the first wall of the tube faces a fluid inlet side of the inlet manifold and the second wall of the faces a side opposite to the inlet side of the inlet manifold; and/or wherein the flat wall of each of the tubes is oriented perpendicular to a longitudinal axis of the inlet manifold.
12. The evaporator of any of claims 7 to 11, wherein the inlet manifold is a cylindrical housing having an opening at the fluid inlet side of the cylindrical housing, wherein the inlet manifold is configured to receive the fluid via the opening.
13. A method for enabling even distribution of a fluid across inlet ports of tubes within an inlet manifold of an evaporator having a downward flow configuration, the method comprising the steps of:
- removing a predetermined area of a first wall and/or a second wall of each of the tubes, wherein the predetermined removed area is at a predefined distance below a first end of the tubes; and disposing the first end of the tubes within the inlet manifold of the evaporator such that a first section of the tubes at the first end and the predetermined removed area remain within the inlet manifold and the tubes protrude from the inlet manifold in a downward direction making a predefined angle from a plane of the inlet manifold, wherein the first end of each of the tubes is disposed within the inlet manifold such that the predetermined removed area remains within the manifold at a bottom end of the first section of the tubes to expose the plurality of channels of the tubes to a fluid present in the manifold via the predetermined removed area.
14. The method of claim 13, wherein the manifold is a hollow cylinder, wherein the predetermined area of the first wall and/or the second wall of the first section of the tubes, adjacent to an inner-bottom curved surface of the manifold; preferably wherein the predetermined removed area has a curved profile corresponding to profile of the inner-bottom curved surface of the manifold.
15. The method of claim 13 or 14, wherein the method comprises the step of laterally exposing the inlet ports of the tubes by trimming off at least a portion of the first end of each of the tubes such that a top edge of the trimmed tubes is oriented horizontally.

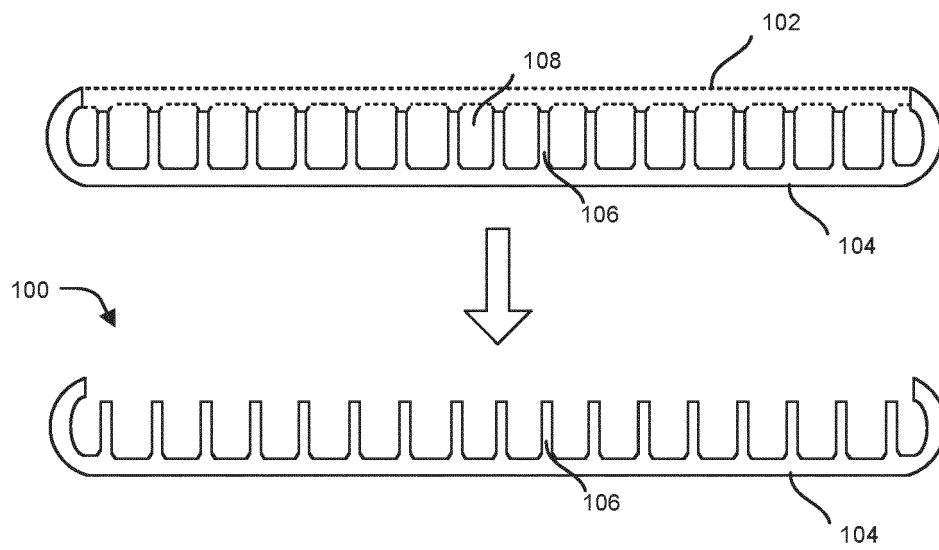


FIG. 1A

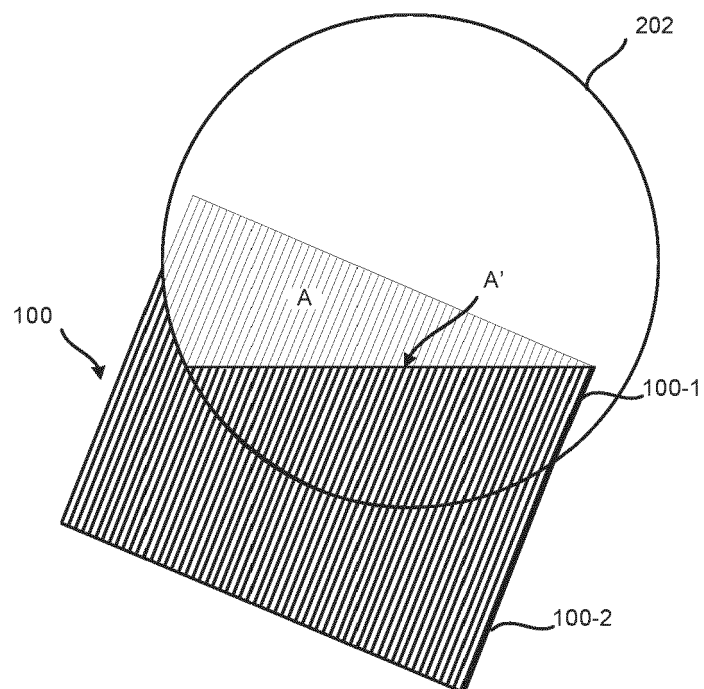


FIG. 1B

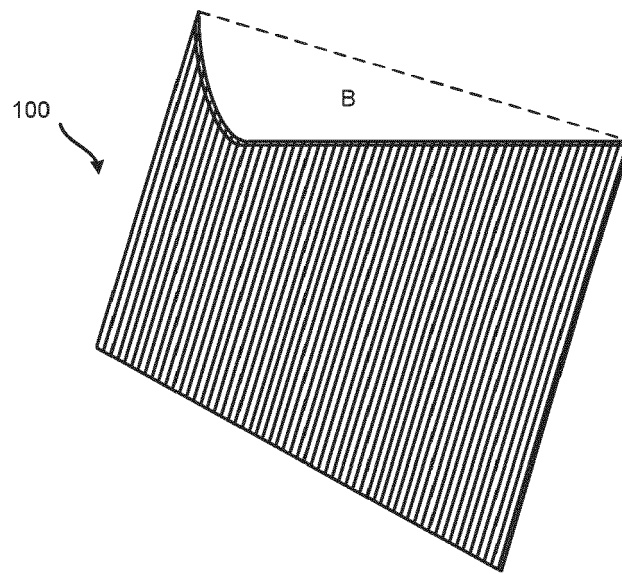


FIG. 1C

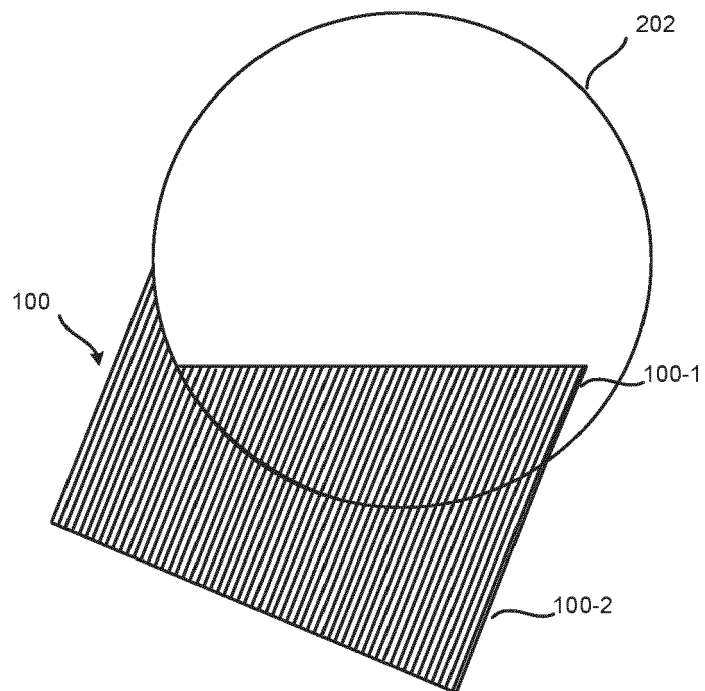


FIG. 1D

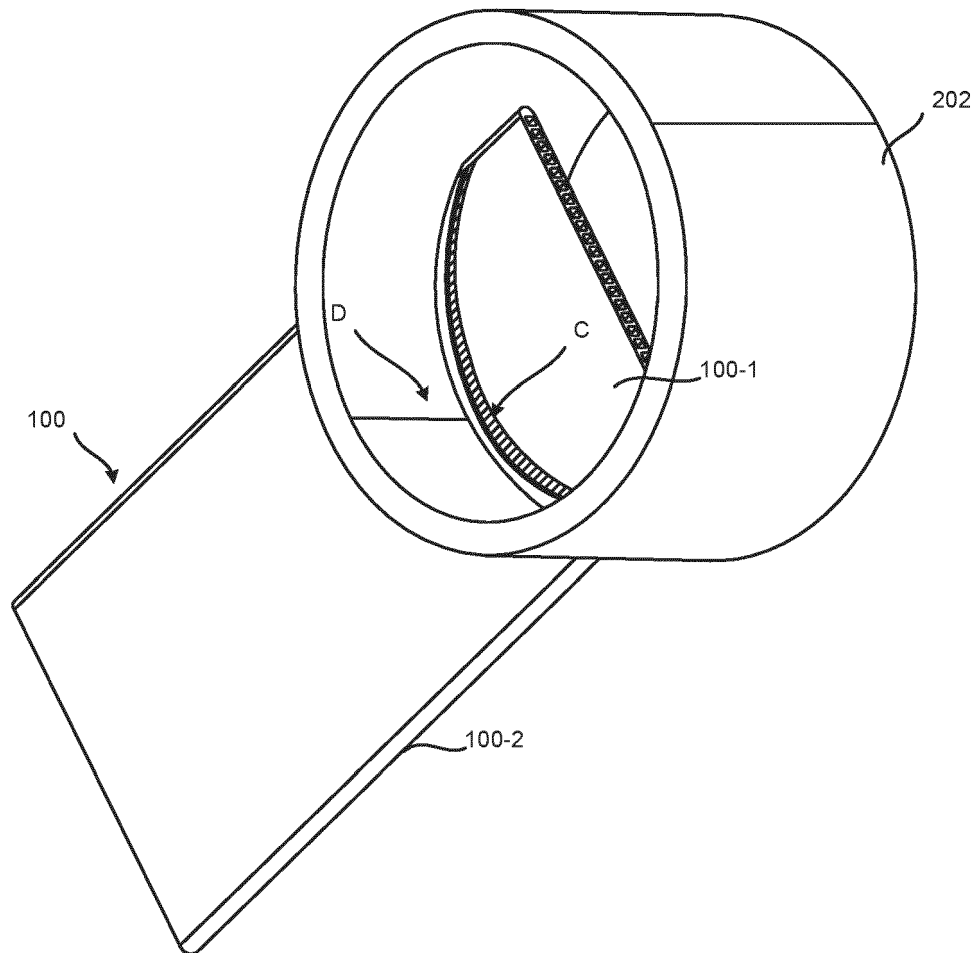


FIG. 1E

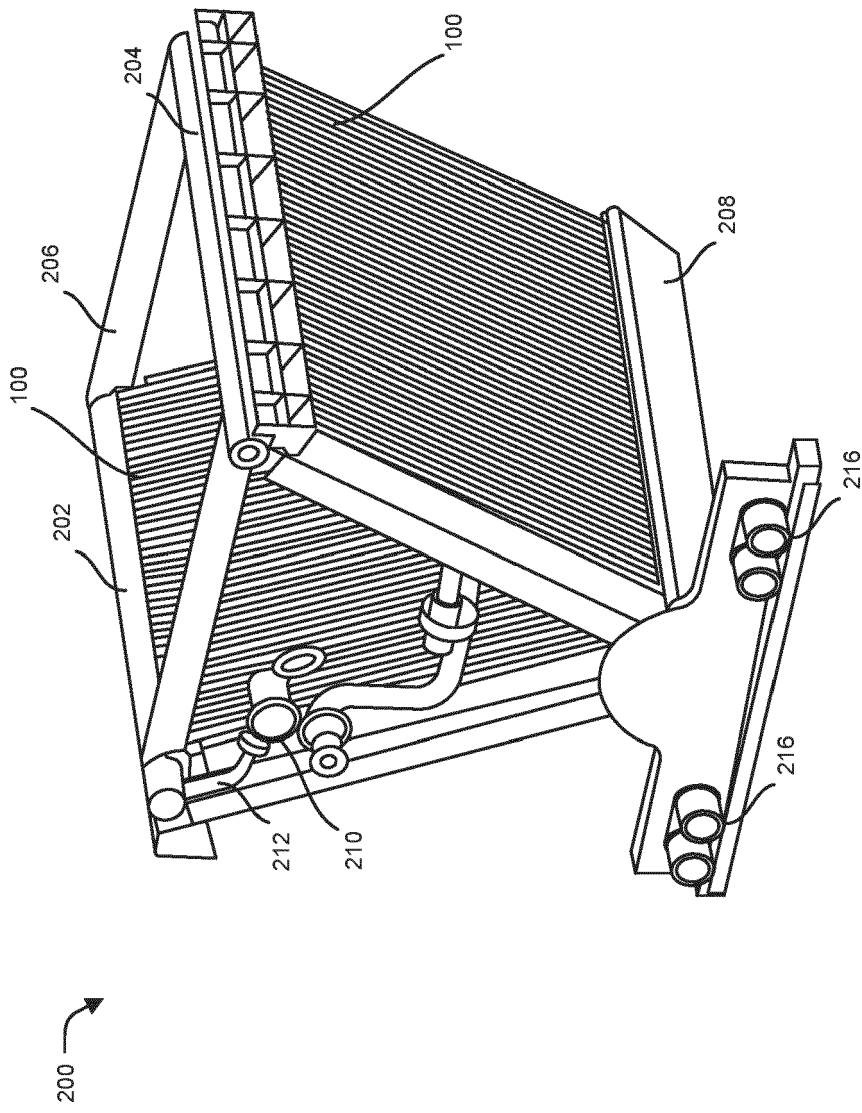


FIG. 2

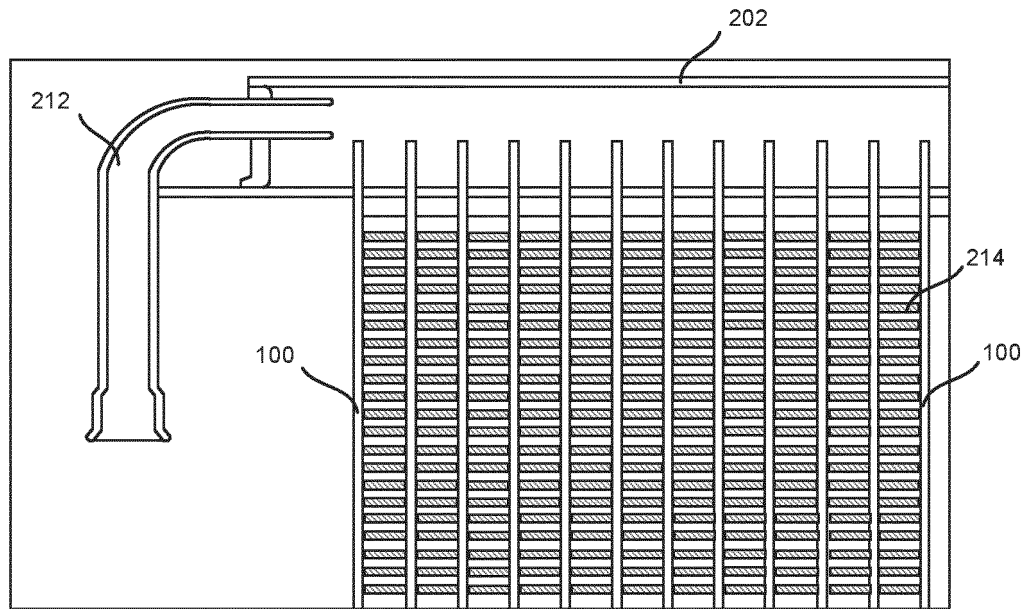


FIG. 3

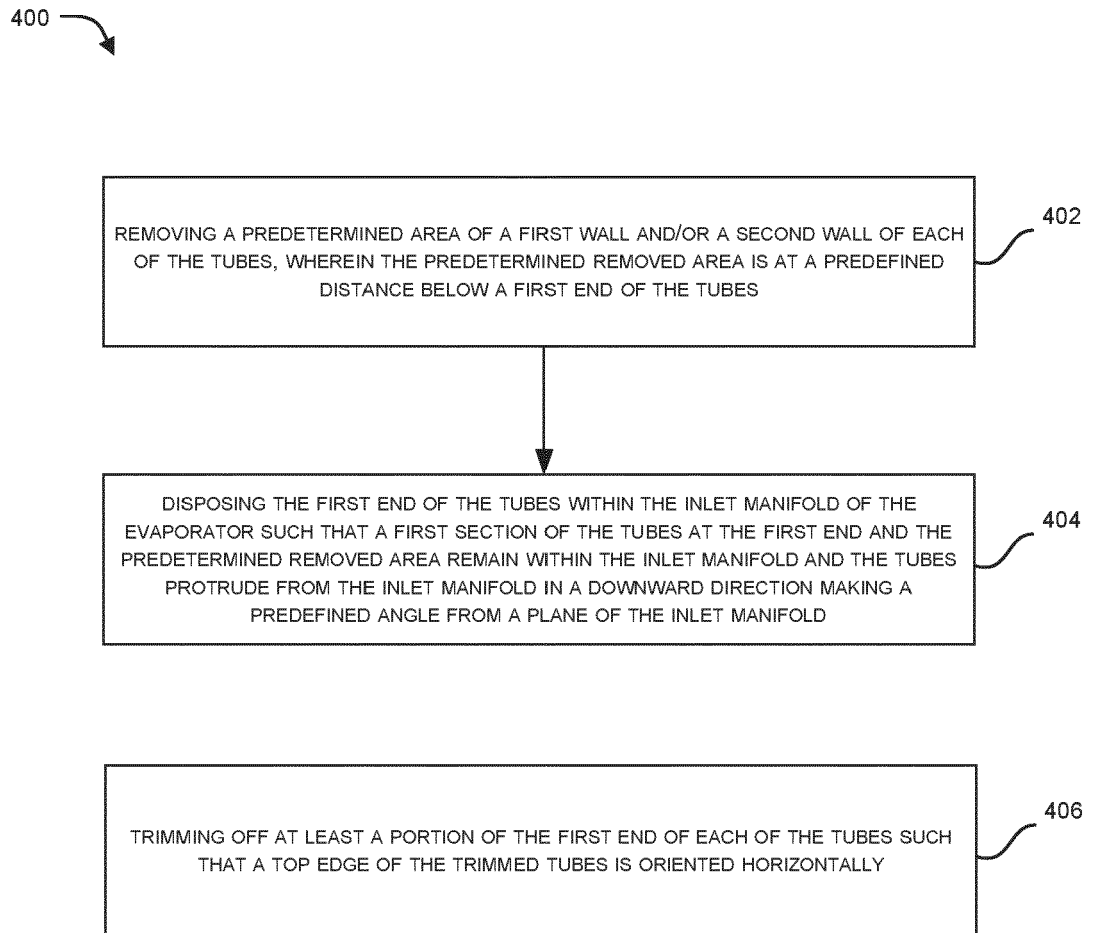


FIG. 4



EUROPEAN SEARCH REPORT

Application Number

EP 23 21 9784

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2011/315363 A1 (MATTER III JEROME ANTHONY [US] ET AL) 29 December 2011 (2011-12-29) * figures *	1-15	INV. F28D1/04 F28D1/053 F28D3/02 F28F1/02
X	----- TW 200 923 303 A (JOHNSON CONTROLS TECH CO [US]) 1 June 2009 (2009-06-01) * figures *	1-15	
A	----- FR 2 712 966 A1 (VALEO THERMIQUE MOTEUR SA [FR]) 2 June 1995 (1995-06-02) * the whole document *	1-15	
A	----- US 2008/148746 A1 (YANIK MUSTAFA K [US] ET AL) 26 June 2008 (2008-06-26) * figures *	1-15	

			TECHNICAL FIELDS SEARCHED (IPC)
			F28D F28F
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
Munich	11 April 2024	Mellado Ramirez, J	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

1
EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 21 9784

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-04-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011315363 A1	29-12-2011	NONE	
TW 200923303 A	01-06-2009	TW 200923303 A	01-06-2009
		US 2009025409 A1	29-01-2009
		WO 2009018150 A1	05-02-2009
FR 2712966 A1	02-06-1995	NONE	
US 2008148746 A1	26-06-2008	US 2008148746 A1	26-06-2008
		WO 2008064247 A1	29-05-2008

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 63477124 [0001]