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(54) DOUBLE-TUBE HEAT EXCHANGER AND REFRIGERATING CYCLE DEVICE

(57) A double pipe heat exchanger includes an inner pipe 2 inside which a first fluid passes, an outer pipe 1 that has a diameter larger than the diameter of the inner pipe 2 and that covers the inner pipe 2, and second fluid passes through a space between the outer pipe 1 and the inner pipe 2, and a heat transfer area enlargement pipe 3 that is provided in the space and that has a projection-depression shape in which a length in the pipe-circumferential direction of inner contact portions 6 to be contact areas with the outer wall of the inner pipe 2 is made to be larger than a length in the pipe-circumferential direction of outer contact portions 7 to be contact areas with the inner wall of the outer pipe 1, and in addition, fin portions between the outer contact portion 7 and the inner contact portion 6 that traverse the space in a pipe cross section come into contact with the outer wall of the inner pipe 2 and the inner wall of the outer pipe 1 in oblique directions.

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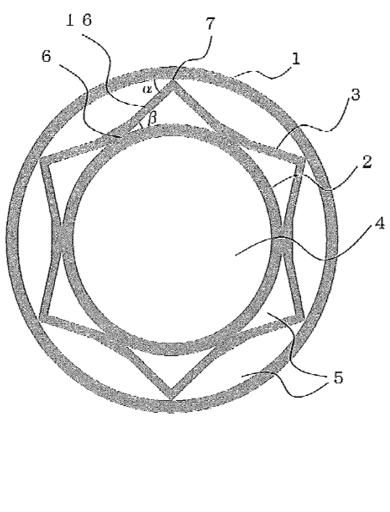

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Description

Technical Field

[0001] The present invention relates to a double pipe heat exchanger in which circular pipes having different pipe diameters are combined to form two channels, and to a refrigeration cycle device including this double pipe heat exchanger.

Background Art

[0002] Examples of conventional double pipe heat exchangers having enhanced heat-transfer performances include one in which a circular pipe having the smaller diameter (hereafter, referred to as an inner pipe) is inserted into a circular pipe having the larger diameter (hereafter, referred to as an outer pipe). In addition, a method is proposed in which the inside of the inner pipe is defined as a first channel, a channel between the two circular pipes is defined as a second channel, and a heat transfer area enlargement pipe that is formed into an undulating shape is inserted into the second channel and brought into intimate contact with the inner pipe and the outer pipe, so as to enhance a heat-transfer performance through an effect of increasing heat-transfer area (see, e.g., Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent Laid-Open No. 2012-63067 (Fig. 1)

Summary of Invention

Technical Problem

[0004] The above-described Patent Literature 1 proposes a double pipe heat exchanger in which a heat transfer area enlargement pipe is inserted to expand a heat-transfer area so as to enhance a heat-transfer performance. However, Patent Literature 1 does not mention a specific measure and the like taken against the heat transfer area enlargement pipe that can enhance the heat-transfer performance efficiently.

[0005] Thus, the present invention has an object to obtain a double pipe heat exchanger and a refrigeration cycle device that can enhance a heat-transfer performance efficiently.

Solution to Problem

[0006] A double pipe heat exchanger according to the present invention includes an inner pipe inside which a first fluid passes, an outer pipe that has a diameter larger than the diameter of the inner pipe and that covers the inner pipe, the inner pipe and the outer pipe configured to allow a second fluid to pass through a space therebetween, and a heat transfer area enlargement pipe that is provided in the space and that has a projection-depression shape in a pipe cross section in which a length in the pipe-circumferential direction of inner contact portions to be contact areas with the outer wall of the inner-pipe is made to be larger than a length in the pipe-circumferential direction of outer contact portions to be contact areas with the inner wall of the outer-pipe, and in addition, fin portions between the inner contact portions and the outer contact portions that traverse the space in the pipe cross section come into contact with the outer wall of the inner-pipe and the inner wall of the outer-pipe in oblique directions.

Advantageous Effects of Invention

[0007] According to the present invention, a heat transfer area enlargement pipe that is in contact with an outer pipe and an inner pipe is provided in such a manner that the length in a pipe-circumferential direction of a contact area with the outer wall of the inner pipe is made larger than the length of the contact area with the inner wall of the outer pipe, and it is thus possible to scatter external force applied to the heat transfer area enlargement pipe in manufacturing, and to expand a heat-transfer area while suppressing poor contact in particular with the inner pipe, so as to enhance a heat-transfer performance.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a diagram for illustrating the configuration of a double pipe heat exchanger according to a first embodiment of the present invention.
[Fig. 2] Fig. 2 is a diagram showing a cross section of the double pipe heat exchanger according to the first embodiment of the present invention, in the other direction.
[Fig. 3] Fig. 3 is a diagram showing a cross section of a double pipe heat exchanger according to a third embodiment of the present invention.
[Fig. 4] Fig. 4 is a diagram for illustrating a lift of a heat transfer area enlargement pipe 3.
[Fig. 5] Fig. 5 is a diagram showing parameters that are set to the double pipe heat exchanger.
[Fig. 6] Fig. 6 is a diagram showing brazed portions according to a fourth embodiment of the present invention.
[Fig. 7] Fig. 7 is a diagram showing refrigeration cycle devices each including the double pipe heat exchanger according to the present invention.

Description of Embodiments

First embodiment

[0009] Fig. 1 is a diagram for illustrating the configuration of a double pipe heat exchanger according to a first embodiment of the present invention. Fig. 1 shows a cross sectional view of the double pipe heat exchanger taken along the direction of flow of refrigerant (in an inner pipe 2 in particular). The double pipe heat exchanger is formed by inserting the inner pipe 2 serving as a circular pipe having a smaller diameter into the inside of an outer pipe 1 serving as a circular pipe having a larger diameter. In addition, end portions of the heat exchanger having a double cylinder structure is configured such that an inner-wall portion of the outer pipe 1 (outer-pipe inner wall) comes into contact with an outer-wall portion of the inner pipe 2 (inner-pipe outer wall) (such that side-wall portions closing the outer pipe 1 cover the inner pipe 2).
[0010] The inside of the inner pipe 2 is defined as an inner channel 4 serving as a first channel, and a space formed between the inner pipe 2 and the outer pipe 1 is defined as an outer channel 5 serving as a second channel. An inlet and outlet of the outer channel 5 for a refrigerant are through holes formed in the wall surface of the outer pipe 1 and connects contact pipes. In addition, a first fluid and a second fluid are allowed to flow in the inner channel 4 and the outer channel 5, respectively. The first fluid and the second fluid having different temperatures flow through the respective channels, which enables heat exchange between the fluids in the double pipe heat exchanger.
[0011] Fig. 2 is a diagram showing a cross section of the double pipe heat exchanger according to the first embodiment of the present invention, taken along another direction. Fig. 2 shows an A-A' cross section in Fig. 1 (a pipe cross section. A cross section taken along a pipe-circumferential direction when viewed in a direction in which the fluids flow). The double pipe heat exchanger of the present embodiment is configured by further inserting a heat transfer area enlargement pipe 3 having an undulating shape that includes projections and depressions, into a space portion of the outer channel 5. In the heat transfer area enlargement pipe 3, an inner wall (the inner wall of the heat transfer area enlargement pipe) comes into contact with the inner-pipe outer wall at the depressed portions, and an outer wall (the outer wall of the heat transfer area enlargement pipe) comes into contact with the outer-pipe inner wall at the projecting portions. In addition, a side wall obliquely traverses the outer channel 5 (the space between the inner pipe 2 and the outer pipe 1) in the pipe cross section, and comes into contact with the inner-pipe outer wall and the outer-pipe inner wall in oblique directions.
[0012] Here, the amount of heat exchange Q, a heat-transfer area A, a heat transfer coefficient K, and a difference dT in temperature between the first fluid and the second fluid relating to the heat exchange generally have a relationship represented by Expression (1).
[0013] [Expression 1]

$$Q = A \cdot K \cdot dT \qquad \cdots (1)$$

[0014] In addition, the heat transfer coefficient K is represented by Expression (2). Here, $\alpha 1$ is the heat transfer coefficient of the first fluid, d1 is the hydraulic diameter of the inner channel 4, $\alpha 2$ is the heat transfer coefficient of the second fluid, and d2 is the hydraulic diameter of the outer channel 5. In addition, λ is the thermal conductivity of the inner pipe 2, dio is the outer diameter of the inner pipe 2, and dii is the inner diameter of the inner pipe 2, and R is a thermal resistance.

[0015] [Expression 2]

$$K = \pi L / \{1/(\alpha 1 \cdot d1) + 1/(\alpha 2 \cdot d2) + \ln(d_{io}/d_{ii})/2\lambda + R\} \quad \cdots (2)$$

[0016] The heat transfer area enlargement pipe 3 comes into contact with the inner pipe 2 to serve as a fin, enabling the enlargement of the heat-transfer area relating to the heat exchange, which enables the increase of the amount of heat exchanged between the first fluid and the second fluid.

[0017] Here, contact areas between the inner-pipe outer wall and the inner wall of the heat transfer area enlargement pipe are defined as inner contact portions 6 (and the length of the contact portions in the pipe-circumferential direction is denoted as L1). In addition, contact areas between the outer-pipe inner wall and the outer wall of the heat transfer area enlargement pipe are defined as outer contact portions 7 (and the length of the contact portion in the pipe-circumferential direction is defined as L2). In addition, portions serving as fins between the inner contact portions 6 and the outer contact portions 7 (side wall surfaces in the projection-depression shape) are defined as fin portions 16. From the viewpoint of increasing the heat-transfer area by the heat transfer area enlargement pipe 3, the double pipe heat exchanger is preferably formed such that the inner contact portions 6 and the outer contact portions 7 are each brought into contact at one point (point contact) in the pipe cross section. The reduction of the contact areas increases, for example, the number of the fin portions 16 in a pipe circumference, a heat-transfer area per fin portion 16, and the like, increasing the heat-transfer area of the whole double pipe heat exchanger. Here, "points" as referred below do not mean mathematical points, which have no area or the like, but mean points that have areas to an extent of securing reliable contacts between the pipes. Note that the contacts will be described as the point contacts, but the contact areas are linear in the double pipe heat exchanger as a whole.

[0018] However, when the inner contact portions 6 are formed to be point contacts, the contact thermal resistance at each inner contact portions 6 is increased. This reduces the heat transfer coefficient K in the above-described Expression (2), resulting in the reduction of the amount of heat exchange Q. In addition, forming the inner contact portions 6 to be the point contacts may cause spots of poor contact. If there are spots at which, for example, the inner-pipe outer wall is not in contact with the inner wall of the heat transfer area enlargement pipe when the inner contact portions 6 are formed to be the point contacts, poor heat transfer occurs, which prevents many heat-transfer areas from being used efficiently.

[0019] Thus, in the double pipe heat exchanger of the first embodiment, the outer contact portions 7 are formed to be point contacts (the length L2 is reduced to zero) so as to expand the heat-transfer area. In addition, the inner contact portions 6 are formed to have a contact length in the pipe cross section (contact areas are to form surfaces in the double pipe heat exchanger as a whole).

[0020] As seen from the above, according to the double pipe heat exchanger of the first embodiment, the outer contact portions 7 are formed to be the point contacts so as to enlarge the heat-transfer area, and the inner contact portions 6 are formed to have the contact length, which enables the prevention of the poor contact between the inner-pipe outer wall and the inner wall of the heat transfer area enlargement pipe. This does not impair but can enhance a heat-transfer performance.

Second embodiment

[0021] The above-described double pipe heat exchanger of the first embodiment includes, as shown in Fig. 2, the heat transfer area enlargement pipe 3 having the projection-and-depression (undulating) shape, in the outer channel 5 formed between the outer pipe 1 and the inner pipe 2. In the heat transfer area enlargement pipe 3, as described in the first embodiment, the inner wall of the heat transfer area enlargement pipe is in contact with the inner-pipe outer wall, and the outer wall of the heat transfer area enlargement pipe is in contact with the outer-pipe inner wall. In addition, the fin portions 16 to be the side walls traverse the outer channel 5 in the pipe cross section.

[0022] To manufacture the double pipe heat exchanger in which the heat transfer area enlargement pipe 3 is brought into contact with the outer pipe 1 and the inner pipe 2 in such a manner, a step of expanding the inner pipe 2 or a step of shrinking the outer pipe 1 is performed after the heat transfer area enlargement pipe 3 is inserted into the outer channel 5.

[0023] Here, if portions of the heat transfer area enlargement pipe 3 to be the fin portions 16 are formed to be perpendicular to the outer pipe 1 and the inner pipe 2, forces applied to portions to be the inner contact portions 6 or the outer contact portions 7 are applied directly to the fin portions 16, in expanding or shrinking the pipe. This incurs the risk of forming the fin portions 16 bent into an unexpected shape. For this reason, the portions to be the fin portions 16 are formed not to be perpendicular, reducing loads posed on the portions to be the fin portions 16 in expanding or shrinking the pipe. Then, the fin portions 16 are brought into contact with the inner-pipe outer wall and the outer-pipe inner wall in oblique directions. For example, when the outer contact portions 7 are formed to be the point contacts like the above-described first embodiment, as shown in Fig. 2, an angle α at which the inner-pipe outer wall comes into contact with the inner wall of the heat transfer area enlargement pipe and an angle β at which the outer wall of the heat transfer area enlargement pipe comes into contact with the outer-pipe inner wall are made to be angles less than 90 degrees, although this is not in particular intended to limit the angles.

[0024] Fig. 3 is a diagram for illustrating a lift of the heat transfer area enlargement pipe 3. For example, when the step of expanding or shrinking the pipe is performed, pressures more than necessary act on the inner pipe 2 and the heat transfer area enlargement pipe 3, the inner contact portions 6 of the heat transfer area enlargement pipe 3 may be deformed, and middle portions thereof, which should be in contact, may be lifted. The occurrence of the lift may increase, for example, the contact thermal resistance, which may impair a heat-transfer performance.

[0025] Thus, for example, to prevent this lift, the fin portions 16 are brought into contact with the inner-pipe outer wall and the outer-pipe inner wall in the oblique directions, and in addition, the heat transfer area enlargement pipe 3 to be inserted into the outer channel 5 of the double pipe heat exchanger is made to have a shape in which the portions to be the fin portions 16, between the portions to be the inner contact portions 6 (depressed portions) and the portions to be the outer contact portions 7 (projecting portions), are formed into arc shapes in the pipe cross section. Forming such a shape allows the heat transfer area enlargement pipe 3 to be deformed to bend, spreading (absorbing) loads on the heat transfer area enlargement pipe 3 even when the heat transfer area enlargement pipe 3 is pressed excessively against the inner pipe 2 in expanding the inner pipe 2 or shrinking the outer pipe 1. For this reason, also in the inner contact portions 6, unreasonable forces are not applied to the heat transfer area enlargement pipe 3, which can prevent a lift. This does not lose but can enhance a heat-transfer performance.

[0026] Here, directions in which the portions to be the fin portions 16 are bent through expanding or shrinking are preferably directions in which the formed fin portions 16 project toward the inner pipe 2 side. By forming the projections toward the inner pipe 2 side, the fin portions 16 are deformed toward the inner pipe 2 side, increasing the contact areas between the fin portions 16 and the inner pipe 2, which enlarges the inner contact portions 6 in length. Heat can be thereby efficiently transmitted from the inner pipe 2. In addition, for example, as shown in Fig. 2, the angle α < the angle β is satisfied, which reduces gaps between the heat transfer area enlargement pipe 3 and the inner pipe 2 in size. Therefore, for example, in brazing the inner contact portion 6, a brazing material is easy to penetrate. This allows heat to be further efficiently transmitted from the inner pipe 2. In addition, the increase of the angle β weakens pressing force in the contact areas between the fin portions 16 and the outer pipe 1, which can suppress the enlargement of the outer contact portions 7 in size.

[0027] Here, it is assumed in the present embodiment that the shape of the heat transfer area enlargement pipe 3 is the arc shape, but is not limited to the arc shape, and a shape having a bent portion at least at one point can bring the advantages of scattering the loads on the portions to be the fin portions 16 and of preventing a lift in the inner contact portions 6. In addition, the above description similarly holds in a double pipe heat exchanger in which, for example, the outer contact portions 7 are not the point contact, and similar advantages can be brought.

Third embodiment

[0028] Fig. 4 is a diagram showing a double pipe heat exchanger according to a third embodiment of the present invention. Fig. 4 shows a pipe cross section similar to the A-A' section in Fig. 1 described in the first embodiment. The double pipe heat exchanger of the present embodiment is configured such that the length L1 of the inner contact portions 6 between the inner-pipe outer wall and the inner wall of the heat transfer area enlargement pipe and the length L2 of the outer contact portions 7 between the outer-pipe inner wall and the outer wall of the heat transfer area enlargement pipe satisfy $L1 > L2$.

[0029] For example, if the relationship of L1 and L2 is $L1 < L2$, end points of the inner contact portion 6 may serve as fulcra to generate deformation when excessive external forces are applied to the outer pipe 1, the inner pipe 2, and the heat transfer area enlargement pipe 3. For this reason, as described in the second embodiment, in the heat transfer area enlargement pipe 3, the middle portion of the inner contact portion 6 may be lifted from the inner pipe 2, resulting in the loss of heat-transfer performance.

[0030] Thus, by satisfying $L1 > L2$, for example, like the first embodiment, even when external forces are applied so as to bring the outer pipe 1 into intimate contact with the heat transfer area enlargement pipe 3 across the outer contact portions 7 each having a contact length when viewed from the front of the pipe cross section, forces applied to the outer contact portions 7 are scattered, which prevents the pipes from being deformed.

[0031] In addition, by satisfying $L1 > L2$, when external forces are applied so as to bring the inner pipe 2 into intimate contact with the heat transfer area enlargement pipe 3, and to bring the outer pipe 1 into intimate contact with the heat transfer area enlargement pipe 3, external forces applied to the inner contact portions 6 are substantially identical to external forces applied to the outer contact portions 7, and thus the outer contact portions 7 are first deformed when excessive external forces are applied. This can prevent the inner contact portions 6, which are most important to reduce the contact thermal resistance, from being lifted, and does not lose but can enhance a heat-transfer performance.

[0032] Next, with respect to the double pipe heat exchanger according to the third embodiment having such characteristics, conditions of shape parameters to satisfy L1 > L2 will be considered.

[0033] Fig. 5 is a diagram showing parameters that are set for shape analysis of the double pipe heat exchanger according to the third embodiment of the present invention. As shown in Fig. 5, the number of projecting portions (depressed portions) of the heat transfer area enlargement pipe 3 is denoted by n, and the outer diameter of the inner-pipe is denoted by dio, and the inner diameter of the outer pipe is denoted by doi.

[0034] In addition, θ0 denotes an angle between the top of a projecting portion of the heat transfer area enlargement pipe 3 and the top of the next projecting portion, θ1 denotes an angle that serves as a guide for forming the projecting portions, and θ2 denotes an angle that serves as a guide for forming the depressed portions. In addition, θ1' denotes a number b of angles each of which is θ1 divided by a (θ1' = b/a x θ1), and θ2' denotes a number b of angles each of which is θ2 divided by a (θ2' = b/a x θ2). Furthermore, a length along which the inner pipe 2 is in contact with the heat transfer area enlargement pipe 3 is denoted by L1, and a length along which the outer pipe 1 is in contact with the heat transfer area enlargement pipe 3 is denoted by L2. Here, it is assumed that the shape of the projecting portions and the shape of the depressed portions are all an identical shape in the heat transfer area enlargement pipe 3. Then, θ0, θ1, θ2, θ1', and θ2' are geometrically represented by Expressions (3) to (6).

[0035] [Expression 3]

$$\theta o = 360/n \quad \cdots (3)$$

[0036] [Expression 4]

$$\theta 2 + \theta 1 = \theta o = 360/n \quad \cdots (4)$$

[0037] [Expression 5]

$$\theta 1' = b/a \cdot \theta 1 \quad \cdots (5)$$

[0038] [Expression 6]

$$\theta 2' = b/a \cdot \theta 2 \quad \cdots (6)$$

[0039] In addition, the length L1 of the inner contact portions 6 and the length L2 of the outer contact portions 7 can be represented by Expressions (7) and (8) respectively.

[0040] [Expression 7]

$$L1 = \pi \cdot 2dio \cdot (\theta 1'/360) \quad \cdots (7)$$

[0041] [Expression 8]

$$L2 = \pi \cdot 2doi \cdot (\theta 2'/360) \quad \cdots (8)$$

[0042] Based on Expressions (3) to (8), the conditions to satisfy L1 > L2 can be represented by Expression (9).

[0043] [Expression 9]

$$\theta 1 > (360/n) \cdot \{doi/(dio + doi)\}\} \quad \cdots (9)$$

[0044] As described above, according to the double pipe heat exchanger of the third embodiment, the length L1 of the inner contact portions 6 between the inner-pipe outer wall and the inner wall of the heat transfer area enlargement pipe, the length L2 of the outer contact portions 7 between the outer-pipe inner wall and the outer wall of the heat transfer area enlargement pipe are made to have the relationship of L1 > L2, and thus the external forces applied to the outer contact portions 7 can be scattered. In addition, by making the external forces applied to inner contact portions 6 substantially identical to the external forces applied to outer contact portions 7, excessive external forces are not applied only to the inner contact portions 6 but scattered, which can prevent a lift in the inner contact portions 6. The above enables the prevention of excessive deformation of each pipe.

Fourth embodiment

[0045] Although not in particular described in the above-described first to third embodiments, it is preferable that each contact area is brazed with a brazing material 15 so as to further secure the contact between the inner-pipe outer wall and the inner wall of the heat transfer area enlargement pipe, and the contact between the outer-pipe inner wall and the outer wall of the heat transfer area enlargement pipe.

[0046] Fig. 6 is a diagram showing brazed portions according to a fourth embodiment of the present invention. For example, after assembling the inner pipe 2, the outer pipe 1, and the heat transfer area enlargement pipe 3, a brazing material 15 or the like is applied, furnace brazing or the like is performed to melt the brazing material 15, brazing contact portions. For example, if the pipes are made of an aluminum or the like, an Al-Si-based (aluminum-silicon-based) alloy in which an aluminum is alloyed with a silicon is used as the brazing material 15.

[0047] Here, if it is difficult to apply the brazing material 15 after the assembly, a cladding material in which the heat transfer area enlargement pipe 3 is clad in (covered with) the brazing material 15 in advance may be used.

Fifth embodiment

[0048] In a fifth embodiment, there will be described an example of a refrigeration cycle device to which the double pipe heat exchanger described in the first to fourth embodiments is applied. Here, four kinds of configurations of the refrigeration cycle device will be described.

[0049] Fig. 7 is a diagram showing examples of the configurations of the refrigeration cycle devices according to the fifth embodiment. In each refrigeration cycle device of the present embodiment, a compressor 8, a condensor 9, an expansion valve 10, an evaporator 11, and a double pipe heat exchanger 12 are connected with pipes to configure a refrigerant circuit.

[0050] The compressor 8 sucks and compresses a refrigerant, and discharges the refrigerant at a high temperature and pressure. Here, the compressor 8 may be configured by, for example, a compressor that controls a rotation speed with an inverter circuit or the like to adjust the amount of discharged refrigerant. The condensor 9 to be a heat exchanger is for performing heat exchange between, for example, air supplied from a blower (not shown) and the refrigerant to condense the refrigerant into a liquid refrigerant (to condense and liquefy the refrigerant).

[0051] In addition, the expansion valve (pressure-reducing valve or throttle) 10 is for decompressing and expanding the refrigerant. The expansion valve is configured by, for example, flow control means such as an electronic expansion valve, and may be configured by, for example, refrigerant amount adjusting means or the like such as an expansion valve and a capillary including a temperature sensitive cylinder. The evaporator 11 is for performing heat exchange between air or the like to evaporate the refrigerant into a gas refrigerant (to evaporate and gasify).

[0052] In addition, the double pipe heat exchanger 12 of the refrigeration cycle device in Fig. 7(a) performs heat exchange between a refrigerant at a high temperature and pressure flowing from the condensor 9 and a refrigerant at a low temperature and pressure flowing from the evaporator 11. Using the double pipe heat exchanger 12 in such a manner enables increasing the temperature of the refrigerant in the condensor 9. It is thereby possible to enhance a capability in heating, and to increase a COP (Coefficient Of Performance: a value obtained by dividing a capability by an input). In addition, the refrigerant flowing from the evaporator 11 can be gasified, which can prevent the liquid refrigerant from returning to the compressor 8.

[0053] The double pipe heat exchanger 12 of a refrigeration cycle device in Fig. 7(b) performs heat exchange between a high-pressure liquid refrigerant at a refrigerant outlet of the condensor 9 and a middle-pressure two-phase refrigerant that has passed through the flow control valve 13. Then, the refrigerant that has been subjected to the heat exchange and has changed into a middle-pressure gas refrigerant is caused to perform bypassing to a suction-side pipe to the compressor 8.

[0054] In such a manner, the refrigeration cycle device in Fig. 7(b) causes the refrigerant that has passed through the condensor 9 to diverge before passing through the expansion valve 10 and to perform bypassing using the double pipe heat exchanger 12, which can reduce the amount of refrigerant flowing downstream side from the expansion valve 10. It is thereby possible to reduce pressure drop, increasing the COP.

[0055] The double pipe heat exchanger 12 of the refrigeration cycle device in Fig. 7(c) performs heat exchange between a high-pressure liquid refrigerant at the refrigerant outlet of the condensor 9 and a middle-pressure two-phase refrigerant that has passed through the flow control valve 13. Then, the refrigerant that has been subjected to the heat exchange and has changed into a middle-pressure gas refrigerant is injected into a middle portion of a compression part of the compressor 8. Here, the compressor 8 of the refrigeration cycle device in Fig. 7(c) is a compressor having a multistage configuration that can perform the injection.

[0056] In such a manner, the refrigeration cycle device in Fig. 7(c) causes the refrigerant that has passed through the condensor 9 to diverge before passing through the expansion valve 10 and to perform bypassing using the double pipe heat exchanger 12, which can reduce the amount of refrigerant flowing downstream side from the expansion valve 10. In addition, the injection into the middle portion of the compressing part of the compressor 8 having the multistage configuration can be performed, and thus an input such as the discharge temperature of the compressor can be reduced, increasing the COP.

[0057] The refrigeration cycle device in Fig. 7(d), the double pipe heat exchanger 12 is used as a condensor. Then, a fluid to be subjected to heat exchange with a refrigerant flowing through a refrigerant circuit is assumed to be water, brine, or the like (hereafter, the description will be made assuming that the fluid is water).

[0058] In Fig. 7(d), a pump 14 forms the flow of water and supplies the water into the double pipe heat exchanger 12. In the double pipe heat exchanger 12, the water is heated through the heat exchange with the refrigerant. Here, the double pipe heat exchanger 12 is used as the condensor, and can be used as an evaporator.

Reference Signs List

[0059] 1 outer pipe 2 inner pipe 3 heat transfer area enlargement pipe 4 inner channel 5 outer channel 6 inner contact portion 7 outer contact portion 8 compressor 9 condensor 10 expansion valve 11 evaporator 12 double pipe heat exchanger 13 flow control valve 14 pump 15 brazing material 16 fin portion.

Claims

1. A double pipe heat exchanger comprising:

an inner pipe inside which a first fluid passes;
an outer pipe that has a diameter larger than a diameter of the inner pipe and that covers the inner pipe, the inner pipe and the outer pipe configured to allow a second fluid to pass through a space defined therebetween; and
a heat transfer area enlargement pipe that is provided in the space and that has a projection-depression shape in a pipe cross section in which a length in a pipe-circumferential direction of inner contact portions to be contact areas with an outer wall of the inner-pipe is made to be larger than a length in a pipe-circumferential direction of outer contact portions to be contact areas with an inner wall of the outer-pipe, and in addition, fin portions between the inner contact portions and the outer contact portions that traverse the space in the pipe cross section come into contact with the outer wall of the inner-pipe and the inner wall of the outer-pipe in oblique directions.

2. The double pipe heat exchanger of claim 1, wherein the fin portions each have an arc shape in the pipe cross section.

3. The double pipe heat exchanger of claim 1 or 2, wherein the fin portions each have a bent shape that projects toward the inner pipe side in the pipe cross section.

4. The double pipe heat exchanger of any one of claims 1 to 3, wherein, in the pipe cross section, an angle between the heat transfer area enlargement pipe and the outer wall of the inner-pipe at each inner contact portion is smaller than an angle between the heat transfer area enlargement pipe and the inner wall of the outer-pipe at each outer contact portion.

5. The double pipe heat exchanger of any one of claims 1 to 4, wherein the contact portions are formed such that the outer contact portions are made to be point contacts in the pipe cross section, and the inner contact portions are made to be line contacts in the pipe cross section.

6. The double pipe heat exchanger of any one of claims 1 to 5, wherein the heat transfer area enlargement pipe is formed so as to satisfy

$$\theta 1 > (360 / n) \times \{doi / (dio + doi)\}$$

where $\theta 1$ is an angle formed between both end portions of the outer contact portion and the center of the inner pipe and the outer pipe, dio is an outer diameter of the inner pipe, doi is an inner diameter of the outer pipe, n is a number of projecting shapes or depressed shapes of the heat transfer area enlargement pipe, and the projecting shapes and the depressed shapes all have an identical shape.

7. The double pipe heat exchanger of any one of claims 1 to 6, wherein the outer contact portions and the inner contact portions are each brazed.

8. The double pipe heat exchanger of claim 7, wherein the heat transfer area enlargement pipe is formed by a cladding material having a surface covered with a brazing material.

9. A refrigeration cycle device that performs heat exchange between two kinds of refrigerants using the double pipe heat exchanger of any one of claims 1 to 8.

10. The refrigeration cycle device of claim 9, wherein at least one of the refrigerants is water or brine.

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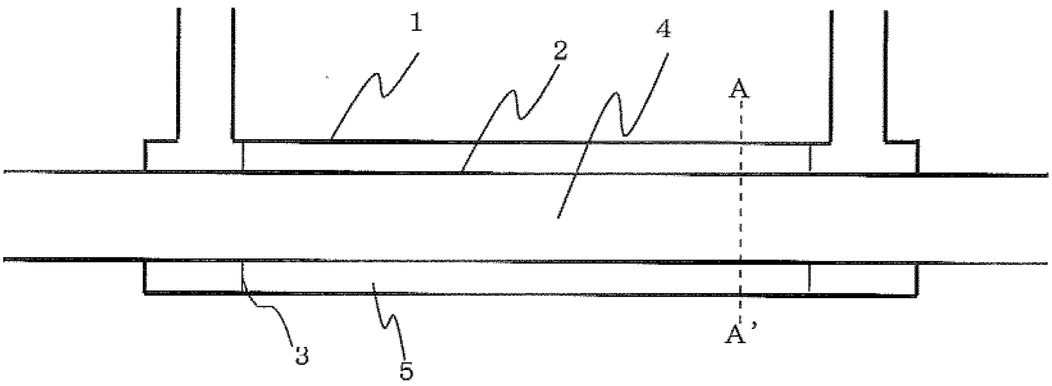

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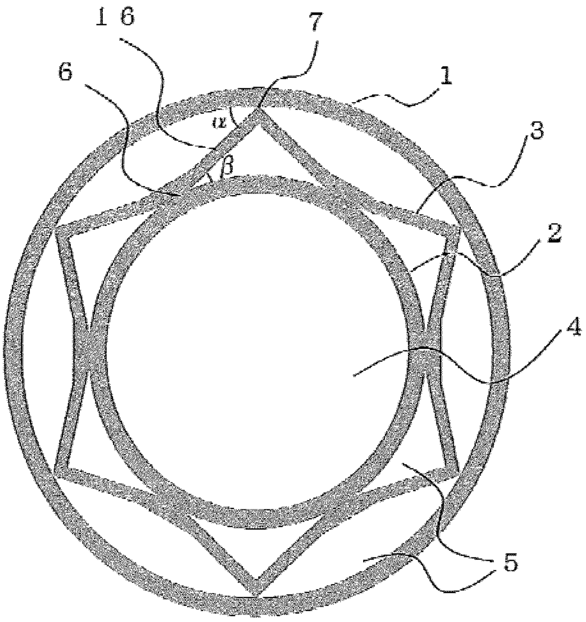

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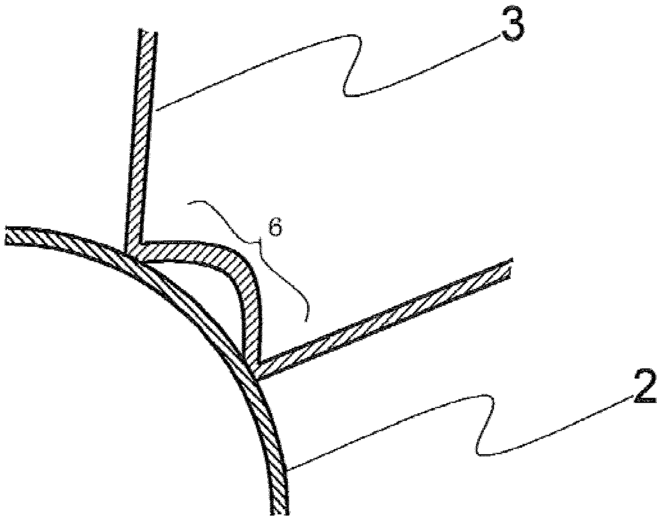
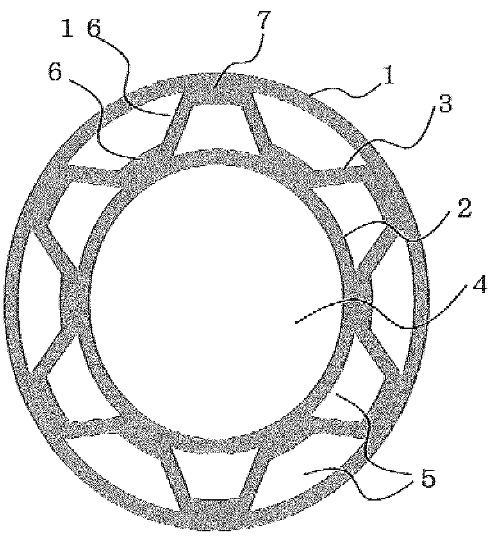
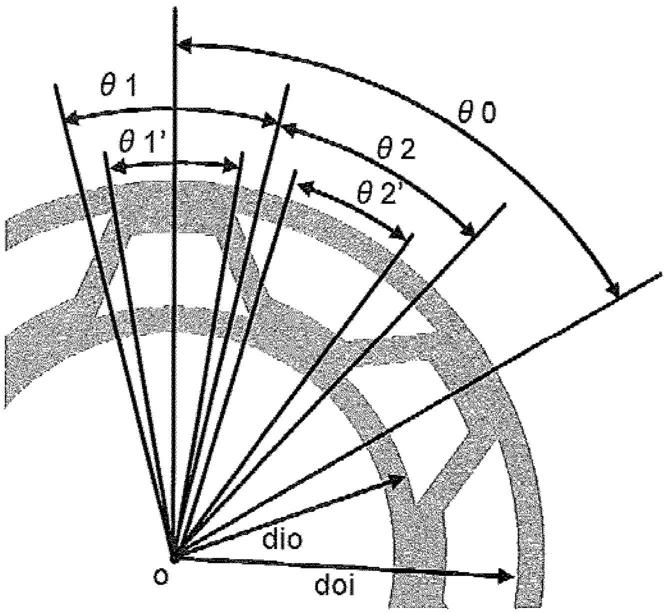


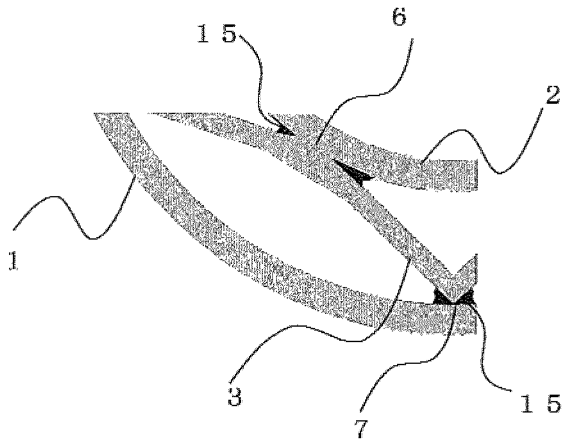
ＦＩＧ．４



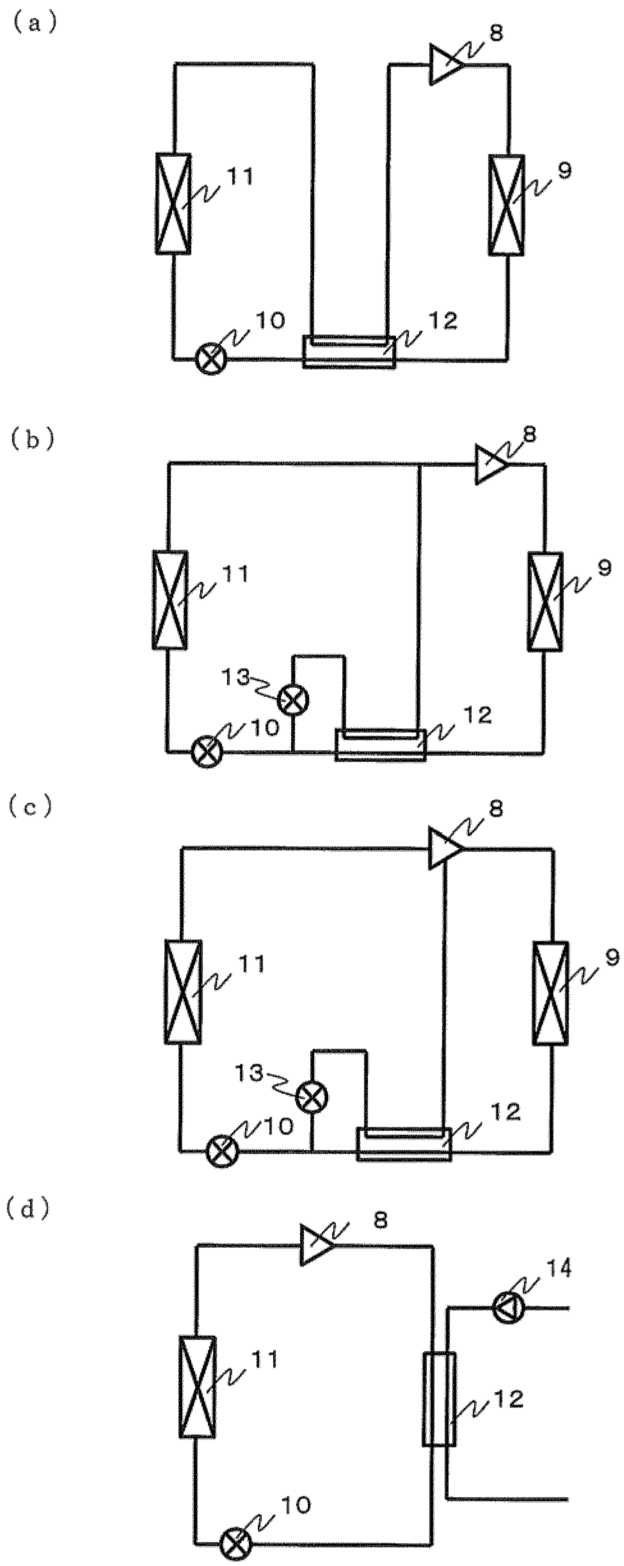
ＦＩＧ．５



ＦＩＧ．６



ＦＩＧ. ７



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/073688

A. CLASSIFICATION OF SUBJECT MATTER
F28D7/10(2006.01)i, *F28F1/40*(2006.01)i, *F28F13/12*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28D7/10, F28F1/40, F28F13/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 2756032 A (Alvis Yates Dowell), 24 July 1956 (24.07.1956), entire text; all drawings (particularly, specification, page 1, column 1, line 15 to column 2, line 61; fig. 1, 3 to 7) (Family: none)	1-3,5-6 7-10 4
Y	JP 2000-79462 A (Maruyasu Industries Co., Ltd.), 21 March 2000 (21.03.2000), entire text; all drawings (particularly, paragraphs [0021], [0037]; fig. 15) (Family: none)	7-8

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 November, 2013 (28.11.13)	10 December, 2013 (10.12.13)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/073688

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 92279/1986(Laid-open No. 204170/1987) (Moji Shinkan Kogyo Kabushiki Kaisha), 26 December 1987 (26.12.1987), entire text; all drawings (particularly, specification, page 6, lines 4 to 13; page 7, line 20 to page 8, line 5, fig. 7; fig. 1 to 3) (Family: none)	9-10
Y	JP 2006-317096 A (Mitsubishi Electric Corp.), 24 November 2006 (24.11.2006), entire text; all drawings (particularly, paragraphs [0011], [0016], [0026], [0029] to [0031]; fig. 1, 4, 5, 7, 9) (Family: none)	9-10

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/073688

1. The expression in claim 6, "θ1 > (360/n)·{doi/(dio + doi)}," is a typographical error for the expression "θ1 < (360/n)·{doi/(dio + doi)}."

Reason: [Equation 7] in [0039] is not L1 = π·2dio·θ1'/360) but L1 = π·2dio·θ2'/360) because it is defined in paragraph [0033] of the description that L1 is the length along which an inner pipe (2) and an increased heat transfer area pipe (3) are in contact with each other and L2 is the length along which an outer pipe (1) and the increased heat transfer area pipe (3) are in contact with each other.

On the other hand, [Equation 8] in [0040] is not L2 = π·2doi·θ2'/360) but L2 = π·2doi·θ1'/360).

From these equations and the expression stated in the description ([Equation 3] - [Equation 6]), it can be determined that θ1 < (360/n)·{doi/(dio + doi)}.

2. Symbols "α" and "β" indicated in Fig. 2 are a typological error for "β" and "α," respectively.

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2012063067 A **[0003]**