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(54) **HEAT EXCHANGERS AND METHODS OF FORMING HEAT EXCHANGERS**
WÄRMETAUSCHER UND VERFAHREN ZUR HERSTELLUNG VON WÄRMETAUSCHERN
ÉCHANGEURS DE CHALEUR ET PROCÉDÉS DE FORMATION D'ÉCHANGEURS DE CHALEUR

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Description

TECHNOLOGICAL FIELD

[0001] Examples of the disclosure relate to heat exchangers and methods of forming heat exchangers. Some relate to heat exchangers and methods of forming heat exchangers for use in two-phase cooling systems.

BACKGROUND

[0002] Heat exchangers such as evaporators and condensers are configured to enable heat transfer within a cooling system. The overall efficiency of the cooling system can be dependent upon the efficiency of the heat transfer occurring in the heat exchangers. WO 01/30528 A1 relates to process for brazing plate/plate and plate/fin multi-channeled structures according to the preamble of claim 1.

[0003] US 2013/0014917 A1 relates to a heat pipe-attached heat sink

[0004] US 2016/0377350 A1 relates to a heat exchanger including a hot passage and a cold passage.

[0005] JPH 07-280484 relates to a a heat transfer tube unit.

BRIEF SUMMARY

[0006] According to the invention, there is provided a heat exchanger according to claim 1 and a method according to claim 9. According to claim 1, there is provided a heat exchanger comprising: a plurality of structures extending from a base plate where adjacent structures are separated by at least a first distance; and at least one cover plate positioned over ends of the plurality of structures so that the at least one cover plate is spaced from the ends of the plurality of structures by a second distance where the second distance is smaller than the first distance; wherein the at least one cover plate is brazed to the plurality of structures by brazing material provided between the ends of the plurality of structures and the at least one cover plate; and wherein the brazing material is provided in a discontinuous configuration so that gaps are provided between portions of brazing material so that a brazing join is formed from brazing materials that has flowed into spacing between the at least one cover plate and the ends of the plurality of structures.

[0007] The brazing material may be provided in a thickness that is smaller than the first distance.

[0008] The first distance and the second distance may be selected so that Laplace pressure causes the brazing material to flow into gaps between the ends of the plurality of structures and the at least one cover plate.

[0009] The plurality of structures may extend substantially perpendicularly out of the base plate.

[0010] The plurality of structures may be evenly spaced across the base plate.

[0011] The plurality of structures may be spaced closer together at edges of the base plate than in a centre of the base plate.

[0012] The base plate may have a surface area that is larger than a heat source to which the heat exchanger is thermally coupled.

[0013] The heat exchanger may comprise a stiffener structure comprising a plurality projecting portions configured to extend between the plurality of structures so as to restrict bending of the plurality of structures.

[0014] At least some of the plurality of structures may extend through the at least one cover plate and further coupling means may be provided on the ends of the plurality of structures that extend through the at least one cover plate.

[0015] The plurality of structures may comprise fins.

[0016] The heat exchanger may comprise an evaporator or a condenser.

[0017] According to various, but not necessarily all, examples of the disclosure there may be provided a method comprising: providing a plurality of structures extending from a base plate where the plurality of structures are separated by at least a first distance; providing brazing material overlaying, at least some of the plurality of structures wherein the brazing material is provided in a discontinuous configuration so that gaps are provided between portions of brazing material; providing at least one cover plate over ends of the plurality of structures and the brazing material so that the at least one cover plate is spaced from the ends of the plurality of structures by a second distance where the second distance is smaller than the first distance; and heating the brazing material so that the brazing material flows into spacing between the at least one cover plate and the ends of the plurality of structures.

[0018] The brazing material may be provided in a thickness that is smaller than the first distance.

[0019] The first distance and the second distance may be selected so that Laplace pressure causes the brazing material to flow into gaps between the ends of the plurality of structures and the at least one cover plate.

[0020] According to various, but not necessarily all, examples of the disclosure there may be provided a heat exchanger comprising: a base plate; a plurality of structures extending out of the base plate; and at least one stiffener structure comprising a plurality projecting portions configured to extend between the plurality of structures so as reduce bending of the plurality of structures.

[0021] The heat exchanger may comprise a cover plate wherein the at least one stiffener structure is provided as part of the cover plate.

[0022] The base plate may be connected to first ends of the plurality of structures and at least one stiffener structure is connected to second ends of the plurality of structures. Sides of the plurality of projecting portions of the stiffener structure may be brazed to sides of the plurality of structures.

[0023] The projecting portions of the stiffener structure may be coupled to all of the plurality of structures.

[0024] The projecting portions of the stiffener structure may be coupled to a subset of the plurality of structures.

[0025] According to various, but not necessarily all, examples of the disclosure there may be provided a two-phase cooling system comprising one or more heat exchangers as described herein.

BRIEF DESCRIPTION

[0026] Some examples will now be described with reference to the accompanying drawings in which:

Fig. 1 shows a general schematic of example of passive two-phase cooling system;
Figs. 2A and 2B show part of an evaporator;
Figs. 3A and 3B show an evaporator being formed;
Fig. 4 shows an example method;
Figs. 5A to 5D show examples for alternative configurations of brazing filler material structures;
Fig. 6 shows an example evaporator being formed;
Figs. 7A and 7B show example evaporators;
Fig. 8 shows an example evaporator; and
Fig. 9 shows a schematic example and main components of passive two phase cooling system.

DETAILED DESCRIPTION

[0027] Fig. 1 schematically shows a two-phase cooling system 101 that can comprise heat exchangers such as evaporators 103 and condensers 105 according to examples of the disclosure.

[0028] In the example of Fig. 1 the two-phase cooling system 101 comprises a passive two-phase cooling system that is driven by gravity rather than a pump, requiring external work input to drive the flow. In the example of Fig. 1 the passive two-phase cooling system 101 comprises a thermosyphon loop. The example heat exchangers can be provided within other types of two-phase cooling system, such as heat pipes, vapor chambers and many others.

[0029] The thermosyphon loop shown in Fig. 1 comprises an evaporator 103, a condenser 105, a downcomer 107 and a riser 109. A working fluid 113 is provided within the thermosyphon loop. When the thermosyphon loop is in use the working fluid 113 circulates through the components of the thermosyphon loop.

[0030] The evaporator 103 is provided at the bottom of the thermosyphon loop so that the working fluid flows down the downcomer 107 into the evaporator 103 under the force of gravity as indicated by the arrow 115. The height of the two-phase cooling system 101 and inner diameter of the downcomer 107 can be selected so that the static head of the fluid within the downcomer 107 causes the fluid to flow through the evaporator 103, riser 109 and condenser 105. The working fluid 113 is normally in the liquid phase 117 when it is in the downcomer 107. In particular the volume of the downcomer 107 filled by the working fluid 113 in the liquid phase 117 depends on the thermosyphon operating conditions and geometry.

[0031] The evaporator 103 comprises any means for transferring heat from a heat source 111 into the working fluid 113. The evaporator 103 is thermally coupled to the heat source 111. A thermal interface material could be used to enable the evaporator 103 to be thermally coupled to the heat source 111. The heat source 111 could comprise an electronic device that generates unwanted heat during operation. The electronic device could be a server, router, network switch, storage device or any other suitable type of device. In some examples the heat sources can comprise a plurality of electronic devices comprised within a data centre, telecommunication equipment room, or network, a communication room, a computer room, a network room or any other suitable arrangement.

[0032] In other examples, the heat source 111 can be an intermediate fluid, therefore heat is exchanged between two working fluids (intermediate fluid and working fluid 113). In these examples, the evaporator 103 is a heat exchanger with a metal wall separating the two streams. The wall can be also manufactured with a ceramic or other materials.

[0033] Heat is transferred from the heat source 111 to the working fluid 113 in the evaporator 103 as indicated by the arrows 119. This heat transfer causes a partial evaporation of working fluid 113 within the evaporator 103 and converts the working fluid 113 from a liquid phase 117 into a mixture of liquid and vapour phase. In particular, the evaporator 103 causes some of the working fluid 113 to be converted into the vapour phase 121 while some remains in a liquid phase 117 so that the fluid expelled from the outlet of the evaporator 103 is a two-phase mixture with a defined value of vapor quality. The two-phase mixture can comprise droplets of vapour entrained within the liquid or other flow regimes depending on the design of the thermosyphon loop, heat load, heat rejection conditions, filling ratio and any other suitable parameter.

[0034] The evaporator 103 is coupled to the riser 109 so that the working fluid expelled from the evaporator 103 flows into the riser 109. This working fluid comprises a two-phase mixture where the vapour phase 121 is less dense than the liquid phase 117. The working fluid 113 within the thermosyphon loop rises through the riser 109, as indicated by the arrows 123. The passive flow in the thermosyphon loop is driven by the density difference between the working fluid 113 in the liquid phase in the downcomer 107 and the working fluid 113 in the two-phase mixture in the riser 109.

[0035] The evaporator 103 can comprise structures that enable efficient transfer from the evaporator 103 into the working fluid 113. For example, the evaporator 103 could comprise wick structures, micro-channels, arrays of fins, a serpentine arrangement of macro- / micro-channels or any suitable combination of such features. Examples of evaporators 103 comprising such structures are shown in Figs. 2 and 3, as well as in Figs. 6 to 8.

[0036] The condenser 105 is provided at the top of the thermosyphon loop. The condenser 105 is positioned above the evaporator 103 so that the working fluid 113 flows downwards from the condenser 105 to the evaporator 103 (via gravity force 115) and upwards from the evaporator 103 to the condenser 105.

[0037] The condenser 105 is coupled to the riser 109 so that the working fluid 113 in the two-phase mixture (vapour phase 121 and liquid phase 117) flows from the riser 109 into the condenser 105. The condenser 105 can comprise any means for cooling the working fluid 113. For example, the condenser 105 could be air-cooled or liquid-cooled. A liquid-cooled condenser 105 could comprise a tube-in tube heat exchanger, a shell- and-tube heat exchanger a plate heat exchanger or any other suitable heat exchanger configuration or arrangement. An air-cooled condenser could comprise a louvered-fin flat tube heat exchanger, a tube-and-fin heat exchanger or any other suitable type of heat exchanger configuration or arrangement. Overall, the condenser 105 can comprise any suitable heat exchanger geometry that enables heat to be removed efficiently from the working fluid 113.

[0038] The condenser 105 is thermally coupled to a coolant 125. A thermal interface material could be used to enable the condenser 105 to be thermally coupled to the coolant 125. In other examples the coolant 125 can be directly integrated in the condenser 105 with a wall interface separating the stream of thermosyphon working fluid 113 from the stream of coolant 125. The wall interface can comprise a highly conductive metal or metal alloy, such as copper, aluminum, brass, or any other suitable metal. In some examples the wall interface can comprise highly conductive ceramics such as Aluminum Nitride (AlN), or polymers such as filled polymer composites.

[0039] The condenser 105 enables heat to be transferred from the working fluid 113 to the coolant 125 as indicated by the arrows 127. This heat transfer causes the working fluid 113 to condense, at least partly, back into the liquid phase 117. The working fluid 113 at the outlet of the condenser 105 can be therefore in the liquid phase 117 or in the two-phase mixture (vapour phase 121 and liquid phase 117).

[0040] The condenser 105 is coupled to the downcomer 107 so that the working fluid 113 can flow down the downcomer 107 by gravity and be returned to the inlet of the evaporator 103.

[0041] Figs. 2A and 2B show part of a heat exchanger 200 that could be used in the two-phase cooling system 101 of Fig. 1 or in any other suitable cooling system. The heat exchanger 200 could be an evaporator 103 or a condenser 105 or any other suitable type of heat exchanger. The heat exchanger 200 can be a macro-scale or micro-scale two-phase heat exchanger. The heat exchanger 200 can be a single-phase heat exchanger or a two-phase heat exchanger 200 or any other suitable type of heat exchanger 200.

[0042] The example heat exchanger 200 comprises a base plate 201, a plurality of structures 203 and at least one cover plate 205. In order to achieve a more robust design the heat exchanger 200 comprises a mechanical bond between the tops of the structures 203 and the cover plate 205. The components of the heat exchanger 200 are not shown to scale in Figs. 2A and 2B. Fig. 2A shows the heat exchanger 200 before the brazing material 207 is melted and Fig. 2B shows the heat exchanger 200 after the brazing material 207 is melted. In Figs. 2A and 2B only a section of the heat exchanger 200 is shown so only two structures 203 are shown. It is to be appreciated that a plurality of structures 203 would be configured to provide a plurality of channels for working fluid through the heat exchanger 200.

[0043] The base plate 201 comprises a flat or substantially flat surface. The base plate 201 can comprise a thermally conductive material. When the heat exchanger 200 is in use as an evaporator 103 the base plate 201 can be thermally coupled to a heat source to enable heat to be transferred from the heat source into working fluid within the evaporator 103.

[0044] The plurality of structures 203 extend out of the surface of the base plate 201. The structures 203 can be machined, brazed, extruded, additively manufactured or obtained by any other suitable fabrication technique or combination of fabrication techniques. The structures 203, at least partially, define flow paths for the working fluid through the heat exchanger 200. In other examples the heat exchanger 200 could comprise a plurality of different types of structures 203 such as fins, plates or any other suitable structures.

[0045] In the example of Figs. 2A and 2B the structures 203 comprise elongate structures that extend perpendicularly, or substantially perpendicularly, out of the base plate 201. In the example shown in Figs. 2A and 2B the structures 203 have rectangular cross sections. Other shapes of structures 203 can be provided in other examples of the disclosure.

[0046] In the example of Figs. 2A and 2B the two adjacent structures 203 are separated by a first distance w. The first distance defines the width of the channel between the structures 203. In some examples the heat exchanger 200 can be configured so that the plurality of structures 203 are evenly spaced across the base plate 201. In such examples the different channels between different adjacent structures 203 would have the same width. In other examples the heat exchanger 200 can be configured so that the plurality of structures 203 have different spacing across the base plate 201. For example, the structures 203 could be spaced further apart on regions of the base plate 201 that are closer to a heat source. This can provide larger channels and more fluid flow in the areas of the heat exchanger 200 which have a higher heat load. For example, the plurality of structures 203 can be spaced closer together at the edges of the base plate 201 than in the centre of the base plate 201.

[0047] In some examples the footprint area of the base plate 201 can be larger than the area of the heat source, to improve heat spreading. In such examples an evaporator 103 having non-uniform channel width can help to provide uniform, or substantially uniform flow distribution in all the channels of the evaporator 103 and thus enhanced thermal performance.

[0048] The structures 203 can comprise any suitable thermally conductive material. The structures 203 can comprise the same material as the base plate 201 and the cover plate 205. In other cases, the base plate 201 and structures 203 can comprise a different material than the one used for the cover plate 205.

[0049] The cover plate 205 is positioned over ends of the plurality of structures 203. The cover plate 205 is provided at the opposite end of the structures 203 to the base plate 201 in order to create a closed volume for the circulation of the working fluid 113.

[0050] The cover plate 205 comprises a flat or substantially flat surface. In the example of Figs. 2A and 2B only part of the cover plate 205 is shown. It is to be appreciated that the cover plate 205 could cover all of the plurality of structures 203 or other structures.

[0051] The cover plate 205 is brazed to the plurality of structures 203 by brazing material 207. The brazing material 207 is provided between the ends of the plurality of structures 203 and the cover plate 205. The brazing material 207 can comprise any suitable material that can be melted and solidified to form a rigid connection between the ends of the structures 203 and the cover plate 205. In some examples the heat exchanger 200 can be further strengthened by brazing the four exterior surfaces of the cover pate 205 to the top part of the base plate 201.

[0052] Fig. 2A shows the heat exchanger 200 before the brazing material 207 has been melted and before the rigid brazing join has been formed. The cover plate 205 is spaced from the ends of the plurality of structures 203 by a second distance d. The second distance d is smaller than the first distance w that defines the gaps between adjacent structures 203.

[0053] In this case the brazing material also has a thickness d that is equal to the spacing between the ends of the structures 203 and the cover plate 205. The thickness of the brazing material is therefore also smaller than the distance between adjacent structures 203.

[0054] The brazing material 207 can be provided in a discontinuous configuration. The brazing material 207 is discontinuous so that, instead of being provided in a continuous sheet there are gaps provided between portions of brazing material 207. For example, the brazing material 207 can be provided as a plurality of lines or a network of crossed lines or in any other suitable configuration. In the example shown in Fig. 2A the discontinuities would extend into the page.

[0055] Fig. 2B shows the heat exchanger 200 after the brazing material 207 has been melted to form a rigid join between the ends of the structures 203 and the cover plate 205. When the brazing material 207 is melted it flows between the ends of the structures 203 and the cover plate 205 so that when the heat exchanger 200 is cooled again a rigid join is formed from the solidified brazing material 207.

[0056] In examples of the disclosure the discontinuous configuration of the brazing material 207 causes the melted brazing material 207 to flow into the spacing between the cover plate 205 and the ends of the plurality of structures 203. The brazing material 207 flows horizontally across the ends of the plurality of structures 203 rather than downwards into the channel between adjacent structures 203. In the example shown in Figs. 2A and 2B the melted brazing material 207 would flow into the page to form the brazing join as shown in Fig. 2B.

[0057] In examples of the disclosure the brazing material 207 flows horizontally across the ends of the plurality of structures 203 rather than downwards into the channels between adjacent structures 203. This means that the volume of the channels for flow of the working fluid 113 is maintained and is not decreased by unwanted brazing material 207 that has flowed into the channels. This can help the heat exchanger 200 to function efficiently.

[0058] The spacing d between the ends of the structures 203 and the cover plate 205 and the width of the channel w between adjacent channels can be selected to control the Laplace pressure. The Laplace pressure causes the brazing material 207 to flow horizontally into gaps between the ends of the plurality of structures 203 and at least one cover plate 205 rather than downwards into the channels between adjacent structures 203. The brazing material 207 can flow by wicking between the spacing between the ends of the structures 203 and the cover plate 205. The width of the channels w is larger than the spacing d between the ends of the structures 203 and the cover plate and the corresponding thickness of the un-melted brazing material 207. As the Laplace pressure is inversely proportional to the thickness of the brazing material 207 this creates a larger pressure differential in the horizontal direction than in the downwards direction so that when the brazing material 207 is melted it will flow in the horizonal direction.

[0059] Figs. 3A to 3B show an example heat exchanger 200 being formed. In this example the heat exchanger 200 is an evaporator 103 and the plurality of structures 203 comprise a plurality of evaporator fins 305. Other types of heat exchanger 200 comprising other types of structures 203 could be formed using a similar process in other types of the disclosure.

[0060] Fig. 3A shows brazing material 207 being provided on the ends of the plurality of evaporator fins 305. Fig. 3B shows a cross section of part of the evaporator 103 before the brazing material 207 is melted.

[0061] Fig. 3A shows the base plate 201 and the plurality of evaporator fins 305 extending out of the base plate 201. The cover plate 205 is not shown in Fig. 3A.

[0062] In the example of Fig. 3A the base plate 201 is a square, or substantially square plate. Other shapes of base plate 201 can be used in other examples of the disclosure.

[0063] The plurality of evaporator fins 305 extend perpendicularly, or substantially perpendicularly out of the base plate 201. In the example of Fig. 3A each of the evaporator fins 305 comprises a thin plate. The plate has a thickness that is several orders of magnitude smaller than the longest length of the plate (along the flow direction). The plates of the evaporator fins 305 are provided in a parallel or substantially parallel arrangement across the surface of base plate 201. Other dimensions and shapes of plates of the evaporator fins 305 that define the flow paths can be used depending on the application and operating conditions.

[0064] Adjacent evaporator fins 305 are separated from each other by a first distance w. In the example of Fig. 3A the evaporator fins 305 are evenly spaced across the surface of the base plate 201 so that each of the evaporator fins 305 are separated from adjacent evaporator fins 305 by the same first distance w. This creates a plurality of parallel, or substantially parallel channels across the surface of the base plate 201 where the channels have a width w.

[0065] The brazing material 207 is provided over the ends of the evaporator fins 305. In the example of Fig. 3A the brazing material 207 is provided in a plurality of wires 301. The wires 301 extend across the ends of the evaporator fins 305. In the example of Fig. 3A the wires 301 extend in a direction that is perpendicular, or substantially perpendicular to the direction of the channels formed by the evaporator fins 305.

[0066] The wires 301 of brazing material 207 are provided in a discontinuous configuration so that gaps are provided between the wires 301. The gaps on top of the evaporator fins 305 provide space for the brazing material 207 to flow when the brazing material 207 is melted ensuring effective bonding between the evaporator fins 305 and cover plate 205. In the example shown in Fig. 3A the wires 301 of brazing material 207 are provided evenly spaced across the ends of the evaporator fins 305. Other arrangements for the wires 301 could be used in other examples of the disclosure.

[0067] The wires 301 of brazing material 207 have a thickness d that is smaller than the width between adjacent pairs of evaporator fins 305.

[0068] Fig. 3B shows a cross section of part of the evaporator 103 before the brazing material 207 is melted. Fig. 3B shows an end of one of the evaporator fins 305 and the wire 301 of brazing material 207 provided between the ends of the evaporator fin 305 and the cover plate 205.

[0069] The cover plate 205 is provided over wire 301 of brazing material 207. The cover plate 205 is spaced from the end of the evaporator fin 305 by a distance d due to the thickness of the wire 301 of brazing material 207. In the example shown in Fig. 3B the wire 301 has a circular, or substantially circular cross section. Other shapes for the wires could be used in other examples of the disclosure.

[0070] When the brazing material 207 is melted the Laplace pressure causes the brazing material to flow in a horizontal direction between the cover plates 205 and the ends of the evaporator fins 305 as indicated by the arrows 303 in Fig. 3B. This direction of flow enables a strong brazing join to be formed but prevents excess brazing material from flowing into the channels formed by the evaporator fins 305.

[0071] Fig. 4 shows an example method that could be used to form heat exchangers 200 in examples of the disclosure. The heat exchanger 200 can be a macro-scale or micro-scale two-phase heat exchanger. The heat exchanger 200 can be for use in two-phase cooling systems 101. The heat exchanger 200 can be an evaporator 103 or a condenser 105 or any other suitable type of heat exchanger 200.

[0072] At block 401 the method comprises providing a plurality of structures 203 extending from a base plate 201 where the structures 203 are separated by at least a first distance w. The structures 203 could comprise any means for defining a flow path for working fluid 113 through the heat exchanger 200. In some examples the plurality of structures 203 could comprise a plurality of evaporator fins 305 as shown in Fig. 3A or in any other suitable type or configuration of structures 203.

[0073] At block 403 the method comprises providing brazing material 207 overlaying, at least some of the structures 203. The brazing material 207 can be provided in a discontinuous configuration so that gaps are provided between portions of brazing material 207. The brazing material 207 could be provided in a plurality of wires 301 as shown in Fig. 3A or in any other suitable configuration. The brazing material 207 is provided in a thickness d that is smaller than the first distance w between pairs of adjacent structures 203.

[0074] At block 405 the method comprises providing at least one cover plate 205 over ends of the plurality of structures 203. At least one cover plate 205 is also provided over the brazing material 207 so that the brazing material 207 is positioned between the ends of the structures 203 and the cover plate 205. The cover plate is spaced from the ends of the plurality of structures 203 by a second distance d where the second distance is smaller than the first distance w. The second distance d can be the same as, or slightly larger than, the thickness of the brazing material 207.

[0075] The method also comprises, at block 407, heating the brazing material 207. The brazing material 207 is heated to a temperature above the melting point so that the molten brazing material 207 flows into spacing between the cover plate 205 and the ends of the plurality of structures 203.

[0076] The distance w between pairs of adjacent structures 203 and the thickness d of the brazing material 207 are selected so that, when the brazing material 207 is melted, Laplace pressure causes the brazing material 207 to flow into gaps between the ends of the plurality of structures 203 and at least one cover plate 205. This prevents the brazing material 207 from flowing into the channels formed by the structures 203. This feature helps to maximize, or substantially maximise, the effective heat transfer area and reduce the total pressure drops within the heat exchanger 200.

[0077] In the above described example, the brazing material 207 is provided in a thickness d that is smaller than the first distance w between pairs of adjacent structures 203. In other examples the brazing material 207 could be provided in a thickness d that is initially larger than the first distance w between pairs of adjacent structures 203. In such examples, when the brazing material 207 is heated, the initial Laplace pressure would cause the molten brazing material 207 to initially flow into the gaps between pairs of adjacent structures 203. However, once the brazing material 207 has flowed to a point where the thickness is less than the first distance w between pairs of adjacent structures 203 then the Laplace pressure would drive the flow of the brazing material 207 into the gap between the ends of the structures 203 and the cover plate 205. Flow into the gaps between pairs of adjacent structures 203 would be halted and reversed to maximize, or substantially maximise, the effective heat transfer area and reduce the total pressure drops within the heat exchanger 200. At these cases the Laplace pressure difference between the meniscus in the gap between adjacent structures 203 and the ends of the structures 203 and the cover plate 205 would drive the flow of the brazing material 207.

[0078] Figs. 5A to 5D show different example configurations of brazing material 207 that could be used in examples of the disclosure. In these examples the brazing material 207 is provided in a discontinuous configuration rather than in a continuous sheet. The discontinuous configuration ensures that there are gaps between portions of the brazing material 207. These gaps provide a spacing between the cover plate 205 and the ends of the structures 203 into which the molten brazing material 207 can flow.

[0079] The thickness of the brazing material 207 can be selected so that Laplace pressure of the brazing material 207 will cause flow of the brazing material 207 horizontally across the ends of the structures 203. The area covered by the brazing material 207 and the discontinuous configuration used for the brazing material 207 can be selected to provide sufficient volume of brazing material 207 so that a secure and rigid brazing join can be formed.

[0080] In the example of Fig. 5A the brazing material 207 is provided in a plurality of wires 301. The plurality of wires 301 can have a circular, or substantially circular, cross section. The plurality of wires 301 can extend perpendicularly to the channels formed by the plurality of structures 203. The wires 301 are provided in an even spacing across the tops of the structures 203 in the example of Fig. 5A. The number and spacing of wires 301 can be selected so as to control the volume of brazing material 207 that is used.

[0081] In the example of Fig. 5B the brazing material 207 is provided in a plurality of dots 501. The dots 501 are provided in an interconnected mesh 503. The interconnected mesh comprises gaps 505 between the dots 501 into which the molten brazing material 207 can flow. The number of dots 501 and the size of the dots 501 can be selected so as to control the volume of brazing material 207 that is used.

[0082] The brazing material 207 shown in Fig. 5C is also provided in an interconnected mesh 503. In this example the interconnected mesh 503 comprises a plurality of circular gaps 505. The circular gaps 505 provide spacing into which the molten brazing material 207 can flow. Other shapes for the gaps 505 could be used in other examples of the disclosure. The number of gaps 505 and the size of the gaps 505 can be selected so as to control the volume of brazing material 207 that is used.

[0083] Fig. 5D shows another example interconnected mesh 503 of brazing material 207. In this example the interconnected mesh 503 can be formed from a plurality of intersecting wires 301. In this example the interconnected mesh 503 provides a plurality of rectangular gaps 505 for the molten brazing material 207 to flow into. The number of wires 301 within the interconnected mesh 503 can be selected so as to control the volume of brazing material 207 that is used.

[0084] In the examples shown in Figs. 4 to 5D the base plate 201 has a substantially square shape. Other shapes could be used in other examples. In some examples the base plate 201 can have a surface area that is larger than the heat source to which the base plate 201 and an evaporator 103 are thermally coupled. This can help to distribute heat across the base plate 201 and can provide better thermal performance.

[0085] In some examples the heat exchanger 200 can comprise additional components that are not shown in Figs. 2 to 5D. In some examples the heat exchanger 200 can comprise a stiffener structure that is configured to restrict bending of the structures 203. The stiffener structure can comprise a plurality of projecting portions that extend between the plurality of structures 203 to hold the structures 203 in place.

[0086] In some examples the heat exchanger 200 can be configured so that at least some of the structures 203 extend through the cover plate 205. This can provide a larger surface for the brazing between the structures 203 and the cover plate 205. Further coupling means can be provided on the ends of the structures 203 that extend through the cover plate 205. The further coupling means can provide further coupling of the structure 203 to the cover plate 205 in addition to the brazing join. This can provide for a more rigid heat exchanger 200 and can enable the heat exchanger 200 to withstand handle high internal operating pressures.

[0087] Fig. 6 shows an example heat exchanger 200 being formed comprising a stiffener structure 601. In this example the heat exchanger 200 is an evaporator 103 with a plurality of structures 203. The stiffener structure 601 is configured to strengthen the heat exchanger 200 and reduce deformation of the heat exchanger 200 during use. The stiffener structure 601 can be provided in heat exchanger 200 as shown in Figs. 2 to 5D and in Figs. 7A to 8 or in any other suitable type of heat exchanger 200.

[0088] The heat exchanger 200 shown in Fig. 6 comprises a base plate 201 and a plurality of structures 203 which can be as described above.

[0089] The stiffener structure 601 can be provided as part of the cover plate 205 or as an additional component between the ends of the structures 203 and the cover plate 205. In the example shown in Fig. 6 the base plate 201 is connected to first ends of the plurality of structures 203 and the stiffener structure 601 is connected to second ends of the plurality of structures 203.

[0090] The stiffener structure 601 comprises a plurality of projecting portions 603 that extend between the plurality of structures 203 to hold the structures 203 in place. The projecting portions 603 can be configured to hole the ends of the structures 203 in place. The projecting portions 603 have a much shorter length compared to the structures 203 so that the projecting portions 603 do not project too far into the channels formed by adjacent pairs of structures 203. This helps to maintain the size of the channels so that sufficient working fluid 113 can flow through the channels when the heat exchanger 200 is in use.

[0091] In the example of Fig. 6 the projection portions 603 of the stiffener structure 601 form an interdigitated structure with the ends of the structures 203. The projection portions 603 are sized and shaped so that they fit tightly into the gaps between the ends of the structures 203. The projection portions 603 grip the sides of the structures 203 to hold the structures 203 in place. In some examples the plurality of projecting portions 603 of the stiffener structure 601 can be brazed to sides of the plurality of structures 203. This can help to prevent movement of the structures 203 relative to the stiffener structure 601 and thus helps to prevent deformation of the heat exchanger 200.

[0092] In the example of Fig. 6 all structures 203 are coupled to projecting portions 603 of the stiffener structure 601. In other examples the projecting portions 603 of the stiffener structure 601 can be coupled to a subset of the plurality of structures 203. Where the projecting portions 603 are coupled to just a subset of the plurality of structures 203 the subset can be selected so as to reduce the deformation of the heat exchanger 200. For example, the structures 203 at the centre of the heat exchanger 200 could be the ones that are most likely to be deformed during use and so the projecting portions 603 can be configured to be coupled to the structures 203 at the centre of the heat exchanger 200.

[0093] In the example of Fig. 6 the stiffener structure 601 is provided as a single component that is coupled to all structures 203. Different arrangements for the stiffener structure 601 can be provided in other examples of the disclosure. For instance, a plurality of different stiffener structures 601 can be provided coupled to different subsets of the structures 203.

[0094] Figs. 7A and 7B show examples of different geometries that can be used for heat exchangers 200. Figs. 7A and 7B show a completed heat exchanger 200. In these examples the heat exchanger 200 is an evaporator 103 with a plurality of structures 203. The heat exchanger 200 could be formed using any of the methods described above. These heat exchangers 200 are configured to provide uniform flow, or substantially uniform flow of the working fluid 113 across the heat exchanger 200 to improve thermal performance. The features shown in Figs. 7A and 7B can be provided in combination with other features of heat exchangers 200 in any of Figs. 2 to 6 or Fig. 8.

[0095] In the examples of Figs. 7A and 7B the heat exchanger 200 comprises a base plate 201 and a plurality of structures 203 extending out of the base plate 201. A cover plate 205 is provided over the structures 203. In the examples of Figs. 7A and 7B the heat exchangers 200 are configured to provide larger channels for flow of working fluid 113 towards the central portion of the base plate 201 compared to edges of the base plate 201. This can help providing a uniform flow distribution of the working fluid.

[0096] The base plate 201 is thermally coupled to a heat source 701. A thermal interface material can be provided between the heat source 701 and the base plate 201 for the thermal coupling. In the examples of Figs. 7A and 7B the base plates 201 are larger than the heat sources 701. Having the larger base plates 201 improve heat spreading and increase the effective heat transfer area which helps to reduce the thermal resistance of the heat exchanger 200.

[0097] In the examples of Figs. 7A and 7B the heat sources 701 are positioned in a central part of the base plates 201. The channels defined by the structures 203 have different widths in order to provide uniform, or substantially uniform, flow distribution across the heat exchanger 200. The channels that are closer to the heat source 701 have larger sizes than the channels that are further away. The widths of the channels that are used can be designed to achieve uniform or substantially uniform, flow distribution while maintaining the mechanical integrity of the heat exchanger 200.

[0098] In the example of Fig. 7A the different channel sizes are obtained by having different spacings between the structures 203. The spacings between adjacent pairs of structures 203 is larger in the centre of the base plate 201 than it is at the edges. The structures 203 are spaced closer together at the edges of the base plate 201 than in the centre of the base plate 201. This creates channels having larger widths at the centre of the base plate 201 and channels having narrower widths at the edges of the base plate 201.

[0099] In the example of Fig. 7B the different channel sizes are obtained by providing an inlet portion 703 that provides a larger channel width in a central portion of the base plate 201 compared to edges of the base plate 201.

The inlet portion 703 could be directly machined in the cover plate 205.

[0100] In this example the inlet portion 703 defines an inlet for the heat exchanger 200. The inlet portion 703 shown in Fig. 7B has two different lengths. A first length is provided towards the centre of the base plate 201 and a second length is provided at the edges of the base plate 201. The first length is shorter than the second length so that the inlet is larger at the centre of the base plate 201 than it is at the edges . It is to be appreciated that other configurations of the inlet portion 703 can be used in other examples of the disclosure.

[0101] In both of the examples shown in Figs. 7A and 7B the heat exchangers 200 are provided into two parts. In these examples the cover plates 205 comprise a central section 705 that divide the heat exchangers 200 into the different parts.

[0102] The cover plates 205 can be bonded to the base plates 201 and the structures 203 by brazing joins 707. In the example shown in Figs. 7A and 7B the brazing joins 707 can be formed along edges of the structures 203 that are at the edges of the base plates 201. Brazing joins 707 are also formed between the central section 705 of the cover plates 205 and the structures 203 that are adjacent to the central section 705. This arrangement of the brazing joins 707 help to provide a better bonding between the base plates 201 and the cover plates 205 and helps to reduce deformation of the heat exchangers 200 during use.

[0103] Fig. 8 shows another example heat exchanger 200. In this example the heat exchanger 200 is an evaporator 103 with a plurality of structures 203. The features shown in Fig. 8 can be provided in combination with other features of heat exchangers 200 in any of Figs. 2 to 7B.

[0104] The heat exchanger 200 comprises a base plate 201, a plurality of structures 203 extending out of the base plate 201 and a cover plate 205. At least some of the plurality of structures 203 extend through the cover plate 205. The base plate 201 is thermally coupled to a heat source 701. The cover plate 205 is joined to the base plate 201 and the structures 203 by a brazing join 707.

[0105] Coupling means 801 are provided on the ends of the structures 203 that extend through the cover plate 205. The coupling means 801 can comprise brazing material or any other suitable means.

[0106] The coupling means 801 can provide additional strength in addition to the brazing join 707 between the cover plate 205 and the structures 203 and/or the base plate 201. The additional coupling means 801 can help to prevent deformation of the heat exchanger 200 during use.

[0107] Fig. 9 show formation of an example two-phase cooling system 101 comprising an evaporator 103 and a condenser 105. The evaporator 103 and condenser 105 are heat exchangers 200 that can be as shown in any of Figs. 2 to 8 or can comprise any combination of the features shown in Figs. 2 to 8.

[0108] The evaporator 103 can be provided within an additional frame before being installed in a server or other system for use. The additional frame can be rigid frame formed from plastic or any other suitable materials. The rigid frame can prevent people from directly accessing the evaporator 103 so as to prevent the evaporator 103 from becoming damaged. The additional frame can also act as a thermal insulator to avoid unwanted air flow impacting the evaporator 103.

[0109] In order to form the two-phase cooling system 101, the evaporator 103 and the condenser 105 can be vacuum brazed. The vacuum brazing of the evaporator 103 mechanically couples the cover plate 205 to the base plate 201 and evaporator fins 305. The vacuum brazing of the condenser 105 mechanically couples the two cover plates 205 to a base plate 201 or any other suitable components. The base plate 201 of the condenser 105 could comprise a double-sided fin plate or any other suitable type of plate.

[0110] The evaporator 103 and the condenser 105 are then connected to a riser 109 and a downcomer 107 via junctions 901, as indicated by the arrows. The junctions 901 form a closed loop for the two-phase cooling system 101. The junctions 901 can have the same inlet diameters as the downcomer 107 and the riser 109. This helps to prevent pressure drops within the two-phase cooling system 101 and helps to maximize, or substantially maximize, the passive flow circulation.

[0111] The various components of the two-phase cooling system 101 can be connected together via any suitable means. In the example of Fig. 9 the evaporator 103 and the condenser 105 are connected to the riser 109 the downcomer 107 by laser spot welding around the internal perimeters of the junctions 901.

[0112] In the example shown in Fig. 9 the two-phase cooling system 101 also comprises a charging port 903. The charging port 903 enables working fluid 113 to be provided into the two-phase cooling system 101. The charging port 903 is provided in the downcomer 107. In this example the charging port 903 is provided at the top of the downcomer 107 close to the condenser 105.

[0113] The term 'comprise' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising Y indicates that X may comprise only one Y or may comprise more than one Y. If it is intended to use 'comprise' with an exclusive meaning then it will be made clear in the context by referring to "comprising only one..." or by using "consisting".

[0114] In this description, reference has been made to various examples. The description of features or functions in relation to an example indicates that those features or functions are present in that example. The use of the term 'example' or 'for example' or 'can' or 'may' in the text denotes, whether explicitly stated or not, that such features or functions are present in at least the described example, whether described as an example or not, and that they can be, but are not necessarily, present in some of or all other examples. Thus 'example', 'for example', 'can' or 'may' refers to a particular instance in a class of examples. A property of the instance can be a property of only that instance or a property of the class or a property of a sub-class of the class that includes some but not all of the instances in the class. It is therefore implicitly disclosed that a feature described with reference to one example but not with reference to another example, can where possible be used in that other example as part of a working combination but does not necessarily have to be used in that other example.

[0115] Although examples have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the claims.

[0116] Features described in the preceding description may be used in combinations other than the combinations explicitly described above.

[0117] Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

[0118] Although features have been described with reference to certain examples, those features may also be present in other examples whether described or not.

[0119] The term 'a' or 'the' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising a/the Y indicates that X may comprise only one Y or may comprise more than one Y unless the context clearly indicates the contrary. If it is intended to use 'a' or 'the' with an exclusive meaning then it will be made clear in the context. In some circumstances the use of 'at least one' or 'one or more' may be used to emphasis an inclusive meaning but the absence of these terms should not be taken to infer any exclusive meaning.

[0120] The presence of a feature (or combination of features) in a claim is a reference to that feature or (combination of features) itself and also to features that achieve substantially the same technical effect (equivalent features). The equivalent features include, for example, features that are variants and achieve substantially the same result in substantially the same way. The equivalent features include, for example, features that perform substantially the same function, in substantially the same way to achieve substantially the same result.

[0121] In this description, reference has been made to various examples using adjectives or adjectival phrases to describe characteristics of the examples. Such a description of a characteristic in relation to an example indicates that the characteristic is present in some examples exactly as described and is present in other examples substantially as described.

[0122] Whilst endeavoring in the foregoing specification to draw attention to those features believed to be of importance it should be understood that the Applicant may seek protection via the claims in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not emphasis has been placed thereon, as long as within the scope of the appended claims.

Claims

1. A heat exchanger (200) comprising:

   a plurality of structures (203, 305) extending from a base plate (201) where adjacent structures (203, 305) are separated by at least a first distance (w); and
   at least one cover plate (205) positioned over ends of the plurality of structures (203, 305) so that the at least one cover plate (205) is spaced from the ends of the plurality of structures (203, 305) by a second distance (d) where the second distance (d) is smaller than the first distance (w);
   wherein the at least one cover plate (205) is brazed to the plurality of structures (203, 305) by brazing material (207) provided between the ends of the plurality of structures (203, 305) and the at least one cover plate (205); **characterised in that**
   wherein the brazing material (207) is provided in a discontinuous configuration so that gaps are provided between portions of brazing material (207) so that a brazing join is formed from brazing material (207) that has flowed into spacing between the at least one cover plate (205) and the ends of the plurality of structures (203, 305).

2. A heat exchanger (200) as claimed in claim 1 wherein the brazing material (207) is provided in a thickness that is smaller than the first distance (w).

3. A heat exchanger (200) as claimed in any preceding claim wherein the first distance (w) and the second distance (d) are selected so that Laplace pressure causes the brazing material (207) to flow into gaps between the ends of the plurality of structures (203, 305) and the at least one cover plate (205).

4. A heat exchanger (200) as claimed in any preceding claim wherein the plurality of structures (203, 305) extend substantially perpendicularly out of the base plate (201).

5. A heat exchanger (200) as claimed in any preceding claim wherein the plurality of structures (203, 305) are spaced closer together at edges of the base plate (201) than in a centre of the base plate (201).

6. A heat exchanger (200) as claimed in any preceding claim comprising a stiffener structure comprising a plurality projecting portions configured to extend between the plurality of structures (203, 305) so as to restrict bending of the plurality of structures (203,

305).

7. A heat exchanger (200) as claimed in any preceding claim wherein the plurality of structures (203, 305) comprises fins.

8. A heat exchanger (200) as claimed in any preceding claim wherein the heat exchanger (200) comprises an evaporator or a condenser.

9. A method comprising:

providing a plurality of structures (203, 305) extending from a base plate (201) where the plurality of structures (203, 305) are separated by at least a first distance (w);
providing brazing material (207) overlaying, at least some of the plurality of structures (203, 305) wherein the brazing material (207) is provided in a discontinuous configuration so that gaps are provided between portions of brazing material (207);
providing at least one cover plate (205) over ends of the plurality of structures (203, 305) and the brazing material (207) so that the at least one cover plate (205) is spaced from the ends of the plurality of structures (203, 305) by a second distance (d) where the second distance (d) is smaller than the first distance (w); and
heating the brazing material (207) so that the brazing material (207) flows into spacing between the at least one cover plate (205) and the ends of the plurality of structures (203, 305).

10. A method as claimed in claim 9 wherein the brazing material (207) is provided in a thickness that is smaller than the first distance (w).

11. A method as claimed in any of claims 9 to 10 wherein the first distance (w) and the second distance (d) are selected so that Laplace pressure causes the brazing material (207) to flow into gaps between the ends of the plurality of structures (203, 305) and the at least one cover plate (205).

Patentansprüche

1. Wärmetauscher (200), umfassend:

eine Vielzahl von Strukturen (203, 305), die sich von einer Grundplatte (201) erstrecken, wobei benachbarte Strukturen (203, 305) durch mindestens einen ersten Abstand (w) getrennt sind; und
mindestens eine Abdeckplatte (205), die über den Enden der Vielzahl von Strukturen (203, 305) angeordnet ist, so dass die mindestens eine Abdeckplatte (205) von den Enden der Vielzahl von Strukturen (203, 305) um einen zweiten Abstand (d) beabstandet ist, wobei der zweite Abstand (d) kleiner als der erste Abstand (w) ist;
wobei die mindestens eine Abdeckplatte (205) mit der Vielzahl von Strukturen (203, 305) durch Lötmaterial (207), das zwischen den Enden der Vielzahl von Strukturen (203, 305) und der mindestens einen Abdeckplatte (205) vorgesehen ist, verlötet ist;
dadurch gekennzeichnet, dass
wobei das Lötmaterial (207) in einer diskontinuierlichen Konfiguration vorgesehen ist, so dass Lücken zwischen Abschnitten des Lötmaterials (207) vorhanden sind, so dass eine Lötverbindung aus Lötmaterial (207) gebildet wird, das in den Zwischenraum zwischen der mindestens einen Abdeckplatte (205) und den Enden der Vielzahl von Strukturen (203, 305) geflossen ist.

2. Wärmetauscher (200) nach Anspruch 1, wobei das Lötmaterial (207) in einer Dicke bereitgestellt wird, die kleiner als der erste Abstand (w) ist.

3. Wärmetauscher (200) nach einem der vorstehenden Ansprüche, wobei der erste Abstand (w) und der zweite Abstand (d) gewählt werden, so dass der Laplace-Druck bewirkt, dass das Lötmaterial (207) in die Lücken zwischen den Enden der Vielzahl von Strukturen (203, 305) und der mindestens einen Abdeckplatte (205) fließt.

4. Wärmetauscher (200) nach einem der vorstehenden Ansprüche, wobei sich die Vielzahl der Strukturen (203, 305) im Wesentlichen senkrecht aus der Grundplatte (201) heraus erstreckt.

5. Wärmetauscher (200) nach einem der vorstehenden Ansprüche, wobei die Vielzahl von Strukturen (203, 305) an den Rändern der Grundplatte (201) näher beieinander liegen als in der Mitte der Grundplatte (201).

6. Wärmetauscher (200) nach einem der vorhergehenden Ansprüche, umfassend eine Versteifungsstruktur, die eine Vielzahl von vorstehenden Abschnitten umfasst, die konfiguriert sind, um sich zwischen der Vielzahl von Strukturen (203, 305) zu erstrecken, um so die Biegung der Vielzahl von Strukturen (203, 305) zu begrenzen.

7. Wärmetauscher (200) nach einem der vorstehenden Ansprüche, wobei die Vielzahl der Strukturen (203, 305) Rippen umfasst.

8. Wärmetauscher (200) nach einem der vorstehenden Ansprüche, wobei der Wärmetauscher (200) einen Verdampfer oder einen Kondensator umfasst.

9. Verfahren, umfassend:

Bereitstellen einer Vielzahl von Strukturen (203, 305), die sich von einer Grundplatte (201) aus erstrecken, wobei die Vielzahl von Strukturen (203, 305) durch mindestens einen ersten Abstand (w) getrennt sind;
Bereitstellen von Lötmaterial (207), das mindestens einige der Vielzahl der Strukturen (203, 305) überlagert, wobei das Lötmaterial (207) in einer diskontinuierlichen Konfiguration vorgesehen ist, so dass Lücken zwischen den Teilen des Lötmaterials (207) entstehen;
Bereitstellen mindestens einer Abdeckplatte (205) über den Enden der Vielzahl der Strukturen (203, 305) und dem Lötmaterial (207), so dass die mindestens eine Abdeckplatte (205) von den Enden der Vielzahl von Strukturen (203, 305) um einen zweiten Abstand (d) beabstandet ist, wobei der zweite Abstand (d) kleiner als der erste Abstand (w) ist; und
Erhitzen des Lötmaterials (207), so dass das Lötmaterial (207) in den Zwischenraum zwischen der mindestens einen Abdeckplatte (205) und den Enden der Vielzahl von Strukturen (203, 305) fließt.

10. Verfahren nach Anspruch 9, wobei das Lötmaterial (207) in einer Dicke bereitgestellt wird, die kleiner als der erste Abstand (w) ist.

11. Verfahren nach einem der Ansprüche 9 bis 10, wobei der erste Abstand (w) und der zweite Abstand (d) gewählt werden, so dass der Laplace-Druck bewirkt, dass das Lötmaterial (207) in die Lücken zwischen den Enden der Vielzahl von Strukturen (203, 305) und der mindestens einen Abdeckplatte (205) fließt.

Revendications

1. Échangeur de chaleur (200) comprenant :

une pluralité de structures (203, 305) s'étendant à partir d'une plaque de base (201) où des structures (203, 305) adjacentes sont séparées d'au moins une première distance (w) ; et
au moins une plaque de couverture (205) positionnée sur les extrémités de la pluralité de structures (203, 305) de sorte que la au moins une plaque de couverture (205) est espacée des extrémités de la pluralité de structures (203, 305) d'une seconde distance (d) où la seconde distance (d) est plus petite que la première distance (w) ;
dans lequel la au moins une plaque de couverture (205) est brasée à la pluralité de structures (203, 305) par un matériau de brasage (207) fourni entre les extrémités de la pluralité de structures (203, 305) et la au moins une plaque de couverture (205) ; **caractérisé en ce que** dans lequel le matériau de brasage (207) est fourni dans une configuration discontinue de sorte que des interstices sont fournis entre des parties de matériau de brasage (207) de sorte qu'une jonction de brasage est formée à partir d'un matériau de brasage (207) qui s'est écoulé dans un espacement entre la au moins une plaque de couverture (205) et les extrémités de la pluralité de structures (203, 305).

2. Échangeur de chaleur (200) selon la revendication 1 dans lequel le matériau de brasage (207) est fourni en une épaisseur qui est plus petite que la première distance (w).

3. Échangeur de chaleur (200) selon une quelconque revendication précédente dans lequel la première distance (w) et la seconde distance (d) sont sélectionnées de sorte que la pression de Laplace amène le matériau de brasage (207) à s'écouler dans des interstices entre les extrémités de la pluralité de structures (203, 305) et la au moins une plaque de couverture (205).

4. Échangeur de chaleur (200) selon une quelconque revendication précédente dans lequel la pluralité de structures (203, 305) s'étendent sensiblement perpendiculairement hors de la plaque de base (201).

5. Échangeur de chaleur (200) selon une quelconque revendication précédente dans lequel la pluralité de structures (203, 305) sont espacées plus rapprochées au niveau des bords de la plaque de base (201) que dans un centre de la plaque de base (201).

6. Échangeur de chaleur (200) selon une quelconque revendication précédente comprenant une structure de raidisseur comprenant une pluralité de parties saillantes configurées pour s'étendre entre la pluralité de structures (203, 305) de façon à limiter la flexion de la pluralité de structures (203, 305).

7. Échangeur de chaleur (200) selon une quelconque revendication précédente dans lequel la pluralité de structures (203, 305) comprend des ailettes.

8. Échangeur de chaleur (200) selon une quelconque revendication précédente dans lequel l'échangeur de chaleur (200) comprend un évaporateur ou un condensateur.

9. Procédé comprenant :

la fourniture d'une pluralité de structures (203, 305) s'étendant à partir d'une plaque de base

(201) où la pluralité de structures (203, 305) sont séparées d'au moins une première distance (w) ;
la fourniture d'un matériau de brasage (207) recouvrant au moins certaines de la pluralité de structures (203, 305) dans lequel le matériau de brasage (207) est fourni dans une configuration discontinue de sorte que des interstices sont fournis entre des parties de matériau de brasage (207) ;
la fourniture d'au moins une plaque de couverture (205) sur les extrémités de la pluralité de structures (203, 305) et le matériau de brasage (207) de sorte que la au moins une plaque de couverture (205) est espacée des extrémités de la pluralité de structures (203, 305) d'une seconde distance (d) où la seconde distance (d) est plus petite que la première distance (w) ; et
le chauffage du matériau de brasage (207) de sorte que le matériau de brasage (207) s'écoule dans l'espacement entre la au moins une plaque de couverture (205) et les extrémités de la pluralité de structures (203, 305).

10. Procédé selon la revendication 9 dans lequel le matériau de brasage (207) est fourni en une épaisseur qui est plus petite que la première distance (w).

11. Procédé selon l'une quelconque des revendications 9 à 10 dans lequel la première distance (w) et la seconde distance (d) sont sélectionnées de sorte que la pression de Laplace amène le matériau de brasage (207) à s'écouler dans des interstices entre les extrémités de la pluralité de structures (203, 305) et la au moins une plaque de couverture (205).

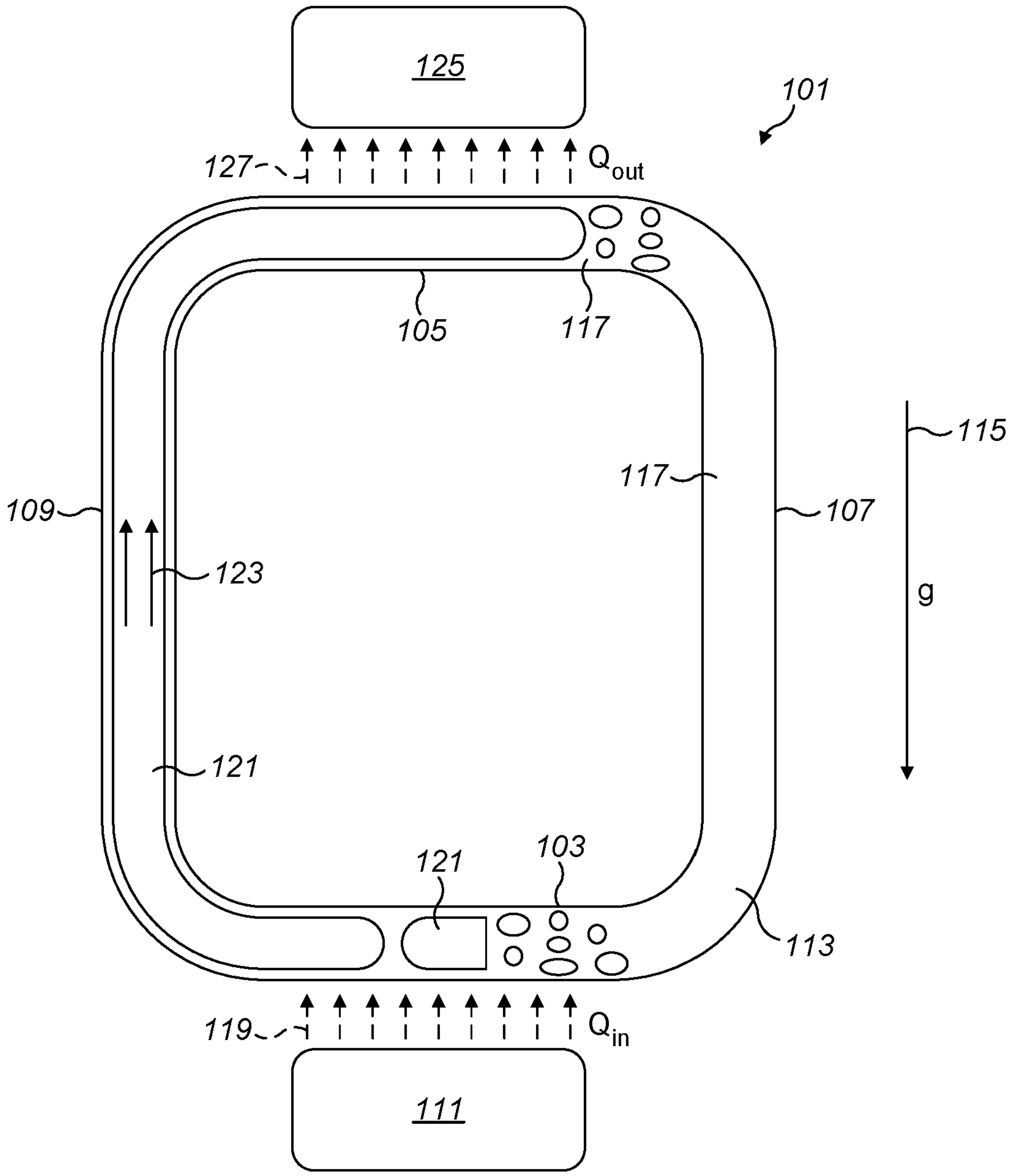
125
101
127
Qout
105
117
115
109
117
107
123
g
121
121
103
113
119
Qin
111

FIG. 1

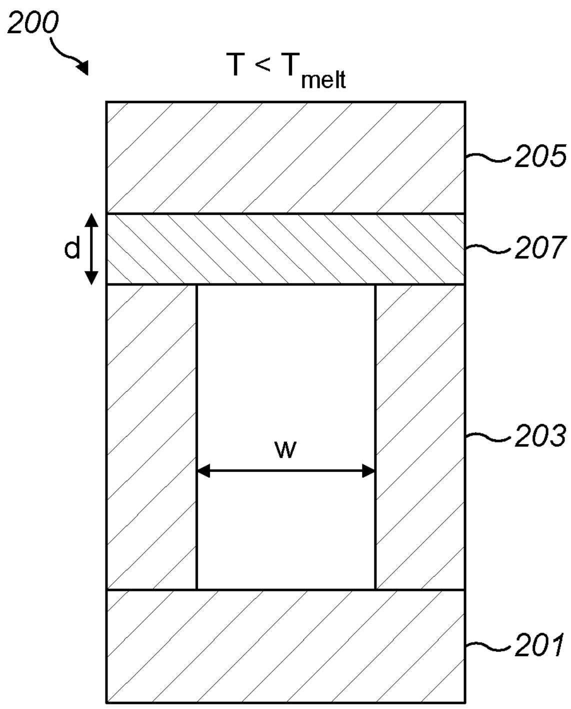

FIG. 2A

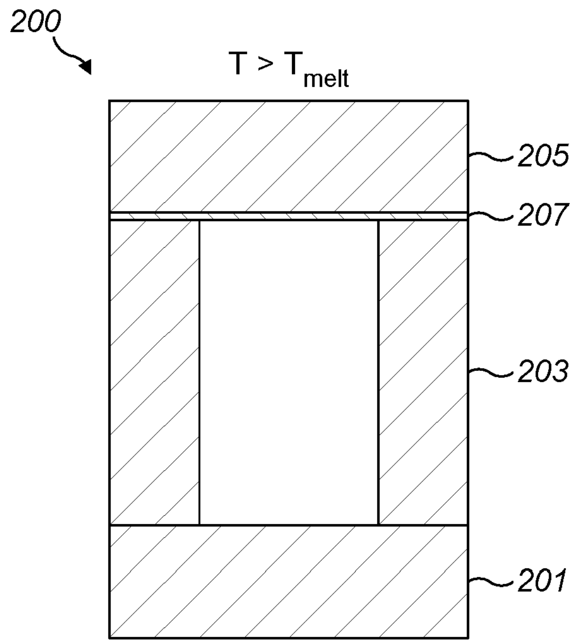

FIG. 2B

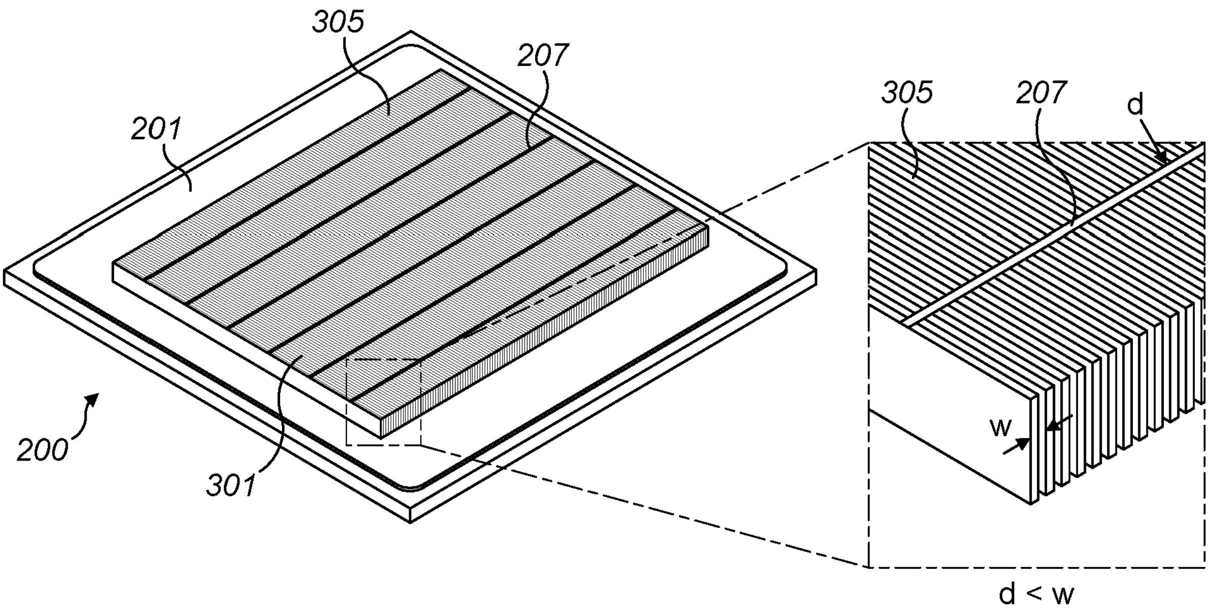

FIG. 3A

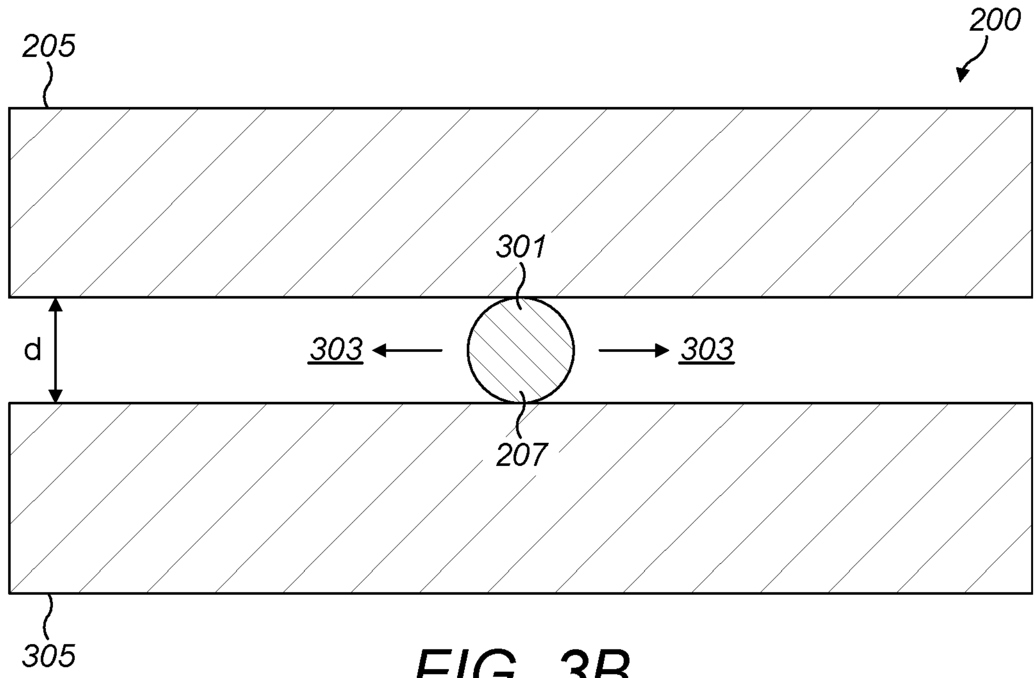
200
205
301
d
303
303
207
305

FIG. 3B

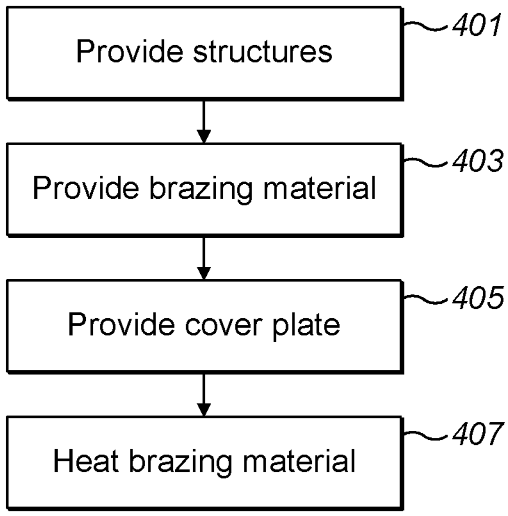
Provide structures
401
Provide brazing material
403
Provide cover plate
405
Heat brazing material
407

FIG. 4

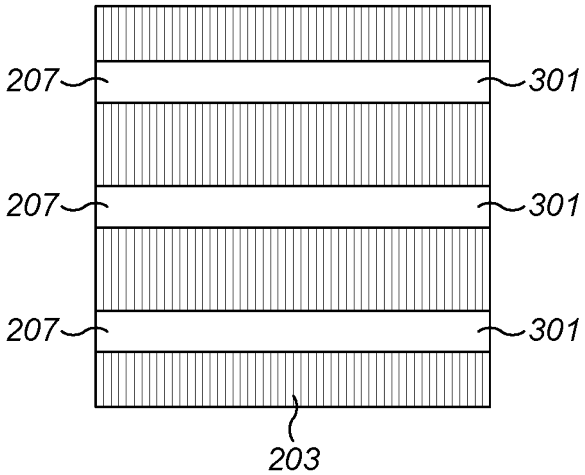

FIG. 5A

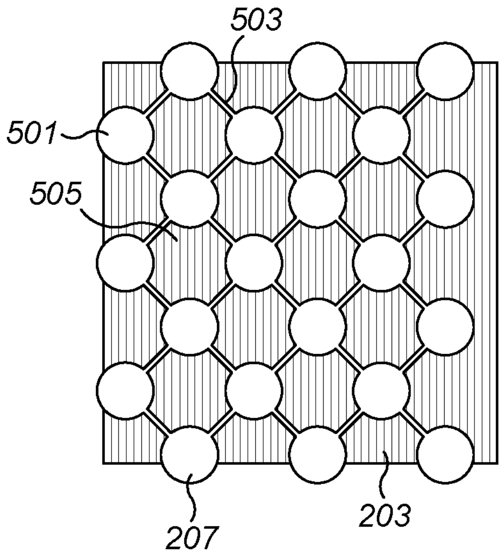

FIG. 5B

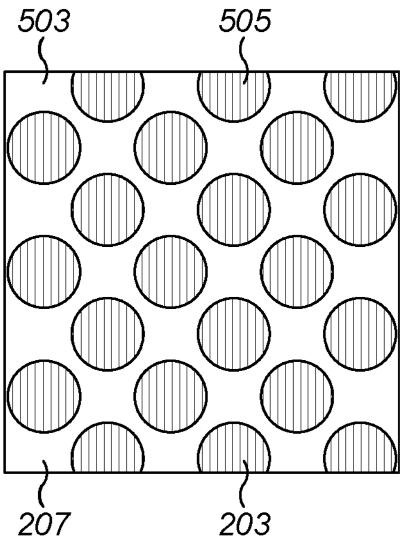

FIG. 5C

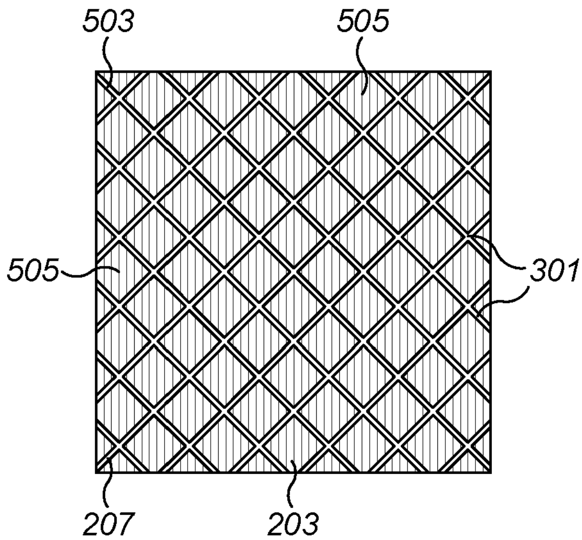

FIG. 5D

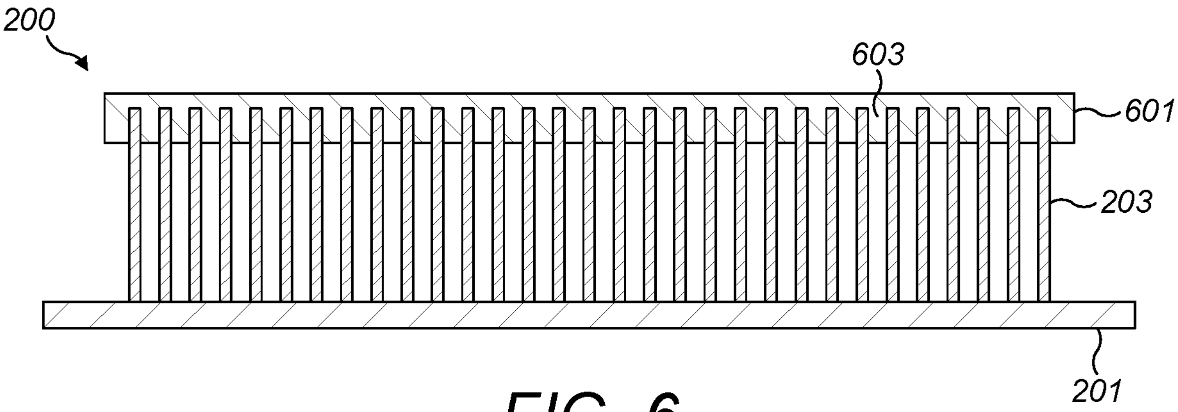

FIG. 6

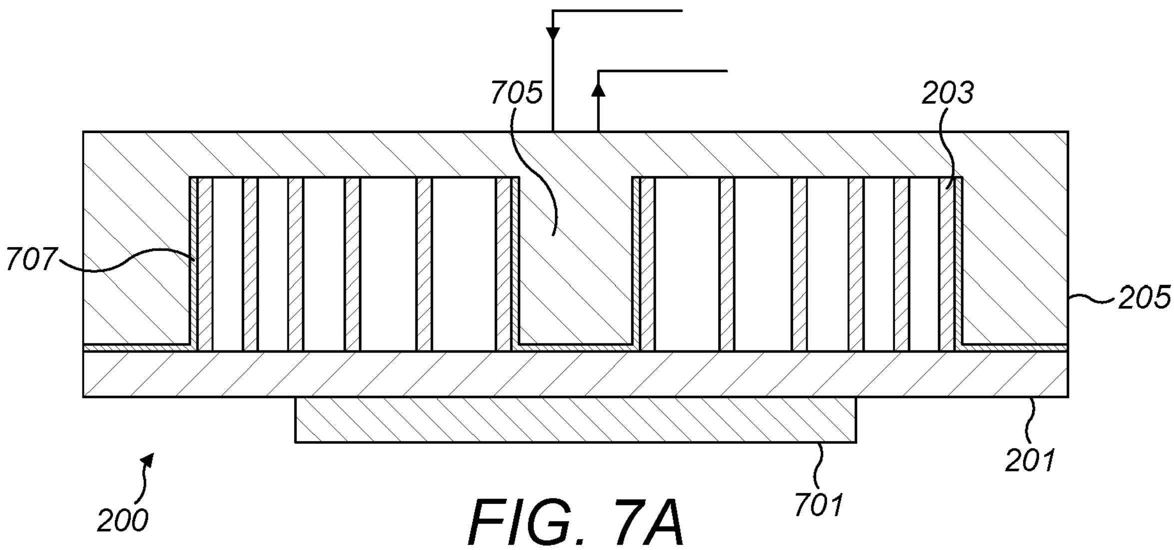

FIG. 7A

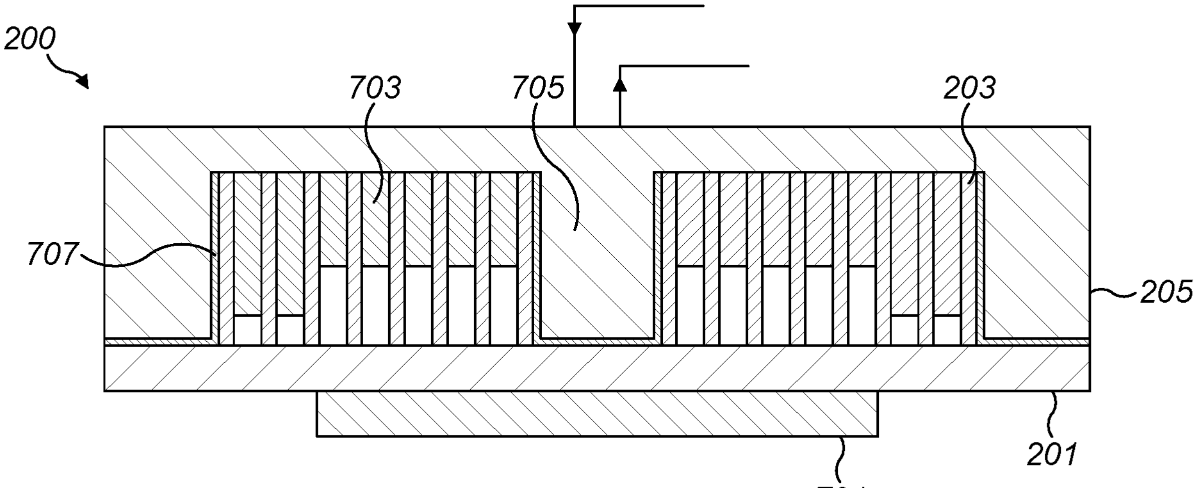

FIG. 7B

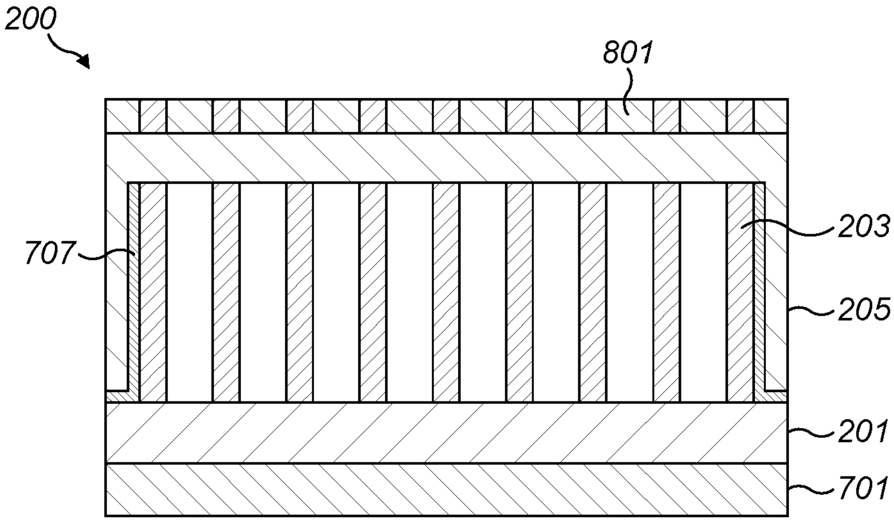

FIG. 8

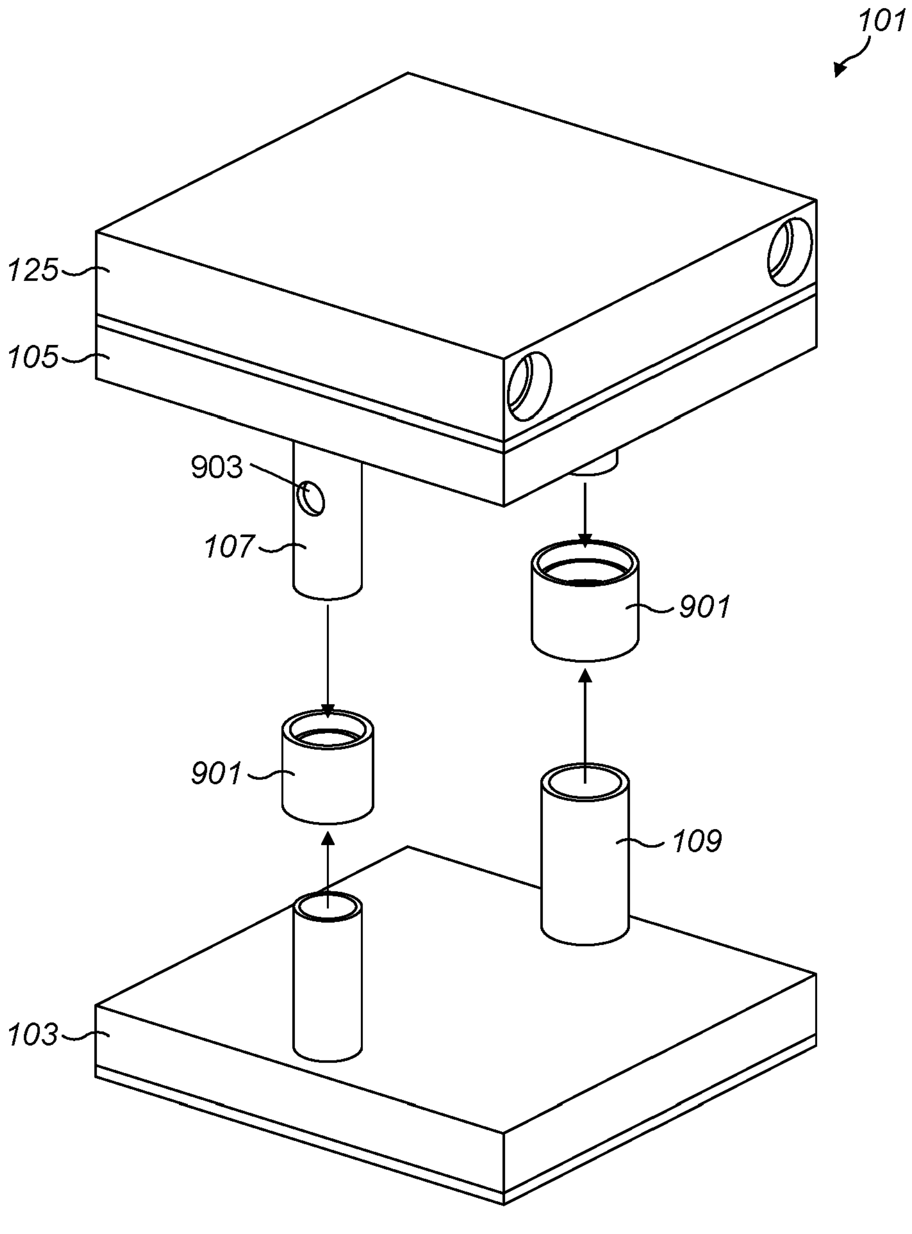

FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 20130014917 A1 **[0003]**
- US 20160377350 A1 **[0004]**