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(2013.01)(73) Assignee: **MAHLE International GmbH**(21) Appl. No.: **16/193,032**(22) Filed: **Nov. 16, 2018**(57) **ABSTRACT**

An evaporator for an air conditioning system includes a plurality of clamshell plates stacked in series along a longitudinal axis and a plurality of core tubes coupled with the stacked clamshell plates. In an upper region of the evaporator, the stacked clamshell plates form an inlet tank and an outlet tank hydraulically communicated with the core tubes for a refrigerant flow. Each of the clamshell plates includes a pooling ridge on a first surface of the clamshell plate for pooling a liquid refrigerant by gravity such that the liquid refrigerant is evenly distributed to inlet core tubes disposed along the longitudinal axis.

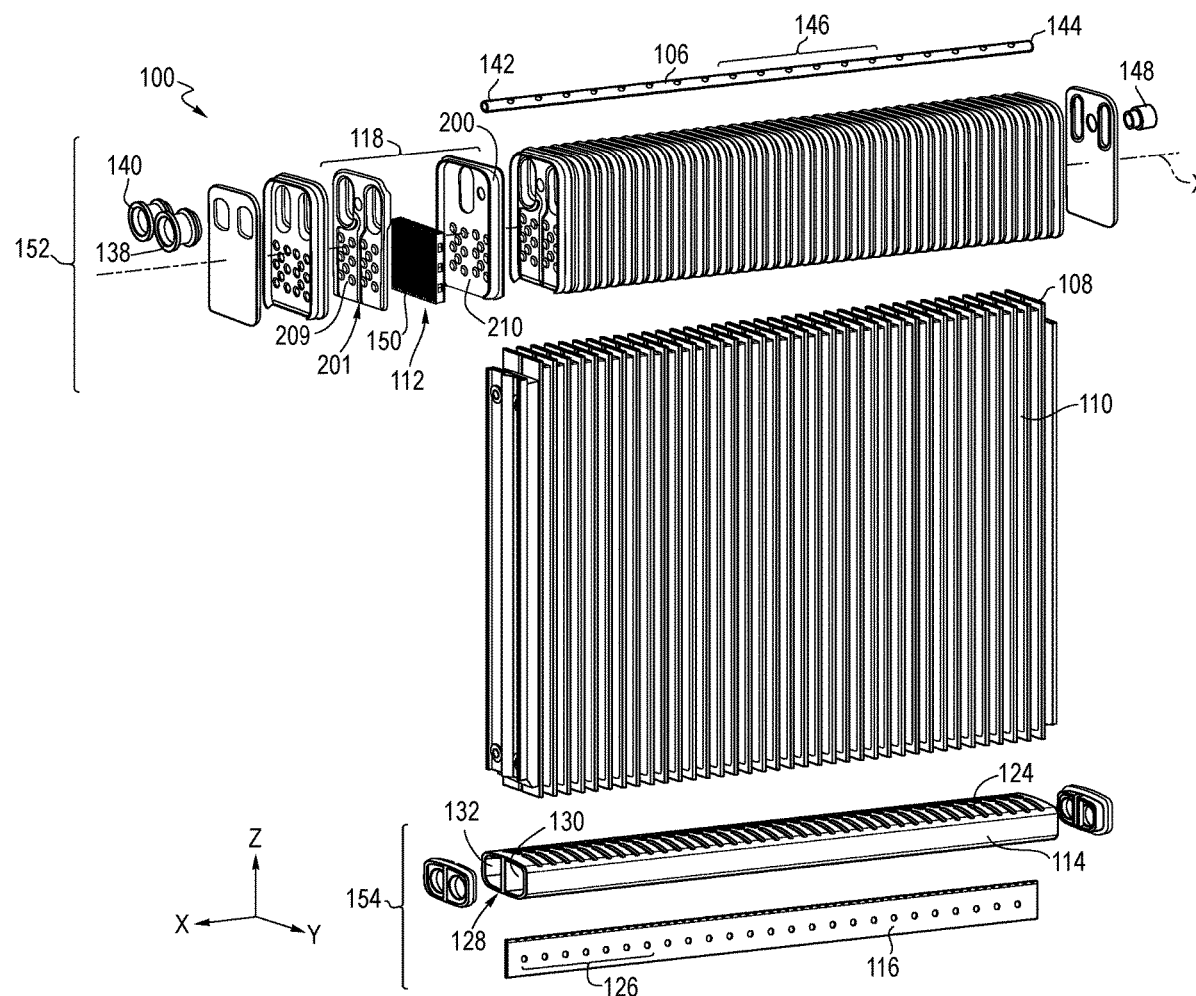


FIG. 1

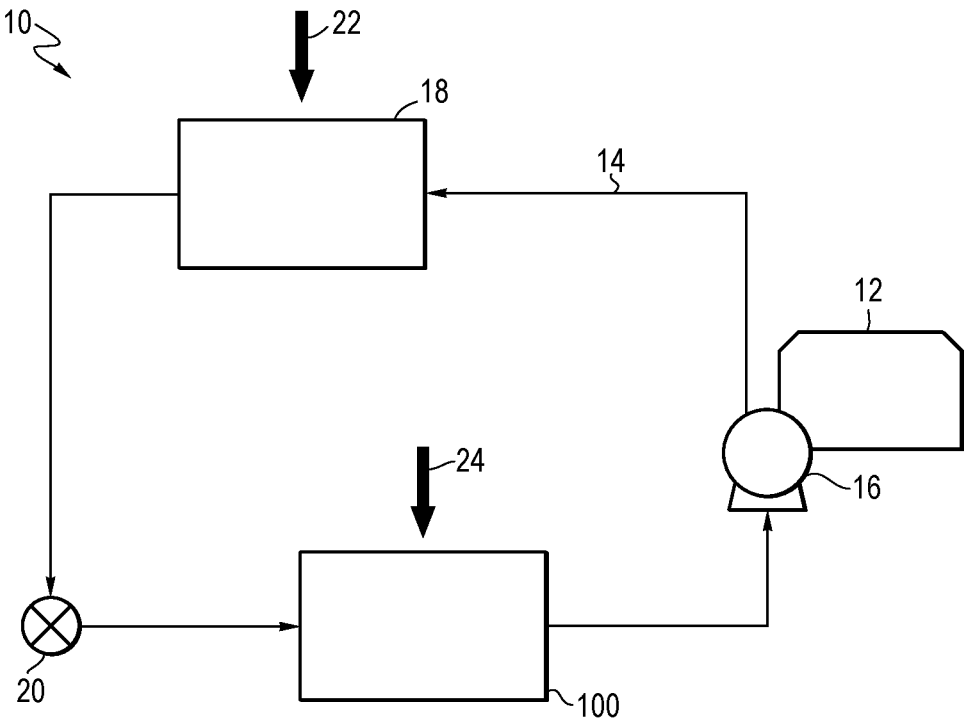


FIG. 2A

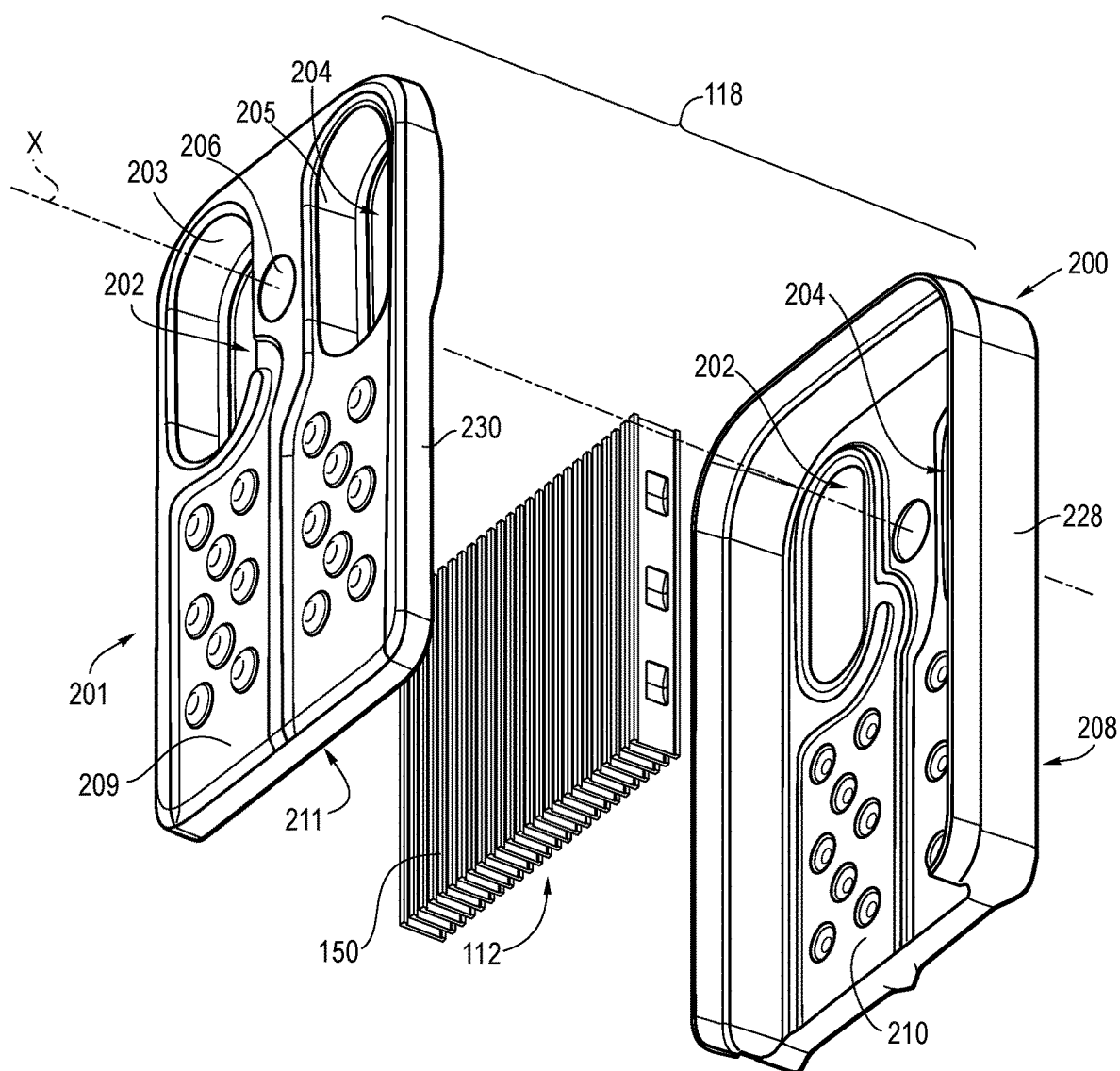


FIG. 2B

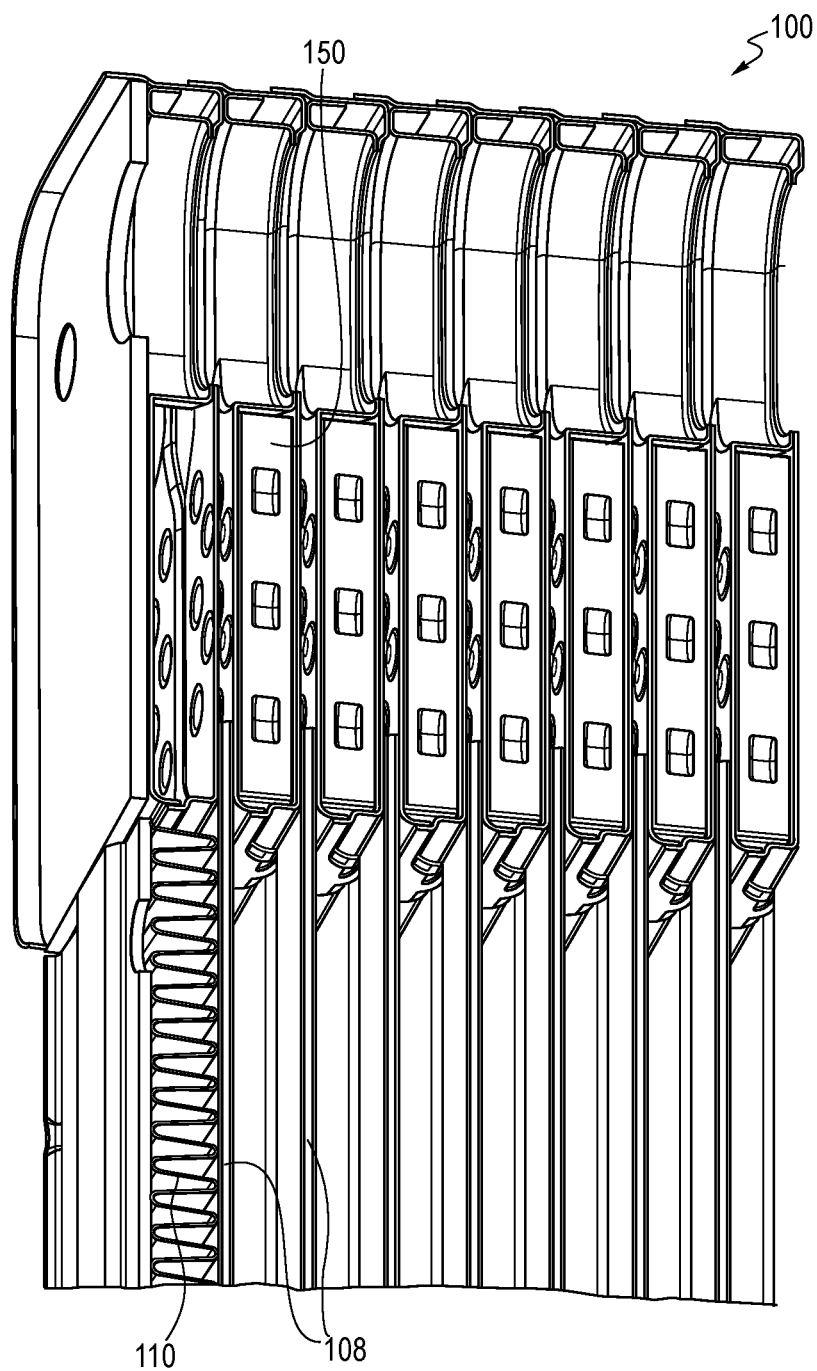


FIG. 3

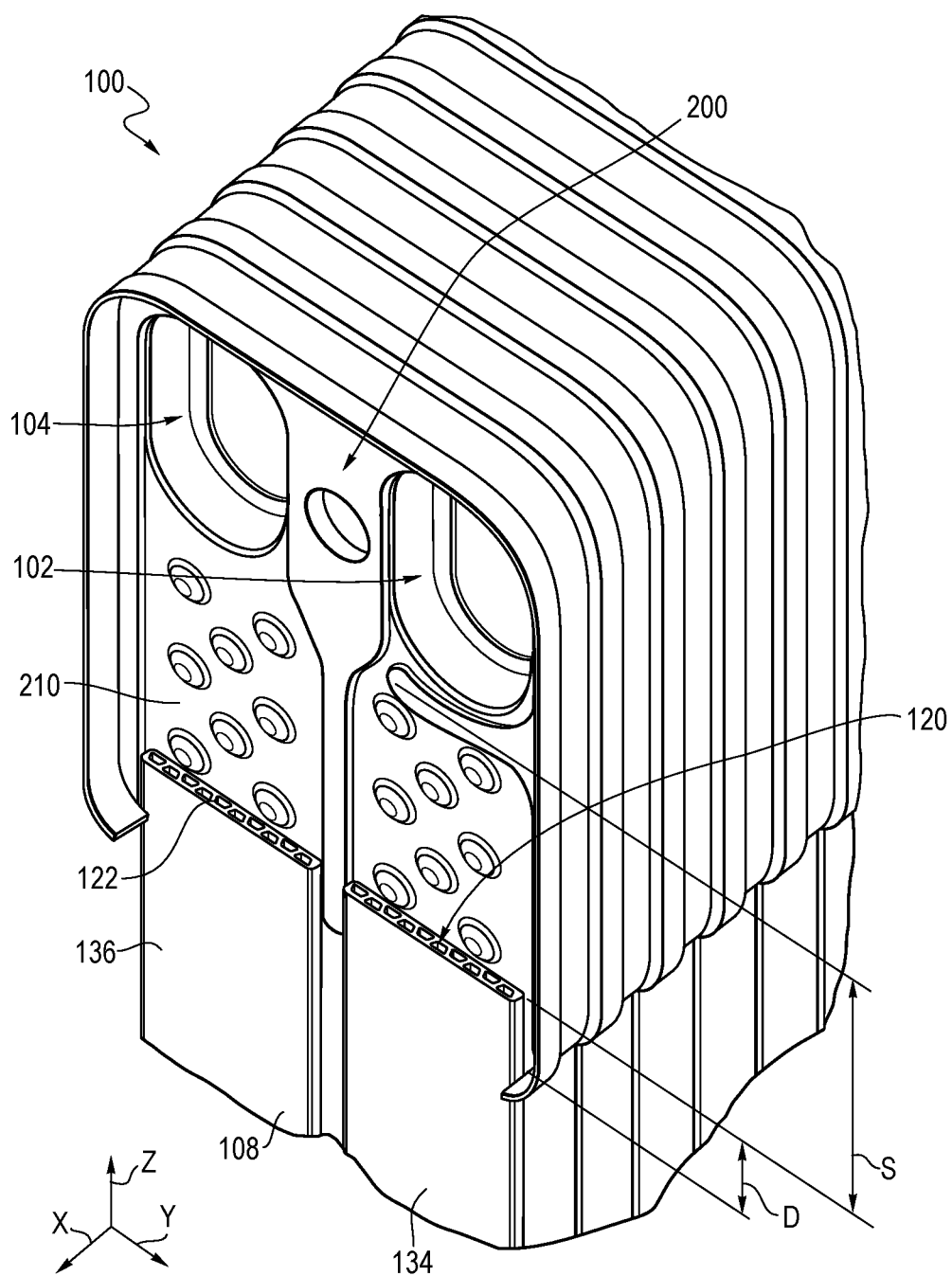
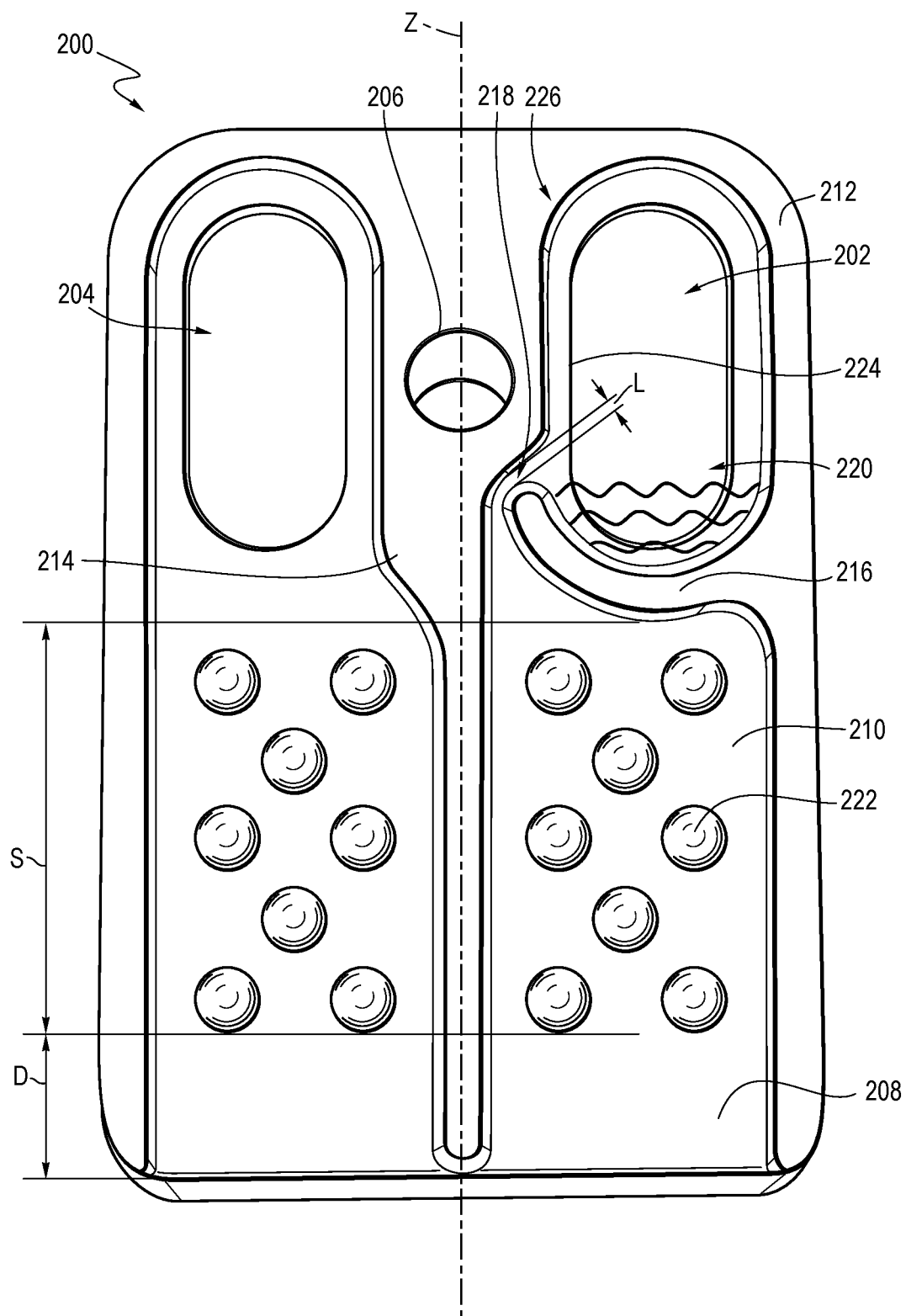


FIG. 4



EVAPORATOR UNIT

FIELD

[0001] The present disclosure relates to an evaporator for an air conditioning system, and more particularly relates to refrigerant distribution in a plate type evaporator for the air conditioning system in a motor vehicle.

BACKGROUND

[0002] An air conditioning system for a motor vehicle typically includes a refrigerant loop having an evaporator located within a heating, ventilation, and air conditioning (HVAC) module for supplying conditioned air to the passenger compartment of the vehicle, an expansion device located upstream of the evaporator, a condenser located upstream of the expansion device in front of the engine compartment, and a compressor located within the engine compartment upstream of the condenser. The above-mentioned components are hydraulically connected in series within the closed refrigerant loop.

[0003] The HVAC modules rely on the evaporator to provide cooled and dehumidified air to the passenger compartment for passengers' comfort and keeping the windshield from fogging. Starting from the inlet of the evaporator, a low pressure two-phase refrigerant having mixture of liquid and vapor enters the evaporator and flows through the tubes of the evaporator where it expands into a low pressure vapor refrigerant by absorbing heat from an incoming air stream. The evaporator requires even refrigerant distribution for optimum performance and uniform air discharge temperature in the passenger compartment of the vehicle.

[0004] Traditional automotive evaporators have two or three refrigerant flow paths in each flow bank. As such, there is minimum number of refrigerant tubes in each path, making refrigerant distribution relatively an easy task. However, for better performance of the evaporator, multipath evaporator systems are developed. The multipath evaporators would require larger tube open area to keep the refrigerant pressure drop reasonably low, as compared to a single path. The required larger tube open area results in larger tube outer dimensions, which cause the airside pressure drop to increase.

[0005] Recently, an evaporator with single flow path in each bank has achieved good refrigerant distribution and very low airside pressure drop. The evaporator utilizes a refrigerant distributor tube with evenly spaced orifices. The refrigerant distributor tube is inserted in the inlet manifold for refrigerant distribution. Such a distributor tube is described, for example, in U.S. Published Patent Application No. 2016/0061497 A1.

[0006] It has been discovered, however, that the function certain evaporator constructions, such as the one where the refrigerant tubes do not protrude into the inlet manifold, would benefit from improvement.

SUMMARY

[0007] It is the object of the present application to provide an evaporator unit in an air conditioning system for a motor vehicle.

[0008] According to one aspect of the present disclosure, the evaporator for the air conditioning system includes a plurality of clamshell plates stacked in series along a longitudinal axis. The stacked clamshell plates form an inlet

tank and an outlet tank in an upper region of the evaporator. The evaporator further includes a plurality of core tubes coupled with the stacked clamshell plates and hydraulically communicates with the inlet tank and the outlet tank for a refrigerant flow. A pooling ridge is formed on an external surface of at least one of the clamshell plates and configured for pooling a liquid refrigerant by gravity such that the liquid refrigerant is evenly distributed to inlet core tubes disposed along the longitudinal axis.

[0009] At least one of the clamshell plates includes an inlet tank opening and an outlet tank opening for forming the inlet tank and outlet tank in the stacked clamshell plates in series along the longitudinal axis. The pooling ridge of the clamshell plate is formed along a bottom edge portion of the inlet tank opening.

[0010] According to a further aspect of the present disclosure, at least one of the clamshell plates further includes a rim ridge along top and lateral sides of the clamshell plate, and a center ridge along a vertical axis of the clamshell plate. The rim ridge, the center ridge and the pooling ridge all are formed as a single ridge. The clamshell plate includes an inlet tank opening and an outlet tank opening, and the inlet tank opening is enclosed by the single ridge with a channel along an edge of the inlet tank opening. The channel is formed between the center ridge and the pooling ridge along the edge of the inlet tank opening for allowing the liquid refrigerant to flow out from a liquid refrigerant pool. In addition, each of the clamshell plates further includes a plurality of spherical bumps in a space below the inlet and outlet opening on the first surface of the clamshell plate.

[0011] According to a further aspect of the present disclosure, at least one of the core tubes includes an open inlet end and an open outlet end. Both open inlet and outlet ends of the core tubes are inserted into the stacked clamshell plates by an insertion depth in the upper region of the evaporator.

[0012] According to a further aspect of the present disclosure, the evaporator includes a distributor tube disposed inside the inlet tank. The distributor tube is configured to receive and expand two phase refrigerant for aliquoting the two phase refrigerant.

[0013] According to a further aspect of the present disclosure, the evaporator includes a transition tank in a lower region of the evaporator for hydraulically connecting with the core tubes for the refrigerant flow from the inlet tank to the outlet tank in a lower region of the evaporator. Furthermore, a flow-modulation plate is disposed within the transition tank for aliquoting the refrigerant from the inlet core tubes to outlet core tubes.

[0014] According to a further aspect of the present disclosure, the evaporator includes a clamshell housing formed by mating a pair of clamshell plates. The clamshell housing forms a phase change material chamber for serving as a cold storage. Each of the clamshell plates is formed from a sheet of heat conductive material.

[0015] According to a further aspect of the present disclosure, the evaporator includes a plurality of fins disposed between and materially joined to the core tubes for facilitating heat exchange.

[0016] Further details and benefits will become apparent from the following detailed description of the appended drawings. The drawings are provided herewith purely for illustrative purposes and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0017] In the drawings,

[0018] FIG. 1 shows a schematic view of an air conditioning system with an evaporator in accordance with an exemplary form of the present disclosure;

[0019] FIG. 2 is a partial exploded view of the evaporator of FIG. 1;

[0020] FIG. 2A is an exploded view of a clamshell housing of the evaporator of FIG. 2;

[0021] FIG. 2B is a partial cross-sectional view of the evaporator of FIG. 2;

[0022] FIG. 3 is a detailed view of an upper region of the evaporator of FIG. 2; and

[0023] FIG. 4 is a plane view of a clamshell plate stacked in the evaporator according to the present disclosure.

[0024] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

DETAILED DESCRIPTION

[0025] The following description is merely exemplary in nature and is in no way intended to limit the present disclosure or its application or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

[0026] FIG. 1 illustrates an air conditioning system 10 for a motor vehicle (not shown). In the example of FIG. 1, the air conditioning system 10 is shown in the vehicle having an engine 12, but the air conditioning system 10 could also be used to cool a building or any other structure. The vehicle has a first operating mode with the engine 12 of the vehicle running and a second operating mode with the engine 12 of the vehicle dormant. The second operating mode could be a number of different driving conditions, e.g. when the vehicle is coasting down a gradient or temporarily stopped at an intersection. During the period of time when the engine 12 is turned off, the air conditioning system 10 continues to provide cooling for the passenger compartment of the vehicle.

[0027] As shown in FIG. 1, the air conditioning system 10 includes a refrigerant loop 14 for cycling a refrigerant. The refrigerant loop 14 includes a compressor 16 for compressing the refrigerant to a heated gas. The compressor 16 is operably connected to the engine 12 of the vehicle. In FIG. 1, the refrigerant loop 14 includes a condenser 18 in fluid communication with the compressor 16 for receiving the heated refrigerant and for transferring heat from the refrigerant to a first flow of air 22 to condense the refrigerant to a liquid. The refrigerant loop 14 further includes an expansion valve 20 in fluid communication with the condenser 18 for receiving the liquid refrigerant and for expanding it into a cold two phase refrigerant. An evaporator 100 completes the refrigerant loop 14 and is in fluid communication with the expansion valve 20 for receiving the cold refrigerant. The evaporator 100 transfers heat from a second flow of air 24 to the refrigerant to evaporate the refrigerant to a gas and to cool the second flow of air 24 for cooling the passenger compartment of the vehicle.

[0028] FIG. 2 illustrates a partially exploded view of a hybrid plate and tube-fin evaporator 100 as an example of the evaporator 100 in FIG. 1. The present disclosure applies but is not limited to the hybrid plate and tube-fin evaporators, plate type evaporators, and any evaporator with various

pass arrangements. The hybrid plate and tube-fin evaporator 100 includes a plurality of clamshell plates. Referring to FIGS. 2 and 2A, furthermore, a clamshell housing 118 is formed by mating a clamshell plate 200 with a second clamshell plate 201.

[0029] As shown in FIG. 2A, each of the clamshell plate 200 and the second clamshell plate 201 has a first surface 208 and 209, and a second surface 210 and 211, respectively. Both clamshell plate 200 and the second clamshell plate 201 are a rectangular shape, and the second surface 210 and 211 of both clamshell plates 200 and 201 is an opposite side of the first surface 208 and 209. However, other suitable shapes of the clamshell plates 200 and 201 according to other forms of the present disclosure may be implemented. When the clamshell plate 200 mates with the second clamshell plate 201 for forming the clamshell housing 118, the second surfaces 210 and 211 of both clamshell plates 200 and 201 are faced each other and formed a phase change material chamber 112.

[0030] In FIG. 2A, both clamshell plates 200 and 201 include an inlet tank opening 202 and an outlet tank opening 204, respectively. The second clamshell plate 201 further includes an inlet tank wall 203 around the perimeter of the inlet tank opening 202 and an outlet tank wall 205 around the perimeter of the outlet tank opening 204. Both walls 203 and 205 of the second clamshell plate 201 are extended toward the clamshell plate 200 for attaching to the second surface 210 of the clamshell plate 200 along a longitudinal axis X, which are perpendicular to the first surface 209 of the second clamshell plate 201. Accordingly, when the second clamshell plate 201 mates with the clamshell plate 200, the extended inlet and outlet tank walls 203 and 205 are attached to the second surface 210 of the clamshell plate 200 for forming an inlet tank 102 and an outlet tank 104, respectively. (See FIG. 3). In addition, as shown in FIG. 2A, the clamshell plate 200 includes a stepped side wall 228 for receiving a side wall 230 of the second clamshell plate 201. The side wall 230 of the second clamshell plate 201 is inserted and enclosed by the stepped side wall 228 of the clamshell plate 200. After that, the side wall 230 and the stepped side wall 228 are attached each other (for example, by brazing). Each of the clamshell plates 200 and 201 may be stamped or otherwise formed from a sheet of heat conductive material, such as an aluminum. However, other suitable materials of the clamshell plates 200 and 201 according to other forms of the present disclosure may be implemented.

[0031] Referring to FIGS. 2, 2A and 3, as described above, the clamshell housing 118 is formed by mating both clamshell plates 200 and 201. Each of the clamshell housings 118 are stacked in series and assembled together. As shown in FIGS. 2, 2A and 3, the stacked clamshell plates 200 and 201 in series form the inlet tank 102 and the outlet tank 104 in an upper region 152 of the evaporator 100. The phase change material chamber 112 formed by the pair of the clamshell plates 200 and 201 is configured to serve as a cold storage having a phase change material. Furthermore, a phase change material fin 150 is provided in the phase change material chamber 112 for enhancing heat conduction due to low conductivity of the phase change material.

[0032] The hybrid plate and tube-fin evaporator 100 with the phase change material chamber 112 is generally used for the vehicle with the second operating mode as described above. The air conditioning system 10 of such a vehicle may

be provided with the evaporator 100 having the phase change material to extend the period of cooling to the passenger compartment in the vehicle when the engine 12 is turned off and/or not driving the compressor 16 such as stop-start vehicles or hybrid vehicles.

[0033] As shown in FIGS. 2, 2B and 3, the hybrid plate and tube-fin evaporator 100 further includes a plurality of core tubes 108 and a plurality of fins 110. The inlet tank 102 and the outlet tank 104 are disposed above the core tubes 108 with respect to the direction of gravity. Generally, the plurality of fins 110 is disposed between and materially joined to the core tubes 108 to facilitate heat exchange between the refrigerant and the second flow of the air 24. For example, the core tubes 108 and fins 110 can be formed as a single unit. In addition, the core tubes 108 and fins 110 are formed of a heat conductive material, preferably an aluminum alloy, assembled onto the clamshell housing 118 and a transition tank 114, and brazed together to form the evaporator 100 heat exchanger assembly. However, other suitable materials of the core tubes 108 and fins 110 according to other forms of the present disclosure may be implemented.

[0034] As shown in FIGS. 2 and 3, each of the core tubes 108 is placed between each of the clamshell housing 118. Accordingly, the core tubes 108 hydraulically connect the inlet tank 102 to the outlet tank 104 for refrigerant flow therebetween. In a lower region 154 of the evaporator 100, the core tubes 108 are coupled with the transition tank 114 to define U-shaped path for refrigerant flow from the inlet tank 102 to the outlet tank 104, thereby enabling the inlet tank 102 and the outlet tank 104 to be placed in a side-by-side parallel arrangement. For example, the core tubes 108 are inserted through slots 124 positioned along the transition tank 114 for refrigerant flow in the lower region 154 of the evaporator 100.

[0035] As shown in FIG. 2, the transition tank 114 is equipped with a flow-modulation plate 116. The flow-modulation plate 116 is disposed generally within the transition tank 114, and is configured to segregate a transition cavity 128 defined by the transition tank 114 into an upstream portion 130 and a downstream portion 132. According to an example of the present disclosure, the flow-modulation plate 116 includes a plurality of openings 126 configured to aliquot refrigerant from inlet core tubes 134 to outlet core tubes 136.

[0036] In FIG. 3, the core tubes 108 are placed between the clamshell housings 118, but an open inlet end 120 and an open outlet end 122 of the core tube 108 do not protrude into each of the inlet and outlet tanks 102 and 104, respectively. Instead, as an example shown in FIGS. 3 and 4, the open inlet and outlet ends 120 and 122 are inserted into the stacked clamshell plates 200 and 201 by an insertion depth D. Accordingly, a space S on the first surface 208 of the clamshell plate 200 between the inlet and outlet tanks 102 and 104 and the open inlet and outlet ends 120 and 122 of the core tubes 108 is formed for the refrigerant flow.

[0037] Referring back to FIGS. 1 and 2, a distributor tube 106 may be disposed within the inlet tank 102 formed by the stacked clamshell plates 200 and 201 for receiving the refrigerant through an inlet port 138 hydraulically connected from the expansion valve 20. The outlet tank 104 formed in the side-by-side parallel arrangement with the inlet tank 102 is hydraulically connected to the compressor 16 through an outlet port 140. The distributor tube 106 is extending substantially along the length of the inlet tank 102 and substan-

tially parallel with a longitudinal axis X. The distributor tube 106 includes an inlet end 142 connected to the inlet port 138, a distal end 144 that may be a blind end opposite that of the inlet end 142, and a plurality of orifices 146 therebetween. The distal end 144 is typically mounted by capturing it in an end cap 148 of the inlet tank 102. The plurality of orifices 146 may be arranged in a linear array parallel to the longitudinal axis X and oriented away from the open inlet ends 120 of the core tubes 108 and substantially in the opposite direction of gravity. As shown in FIG. 2, the inlet tank 102 and the outlet tank 104 are located at the upper region 152 of the evaporator 100 and the transition tank 114 is the lower region 154 of the evaporator 100 when the evaporator 100 is installed in the vehicle.

[0038] The distributor tube 106 is configured to cooperate with the expansion valve to improve refrigerant aliquoting across the core tubes 108. Generally, the expansion valve 20 expands a liquid refrigerant from the condenser 18 into a first mixture of two phase refrigerant and the distributor tube 106 expands the first mixture into a second mixture of two phase refrigerant. The refrigerant enters the distributor tube 106 as a mixture of liquid and vapor generated by the expansion valve 20 for achieving good refrigerant distribution and very low airside pressure drop.

[0039] As an example, FIG. 4 illustrates the first surface 208 of the clamshell plate 200. In FIG. 4, the clamshell plate 200 includes the inlet tank opening 202 and the outlet tank opening 204 for forming the inlet tank 102 and the outlet tank 104, respectively (see FIG. 3). The clamshell plate 200 further includes a phase change material port 206 for allowing for the ease of filling the phase change material chamber 112 with the phase change material during manufacturing, and also allowing for the phase change material to migrate from one chamber 112 to another to account for unequal expansion and/or contraction of the phase change material.

[0040] In FIG. 4, the clamshell plate 200 includes a rim ridge 212 on the first surface 208 along top and lateral sides of the clamshell plate 200 and a center ridge 214 at the center area of the clamshell plate 200 along the vertical axis Z. The clamshell plate 200 further includes a pooling ridge 216 (e.g., U-shape) formed along an edge 224 at the bottom portion of the inlet tank opening 202 on the first surface 208. As shown in FIG. 4, the rim ridge 212 and the center ridge 214 are connected as a single unit, and the pooling ridge 216 is also connected with the rim ridge 212 as a single unit. Accordingly, all ridges 212, 214 and 216 are formed as a single ridge 226.

[0041] As shown in FIG. 4, the ridges 212, 214 and 216 surround along the edge 224 of the inlet tank opening 202. Accordingly, the inlet tank opening 202 is enclosed by the single ridges 226 with a channel 218 along the edge 224 of the inlet tank opening 202 on the first surface 208. As shown in FIG. 4, the channel 218 is not protruded on the first surface 208, and forms an opening between the pooling ridge 216 and the center ridge 214 along the edge 224 of the inlet tank opening 202. The channel 218 is configured to allow the liquid refrigerant to flow out from a liquid refrigerant pool 220 formed on the inlet tank opening 202. The opening length L of the channel 218 is preferably 2.5 mm±2.0 mm. As shown in FIG. 4, the clamshell plate 200 further includes a plurality of spherical bumps 222 on the first surface 208 in the space S for refrigerant flow. However,

other suitable pooling features including shapes and/or sizes in accordance with other forms of the present disclosure may be implemented.

[0042] In FIG. 4, the pooling ridge **216** is configured for enabling liquid refrigerant to pool before feeding each of the inlet core tubes **134**. The pooling ridge **216** at the bottom of the inlet tank opening **202** forces refrigerant to feed through the channel **218**. Due to the gravity, liquid refrigerant tends to pool at the bottom of the inlet tank opening **202** before the refrigerant gets to the channel **218**. As such, the liquid refrigerant gets a chance to level out between the left, center and right sections of the inlet core tubes **134** along the longitudinal axis X, and each channel **218** allows liquid refrigerant to be distributed from the same pool **220** of liquid refrigerant. Therefore, the pooling ridge **216** with the channel **218** is configured for enabling the liquid refrigerant evenly to feed to each of the inlet core tubes **134**. According to a form of the present disclosure, the pooling feature of the clamshell plate **200** is easily formed with no additional material and manufacturing cost.

[0043] In a conventional design of a hybrid plate and tube-fin evaporator, we have discovered that the vapor refrigerant tends to escape through the first couple of orifices of a distributor tube, carrying certain amount of liquid refrigerant with the vapor because open inlet ends of the core tubes do not protruded into an inlet tank of the evaporator. For the remaining mixture, more liquid pools towards the distal end of the distributor tube due to the different physical properties of the liquid and vapor phases and a separation of the two phase of the refrigerant is occurred. As a result, more liquid is fed to the evaporator core tubes that are further away from the inlet port of the inlet tank, whereas the core tubes at the center section of the evaporator starve of liquid refrigerant, causing a warm zone in the center section of the evaporator.

[0044] As described above, in the conventional hybrid plate and tube-fin evaporator, such a refrigerant distribution (e.g., a warm zone in the center section of the core tubes) has been observed under low evaporator load conditions with mid ambient and/or high compressor out pressure (i.e., idle state). Table 1 with data below shows the air outlet thermocouple grid (e.g., 5x5 Outlet Grid) for low airflow idle condition, with the inlet and outlet ports on the left. The warm temperature readings indicate starvation of liquid refrigerant in the center section of the core tubes.

[0045] According to the exemplary form of the present disclosure, Table 2 with data below shows the air outlet thermocouple grid (e.g., 5x5 Outlet Grid) for the same condition as Table 1 with the clamshell plates **200** and **201** including the pooling feature of the liquid refrigerant as shown in FIG. 4. The pooling feature of the liquid refrigerant in the clamshell plates **200** and **201** efficiently improves refrigerant distribution to each of the core tubes **108** in the hybrid plate and tube-fin evaporator **100**. Compared to the table 1, it is observed that the temperature spread is reduced from 11.87° C. to 3.37° C. in the table 2. Accordingly, the liquid refrigerant is evenly distributed to the core tubes **108** of the evaporator **100**.

TABLE 2

I/O	13.49	13.86	13.91	14.28	16.44
	13.73	15.02	14.4	14.94	16.71
	14.39	15.35	14.77	14.47	15.19

TABLE 2-continued

14.36	15.68	14.73	13.62	14.07
14.26	16.3	14.46	13.34	13.97
Average: 14.63° C.			Min: 13.34° C.	
Spread: 3.37° C.			Max: 16.71° C.	
Flow Direction: Towards You				

TABLE 1

I/O	8.61	12.78	15.91	9.89	6.35
	8.17	14.52	16.86	14.14	6.74
	6.8	11.59	15.26	15.06	6.84
	5.81	7.58	11.9	13.82	6.24
	4.99	5.7	6.92	8.03	5.78
Average: 9.85° C.			Min: 4.99° C.		
Spread: 11.87° C.			Max: 16.86° C.		
Flow Direction: Towards You					

[0046] While the above description constitutes the preferred embodiments of the present invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope and fair meaning of the accompanying claims.

What is claimed is:

1. An evaporator for an air conditioning system, the evaporator comprising:

- a plurality of clamshell plates stacked in series along a longitudinal axis and the stacked clamshell plates forming an inlet tank and an outlet tank in an upper region of the evaporator;
- a plurality of core tubes coupled with the stacked clamshell plates and hydraulically communicating with the inlet tank and the outlet tank for a refrigerant flow; and
- a pooling ridge formed on a first surface of at least one of the clamshell plates and configured for pooling a liquid refrigerant by gravity such that the liquid refrigerant is evenly distributed to inlet core tubes disposed along the longitudinal axis.

2. The evaporator of claim 1, wherein at least one of the clamshell plates includes an inlet tank opening and an outlet tank opening for forming the inlet and outlet tanks in the stacked clamshell plates in series along the longitudinal axis, and the pooling ridge of the clamshell plate is formed along a bottom edge portion of the inlet tank opening.

3. The evaporator of claim 1, wherein at least one of the clamshell plates further includes a rim ridge along top and lateral sides of the clamshell plate, and a center ridge along a vertical axis of the clamshell plate.

4. The evaporator of claim 3, wherein the rim ridge, the center ridge and the pooling ridge are formed as a single ridge.

5. The evaporator of claim 4, wherein the clamshell plate includes an inlet tank opening and an outlet tank opening, and the inlet tank opening is enclosed by the single ridge with a channel along an edge of the inlet tank opening.

6. The evaporator of claim 5, wherein the channel is formed between the center ridge and the pooling ridge along the edge of the inlet tank opening for allowing the liquid refrigerant to flow out from a liquid refrigerant pool.

7. The evaporator of claim 1, wherein at least one of the core tubes includes an open inlet end and an open outlet end, and the open inlet and outlet ends of the core tubes are inserted into the stacked clamshell plates by an insertion depth in the upper region of the evaporator.

8. The evaporator of claim 1, wherein the evaporator further includes a distributor tube disposed inside the inlet tank and configured to receive and expand two phase refrigerant for aliquoting the two phase refrigerant.

9. The evaporator of claim 1, wherein the evaporator further includes a transition tank in a lower region of the evaporator for hydraulically connecting with the core tubes for the refrigerant flow from the inlet tank to the outlet tank.

10. The evaporator of claim 9, wherein a flow-modulation plate is disposed within the transition tank for aliquoting the refrigerant from the inlet core tubes to outlet core tubes.

11. The evaporator of claim 1, wherein a clamshell housing formed by mating a pair of clamshell plates forms a phase change material chamber for serving as a cold storage.

12. The evaporator of claim 1, wherein each of the clamshell plates is formed from a sheet of heat conductive material.

13. The evaporator of claim 1, wherein a plurality of fins are disposed between and materially joined to the core tubes for facilitating heat exchange.

14. The evaporator of claim 1, wherein each of the clamshell plates further includes a plurality of spherical bumps in a space below the inlet and outlet opening on the first surface of the clamshell plate.

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