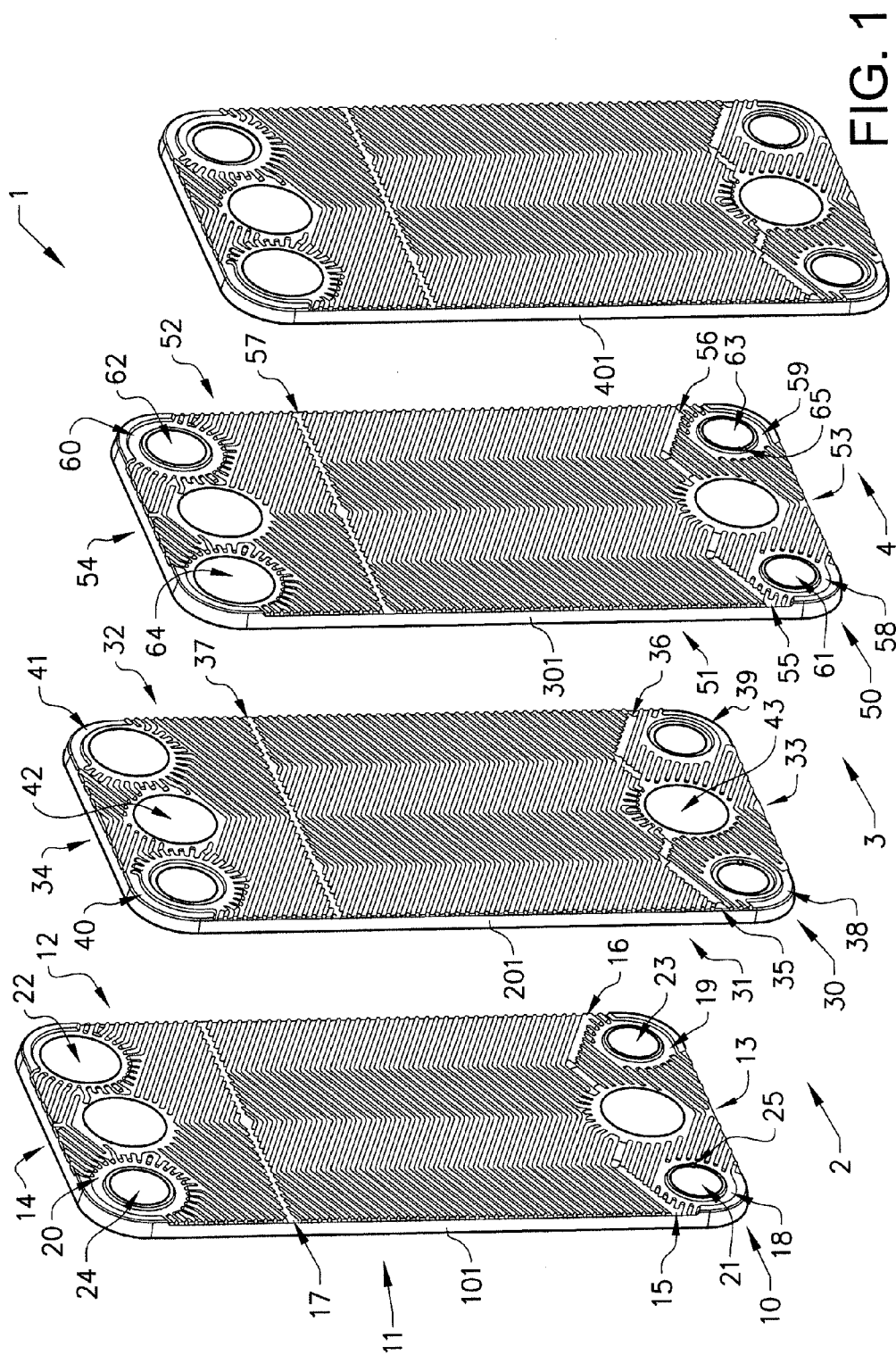




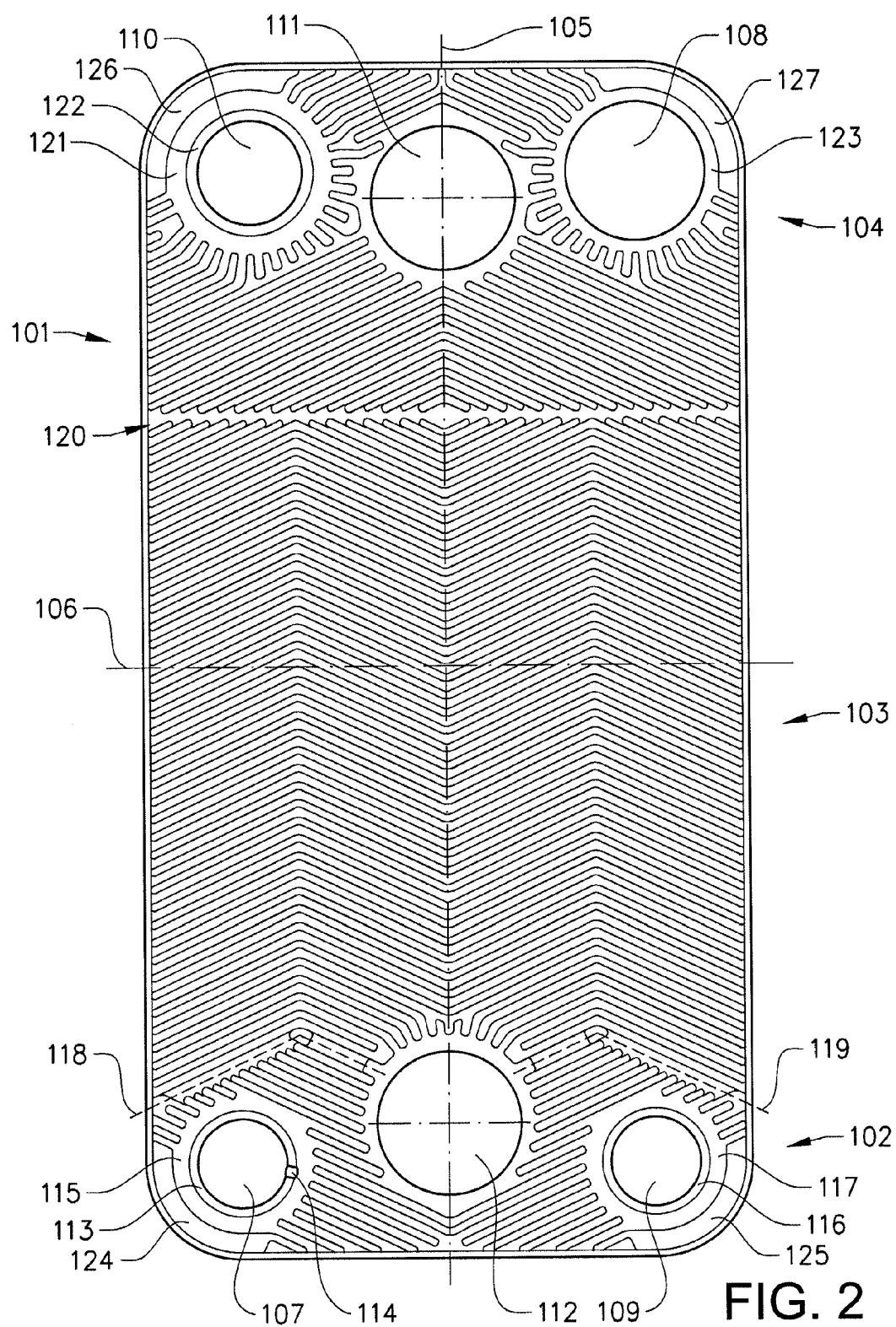
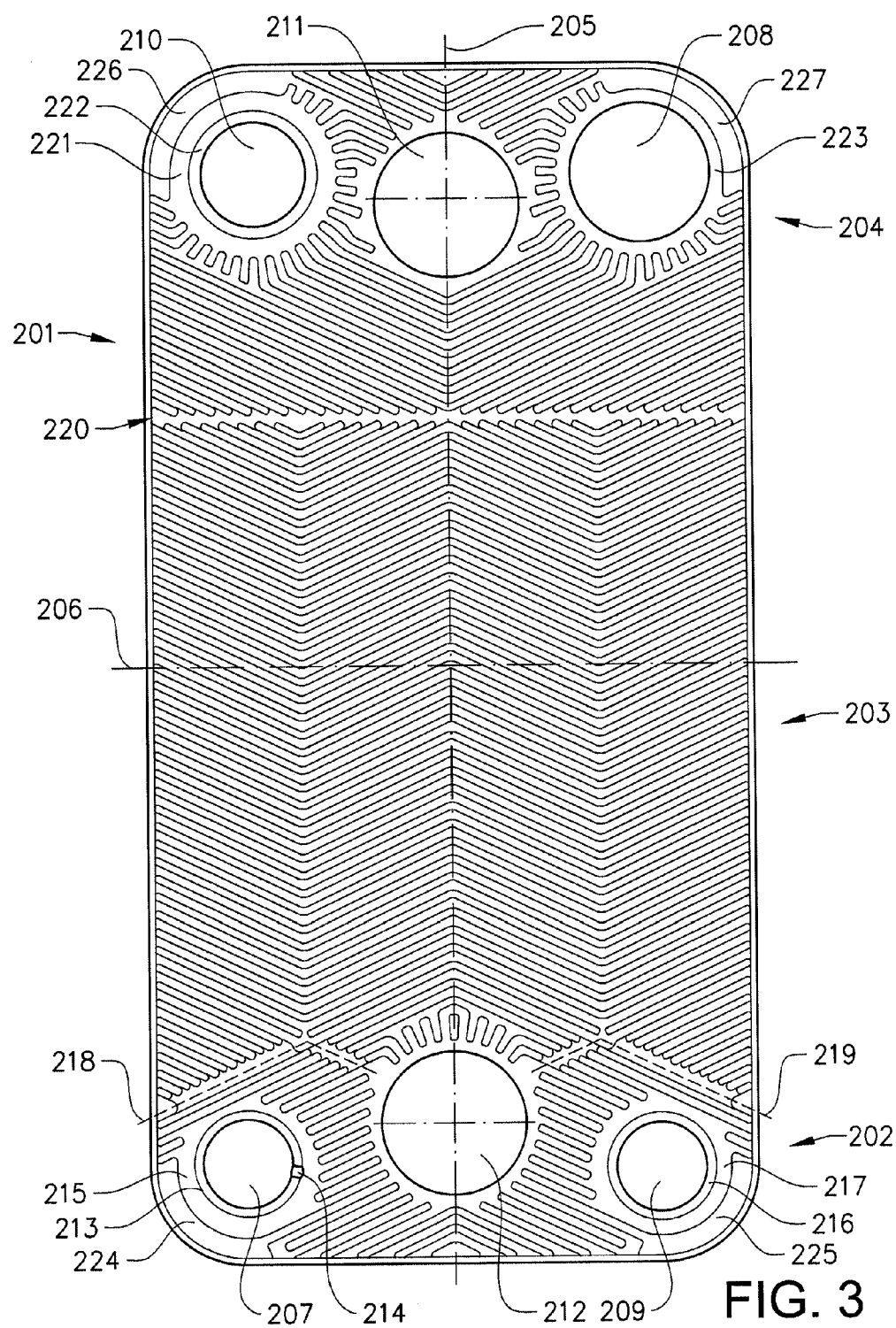
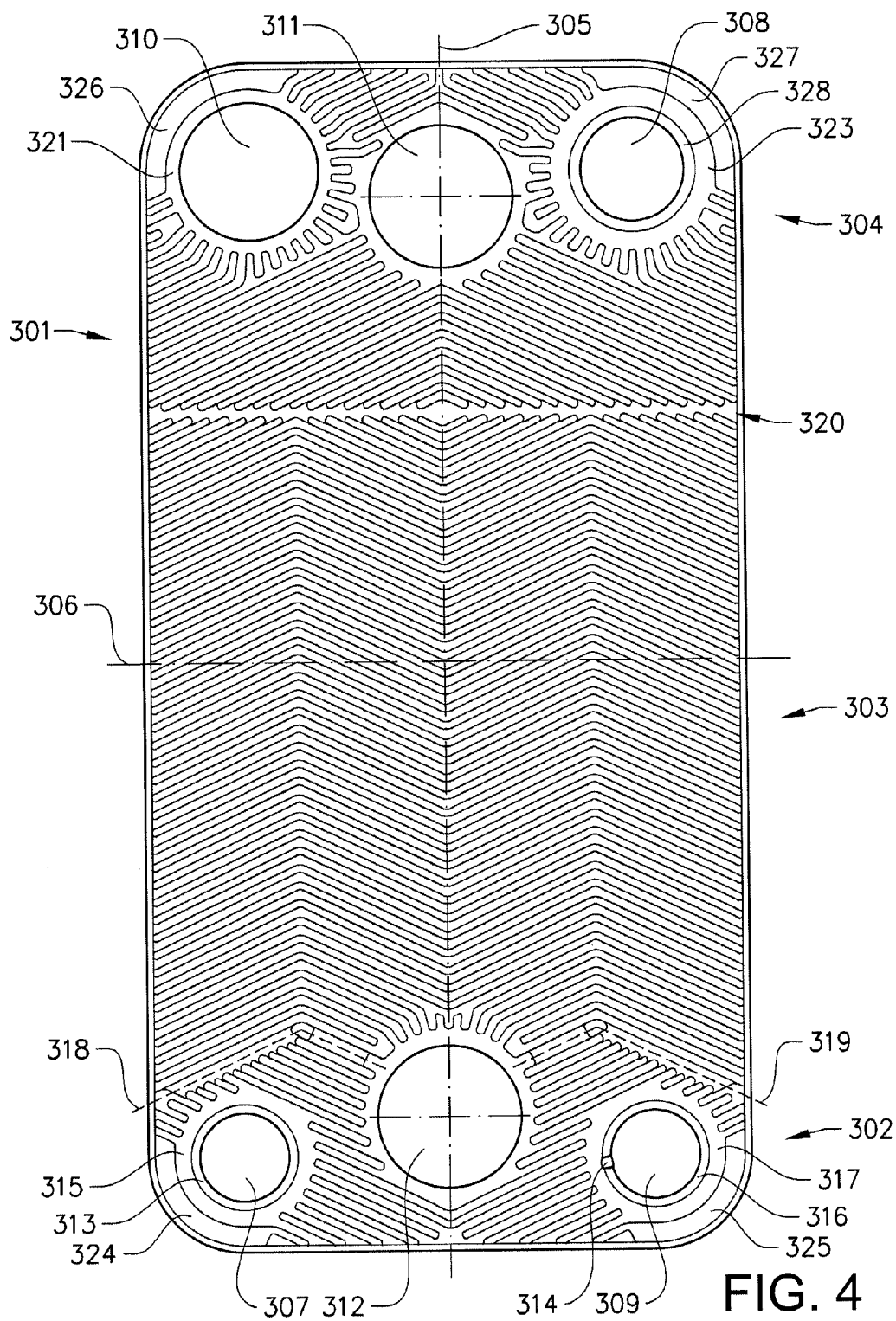


FIG. 2





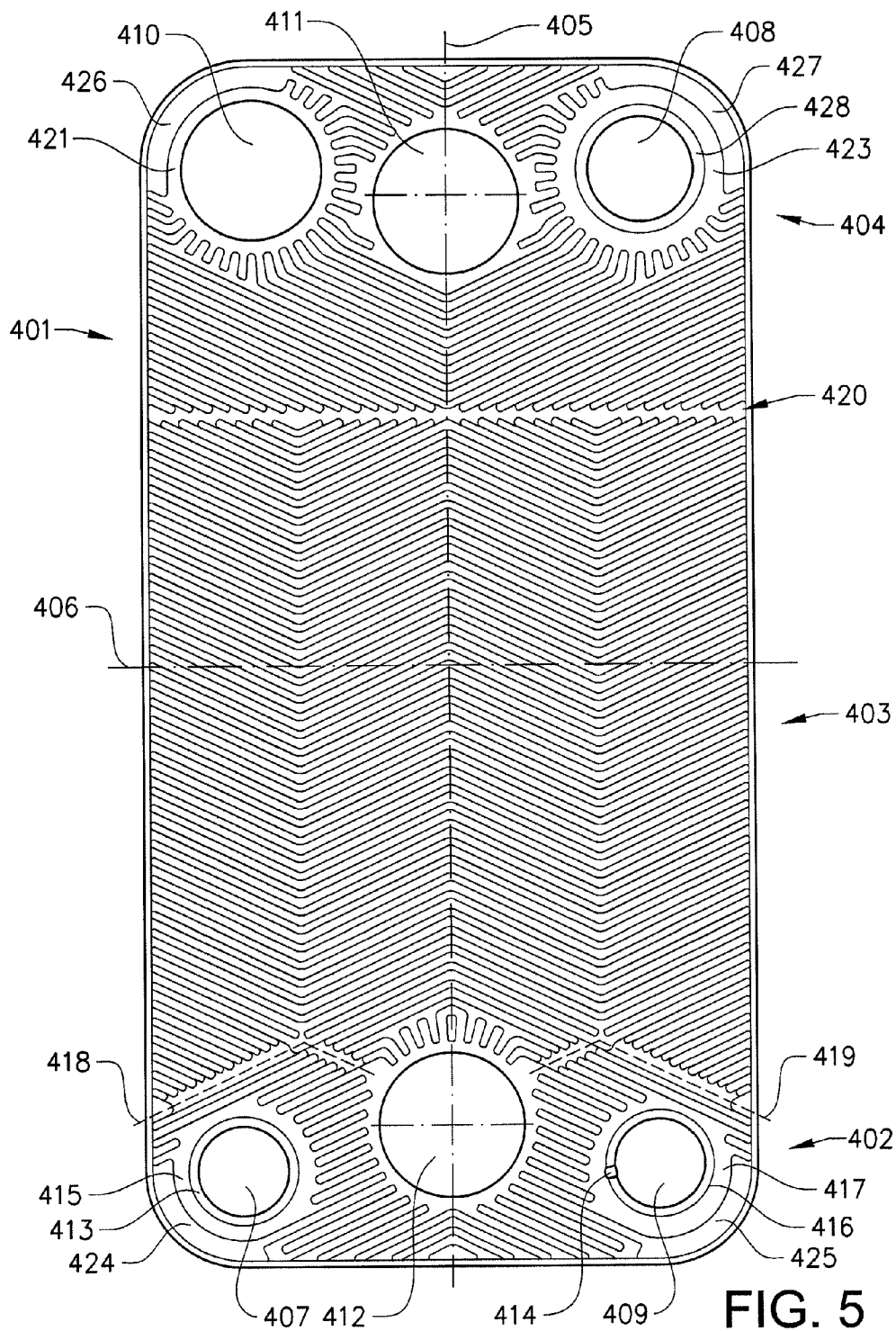


FIG. 5

HEAT EXCHANGER

TECHNICAL FIELD

[0001] The present invention relates to a plate heat exchanger having three separate fluid circuits. Such a plate heat exchanger will have two independent refrigerant circuits and one liquid circuit.

BACKGROUND ART

[0002] Plate heat exchangers having three separate fluid circuits, one circuit for the liquid and two circuits for the refrigerant, show some advantages with respect to heat exchangers having two fluid circuits. Such a heat exchanger allows for a well balanced cooling effect with less risk of freezing when used as an evaporator. It will also operate under partial load conditions in an efficient way which will reduce energy consumption. The installation will be easier and faster, which will reduce installation cost. Further, it will allow for a simpler and thus less expensive control system.

[0003] One common use of three circuit heat exchangers is as evaporators for evaporation of refrigerants flowing in refrigeration systems. Such a refrigeration system normally includes a compressor, a condenser, an expansion valve and an evaporator. A plate heat exchanger used as an evaporator in a system of this kind often has heat exchanging plates that are welded or brazed together, but also sealing gaskets may be used for sealing between the heat transferring plates.

[0004] EP 0765461 B shows a plate heat exchanger with flow passages for three different fluids between the plates. The delivery of the three fluids to the core of plates is done in such a way that passages for the fluid number one are present on both sides of every passage for each one of the two remaining fluids. The passages are created using two different kinds of plates. Good sealing between adjacent plates at the openings creating the inlet and outlet channels for the three fluids is created by designing the areas around the ports, thereby defining a system with annular planar plateaus.

[0005] EP 1062472 B shows another example of a three fluid circuit heat exchanger. This application mainly concerns the connection of the port holes in an airtight manner.

[0006] EP 0965025 B describes a plate heat exchanger for three heat exchanging fluids. The port holes of the heat exchanger are pair wise aimed for the flowing through of the respective heat exchanging fluids and the port holes are symmetrically positioned on both sides of a heat transferring part in such a way that a straight line drawn between the centres of the port holes divides the heat transferring part into two alike parts.

[0007] These heat exchangers will function perfectly well in some applications. Still, in the present heat exchangers, there is room for improvements.

DISCLOSURE OF INVENTION

[0008] An object of the invention is therefore to provide an improved heat exchanger having an improved flow distribution in each flow circuit. A further object of the invention is to provide a heat exchanger having an improved heat transfer coefficient.

[0009] The solution to the problem according to the invention is described in the characterizing part of claim 1. Claims 2 to 11 contain advantageous embodiments of the heat exchanger plate. Claims 12 to 21 contain advantageous

embodiments of a heat exchanger assembly. Claim 22 contains an advantageous heat exchanger.

[0010] With a heat exchanger plate for the use in a three circuit heat exchanger assembly, where the plate comprises a first distribution area having three port holes, a heat exchange area and a second distribution area having three port holes, where the plate comprises a corrugated pattern having ridges and valleys, the object of the invention is achieved in that the central port hole of the first distribution area is positioned at a vertical distance from the short end of the plate such that a fluid passage is obtainable between the central port hole and the short end of the plate when two plates are stacked to form a fluid channel between the plates.

[0011] By this first embodiment of the plate for a heat exchanger assembly, a heat exchanger plate is obtained which allows for an improved flow distribution in the first distribution passage for the refrigerant circuits. The advantage of this is that a larger part of the heat exchanger plate, i.e. the area around the passive inlet port, can also be used as an effective heat transfer surface. Another advantage is that the flow distribution of the fluid in the first or lower distribution passage is improved, which in turn improves the flow distribution in the heat transfer passage. Another advantage is that the flow in the liquid circuit and into the liquid outlet port is also improved. The efficiency of the heat exchanger will thus be improved.

[0012] In an advantageous development of the inventive plate, the central port hole of the second distribution area is positioned at a vertical distance from the short end of the plate such that a fluid passage is obtainable between the central port hole and the short end of the plate when two plates are stacked to form a fluid channel between the plates. The advantage of this is that a larger part of the heat exchanger plate, i.e. the area around the passive outlet port, can also be used as an effective heat transfer surface. Another advantage is that the flow distribution of the liquid from the inlet port is improved, which in turn improves the liquid flow distribution in the heat transfer passage. The efficiency of the heat exchanger will thus be further improved.

[0013] In an advantageous development of the inventive plate, at least one corner of the plate is provided with a flat, ring-shaped bypass section adapted to form a refrigerant bypass passage around a port when two plates are stacked to form a refrigerant fluid channel between the plates. This will improve the fluid distribution in the refrigerant channels of the heat exchanger.

[0014] In an advantageous development of the inventive plate, at least one water bypass section is provided at a corner of the plate such that a water passage is obtainable between two adjacent bypass sections when two plates are stacked to form a water channel between the plates. This will improve the fluid distribution in the water channel of the heat exchanger.

[0015] In further advantageous developments of the inventive plate, a lower distribution groove is provided between the first distribution area and the heat exchange area, the lower distribution groove comprises at least one restriction area, and an upper distribution groove is provided between the heat exchange area and the upper distribution area. All these developments will allow for an improved fluid distribution in a heat exchanger.

[0016] In an advantageous development of the inventive plate, the first distribution area exhibits a chevron shape having a first layout, the second distribution area exhibits a chev-

ron shape having a second layout and where the heat exchange area exhibits a chevron shape having a third layout, where the chevron shape of the first layout is directed in a first angular direction and the chevron shape of the second layout is directed in the opposite angular direction. This will allow for an improved heat transfer of the heat exchanger.

[0017] With a heat exchanger assembly, comprising four inventive heat exchanger plates, the object of the invention is achieved in that the first plate, the second plate, the third plate and the fourth plate are different.

[0018] In an advantageous development of the inventive assembly, where a first refrigerant channel is provided between the first plate and the second plate, a water channel is provided between the second plate and the third plate and a second refrigerant channel is provided between the third plate and the fourth plate, and where each fluid channel comprises a first distribution passage provided between two adjacent first distribution areas, a heat exchange passage provided between two adjacent heat exchange areas and a second distribution passage provided between two adjacent second distribution areas, a horizontal passage is provided in the first distribution passage between the central water port and the short end of the assembly. This is advantageous in that the horizontal passage will improve the flow distribution in the first distribution passage which in turn will improve the flow distribution in the heat transfer passage. This will allow a larger part of the heat exchanger plate, i.e. the area around the passive inlet port, to function as an effective heat transfer surface. Another advantage is that the fluid flow in the liquid circuit is improved since the complete liquid outlet port is open. The efficiency of the heat exchanger will thus be improved.

[0019] In an advantageous development of the inventive assembly, a horizontal passage is provided in the second distribution passages between the central water port and the neighbouring short end of the assembly. The advantage of this is that a larger part of the heat exchanger plate, i.e. the area around the passive outlet port, can also be used as an effective heat transfer surface. Another advantage is that the flow distribution of the liquid from the inlet port is improved, which in turn improves the liquid flow distribution in the heat transfer passage. The efficiency of the heat exchanger will thus be further improved.

[0020] In an advantageous development of the inventive assembly, a water bypass passage is provided in a water distribution passage between a refrigerant port and a corner of the assembly. This is advantageous in that a water bypass is obtained, which will improve the water flow distribution in the heat exchanger considerably.

[0021] In an advantageous development of the inventive assembly, a refrigerant bypass passage is provided around a refrigerant port in a refrigerant distribution passage. This is advantageous in that the refrigerant flow distribution is improved considerably.

[0022] In an advantageous development of the inventive assembly, the active refrigerant inlet ports are provided with inlet nozzles, where the angle of the inlet nozzles is between 0 and 180 degrees relative a vertical axis and where the inlet nozzle points towards the central vertical axis of the assembly. In this way, the inlet nozzle will point towards the centre of the heat exchanger, which will improve the fluid distribution in the heat exchanger.

[0023] In an advantageous development of the inventive assembly, a lower distribution path is provided between a

lower distribution passage and a heat exchange passage. This is advantageous in that the flow distribution in the lower distribution passage can be controlled in a more refined way, such that the flow into the heat exchange passage can become as even as possible.

[0024] In an advantageous development of the inventive assembly, the lower distribution path comprises at least one restriction means such that a flow restriction is obtained in the lower distribution path. This is advantageous in that the flow distribution in the lower distribution passage can be controlled in a more refined way, such that the flow into the heat exchange passage can be as even as possible.

[0025] In an advantageous development of the inventive assembly, an upper distribution path is provided between the heat exchange passage and the upper distribution passage. This is advantageous in that the flow distribution into the upper distribution passage can be evened out further.

[0026] In a three-circuit heat exchanger, comprising a plurality of inventive heat exchanger assemblies and further comprising at least a front plate and a back plate, an improved heat exchanger is obtained.

BRIEF DESCRIPTION OF DRAWINGS

[0027] The invention will be described in greater detail in the following, with reference to the embodiments that are shown in the attached drawings, in which

[0028] FIG. 1 shows a heat exchanger plate assembly according to the invention,

[0029] FIG. 2 shows a first heat exchanger plate to be used in a heat exchanger plate assembly according to the invention,

[0030] FIG. 3 shows a second heat exchanger plate to be used in a heat exchanger plate assembly according to the invention,

[0031] FIG. 4 shows a third heat exchanger plate to be used in a heat exchanger plate assembly according to the invention, and

[0032] FIG. 5 shows a fourth heat exchanger plate to be used in a heat exchanger plate assembly according to the invention.

MODES FOR CARRYING OUT THE INVENTION

[0033] The embodiments of the invention with further developments described in the following are to be regarded only as examples and are in no way to limit the scope of the protection provided by the patent claims.

[0034] In the examples below, water is used as an example of a fluid that is to be cooled or heated. The fluid that is to be cooled or heated is adapted to be used in a single-phase, in a solely liquid state. The layout of the heat exchanger is thus adapted to a single-phase liquid for the water circuit. It is of course possible to use other fluids as well, such as different mixtures of waters and other fluids, e.g. for the purpose of anti-freezing or corrosion protection. A refrigerant is used as an example of a fluid that is to be evaporated or condensed. This fluid will preferably be used in two phases, a liquid state and a vapour state, but it is possible to use the fluid only in a single state, either in a liquid state, a vapour state or a mixture. The layout of the heat exchanger is thus adapted to a two-phase fluid for the other fluid circuits.

[0035] The invention relates to a plate heat exchanger having three separate channel types allowing for three different fluid flow circuits. One of the channels is adapted to carry a single-phase liquid that is to be heated or cooled. In this

application, water will be used as an example of such a liquid. The other two channels are adapted to carry a two-phase refrigerant that is adapted to evaporate or condensate in the heat exchanger. The channels may either be connected so that one refrigerant is common to both circuits or the channels may be separated so that a different refrigerant can be used in each circuit. In this application, a two phase saturated fluid that is in a somewhat pressurized state when entering the heat exchanger and which will evaporate in the heat exchanger is used as an example of a refrigerant.

[0036] Further, the plate heat exchanger is in the described example of the permanently joined type, i.e. the plates are brazed, glued, bonded, soldered or welded together to form a complete heat exchanger. The plate heat exchanger comprises a plurality of heat exchanger assemblies, where each assembly comprises four different heat exchanger plates. It is however also possible to use different sealing types, e.g. gaskets between the plates, welded plates or semi-welded plate unit with gaskets between every second plate.

[0037] The heat exchanger plates are formed using two different pressing tools, thereby obtaining two different plate types, a first plate type having a chevron layout in one direction and a second plate type having a chevron layout in the opposite direction. The layout comprises a corrugation pattern consisting of ridges and valleys which extend across the plates in a chevron layout with angle direction change points along longitudinal lines dividing the plate width into equal parts. The corrugation pattern together with the chevron layout is laid out such as to provide many crossing points of the pattern when the plates are stacked together, thereby creating a strong and rigid heat exchanger having a efficient heat transfer. Corrugated pattern and layouts of this kind are well known to the skilled person. It is also possible to use a corrugated pattern having the same angle over the complete surface, i.e. which does not have any direction change points.

[0038] Each plate type is in a second operation run through one or more further pressing/cutting operations, thereby creating four different plates. In the further operations, the port hole regions of the plates are pressed and cut to the final shape and the nozzle indentation is formed.

[0039] The resulting plates, comprising a first plate **101**, a second plate **201**, a third plate **301** and a fourth plate **401**, are stacked so that they form a heat exchanger plate assembly. The plates are stacked such that every other plate is of the same plate type if the size and layout of the port hole region and the nozzle are not considered. The port hole regions will differ between the plates, as will be described below. It is also possible to give the first and the second plate types different angles of the chevron layout. The layout of the first plate type can thus have a slightly smaller angle and the layout of the second plate type a slightly larger angle, so that the mean value of the angles corresponds to the desired angle value of the layout.

[0040] Each heat exchanger plate comprises a first or lower distribution area comprising three port holes, a central heat exchange area and a second or upper distribution area comprising three port holes. Each plate has a longitudinal or vertical axis and a lateral or horizontal axis. The port holes of the first distribution area are arranged symmetrically with respect to the longitudinal axis. The port holes of the second distribution area are also arranged symmetrically with respect to the longitudinal axis. The port holes of the first and second distribution areas may be arranged symmetrically with respect to each other. In an advantageous embodiment, the

port holes of the first and second distribution areas are however not arranged symmetrically with respect to each other, since the port holes adapted for an evaporated phase of a refrigerant are larger in diameter than the port holes adapted for a flushed liquid vapour mixture of the refrigerant, and the port holes are positioned at approximately the same distance from the corners of the plates. In this embodiment, the port holes in the second distribution area are adapted for the refrigerant in the vapour state and the port holes in the first distribution area are adapted for the liquid refrigerant.

[0041] The heat exchanger is in one example intended to be used for rising film evaporation on the refrigerant channel side and cooling on the water side in a counter-current flow arrangement. Below, a heat exchanger used for rising film evaporation will be used to exemplify the invention. The references in the description will thus refer to the geometries for the position of such a vertical, upright heat exchanger. It is also possible to use the heat exchanger in other positions if required, e.g. at different angles around the horizontal axis. The refrigerant two-phase fluid may be a mixture of liquid and vapour when entering the heat exchanger and may be completely evaporated, and even superheated, when leaving the heat exchanger. The heat exchanger may also be used with the water and the refrigerant flowing in the same directions, i.e. a co-current flow. The heat exchanger described is adapted for a diagonal flow of the refrigerant, i.e. the refrigerant will enter the heat exchanger through a port at a lower corner of the heat exchanger and will leave the heat exchanger through a port in the opposite higher corner. It is of course also possible to adapt the heat exchanger for a parallel flow, where the refrigerant enters the heat exchanger through a port at a lower corner of the heat exchanger and leaves the heat exchanger through a port in the higher corner on the same side, by adapting the inlet or outlet ports accordingly.

[0042] The heat exchanger may also be used for falling film refrigerant condensation while heating the water side in a counter-current flow or co-current flow arrangement. The two-phase refrigerant fluid may be in a superheated or saturated vapour state when entering the heat exchanger through the upper distribution passage and may be partly or completely condensed and even sub-cooled when leaving the heat exchanger through the lower refrigerant port. The heat exchanger may also be used as a desuperheater or gas cooler in a single phase heat transfer, or an economizer for evaporation, and similar uses, depending on the requirements of the installation. Small modifications may, depending on the use, be required in the plate layout.

[0043] The first heat exchanger plate **101**, shown in FIG. 2, comprises a first or lower distribution area **102**, a heat exchange area **103** and a second or upper distribution area **104**. The plate has a longitudinal or vertical axis **105** and a lateral or horizontal axis **106**. The lower distribution area **102** is provided with a first refrigerant inlet port hole **107**, a water outlet port hole **112** and a second refrigerant inlet port hole **109**. The first inlet port hole **107** is provided with a nozzle indentation **114**.

[0044] It is to be understood that the complete surface of a heat exchanger plate, where there is a fluid passage on the other side of the plate, is a heat transfer area. The heat exchange area **103** is thus referred to as a heat exchange area since the main purpose is that of heat transfer, even though there will be some fluid distribution also in the heat exchange area. The lower and upper distribution areas have the dual purpose of both fluid distribution as well as heat transferral.

[0045] The layout of the first distribution area **102** exhibits a single chevron shape, i.e. a V shape, where the direction change point is central to the plate, dividing the first distribution area in two equal parts. The layout angle of the V layout is preferably between 50 and 70 degrees with respect to the vertical axis of the heat exchanger. The interior angle of the V shape is thus between 100 and 140 degrees. Other angles are plausible but it is advantageous that the interior angle of the V shape is obtuse. By giving the chevron layout a rather small angle in relation to the horizontal axis, the friction factor in the horizontal direction of the lower distribution channel will be relatively low, which will facilitate the distribution of the refrigerant over the plate width.

[0046] The heat exchange area **103** is provided with a corrugated pattern exhibiting a chevron layout, i.e. a W shape, having three direction change points dividing the heat exchange area in four equal parts. The interior angle between the chevrons is of great importance for the friction factor of a channel. For the same interior angle, one advantage of using a W shape instead of a V shape is that the mean friction factor for the heat transfer area will be higher than when using a V shape. The heat transfer coefficient will thus be higher than for a conventional V shape. The use of the W shape gives a layout with three direction changes. It is also possible to use a chevron layout having two, four or even more direction changes. At the transition region of the chevrons, i.e. at the direction change points, the horizontal and also the vertical flow velocity component is reduced and may be close to zero. In the shown first plate, the layout resembles a W placed upside down.

[0047] The angle of the corrugated W shape is preferably between 50 and 70 degrees with respect to the vertical axis of the heat exchanger. The interior angle of a chevron is thus between 100 and 140 degrees. The interior angle of the chevrons of the heat exchange area may be the same as the chevrons of the first distribution area, or it may be somewhat smaller. Other angles are plausible but it is important that the interior angle of the chevrons is obtuse. The friction factor of the heat exchange passage depends e.g. on the interior angle of the chevron shape together with the number of direction changes.

[0048] The upper distribution area **104** of the plate is provided with a first refrigerant outlet port hole **108**, a water inlet port hole **111** and a second refrigerant outlet port hole **110**. The corrugated pattern of the upper distribution area exhibits a chevron layout resembling a single V placed upside down. The interior angle of the V shape may be the same as for the lower distribution area.

[0049] The interior angle of the chevrons in the lower distribution area, the heat exchange area and the upper distribution area may be the same or they may differ. In an advantageous embodiment, the chevrons of the lower distribution area and the heat exchange area are provided with the same interior angle. The chevron shape of the upper distribution area is in this embodiment provided with an angle that is smaller with respect to the vertical axis. In a further advantageous embodiment, the chevrons of the lower distribution area is provided with a first angle, the chevrons of the heat exchange area are provided with a second, smaller angle and the chevrons of the upper distribution area is provided with an even smaller angle. Preferably, the angles are in the interval of between 50 and 70 degrees. The advantage of having different interior angles of the different areas is that, when the refrigerant is evaporating, the volume flow will be higher in the

upper part of the heat exchanger. The different interior angles will thus give a lower flow resistance when the volume flow increases with the flow direction in the channel. The same applies when the flow is opposite and the heat exchanger is used to condense a vapour. A smaller interior chevron angle in relation to the vertical axis will give a lower flow resistance in this flow direction.

[0050] The second heat exchanger plate **201**, shown in FIG. 3, comprises a lower distribution area **202**, a heat exchange area **203** and an upper distribution area **204**. The plate has a vertical axis **205** and a horizontal axis **206**. The lower distribution area **202** is provided with a first refrigerant inlet port hole **207**, a water outlet port hole **212** and a second refrigerant inlet port hole **209**. The first inlet port hole **207** is provided with a nozzle indentation **214**.

[0051] The layout of the lower distribution area **202** exhibits a single chevron shape, i.e. a V shape, where the V shape resembles a V placed upside down. The direction change point is central to the plate, dividing the first distribution area in two equal parts. Apart from the direction of the chevron shape, the angles of the layout are the same as for the first plate.

[0052] The heat exchange area **203** is provided with a corrugated pattern exhibiting a chevron layout, i.e. a W shape, having three direction change points dividing the heat exchange area in four equal parts. In the shown second plate, the layout resembles a W. Apart from the direction of the chevron shape, the angles of the layout are the same as for the first plate.

[0053] The upper distribution area **204** of the second plate is provided with a first refrigerant outlet port hole **208**, a water inlet port hole **211** and a second refrigerant outlet port hole **210**. The corrugated cross pattern of the upper distribution area exhibits a chevron layout resembling a single V. The interior angle of the V shape may be the same as for the lower distribution area. Apart from the direction of the chevron shape, the angles of the layout are the same as for the first plate.

[0054] The third heat exchanger plate **301**, shown in FIG. 4, comprises a lower distribution area **302**, a heat exchange area **303** and an upper distribution area **304**. The plate has a vertical axis **305** and a horizontal axis **306**. The lower distribution area **302** is provided with a first refrigerant inlet port hole **307**, a water outlet port hole **312** and a second refrigerant inlet port hole **309**. The upper distribution area **304** of the plate is provided with a first refrigerant outlet port hole **308**, a water inlet port hole **311** and a second refrigerant outlet port hole **310**. Apart from the port holes and the nozzle indentation, the third heat exchanger plate resembles the first heat exchanger plate.

[0055] The fourth heat exchanger plate **401**, shown in FIG. 5, comprises a lower distribution area **402**, a heat exchange area **403** and an upper distribution area **404**. The plate has a vertical axis **405** and a horizontal axis **406**. The lower distribution area **402** is provided with a first refrigerant inlet port hole **407**, a water outlet port hole **412** and a second refrigerant inlet port hole **409**. The upper distribution area **404** of the plate is provided with a first refrigerant outlet port hole **408**, a water inlet port hole **411** and a second refrigerant outlet port hole **410**. Apart from the port holes and the nozzle indentation, the fourth heat exchanger plate resembles the second heat exchanger plate.

[0056] In the description, the phrase active inlet port means that the inlet port is open to let refrigerant flow through that

inlet port into that refrigerant channel. A passive inlet port means that the inlet port is sealed so that no refrigerant can flow into the refrigerant channel through the passive inlet port. The same applies for the phrase active outlet port, which means that the outlet port is in contact with the refrigerant channel so that the refrigerant flows out of the active outlet port. A passive outlet port is sealed so that no refrigerant can flow out from the refrigerant channel through the passive outlet port.

[0057] In FIG. 1, an inventive heat exchanger plate assembly 1 comprising a first plate 101, a second plate 201, a third plate 301 and a fourth plate 401 is shown. The different plates are shown in FIGS. 2-5. The plates are stacked on each other in the number required for a specific heat exchanger. In this way, a heat exchanger comprising a plurality of assemblies is formed. The number of assemblies is selectable depending on the required specifications of a heat exchanger. A complete heat exchanger will also include a specific front plate and back plate (not shown) having a larger thickness than the individual heat exchanger plates. The front plate and back plate will comprise connections etc. In a complete heat exchanger, the liquid channel closest to the front and back plate will be a water channel. A separate heat exchanger plate forming a water channel with the first plate may thus be comprised in the front plate, and a separate heat exchanger plate forming a water channel with the fourth plate may thus be comprised in the back plate. The front and back plates will strengthen the heat exchanger, making it more stable and rigid.

[0058] The heat exchanger is of the brazed type. Between the first and the second plate, a first refrigerant channel 2 is formed. Between the second and the third plate, a water channel 3 is formed. Between the third and the fourth plate, a second refrigerant channel 4 is formed. Between the fourth plate and the first plate of a further assembly, a water channel is formed. In this way, the heat exchanger will have alternating first and second refrigerant channels, being surrounded by a water channel on each side.

[0059] Both a refrigerant channel and a water channel will comprise a lower distribution passage, a heat exchange passage and an upper distribution passage. The vertical length of the lower distribution passage is preferably less than half of the width of the heat exchanger, while the vertical length of the upper distribution passage is preferably less than two thirds of the width of the heat exchanger.

[0060] When the first plate 101 and the second plate 201 are positioned next to each other, a first refrigerant channel 2 is formed. The refrigerant will enter the first refrigerant channel through a first refrigerant inlet port 21, being an active inlet port, created by the first refrigerant inlet port holes 107, 207. The inlet port holes 107, 207 are provided with concentric sealing sections 113, 213 that will bear on each other. The inlet into the first refrigerant channel is provided by an inlet nozzle 25 in the sealing sections. The inlet nozzle is obtained by nozzle indentations 114, 214 in one or both of the sealing sections, pressed in the second press operation. The size of the inlet nozzle, i.e. the length and the cross section, together with the angular position of the inlet nozzle are both important for the refrigerant distribution in the lower distribution passage 10 created between the lower distribution areas 102 and 202. The size of the inlet nozzle depends partly on the inlet pressure of the refrigerant and is selected to achieve an even flow distribution over all refrigerant channels in a complete heat exchanger. The angular position of the inlet nozzle is chosen

such that the refrigerant can distribute evenly over the total width of the heat exchanger in each refrigerant channel.

[0061] The inlet nozzle may be directed in any chosen angle, depending e.g. on the corrugated pattern layout in the lower distribution passage and the bypass section around the inlet port. Preferably, the angle of the inlet nozzle is between 0 and 180 degrees relative a vertical axis and pointing towards the central vertical axis of the plate, and more preferably between 90 and 150 degrees.

[0062] In one embodiment, the inlet port is opened. This may be advantageous when the heat exchanger is used such that the inlet port acts as a vapour outlet port, e.g. in a gas cooler. In order to avoid vapour from blocking the outlet, the sealing section and the nozzle are cut away in the production stage. Instead, an open port, resembling outlet port 22, is obtained. Such a port will allow vapour or a mixture of vapour and liquid to exit through the port.

[0063] In order to improve the refrigerant distribution further, the active inlet port is provided with an active inlet port bypass passage 18 around the inlet port, allowing the refrigerant to flow around both sides of the inlet port. Each plate comprises a bypass section 115, 215 extending around the entire first inlet port hole. The bypass section has the same pressing depth as the corrugations of the plate. The resulting bypass passage 18 will thus have the height of two times the pressing depth, which means that the friction pressure drop in the bypass passage will be much smaller than through the corrugation pattern. The bypass passage 18 will thus distribute part of the refrigerant from the inlet nozzle to the distribution area around the active inlet port.

[0064] Part of the refrigerant from the nozzle will also continue in the direction from the nozzle into the corrugation pattern and further towards the second refrigerant inlet port 23, being a passive inlet port. Since the water outlet port holes 112, 212 are positioned at a vertical distance from the lower short end of the plate, a lower horizontal passage 13 is formed in the lower distribution channel between the water outlet port and the lower short end of the heat exchanger. The refrigerant can thus flow below the water outlet port and over to the region around the passive inlet port. The refrigerant flow out of the inlet nozzle has in this example approximately the same angle as the corrugation pattern of the first plate, so that part of the refrigerant can pass mainly in a horizontal direction below the water outlet port with a relatively small friction factor and thus at a relatively high flow rate. When the refrigerant reaches the region around the passive inlet port, a passive inlet port bypass passage 19 around the passive inlet port will facilitate the distribution of the refrigerant to the area around the passive inlet port. The bypass passage 19 around the passive inlet port 23 is created in the same way as at the active inlet port, by each plate comprising a bypass section 117, 217 extending around the entire second inlet port hole. The bypass section has the same pressing depth as the corrugations of the plate. The resulting bypass passage will thus have the height of two times the pressing depth, which means that the friction in the bypass passage will be much smaller than through the corrugation pattern. The bypass passage will thus distribute part of the refrigerant to the distribution area around the passive inlet port. The second inlet port holes 109, 209 are provided with concentric sealing sections 116, 216 that will bear on each other and will thus seal off the passive inlet port.

[0065] The flat, circular section around the water outlet port holes 112, 212 bear on each other so that the water outlet port

is sealed to the refrigerant channel. The water outlet holes are positioned at a vertical distance from the lower short end of each plate. A water outlet hole is larger in diameter than a refrigerant inlet port hole, and the centre of a water outlet hole is positioned closer to the horizontal axis of a plate than the centre of the refrigerant inlet port holes. In this way, a lower horizontal passage **13** is created in the refrigerant channel between the water outlet port and the lower short end of the heat exchanger. Through this passage, the refrigerant can pass below the water outlet port to the region around the passive inlet port. This considerably improves the distribution of refrigerant over the channel width, and gives a more uniform flow over the channel width and thus through the heat exchange passage. The passage below the water outlet port will also increase the effective heat transfer area of the heat exchanger with the region around the passive inlet port.

[0066] In order to improve the distribution of the refrigerant further, the first refrigerant channel is provided with lower distribution paths **15**, **16** placed above the active and the passive inlet ports, between the lower distribution passage **10** and the heat exchange passage **11**. The lower distribution paths are created by mainly flat distribution grooves **118**, **119**, **218**, **219** pressed in the plates between the V shape of the distribution area and the W shape of the heat exchange area, extending from the long side of a plate to the water outlet port hole. The lower distribution paths will on one hand facilitate the distribution of the refrigerant uniformly into the heat exchange passage **11** and on the other hand act as a transitional region for the V shaped layout of the distribution area and the W shaped layout of the heat exchange area. The height of the lower distribution paths and also the shape may be selected in order to optimise the flow distribution. The height of a pressed groove may in one example be approximately half the pressing depth of a plate. To improve the mechanical strength of the heat exchanger, a lower distribution path may also comprise one or more contact points. Since corresponding distribution paths will be created in the water channel, the height of a lower distribution path in the refrigerant channel is preferably not more than a total of one pressing depth. The lower distribution paths will have a low flow resistance in the horizontal direction of the channel, compared to the flow resistance through a flow tube with the same length and width in the corrugated pattern of the heat exchange passage.

[0067] If required, the lower distribution paths **15**, **16** may comprise one or more restriction areas in order to control the flow distribution over the width of the channel in the lower distribution passage. The size and position of the restriction areas are chosen such that the flow through a distribution path **15** or **16** is as evenly distributed as possible. The restrictions may be achieved by altering the pressing depth of the position of the restriction area in the plates, i.e. by altering the height of the restriction area, and/or by altering the width of the restriction area along the lower distribution path. In this way, different restrictions may be positioned at different positions in the lower distribution paths **15**, **16**. The restrictions will give a locally increased flow resistance that will provide a flow distribution over the width of the lower distribution paths. In one example, the restrictions cover most of the distribution paths, thereby creating one or a few small openings between the distribution passage and the heat exchange passage. The size and positions of the restrictions may be decided on by experiments or by calculations. The distribution of the refrigerant flowing into the heat exchange passage will thus be improved.

[0068] After entering the active inlet port **21** and being distributed in the lower distribution passage **10**, the refrigerant will enter and pass the heat exchange passage **11** created between the heat exchange areas **103**, **203**. The heat exchange passage, with all the contact points between the corrugated patterns of the two plates, provides a large heat exchange area and a relatively high friction flow resistance, which ensures an efficient heat transfer between the refrigerant and the water channels. The W shape increases the friction pressure drop somewhat in the heat exchange passage compared with a single V shape, which improves the total heat transfer of the heat exchanger.

[0069] Between the heat exchange area and the upper distribution area of each plate a horizontal flat distribution groove **120**, **220** is pressed in each plate, creating an upper distribution path **17** in the first refrigerant channel. The upper distribution path will allow the refrigerant flow to distribute and at the same time to even out the differences in pressure, that may arise in the heat exchange passage due to variations of the evaporation of the refrigerant, prior to entering the upper distribution passage created between the upper distribution areas **104**, **204** of the plates. The upper distribution path will have a low flow resistance in the horizontal direction of the heat exchanger, which will facilitate the distribution of the refrigerant before entering the upper distribution passage **12**. Mainly in the upper distribution passage, the evaporation of the refrigerant will be finalized and a superheating of the refrigerant vapour may also occur. The height of each distribution groove is approximately half the pressing depth of a plate, since a corresponding horizontal distribution path will be created in the water channel. This will give the upper distribution path a total height of one pressing depth.

[0070] The refrigerant, being to a large degree in an evaporated state, enters the upper distribution passage created by the upper distribution areas **104**, **204** of the plates. The first refrigerant outlet port **22**, being an active port, is created between the plates at the first refrigerant outlet port holes **108**, **208**. Part of the refrigerant will enter the upper distribution passage on the right side of the vertical axis **105**, and part of the refrigerant will enter the upper distribution passage on the left side of the vertical axis **105**. Part of the refrigerant will reach a bypass passage **20** created by bypass sections **121**, **221** extending around the entire second outlet port **24**. The second refrigerant outlet port holes **110**, **210** are provided with concentric sealing sections **122**, **222** that will bear on each other and seal the second outlet port **24**, being a passive outlet port. A bypass section has the same pressing depth as the corrugations of the plate. The resulting bypass passage **20** will thus have the height of two times the pressing depth, which means that the flow resistance in the bypass passage will be much smaller than through the corrugation pattern. The bypass passage will thus allow a considerable part of the refrigerant, which may be superheated, to pass mainly horizontally over to the active outlet port via the horizontal passage above the water inlet port.

[0071] The flat, circular section around the water inlet port holes **111**, **211** bear on each other so that the water inlet is sealed from the refrigerant channel. The water inlet port holes are positioned at a vertical distance below the upper short end of each plate. The centre of a water inlet hole is positioned closer to the horizontal axis of a plate than the centre of the refrigerant outlet port holes. In this way, an upper horizontal passage **14** is provided in the refrigerant channel between the water inlet port and the upper short end of the heat exchanger.

Through this horizontal passage, the refrigerant can flow above the water inlet port from the bypass passage **20** at the passive outlet port **24** to the active outlet port **22** formed between the first refrigerant outlet port holes **108**, **208**. This decreases the flow resistance for the vapour, which may be superheated, and improves the flow distribution in the upper distribution passage considerably. Further, this horizontal passage prevents vapour to cumulate around the passive outlet port which would lead to an insulating area with vapour standing still in the area around the passive outlet port. The passage will also enlarge the total effective heat transfer area of the heat exchanger by the region around the passive outlet port.

[0072] When the second plate **201** and the third plate **301** are positioned next to each other, a water channel **3** is created. The water will enter the water channel through the water inlet port **42** created by the water inlet port holes **211**, **311**. The water will leave the water channel through the water outlet port **43** created by the water outlet port holes **212**, **312**. All the refrigerant ports will be sealed so that the water and refrigerant will not mix. When the second and third plates are stacked, the bypass sections **215**, **315** will bear on each other and will thus seal the first refrigerant inlet port. The same applies for the bypass sections **217**, **317** and the bypass sections **221**, **321** which will also bear on each other so that the second refrigerant inlet port and the second refrigerant outlet port are sealed. The first refrigerant outlet port is sealed by the flat sections **223**, **323** around the first refrigerant outlet port holes **208**, **308** bearing on each other.

[0073] The water inlet holes **211**, **311** are positioned at a vertical distance from the upper short end of each plate edge of each plate. The centre of a water inlet hole is positioned closer to the horizontal axis of a plate than the centre of the refrigerant outlet port holes. In this way, an upper horizontal passage **34** is created in the water channel between the water inlet port and the upper short end of the heat exchanger. This enlarges the useful water inlet cross flow area which in turn improves the water distribution in the upper distribution passage and decreases the pressure drop of the water channel.

[0074] In order to improve the water distribution further and also to decrease the water pressure drop, the water channel is provided with upper water bypass passages **40**, **41** between the passive second and first refrigerant outlet ports and the upper corners of the heat exchanger. The upper water bypass passages **40**, **41** are created by water bypass sections **226**, **227**, **326**, **327** outside each one of the second and first refrigerant outlet port holes. These bypass sections bear on each other when the plates are positioned to create a refrigerant channel, which means that the water bypass passages will have a height of two times the pressing depth. These water bypass passages will thus have a low friction pressure drop and will considerably facilitate water side distribution over the entire upper distribution passage.

[0075] When the water is distributed in the upper distribution passage **32**, the water passes horizontal flat distribution grooves **220**, **320** pressed in each plate, creating an upper horizontal distribution path **37** in the water channel. This distribution path allows for an additional distribution of the water so that the water pressure along the entire upper distribution path is substantially equal. The upper distribution path also acts as the transitional region between the V shape of the upper distribution passage and the W shape of the heat exchange passage. The height of each distribution groove is

approximately half the pressing depth of a plate. This will give the upper distribution path a height of a total of one pressing depth.

[0076] After passing the upper distribution path **37**, the water will enter and pass the heat exchange passage **31** created between the heat exchange areas **203**, **303**. The heat exchange passage, with all the contact points between the corrugated patterns of the two plates, provides a large heat exchanger area and a relatively high friction factor, which ensures an efficient heat transfer between the water and the refrigerant channels. The W shaped layout increases the friction factor somewhat in the heat exchange passage in relation to a single V layout, which will improve the heat transfer.

[0077] When the water has passed the heat exchange passage **31**, it enters the lower distribution passage **30** through two lower distribution paths **35**, **36** positioned between the heat exchange passage and the lower distribution passage. These lower distribution paths are created by mainly flat distribution grooves **218**, **219**, **318**, **319** pressed in the plates between the V shape of the distribution area and the W shape of the heat exchange area, extending from the long side of a plate to the water outlet port hole. These distribution paths will both facilitate to distribute the water uniformly into the lower distribution passage and act as a transitional region for the W shaped layout of the heat exchange passage and the V shaped layout of the lower distribution passage. The height of the lower distribution paths and also the shape may be selected in order to optimise the flow distribution. The height of a pressed groove may in one example be approximately half the pressing depth of a plate. To improve the mechanical strength of the heat exchanger, a lower distribution path may also comprise one or more contact points. The distribution paths will have a low flow resistance in the horizontal direction of the heat exchanger, compared to the flow resistance through the corrugated pattern in the lower distribution passage. This will facilitate an even flow distribution of the water into the lower distribution passage.

[0078] Some of the water, especially the water from the centre of the heat exchange passage **31**, will enter the water outlet port **43** created by the water outlet port holes **212**, **312** directly from the heat exchange passage above. Since the corrugated pattern around the water outlet port allows for a water flow from all directions into the water outlet port, the water outlet port is fully open. This will allow for part of the water distributed to the lower distribution area to enter the water outlet opening via the pattern between the water outlet port and the refrigerant inlet ports and also from the pattern below the water outlet port.

[0079] In order to improve the water distribution further, the lower distribution passage **30** is provided with lower water bypass passages **38**, **39** between the passive first and second refrigerant inlet ports and the lower corners of the heat exchanger. The lower water bypass passages are created by water bypass sections **224**, **225**, **324**, **325** at each one of the first and second refrigerant inlet port holes. These bypass sections bear on each other when the plates are positioned to create a refrigerant passage, which means that the lower water bypass passage will have a height of two times the press depth. These lower water bypass passages will thus have a low friction pressure drop and will contribute considerably to the guiding of the water flow to the water outlet port.

[0080] In order to improve the water distribution and to enlarge the effective heat transfer area of the heat exchanger, the water outlet port holes are positioned at a vertical distance

from the lower short end of each plate. In this way, a lower horizontal passage 33 is created in the water channel between the water outlet port and the lower short end of the heat exchanger. Through this horizontal passage, the water can flow into the water outlet port also from below the port, improving the efficiency of the heat exchanger. The lower bypass passages together with the upward offset of the water outlet port improve the outlet flow distribution of water considerably and decreases the outlet pressure drop all around the port periphery by enlarging the useful water cross flow area.

[0081] The second refrigerant channel 4 is created between the third plate 301 and the fourth plate 401 when they are positioned next to each other and resembles the first refrigerant channel. The difference between the first refrigerant channel and the second refrigerant channel are only the inlet and outlet ports and the inlet nozzle.

[0082] The refrigerant will enter the second refrigerant channel through a second refrigerant inlet port 63, being an active inlet port, created by the refrigerant inlet port holes 309, 409. The inlet port holes 309, 409 are provided with concentric sealing sections 316, 416 that will bear on each other. The inlet into the second refrigerant channel is provided by an inlet nozzle 65 through the sealing sections. The inlet nozzle is obtained by nozzle indentation 314, 414 in one or both of the sealing sections. The size of the inlet nozzle, i.e. the length and the cross section, together with the angular position of the inlet nozzle are both important for the refrigerant distribution in the lower distribution passage 50 created between the lower distribution areas 302 and 402. The size of the inlet nozzle is selected partly depending on the pressure drop of the refrigerant circuit and is selected to obtain an even flow distribution over all refrigerant channels in the refrigerant circuit in a complete heat exchanger. The angular position of the inlet nozzle is chosen such that the refrigerant can distribute evenly over the total width of the heat exchanger in each refrigerant channel.

[0083] The inlet nozzle may be directed in any chosen angle, depending e.g. on the corrugated pattern layout in the lower distribution passage and the bypass section around the inlet port. Preferably, the angle of the inlet nozzle is between 0 and 180 degrees relative a vertical axis and pointing towards the central vertical axis of the plate, and more preferably between 90 and 150 degrees.

[0084] In order to improve the refrigerant distribution further, the active inlet port is provided with an active inlet bypass passage 59 around the inlet port, allowing the refrigerant to flow around both sides of the inlet port. Each plate comprises a bypass section 317, 417 extending around the entire inlet port hole. The bypass section has the same pressing depth as the corrugations of the plate. The resulting active inlet bypass passage will thus have the height of two times the pressing depth, which means that the friction in the bypass passage will be much smaller than through the corrugation pattern. The bypass passage will thus distribute part of the refrigerant from the inlet nozzle to the distribution area around the active inlet port.

[0085] Part of the refrigerant from the nozzle will also continue in the direction from the nozzle into the corrugation pattern in the direction towards the first refrigerant inlet port 61, being a passive inlet port. Since the water outlet port holes 312, 412 are positioned at a vertical distance from the lower short end of each plate, a lower horizontal passage 53 is formed in the lower distribution channel between the water outlet port and the lower short end of the heat exchanger. The

refrigerant can thus flow below the water outlet port to the region around the passive inlet port. The refrigerant flow out of the inlet nozzle has in this example approximately the same angle as the corrugation pattern of the third plate, so that part of the refrigerant can pass mainly in a horizontal direction below the water outlet port with a relatively small friction factor and thus a relatively high flow rate. When the refrigerant reaches the region around the passive inlet port 61, a bypass passage 58 around the passive inlet port will help distribute the refrigerant to the area around the passive inlet port. The bypass passage 58 is created in the same way as at the active inlet port, by each plate comprising a bypass section 315, 415 extending around the entire first refrigerant inlet port hole. A bypass section has the same pressing depth as the corrugations of the plate. The resulting bypass passage will thus have the height of two times the pressing depth, which means that the friction in the bypass passage will be much smaller than through the corrugation pattern. The bypass passage will thus distribute part of the refrigerant to the distribution area around the passive inlet port. The first inlet port holes 307, 407 are provided with concentric sealing sections 313, 413 that will bear on each other and will thus seal off the passive inlet port.

[0086] The flat, circular section around the water outlet port holes 312, 412 bear on each other so that the water outlet port is sealed to the refrigerant channel. The water outlet port holes are positioned at a vertical distance from the lower short end of each plate. A water outlet hole is larger in diameter than a refrigerant inlet port hole, and the centre of a water outlet hole is positioned closer to the horizontal axis of a plate than the centre of the refrigerant inlet port holes. In this way, a lower horizontal passage 53 is created in the refrigerant channel between the water outlet port and the lower short end of the heat exchanger. Through this horizontal passage, the refrigerant can pass below the water outlet port to the region around the passive inlet port. This improves the distribution of refrigerant considerably over the plate width, which gives a more uniform flow through the heat exchange passage and also enlarges the total effective heat transfer area of the heat exchanger with the region around the passive inlet port.

[0087] In order to enhance the distribution of the refrigerant further, the second refrigerant channel is provided with lower distribution paths 55, 56 placed above the passive and the active inlet ports, between the lower distribution passage 50 and the heat exchange passage 51. The lower distribution paths are created by mainly flat distribution grooves 318, 319, 418, 419 in the plates between the V shape of the distribution area and the W shape of the heat exchange area, extending from the long side of a plate to the water outlet port hole. The lower distribution paths will on the one hand facilitate the uniform distribution of the refrigerant into the heat exchange passage 51 and on the other hand act as a transitional region for the V shaped layout of the distribution area and the W shaped layout of the heat exchange area. The height of the lower distribution paths and also the shape may be selected in order to optimise the flow distribution. The height of a groove may in one example be approximately half the pressing depth of a plate. To improve the mechanical strength of the heat exchanger, the lower distribution path may also comprise one or more contact points. Since corresponding distribution paths will be created in the water channel, the height of a lower distribution path in the refrigerant channel is preferably not more than a total of one pressing depth. The lower distribution paths will have a low flow resistance in the horizontal

direction of the heat exchanger, compared to the flow resistance through a flow tube with the same length and width in the corrugated pattern of the heat exchange passage. The lower distribution paths **55**, **56** may also comprise one or more restriction areas in order to control the flow distribution over the channel width in the lower distribution passage. The restrictions may be fairly small, resembling one or more contact points, or they may be relatively large, such that only one or a few small passages are created between the distribution passage and the heat exchange passage.

[0088] After entering the active inlet port **63** and being distributed in the lower distribution passage **50**, the refrigerant will enter and pass the heat exchange passage **51** in the same way as described for the first refrigerant channel.

[0089] Between the heat exchange area and the upper distribution area of each plate is a horizontal flat distribution groove **320**, **420** pressed in each plate, creating an upper distribution path **57** in the second refrigerant channel. The upper distribution path will allow the differences in pressure that may arise in the heat exchange passage due to variations of the evaporation of the refrigerant to even out before the refrigerant enters the upper distribution passage **52** created between the upper distribution areas **304**, **404** of the plates. The refrigerant may at this stage be partly or fully evaporated, and may even be superheated. The upper distribution path will have a low flow resistance in the horizontal direction of the heat exchanger, which will facilitate the distribution of the refrigerant before entering the upper distribution passage. The height of each distribution path is approximately half the pressing depth of a plate, since a corresponding horizontal distribution path will be created in the water channel. This will give the distribution path a height of a total of one pressing depth.

[0090] The refrigerant, being in this cross section to a large degree in vapour form, enters the upper distribution passage **52** created by the upper distribution areas **304**, **404** of the plates. The second refrigerant outlet port **64**, being an active port, is created between the plates at the second refrigerant outlet port holes **310**, **410**. Part of the refrigerant will enter the upper distribution passage on the left side of the vertical axis **305**, and part of the refrigerant will enter the upper distribution passage on the right side of the vertical axis **305**. Part of the refrigerant will reach a passive outlet port bypass passage **60** created by bypass sections **323**, **423** extending around the entire first refrigerant outlet port **62**, being a passive outlet port. The first refrigerant outlet port holes **308**, **408** are provided with concentric sealing sections **328**, **428** that will bear on each other and seal the first outlet port. A bypass section has the same pressing depth as the corrugations of the plate. The resulting bypass passage will thus have the height of two times the pressing depth, which means that the friction in the bypass passage will be much smaller than through the corrugation pattern. The bypass passage will thus allow a considerable part of the refrigerant, which may be superheated, to pass over to the active outlet port via the cross corrugation pattern passage above the water inlet port.

[0091] The flat, circular section around the water inlet port holes **311**, **411** bear on each other so that the water inlet is sealed from the refrigerant channel. The water inlet port holes are positioned at a vertical distance from the upper short end of each plate. The centre of a water inlet hole is positioned closer to the horizontal axis of a plate than the centre of the refrigerant outlet port holes. In this way, an upper horizontal passage **54** is provided in the refrigerant channel between the

water inlet port and the upper short end of the heat exchanger. Through this horizontal passage, the refrigerant can flow above the water inlet port from the bypass passage **60** at the passive outlet port **62** to the active outlet port **64** formed between the second refrigerant outlet port holes **310**, **410**. This improves the flow distribution of refrigerant considerably in the upper distribution passage and prevents heat congestion around the passive outlet port. Further, the total effective heat transfer area of the heat exchanger is enlarged by the region around the passive outlet port.

[0092] By the invention, an improved three-circuit plate heat exchanger can be obtained, which shows a considerable improvement in the overall thermal performance of the heat exchanger. This is due to the improved flow distribution in the heat exchanger. The invention is not to be regarded as being limited to the embodiments described above, a number of additional variants and modifications being possible within the scope of the subsequent patent claims.

REFERENCE SIGNS

[0093]	1: Plate assembly
[0094]	2: First refrigerant channel
[0095]	3: Water channel
[0096]	4: Second refrigerant channel
[0097]	10: Lower distribution passage
[0098]	11: Heat exchange passage
[0099]	12: Upper distribution passage
[0100]	13: Lower horizontal passage
[0101]	14: Upper horizontal passage
[0102]	15: Lower distribution path
[0103]	16: Lower distribution path
[0104]	17: Upper distribution path
[0105]	18: First refrigerant inlet port bypass passage
[0106]	19: Second refrigerant inlet port bypass passage
[0107]	20: Second refrigerant outlet port bypass passage
[0108]	21: Active inlet port
[0109]	22: Active outlet port
[0110]	23: Passive inlet port
[0111]	24: Passive outlet port
[0112]	25: Inlet nozzle
[0113]	30: Lower distribution passage
[0114]	31: Heat exchange passage
[0115]	32: Upper distribution passage
[0116]	33: Lower horizontal passage
[0117]	34: Upper horizontal passage
[0118]	35: Lower distribution path
[0119]	36: Lower distribution path
[0120]	37: Upper distribution path
[0121]	38: Water bypass passage
[0122]	39: Water bypass passage
[0123]	40: Water bypass passage
[0124]	41: Water bypass passage
[0125]	42: Water inlet port
[0126]	43: Water outlet port
[0127]	50: Lower distribution passage
[0128]	51: Heat exchange passage
[0129]	52: Upper distribution passage
[0130]	53: Lower horizontal passage
[0131]	54: Upper horizontal passage
[0132]	55: Lower distribution path
[0133]	56: Lower distribution path
[0134]	57: Upper distribution path
[0135]	58: First refrigerant inlet port bypass passage
[0136]	59: Second refrigerant inlet port bypass passage

[0137] 60: First refrigerant outlet port bypass passage
 [0138] 61: Passive inlet port
 [0139] 62: Passive outlet port
 [0140] 63: Active inlet port
 [0141] 64: Active outlet port
 [0142] 65: Inlet nozzle
 [0143] 101: First heat exchanger plate
 [0144] 102: Lower distribution area
 [0145] 103: Heat exchange area
 [0146] 104: Upper distribution area
 [0147] 105: Vertical axis
 [0148] 106: Horizontal axis
 [0149] 107: First refrigerant inlet port hole
 [0150] 108: First refrigerant outlet port hole
 [0151] 109: Second refrigerant inlet port hole
 [0152] 110: Second refrigerant outlet port hole
 [0153] 111: Water inlet port hole
 [0154] 112: Water outlet port hole
 [0155] 113: Sealing section
 [0156] 114: Nozzle indentation
 [0157] 115: Bypass section
 [0158] 116: Sealing section
 [0159] 117: Bypass section
 [0160] 118: Lower distribution groove
 [0161] 119: Lower distribution groove
 [0162] 120: Upper distribution groove
 [0163] 121: Bypass section
 [0164] 122: Sealing section
 [0165] 123: Flat section
 [0166] 124: Lower water bypass section
 [0167] 125: Lower water bypass section
 [0168] 126: Upper water bypass section
 [0169] 127: Upper water bypass section
 [0170] 201: Second heat exchanger plate
 [0171] 202: Lower distribution area
 [0172] 203: Heat exchange area
 [0173] 204: Upper distribution area
 [0174] 205: Vertical axis
 [0175] 206: Horizontal axis
 [0176] 207: First refrigerant inlet port hole
 [0177] 208: First refrigerant outlet port hole
 [0178] 209: Second refrigerant inlet port hole
 [0179] 210: Second refrigerant outlet port hole
 [0180] 211: Water inlet port hole
 [0181] 212: Water outlet port hole
 [0182] 213: Sealing section
 [0183] 214: Nozzle indentation
 [0184] 215: Bypass section
 [0185] 216: Sealing section
 [0186] 217: Bypass section
 [0187] 218: Lower distribution groove
 [0188] 219: Lower distribution groove
 [0189] 220: Upper distribution groove
 [0190] 221: Bypass section
 [0191] 222: Sealing section
 [0192] 223: Flat section
 [0193] 224: Lower water bypass section
 [0194] 225: Lower water bypass section
 [0195] 226: Upper water bypass section
 [0196] 227: Upper water bypass section
 [0197] 301: Third heat exchanger plate
 [0198] 302: Lower distribution area
 [0199] 303: Heat exchange area
 [0200] 304: Upper distribution area

[0201] 305: Vertical axis
 [0202] 306: Horizontal axis
 [0203] 307: First refrigerant inlet port hole
 [0204] 308: First refrigerant outlet port hole
 [0205] 309: Second refrigerant inlet port hole
 [0206] 310: Second refrigerant outlet port hole
 [0207] 311: Water inlet port hole
 [0208] 312: Water outlet port hole
 [0209] 313: Sealing section
 [0210] 314: Nozzle indentation
 [0211] 315: Bypass section
 [0212] 316: Sealing section
 [0213] 317: Bypass section
 [0214] 318: Lower distribution groove
 [0215] 319: Lower distribution groove
 [0216] 320: Upper distribution groove
 [0217] 321: Flat section
 [0218] 323: Bypass section
 [0219] 324: Lower water bypass section
 [0220] 325: Lower water bypass section
 [0221] 326: Upper water bypass section
 [0222] 327: Upper water bypass section
 [0223] 328: Sealing section
 [0224] 401: Fourth heat exchanger plate
 [0225] 402: Lower distribution area
 [0226] 403: Heat exchange area
 [0227] 404: Upper distribution area
 [0228] 405: Vertical axis
 [0229] 406: Horizontal axis
 [0230] 407: First refrigerant inlet port hole
 [0231] 408: First refrigerant outlet port hole
 [0232] 409: Second refrigerant inlet port hole
 [0233] 410: Second refrigerant outlet port hole
 [0234] 411: Water inlet port hole
 [0235] 412: Water outlet port hole
 [0236] 413: Sealing section
 [0237] 414: Nozzle indentation
 [0238] 415: Bypass section
 [0239] 416: Sealing section
 [0240] 417: Bypass section
 [0241] 418: Lower distribution groove
 [0242] 419: Lower distribution groove
 [0243] 420: Upper distribution groove
 [0244] 421: Flat section
 [0245] 423: Bypass section
 [0246] 424: Lower water bypass section
 [0247] 425: Lower water bypass section
 [0248] 426: Upper water bypass section
 [0249] 427: Upper water bypass section
 [0250] 428: Sealing section

1. A heat exchanger plate for use in a three circuit heat exchanger assembly, where the plate comprises a first distribution area having three port holes, a heat exchange area and a second distribution area having three port holes, where the plate comprises a corrugated pattern having ridges valleys, wherein the central port hole of the first distribution area is positioned at a vertical distance from a first short end of the plate such that a fluid passage is obtainable between the central port hole and the first short end of the plate when two plates are stacked to form a fluid channel there between.

2. The plate according to claim 1, wherein the central port hole of the second distribution area is positioned at a vertical distance from a second short end of the plate such that a fluid passage is obtainable between the central port hole and the

second short end of the plate when two plates are stacked to form a fluid channel there between.

3. The plate according to claim 1 or 2, wherein a port hole at a first corner of the plate is provided with a flat, ring-shaped bypass section adapted to form a refrigerant bypass passage around a port when two plates are stacked to form a refrigerant fluid channel between the plates.

4. The plate according to claim 3, wherein a water bypass section is provided at a second corner of the plate such that a water passage is obtainable between two adjacent bypass sections when two plates are stacked to form a water channel between the plates.

5. The plate according to claim 1, wherein the first distribution area exhibits a chevron shape having a first layout, the second distribution area exhibits a chevron shape having a second layout and where the heat exchange area exhibits a chevron shape having a third layout, where the chevron shape of the first layout is directed in a first angular direction and the chevron shape of the second layout is directed in the opposite angular direction.

6. The plate according to claim 5, wherein the chevron shape of the third layout is directed in the same angular direction as the chevron shape of the first layout.

7. The plate according to claim 5, wherein the chevron shape of the third layout has more direction changes than the first and the second layout.

8. The plate according to claim 5, wherein the first and the second chevron shape resembles a V and the third chevron shape resembles a W.

9. The plate according to claim 1, wherein a lower distribution groove is provided between the first distribution area and the heat exchange area such that a lower distribution path is obtainable between two adjacent lower distribution grooves when two plates are stacked to form a fluid channel between the plates.

10. The plate according to claim wherein at least one of the lower distribution grooves comprises at least one restriction area such that a flow restriction is obtained in the lower distribution path.

11. The plate according to claim 9, wherein an upper distribution groove is provided between the heat exchange area and the second distribution area such that an upper distribution path is obtainable between two adjacent upper distribution grooves when two plates are stacked to form a fluid channel between the plates.

12. A heat exchanger assembly, comprising four plates according to claim 1 or 2, wherein the first plate, the second plate, the third plate and the fourth plate differ from each other.

13. The heat exchanger assembly according to claim 12, where a first refrigerant channel is provided between the first plate and the second plate, a water channel is provided between the second plate and the third plate and a second refrigerant channel is provided between the third plate and the fourth plate, and where each fluid channel comprises a first distribution passage provided between two adjacent first distribution areas, a heat exchange passage provided between two adjacent heat exchange areas and a second distribution passage provided between two adjacent second distribution areas, wherein a horizontal passage is provided in the first distribution passage between the central water port and the neighbouring short end of the assembly.

14. The heat exchanger assembly according to claim 12, wherein a horizontal passage is provided in the second distribution passage between the central water port and the neighbouring short end of the assembly.

15. The heat exchanger assembly according to claim 12, wherein a water bypass passage is provided in a water distribution passage between a refrigerant port and a corner of the assembly.

16. The heat exchanger assembly according to claim 12, wherein a refrigerant bypass passage is provided around a refrigerant port in a refrigerant distribution passage.

17. The heat exchanger assembly according to claim 12, wherein an active inlet port is provided with an inlet nozzle and a second active inlet port is provided with an inlet nozzle, where the angles of the inlet nozzles are between 0 and 180 degrees relative to a vertical axis and where the inlet nozzles point towards the central vertical axis of the assembly.

18. The heat exchanger assembly according to claim 17, wherein the angles of the inlet nozzles are between 90 and 150 degrees.

19. The heat exchanger assembly according to claim 12, wherein a lower distribution path is provided between a lower distribution passage and a heat exchange passage.

20. The heat exchanger assembly according to claim 12, wherein an upper distribution path is provided between a heat exchange passage and an upper distribution passage.

21. The heat exchanger assembly according to claim 12, wherein the heat exchanger plates are joined by gluing, soldering, brazing, bonding or welding.

22. A three-circuit heat exchanger, comprising a plurality of heat exchanger assemblies according to claim 12, and further comprising a front plate and a back plate.

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