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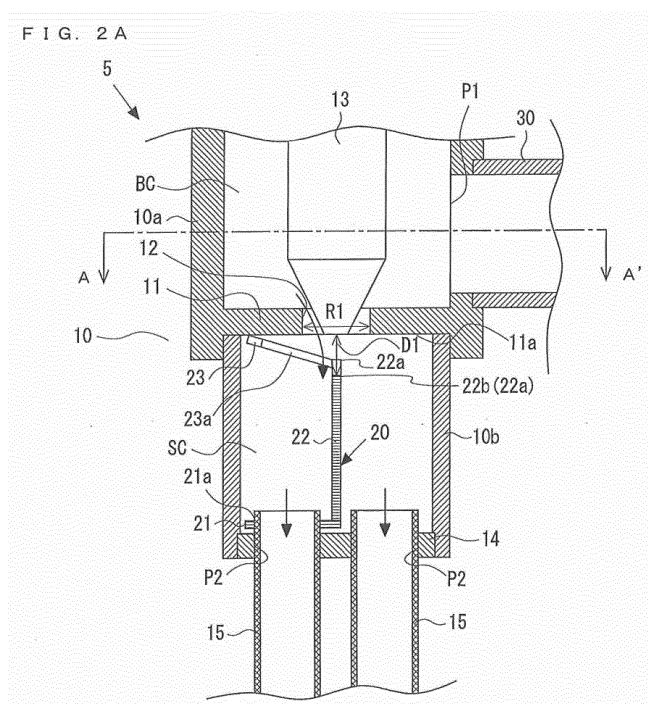
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(54) **EXPANSION VALVE AND COOLING CYCLE DEVICE USING SAME**

(57) An expansion valve includes a main body unit in which a valve chamber and a refrigerant dividing chamber are separated by a separation wall, an expansion section is opened to the separation wall so that the valve chamber and the refrigerant dividing chamber communicate with each other, and a plurality of branch ports that communicate with the refrigerant dividing chamber are provided; a valve body configured to adjust an opening

of the expansion section; and a partition section in a plate shape that is disposed in the refrigerant dividing chamber so as to separate the refrigerant dividing chamber for the plurality of branch ports, wherein at least part of an upper edge of the partition section is positioned in an opening of the expansion section in vertical view to the separation wall.



Description

Citation List

Technical Field

Patent Literature

[0001] The present invention relates to an expansion valve having a refrigerant distribution function and a refrigeration cycle apparatus using the same.

5 **[0005]**

Background Art

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2009-24937

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2010-32185

[0002] A refrigeration cycle apparatus includes an expansion valve that reduces pressure of high pressure refrigerant and converts the refrigerant into a gas-liquid two-phase state of low pressure and low quality, and an evaporator disposed downstream of the expansion valve is connected to the expansion valve. The refrigerant becomes a gas-liquid two-phase state in the expansion valve, and exchanges heat with air and water and becomes a gas-liquid two-phase state of low pressure and high quality or an overheated gas state in the evaporator. When the evaporator is formed by a multi-path heat exchanger made up of a plurality of paths (refrigerant flow paths), the refrigerant needs to be appropriately distributed to each of the paths.

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Summary of Invention

Technical Problem

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[0003] Conventionally, the expansion valve is proposed which includes an expansion valve and a refrigerant distributing device integrally formed by providing the distributor in the expansion valve so as to perform distribution of refrigerant to each of the paths (for example, see Patent Literature 1). The expansion valve disclosed in Patent Literature 1 includes a valve chamber and a refrigerant dividing chamber which are separated by a separation wall, and the valve chamber and the refrigerant dividing chamber communicate with each other via an expansion section formed on the separation wall. When the refrigerant flows into the expansion valve, the refrigerant pressure is reduced in the expansion section and flows into the refrigerant dividing chamber in a mist state (gas-liquid two-phase state) and is divided in the refrigerant dividing chamber for each of the plurality of branch pipes.

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[0006] The refrigerant immediately after flowing out the expansion valve is a mist flow which is easily uniformly distributed. However, the refrigerant which flows into the evaporator is not always a mist flow, and may become a slug flow or plug flow at the inlet of evaporator. As a result, gas and liquid of refrigerant in a gas-liquid two-phase state may be separated and may not be appropriately distributed due to the effect of gravity. As described in Patent Literature 1, even if the refrigerant which flows out the valve chamber is in a mist state in the refrigerant dividing chamber, the refrigerant is mutually affected in the refrigerant dividing chamber before it reaches the branch pipes, causes turbulence and becomes a non-uniform flow. When a refrigerant flow rate is sufficiently large, a non-uniform flow becomes a uniform flow when it collides against a wall surface of the refrigerant dividing chamber, thereby allowing the refrigerant to be distributed to the respective branch pipes with an intended distribution ratio in the refrigerant dividing chamber. However, when the refrigerant flow rate is small, an energy in collision is also small and does not generate a uniform flow, and accordingly, the refrigerant may not be appropriately distributed to the respective branch pipes. Further, under an operation condition in which a refrigeration (air conditioning) load is small, the refrigerant flow rate in the expansion valve is small. Accordingly, the refrigerant does not become a mist state even if the refrigerant pressure is reduced in the expansion section and flows into the expansion valve in a gas-liquid two-phase state, and may fail to be distributed to the respective branch pipes with an intended distribution ratio.

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[0004] Patent Literature 2 discloses the expansion valve in which a refrigerant inlet port communicates with refrigerant outlet ports via an orifice and a refrigerant dividing chamber, and includes a valve body that adjusts an opening of the orifice. The refrigerant outlet ports are arranged at equal interval in a circumferential direction of the refrigerant dividing chamber about the orifice. The valve body is disposed on a downstream side of the orifice, and the refrigerant dividing chamber forms a flow path which gradually extends toward the outer periphery. The refrigerant is guided by a flow guide section formed in a protruding shape at the orifice from the orifice to the refrigerant dividing chamber while being expanded, and is uniformly distributed to the refrigerant outlet ports.

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[0007] In Patent Literature 2, the refrigerant flows from the orifice to the refrigerant dividing chamber while being expanded and into the refrigerant outlet ports which are disposed in a circumferential direction at equal interval, and is distributed while being guided by the valve body and the refrigerant dividing chamber, unlike Patent Literature 1 in which the refrigerant collides against the wall surface and is uniformly distributed. However, similar to Patent Literature 1, the refrigerant is mutually affected in the refrigerant dividing chamber before the refrigerant reaches the refrigerant outlet ports, causes turbulence and becomes a non-uniform flow. As a result, the refrigerant

erant may not be uniformly distributed. In addition to that, a flow of opposite direction is not taken into consideration, and a refrigerant noise may occur in a gas-liquid two-phase flow. Further, the refrigerant may not be distributed at intentionally different ratio instead of uniform distribution.

[0008] The present invention has been made to solve the above problems, and an object of the invention is to provide an expansion valve which can distribute the refrigerant in a refrigerant dividing chamber at an intended distribution ratio with high accuracy, and a refrigeration cycle apparatus using the same. Solution to Problem

[0009] An expansion valve of the present invention includes a main body unit in which a valve chamber and a refrigerant dividing chamber are separated by a separation wall, an expansion section is opened to the separation wall so that the valve chamber and the refrigerant dividing chamber communicate with each other, and a plurality of branch ports that communicate with the refrigerant dividing chamber are provided; a valve body configured to adjust an opening of the expansion section; and a partition section in a plate shape that is disposed in the refrigerant dividing chamber so as to separate the refrigerant dividing chamber for the plurality of branch ports, wherein at least part of an upper edge of the partition section is positioned in an opening of the expansion section in vertical view to the separation wall.

Advantageous Effects of Invention

[0010] According to the expansion valve of the present invention, since the partition section divides the refrigerant dividing chamber for a plurality of branch ports, the pressure such as a pressure reduction, expansion and the like is adjustable while the refrigerant can be distributed to each of the branch ports with an intended distribution ratio regardless of the amount of refrigerant flow rate.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a refrigerant circuit view which shows a refrigeration cycle apparatus of Embodiment 1 of the present invention.

[Fig. 2A] Fig. 2A is a schematic cross sectional view which shows an expansion valve of Embodiment 1 of the present invention.

[Fig. 2B] Fig. 2B is a schematic partial cross sectional view which shows the expansion valve of Embodiment 1 of the present invention.

[Fig. 3A] Fig. 3A is a schematic top view which shows a partition section in a second housing of Fig. 2A.

[Fig. 3B] Fig. 3B is a schematic view which shows a cross section of a first housing of Fig. 2A taken along the line A-A'.

[Fig. 4A] Fig. 4A is a schematic top view which shows

one example of the partition section in the expansion valve of Fig. 2A.

[Fig. 4B] Fig. 4B is a schematic side view which shows one example of the partition section in the expansion valve of Fig. 2A.

[Fig. 4C] Fig. 4C is a schematic development view which shows one example of the partition section in the expansion valve of Fig. 2A.

[Fig. 5A] Fig. 5A is a schematic top view which shows the partition section in the expansion valve of Embodiment 2 of the present invention.

[Fig. 5B] Fig. 5B is a schematic side view which shows the partition section in the expansion valve of Embodiment 2 of the present invention.

[Fig. 5C] Fig. 5C is a schematic development view which shows the partition section in the expansion valve of Embodiment 2 of the present invention.

[Fig. 5D] Fig. 5D is a schematic view which shows a cross section of a first housing of Fig. 2A taken along the line A-A'.

[Fig. 6A] Fig. 6A is a schematic cross sectional view which shows the expansion valve of Embodiment 3 of the present invention.

[Fig. 6B] Fig. 6B is a schematic view which shows a cross section of a first housing of Fig. 6A taken along the line A-A'.

[Fig. 7] Fig. 7 is a schematic cross sectional view which shows the expansion valve of Embodiment 4 of the present invention.

[Fig. 8A] Fig. 8A is a schematic top view which shows the partition section in the second housing of Fig. 7.

[Fig. 8B] Fig. 8B is a schematic view which shows a cross section of the first housing of Fig. 7 taken along the line A-A'.

[Fig. 9] Fig. 9 is a schematic view which shows a refrigeration cycle apparatus of Embodiment 5 of the present invention.

Description of Embodiments

Embodiment 1

[0012] Referring to the drawings, an expansion valve of Embodiment 1 of the present invention will be described. Fig. 1 is a refrigerant circuit view which shows a refrigeration cycle apparatus of Embodiment 1 of the present invention, and a refrigeration cycle apparatus 1 will be described with reference to Fig. 1. The refrigeration cycle apparatus 1 performs both cooling operation and heating operation, and an outdoor unit 1 A and an indoor unit 1 B are connected to each other by a liquid pipe 9A and a gas pipe 9B. The outdoor unit 1 A includes a compressor 2, a flow path switching device 3, and an outdoor side heat exchanger 4. The compressor 2 suctions refrigerant, and compresses the refrigerant and discharges the refrigerant in a high temperature and high pressure state. The compressor 2 has a discharge side connected to the flow path switching device 3 and a suc-

tion side connected to a suction pipe 9.

[0013] The flow path switching device 3 switches between a heating flow path and a cooling flow path according to switching of the operation mode of a cooling operation and a heating operation, and is made up of, for example, a four-way valve. During cooling operation, the flow path switching device 3 connects the discharge side of the compressor 2 and the outdoor side heat exchanger 4 and connects the suction side of the compressor 2 and the gas pipe 9B. Then, the refrigerant discharged from the compressor 2 flows to the outdoor side heat exchanger 4, and the refrigerant discharged from the indoor unit 1 B flows to the outdoor unit 1A via the gas pipe 9B. During heating operation, the flow path switching device 3 connects the suction side of the compressor 2 to the outdoor side heat exchanger 4 and connects the discharge side of the compressor 2 and the gas pipe 9B. Then, the refrigerant discharged from the compressor 2 flows to the indoor unit 1 B and the refrigerant discharged from the indoor unit 1 B flows to the outdoor unit 1 A via the liquid pipe 9A. Although the example is described for the case where a four-way valve is used as the flow path switching device 3, the invention is not limited thereto. For example, a combination of a plurality of two-way valves may be used.

[0014] The outdoor side heat exchanger 4 is provided for exchanging heat between the refrigerant and air (outside air), and includes, for example, a heat transfer pipe that allows the refrigerant to flow therethrough and a fin that is provided for increasing heat transfer area between the refrigerant flowing in the heat transfer pipe and outside air. The outdoor side heat exchanger 4 is disposed and connected between the flow path switching device 3 and the liquid pipe 9A, and serves as a condenser that condenses and liquefies the refrigerant during cooling operation and as an evaporator that evaporates and vaporizes the refrigerant during heating operation.

[0015] The indoor unit 1 B includes an expansion valve 5, an indoor side heat exchanger 7 and a header 8. The expansion valve 5 serves as a reducing valve or an expansion valve that adjusts a pressure of refrigerant which passes through the indoor side heat exchanger 7, and is disposed and connected between the liquid pipe 9A and the indoor side heat exchanger 7. The indoor side heat exchanger 7 serves as an evaporator (heat receiving device) during cooling operation and as a condenser (heat radiating device) during heating operation. Then, the indoor side heat exchanger 7 exchanges heat between indoor air and the refrigerant to perform cooling and heating of a space. In particular, the indoor side heat exchanger 7 is made up of a multi-path heat exchanger which includes a plurality of paths, for example, a heat exchanger which includes two paths. The expansion valve 5 has a distribution function of distributing the refrigerant to the respective paths of the indoor side heat exchanger 7 via capillary tubes 6. During cooling operation, the refrigerant which is distributed by the expansion valve 5 flows into the respective paths of the indoor side heat exchanger

7 and merges in the header 8. During heating operation, the refrigerant flows from the header 8 into the respective paths of the indoor side heat exchanger 7 and the refrigerant which flows out the respective paths merges at the expansion valve 5.

[0016] It is desirable to use a small amount of refrigerant having low GWP as refrigerant of the above refrigeration cycle apparatus 1 for prevention of global warming, and GWP can be reduced compared to the conventional fluorocarbon refrigerant when refrigerant having a relatively high GWP such as R32, HFO refrigerant, HCFO refrigerant and flammable refrigerant.

[0017] A flow of refrigerant in the refrigeration cycle apparatus 1 during cooling operation and heating operation will be described below. First, with reference to Fig. 1, an operation example of the refrigeration cycle apparatus 1 during cooling operation will be described. The discharge side of the compressor 2 and the gas pipe 9B are connected and the outdoor side heat exchanger 4 and the suction side of the compressor 2 are connected by the flow path switching device 3. The refrigerant of a low pressure gas is compressed in the compressor 2 and becomes a high pressure gas. The refrigerant in a state of high pressure gas exchanges heat with outside air in the outdoor side heat exchanger (condenser) 4, and is condensed and becomes high pressure liquid refrigerant by transferring energy of the refrigerant to a heat source (such as air and water).

[0018] Then, the refrigerant flows to the expansion valve 5 via the liquid pipe 9A and the refrigerant pressure is reduced. The refrigerant becomes a low pressure two-phase state and branches at the expansion valve 5 and flows into the respective paths of the indoor side heat exchanger 7 via the capillary tubes 6. In the indoor side heat exchanger (evaporator) 7, the refrigerant absorbs an energy of water on a load side or outside air while passing through paths in the indoor side heat exchanger 7 and evaporates to become a low pressure gas. Here, water or air which has exchanged heat with the refrigerant is cooled. After that, refrigerant in the plurality of paths of the indoor side heat exchanger 7 is collected in the header 8 and is suctioned to the compressor 2 via the gas pipe 9B.

[0019] Next, with reference to Fig. 1, an operation example of the refrigeration cycle apparatus 1 during heating operation will be described. The discharge side of the compressor 2 and the gas pipe 9B are connected and the outdoor side heat exchanger 4 and the suction side of the compressor 2 are connected by the flow path switching device 3. The refrigerant in a state of low pressure gas flows into the compressor 2 and is compressed therein and becomes a high pressure gas. Then, refrigerant in a state of high pressure gas flows through the gas pipe 9B and branches at the header 8 into the plurality of paths of the indoor side heat exchanger (condenser) 7. The refrigerant transfers energy to water on a load side or outside air while passing through paths in the indoor side heat exchanger 7. Here, the refrigerant is

condensed and becomes high pressure liquid refrigerant, and the water or air after heat exchange is heated.

[0020] After that, the high pressure liquid refrigerant flows from the indoor side heat exchanger (condenser) 7 into the expansion valve 5 via the capillary tubes 6. The refrigerant which has passed through the plurality of paths of the indoor side heat exchanger 7 is collected in the expansion valve 5 and the refrigerant pressure is reduced so that the refrigerant becomes a low pressure two-phase state. The refrigerant of a low pressure two-phase state passes through the liquid pipe 9A and flows into the outdoor side heat exchanger 4. In the outdoor side heat exchanger (evaporator) 4, the refrigerant absorbs an energy of water in outside air or air and evaporates to become a low pressure gas. After that, the refrigerant flows back to the suction side of the compressor 2 via the flow path switching device 3.

[0021] As described above, the indoor side heat exchanger 7 includes the plurality of paths, and distribution and collection of refrigerant is performed by the expansion valve 5. Here, Fig. 2A is a schematic cross sectional view of the expansion valve of Embodiment 1 of the present invention, Fig. 2B is a schematic partial cross sectional view of the expansion valve of Embodiment 1 of the present invention. With reference to Fig. 2A, Fig. 2B, the expansion valve 5 will be described. Further, Fig. 2A shows an example of the indoor side heat exchanger 7 having two paths. The expansion valve 5 has a distribution function of distributing and collecting the refrigerant into the respective paths of the indoor side heat exchanger 7, and includes a main body unit 10, a valve body 13, and a partition section 20.

[0022] The main body unit 10 has a valve chamber BC and a refrigerant dividing chamber SC separated by a separation wall 11. Specifically, the main body unit 10 includes a first housing 10a having the valve chamber BC and a second housing 10b having the refrigerant dividing chamber SC. The first housing 10a is formed, for example, by cutting a brass cast into a cylindrical shape and includes the separation wall 11 of a plate shape which is perpendicular to the cylindrical portion. Then, the valve chamber BC that is defined by the cylindrical portion and the separation wall 11 is formed in the first housing 10a. A connection port P1 which communicates with the valve chamber BC is formed on a side surface of the first housing 10a, and a pipe 30 which communicates with the liquid pipe 9A (see Fig. 1) is formed at the connection port. The refrigerant flows between the valve chamber BC and the liquid pipe 9A via the connection port P1 and the pipe 30. Further, an expansion section 12 in a circular shape is formed on the separation wall 11 so as to allow the valve chamber BC and the refrigerant dividing chamber SC to communicate with each other.

[0023] The second housing 10b is formed, for example, in a cylindrical shape, and one opening of which is mounted on the separation wall 11. A mounting member 14 on which a plurality of branch ports P2 are formed is fixed

to the other opening of the second housing 10b. Branch pipes 15 are mounted in each of the plurality of branch ports P2 of the mounting member 14 by brazing or the like so as to extend into the refrigerant dividing chamber SC.

[0024] The valve body 13 adjusts an opening of the expansion section 12 and is disposed in the valve chamber BC above the expansion section 12. The valve body 13 has an end formed in a cone shape, and the end is configured to move in the expansion section 12 by a driving device disposed on an upper side of the first housing 10a, which is not shown in the figure. Accordingly, as a position of the valve body 13 changes, an area of a path of an expansion section 12 which is a small path formed between a periphery of the expansion section 12 (valve seat) and the valve body 13 varies, thereby adjusting an opening of the expansion section 12.

[0025] The partition section 20 is disposed in the refrigerant dividing chamber SC and separates the refrigerant dividing chamber SC for each of a plurality of branch ports P2. Fig. 3A is a schematic view which shows the partition section in the second housing 10b of Fig. 2A, Fig. 3B is a schematic view which shows a cross section of the first housing 10a of Fig. 2A taken along the line A-A', and Fig. 4 is a schematic top view which shows one example of the partition section 20 in the expansion valve 5 of Fig. 2A. With reference to Fig. 2 to Fig. 4, the partition section 20 will be described. Further, Fig. 4A is a schematic top view of the partition section 20, Fig. 4B is a schematic side view of the partition section 20, and Fig. 4C is a schematic development view of the partition section 20, and this example shows the case where the refrigerant is equally distributed to two branch ports P2.

[0026] The partition section 20 is integrally formed of, for example, a plate-shaped stainless steel (SUS) and includes a fixation piece 21, a partition wall 22, and an elastic piece 23. The fixation piece 21 is a portion for fixing the partition section 20 in the refrigerant dividing chamber SC and is formed in a semi-circular shape. The outer shape of the fixation piece 21 is the same as the inner diameter of the second housing 10b or smaller than the inner diameter of the second housing 10b. The fixation piece 21 has a hole 21a in which the branch pipe 15 is inserted. When the branch pipe 15 is inserted into the hole 21a, the partition section 20 is fixed to the mounting member 14 by brazing or the like. The diameter of the hole 21a is the same as the diameter of the branch pipe 15, or a fine gap is formed therebetween. The fixation piece 21 is fixed to the mounting member 14 and the branch pipe 15 by brazing or the like. The above described branch pipe 15 is formed to extend into the refrigerant dividing chamber SC for connection to the fixation piece 21, and one branch pipe 15 of the plurality of branch pipes 15 may extend into the refrigerant dividing chamber SC.

[0027] The partition wall 22 is a plate member that extends from the fixation piece 21 to the expansion section 12, and separates the refrigerant dividing chamber SC

for each of the plurality of branch ports (see the arrow in Fig. 2A). The width of the partition wall 22 is larger than the inner diameter of the second housing 10b, and the both ends of the partition wall 22 are fixed to the inner peripheral surface of the second housing 10b. An upper edge 22a of the partition wall 22 is positioned in the opening of the expansion section 12 in a vertical view to the separation wall 11. That is, as shown in Fig. 3B, the partition wall 22 is located at a position in which the upper edge 22a of the partition wall 22 can be seen through the opening of the expansion section 12 as seen downwardly in the A-A' cross sectional direction of Fig. 2A from the valve chamber BC.

[0028] The partition wall 22 has a height which extends to a position immediately under the expansion section 12. Specifically, a recess 22b is formed at a substantially center of the upper edge 22a of the partition wall 22 such that a distance D1 between the lowest end of the recess 22b and a lower surface 11a of the separation wall 11 to which the expansion section 12 is open is smaller than a diameter R1 of the expansion section 12 ($D1 < R1$). That is, a maximum distance between the lower surface 11a of the separation wall 11 to which the expansion section 12 is open and the upper edge 22a of the partition wall 22 is smaller than the diameter R1 of the expansion section 12. Accordingly, since the refrigerant is distributed immediately after flowing out the expansion section 12 and before non-uniformly dispersed due to the upper edge 22a of the partition wall 22 (the lowest end of the recess 22b) extending to a position immediately under the expansion section 12, the refrigerant is distributed to each of the branch ports P2 with an intended distribution ratio regardless of the amount of refrigerant flow rate and the state of refrigerant, and the flowing noise of refrigerant can be minimized. Further, the recess 22b is formed to prevent the valve body 13 from coming into contact with the upper edge 22a of the partition wall 22.

[0029] Although the above Embodiment 1 is described for the example in which the recess 22b is formed at a substantially center of the upper edge 22a of the partition wall 22, the recess 22b is not necessarily formed on the upper edge 22a as long as a distance from the lower surface 11a of the separation wall 11 is provided so as to prevent the valve body 13 from coming into contact with the upper edge 22a. In this case, the distance D1 is a distance between the upper edge 22a of the partition wall 22 and the lower surface 11a of the separation wall 11 to which the expansion section 12 is open.

[0030] Fig. 2B is a schematic partial cross sectional view which shows the expansion valve of Embodiment 1 of the present invention.

[0031] A taper section 22c may be formed on the upper edge 22a of the partition wall 22 such that a thickness of the partition wall 22 decreases toward the expansion section 12 as shown in Fig. 2B. Since the taper section 22c is provided on the upper edge 22a, the refrigerant can be distributed with reduced resistance when the upper edge 22a (recess 22b) of the partition wall 22 moves

close to the expansion section 12 and the refrigerant comes into contact with the upper edge 22a, thereby reducing the flowing noise of refrigerant or a pressure loss.

[0032] Further, the partition wall 22 is disposed so that the refrigerant dividing chamber SC is divided depending on the distribution ratio for each of the plurality of branch pipes 15 (branch ports P2). For example, when the distribution ratio for two paths are equal, the cross sectional area of the refrigerant dividing chamber SC (an area of the expansion section 12) is divided by equal area ratio. Accordingly, since the position of the partition wall 22 is changed depending on an intended distribution ratio, distribution ratio can be easily decided depending on the type of heat exchanger.

[0033] The elastic piece 23 is formed in a semi-circular shape and is configured to come into contact with the separation wall 11 and biases the partition wall 22 toward the fixation piece 21 by an elastic force. The outer shape of the elastic piece 23 is the same as the inner diameter of the second housing 10b or smaller than the inner diameter of the second housing 10b. Further, an opening 23a is formed on the elastic piece 23 such that the refrigerant flows between the expansion section 12 and the branch pipe 15 through the opening 23a. Further, the diameter of the semi-circle of the opening 23a is formed to be the same as or slightly larger than the diameter of the expansion section (valve seat) 12.

[0034] With reference to Figs. 2 to 4, an example of assembly process of the expansion valve 5 will be described. First, the second housing 10b, the valve body 13 and a driving device which is not shown in the figure are mounted on the first housing 10a so that the first assembly body is assembled. Further, the branch pipe 15 is inserted into the branch port P2 of the mounting member 14 and fixed thereto. Then, a hole 21a of the partition section 20 is inserted over the branch pipe 15 which extends from the mounting member 14 so that the second assembly body is assembled. After that, the second assembly body is assembled to the first assembly body, and the expansion valve 5 is completed. In so doing, while the elastic piece 23 comes into contact with the separation wall 11 and the partition wall 22 is biased toward the mounting member 14, a phase (rotation direction) of the mounting member 14 is adjusted so that the partition wall 22 is positioned at a predetermined position. Since the mounting member 14 is fixed to the second housing 10b after the branch pipe 15 and the partition section 20 are mounted on the mounting member 14, the phase (rotation direction) of the expansion section 12 in the main body unit 10 and the partition section 20 in the mounting member 14 can be easily aligned.

[0035] With reference to Figs. 2 to 4, a cooling operation of the expansion valve 5 in which the refrigerant is distributed to the plurality of branch pipes 15 will be described. First, high pressure liquid refrigerant is introduced from a pipe 30 into the valve chamber BC and is reduced in pressure at the expansion section 12. In so doing, a passing area in the expansion section 12 is ad-

justed by the valve body 13. Then, the refrigerant becomes a uniform mist flow, and flows from the valve chamber BC of the first housing 10a into the refrigerant dividing chamber SC of the second housing 10b. After that, the refrigerant in a mist flow is distributed in the partition section 20 and flows into the branch pipes 15.

[0036] As the flow path area of the expansion section 12 becomes smaller, the refrigerant tends to flow along a generatrix of the cone portion of the valve body 13. Accordingly, when the refrigerant flows from the expansion section 12 into the refrigerant dividing chamber SC, the general flow of refrigerant is directed so that the flow causes collision in the refrigerant dividing chamber SC and is mutually affected. When the flow rate is small, collision energy is not enough to generate a sufficiently uniform flow. Since the refrigerant is divided by the partition section 20 in the state of mist flow immediately after the expansion section 12 regardless of the flow rate flowing through the expansion valve 5, the refrigerant flow toward the respective branch pipes 15 can be prevented from being mutually affected. Accordingly, the refrigerant can be distributed to the respective branch pipes 15 at an intended distribution ratio regardless of refrigerant flow rate and the state of refrigerant. Particularly, since the refrigerant is divided by the partition section 20 immediately under the expansion section 12, the refrigerant can be distributed regardless of the amount of flow rate.

[0037] When the refrigerant flow rate is large, flowing noise of refrigerant may occur due to (front) collision of refrigerant against the wall surface of the refrigerant dividing chamber SC when the flow of refrigerant is branched. Further, when the refrigerant in the pipe 30 is in a gas-liquid two-phase state such as slug flow or plug flow, the refrigerant flows into the refrigerant dividing chamber SC in an intermittent state in which gas and liquid alternately pass through the expansion section 12. Since the refrigerant dividing chamber SC is divided by the partition section 20 to increase the paths, energy diffusion is facilitated, thereby reducing occurrence of intermittent flow noise of refrigerant. Further, since the partition section 20 is a plate member and has a small area in a normal direction of the partition section 20, the flowing noise of refrigerant can be reduced. Further, since elasticity (spring) of the partition section 20 allows for contact, noise occurrence due to vibration of contact section can be prevented.

[0038] With reference to Figs. 2 to 4, a heating operation of the expansion valve 5 in which the refrigerant is collected to the pipe 30 from the plurality of branch pipes 15 will be described. First, the refrigerant is introduced from the plurality of branch pipes 15 into the refrigerant dividing chamber SC of the second housing 10b, and flows into the valve chamber BC of the first housing 10a through the expansion section 12. After that, the refrigerant in the valve chamber BC flows out the connection port P1 via the pipe 30 into the liquid pipe 9A.

[0039] When the refrigerant passing through the branch pipes 15 is in a gas-liquid two-phase state such

as slug flow or plug flow, gas and liquid intermittently pass through the expansion section 12 into the valve chamber BC. Particularly, when the refrigerant at the outlet of the indoor side heat exchanger (condenser) 7 is in a gas-liquid two-phase state, the alignment is collected in the refrigerant dividing chamber SC in which the flow speed becomes slow. Accordingly, since intermittence of gas and liquid becomes significant when the refrigerant flows into the expansion section 12, the flowing noise of refrigerant may increase. However, the refrigerant which flows from the respective branch pipes 15 into the refrigerant dividing chamber SC is collected immediately before the alignment passes through the expansion section 12 (valve seat) without being mutually affected since the partition section 20 is provided, thereby reducing an intermittent refrigerant flow and minimizing occurrence of intermittent flowing noise of refrigerant.

[0040] As described above, since the expansion valve 5 has a distribution function of the refrigerant, the expansion valve 5 can minimize the flowing noise of refrigerant while distributing the refrigerant with an intended distribution ratio regardless of the amount of refrigerant flow rate and the state of refrigerant. Further, since the expansion valve 5 can perform pressure reduction or expansion of refrigerant and also has a distribution function, it is possible to decrease the number of parts, save a space, improve workability, and reduce the cost. Particularly, when the heat exchanger has smaller diameter in order to reduce the amount of refrigerant, the number of paths increases accordingly. The increase in the number of paths, however, can be accommodated without providing additional distributors.

[0041] Further, although the refrigerant can be in a uniform state in the refrigerant dividing chamber SC and can be equally distributed, it is necessary to adjust a flow path resistance (pipe length) of a pipe which connects branch pipes and the evaporator in order to distribute the refrigerant at intentionally different refrigerant flow rate. As a result, since a pressure loss increases, a required diameter of expansion valve 5 or a pipe diameter needs to be increased, leading to increase in cost. On the other hand, as described above, since the distribution ratio can be adjusted by varying the position of the partition wall 22, an intended distribution ratio can be easily provided.

Embodiment 2

[0042] Fig. 5 is a schematic view which shows the partition section in the expansion valve of Embodiment 2 of the present invention, and with reference to Fig. 5, a partition section 120 will be described. Further, Fig. 5A is a schematic top view of the partition section 120, Fig. 5B is a schematic side view of the partition section 120, Fig. 5C is a schematic development view of the partition section 120, and Fig. 5D is a schematic view which shows a cross section of the first housing 10a of Fig. 2A taken along the line A-A'. In the partition section 120 of Fig. 5, the same reference numbers are used for the same con-

figuration of the partition section 20 of Fig. 4, and the explanation thereof is omitted. The partition section 120 of Fig. 5 differs from the partition section 20 of Fig. 4 in the number of branches and the configuration of an elastic piece 123.

[0043] The partition section 120 of Fig. 5 is mounted on the mounting member 14 which has three branch ports P2 and is formed to separate the refrigerant dividing chamber SC into three spaces by bending a plate member. The branch pipes 15 are each inserted into a plurality of branch ports P2, and fixation pieces 121 are disposed on two branch ports P2 and have holes 121 a to be inserted over two branch pipes 15. Further, three partition walls 122 corresponding to three branch ports P2 are formed on the fixation pieces 121. The elastic piece 123 is formed of a plate shaped piece that is in contact with the separation wall 11 while avoiding the expansion section 12. Similar to Embodiment 1, an upper edge 122a of the partition wall 122 is located in the opening of the expansion section 12 in vertical view to the separation wall 11. That is, as shown in Fig. 5D, the partition wall 122 is located at a position in which the upper edge 122a of the partition wall 122 can be seen through the opening of the expansion section 12 as seen downwardly in the A-A' cross sectional direction of Fig. 2A from the inside of the valve chamber BC.

[0044] Further, a recess 122b is formed on the upper edge 122a of the partition wall 122, such that the distance D1 between the lowest end of the recess 122b and a lower surface 11 a of the separation wall 11 to which the expansion section 12 is open is smaller than the diameter R1 of the expansion section 12 ($D1 < R1$, see Fig. 2A). That is, the maximum distance between the lower surface 11 a of the separation wall 11 to which the expansion section 12 is open and the upper edge 122a of the partition wall 122 is smaller than the diameter R1 of the expansion section 12. Accordingly, since the refrigerant is distributed immediately after flowing out the expansion section 12 and before non-uniformly dispersed due to the upper edge 122a of the partition wall 122 (the lowest end of the recess 122b) extending to a position immediately under the expansion section 12, the refrigerant is distributed to each of the branch ports P2 with an intended distribution ratio regardless of the amount of refrigerant flow rate and the state of refrigerant, and the flowing noise of refrigerant can be minimized. Further, the recess 122b is formed to prevent the valve body 13 from coming into contact with the upper edge 122a of the partition wall 122.

[0045] Although the above Embodiment 2 is described for the example in which the recess 122b is formed at a substantially center of the upper edge 122a of the partition wall 122, the recess 122b is not necessarily formed on the upper edge 122a as long as a distance from the lower surface 11 a of the separation wall 11 is provided so as to prevent the valve body 13 from coming into contact with the upper edge 122a. In this case, the distance D1 is a distance between the upper edge 122a of the

partition wall 122 and the lower surface 11 a of the separation wall 11 to which the expansion section 12 is open.

[0046] Similar to Embodiment 1, a taper section may be formed on the upper edge 122a of the partition wall 122 such that a thickness of the partition wall 122 decreases toward the expansion section 12 as shown in Fig. 2B.

[0047] In this partition section 120, occurrence of the flowing noise of refrigerant can also be prevented while the refrigerant can be distributed at an intended distribution ratio regardless of refrigerant flow rate and the state of refrigerant similar to Embodiment 1. Particularly, when the heat exchanger has smaller diameter in order to reduce the amount of refrigerant, the number of paths increases accordingly. The increase in the number of paths, however, can be accommodated without providing additional.

Embodiment 3

[0048] Fig. 6A is a schematic view which shows the expansion valve of Embodiment 3 of the present invention, and Fig. 6B is a schematic view which shows a cross section of the first housing 10a of Fig. 6A taken along the line A-A'. With reference to Fig. 6A and Fig. 6B, an expansion valve 205 will be described. In the expansion valve 205 of Fig. 6A, the same reference numbers are used for the same configuration of the expansion valve 5 of Fig. 2A, and the explanation thereof is omitted. The expansion valve 205 of Fig. 6A differs from the expansion valve 5 of Fig. 2A in that the partition section 220 is formed by a wall surface of the branch pipes 15.

[0049] In Fig. 6A, an auxiliary housing 10c is fixed to the second housing 10b by brazing or the like, and the mounting member 14 having a branch port is mounted on the auxiliary housing 10c. The plurality of branch pipes 15 are disposed in the refrigerant dividing chamber SC and extend from the branch port P2 to a position immediately under the expansion section 12. The wall surface of the branch pipe 15 serves as the partition section 220, and separates an inner space and an outer space of the branch pipe 15 in the refrigerant dividing chamber SC. In other words, the refrigerant which flows out the expansion section 12 is directed to flow into the branch pipe 15 immediately under the expansion section 12.

[0050] Similar to Embodiments 1 and 2, an upper edge 220a of the partition section 220 (branch pipe 15) is positioned in the opening of the expansion section 12 in a vertical view to the separation wall 11. That is, as shown in Fig. 6B, the partition section 220 is located at a position in which the upper edge 220a of the partition section 220 can be seen through the opening of the expansion section 12 as seen downwardly from the valve chamber BC in the A-A' cross sectional direction of Fig. 6A.

[0051] Further, the distance D1 between the upper edge 220a of the partition section 220 and the lower surface 11 a of the separation wall 11 to which the expansion section 12 is open is smaller than the diameter R1 of the

expansion section 12 ($D1 < R1$). Accordingly, since the refrigerant is distributed immediately after flowing out the expansion section 12 and before non-uniformly dispersed due to the upper edge 220a of the partition section 220 extending to a position immediately under the expansion section 12, the refrigerant is distributed to each of the branch ports P2 with an intended distribution ratio regardless of the amount of refrigerant flow rate and the state of refrigerant, and the flowing noise of refrigerant can be minimized.

[0052] Further, similar to Embodiments 1 and 2, a taper section may be formed on the upper edge 220a of the partition section 220 such that a thickness of the partition section 220 decreases toward the expansion section 12 as shown in Fig. 2B.

[0053] As described above, in the case where the partition section 220 is formed by the branch pipe, the refrigerant can be distributed at an intended distribution ratio regardless of refrigerant flow rate and the state of refrigerant. In addition, since the branch pipe 15 serves as the partition section 20, it is possible to decrease the number of parts, reduce the cost, and improve work efficiency. Further, since the partition section 220 (branch pipe 15) is not in direct contact with the second housing 10b in the refrigerant dividing chamber SC, occurrence of noise caused by installation of the partition section 220 can be prevented.

[0054] Further, during assembly of the above expansion valve 205, the mounting member 14 on which the plurality of branch pipes 15 are mounted is fixed to the auxiliary housing 10c so as to assemble a second assembly body, and the auxiliary housing 10c is fixed to the first assembly body. Accordingly, since mounting of the mounting member 14 on the main body unit 10 itself is not necessary, assembly operation can be facilitated. Further, since a distance between a connecting position of the branch port P2 and the branch pipe 15 in the mounting member 14 and a connecting position of the second housing 10b and the auxiliary housing 10c can be increased, a brazing section of the mounting member 14 and a brazing section of the branch pipe 15 are not likely to be melted again during brazing operation, thereby improving workability.

Embodiment 4

[0055] Fig. 7 is a schematic view which shows the expansion valve of Embodiment 4 of the present invention, Fig. 8A is a schematic view which shows the partition section in the second housing 10b of Fig. 7, and Fig. 8B is a schematic view which shows a cross section of the first housing 10a of Fig. 7 taken along the line A-A'. With reference to Fig. 7, Fig. 8A and Fig. 8B, an expansion valve 305 will be described. In the expansion valve 305 of Fig. 7, Fig. 8A and Fig. 8B, the same reference numbers are used for the same configuration of the expansion valve 5 of Fig. 2. The expansion valve 305 of Fig. 7, Fig. 8A and Fig. 8B differs from the expansion valve 5 of Fig.

2 in a configuration of the partition section 320.

[0056] The partition section 320 of Fig. 7, Fig. 8A and Fig. 8B is an integrally formed single member which is made of resin or metal by casting, forging or the like. For example, the partition section 320 has an outer shape which is the same as the inner surface of the refrigerant dividing chamber SC, and a cylindrical shape which is the same as or smaller than the radius of the second housing 10b. Accordingly, noise caused by the partition section 320 coming into contact with the inner peripheral surface of the second housing 10b can be prevented.

[0057] The partition section 320 has a plurality of through holes 320a which extend from the expansion section 12 to the branch port P2, and a leaf spring 321 of an annular shape is disposed between the separation wall 11 and the partition section 320. The through holes 320a is formed to have a curved surface so that a cross sectional area decreases from the expansion section 12 to the branch port P2, and adjacent through holes 320a are separated from each other by a plate section which has a curved surface. Further, the leaf spring 321 biases the partition section 320 toward the mounting member 14, thereby preventing occurrence of machine noise caused by vibration of the partition section 320. In the mounting member 14 of Fig. 7, the branch pipe 15 does not extend from the branch port P2 to the refrigerant dividing chamber SC, and the distributed refrigerant directly flows into the branch port P2.

[0058] Similar to Embodiments 1 to 3, the upper edge 320b of the partition section 320 is positioned in the opening of the expansion section 12 in a vertical view to the separation wall 11. That is, as shown in Fig. 8B, the upper edge 320b is located at a position in which the upper edge 320b of the partition section 320 can be seen through the opening of the expansion section 12 as seen downwardly from the valve chamber BC in the A-A' cross sectional direction of Fig. 7.

[0059] Further, a recess 320c is formed on the upper edge 320b of the partition section 320 such that the distance D1 between the lowest end of the recess 320c and a lower surface 11a of the separation wall 11 to which the expansion section 12 is open is smaller than a diameter R1 of the expansion section 12 ($D1 < R1$). That is, a maximum distance between the lower surface 11a of the separation wall 11 to which the expansion section 12 is open and the upper edge 320b of the partition wall 320 is smaller than the diameter R1 of the expansion section 12. Accordingly, since the refrigerant is distributed immediately after flowing out the expansion section 12 and before non-uniformly dispersed due to the upper edge 320b of the partition section 320 (the lowest end of the recess 320c) extending to a position immediately under the expansion section 12, the refrigerant is distributed to each of the branch ports P2 with an intended distribution ratio regardless of the amount of refrigerant flow rate and the state of refrigerant, and the flowing noise of refrigerant can be minimized. Further, the recess 320c is formed to prevent the valve body 13 from coming into contact with

the upper edge 320b of the partition section 320.

[0060] Although the above Embodiment 4 is described for the example in which the recess 320c is formed on the upper edge 320b of the partition section 320, the recess 320c is not necessarily formed on the upper edge 320b as long as a distance from the lower surface 11 a of the separation wall 11 is provided so as to prevent the valve body 13 from coming into contact with the upper edge 320b. In this case, the distance D1 is a distance between the upper edge 320b of the partition section 320 and the lower surface 11 a of the separation wall 11 to which the expansion section 12 is open.

[0061] Further, similar to Embodiments 1 to 3, a taper section may be formed on the upper edge 320b of the partition section 320 such that a thickness of the upper edge 320b decreases toward the expansion section 12 as shown in Fig. 2B.

[0062] In the expansion valve 305 having the above configuration of the partition section 320, occurrence of the flowing noise of refrigerant can also be prevented while the refrigerant can be distributed at an intended distribution ratio regardless of refrigerant flow rate and the state of refrigerant similar to Embodiments 1 to 3. Since the partition section 320 is formed of an integral part, it is possible to decrease the number of parts, reduce the cost, and improve workability.

Embodiment 5

[0063] Fig. 9 is a schematic view which shows a refrigeration cycle apparatus of Embodiment 5 of the present invention. With reference to Fig. 9, a refrigeration cycle apparatus 400 will be described. In the refrigeration cycle apparatus 400 of Fig. 9, the same reference numbers are used for the same configuration of the refrigeration cycle apparatus 1 of Fig. 1, and the explanation thereof is omitted. The refrigeration cycle apparatus 400 of Fig. 9 differs from the refrigeration cycle apparatus 1 of Fig. 1 in that an outdoor side heat exchanger 404 of an outdoor unit 400A is a multi-path heat exchanger, and the expansion valve having a distribution function is used. Although the expansion valve 5 of Fig. 2 is described as an example, the expansion valves 205, 305 of Fig. 5 and Fig. 6 may also be used.

[0064] The refrigeration cycle apparatus 400 has a configuration in which a plurality of indoor units 1 B are connected to one outdoor unit 400A. Further, the outdoor unit 400A includes an accumulator 405 on the suction side of the compressor 2. The accumulator 405 is configured to store extra refrigerant or extra refrigerant for a transitional change in operation, and is configured such that the refrigerant flows into the accumulator 405 from the flow path switching device 3 and is supplied to the suction side of the compressor 2 via the suction pipe 9.

[0065] The outdoor side heat exchanger 404 is connected to the flow path switching device 3 via a header 403 and connected to the liquid pipe 9A via the expansion valve 5. During cooling operation, the expansion valve 5

collects the refrigerant flowing out the respective paths of the outdoor side heat exchanger 404 and flows the alignment to the liquid pipe 9A. During heating operation, the expansion valve 5 distributes the refrigerant flowing from the liquid pipe 9A to the respective paths of the outdoor side heat exchanger 404 so that the refrigerant flows out the respective paths.

[0066] As described above, the outdoor side heat exchanger 404 can use the expansion valve 5 for the multi-path heat exchanger so that the refrigerant can be distributed with an intended distribution ratio, while reducing the flowing noise of refrigerant. Further, since the expansion valves 5 are provided for each of the outdoor unit 400A and the indoor unit 1 B, a liquid pipe density is reduced, thereby reducing the refrigerant amount. Further, since the expansion valves 5 are provided on both ends of the liquid pipe 9A, the expansion valve 5 can be controlled so that the refrigerant in the liquid pipe 9A becomes a gas-liquid two-phase state. Accordingly, since a pressure loss of the refrigerant in two-phase gas-phase state is larger than a pressure loss of the liquid refrigerant, unnecessary pressure loss can be reduced.

[0067] Embodiments of the present invention are not limited to the above described Embodiments. For example, the indoor side heat exchanger 7 of Fig. 1 and the outdoor side heat exchanger 404 of Fig. 9 are described as having two paths, and described as having three paths in Fig. 3. However, four or more paths may be provided.

[0068] Further, although the main body unit 10 in Fig. 2 and Fig. 5 is described as examples in which the first housing 10a and the second housing 10b are provided as separate members, the main body unit 10 may be integrally formed. Further, although Embodiments 1, 2 are described as the branch pipe 15 extends from the branch port P2 to the refrigerant dividing chamber SC, the fixation piece 21 may be fixed to the mounting member 14 so that the hole 21 a is located above the branch port P2.

Reference Signs List

[0069] 1, 400 refrigeration cycle apparatus 1 A, 400A outdoor unit 1 B indoor unit 2 compressor 3 flow path switching device 4, 404 outdoor side heat exchanger 5, 205, 305 expansion valve 6 capillary tube 7 indoor side heat exchanger 8 header 9 suction pipe 9A liquid pipe 9B gas pipe 10 main body unit 10a first housing 10b second housing 10c auxiliary housing 11 separation wall 12 expansion section 13 valve body 14 mounting member 15 branch pipe 20, 120, 220, 320 partition section 21, 121 fixation piece 21 a, 121 a hole 22, 122 partition wall 22a, 122a, 220a, 320b upper edge 22b, 122b, 320c recess 22c taper section 23, 123 elastic piece 23a opening 30 pipe, 205 expansion valve 320a through hole 321 leaf spring 404 header 405 accumulator BC valve chamber P1 connection port P2 branch port SC refrigerant dividing chamber

Claims**1.** An expansion valve comprising:

a main body unit in which a valve chamber and a refrigerant dividing chamber are separated by a separation wall, an expansion section is opened to the separation wall so that the valve chamber and the refrigerant dividing chamber communicate with each other, and a plurality of branch ports that communicate with the refrigerant dividing chamber are provided;
 a valve body configured to adjust an opening of the expansion section; and
 a partition section in a plate shape that is disposed in the refrigerant dividing chamber so as to separate the refrigerant dividing chamber for the plurality of branch ports, wherein at least part of an upper edge of the partition section is positioned in an opening of the expansion section in vertical view to the separation wall.

2. The expansion valve of claim 1, wherein a maximum distance between a lower surface of the separation wall to which the expansion section is open and the upper edge of the partition section is smaller than a diameter of the expansion section.**3.** The expansion valve of claim 2, wherein a recess is formed on the upper edge of the partition section at a position facing the expansion section, and the maximum distance is a distance between a lower surface of the separation wall to which the expansion section is open and a lower end of the recess of the upper edge of the partition section.**4.** The expansion valve of any one of claims 1 to 3, wherein a taper section having a thickness that decreases toward the expansion section is formed on the upper edge of the partition section.**5.** The expansion valve of any one of claims 1 to 4, wherein the main body unit includes a first housing defining the valve chamber on one side of the separation wall and a second housing defining the refrigerant dividing chamber on an other side of the separation wall.**6.** The expansion valve of claim 5, wherein the main body unit includes a mounting member having the plurality of branch ports that is mounted on the second housing.**7.** The expansion valve of any one of claims 1 to 6, wherein the partition section is disposed so that the refrigerant dividing chamber is divided depending on a distribution ratio of refrigerant for the plurality of

branch ports.

8. The expansion valve of any one of claims 1 to 7, wherein the partition section includes a fixation piece fixed to the main body unit, a partition wall in a plate shape that extends from the fixation piece to the expansion section, and an elastic piece disposed on the partition wall and comes into contact with the separation wall to bias the partition wall toward the fixation piece.**9.** The expansion valve of claim 8, wherein a branch pipe is inserted in each of the plurality of branch ports so as to protrude into the refrigerant dividing chamber, the fixation piece has a hole into which a protruded portion of the branch pipe is inserted, and the branch pipe is inserted in the hole to fix the partition section to the main body unit.**10.** The expansion valve of any one of claims 1 to 7, wherein the partition section is formed of a wall surface of each of the plurality of branch pipes that is disposed to protrude from the branch port to the expansion section.**11.** The expansion valve of any one of claims 1 to 7, wherein the partition section is a member that has an outer shape that is the same as an inner shape of the refrigerant dividing chamber and has a plurality of through holes formed so as to be connected from the expansion section to the branch port.**12.** A refrigeration cycle apparatus in which an indoor unit having an indoor side heat exchanger and an outdoor unit having an outdoor side heat exchanger are connected by a pipe, wherein the indoor side heat exchanger and/or the outdoor side heat exchanger is formed of a multi-path heat exchanger that includes a plurality of paths, and the indoor side heat exchanger and/or the outdoor side heat exchanger is connected to the expansion valve of any one of claims 1 to 11.

FIG. 1

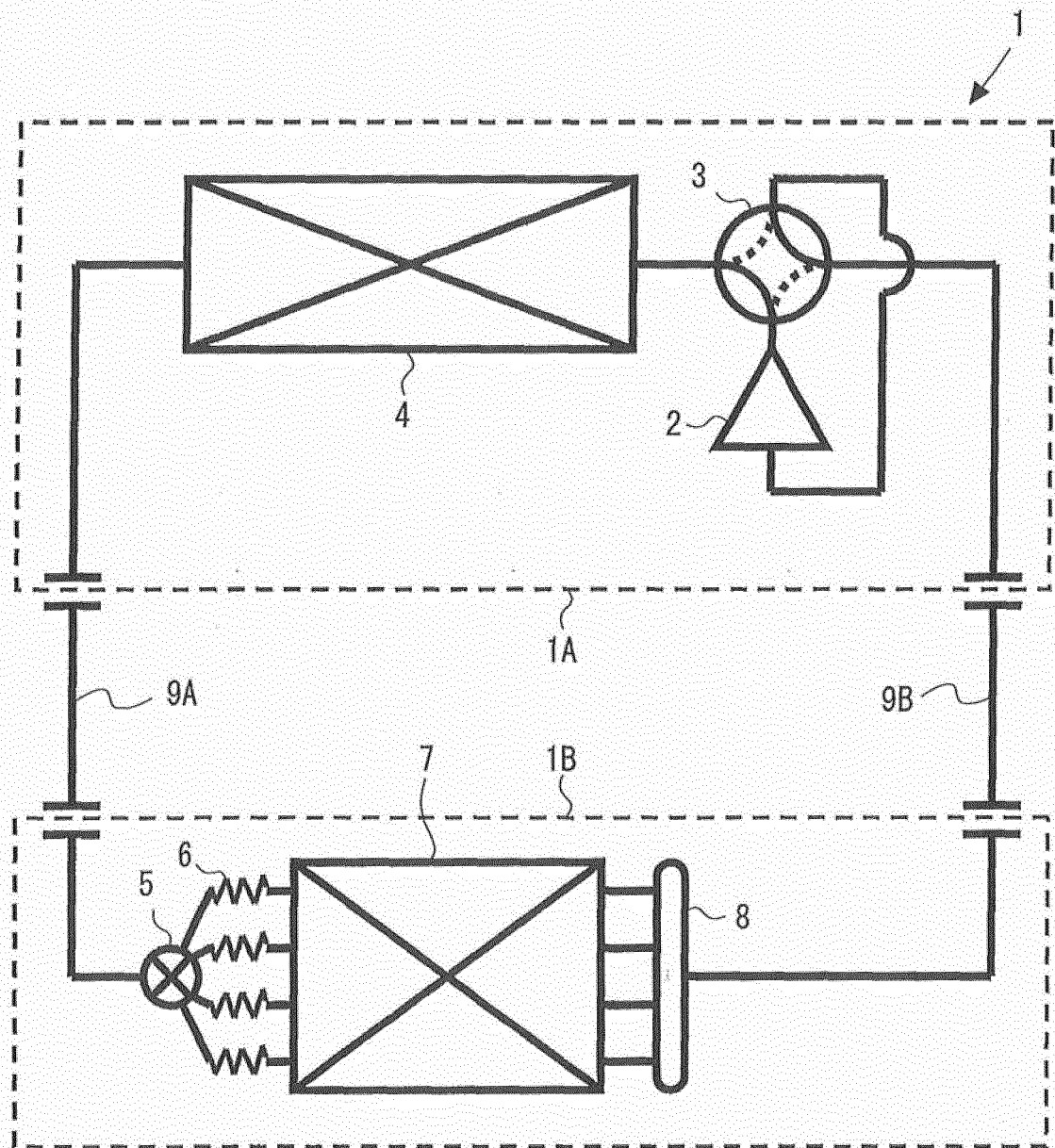


FIG. 2A

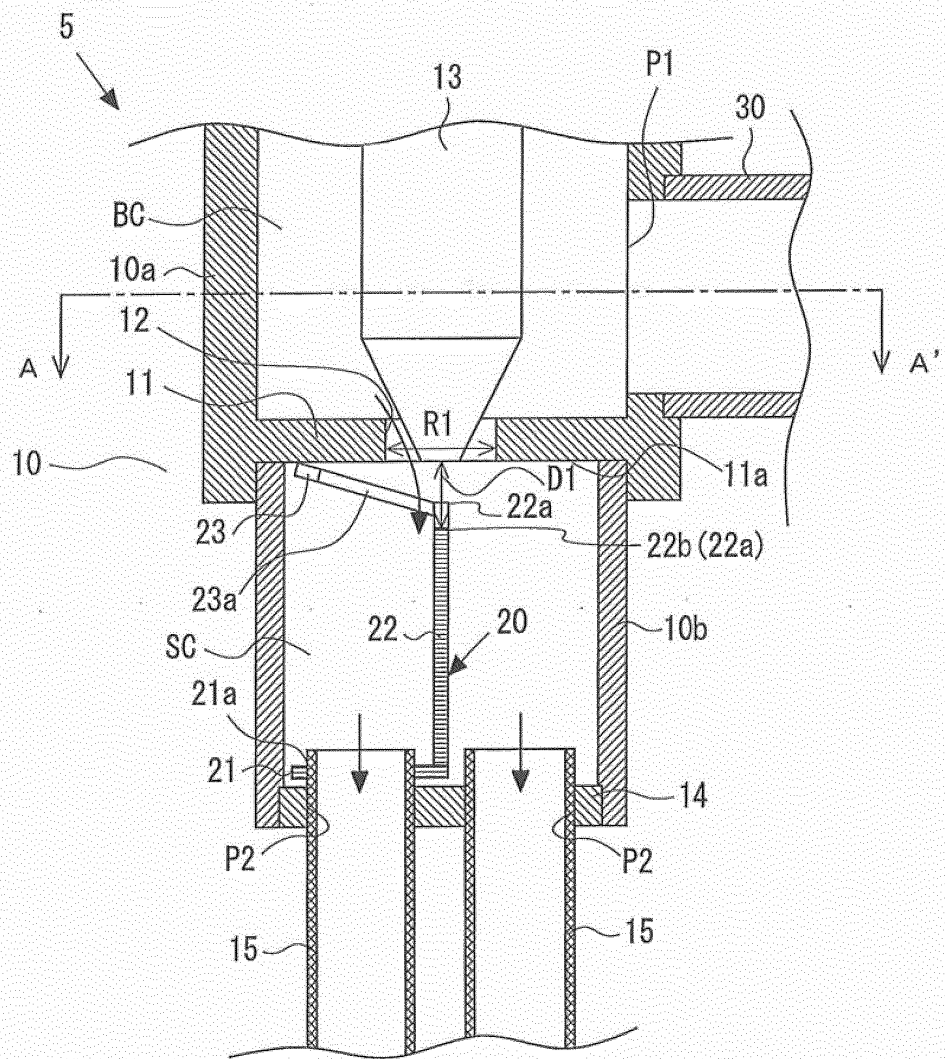


FIG. 2B

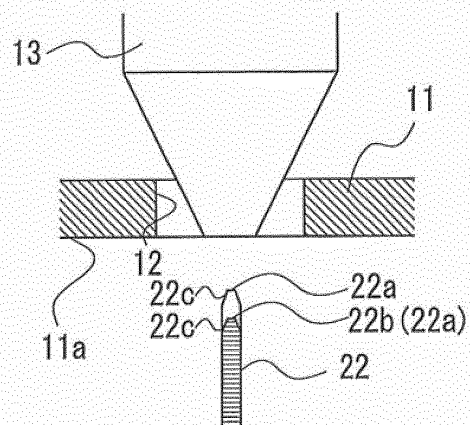


FIG. 3A

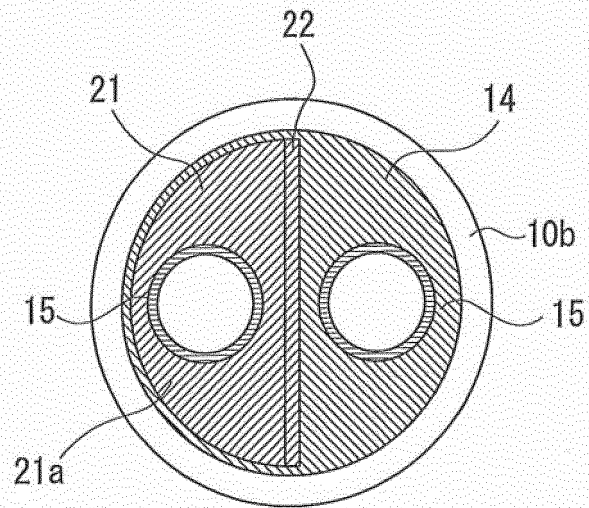


FIG. 3B

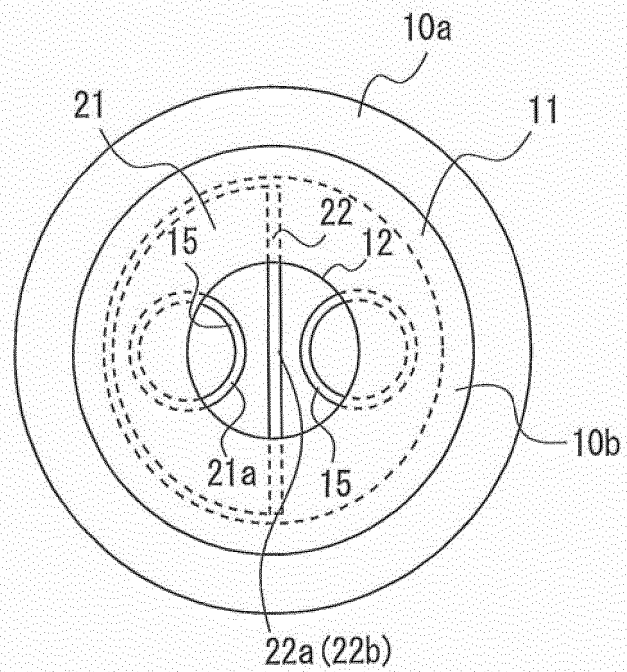


FIG. 4A

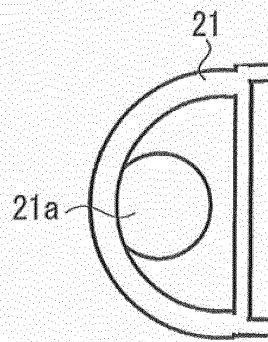


FIG. 4B

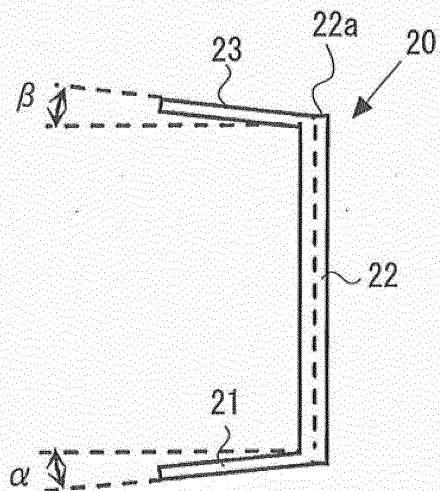


FIG. 4C

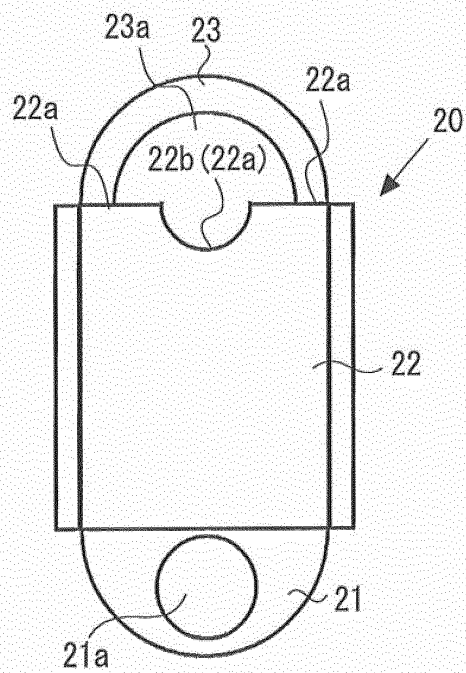


FIG. 5A

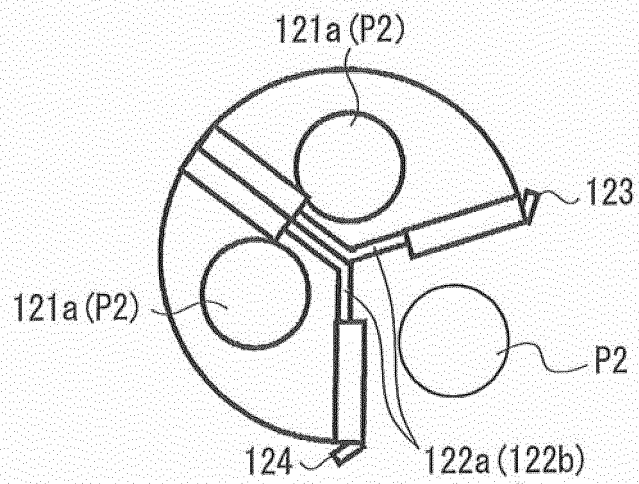


FIG. 5B

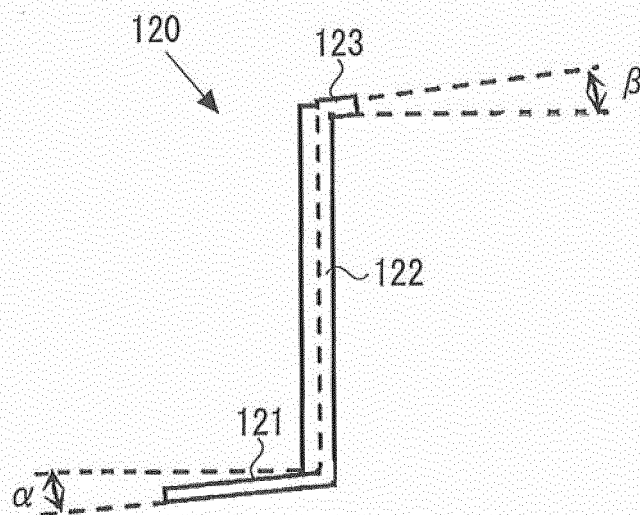


FIG. 5C

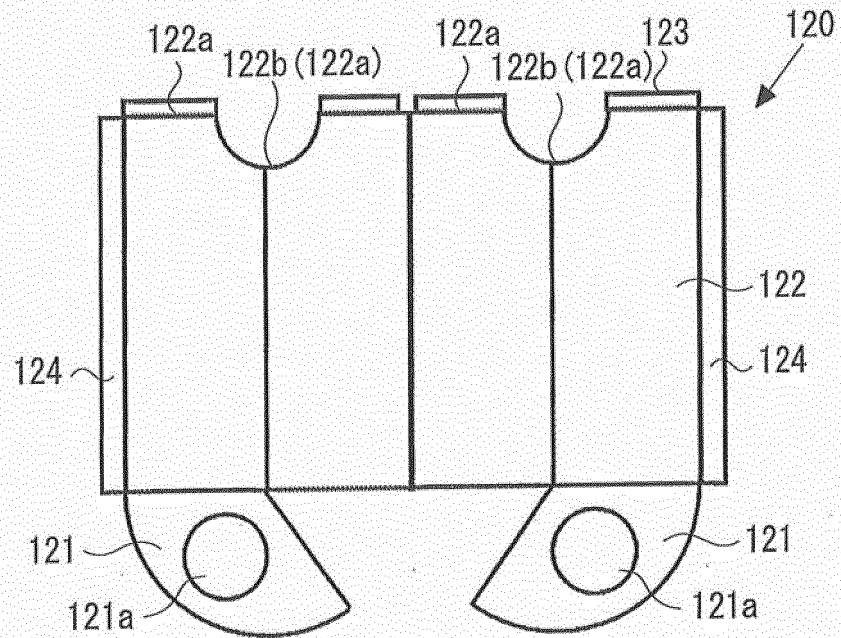


FIG. 5D

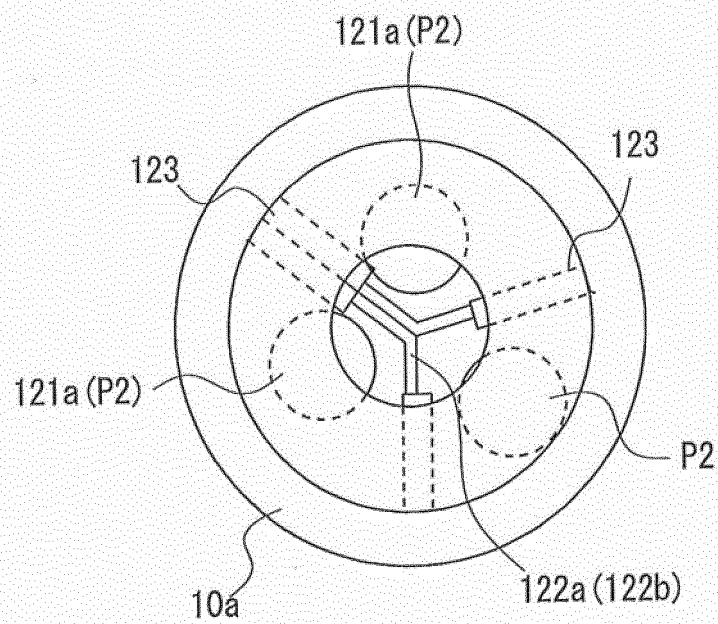


FIG. 6A

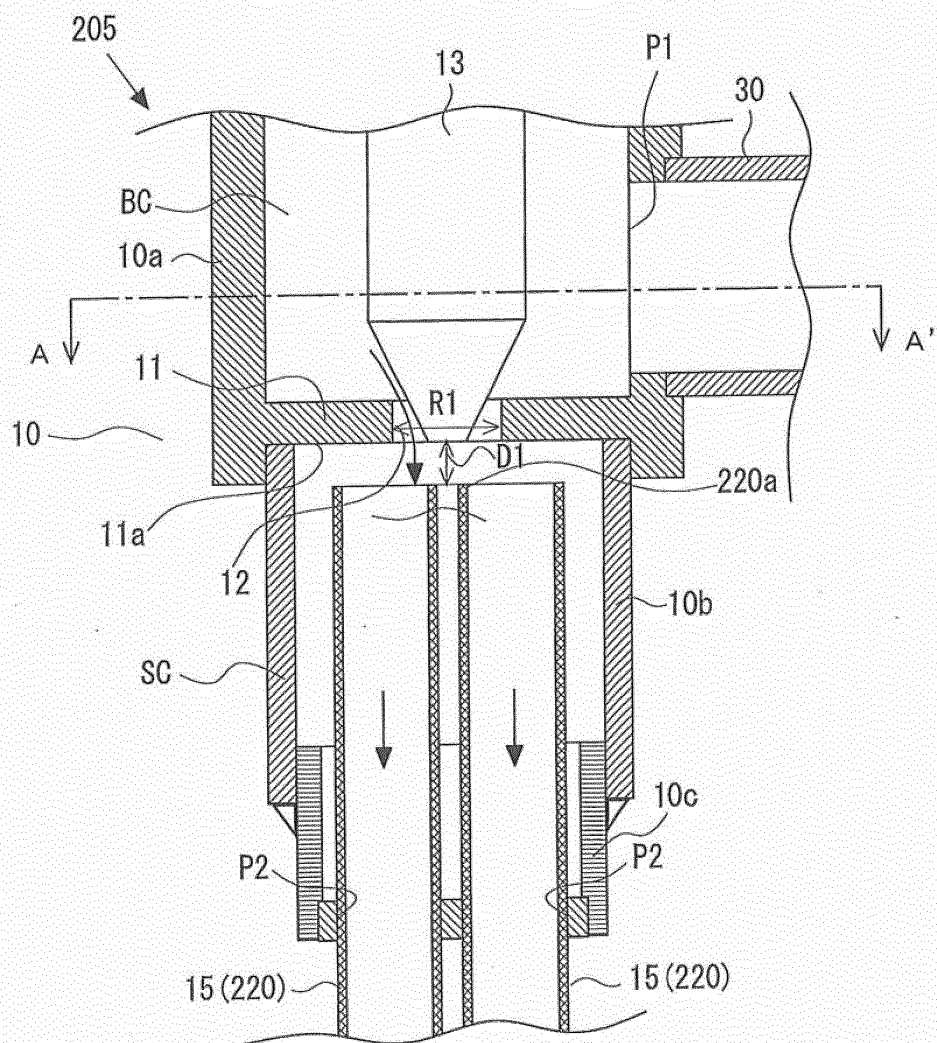


FIG. 6B

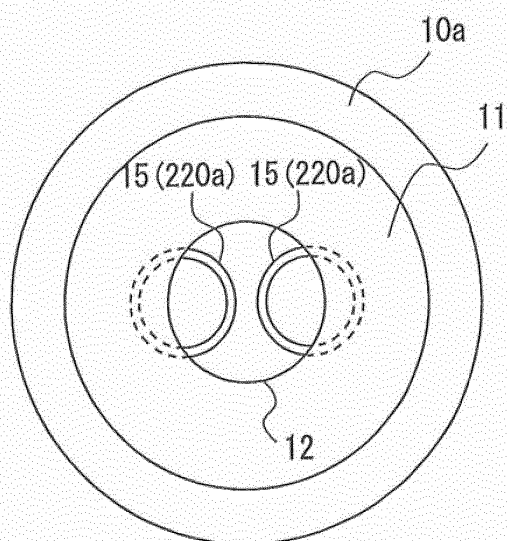


FIG. 7

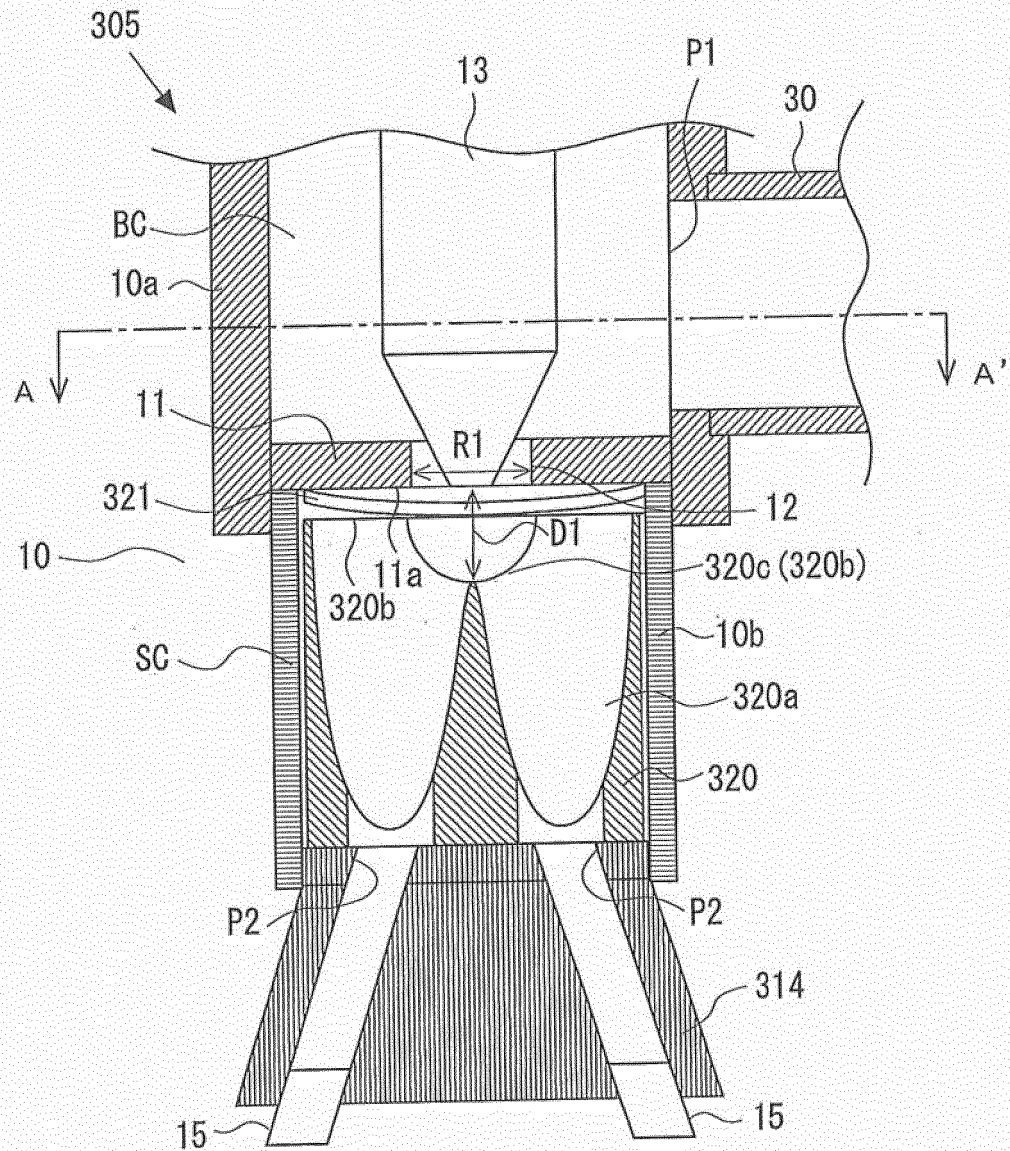


FIG. 8A

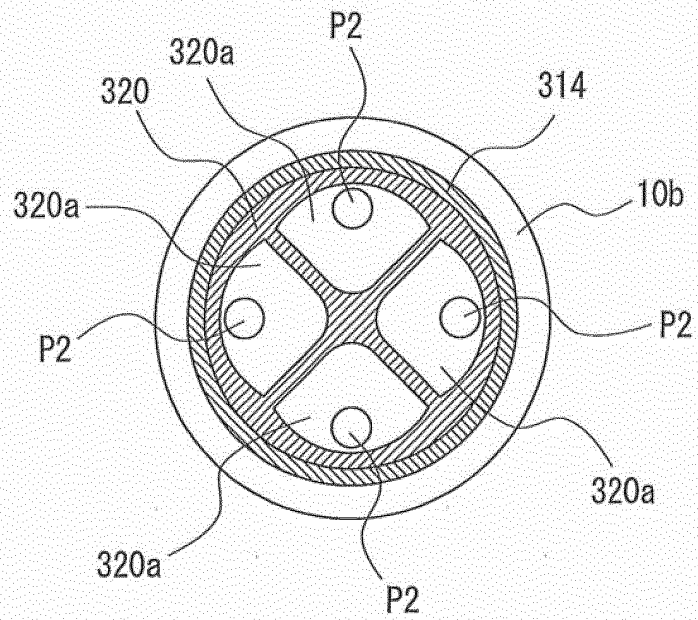


FIG. 8B

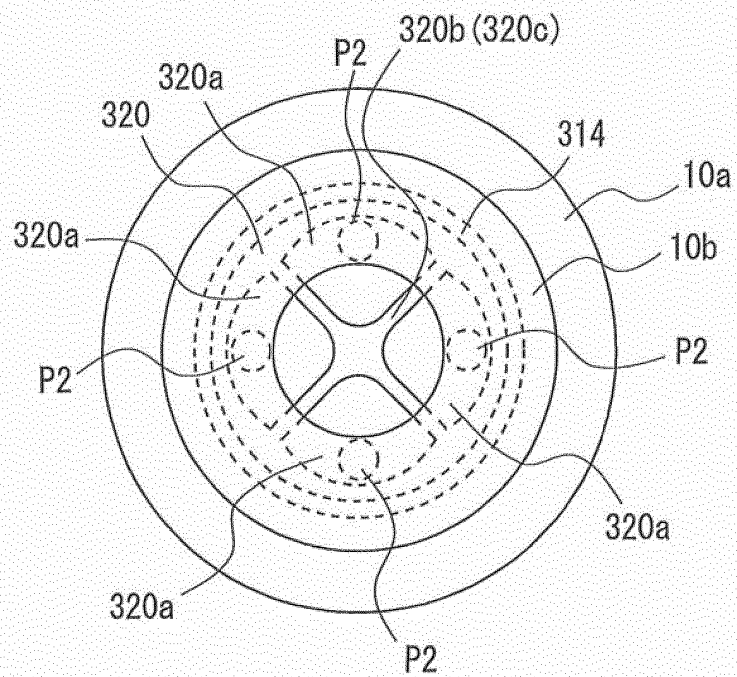
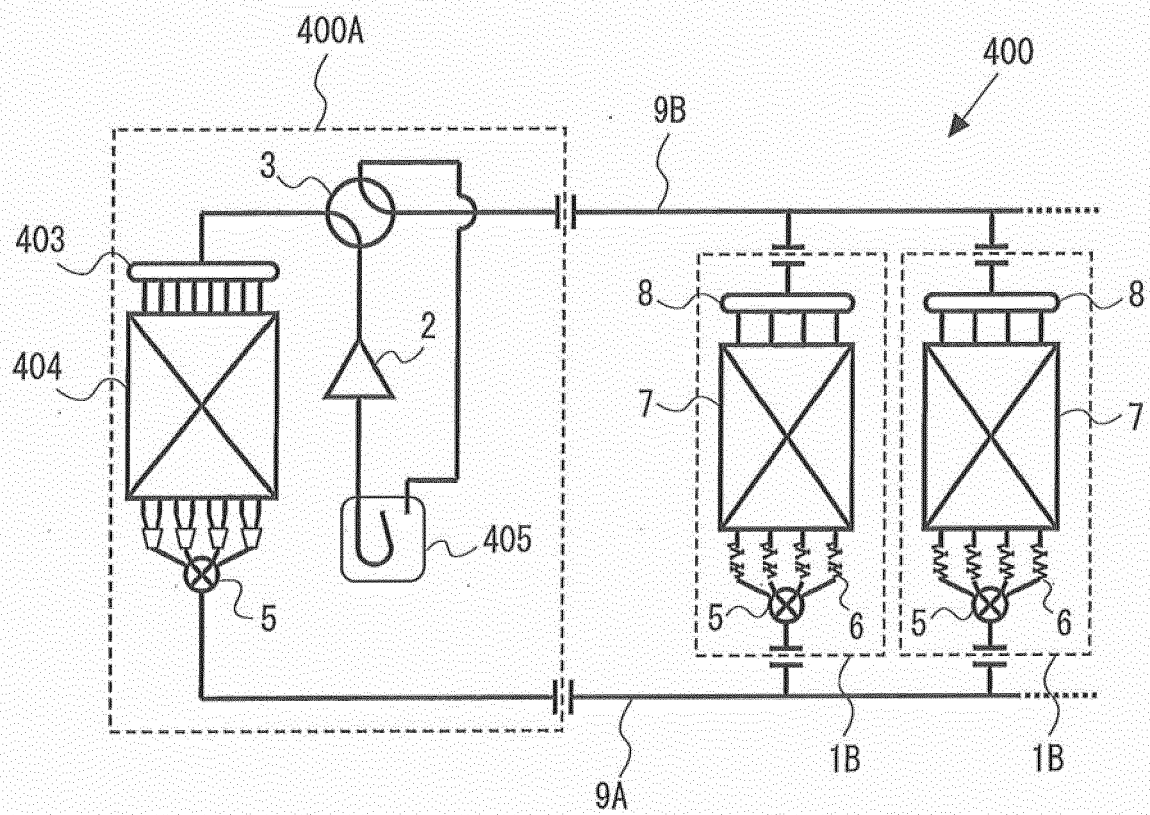


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/080569

A. CLASSIFICATION OF SUBJECT MATTER

F25B41/06(2006.01) i, F25B41/00(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)

F25B41/06, F25B41/00

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 1996-2014

Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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.
Y A	WO 2008/001803 A1 (Daikin Industries, Ltd.), 03 January 2008 (03.01.2008), entire text; all drawings (particularly, paragraphs [0117] to [0118], [0123] to [0124]; fig. 22, 25) & JP 2008-32380 A & US 2009/0183520 A1 & EP 2034259 A1 & AU 2007266111 A & KR 10-2009-0033180 A & CN 101466986 A & KR 10-1045759 B	1-2, 4-7, 10-12 3, 8-9

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

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search
24 January, 2014 (24.01.14)Date of mailing of the international search report
04 February, 2014 (04.02.14)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/080569

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 011395/1971 (Laid-open No. 10952/1972)	1-2, 4-7, 10-12
A	(Hitachi, Ltd.), 09 October 1972 (09.10.1972), entire text; all drawings (particularly, specification, page 3, line 13 to page 5, line 11; fig. 2, 3) (Family: none)	3, 8-9
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 62794/1992 (Laid-open No. 18864/1994)	1-2, 4-7, 10-12
A	(Toyo Radiator Co., Ltd.), 11 March 1994 (11.03.1994), entire text; all drawings (particularly, paragraphs [0002] to [0025]; fig. 1 to 8) (Family: none)	3, 8-9
Y	JP 6-2990 A (Daikin Industries, Ltd.), 11 January 1994 (11.01.1994), entire text; all drawings (particularly, paragraphs [0003], [0010] to [0015]; fig. 1 to 2) (Family: none)	2, 10
Y	JP 2009-24937 A (Daikin Industries, Ltd.), 05 February 2009 (05.02.2009), entire text; all drawings (particularly, paragraphs [0025] to [0067]; fig. 1 to 8) (Family: none)	5-6
Y	JP 2010-190523 A (Mitsubishi Heavy Industries, Ltd.), 02 September 2010 (02.09.2010), entire text; all drawings (particularly, paragraphs [0005], [0026] to [0033]; fig. 3 to 5) (Family: none)	11
Y	JP 2004-183955 A (Sharp Corp.), 02 July 2004 (02.07.2004), entire text; all drawings (particularly, paragraphs [0009] to [0062]; fig. 1 to 10) (Family: none)	11
Y	WO 2009/004760 A1 (Daikin Industries, Ltd.), 08 January 2009 (08.01.2009), entire text; all drawings (particularly, paragraph [0090]; fig. 3) & JP 2009-14030 A	12

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009024937 A [0005]
- JP 2010032185 A [0005]