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(54) **HEAT EXCHANGER**

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(57) **ABSTRACT**

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A heat exchanger is used for an air conditioner installed in a vehicle such as an electric car and is basically designed as a laminated type, which is constructed by assembling a pair of heat-exchanger units together. Herein, each of the heat-exchanger units is constructed by a pair of headers, which are arranged in parallel with each other in a vertical direction and between which tubes and cooling fins are alternately arranged along a horizontal direction. Herein, each of the tubes and each of the cooling fins are extended in the vertical direction between the headers. Partition plates are arranged inside of the headers at selected positions such that an overall front area in which the tubes and cooling fins are alternately arranged between the headers is divided into a number of parts, among which refrigerant sequentially flow from one part to another in a reciprocating manner. Herein, all the parts can be equally divided to have a same sectional area, or they are gradually changed (i.e., reduced or enlarged) in sectional area along a refrigerant flow direction corresponding to the horizontal direction. It is possible to change an overall front shape of the heat exchanger, which is originally a rectangular shape, to a prescribed shape such as an L-shape using an intermediate header, by which the heat exchanger is arranged not to interfere with some device or equipment inside of the vehicle.

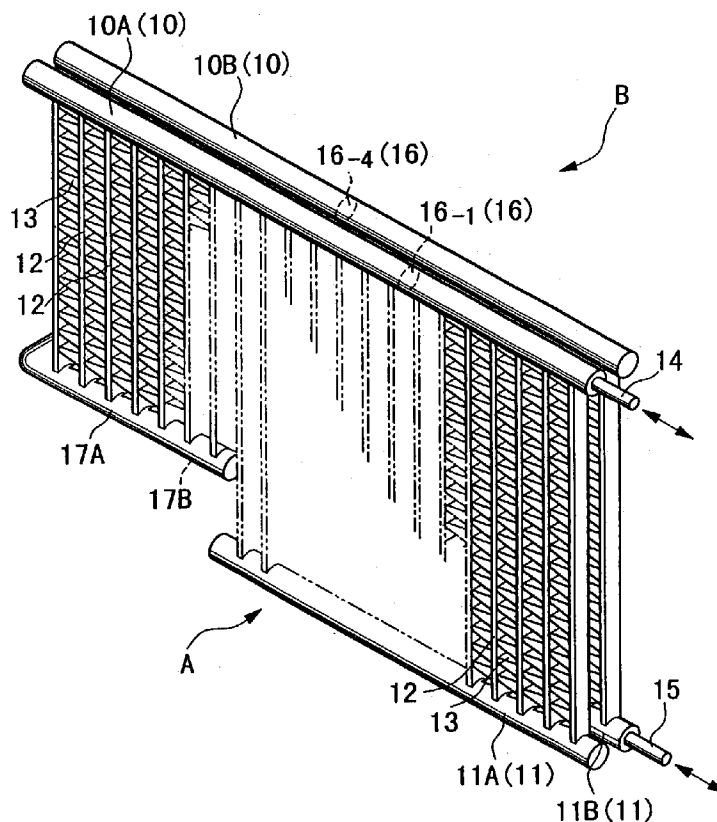


FIG. 1

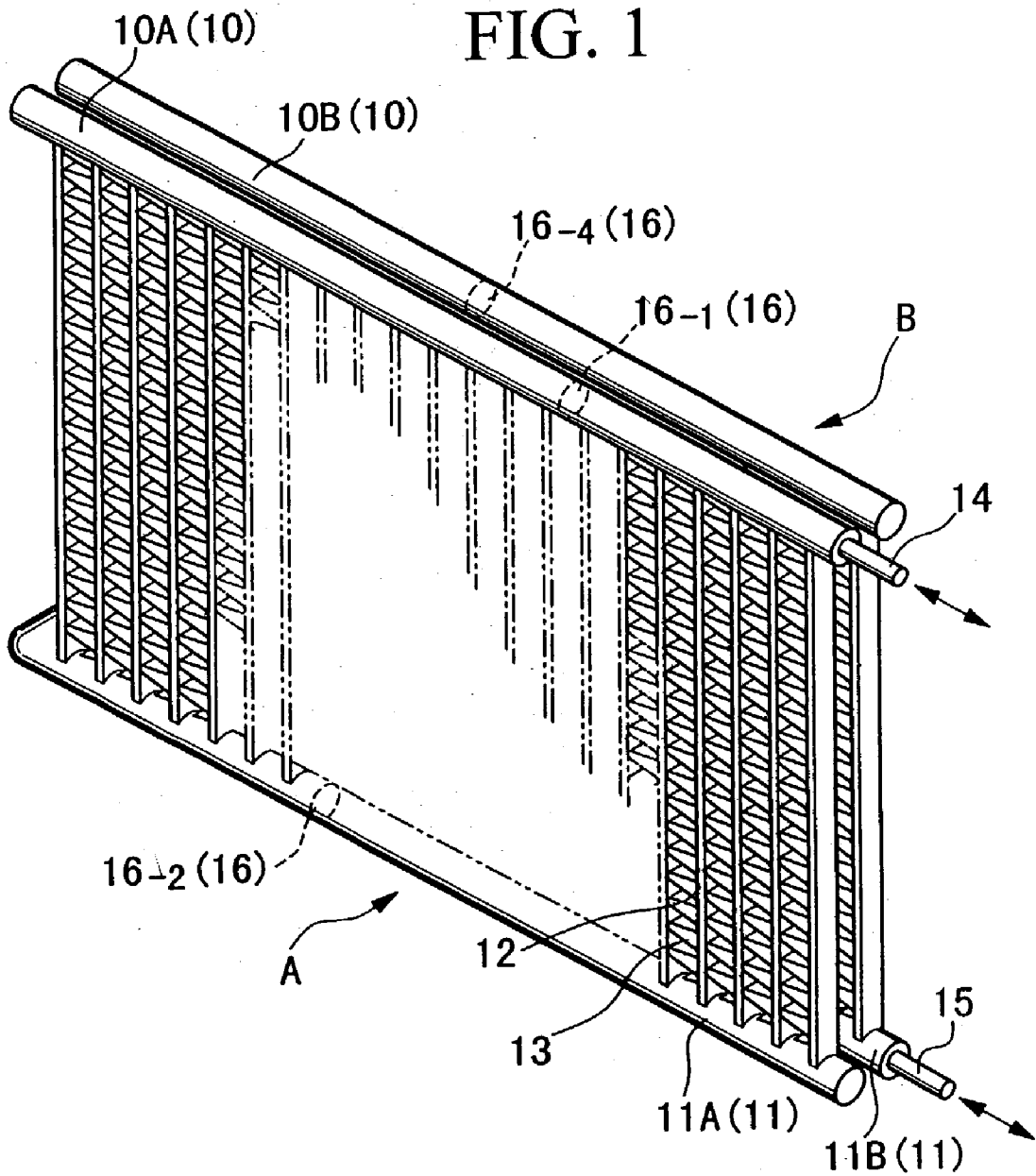


FIG. 2

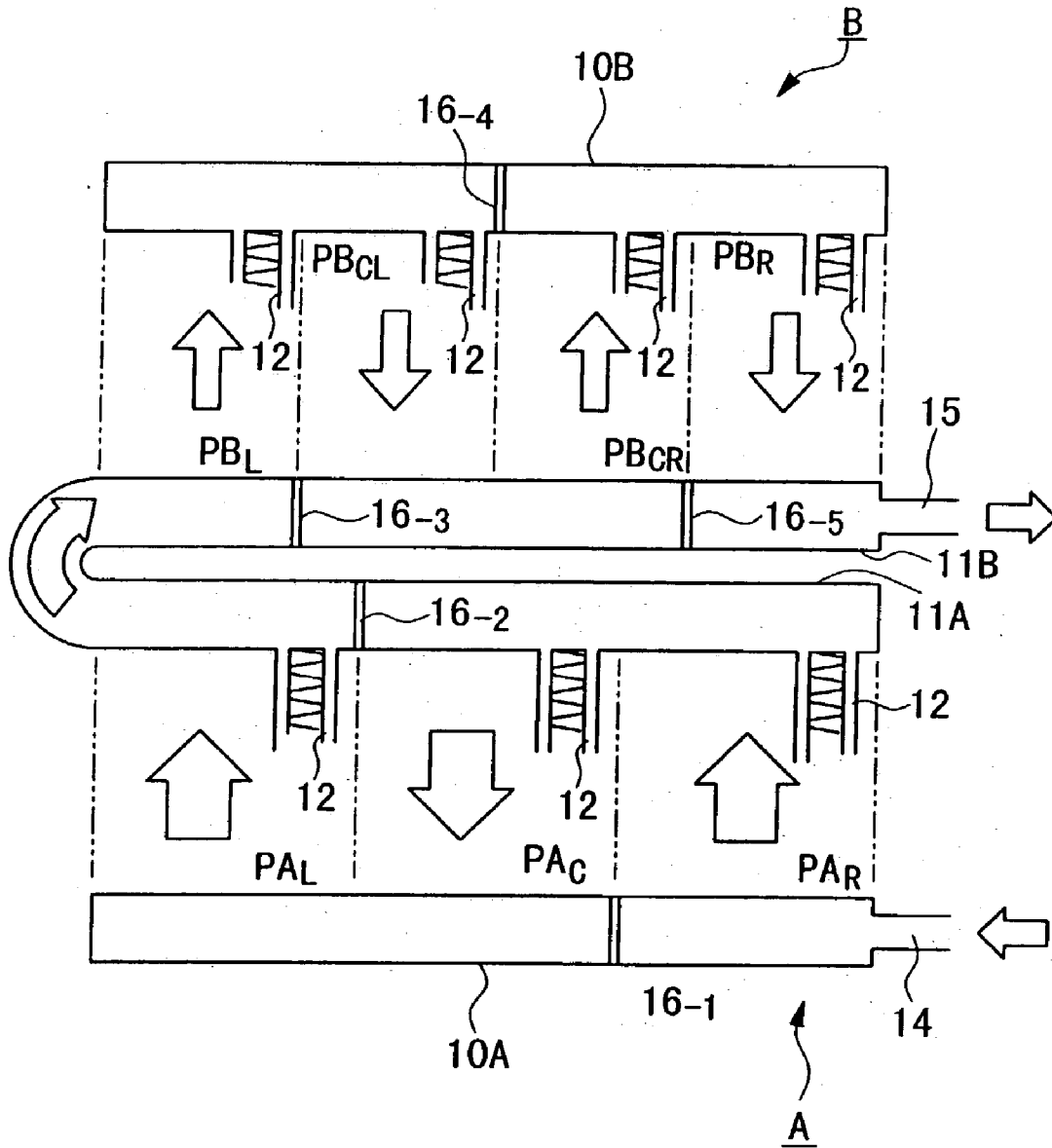


FIG. 3

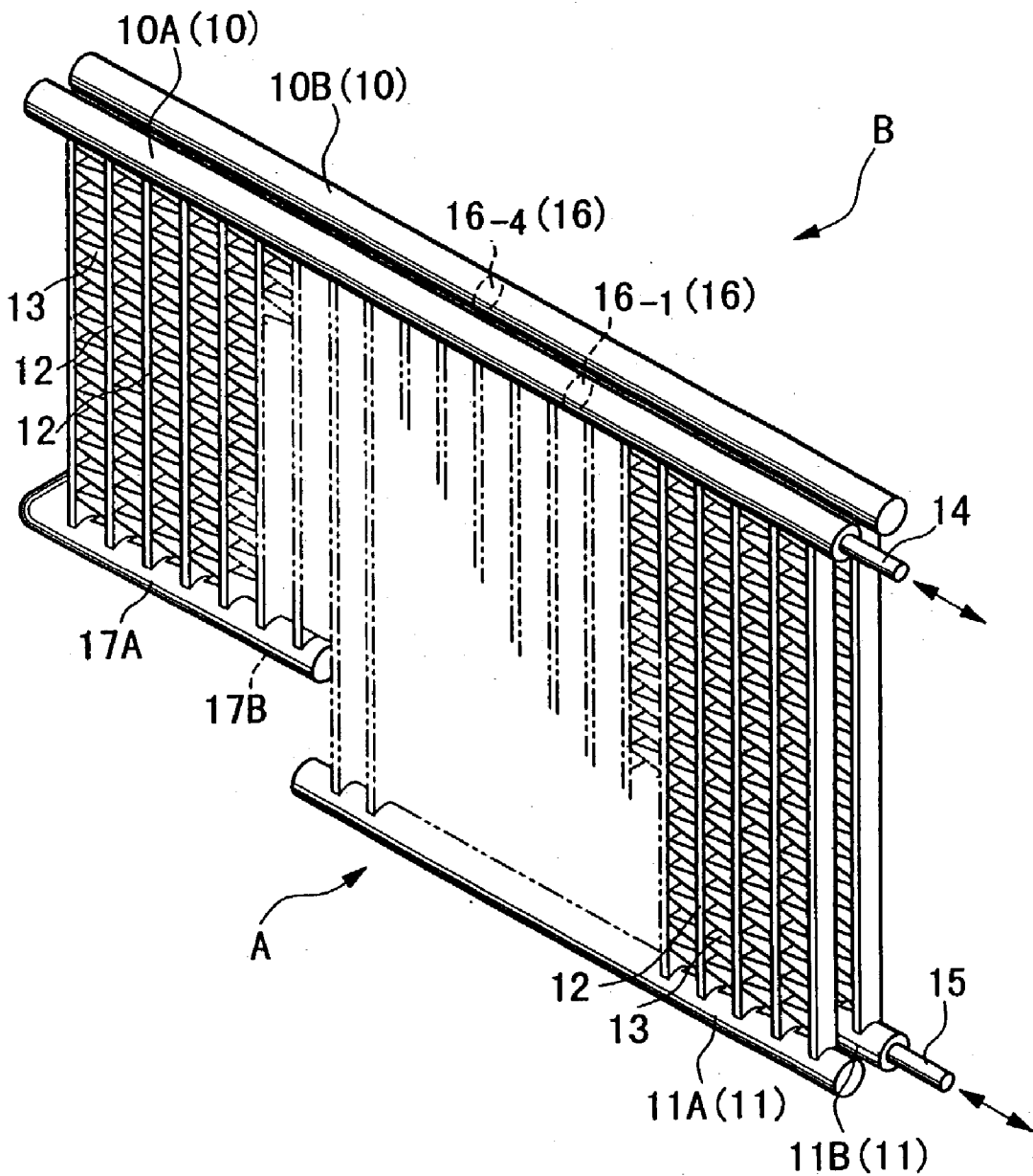


FIG. 4

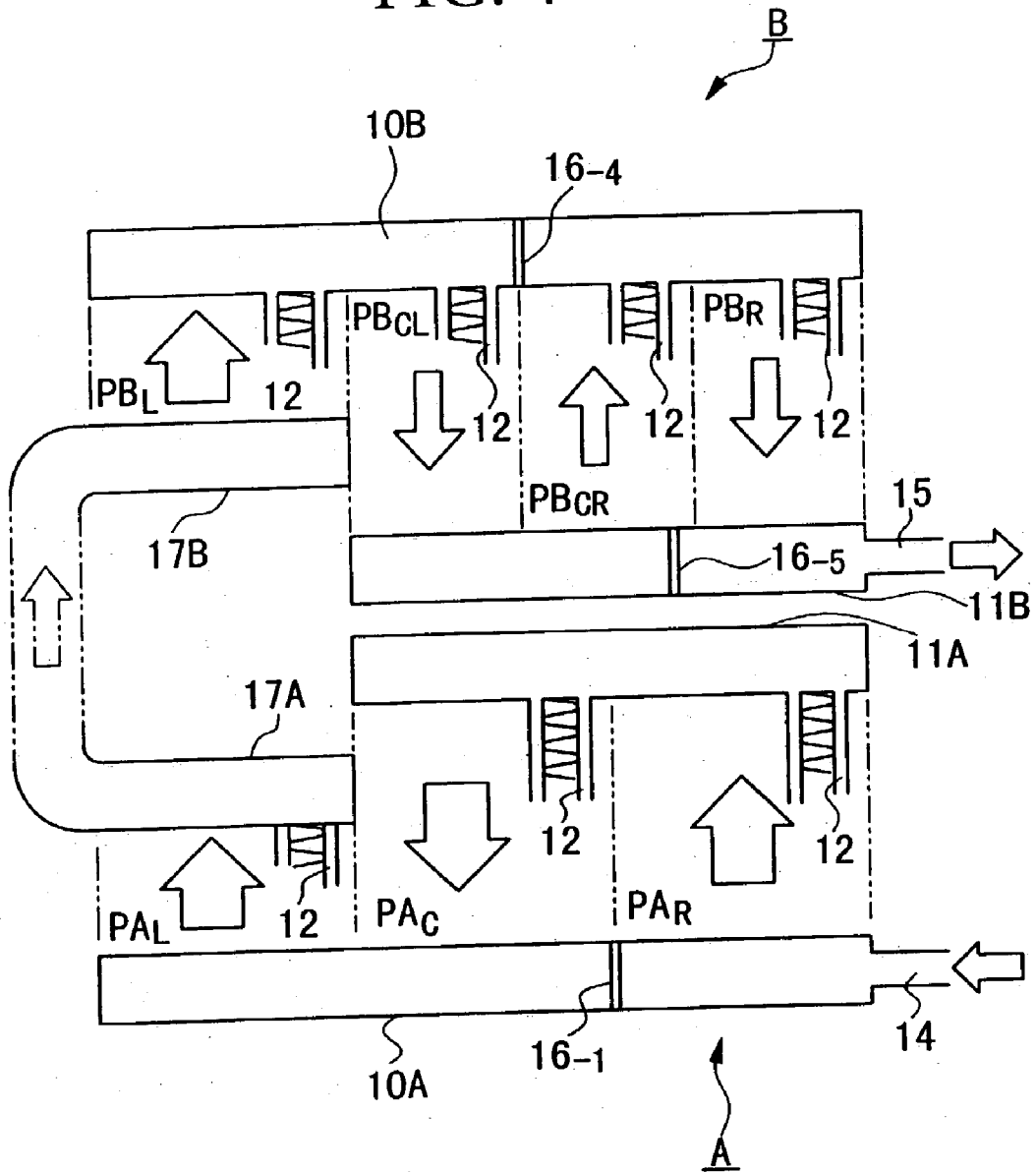


FIG. 5A

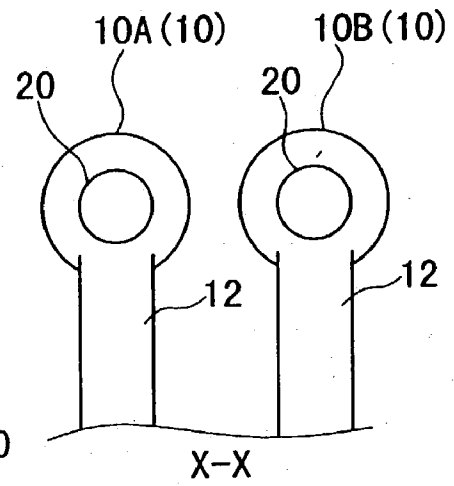
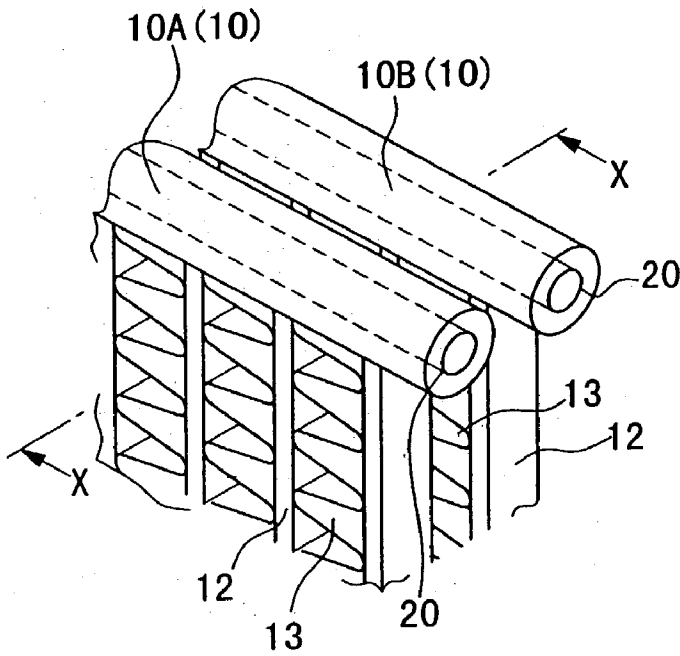


FIG. 5B

FIG. 6A

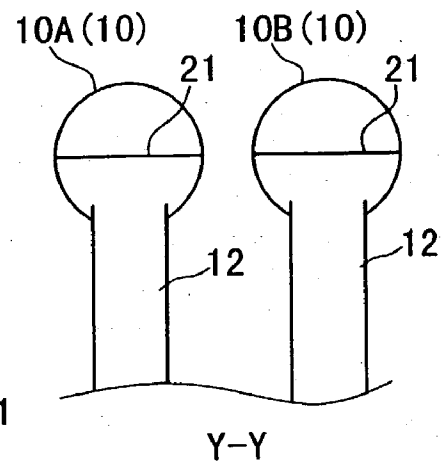
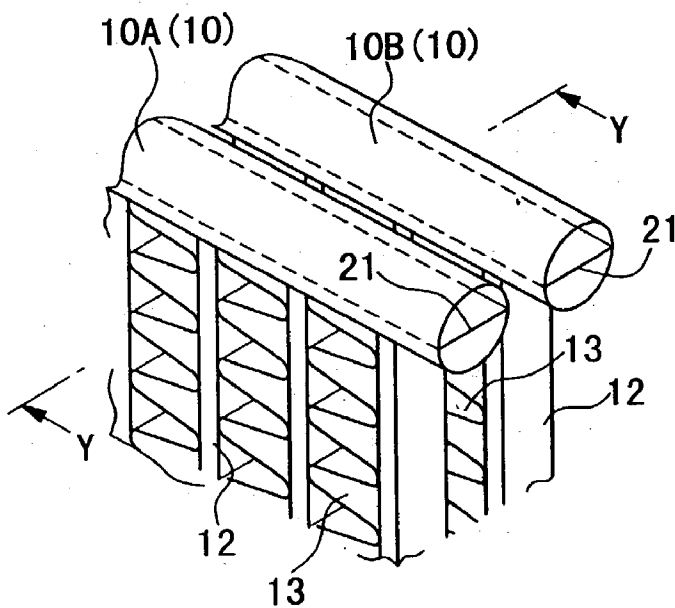
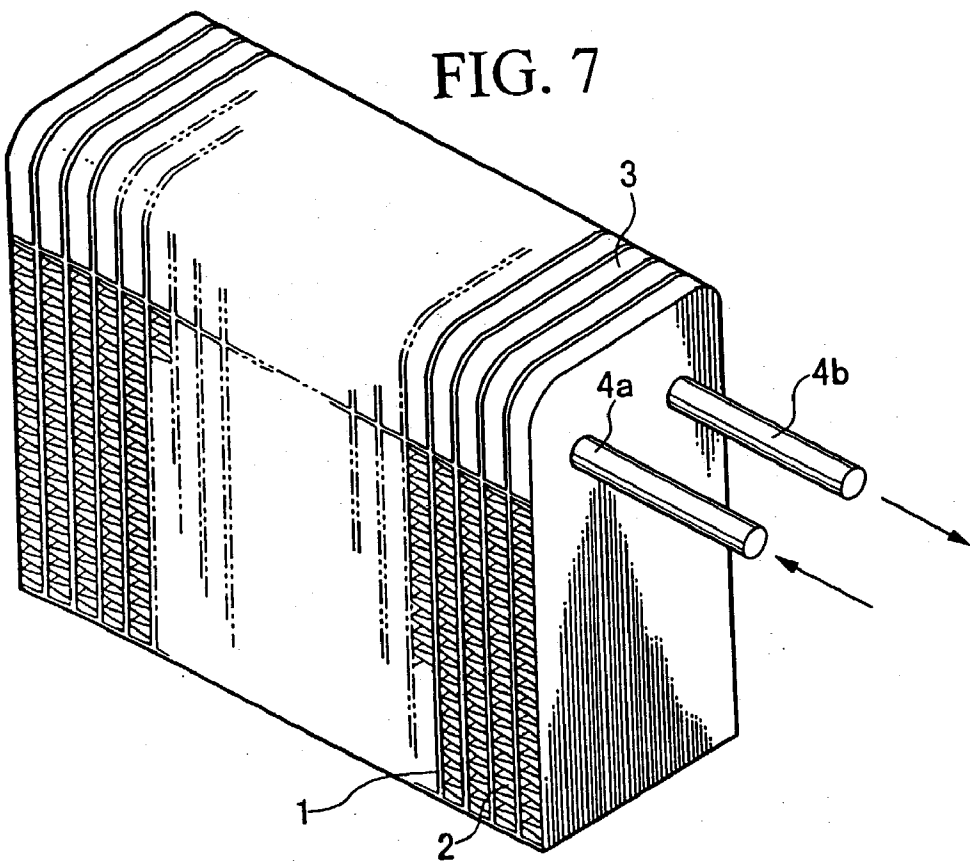
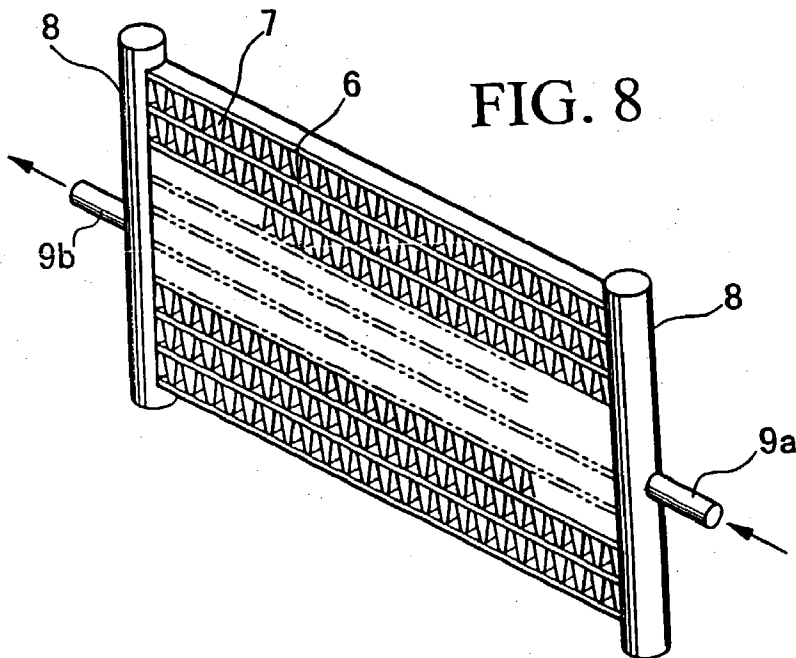


FIG. 6B



BACKGROUND ART



HEAT EXCHANGER

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to heat exchangers which are installed in air conditioners used for vehicles.

[0003] This application is based on Patent Application No. Hei 11-15,3025 filed in Japan, the content of which is incorporated herein by reference.

[0004] 2. Description of the Related Art

[0005] In general, vehicles are equipped with air conditioners to cool or warm the air therein. The air conditioners are equipped with heat exchanger units that cool or warm the air circulating in the vehicles.

[0006] The heat exchanger units are normally used for evaporators or heaters. Herein, the evaporators have evaporating functions to cool down the air by exchanging heat between the air and refrigerant flowing in refrigerant circulation systems. The heaters warm the air by exchanging heat between the air and cooling water flowing in cooling water circulation systems for engines.

[0007] Recently, people tend to have high environmental awareness with regard to various environmental issues. As one solution against the pollution of the environment, electric cars attract a great deal of attention of engineers and scientists. The electric cars install electric motors as driving power sources instead of internal-combustion engines. So, the electric cars are capable of traveling in a clean manner without producing exhaust gas that is one cause of the air pollution.

[0008] One major problem in development of the air conditioners installed in the electric cars is incapability of using cooling water of engines, which is conventionally used as heat sources for the heaters of the air conditioners. To cope with such a disadvantage, engineers propose to use air conditioners of the heat-pump type. In order to facilitate the air conditioners of the heat-pump type, it is necessary to reform the heat exchangers (particularly, evaporators) in structure. That is, the heat exchangers which are conventionally used as evaporators for cooling down the air are restructured to act as heaters that warm up the air as well.

[0009] FIG. 7 diagrammatically shows an outline structure of an evaporator conventionally used. That is, the evaporator of FIG. 7 is mainly constructed by plate tubes 1, cooling fins 2 and headers 3 as well as a refrigerant inlet pipe 4a and a refrigerant outlet pipe 4b. Each of the plate tubes 1 is constructed by two sheets of plates, which are arranged tightly and closely with each other and between which a U-shaped refrigerant passage is formed. So, refrigerant flows up and down in the U-shaped refrigerant passage in a reciprocating manner. In addition, the plate tubes 1 are arranged in parallel with each other by way of equal spacing therebetween. Further, the cooling fins 2 adhered to the plate tubes 1 respectively in such a manner that each of the cooling fins is sandwiched between two plate tubes. The headers 3 are located on upper portions of the plate tubes 1 to provide spaces being communicating with refrigerant passages respectively. So, refrigerant is introduced from the refrigerant inlet pipe 4a into the spaces of the headers 3, from which the refrigerant is distributed to the plate tubes 1

respectively. In addition, refrigerant that circulate in the plate tubes 1 and is output from the plate tubes 1 respectively is collected by the headers 3, from which the refrigerant is exhausted by way of the refrigerant outlet pipe 4b.

[0010] The evaporator having the aforementioned structure needs relatively low pressure for the refrigerant circulating in the plate tubes 1. For this reason, the evaporator does not normally have a high pressure-proof strength against high-pressure and high-temperature refrigerant, which is normally used in the condenser (i.e., heater). Therefore, the aforementioned evaporator cannot be used as the condenser.

[0011] Some of the air conditioners used for the vehicles are equipped with condensers that condense and liquefy refrigerant by exchanging heat between the refrigerant circulating in refrigerant circulation systems and external air outside of the vehicles.

[0012] FIG. 8 diagrammatically shows a condenser conventionally used. That is, the condenser of FIG. 8 is constructed by flat tubes 6 used for refrigerant passages, cooling fins 7 and headers 8 as well as a refrigerant inlet pipe 9a and a refrigerant outlet pipe 9b. The flat tubes 6 are horizontally arranged between the headers 8 and are held at different locations, which differ from each other in elevation by prescribed intervals of distance therebetween. In addition, the cooling fins 7 are arranged in connection with the flat tubes 6 in such a manner that each of the cooling fins is sandwiched between two flat tubes. Herein, the cooling fins 7 are bonded together with the flat tubes 6 by brazing. The headers 8 have spaces communicating with the refrigerant passages formed inside of the flat tubes 6. So, refrigerant is introduced from the refrigerant inlet pipe 9a into one header 8 (illustrated at a right side in FIG. 8), by which the refrigerant is distributed to the flat tubes 6 respectively. In addition, refrigerant that circulate in the flat tubes 6 and is output from the flat tubes 6 is collected by another header 8 (illustrated at a left side in FIG. 8), by which the refrigerant is exhausted by way of the refrigerant outlet pipe 9b.

[0013] By installing the condenser having the aforementioned structure in the air conditioner of the vehicle, it is possible to demonstrate condensing functions effectively. However, if the condenser is used as the evaporator, the condenser functions to cool humid components of the air so that condensed water is attached to surfaces of the cooling fins, then, the condensed water enter into gaps of the cooling fins. In that case, it is difficult to remove the condensed water from inside areas of the cooling fins. In addition, there is a problem in which the condensed water prevent the air from circulating among the cooling fins so that heat-exchange capability should be reduced.

[0014] As described above, it is impossible to use the evaporator and condenser, conventionally used for the air conditioner of the vehicle, directly for the air conditioner of the heat-pump type being installed in the electric car. In short, it is demanded to develop a specially designed heat exchanger that has a new structure being used for the air conditioner installed in the electric car.

SUMMARY OF THE INVENTION

[0015] It is an object of the invention to provide a heat exchanger that is preferable for use in a air conditioner of a heat-pump type being installed in an electric car.

[0016] A heat exchanger of this invention is used for an air conditioner installed in a vehicle such as an electric car and is basically designed as a laminated type, which is constructed by assembling a pair of heat-exchanger units together. Herein, each of the heat-exchanger units is constructed by a pair of headers, which are arranged in parallel with each other in a vertical direction and between which tubes and cooling fins are alternately arranged along a horizontal direction. Herein, each of the tubes and each of the cooling fins are extended in a vertical direction between the headers. Partition plates are arranged inside of the headers at selected positions such that an overall front area in which the tubes and cooling fins are alternately arranged between the headers is divided into a number of parts, among which refrigerant sequentially flow from one part to another in a reciprocating manner. Herein, all the parts can be equally divided to have a same sectional area, or they are gradually changed (i.e., reduced or enlarged) in sectional area along a refrigerant flow direction corresponding to the horizontal direction by which the refrigerant flow among the parts.

[0017] It is possible to change an overall front shape of the heat exchanger, which is originally a rectangular shape, to a prescribed shape such as an L-shape and a U-shape, by which the heat exchanger is arranged not to interfere with some device or equipment inside of the vehicle. For example, an intermediate header is arranged in parallel with the header and is located at an intermediate position in elevation between the headers, so tubes and cooling fins are correspondingly arranged in connection with the intermediate header.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and other objects, aspects and embodiments of the present invention will be described in more detail with reference to the following drawing figures, of which:

[0019] FIG. 1 is a perspective view showing an outline of a construction of a heat exchanger which is designed as a laminated type in accordance with a first embodiment of the invention;

[0020] FIG. 2 is an expanded flow diagram showing refrigerant circulation paths being formed inside of heat-exchanger units A, B which are assembled together;

[0021] FIG. 3 is a perspective view showing an outline of a construction of a heat exchanger which is designed as a laminated type in accordance with a second embodiment of the invention;

[0022] FIG. 4 is an expanded flow diagram showing refrigerant circulation paths being formed inside of heat-exchanger units A, B which are assembled together by way of intermediate headers;

[0023] FIG. 5A is an enlarged perspective view partly in section showing a selected upper-right part of a heat exchanger which is designed in accordance with a third embodiment of the invention;

[0024] FIG. 5B is a simplified sectional illustration showing internal pipes being inserted into headers;

[0025] FIG. 6A is an enlarged perspective view partly in section showing the selected upper-right part of the heat

exchanger of FIG. 5A, which is modified to replace the internal pipes with partition boards;

[0026] FIG. 6B is a simplified sectional illustration showing the partition boards being inserted into the headers;

[0027] FIG. 7 is a perspective view showing an example of an evaporator conventionally used; and

[0028] FIG. 8 is a perspective view showing an example of a condenser conventionally used.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0029] This invention will be described in further detail by way of examples with reference to the accompanying drawings.

[0030] [A] First Embodiment

[0031] Now, a heat exchanger that is designed in accordance with a first embodiment of the invention will be described with reference to FIGS. 1 and 2.

[0032] The heat exchanger of the first embodiment is basically designed as a heat exchanger of a laminated type, which is constructed by assembling two heat-exchanger units A, B of a parallel flow type together. Each of the heat-exchanger units A, B is constructed by a pair of headers 10, 11, tubes 12 and cooling fins 13. Herein, the headers 10, 11 are located vertically apart from each by a prescribed interval of distance and are arranged in parallel with each other in elevation. In addition, the tubes 12 and the cooling fins 13 are arranged between the headers 10, 11 in a horizontal direction and alternately with each other such that one cooling fin is sandwiched between two tubes. Further, both ends of the tubes 12 communicate with internal spaces of the headers 10, 11 respectively. Thus, refrigerant passages formed insides of the tubes 12 are interconnected together with respect to each of the heat-exchanger units A, B, which are interconnected together by the headers 11 (i.e., 11A, 11B, see FIG. 2). As a result, refrigerant flow through refrigerant circulation paths, which are formed in the heat-exchanger units A, B respectively and are interconnected together, so that the refrigerant sequentially circulate through the heat-exchanger units A, B.

[0033] Each of the header 10, 11 is constructed by a seamless pipe having a circular sectional shape. Both ends of the header is closed by terminal plates each having a circular shape. Each of the tubes 12 has a flat shape whose width is shorter than a diameter of the header and is made by a porous extrusion tube containing passages being partitioned in a width direction thereof. Ends of the tube 12 are inserted into insertion holes (not shown) respectively formed on the headers 10, 11 at selected positions, and are adhered to the headers 10, 11 respectively by brazing. So, refrigerant introduced into the headers 10, 11 is distributed to the tubes 12 respectively. Each of the cooling fins 13 is made by bending a band-shaped plate material to be corrugated with waves. So, the cooling fins 13 are arranged in connection with the tubes 12 such that crest portions of the "corrugated" cooling fin 13 are brought into contact with and bonded together with its adjacent tubes by brazing.

[0034] Substantially, no difference in appearance is provided between the heat-exchanger units A, B. Concretely speaking, the heat-exchanger unit A is constructed using a

pair of an upper header 10A and a lower header 11A between which the tubes and cooling fins are arranged, while the heat-exchanger unit B is constructed using a pair of an upper header 10B and a lower header 11B between which the tubes and cooling fins are arranged. Herein, a refrigerant inlet/outlet pipe 14 is provided to communicate with one end of the header 10A of the heat-exchanger unit A, while a refrigerant inlet/outlet pipe 15 is provided to communicate with one end of the header 11B of the heat-exchanger unit B. In addition, the lower headers 11A, 11B of the heat-exchanger units A, B are interconnected with each other with prescribed ends thereof to communicate with each other with internal spaces thereof

[0035] FIG. 2 shows an layout of the refrigerant circulation paths being formed in the heat-exchanger units A, B. To clearly show the refrigerant circulation paths, FIG. 2 shows an expanded flow diagram of the heat-exchange units A, B.

[0036] As shown in FIG. 2, a number of partition plates 16 (specifically, 16-1 to 16-5) are arranged at selected positions inside of the headers 10A, 11A, 10B, 11B. By provision of the partition plates 16, the refrigerant circulation paths are arranged such that refrigerant will flow between the headers 10A, 11A (or between the headers 10B, 11B) in a reciprocating manner.

[0037] Next, operations of the heat-exchanger units A, B will be described with respect to refrigerant that flow through the refrigerant circulation paths.

[0038] In FIG. 2, an overall area of the heat-exchanger unit A is equally divided into three sections, namely, a right part PA_R, a center part PA_C and a left part PA_L, each of which occupies a one-third ($\frac{1}{3}$) area. In addition, an overall area of the heat-exchanger unit B is equally divided into four sections, namely, a right part PB_R, a center-right part PB_{CR}, a center-left part PB_{CL} and a left part PB_L, each of which occupies a one-fourth ($\frac{1}{4}$) area.

[0039] Now, refrigerant is introduced into the upper header 10A of the heat-exchanger unit A by way of the refrigerant inlet/outlet pipe 14. In the upper header 10A, the refrigerant is blocked by the partition plate 16-1, so that the refrigerant is distributed to the tubes 12 belonging to the right part PA_R of the heat-exchanger unit A. Herein, the distributed refrigerant flow through the tubes 12 of the right part PA_R and is then output toward the lower header 11A. In the lower header 11A, the refrigerant is blocked by the partition plate 16-2, so the refrigerant is distributed to the tubes 12 belonging to the center part PA_C of the heat-exchanger unit A. The distributed refrigerant flow through the tubes 12 of the center part PA_C and is then output toward the upper header 10A. Then, the refrigerant is blocked by the closed end of the upper header 10A, so the refrigerant is distributed to the tubes 12 belonging to the left part PA_L of the heat-exchanger unit A. The distributed refrigerant flow through the tubes 12 of the left part PA_L and is then output toward the lower header 11A.

[0040] Because the lower header 11A of the heat-exchanger unit A is interconnected with the lower header 11B of the heat-exchanger unit B, the refrigerant output from the tubes 12 of the left part PA_L of the heat-exchanger unit A is forced to flow from the lower header 11A to the lower header 11B. That is, the refrigerant output from the heat-exchange unit A is input to the heat-exchange unit B by way of the

lower headers 11A, 11B which are interconnected with each other. In the lower header 11B, the refrigerant is blocked by the partition plate 16-3, so the refrigerant is distributed to the tubes 12 belonging to the left part PB_L of the heat-exchanger unit B. The distributed refrigerant flow through the tubes 12 of the left part PB_L and is then output toward the upper header 10B. In the upper header 10B, the refrigerant is blocked by the partition plate 16-4, so the refrigerant is distributed to the tubes 12 belonging to the center-left part PB_{CL} of the heat-exchanger unit B. The distributed refrigerant flow through the tubes 12 of the center-left part PB_{CL} and is then output toward the lower header 11B. In the lower header 11B, the refrigerant is blocked by the partition plate 16-5, so the refrigerant is distributed to the tubes 12 belonging to the center-right part PB_{CR}. The distributed refrigerant flow through the tubes 12 of the center-right part PB_{CR} and is then output toward the upper header 10B. Then, the refrigerant is blocked by the closed end of the upper header 10B, so the refrigerant is distributed to the tubes 12 belonging to the right part PB_R. The distributed refrigerant flow through the tubes 12 of the right part PB_R and is then output toward the lower header 11B. Thereafter, the refrigerant is forced to be output by way of the refrigerant inlet/outlet pipe 15 connected with the lower header 11B of the heat-exchanger unit B.

[0041] As described before, each of the headers 10A, 11A, 10B, 11B is constructed by the seamless pipe, while each of the tubes 12 is constructed by the porous extrusion tube. Thus, the heat exchanger of the first embodiment is capable of improving a pressure-proof strength entirely. In addition, the heat exchanger is designed such that the tubes 12 are arranged in a vertical direction. Therefore, when the heat exchanger is used as an evaporator, condensed water attached to surfaces of the cooling fins 13 drop downwardly with ease by way of the tubes 12 being vertically arranged. Thus, it is possible to effectively remove the condensed water from interior gaps of the cooling fins 13.

[0042] Generally speaking, the electric cars are limited in spaces being secured for installation of air conditioners because they are equipped with specially designed devices and mechanisms, which differ from conventional devices and mechanisms being installed in general cars equipped with internal-combustion engines. The present embodiment is designed to cope with limitation in space for installation of the air conditioner in the electric car. That is, the present embodiment provides a laminated type of the heat exchanger, in which the heat-exchanger units A, B are arranged closely with each other in a laminated manner and which is easily installed in the electric car. So, it is possible to obtain a desired heat-exchange capability while reducing an overall volume of the heat exchanger of the laminated type.

[0043] By arranging partition plates 16 in the headers 10, 11 at the prescribed positions, it is possible to freely set and arrange the refrigerant circulation paths in the heat exchanger. When the aforementioned heat exchanger is installed in the air conditioner, it is possible to freely design layouts for the refrigerant circulation paths by changing (e.g., increasing) a number of the parts being arranged in the heat exchanger in accordance with various conditions.

[0044] FIG. 2 merely shows one example of the layout for the refrigerant circulation paths, in which total seven parts

are arranged in the heat exchanger having the prescribed refrigerant circulation paths, wherein the heat-exchanger unit A is arranged in an upstream side while the heat-exchanger unit B is arranged in a downstream side. That is, an overall area for arranging the tubes 12 in the heat-exchanger unit A is divided into three parts, while an overall area for arranging the tubes 12 in the heat-exchanger unit B is divided into four parts. As compared with the heat-exchanger unit B, the heat-exchanger unit A has a large number of tubes 12 being allocated to each of the parts. In other words, a sum of sectional areas being measured from the refrigerant circulation paths within one part becomes large in the heat-exchanger unit A corresponding to the upstream side, but it becomes small in the heat-exchanger unit B corresponding to the downstream side. That is, sectional areas of the refrigerant circulation paths become small along a refrigerant flow direction that directs from the upstream side to the downstream side.

[0045] In the case of the condenser being designed using the aforementioned heat exchanger, the refrigerant circulating in the condenser is not maintained constantly in dryness. That is, the dryness is gradually reduced in processes for condensation and liquefaction in the condenser. For this reason, if the sectional areas of the refrigerant circulation paths are constantly maintained, regardless of the refrigerant flow direction, refrigerant pressures are increased in the upstream side but are decreased in the downstream side. Therefore, if the condenser is designed using the heat exchanger in which sectional areas of refrigerant circulation paths are maintained constantly in all parts, it may be difficult to produce a high heat transfer rate, and it may be difficult to reduce pressure loss. Because, the pressure loss becomes large in the upstream side in which refrigerant has a high degree of dryness and a high pressure, while the heat transfer rate becomes small in the downstream side in which refrigerant has a low degree of dryness and a low pressure.

[0046] To cope with the aforementioned drawbacks, the heat exchanger of the present embodiment is designed such that as shown in FIG. 2, sums of the sectional areas of the refrigerant circulation paths are gradually reduced along the refrigerant flow direction. Therefore, the present embodiment is capable of changing pressure of the refrigerant in response to variations of the dryness of the refrigerant, namely, it is possible to reduce the pressure in the upstream side, and it is possible to increase the pressure in the downstream side. Thus, it is possible to produce a high heat transfer rate while reducing pressure loss in the heat exchanger as a whole.

[0047] In the case of the evaporator which is designed using the aforementioned heat exchanger, the refrigerant circulating in the evaporator is not maintained constantly in dryness. That is, the dryness of the refrigerant is gradually increased in processes for evaporation and gasification in the evaporator. Therefore, if the sectional areas of the refrigerant circulation paths are maintained constant, regardless of the refrigerant flow direction, pressure of the refrigerant is reduced in the upstream side but is increased in the downstream side. As a result, a heat transfer rate is reduced in the upstream side in which the refrigerant has a low degree of dryness and a low pressure, while pressure loss is increased in the downstream side in which the refrigerant has a high degree of dryness and a high pressure.

[0048] In the case of the evaporator, the heat exchanger is modified such that the refrigerant is forced to flow in directions reverse to directions shown in FIG. 2. That is, the heat-exchanger unit B is arranged as the upstream side, while the heat-exchanger unit A is arranged as the downstream side. Therefore, sums of the sectional areas of the refrigerant circulation paths are gradually increased along a refrigerant flow direction, which is reverse to the refrigerant flow direction shown in FIG. 2. For this reason, it is possible to change pressure of the refrigerant adequately in response to variations of the dryness of the refrigerant in the evaporator. Namely, it is possible to increase the pressure of the refrigerant in the upstream side, and it is possible to reduce the pressure of the refrigerant in the downstream side. Thus, it is possible to produce a high heat transfer rate while reducing pressure loss in the heat exchanger as a whole.

[0049] Incidentally, the first embodiment is designed to change sums of the sectional areas of the refrigerant circulation paths in a two-stage manner between the heat-exchanger units A and B. Of course, it is possible to set three or four stages for changing them by changing arrangement of the partition plates. That is, it is possible to change the sums of the sectional areas of the refrigerant circulation paths in a more precise manner.

[0050] [B] Second Embodiment

[0051] Next, a heat exchanger which is designed in accordance with a second embodiment of the invention will be described with reference to FIGS. 3 and 4, wherein parts equivalent to those shown in FIGS. 1 and 2 are designated by the same reference numerals, hence, the description thereof will be omitted.

[0052] As similar to the first embodiment, the heat exchanger of the second embodiment is designed as a laminated type, which is constructed by assembling heat-exchanger units A, B of a parallel-flow type together. As compared with the first embodiment shown in FIG. 1, the second embodiment shown in FIG. 3 is characterized by that the heat-exchanger units A, B are shortened by partially cutting out lower headers 11 and their peripheral portions. In the case of the heat-exchanger unit A, the lower header 11A and its peripheral portions are partially cut out. Instead of cut portions regarding the lower header 11A, an intermediate header 17A is provided and arranged in parallel with the upper header 10A. Herein, the intermediate header 17A is located at an intermediate position in elevation between the headers 10A and 11A. In addition, tubes 12 and cooling fins 13 are also arranged between the upper header 10A and the intermediate header 17A. Herein, the tubes 12 and the cooling fins 13 are arranged alternately in a horizontal direction such that one cooling fin is arranged between two tubes.

[0053] As similar to the heat-exchanger unit A, the heat-exchanger unit B is equipped with an intermediate header 17B, which is arranged between the upper header 10B and the lower header 11B being partially cut out. In addition, tubes 12 and cooling fins 13 are arranged between the upper header 10B and the intermediate header 17B and are also arranged alternately in a horizontal direction such that one cooling fin is arranged between two tubes.

[0054] The intermediate headers 17A, 17B are closed at one ends thereof, while they are interconnected with each

other by way of other ends thereof. That is, the intermediate headers 17A, 17B are integrally connected together to form a U-shaped refrigerant path shown in FIG. 4. In front view, the heat exchange of the laminated type shown in FIG. 3 roughly has an L shape, which is actualized by partially cutting out the rectangular shape.

[0055] FIG. 4 shows overall refrigerant circulation paths being formed in the heat-exchanger units A, B. To clearly illustrate the refrigerant circulation paths, FIG. 4 shows an expanded flow diagram in which the heat-exchanger units A, B are expanded with respect to flows of refrigerant.

[0056] In the second embodiment, a number of partition plates 16 are arranged in the headers 10A, 11A, 10B, 11B at selected positions shown in FIG. 4.

[0057] As similar to the first embodiment shown in FIG. 2, an overall area of the heat-exchanger unit A is equally divided into three sections, namely, a right part PA_R, a center part PA_C and a left part PA_L, each of which occupies a one-third ($\frac{1}{3}$) area. In addition, an overall area of the heat-exchanger unit B is divided into four sections, namely, a right part PB_R, a center-right part PB_{CR}, a center-left part PB_{CL} and a left part PB_L. Herein, the left part PB_L occupies a one-third ($\frac{1}{3}$) area, while each of the other parts PB_R, PB_{CR} and PB_{CL} occupies a two-ninths ($\frac{2}{9}$) area.

[0058] Now, the heat-exchanger units A, B will be described with respect to the refrigerant circulation paths. At first, refrigerant is introduced into the upper header 10A of the heat-exchanger unit A by way of the refrigerant inlet/outlet pipe 14. In the upper header 10A, the refrigerant is blocked by a partition plate 16-1 and is distributed to the tubes 12 belonging to the right part PA_R of the heat-exchanger unit A. The distributed refrigerant flow through the tubes 12 of the right part PA_R and is then output toward the lower header 11A. In the lower header 11A, the refrigerant is blocked by its closed end and is forced to flow toward the center part PA_C of the heat-exchanger unit A. So, the refrigerant is distributed to the tubes 12 belonging to the center part PA_C. The distributed refrigerant flow through the tubes 12 of the center part PA_C and is then output toward the upper header 10A. In the upper header 10A, the refrigerant is blocked by the partition plate 16-1 and is forced to flow toward the left part PA_L. So, the refrigerant is distributed to the tubes 12 belonging to the left part PA_L. As compared with the tubes belonging to the parts PA_R and PA_C, the tubes belonging to the left part PA_L are shortened in lengths. The distributed refrigerant flow through the tubes 12 of the left part PA_L and is then output toward the intermediate header 17A.

[0059] That is, the refrigerant flow into the intermediate header 17A, one end of which is closed but another end of which is interconnected with the intermediate header 17B of the heat-exchanger unit B. So, the refrigerant flows through the intermediate headers 17A, 17B sequentially. In the intermediate header 17B whose one end is closed, the refrigerant is forced to flow into the tubes 12 belonging to the left part PB_L of the heat-exchanger unit B. So, the refrigerant is distributed to the tubes 12 of the left part PB_L. The distributed refrigerant flow through the tubes 12 of the left part PB_L and is then output toward the upper header 10B, both ends of which are closed. In the upper header 10B, the refrigerant is blocked by a partition plate 16-4 and is forced to flow toward the center-left part PB_{CL} of the heat-ex-

changer unit B. So, the refrigerant is distributed into the tubes belonging to the center-left part PB_{CL}. The distributed refrigerant flow through the tubes 12 of the center-left part PB_{CL} and is then output toward the lower header 11B whose one end is closed. In the lower header 11B, the refrigerant is blocked by a partition plate 16-5 and is forced to flow toward the center-right part PB_{CR}. So, the refrigerant is distributed to the tubes 12 belonging to the center-right part PB_{CR}. The distributed refrigerant flow through the tubes 12 of the center-right part PB_{CR} and is then output toward the upper header 10B. In the upper header 10B, the refrigerant is blocked by the partition plate 16-4 and is forced to flow toward the right part PB_R. So, the refrigerant is distributed to the tubes 12 of the right part PB_R. The distributed refrigerant flow through the tubes 12 of the right part PB_R and is then output toward the lower header 11B. In the lower header 11B, the refrigerant is blocked by the partition plate 16-5 and is forced to flow toward the refrigerant inlet/outlet pipe 15. Thus, the refrigerant is output by way of the refrigerant inlet/outlet pipe 15.

[0060] As described above, the heat exchanger of the second embodiment is characterized by providing the intermediate headers 17A, 17B in connection with the heat-exchanger units A, B respectively. As compared with the foregoing heat exchanger of the parallel-flow type which has a rectangular shape, the second embodiment forms the heat exchanger of the parallel-flow type to roughly have an L shape.

[0061] As compared with the rectangular shape, the L shape is reduced in total area, in other words, the L shape is able to provide a certain space, which can be used to install some device or equipment of the vehicle.

[0062] So, the second embodiment has an advantage in application to the electric car which is limited in space for installation of the heat exchanger. That is, even if the electric car does not provide a sufficient space for installation of the heat exchanger, the heat exchanger is modified in shape to avoid interference with other device or equipment. So, the second embodiment is capable of providing the heat exchanger whose shape is modified to enable installation in a limited space, which is narrow and is hard to install the rectangular heat exchanger.

[0063] Incidentally, FIG. 3 merely shows one example of the shape being applied to the heat exchanger. That is, the heat exchanger can be further changed in shape by using the aforementioned technique of the second embodiment (e.g., provision of intermediate headers). So, it is possible to construct the heat exchanger to have a prescribed shape such as a U-shape, an E-shape and a step-like shape other than the L-shape.

[0064] [C] Third Embodiment

[0065] Next, a heat exchanger that is designed in accordance with a third embodiment of the invention will be described with reference to FIGS. 5A and 5B, wherein parts equivalent to those shown in FIG. 1 are designated by the same reference numerals, hence, the description thereof will be omitted.

[0066] FIG. 5A shows a selected part (i.e., an upper-right part) of the heat exchanger of the laminated type, which is constructed by assembling heat-exchanger units A, B together. The third embodiment is characterized by that

internal pipes (or space occupation members) **20** each having a circular sectional shape are respectively inserted into the upper headers **10A**, **10B** in such a way that center axes thereof coincide with center axes of the upper headers **10A**, **10B** in their length directions. As shown in **FIG. 5B**, the internal pipes **20** occupy certain areas of the upper headers **10A**, **10B** in section, but they are isolated from refrigerant passages provided inside of the upper headers **10A**, **10B** respectively. As similar to the upper headers **10A**, **10B**, internal pipes are also inserted into the lower headers **11A**, **11B** respectively, which is not illustrated by figures.

[0067] By insertion of the internal pipe **20** in the header, it is possible to reduce the refrigerant passage in volume with respect to each of the headers. That is, the internal pipe **20** prohibits stagnation of refrigerant inside of the header. This increases a circulation efficiency of the refrigerant, so it is possible to reduce a start-up time for starting up an initial operation of the air conditioner. In addition, it is possible to reduce an amount of refrigerant circulating through a refrigerant circulation system of the heat exchanger.

[0068] The internal pipe **20** having a circular sectional shape is employed as the space occupation member in consideration of its pressure-proof strength. In the case of the condenser which is constructed using the heat exchanger, high-pressure and high-temperature refrigerant flow into the upper header (i.e., **10A**) in the upstream side of the heat exchanger. In that case, the "circularly shaped" internal pipe **20** can demonstrate a sufficiently high pressure-proof strength against the "surrounding" high-pressure refrigerant in the header.

[0069] Incidentally, the space occupation member is not necessarily formed like the internal pipe **20**. For example, it is possible to provide an elongated partition board **21** being inserted into the header as shown in **FIG. 6A**. Herein, the partition board **21** is elongated in a length direction of the header. As shown in **FIG. 6B**, the partition board **21** partitions an internal space of the header into two sections. By using the partition boards **21** being respectively inserted into the headers, it is possible to obtain effects similar to the aforementioned effects being demonstrated by the internal pipes **20** inserted into the headers. However, the partition board **21** is formed by a flat board, which cannot provide a sufficiently high pressure-proof strength against the refrigerant. So, it is necessary to introduce some ideas for strengthening the partition board **21**. For example, the partition board **21** is designed to have a sufficiently large thickness, or ribs are provided for reinforcement of the partition board **21**.

[0070] As described heretofore, this invention has a variety of technical features and effects, which are summarized as follows:

[0071] (1) A heat exchange of this invention is basically used for an air conditioner installed in a vehicle and is constructed by a pair of headers which are arranged in parallel with each other in a vertical direction and between which tubes and cooling fins are alternately arranged along a horizontal direction. Herein, each of the tubes is extended vertically, so if the heat exchanger is used as an evaporator, condensed water being attached to surfaces of the cooling fins easily drop down by way of the tubes

vertically extended. Therefore, it is possible to efficiently remove the condensed water from internal gaps of the cooling fins. This helps the air to flow between the cooling fins in a good manner, so it is possible to avoid reduction of a heat-exchange capability due to adhesion of the condensed water to the cooling fins.

[0072] (2) The heat exchanger is equipped with partition plates, which are arranged inside of the headers at selected positions. By adequately arranging the partition plates, it is possible to freely configure a layout for refrigerant circulation paths within the headers and tubes in response to various conditions of the air conditioner installed in the vehicle.

[0073] (3) The heat exchanger is equipped with an intermediate header, which is located at an intermediate position in elevation between the headers and is arranged in parallel with one of the headers, so that tubes and cooling fins are correspondingly arranged in connection with the intermediate header. By providing such an intermediate header, it is possible to change an overall front shape of the heat exchanger, which is originally a rectangular shape, to a desired shape such as an L-shape and a U-shape. By adequately designing the overall front shape of the heat exchanger, it is possible to arrange the heat exchanger not to interfere with some device or equipment being installed in the vehicle, especially, electric vehicle.

[0074] (4) The heat exchanger is equipped with a space occupation member such as an internal pipe and a flat board, which is arranged inside of the header to reduce an internal space of the header in which refrigerant flow. By provision of the space occupation member, it is possible to control stagnation of the refrigerant inside of the header. Therefore, it is possible to increase a circulation efficiency of the refrigerant, so it is possible to reduce a start-up time for starting up an initial operation of the air conditioner. In addition, it is possible to reduce an amount of refrigerant which circulate through a refrigerant circulation system of the heat exchanger.

[0075] (5) The heat exchanger is designed as a laminated type, which is constructed by assembling together multiple heat-exchanger units, each of which is constructed by a pair of headers as well as tubes and cooling fins and which are interconnected with each other by way of headers. Thus, it is possible to obtain a desired heat-exchange capability while reducing the heat exchanger in volume.

[0076] As this invention may be embodied in several forms without departing from the spirit of essential characteristics thereof, the present embodiments are therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within metes and bounds of the claims, or equivalence of such

metes and bounds are therefore intended to be embraced by the claims.

What is claimed is:

1. A heat exchanger that is installed in an air conditioner used for a vehicle to cool or warm air inside of the vehicle, said heat exchanger comprising:

- a pair of a first header and a second header which are extended in a horizontal direction and are arranged apart in parallel with each other in a vertical direction;
- a plurality of tubes, each of which is vertically extended between and interconnected with the first and second headers to communicate with internal spaces of the first and second headers with end portions thereof respectively, said plurality of tubes being arranged along the horizontal direction with equal intervals of distance being provided therebetween; and
- a plurality of cooling fins, each of which is vertically extended between the first and second headers, said plurality of cooling fins being arranged alternately in connection with the plurality of tubes along the horizontal direction such that one cooling fin is sandwiched between two tubes in the horizontal direction,

wherein refrigerant is introduced into the first header so that the refrigerant circulates through the tubes as well as the first and second headers and is then exhausted by way of the second header,

wherein a third header which is extended in the horizontal direction and is arranged apart in parallel with the first header in a vertical direction;

- a plurality of secondary tubes, each of which is vertically extended between and interconnected with the first header and the third header to communicate with internal spaces of the first and third headers with end portions thereof respectively, said plurality of secondary tubes are arranged along the horizontal direction with equal intervals of distance being provided therebetween; and
- a plurality of secondary cooling fins, each of which is vertically extended between the first and third headers, said plurality of secondary cooling fins being arranged alternately in connection with the plurality of secondary tubes along the horizontal direction such that one secondary cooling fin is sandwiched between two secondary tubes.

2. A heat exchanger according to claim 1 wherein the third header is located at an intermediate position in elevation between the first and second headers, so that both of the secondary tubes and the secondary cooling fins arranged between the first and third headers are shortened in length as compared with the tubes and the cooling fins arranged between the first and second headers.

3. A heat exchanger according to claim 1 wherein a space occupation member is arranged inside of the header so as to reduce an internal space of the header in volume in which the refrigerant flow.

4. A heat exchanger according to claim 1 wherein an internal pipe is inserted into the header as a space occupation member to reduce an internal space of the header in volume in which the refrigerant flow.

5. A heat exchanger according to claim 1 wherein a flat board is inserted into the header as a space occupation member to reduce an internal space of the header in volume in which the refrigerant flow.

6. A heat exchanger according to claim 1 wherein a space occupation member is arranged inside of the header so as to reduce an internal space of the header in volume in which the refrigerant flow.

7. A heat exchanger according to claim 1 wherein an internal pipe is inserted into the header as a space occupation member to reduce an internal space of the header in volume in which the refrigerant flow.

8. A heat exchanger according to claim 1 wherein a flat board is inserted into the header as a space occupation member to reduce an internal space of the header in volume in which the refrigerant flow.

9. A heat exchanger that is installed in an air conditioner used for a vehicle to cool or warm air inside of the vehicle, said heat exchanger comprising:

- a pair of a first header and a second header which are extended in a horizontal direction and are arranged apart in parallel with each other in a vertical direction;

- a plurality of tubes, each of which is vertically extended between and interconnected with the first and second headers to communicate with internal spaces of the first and second headers with end portions thereof respectively, said plurality of tubes being arranged along the horizontal direction with equal intervals of distance being provided therebetween; and

- a plurality of cooling fins, each of which is vertically extended between the first and second headers, said plurality of cooling fins being arranged alternately in connection with the plurality of tubes along the horizontal direction such that one cooling fin is sandwiched between two tubes in the horizontal direction,

wherein refrigerant is introduced into the first header so that the refrigerant circulates through the tubes as well as the first and second headers and is then exhausted by way of the second header,

wherein a third header which is extended in the horizontal direction and is arranged apart in parallel with the first header in a vertical direction;

- a plurality of secondary tubes, each of which is vertically extended between and interconnected with the first header and the third header to communicate with internal spaces of the first and third headers with end portions thereof respectively, said plurality of secondary tubes are arranged along the horizontal direction with equal intervals of distance being provided therebetween; and

- a plurality of secondary cooling fins, each of which is vertically extended between the first and third headers, said plurality of secondary cooling fins being arranged alternately in connection with the plurality of secondary tubes along the horizontal direction such that one secondary cooling fin is sandwiched between two secondary tubes,

wherein a plurality of partition plates which are arranged inside of the first and second headers at selected positions, so that the refrigerant circulate through the

tubes as well as the first and second headers in a reciprocating manner by being blocked by the partition plates.

10. A heat exchanger according to claim 9 wherein the plurality of partition plates are arranged inside of the first and second headers respectively such that an overall area in which the tubes and the cooling fins are alternately arranged between the first and second headers is divided into a number of parts, and wherein the refrigerant circulate through the tubes between the first and second headers in the reciprocating manner such that the refrigerant flow through the tubes belonging to each part in a prescribed direction.

11. A heat exchanger according to claim 9 wherein the plurality of partition plates are arranged such that the parts are gradually reduced in sectional area along a refrigerant flow direction corresponding to the horizontal direction by which the refrigerant flow sequentially among the sections from one part to another in the reciprocating manner.

12. A heat exchanger according to claim 9 wherein the plurality of partition plates are arranged such that the parts are gradually enlarged in sectional area along a refrigerant flow direction corresponding to the horizontal direction by which the refrigerant flow sequentially among the sections from one part to another in the reciprocating manner.

13. A heat exchanger according to claim 9 wherein a space occupation member is arranged inside of the header so as to

reduce an internal space of the header in volume in which the refrigerant flow.

14. A heat exchanger according to claim 9 wherein an internal pipe is inserted into the header as a space occupation member to reduce an internal space of the header in volume in which the refrigerant flow.

15. A heat exchanger according to claim 9 wherein a flat board is inserted into the header as a space occupation member to reduce an internal space of the header in volume in which the refrigerant flow.

16. A heat exchanger according to claim 9 wherein a space occupation member is arranged inside of the header so as to reduce an internal space of the header in volume in which the refrigerant flow.

17. A heat exchanger according to claim 9 wherein an internal pipe is inserted into the header as a space occupation member to reduce an internal space of the header in volume in which the refrigerant flow.

18. A heat exchanger according to claim 9 wherein a flat board is inserted into the header as a space occupation member to reduce an internal space of the header in volume in which the refrigerant flow.

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