

DESCRIPTION

Title of the Invention:

HEAT EXCHANGE DEVICE, EVAPORATOR, AND REFRIGERATION STORAGE UNIT

Technical Field

- [0001] The present invention relates to heat exchange devices inside which refrigerant is passed, evaporators to which such heat exchange devices are connected, and refrigeration storage units, such as refrigerators and freezers, employing such heat exchange devices and evaporators.

Background Art

- [0002] Many refrigeration storage units such as refrigerators (and freezers) are provided with a compression refrigeration device as a cooling device. Some compression refrigeration devices are provided with a capillary pipe as a restrictor (orifice) for lowering the pressure of refrigerant that has been compressed by a compressor and liquefied by a condenser. The refrigerant is depressurized by the capillary pipe and flows into an evaporator, where the refrigerant vaporizes. The vaporized, low-temperature refrigerant exchanges heat with and thereby refrigerates the air around the evaporator. The refrigerant then exits from the evaporator and flows through a suction pipe into the compressor.
- [0003] In the compression refrigeration device, the capillary pipe is connected to an inlet pipe of the evaporator, and is joined to a suction pipe-side pipe for heat exchange. Hot refrigerant flows through the capillary pipe, and cold refrigerant flows through the suction pipe; heat exchange between the refrigerant flowing through the two pipes enables enhancement in the efficiency of the refrigeration cycle of the compression refrigeration device. Moreover, raising the temperature of the refrigerant flowing through the suction pipe has an effect of suppressing frost deposition on the suction pipe.
- [0004] In the compression refrigeration device described above, for improved refrigeration cycle efficiency, there are provided two capillary pipes having different

resistance (having different inner diameters and/or lengths) and a switch valve. Selection between the capillary pipes allows adjustment of refrigeration performance in some compression refrigeration devices in practical use. In a compression refrigeration device so structured, two capillary pipes lie in contact with one suction pipe (see, for example, Japanese Patent Application Publication No. 2002-372319).

[0005] In the compression refrigeration device described above, at the place where the two capillary pipes meet, a confluence member is used in which the two capillary pipes are inserted to be led to a single pipe (see, for example, Japan Patent Publication No. 3076522, Japan Utility Model Publication No. 3118033, and Japanese Patent Application Publication No. 2009-168196). In cases where, as described above, two capillary pipes are provided, the two capillary pipes need to be united by use of a confluence member as disclosed in Japan Patent Publication No. 3076522, Japan Utility Model Publication No. 3118033, Japanese Patent Application Publication No. 2009-168196, etc., and this results in an increased number of components.

[0006] The evaporator mentioned above is so configured that, after it is installed inside a refrigeration storage unit, piping is connected to it. This makes it impossible to use, as a heat source for brazing, a torch, which poses a high risk of causing ignition. Instead, an induction-based heating device is used, which permits local heating. When the confluence member mentioned above is heated, parts to be brazed need to be heated one by one, and this increases the trouble and time involved.

[0007] Moreover, in cases where a confluence member as mentioned above is used, brazing needs to be performed at least at three places (the joints with the confluence member of each of the two capillary pipes and the pipe to which they are led after meeting), and this accordingly increases the trouble and time required in the manufacture. Furthermore, the fitting of the confluence member requires space inside the refrigeration storage unit, and depending on the place where the confluence member is arranged, it may be difficult to check for leakage of refrigerant etc. around the confluence member.

[0008] As a solution, there has been proposed a structure where two capillary pipes are inserted directly into a single pipe as an inlet pipe. This structure helps reduce the number of components. Fig. 11 is a perspective view of two capillary pipes inserted directly in an inlet pipe. As shown in Fig. 11, the tip end of the inlet pipe 95 is so

shaped as to have two cylindrical portions 951 lying side by side and a bridge portion 952 connecting the cylindrical portions 951 together, and in each of the cylindrical portions 951, one of the capillary pipes 941 and 942 is inserted. Then, between the cylindrical portions 951 and the capillary pipes 941 and 942, molten filler metal is poured to fasten them together.

List of Citations

Patent Literature

[0009] Patent Document 1: Japan Patent Publication No. 3076522

Patent Document 2: Japan Utility Model Publication No. 3118033

Patent Document 3: Japanese Patent Application Publication No. 2009-168196

Patent Document 4: Japanese Patent Application Publication No. 2002-372319

Summary of the Invention

Problem to be Solved by the Invention

[0010] The capillary pipes and the suction pipe mentioned above require a certain contact length for an enhanced effect of heat exchange between the refrigerant flowing through them. To give the refrigeration storage unit a large interior volume, no large space can be allotted to the compression refrigeration device. Instead, the capillary pipes and the suction pipe are bent to meander. Such bending of the capillary pipes and the suction pipe is performed after the capillary pipes and the suction pipe are fastened together in contact with each other.

[0011] In a case where, as in the invention disclosed in Japanese Patent Application Publication No. 2002-372319, two capillary pipes lie in contact with a suction pipe, depending on the direction in which the capillary pipes and the suction pipe are bent, the capillary pipes tend to cave into the suction pipe or flatten, and this makes their bending difficult. This can be avoided by first bending the capillary pipes and the suction pipe separately and then brazing them together. This, however, requires bending to be performed an increased number of times, and requires the bent parts of the capillary pipes and the suction pipe to be given an accurate curvature, increasing the trouble and time involved.

[0012] In a case where, as shown in Fig. 11, an inlet pipe 95 has a cross-sectional

shape in which cylinders each surrounding one of two capillary pipes lie side by side and are connected together, the bridge portion 952 has recessed surfaces, and this makes it difficult to heat the entire part uniformly at a time. For accurate brazing, therefore, the cylindrical portions 951 need to be heated separately, and in addition the gap in the bridge portion 952 also needs brazing, resulting in an increased number of manufacturing steps.

[0013] Moreover, since the adjacent capillary pipes 941 and 942 are arranged apart from each other, they are acted upon by a force separately. This makes the capillary pipes 941 and 942 prone to deformation and breakage.

[0014] To prevent their fine openings from being filled with filler metal, the tip ends of the capillary pipes 941 and 942 need to reach into the inlet pipe 95 beyond the cylindrical portions 951. When refrigerant restricted by the capillary pipes 941 and 942 flows into an evaporator, it vaporizes due to a sharp difference in pressure, and produces impact. If the two capillary pipes 941 and 942 are arranged close to and without contact with each other inside the inlet pipe 95, the impact produced when the refrigerant is jetted out tends to make their respective tip end portions vibrate, causing them to repeatedly move in and out of contact with each other, that is to say, chatter.

[0015] An object of the present invention is therefore to provide a heat exchange device that is so structured that two capillary pipes lie in contact with one suction pipe and that performs heat exchange reliably, suppresses noise such as chattering noise, and suppresses an increase in the number of components and manufacturing steps, an evaporator, and a refrigeration storage unit employing those.

Solution to the Problem

[0016] To achieve the above object, according to one aspect of the present invention, a heat exchange device is provided with: a low-temperature pipe through which low-temperature refrigerant is passed and which is bent at least at one place; and two high-temperature pipes through which high-temperature refrigerant is passed and of which at least middle parts are fastened to the low-temperature pipe in contact therewith. The two high-temperature pipes are arranged side by side in a direction crossing the direction in which the low-temperature pipe is bent and in symmetry about the low-temperature pipe.

- [0017] With this structure, when the low-temperature pipe is bent with the two high-temperature pipes fastened to the low-temperature pipe in contact with it, the curvatures in the bent parts of the two high-temperature pipes and the low-temperature pipe can be adjusted appropriately. This makes the high-temperature pipes less likely to come off, flatten, or cave into the low-temperature pipe.
- [0018] In the structure described above, preferably, at least the parts of the two high-temperature pipes fastened to the low-temperature pipe in contact therewith are arranged in the direction perpendicular to the direction in which the low-temperature pipe is bent. In this case, the curvatures of the two high-temperature pipes and the one low-temperature pipe can be made equal. This most effectively makes the high-temperature pipes less likely to come off, flatten, or cave into the low-temperature pipe.
- [0019] In the structure described above, preferably, the two high-temperature pipes are pipes that differ from each other in at least one of inner diameter and length.
- [0020] In the structure described above, preferably, the low-temperature pipe is a suction pipe arranged between an evaporator and a compressor, the two high-temperature pipes are capillary pipes arranged between a condenser and the evaporator, the two capillary pipes are pipes formed parallel to each other in a refrigerant circuit, both end parts of the two capillary pipes are separated from the suction pipe, and at least end parts of the two capillary pipes closer to the evaporator are annealed.
- [0021] With this structure, annealing makes the two capillary pipes easy to deform, and increases flexibility in their handling, leading to enhanced workability.
- [0022] In the structure described above, preferably, the end parts of the two capillary pipes closer to the evaporator are bundled together with a fastening member. The fastening member may be a filler metal ring, tape, a ribbon, or the like. Bundling together the end parts of the capillary pipes closer to the evaporator in this way makes their tip ends less likely to break, and makes it easy to fit the capillary pipes to the evaporator. The filler metal ring may be a circular one surrounding the two capillary pipes, or a C-shaped one that is partly open.
- [0023] To achieve the above object, according to another aspect of the present invention, an evaporator to which a heat exchange device having any of the structures described above is connected is provided with an inlet pipe having in an end part

thereof an opening in which the two capillary pipes are together inserted. The inlet pipe has a capillary pipe holding portion in a tip end part of which the two capillary pipes are inserted to be fastened thereto by brazing. The capillary pipe holding portion has an oval-cylindrical inner circumferential portion that can hold the two capillary pipes in contact with each other in a state where the axes thereof lie side by side, and an outer circumferential portion of which the projected face in the axial direction has an oval shape extending in the same direction as the inner circumferential portion. The projected face has a smaller projected area than the remaining part of the inlet pipe.

[0024] With this structure, brazing can be achieved by pouring filler metal while the two capillary pipes and the inlet pipe are heated together, and this helps shorten the time needed for brazing. Moreover, owing to the structure where the suction pipe and the capillary pipes are arranged close together, connection between the suction pipe and the outlet pipe and connection between the capillary pipes and the inlet pipe can be performed in succession. This helps reduce the manufacturing time accordingly.

[0025] With this structure, the two capillary pipes are, in a state in contact with each other, held in the inlet pipe. The two capillary pipes are in line contact with each other at their respective side surfaces. During the brazing of the inlet pipe, the filler metal permeates finely between the line-contact parts by capillarity. The two capillary pipes are thereby united into a single piece, and thus even when impact or the like due to a sudden drop in the pressure of refrigerant causes vibration to be transmitted to one of the capillary pipes, it does not repeatedly move into and out of contact with the other. It is thus possible to suppress chattering noise resulting from their moving into and outlet contact with each other.

[0026] Moreover, the axial-direction projected area of the capillary pipe holding portion holding the two capillary pipes is smaller than the axial-direction projected area of the remaining part. As a result, the capillary pipe holding portion has no part where its thickness from the outer circumferential portion to the inner circumferential portion change greatly. Thus, even when a high-frequency induction heating device is used, the capillary pipes can be heated in a short time. This makes it possible to pour molten filler metal into the gap between the capillary pipes and the capillary pipe holding portion in a short time reliably. Furthermore, by fastening the capillary pipes and the capillary pipe holding portion together reliably, it is possible to increase the

strength of the joined part and the accuracy of brazing, and thus to suppress disjoining due to vibration or impact and chattering noise resulting from the two capillary pipes repeatedly moving into and out of contact with each other.

[0027] In the structure described above, preferably, the capillary pipe holding portion has such a length that tip end parts of the two capillary pipes can penetrate the capillary pipe holding portion.

[0028] With this structure, the tip ends of the capillary pipes penetrate the capillary pipe holding portion, and thus there is a large clearance between the tip ends Fig. the capillary pipes and the inlet pipe. Thus, even when a somewhat larger amount of filler metal is poured in, it is possible to make the capillary pipes less likely to be filled with filler metal.

[0029] In the structure described above, preferably, the two capillary pipes are pipes that differ from each other in at least one of inner diameter and length.

[0030] In the structure described above, preferably, the inlet pipe is formed of a metal different from the metal of which an heat exchange portion of the evaporator is formed, and the joint faces of the inlet pipe and of a pipe of the heat exchange portion are brought together and joined together such that the inner surfaces thereof are flush.

[0031] With this structure, during operation where refrigerant is passed through the two capillary pipes simultaneously, the refrigerant flows from those capillary pipes into the capillary pipe holding portion at different speeds. In this case, the capillary pipe holding portion is in a state where a vortex is likely to occur. However, owing to joining with flush pipe inner surfaces, a vortex is less likely to develop in the refrigerant passage, and thus it is possible to suppress generation and development of noise and vibration.

[0032] In the structure described above, preferably, the inner circumference of the capillary pipe holding portion is such that, when the evaporator is installed inside a refrigeration storage unit, the two capillary pipes lie side by side in the depth direction of the refrigeration storage unit.

[0033] With this structure, filler metal can be poured between the two capillary pipes and the inner circumference of the capillary pipe holding portion without being obstructed by the back wall member of the refrigeration storage unit. Thus, it is possible to firmly fasten the two capillary pipes to the capillary pipe holding portion,

and thereby to suppress chattering noise resulting from the capillary pipes vibrating against each other.

[0034] In the structure described above, preferably, in the opening, a taper is formed so as to be increasingly wide open outward toward the tip end. Here, the taper is, for example, one that, when the evaporator is installed at the installation site, has a greater length in a lower inclined surface than elsewhere.

[0035] The heat exchange devices and (or) evaporators described above are incorporated in devices such as refrigeration storage units that performs refrigeration inside them.

Advantageous Effects of the Invention

[0036] According to the present invention, it is possible to provide a heat exchange device that is so structured that two capillary pipes lie in contact with one suction pipe and that performs heat exchange reliably, suppresses noise such as chattering noise, and suppresses an increase in the number of components and manufacturing steps, an evaporator, and a refrigeration storage unit employing those.

Brief Description of Drawings

[0037] Fig. 1 is a schematic diagram of a compression refrigeration device and a refrigeration storage unit provided with an evaporator according to the invention;
Fig. 2 is a perspective view of an example of an evaporator according to the invention;
Fig. 3 is a plan view of a heat exchange pipe as a heat exchange device according to the invention;
Fig. 4 is a perspective sectional view of the heat exchange pipe shown in Fig. 3;
Fig. 5 is a perspective view of an inlet pipe of an evaporator according to the invention;
Fig. 6 is a side view of the inlet pipe shown in Fig. 5 as seen from a direction along its axis;
Fig. 7 is a sectional view of the inlet pipe shown in Fig. 6 cut long line VII-VII;
Fig. 8 is a sectional view of the inlet pipe shown in Fig. 6 cut long line VIII-VIII;
Fig. 9 is an enlarged perspective view of part IX of the evaporator shown in Fig. 2;
Fig. 10 is a sectional view of an inlet pipe of an evaporator according to the invention;

and

Fig. 11 is a perspective view of two capillary pipes inserted directly in an inlet pipe.

Description of Embodiments

[0038] An embodiment of the present invention will be described below with reference to the accompanying drawings. Fig. 1 is a schematic diagram of a compression refrigeration device and a refrigeration storage unit (refrigeration storage unit) provided with an evaporator according to the invention. As shown in Fig. 1, the refrigeration storage unit is provided with a refrigeration compartment R1, which is a refrigerated region, and a freezing compartment R2, which is a frozen region. The refrigeration storage unit Rf is further provided with a compression refrigeration device A for refrigerating the inside of the freezing compartment R2. The compression refrigeration device A is provided with a compressor 1, a condenser 2, a switch valve 3, and a heat exchange pipe Hp as a heat exchange device, and constitutes a refrigeration cycle having refrigerant sealed inside. The heat exchange device according to the invention includes a first capillary pipe 41, a second capillary pipe 42, an evaporator 5, and a suction pipe 6.

[0039] In the refrigeration storage unit Rf, the refrigeration compartment R1 and the freezing compartment R2 are separated from each other by a heat-insulating material. In the heat-insulating material separating the refrigeration compartment R1 and the freezing compartment R2 from each other, a duct (not shown) is formed which allows air to flow between the refrigeration compartment R1 and the freezing compartment R2. As will be described later, the evaporator 5 is arranged only in the freezing compartment R2, and the compression refrigeration device A refrigerates the freezing compartment R2. The refrigeration storage unit Rf is so configured that the cold air in the freezing compartment R2 is fed through the duct into the refrigeration compartment R1 and the refrigeration compartment R1 is thereby refrigerated. Further provided are a fan (not shown) for circulating inside the freezing compartment R2 the cold air that has undergone heat exchange with the evaporator 5 and a fan (not shown) for feeding the cold air in the freezing compartment R2 through the duct into the refrigeration compartment R1.

[0040] First, the compression refrigeration device A will be described. The

compressor 1 is an electric motor which compresses refrigerant and feeds it to the condenser 2. The compressor 1 is arranged outside the heat-insulating box member of the refrigeration storage unit Rf. The condenser 2 refrigerates and condenses the refrigerant fed from the compressor 1. In the compression refrigeration device A, the condenser 2 is configured as piping laid around outside the heat-insulating box member of the refrigeration storage unit Rf, and while refrigerant passes through the piping, the heat of the refrigerant is rejected out of the refrigeration storage unit Rf. The condenser 2 may be configured in any other manner, and may employ a commonly used air-cooled or water-cooled heat exchanger. For high heat exchange efficiency, the condenser 2 is formed of a metal with high thermal conductivity, such as copper. Other than copper, any metal with high electrical conductivity may be adopted, such as aluminum (alloy).

[0041] The switch valve 3 is an electromagnetic valve for letting the refrigerant from the condenser 2 flow through one or both of the first and second capillary pipes 41 and 42. The switch valve 3 is so configured as to perform switching according to the temperature inside the refrigeration compartment R1 and (or) the freezing compartment R2, the rotation speed of the compressor 1, etc. Like the condenser 2, the switch valve 3 is arranged outside the heat-insulating box member of the refrigeration storage unit Rf. The switch valve 3 also has the function of stopping the refrigerant such that it flows into neither of the first and second capillary pipes 41 and 42. When the compressor 1 is inoperative, by operating the switch valve 3 so as to suppress the outflow of the refrigerant from the condenser 2, it is possible to suppress a drop in the condenser 2-side refrigerant pressure, and thereby to make the compression refrigeration device A more energy-saving.

[0042] The first and second capillary pipes 41 and 42 are copper pipes with a smaller inner diameter than the piping from the condenser 2, and serve as a restrictor (orifice) for lowering the pressure of the refrigerant from the condenser 2. The refrigerant that exits from the first or second capillary pipe 41 or 42 diffuses and evaporates. The first and second capillary pipes 41 and 42 have different inner diameters. Owing to the first and second capillary pipes 41 and 42 having different inner diameters in this way, the first and second capillary pipes 41 and 42 provide different resistance. In the compression refrigeration device A, resistance is adjusted on the basis of a difference

in inner diameter between capillary pipes; instead, pipes of the same inner diameter may be used, and resistance may be adjusted by varying their lengths or by varying both their inner diameters and lengths.

[0043] The first and second capillary pipes 41 and 42 are united and are directly connected to an inlet pipe 51 of the evaporator 5. Thus, the first and second capillary pipes 41 and 42 are pipes that connect between the switch valve 3, which is arranged outside the heat-insulating box member, and the evaporator 5, which is arranged inside the freezing compartment R2 (inside the heat-insulating box member), and transversely penetrate the heat-insulating box member. The refrigerant passing through the first and second capillary pipes 41 and 42 has high temperature (in relative term); thus, so that its heat may not conduct to the refrigeration compartment R1 and the freezing compartment R2, and also so that the refrigerant may not be heated by the heat from the condenser 2, the first and second capillary pipes 41 and 42 are, except in their end parts connecting to the switch valve 3 and in their end parts connecting to the evaporator 5, arranged in a heat-insulating portion which is a space formed inside the heat-insulating layer of the heat-insulating box member.

[0044] The evaporator 5 is a heat exchanger at which the refrigerant passing inside exchanges heat with the air outside so that the air outside is refrigerated, and is arranged inside the freezing compartment R2. Fig. 2 is a perspective view of an example of an evaporator according to the invention. As shown in Fig. 2, the evaporator 5 is provided with a heat exchange portion 50, an inlet pipe 51 through which refrigerant is introduced into the heat exchange portion 50, and an outlet pipe 52 through which the refrigerant in the heat exchange portion 50 is discharged. The heat exchange portion 50 is provided with a meandering pipe 501 and a plurality of fins arranged parallel to one another and penetrated by the pipe. The pipe 501 has straight and curved parts, and in the heat exchange portion 50, the straight parts penetrate the fins. The fins increase the surface area of the heat exchange portion 50, and enhances the refrigerating effect by the refrigerant. The different parts of the evaporator 5 will be described in detail later.

[0045] To the outlet pipe 52 of the evaporator 5, the suction pipe 6 is connected. The suction pipe 6 is a pipe that connects between the evaporator 5 and the compressor 1. The suction pipe 6 lies in contact with the first and second capillary pipes 41 and 42.

Between the refrigerant passing through the suction pipe 6 and the refrigerant passing through the first and second capillary pipes 41 and 42, heat is exchanged. To allow heat exchange between the refrigerant passing inside the suction pipe 6 and the refrigerant passing through the first or second capillary pipe 41 or 42, the suction pipe 6 is formed of a metal (here, a copper pipe) with high thermal conductivity, such as copper or aluminum. Like the first and second capillary pipes 41 and 42, the suction pipe 6 is arranged in the heat-insulating portion formed in the heat-insulating box member.

[0046] As the method for fastening the first and second capillary pipes 41 and 42 and the suction pipe 6 together, it is possible to adopt one involving soldering or one involving tying with metal tape. Other than these, it is possible to adopt any of many different fastening methods that affect as little as possible the first and second capillary pipes 41 and 42 and the suction pipe 6.

[0047] The suction pipe 6 is connected to the compressor 1, and is arranged, in its part from the heat-insulating portion to the compressor 1, outside the heat-insulating layer of the heat-insulating box member. The refrigerant passing through the suction pipe 6 is heated by heat exchange with the refrigerant passing through the first or second capillary pipe 41 or 42, and thus the suction pipe 6 is heated. This suppresses deposition of frost and dew on the part of the suction pipe 6 arranged outside the heat-insulating layer.

[0048] The refrigerant is compressed by the compressor 1 into high-temperature high-pressure refrigerant gas, which flows into the condenser 2. While passing inside the condenser 2, the high-temperature high-pressure refrigerant gas exchanges heat with the air outside and thereby condenses and liquefies. The condensed and liquefied refrigerant then flows, according to how the switch valve 3 is switched, into either the first or second capillary pipe 41 or 42.

[0049] In the first or second capillary pipe 41 or 42, the refrigerant is depressurized. The first and second capillary pipes 41 and 42 have different resistance, and according to the rotation speed of the compressor 1, whichever of the first and second capillary pipes 41 and 42 is appropriate is selected. Or, while the rotation speed of the compressor 1 is kept constant, selecting the first or second capillary pipe 41 or 42 allows adjustment of the evaporation temperature of the refrigerant in the evaporator 5.

[0050] The refrigerant depressurized in the first or second capillary pipe 41 or 42 flows, in a low-temperature low-pressure state, into the evaporator 5. The first and second capillary pipes 41 and 42 are connected to the inlet pipe 51 of the evaporator 5, and thus both the refrigerant that has passed through the first capillary pipe 41 and the refrigerant that has passed through the second capillary pipe 42 flow through the inlet pipe 51 into the evaporator 5.

[0051] Having flowed into the evaporator 5, the refrigerant vaporizes due to a sharp difference in pressure. The vaporized refrigerant, now in the form of low-temperature refrigerant gas, circulates in the heat exchange portion 50 of the evaporator 5. While circulating in the heat exchange portion 50, the refrigerant exchanges heat with the air inside the freezing compartment R2 and thereby refrigerates the freezing compartment R2. Having circulated in the heat exchange portion 50, the refrigerant, now with higher temperature resulting from heat exchange, flows through the outlet pipe 52 into the suction pipe 6. The suction pipe 6 lies in contact with the first and second capillary pipes 41 and 42, and thus the low-temperature refrigerant passing through the suction pipe 6 exchanges heat with the high-temperature refrigerant passing through the first or second capillary pipe 41 or 42. The heat exchange between the refrigerant passing through the suction pipe 6 and the refrigerant passing through the first or second capillary pipe 41 or 42 will be described later.

[0052] Next, a heat exchange pipe as a heat exchange device according to the invention will be described with reference to the relevant drawings. Fig. 3 is a plan view of a heat exchange pipe as a heat exchange device according to the invention, and Fig. 4 is a perspective sectional view of the heat exchange pipe shown in Fig. 3. As shown in Fig. 4, in the heat exchange pipe (heat exchange device) Hp, the first and second capillary pipes 41 and 42 and the suction pipe 6 lie in contact with each other at their respective outer circumferential surfaces. The first and second capillary pipes 41 and 42 are pipe members with smaller outer and inner diameters than the suction pipe 6.

[0053] More specifically, the first and second capillary pipes 41 and 42 are connected, at one end, to the switch valve 3 and, at the other end, to the inlet pipe 51 of the evaporator 5, and are passages of high-temperature refrigerant. On the other hand, the suction pipe 6 is connected, at one end, to the compressor 1 and, at the other end, to

the outlet pipe 52 of the evaporator 5, and is a passage of low-temperature refrigerant.

[0054] The first and second capillary pipes 41 and 42 and the suction pipe 6 are bonded and fastened together heat-exchangeably to form the heat exchange pipe Hp. It is preferable that the suction pipe 6 be formed of a metal (here, a copper pipe) with high thermal conductivity, such as copper or aluminum. As the method for fastening the first and second capillary pipes 41 and 42 and the suction pipe 6 together, it is possible to adopt one involving soldering. Other than that, it is possible to adopt any of many different methods that affect as little as possible the first and second capillary pipes 41 and 42 and the suction pipe 6. The parts of the suction pipe 6 and the first and second capillary pipes 41 and 42 where they lie in contact with each other are arranged inside the heat-insulating portion.

[0055] Specifically, in the heat exchange pipe Hp, middle parts of the first and second capillary pipes 41 and 42 and a middle part of the suction pipe 6 are fastened together by brazing so as to lie in contact with each other for heat exchange inside the heat-insulating portion. The members to which the first and second capillary pipes 41 and 42 are connected (that is, the inlet pipe 51 of the evaporator 5 and the switch valve 3) differ from the members to which the suction pipe 6 is connected (that is, the outlet pipe 52 of the evaporator 5 and the compressor 1), and thus both end parts of the first and second capillary pipes 41 and 42 are formed apart from the suction pipe 6.

[0056] In the heat exchange pipe Hp, in the parts of the first and second capillary pipes 41 and 42 and the suction pipe 6 where they lie contact with each other, heat is exchanged between the high-temperature refrigerant passing through the first or second capillary pipe 41 or 42 and the low-temperature refrigerant passing through the suction pipe 6. That is, the refrigerant passing through the first or second capillary pipe 41 or 42 is cooled so that it evaporates at lower temperature in the evaporator 5, contributing to higher cycle efficiency of the compression refrigeration device. On the other hand, the low-temperature refrigerant passing through the suction pipe 6 is heated by heat exchange with the high-temperature refrigerant passing through the first or second capillary pipe 41 or 42, and is, as refrigerant gas with temperature adequate for operation, sucked into the compressor 1. Although the part of the suction pipe 6 close to the compressor 1 is arranged outside the heat-insulating portion, since the refrigerant has been warmed, moisture in the air is unlikely to deposit as frost on

the surface of the suction pipe 6.

[0057] An insufficient length of the parts (middle parts) of the first and second capillary pipes 41 and 42 and the suction pipe 6 where they lie in contact with each other leads to a reduced amount of heat exchanged, and thus a diminished effect of heat exchange. To avoid that, in the heat exchange pipe Hp, as shown in Fig. 3, the parts of the first and second capillary pipes 41 and 42 and the suction pipe 6 where they are fastened together in contact with each other is made to meander to increase the length of contact between the first and second capillary pipes 41 and 42 and the suction pipe 6.

[0058] In this way, an increased amount of heat is exchanged between the refrigerant passing through the first or second capillary pipe 41 or 42 and the refrigerant passing through the suction pipe 6. By increasing the amount of heat exchanged, it is possible to enhance the effect mentioned above. The heat exchange pipe Hp has a shape bent at two places. This, however, is not meant as any limitation; the number of bends and the shape may be designed to suit the site where the heat exchange pipe Hp is installed.

[0059] The heat exchange pipe Hp is fabricated by bending after the suction pipe 6 and the first and second capillary pipes 41 and 42 are fastened together. At this time, if the suction pipe 6 and the first and second capillary pipes 41 and 42 have different curvatures, the first and (or) second capillary pipe 41 and (or) 42 may flatten, or the first and (or) second capillary pipe 41 and (or) 42 may cave into the suction pipe 6, or the first and (or) second capillary pipe 41 and (or) 42 may come off the suction pipe 6. To avoid that, as shown in Fig. 4, in the heat exchange pipe Hp, the first and second capillary pipes 41 and 42 are fitted to the suction pipe 6 symmetrically about its center on a line crossing the bending direction of the suction pipe 6.

[0060] Performing bending with the first and second capillary pipes 41 and 42 fitted to the suction pipe 6 in this way gives the bent parts of the first and second capillary pipes 41 and 42 and the suction pipe 6 the same or substantially the same curvature. This makes the first and second capillary pipes 41 and 42 and the suction pipe 6 less likely to be displaced from each other when bent, and makes the first and second capillary pipes 41 and 42 less likely to flatten or cave into the suction pipe 6. Thus, the first and second capillary pipes 41 and 42 are fitted to the suction pipe 6 with the centers of the former on a line substantially perpendicular to the bending direction of

the suction pipe 6.

[0061] When the suction pipe 6 and the first and second capillary pipes 41 and 42 have the same curvature, no deformation difference occurs. Thus, it is preferable that the first and second capillary pipes 41 and 42 be arranged with their centers on a line perpendicular to the bending direction of the suction pipe 6. As the method for bending a pipe member having a plurality of pipes put together in this way, it is possible to adopt one involving pressing them with a plurality of rollers. This, however, is not meant to be any limitation; any of many different processing methods may instead be adopted whereby the pipe member can be bent without flattening or caving-in.

[0062] The parts of the first and second capillary pipes 41 and 42 formed apart from the suction pipe 6 (at least the parts contiguous with the inlet pipe 51 of the evaporator 5) are heat-treated (annealed) so as to be deformable.

[0063] Since the tip ends of the first and second capillary pipes 41 and 42 are deformable, these can be, as necessary, united at a position away from the suction pipe 6. The first and second capillary pipes 41 and 42 so united can be laid around as far as they reach. By contrast, the suction pipe 6, which is not heat-treated, is rigid, and is hardly deformable. Also, the parts of the first and second capillary pipes 41 and 42 where they are brazed to the suction pipe 6 in contact with it are not heat-treated, and are rigid.

[0064] An inlet pipe of an evaporator according to the invention will now be described with reference to the relevant drawings. Fig. 5 is a perspective view of an inlet pipe of an evaporator according to the invention, Fig. 6 is a side view of the inlet pipe shown in Fig. 5 as seen from a direction along its axis, Fig. 7 is a sectional view of the inlet pipe shown in Fig. 6 cut along line VII-VII, and Fig. 8 is a sectional view of the inlet pipe shown in Fig. 6 cut along line VIII-VIII.

[0065] The pipe 501 of the evaporator 5 is a pipe member formed of aluminum, and the inlet pipe 51 is a pipe member formed of copper. Thus, the pipe 501 and the inlet pipe 51 form a joint of different metals. As the method for joining together pipes of different metals, commonly used are a method (side fusion) in which a narrowed tip end of a pipe is inserted inside a widened tip end of another pipe and the parts where the two pipes lie in contact with each other are thermally fused together, and one

(flash butt fusion) in which end faces of two pipes are brought into contact with each other in the axial direction and are thermally fused together.

[0066] Side fusion is comparatively free from formation of burrs inside and thus does not need removal of burrs after joining. Side fusion, however, requires widening of a tip end of one pipe and narrowing of a tip end of the other pipe, and thus the pipe thickness is difficult to adjust, such adjustment being costlier than removal of burrs. On the other hand, flash butt fusion requires removal of burrs after joining, but leaves the inner surface of the joint smooth. Overall, flash butt fusion requires less cost and provides a smoother inner surface than side fusion. Accordingly, in the evaporator 5 according to the invention, the inlet pipe 51 and the pipe 501 are joined together by flash butt fusion.

[0067] Though not considered in this embodiment, depending on the structure of the switch valve 3, refrigerant can be passed through one or both of the first and second capillary pipes 41 and 42. Since the first and second capillary pipes 41 and 42 have different resistance, when refrigerant is passed through both of the first and second capillary pipes 41 and 42, different speeds of the refrigerant at the outlets tend to produce a vortex. In such piping where refrigerant that produces or tends to produce a vortex passes, using a joining method, like side fusion, that forms a restricted joint promotes the formation of a vortex and produce loud noise. From this perspective also, it is preferable that the inlet pipe 51, which holds the first and second capillary pipes 41 and 42, and the pipe 501 be joined together by flash butt fusion as in this invention.

[0068] On the tip-end side of the inlet pipe 51, a capillary pipe holding portion 511 is formed which holds the first and second capillary pipes 41 and 42 together. As shown in Figs. 3 and 4, the capillary pipe holding portion 511 is so formed that its end face cut in the direction perpendicular to its center axis has an oval shape. In the inlet pipe 51, the inside of the capillary pipe holding portion 511 including an opening 510 has an oval shape. This oval shape is so sized and shaped that, when the first and second capillary pipes 41 and 42 are inserted together, they slide on the inner wall of the inlet pipe 51.

[0069] After the first and second capillary pipes 41 and 42 bundled together are inserted together in the capillary pipe holding portion 511, the first and second capillary pipes 41 and 42 and the capillary pipe holding portion 511 are fastened

together by brazing. The inlet pipe 51 may be formed to have, in an end part, an oval shape like the capillary pipe holding portion 511 at the time of manufacture, or a pipe member having a uniform cross-sectional shape may be processed to form a capillary pipe holding portion 511 having an oval shape with a uniform wall thickness in the circumferential direction.

[0070] Next, the fitting of the heat exchange pipe Hp and the evaporator 5 to the refrigeration storage unit Rf will be described. In the manufacture of the refrigeration storage unit Rf, before the evaporator 5 is fitted to the freezing compartment R2, the heat exchange pipe Hp is fitted inside the heat-insulating portion of the heat-insulating box member. At this time, the evaporator 5-side end parts of the first and second capillary pipes 41 and 42 and the suction pipe 6 have been led, through an unillustrated opening, into the freezing compartment R2.

[0071] As mentioned previously, whereas the tip end part of the suction pipe 6 is hardly deformable, the tip end parts of the first and second capillary pipes 41 and 42 are deformable. Accordingly, the evaporator 5 is arranged inside the freezing compartment R2 in such a way that the suction pipe 6 penetrates the outlet pipe 52. With the suction pipe 6 put through the outlet pipe 52, the evaporator 5 is fixed inside the freezing compartment R2 of the refrigeration storage unit Rf. Then, the first and second capillary pipes 41 and 42 are together inserted in the inlet pipe 51 of the evaporator 5. Then, filler metal is poured into the gap between the first and second capillary pipes 41 and 42 and the inlet pipe 51 and the gap between the suction pipe 6 and the outlet pipe 52, so that fastening is achieved by brazing. Thus, the tip end parts of the first and second capillary pipes 41 and 42 are put together, and are fastened to the capillary pipe holding portion 511.

[0072] The brazing of the first and second capillary pipes 41 and 42 to the inlet pipe 51 will now be described in detail with reference to the relevant drawing. Fig. 9 is an enlarged perspective view of part IX of the evaporator shown in Fig. 2.

[0073] With the suction pipe 6 inserted in the outlet pipe 52, the evaporator 5 is fixed inside the freezing compartment R2. Then, the first and second capillary pipes 41 and 42 are together inserted in the inlet pipe 51. When inserted in the inlet pipe 51 (when handled), the first and second capillary pipes 41 and 42 may get twisted or caught, causing their tip ends to come apart from each other. With the tip ends of the first and

second capillary pipes 41 and 42 apart from each other, these are difficult to insert in the inlet pipe 51.

[0074] To avoid that, as shown in Fig. 9, before being inserted in the inlet pipe 51, the first and second capillary pipes 41 and 42 are bundled together with a filler metal ring 43. Bundling the first and second capillary pipes 41 and 42 together with the filler metal ring 43 makes their tip ends less likely to come apart. This makes it possible to insert the first and second capillary pipes 41 and 42 snug into the capillary pipe holding portion 511 through the opening 510 of the inlet pipe 51.

[0075] The filler metal ring 43 may be one helically twisted as shown in Fig. 9, or may be one, like the filler metal ring 44, formed to have ends put against each other, or may be one, like the filler metal ring 45, formed in a C-shape to be partly open. The filler metal rings 43, 44, and 45 are formed of copper, that is, the same material as the first and second capillary pipes 41 and 42. This, however, is not meant as any limitation; any other material may be used that can bundle the first and second capillary pipes 41 and 42 firmly together. Instead of a filler metal ring, tape or the like may be used to achieve bundling together.

[0076] After the first and second capillary pipes 41 and 42 are inserted in the inlet pipe 51, the inlet pipe 51 and the first and second capillary pipes 41 and 42 are heated, and molten filler metal is poured into the gap between the inlet pipe 51 and the first and second capillary pipes 41 and 42 to achieve brazing. The filler metal fills the gap between the contacting parts of the first and second capillary pipes 41 and 42 and the inlet pipe 51. Then, by capillarity, the filler metal permeates through the gap between the inlet pipe 51 and the first capillary pipe 41 and the gap between the inlet pipe 51 and the second capillary pipe 42.

[0077] In the refrigeration storage unit Rf, the evaporator 5 is arranged near the wall of the freezing compartment R2. This makes it difficult to use, for the heating of the inlet pipe 51 and the first and second capillary pipes 41 and 42, a torch, with which uniform heating can easily be achieved. Instead, here, a heating method is adopted that employ an induction heating device, which does not cause ignition. The induction heating device has a coil arranged close to the inlet pipe 51 so as to achieve heating by induction.

[0078] If during heating there is a large difference in temperature between the first and

second capillary pipes 41 and 42 and the capillary pipe holding portion 511, the filler metal may distribute unevenly, leading to incomplete fastening or formation of a gap through which refrigerant can leak. To avoid that, as shown in Fig. 6, the capillary pipe holding portion 511 is formed out of a pipe member having a substantially uniform thickness in the circumferential direction. Owing to the capillary pipe holding portion 511 being a pipe member having a substantially uniform thickness in the circumferential direction in this way, it is possible to achieve heating to substantially uniform temperature by induction heating.

[0079] Owing to the structure in which the first and second capillary pipes 41 and 42 are, in a state lying side by side left to right (in the direction of the depth of the refrigeration storage unit Rf), inserted in the inlet pipe 51, during brazing, gaps into which the molten filler metal flows are formed above and below between the contacting parts of the first and second capillary pipes 41 and 42 and the inlet pipe 51. The molten filler metal is poured into those gaps formed above and below, and this makes brazing easy.

[0080] Since the gaps between the contacting parts of the first and second capillary pipes 41 and 42 and the inlet pipe 51 are formed above and below, the brazing worker can easily check the gaps visually. It is thus easy to confirm that the gaps between the contacting parts of the first and second capillary pipes 41 and 42 and the inlet pipe 51 are completely filled with the filler metal, and thus it is easy to confirm that the inlet pipe 51 and the first and second capillary pipes 41 and 42 are fastened together firmly.

[0081] As shown in Figs. 2, 5, 6, etc., the opening 510 of the inlet pipe 51 has an oval shape in which the first and second capillary pipes 41 and 42 lie side by side left to right (in the depth direction). For smooth insertion of the first and second capillary pipes 41 and 42 bundled together into the opening 510, as shown in Fig. 6, in the opening 510 of the inlet pipe 51, a taper portion 512 is formed that is increasingly wide open outward. Owing to the provision of the taper portion 512, the tip ends of the first and second capillary pipes 41 and 42 bundled together are guided by the taper portion 512 toward the center of the opening 510. This permits the first and second capillary pipes 41 and 42 bundled together to be inserted into the inlet pipe 51 with improved workability.

[0082] In the refrigeration storage unit Rf, typically, the freezing compartment R2, which is colder, is formed below the refrigeration compartment R1, and the evaporator 5 is arranged in the freezing compartment R2. In the manufacture of the refrigeration storage unit Rf so constructed, the assembly worker usually reaches for the evaporator 5 from above. In that case, the worker usually inserts the first and second capillary pipes 41 and 42 bundled together into the opening 510 of the inlet pipe 51 from above, with the former in a slanted position. Even in this case, owing to the taper portion 512 formed in the opening 510 of the inlet pipe 51, the first and second capillary pipes 41 and 42 bundled together can easily be inserted into the opening 510, with improved workability.

[0083] As mentioned above, the taper portion 512 formed in the opening 510 of the inlet pipe 51 makes easy the insertion of the first and second capillary pipes 41 and 42 bundled together. In addition, it also helps collect the filler metal molten during the fastening together of the first and second capillary pipes 41 and 42 and the capillary pipe holding portion 511. The filler metal permeates, from where it is collected, along the two of the first and second capillary pipes 41 and 42, and therefore, even if the first and (or) second capillary pipe 41 and (or) 42 get twisted and a gap is formed between the first and (or) second capillary pipe 41 and (or) 42 and the capillary pipe holding portion 511, it is possible to pour in an amount of filler metal sufficient to fasten them together.

[0084] In this way, the first and second capillary pipes 41 and 42 can reliably be put together into a single piece, and the first and second capillary pipes 41 and 42 can be firmly fastened to the capillary pipe holding portion 511. Moreover, since the filler metal can be collected in the taper portion 512, even when a somewhat larger amount of filler metal is poured, the filler metal is unlikely to obstruct the tip ends of the first and (or) second capillary pipe 41 and (or) 42.

[0085] In the compression refrigeration device A, when refrigerant flows from the first and (or) second capillary pipe 41 and (or) 42 into the capillary pipe holding portion 511, it is instantaneously depressurized (quick depressurization) and vaporized. At this time, impact tends to act upon the first and (or) second capillary pipe 41 and (or) 42 (in particular, its tip end). In a structure where, as in this invention, the first and second capillary pipes 41 and 42 are put together into a single piece by brazing

and are firmly fastened to the capillary pipe holding portion 511, the first and (or) second capillary pipe 41 and (or) 42 are less likely to suffer breakage or the like due to impact.

[0086] As mentioned above, impact resulting from quick depressurization may cause vibration of the first and (or) second capillary pipe 41 and (or) 42. Even when such vibration occurs, since the first and second capillary pipes 41 and 42 are put together into a single piece up to their end parts by brazing and are firmly fastened to the capillary pipe holding portion 511, the first and second capillary pipes 41 and 42 are prevented from producing chattering noise by repeatedly moving into and out of contact with each other in rapid succession inside the inlet pipe 51.

[0087] The quick depressurization of the refrigerant flowing out of the first and second capillary pipes 41 and 42 tends to occur, for example, immediately after the start (restart) of the operation of the compressor 1 and immediately after the switching of the capillary pipe to pass the refrigerant through. Impact as mentioned above may result, not only from quick depressurization, but also when the switch valve 3 so operates as to stop the circulation of the refrigerant suddenly.

[0088] In the embodiment described above, the taper portion 512 formed in the opening 510 of the inlet pipe 51 is formed so as to have an inclined surface with a uniform length around the entire circumference of the opening 510. As described above, owing to the provision of the taper portion 512, the first and second capillary pipes 41 and 42 can reliably be guided through the opening 510 into the capillary pipe holding portion 511. Filler metal can also be collected in the taper portion 512 during brazing, and this permits the first and second capillary pipes 41 and 42 and the capillary pipe holding portion 511 to be fastened together firmly.

[0089] In the evaporator 5, the tip ends of the first and second capillary pipes 41 and 42 penetrate the capillary pipe holding portion 511 and reach the part of the inlet pipe 51 where it is widened inside. Thus, even when a somewhat larger amount of filler metal has permeated, it flows into the wide space inside the inlet pipe 51, and this makes the tip ends of the first and second capillary pipes 41 and 42 less likely to be filled with the filler metal. Moreover, as described above, through heating by induction heating, the first and second capillary pipes 41 and 42 and the capillary pipe holding portion 511 can be heated locally. Thus, by performing heating in such a way

that, while the part of the inlet pipe 51 close to the opening 510 is heated to high temperature, the part of the inlet pipe 51 close to where the tip ends of the first and second capillary pipes 41 and 42 reach is heated to lower temperature that causes the filler metal to condense, it is possible to prevent an excessive amount of filler metal from permeating into the inlet pipe 51.

[0090] The opening 510 shown in Figs. 5 and 6 has a taper portion 512 having an inclined surface with a uniform size around the circumference, but this is not meant as any limitation. To follow is a description of an inlet pipe having an opening where a differently shaped taper portion is formed. Fig. 10 is a sectional view of an inlet pipe of an evaporator according to the invention. The opening 510 shown in Fig. 10 is provided with a lower taper portion 513 that, when the evaporator 5 is installed inside the refrigeration storage unit Rf, has an inclined surface with a greater length than elsewhere.

[0091] As mentioned previously, the assembly worker usually inserts the first and second capillary pipes 41 and 42 bundled together into the opening 510 of the inlet pipe 51 from above, with the former in a slanted state. Thus, by forming the lower taper portion 513 to have a longer inclined surface than the inclined surface elsewhere, it is possible to insert the first and second capillary pipes 41 and 42 bundled together into the capillary pipe holding portion 511 more easily than with the taper portion 512 having a uniformly-sized inclined surface around the entire circumference of the opening 510. The larger lower inclined surface results in a larger gap there between the contacting parts of the first and second capillary pipes 41 and 42 and the inlet pipe 51, and a larger amount of filler metal is collected in the lower taper portion 513. This permits the gaps between the first and second capillary pipes 41 and 42 and the inlet pipe 51 to be filled reliably.

[0092] With a heat exchange device and an evaporator according to the present invention, a capillary pipe and an inlet pipe, and a suction pipe and an outlet pipe, are joined together by brazing after an evaporator is installed in a freezing compartment, and thus the brazed parts are located inside the freezing compartment. As a result, after the assembly of a refrigeration storage unit, during loading of refrigerant and inspection, it is easy to check for leakage of refrigerant at joints, and it is easy to remedy leakage of refrigerant. Thus, a refrigeration storage unit according to the

invention contributes to a higher yield and easy repair and maintenance.

- [0093] In the above description, the joining method called brazing uses silver-free phosphorus copper (BCuP-2 as designated in Japanese Industrial Standards), which exhibits high permeability (liquidity) when molten. Although the above description deals with an example where one thick pipe and two thin pipes arranged along it are a suction pipe and two capillary pipes, this is not meant as any limitation.

Industrial Applicability

- [0094] The present invention finds applications in refrigeration storage units, such as refrigerators and freezers, that perform refrigeration inside them by use of refrigerant.

List of Reference Signs

- [0095]
- | | |
|-----|----------------------------------|
| Rf | refrigeration storage unit |
| R1 | refrigeration compartment |
| R2 | freezing compartment |
| Hp | heat exchange pipe |
| A | compression refrigeration device |
| 1 | compressor |
| 2 | condenser |
| 3 | switch valve |
| 41 | first capillary pipe |
| 42 | second capillary pipe |
| 5 | evaporator |
| 50 | heat exchange portion |
| 501 | pipe |
| 51 | inlet pipe |
| 510 | opening |
| 511 | capillary pipe holding portion |
| 512 | taper portion |
| 513 | lower taper portion |
| 52 | outlet pipe |
| 6 | suction pipe |

CLAIMS

[Claim 1]

A heat exchange device comprising:

a suction pipe that connects between an evaporator and a compressor and that is bent at least at one place, the suction pipe having a low-temperature refrigerant passing therethrough; and

two capillary pipes that connect between a condenser and the evaporator, and that are arranged in a direction crossing a bending direction of the suction pipe and in symmetry about the low-temperature pipe, the capillary pipes being, at least at a surface of a middle part thereof, fastened to the suction pipe in contact therewith by blazing, the capillary pipes having a high-temperature refrigerant passing therethrough,

wherein

a pipe portion of an inlet pipe of the evaporator is shaped such that the two capillary pipes can be, in a state arranged side by side in a horizontal direction, inserted therein and fastened thereto by blazing, and

at an opening at a tip end of the pipe portion of the inlet pipe of the evaporator, a taper is formed such that, when gaps between a contact part between the two capillary pipes and the pipe portion are formed one at top and one at bottom, the taper is increasingly wide open outward toward the tip end and a length of a slope is greater at bottom than elsewhere.

[Claim 2]

The heat exchange device according to claim 1, wherein

the two capillary pipes are arranged, at least in the part thereof fastened in contact, in a direction perpendicular to the bending direction of the suction pipe.

[Claim 3]

The heat exchange device according to claim 1 or 2, wherein

the two capillary pipes are pipes that differ in at least one of inner diameter and length.

[Claim 4]

The heat exchange device according to any one of claims 1 to 3, wherein

the two capillary pipes are, at both end parts thereof, separated from the suction pipe,
and

the two capillary pipes are, at least in an end part thereof inserted into and fastened to
the inlet pipe of the evaporator, annealed.

[Claim 5]

The heat exchange device according to any one of claims 1 to 4, wherein
the two capillary pipes are, in an end part thereof inserted into and fastened to the
evaporator, bundled together with a fastening member.

[Claim 6]

The heat exchange device according to claim 5, wherein
the fastening member is a filler metal ring.

[Claim 7]

A heat exchange device comprising:
a suction pipe that connects between an evaporator and a compressor and that is bent
at least at one place, the suction pipe having a low-temperature refrigerant passing
therethrough; and

two capillary pipes that connect between a condenser and the evaporator, and that are
arranged in a direction crossing a bending direction of the suction pipe and in symmetry
about the low-temperature pipe, the capillary pipes being, at least at a surface of a middle part
thereof, fastened to the suction pipe in contact therewith by blazing, the capillary pipes
having a high-temperature refrigerant passing therethrough,

wherein

a pipe portion of an inlet pipe of the evaporator is shaped such that the two capillary
pipes can be, in a state arranged side by side in a horizontal direction, inserted thereinto and
fastened thereto by blazing,

the two capillary pipes are, at least in an end part thereof inserted into and fastened to
the inlet pipe of the evaporator, annealed, and

the two capillary pipes are, in an end part thereof inserted into and fastened to the
evaporator, bundled together with a filler metal ring.

[Claim 8]

A refrigeration storage unit comprising the heat exchange device according to any one of claims 1 to 7.