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(54) **EXPANSION VALVE**

(57) An orifice (60) formed in a valve seat (12) has an orifice entrance (61) having the smallest diameter, an orifice middle section (62) which widens in diameter along the direction of refrigerant outflow from the orifice entrance (61) so as to form a first taper angle, and an orifice exit (63) which either widens in diameter or does not change in diameter along the direction of refrigerant outflow from the orifice middle section (62) so as to form a second taper angle smaller than the first taper angle.

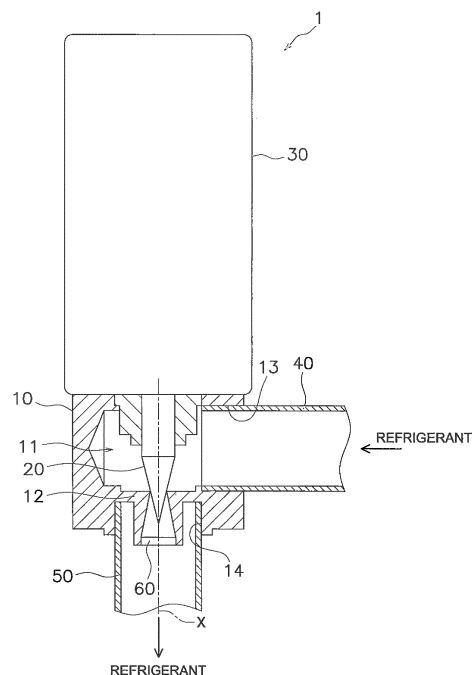


FIG. 1

EP 2 620 724 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an expansion valve, and particularly relates to an expansion valve which is provided to a refrigerant circuit of a refrigeration apparatus and which depressurizes a liquid refrigerant.

BACKGROUND ART

[0002] In the past, there have been expansion valves such as the one disclosed in Patent Literature 1 (Japanese Laid-open Patent Application No. 2009-228689). This expansion valve is provided to a refrigerant circuit of a refrigeration apparatus and is used to depressurize a liquid refrigerant, and as shown in FIG. 5, the expansion valve has primarily a valve main body 10, a valve body 20, and a drive mechanism 30. The valve main body 10 is a member in which a valve seat 12 opening into a valve chest 11 is formed. Formed in the valve main body 10 are a refrigerant inlet 13 where refrigerant flows in from the side of the valve chest 11, and a refrigerant outlet 14 where refrigerant flows out underneath the valve chest 11. A refrigerant inflow tube 40 is connected to the refrigerant inlet 13, and a refrigerant outflow tube 50 is connected to the refrigerant outlet 14. The valve body 20 is a member that is caused to reciprocate relative to the valve seat 12 by the drive mechanism 30. The drive mechanism 30 is composed of a motor, a solenoid, or the like. With such a configuration, the flow rate of liquid refrigerant passing between the refrigerant inflow tube 40 and the refrigerant outflow tube 50 is adjusted while the refrigerant is depressurized.

SUMMARY OF THE INVENTION

[0003] In the conventional expansion valve described above, an orifice 80 is formed in the valve seat 12 as shown in FIG. 6. This orifice 80 is composed only of a portion 81 which has the same diameter (a diameter D0) along the direction of refrigerant outflow (specifically, downward along the reciprocating direction axis line X of the valve body 20). There are cases in which such an expansion valve is used under conditions such that the refrigerant passes through the refrigerant inlet 13 in a liquid single phase and through the refrigerant outlet 14 also in a liquid single phase, and the noise generated in such usage conditions becomes a problem.

[0004] An object of the present invention is to minimize the noise that occurs under conditions such that the refrigerant passes through the refrigerant inlet in a liquid single phase and through the refrigerant outlet also in a liquid single phase, in an expansion valve which is provided to a refrigerant circuit of a refrigeration apparatus and which depressurizes a liquid refrigerant.

[0005] An expansion valve according to a first aspect is an expansion valve which is provided to a refrigerant

circuit of a refrigeration apparatus and which depressurizes a liquid refrigerant, the expansion valve comprising a valve main body in which a valve seat opening into a valve chest is formed, and a valve body which reciprocates relative to the valve chest. An orifice formed in the valve seat has an orifice entrance having the smallest diameter, an orifice middle section which widens in diameter along the direction of refrigerant outflow from the orifice entrance so as to form a first taper angle, and an orifice exit which either widens in diameter or does not change in diameter along the direction of refrigerant outflow from the orifice middle section so as to form a second taper angle smaller than the first taper angle.

[0006] The inventors of the present application have discovered that when the expansion valve is used under conditions such that the refrigerant passes through the refrigerant inlet in a liquid single phase and through the refrigerant outlet also in a liquid single phase, noise is caused by sounds from cavitation when the refrigerant passes through the orifice and resonance sounds in the refrigerant outflow tube after the refrigerant passes through the orifice. Specifically, in the conventional expansion valve, when the refrigerant passes through the orifice, separation of the refrigerant flow occurs immediately after the refrigerant has flowed from the valve chest, which has a large flow passage cross section, to the orifice, which has a small flow passage cross section. Localized drops in pressure are caused by this separation, and cavitation occurs in the portions where these localized drops in pressure occur. Such cavitation is one cause of the noise. When separation in the refrigerant flow occurs while the refrigerant is passing through the orifice, the refrigerant will spurt, causing the pressure to fluctuate, and the refrigerant will flow into the refrigerant outflow tube through the refrigerant outlet. Resonance sounds occur in the refrigerant outflow tube due to the pressure fluctuation reaching the refrigerant outflow tube. Such resonance sounds are one cause of the noise.

[0007] In view of this, the inventors of the present application have conducted thoroughgoing experiments towards designing a shape of the orifice that would address such noise. The inventors of the present application have discovered that the noise described above can be minimized if the orifice has an orifice entrance having the smallest diameter, an orifice middle section which widens in diameter along the direction of refrigerant outflow from the orifice entrance so as to form a first taper angle, and an orifice exit which either widens in diameter or does not change in diameter along the direction of refrigerant outflow from the orifice middle section so as to form a second taper angle smaller than the first taper angle.

[0008] With such a shape of the orifice, the refrigerant flowing into the orifice from the valve chest first flows into the orifice entrance of the orifice, similar to the conventional example, immediately after which flow separation occurs, and local drops in pressure are likely to occur due to this separation. However, because of the formation of the orifice middle section which widens in diameter

along the direction of refrigerant outflow from the orifice entrance, the pressure of the refrigerant can be recovered immediately after it has flowed into the orifice entrance. Such pressure recovery minimizes the occurrence of cavitation, and as a result minimizes the sounds caused by cavitation when the refrigerant passes through the orifice. With the mere intention to recover refrigerant pressure through the orifice middle section, there is a risk that the separation of refrigerant flow will remain, the refrigerant will spurt, causing the pressure to fluctuate, and the refrigerant will flow into the refrigerant outflow tube through the refrigerant outlet. However, the separated refrigerant can re-agglutinate because of the formation of the orifice exit wherein the diameter widens or the diameter does not change from the orifice middle section along the direction of refrigerant outflow so as to form a second taper angle which is smaller than the first taper angle. Such re-agglutination of the refrigerant minimizes the occurrences of spurting which causes pressure fluctuation, and as a result, resonance sound in the refrigerant outflow tube is minimized.

[0009] As described above, in the expansion valve, employing the shape of the orifice having the orifice entrance, the orifice middle section, and the orifice exit as described above makes it possible to minimize noises occurring when the expansion valve is used in conditions such that the refrigerant passes through the refrigerant inlet in a liquid single phase and through the refrigerant outlet also in a liquid single phase.

[0010] An expansion valve according to a second aspect is the expansion valve according to the first aspect, characterized in that a first outflow direction length of the orifice middle section along the direction of refrigerant outflow is one or more times the minimum diameter of the orifice entrance.

[0011] In this expansion valve, because the first outflow direction length of the orifice middle section along the direction of refrigerant outflow is one or more times the minimum diameter of the orifice entrance, refrigerant can re-agglutinate not only in the orifice exit but in the orifice middle section as well, whereby the effect of minimizing resonance sounds in the refrigerant outflow tube can be improved.

[0012] An expansion valve according to a third aspect is the expansion valve according to the first or second aspect, characterized in that the first taper angle is 10 degrees or greater and 60 degrees or less.

[0013] In this expansion valve, because the first taper angle is 10 degrees or greater, the effect of pressure recovery immediately after the refrigerant has flowed into the orifice entrance can be reliably achieved. Moreover, because the first taper angle is 60 degrees or less, it is also possible for the refrigerant in the orifice middle section to re-agglutinate. Specifically, in this expansion valve, having the first taper angle in the angle range described above makes both pressure recovery and refrigerant re-agglutination possible.

[0014] An expansion valve according to a fourth aspect

is the expansion valve according to any of the first through third aspects, characterized in that a second inclination angle formed by the orifice exit with a plane orthogonal to the direction of refrigerant outflow is greater than a first inclination angle formed by the orifice middle section with a plane orthogonal to the direction of refrigerant outflow, and is 90 degrees or less.

[0015] In this expansion valve, because the second inclination angle formed by the orifice exit with a plane orthogonal to the direction of refrigerant outflow is 90 degrees or less, the diameter can be prevented from narrowing along the direction of refrigerant outflow. The refrigerant flow can thereby be prevented from contracting in the orifice exit, and the effect of minimizing pressure fluctuation in the orifice exit can be improved.

[0016] An expansion valve according to a fifth aspect is the expansion valve according to any of the first through fourth aspects, characterized in that a second outflow direction length of the orifice exit along the direction of refrigerant outflow is equal to or less than the first outflow direction length of the orifice middle section along the direction of refrigerant outflow.

[0017] In this expansion valve, because the second outflow direction length of the orifice exit along the direction of refrigerant outflow is equal to or less than the first outflow direction length of the orifice middle section along the direction of refrigerant outflow, the orifice exit can be prevented from becoming too long, and increases in pressure loss in the orifice exit can be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG. 1 is a schematic cross-sectional view of an expansion valve according to an embodiment of the present invention.

FIG. 2 is a cross-sectional view showing a valve seat of an expansion valve according to an embodiment of the present invention.

FIG. 3 is a graph showing the relationship between cavitation number and noise value depending on differences in the shape of an orifice formed in the valve seat.

FIG. 4 is a cross-sectional view showing the valve seat of an expansion valve according to a comparative example.

FIG. 5 is a schematic cross-sectional view of an expansion valve according to a conventional example.

FIG. 6 is a cross-sectional view showing the valve seat of the expansion valve according to the conventional example.

DESCRIPTION OF EMBODIMENTS

[0019] An embodiment of the expansion valve according to the present invention is described hereinbelow based on the drawings. The specific configuration of the

embodiment of the expansion valve according to the present invention is not limited to the following embodiment, and can be modified within a range that does not deviate from the scope of the invention.

(1) Configuration

[0020] FIG. 1 is a schematic cross-sectional view of an expansion valve 1 according to an embodiment of the present invention. FIG 2 is a cross-sectional view showing a valve seat of an expansion valve according to an embodiment of the present invention. Components in FIGS. 1 and 2 that are similar to those of FIGS. 5 and 6 showing a conventional example (specifically, components other than the orifice 80) are denoted by the same symbols.

[0021] Similar to the conventional example (FIGS. 5 and 6), the expansion valve 1 is an expansion valve which is provided to a refrigerant circuit of a refrigeration apparatus and which depressurizes a liquid refrigerant, and the expansion valve has primarily a valve main body 10, a valve body 20, and a drive mechanism 30. The valve main body 10 is a member in which a valve seat 12 opening into a valve chest 11 is formed. Formed in the valve main body 10 are a refrigerant inlet 13 where refrigerant flows in from the side of the valve chest 11, and a refrigerant outlet 14 where refrigerant flows out underneath the valve chest 11. A refrigerant inflow tube 40 is connected to the refrigerant inlet 13, and a refrigerant outflow tube 50 is connected to the refrigerant outlet 14. The valve body 20 is a member that is reciprocated relative to the valve seat 12 by the drive mechanism 30. The drive mechanism 30 is composed of a motor, a solenoid, or the like. Such a configuration is designed so that the flow rate of liquid refrigerant passing between the refrigerant inflow tube 40 and the refrigerant outflow tube 50 is adjusted while the refrigerant is depressurized. There are also cases in which the expansion valve 1 is used in conditions such that the refrigerant passes through the refrigerant inlet 13 in a liquid single phase and through the refrigerant outlet 14 also in a liquid single phase.

[0022] In the valve seat 12, similar to the conventional example (FIG. 6), an orifice 60 is formed in the valve seat 12. The orifice 60 has an orifice entrance 61, an orifice middle section 62, and an orifice exit 63.

[0023] The orifice entrance 61, which faces the valve chest 11, is the portion having the smallest diameter. The orifice entrance 61 is a cylindrical portion having the same diameter (a minimum diameter D_0) along the direction of refrigerant outflow (specifically, downward along a reciprocating direction axis line X of the valve body 20). Denoting the length of the orifice entrance 61 in the refrigerant outflow direction as the entrance length L_0 , the entrance length L_0 is much smaller than the minimum diameter D_0 , and in this case is 0.3 times or less the length of the minimum diameter D_0 . By coming in contact with the orifice entrance 61, the valve body 20 blocks the flow of refrigerant between the refrigerant inlet 13 and

the refrigerant outlet 14, and by separating from the orifice entrance 61, the valve body 20 allows refrigerant to flow between the refrigerant inlet 13 and the refrigerant outlet 14.

[0024] The orifice middle section 62 is a cylindrical portion which widens in diameter from the orifice entrance 61 toward the direction of refrigerant outflow so that a first taper angle α is created. Denoting the length of the orifice middle section 62 along the direction of refrigerant outflow as the first outflow direction length L_1 , the first outflow direction length L_1 is one or more times the minimum diameter D_0 . The first taper angle α is an angle 10 degrees or greater and 60 degrees or less. The inclination angle formed by the orifice middle section 62 with a plane orthogonal to the direction of refrigerant outflow (the angle on the side forming an acute angle in this case) is a first inclination angle θ .

[0025] The orifice exit 63 is a cylindrical portion wherein the diameter widens or the diameter does not change from the orifice middle section 62 along the direction of refrigerant outflow, so as to form a second taper angle β which is smaller than the first taper angle α . Denoting the length of the orifice exit 63 along the direction of refrigerant outflow as the second outflow direction length L_2 , the second outflow direction length L_2 is equal to or less than the first outflow direction length L_1 . The second outflow direction length L_2 is also equal to or greater than 0.3 times the minimum diameter D_0 . Denoting the inclination angle formed by the orifice exit 63 with a plane orthogonal to the direction of refrigerant outflow (the angle on the side forming an acute angle in this case) as the second inclination angle ζ , the second inclination angle ζ is greater than the first inclination angle θ and is equal to or less than 90 degrees.

(2) Action and Characteristics

[0026] When the expansion valve 1 described above is actuated, similar to the conventional example, refrigerant flowing into the orifice 60 from the valve chest 11 first flows into the orifice entrance 61 of the orifice 60, immediately after which flow separation occurs, and local drops in pressure are likely to occur due to this separation. However, because of the formation of the orifice middle section 62 which widens in diameter along the direction of refrigerant outflow from the orifice entrance 61, the pressure of the refrigerant can be recovered immediately after it has flowed into the orifice entrance 61. Such pressure recovery minimizes the occurrence of cavitation, and as a result minimizes the sounds caused by cavitation when the refrigerant passes through the orifice 60. With the mere intention to recover refrigerant pressure through the orifice middle section 62, there is a risk that the separation of refrigerant flow will remain, the refrigerant will spurt, causing the pressure to fluctuate, and the refrigerant will flow into the refrigerant outflow tube 50 through the refrigerant outlet 14. However, the separated refrigerant can re-agglutinate because of the

formation of the orifice exit 63 wherein the diameter widens or the diameter does not change from the orifice middle section 62 along the direction of refrigerant outflow so as to form a second taper angle β which is smaller than the first taper angle α . Such re-agglutination of the refrigerant minimizes the occurrences of spurting which causes pressure fluctuation, and as a result, resonance sound in the refrigerant outflow tube 50 is minimized.

[0027] As described above, in the expansion valve 1, employing the shape of the orifice 60 having the orifice entrance 61, the orifice middle section 62, and the orifice exit 63 as described above makes it possible to minimize noises occurring when the expansion valve is used in conditions such that the refrigerant passes through the refrigerant inlet 13 in a liquid single phase and through the refrigerant outlet 14 also in a liquid single phase.

[0028] In the expansion valve 1, because the first outflow direction length L1 of the orifice middle section 62 along the direction of refrigerant outflow is one or more times the minimum diameter D0 of the orifice entrance 61, refrigerant can re-agglutinate not only in the orifice exit 63 but in the orifice middle section 62 as well, whereby the effect of minimizing resonance sounds in the refrigerant outflow tube 50 can be improved. Because the second outflow direction length L2 of the orifice exit 63 along the direction of refrigerant outflow is equal to or greater than 0.3 times the minimum diameter D0 of the orifice entrance 61, the effect of minimizing resonance sounds in the refrigerant outflow tube 50 can be reliably achieved.

[0029] In this expansion valve 1, because the first taper angle α is 10 degrees or greater, the effect of pressure recovery immediately after the refrigerant has flowed into the orifice entrance 61 can be reliably achieved. Moreover, because the first taper angle α is 60 degrees or less, it is also possible for the refrigerant in the orifice middle section 62 to re-agglutinate. Specifically, in the expansion valve 1, having the first taper angle α in the angle range described above makes both pressure recovery and refrigerant re-agglutination possible.

[0030] In this expansion valve 1, because the second inclination angle β formed by the orifice exit 63 with a plane orthogonal to the direction of refrigerant outflow is 90 degrees or less, the diameter can be prevented from narrowing along the direction of refrigerant outflow. The refrigerant flow can thereby be prevented from contracting in the orifice exit 63, and the effect of minimizing pressure fluctuation in the orifice exit 63 can be improved. In order to allow refrigerant to re-agglutinate while preventing the refrigerant flow from contracting in the orifice exit 63, it is preferable to employ a configuration for the orifice exit 63 in which the diameter does not change due to the second inclination angle β being 90 degrees.

[0031] Furthermore, in this expansion valve 1, because the second outflow direction length L2 of the orifice exit 63 along the direction of refrigerant outflow is equal to or less than the first outflow direction length L1 of the orifice middle section 62 along the direction of refrigerant

outflow, the orifice exit 63 can be prevented from becoming too long, and increases in pressure loss in the orifice exit 63 can be prevented.

5 (3) Experimental example

[0032] Next, an experimental example of the orifice 60 described above is shown in FIG. 3, together with a comparative example (FIG. 4) and a conventional example (FIG. 6). FIG. 3 is a graph showing the relationship between cavitation number and noise value according to differences in the shape of the orifice formed in the valve seat 12. FIG. 4 is a cross-sectional view showing the valve seat 12 of an expansion valve according to a comparative example.

[0033] First is a description of an experiment relating to the working example (FIG. 2) of the orifice 60 according to an embodiment of the present invention. The dimensions and measurement conditions of the orifice 60 were set in the following manner. First, the minimum diameter D0 was set to 1.6 mm, the entrance length L0 to 0.5 mm, the first taper angle α to 20 degrees (the first inclination angle θ to 80 degrees), the first outflow direction length L1 to 3.8 mm, the second taper angle β to 0 degrees (the second inclination angle ζ to 90 degrees), and the second outflow direction length L2 to 0.7 mm. R410A was used as the refrigerant, the depressurization width between the refrigerant inlet 13 and the refrigerant outlet 14 was 0.8 MPa, the refrigerant flow rate was 75 to 85 kg/h, and while the cavitation number σ (based on the refrigerant outlet 14) was varied between approximately -0.1 to approximately 0.9 by varying the refrigerant temperature between 5°C to 25°C, the noise value (the noise value caused by cavitation) in the expansion valve 1 alone at a distance of 0.3 m was measured (refer to the value of the working example in FIG. 3). Measurement of resonance sounds was also taken separately while the refrigerant outflow tube 50 was connected.

[0034] According to such an experiment, in the working example (FIG. 2) of the orifice 60, it can be seen that the noise value caused by cavitation is minimized to 55 dBA or less in conditions such that the refrigerant passes through the refrigerant inlet 13 in a liquid single phase and through the refrigerant outlet 14 also in a liquid single phase (in other words, conditions such that the cavitation number σ is 0 or greater). In the working example of the orifice 60, there was no resonance in the refrigerant outflow tube 50, and noise from resonance sounds was at a level that could be ignored.

[0035] In the orifice 80 of the conventional example (FIG. 6), wherein the minimum diameter D0 was 1.6 mm and the length of the orifice 80 in the direction of refrigerant outflow was 5.0 mm, the noise level caused by cavitation increased to a maximum of 65 dBA under the same measurement conditions as the working example, and the noise level caused by cavitation had increased by about 10 dBA above that of the working example of the orifice 60 described above (refer to the value of the con-

ventional example in FIG 3). In the orifice 80 of the conventional example, similar to the working example of the orifice 60, there was no resonance in the refrigerant outflow tube 50, and noise from resonance sounds was at a level that could be disregarded.

[0036] In an orifice 70 of the comparative example (FIG 4), wherein the orifice exit 63 is omitted from the working example of the orifice 60, the first taper angle α of an orifice middle section 72 was 150 degrees, and the first outflow direction length L1 of the orifice middle section 72 was 1.0 mm, the noise level caused by cavitation was at the same level as that of the working example of the orifice 60 described above under the same measurement conditions as the working example (refer to the value of the comparative example in FIG 3). However, in the orifice 70 of the comparative example, unlike the working example of the orifice 60 and/or the orifice 80 of the conventional example, there was resonance in the refrigerant outflow tube 50, and noise caused by resonance sounds was at an extremely high level.

[0037] It can be seen from which that the noise level caused by cavitation can be minimized by forming the orifice middle sections 62, 72 widening in diameter along the direction of refrigerant outflow from the orifice entrances 61, 71, as in the working example (FIG. 2) and/or the comparative example (FIG. 4). However, as in the orifice 70 (FIG. 4) of the comparative example, when the first taper angle α is too large or the first outflow direction length L1 is too short, it is clear that resonance in the refrigerant outflow tube 50 occurs readily. As in the working example (FIG. 2), noise caused by resonance sounds can be brought down to an insignificant level by forming the orifice exit 63 wherein the diameter widens or the diameter does not change so as to form the second taper angle β smaller than the first taper angle α along the direction of refrigerant outflow from the orifice middle section 61. Conversely, it is clear that if the orifice middle section 72 is formed but an orifice exit is not as in the comparative example (FIG. 4), resonance occurs in the refrigerant outflow tube 50, and the noise caused by resonance sounds reaches an extremely high level.

[0038] As described above, it is clear that when a shape for the orifice 60 is employed which has the orifice entrance 61, the orifice middle section 62, and the orifice exit 63, such as in the working example, it is possible to effectively minimize both noise caused by cavitation and noise caused by resonance occurring under conditions such that the refrigerant passes through the refrigerant inlet 13 in a liquid single phase and through the refrigerant outlet 14 also in a liquid single phase.

INDUSTRIAL APPLICABILITY

[0039] The present invention has a wide range of application in expansion valves which are provided to refrigerant circuits of refrigeration apparatuses and which depressurize liquid refrigerant.

REFERENCE SIGNS LIST

[0040]

- | | | |
|----|----|------------------------|
| 5 | 1 | Expansion valve |
| | 10 | Valve main body |
| | 11 | Valve chest |
| | 12 | Valve seat |
| | 13 | Refrigerant inlet |
| 10 | 14 | Refrigerant outlet |
| | 20 | Valve body |
| | 60 | Orifice |
| | 61 | Orifice entrance |
| | 62 | Orifice middle section |
| 15 | 63 | Orifice exit |

CITATION LIST

PATENT LITERATURE

[0041]

[Patent Literature 1]
Japanese Laid-open Patent Application No.
2009-228689

Claims

- | | | |
|----|----|--|
| 30 | 1. | An expansion valve (1) which is provided to a refrigerant circuit of a refrigeration apparatus and which depressurizes a liquid refrigerant, the expansion valve comprising a valve main body (10) in which a valve seat (12) opening into a valve chest (11) is formed, and a valve body (20) which reciprocates relative to the valve chest; |
| 35 | | the expansion valve being characterized in that an orifice (60) formed in the valve seat has an orifice entrance (61) having the smallest diameter, an orifice middle section (62) which widens in diameter along the direction of refrigerant outflow from the orifice entrance so as to form a first taper angle, and an orifice exit (63) which either widens in diameter or does not change in diameter along the direction of refrigerant outflow from the orifice middle section so as to form a second taper angle smaller than the first taper angle. |
| 40 | | |
| 45 | | |
| 50 | 2. | The expansion valve (1) according to claim 1, characterized in that: |
| | | a first outflow direction length of the orifice middle section (62) along the direction of refrigerant outflow is one or more times the minimum diameter of the orifice entrance (61). |
| 55 | | |
| | 3. | The expansion valve (1) according to claim 1 or 2, characterized in that: |

the first taper angle is 10 degrees or greater and 60 degrees or less.

4. The expansion valve (1) according to any of claims 1 through 3, **characterized in that:** 5

a second inclination angle formed by the orifice exit (63) with a plane orthogonal to the direction of refrigerant outflow is greater than a first inclination angle formed by the orifice middle section (62) with a plane orthogonal to the direction of refrigerant outflow, and is 90 degrees or less. 10

5. The expansion valve (1) according to any of claims 1 through 4, **characterized in that:** 15

a second outflow direction length of the orifice exit (63) along the direction of refrigerant outflow is equal to or less than the first outflow direction length of the orifice middle section (62) along the direction of refrigerant outflow. 20

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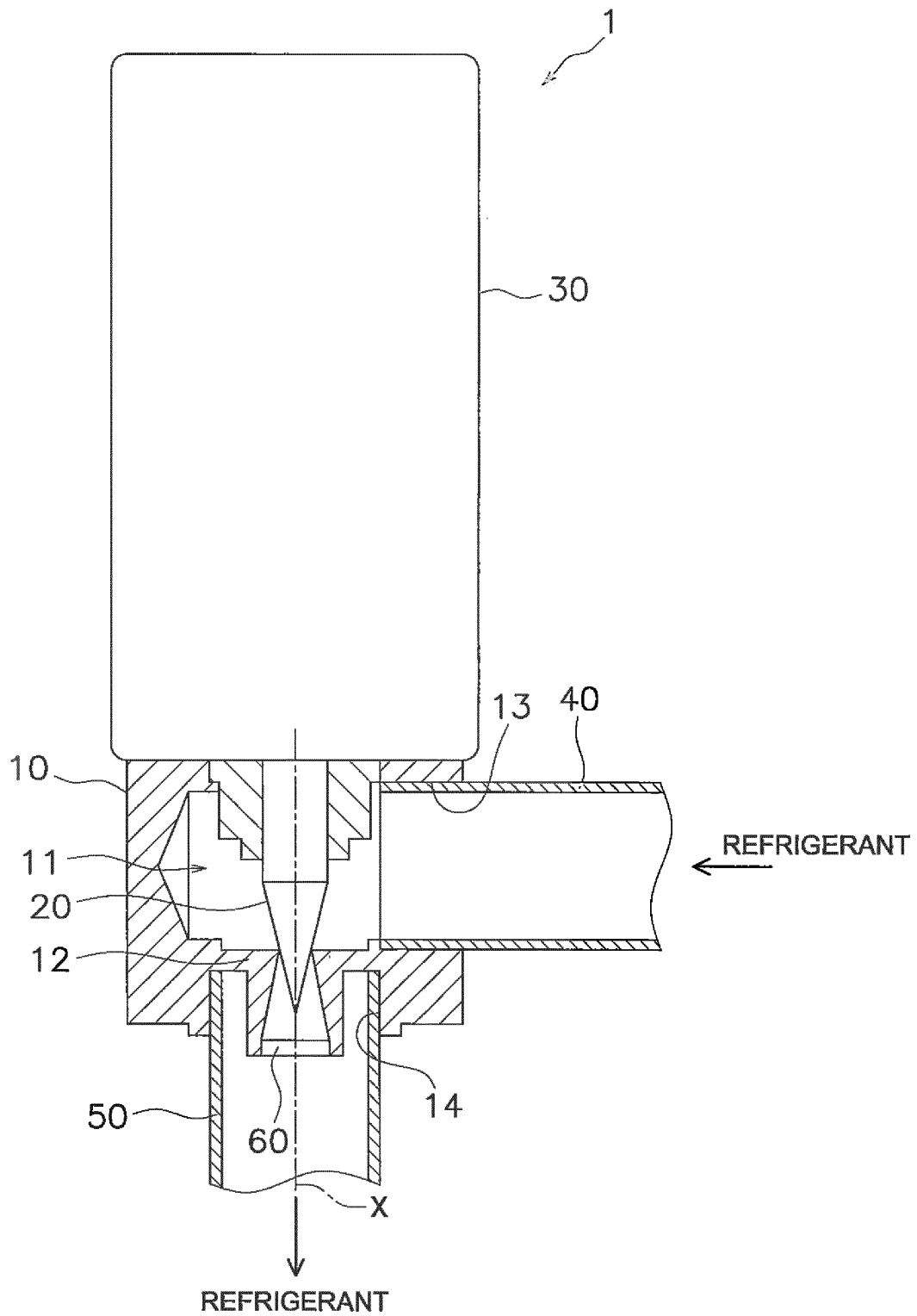


FIG. 1

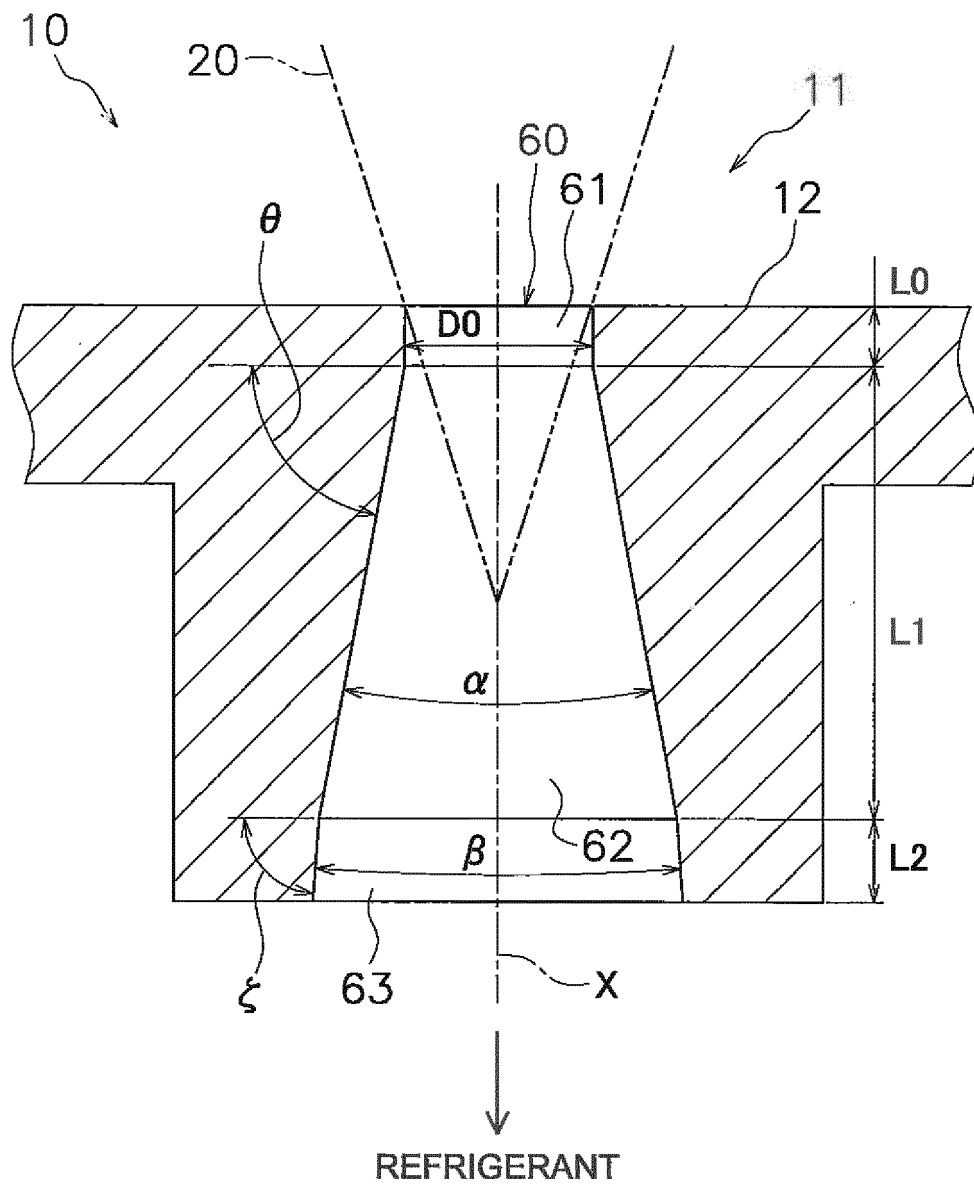


FIG. 2

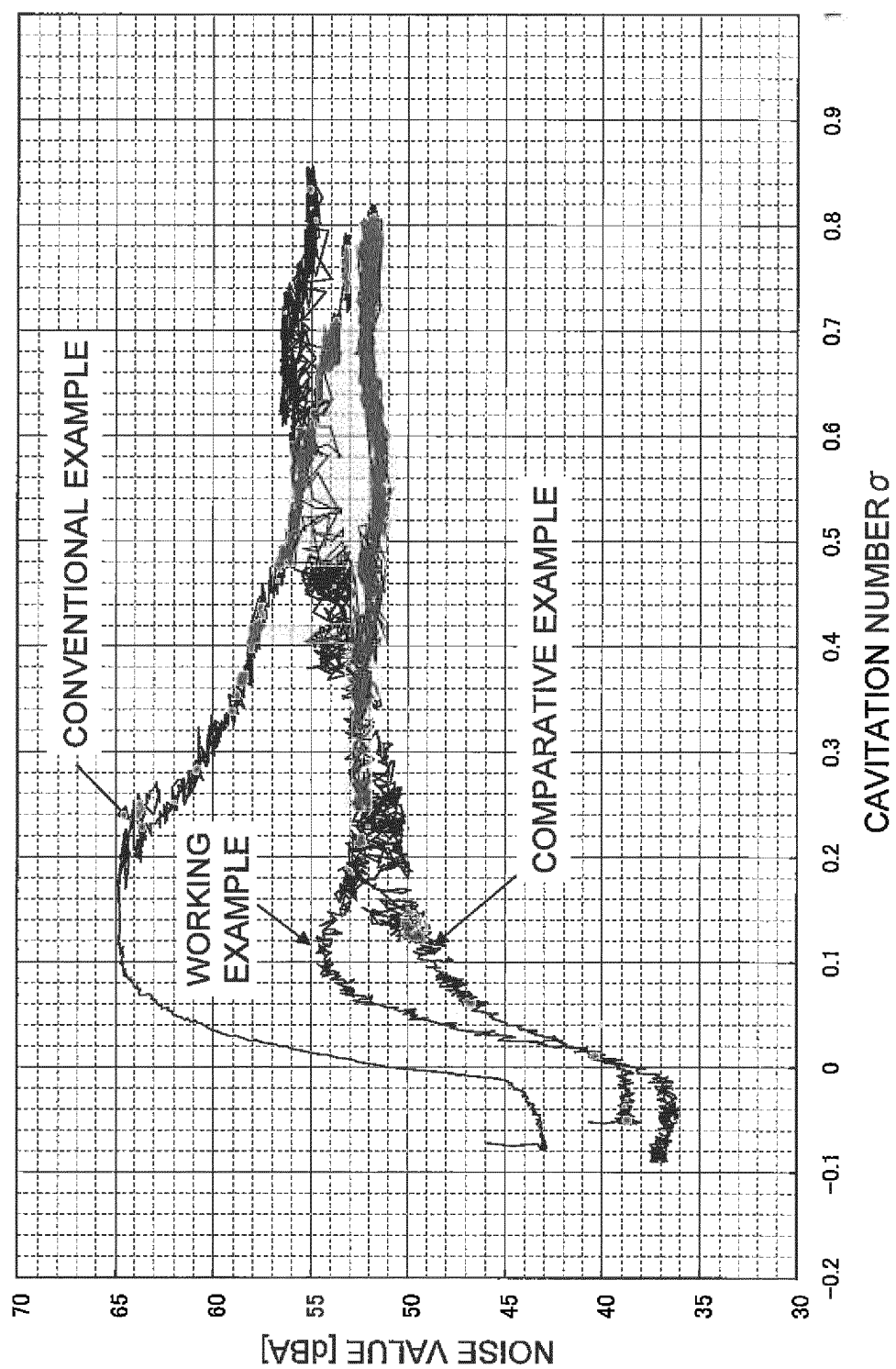


FIG. 3

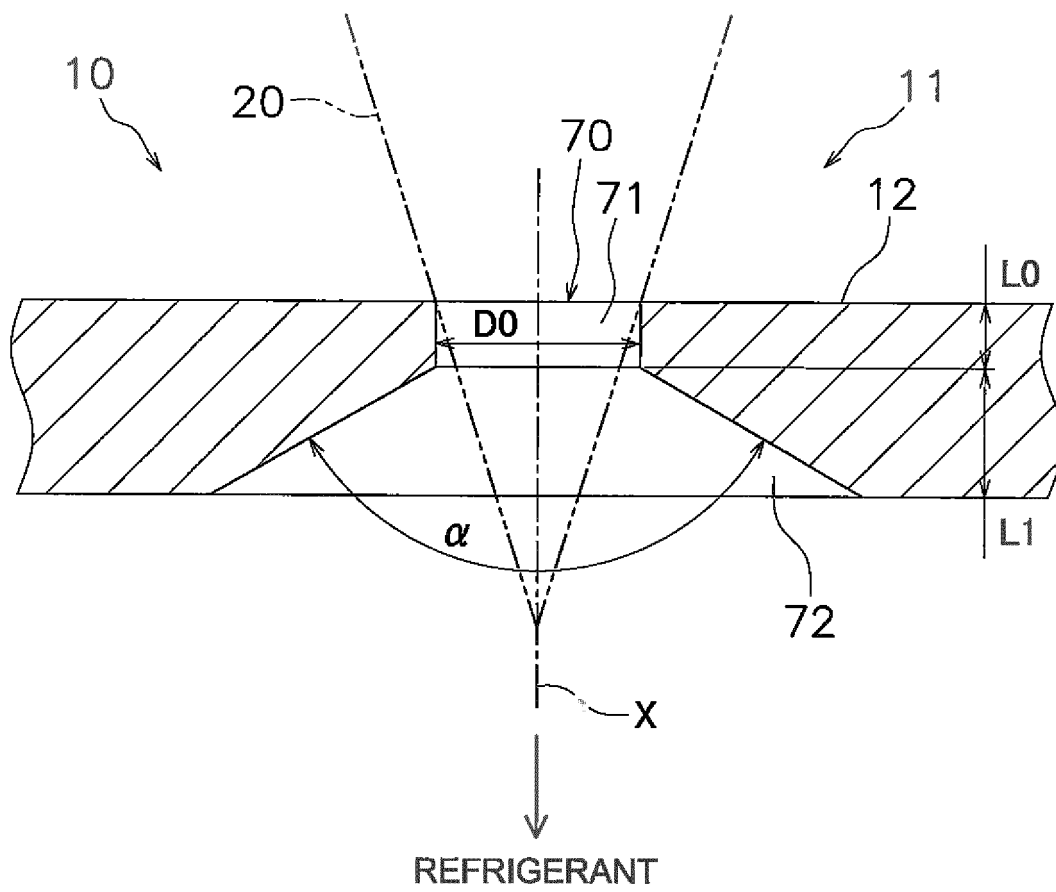


FIG. 4

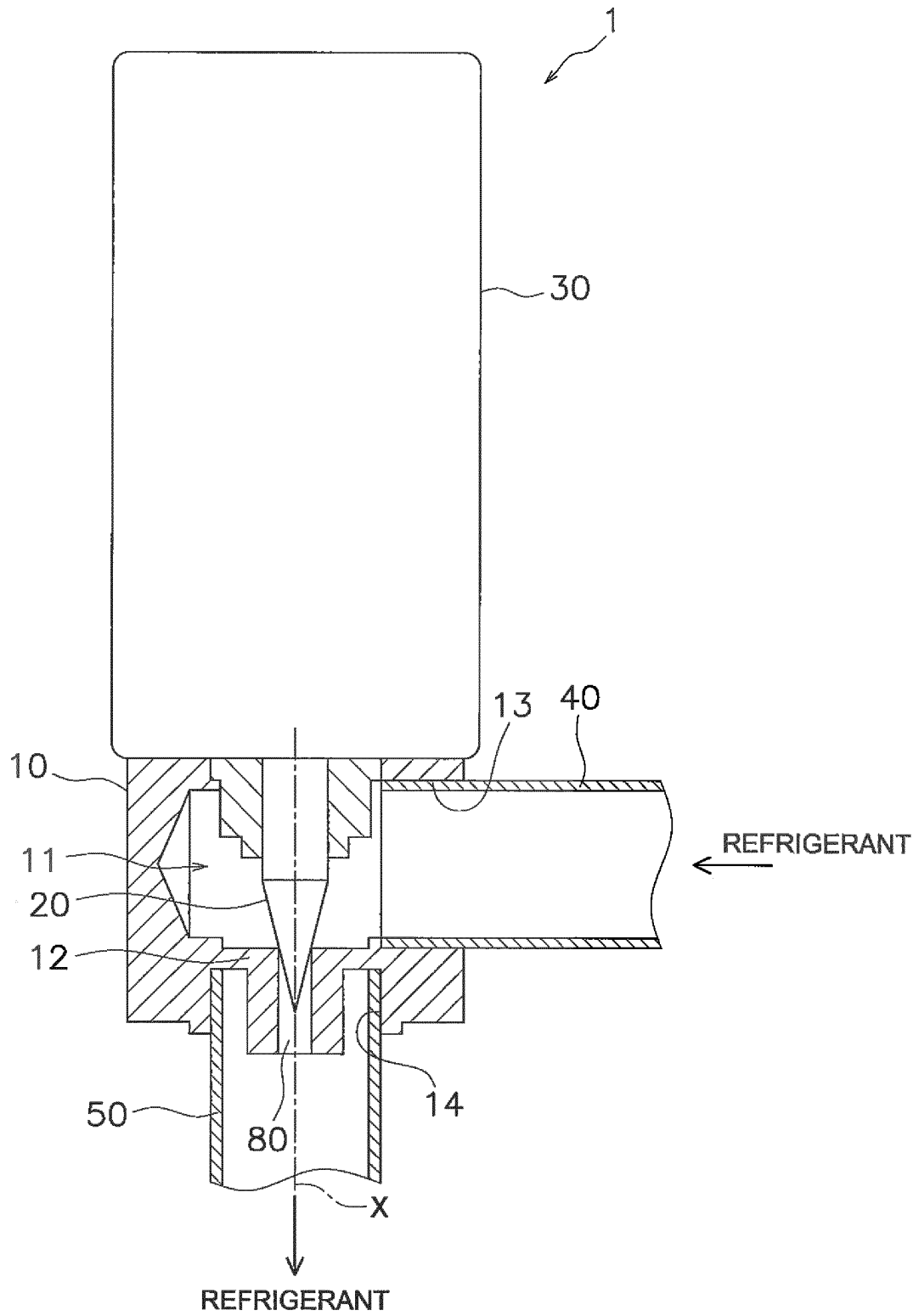


FIG. 5

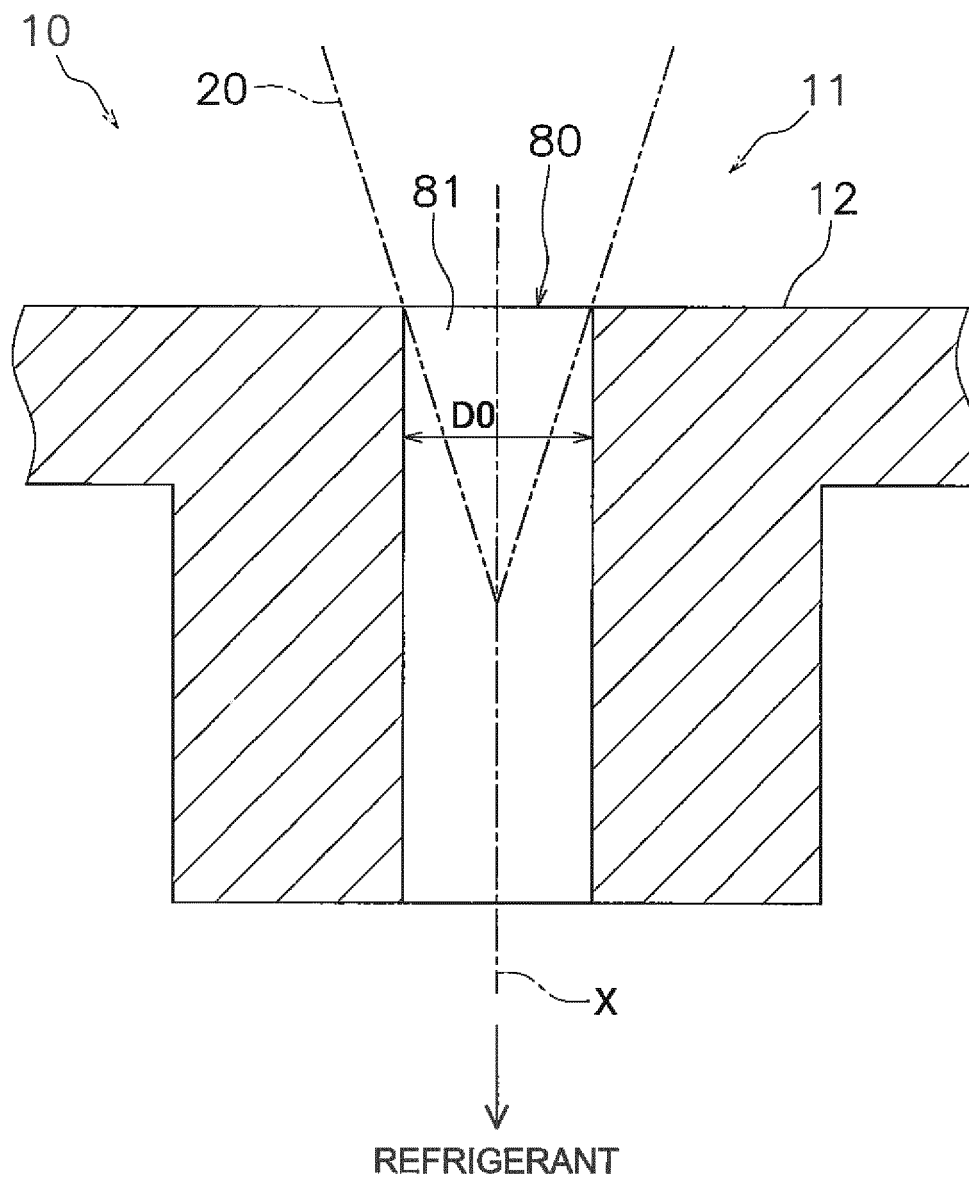


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/071574

A. CLASSIFICATION OF SUBJECT MATTER

F25B41/06(2006.01)i, F16K1/42(2006.01)i, F16K47/02(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, F16K1/42, F16K47/02, 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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2004-132498 A (Daikin Industries, Ltd.), 30 April 2004 (30.04.2004), paragraphs [0009], [0024], [0025]; fig. 1 (Family: none)	1-5
A	JP 2004-340260 A (Saginomiya Seisakusho, Inc.), 02 December 2004 (02.12.2004), entire text; all drawings (Family: none)	1-5
A	JP 2007-107623 A (Fuji Koki Corp.), 26 April 2007 (26.04.2007), entire text; all drawings & KR 10-2007-0041314 A & CN 1948795 A	1-5

☐ 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
24 November, 2011 (24.11.11)

Date of mailing of the international search report
06 December, 2011 (06.12.11)

Name and mailing address of the ISA/
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Patent documents cited in the description

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