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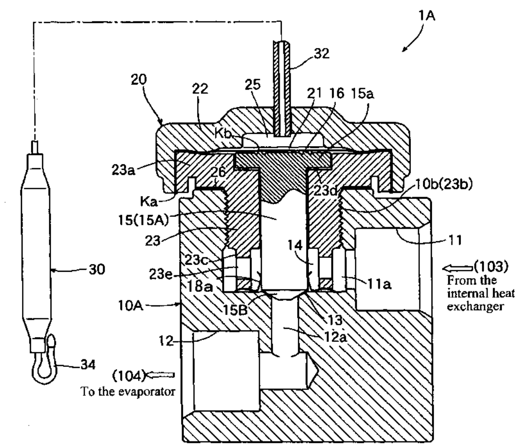
(54) Pressure control valve

(57) A pressure control valve to be integrated into a steam-compression type refrigerating cycle (100) comprising a compressor (101) for circulating CO_2 employed as a refrigerant, a gas cooler (102) for cooling the refrigerant compressed by the compressor, an evaporator (104) into which the refrigerant is designed to be introduced from the gas cooler, and an internal heat exchanger (103) for performing heat exchange between the refrigerant on the outlet side of the evaporator and the refrigerant on the outlet side of the gas cooler; the pressure control valve being constructed to pass the refrigerant to the evaporator after adjusting, depending on the temperature of the refrigerant on the outlet side of the gas cooler, the pressure of the refrigerant introduced therein via the internal heat exchanger from the gas cooler. This pressure control valve comprises: a temperature-sensing cylinder (30) for sensing the temperature of refrigerant on the outlet side of the gas cooler; a temperature-sensing pressure responding element (20) which is provided with a temperature-sensing chamber (25) communicated through a capillary tube (32) with the temperature-sensing cylinder and designed to drive a valve body (15) into a closed or open state in response to fluctuations of inner pressure of the temperature-sensing chamber; and a valve main body (10A) attached integrally to the pressure responding element; wherein the temperature-sensing cylinder and the temperature-sensing chamber are filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a pressure control valve which is adapted to be integrated into a steam-compression type refrigerating cycle where CO_2 is employed as a refrigerant (CO_2 cycle) for adjusting the pressure of refrigerant on the gas cooler (radiator) outlet side in conformity with the temperature of refrigerant. In particular, the present invention relates to a pressure control valve which is suitable for use in a steam-compression type refrigerating cycle to be employed in a car air conditioner provided with an internal heat exchanger for performing heat exchange between the refrigerant on the outlet side of an evaporator and the refrigerant on the outlet side of the gas cooler.

[0002] FIG. 21 shows one example of the steam-compression type refrigerating cycle into which a pressure control valve of this kind is integrated. The refrigerating cycle 100 shown herein is constituted by: a compressor 101 for circulating CO_2 employed as a refrigerant; a gas cooler (radiator) 102 for cooling the refrigerant that has been compressed by the compressor 101; an evaporator 104 into which the refrigerant is designed to be introduced from the gas cooler 102; an internal heat exchanger 103 for performing heat exchange between the refrigerant on the outlet side of the evaporator 104 and the refrigerant on the outlet side of the gas cooler 102; an accumulator (gas-liquid separator) 105 for dividing the refrigerant from the evaporator 104 into a gas phase refrigerant and a liquid phase refrigerant and for introducing the gas phase refrigerant into the intake side of the compressor 101 through the heat exchanger 103 while accumulating surplus refrigerant; and a pressure control valve 110 for passing the refrigerant to the evaporator 104 after adjusting, depending on the temperature of the refrigerant on the outlet side of the gas cooler 102, the pressure of the refrigerant that has been introduced via the internal heat exchanger 103 into the pressure control valve 110 from the gas cooler 102.

[0003] The pressure control valve 110 is provided for effectively operating the refrigerating cycle 100. In other words, the pressure control valve 110 is provided for adjusting the pressure of the refrigerant on the outlet side of the gas cooler 102 so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102 (For example, under the condition where the temperature of the refrigerant on the outlet side is 40°C, when the coefficient of performance can be made maximum if the pressure of the refrigerant on the outlet side is set to 10MPa, the pressure control valve 110 is controlled so that the pressure of the refrigerant on the outlet side may become 10MPa). As shown in JP Laid-open Patent Publication (Kokai) No.2001-81157 for example, this pressure control valve 110 is provided with: a pressure-adjusting inlet port 111 for introducing therein the refrigerant from the gas cooler 102 through the internal heat exchanger 103; a pressure-adjusting outlet port 112 for sending the refrigerant to the evaporator 104 after adjusting the pressure of the refrigerant depending on the temperature of the refrigerant on the outlet side of the gas cooler 102; a temperature-sensing inlet port 113 for introducing therein the refrigerant from the gas cooler 102; a temperature-sensing outlet port 114 for sending the refrigerant to the internal heat exchanger 103; a temperature-sensing introduction chamber (not shown) interposed between the temperature-sensing inlet port 113 and the temperature-sensing outlet port 114; a temperature-sensing pressure responding element (not shown) comprising a temperature-sensing chamber for sensing the temperature of the refrigerant that has been introduced into the temperature-sensing introduction chamber, the temperature-sensing pressure responding element being further capable of driving a valve body into a closed or open state in response to fluctuations of inner pressure of the temperature-sensing chamber; a valve main body (the entire control valve shown herein) having the temperature-sensing pressure responding element accommodated therein; and a spring member (not shown) disposed inside the valve main body and urging the valve body to move in the direction to reduce the opening degree of valve (valve-closing direction) ; wherein the opening degree of valve (the lifting quantity of the valve body) is determined by a balance between the valve-opening force originating from a pressure difference between the inside and outside of the temperature-sensing chamber and the valve-closing force by the spring member.

BRIEF SUMMARY OF THE INVENTION

[0004] Even in the case of the pressure control valve mentioned above, there is an increasing demand to reduce the manufacturing cost, so that there are strong demands to simplify the structure thereof, to decrease the number of parts, and to reduce the working and assembling cost.

[0005] The present invention has been made in response to the demands mentioned above and, therefore, an object of the present invention to provide a pressure control valve which is capable of appropriately adjusting the pressure of the refrigerant on the outlet side of the gas cooler in conformity with the temperature of the refrigerant on this outlet side, and also capable of effectively realizing the simplification of the structure thereof, the reduction of the number of parts, and the reduction of the working and assembling cost.

[0006] With a view to attaining the aforementioned object, there is provided, according to one aspect of the present invention, a pressure control valve which is adapted to be integrated into a steam-compression type refrigerating cycle which is constituted fundamentally by: a compressor for circulating CO_2 employed as a refrigerant, a gas cooler for cooling the refrigerant that has been compressed by the compressor, an evaporator into which the refrigerant is designed to be introduced from the gas cooler, and an internal heat exchanger for performing heat exchange between the refrigerant on the outlet side of the evaporator and the refrigerant on the outlet side of the gas cooler; the pressure control valve being constructed to pass the refrigerant to the evaporator after adjusting, depending on the temperature of the refrigerant on the outlet side of the gas cooler, the pressure of the refrigerant that has been introduced therein via the internal heat exchanger from the gas cooler.

[0007] This pressure control valve comprises a temperature-sensing cylinder for sensing the temperature of the refrigerant on the outlet side of the gas cooler, a temperature-sensing pressure responding element which is provided with a temperature-sensing chamber communicated through a capillary tube with the temperature-sensing cylinder and designed to drive a valve body into a closed or open state in response to fluctuations of inner pressure of the temperature-sensing chamber, and a valve main body attached integrally to the pressure responding element, wherein the temperature-sensing cylinder and the temperature-sensing chamber are filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler.

[0008] According to a second aspect of the present invention, there is provided a pressure control valve which is adapted to be disposed in the vicinity of the gas cooler or in the vicinity of the outlet port of the gas cooler of a steam-compression type refrigerating cycle which is constituted fundamentally by: a compressor for circulating CO_2 employed as a refrigerant, a gas cooler for cooling the refrigerant that has been compressed by the compressor, an evaporator into which the refrigerant is designed to be introduced from the gas cooler, and an internal heat exchanger for performing heat exchange between the refrigerant on the outlet side of the evaporator and the refrigerant on the outlet side of the gas cooler; the pressure control valve being constructed to pass the refrigerant to the evaporator after adjusting, depending on the temperature of the refrigerant on the outlet side of the gas cooler, the pressure of the refrigerant that has been introduced therein via the internal heat exchanger from the gas cooler.

[0009] This pressure control valve comprises a temperature-sensing pressure responding element which is provided with a temperature-sensing chamber for sensing the temperature of refrigerant on the outlet side of the gas cooler and designed to drive a valve body into a closed or open state in response to fluctuations of inner pressure of the temperature-sensing chamber, and a valve main body attached integrally to the pressure responding element, wherein the temperature-sensing chamber is filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler.

[0010] Preferably, the valve main body is formed of an approximately rectangular parallelepiped body which is cut out from an extruded rod having a rectangular cross-section and provided with a refrigerant entrance port, a mounting portion for the pressure responding element, and a valve seat portion for removably receiving the valve body.

[0011] In a preferable embodiment, the valve main body is provided with at least one engaging portion selected from an external thread portion, a flange portion, an internal thread portion for receiving bolts, and an insertion hole for mounting the valve main body on the gas cooler or on the internal heat exchanger.

[0012] Preferably, the temperature-sensing pressure responding element is constituted by a diaphragm; a cap member having an inverted U-shaped cross-section for partitioning, in cooperation with the diaphragm, the temperature-sensing chamber; and a cylindrical cap-receiving member for holding, in cooperation with the cap member, an outer circumferential portion of the diaphragm to hermetically sealing the pressure responding element, the cylindrical cap-receiving member comprising a flange portion for enabling the valve body to be slidably inserted therein; wherein the cap-receiving member is additionally provided on an outer circumferential wall of the cylindrical portion thereof with an external thread for attaching the pressure responding element to the valve main body.

[0013] In a further preferable embodiment, the valve main body is further provided therein with a restraining spring for suppressing the vibration of the valve body. In this case, the restraining spring for vibration is preferably formed of an elastic plate and constituted by a generally annular bottom portion having an inverted V-shaped cross-section and being press-contacted with the valve main body by means of the cap-receiving member, and by a plurality of tongue-shaped flexible flaps extending upward from an inner periphery of the annular bottom portion and elastically contacted with the outer circumferential wall of the valve body.

[0014] In a further preferable embodiment, the valve body and the diaphragm are disposed coaxially and one end portion of the valve body is bonded to the diaphragm by means of projection welding.

[0015] In a still further preferable embodiment, the diaphragm is formed of a closed-end shortened cylindrical body, and the outer edge portion and cylindrical portion of the diaphragm are held between the cap member and the cap-receiving member to hermetically seal the pressure responding element, wherein the lower end portion of this laminated portion is welded to each other throughout the entire periphery thereof.

[0016] Preferably, the cap-receiving member is formed of two parts, i.e. a cylindrical portion having an external thread portion, and a flange portion which can be manufactured by press-working a plate.

[0017] In the pressure control valve according to the second aspect of the present invention, the temperature-sensing chamber is provided, on the outer circumference thereof, with temperature-sensing fins, or with a temperature-sensing fin-attached cylindrical or cap body.

[0018] Further, in another preferable embodiment, the valve body is partitioned into an axis portion and an enlarged portion, and the valve seat of the valve main body is provided with a plurality of bleed notches.

[0019] According to a third aspect of the present invention, there is provided a pressure control valve which is adapted to be integrated into a steam-compression type refrigerating cycle which is constituted fundamentally by: a compressor for circulating CO_2 employed as a refrigerant, a gas cooler for cooling the refrigerant that has been compressed by the compressor, an evaporator into which the refrigerant is designed to be introduced from the gas cooler, and an internal heat exchanger for performing heat exchange between the refrigerant on the outlet side of the evaporator and the refrigerant on the outlet side of the gas cooler; the pressure control valve being constructed to pass the refrigerant to the evaporator after adjusting, depending on the temperature of the refrigerant on the outlet side of the gas cooler, the pressure of the refrigerant that has been introduced therein via the internal heat exchanger from the gas cooler.

[0020] This pressure control valve comprises a temperature-sensing inlet port for introducing therein the refrigerant from the gas cooler; a temperature-sensing outlet port for sending the refrigerant to the internal heat exchanger; a temperature-sensing introduction chamber interposed between the temperature-sensing inlet port and the temperature-sensing outlet port; a temperature-sensing pressure responding element comprising a temperature-sensing chamber for sensing the temperature of the refrigerant that has been introduced into the temperature-sensing introduction chamber, the tenperature-sensing pressure responding element being further capable of driving a valve body into a closed or open state in response to fluctuations of inner pressure of the temperature-sensing chamber; and a valve main body to which the temperature-sensing pressure responding element can be integrally attached; wherein the temperature-sensing chamber is filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler.

[0021] Preferably, the valve main body is formed of a solid body which is cut out from an extruded rod having a +-shaped or rectangular cross-section and provided with the aforementioned temperature-sensing inlet port, the aforementioned temperature-sensing outlet port, the aforementioned temperature-sensing introduction chamber, the aforementioned pressure-adjusting inlet port, the aforementioned pressure-adjusting outlet port, a mounting portion for the pressure responding element, and a valve seat portion for removably receiving the valve body.

[0022] In a further preferable embodiment, a guide hole for enabling the valve body to be slidably inserted therein is provided over the valve seat of the valve main body, wherein the aforementioned temperature-sensing inlet port, temperature-sensing outlet port and temperature-sensing introduction chamber are disposed over the guide hole, and the aforementioned pressure-adjusting inlet port, pressure-adjusting outlet port and a valve chamber are disposed below the guide hole.

[0023] In a preferable embodiment, the valve main body is provided with at least one engaging portion selected from an external thread portion, a flange portion, an internal thread portion for receiving bolts, and an insertion hole for attaching the valve main body to the gas cooler, to a pipe coupler for connection with the evaporator, or to the internal heat exchanger.

[0024] Preferably, the temperature-sensing pressure responding element is constituted by a diaphragm; a cap member having an inverted U-shaped cross-section for partitioning, in cooperation with the diaphragm, the temperature-sensing chamber; and a cylindrical cap-receiving member for holding, in cooperation with the cap member, an outer circumferential portion of the diaphragm to hermetically sealing the pressure responding element, the cylindrical cap-receiving member comprising a flange portion for enabling the valve body to be inserted therein through the inner periphery thereof; wherein the cap-receiving member is additionally provided on an outer circumferential wall of the cylindrical portion thereof with an external thread for attaching the pressure responding element to the valve main body.

[0025] In a further preferable embodiment, the valve body and the diaphragm are disposed coaxially and one end portion of the valve body is bonded to the diaphragm by means of projection welding.

[0026] In a still further preferable embodiment, the valve body is consisted of a columnar valve rod, and a valve body portion formed at a lower end portion of the valve rod, wherein the valve rod is composed of a shaft portion, and an enlarged portion which is formed integral with or fixedly secured to an upper portion of the shaft portion. The aforementioned diaphragm is coupled to an upper surface of the enlarged portion.

[0027] In another preferable embodiment, the temperature-sensing introduction chamber is formed between the valve rod and the cylindrical portion of the cap-receiving member.

[0028] In a further preferable embodiment, the valve body is provided with a longitudinal hole having an open top, and the diaphragm is provided with a through-hole for enabling the temperature-sensing chamber to the longitudinal hole, thereby constituting one extended temperature-sensing chamber consisting of the temperature-sensing chamber and the longitudinal hole.

[0029] In a still further preferable embodiment, the diaphragm is formed of a closed-end shortened cylindrical body, and the outer edge portion and cylindrical portion of the diaphragm are held between the cap member and the cap-receiving member to hermetically seal the pressure responding element, wherein the lower end portion of this laminated portion is welded to each other throughout the entire periphery thereof.

[0030] In a still further preferable embodiment, the valve body is provided, along the whole length of the circumferential wall thereof, with a trench for interrupting heat transmission between the temperature-sensing inlet port and the temperature-sensing outlet port, and between the pressure-adjusting inlet port and the pressure-adjusting outlet port. The valve seat of the valve main body is provided with a plurality of bleed notches, and the valve rod of the valve body is provided with a plurality of annular trenches.

[0031] The pressure control valve according to the present invention is featured in that the sensing of the temperature of the refrigerant on the outlet side of gas cooler is performed not through the introduction of the refrigerant into the valve main body as conventionally executed, but through the provision of a temperature-sensing cylinder or through the positioning of the pressure control valve itself at the gas cooler (or in the vicinity of the outlet port thereof); that the temperature-sensing pressure responding element is not integrated into the valve main body but is externally attached to the valve main body by means of screwing, etc.; and that since the temperature-sensing cylinder and the temperature-sensing chamber are filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler, thereby making it possible to adjust the opening degree of valve by making use of only the temperature-sensing pressure responding element without necessitating the employment of a spring member, it is no longer necessary to arrange a temperature-sensing inlet port, a temperature-sensing outlet port, or a spring member. As a result, the pressure of refrigerant on the outlet side of gas cooler can be appropriately adjusted in conformity with the temperature of the refrigerant on the outlet side of gas cooler, thus effectively realizing the simplification of the structure thereof, the reduction of the number of parts, and the reduction of the working and assembling cost.

[0032] Further, according to the pressure control valve of the present invention, since it is possible to adjust the opening degree of valve by making use of only the temperature-sensing pressure responding element, it is possible to simplify the structure of pressure control valve and to reduce the number of parts as compared with the conventional pressure control valve where the opening degree of valve (the lifting quantity of the valve body) is determined by a balance between the valve-opening force originating from a pressure difference between the inside and outside of the temperature-sensing chamber and the valve-closing force by the spring member. Further, the pressure control valve of the present invention is also featured in that the temperature-sensing pressure responding element is not integrated into the valve main body but is externally attached to the valve main body by means of screwing, etc.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0033]

FIG. 1 is a longitudinal sectional view illustrating a first embodiment of the pressure control valve according to the present invention;

FIG. 2 is a flow chart illustrating one example of a steam-compression type refrigerating cycle where the pressure control valve according to the first embodiment is installed;

FIG. 3 is an enlarged cross-sectional view illustrating a coupled state between a diaphragm and a valve body;

FIGs. 4 (A) to 4 (C) are enlarged cross-sectional views each illustrating an example of the restraining spring for vibration;

FIG. 5 is a longitudinal sectional view illustrating a second embodiment of the pressure control valve according to the present invention;

FIG. 6 is a longitudinal sectional view illustrating a third embodiment of the pressure control valve according to the present invention;

FIG. 7 is a plan view illustrating a fourth embodiment of the pressure control valve according to the present invention;

FIG. 8 is a right side view illustrating a fourth embodiment of the pressure control valve according to the present invention;

FIG. 9 is a flow chart illustrating one example of a steam-compression type refrigerating cycle where the pressure control valve according to the fourth embodiment is installed;

FIGs. 10(A) and 10(B) are partially cut views each illustrating a technique of enhancing the temperature sensitivity of temperature-sensing chamber;

FIG. 11 is a longitudinal sectional view illustrating a fifth embodiment of the pressure control valve according to the present invention;

FIG. 12 is a plan view of the pressure control valve shown in FIG. 11;

FIG. 13 is a left side view of the pressure control valve shown in FIG. 11;

FIG. 14 is a flow chart illustrating one example of a steam-compression type refrigerating cycle where the pressure control valve according to the fifth embodiment is installed;

FIG. 15 is an enlarged cross-sectional view illustrating a coupled state between a diaphragm and a valve body;

FIG. 16 is a longitudinal sectional view illustrating a sixth embodiment of the pressure control valve according to the present invention;

FIG. 17 is a plan view of the pressure control valve shown in FIG. 16;

FIG. 18 is a longitudinal sectional view illustrating a seventh embodiment of the pressure control valve according to the present invention;

FIG. 19 is a longitudinal sectional view illustrating an eighth embodiment of the pressure control valve according to the present invention;

FIG. 20 is a left side view of the pressure control valve shown in FIG. 19; and

FIG. 21 is a flow chart illustrating one example of a steam-compression type refrigerating cycle where the pressure control valve of the prior art is installed.

DETAILED DESCRIPTION OF THE INVENTION

[0034] Next, various embodiments of the pressure control valve according to the present invention will be explained in detail with reference to the drawings.

[0035] FIG. 1 shows a longitudinal sectional view illustrating a first embodiment of the pressure control valve according to the present invention. The pressure control valve 1A according to the first embodiment shown herein is adapted to be integrated into a steam-compression type refrigerating cycle 100A which is fundamentally constructed in the same manner as shown FIG. 11 mentioned above, wherein the refrigerant to be introduced into the pressure control valve 1A from a gas cooler 102 through an internal heat exchanger 103 is enabled to enter into an evaporator 104 after being adjusted in pressure depending on the temperature of refrigerant on the outlet side of the gas cooler 102 as shown in FIG. 2. By the way, in the refrigerating cycle 100A shown in FIG. 2, the portions or members constructed or functioning in the same manner as those of the refrigerating cycle 100 shown FIG. 11 will be identified by the same reference numerals, thereby omitting the explanations thereof.

[0036] The pressure control valve 1A is provided for effectively operating the refrigerating cycle 100A. In other words, the pressure control valve 1A is provided for adjusting the pressure of the refrigerant on the outlet side of the gas cooler 102 so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102. This pressure control valve 1A is constituted by a valve main body 10A, a valve body 15 consisting of a valve rod 15A and a valve body portion 15B having a truncated cone-like configuration and formed at a lower end portion of the valve rod 15A, a temperature-sensing pressure responding element 20, and a temperature-sensing cylinder 30 made of a metal excellent in heat conductivity for sensing the temperature of refrigerant on the outlet side of the gas cooler 102, the opposite ends of the cylinder 30 being tapered into a cone-like configuration.

[0037] The valve main body 10A is provided with a pressure-adjusting inlet port (coupler) 11 which is opened in a sidewall of the valve main body 10A and communicated with an inlet passageway 11a for introducing a refrigerant therein from the gas cooler 102 through the internal heat exchanger 103, a pressure-adjusting outlet port (coupler) 12 which is opened opposite to the aforementioned inlet port 11 and communicated with an outlet passageway 12a for discharging the refrigerant therefrom to the evaporator 104 after adjusting the pressure of refrigerator in conformity with the temperature of refrigerant on the outlet side of the gas cooler 102, a valve seat 13 mounted on an upper end portion of the outlet passageway 12a and having a truncated cone-like configuration for removably receiving the valve body 15 (the valve body portion 15B thereof), a valve chamber 14 defined over this valve seat 13, and an internal thread portion 10b for attaching the temperature-sensing pressure responding element 20 to the valve main body 10A. By the way, the valve seat 13 is provided with a small bleed notch (not shown), so that the opening degree of the pressure control valve corresponds to a quantity of lift from the valve seat 13 of valve body 15 (the valve body portion 15B thereof). Since the valve seat 13 is formed through notch-forming using a press, the working of the outlet passageway 12a would become easier and, at the same time, it is possible to obtain a self-cleaning effect during the operation of the control valve.

[0038] The temperature-sensing pressure responding element 20 is constituted by a closed-end short cylindrical diaphragm 21; a cap member 22 having an inverted U-shaped cross-section for partitioning, in cooperation with the diaphragm 21, the temperature-sensing chamber(diaphragm chamber) 25; and a cylindrical cap-receiving member 23 for holding, in cooperation with the cap member 22, an outer circumferential portion of the diaphragm 21 (an outer circumferential edge portion and a cylindrical portion) to hermetically sealing the pressure responding element 20, the cylindrical cap-receiving member 23 comprising a flange portion 23a for enabling the valve body 15 to be slidably inserted therein. A lower end portion of the superimposed portion (sandwiched portion) of the cap member 22, cap-receiving member 23 (the flange portion 23a thereof) and the diaphragm 21 is entirely bonded to each other by means of welding (a welded portion Ka). At a lower portion of the cap-receiving member 23, there is provided with a thin constricted portion 23c for defining the valve chamber 24, and this thin constricted portion 23c is provided with a through-hole 23e constituting an inlet passageway 11a.

[0039] A diametrally enlarged portion 15a is formed on the top of the valve rod 15A of valve body 15 and is enabled to move up and down in a recessed portion 23d formed at an upper central portion of the cap-receiving member 23. On a central portion of the upper surface of the diametrally enlarged portion 15a, there are formed an annular ridge 16 having a trapezoidal cross-section as shown in FIG. 3 and a pair of annular trenches 16a and 16b located on the opposite sides of the annular ridge 16. To this annular ridge 16, the diaphragm 21 is bonded by means of projection welding (a welded portion Kb), thus positioning the diaphragm 21 coaxial with the valve body 15 (a common axial line Ox).

[0040] The cap-receiving member 23 is provided, on an outer circumferential wall of the cylindrical portion thereof, with an external thread portion 23b which is adapted to be engaged with the internal thread portion 10b for attaching the pressure responding element to the valve main body 10A. The unit consisting of the valve body 15 and the temperature-sensing pressure responding element 20 which are integrally bonded as described above is mounted on the valve main body 10A in such a manner that, under the condition where a restraining spring 18 for vibration (to be discussed hereinafter) is disposed in the vicinity of a lower end portion of the valve rod 15A, the external thread portion 23b is engaged with the internal thread portion 10b of valve main body 10A and, at the same time, the unit is rotated entirely, thus mounting the unit on the valve main body 10A. By the way, a gasket 26 is interposed between the lower surface of the cap-receiving member 23 and the upper surface of the valve main body 10A.

[0041] Meanwhile, the restraining spring 18 for suppressing the vibration of the valve body 15 is disposed at the bottom of the valve chamber 14 of valve main body 10A. As shown in FIGs. 4(A) and 4(b), this restraining spring 18 for vibration is formed of an elastic plate and constituted by a generally annular (having a plurality (eight in this embodiment) of teeth 18a externally extending and spaced apart from each other at equal angular intervals) bottom portion 18A having an inverted V-shaped configuration which is designed to be flattened as it is pressed onto the valve main body 10A by the thin constricted portion 23c on the occasion of mounting (through screwing) the cap-receiving member 23 on the valve main body 10A, and a plurality (four in this embodiment) of tongue-shaped flexible flaps 18B spaced apart from each other at equal angular intervals (symmetrical in every directions). By the way, a distal end portion of each of the tongue-shaped flexible flaps 18B is bent toward the outer circumferential wall of the valve body 15 so as to facilitate mounting thereof on the valve rod 15A. Further, the restraining spring 18 for vibration shown in FIGs. 4 (A) and 4(b) is configured so as to enable the inner circumferential portion and outer circumferential portion of the bottom portion 18A to contact with the valve main body 10A from the beginning. However, it is also possible to employ restraining spring 18' for vibration which is designed such that only the outer circumferential portion of the bottom portion 18A is permitted to contact with the valve main body 10A at first without the inner circumferential portion thereof being permitted to contact with the valve main body 10A at first as shown in FIG. 4 (C).

[0042] In this embodiment, in order to detect the temperature of refrigerant on the outlet side of gas cooler 102, the temperature-sensing cylinder 30 is disposed in contact with an upstream end portion (in the vicinity of the outlet port 102b of gas cooler 102) of a conduit defining a channel 122 between the gas cooler 102 and the internal heat exchanger 103 as shown in FIG. 2 and fixed to this upstream end portion by means of a suitable fastener. Further, the temperature-sensing cylinder 30 is communicated via a capillary tube 32 with the temperature-sensing chamber 25. One end of the capillary tube 32 is hermetically connected with the temperature-sensing cylinder 30 and the other end thereof is hermetically connected with the temperature-sensing chamber 25. The temperature-sensing cylinder 30 and the temperature-sensing chamber 25 are charged, through a short capillary tube 34 connected with the other end of the temperature-sensing cylinder 30, with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler 102 in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102 (For example, under the condition where the temperature of the refrigerant on the outlet side is 40°C, when the coefficient of performance can be made maximum if the pressure of the refrigerant on the outlet side is set to 10MPa, it is controlled so that the pressure of the refrigerant on the outlet side may become 10MPa). Under this condition, the distal end of the capillary tube 34 is sealed.

[0043] In this structure as described above, the temperature (fluctuation thereof) of refrigerant on the outlet side of the gas cooler 102 is detected by the temperature-sensing cylinder 30 and the temperature (fluctuation thereof) thus detected is transmitted via the capillary tube 32 to the temperature-sensing chamber 25, thereby rendering the inner pressure (fluctuation thereof) of the temperature-sensing chamber 25 to conform with the temperature (fluctuation thereof) of refrigerant on the outlet side of the gas cooler 102. As a result, the diaphragm 21 is actuated in response to the inner pressure (fluctuation thereof) of the temperature-sensing chamber 25, thereby driving the valve body 15 in an opening or closing direction to adjust the opening degree of valve, thus adjusting the pressure of refrigerant on the outlet side of the gas cooler 102 so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102.

[0044] As explained above, the pressure control valve 1A according to this embodiment is featured in that the sensing of the temperature of the refrigerant on the outlet side of gas cooler 102 is performed not through the introduction of the refrigerant into the valve main body 10A as conventionally executed, but through the provision of a temperature-sensing cylinder 30; that the temperature-sensing pressure responding element 20 is not integrated into the valve main body 10A but is externally attached to the valve main body 10A by means of screwing, etc.;

and that since the temperature-sensing cylinder 30 and the temperature-sensing chamber 25 are filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler 102 so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102, thereby making it possible to adjust the opening degree of valve by making use of only the temperature-sensing pressure responding element 20 without necessitating the employment of a spring member, it is no longer necessary to arrange a temperature-sensing inlet port, a temperature-sensing outlet port, or a spring member. As a result, the pressure of refrigerant on the outlet side of gas cooler 102 can be appropriately adjusted in conformity with the temperature of the refrigerant on the outlet side of gas cooler, thus effectively realizing the simplification of the structure thereof, the reduction of the number of parts, and the reduction of the working and assembling cost.

[0045] FIG. 5 shows a longitudinal sectional view illustrating a second embodiment of the pressure control valve according to the present invention. The pressure control valve 1B according to the second embodiment shown herein is fundamentally the same in construction as that of the pressure control valve 1A of the first embodiment (the portions or members constructed or functioning in the same manner as those of the pressure control valve 1A of the first embodiment will be identified by the same reference numerals, thereby omitting the explanations thereof). In the pressure control valve 1B of this embodiment however, a valve main body 10B is disposed in a valve-mounting portion 130 of the heat exchanger 103, thereby enabling the pressure control valve 1B to be easily attached to the internal heat exchanger 103 or to the gas cooler 102 and also making it unnecessary to connect the pressure control valve 1B with a conduit and the like for forming a channel.

[0046] Namely, the valve main body 10B is formed of a cylindrical configuration having a closed bottom and a step portion. This valve main body 10B is also provided, on the outer circumferential wall thereof, with an external thread portion 19 to be engaged with the internal thread portion 135 of the valve-mounting portion 130 which is formed in the internal heat exchanger 103 in advance. Further, a pair of right and left pressure-adjusting inlet ports 11 are formed at a lower wall portion of the valve main body 10B, these inlet ports 11 being directed downward obliquely. Additionally, a pressure-adjusting outlet port 12 is formed at a central portion of the bottom of valve main body 10B. An O-ring 41 for sealing an interface between the valve main body 10B and the valve-mounting portion 130 is mounted at an upper portion of the valve main body 10B. Furthermore, the valve main body 10B is also provided, at an outer peripheral portion of the underside of the valve main body 10B, with an annular ridge 42 having a triangular or trapezoidal cross-section for preventing a refrigerant from flowing through an interface between the inlet ports 11 and the pressure-adjusting outlet port 12.

[0047] The pressure control valve 1B thus constructed can be mounted on the valve-mounting portion 130 by engaging the external thread portion 19 thereof with the internal thread portion 135 of the valve-mounting portion 130 and, at the same time, by rotating it entirely. On this occasion, the annular ridge 42 provided on the underside of the valve main body 10B is pressed against the bottom surface of the valve-mounting portion 130 to shield an interface between the inlet ports 11 and the pressure-adjusting outlet port 12.

[0048] In this embodiment, the refrigerant from the gas cooler 102 is permitted to flow from an inlet channel 136 provided at a lower portion of the valve-mounting portion 130 after passing through the internal heat exchanger 103 into the inlet ports 11 through a space formed between the lower outer wall of the valve main body 10B (a wall portion outer than the annular ridge 42) and the inner circumferential wall of the valve-mounting portion 130. Thereafter, the refrigerant is permitted to enter into the valve chamber 14 and, while being reduced in pressure depending on the opening degree of valve, discharged from the valve chamber 14 to the pressure-adjusting outlet port 12. Then, the refrigerant is delivered, through an outlet channel 137 provided at a lower portion of the valve-mounting portion 130, to the evaporator 104.

[0049] FIG. 6 shows a longitudinal sectional view illustrating a third embodiment of the pressure control valve according to the present invention. The pressure control valve 1C according to the third embodiment shown herein is fundamentally the same in construction as that of the pressure control valve 1A of the first embodiment (the portions or members constructed or functioning in the same manner as those of the pressure control valve 1A of the first embodiment will be identified by the same reference numerals, thereby omitting the explanations thereof).

[0050] While the first embodiment shown in FIG. 1 illustrates an example wherein the valve main body 10A is constructed such that the conduit extending from the internal heat exchanger 103 and the conduit extending to the evaporator 104 are both arranged horizontally, the valve main body 10C of the third embodiment shown in FIG. 6 is constructed such that the conduit extending to the evaporator 104 is disposed perpendicular to the conduit extending from the internal heat exchanger 103. Therefore, by exchanging the valve main body 10C of the third embodiment for the valve main body 10A of the first embodiment in assembling the pressure control valve, it is possible to provide a pressure control valve which is capable of coping with either the horizontal conduit or the vertical conduit. In the pressure control valve 1C according to the third embodiment, the cap-receiving member 23 is formed of two parts, i.e. a step-attached cylindrical portion 23A having an external thread portion 23b, and an annular flange portion 23B formed of plate material and having an inverted U-shaped cross-section.

Further, the valve rod 15A is partitioned into a shaft portion 15A' and a diametrally enlarged portion 15a having a T-shaped cross-section. When partitioned in this manner, only the diametrally enlarged portion 15a can be made of SUS304 and the shaft portion 15A' may be formed of SUS303, which is advantageous in terms of working cost.

[0051] Since it is difficult to manufacture the step-attached cylindrical portion 23A of the cap-receiving member 23 where the external thread portion 23b by means of press-working, it will be manufactured by way of cutting work. The annular flange portion 23B can be manufactured by means of press-working which can be performed at a relatively low cost. In this case, an upper enlarged portion 23g of the step-attached cylindrical portion 23A is press-inserted into a stepped inner circumferential portion of the annular flange portion 23B to form an assembled body, to which the valve rod 15A (where the shaft portion and the diametrally enlarged portion are integrated through press-insertion) which is integrated with the diaphragm 21, and the cap member 22 are successively secured in the mentioned order by means of projection welding. Thereafter, the cap-receiving member 23, the diaphragm 21 and the cap member 22 are integrally welded along the entire peripheral portion Ka thereof. The attachment of the temperature-sensing pressure responding element 20 to the valve main body 10C can be as follows. Namely, the annular flange portion 23B is fitted in an annular ridge portion 10f projected on the upper surface of the valve main body 10C, and, at the same time, the external thread portion 23b is engaged with the internal thread portion 10b of the valve main body 10C and the temperature-sensing pressure responding element 20 is entirely rotated and screwed down, thereby securing the temperature-sensing pressure responding element 20 to the valve main body 10C. By the way, a gasket 46 is interposed between the upper surface of the annular ridge portion 10f of valve main body 10C and the recessed portion of the annular flange portion 23B. Since the cap-receiving member 23 is partitioned into two members and one of which is manufactured by means of press working which can be performed at a relatively low cost, it is possible to reduce the manufacturing cost of parts.

[0052] Further, a short shaft portion of the diametrally enlarged portion 15a having a T-shaped cross-section is integrally secured to an upper portion of the shaft portion 15A' of valve rod 15A by means of press-insertion, etc. Since the valve rod 15A is partitioned into the shaft portion 15A' and the diametrally enlarged portion 15a as described above, the formation of the annular ridge portion 16 to be utilized in the bonding thereof to the diaphragm 21 by means of projection welding can be facilitated.

[0053] FIG. 7 is a plan view illustrating a fourth embodiment of the pressure control valve according to the present invention, and FIG. 8 is a right side view thereof. The pressure control valve 1D according to the fourth embodiment shown herein is fundamentally the same in construction as that of the pressure control valve 1A of the first embodiment, except that the temperature-sensing cylinder 30 is not provided therein. Therefore, the details on the internal constituent components should be referred to the description of the first embodiment.

[0054] As shown in FIG. 9, the pressure control valve 1D according to the fourth embodiment is adapted to be mounted on the gas cooler 102 of a steam-compression type refrigerating cycle 100B which is fundamentally constructed in the same manner as shown FIG. 2, wherein the refrigerant to be introduced into the pressure control valve 1D from a gas cooler 102 through an internal heat exchanger 103 is enabled to enter into an evaporator 104 after being adjusted in pressure depending on the temperature of refrigerant on the outlet side of the gas cooler 102.

[0055] More specifically, the pressure control valve 1D (the temperature-sensing chamber 25 thereof) is arranged in front of the gas cooler 102 for example as shown in FIG. 9 so as to directly detect the temperature of refrigerant on the outlet side of gas cooler 102.

[0056] Further, the temperature-sensing chamber 25 of the temperature-sensing pressure responding element 20 is charged, through a short capillary tube 39 secured to the temperature-sensing chamber 25, with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler 102 in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102 (For example, under the condition where the temperature of the refrigerant on the outlet side is 40°C, when the coefficient of performance can be made maximum if the pressure of the refrigerant on the outlet side is set to 10MPa, it is controlled so that the pressure of the refrigerant on the outlet side may become 10MPa). Under this condition, the distal end of the capillary tube 39 is sealed.

[0057] In this structure as described above, the temperature of refrigerant on the outlet side of the gas cooler 102 is detected by the temperature-sensing chamber 25, thereby rendering the inner pressure of the temperature-sensing chamber 25 to conform with the temperature of refrigerant on the outlet side of the gas cooler 102. As a result, the diaphragm 21 is actuated in response to the fluctuation of inner pressure of the temperature-sensing chamber 25, thereby driving the valve body 15 in an opening or closing direction to adjust the opening degree of valve, thus adjusting the pressure of refrigerant on the outlet side of the gas cooler 102 so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102.

[0058] As explained above, the pressure control valve 1D according to this embodiment is featured in that the sensing of the temperature of the refrigerant on the outlet side of gas cooler 102 is performed not through the introduction of the refrigerant into the valve main body 10A as conventionally executed, but through the positioning of the pressure control valve 1D itself in front of the gas cooler 102; that the temperature-sensing pressure responding element 20 is not integrated into the valve main body 10D but is externally attached to the valve main body 10D by means of screwing, etc. as in the case of the first embodiment; and that since the temperature-sensing chamber 25 is filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler 102 so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102, thereby making it possible to adjust the opening degree of valve by making use of only the temperature-sensing pressure responding element 20 without necessitating the employment of a spring member, it is no longer necessary to arrange a temperature-sensing inlet port, a temperature-sensing outlet port, or a spring member. As a result, the pressure of refrigerant on the outlet side of gas cooler 102 can be appropriately adjusted in conformity with the temperature of the refrigerant on the outlet side of gas cooler, thus effectively realizing the simplification of the structure thereof, the reduction of the number of parts, and the reduction of the working and assembling cost.

[0059] By the way, in the cases of the pressure control valves 1A, 1C and 1D according to the aforementioned first, third and fourth embodiments, the valve main bodies 10A, 10C and 10D are respectively formed of an approximately rectangular parallelepiped body which is cut out from an extruded aluminum rod having a rectangular cross-section and provided with a refrigerant inlet port 11, with a refrigerant outlet port 12, with a mounting portion (internal thread portion 10b) for the pressure responding element, with internal thread portions 51 and 52 to be used for attaching the pressure control valves 1A, 1C and 1D to a conduit member or the internal heat exchanger 103, and with a valve seat portion. As a result, it is possible to further simplify the structure the pressure control valve, to reduce the number of parts, and save the working and assembling cost.

[0060] Furthermore, in order to enhance the temperature sensitivity of the temperature-sensing chamber 25, it is preferable to provide the temperature-sensing chamber 25 with a plurality of temperature-sensing fins or to attach a cylindrical body or cap-like body having temperature-sensing fins to the outer circumferential wall of the temperature-sensing chamber 25.

[0061] FIGs. 11, 12 and 13 are a cross-sectional view, a plan view and a left side view of the pressure control valve, respectively, all illustrating a fifth embodiment of the present invention. As shown in FIG. 14, the pressure control valve 1E according to the fifth embodiment shown herein is adapted to be integrated into a steam-compression type refrigerating cycle 100C which is fundamentally constructed in the same manner as shown FIG. 21 mentioned above, wherein the refrigerant to be introduced into the pressure control valve 1E from a gas cooler 102 through an internal heat exchanger 103 is enabled to enter into an evaporator 104 after being adjusted in pressure depending on the temperature of refrigerant on the outlet side of the gas cooler 102. By the way, in the refrigerating cycle 100C shown in FIG. 14, the portions or members constructed or functioning in the same manner as those of the refrigerating cycle 100 shown FIG. 21 will be identified by the same reference numerals, thereby omitting the explanations thereof.

[0062] The pressure control valve 1E is provided for effectively operating the refrigerating cycle 100C. In other words, the pressure control valve 1E is provided for adjusting the pressure of the refrigerant on the outlet side of the gas cooler 102 so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102. This pressure control valve 1E is constituted by a valve main body 10A, a valve body 15 consisting of a valve rod 15A and a valve body portion 15B having a truncated cone-like configuration and formed at a lower end portion of the valve rod 15A, and a temperature-sensing pressure responding element 20.

[0063] The valve main body 10E is formed of a solid body which is cut out from an extruded aluminum rod having a +-shaped cross-section (see FIG. 13) and provided with the following constituent components which are formed through cutting work. Namely, this valve main body 10E is provided, at a lower portion thereof, with a pressure-adjusting inlet port (coupler) 11 which is opened in a right sidewall of the valve main body 10E and communicated with an inlet passageway 11a for introducing a refrigerant therein from the gas cooler 102 through the internal heat exchanger 103, a valve chamber 14 into which a refrigerant is introduced from the pressure-adjusting inlet port 11, a valve seat 13 defining the bottom of the valve chamber 14 and having a truncated cone-like configuration for removably receiving the valve body 15 (the valve body portion 15B thereof), and a pressure-adjusting outlet port (coupler) 12 which is opened in a left sidewall of the valve main body 10E and communicated with an outlet passageway 12a for delivering the refrigerant from the valve chamber 14 to the evaporator 104. By the way, the valve seat 13 is provided with a small bleed notch (not shown), so that the opening degree of the pressure control valve 1E corresponds to a quantity of lift from the valve seat 13 of valve body 15 (the valve body portion 15B thereof). Since the valve seat 13 is formed through notch-forming using a press, the working of the outlet passageway 12a would become easier and, at the same time, it is possible to obtain a self-cleaning effect during the operation of the control valve.

[0064] A guide hole 18a communicating with the valve chamber 14 is formed at a central portion of the valve main body 10E, thus enabling the valve rod 15A (an intermediate diametrally enlarged portion 15c thereof) to be slidably inserted into the guide hole 18a. Above this guide hole 18a, i.e. at an upper portion of the valve main body 10E, there are formed a temperature-sensing inlet port 61 which is opened on the left side of the valve main body 10E for introducing a refrigerant therein from the gas cooler 102, and a temperature-sensing outlet port 62 which is opened on the right side of the valve main body 10E for delivering the refrigerant to the internal heat exchanger 103. A temperature-sensing introduction chamber 60 is formed between the temperature-sensing inlet port 61 and the temperature-sensing outlet port 62. An internal thread portion 10b for attaching the temperature-sensing pressure responding element 20 to the valve main body 10E, as described hereinafter, is formed on an upper circumferential wall of the valve main body 10E. By the way, an O-ring 48 for preventing the flow of refrigerant between the valve chamber 14 and the temperature-sensing introduction chamber 60 is mounted on the intermediate diametrally enlarged portion 15c of valve rod 15. Further, the temperature-sensing outlet port 62 is offset back and forth relative to the temperature-sensing inlet port 61.

[0065] The temperature-sensing pressure responding element 20 is constituted by a closed-end short cylindrical diaphragm 21; a cap member 22 having an inverted U-shaped cross-section for partitioning, in cooperation with the diaphragm 21, the temperature-sensing chamber(diaphragm chamber) 25; and a cylindrical cap-receiving member 23 for holding, in cooperation with the cap member 22, an outer circumferential portion of the diaphragm 21 (an outer circumferential edge portion and a cylindrical portion) to hermetically sealing the pressure responding element 20, the cylindrical cap-receiving member 23 comprising a flange portion 23a for enabling the valve body 15 to be slidably inserted therein. A lower end portion of the superimposed portion (sandwiched portion) of the cap member 22, cap-receiving member 23 (the flange portion 23a thereof) and the diaphragm 21 is entirely bonded to each other by means of welding (a welded portion Ka).

[0066] The valve rod 15A of the valve body 15 is constituted by a shaft portion 15a and a diametrally enlarged portion 15b having a T-shaped cross-section. This diametrally enlarged portion 15b is disposed in such a manner that the axis thereof is fixedly secured, through press-insertion or welding, to a vertical hole formed on an upper end portion of the shaft portion 15a, and the top portion (disc portion) thereof is inserted, in a floating manner, in a recessed portion 23d formed at an upper central portion of the cap-receiving member 23, so that the top portion (disc portion) thereof is enabled to move up and down in the recessed portion 23d. On a central portion of the upper surface of the diametrally enlarged portion 15b, there are formed an annular ridge 16 having a trapezoidal cross-section as shown in FIG. 15 and a pair of annular trenches 16a and 16b located on the opposite sides of the annular ridge 16. To this annular ridge 16, the diaphragm 21 is bonded by means of projection welding (a welded portion Kb), thus positioning the diaphragm 21 coaxial with the valve body 15 (a common axial line Ox).

[0067] Meanwhile, the temperature-sensing chamber 25 of the temperature-sensing pressure responding element 20 is charged, through a short capillary tube 39 secured to the temperature-sensing chamber 25, with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler 102 in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102 (For example, under the condition where the temperature of the refrigerant on the outlet side is 40°C, when the coefficient of performance can be made maximum if the pressure of the refrigerant on the outlet side is set to 10MPa, it is controlled so that the pressure of the refrigerant on the outlet side may become 10MPa). Under this condition, the distal end of the capillary tube 39 is sealed.

[0068] The cap-receiving member 23 is provided, on an outer circumferential wall of the cylindrical portion thereof, with an external thread portion 23b which is adapted to be engaged with the internal thread portion 10b for attaching the pressure responding element to the valve main body 10E. The unit consisting of the valve body 15 and the temperature-sensing pressure responding element 20 which are integrally bonded as described above is mounted on the valve main body 10A in such a manner that the external thread portion 23b is engaged with the internal thread portion 10b of valve main body 10E and, at the same time, the unit is rotated entirely, thus mounting the unit on the valve main body 10E. Under the condition where the unit is mounted on the valve main body 10E, the temperature-sensing chamber 60 is formed between the cap-receiving member 23 and an upper portion of the valve rod 15, thereby enabling the temperature of refrigerant in this temperature-sensing chamber 60 to be detected by the temperature-sensing chamber 25.

[0069] By the way, a gasket 26 is interposed between the underside of the cap-receiving member 23 and an upper surface of the valve main body 10E. Further, on the right and left sidewalls of the valve main body 10E, there are provided tapped holes 51 and 52 and circular holes 53 and 54 for mounting the pressure control valve 1E on joint pipe couplers for the gas cooler 102 or the evaporator 104, or on the internal heat exchanger 103.

[0070] In this structure as described above, when the refrigerant on the outlet side of the gas cooler 102 is delivered from the temperature-sensing inlet port 61 to the temperature-sensing chamber 60, the temperature of refrigerant on the outlet side of the gas cooler 102 is detected by the temperature-sensing chamber 25, thereby rendering the inner pressure of the temperature-sensing chamber 25 to conform with the temperature of refrigerant on the outlet side of the gas cooler 102. As a result, the diaphragm 21 is actuated in response to the fluctuation of inner pressure of the temperature-sensing chamber 25, thereby driving the valve body 15 in an opening or closing direction to adjust the opening degree of valve, thus adjusting the pressure of refrigerant on the outlet side of the gas cooler 102 so as to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler 102.

[0071] As explained above, according to the pressure control valve 1E of this embodiment, since the opening degree of valve is adjusted by means of only the temperature-sensing pressure responding element 20, it is possible to simplify the structure of the pressure control valve and to reduce the number of parts as compared with the conventional pressure control valve wherein the opening degree of valve (the lifting quantity of the valve body) is determined by a balance between the valve-opening force originating from a pressure difference between the inside and outside of the temperature-sensing chamber and the valve-closing force by the spring member. Further, since the temperature-sensing pressure responding element is not integrated into the valve main body but is externally attached to the valve main body by means of screwing, etc., it is possible to effectively realize the simplification of the structure thereof, the reduction of the number of parts, and the reduction of the working and assembling cost.

[0072] FIGs. 16 and 17 are a longitudinal cross-sectional view and a plan view of the pressure control valve, respectively, all illustrating a sixth embodiment of the present invention. The pressure control valve 1F according to the sixth embodiment shown herein is fundamentally the same in construction as that of the pressure control valve 1E of the fifth embodiment (the portions or members constructed or functioning in the same manner as those of the pressure control valve 1E of the fifth embodiment will be identified by the same reference numerals, thereby omitting the explanations thereof). In the pressure control valve 1F of this embodiment however, it is designed such that the pressure control valve 1F can be easily mounted on the heat exchanger 103 or the gas cooler 102, and that it is no longer necessary to connect the pressure control valve 1F with a conduit and the like for forming a channel. Namely, the valve main body 10F is formed of a cylindrical configuration having a closed bottom and a step portion. This valve main body 10F is also provided, on the outer circumferential wall thereof, with an external thread portion 19 to be engaged with the internal thread portion 135 of the valve-mounting portion 130 which is formed in the internal heat exchanger 103 in advance. Further, a flange 70 hexagonal in plan view is attached to an upper edge portion of the valve main body 10b. A couple of O-rings 71 and 72 are disposed respectively over and below the pressure-adjusting inlet port 11 and the pressure-adjusting outlet port 12 which are provided at a lower portion of the valve main body 10F.

[0073] The pressure control valve 1F thus constructed can be mounted on the valve-mounting portion 130 by engaging the external thread portion 19 thereof with the internal thread portion 135 of the valve-mounting portion 130 and, at the same time, by rotating it (the flange 70) entirely.

[0074] In this embodiment, the refrigerant for pressure control which has been delivered from the gas cooler 102 is permitted to flow from an inlet channel 136 provided at a lower portion of the valve-mounting portion 130 to the valve chamber 14. Then, while being reduced in pressure depending on the opening degree of valve, the refrigerant is discharged from the valve chamber 14 and delivered, through an outlet channel 137 provided at a lower portion of the valve-mounting portion 130, to the evaporator 104.

[0075] Further, the refrigerant delivered from the gas cooler 102 is permitted to flow from an inlet channel 141 provided at an upper portion of the valve-mounting portion 130 into a temperature-sensing inlet port 61 of the valve main body 10 and, at the same time, introduced into the temperature-sensing introduction chamber 60, wherein the temperature of the refrigerant is detected by the temperature-sensing chamber 25. Thereafter, the refrigerant is delivered from a temperature-sensing outlet port 62 to the internal heat exchanger 103 through an outlet channel 142 provided at an upper portion of the valve-mounting portion 130.

[0076] FIG. 18 is a longitudinal cross-sectional view of the pressure control valve illustrating a seventh embodiment of the present invention. The pressure control valve 1G according to the seventh embodiment shown herein is fundamentally the same in construction as that of the pressure control valve 1E of the fifth embodiment (the portions or members constructed cr functioning in the same manner as those of the pressure control valve 1E of the fifth embodiment will be identified by the same reference numerals, thereby omitting the explanations thereof) . In the pressure control valve 1G of this embodiment however, it is designed such that the diametrally enlarged portion 15b is integrally attached to an upper edge portion of the shaft portion 15a of valve rod 15A and, at the same time, a vertical hole 19 having an open top is formed in the shaft portion 15a, that a through-hole 21a interconnecting the temperature-sensing chamber 25 with the vertical hole 19 is formed at a central portion of the diaphragm 21, and that an expanded temperature-sensing chamber is formed by a combination of the temperature-sensing chamber 25 and the vertical hole 19.

[0077] Since the temperature-sensing chamber is expanded toward the temperature-sensing introduction chamber 60, it is possible to enhance the temperature-sensing capability of the temperature-sensing chamber.

[0078] FIGs. 19 and 20 are a longitudinal cross-sectional view and a left side view of the pressure control valve, respectively, all illustrating an eighth embodiment of the present invention. The pressure control valve 1H according to the eighth embodiment shown herein is fundamentally the same in construction as that of the pressure control valve 1E of the fifth embodiment (the portions or members constructed or functioning in the same manner as those of the pressure control valve 1E of the fifth embodiment will be identified by the same reference numerals, thereby omitting the explanations thereof) . In the pressure control valve 1H of this embodiment however, it is designed such that a large number of annular trenches 15b are formed on the shaft portion 15a of the valve rod 15A, thereby enabling the heat of the refrigerant in the temperature-sensing chamber 60 to be readily detected by the shaft portion 15a, thus enhancing the temperature-sensing function of the shaft portion 15a. Further, the pressure control valve 1H is provided, on the entire circumferential wall thereof, with a trench 64 for shielding the transmission of heat between the pressure-adjusting inlet port 11 and the pressure-adjusting outlet port 12.

Claims

1. A pressure control valve which is adapted to be integrated into a steam-compression type refrigerating cycle which is constituted by: a compressor for circulating CO_2 employed as a refrigerant, a gas cooler for cooling the refrigerant that has been compressed by the compressor, an evaporator into which the refrigerant is designed to be introduced from the gas cooler, and an internal heat exchanger for performing heat exchange between the refrigerant on the outlet side of the evaporator and the refrigerant on the outlet side of the gas cooler; the pressure control valve being constructed to pass the refrigerant to the evaporator after adjusting, depending on the temperature of the refrigerant on the outlet side of the gas cooler, the pressure of the refrigerant that has been introduced therein via the internal heat exchanger from the gas cooler;
said pressure control valve comprising:

a temperature-sensing cylinder for sensing the temperature of the refrigerant on the outlet side of the gas cooler;
a temperature-sensing pressure responding element which is provided with a temperature-sensing chamber communicated through a capillary tube with the temperature-sensing cylinder and designed to drive a valve body into a closed or open state in response to fluctuations of inner pressure of the temperature-sensing chamber; and
a valve main body attached integrally to the pressure responding element;
wherein the temperature-sensing cylinder and the temperature-sensing chamber are filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler.

2. A pressure control valve which is adapted to be disposed in the vicinity of the gas cooler or in the vicinity of the outlet port of the gas cooler of a steam-compression type refrigerating cycle which is constituted by: a compressor for circulating CO_2 employed as a refrigerant, a gas cooler for cooling the refrigerant that has been compressed by the compressor, an evaporator into which the refrigerant is designed to be introduced from the gas cooler, and an internal heat exchanger for performing heat exchange between the refrigerant on the outlet side of the evaporator and the refrigerant on the outlet side of the gas cooler; the pressure control valve being constructed to pass the refrigerant to the evaporator after adjusting, depending on the temperature of the refrigerant on the outlet side of the gas cooler, the pressure of the refrigerant that has been introduced therein via the internal heat exchanger from the gas cooler;
said pressure control valve comprising:

a temperature-sensing pressure responding element which is provided with a temperature-sensing chamber for sensing the temperature of refrigerant on the outlet side of the gas cooler and designed to drive a valve body into a closed or open state in response to fluctuations of inner pressure of the temperature-sensing chamber; and
a valve main body attached integrally to the pressure responding element;
wherein the temperature-sensing chamber is filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler in order to secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler.

3. The pressure control valve according to claim 1 or 2, wherein the valve main body is formed of an approximately rectangular parallelepiped body which is cut out from an extruded rod having a rectangular cross-section and provided with a refrigerant entrance port, a mounting portion for the pressure responding element, and a valve seat portion for removably receiving the valve body.

4. The pressure control valve according to claim 1 or 2, wherein the valve main body is provided with at least one engaging portion selected from an external thread portion, a flange portion, an internal thread portion for receiving bolts, and an insertion hole for attaching the valve main body to a pipe coupler or to the internal heat exchanger.

5. The pressure control valve according to claim 1 or 2, wherein the temperature-sensing pressure responding element is constituted by a diaphragm; a cap member having an inverted U-shaped cross-section for partitioning, in cooperation with the diaphragm, the temperature-sensing chamber; and a cylindrical cap-receiving member for holding, in cooperation with the cap member, an outer circumferential portion of the diaphragm to hermetically sealing the pressure responding element, the cylindrical cap-receiving member comprising a flange portion for enabling the valve body to be slidably inserted therein; wherein the cap-receiving member is additionally provided on an outer circumferential wall of the cylindrical portion thereof with an external thread for attaching the pressure responding element to the valve main body.

6. The pressure control valve according to claim 1 or 2, wherein the valve main body is further provided therein with a restraining spring for suppressing the vibration of the valve body.

7. The pressure control valve according to claim 6, wherein the restraining spring for vibration is formed of an elastic plate and constituted by a generally annular bottom portion having an inverted V-shaped cross-section and being press-contacted with the valve main body by means of the cap-receiving member, and by a plurality of tongue-shaped flexible flaps extending upward from an inner periphery of the annular bottom portion and elastically contacted with an outer circumferential wall of the valve body.

8. The pressure control valve according to claim 5, wherein the valve body and the diaphragm are disposed coaxially and one end portion of the valve body is bonded to the diaphragm by means of projection welding.

9. The pressure control valve according to claim 5, wherein the diaphragm is formed of a closed-end shortened cylindrical body, and an outer edge portion and cylindrical portion of the diaphragm are held between the cap member and the cap-receiving member to hermetically seal the pressure responding element, wherein the lower end portion of this laminated portion is welded to each other throughout the entire periphery thereof.

10. The pressure control valve according to claim 5, wherein the cap-receiving member is formed of two parts, i.e. a cylindrical portion having an external thread portion, and a flange portion which can be manufactured by press-working a plate.

11. The pressure control valve according to claim 2, wherein the temperature-sensing chamber is provided, on an outer circumference thereof, with temperature-sensing fins, or with a temperature-sensing fin-attached cylindrical or cap body.

12. The pressure control valve according to claim 1 or 2, wherein the valve body is partitioned into an axis portion and an enlarged portion.

13. The pressure control valve according to claim 1 or 2, wherein the valve seat of the valve main body is provided with a plurality of bleed notches.

14. A pressure control valve which is adapted to be integrated into a steam-compression type refrigerating cycle which is constituted by: a compressor for circulating CO_2 employed as a refrigerant, a gas cooler for cooling the refrigerant that has been compressed by the compressor, an evaporator into which the refrigerant is designed to be introduced from the gas cooler, and an internal heat exchanger for performing heat exchange between the refrigerant on the outlet side of the evaporator and the refrigerant on the outlet side of the gas cooler; the pressure control valve being constructed to pass the refrigerant to the evaporator after adjusting, depending on the temperature of the refrigerant on the outlet side of the gas cooler, the pressure of the refrigerant that has been introduced therein via the internal heat exchanger from the gas cooler;
said pressure control valve comprising:

a temperature-sensing inlet port for introducing therein the refrigerant from the gas cooler;
a temperature-sensing outlet port for sending the refrigerant to the internal heat exchanger;
a temperature-sensing introduction chamber interposed between the temperature-sensing inlet port and the temperature-sensing outlet port;
a temperature-sensing pressure responding element comprising a temperature-sensing chamber for sensing the temperature of the refrigerant that has been introduced into the temperature-sensing introduction chamber, the temperature-sensing pressure responding element being further capable of driving a valve body into a closed or open state in response to fluctuations of inner pressure of the temperature-sensing chamber; and
a valve main body to which the temperature-sensing pressure responding element can be integrally attached;
wherein the temperature-sensing chamber is filled with CO_2 at a predetermined density and also with a bulking quantity of an inert gas, thereby enabling to adjust the pressure of refrigerant on the outlet side of the gas cooler in order to

secure a maximum coefficient of performance relative to the temperature of refrigerant on the outlet side of the gas cooler.

15. The pressure control valve according to claim 14, wherein the valve main body is formed of a solid body which is cut out from an extruded rod having a +-shaped or rectangular cross-section and provided with the temperature-sensing inlet port, the temperature-sensing outlet port, the temperature-sensing introduction chamber, the pressure-adjusting inlet port, the pressure-adjusting outlet port, a mounting portion for the pressure responding element, and a valve seat portion for removably receiving the valve body.

16. The pressure control valve according to claim 15, wherein a guide hole for enabling the valve body to be slidably inserted therein is provided over the valve seat of the valve main body, wherein the temperature-sensing inlet port, temperature-sensing outlet port and temperature-sensing introduction chamber are disposed over the guide hole, and the pressure-adjusting inlet port, pressure-adjusting outlet port and a valve chamber are disposed below the guide hole.

17. The pressure control valve according to claim 14, wherein the valve main body is provided with at least one engaging portion selected from an external thread portion, a flange portion, an internal thread portion for receiving bolts, and an insertion hole for attaching the valve main body to the gas cooler, to a pipe coupler for connection with the evaporator, or to the internal heat exchanger.

18. The pressure control valve according to claim 14, wherein the temperature-sensing pressure responding element is constituted by a diaphragm; a cap member having an inverted U-shaped cross-section for partitioning, in cooperation with the diaphragm, the temperature-sensing chamber; and a cylindrical cap-receiving member for holding, in cooperation with the cap member, an outer circumferential portion of the diaphragm to hermetically sealing the pressure responding element, the cylindrical cap-receiving member comprising a flange portion for enabling the valve body to be inserted therein through the inner periphery thereof; wherein the cap-receiving member is additionally provided on an outer circumferential wall of the cylindrical portion thereof with an external thread for attaching the pressure responding element to the valve main body.

19. The pressure control valve according to claim 18, wherein the valve body and the diaphragm are disposed coaxially and one end portion of the valve body is bonded to the diaphragm by means of projection welding.

20. The pressure control valve according to claim 8 or 19, wherein the valve body is consisted of a columnar valve rod, and a valve body portion formed at a lower end portion of the valve rod, wherein the valve rod is composed of a shaft portion, and an enlarged portion which is formed integral with or fixedly secured to an upper portion of the shaft portion, the diaphragm being coupled to an upper surface of the enlarged portion.

21. The pressure control valve according to claim 18, wherein the temperature-sensing introduction chamber is formed between the valve rod and the cylindrical portion of the cap-receiving member.

22. The pressure control valve according to claim 18, wherein the valve body is provided with a longitudinal hole having an open top, and the diaphragm is provided with a through-hole for enabling the temperature-sensing chamber to the longitudinal hole, thereby constituting one extended temperature-sensing chamber consisting of the temperature-sensing chamber and the longitudinal hole.

23. The pressure control valve according to claim 18, wherein the diaphragm is formed of a closed-end shortened cylindrical body, and the outer edge portion and cylindrical portion of the diaphragm are held between the cap member and the cap-receiving member to hermetically seal the pressure responding element, wherein the lower end portion of the laminated portion is welded to each other throughout the entire periphery thereof.

24. The pressure control valve according to claim 15, wherein the valve body is provided, along the whole length of the circumferential wall thereof, with a trench for interrupting heat transmission between the temperature-sensing inlet port and the temperature-sensing outlet port, and between the pressure-adjusting inlet port and the pressure-adjusting outlet port.

25. The pressure control valve according to claim 15, wherein the valve seat of the valve main body is provided with a plurality of bleed notches.

26. The pressure control valve according to claim 20, wherein the valve rod of the valve body is provided with a plurality of annular trenches.

FIG. 1

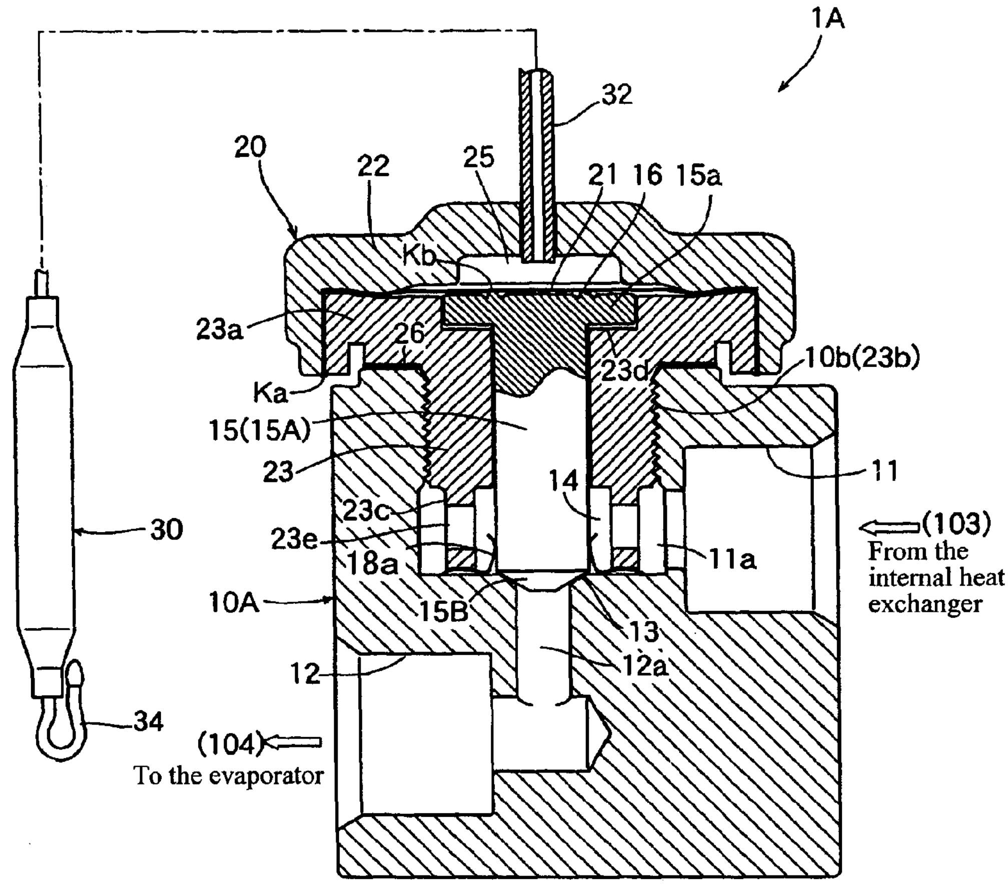
1A
32
20
22
25
21 16 15a
Kb
23a
26
23d
10b(23b)
Ka
15(15A)
23
14
11
23c
30
23e
18a
11a
(103)
From the internal heat exchanger
10A
15B
13
12a
12
34
(104)
To the evaporator

FIG. 2

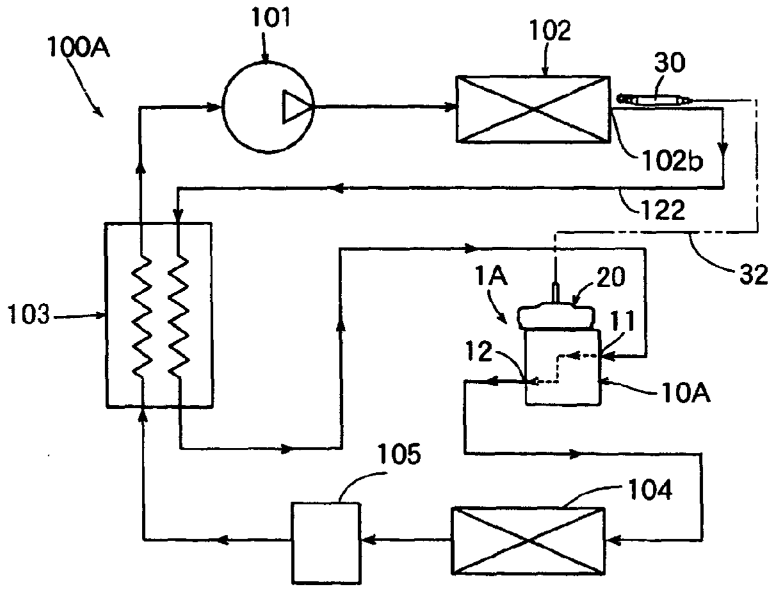
101
102
100A
30
102b
122
32
1A
20
103
11
12
10A
105
104

FIG. 3

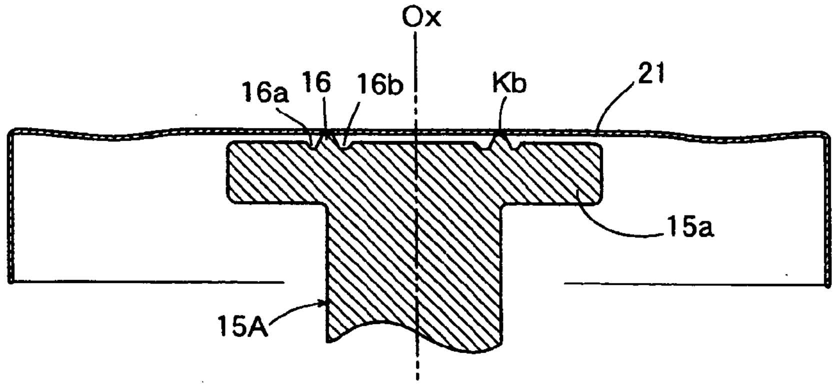

FIG. 4 (A)

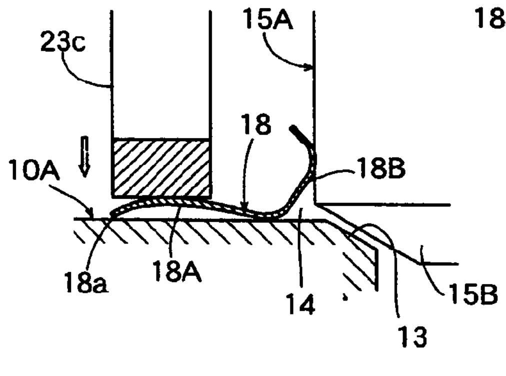

FIG. 4 (B)

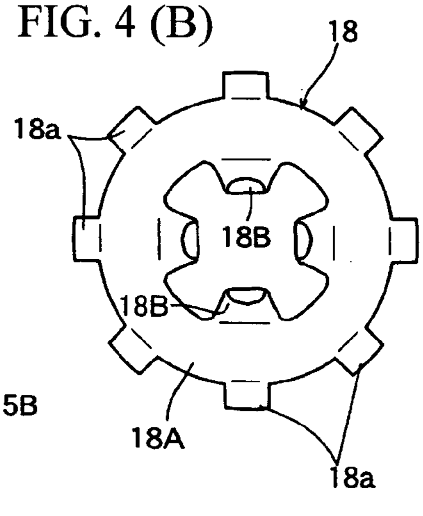

FIG. 4 (C)

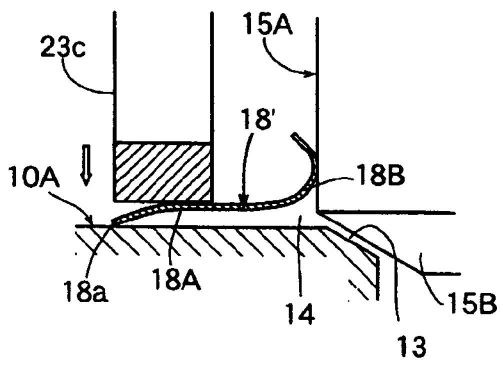

FIG. 5

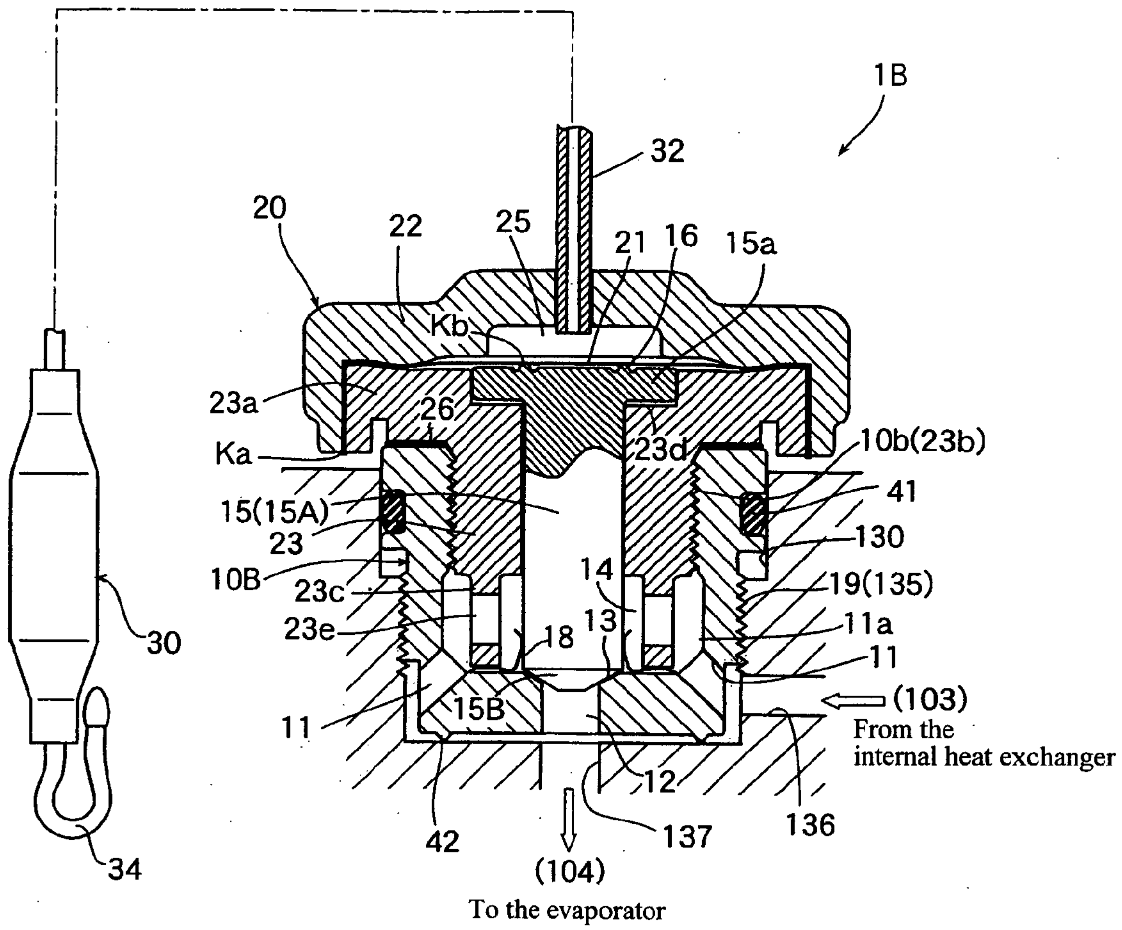
1B
32
20
22
25
21
16
15a
Kb
23a
26
23d
Ka
10b(23b)
41
15(15A)
23
130
10B
23c
14
19(135)
23e
13
11a
18
11
11
15B
(103)
From the
internal heat exchanger
12
30
42
137
136
34
(104)
To the evaporator

FIG. 6

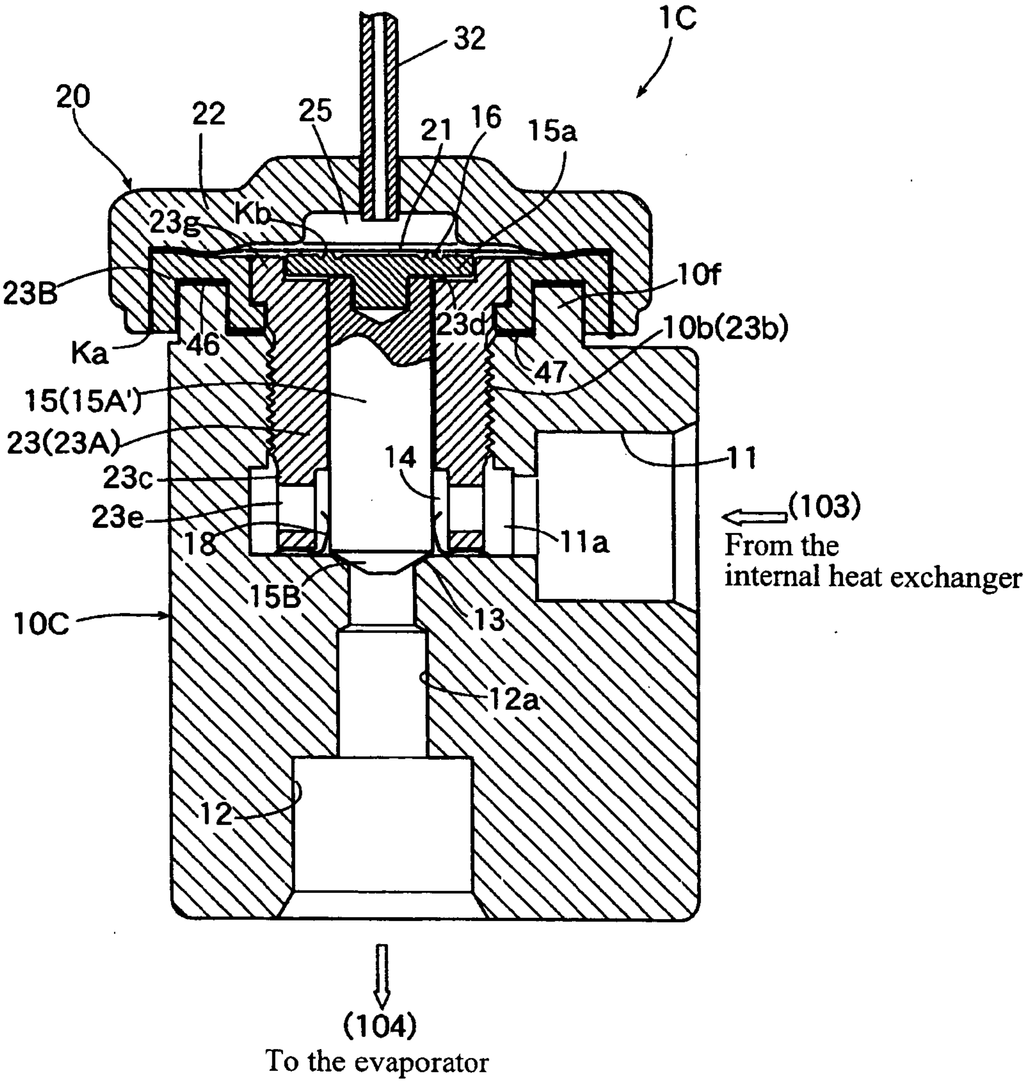
1C
32
20
22
25
21
16
15a
23g
Kb
23B
10f
23d
Ka
46
10b(23b)
47
15(15A')
23(23A)
14
11
23c
(103)
23e
11a
From the
internal heat exchanger
18
15B
13
10C
12a
12
(104)
To the evaporator

FIG. 7

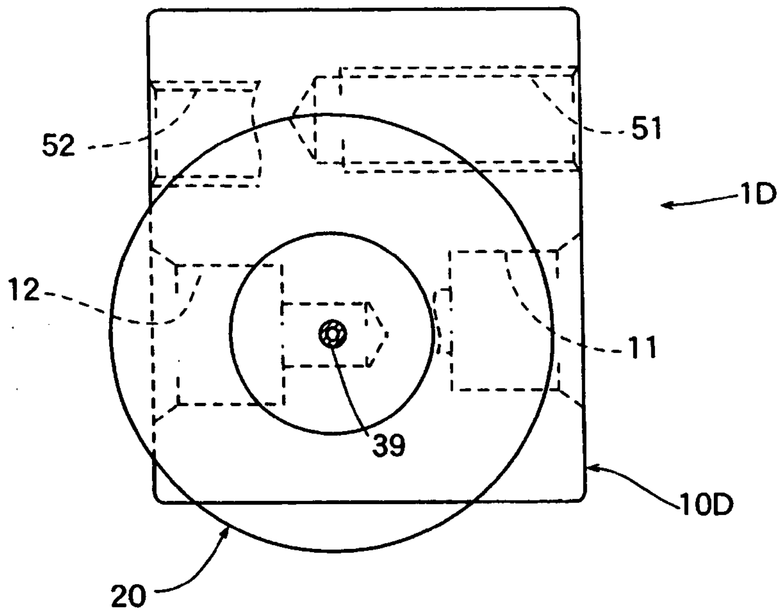

FIG. 8

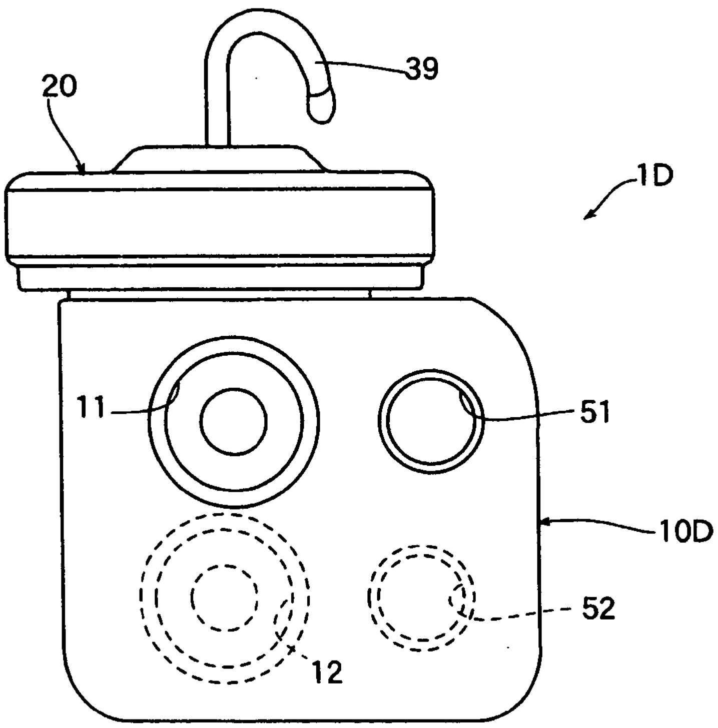

FIG. 9

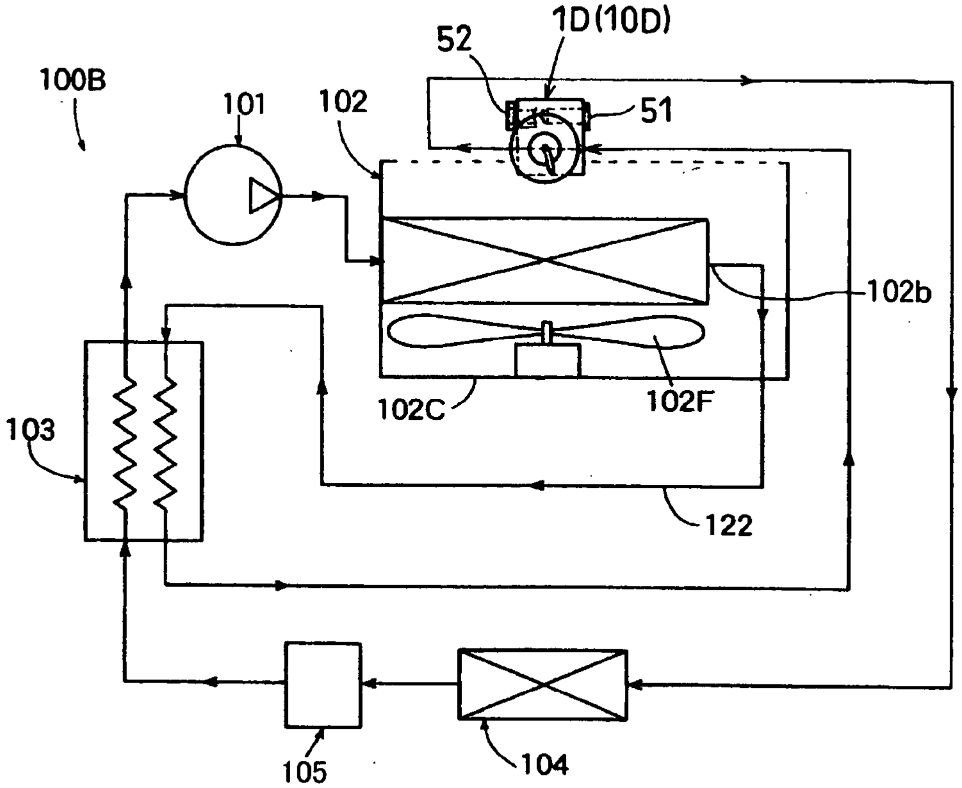

FIG. 10 (A)

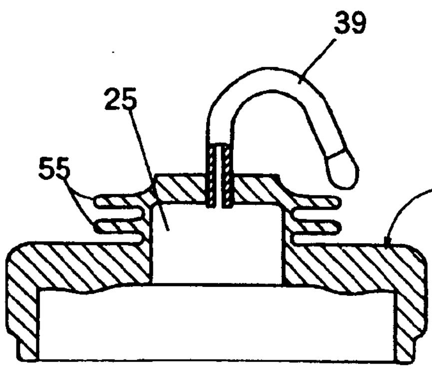

FIG. 10 (B)

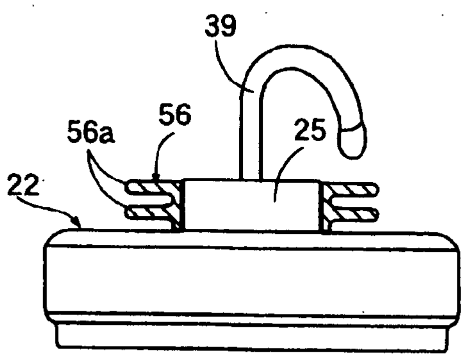

FIG. 11

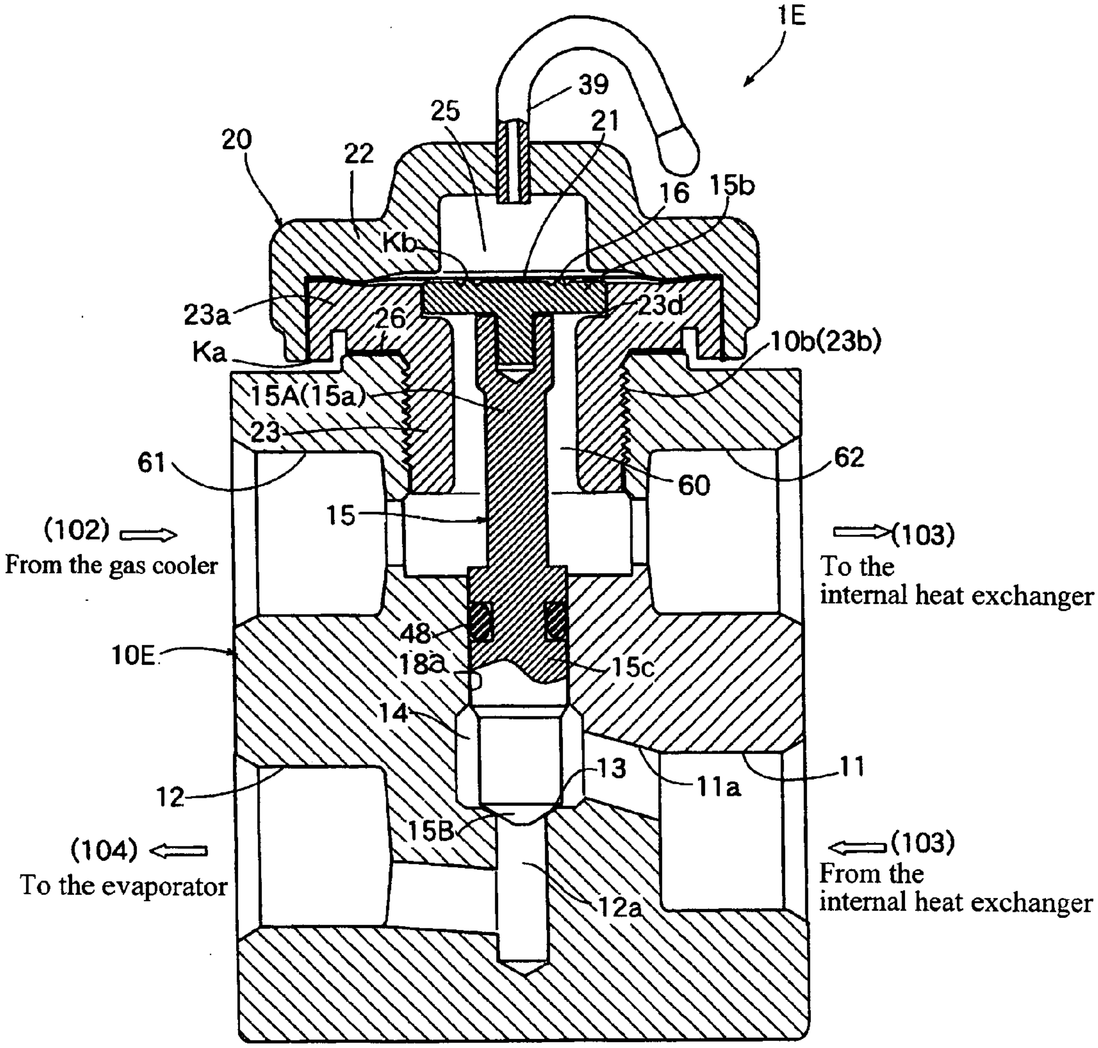
1E
39
25
21
20
22
16
15b
Kb
23a
26
23d
Ka
10b(23b)
15A(15a)
23
61
62
60
15
(102)
From the gas cooler
(103)
To the
internal heat exchanger
10E
48
18a
15c
14
13
11a
11
12
15B
(104)
To the evaporator
(103)
From the
internal heat exchanger
12a

FIG. 12

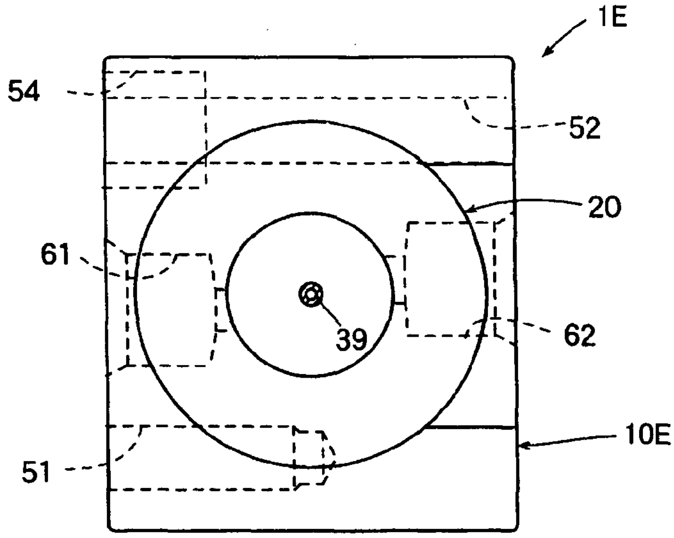

FIG. 13

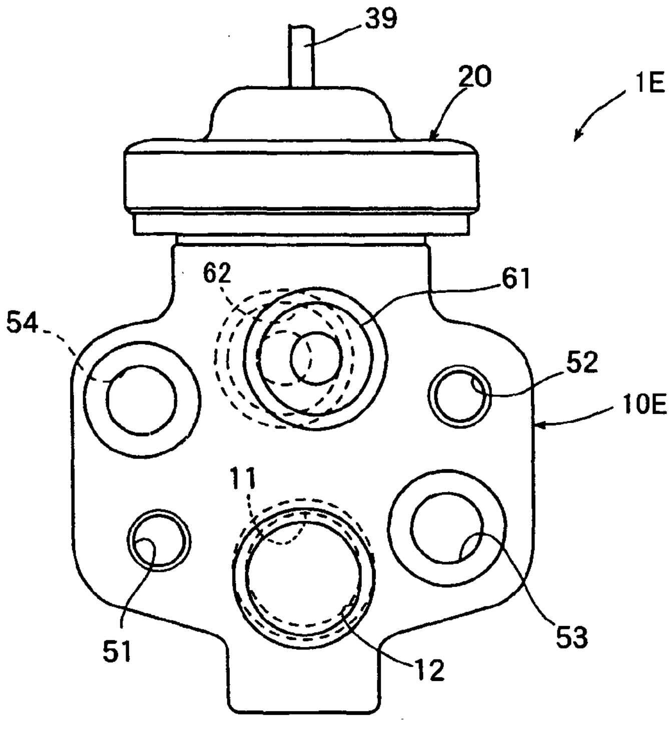

FIG. 14

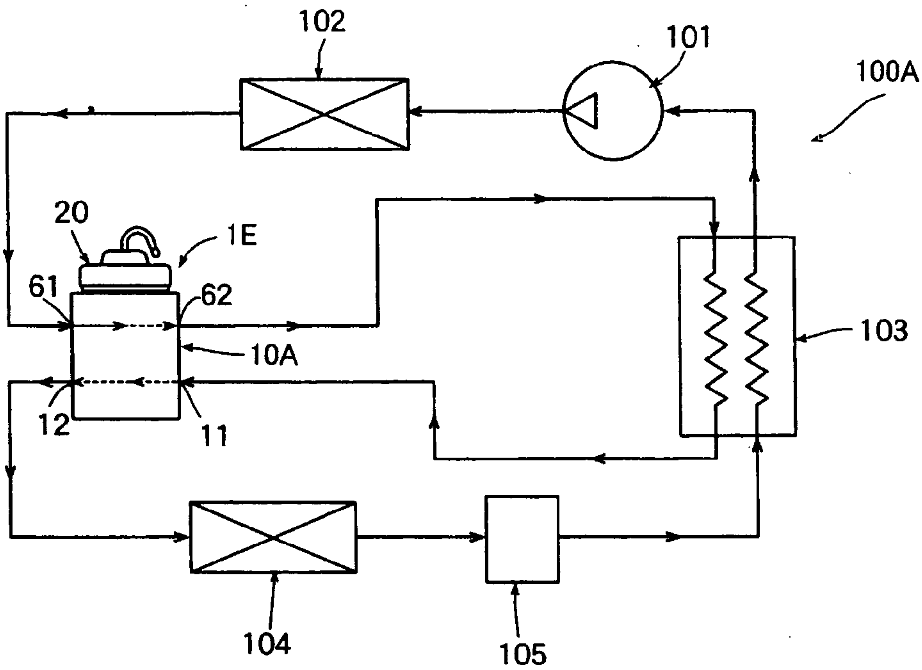
102
101
100A
20
1E
61
62
10A
103
12
11
104
105

FIG. 15

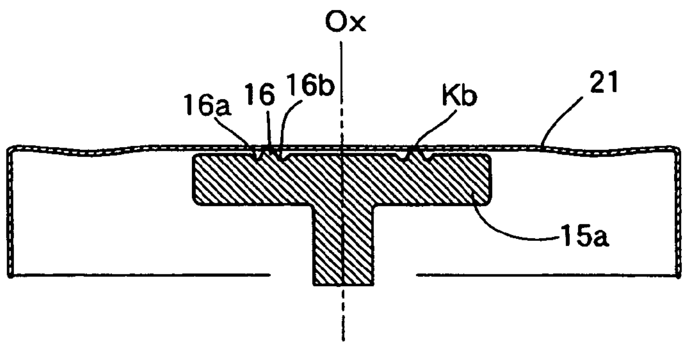
Ox
16a
16
16b
Kb
21
15a

FIG. 16

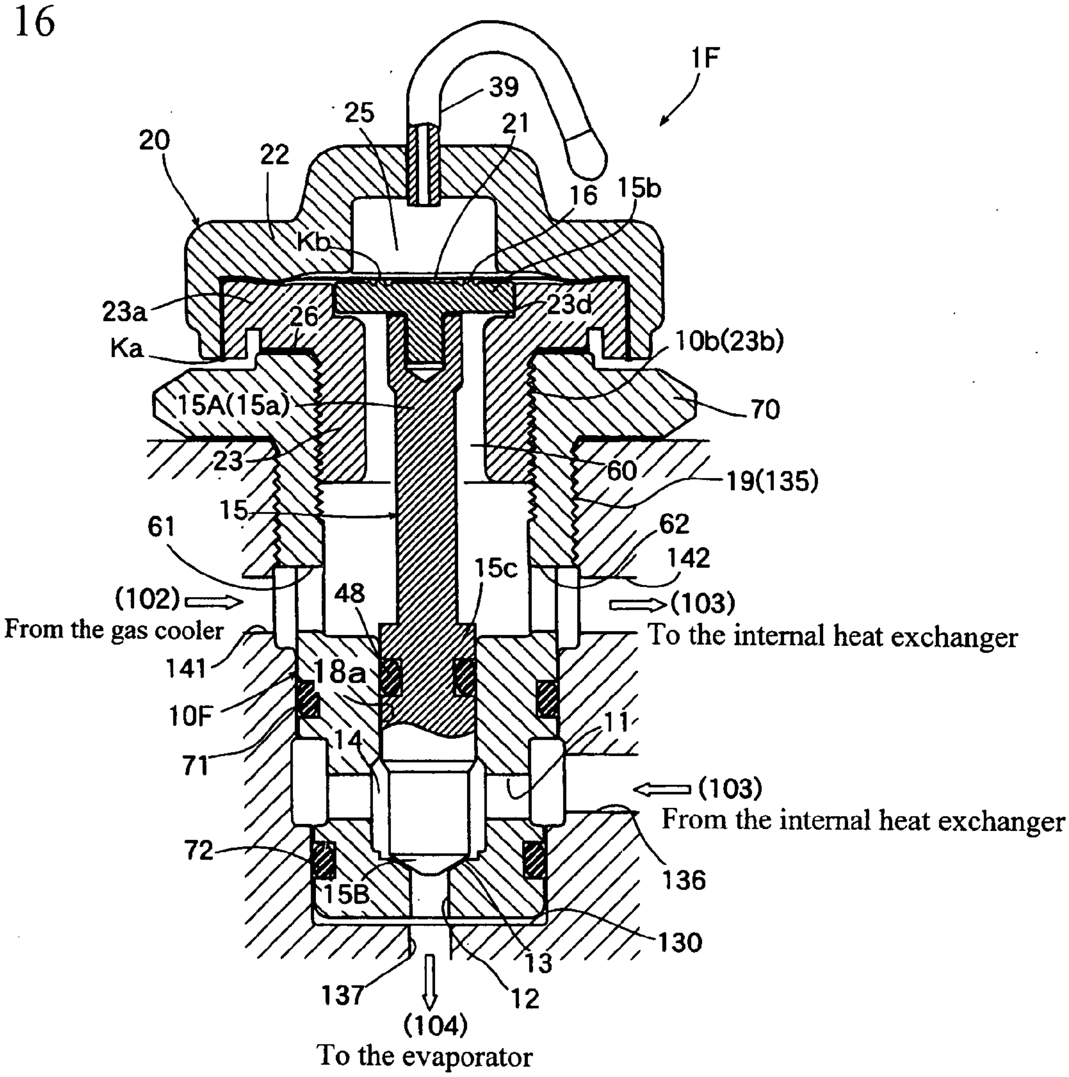
1F
39
25
21
20
22
16
15b
Kb
23a
26
23d
Ka
10b(23b)
15A(15a)
70
23
60
19(135)
15
61
62
142
15c
(102)
48
(103)
From the gas cooler
To the internal heat exchanger
141
18a
10F
11
71
14
(103)
From the internal heat exchanger
72
136
15B
130
13
137
12
(104)
To the evaporator

FIG. 17

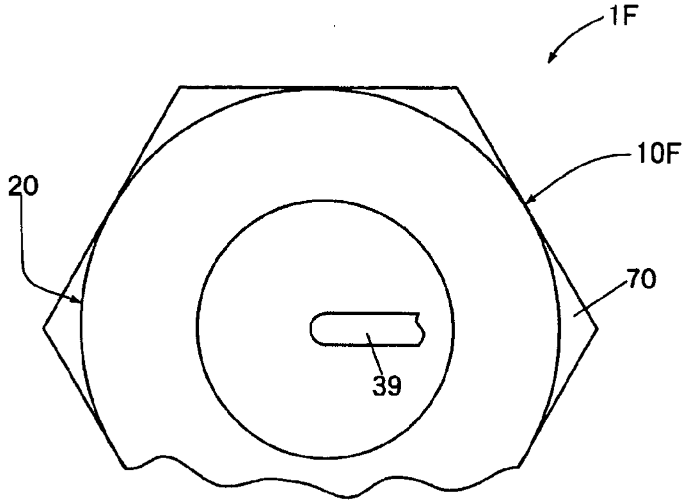
1F
10F
20
70
39

FIG. 18

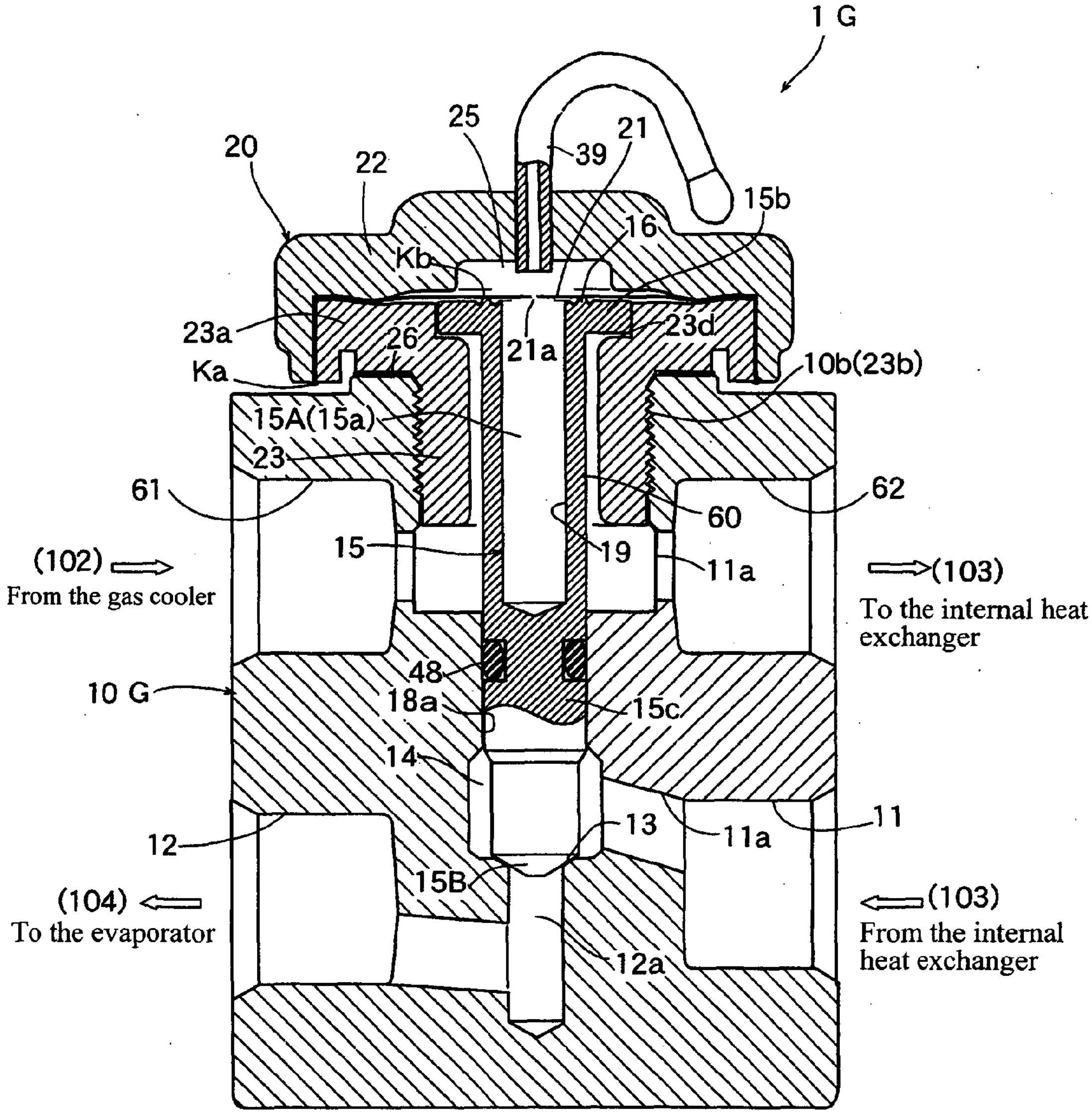
1 G
20
22
25
39
21
15b
16
Kb
23a
26
21a
23d
Ka
10b(23b)
15A(15a)
23
61
60
62
15
19
11a
(102)
From the gas cooler
(103)
To the internal heat exchanger
48
10 G
18a
15c
14
11
12
13
11a
15B
(104)
To the evaporator
(103)
From the internal heat exchanger
12a

FIG. 19

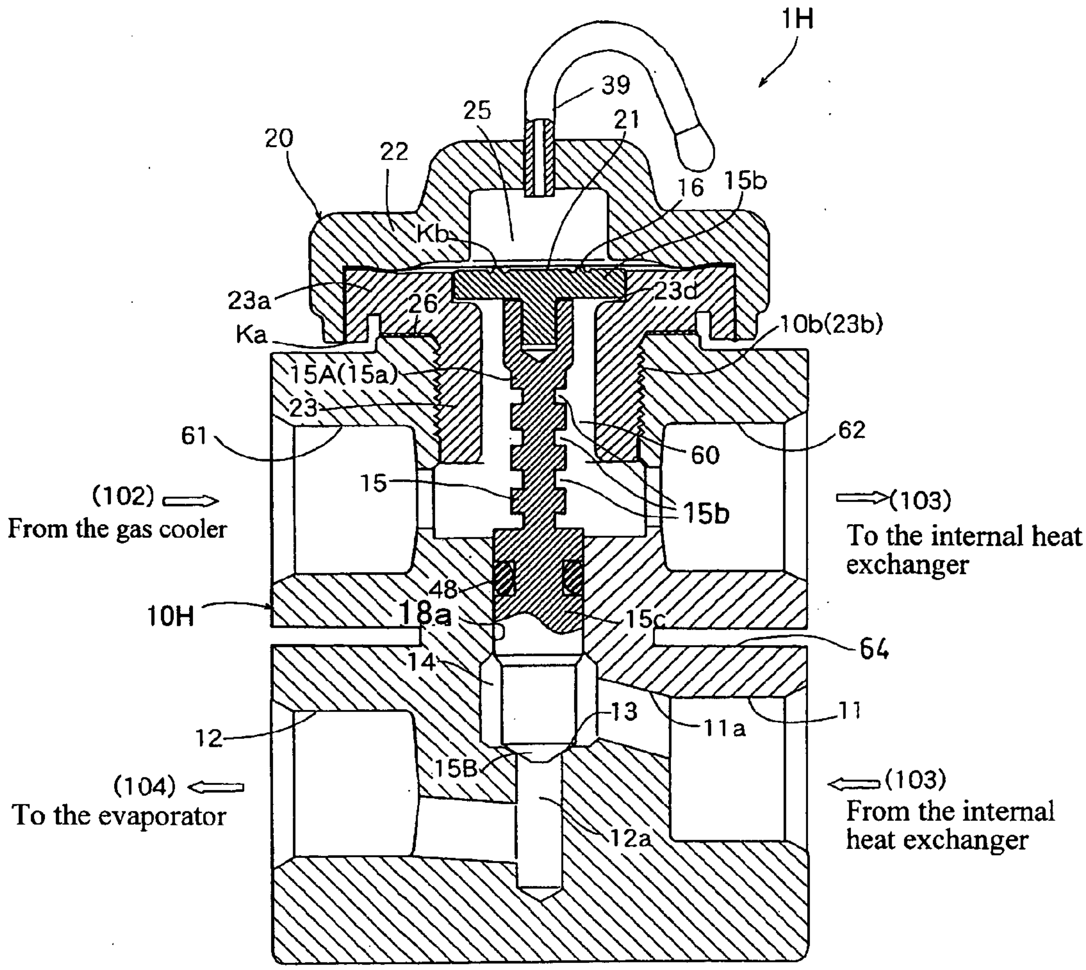
1H
39
25
21
20
22
16
15b
Kb
23a
26
23d
Ka
10b(23b)
15A(15a)
23
61
62
60
(102)
From the gas cooler
15
15b
(103)
To the internal heat exchanger
48
10H
18a
15c
64
14
13
12
11a
11
15B
(104)
To the evaporator
(103)
From the internal heat exchanger
12a

FIG. 20

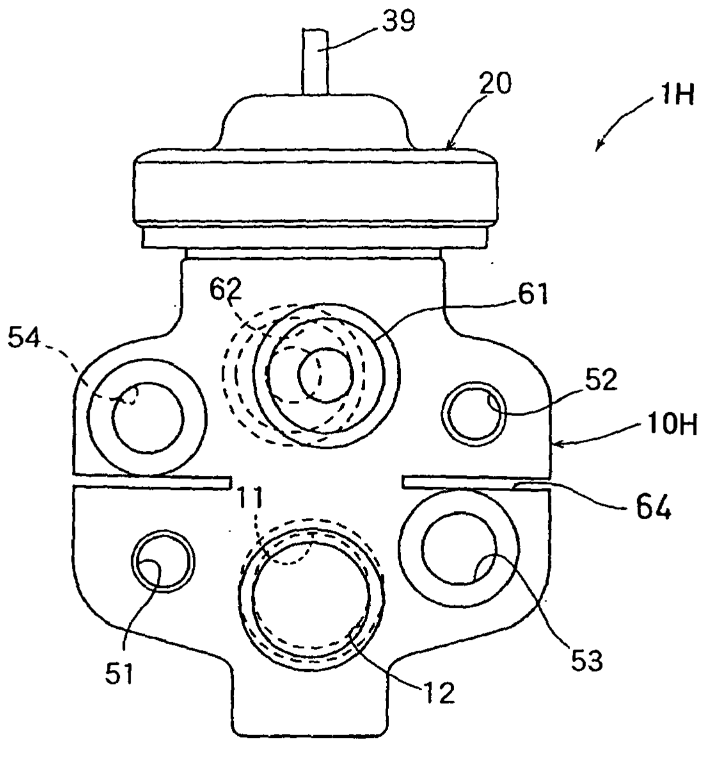

FIG. 21