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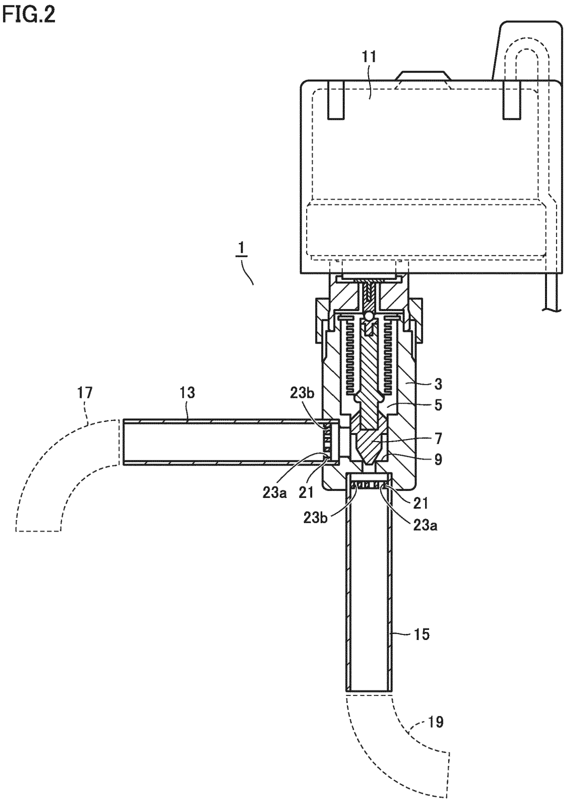
(54) EXPANSION VALVE AND REFRIGERATION CYCLE DEVICE PROVIDED WITH SAME

(57) An expansion valve (1) has a valve main body (3) provided with a valve chamber (5). The valve main body (3) is provided with a valve seat (9), into which a valve body (7) is inserted. The valve main body (3) is provided with a first pipe (13) and a second pipe (15) which are each in communication with the valve chamber (5). A baffle plate (21) is arranged at each of a portion where the valve main body (3) and the first pipe (13) are connected, and a portion where the valve main body (3) and the second pipe (15) are connected. The baffle plate (21) is provided with refrigerant paths (23a) and refrigerant paths (23b) having different path areas through which refrigerant passes. The path area of the refrigerant path (23b) is smaller than the path area of the refrigerant path (23a). The baffle plate (21) has a uniform thickness (T).

FIG.2



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Description

TECHNICAL FIELD

[0001] The present invention relates to an expansion valve, and a refrigeration cycle apparatus including the same. In particular, the present invention relates to an expansion valve including a baffle plate, and a refrigeration cycle apparatus including the expansion valve.

BACKGROUND ART

[0002] A refrigeration cycle apparatus such as an air conditioning apparatus includes a refrigerant circuit including a compressor, a condenser, an expansion valve, and an evaporator connected in order.

[0003] The expansion valve of the refrigeration cycle apparatus (air conditioning apparatus) has functions of decompressing high-pressure liquid refrigerant condensed in the condenser to be easily evaporated in the evaporator, and adjusting the flow rate of the refrigerant. The expansion valve includes an orifice and a valve body (needle), and the pressure and the flow rate of the refrigerant are adjusted by changing the position of the valve body with respect to the orifice.

[0004] Generally, high-pressure liquid refrigerant flows into an inlet of the expansion valve, and decompressed two-phase state refrigerant is discharged from an outlet of the expansion valve. However, depending on the operating situation of the refrigeration cycle apparatus, high-pressure liquid refrigerant and gas refrigerant may flow into the inlet of the expansion valve. On this occasion, noise (refrigerant noise) may be produced in the expansion valve, as the two-phase state refrigerant including the liquid refrigerant and the gas refrigerant flows thereinto. In order to suppress such refrigerant noise, measures have been conventionally taken (for example, PTL 1, PTL 2).

CITATION LIST

PATENT LITERATURE

[0005]

PTL 1: Japanese Patent Laying-Open No. 2007-162851

PTL 2: Japanese Patent Laying-Open No. 2014-238207

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] As described above, in the refrigeration cycle apparatus, various measures are taken to suppress refrigerant noise produced when the two-phase state refrigerant flows into the expansion valve during operation. The present invention has been made as part of the measures against refrigerant noise, and one object thereof is to provide an expansion valve in which refrigerant noise is suppressed, and another object thereof is to provide a refrigeration cycle apparatus including such an expansion valve.

SOLUTION TO PROBLEM

[0007] An expansion valve in accordance with the present invention includes a valve main body, a valve body, a first flow path, a second flow path, and a baffle plate. The valve main body includes a valve chamber, and a valve seat having an opening in communication with the valve chamber. The valve body is inserted into the opening in the valve seat for adjusting a degree of opening of the opening. The first flow path is in communication with the valve chamber. The second flow path is in communication with the opening in the valve seat. The baffle plate is arranged in a flow path into which refrigerant flows toward the valve chamber, of the first flow path and the second flow path, in a direction intersecting a direction in which the refrigerant flows. In a case where the refrigerant includes liquid refrigerant and gas refrigerant, a ratio of the liquid refrigerant to the liquid refrigerant and the gas refrigerant in weight ratio is defined as a liquid ratio. Refrigerant paths allowing the refrigerant to pass therethrough are formed in the baffle plate, in a manner in which path resistance increases from a first portion of the baffle plate that is to be located in a region where refrigerant having a low liquid ratio flows, toward a second portion of the baffle plate that is to be located in a region where refrigerant having a high liquid ratio flows.

[0008] A refrigeration cycle apparatus in accordance with the present invention is a refrigeration cycle apparatus including the expansion valve described above.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] According to the expansion valve in accordance with the present invention, refrigerant noise can be suppressed, because the refrigerant paths allowing the refrigerant to pass therethrough are formed in the baffle plate, in a manner in which path resistance increases from the first portion of the baffle plate that is to be located in the region where the refrigerant having a low liquid ratio flows, toward the second portion of the baffle plate that is to be located in the region where the refrigerant having a high liquid ratio flows.

[0010] According to the refrigeration cycle apparatus in accordance with the present invention, refrigerant noise of the refrigeration cycle apparatus can be suppressed, because the refrigeration cycle apparatus includes the expansion valve described above.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

Fig. 1 is a view showing a refrigerant circuit of a refrigeration cycle apparatus in accordance with each embodiment.
Fig. 2 is a side view including a partial cross section of an expansion valve having baffle plates in accordance with a first embodiment.
Fig. 3 is a perspective view of a baffle plate arranged in the expansion valve in the same embodiment.
Fig. 4 is a plan view showing the relation between refrigerant paths in the baffle plate and the orientation of the centrifugal force in the same embodiment.
Fig. 5 is a cross sectional view showing the relation between the structure of the baffle plate along a cross sectional line V-V shown in Fig. 4 and the orientation of the centrifugal force in the same embodiment.
Fig. 6 is a cross sectional view schematically showing a manner in which refrigerant within a first pipe and within a second pipe flows through the baffle plate in the same embodiment.
Fig. 7 is a partial cross sectional view showing an expansion valve in accordance with a comparative example.
Fig. 8 is a plan view showing a baffle plate arranged in the expansion valve in accordance with the comparative example.
Fig. 9 is a graph showing the relation between refrigerant noise and path resistance in the same embodiment, together with the relation therebetween in the comparative example.
Fig. 10 is a graph showing the relation between pressure loss and path resistance in the same embodiment, together with the relation therebetween in the comparative example.
Fig. 11 is a perspective view showing a baffle plate arranged in an expansion valve in accordance with a second embodiment.
Fig. 12 is a plan view showing the relation between refrigerant paths in the baffle plate and the orientation of the centrifugal force in the same embodiment.
Fig. 13 is a cross sectional view showing the relation between the structure of the baffle plate along a cross sectional line XIII-XIII shown in Fig. 12 and the orientation of the centrifugal force in the same embodiment.
Fig. 14 is a cross sectional view schematically showing a manner in which refrigerant within a first pipe and within a second pipe flows through the baffle plate in the same embodiment.
Fig. 15 is a perspective view showing a baffle plate arranged in an expansion valve in accordance with a third embodiment.
Fig. 16 is a plan view showing the relation between refrigerant paths in the baffle plate and the orientation of the centrifugal force in the same embodiment.
Fig. 17 is a cross sectional view showing the relation between the structure of the baffle plate along a cross sectional line XVII-XVII shown in Fig. 16 and the orientation of the centrifugal force in the same embodiment.
Fig. 18 is a cross sectional view schematically showing a manner in which refrigerant within a first pipe and within a second pipe flows through the baffle plate in the same embodiment.
Fig. 19 is a side view including a partial cross section of an expansion valve having baffle plates in accordance with a fourth embodiment.
Fig. 20 is a side view including a partial cross section of an expansion valve having baffle plates in accordance with a fifth embodiment.

DESCRIPTION OF EMBODIMENTS

[0012] First, an example of a refrigeration cycle apparatus to which an expansion valve in accordance with each embodiment is applied will be specifically described.

[0013] As shown in Fig. 1, in a refrigeration cycle apparatus 51 such as an air conditioning apparatus, a refrigerant circuit including a compressor 53, a condenser 55, an expansion valve 1, and an evaporator 57 connected in order is formed. Refrigerant compressed by compressor 53 turns into high-temperature and high-pressure gas refrigerant and is discharged from compressor 53. The discharged high-temperature and high-pressure gas refrigerant is delivered to condenser 55. In condenser 55, heat exchange is performed between the refrigerant flowing therein and air blown into condenser 55. By the heat exchange, the high-temperature and high-pressure gas refrigerant is condensed and turns into high-pressure liquid refrigerant.

[0014] The high-pressure liquid refrigerant discharged from condenser 55 turns into low-pressure two-phase state refrigerant including gas refrigerant and liquid refrigerant, by expansion valve 1. The two-phase state refrigerant flows into evaporator 57. In evaporator 57, heat exchange is performed between the two-phase state refrigerant flowing therein and air blown into evaporator 57. By the heat exchange, the liquid refrigerant is evaporated and turns into low-pressure gas refrigerant.

[0015] The low-pressure gas refrigerant discharged from evaporator 57 flows into compressor 53, is compressed, and turns into high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant is discharged again from compressor 53, and is delivered to condenser 55. Thereafter, this cycle is to be repeated.

[0016] Next, expansion valve 1 used in refrigeration cycle apparatus 51 will be described in each embodiment.

First Embodiment

(Structure)

[0017] Expansion valve 1 has functions of decompressing the high-pressure liquid refrigerant condensed in condenser 55 (see Fig. 1) to be easily evaporated in evaporator 57, and adjusting the flow rate of the refrigerant.

[0018] As shown in Fig. 2, expansion valve 1 has a valve main body 3. Valve main body 3 is provided with a valve chamber 5. In addition, valve main body 3 is provided with a valve seat 9. A valve body 7 (needle) is inserted into valve seat 9. A drive unit 11 is provided above valve main body 3.

[0019] Valve body 7 is to be moved by drive unit 11 in an up/down direction. An annular throttle portion is formed by inserting valve body 7 into valve seat 9, and the flow path area of the throttle portion is adjusted by moving valve body 7 in the up/down direction.

[0020] In valve body 7, a cylindrical portion and a conical portion are integrally formed. The conical portion forms the annular throttle portion between itself and the valve seat. The cylindrical portion of valve body 7 does not need to have an exact cylindrical shape, due to the method of fixing it to a pressure loss body. In addition, the conical portion of valve body 7 does not need to have an exact conical shape, and may have any tapering shape.

[0021] Valve main body 3 is provided with a first pipe 13 (first flow path) and a second pipe 15 (second flow path) which are each in communication with valve chamber 5.

A baffle plate 21 is arranged at a portion where valve main body 3 and first pipe 13 are connected. In addition, another baffle plate 21 is arranged at a portion where the valve main body and second pipe 15 are connected. The structure of baffle plate 21 will be described later.

[0022] A first connection pipe 17 is connected to first pipe 13. A second connection pipe 19 is connected to second pipe 15. First connection pipe 17 and second connection pipe 19 are curved pipes. The position of baffle plate 21 (circumferential position) is determined by the orientation of first connection pipe 17 (curved pipe). In addition, the position of baffle plate 21 (circumferential position of the flow path) is determined by the orientation of second connection pipe 19 (curved pipe).

[0023] Next, the structure of baffle plate 21 will be described. As shown in Fig. 3, baffle plate 21 is provided with refrigerant paths 23a and refrigerant paths 23b having different path areas through which the refrigerant passes. The path area of refrigerant path 23b is smaller than the path area of refrigerant path 23a. Baffle plate 21 has a uniform thickness T.

[0024] It should be noted that, instead of having uniform thickness T, baffle plate 21 may have a thickness which is thin on a side where refrigerant paths 23a are arranged, and is thick on a side where refrigerant paths 23b are arranged. For example, its thickness may be changed continuously in a manner shown in Fig. 13 described later, or may be changed discontinuously in two or more stages.

(Function and Effect)

[0025] As described above, generally, high-pressure liquid refrigerant flows into the expansion valve, and decompressed two-phase state refrigerant including liquid refrigerant and gas refrigerant flows out of the expansion valve. However, at the start-up of the refrigeration cycle apparatus or under specific conditions, instead of high-pressure liquid refrigerant (single phase), high-pressure two-phase state refrigerant including liquid refrigerant and gas refrigerant may flow into the expansion valve.

[0026] When the high-pressure two-phase state refrigerant flows into the expansion valve, a discontinuous flow of the gas refrigerant and the liquid refrigerant occurs at the throttle portion in the expansion valve, and refrigerant noise may be produced discontinuously. In particular, harsh noise (refrigerant noise) may be produced, such as refrigerant noise having a specific frequency or refrigerant noise having a discontinuous frequency produced at random.

[0027] Although the refrigerant flowing into the expansion valve is two-phase state refrigerant, the degree of dryness is low. In addition, although the gas refrigerant has a large volume, the liquid refrigerant has a high ratio (liquid ratio). Further, the flow velocity at which the refrigerant flows into the expansion valve is relatively low.

Thus, when a curved pipe is arranged for example as a pipe for guiding the refrigerant to the expansion valve, distribution of the liquid refrigerant and the gas refrigerant in a flow path cross section becomes non-uniform. In addition, it is also conceivable that distribution of the liquid refrigerant and the gas refrigerant in the flow path cross section becomes non-uniform due to gravity.

[0028] Here, in a case where the refrigerant includes liquid refrigerant and gas refrigerant, the ratio of the liquid refrigerant to the liquid refrigerant and the gas refrigerant in weight ratio is defined as a liquid ratio. Refrigerant paths 23a having a large path area are formed in a portion of baffle plate 21 where refrigerant having a low liquid ratio is to flow (a first portion). Refrigerant paths 23b having a small path area are formed in a portion of baffle plate 21 where refrigerant having a high liquid ratio is to flow (a second portion).

[0029] First connection pipe 17 serving as a curved pipe is connected to first pipe 13. In addition, second connection pipe 19 serving as a curved pipe is connected to second pipe 15. Here, it is assumed that the refrigerant flows from first connection pipe 17, through first pipe 13, into valve chamber 5 of expansion valve 1, as an operation mode of refrigeration cycle apparatus 51 (see Fig. 1). In this case, while the refrigerant flows within first connection pipe 17, on an outer circumferential side within first connection pipe 17, refrigerant having a higher liquid ratio than that on an inner circumferential side flows, due to the centrifugal force. Thus, within first pipe 13, the refrigerant having a high liquid ratio flows in an upper region in the drawing, and the refrigerant having a low liquid ratio flows in a lower region in the drawing.

[0030] On the other hand, it is assumed that the refrigerant flows from second connection pipe 19, through second pipe 15, into valve chamber 5 of expansion valve 1, as an operation mode of refrigeration cycle apparatus 51 (see Fig. 1). In this case, while the refrigerant flows within second connection pipe 19, on an outer circumferential side within second connection pipe 19, refrigerant having a higher liquid ratio than that on an inner circumferential side flows, due to the centrifugal force. Thus, within second pipe 15, the refrigerant having a high liquid ratio flows in a left region in the drawing, and the refrigerant having a low liquid ratio flows in a right region in the drawing.

[0031] Therefore, in baffle plate 21 arranged at the portion where first pipe 13 is connected, refrigerant paths 23b having a small path area are located in the portion of baffle plate 21 that is to be located on the upper side within first pipe 13 (the second portion), and refrigerant paths 23a having a large path area are located in the portion of baffle plate 21 that is to be located on the lower side within first pipe 13 (the first portion).

[0032] On the other hand, in baffle plate 21 arranged at the portion where second pipe 15 is connected, refrigerant paths 23b having a small path area are located in the portion of baffle plate 21 that is to be located on the left side within second pipe 15 (the second portion), and refrigerant paths 23a having a large path area are located in the portion of baffle plate 21 that is to be located on the right side within second pipe 15 (the first portion).

[0033] That is, as shown in Figs. 4 and 5, in baffle plate 21, considering the orientation of the centrifugal force (indicated by an arrow CFV) acting on the refrigerant, refrigerant paths 23b having a small path area are located on a side on which the centrifugal force acts (a side to which arrow CFV is oriented), and refrigerant paths 23a having a large path area are located on a side opposite to the side on which the centrifugal force acts.

[0034] As shown in Fig. 6, since the refrigerant having a high liquid ratio passes through refrigerant paths 23b having a small path area, the velocity of the liquid refrigerant is increased (see a dotted-line arrow). Since the refrigerant having a low liquid ratio passes through refrigerant paths 23a having a large path area, air bubbles of the gas refrigerant are divided. The divided air bubbles of the gas refrigerant are stirred by the liquid refrigerant having an increased flow velocity.

[0035] Thereby, after the refrigerant passes through baffle plate 23, distribution of the liquid refrigerant and the gas refrigerant becomes relatively uniform, and the two-phase state refrigerant flows to the throttle portion of expansion valve 1. As a result, refrigerant noise of the refrigerant flowing through expansion valve 1 can be reduced. This will be described in comparison with an expansion valve in accordance with a comparative example.

[0036] As shown in Fig. 7, an expansion valve 101 in accordance with the comparative example has a valve main body 103. Valve main body 103 is provided with a valve chamber 105. In addition, valve main body 103 is provided with a valve seat 109. A valve body 107 (needle) is inserted into valve seat 109. An annular throttle portion is formed between valve seat 109 and valve body 107 by inserting valve body 107 into valve seat 109.

[0037] Valve main body 103 is provided with a first pipe 113 and a second pipe 115 which are each in communication with valve chamber 105. Here, for example, a baffle plate 121 is arranged at a portion where valve main body 103 and second pipe 115 are connected.

[0038] Refrigerant paths allowing refrigerant to pass therethrough is formed in baffle plate 121 of expansion valve 101 in accordance with the comparative example. Fig. 8 shows baffle plates 121a, 121b, 121c, and 121d as variations of baffle plate 121. Refrigerant path(s) 123 is/are formed in each of baffle plates 121a to 121d. As shown in Fig. 8, in each of baffle plates 121a to 121d, refrigerant paths 123 having the same opening diameter are formed at positions which are symmetric with respect to a line or a point.

[0039] Here, it is assumed that, in a case where high-pressure two-phase state refrigerant including liquid refrigerant and gas refrigerant flows into second pipe 115 of the expansion valve, refrigerant having a high liquid ratio flows in a left region in the drawing, and refrigerant having a low liquid ratio flows in a right region in the drawing within second pipe 115, due to the centrifugal force acting on the refrigerant flowing through a connection pipe not shown.

[0040] In this case, since refrigerant paths 123 are formed at positions which are symmetric with respect to a line or a point in each of baffle plates 121a to 121d, it is not possible to fully increase the velocity of the refrigerant having a high liquid ratio. In addition, it is not possible to fully divide air bubbles of the refrigerant having a low liquid ratio. Accordingly, it is not possible to uniformize distribution of the liquid refrigerant and the gas refrigerant flowing into expansion valve 101.

[0041] In contrast to expansion valve 101 in accordance with the comparative example, in expansion valve 1 in accordance with the embodiment, since the refrigerant having a high liquid ratio passes through refrigerant paths 23b having a small path area and a high path resistance, the velocity of the liquid refrigerant is increased. However, pressure loss is relatively small. On the other hand, since the refrigerant having a low liquid ratio passes through refrigerant paths 23a having a large path area and a low path resistance, air bubbles of the gas refrigerant are divided. However, pressure loss is relatively small.

[0042] Thereby, after the refrigerant passes through baffle plate 21, the divided air bubbles of the gas refrigerant are stirred by the liquid refrigerant having an increased flow velocity, and distribution of the liquid refrigerant and the gas refrigerant becomes relatively uniform (flow is regulated) while pressure loss is suppressed, which can achieve a reduction in refrigerant noise. As results showing this effect, Fig. 9 shows the relation between refrigerant noise and path resistance, and Fig. 10 shows the relation between pressure loss and path resistance.

[0043] In the graph shown in Fig. 9, the axis of abscissas represents path resistance, and the axis of ordinates represents refrigerant noise. As path resistance decreases, that is, as the refrigerant paths have a larger path area, refrigerant noise tends to increase.

[0044] In addition, in the graph shown in Fig. 10, the axis of abscissas represents path resistance, and the axis of ordinates represents pressure loss. As path resistance decreases, that is, as the refrigerant paths have a larger path area, pressure loss tends to decrease.

[0045] In baffle plate 21 of expansion valve 1 in accordance with the first embodiment, refrigerant paths 23b having a high path resistance and refrigerant paths 23a having a low path resistance are arranged according to the liquid ratios of the refrigerant flowing into expansion valve 1. In contrast, in baffle plate 121 of expansion valve 101 in accordance with the comparative example, the refrigerant paths having the same path area are arranged to be symmetric with respect to a line or a point.

[0046] Thereby, as shown in Fig. 9, when comparison is made at the same average path resistance, refrigerant noise can be reduced in baffle plate 21 of expansion valve 1 in accordance with the first embodiment, when compared with baffle plate 121 of expansion valve 101 in accordance with the comparative example. In addition, when comparison is made at the same average path resistance, an increase in pressure loss can be suppressed in baffle plate 21 of expansion valve 1 in accordance with the first embodiment, when compared with baffle plate 121 of expansion valve 101 in accordance with the comparative example.

[0047] It should be noted that the above description has been given of the case where baffle plates 21 are formed in expansion valve 1 described above, at both the portion where first pipe 13 is connected to expansion valve 1 and the portion where second pipe 15 is connected to expansion valve 1. In particular, the refrigerant flowing through second pipe 15 toward expansion valve 1 is to flow toward valve seat 9 or valve body 7 after flowing through second pipe 15. On this occasion, if distribution of the liquid refrigerant and the gas refrigerant is non-uniform, the non-uniform distribution may have an influence on the production of refrigerant noise. Accordingly, baffle plate 21 is desirably arranged at least in a flow path (pipe) through which the refrigerant flows toward valve seat 9 or the like.

[0048] In addition, although the above description has been given of the case where two types of refrigerant paths 23a and 23b are formed as refrigerant paths having different path areas in each baffle plate 21 arranged in expansion valve 1 described above, the baffle plate may have three or more types of refrigerant paths having different path areas (not shown) formed therein. Also in this case, it is only necessary to arrange the refrigerant paths such that their path areas gradually decrease along the orientation on which the centrifugal force acts.

Second Embodiment

[0049] Here, an example of variations of baffle plate 21 arranged in expansion valve 1 (see Fig. 2) will be described. It should be noted that, since the structure of the expansion valve and the arrangements and structures of the first pipe, the second pipe, the first connection pipe, and the second connection pipe, which are not shown, are the same as the arrangements and structures shown in Fig. 2, the description thereof will not be repeated unless necessary.

[0050] As shown in Fig. 11, baffle plate 21 is provided with a plurality of refrigerant paths 23b having a substantially uniform path area through which refrigerant passes. The plurality of refrigerant paths 23b are arranged with a substantially uniform pitch. In baffle plate 21, a thickness on one end side in one diametrical direction is defined as a thickness T1. A thickness on the other end side in the one diametrical direction is defined as a thickness T2 thinner than thickness T1.

[0051] As shown in Figs. 12 and 13, baffle plate 21 is arranged such that a portion having thickness T1 is located on a side on which the centrifugal force acts (a side to which arrow CFV is oriented), and a portion having thickness T2 is located on a side opposite to the side on which the centrifugal force acts.

[0052] Path resistance of refrigerant paths 23b formed in the portion where the thickness of baffle plate 21 is relatively thick is higher than path resistance of refrigerant paths 23b formed in the portion where the thickness of baffle plate 21 is relatively thin. That is, refrigerant paths 23b are arranged such that path resistance of baffle plate 21 increases toward the side on which the centrifugal force acts (the side to which arrow CFV is oriented).

[0053] In baffle plate 21 of expansion valve 1 described above, as shown in Fig. 14, since refrigerant having a high liquid ratio passes through refrigerant paths 23b having a high path resistance, the velocity of liquid refrigerant is increased (see a dotted-line arrow). Since refrigerant having a low liquid ratio passes through refrigerant paths 23b having a low path resistance, air bubbles of gas refrigerant are divided. The divided air bubbles of the gas refrigerant are stirred by the liquid refrigerant having an increased flow velocity.

[0054] Thereby, as in baffle plate 21 described in the first embodiment, after the refrigerant passes through baffle plate 23, distribution of the liquid refrigerant and the gas refrigerant becomes relatively uniform, and the two-phase state refrigerant flows to a throttle portion of expansion valve 1. As a result, refrigerant noise can be reduced.

[0055] In addition, in baffle plate 21 described above, since the plurality of refrigerant paths 23b are arranged with a substantially uniform pitch, refrigerant paths 23b are easily processed. Further, since the plurality of refrigerant paths 23b are formed at a uniform pitch, distribution of the liquid refrigerant and the gas refrigerant easily becomes more uniform after the refrigerant flows through baffle plate 21, which can contribute to a further reduction in refrigerant noise.

Third Embodiment

[0056] Here, another example of the variations of baffle plate 21 arranged in expansion valve 1 (see Fig. 2) will be described. It should be noted that, since the structure of the expansion valve and the arrangements and structures of the first pipe, the second pipe, the first connection pipe, and the second connection pipe, which are not shown, are the same as the arrangements and structures shown in Fig. 2, the description thereof will not be repeated unless necessary.

[0057] As shown in Fig. 15, baffle plate 21 is provided with a plurality of refrigerant paths 23c and a plurality of refrigerant paths 23d having a substantially uniform path area through which refrigerant passes. The plurality of refrigerant paths 23c and the plurality of refrigerant paths 23d are arranged with a substantially uniform pitch. Baffle plate 21 has thickness T. Refrigerant paths 23c are formed in a direction substantially orthogonal to baffle plate 21, along a direction in which the refrigerant flows. In contrast, refrigerant paths 23d are formed to be inclined in a direction intersecting the orthogonal direction, to intersect the direction in which the refrigerant flows.

[0058] As shown in Figs. 16 and 17, baffle plate 21 is arranged such that refrigerant paths 23d are located on a side on which the centrifugal force acts (a side to which arrow CFV is oriented), and refrigerant paths 23c are located on a side opposite to the side on which the centrifugal force acts.

[0059] Path resistance of refrigerant paths 23d formed in baffle plate 21 to intersect the flow of the refrigerant is higher than path resistance of refrigerant paths 23c formed in baffle plate 21 along the flow of the refrigerant. That is, refrigerant paths 23c and refrigerant paths 23d are arranged such that path resistance of baffle plate 21 increases toward the side on which the centrifugal force acts (the side to which arrow CFV is oriented).

[0060] In baffle plate 21 of expansion valve 1 described above, as shown in Fig. 18, since refrigerant having a high liquid ratio passes through refrigerant paths 23d having a high path resistance, the velocity of liquid refrigerant is increased (see a dotted-line arrow). Since refrigerant having a low liquid ratio passes through refrigerant paths 23c having a low path resistance, air bubbles of gas refrigerant are divided. The divided air bubbles of the gas refrigerant are stirred by the liquid refrigerant having an increased flow velocity.

[0061] Thereby, as in baffle plate 21 described in the first embodiment, after the refrigerant passes through baffle plate 23, distribution of the liquid refrigerant and the gas refrigerant becomes relatively uniform, and the two-phase state refrigerant flows to a throttle portion of expansion valve 1. As a result, refrigerant noise can be reduced.

[0062] It should be noted that the above description has been given of the case where baffle plate 21 of expansion valve 1 described above is provided with refrigerant paths 23d inclined uniformly to intersect the direction in which the refrigerant flows, as refrigerant paths having a relatively high path resistance.

[0063] The inclined angle of the refrigerant paths with respect to the direction in which the refrigerant flows is not limited to one angle, and refrigerant paths inclined at two or more different angles may be formed. In that case, it is only necessary to arrange the refrigerant paths such that their inclined angles gradually increase toward the side on which the centrifugal force acts (the side to which arrow CFV is oriented).

Fourth Embodiment

[0064] Here, an example of variations of a pipe connected to expansion valve 1, and a baffle plate will be described.

[0065] In each of the embodiments described above, the description has been given of the case where first connection pipe 17 serving as a curved pipe is connected to first pipe 13 serving as a straight pipe. When first pipe 13 serving as a straight pipe has a relatively short length, refrigerant flowing within first pipe 13 flows under the influence of the centrifugal force. However, when first pipe 13 has a long length, the refrigerant flowing within first pipe 13 is gradually more likely to be influenced by gravity than the centrifugal force.

[0066] As shown in Fig. 19, when first pipe 13 connected to expansion valve 1 has a length L which is equivalent to five times or more of an inner diameter of first pipe 13, the influence of gravity on the refrigerant flowing within first pipe 13 gradually becomes dominant. Thus, within first pipe 13, refrigerant having a high liquid ratio flows in a lower portion within first pipe 13, and refrigerant having a low liquid ratio flows in an upper portion within first pipe 13.

[0067] In this case, baffle plate 21 arranged at a portion where first pipe 13 is connected is arranged such that refrigerant paths 23b having a high path resistance are located on the lower side, and refrigerant paths 23a having a low path resistance are located on the upper side.

[0068] Since the refrigerant having a high liquid ratio flowing in the lower portion within first pipe 13 due to the action of gravity passes through refrigerant paths 23d having a high path resistance, the velocity of liquid refrigerant is increased. On the other hand, since the refrigerant having a low liquid ratio flowing in the upper portion within first pipe 13 passes through refrigerant paths 23c having a low path resistance, air bubbles of gas refrigerant are divided. The divided air bubbles of the gas refrigerant are stirred by the liquid refrigerant having an increased flow velocity.

[0069] Thereby, as described in the first embodiment, after the refrigerant passes through baffle plate 23, distribution of the liquid refrigerant and the gas refrigerant becomes relatively uniform, and the two-phase state refrigerant flows to a throttle portion of expansion valve 1. As a result, refrigerant noise can be reduced.

Fifth Embodiment

[0070] Here, an example of an expansion valve which allows easy confirmation of the arrangement relation of a baffle plate will be described.

[0071] As shown in Fig. 20, first pipe 13 connected to expansion valve 1 is provided with a protrusion 14, and second pipe 15 is provided with a protrusion 16. In this case, protrusion 14 is formed to protrude from the inside toward the outside of first pipe 13, at a portion of a pipe wall portion on a side where refrigerant having a high liquid ratio flows within first pipe 13. In addition, protrusion 16 is formed to protrude from the inside toward the outside of second pipe 15, at a portion of a pipe wall portion on a side where refrigerant having a high liquid ratio flows within second pipe 15.

[0072] In the expansion valve described above, when first connection pipe 17 serving as a curved pipe is connected to first pipe 13, whether or not baffle plate 21 is arranged at a predetermined position (circumferential position) for reducing refrigerant noise with respect to the direction of the curve of first connection pipe 17 can be easily confirmed based on the position of protrusion 14 provided in first pipe 13.

[0073] In addition, when second connection pipe 19 serving as a curved pipe is connected to second pipe 15, whether or not baffle plate 21 is arranged at a predetermined position (circumferential position) for reducing refrigerant noise with respect to the direction of the curve of second connection pipe 19 can be easily confirmed based on the position of protrusion 16 provided in second pipe 15.

[0074] This can suppress such incorrect assembly that the position (circumferential position) of baffle plate 21 in expansion valve 1 is misaligned from the predetermined position for reducing refrigerant noise when refrigeration cycle apparatus 51 (see Fig. 1) is assembled.

[0075] It should be noted that the above description has been given of the case where whether or not baffle plate 21 is arranged at the predetermined position (circumferential position) for reducing refrigerant noise with respect to the position of the curved pipe is confirmed based on protrusion 14 in expansion valve 1 described above, such a feature is not limited to protrusion 14 as long as the feature serves as a mark which allows confirmation of the predetermined position (circumferential position) for reducing refrigerant noise.

[0076] The expansion valves including the baffle plates which have been described in the respective embodiments can be combined in various ways as necessary.

[0077] The embodiments disclosed herein are illustrative, and the present invention is not limited thereto. The scope of the present invention is defined by the scope of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the scope of the claims.

INDUSTRIAL APPLICABILITY

[0078] The present invention is effectively applied to an expansion valve used for a refrigeration cycle apparatus.

REFERENCE SIGNS LIST

[0079] 1: expansion valve; 3: valve main body; 5: valve chamber; 7: valve body; 9: valve seat; 11: drive unit; 13: first pipe; 14: protrusion; 15: second pipe; 16: protrusion; 17: first connection pipe; 19: second connection pipe; 21: baffle plate; 23a, 23b, 23c, 23d: refrigerant path; 31: liquid refrigerant; 33: gas refrigerant; CFV: arrow; 51: refrigeration cycle apparatus; 53: compressor; 55: condenser; 57: evaporator.

Claims

1. An expansion valve comprising:

a valve main body including a valve chamber, and a valve seat having an opening in communication with the valve chamber;
a valve body inserted into the opening in the valve seat for adjusting a degree of opening of the opening;
a first flow path in communication with the valve chamber;
a second flow path in communication with the opening in the valve seat; and
a baffle plate arranged in a flow path into which refrigerant flows toward the valve chamber, of the first flow path and the second flow path, in a direction intersecting a direction in which the refrigerant flows,
in a case where the refrigerant includes liquid refrigerant and gas refrigerant, when a ratio of the liquid refrigerant to the liquid refrigerant and the gas refrigerant in weight ratio is defined as a liquid ratio,
refrigerant paths allowing the refrigerant to pass therethrough being formed in the baffle plate, in a manner in which path resistance increases from a first portion of the baffle plate that is to be located in a region where refrigerant having a low liquid ratio flows, toward a second portion of the baffle plate that is to be located in a region where refrigerant having a high liquid ratio flows.

2. The expansion valve according to claim 1, wherein the baffle plate has a first thickness, in the baffle plate,

   in the first portion, first refrigerant paths having a first path cross sectional area are formed as the refrigerant paths,
   in the second portion, second refrigerant paths having a second path cross sectional area are formed as the refrigerant paths, and
   the second path cross sectional area is smaller than the first path cross sectional area.

3. The expansion valve according to claim 1, wherein in the baffle plate,

   the first portion has a first thickness,
   the second portion has a second thickness thicker than the first thickness, in the first portion, first refrigerant paths having a first path cross sectional area are formed as the refrigerant paths,
   in the second portion, second refrigerant paths having a second path cross sectional area are formed as the refrigerant paths, and
   the first path cross sectional area and the second path cross sectional area are set to be identical.

4. The expansion valve according to claim 1, wherein the baffle plate has a first thickness, in the baffle plate,

   in the first portion, first refrigerant paths having a first path cross sectional area are formed as the refrigerant paths,
   in the second portion, second refrigerant paths having a second path cross sectional area are formed as the refrigerant paths,
   the first path cross sectional area and the second path cross sectional area are set to be identical, and
   the second refrigerant paths are inclined with respect to a direction in which the refrigerant flows through the first refrigerant paths, in a manner in which the refrigerant having flowed through the second refrigerant paths approaches the refrigerant having flowed through the first refrigerant paths.

5. The expansion valve according to claim 1, comprising:

   a first pipe serving as the first flow path; and
   a second pipe serving as the second flow path, wherein
   a straight pipe is connected to a pipe which is horizontally arranged and through which the refrigerant flows toward the valve chamber, of the first pipe and the second pipe, and
   the straight pipe has a length which is five times or more of an opening diameter of the straight pipe.

6. The expansion valve according to claim 1, comprising:

   a first pipe serving as the first flow path; and
   a second pipe serving as the second flow path, wherein
   a pipe through which the refrigerant flows toward the valve chamber, of the first pipe and the second pipe, is provided with a mark at a circumferential position of the pipe where the second portion of the baffle plate is located.

7. The expansion valve according to claim 6, wherein the mark includes a protrusion protruding from an inside toward an outside of the pipe.

8. The expansion valve according to any one of claims 1 to 4, comprising:

   a first pipe serving as the first flow path; and
   a second pipe serving as the second flow path, wherein
   a curved pipe is connected to a pipe through which the refrigerant flows toward the valve chamber, of the first pipe and the second pipe, and
   the baffle plate is arranged such that the refrigerant having flowed on an outer circumferential side of the curved pipe flows through the refrigerant paths formed in the second portion of the baffle plate.

9. The expansion valve according to any one of claims 1 to 8, wherein the baffle plate is arranged in the second flow path in communication with the opening in the valve seat.

10. A refrigeration cycle apparatus comprising the expansion valve according to any one of claims 1 to 9.

FIG.1

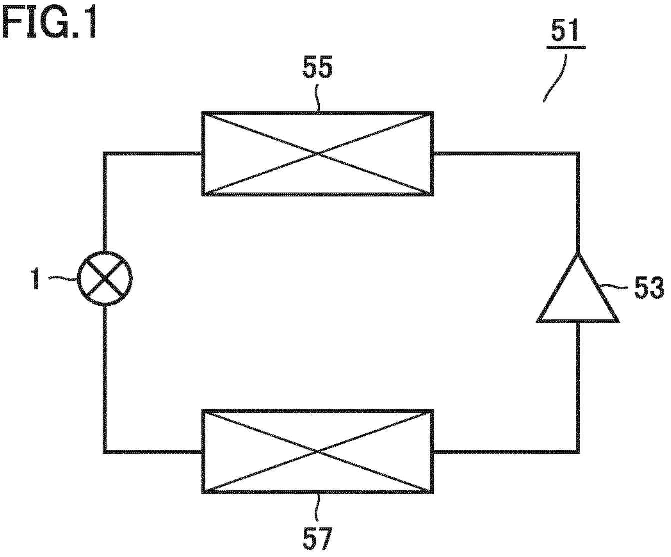


FIG.2

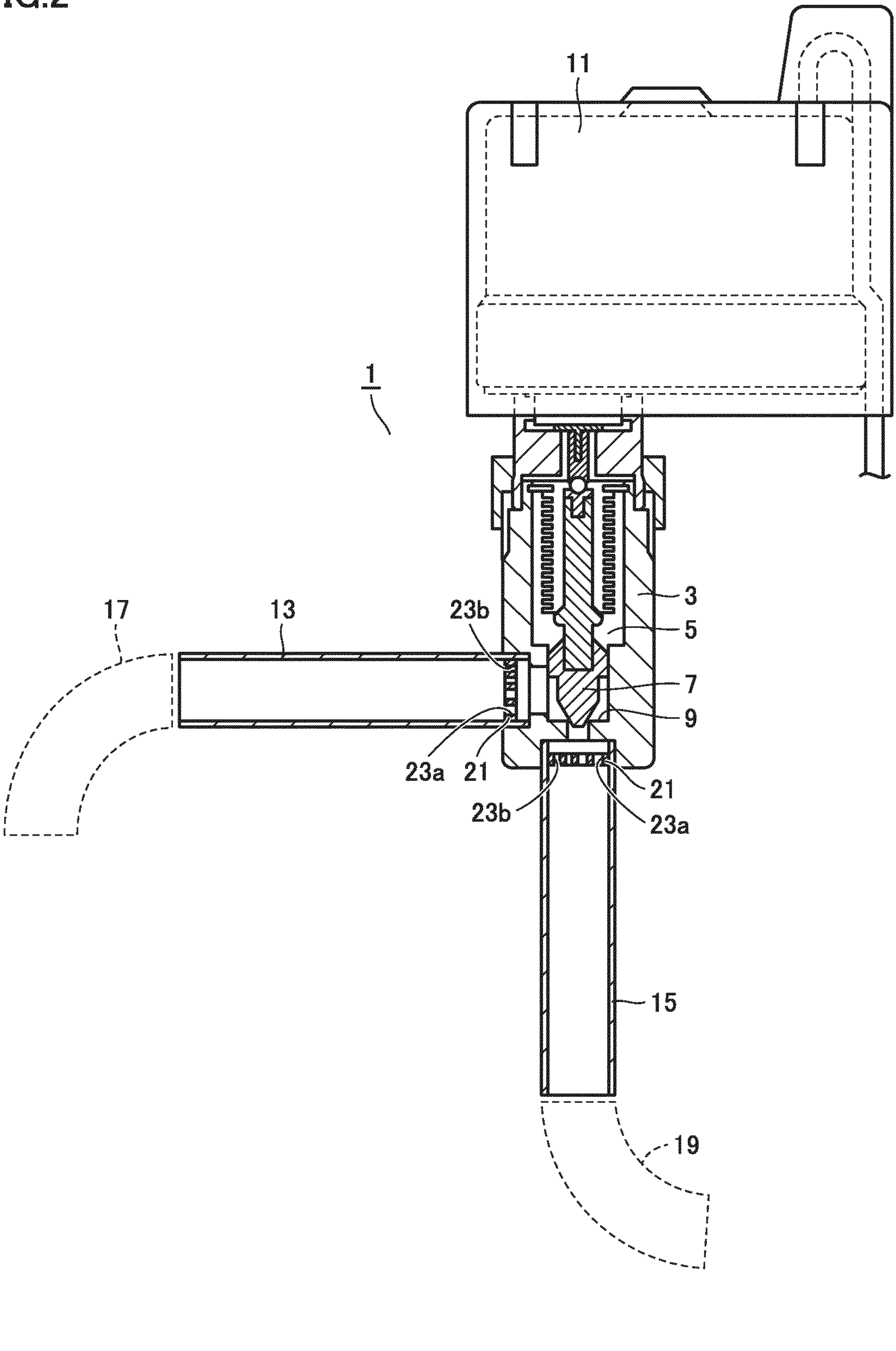


FIG.3

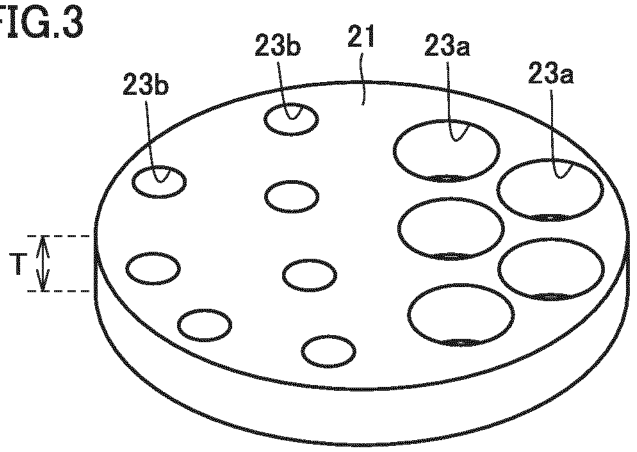


FIG.4

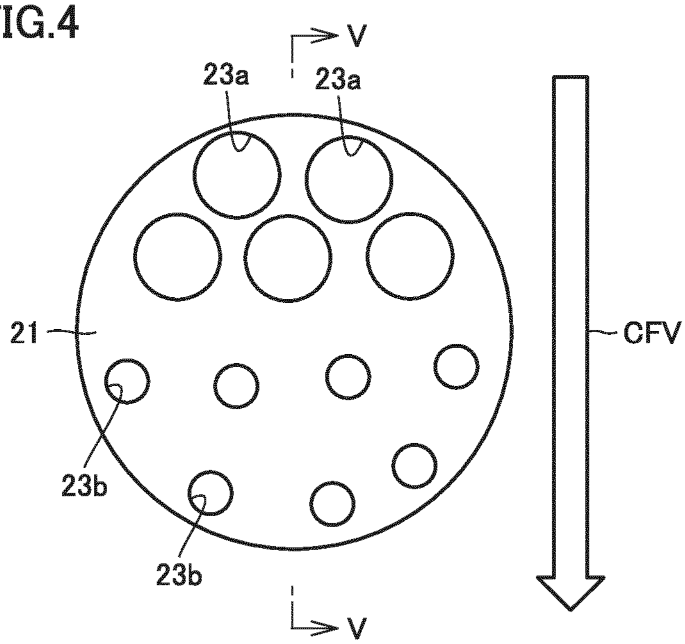


FIG.5

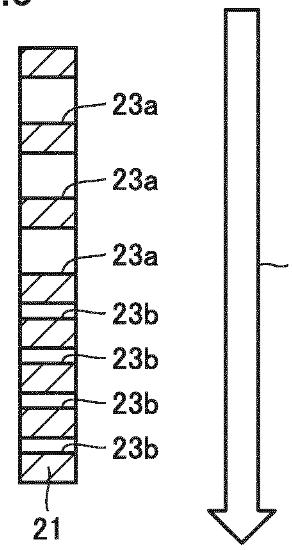
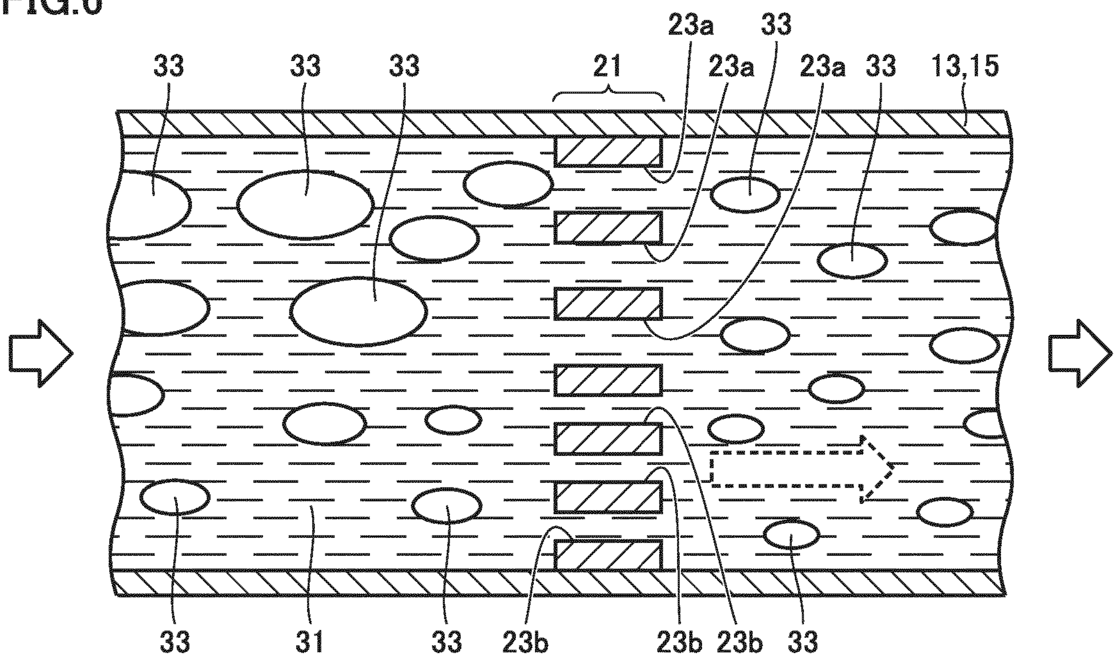

23a
23a
23a
23b
23b
23b
23b
21
CFV

FIG.6


23a
33
33
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23a
23a
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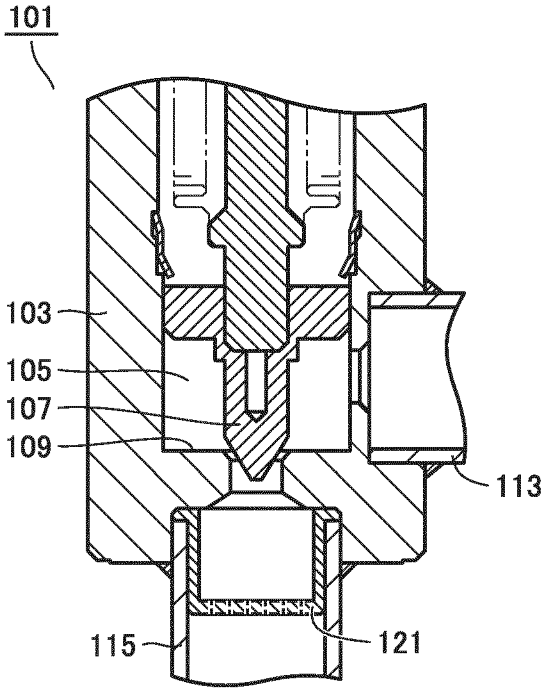
13,15
33
31
33
23b
23b
23b
33

FIG.7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121

FIG.8

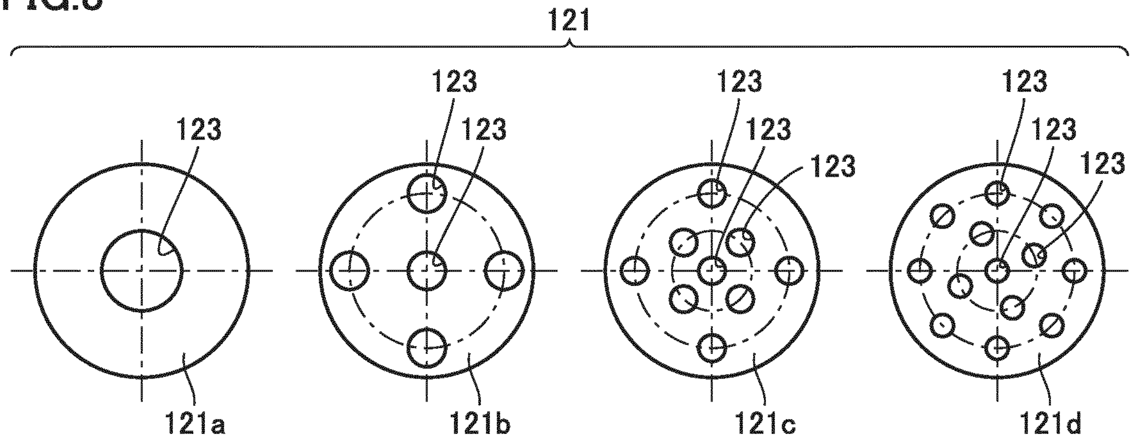

121
123
123
123
123
123
123
123
123
123
123
121a
121b
121c
121d

FIG.9

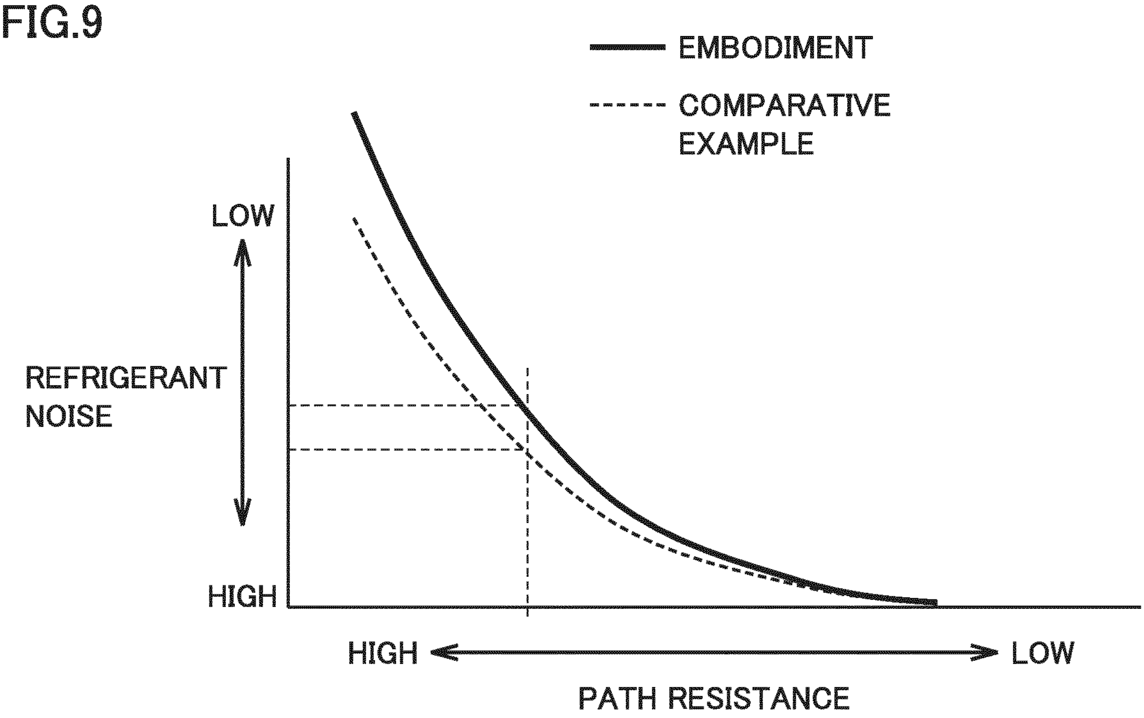

EMBODIMENT
COMPARATIVE EXAMPLE
LOW
REFRIGERANT NOISE
HIGH
HIGH
LOW
PATH RESISTANCE

FIG.10

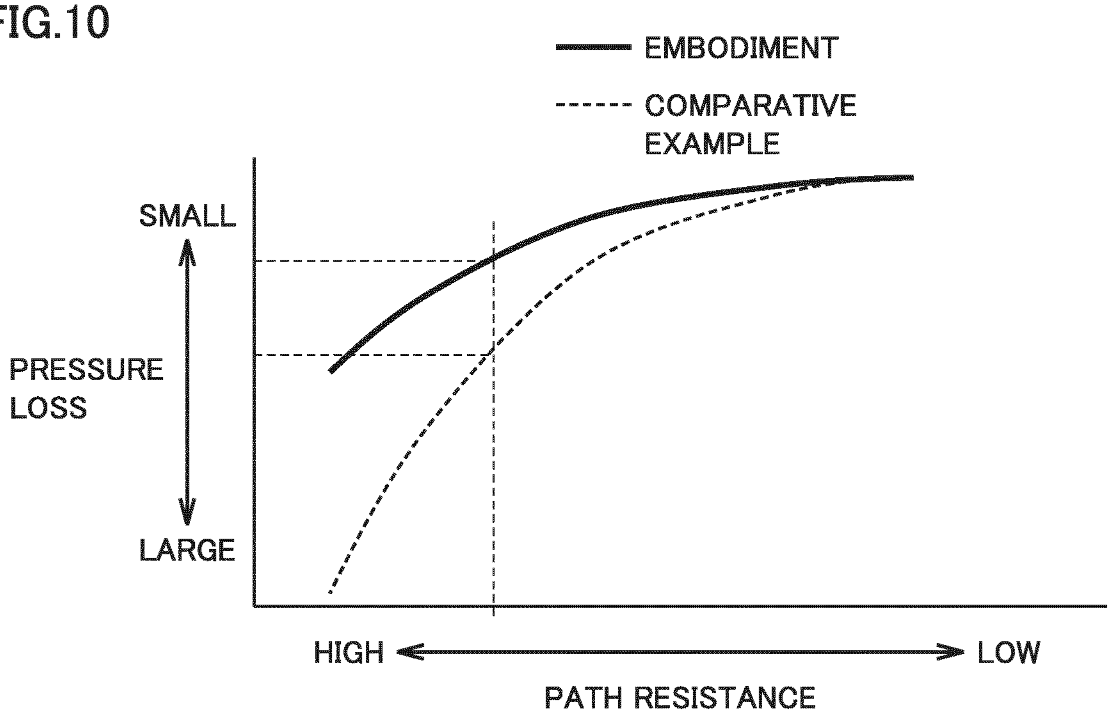

EMBODIMENT
COMPARATIVE EXAMPLE
SMALL
PRESSURE LOSS
LARGE
HIGH
LOW
PATH RESISTANCE

FIG.11

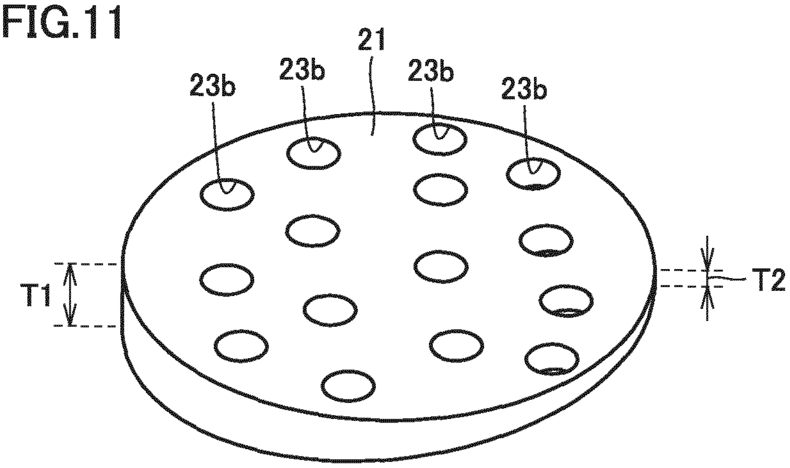


FIG.12

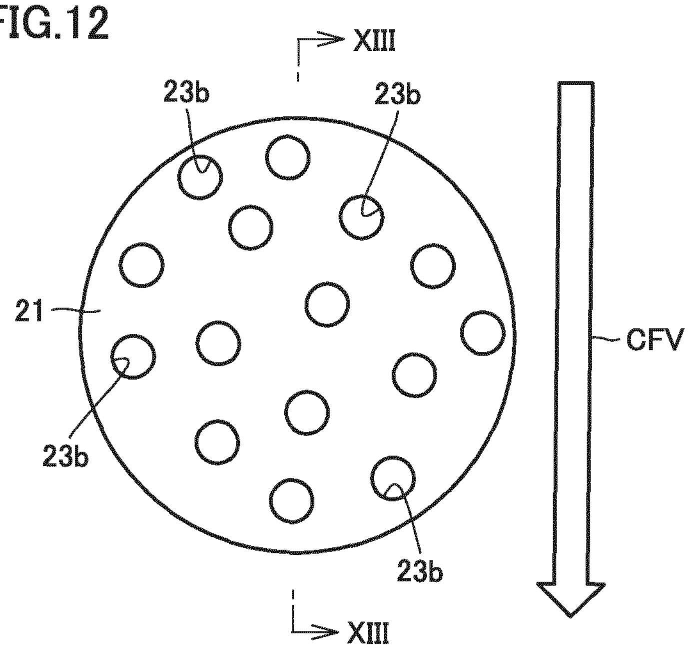


FIG.13

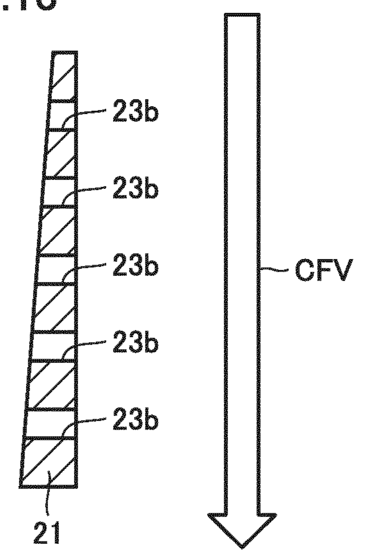
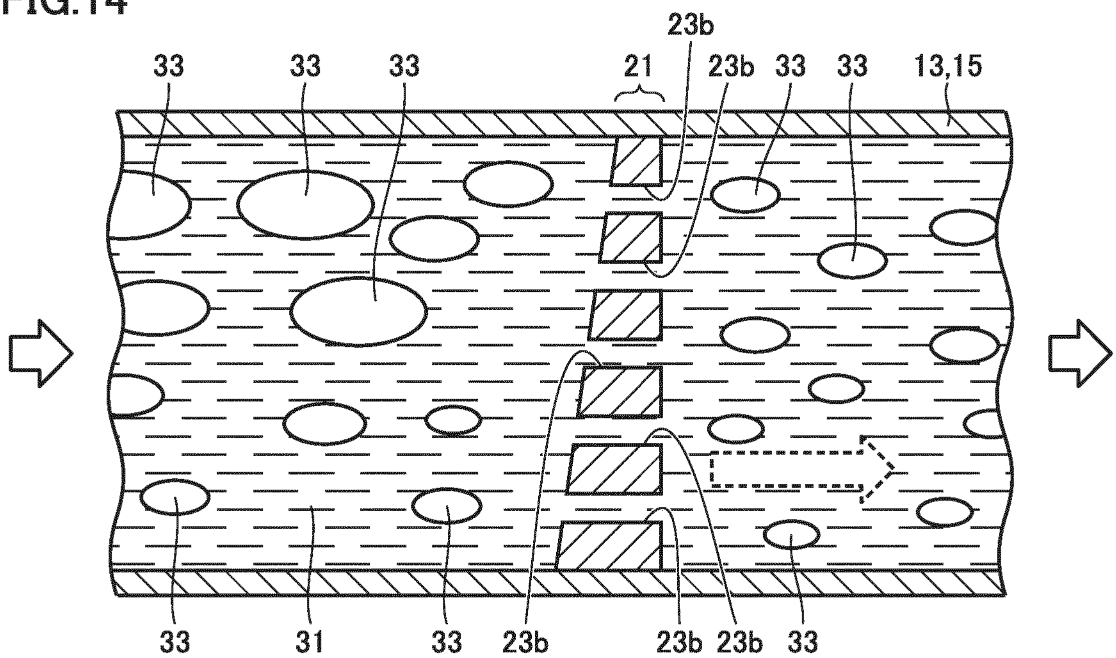

23b
23b
23b
23b
23b
CFV
21

FIG.14


23b
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23b
23b
23b
33

FIG.15

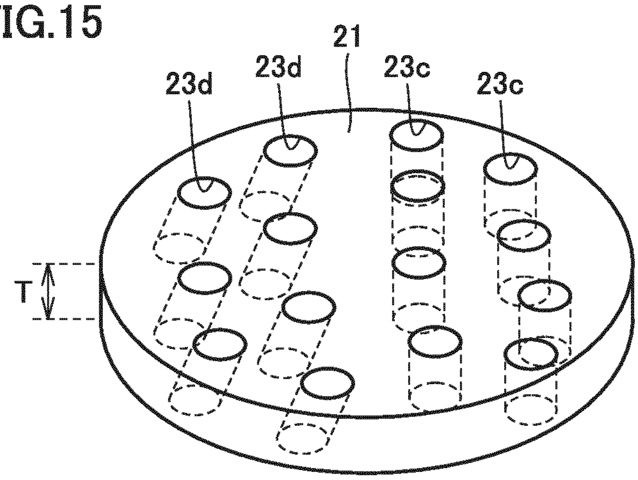

21
23d
23d
23c
23c
T

FIG.16

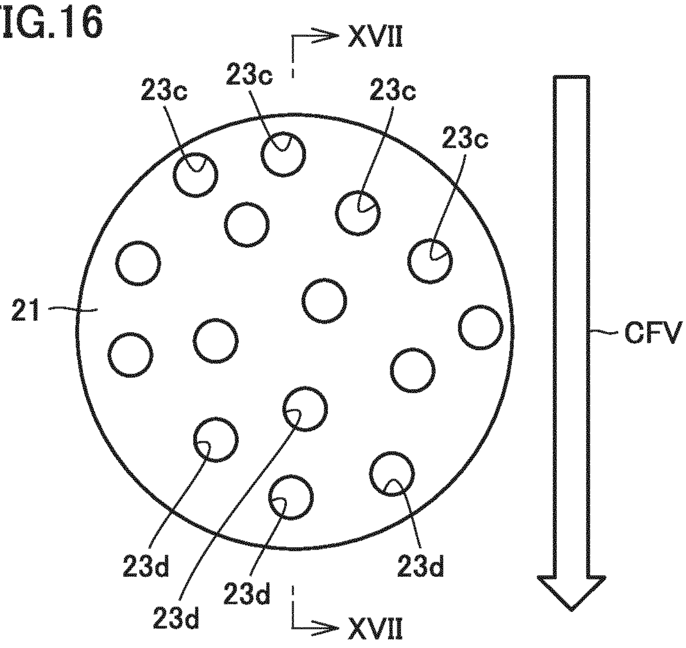

XVII
23c
23c
23c
23c
21
CFV
23d
23d
23d
23d
XVII

FIG.17

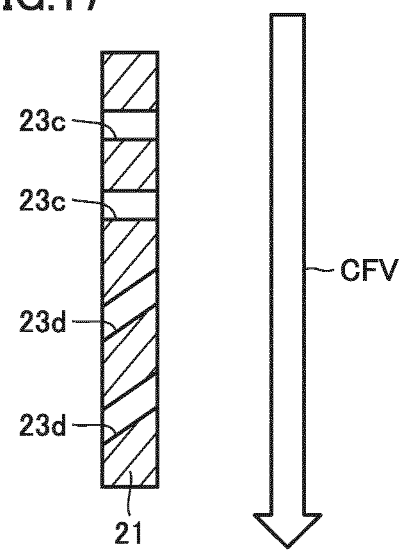
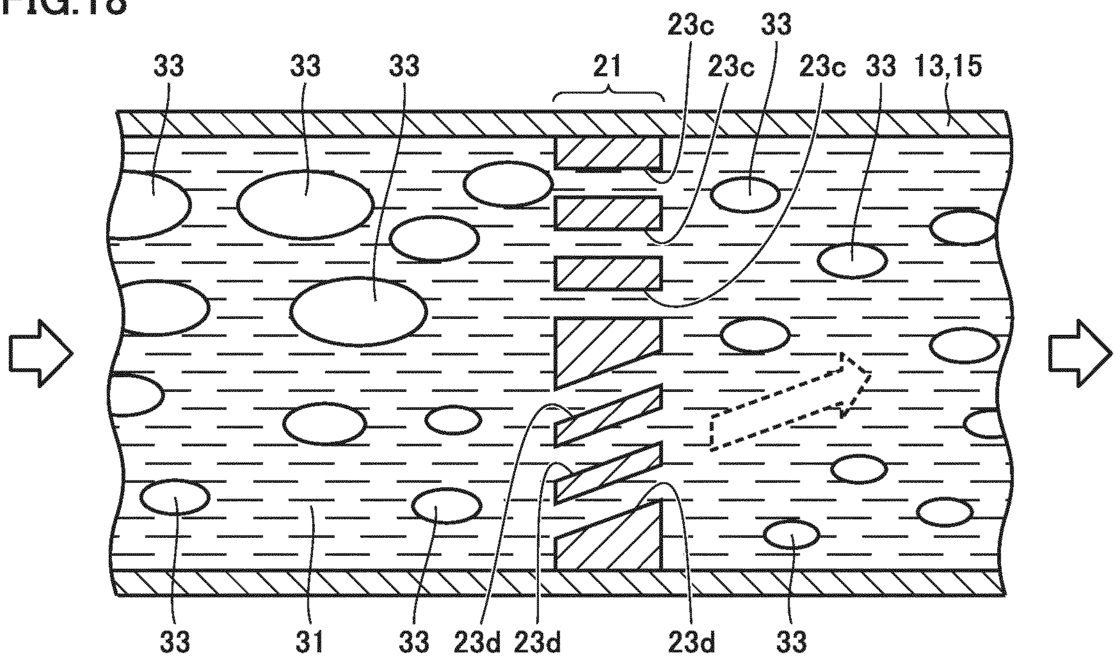

23c
23c
23d
23d
21
CFV

FIG.18


23c
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23d
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23d
33

FIG.19

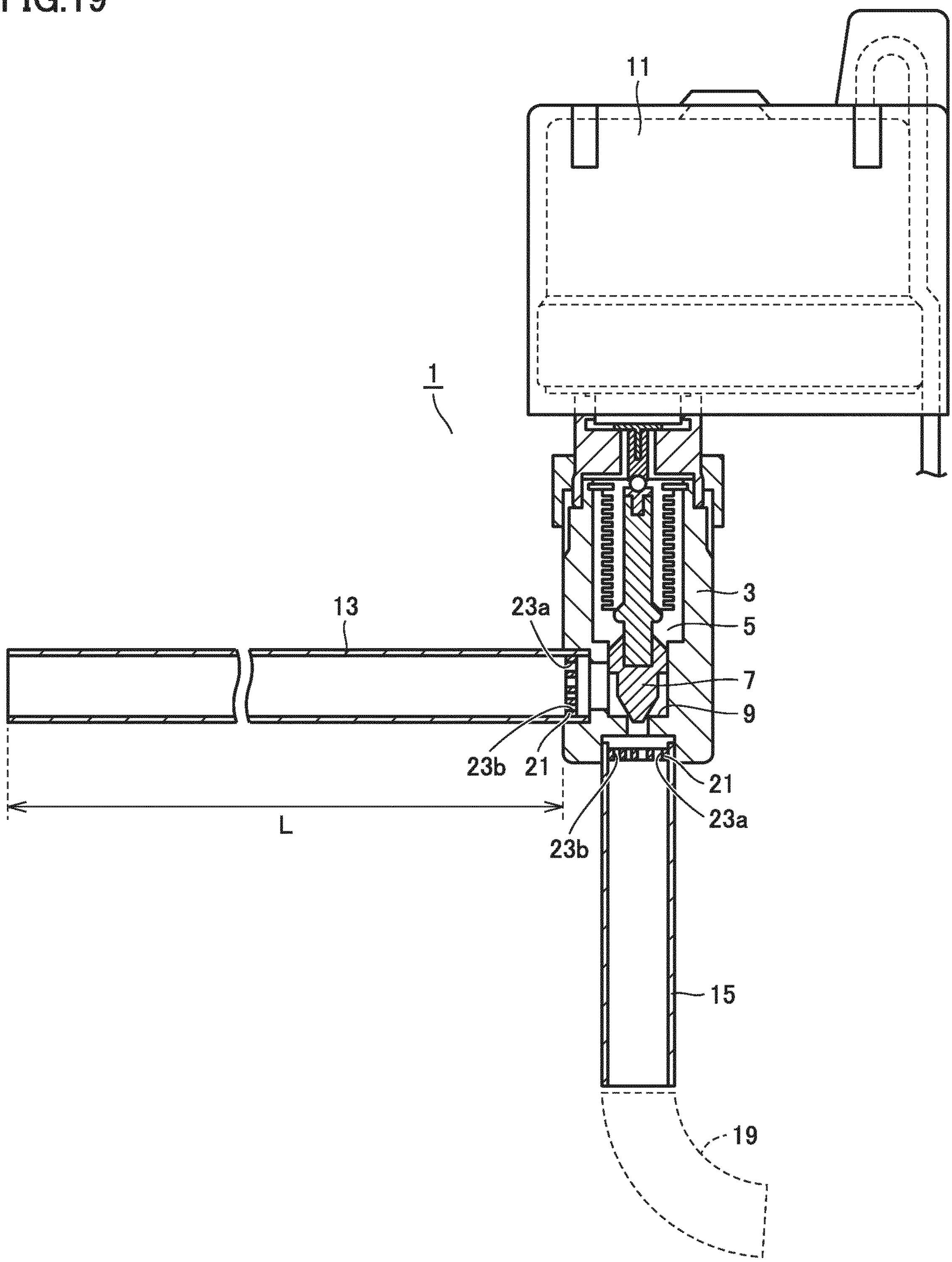
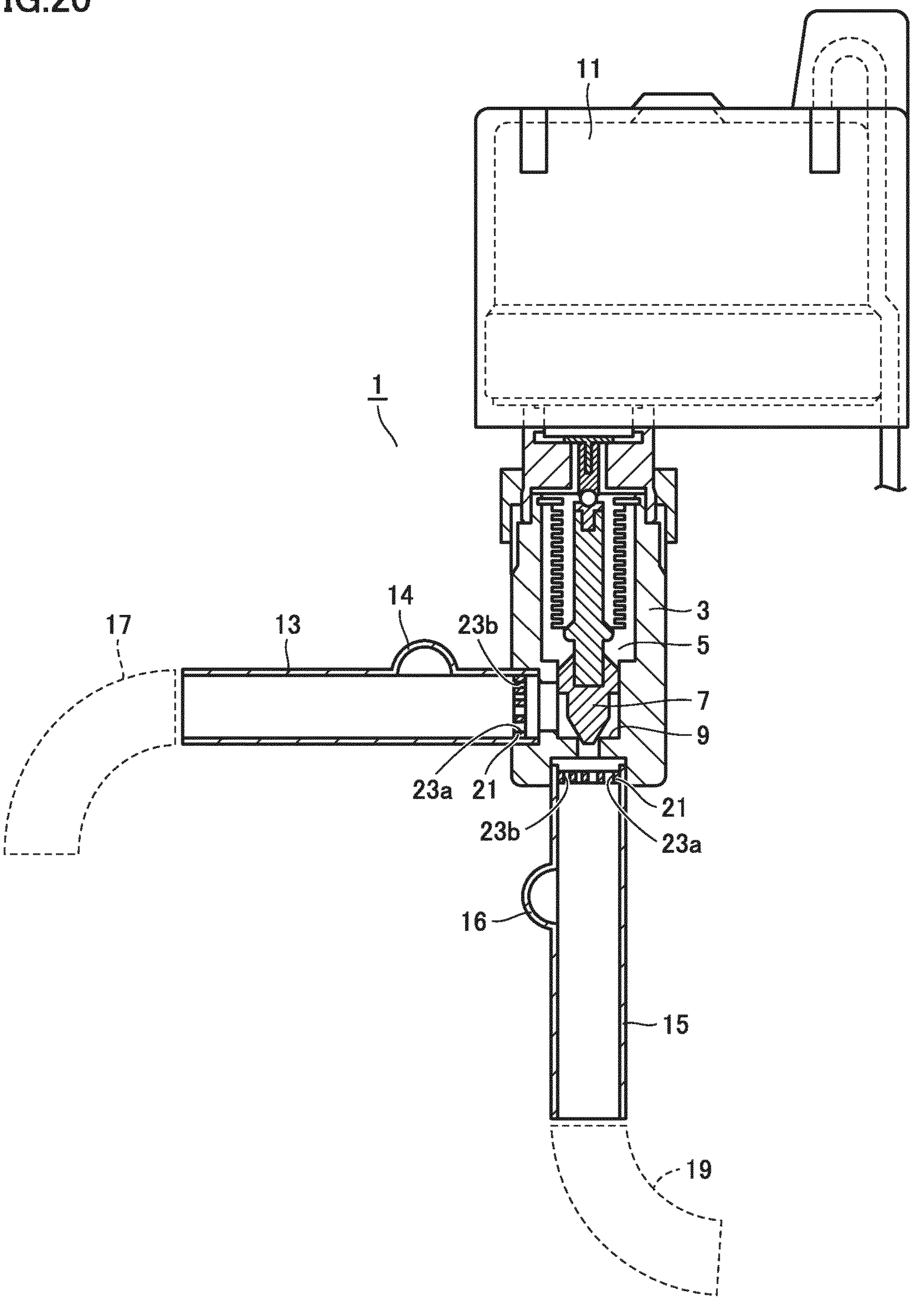


FIG.20



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/000836

A. CLASSIFICATION OF SUBJECT MATTER
F25B41/06(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

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	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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.
A	WO 2016/002022 A1 (Mitsubishi Electric Corp.), 07 January 2016 (07.01.2016), entire text; all drawings (Family: none)	1-10
A	JP 2006-275452 A (Mitsubishi Electric Corp.), 12 October 2006 (12.10.2006), entire text; all drawings (Family: none)	1-10
A	JP 2004-76957 A (Daikin Industries, Ltd.), 11 March 2004 (11.03.2004), entire text; all drawings (Family: none)	1-10

☒ 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
07 March 2017 (07.03.17)

Date of mailing of the international search report
21 March 2017 (21.03.17)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3,Kasumigaseki,Chiyoda-ku,
Tokyo 100-8915,Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/000836

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-238207 A (Fuji Koki Corp.), 18 December 2014 (18.12.2014), entire text; all drawings (Family: none)	1-10
A	JP 50-83820 A (Tsuru Agenchiyureru Akuchiepuragu), 07 July 1975 (07.07.1975), entire text; all drawings (Family: none)	1-10

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Patent documents cited in the description

- JP 2007162851 A **[0005]**
- JP 2014238207 A **[0005]**