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(54) Heat exchanger for refrigeration cycle

(57) Disclosed herein is a heat exchanger for a refrigeration cycle which is configured in such a manner that refrigerant discharged from a compressor circulates a condenser, a capillary tube, an evaporator, a suction pipe and the compressor in sequential order, and in which the outer surface of the capillary tube and the outer surface of the suction pipe are in thermal contact with each other. In the heat exchanger, the suction pipe and the capillary tube are made of aluminum which is inexpensive, instead of the copper-made suction pipe and the copper-made capillary tube of existing heat exchangers for the refrigeration cycle, and which is easy to apply the meandering. The capillary tube is made of aluminum alloy selected from JIS 3000 series alloy and the suction pipe is made of aluminum selected from JIS 1000 series aluminum. The outer surface of the capillary tube and the outer surface of the suction pipe are melted and bonded together, or particularly, are melted and bonded together by fiber laser beam radiation. Moreover, the invention is directed to a refrigerator being equipped with a heat exchanger of the kind as mentioned above.

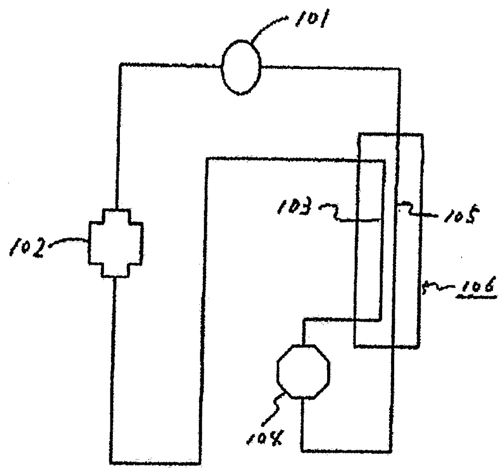

Fig. 1

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Description

BACKGROUND OF THE INVENTION:

Field of the Invention:

[0001] The present invention relates to a heat exchanger for a refrigeration cycle used in, for instance, refrigerators.

Background Art:

[0002] In general, a refrigerator has a refrigeration cycle that refrigerant discharged from a compressor passes through a condenser, capillary tube, an evaporator, and a suction pipe in order and returns to the compressor.

[0003] The refrigerant compressed in the compressor is converted into gas of high temperature and pressure and sent to the condenser, and radiates heat in the condenser so as to be liquefied. The liquefied refrigerant is sent to the evaporator after passing through the capillary tube. The liquefied refrigerant sent from the capillary tube to the evaporator is evaporated by the evaporator and takes heat around the refrigerant so as to generate cold air. The evaporated refrigerant passes through the suction pipe, and then, returns to the compressor so as to be compressed again.

[0004] In the above refrigeration cycle, the refrigerant passing through the capillary tube has relatively high temperature. In order to improve cooling efficiency, it is effective to reduce temperature of the refrigerant introduced into the evaporator from the capillary tube. For this, well-known is a method of abutting the suction pipe in which refrigerant of relatively lower temperature flows on the capillary tube. That is, heat exchange is carried out between the refrigerant of the suction pipe and the refrigerant of the capillary tube so as to reduce the temperature of the refrigerant flowing in the capillary tube. In order to connect the capillary tube and the suction pipe with each other in the heat exchanger for the refrigeration cycle, a method of soldering the capillary tube and the suction pipe in a state where they abut on each other in parallel has been frequently used.

[0005] The capillary tube is generally a thin tube which is about Φ 0.6 mm to Φ 0.8 mm in inner diameter and is about Φ 2.0 mm to Φ 3.0 mm in outer diameter, and the suction pipe is a round pipe which is about Φ 4.5 mm to Φ 6.5 mm in inner diameter and is about Φ 6.0 mm to Φ 8.0 mm in outer diameter. Moreover, the capillary tube and the suction pipe are respectively about 2,000 mm to 5,000 mm in length, but their lengths may be changed according to sizes of refrigerators.

[0006] In the case of heat exchangers for the refrigeration cycle equipped in refrigerators on the market all over the world including Japan, the suction pipe made of copper and the capillary tube made of copper are connected integrally with each other in a state where their outer surfaces are in thermal contact with each other. The copper-made suction pipe and the copper-made capillary tube have been practically applied up to now because they have high heat-exchanging efficiency and excellent corrosion resistance and are easy to be connected integrally by soldering.

[0007] Cost reduction of products is a permanent task in the manufacturing industry. If cost reduction of the heat exchangers for the refrigeration cycle is realized, cost reduction of refrigerators as products can be also realized. In order to realize the cost reduction of the refrigerators as the products, it is demanded that functions and quality of the heat exchanger suffer nothing by comparison with the existing heat exchanger within a permissible range. Moreover, it should avoid improving the heat exchanger so as to change the structure into a refrigeration cycle system or changing the entire structure of the refrigerator. For this, the improved heat exchanger must has the same structure as the existing heat exchanger, namely, the shapes of the suction pipe and the capillary tube, for instance, the inner diameter, the outer diameter, the length of the pipe or the tube) of the heat exchanger must be kept in the permissible range.

[0008] The inventors of the present invention have judged that if the suction pipe and the capillary tube are made of aluminum instead of copper, the heat exchanger for the refrigeration cycle suffers nothing by comparison with the existing heat exchanger with the refrigeration cycle and has the same structure as the existing heat exchanger for the refrigeration cycle in fact. That is, the inventors of the present invention have judged that it was possible to provide a cost-reducible heat exchanger for a refrigeration cycle, and so, proposed the invention according to WO 2012/050085 A1.

[0009] WO 2012/050085 A1 discloses a heat exchanger for a refrigeration cycle and a method of manufacturing the same. According to said document, the capillary tube and the suction pipe are respectively made of aluminum, and a brazing material selected from an Al-Si alloy or a Zn-Al alloy is melted at the connected portions between the outer surface of the capillary tube and the outer surface of the suction pipe so that a fillet is formed thereon.

[0010] Furthermore, in WO 2012/050085 A1, it is described that a small spot heat source is applied to the connected portions to heat the connected portions in a short time so as to minimize a thermal influence on the suction pipe and the capillary tube in a state where the outer surface of the aluminum-made suction pipe and the outer surface of the aluminum-made capillary tube are welded with pressure, so that a heat exchanger for a refrigeration cycle with excellent heat-exchanging efficiency can be manufactured because it is prevented that the thin capillary tube is transformed or melted and damaged due to overheating. In detail, using laser beams as the heat source, laser welding is applied to the outer surface of the suction pipe and the outer surface of the capillary tube are welded with pressure in the state where they are welded with pressure, so that the outer surfaces are bound together in a melted state.

SUMMARY OF THE INVENTION

[0011] The refrigeration cycle has a merit in that refrigerating capacity of the evaporator is increased so as to reduce power consumption if the portions where the outer surface of the capillary tube and the outer surface of the suction pipe are in thermal contact with each other, namely, a heat-exchanging distance, can be longer. Moreover, if meandering can be applied to the heat exchanger so that the heat exchanger can be made in a compact size, the heat-exchanging distance can be longer even in a limited space like refrigerators.

[0012] Accordingly, the present invention has been made to solve the above-mentioned problems occurring in the prior arts, and it is an object of the present invention to provide a heat exchanger for a refrigeration cycle, in which a suction pipe and a capillary tube are made of aluminum which is inexpensive, instead of the copper-made suction pipe and the copper-made capillary tube of the existing heat exchanger for the refrigeration cycle, and which is easy to apply the meandering.

[0013] The inventors of the present invention selected JIS 1000 series aluminum, which is the highest in thermal conductivity and has excellent machinability, corrosion resistance, weldability, and so on, as a material for the suction pipe, and selected an aluminum alloy, which does not deteriorate machinability and corrosion resistance of JIS 1000 series aluminum, increases intensity and has excellent thermal conductivity and weldability, as a material for the capillary tube smaller in diameter than the suction pipe in order to create the present invention.

[0014] To achieve the above objects, the present invention provides a heat exchanger for a refrigeration cycle which is configured in such a manner that refrigerant discharged from a compressor circulates a condenser, a capillary tube, an evaporator, a suction pipe and the compressor in sequential order, and in which the outer surface of the capillary tube and the outer surface of the suction pipe are in thermal contact with each other, wherein the capillary tube is made of aluminum alloy selected from JIS 3000 series alloy and the suction pipe is made of aluminum selected from JIS 1000 series aluminum, and the outer surface of the capillary tube and the outer surface of the suction pipe are melted and bonded together.

[0015] In another aspect of the present invention, the present invention provides a heat exchanger for a refrigeration cycle which is configured in such a manner that refrigerant discharged from a compressor circulates a condenser, a capillary tube, an evaporator, a suction pipe and the compressor in sequential order, and in which the outer surface of the capillary tube and the outer surface of the suction pipe are in thermal contact with each other, wherein the capillary tube is made of aluminum alloy selected from JIS 3000 series alloy and the suction pipe is made of aluminum selected from JIS 1000 series aluminum, and the outer surface of the capillary tube and the outer surface of the suction pipe are melted and bonded together by fiber laser beam radiation.

[0016] Furthermore, the present invention provides a refrigerator equipped with the heat exchanger for the refrigeration cycle.

[0017] The heat exchanger for the refrigeration cycle according to the present invention suffers nothing in functions and quality within the permissible range by comparison with the existing heat exchanger for the refrigeration cycle, substantially has the same structure as the existing heat exchanger, namely, the shapes (inner diameter, outer diameter, and length) of the suction pipe and the capillary tube constituting the heat exchanger are within the permissible range, includes the suction pipe and the capillary tube made of aluminum, which is inexpensive, and is easy to apply the meandering.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The above and other objects, features and advantages of the present invention will be apparent from the following detailed description of the preferred embodiments of the invention in conjunction with the accompanying drawings, in which:

FIG. 1 is a view showing the basic structure of a refrigeration cycle using a heat exchanger according to the present invention;

FIG. 2 is a perspective view of the heat exchanger according to the present invention;

FIG. 3 is a conceptual view of a fiber laser welding machine;

FIG. 4 is a view showing a state where outer surfaces of a suction pipe and a capillary tube are welded with pressure by a pressure roller;

FIG. 5 is a mimetic diagram for showing a manufacturing method of the heat exchanger according to the present invention;

FIG. 6 is a schematic diagram of a refrigerator in which the refrigeration cycle using a meandering heat exchanger is equipped; and

FIG. 7 is an enlarged schematic diagram of the meandering heat exchanger of FIG. 6.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] In the present invention, a capillary tube 103 which is made of aluminum alloy selected from JIS 3000 series alloy is simply named a capillary tube 103, and a suction pipe 105 which is made of aluminum selected from JIS 1000 series aluminum is simply named a suction pipe 105.

[0020] Reference will be now made in detail to the preferred embodiment of the present invention with reference to the attached drawings. FIG. 1 is a view showing the basic structure of a refrigeration cycle using a heat exchanger according to the present invention. A refrigeration cycle illustrated in FIG. 1 includes a compressor 101 for sucking and discharging refrigerant; a condenser 102 having an end connected to a refrigerant discharge side of the compressor 101; a capillary tube 103 having an end connected to the other end of the condenser 102; an evaporator 104 having an end connected to the other end of the capillary tube 103; and a suction pipe 105 having an end connected to the other end of the evaporator 104 and the other end connected to a refrigerant suction side of the compressor 101. In the refrigeration cycle, the outer surface of the suction pipe 105 made of aluminum selected from JIS 1000 series aluminum and the outer surface of the capillary tube 103 made of aluminum alloy selected from JIS 3000 series alloy are in thermal contact with each other, so that a heat exchanger 106 for the refrigeration cycle according to the present invention is formed. The outer surface of the suction pipe 105 made of aluminum selected from JIS 1000 series aluminum and the outer surface of the capillary tube 103 made of aluminum alloy selected from JIS 3000 series alloy are melted and bonded together.

[0021] The refrigeration cycle according to the present invention may further include an accumulator, which is disposed between the evaporator 104 and the suction pipe 105 for separating evaporated gas refrigerant from liquid refrigerant so as to face the gas refrigerant toward the compressor 101, and a drier, which is disposed between the condenser 102 and the capillary tube 103 for removing moisture.

[0022] The refrigerant compressed in the compressor 101 becomes gas of high temperature and pressure and is sent to the condenser 102, and then, radiates heat in the condenser 102 to be liquefied. The liquefied refrigerant is decompressed while passing through the capillary tube 103 and sent to the evaporator 104, and here, the liquefied refrigerant takes heat around the refrigerant while being evaporated, and hence, the surrounding air is cooled. The evaporated refrigerant of low temperature passes through the suction pipe 105 and returns to the compressor 101 so as to be compressed. It is preferable that the used refrigerant is hydrocarbon-based refrigerant, such as cyclopentane, isobutane, and so on, which is low in coefficient of global warming.

[0023] In the refrigeration cycle, because the capillary tube 103 and the suction pipe 105 are in thermal contact with each other, the liquid-phase refrigerant flowing in the capillary tube 103 is cooled by refrigerant of lower temperature flowing in the suction pipe 105 so as to improve cooling efficiency.

[0024] FIG. 2 is a perspective view of the heat exchanger according to the present invention. In the heat exchanger 106, the outer surface of the suction pipe 105 and the outer surface of the capillary tube 103 are connected with each other in a state where the outer surfaces are melted, and hence, the capillary tube 103 and the suction pipe 105 becomes in thermal contact with each other. In detail, the connected portions of the outer surfaces of the capillary tube 103 and the suction pipe 105 are melted and bonded with each other by laser beam radiation.

[0025] The capillary tube 103 of the heat exchanger 106 according to the present invention is made of aluminum alloy selected from JIS 3000 series alloy, and the suction pipe 105 is made of aluminum selected from JIS 1000 series aluminum. As the aluminum alloy selected from JIS 3000 series alloy used for the capillary tube, there are A3003, A3004, A3103, A3104, and so on. Moreover, as the JIS 1000 series aluminum used in the suction pipe, there are A1050, A1070, A1100, A1200, and so on.

[0026] The inner diameter, the outer diameter and the length of the capillary tube 103 and the inner diameter, the outer diameter and the length of the suction pipe 105 are not specially restricted, and it is good that the inner diameters, the outer diameters and the lengths of the capillary tube 103 and the suction pipe 105 are to the same extent as those used in refrigerators for home use, business use or others. The capillary tube 103 is about Φ 0.6 mm to Φ 0.8 mm in inner diameter and is about Φ 2.0 mm to Φ 3.0 mm in outer diameter. Additionally, the suction pipe 105 is a round pipe which is about Φ 4.5 mm to Φ 6.5 mm in inner diameter and is about Φ 6.0 mm to Φ 8.0 mm in outer diameter. The capillary tube 103 and the suction pipe 105 are respectively about 2,000 mm to 5,000 mm in length, but their lengths may be changed according to sizes of refrigerators to which the heat exchanger according to the present invention is applied.

[0027] FIG. 3 is a conceptual view of a fiber laser welding machine used when the heat exchanger 106 is manufactured. Here, in the present invention, a fiber laser welding machines is used as the laser welding machine. The reference numeral 301 designates a fiber laser main body, 302 designates optical fiber (fiber diameter is Φ), and 303 designates a laser beam radiation unit. Laser beams (LB), which are indicated by broken lines in the drawing, induced to the laser beam radiation unit 303 are configured to become parallel beams by a lens L1 (focal distance is f1), and to be collected by another lens L2 (focal distance is f2), so that the laser beams (LB) of a predetermined spot diameter are radiated to a work piece 405 (See FIG. 4) moving in one direction relative to the laser beams (LB).

[0028] In the meantime, while the work piece 405 is pressed by pressure rollers 401 and 402, the outer surfaces of the suction pipe 105 and the capillary tube 103 are welded with pressure (See FIG. 4), but in the drawings, it is illustrated with simplicity. In the drawing, the work piece 405 is moved in an arrow (→) direction (from the left to the right in the drawing). The reference numeral 308 designates a nitrogen bombe, and 307 designates a nitrogen gas injection nozzle. In laser welding, inert gas, such as argon gas, may be used in order to prevent oxidation of the work piece 405.

[0029] FIG. 4 is a view showing a state where the pressure rollers 401 and 402 which are pressing jigs press the work piece 405 (which means a state where the suction pipe 105 and the capillary tube 103 are attached to each other in parallel) so that the outer surfaces of the suction pipe and the capillary tube are welded with pressure by the pressure rollers, wherein FIG. 4(a) is a side elevation view and FIG. 4(b) is a plan view.

[0030] The pressure roller 401 presses the side of the suction pipe 105 toward the capillary tube 103. The pressure roller 401 is a roller which has an arc-shaped recess formed in correspondence with the outer diameter of the suction pipe 105. The pressure roller 402 presses the side of the capillary tube 103 toward the suction pipe 105. The pressure roller 402 is a roller which has an arc-shaped recess formed in correspondence with the outer diameter of the capillary tube 103. The reference numeral 403 designates a shaft of the pressure roller 401, and 404 designates a shaft of the pressure roller 402. At least one side of the shaft 403 and the shaft 404 is fixed in such a way as to be adjustable in position in a vertical direction (a direction of a line passing central points of the suction pipe 105 and the capillary tube 103) to an axial direction of a housing (not shown).

[0031] In FIG. 4, two pairs of the pressure rollers 401 and 402 disposed at a proper spaced interval from each other press the work piece 405 so as to weld the outer surfaces of the suction pipe 105 and the capillary tube 103 with pressure, but the present invention is not restricted to the above. For instance, a pair of the pressure rollers 401 and 402 may press the work piece 405 so as to weld the outer surfaces of the suction pipe 105 and the capillary tube 103 with pressure. The pressure rollers 401 and 402 may be made of copper, brass or aluminum which provides excellent thermal conductivity, or may be made of polymer, such as urethane.

[0032] In order to manufacture the heat exchanger according to the present invention, first, the suction pipe 105 made of aluminum selected from JIS 1000 series aluminum and the capillary tube 103 made of aluminum alloy selected from JIS 3000 series alloy are attached to each other in parallel, and then, are pressed by the pressure jigs, so that the outer surfaces of the suction pipe 105 and the capillary tube 103 are welded with pressure. Next, while the suction pipe 105 and the capillary tube 103 are moved relative to laser beams in the state where the outer surfaces of the suction pipe 105 and the capillary tube 103 are welded with pressure, laser beams are radiated to the connected portions of the outer surfaces of the suction pipe 105 and the capillary tube 103, so that the outer surfaces of the suction pipe 105 and the capillary tube 103 are melted and bonded with each other.

[0033] Here, "the state where the suction pipe 105 made of aluminum selected from JIS 1000 series aluminum and the capillary tube 103 made of aluminum alloy selected from JIS 3000 series alloy are attached to each other in parallel" means that the suction pipe 105 and the capillary tube 103 are arranged side by side in such a manner that the outer surfaces of them abut on each other as shown in FIGS. 4 and 5.

[0034] FIG. 5 is a mimetic diagram for showing a manufacturing method of the heat exchanger according to the present invention, wherein FIG. 5(a) is a side elevation view and FIG. 5(b) is a plan view. In FIG. 5, a pair of pressure rollers 401 and 402 press the work piece 405 so that the outer surfaces of the suction pipe 105 and the capillary tube 103 are welded together with pressure, and then, laser welding is carried out while nitrogen gas is injected. The work piece 405 is moved in an arrow (←) direction relative to the laser beams (LB) (from the right to the left in the drawing). The movement speed of the work piece 405 becomes faster when output of the fiber laser becomes larger, but the standard of the movement speed of the work piece 405 is about 3 m/min to 5 m/min when the peak output of the fiber laser is about 1000 W.

[0035] It is preferable that the laser beams (LB) to the work piece 405 are radiated in an inclined direction to the work piece 405 in order to avoid light returning from the work piece 405. The laser beam radiation unit 303 is inclined toward the upstream side of the movement direction of the work piece (in this instance, the laser beams (LB) are radiated toward the front side of the heading direction of the work piece 405), or inclined toward the downstream side of the movement direction of the work piece (in this instance, the laser beams (LB) are radiated toward the rear side of the heading direction of the work piece 405).

[0036] It is preferable that a radiation location of the laser beams (LB) to the work piece 405 is within a range from the position where a pair of the pressure rollers 401 and 402 press the work piece 405 to a position directly next to the downstream side of the work piece movement direction, and more preferably, the radiation location of the laser beams (LB) to the work piece 405 is the position where a pair of the pressure rollers 401 and 402 press the work piece 405. Moreover, in the case that two pairs of the pressure rollers 401 and 402 press the work piece 405 so that the outer surfaces of the suction pipe 105 and the capillary tube 103 are welded together with pressure, it is preferable that the radiation location of the laser beams (LB) is within a range from the position where the pressure rollers 401 and 402 located at the downstream side of the work piece movement direction press the work piece 405 to the position directly next to the downstream side of the work piece movement direction. More preferably, the radiation location of the laser beams (LB) is the position where the pressure rollers 401 and 402 located at the downstream side of the work piece movement direction press the work piece 405.

[0037] In the meantime, in FIG. 5(b), it is illustrated that the radiation location of the laser beams (LB) is more downward than the position directly next to the downstream side of the work piece movement direction, which is the position where a pair of the pressure rollers 401 and 402 press the work piece 405. The reason is to draw the laser beam radiation unit 303 and the nitrogen gas injection nozzle 307 on the same plane for convenience sake.

[0038] It is preferable that an injection location of the nitrogen gas injected from the nitrogen gas injection nozzle 307 toward the work piece 405 is nearly the same as the radiation location of the laser beams (LB). Furthermore, it is preferable that the injection direction of nitrogen gas is the same as the movement direction of the work piece 405. When nitrogen gas is injected in the above direction, the connected portions directly after welding are covered with a nitrogen gas atmosphere so as to securely block it from oxygen. A flow rate of nitrogen gas is about 10 L/min (10 liter per minute). Meanwhile, in FIG. 5(b), the signal of "xxxxx" at the contact portions of the suction pipe 105 and the capillary tube 103 indicates the state where the outer surfaces of the suction pipe 105 and the capillary tube 103 are melted and bonded by laser beam welding.

[0039] FIG. 6 is a schematic diagram of a refrigerator in which the refrigeration cycle using a meandering heat exchanger is equipped. The reference numeral 601 designates a refrigerator main body, 602 designates a first ceiling face part of the refrigerator main body, and 603 designates a second ceiling face part. The compressor 101 is arranged at a part of the second ceiling face part 603, and the condenser is arranged at a part of the first ceiling face part 602. The refrigerant compressed in the compressor 101 becomes gas of high temperature and pressure, and is sent to the condenser 102 arranged above the compressor 101 after passing through a connection pipe 604 in a refrigerant discharge part (not shown). The refrigerant of high temperature and pressure heat-exchanges with the upper air of the refrigerator main body 601 in the condenser 102 and radiates heat so as to be liquefied. The condensed and liquefied refrigerant is sent to the capillary tube 103, is decompressed while heat-exchanging at the portion (for convenience, the reference numeral 106 is designated thereto in the drawing) where the outer surfaces of the capillary tube 103 and the suction pipe 105 are melted and bonded together, and then reaches the evaporator 104 arranged below the compressor 101. The air cooled by the evaporation action of the refrigerant inside the evaporator 104 is introduced into a cold compartment or a freezing compartment by a cooling fan (not shown) so as to cool the compartment. The refrigerant evaporated by taking evaporative latent heat inside the evaporator 104 passes the suction pipe through the accumulator (not shown) disposed at a refrigerant outlet part (y) of the evaporator 104, and then, is sucked into the evaporator 101.

[0040] FIG. 7 is an enlarged schematic diagram of the meandering heat exchanger arranged in the refrigerator main body 601 as shown in FIG. 6. In the drawing, "a" designates a refrigerant inlet part of the capillary tube, and "b" designates a refrigerant outlet part. In the drawing, "c" designates a refrigerant inlet part of the suction pipe, and "d" designates a refrigerant outlet part. The refrigerant inlet part (a) of the capillary tube 103 is connected to a refrigerant outlet part of a drier (not shown) connected to the condenser 102. The refrigerant outlet part (b) of the capillary tube 103 is connected to a refrigerant inlet part (designated by "x" in FIG. 6) of the evaporator 104. The refrigerant inlet part (c) of the suction pipe 105 is connected to a refrigerant outlet part of the accumulator (not shown). The refrigerant outlet part (d) of the suction pipe 105 is connected to a refrigerant sucking part (not shown) of the compressor 101.

[0041] In the heat exchanger 106 according to the present invention, excepting both end portions of the capillary tube 103 and the suction pipe 105, the outer surfaces of the capillary tube 103 and the suction pipe 105 are melted and bonded together. It is preferable that the length of the connected portions of the outer surface of the suction pipe 105 which heat-exchanges with the outer surface of the capillary tube 103 is nearly more than 80% of the length of the capillary tube 103 in order to effectively carry out heat-exchange and to improve efficiency of the refrigeration cycle.

[0042] In the present invention, because the suction pipe 105 is made of aluminum selected from JIS 1000 series aluminum and the capillary tube 103 is made of aluminum alloy selected from JIS 3000 series alloy, the meandering heat exchanger as shown in FIG. 7 can be easily obtained. The meandering of the heat exchanger into a predetermined shape can be easily carried out by the typical method using a bender.

[0043] In the case that the heat exchanger 106 according to the present invention is the meandering heat exchanger as illustrated in FIG. 7, the heat exchanger which is several times longer than the height of the refrigerator main body 601 can be adopted to the refrigerator, and hence, the liquid-phase refrigerant flowing in the capillary tube 103 can be sufficiently cooled by the refrigerant of low temperature flowing in the suction pipe 105.

[0044] Because heat exchange can be effectively carried out when the thermal contact portions of the capillary tube and the suction pipe are longer, it is preferable that the heat exchanger applied to the refrigerator is longer. Moreover, because the air near to the condenser gets warm, by heat exchanger with the condenser, it is preferable that the evaporator is spaced apart from the condenser. For this, as shown in FIG. 6, preferably, the compressor 101 is arranged at a part of the ceiling face of the refrigerator main body 601 and the condenser 102 is arranged above the compressor 101, and at the same time, the evaporator 104 is arranged below the compressor 101, in detail, at a lower portion of the refrigerator main body 601.

[0045] In the present invention, the suction pipe and the capillary tube are respectively made of aluminum materials, which are still more inexpensive than copper, and the heat exchanger for the refrigeration cycle which is easy to apply the meandering process can be provided. Therefore, the heat exchanger 106 according to the present invention which is meandering and has a compact size is several times longer than the height of the refrigerator main body, preferably, two or three times longer. So, as shown in FIG. 6, the heat exchanger is applied to the refrigerator having the structure that the compressor 101 is arranged at a part of the ceiling face of the refrigerator main body 601, the condenser 102 is arranged above the compressor 101, and the evaporator 104 is arranged below the compressor 101 (in detail, at a lower portion of the refrigerator main body 601).

[0046] Using the suction pipe of A1070 and the capillary tube of A3103, the heat exchanger according to the present invention was manufactured using the fiber laser welding machine.

Suction pipe:	Φ 6.4 mm in outer diameter, 0.7 mm in thickness, Φ 5 mm in inner diameter, 3540 mm in length;
Capillary tube:	Φ 2 mm in outer diameter, 0.65 mm in thickness, Φ 0.7 mm in inner diameter, 3660 mm in length;

Fiber laser welding machine:

1070 nm to 1100 nm in oscillation wavelength,
Φ 0.1 mm in fiber diameter of an optical fiber 302,
100 mm in focal distance (f1) of lens (L1),
200 mm in focal distance(f2) of lens(L2),
Φ 0.2 mm in laser beam spot diameter,
800 W in peak output.

[0047] In the state where the laser beam spot diameter is Φ 0.2 mm, the focal location was the surface of the work piece 405, and the spot center of the laser beams (LB) was adjusted in such a way as to be biased toward the suction pipe by 0.5 mm on the basis of the line that the suction pip 105 and the capillary tube 103 were in contact with each other. The radiation location of the laser beams (LB) in the work piece movement direction relative to the work piece 405 was adjusted to the position where the pressure rollers 401 and 402 press the work piece 405. The pressure rollers 401 and 402 were made of copper. The movement speed of the work piece 405 was 50 mm/s (mm per second). Furthermore, nitrogen gas whose flow rate was 10 L/min (10 liter per minute) was used as shielding gas, and was injected in the same direction as the movement direction of the work piece 405.

[0048] A meandering heat exchanger as illustrated in FIG. 7 was manufactured by applying the typical method to the heat exchanger using the bender.

Industrial Applicability:

[0049] The heat exchanger according to the present invention is applicable to refrigerators, and so on.

Claims

1. A heat exchanger (106) for a refrigeration cycle which is configured in such a manner that refrigerant discharged from a compressor (101) circulates a condenser (102), a capillary tube (103), an evaporator (104), a suction pipe

(105) and the compressor (101) in sequential order, and in which the outer surface of the capillary tube (103) and the outer surface of the suction pipe (105) are in thermal contact with each other,
wherein the capillary tube (103) is made of aluminum alloy selected from JIS 3000 series alloy and the suction pipe (105) is made of aluminum selected from JIS 1000 series aluminum, and the outer surface of the capillary tube (103) and the outer surface of the suction pipe (105) are melted and bonded together.

2. The heat exchanger according to claim 1, wherein the outer surface of the capillary tube (103) and the outer surface of the suction pipe (105) are melted and bonded together by fiber laser beam radiation.

3. A refrigerator (601) equipped with the heat exchanger (106) for the refrigeration cycle of claim 1 or 2.

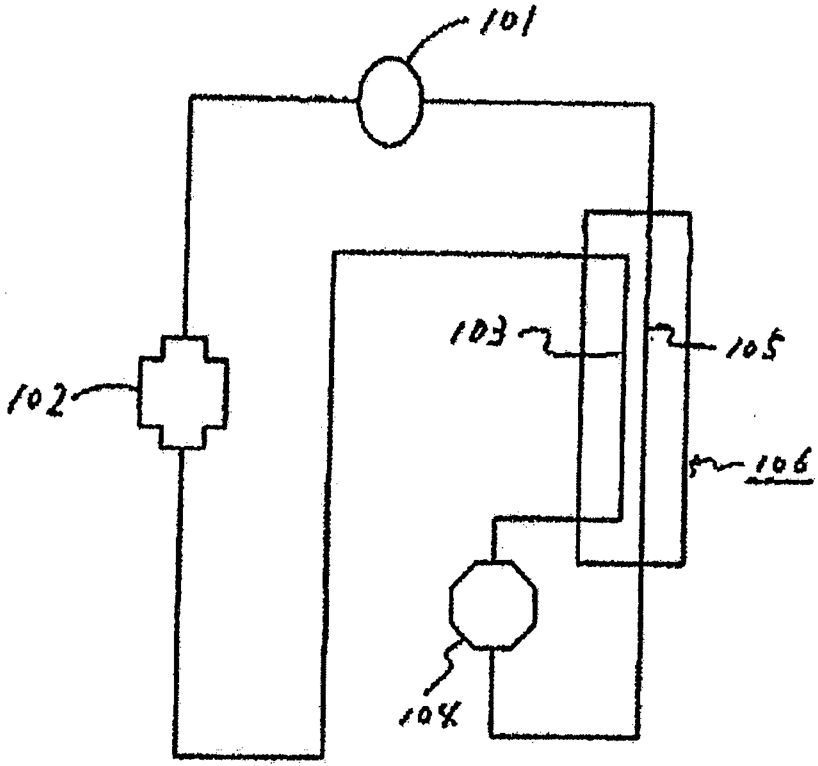

Fig. 1

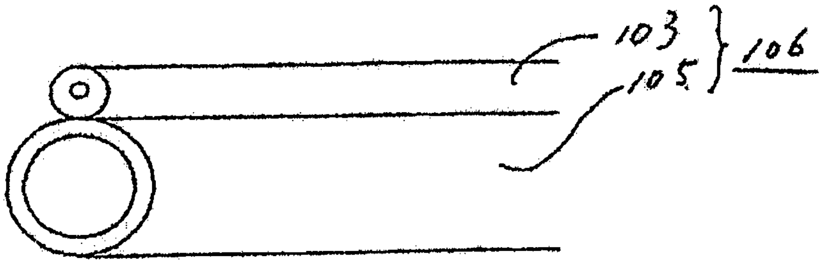

Fig. 2

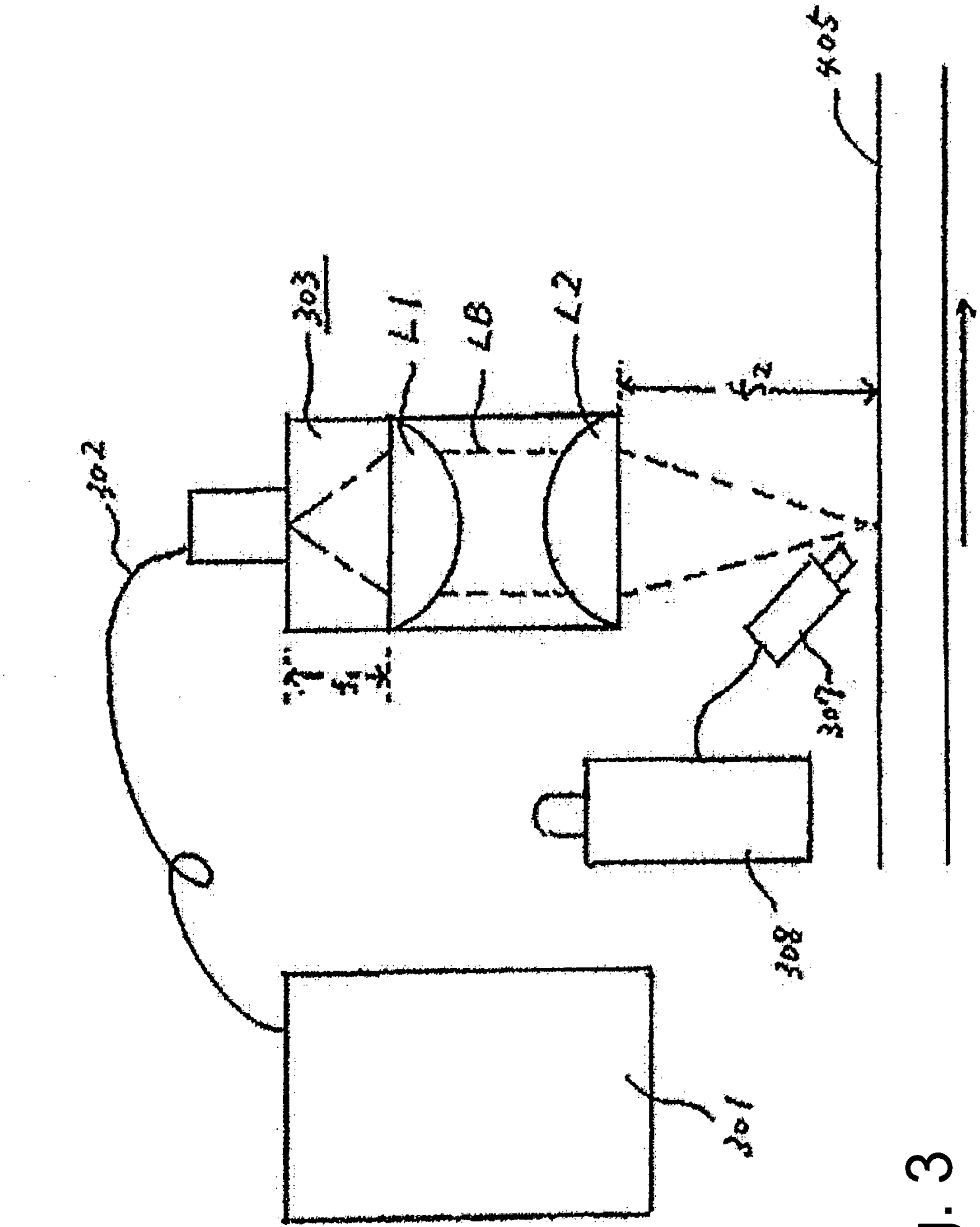

Fig. 3

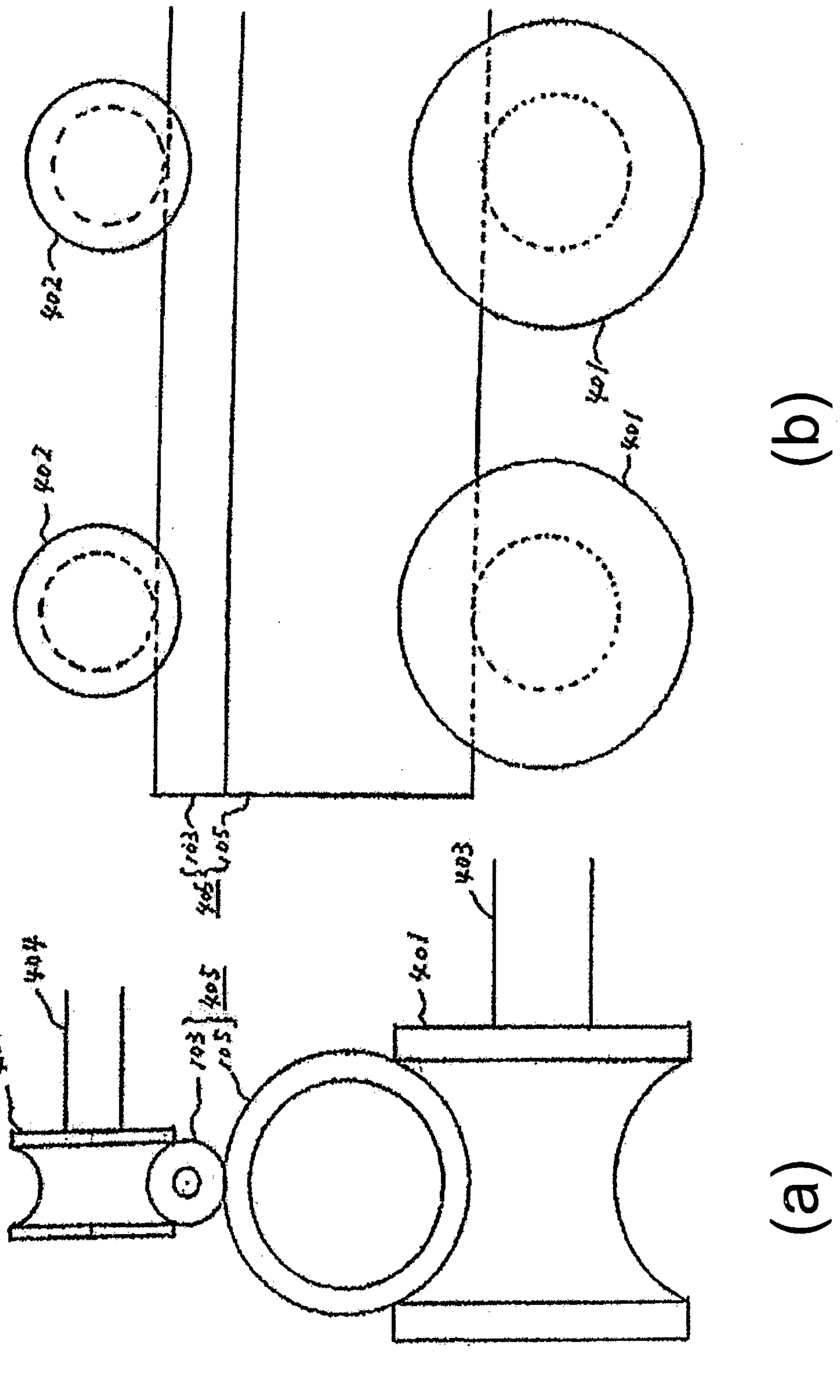

Fig. 4

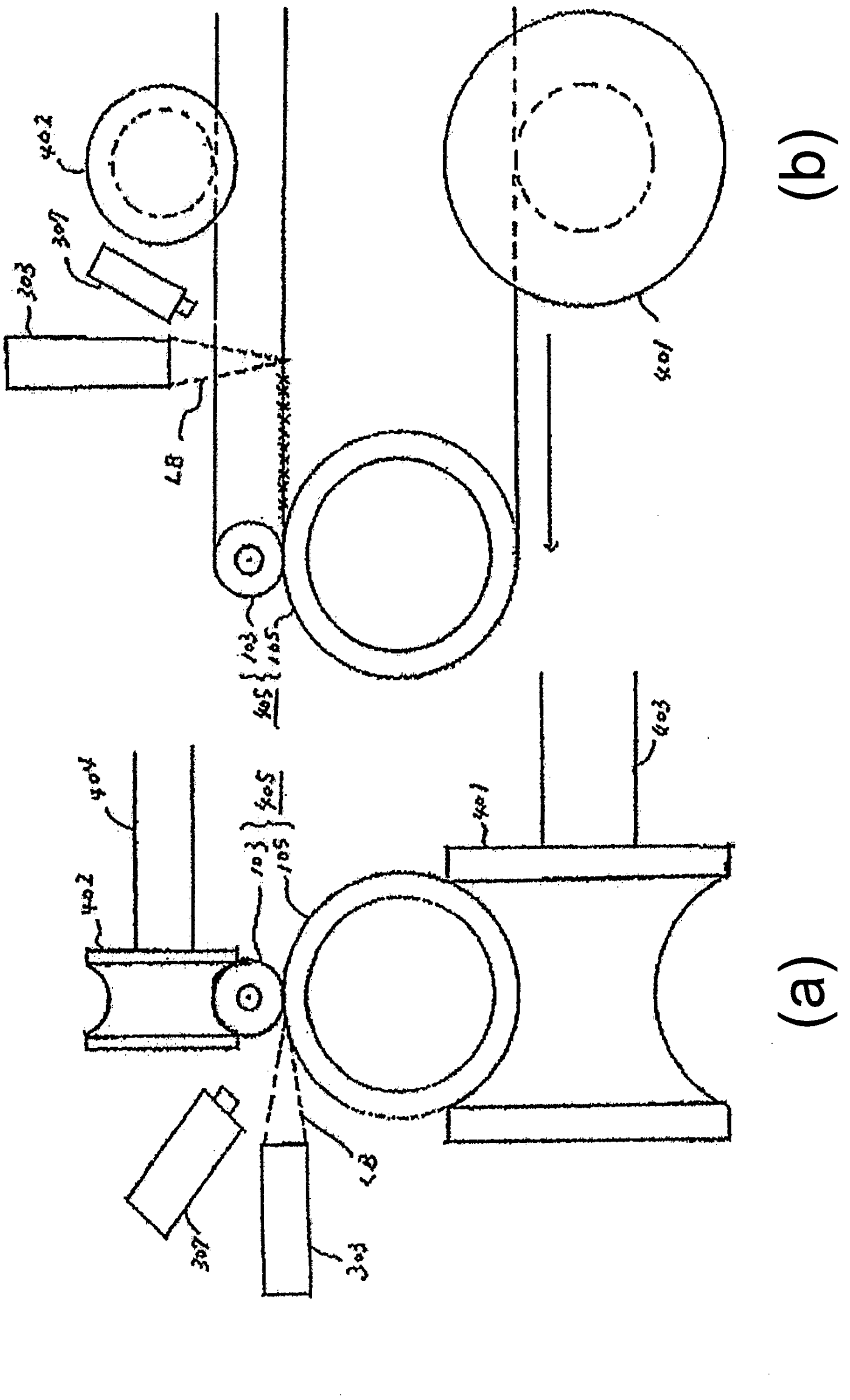

Fig. 5

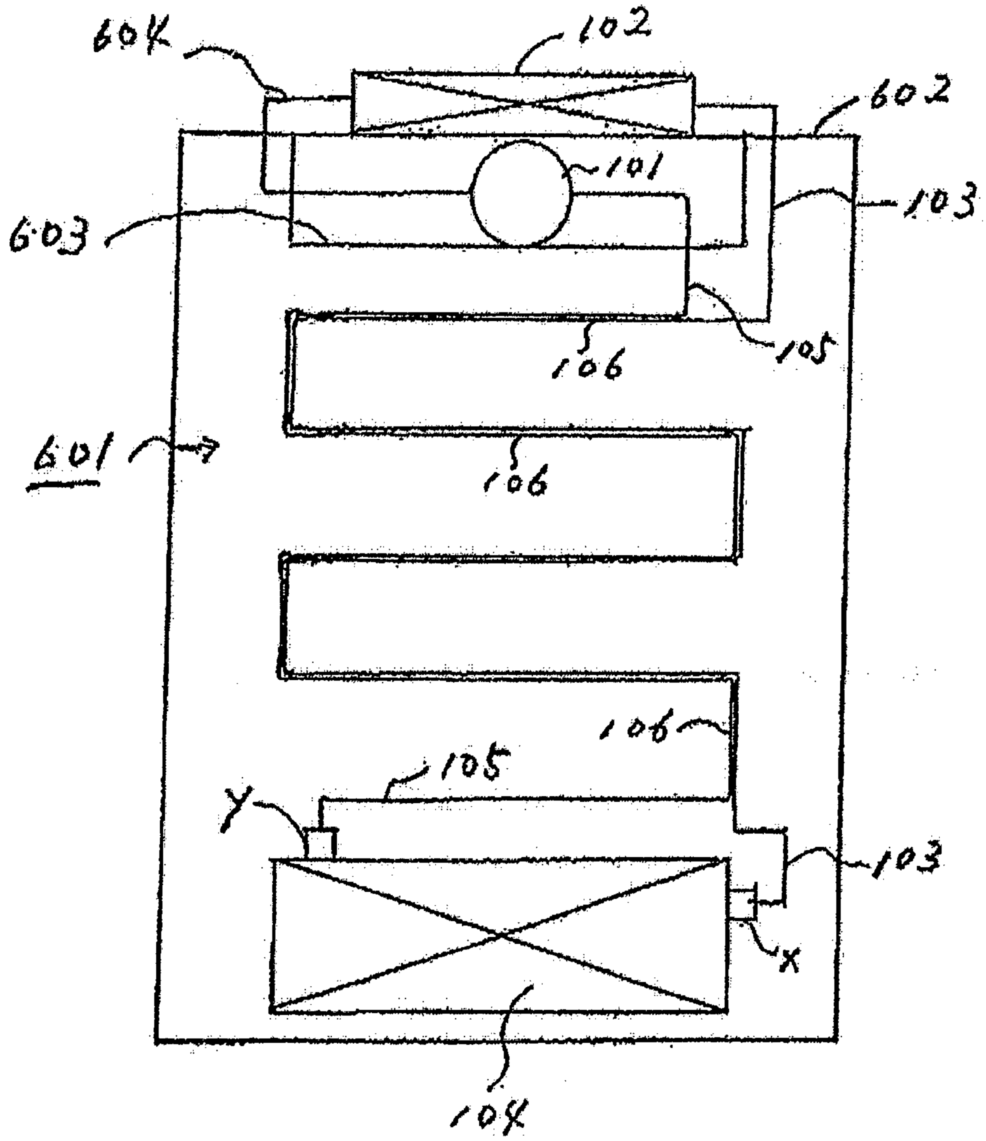

Fig. 6

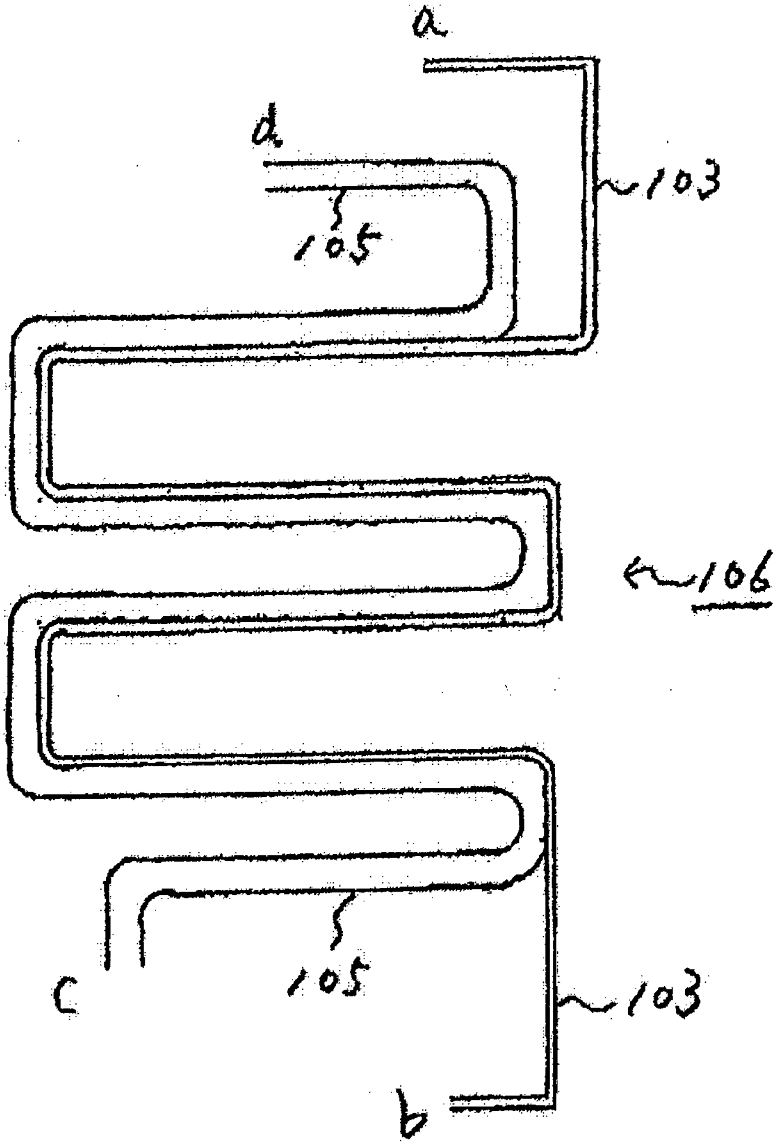

Fig. 7

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EUROPEAN SEARCH REPORT

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EP 13 00 2109

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	24 July 2013	Gasper, Ralf

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