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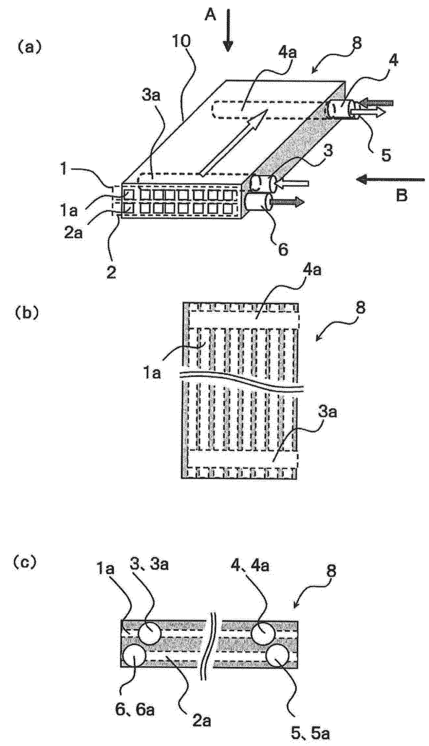
(54) HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE PROVIDED THEREWITH

(57) A compact, readily-manufacturable heat exchanger and a refrigeration cycle apparatus equipped with the same are provided.

One of opposite ends of a main body (10) in a refrigerant flowing direction is provided with a first inlet communication hole (3a) that extends in a direction of arrangement of first refrigerant channels (1a) and that communicates with all of the first refrigerant channels (1a). The other end is provided with a first outlet communication hole (4a) that extends in the direction of arrangement of the first refrigerant channels (1a) and that communicates with all of the first refrigerant channels (1a).

FIG. 1



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Description

Technical Field :

[0001] The present invention relates to a heat exchanger that exchanges heat between a first refrigerant and a second refrigerant and to a refrigeration cycle apparatus equipped with the heat exchanger.

Background Art

[0002] Heat exchangers in the conventional art include a first flat pipe having a flat shape and a plurality of through-holes through which a high-temperature refrigerant flows, a second flat pipe having a flat shape and a plurality of through-holes through which a low-temperature refrigerant flows, first headers connected to opposite ends of the first flat pipe, and second headers connected to opposite ends of the second flat pipe.

[0003] The first flat pipe and the second flat pipe longitudinally extend in parallel to each other (i.e., in a refrigerant flowing direction), and the flat surfaces thereof are stacked in contact with each other by, for example, brazing, whereby high heat exchanging performance is achieved (e.g., see Patent Literature 1).

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication JP-A-2002-340 485 (page 8, FIG. 1)

Summary of Invention

Technical Problem

[0005] However, because the flat pipes are joined to each other in the heat exchanger described above, the joint surfaces act as thermal resistance, which is a problem in that the heat exchanging performance deteriorates.

[0006] Moreover, when the joining process is performed by brazing, for example, voids tend to form between the joint surfaces, which may problematically lead to deterioration in the heat exchanging performance.

[0007] Furthermore, when the joining process between the headers and the flat pipes and the joining process between the two flat pipes are to be performed simultaneously by brazing, the entire heat exchanger needs to be controlled to a uniform temperature during the process, the gaps between the headers and the flat pipes suitable for brazing need to be controlled with high precision, and so on. This is a problem in that the manufacturing process of the heat exchanger is complicated and difficult.

[0008] In addition, if multiple layers are to be stacked for increasing the heat exchanging capacity, there is a problem in terms of, for example, interference of the headers.

[0009] The present invention has been made to solve the aforementioned problems, and a first object thereof is to provide a compact, readily-manufacturable heat exchanger and a refrigeration cycle apparatus equipped with the same.

[0010] A second object of the present invention is to provide a heat exchanger and a refrigeration cycle apparatus with enhanced heat exchanging performance.

Solution to Problem

[0011] A heat exchanger according to the present invention includes a first refrigerant path in which a plurality of first refrigerant channels through which a first refrigerant flows are arranged in a single row; a second refrigerant path in which a plurality of second refrigerant channels through which a second refrigerant flows are arranged in a single row; first communication holes that are formed at opposite ends of the first refrigerant path, extend through in a direction of arrangement of the plurality of first refrigerant channels, and communicate with all of the first refrigerant channels; and second communication holes that are formed at opposite ends of the second refrigerant path, extend through in a direction of arrangement of the plurality of second refrigerant channels, and communicate with all of the second refrigerant channels.

[0012] The first refrigerant flows into one of the first communication holes formed at the opposite ends of the first refrigerant path, flows through the first refrigerant channels, and flows outside via the other first communication hole.

The second refrigerant flows into one of the second communication holes formed at the opposite ends of the second refrigerant path, flows through the second refrigerant channels, and flows outside via the other second communication hole.

[0013] The first refrigerant channels and the second refrigerant channels extend in parallel to each other and are disposed adjacent to each other, and the first refrigerant and the second refrigerant exchange heat via a partition at adjacent surfaces of the first refrigerant channels and the second refrigerant channels.

Advantageous Effects of Invention

[0014] According to the present invention, since the first communication holes and the second communication holes are provided within the heat exchanger, additional header pipes for connecting to the first refrigerant path and the second refrigerant path do not need to be provided, whereby the heat exchanger can be made compact and the manufacturing process can be simplified.

Brief Description of Drawings

[0015]

FIG. 1 illustrates the structure of a heat exchanger 8 according to Embodiment 1 of the present invention.
FIG. 2 illustrates the structure of a heat exchanger 8a according to Embodiment 2 of the present invention.
FIG. 3 illustrates the structure of a heat exchanger 8b according to Embodiment 3 of the present invention.
FIG. 4 illustrates the structure of a heat exchanger 8c according to Embodiment 4 of the present invention.
FIG. 5 illustrates the structure of a heat exchanger 8d according to Embodiment 5 of the present invention.
FIG. 6 is a refrigerant circuit diagram illustrating an example of a refrigeration cycle apparatus, according to Embodiment 6 of the present invention.
FIG. 7 is a refrigerant circuit diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 7 of the present invention.
FIG. 8 is a refrigerant circuit diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 8 of the present invention.

Description of Embodiments

Embodiment 1

Configuration of Heat Exchanger 8

[0016] FIG. 1 illustrates the structure of a heat exchanger 8 according to Embodiment 1 of the present invention. Specifically, FIG. 1 (a) is a perspective view of the heat exchanger 8, FIG. 1(b) is a plan view as viewed in a direction indicated by an arrow A in FIG. 1 (a), and FIG. 1 (c) is a side view as viewed in a direction indicated by an arrow B in FIG. 1 (a).

[0017] As shown in FIG. 1, a main body 10 of the heat exchanger 8 according to Embodiment 1 has a first refrigerant path 1 that extends through the main body 10 in the longitudinal direction thereof and that is formed by arranging a plurality of first refrigerant channels 1a, through which a first refrigerant (e.g., high-temperature refrigerant) flows, in a single row.

[0018] Moreover, a second refrigerant path 2 extending through the main body 10 in the longitudinal direction and formed by arranging a plurality of second refrigerant channels 2a, through which a second refrigerant (e.g., low-temperature, refrigerant) flows, in a single row is formed adjacent to the first refrigerant channels 1a of the first refrigerant path 1.

[0019] Therefore, the first refrigerant path I and the second refrigerant path 2 are integrally formed in the main body 10. The main body 10 having the first refrigerant path I and the second refrigerant path 2 is composed of, for example, aluminum, an aluminum alloy, copper, a copper alloy, steel, or a stainless alloy and is manufactured by, for example, extrusion or pultrusion molding.

[0020] One of the opposite ends of the main body 10 in the refrigerant flowing direction is provided with a first inlet communication hole 3a that extends in the direction of arrangement of the first refrigerant channel 1a and that communicates with all of the first refrigerant channels 1a. The other end is provided with a first outlet communication hole 4a that extends in the direction of arrangement of the first refrigerant channels 1a and that communicates with all of the first refrigerant channels 1a.

[0021] Furthermore, of the opposite ends of the main body 10 in the refrigerant, flowing direction, the end that is provided with the first outlet communication hole 4a is provided with a second inlet communication hole 5a that extends in the direction of arrangement of the second refrigerant channels 2a and that communicates with all of the second refrigerant channels 2a.

[0022] Of the opposite ends of the main body 10 in the refrigerant flowing direction, the end that is provided with the first inlet communication hole 3a is provided with a second outlet communication hole 6a that extends in the direction of arrangement of the second refrigerant channels 2a and that communicates with all of the second refrigerant channels 2a.

[0023] The first inlet communication hole 3a and the second outlet communication hole 6a are slightly displaced from each other in the refrigerant flowing direction of the first refrigerant channels 1a (or the second refrigerant channels 2a). Moreover, the first outlet communication hole 4a and the second inlet communication hole 5a are slightly displaced from each other in the refrigerant flowing direction of the first refrigerant channels 1a (or the second refrigerant) channels 2a).

[0024] The extending direction of the first inlet communication hole 3a and the first outlet communication hole 4a does not necessary need to be orthogonal to the direction of the first refrigerant channels 1a. Moreover, the extending direction of the second inlet communication hole 5a and the second outlet communication hole 6a does not necessary need to be orthogonal to the direction of the second refrigerant channels 2a.

[0025] First ends of the first inlet communication hole 3a, the first outlet communication hole 4a, the second inlet communication hole 5a, and the Second outlet communication hole 6a are open and are connected to a first inlet connection pipe 3, a first outlet connection pipe 4, a second inlet connection pipe 5, and a second outlet connection pipe 6, respectively, so as to communicate with the outside. Second ends of the first inlet communication hole 3a, the first outlet communication hole 4a, the second inlet communication hole 5a, and the second outlet communication hole 6a are closed by, for example, sealing members.

[0026] As shown in FIG. 1, the open (or closed) ends of the first inlet communication hole 3a, the first outlet communication hole 4a, the second inlet communication hole 5a, and the second outlet communication hole 6a are all disposed at the same side. However, the configuration is not limited to this; the open (or closed) ends do not need to be disposed at the same side so long as each communication hole has one end that is open and the other end that is closed.

[0027] The opposite ends of the first refrigerant channels 1a and the second refrigerant channels 2a extending through the main body 10 in the longitudinal direction thereof are sealed by, for example, pinching or by using scaling members (not shown).

[0028] The first inlet communication hole 3a and the first outlet communication hole 4a correspond to "first communication holes" according to the present invention, and the second inlet communication hole 5a and the second outlet communication hole 6a correspond to "second communication holes" according to the present invention.

<u>Heat Exchanging Operation of Heat Exchanger 8</u>

[0029] Next, a heat exchanging operation between the first refrigerant and the Second refrigerant in the heat exchanger 8 will be described with reference to FIG. 1.

[0030] The first refrigerant flows into the first inlet communication hole 3a via the first inlet connection pipe 3, flows through the first refrigerant path I and the first outlet communication hole 4a in that order, and then flows out from the first outlet connection pipe 4. The second refrigerant flows into the second inlet communication hole 5a via the second inlet connection pipe 5, flows through the second refrigerant path 2 and the second outlet communication hole 6a in that order, and then flows out from the second outlet connection pipe 6. During that time, the first refrigerant flowing through the first refrigerant path 1 and the second refrigerant flowing through the second refrigerant path 2 exchange heat in a countercurrent manner via a partition between the two refrigerant paths.

<u>Advantages of Embodiment 1</u>

[0031] In the heat exchanger 8 having the above-described configuration, since the first refrigerant path 1 and the second refrigerant path 2 are integrally formed in the main body 10, thermal resistance occurring at joint surfaces in a case where a pipe through which the first refrigerant flows and a pipe through which the second refrigerant flows are separately provided is suppressed, thereby allowing for enhanced heat exchanging performance.

[0032] Furthermore, because the first inlet communication hole 3a and the first outlet communication hole 4a are provided within the main body 10 of the heat exchanger 8, no additional header pipe for connecting to the first refrigerant path 1 needs to be provided, whereby the heat exchanger 8 can be made compact and the manufacturing process can be simplified. This similarly applies to the second inlet communication hole 5a and the second outlet communication hole 6a with respect to the second refrigerant path 2.

[0033] Furthermore, because the first inlet communication hole 3a and the second outlet communication hole 6a are slightly displaced from each other in the refrigerant flowing direction and the first outlet communication hole 4a and the second inlet communication hole 5a are also slightly displaced from each other in the refrigerant flowing direction, the distance between the adjoining first and second refrigerant paths 1 and 2 can be reduced, as compared with a case where such displacement configuration is not used, whereby the heat exchanger 8 can be made compact.

[0034] Although the first refrigerant channels 1a and the second refrigerant channels 2a each have a rectangular shape in cross section, as shown in FIG. 1, the cross-sectional shape is not limited to this, for example, the cross-sectional shape may be polygonal, circular for increasing pressure resistibility, elongated, or ellipsoidal. In this case, it is needless to say that the cross-sectional shape of the first refrigerant channels 1a and the cross-sectional shape of the second refrigerant channels 2a do not need to be the same.

[0035] Moreover, in order to enhance heat transferability, the heat transfer area of each refrigerant path may be increased by providing a groove in the inner surface thereof. In this case, the grooves may be formed simultaneously with the extrusion and pultrusion molding process of the heat exchanger 8 so that the manufacturing process can be simplified.

[0036] Furthermore, although the first refrigerant path 1 and the second refrigerant path 2 have the same number of refrigerant channels, as shown in FIG. 1, the configuration is not limited to this. Specifically, the two paths may have a different number of refrigerant channels in accordance with the operating conditions and the physical flow properties of the refrigerants in the heat exchanger 8 so that a favorable heat exchanger with high heat transferability and low pressure loss can be obtained.

[0037] Furthermore, although the first refrigerant path 1 and the second refrigerant path 2 are integrally formed in the main body 10, as shown in FIG. 1, the configuration is not limited to this. Specifically, if the first refrigerant path I and the second refrigerant path 2 are provided as separate pipes and are joined to each other by, for example, brazing, the first inlet communication hole 3a and the first outlet communication hole 4a may be provided in the pipe of the first refrigerant path I so that no additional header pipe for connecting to the refrigerant channels of the first refrigerant path 1 needs to be provided, whereby the heat exchanger can be made compact and the manufacturing process can be simplified. This similarly applies to a case where the second inlet communication hole 5a and the second outlet communication hole 6a are provided in the pipe of the second refrigerant path 2.

[0038] Furthermore, the first inlet connection pipe 3 and the first outlet connection pipe 4 may be formed by inserting pipes into the first inlet communication hole 3a and the first outlet communication hole 4a, respectively. Specifically, these inserted pipes have openings, such as slits, opening only in a direction from the first inlet communication hole 3a toward the first outlet communication hole 4a and in a direction from the first outlet communication hole 4a toward the first inlet communication hole 3a.

[0039] Thus, when the opposite ends of the first refrigerant channels 1a and the second refrigerant channels 2a are to be sealed by, for example, brazing using sealing members, the refrigerant channels can be prevented from being narrowed due to excess sealing members entering the refrigerant channels, thereby suppressing variations in production. The same effect can be achieved for the second inlet connection pipe 5 and the second outlet connection pipe 6 by applying the same configuration thereto.

[0040] Although the first refrigerant flowing through the first refrigerant path I and the second refrigerant flowing through the second refrigerant path 2 exchange heat in a countercurrent manner, the two refrigerants may alternatively exchange heat by flowing parallel to each other. For example, by making the first refrigerant flow in from the first inlet connection pipe 3 and the second refrigerant flow in from the second outlet connection pipe 6, the first refrigerant and the second refrigerant are made to flow parallel to each other.

Embodiment 2

[0041] A heat exchanger 8a according to Embodiment 2 will now be described by focusing mainly on differences from the configuration and the operation of the heat exchanger 8 according to Embodiment 1.

Configuration of Heat Exchanger 8a

[0042] FIG. 2 illustrates the structure of the heat exchanger 8a according to Embodiment 2 of the present invention.

[0043] As shown in FIG. 2, in the main body 10 of the heat exchanger 8a according to Embodiment 2, the first refrigerant path 1 through which the first refrigerant flows is constituted of the plurality of first refrigerant channels 1a arranged in a single row and a plurality of first refrigerant channels 1b that are arranged in a single row adjacent to the first refrigerant channels 1a. The second refrigerant path 2 through which the second refrigerant flows is constituted of the plurality of second refrigerant channels 2a arranged in a single row and a plurality of second refrigerant channels 2b that are arranged in a single row adjacent to the second refrigerant channels 2a,

[0044] In other words, the first refrigerant path 1 and the second refrigerant path 2 are each constituted of two sets of refrigerant channels, and the first refrigerant channels 1b in the first refrigerant path I and the second refrigerant, channels 2a in the second refrigerant path 2 are disposed adjacent to each other, as shown in FIG. 2.

[0045] One of the opposite ends of the main body 10 in the refrigerant flowing direction is provided with the first inlet communication hole 3a that extends in the direction of arrangement of the first refrigerant channels 1a (and the first refrigerant channels 1b) and that communicates with all of the first refrigerant channels 1a and the first refrigerant channels 1b.

[0046] The other end is provided with the first outlet communication hole 4a that extends in the direction of arrangement of the first refrigerant channels 1a (and the first refrigerant channels 1b) and that communicates with all of the first refrigerant channels 1a and the first refrigerant channels 1b.

[0047] Furthermore, of the opposite ends of the main body 10 in the refrigerant flowing direction, the end that is provided with the first outlet communication hole 4a is provided with the second inlet communication hole 5a that extends in the direction of arrangement of the second refrigerant channels 2a (and the second refrigerant channels 2b) and that communicates with all of the second refrigerant channels 2a and the second refrigerant channels 2b.

[0048] Of the opposite ends of the main body 10 in the refrigerant flowing directions, the end that is provided with the first inlet communication hole 3a is provided with the second outlet communication hole 6a that extends in the direction of arrangement of the second refrigerant channels 2a (and the second refrigerant channels 2b) and that communicates with all of the second refrigerant channels 2a and the second refrigerant channels 2b.

[0049] The opposite ends of the first refrigerant channels 1a, the first refrigerant channels. 1b, the second refrigerant channels 2a, and the second refrigerant channels 2b extending through the main body 10 in the longitudinal direction thereof are sealed by, for example, pinching or by using sealing members (not shown).

<u>Heat Exchanging Operation of Heat Exchanger 8a</u>

[0050] Next, a heat exchanging operation between the first refrigerant and the second refrigerant in the heat exchanger 8a will be described with reference to FIG. 2.

[0051] The first refrigerant flows into the first inlet communication hole 3a via the first inlet connection pipe 3, flows through the first refrigerant channels 1a and the first refrigerant channels 1b constituting the first refrigerant path 1, flows through the first outlet communication hole 4a, and then flows out from the first outlet connection pipe 4. The second refrigerant flows into the second inlet communication hole 5a via the second inlet connection pipe 5, flows through the second refrigerant channels 2a and the second refrigerant channels 2b constituting the second refrigerant path 2, flows through the second outlet communication hole 6a, and then flows out from the second outlet connection pipe 6.

[0052] During that time, the first refrigerant flowing through the first refrigerant channels 1a and the first refrigerant channels 1b and the second refrigerant flowing through the second refrigerant channels 2a and the second refrigerant channels 2b exchange heat in a countercurrent manner via a partition between the first refrigerant channels 1b and the second refrigerant channels 2a.

<u>Advantages of Embodiment 2</u>

[0053] In the heat exchanger 8a described above, even though the refrigerant paths are each constituted of multiple sets of refrigerant channels, the refrigerant channels are integrally formed. Therefore, in addition to the advantages of the heat exchanger 8 according to Embodiment I, thermal resistance occurring in a case where the refrigerant channels are separately formed is suppressed, thereby allowing for enhanced heat exchanging performance.

[0054] Furthermore, since each refrigerant path is constituted of two sets of refrigerant channels and these refrigerant channels converge on a single communication hole, the number of communication holes can be reduced, thereby simplifying the manufacturing process of the heat exchanger 8a.

[0055] Since a single communication hole is formed for converging two sets of refrigerant channels, the distance between the two sets of refrigerant channels of each refrigerant path can be reduced, whereby the heat exchanger 8a can be made compact.

[0056] Furthermore, since each refrigerant path is constituted of two sets of refrigerant channels, the heat exchanging capacity can be increased.

[0057] Although the number of refrigerant channels is the same among the first refrigerant channels 1a, the first refrigerant channels 1b, the second refrigerant channels 2a, and the second refrigerant channels 2b as shown in FIG. 2, the configuration is not limited to this.

[0058] Specifically, the number of refrigerant channels may be varied in accordance with the operating conditions and the physical flow properties of the refrigerants in the heat exchanger 8a so that a favorable heat exchanger with high heat transferability and low pressure loss can be obtained.

[0059] Furthermore, although each refrigerant path is constituted of two sets of refrigerant channels (e.g., the first refrigerant path 1 is constituted of two sets of refrigerant channels, i.e., the first refrigerant channels 1a and the first refrigerant channels 1b), as shown in FIG. 2, the configuration is not limited to this.

[0060] Specifically, for example, if the heat exchanging capacity is to be increased or if the pressure loss is to be reduced by increasing the channel area, each refrigerant path may be constituted of three or more sets of refrigerant channels. Moreover, the number of sets of refrigerant channels in the first refrigerant path 1 and the number of sets of refrigerant channels in the second refrigerant path 2 do not need to be the same.

[0061] Furthermore, the first inlet communication hole 3a and the second outlet communication hole 6a may be displaced from each other in the flowing direction of the first refrigerant path 1 (or the second refrigerant path 2), as in Embodiment 1. The same applies to the first outlet communication hole 4a and the second inlet communication hole 5a.

[0062] Accordingly, the distance between the adjoining first and second refrigerant paths 1 and 2 (i.e., the distance between the first refrigerant channels 1b and the second refrigerant channels 2a in FIG. 2) can be reduced, whereby the heat exchanger 8a can be made compact.

Embodiment 3

[0063] A heat exchanger 8b according to Embodiment 3 will now be described by focusing mainly on differences from the configuration and the operation of the heat exchanger 8 according to Embodiment 1.

Configuration of Heat Exchanger 8b

[0064] FIG. 3 illustrates the structure of the heat exchanger 8b according to Embodiment 3 of the present invention. Specifically, FIG. 3(a) is a perspective view of the heat exchanger 8b, FIG. 3(b) is a plan view as viewed in a direction indicated by an arrow A in FIG. 3(a), and FIG. 3(c) is a side view as viewed in a direction indicated by an arrow B in FIG. 3(a).

[0065] As shown in FIG. 3, in the main body 10 of the heat exchanger 8b according to Embodiment 3, the first refrigerant path I through which the first refrigerant flows is constituted of the plurality of first refrigerant channels 1a arranged in a single row and the plurality of first refrigerant channels 1b arranged in a single row. The second refrigerant path 2 through which the second refrigerant flows is constituted of the plurality of second refrigerant channels 2a arranged in a single row and the plurality of second refrigerant channels 2b arranged in a single row.

[0066] Moreover, the rows of the refrigerant channels in the first refrigerant path 1 and the rows of the refrigerant channels in the second refrigerant path 2 are alternately arranged. Specifically, as viewed in the direction of the arrow B in FIG. 3(a), the refrigerant channels are arranged in the following order from the top: the first refrigerant channels 1a, the second refrigerant channels 2a, the first refrigerant channels I b, and the second refrigerant channels 2b.

[0067] One of the opposite ends of the main body 10 in the refrigerant flowing direction is provided with the first inlet communication hole 3a that extends in the direction of arrangement of the first refrigerant channels 1a and that communicates with all of the first refrigerant channels 1a, and is also provided with a first inlet communication hole 3b that extends in the direction of arrangement of the first refrigerant channels 1b and that communicates with all of the first refrigerant channels 1b.

[0068] The other end is provided with the first outlet communication hole 4a that extends in the direction of arrangement of the first refrigerant channels 1a and that communicates with all of the first refrigerant channels 1a, and is also provided with a first outlet communication hole 4b that extends in the direction of arrangement of the first refrigerant channels 1b and that communicates with all of the first refrigerant channels 1b.

[0069] Moreover, of the opposite ends of the main body 10 in the refrigerant flowing direction, the end that is provided with the first outlet communication hole 4a and the first outlet communication hole 4b is provided with the second inlet communication hole 5a that extends in the direction of arrangement of the second refrigerant channels 2a and that communicates with all of the second refrigerant channels 2a, and is also provided with a second inlet communication hole 5b that extends in the direction of arrangement of the second refrigerant channels 2b and that communicates with all of the second refrigerant channels 2b.

[0070] The other end is provided with the second outlet communication hole 6a that extends in the direction of arrangement of the second refrigerant channels 2a and that communicates with all of the second refrigerant channels 2a, and is also provided with a second outlet communication hole 6b that extends in the direction of arrangement of the second refrigerant channels 2b and that communicates with all of the second refrigerant channels 2b.

[0071] As shown in FIG. 3, the extending direction of the first inlet communication hole 3a and the first outlet communication hole 4a does not necessary need to be orthogonal to the direction of the first refrigerant channels 1a. Moreover, the extending direction of the first inlet communication hole 3b and the first outlet communication hole 4b does not necessary need to be orthogonal to the direction of the first refrigerant channels 1b.

[0072] This similarly applies to the extending direction of the second inlet communication hole 5a and the second inlet communication hole 5b as well as the second outlet communication hole 6a and the second outlet communication hole 6b.

[0073] The opposite ends of the first inlet communication hole 3a, the first inlet communication hole 3b, the first outlet communication hole 4a, the first outlet communication hole 4b, the second inlet communication hole 5a, the second inlet communication hole 5b, the second outlet communication hole 6a, and the second outlet communication hole 6b are closed by, for example, sealing members.

[0074] Furthermore, the opposite ends of the first refrigerant channels 1a, the first refrigerant channels 1b, the second refrigerant channels 2a, and the second refrigerant channels 2b extending through the main body 10 in the longitudinal direction thereof are sealed by, for example, pinching or by using sealing members (not shown).

[0075] Furthermore, a first inlet convergence hole 31 that communicates with both the first inlet communication hole 3a and the first inlet communication hole 3b is formed so as to extend in the direction of arrangement thereof, and a first outlet convergence hole 41 that communicates with both the first outlet communication hole 4a and the first outlet communication hole 4b is formed so as to extend in the direction of arrangement thereof.

[0076] Moreover, a second inlet convergence hole 51 that communicates with both the second inlet communication hole 5a and the second inlet communication hole 5b is formed so as to extend in the direction of arrangement thereof, and a second outlet convergence hole 61 that communicates with both the second outlet communication hole 6a and the second outlet communication hole 6b is formed so as to extend in the direction of arrangement thereof.

[0077] When viewed in the direction of the arrow A (plan view) in FIG. 3(a), the first inlet convergence hole 31, the first outlet convergence hole 41, the second inlet convergence hole 51, and the second outset convergence hole 61 are all formed at the same side (i.e., at the right side in FIG. 3(b)). However, the configuration is not limited to this.

[0078] Specifically, for example, the first inlet convergence hole 31 may be formed at any position so long as the position thereof is along the direction of arrangement of the first inlet communication hole 3a and the first inlet communication hole 3b. Furthermore, as shown in FIG. 3 (a), the extending direction of the first inlet convergence hole 31 does not necessary need to be orthogonal to the extending direction of the first inlet communication hole 3a and the first inlet communication hole 3b. This similarly applies to the first outlet convergence hole 41, the second inlet convergence hole 51, and the second outlet convergence hole 61.

[0079] Furthermore, first ends of the first inlet convergence hole 31, the first outlet convergence hole 41, the second inlet convergence hole 51, and the second outlet convergence hole 61 are open and are connected to the first inlet connection pipe 3, the first outlet connection pipe 4, the second inlet connection pipe 5, and the second outlet connection pipe 6, respectively, so as to communicate with the outside. Second ends of the first inlet convergence hole 31, the first outlet convergence hole 41, the second inlet convergence hole 51, and the second outlet convergence hole 61 are closed by, for example, sealing members.

[0080] As shown in FIG. 3, the open (or closed) ends of the first inlet convergence hole 31, the first outlet convergence hole 41, the second inlet convergence hole 51, and the second outlet convergence hole 61 are all disposed at the same side. However, the configuration is not limited to this; the open (or closed) ends do not need to be disposed at the same side so long as each convergence hole has one end that is open and the other end that is closed.

[0081] The first inlet communication hole 3a, the first inlet communication hole 3b, the first outlet communication hole 4a, and the first outlet communication hole 4b correspond to "first communication holes" according to the present invention, and the second inlet communication hole 5a, the second inlet communication hole 5b, the second outlet communication hole 6a, and the second outlet communication hole 6b correspond to "second communication holes" according to the present invention.

[0082] The first inlet convergence hole 31 and the first outlet convergence hole 41 correspond to "first convergence holes" according to the present invention, and the second inlet convergence hole 51 and the Second outlet convergence hole 61 correspond to "second convergence holes" according to the present invention.

<u>Heat Exchanging Operation of Heat Exchanger 8b</u>

[0083] Next, a heat exchanging operation between the first refrigerant and the second refrigerant in the heat exchanger 8b will be described with reference to FIG. 3.

[0084] The first refrigerant flows into the first inlet convergence hole 31 via the first inlet connection pipe 3 and then flows into the first inlet communication hole 3a and the first inlet communication hole 3b. The first refrigerant flowing into the first inlet communication hole 3a flows through the first refrigerant channels 1a and then flows out to the first outlet communication hole 4a.

[0085] The first refrigerant flowing into the first inlet communication hole 3b flows through the first refrigerant channels 1b and then flows out to the first outlet communication hole 4b. Then, the first refrigerant flowing out to the first outlet communication hole 4a and the first refrigerant flowing out to the first outlet communication hole 4b merge at the first outlet convergence hole 41 before flowing out from the first outlet connection pipe 4.

[0086] The second refrigerant flows into the second inlet convergence hole 51 via the second inlet connection pipe 5 and then flows into the second inlet communication hole 5a and the second inlet communication hole 5b. The second refrigerant flowing into the second inlet communication hole 5a flows through the second refrigerant channels 2a and then flows out to the second outlet communication hole 6a. The second refrigerant flowing into the second inlet communication hole 5b flows through the second refrigerant channels 2b and then flows out to the second outlet communication hole 6b.

[0087] The second refrigerant flowing out to the second outlet communication hole 6a and the second refrigerant flowing out to the second outlet communication hole 6b merge at the second outlet convergence hole 61 before flowing out from the second outlet connection pipe 6.

[0088] The first refrigerant flowing through the first refrigerant channels 1a and the first refrigerant channels 1b and the second refrigerant flowing through the second refrigerant channels 2a and the second refrigerant channels 2b exchange heat in a countercurrent manner via partitions between the refrigerant channels.

Advantages of Embodiment 3

[0089] In the heat exchanger 8b described above, even though the refrigerant paths are each constituted of two sets of refrigerant channels, the refrigerant channels are integrally formed. Therefore, in addition to the advantages of the heat exchanger 8 according to Embodiment 1, thermal resistance occurring in a case where the refrigerant channels are separately formed is suppressed, thereby allowing for enhanced heat exchanging performance.

[0090] Furthermore, because the first inlet convergence hole 31 and the first outlet convergence hole 41 are provided within the main body 10 of the heat exchanger 8b, additional header pipes for connecting to the first inlet communication hole 3a, the first inlet communication hole 3b, the first outlet communication hole 4a, and the first outlet communication hole 4b do not need to be provided. Thus, the heat exchanger 8 can be made compact and the manufacturing process can be simplified. This similarly applies to the second inlet convergence hole 51 and the second outlet convergence hole 61.

[0091] Furthermore, since each refrigerant path is constituted of two sets of refrigerant channels and these refrigerant channels converge on a single communication hole, the number of communication holes can be reduced, thereby simplifying the manufacturing process of the heat exchanger 8b.

[0092] Moreover, since each refrigerant path is constituted of two sets of refrigerant channels, the heat exchanging capacity can be increased.

[0093] Unlike the heat exchanger 8a according to Embodiment 2, the first refrigerant path 1 constituted of two sets of refrigerant channels and the second refrigerant path 2 constituted of two sets of refrigerant channels are not disposed adjacent to each other in the heat exchanger 8b according to Embodiment 3. Instead, the rows of the refrigerant channels of the first refrigerant path 1 and the rows of the refrigerant channels of the second refrigerant path 2 are alternately arranged.

[0094] Thus, the refrigerant flowing through the refrigerant channels of each set and the refrigerant flowing through the refrigerant channels of another set that is adjacent thereto have different structures, so that the heat exchanging performance is further enhanced, as compared with that of the heat exchanger 8a according to Embodiment 2.

[0095] Although the first refrigerant path I and the second refrigerant path 2 are integrally formed in the main body 10, as shown in FIG. 3, the configuration is not limited to this. Specifically, if the first refrigerant path 1 and the second refrigerant path 2 are provided as separate pipes and are joined to each other by, for example, brazing, the first inlet communication hole 3a, the first inlet communication hole 3b, the first outlet communication hole 4a, and the first outlet communication hole 4b may be provided in the pipe of the first refrigerant path I so that an additional header pipe for connecting to the refrigerant channels of the first refrigerant path 1 does not need to be provided, whereby the heat exchanger can be made compact and the manufacturing process can be simplified.

[0096] This similarly applies to a case where the second inlet communication hole 5a, the second inlet communication hole 5b, the second outlet communication hole 6a, and the second outlet communication hole 6b are provided in the pipe of the second refrigerant path 2.

[0097] Furthermore, although each refrigerant path is constituted of two sets of refrigerant channels (e.g., the first refrigerant path 1 is constituted of two sets of refrigerant channels, i.e., the first refrigerant channels 1a and the first refrigerant channels 1b), as shown in FIG. 3, the configuration is not limited to this.

[0098] Specifically, for example, if the heat exchanging capacity is to be increased or if the pressure loss is to be reduced by increasing the channel area, each refrigerant path may be constituted of three or more sets of refrigerant channels. Moreover, the number of sets of refrigerant channels in the first refrigerant path 1 and the number of sets of refrigerant channels in the second refrigerant path 2 do not need to be the same.

Embodiment 4

[0099] A heat exchanger 8c according to Embodiment 4 will now be described by focusing mainly on differences from the configuration and the operation of the heat exchanger 8 according to Embodiment 1.

Configuration of Heat Exchanger 8c

[0100] FIG. 4 illustrates the structure of the heat exchanger 8c according to Embodiment 4 of the present invention.

[0101] As shown in FIG. 4, in the heat exchanger 8c according to Embodiment 4, one of the opposite ends of the main body 10 in the refrigerant flowing direction is provided with a first inlet communication hole 3aa that extends in the direction of arrangement of the first refrigerant channels 1a and that communicates with one or more of the first refrigerant channels 1a (referred to as "first first refrigerant channel group" hereinafter). Moreover, a first inlet communication hole 3ab that communicates with the remaining first refrigerant channel or channels 1a is formed.

[0102] The other end is provided with a first outlet communication hole 4aa that extends in the direction of arrangement of the first refrigerant channels 1a. Among the first refrigerant channels 1a, the first outlet communication hole 4aa communicates with all of the first refrigerant channels 1a communicating with the first inlet communication hole 3aa and also communicates with one or more of the first refrigerant channels 1a (referred to as "second first refrigerant channel group" hereinafter) that communicate with the first inlet communication hole 3ab.

[0103] Moreover, a first outlet communication hole 4ab that communicates with the remaining first refrigerant channel or channels 1a (referred to as "third first refrigerant channel group" hereinafter) communicating with the first inlet communication hole 3ab is also formed.

[0104] Furthermore, of the opposite ends of the main body 10 in the refrigerant flowing direction, the end that is provided with the first outlet communication hole 4aa and the first outlet communication hole 4ab is provided with a second inlet communication hole 5ab that extends in the direction of arrangement of the second refrigerant channels 2a and that communicates with one or more of the second refrigerant channels 2a (referred to as "first second refrigerant channel group" hereinafter). Moreover, a second inlet communication hole 5aa that communicates with the remaining second refrigerant channel or channels 2a is also formed.

[0105] Furthermore, of the opposite ends of the main body 10 in the refrigerant flowing direction, the end that is provided with the first inlet communication hole 3aa and the first inlet communication hole 3ab is provided with a second outlet communication hole 6ab that extends in the direction of arrangement of the second refrigerant channels a.

[0106] Among the second refrigerant channels 2a, the second outlet communication hole 6ab communicates with all of the second refrigerant channels 2a communicating with the second inlet communication hole 5ab and also communicates with one or more of the second refrigerant channels 2a (referred to as "second second refrigerant channel group" hereinafter) communicating with the second inlet communication hole 5aa.

[0107] Moreover, a second outlet communication hole 6aa that communicates with the remaining second refrigerant channel or channels 2a (referred to as "third second refrigerant channel group" hereinafter) communicating with the second inlet communication hole 5aa is also formed.

[0108] The "first first refrigerant channel group" is formed adjacent to the "third second refrigerant channel group", the "second first refrigerant channel group" is formed adjacent to the "second second refrigerant channel group", and the "third first refrigerant channel group" is formed adjacent to the "first second refrigerant channel group".

[0109] In the refrigerant flowing direction of the first refrigerant channels 1a (or the second refrigerant channels 2a), the first inlet communication hole 3aa and the second outlet communication hole 6aa are slightly displaced from each other, and the first inlet communication hole 3ab and the second outlet communication hole 6ab are slightly displaced from each other.

[0110] Moreover, in the refrigerant flowing direction of the first refrigerant channels 1a (or the second refrigerant channels 2a), the first outlet communication hole 4aa and the second inlet communication hole 5aa are slightly displaced from each other, and the first outlet communication hole 4ab and the second inlet communication hole 5ab are slightly displaced from each other.

[0111] The first inlet communication hole 3aa, the first inlet communication hole 3ab, the first outlet communication hole 4aa, and the first outlet communication hole 4ab do not necessarily need to extend orthogonally to the direction of the first refrigerant channels 1a. Likewise, the second inlet communication hole 5aa, the second inlet communication hole 5ab, the second outlet communication hole 6aa, and the second outlet communication hole 6ab do not necessarily need to extend orthogonally to the direction of the second refrigerant channels 2a.

[0112] Furthermore, although the first inlet communication hole 3aa and the first inlet communication hole 3ab extend in the same direction and are coaxial witch each other, as shown in FIG. 4, the two holes do not necessarily have to extend in the same direction or be coaxial with each other.

[0113] This similarly applies to the first outlet communication hole 4aa and the first outlet communication hole 4ab, the second inlet communication hole 5aa and the second inlet communication hole 5ab, and the second outlet communication hole 6aa and the second outlet communication hole 6ab.

[0114] First ends of the first inlet communication hole 3aa, the first outlet communication hole 4ab, the second inlet communication hole 5ab, and the second outlet communication hole 6aa are open and are connected to the first inlet connection pipe 3, the first outlet connection pipe 4, the second inlet connection pipe 5 (not shown in FIG. 4 due to being located behind the first outlet connection pipe 4), and the second outlet connection pipe 6, respectively, so as to communicate with the outside.

[0115] The first inlet communication hole 3aa corresponds to a "first divided-communication-hole inflow section" according to the present invention, the first inlet communication hole 3ab and the first outlet communication hole 4aa correspond to a "first divided-communication-hole turnaround section" according to the present invention, and the first outlet communication hole 4ab corresponds to a "first divided-communication-hole outflow section" according to the present invention.

[0116] The second inlet communication hole 5ab corresponds to a "second divided-communication-hole inflow section" according to the present invention, the second inlet communication hole 5aa and the second outlet communication hole 6ab correspond to a "second divided-communication-hole turnaround section" according to the present invention, and the second outlet communication hole 6aa corresponds to a "second divided-communication-hole outflow section" according to the present invention.

Heat Exchanging Operation of Heat Exchanger 8c

[0117] Next, a heat exchanging operation between the first refrigerant and the second refrigerant in the heat exchanger 8c will be described with reference to FIG. 4.

[0118] The first refrigerant flows into the first inlet communication hole 3aa via the first inlet connection pipe 3, flows through the first refrigerant channels 1a, the first outlet communication hole 4aa, the first refrigerant channels I a again, the first inlet communication hole 3ab, the first refrigerant channels I a again, and the first outlet communication hole 4ab in that order, and then flows out from the first outlet connection pipe 4.

[0119] The second refrigerant flows into the second inlet communication hole 5ab via the second inlet connection pipe 5, flows through the second refrigerant channels 2a, the second outlet communication hole 6ab, the second refrigerant channels 2a again, the second inlet communication hole 5aa, the second refrigerant channels. 2a again, and the second outlet communication hole 6aa in that order, and then flows out from the second outlet connection pipe 6. During that time, the first refrigerant and the second refrigerant exchange heat in a countercurrent manner via a partition between the two refrigerant paths.

Advantages of Embodiment 4

[0120] In the heat exchanger 8c described above, if the sectional area of the channels is to be reduced and the refrigerant flow paths are to be extended for maximizing the heat exchanging performance in accordance with the operating conditions and the physical properties of the refrigerants, the refrigerant flow paths can be turned around inside. Therefore, in addition to the advantages of the heat exchanger 8 according to Embodiment 1, the heat exchanging performance can be maximized while minimizing the size of the heat exchanger 8c.

[0121] Furthermore, since the first inlet communication hole 3aa and the like for turning around the refrigerant flow paths are formed within the main body 10 of the heat exchanger 8c, additional pipes do not need to be provided, whereby the heat exchanger 8c can be made compact.

[0122] Although the first refrigerant and the second refrigerant are both made to flow by being turned around in the heat exchanger 8c according to Embodiment 4, the configuration is not limited to this. One of the refrigerants may be made to turn around, whereas the other refrigerant may be made to flow linearly as in Embodiment 1.

[0123] In this case, the refrigerant to be made to turn around may be selected in accordance with the operating conditions and the physical properties of the refrigerants in the heat exchanger so that a favorable heat exchanger with high heat transferability and low pressure loss can be obtained.

[0124] Furthermore, the first inlet communication hole 3aa, the first inlet communication hole 3ab, the first outlet communication hole 4aa, and the first outlet communication hole 4ab may have the configurations described above, whereas the second inlet communication hole 5aa, the second inlet communication hole 5ab, the second outlet communication hole 6aa, and the second outlet communication hole 6ab may have the following configurations.

[0125] However, the positional relationship between the first inlet communication holes 3aa and 3ab and the second outlet communication holes 6aa and 6ab as well as the positional relationship between the second outlet communication holes 4aa and 4ab and the second inlet communication holes 5aa and 5ab are the same as those shown in FIG. 4.

[0126] Specifically, of the opposite ends of the main body 10 in the refrigerant flowing direction, the end provided with the first outlet communication hole 4aa and the first outlet communication hole 4ab is provided with the second inlet communication hole 5aa that extends in the direction of arrangement of the second refrigerant channels 2a and that communicates with one or more of the second refrigerant channels 2a (corresponding to the "third second refrigerant channel group" described above).

[0127] Moreover, the second inlet communication hole 5ab that communicates with the remaining second refrigerant channel or channels 2a is formed. Of the opposite ends of the main body 10 in the refrigerant flowing direction, the end provided with the first inlet communication hole 3aa and the first inlet communication hole 3ab is provided with the second outlet communication hole 6aa that extends in the direction of arrangement of the second refrigerant channels 2a.

[0128] Among the second refrigerant channels 2a, the second outlet communication hole 6aa communicates with all of the second refrigerant channels 2a communicating with the second inlet communication hole 5aa and also communicates with one or more of the second refrigerant channels 2a (corresponding to the "second second refrigerant channel group" described above) communicating with the second inlet communication hole 5ab.

[0129] Moreover, the second outlet communication hole 6ab that communicates with the remaining second refrigerant channel or channels 2a (corresponding to the "first first refrigerant channel group" described above) communicating with the second inlet communication hole 5ab is formed. In this case, first ends of the second inlet communication hole 5aa and the second outlet communication hole 6ab are open and are connected to the second inlet connection pipe 5 and the second outlet connection pipe 6, respectively, so as to communicate with the outside.

[0130] Even with the above configuration, the first refrigerant and the second refrigerant can exchange heat in a countercurrent manner, so that advantages similar to those of the heat exchanger 8c shown in FIG. 4 can be achieved.

[0131] Furthermore, although the communication hole corresponding to the first inlet communication hole 3a in the heat exchanger 8 according to Embodiment I is divided into two holes (i.e., the first inlet communication hole 3aa and the first inlet communication hole 3ab) in the heat exchanger 8c according to Embodiment 4 (the same applies to the first outlet communication hole 4aa and the first outlet communication hole 4ab, etc.), as shown in FIG. 4, the configuration is not limited to this.

[0132] Specifically, the communication hole may be divided into three or more holes so that the number of times each refrigerant is turned around is increased. In this case, depending on the divided configuration, two first outlet communication holes 4ab would be disposed at one end of the first refrigerant channels 1a in the direction of arrangement thereof, causing the first refrigerant to flow into or out from the holes. Accordingly, the refrigerant flow paths can be made longer while maintaining the current size of the heat exchanger, whereby the heat exchanging performance can be further enhanced.

[0133] Furthermore, the turnaround refrigerant-flow-path configuration of the heat exchanger 8c according to Embodiment 4 is also applicable to Embodiment 2 and Embodiment 3.

Embodiment 5

[0134] A heat exchanger 8d according to Embodiment 5 will now be described by focusing mainly on differences from the configuration and the operation of the heat exchanger 8b according to Embodiment 3.

Configuration of Heat Exchanger 8d

[0135] FIG. 5 illustrates the structure of the heat exchanger 8d according to Embodiment 5 of the present invention. Specifically, FIG. 5(a) is a perspective view of the heat exchanger 8d, FIG. 5(b) is a plan view as viewed in a direction indicated by an arrow A in FIG. 5(a), and FIG. 5(c) is a side view as viewed in a direction indicated by an arrow B in FIG. 5(a).

[0136] As shown in FIG. 5, a first convergence hole 31a that communicates with the first inlet communication hole 3a and a first convergence hole 31b that communicates with the first inlet communication hole 3b are formed in the direction of arrangement of the first inlet communication hole 3a and the first inlet communication hole 3b. Moreover, a first intermediate convergence hole 41 a that communicates with both the first outlet communication hole 4a and the first outlet communication hole 4b is formed in the direction of arrangement thereof.

[0137] Furthermore, a second intermediate convergence hole 51a that communicates with both the second inlet communication hole 5a and the second inlet communication hole 5b is formed in the direction of arrangement thereof. Moreover, a second convergence hole 61a that communicates with the second outlet communication hole 6a and a second convergence hole 61b that communicates with the second outlet communication hole 6b are formed in the direction of arrangement of the second outlet communication hole 6a and the second outlet communication hole 61a.:

[0138] First ends of the first convergence hole 31a, the first convergence hole 31 b, the second convergence hole 61a, and the second convergence hole 61b are open and are connected to the first inlet connection pipe 3, the first outlet connection pipe 4, the second outlet connection pipe 6, and the second inlet connection pipe 5, respectively, so as to communicate with the outside.

[0139] The opposite ends of the first intermediate convergence hole 41a and the second intermediate convergence hole 51a are closed by, for example sealing members. Therefore, the surface of the main body 10 that is opposite the surface thereof connected to the first inlet connection pipe 3 and the second outlet connection pipe 6 is connected to the first outlet connection pipe 4 and the second inlet connection pipe 5.

[0140] When viewed in the direction of the arrow A (plan view) in FIG, 5, the first convergence hole 31a, the first convergence hole 31b, the first intermediate convergence hole 41a, the second intermediate convergence hole 51a, the second convergence hole 61a, and the second convergence hole 61b are all formed at the same side (i.e., at the right side).

[0141] However, the configuration is not limited to this. Specifically, for example, the first convergence hole 31a may be formed at any position so long as it communicates with the first inlet communication hole 3a and has an opening oriented toward the outside. This similarly applies to the first convergence hole 31b, the second convergence hole 61a, and the second convergence hole 61b.

[0142] The first intermediate convergence hole 41a may be formed at any position so long as the position thereof is parallel to the direction of arrangement of the first outlet communication hole 4a and the first outlet communication hole 4b. This similarly applies to the second intermediate convergence hole 51a.

[0143] Furthermore, as shown in FIG. 5, the extending direction of the first intermediate convergence hole 41 a does not necessarily need to be orthogonal to the extending direction of the first outlet communication hole 4a and the first outlet communication hole 4b. This similarly applies to the second intermediate convergence hole 51a.

[0144] The first convergence hole 31a corresponds to "first-convergence-hole inflow section" according to the present invention, and the first convergence hole 31b corresponds to "first-convergence-hole outflow section" according to the present invention. The second convergence hole 61b corresponds to "second-convergence-hole inflow section" according to the present invention, and the second convergence hole 61a corresponds to "second-convergence-hole outflow section" according to the present invention.

Heat Exchanging Operation of Heat Exchanger 8d

[0145] Next, a heat exchanging operation between the first refrigerant and the second refrigerant in the heat exchanger 8d will be described with reference to FIG. 5.

[0146] The first refrigerant flows into the first convergence hole 31a via the first inlet connection pipe 3 and then flows into the first inlet communication hole 3a. The first refrigerant flowing into the first inlet communication hole 3a flows through the first refrigerant channels 1a and then flows out to the first outlet communication hole 4a. The first refrigerant flowing out to the first outlet communication hole 4a flows out to the first outlet communication hole 4b via the first intermediate convergence hole 41a.

[0147] The first refrigerant flowing out to the first outlet communication hole 4b flows through the first refrigerant channels 1b and then flows out to the first inlet communication hole 3b. The first refrigerant flowing out to the first inlet communication hole 3b travels through the first convergence hole 31b, and flows out via the first outlet connection pipe 4.

[0148] The second refrigerant flows into the second convergence hole 61b via the second inlet connection pipe 5 and then flows into the second outlet communication hole 6b The second refrigerant flowing into the second outlet communication hole 6b flows through the second refrigerant channels 2b and then flows out to the second inlet communication hole 5b. The second refrigerant flowing out to the second inlet communication hole 5b flows out to the second inlet communication hole 5a via the second intermediate convergence hole 51a.

[0149] The second refrigerant flowing out to the second inlet communication hole 5a flows through the second refrigerant channels 2a and then flows out to the second outlet communication hole 6a. The second refrigerant flowing out to the second outlet communication hole 6a travels through the second convergence hole 61a and flows out via the second outlet connection pipe 6.

[0150] The first refrigerant flowing through the first refrigerant channels 1a and the second refrigerant flowing through the second refrigerant channels 2a exchange heat in a countercurrent manner via a partition between the refrigerant channels. Furthermore, the first refrigerant flowing through the first refrigerant channels 1b and the second refrigerant flowing through the second refrigerant channels 2b exchange heat in a countercurrent manner via a partition between the refrigerant channels.

[0151] Although the first refrigerant flowing through the first refrigerant channels 1b and the second refrigerant flowing through the second refrigerant channels 2a have a parallel-current relationship, it is needless to say that the two refrigerants exchange heat via a partition between the refrigerant channels.

Advantages of Embodiment 5

[0152] In the heat exchanger 8d described above, if the sectional area of the channels is to be reduced and the refrigerant flow paths are to be extended for maximizing the heat exchanging performance in accordance with the operating conditions and the physical properties of the refrigerants, the refrigerant flow paths can be turned around inside. Therefore, in addition to the advantages of the heat exchanger 8c according to Embodiment 3, the heat exchanging performance can be maximized while minimizing the size of the heat exchanger 8d.

[0153] Furthermore, since the first intermediate convergence hole 41a and the like for turning around the refrigerant flow paths are formed within the main body 10 of the heat exchanger 8d, additional pipes do not need to be provided, whereby the heat exchanger 8d can be made compact.

[0154] Although the first refrigerant and the second refrigerant are both made to flow by being turned around in the heat exchanger 8d according to Embodiment 5, the configuration is not limited to this. One of the refrigerants may be made to turn around, whereas the other refrigerant may be made to flow linearly as in Embodiment 4.

[0155] In this case, the refrigerant to be made to turn around may be selected in accordance with the operating conditions and the physical properties of the refrigerants in the heat exchanger so that a favorable heat exchanger with high heat transferability and low pressure loss can be obtained.

Embodiment 6

[0156] The heat exchanger according to each of Embodiment 1 to Embodiment 5 described above can be installed in a refrigeration cycle apparatus, such as an air-conditioning apparatus, a hot-water storage apparatus, and a refrigerator. The refrigeration cycle apparatus according to Embodiment 6 is described as being equipped with the heat exchanger 8 according to Embodiment I as an example.

Configuration of Refrigeration Cycle Apparatus 200

[0157] FIG. 6 is a refrigerant circuit diagram illustrating an example of the refrigeration cycle apparatus according to Embodiment 6 of the present invention.

[0158] As shown in FIG. 6, a refrigeration cycle apparatus 200 includes a first refrigerant circuit formed by connecting a first compressor 230, a first radiator 231, the heat exchanger 8, a first pressure-reducing device 232, and a first cooler 233 in that order by using a refrigerant pipe.

[0159] In the heat exchanger 8, the first inlet connection pipe 3 is connected to the first radiator 231 by the refrigerant pipe, and the first outlet connection pipe 4 is connected to the first pressure-reducing device 232 by the refrigerant pipe. The first refrigerant circuit operates based on a vapor-compression refrigeration cycle by causing the first refrigerant, which is a high-temperature refrigerant, to circulate therethrough.

[0160] Moreover, the refrigeration cycle apparatus 200 includes a second refrigerant circuit formed by connecting a second compressor 240, a second radiator 241, a second pressure-reducing device 242, and the heat exchanger 8 in that order by using a refrigerant pipe. In the heat exchanger 8, the second inlet connection pipe 5 is connected to the second pressure-reducing device 242 by the refrigerant pipe, and the second outlet connection pipe 6 is connected to the second compressor 240 by the refrigerant pipe. The second refrigerant circuit operates based on a vapor-compression refrigeration cycle by causing the second refrigerant, which is a low-temperature refrigerant, to circulate therethrough.

[0161] Each of the first refrigerant and the second refrigerant used is a refrigerant, such as carbon dioxide, an HFC-based refrigerant, an HC-based refrigerant, an HFO-based refrigerant, or ammonia, or a refrigerant mixture containing these refrigerants. The following description of Embodiment 6 will be directed to a case where carbon dioxide is used as the first refrigerant.

Operation of Refrigeration Cycle Apparatus 200

[0162] The first refrigerant in a gas state is compressed by the first compressor 230 and is discharged therefrom as a refrigerant in a high-temperature high-pressure supercritical state. The first refrigerant in the high-temperature high-pressure supercritical state flows into the first radiator 231 and exchanges heat with, for example, air so as to transfer heat thereto, thereby becoming a refrigerant in a high-pressure supercritical state.

[0163] The first refrigerant in the high-pressure supercritical state flows into the heat exchanger 8 and is cooled by transferring heat to the second refrigerant flowing through the second refrigerant circuit in the heat exchanger 8, and then flows into the first pressure-reducing device 232 where the first refrigerant is reduced in pressure, thereby becoming a low-temperature low-pressure two-phase gas-liquid refrigerant.

[0164] This low-temperature low-pressure two-phase gas-liquid refrigerant flows into the first cooler 233 where the refrigerant exchanges heat with, for example, air so as to evaporate, thereby becoming a refrigerant in a low-temperature low-pressure gas state. The first refrigerant in the low-temperature low-pressure gas state is suctioned into the first compressor 230 again so as to be compressed.

[0165] The second refrigerant in a gas state is compressed by the second compressor 240 and is discharged therefrom as a refrigerant in a high-temperature high-pressure gas state. The second refrigerant in the high-temperature high-pressure gas state flows into the second radiator 241 and exchanges heat with, for example, air so as to condense, thereby becoming a refrigerant in a high-pressure liquid state. The second refrigerant in the high-pressure liquid state flows into the second pressure-reducing device 242 where the second refrigerant is reduced in pressure, thereby becoming a low-temperature low-pressure two-phase gas-liquid refrigerant.

[0166] This low-temperature low-pressure two-phase gas-liquid refrigerant flows into the heat exchanger 8 and evaporates by receiving heat from the first refrigerant flowing through the first refrigerant circuit in the heat exchanger 8, thereby becoming a refrigerant in a low-temperature low-pressure gas state. The second refrigerant in the low-temperature low-pressure gas state is suctioned into the second compressor 240 again so as to be compressed.

Advantages of Embodiment 6

[0167] In the refrigeration cycle apparatus 200 having the above-described configuration, a high degree of supercooling of the first refrigerant flowing out from the first radiator 231 can be ensured, so that the efficiency of the refrigeration cycle apparatus 200 can be significantly improved. In particular, because carbon dioxide is used as the first refrigerant in the above-described example, the efficiency of the refrigeration cycle apparatus 200 is particularly improved when the first refrigerant at a critical point or higher transfers heat to the second refrigerant in the heat exchanger 8.

[0168] Furthermore, the compactness of the heat exchanger 8 contributes to compactness of the entire refrigeration cycle apparatus 200.

[0169] Although carbon dioxide is used as an example of the first refrigerant flowing through the first refrigerant circuit in the above description, the first refrigerant is not limited to carbon dioxide; it is needless to say that a refrigerant, such as an HFC-based refrigerant, an HC-based refrigerant, an HFO-based refrigerant, or ammonia, or a refrigerant mixture containing these refrigerants may be used.

[0170] Even in that case, a high degree of supercooling of the first refrigerant flowing out from the first radiator 231 can be ensured, so that the efficiency of the refrigeration cycle apparatus 200 can be improved.

[0171] Although the heat exchanger 8 is used as a radiator in the refrigeration cycle apparatus 200 shown in FIG. 6, the configuration is not limited to this. The heat exchanger 8 may also be used as a cooler by reversing the circulating direction of the first refrigerant by using, for example, a four-way valve.

[0172] Although the second refrigerant circuit is based on a vapor-compression refrigeration cycle in Embodiment 6, the second refrigerant may alternatively be water or brine (antifreeze), such as an ethylene glycol aqueous solution, and the second compressor 240 may be constituted of a pump.

[0173] Although the heat exchanger 8 according to Embodiment I is used as an example of a heat exchanger in the refrigeration cycle apparatus 200 according to Embodiment 6, as shown in FIG. 6, the heat exchanger is not limited to the above. It is needless to say that the heat exchanger used may alternatively be any of the heat exchangers 8a to 8d according to Embodiment 2 to Embodiment 5.

Embodiment 7

[0174] A refrigeration cycle apparatus 200a according to Embodiment 7 will now be described by focusing mainly on differences from the configuration and the operation of the refrigeration cycle apparatus 200 according to Embodiment 6.

Configuration of Refrigeration Cycle Apparatus 200a

[0175] FIG. 7 is a refrigerant circuit diagram illustrating an example of the refrigeration cycle apparatus according to Embodiment 7 of the present invention.

[0176] As shown in FIG. 7, the refrigeration cycle apparatus 200a is obtained by removing the first radiator 231 from the configuration of the refrigeration cycle apparatus 200 according to Embodiment 6 shown in FIG. 6 and is configured to make the heat exchanger 8 cool all of the high-temperature high-pressure first refrigerant discharged from the first compressor 230.

[0177] Specifically, the refrigeration cycle apparatus 200a shown in FIG. 7 is a so-called secondary-loop refrigeration cycle apparatus, In this case, the heat exchanger 8 according to Embodiment 7 functions as both the first radiator 231 and the heat exchanger 8 in Embodiment 7.

Advantages of Embodiment 7

[0178] With the above-described configuration, the heat exchanging amount, required in the heat exchanger 8 is increased, so that the percentage of the volume of the heat exchanger 8 occupying the entire refrigeration cycle apparatus 200a is greater than that in the refrigeration cycle apparatus 200 according to Embodiment 7 equipped with the first radiator 231. In this case, the compactness of the heat exchanger 8 contributes to compactness of the entire refrigeration cycle apparatus 200a.

[0179] Although the heat exchanger 8 is used as a radiator in the refrigeration cycle apparatus 200a shown in FIG. 7, the configuration is not limited to this. The heat exchanger 8 may also be used as a cooler by reversing the circulating direction of the first refrigerant by using, for example, a four-way valve.

Embodiment 8

[0180] A refrigeration cycle apparatus according to Embodiment 8 is described as being equipped with the heat exchanger 8 according to Embodiment 1 as an example.

Configuration of Refrigeration Cycle Apparatus 200b

[0181] FIG. 8 is a refrigerant circuit diagram illustrating an example of the refrigeration cycle apparatus according to

Embodiment 8 of the present invention.

[0182] As shown in FIG. 8, a refrigeration cycle apparatus 200b includes a refrigerant circuit formed by connecting a compressor 250, a radiator 251, the heat exchanger 8, a pressure-reducing device 252, and a cooler 253 in that order by using a refrigerant pipe.

[0183] Furthermore, a bypass pipe 255 branching off from the refrigerant pipe between the heat exchanger 8 and the pressure-reducing device 252 is connected to an injection port 256 provided in a compression chamber of the compressor 250, or is connected between the compressor 250 and the cooler 253, although not shown.

[0184] In the bypass pipe 255, a bypass pressure-reducing device 254 and the heat exchanger 8 are disposed in that order from a branch point of the refrigerant pipe between the heat exchanger 8 and the pressure-reducing device 252.

[0185] In the heat exchanger 8, the first inlet connection pipe 3 is connected to the radiator 251 by the refrigerant pipe, and the first outlet connection pipe 4 is connected to the pressure-reducing device 252 by the refrigerant pipe. Furthermore, in the heat exchanger 8, the second inlet connection pipe 5 is connected to the bypass pressure-reducing device 254 by the refrigerant pipe, and the second outlet connection pipe 6 is connected to the injection port 256 of the compressor 250 by the refrigerant pipe, or is connected between the compressor 250 and the cooler 253, although not shown.

Operation of Refrigeration Cycle Apparatus 200b

[0186] A gas refrigerant is compressed by the compressor 250 and is discharged therefrom as a high-temperature high-pressure gas refrigerant. This high-temperature high-pressure gas refrigerant flows into the radiator 251 and exchanges heat with, for example, air so as to transfer heat thereto. Then, the high-pressure refrigerant (high-temperature refrigerant) flowing out from the radiator 251 flows into the heat exchanger 8.

[0187] The high-pressure refrigerant (high-temperature refrigerant) flowing into the heat exchanger 8 is cooled by transferring heat to a low-temperature refrigerant flowing out from the bypass pressure-reducing device 254, and then flows into the pressure-reducing device 252 so as to be reduced in pressure, thereby becoming a low-temperature low-pressure two-phase gas-liquid refrigerant.

[0188] This low-temperature low-pressure two-phase gas-liquid refrigerant flows into the cooler 253 and exchanges heat with, for example, air so as to evaporate, thereby becoming a low-temperature low-pressure gas refrigerant. This low-temperature low-pressure gas refrigerant is suctioned into the compressor 250 again so as to be compressed.

[0189] before flowing into the pressure-reducing device 252, a portion of the refrigerant flowing out from the heat exchanger 8 diverges and flows into the bypass pipe 255. The refrigerant flowing into the bypass pipe 255 is reduced in pressure by the bypass pressure-reducing device 254 so as to become a low-temperature two-phase gas-liquid refrigerant (low-temperature refrigerant), which then flows into the heat exchanger 8.

[0190] The low-temperature two-phase gas-liquid refrigerant (low-temperature refrigerant) flowing into the heat exchanger 8 is heated by receiving heat from the high-temperature refrigerant, and is injected into the compression chamber via the injection port 256 of the compressor 250.

[0191] The refrigerant circulating through the refrigeration cycle apparatus 200b is a refrigerant, such as carbon dioxide, an HFC-based refrigerant, an HC-based refrigerant, an HFO-based refrigerant, or ammonia, or a refrigerant mixture containing these refrigerants.

Advantages of Embodiment 8

[0192] In the refrigeration cycle apparatus 200b having the above-described configuration, a high degree of supercooling of the refrigerant flowing out from the radiator 251 can be ensured, so that the efficiency of the refrigeration cycle apparatus 200b can be significantly improved.

[0193] Furthermore, in the refrigeration cycle apparatus 200b shown in PIG. 8, the higher the saturation temperature (gas-liquid equilibrium temperature) of the low-temperature refrigerant flowing into the injection port 256 from the heat exchanger 8, the higher the efficiency of the compressor 250, whereby the required power can be reduced.

[0194] Furthermore, as shown in FIG. 8, when the high-temperature refrigerant flowing out from the radiator 251 is cooled by the heat exchanger 8, if the temperature of the high-temperature refrigerant flowing out from the radiator 251 is relatively high particularly due to a high outside air temperature, a sufficiently large temperature difference between the high-temperature refrigerant and the low-temperature refrigerant can be ensured in the heat exchanger 8.

[0195] Therefore, the low-temperature refrigerant to be injected into the compression chamber of the compressor 250 via the injection port 256 can be maintained at a higher temperature, whereby high efficiency of the first compressor 230 can be ensured.

[0196] In a case where the other end of the bypass pipe 255 is connected between the compressor 250 and the cooler 253, the flow rate of the refrigerant flowing through the cooler 253 can be reduced without lowering the refrigeration effect, as compared with a case where the heat exchanger 8 is not used. In particular, when the pipe between the compressor 250 and the cooler 253 is long, performance deterioration caused by an increase in pressure loss can be suppressed.

[0197] Furthermore, the compactness of the heat exchanger 8 contributes to compactness of the entire refrigeration cycle apparatus 200b.

[0198] ,

Reference Signs List

[0199]

1	first refrigerant path
1a, 1b	first refrigerant channel
2	second refrigerant path
2a, 2b	second refrigerant channel
3	first inlet connection pipe
3a, 3aa, 3ab, 3b	first inlet communication hole
4	first outlet connection pipe
4a, 4aa, 4ab, 4b	first outlet communication hole
5	second inlet connection pipe
5a, 5aa, 5ab, 5b	second inlet communication hole
6	second outlet connection pipe
6a, 6aa, 6ab, 6b	second outlet communication hole
8, 8a to 8d	heat exchanger
10	main body
31	first inlet convergence hole
31a, 31b	first convergence hole
41	first outlet convergence hole
41a	first intermediate convergence hole
51	second inlet convergence hole
51a	second intermediate convergence hole
61	second outlet convergence hole
61a, 61b	second convergence hole
200, 200a, 200b	refrigeration cycle apparatus
230	first compressor
231	fist radiator
232	first pressure-reducing device
233	first cooler
240	second compressor
241	second radiator
242	second pressure-reducing device
250	compressor
251	radiator
252	pressure-reducing device
253	cooler
254	bypass pressure-reducing device
255	bypass pipe
256	injection port

Claims

1. A heat exchanger comprising:

- a first refrigerant path in which a plurality of first refrigerant channels through which a first refrigerant flows are arranged in a single row;
- a second refrigerant path in which a plurality of second refrigerant channels through which a second refrigerant flows are arranged in a single row;
- first communication holes that are formed at opposite ends of the first refrigerant path, extend through in a direction of arrangement of the plurality of first refrigerant channels, and communicate with the plurality of first

refrigerant channels; and
- second communication holes that are formed at opposite ends of the second refrigerant path, extend through in a direction of arrangement of the plurality of second refrigerant channels, and communicate with the plurality of second refrigerant channels,

wherein the first refrigerant is adapted to flow into one of the first communication holes formed at the opposite ends of the first refrigerant path, flow through the first refrigerant channels, and flow outside via the other first communication hole,
wherein the second refrigerant is adapted to flow into one of the second communication holes formed at the opposite ends of the second refrigerant path, flow through the second refrigerant channels, and flow outside via the other second communication hole, and
wherein the first refrigerant channels and the second refrigerant channels extend in parallel to each other and are disposed adjacent to each other, and the first refrigerant and the second refrigerant are adapted to exchange heat via a partition at adjacent surfaces of the first refrigerant channels and the second refrigerant channels.

2. The heat exchanger of claim 1,
wherein the first refrigerant path and the second refrigerant path are integrally formed.

3. The heat exchanger of claim 1 or 2,
wherein, of the first communication holes formed at the opposite ends of the first refrigerant path and the second communication holes formed at the opposite ends of the second refrigerant path, the first communication hole and the second communication hole located at a same side are displaced from each other by a predetermined amount in a channel-extending direction of the first refrigerant path or the second refrigerant path.

4. The heat exchanger of any one of claims 1 to 3,
wherein the first refrigerant path has a plurality of first refrigerant channel groups, each of which is a set of a plurality of the first refrigerant channels, and
wherein the second refrigerant path has a plurality of second refrigerant channel groups, each of which is a set of a plurality of the second refrigerant channels.

5. The heat exchanger of claim 4,
wherein the plurality of first refrigerant channel groups in the first refrigerant path are disposed adjacent to each other and are arranged such that directions of arrangement of the first refrigerant channels are parallel to one another, and
wherein the plurality of second refrigerant channel groups in the second refrigerant path are disposed adjacent to each other and are arranged such that directions of arrangement of the second refrigerant channels are parallel to one another,
wherein a first refrigerant channel group located at one end of the plurality of first refrigerant channel groups disposed adjacent to each other is disposed adjacent to a second refrigerant channel group located at one end of the plurality of second refrigerant channel groups disposed adjacent to each other, and the direction of arrangement of the first refrigerant channels in the first refrigerant channel group is parallel to the direction of arrangement of the second refrigerant channels in the second refrigerant channel group,
wherein the first communication holes communicate with all of the first refrigerant channels constituting the plurality of first refrigerant channel groups, and
wherein the second communication holes communicate with all of the second refrigerant channels constituting the plurality of second refrigerant channel groups.

6. The heat exchanger of any one of claims 1 to 5,
wherein, in an extending direction of each first communication hole, the first communication hole has one end that is closed and another end that is open such that the first refrigerant flows into and out from the open end thereof, and
wherein, in an extending direction of each second communication hole, the second communication hole has one end that is open and another end that is closed such that the second refrigerant flows into and out from the open end thereof.

7. The heat exchanger of claim 4,
wherein the first refrigerant channel groups in the first refrigerant path and the second refrigerant channel groups in the second refrigerant path are alternately arranged adjacent to each other, and the directions of arrangement in all of the groups of refrigerant channels are parallel to one another,

wherein the first communication holes are formed at opposite ends of each first refrigerant channel group, and opposite ends of each first communication hole in an extending direction thereof are closed, wherein the second communication holes are formed at opposite ends of each second refrigerant channel group, and opposite ends of each second communication hole in an extending direction thereof are closed, wherein the heat exchanger further comprises first convergence holes extending through in a direction of arrangement of the plurality of first communication holes and communicating with the plurality of first communication holes; and second convergence holes extending through in a direction of arrangement of the plurality of second communication holes and communicating with the plurality of second communication holes,
wherein the first refrigerant is adapted to flow into one of the first convergence holes formed at the opposite ends of the first refrigerant path, flow through the first refrigerant channels, and flow outside via the other first convergence hole, and
wherein the second refrigerant is adapted to flow into one of the second convergence holes formed at the opposite ends of the second refrigerant path, flow through the second refrigerant channels, and flow outside via the other second convergence hole.

8. The heat exchanger of claim 7,
wherein, in an extending direction of each first convergence hole of the plurality of first convergence holes, the first convergence hole has one end that is closed and another end that is open such that the first refrigerant is adapted to flow into and out from the open ends thereof, and
wherein, in an extending direction of each second convergence hole, the second convergence hole has one end that is closed and another end that is open such that the second refrigerant is adapted to flow into and out from the open ends thereof.

9. The heat exchanger of any one of claims 1 to 8,
wherein at least one of the first communication holes formed at the opposite ends of the first refrigerant path is divided into multiple sections, and
wherein the multiple sections include one first divided-communication-hole inflow section into which the first refrigerant flows from outside and that makes the first refrigerant flow to one or more of the plurality of first refrigerant channels, at least one first divided-communication-hole turnaround section that causes the first refrigerant flowing from the one or more of the first refrigerant channels to turn around and flow to a different one or more of the first refrigerant channels other than the one or more of the first refrigerant channels, and one first divided-communication-hole outflow section that causes the first refrigerant flowing from the first divided-communication-hole turnaround section through the different one or more of the first refrigerant channels to flow outside, so that the first refrigerant flows through the first refrigerant path by being turned around therein.

10. The heat exchanger of claim 9,
wherein at least one of the second communication holes formed at the opposite ends of the second refrigerant path is divided into multiple sections, and
wherein the multiple sections include one second divided-communication-hole inflow section into which the second refrigerant flows from outside and that makes the second refrigerant flow to one or more of the plurality of second refrigerant channels, at least one second divided-communication-hole turnaround section that causes the first refrigerant flowing from the one or more of the second refrigerant channels to turn around and flow to a different one or more of the second refrigerant channels other than the one or more of the second refrigerant channels, and one second divided-communication-hole outflow section that causes the second refrigerant flowing from the second divided-communication-hole turnaround section through the different one or more of the second refrigerant channels to flow outside, so that the second refrigerant flows through the second refrigerant path by being turned around therein.

11. The heat exchanger of claim 4,
wherein the first refrigerant channel groups in the first refrigerant path and the second refrigerant channel groups in the second refrigerant path are alternately arranged adjacent to each other, and the directions of arrangement of the refrigerant channels in all of the groups of refrigerant channels are parallel to one another,
wherein the first communication holes are formed at opposite ends of each first refrigerant channel group, and opposite ends of each first communication hole in an extending direction thereof are closed, wherein the second communication holes are formed at opposite ends of each second refrigerant channel group, and opposite ends of each second communication hole in an extending direction thereof are closed, wherein the heat exchanger further comprises first convergence holes each constituted of a first-convergence-hole inflow section extending through and communicating with one or more of a plurality of the first communication holes located at one end of the opposite ends of the first refrigerant path and a first-convergence-hole outflow section extending through and communicating

with remainder of the first communication holes located at the one end; a first intermediate convergence hole extending through in a direction of arrangement of a plurality of the first communication holes located at an end, which is opposite from an end provided with the first convergence hole, of the opposite ends of the first refrigerant path and communicating with the plurality of first communication holes; and second convergence holes extending through in a direction of arrangement of the plurality of second communication holes and communicating with the plurality of second communication holes,
wherein the first refrigerant flows into the first-convergence-hole inflow section formed at one end of the first refrigerant path, flows through one or more of the first refrigerant channel groups, travels through the first intermediate convergence hole, flows through a different one or more of the first refrigerant channel groups by being turned around therein, and flows outside via the first-convergence-hole outflow section, and wherein the second refrigerant flows into one of the second convergence holes formed at the opposite ends of the second refrigerant path, flows through the second refrigerant channels, and flows outside via the other second convergence hole.

12. The heat exchanger of claim 4,
wherein the first refrigerant channel groups in the first refrigerant path and the second refrigerant channel groups in the second refrigerant path are alternately arranged adjacent to each other, and the directions of arrangement of the refrigerant channels in all of the groups of refrigerant channels are parallel to one another,
wherein the first communication holes are formed at opposite ends of each first refrigerant channel group, and opposite ends of each first communication hole in an extending direction thereof are closed, wherein the second communication holes are formed at opposite ends of each second refrigerant channel group, and opposite ends of each second communication hole in an extending direction thereof are closed, wherein the heat exchanger further comprises first convergence holes each constituted of a first-convergence-hole inflow section extending through and communicating with one or more of a plurality of the first communication holes located at one end of the opposite ends of the first refrigerant path and a first-convergence-hole outflow section extending through and communicating with remainder of the first communication holes located at the one end; a first intermediate convergence hole extending through in a direction of arrangement of a plurality of the first communication holes located at an end, which is opposite from an end provided with the first convergence hole, of the opposite ends of the first refrigerant path and communicating with the plurality of first communication holes; second convergence holes constituted of a second-convergence-hole inflow section extending through and communicating with one or more of a plurality of the second communication holes located at one end of the opposite ends of the second refrigerant path and a second-convergence-hole outflow section extending through and communicating with remainder of the second communication holes located at the one end; and a second intermediate convergence hole extending through in a direction of arrangement of a plurality of the second communication holes located at an end, which is opposite from an end provided with the second convergence hole, of the opposite ends of the second refrigerant path and communicating with the plurality of second communication holes,
wherein the first refrigerant flows into the first-convergence-hole inflow section formed at one end of the first refrigerant path, flows through one or more of the first refrigerant channel groups, travels through the first intermediate convergence hole, flows through a different one or more of the first refrigerant channel groups by being turned around therein, and flows outside via the first-convergence-hole outflow section, and wherein the second refrigerant flows into the second-convergence-hole inflow section formed at one end of the second refrigerant path, flows through one or more of the second refrigerant channel groups, travels through the second intermediate convergence hole, flows through a different one or more of the second refrigerant channel groups by being turned around therein, and flows outside via the second-convergence-hole outflow section.

13. The heat exchanger of any one of claims 1 to 12,
wherein the first refrigerant and the second refrigerant are adapted to flow in directions for forming a countercurrent in at least one or more of the refrigerant channels.

14. A refrigeration cycle apparatus comprising:

the heat exchanger of any one of claims 1 to 13.

FIG. 1

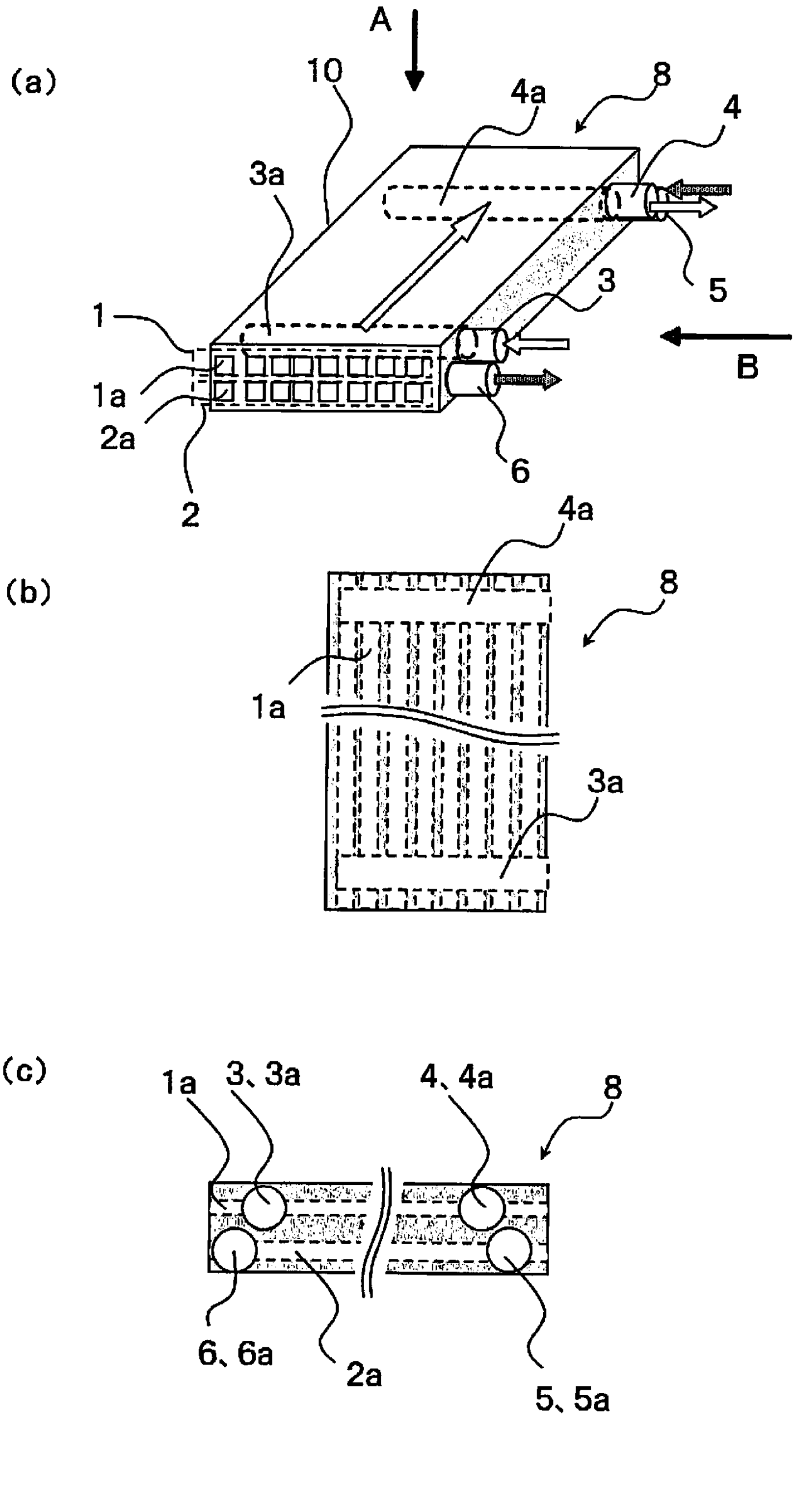


FIG. 2

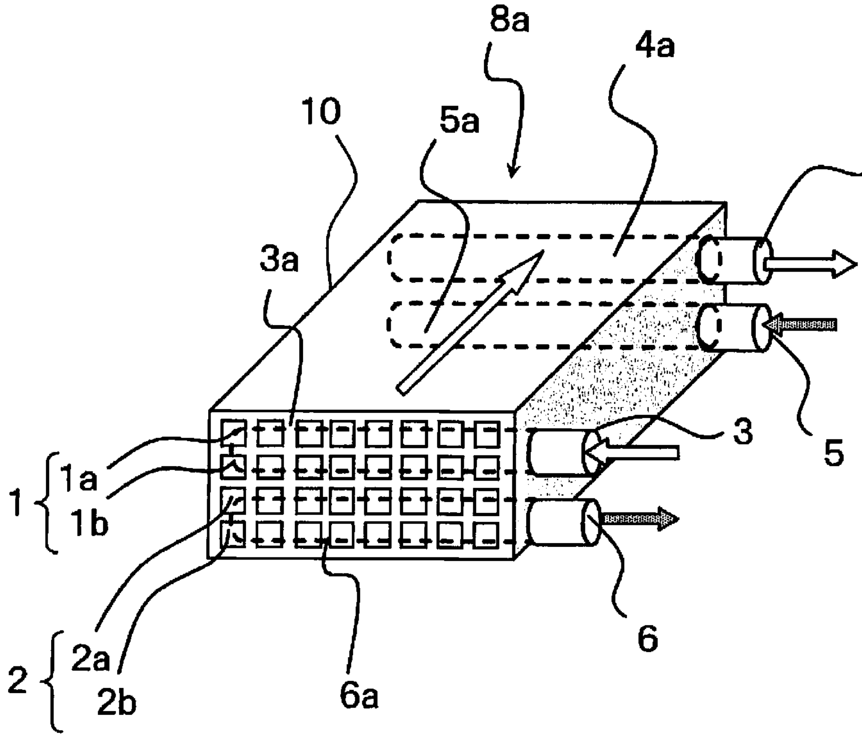
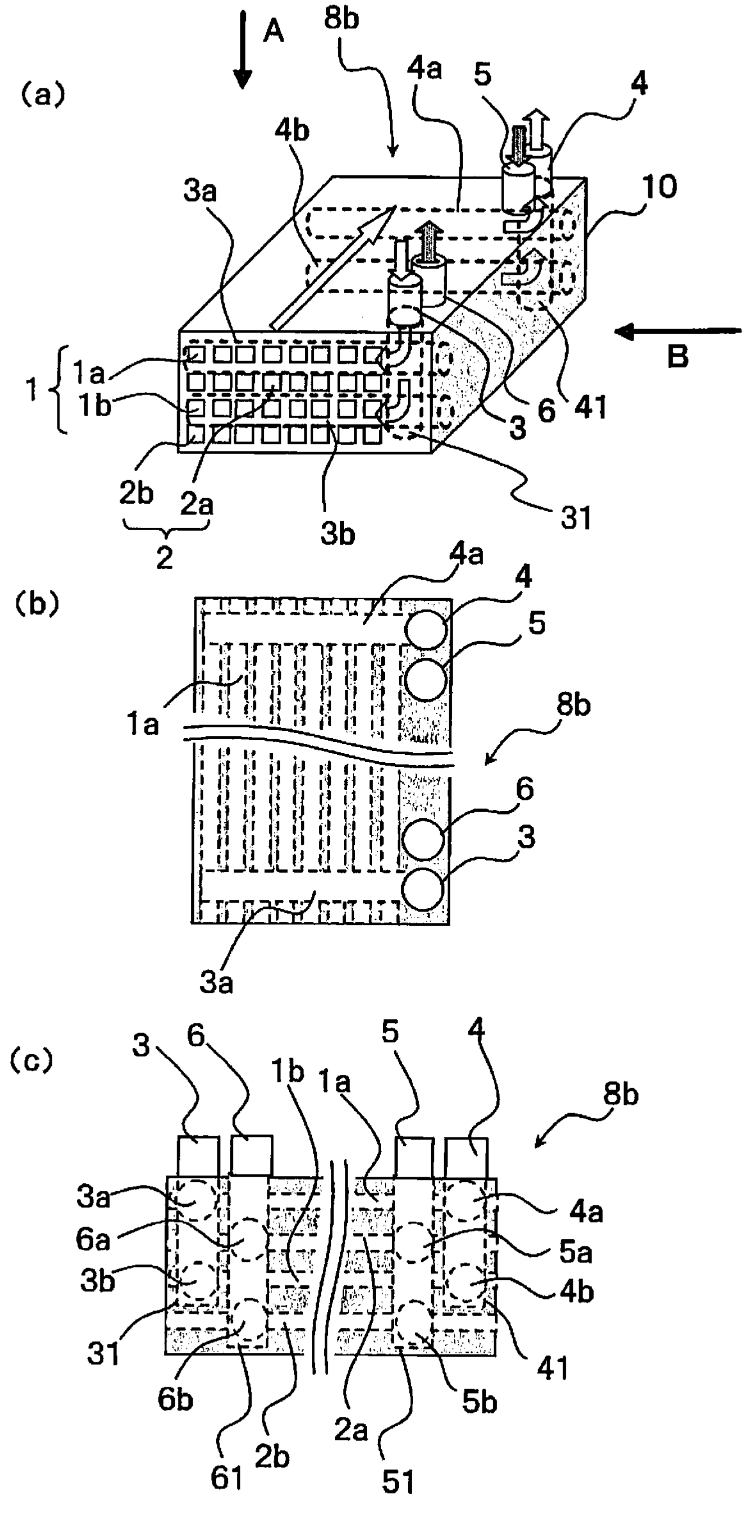


FIG. 3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4
4b
3a
10
B
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2b
2a
2
3b
(b)
4a
4
5
1a
8b
6
3
3a
(c)
3
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1b
1a
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FIG. 4

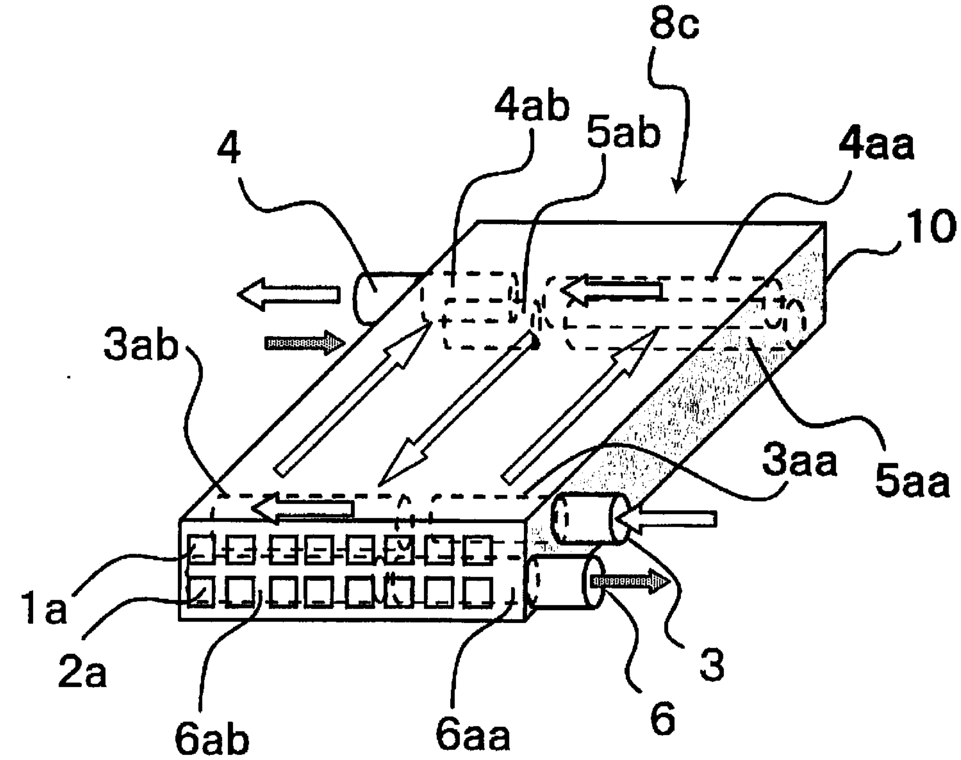
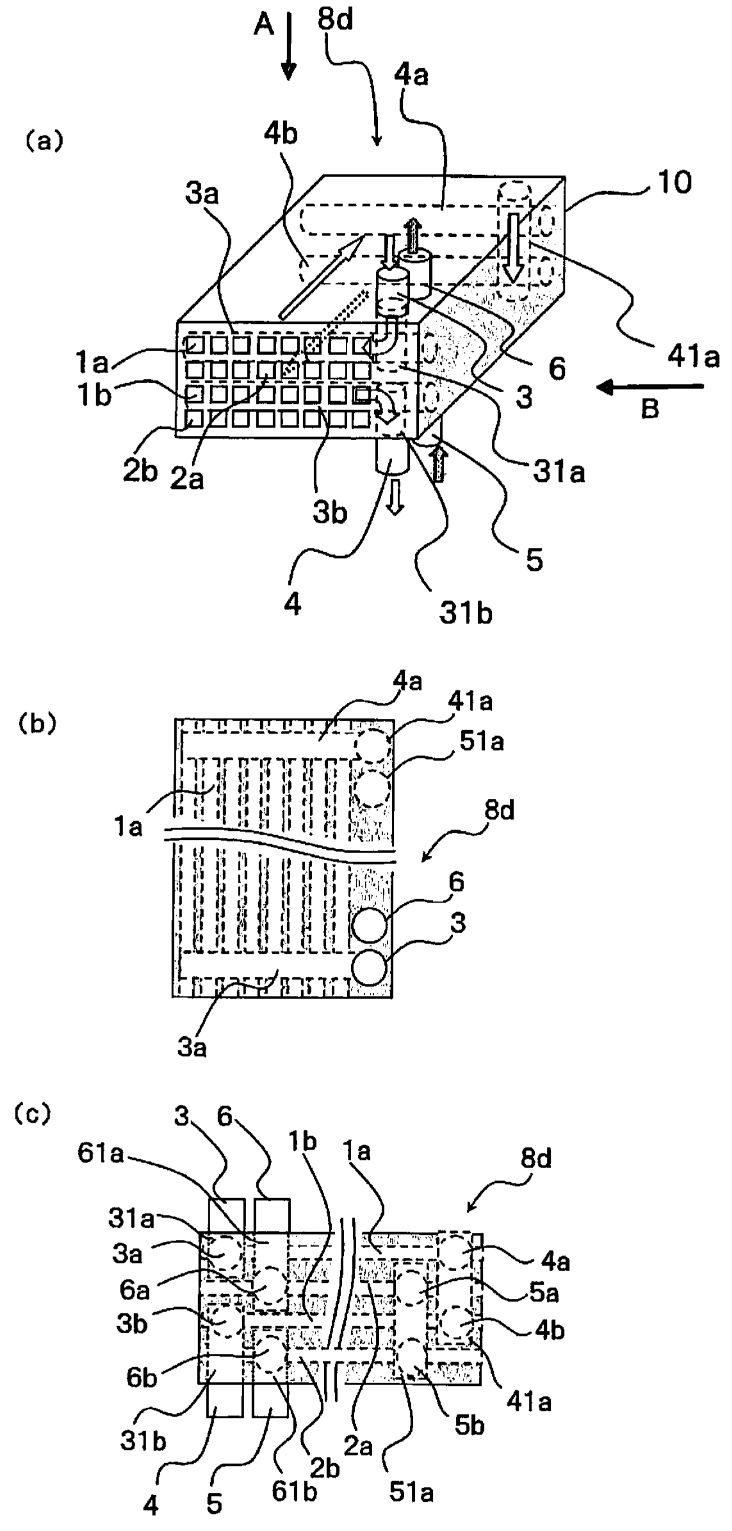


FIG. 5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5
4
31b
(b)
4a
41a
51a
1a
8d
6
3
3a
(c)
3
6
61a
1b
1a
8d
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3a
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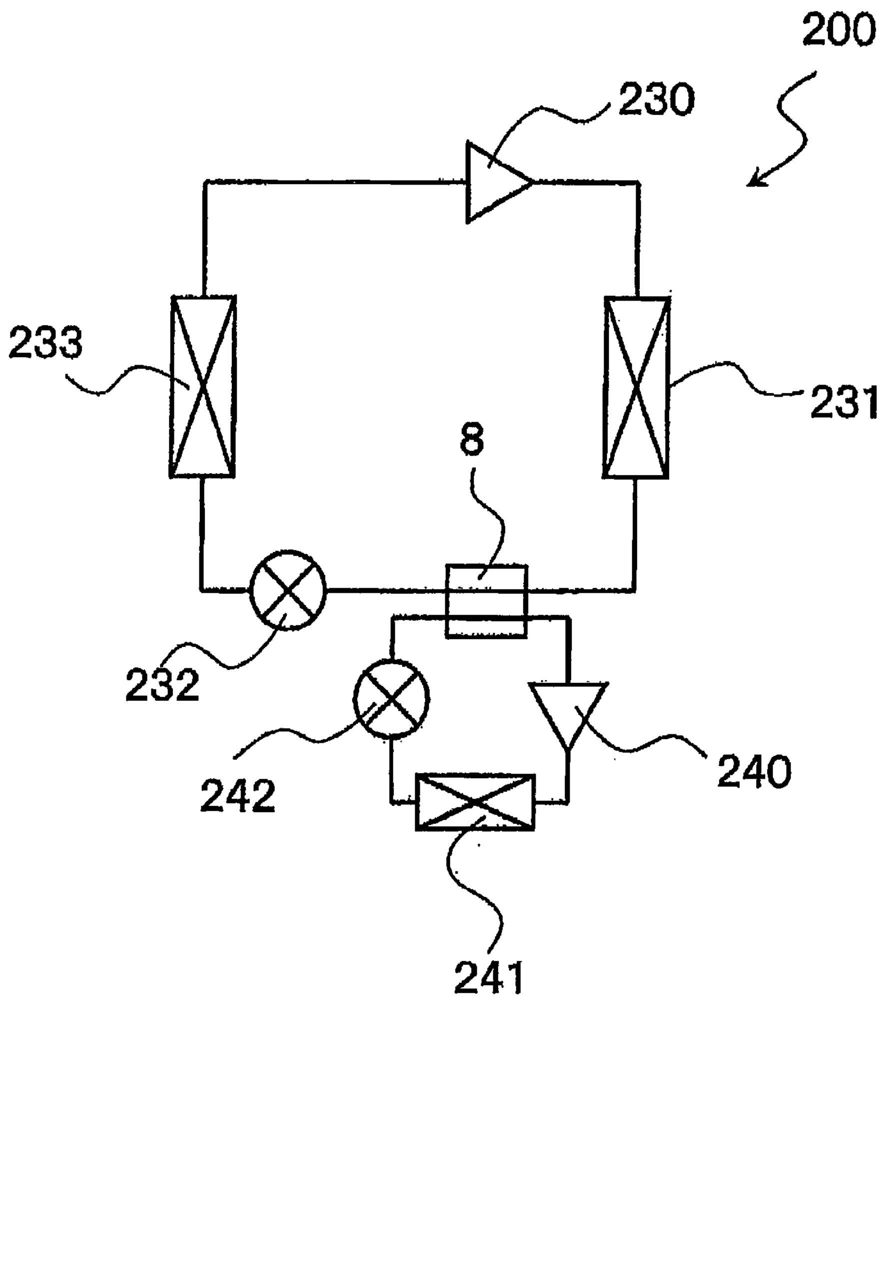
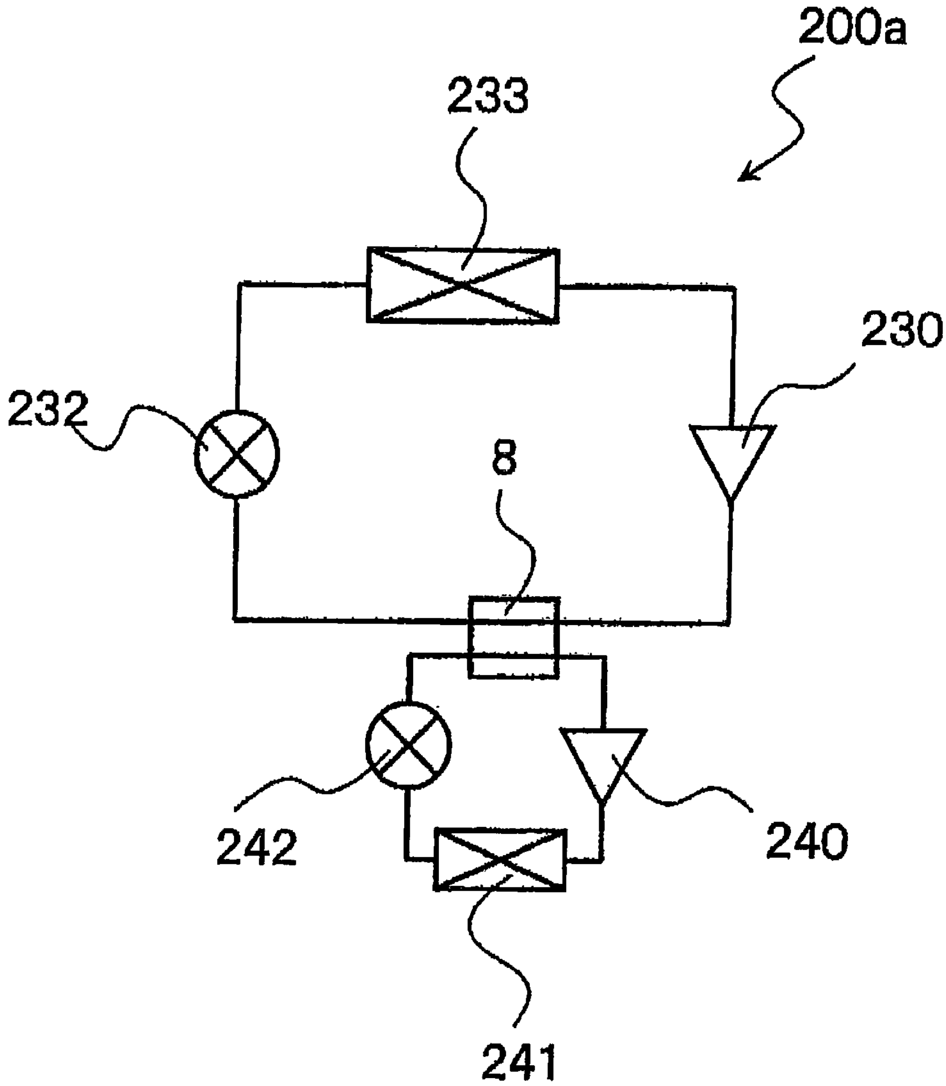
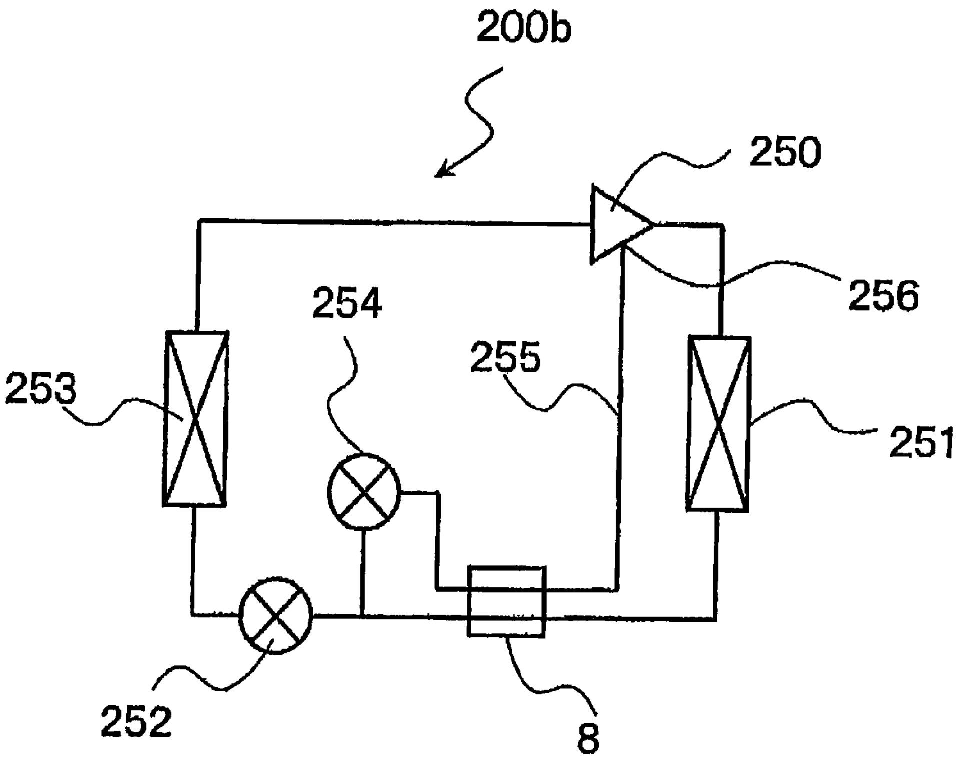
FIG. 6



F I G. 7



F I G. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/002550

A. CLASSIFICATION OF SUBJECT MATTER
F28D7/00(2006.01)i, *F28F1/02*(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)
F28D7/00, F28F1/02

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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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	JP 2003-202197 A (Denso Corp.), 18 July 2003 (18.07.2003), entire text; all drawings & DE 10300054 A1	1,2,13,14 3-12
Y	JP 2002-98424 A (Zexel Valeo Climate Control Corp.), 05 April 2002 (05.04.2002), entire text; all drawings (particularly, paragraph [0069]; fig. 8, 9) (Family: none)	3-8,11,12
Y	JP 2001-50685 A (Sanyo Electric Co., Ltd.), 23 February 2001 (23.02.2001), entire text; all drawings (particularly, fig. 3) (Family: none)	7-12

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

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Date of the actual completion of the international search	Date of mailing of the international search report
24 June, 2011 (24.06.11)	05 July, 2011 (05.07.11)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
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