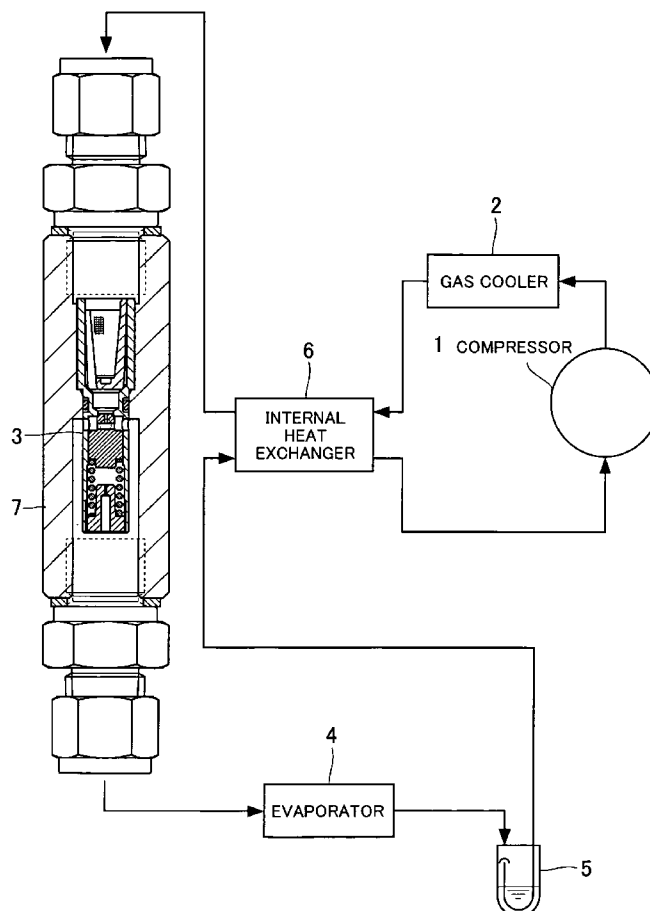




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(19) **United States**(12) **Patent Application Publication**
Tsugawa et al.(10) **Pub. No.: US 2006/0117793 A1**(43) **Pub. Date: Jun. 8, 2006**(54) **EXPANSION DEVICE**(52) **U.S. Cl. 62/527; 62/222**(75) Inventors: **Tokumi Tsugawa**, Tokyo (JP);
Masaaki Tonegawa, Tokyo (JP)Correspondence Address:
**WESTERMAN, HATTORI, DANIELS &
ADRIAN, LLP**
1250 CONNECTICUT AVENUE, NW
SUITE 700
WASHINGTON, DC 20036 (US)(73) Assignee: **TGK CO., LTD.**, Tokyo (JP)(21) Appl. No.: **11/293,278**(22) Filed: **Dec. 5, 2005**(30) **Foreign Application Priority Data**Dec. 7, 2004 (JP) 2004-354142
Sep. 29, 2005 (JP) 2005-283622**Publication Classification**(51) **Int. Cl.****F25B 41/06** (2006.01)**F25B 41/04** (2006.01)(57) **ABSTRACT**

An expansion device which is capable of reducing generation of untoward noise due to vibration of a valve element and suppressing a valve element suction phenomenon which occurs when high-pressure refrigerant flows through a variable orifice formed between a valve seat and the valve element. A damper chamber is formed by a cylinder formed in a housing formed with a valve seat, a piston integrally formed with a valve element, and an adjustment screw. When the valve element undergoes a sudden change in pressure of introduced refrigerant, the volume of the damper chamber changes to accommodate sudden motion of the valve element, whereby vibration of the valve element is suppressed, to reduce generation of untoward noise. The ratio (b/a) of the valve element diameter (b) of the valve element to the port diameter (a) of a valve hole is set to a value not larger than 1.5 so as to suppress a valve element suction phenomenon and pass refrigerant at a flow rate corresponding to a differential pressure between a primary pressure and a secondary pressure.



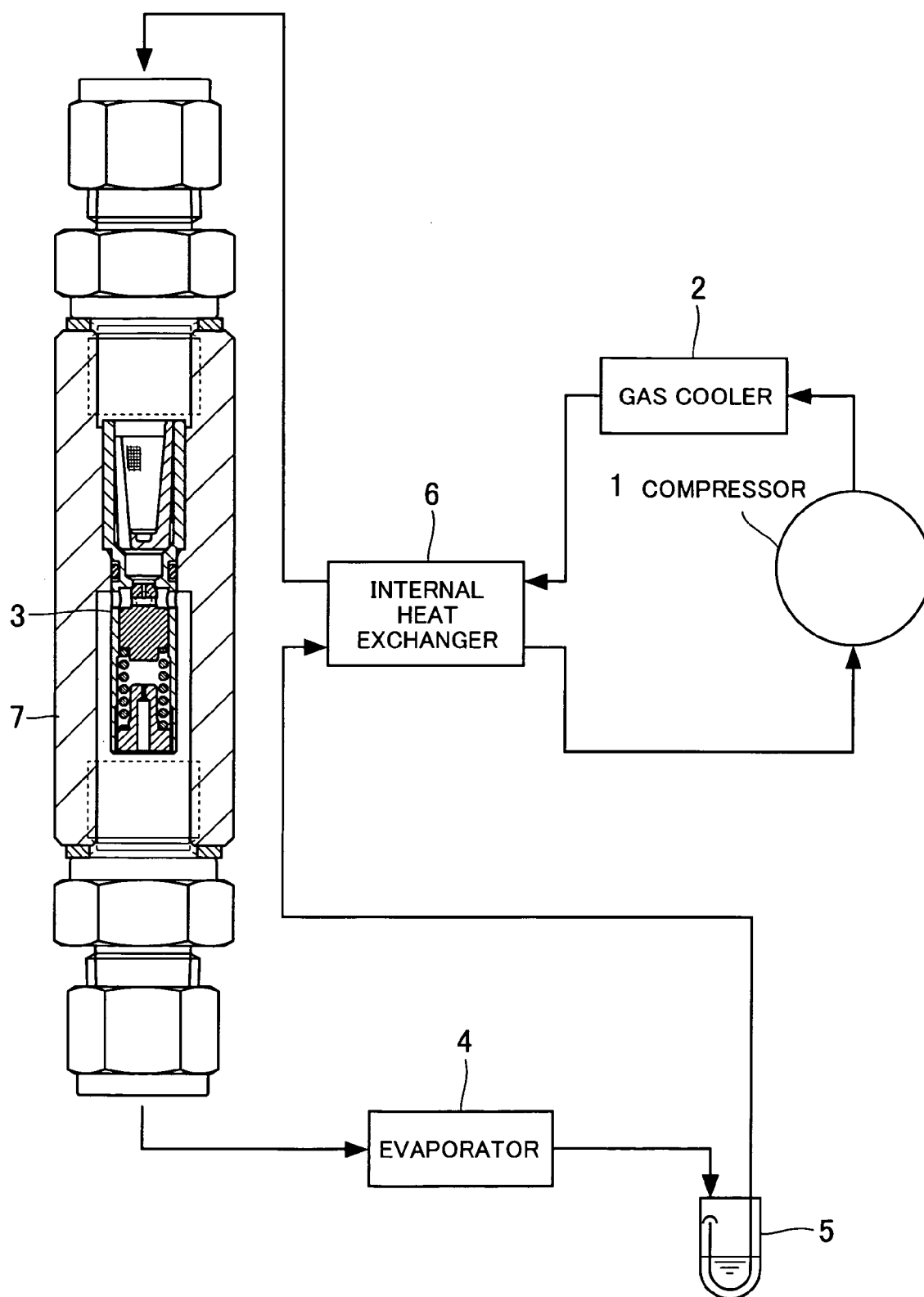


FIG. 1

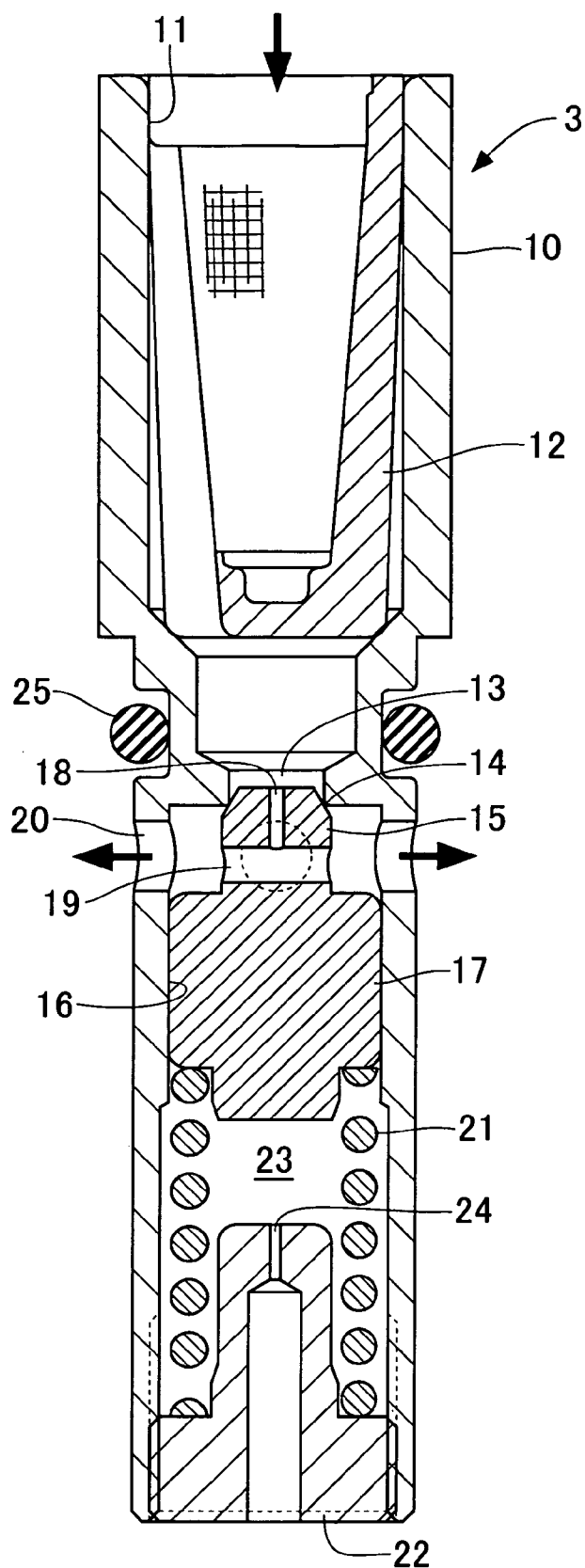


FIG. 2

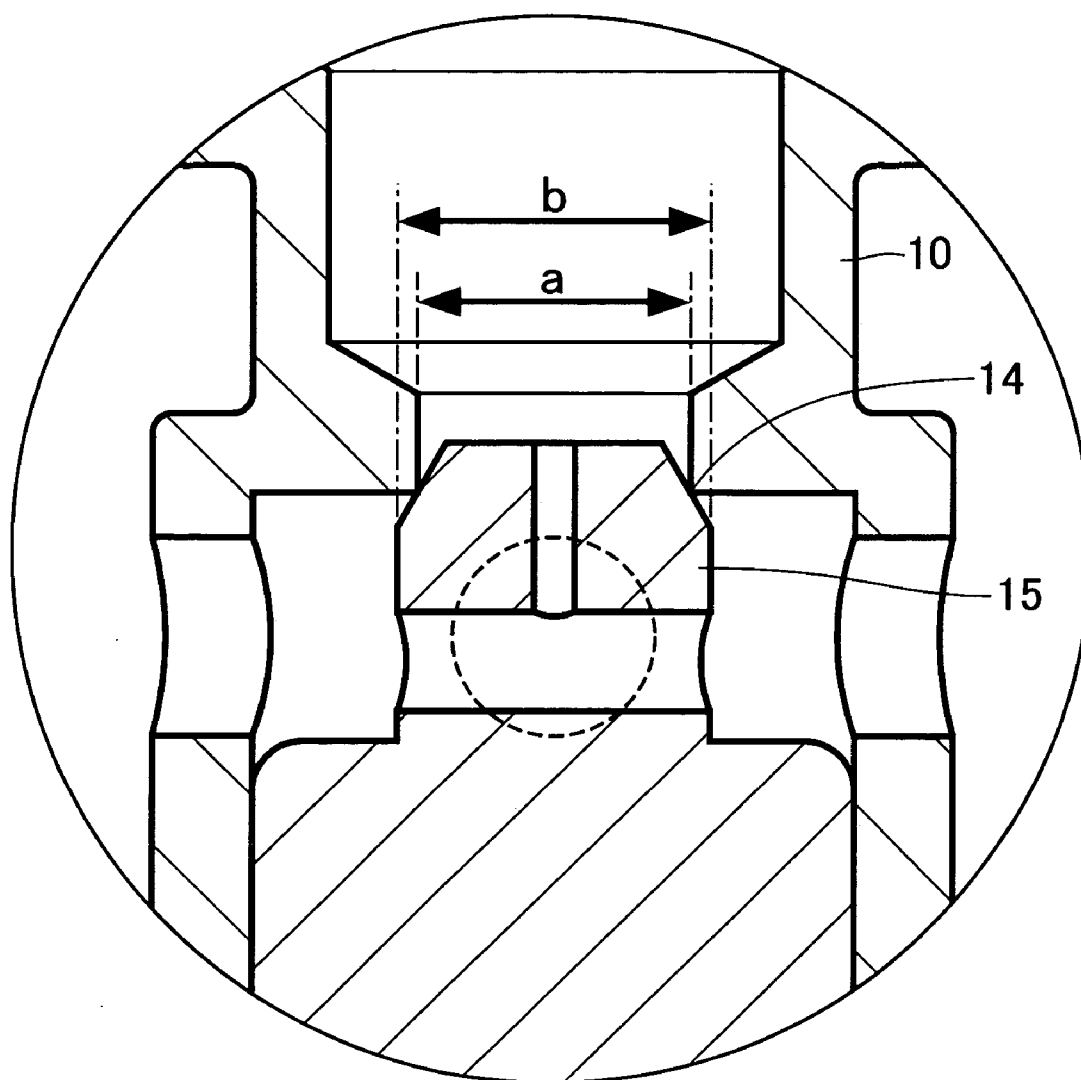


FIG. 3

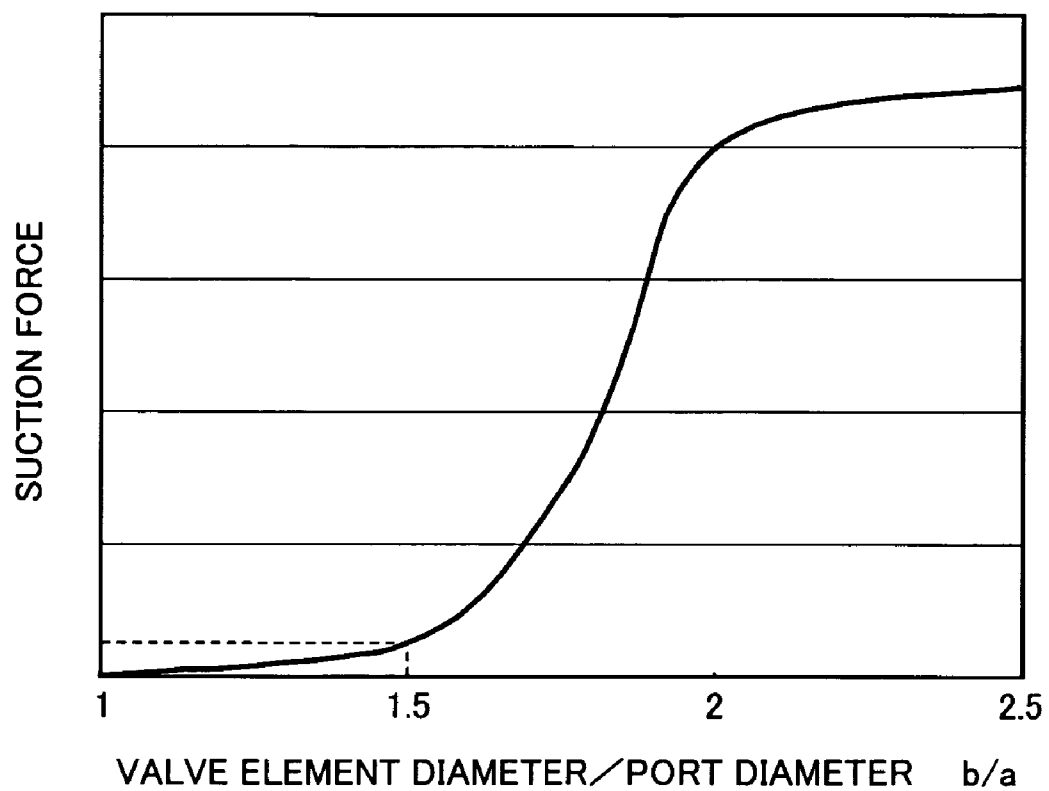


FIG. 4

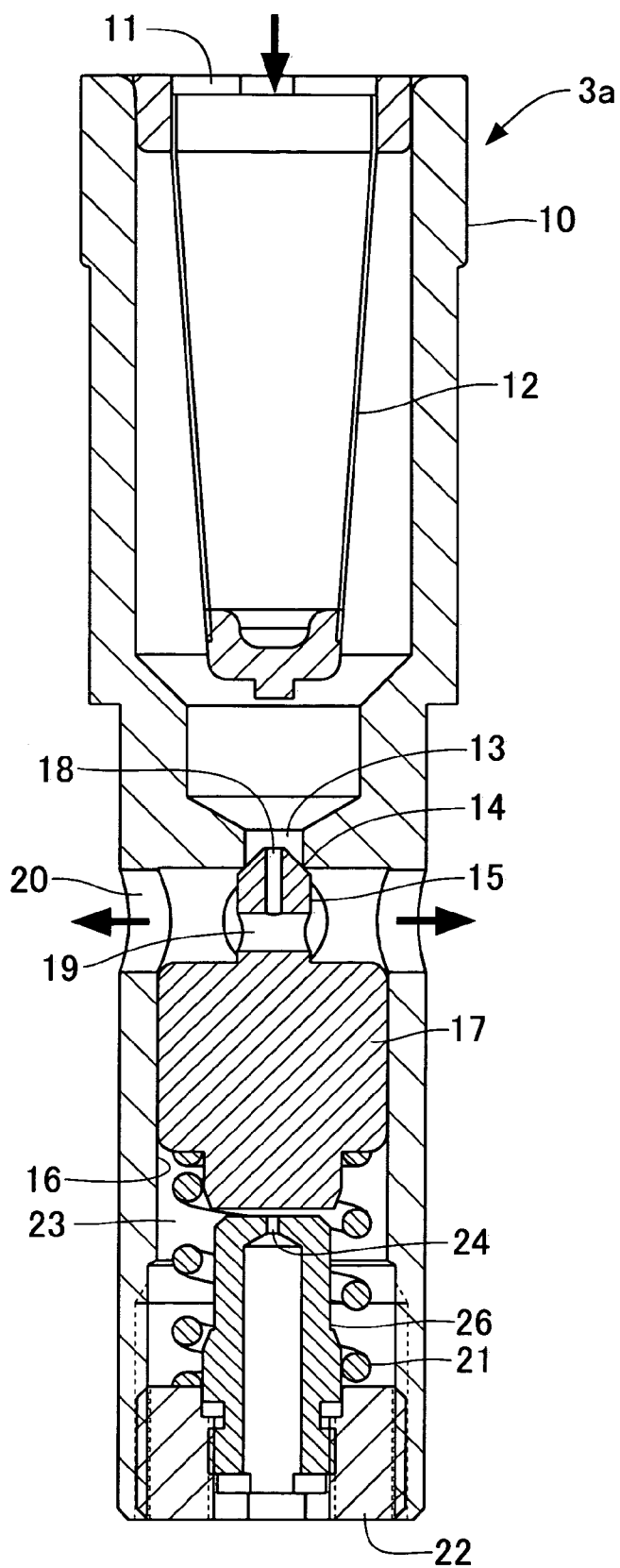


FIG. 5

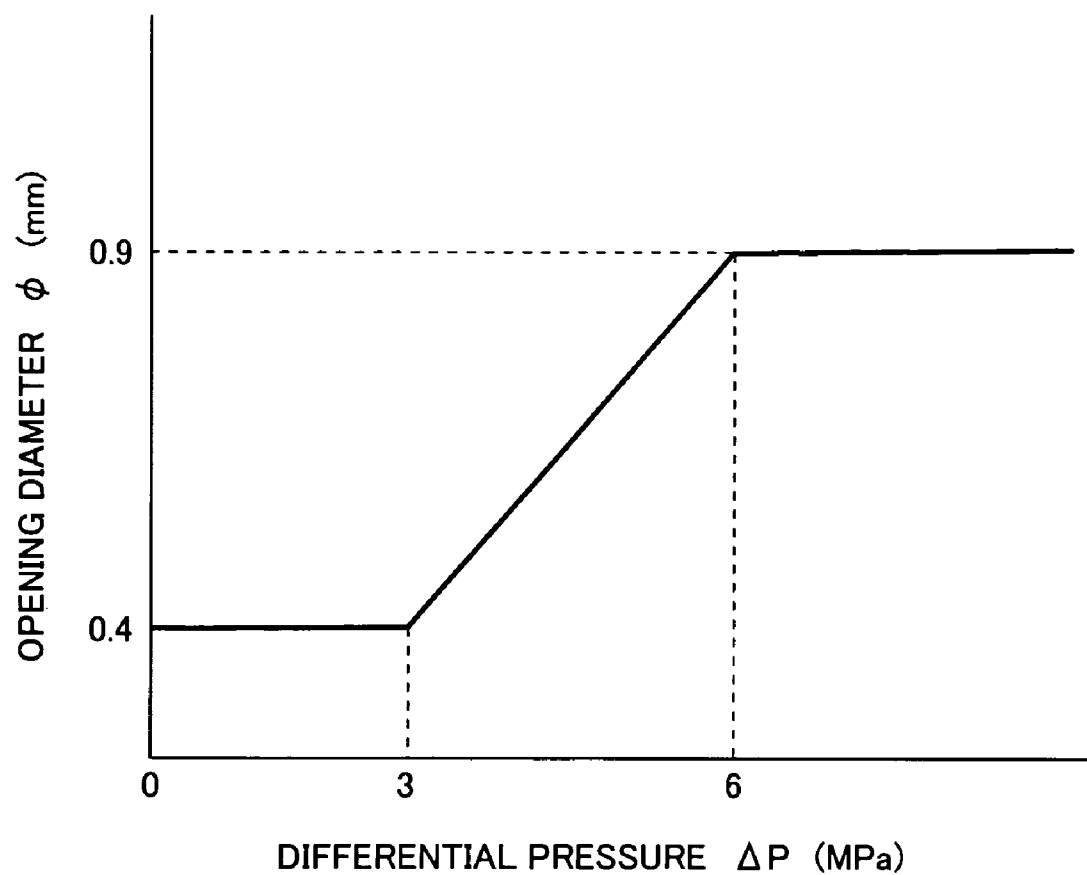


FIG. 6

EXPANSION DEVICE

CROSS-REFERENCES TO RELATED APPLICATIONS, IF ANY

[0001] This application claims priorities of Japanese Application No. 2004-354142 filed on Dec. 7, 2004, entitled "EXPANSION DEVICE" and No. 2005-283622 filed on Sep. 29, 2005, entitled "EXPANSION DEVICE".

BACKGROUND OF THE INVENTION

[0002] (1) Field of the Invention

[0003] The present invention relates to an expansion device used in a refrigeration cycle for an automotive air conditioner, and more particularly to an expansion device which is suitably applicable to a refrigeration cycle using carbon dioxide (CO₂) as refrigerant.

[0004] (2) Description of the Related Art

[0005] In general, as a refrigeration cycle for an automotive air conditioner, there is used a refrigeration cycle that employs a receiver for separating refrigerant condensed by a condenser into a gas and a liquid and a thermostatic expansion valve for expanding liquid refrigerant obtained by the gas/liquid separation. On the other hand, there is also known a refrigeration cycle that employs an expansion device (orifice) for throttling and expanding refrigerant condensed by a condenser and an accumulator for separating refrigerant evaporated by an evaporator into a gas and a liquid.

[0006] The expansion device is implemented by an orifice tube which is not capable of controlling the flow rate of refrigerant, or a variable orifice having the function of controlling the flow rate of refrigerant such as a thermostatic expansion valve. The expansion device implemented by a variable orifice is constructed as a differential pressure valve in which a valve element is urged in the valve-closing direction by a spring, and has a characteristic that when the differential pressure between the inlet pressure and the outlet pressure of refrigerant is small, the valve closes, whereas when the differential pressure exceeds a predetermined value, the valve opens. The differential pressure valve opens when differential pressure thereacross reaches a predetermined value, to reduce the differential pressure, whereby a valve element thereof moves in the valve-closing direction, and when the valve element moves in the valve-closing direction, the differential pressure rises to move the valve element in the valve-opening direction. The differential pressure valve repeatedly performs this operation, and hence the valve element is vibrated in its opening/closing directions, which can cause untoward noise. Particularly in an expansion device applied to a refrigeration cycle using CO₂ as refrigerant, since a very small stroke of a valve element is controlled by a very large differential pressure, when the pressure rises and falls sharply, it is difficult to immediately stop the valve element at a balanced position. Therefore, the valve element is inevitably vibrated in its opening/closing directions, thereby generating untoward noise. When the valve element is vibrated, the flow rate of refrigerant increases, and the vaporization temperature of the refrigerant in an evaporator becomes high, so that the blowing temperature of air which has passed through the evaporator and is blown into a passenger compartment also becomes

high. Further, the instability of the valve operation can cause hunting of the refrigeration cycle, which makes the blowing temperature of air from the evaporator unstable.

[0007] To solve the above problems, there has been proposed an expansion device which is capable of suppressing vibration of a valve element (see e.g. Japanese Unexamined Patent Publication (Kokai) No. 2004-218918 (Paragraph Nos. [0022] to [0023], FIG. 4)). According to this expansion device, a vibration proof spring is mounted on a valve element such that the valve element performs sliding operation with the vibration proof spring pressed against the inner wall surface of a housing accommodating the valve element. Thus, the motion of the valve element in its opening/closing directions is restricted by sliding resistance to suppress vibration of the valve element, so that generation of untoward noise due to the vibration of the valve element can be prevented.

[0008] In the conventional expansion device, however, since the vibration proof spring mounted on the valve element for preventing generation of untoward noise is pressed against the inner wall surface of the housing, a frictional force acting between the spring and the wall surface increases, which produces a large hysteresis in the flow rate characteristic of the valve. As a result, the valve element is displaced from a position set as an optimum position, causing degradation of the efficiency of the refrigeration cycle.

[0009] Further, in the conventional expansion device formed by a differential pressure valve and applied to a refrigeration cycle using CO₂ as refrigerant, the diameter of the valve element for opening and closing a valve hole is designed to be larger than the port diameter of the valve hole so as to fully close the valve hole in a region where the differential pressure is small, and hence a lap margin between the valve hole and the valve element is large. Therefore, when high-pressure CO₂ refrigerant passes through an orifice formed by the valve hole and the valve element, flow velocity increases to cause a valve element suction phenomenon. As a result, the valve element moves in the valve-closing direction to make the flow rate smaller than a set flow rate, which makes it impossible to obtain sufficient cooling power.

SUMMARY OF THE INVENTION

[0010] The present invention has been made in view of these problems, and an object thereof is to provide an expansion device which is capable of reducing generation of untoward noise and suppressing occurrence of the valve element suction phenomenon.

[0011] To solve the above problems, the present invention provides an expansion device having a valve element disposed at a location downstream of a valve seat in a state urged in a valve-closing direction by a spring, the expansion device being capable of passing refrigerant at a flow rate corresponding to a differential pressure between a primary pressure in a refrigerant inlet port and a secondary pressure in a refrigerant outlet port, comprising damper means provided in the valve element, for accommodating motion of the valve element in an opening or closing direction when the valve element undergoes a sudden change in pressure.

[0012] The above and other objects, features and advantages of the present invention will become apparent from the

following description when taken in conjunction with the accompanying drawings which illustrate preferred embodiments of the present invention by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a schematic view of a refrigeration cycle to which an expansion device according to the present invention is applied.

[0014] **FIG. 2** is a central longitudinal cross-sectional view showing the arrangement of the expansion device.

[0015] **FIG. 3** is an enlarged cross-sectional view of essential parts of a differential pressure valve.

[0016] **FIG. 4** is a diagram showing changes in the suction force of a valve element of the differential pressure valve.

[0017] **FIG. 5** is a central longitudinal cross-sectional view showing another example of the arrangement of the expansion device.

[0018] **FIG. 6** is a diagram showing an example of a valve-opening characteristic of the expansion device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] Hereinafter, an embodiment of the present invention will be described in detail based on an example in which it is applied to a refrigeration cycle for an automotive air conditioner using CO₂ as refrigerant.

[0020] **FIG. 1** is a schematic view of the refrigeration cycle to which an expansion device according to the present invention is applied.

[0021] This refrigeration cycle comprises a compressor 1 for compressing refrigerant, a gas cooler 2 for cooling the compressed refrigerant, the expansion device 3 for adiabatically expanding the cooled refrigerant, an evaporator 4 for evaporating the adiabatically expanded refrigerant, an accumulator 5 disposed downstream of the evaporator 4, for storing surplus refrigerant in the refrigeration cycle, and an internal heat exchanger 6 for cooling the refrigerant cooled by the gas cooler 2, using refrigerant delivered from the accumulator 5 to the compressor 1.

[0022] The expansion device 3 is disposed within a hollow cylindrical body 7. The body 7 has its upstream-side end connected to a pipe extending from the internal heat exchanger 6 by a joint, and its downstream-side end connected to a pipe extending toward the evaporator 4 by a joint.

[0023] Basically, the operation of a refrigeration cycle using CO₂ as refrigerant is substantially the same as that of a refrigeration cycle using chlorofluorocarbon. More specifically, the compressor 1 draws gaseous-phase refrigerant produced through gas-liquid separation in the accumulator 5, and compresses the gaseous-phase refrigerant into high-temperature, high-pressure refrigerant in a gaseous phase or supercritical state, to discharge the same. The refrigerant discharged from the compressor 1 is cooled by the gas cooler 2 and then delivered to the expansion device 3 via the internal heat exchanger 6. In the expansion device 3, the introduced high-temperature, high-pressure refrigerant in the supercritical or liquid phase state is adiabatically expanded to have its phase state changed from the liquid phase state to a two-phase state of low-temperature, low-

pressure gas and liquid, and then delivered to the evaporator 4. In the evaporator 4, the refrigerant in the two-phase gas-liquid state is evaporated by air within a vehicle compartment. As the refrigerant is evaporated, it cools air in the vehicle compartment by depriving the air of latent heat of vaporization. The refrigerant evaporated in the evaporator 4 is delivered to the accumulator 5 and temporarily stored therein. A gaseous-phase portion of the refrigerant stored in the accumulator 5 is returned to the compressor 1 via the internal heat exchanger 6. It should be noted that in the case of the refrigeration cycle using CO₂, the internal heat exchanger 6 further cools the high-temperature refrigerant cooled in the gas cooler 2, by the low-temperature refrigerant delivered from the accumulator 5 to the compressor 1, or further heats the low-temperature refrigerant delivered from the accumulator 5 to the compressor 1, by the high-temperature refrigerant from the gas cooler 2.

[0024] **FIG. 2** is a central longitudinal cross-sectional view of the arrangement of the expansion device. The expansion device 3 has a hollow cylindrical housing 10. The housing 10 has an upper open end thereof, as viewed in **FIG. 2**, forming a primary-side refrigerant inlet port 11, via which the high-pressure refrigerant is introduced, and a strainer 12 is fitted in the refrigerant inlet port 11. The housing 10 has an axially central portion thereof formed with a valve hole 13, and the lower peripheral edge, as viewed in **FIG. 2**, of the valve hole 13 forms a valve seat 14. A valve element 15 is disposed in a manner opposed to the valve seat 14 from below as viewed in **FIG. 2**. The valve element 15 is integrally formed with a piston 17 axially slidably fitted in a cylinder 16 formed in the housing 10 extending in the same axial direction as the valve element 15. The valve element 15 is formed therein with a fixed orifice 18 which communicates with a horizontal through hole 19 extending there-through in a direction orthogonal to the axis of the housing 10. The fixed orifice 18 is formed so as to pass a minute amount of refrigerant therethrough when the valve element 15 is seated on the valve seat 14, placing the expansion device 3 in the closed state, to thereby enable circulation of a minimum amount of lubricating oil dissolved in refrigerant, which is required for lubrication of the compressor 1.

[0025] A secondary-side chamber in which the valve element 15 is disposed is in communication with the outside via a refrigerant outlet port 20 formed in the housing 10. The piston 17 is urged by a spring 21 in a valve-closing direction. Thus, a valve comprised of the valve seat 14 and the valve element 15 forms a differential pressure valve operated by the balance between the differential pressure between a primary pressure on the upstream side of the valve hole 13 and a secondary pressure on the downstream side of the same and the load of the spring 21. The spring 21 is received by an adjustment screw 22 screwed into the lower end, as viewed in **FIG. 2**, of the housing 10, and the load of the spring 21 is adjusted by the screwing amount of the adjustment screw 22.

[0026] A space defined by the housing 10, the piston 17, and the adjustment screw 22 forms a damper chamber 23. The damper chamber 23 is in communication with the secondary side of the expansion device via a fixed orifice 24 formed through the adjustment screw 22. Thus, the damper chamber 23 allows refrigerant to flow between the same and the secondary side of the expansion device via a clearance between the housing 10 and the piston 17, and the fixed

orifice **24** formed through the adjustment screw **22**. Further, an O ring **25** for performing liquid sealing between the primary side and the secondary side when the expansion device **3** is inserted into the body **7** is circumferentially fitted on the outer periphery of the housing **10**.

[0027] In the expansion device constructed as above, when the differential pressure between the primary pressure of the refrigerant introduced into the refrigerant inlet port **11** and the secondary pressure of the refrigerant in the refrigerant outlet port **20** is smaller than a predetermined value determined by the load of the spring **21**, the valve element **15** is seated on the valve seat **14** to close the expansion device. Therefore, refrigerant introduced into the refrigerant outlet port **20** flows through the fixed orifice **18** in the valve element **15** at a minimum necessary flow rate.

[0028] Then, when the primary pressure of the refrigerant received by the valve element **15** increases against the load of the spring **21**, the valve element **15** is moved away from the valve seat **14** to thereby place the expansion device in the open state. As a consequence, the primary-side refrigerant flows into the secondary side via a variable orifice between the valve seat **14** and the valve element **15**. At this time, the high-temperature, high-pressure gaseous-phase refrigerant is adiabatically expanded into low-temperature, low-pressure refrigerant in a gas-liquid mixture state to flow out via the refrigerant outlet port **20**. Thereafter, the valve element **15** is lifted to a position where the differential pressure between the primary pressure and the secondary pressure and the load of the spring **21** are balanced, and stops at the position, whereby the expansion device can pass refrigerant at a flow rate corresponding to the differential pressure between the primary pressure and the secondary pressure. The valve element **15** moves without large sliding resistance in accordance with a change in the primary pressure, so that when the primary pressure is changing gently, it is possible to reduce hysteresis of flow rate characteristics.

[0029] When the pressure of the refrigerant introduced into the refrigerant inlet port **11** rises sharply, the valve element **15** receives the pressure to be urged to move quickly in the valve-opening direction. However, the piston **17** integrally formed with the valve element **15** also moves in the valve-opening direction to reduce the volume of the damper chamber **23**, which causes pressure within the damper chamber **23** to rise and act to return the piston **17** in the valve-closing direction. This accommodates the sudden motion of the valve element **15** in the valve-opening direction to prevent the valve element **15** from moving in the valve-opening direction in accordance with the sharp rise in the primary pressure. Thereafter, the increased pressure within the damper chamber **23** is progressively released through a clearance between the cylinder **16** and the piston **17** and the fixed orifice **24** formed through the adjustment screw **22**, to lose a force for returning the piston **17** in the valve-closing direction. On the other hand, when the pressure of the refrigerant introduced into the refrigerant inlet port **11** falls sharply, the valve element **15** and the piston **17** integrally formed therewith operates in a manner opposite to the above case in which the pressure rises sharply, and for the same reason described above, the valve element **15** cannot move in the valve-closing direction in accordance with the sharp fall in the primary pressure. Thus, even when the primary pressure sharply rises or falls, it is possible to suppress sudden motion of the valve element **15**, thereby

preventing vibration of the same, and dramatically reducing generation of untoward noises.

[0030] FIG. 3 is an enlarged cross-sectional view of essential parts of the differential pressure valve, and FIG. 4 is a diagram showing changes in the suction force of the valve element of the differential pressure valve.

[0031] In this expansion device, as shown in FIG. 3, the variable orifice is formed by the valve seat **14** integrally formed with the housing **10** and the valve element **15** disposed in a manner movable to and away from the valve seat **14**. The valve element **15** has a valve element diameter "b" larger than a port diameter "a" of the valve hole so that the differential pressure valve can be fully closed, and on the secondary side of the variable orifice, there exists a lap margin of width (b-a).

[0032] Accordingly, when high-pressure CO₂ refrigerant passes through the variable orifice at high speed, turbulence of the flow of refrigerant occurs on the secondary side to cause the suction phenomenon of the valve element **15** being attracted toward the valve seat **14**. The occurrence of the suction phenomenon causes motion of the valve element **15** in the valve-closing direction, and hence in the differential pressure valve in which valve lift is determined depending on the differential pressure, the flow rate becomes lower than a flow rate corresponding to the differential pressure.

[0033] It turned out that the suction phenomenon is largely related to the ratio (b/a) of the valve element diameter "b" to the port diameter "a". FIG. 4, in which the abscissa represents the ratio (b/a) of the valve element diameter "b" to the port diameter "a", and the ordinate represents the suction force, shows that the suction force is small in a region where the ratio (b/a) is low, and as the ratio (b/a) is higher, the suction force is larger. Presumably, this is because in the region where the ratio (b/a) is low, the lap margin is small, and hence the influence of turbulence of the refrigerant flow upon the valve element **15** is small. It is apparent from the relationship shown in FIG. 4 that when the ratio (b/a) of the valve element diameter "b" to the port diameter "a" is not higher than 1.5, the suction force is small, and the influence of the suction phenomenon upon the valve element **15** is slight. In the present preferred embodiment, the valve element diameter "b" is made closer to the port diameter "a" to reduce the lap margin, whereby the ratio (b/a) of the valve element diameter "b" to the port diameter "a" is set to 1.16.

[0034] Since the suction phenomenon of the valve element **15** being attracted to the valve seat **14** due to the flow of refrigerant is suppressed, it is possible to set the characteristics of the expansion device to some extent by calculation based on only the balance between the pressure received by the valve element **15** and the load of the spring **21**. Further, since the motion of the valve element **15** in the valve-closing direction due to the suction phenomenon is prevented during operation of the expansion device, it is possible to make refrigerant flow at a predetermined flow rate to thereby prevent the cooling power of the refrigeration cycle from becoming insufficient.

[0035] The expansion device **3** described above provides a variable orifice having a characteristic that when the valve is closed, refrigerant flows through the fixed orifice **18** formed through the valve element **15** and a characteristic

that after the valve is opened, the valve element **15** is progressively lifted according to the differential pressure, i.e. a variable orifice having a single characteristic change point. Next, a description will be given of an expansion device which has two characteristic change points, i.e. three stages of characteristics, thereby making it possible to enhance the degree of freedom in configuring the settings of the expansion device when it is applied to a refrigeration cycle.

[0036] **FIG. 5** is a central longitudinal cross-sectional view showing another example of the arrangement of the expansion device, and **FIG. 6** is a diagram showing an example of the valve-opening characteristic of the expansion device. In **FIG. 5**, component elements identical or equivalent to those shown in **FIG. 2** are designated by the same reference numerals, and detailed description thereof is omitted.

[0037] As shown in **FIG. 5**, the expansion device **3a** is provided with a stopper **26** which is screwed in the adjustment screw **22** for adjusting the load of the spring **21**, in a manner movable back and forth along the axis of the adjustment screw **22**. The stopper **26** is provided for restricting the stroke of the piston **17** in the valve-opening direction to thereby restrict the maximum lift amount of the valve element **15** integrally formed with the piston **17**. The maximum lift amount can be determined by adjusting the screw-in amount of the stopper **26** after the load of the spring **21** is adjusted by the adjustment screw **22**.

[0038] The stopper **26** has a hollow part open to the secondary side similarly to the refrigerant outlet port **20**, and the fixed orifice **24** for the damper chamber **23** is formed through an end of the stopper **26** opposed to the piston **17**. Of course, the piston **17** or the stopper **26** has its opposed end face formed e.g. with a groove intersecting the axis of the fixed orifice **24** so as to prevent the fixed orifice **24** from being closed when the piston **17** comes into abutment with the stopper **26**.

[0039] As described above, when the differential pressure valve opens and the piston **17** integrally formed with the valve element **15** reaches the valve-opening stroke determined according to the screw-in position of the stopper **26**, the piston **17** comes into abutment with the stopper **26**, whereby the further stroke of the piston **17** is inhibited. Thus, two change points of the valve-opening characteristic can be set as illustrated in **FIG. 6**.

[0040] In **FIG. 6** showing the valve-opening characteristic, the abscissa represents the differential pressure across the valve element **15**, and the ordinate represents an opening area formed when the valve element **15** is lifted, which is indicated by an opening diameter as the diameter of a circle having the same area as the opening area. As shown in **FIG. 6**, the differential pressure valve has a characteristic that when the differential pressure is small and the valve is in the closed state, even if the differential pressure changes, a constant opening diameter is maintained by the fixed orifice **18**. When the differential pressure has risen to a valve-opening point (3 MPa in the illustrated example) determined by adjustment of the spring **21** by the adjustment screw **22**, the differential pressure valve starts to open, whereafter the differential pressure valve has a characteristic that the opening diameter changes according to the differential pressure. Then, with further rise in the differential pressure, the valve

element **15** is progressively lifted until the piston **17** integrally formed with the valve element **15** is brought into abutment with the stopper **26** (6 MPa in the illustrated example). As a consequence, the valve element **15** is not allowed to move any further in the valve-opening direction even when the differential pressure further rises, so that the differential pressure valve has a characteristic that the opening diameter does not change even when the differential pressure rises. The change point on the high differential pressure side can be changed by adjusting the stopper **26**.

[0041] Accordingly, in the expansion device **3a**, the two change points of the valve-opening characteristic can be adjusted separately by the adjustment screw **22** and the stopper **26**. This makes it possible to adjust the two change points in the case where the expansion device **3a** is applied to a refrigeration cycle and tailoring the characteristic of the expansion device **3a** to a point desirable in terms of system efficiency, so that the degree of freedom in configuring the settings of the characteristic of the expansion device **3a** can be enhanced. Further, after the differential pressure has exceeded a predetermined value, the opening diameter no longer increases with a rise in the differential pressure, and hence excessive flow of refrigerant is prevented in a region where the differential pressure is large, which makes it possible to adjust the characteristic of the expansion device **3a** to a region ensuring excellent efficiency.

[0042] Although both of the expansion device **3** shown in **FIG. 2** and the expansion device **3a** shown in **FIG. 5** are provided with the adjustment screw **22** as the adjustment member for adjusting the load of the spring **21**, the adjustment member may be formed by a press-fitted member which is press-fitted into the open end of the cylinder **16**. In this case, the load of the spring **21** can be determined by adjusting the press-fitting amount of the press-fitted member. Similarly, the stopper **26** screwed into the adjustment screw **22** of the expansion device **3a** may be configured to be press-fitted into the adjustment screw **22** such that the maximum stroke position of the piston **17** in the valve-opening direction can be determined by adjusting the press-fitting amount of the stopper **26**.

[0043] The expansion device according to the present invention has the valve element thereof provided with the damper means, whereby even if the valve element undergoes a sharp change in the pressure of refrigerant, it is possible to suppress vibration of the valve element in the opening or closing direction, thereby reducing generation of untoward noise. Further, it is possible to prevent the flow rate of refrigerant from being increased due to vibration of the valve element, to thereby suppress rise in blowing temperature.

[0044] Further, since the damper means prevents vibration of the valve element, occurrence of hunting can be suppressed, which makes it possible to stabilize the blowing temperature.

[0045] Furthermore, the damper means is provided as a measure for preventing generation of untoward noise, and therefore it is possible to reduce hysteresis more dramatically than by the measure utilizing sliding resistance, to thereby obtain stable characteristics and operate the refrigeration cycle efficiently.

[0046] Moreover, the valve element diameter is made closer to the port diameter, and the ratio of the valve element

diameter to the port diameter is set to a value not larger than 1.5, so that the valve element suction phenomenon can be suppressed. As a result, the characteristics of the expansion device can be set to some extent by calculation based on only the balance between the pressure received by the valve element and the load of the spring, which facilitates adjustment of the characteristics. Further, due to suppression of occurrence of the suction phenomenon, it is possible to prevent reduction of the flow rate of refrigerant, thereby securing the cooling power.

[0047] The foregoing is considered as illustrative only of the principles of the present invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and applications shown and described, and accordingly, all suitable modifications and equivalents may be regarded as falling within the scope of the invention in the appended claims and their equivalents.

What is claimed is:

1. An expansion device having a valve element disposed at a location downstream of a valve seat in a state urged in a valve-closing direction by a spring, the expansion device being capable of passing refrigerant at a flow rate corresponding to a differential pressure between a primary pressure in a refrigerant inlet port and a secondary pressure in a refrigerant outlet port, comprising:

damper means provided in the valve element, for accommodating motion of the valve element in an opening or closing direction when the valve element undergoes a sudden change in pressure.

2. The expansion device according to claim 1, wherein the damper means comprises a cylinder formed in a housing formed with the valve seat such that the cylinder extends in the same axial direction as the valve element, a piston disposed in the cylinder and integrally formed with the valve element, and a damper chamber whose volume can be changed by the piston.

3. The expansion device according to claim 2, wherein the damper chamber is closed by an adjustment member screwed or press-fitted in an open end of the cylinder, and the spring is interposed between the piston and the adjustment member.

4. The expansion device according to claim 3, wherein the adjustment member is formed with a fixed orifice in communication with the damper chamber.

5. The expansion device according to claim 3, comprising a stopper screwed or press-fitted in the adjustment member in a manner movable back and forth along an axis of the adjustment member, for restricting a stroke of the piston in a valve-opening direction.

6. The expansion device according to claim 5, wherein the stopper is formed with a fixed orifice communicating with the damper chamber.

7. The expansion device according to claim 1, wherein a ratio (b/a) of a valve element diameter (b) of the valve element to a port diameter (a) of the valve hole is not larger than 1.5.

8. The expansion device according to claim 1, applied to a refrigeration cycle using carbon dioxide as the refrigerant.

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