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(71) Applicant: **Fuji Electric Co., Ltd.**
**Kawasaki-shi,**
**Kanagawa 210-9530 (JP)**

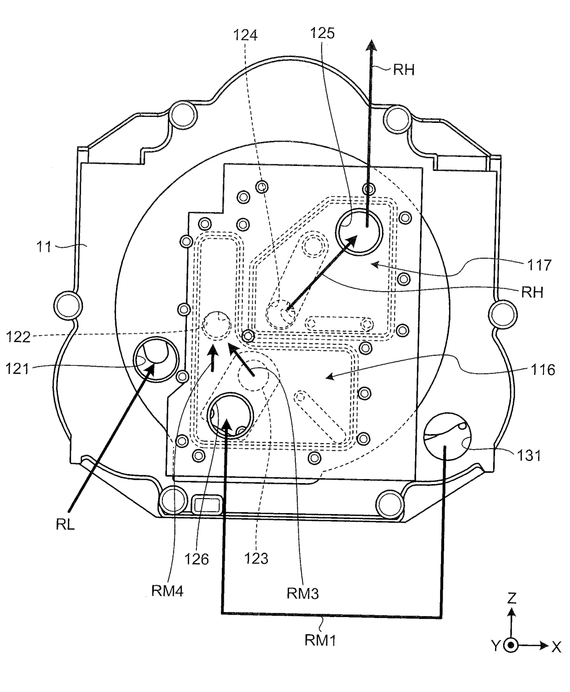
(72) Inventors:
- **AJIMA, Masaaki**
  **Kawasaki-shi, Kanagawa 210-9530 (JP)**
- **IWASAKI, Masamichi**
  **Kawasaki-shi, Kanagawa 210-9530 (JP)**
- **TERAWAKI, Hiroyuki**
  **Kawasaki-shi, Kanagawa 210-9530 (JP)**

(74) Representative: **Appelt, Christian W.**
**Boehmert & Boehmert**
**Anwaltspartnerschaft mbB**
**Pettenkoferstrasse 22**
**80336 München (DE)**

(54) **MULTIPLE-STAGE COMPRESSOR**

(57) Such a multi-stage compressor is provided that a number of valves, openings, and tubes, which are specific to two-stage compression, are arranged in an integrated manner so as to improve maintainability and compactness of the device. The compressor therefore includes a plurality of compression chambers in a housing, a medium-pressure refrigerant discharge port 123 that discharges medium-pressure refrigerant RM3 from a low-stage compression chamber of the compression chambers, a medium-pressure refrigerant suction port 122 that is open in the same direction as the medium-pressure refrigerant discharge port 123 and induces the medium-pressure refrigerant RM3 to a high-stage compression chamber of the compression chambers, a high-pressure refrigerant discharge port 124 that is open in the same direction as the medium-pressure refrigerant discharge port 123 and discharges high-pressure refrigerant discharged from the high-stage compression chamber of the compression chambers, and a refrigerant connection cover that is detachably mounted on the housing, and forms a medium-pressure refrigerant chamber 116 communicating with the medium-pressure refrigerant suction port 122 and the medium-pressure refrigerant discharge port 123 and having an external medium-pressure refrigerant connection induction port 126 that is open toward the outside, and forms a high-pressure refrigerant chamber 117 communicating with the high-pressure refrigerant discharge port 124 and has a high-pressure refrigerant ejection port 125 that is open toward the outside.

FIG.34

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## Description

### Field

**[0001]** The present invention relates to a multi-stage compressor with a multi-stage compression mechanism, the multi-stage compressor capable of achieving compactness of a system with an uncomplicated configuration even when an amount of circulating refrigerant introduced to a low-stage compression mechanism differs from that introduced to a high-stage compression mechanism.

### Background

**[0002]** Compressors including a two-stage compression mechanism inside one scroll compressor have been conventionally known. For example, Patent Literature 1 discloses a two-stage compression scroll compressor that is provided with a land portion for dividing a compression chamber of a fixed scroll into two stages, that forms a low-stage compression mechanism and a high-stage compression mechanism respectively on the outer periphery and the inner periphery, which are divided by the land, and that introduces air compressed by the low-stage compression mechanism to the high-stage compression mechanism.

### Citation List

### Patent Literature

**[0003]** Patent Literature 1: Japanese Laid-open Patent Publication No. 2004-332556

### Summary

### Technical Problem

**[0004]** In the above-described two-stage compression scroll compressor, the circulating refrigerant compressed in the low-stage compression mechanism is compressed in the high-stage compression mechanism as it is. When the two-stage compression scroll compressor is to be applied for a two-stage compression two-stage expansion cycle compressor, medium-pressure refrigerant expanded by a high-stage expansion valve is introduced into the high-stage compression mechanism. Consequently, the amount of circulating refrigerant introduced to the high-stage compression mechanism becomes larger than the amount of circulating refrigerant introduced to the low-stage compression mechanism, and this makes it difficult to achieve two-stage compression. Achieving this two-stage compression two-stage expansion cycle needs a pair of scroll compressors constituted of a low-stage scroll compressor and a high-stage scroll compressor. Accordingly, a two-stage compression two-stage expansion cycle scroll compressor increases in size and has a complex layout of tubes.

**[0005]** Considering the above-described fact, the present invention aims to provide a multi-stage compressor having a large number of valves, openings, and tubes, which are specific to the two-stage compression, arranged in an integrated manner so as to improve the maintainability and compactness of the multi-stage compressor.

### Solution to Problem

**[0006]** To solve the above problem and attain the object, a multi-stage compressor includes: a plurality of compression chambers formed in a housing; a medium-pressure refrigerant discharge port that discharges medium-pressure refrigerant from a low-stage compression chamber of the compression chambers; a medium-pressure refrigerant suction port that is open in a same direction as the medium-pressure refrigerant discharge port and induces the medium-pressure refrigerant into a high-stage side of the compression chambers; a high-pressure refrigerant discharge port that is open in a same direction as the medium-pressure refrigerant discharge port and discharges high-pressure refrigerant discharged from a high-stage compression chamber of the compression chambers; and a refrigerant connection cover that is detachably mounted on the housing, and that forms a medium-pressure refrigerant chamber, which communicates with the medium-pressure refrigerant suction port and the medium-pressure refrigerant discharge port and which has an external medium-pressure refrigerant connection induction port that is open toward an outside and a high-pressure refrigerant chamber, which communicates with the high-pressure refrigerant discharge port and which has a high-pressure refrigerant ejection port open toward an outside.

**[0007]** Further, in the multi-stage compressor according to the present invention, the housing has a housing medium-pressure refrigerant suction port that is open in a same direction as the medium-pressure refrigerant discharge port and that discharges medium-pressure refrigerant through a seal in the housing, and the medium-pressure refrigerant suction port and the external medium-pressure refrigerant connection induction port are connected with each other with a tube.

**[0008]** Further, in the multi-stage compressor according to the present invention, a high-pressure relief unit that allows the high-stage compression chamber and the high-pressure refrigerant chamber to communicate with each other when an inner pressure of the high-stage compression chamber becomes equal to or greater than a predetermined value is provided in the high-pressure refrigerant chamber of the housing.

**[0009]** Further, in the multi-stage compressor according to the present invention, a medium-pressure relief unit that allows the low-stage compression chamber and the medium-pressure refrigerant chamber to communicate with each other when an inner pressure of the low-stage compression chamber becomes equal to or greater than a predetermined value is provided in the medium-pressure refrigerant chamber of the housing.

**[0010]** Further, in the multi-stage compressor according to the present invention, a check valve for preventing circulating back to a compression chamber through the medium-pressure refrigerant discharge port is provided in the medium-pressure refrigerant chamber of the housing.

**[0011]** Further, in the multi-stage compressor according to the present invention, a check valve for preventing circulating back to a compression chamber through the high-pressure refrigerant discharge port is provided in the high-pressure refrigerant chamber of the housing.

**[0012]** Further, in the multi-stage compressor according to the present invention, the multi-stage compressor is a scroll compressor including an orbiting scroll and a fixed scroll, and the fixed scroll constitutes a part of the housing, and the refrigerant connection cover is mounted on the fixed scroll.

**[0013]** Further, in the multi-stage compressor according to the present invention, a capacity of the medium-pressure refrigerant chamber is larger than a capacity of the high-pressure refrigerant chamber.

**[0014]** Further, in the multi-stage compressor according to the present invention, a notch for positioning is formed on the refrigerant connection cover.

**[0015]** Further, in the multi-stage compressor according to the present invention, the multi-stage compressor is used for a two-stage compression two-stage expansion thermal cycle system.

Advantageous Effects of Invention

**[0016]** According to the present invention, a large number of valves, openings, and tubes, which are specific to two-stage compression, are arranged in an integrated manner so as to be able to improve the maintainability and compactness of the multi-stage compressor.

Brief Description of Drawings

**[0017]**

FIG. 1 is a circuit diagram that illustrates a schematic configuration of a thermal cycle system that uses a scroll compressor, which is a multi-stage compressor of a first embodiment of the present invention.
FIG. 2 is a p-h diagram of the thermal cycle system of FIG. 1.
FIG. 3 is a sectional view that illustrates the configuration of the scroll compressor.
FIG. 4 is a sectional view along A-A line of FIG. 3.
FIG. 5 is a sectional view of a fixed scroll and an orbiting scroll illustrated in FIG. 3.
FIG. 6 is a perspective view of the fixed scroll of FIG. 4 viewed from diagonally below.
FIG. 7 is a perspective view of the orbiting scroll of FIG. 4 viewed from diagonally above.
FIGS. 8 is an illustrative drawing to illustrate compression operation of a symmetric-type scroll compressor.
FIG. 9 is an illustrative drawing to explain compression operation of an asymmetric-type scroll compressor.
FIG. 10 is an illustrative drawing to explain relation between a point on an involute curve and an involute roll angle.
FIG. 11 is a diagram for comparison of compression operation of the symmetric-type scroll compressor and the asymmetric-type scroll compressor.
FIG. 12 is an illustrative diagram to explain compression operation of the asymmetric-type scroll compressor that reduces the loss of recompression.
FIG. 13 is a sectional view of a slanted orbiting scroll.
FIG. 14 is an illustrative drawing to explain a reduction in the compression efficiency occurring at an outer compression area under the condition of FIG. 13.
FIG. 15 is an illustrative drawing to explain a reduction in the volumetric efficiency occurring at an inner compression area under the condition of FIG. 13.
FIG. 16 is a sectional view of an annular seal mounted on a front end surface of an outer wall of the fixed scroll.
FIG. 17 is a sectional view of the scroll compressor with the annular seal, along B-B line of FIG. 3.

FIG. 18 is a sectional view of the annular seal mounted on a base plate of the orbiting scroll.
FIG. 19 is an example drawing of the annular seal having a separation gap.
FIG. 20 is another example drawing of the annular seal having a separation gap.
FIG. 21 is an example drawing of the annular seal having hollow portions.
FIG. 22 is a circuit diagram that illustrates an example thermal cycle system.
FIG. 23 is a p-h diagram of the thermal cycle system of FIG. 22.
FIG. 24 is a circuit diagram that illustrates an example thermal cycle system.
FIG. 25 is a p-h diagram of the thermal cycle system of FIG. 24.
FIG. 26 is a circuit diagram that illustrates an example thermal cycle system.
FIG. 27 is a p-h diagram of the thermal cycle system of FIG. 26.
FIG. 28 is a circuit diagram that illustrates an example thermal cycle system.
FIG. 29 is a p-h diagram of the thermal cycle system of FIG. 28.
FIG. 30 is a vertical sectional view that illustrates the configuration of a scroll compressor of a fourth embodiment.
FIG. 31 is a perspective view of the scroll compressor of FIG. 30 viewed diagonally from the right.
FIG. 32 is a perspective view of the scroll compressor of FIG. 30 viewed diagonally from the left.
FIG. 33 is a perspective view of a refrigerant connection cover of FIG. 30 viewed from the back thereof.
FIG. 34 is a front view with the refrigerant connection cover mounted.
FIG. 35 is a front view with the refrigerant connection cover removed.

## Description of Embodiments

**[0018]** Embodiments of the present invention will now be described with reference to the accompanying drawings.

## First Embodiment

### Summary of Application to System

**[0019]** FIG. 1 is a circuit diagram that illustrates a schematic configuration of a thermal cycle system 1 that uses a scroll compressor 2, which is a multi-stage compressor of a first embodiment of the present invention. FIG. 2 is a p-h diagram of the thermal cycle system 1 of FIG. 1. The scroll compressor 2 is a two-stage compressor and is an example multi-stage compressor. The thermal cycle of the thermal cycle system 1 is particularly a two-stage compression two-stage expansion cycle.

**[0020]** A high-stage compression chamber of the scroll compressor 2 generates a high-pressure refrigerant RH of circulating refrigerant amount GH and introduces the refrigerant to a condenser 3 (from point P2 to point P3 of FIG. 2). The high-pressure refrigerant RH is condensed by the condenser 3 and rejects heat thereof. The high-pressure refrigerant RH is then supercooled by a supercooling device 4 (from point P3 to point P4 of FIG. 2). The high-pressure refrigerant RH is depressurized by a high-stage expansion valve 5 and expands (from point P4 to point P5 of FIG. 2) to be a medium-pressure refrigerant RM and is introduced to a gas-liquid separator 6. A gaseous medium-pressure refrigerant RM1, which is vapor of the medium-pressure refrigerant RM, is introduced to the high-stage compression chamber of the scroll compressor 2 (point P2 of FIG. 2). A liquid medium-pressure refrigerant RM2 of the medium-pressure refrigerant RM is depressurized by a low-stage expansion valve 7 and expands and turns into a low-pressure refrigerant RL (from point P6 to point P7 of FIG. 2), and is introduced to an evaporator 8. The low-pressure refrigerant RL is evaporated by the evaporator 8 (from point P7 to point P1 of FIG. 2), and is introduced to a low-stage compression chamber of the scroll compressor 2 (point P1 of FIG. 2).

**[0021]** The low-stage compression chamber of the scroll compressor 2 compresses the introduced low-pressure refrigerant RL into the medium-pressure refrigerant RM3. The high-stage compression chamber of the scroll compressor 2 compresses the medium-pressure refrigerants RM1 and RM3 into the high-pressure refrigerant RH. The low-stage compression chamber of the scroll compressor 2 receives circulating refrigerant amount GL in a liquid state separated by the gas-liquid separator 6. The high-stage compression chamber of the scroll compressor 2 receives circulating refrigerant amount GH the amount of which is the sum of circulating refrigerant amount GM in a gaseous state separated by the gas-liquid separator 6 and the circulating refrigerant amount GL introduced from the low-stage compression chamber. The amount of circulating refrigerant introduced to the high-stage compression chamber is therefore larger than that introduced to the low-stage compression chamber.

### Scroll Compressor

**[0022]** FIG. 3 is a sectional view that illustrates the configuration of the scroll compressor 2. FIG. 4 is a sectional view along A-A line of FIG. 3. FIG. 5 is a sectional view of a fixed scroll 11 and an orbiting scroll 12 illustrated in FIG. 3. FIG.

6 is a perspective view of the fixed scroll 11 of FIG. 4 viewed from diagonally below. FIG. 7 is a perspective view of the orbiting scroll 12 of FIG. 4 viewed from diagonally above.

**[0023]** The fixed scroll 11 and the orbiting scroll 12 form a later-described outer compression area 40, functioning as a low-pressure compression chamber, and a later-described inner compression area 41, functioning as a high-pressure compression chamber, and conduct two-stage compression. As illustrated in FIG. 3, the fixed scroll 11 and the orbiting scroll 12 are arranged in a housing 10 including housings 10a and 10b. Two-stage compression is conducted with the orbiting scroll 12 making orbital motion with respect to the fixed scroll 11 in a rotational direction AL. A crankshaft 13 transfers torque from a rotary drive source (not illustrated) to the orbiting scroll 12. A thrust bearing 14 supports rotation of the orbiting scroll 12 in the thrust direction. A medium-pressure chamber 16 and a high-pressure chamber 17 are formed in the housing 10. The crankshaft 13 is provided with a balance weight 15 for balancing orbital motion of the orbiting scroll 12.

**[0024]** A low-pressure refrigerant suction tube L1 is a tube to introduce the low-pressure refrigerant RL into the outer compression area 40. A medium-pressure refrigerant suction tube L2 is a tube to introduce the medium-pressure refrigerant RM1 into the medium-pressure chamber 16. A high-pressure refrigerant discharge tube L3 is a tube to discharge the high-pressure refrigerant RH, discharged from the inner compression area 41 through a discharge valve 18 and the high-pressure chamber 17, outside the housing 10.

Two-stage Compression Mechanism

**[0025]** As illustrated in FIG. 4 to FIG. 7, the fixed scroll 11 includes fixed scroll plate-like spiral tooth 11b vertically arranged on a base plate 11a. The orbiting scroll 12 includes orbiting scroll plate-like spiral tooth 12b vertically arranged on a base plate 12a. The fixed scroll plate-like spiral tooth 11b of the fixed scroll 11 and the orbiting scroll plate-like spiral tooth 12b of the orbiting scroll 12 mesh with each other at respective front ends. This structure forms the outer compression area 40 and the inner compression area 41. In the outer compression area 40 and the inner compression area 41, compression chambers are formed outside and inside the orbiting scroll 12. With orbital motion of the orbiting scroll 12, the capacity of the compression chamber is reduced, and the compression chamber is shifted toward the center. This process compresses refrigerant in the compression chamber.

**[0026]** As illustrated in FIG. 4, a partition wall 20 is provided that connects the adjacent fixed scroll plate-like spiral tooth 11b so as to partition the compression chamber between a spiral start point PA in the center side of the fixed scroll plate-like spiral tooth 11b, and a spiral end point PB close to the outside. The orbiting scroll plate-like spiral tooth 12b has a separation area E (see FIG. 7) formed therein that splits the orbiting scroll plate-like spiral tooth 12b so as not to interfere with the partition wall 20 in accordance with orbital motion of the orbiting scroll 12 at a location corresponding to the partition wall 20. The partition wall 20 defines the outer compression area 40 and the inner compression area 41. As illustrated in FIG. 5 to FIG. 7, providing the separation area E allows the orbiting scroll plate-like spiral tooth 12b to have an orbiting scroll plate-like spiral tooth 32 that orbits in the outer compression area 40 and an orbiting scroll plate-like spiral tooth 33 that orbits in the inner compression area 41. The partition wall 20 allows the fixed scroll plate-like spiral tooth 11b to have a fixed scroll plate-like spiral tooth 30 that forms the outer compression area 40 and a fixed scroll plate-like spiral tooth 31 that forms the inner compression area 41.

**[0027]** At an outer end of the spiral of the orbiting scroll plate-like spiral tooth 32 in the outer compression area 40, a low-pressure refrigerant suction port 21 is formed and is connected with the low-pressure refrigerant suction tube L1. Furthermore, at the inner end of the spiral of the orbiting scroll plate-like spiral tooth 32 in the outer compression area 40, a medium-pressure refrigerant discharge port 23 is formed that discharges the medium-pressure refrigerant RM3 compressed in the outer compression area 40 to the medium-pressure chamber 16. At the outer end of the spiral of the orbiting scroll plate-like spiral tooth 33 in the inner compression area 41, a medium-pressure refrigerant suction port 22 is formed so as to be connected to the medium-pressure chamber 16 to suck the medium-pressure refrigerants RM1 and RM3. Furthermore, at an inner end, which is the center, of the spiral of the orbiting scroll plate-like spiral tooth 33 in the inner compression area 41, a high-pressure refrigerant discharge port 24 is formed. The high-pressure refrigerant discharge port 24 is connected to the high-pressure chamber 17 through the discharge valve 18, and discharges the high-pressure refrigerant RH compressed in the inner compression area 41 outside through the high-pressure refrigerant discharge tube L3.

**[0028]** Because the amount of circulating refrigerant sucked into the inner compression area 41 is larger than that sucked into the outer compression area 40, as illustrated in FIG. 5, heights h2 of the fixed scroll plate-like spiral tooth 31 and the orbiting scroll plate-like spiral tooth 33 of the inner compression area 41 are set larger than heights h1 of the fixed scroll plate-like spiral tooth 30 and the orbiting scroll plate-like spiral tooth 32 of the outer compression area 40. By adjusting the heights h1 and h2, the compression capacity of the inner compression area 41 can be larger than that of the outer compression area 40. With this configuration, even when medium-pressure refrigerant expanded by the high-stage expansion valve is introduced to the high-stage compression mechanism, and the amount of circulating refrigerant in the high-stage compression mechanism is increased relative to the amount of circulating refrigerant introduced in the low-stage compression mechanism, it is possible to achieve compactness of the system with a simple configuration.

**[0029]** As illustrated in FIG. 5, tip seals 51 and 52 are attached to the respective front ends of the fixed scroll plate-like spiral tooth 11b and the orbiting scroll plate-like spiral tooth 12b. The tip seals 51 and 52 prevent the refrigerant from leaking between the outside and the inside of the fixed scroll plate-like spiral tooth 11b and from leaking between the outside and the inside of the orbiting scroll plate-like spiral tooth 12b during compression by the above-described outer compression area 40 and inner compression area 41.

Second Embodiment

Application of Configuration of Asymmetric-type Scroll Compressor

**[0030]** As illustrated in FIG. 8, the scroll compressor 2 of a second embodiment has a spiral end point PB10 of the fixed scroll 11 and a spiral end point PB11 of the orbiting scroll 12 symmetrically arranged with respect to the center (the location of the high-pressure refrigerant discharge port 24).

**[0031]** As illustrated in FIG. 8(a), in the outer compression area 40, first the low-pressure refrigerant RL forms a first inner compression chamber 60-1 inside the orbiting scroll 12 and a first outer compression chamber 61-1 outside the orbiting scroll 12. Meanwhile, a full turn (360°) of the orbiting scroll 12 changes the first inner compression chamber 60-1 into a compressed second inner compression chamber 60-2 and changes the first outer compression chamber 61-1 into a compressed second outer compression chamber 61-2. The first inner compression chamber 60-1 and the first outer compression chamber 61-1 have respective statuses of chambers before the full turn of the second inner compression chamber 60-2 and second outer compression chamber 61-2.

**[0032]** FIG. 8(b) illustrates a state in which the orbiting scroll 12 of FIG. 8(a) has turned by a communication angle $\theta A$ at which the second inner compression chamber 60-2 communicates with the medium-pressure refrigerant discharge port 23. In this state, the medium-pressure refrigerant in the second inner compression chamber 60-2 communicates with the medium-pressure refrigerant discharge port 23 and is discharged therefrom, and at the same time, communicates with the first outer compression chamber 61-1. Thus, as indicated by an arrow A1, the compressed medium-pressure refrigerant in the second inner compression chamber 60-2, the pressure of which is relatively higher than that of the first outer compression chamber 61-1, leaks into the first outer compression chamber 61-1. This leakage causes loss of recompression and thus reduces the efficiency of compression.

**[0033]** For the above issue, as illustrated in FIG. 9, it is preferable that a spiral end point PB20 of the fixed scroll 11 and a spiral end point PB21 of the orbiting scroll 12 be asymmetrically arranged with respect to the center (the location of the high-pressure refrigerant discharge port 24). This asymmetric-type scroll compressor, as illustrated in FIG. 9, has a spiral end point of the fixed scroll 11 moved by an involute roll angle $\theta a$ in the range of $0° < \theta a \leq 180°$ from the spiral end point PB10 of the fixed scroll 11 of the symmetric-type scroll compressor. In FIG. 9, the spiral end point PB20 is such that the involute roll angle $\theta a$ is 180°.

**[0034]** The inner walls and the outer walls of the fixed scroll 11 and the orbiting scroll 12 form involute curves LI. The involute curve LI is a plane curve the normal of which is constantly in contact with a specific circle (a basic circle C). As illustrated in FIG. 10, a position on the involute curve $PB(\theta) = \{PBx(0), PBy(\theta)\}$ is given by the following formula, where $\theta(°)$ is the involute roll angle of the involute curve LI and R is the radius of the basic circle C.

$$PBx(\theta) = R\{\cos\theta + (\theta \times \pi/180)\sin\theta\}$$

$$PBy(\theta) = R\{\sin\theta - (\theta \times \pi/180)\cos\theta\}$$

The above-described involute roll angle $\theta a$ is therefore calculated as $\theta a = \theta 2 - \theta 1$, where $\theta 1$ is an involute roll angle of the spiral end point PB10 and $\theta 2$ is an involute roll angle of the spiral end point PB20. In other words, the spiral end point PB20 is a point extended from the spiral end point PB10 by the involute roll angle $\theta a$.

**[0035]** In comparison with the symmetric-type scroll compressor of FIG. 8(a), the asymmetric-type scroll compressor of FIG. 9 has the spiral end point PB20 of the fixed scroll 11 and the spiral end point PB21 of the orbiting scroll 12 located at the same angular position. In this layout of the asymmetric-type scroll compressor, when the first inner compression chamber 60-1 and the first outer compression chamber 61-1 of FIG. 8(a) are formed, an outer compression chamber 61-0 that is half turn behind has already been formed. The outer compression chamber 61-0 changes into the first outer compression chamber 61-1 after a full turn. In other words, when the first inner compression chamber 60-1 is formed, the first outer compression chamber 61-1 has been compressed since a half cycle before. At the communication angle $\theta A$ in FIG. 8(b), the pressure of the first outer compression chamber 61-1 becomes substantially equal to the pressure of the second inner compression chamber 60-2. This reduces the amount of the medium-pressure refrigerant compressed in the second inner compression chamber 60-2 to be leaked into the first outer compression chamber 61-1. Accordingly, the loss of recompression decreases and a reduction in the efficiency of compression can be prevented.

**[0036]** FIGS. 11 are diagrams for comparison between the symmetric-type scroll compressor of FIG. 8 and the asymmetric-type scroll compressor of FIG. 9 regarding changes in the pressure of the inner compression chamber and the outer compression chamber and a difference in the pressure therebetween at the communication angle θA. The characteristic curves L60-1, L60-2, L61-0, L61-1, and L61-2 indicate changes in the pressure of the first inner compression chamber 60-1, the second inner compression chamber 60-2, the outer compression chamber 61-0, the first outer compression chamber 61-1, and the second outer compression chamber 61-2, respectively. In the asymmetric-type scroll compressor illustrated in FIG. 11(b), compression in the outer compression chamber 61-0, which turns into the first outer compression chamber 61-1, starts at an angle of rotation θ1 one turn behind at which the angle of rotation is 0°. This cycle therefore raises the initial pressure (at an angle of rotation of 0°) of the first outer compression chamber 61-1. A pressure difference PR2 at the communication angle θA is therefore reduced in comparison with a pressure difference PR1 of the symmetric-type scroll compressor of FIG. 11(a) by a pressure difference ΔPR.

**[0037]** As a result of this, as illustrated in FIG. 12, the asymmetric-type scroll compressor has a recompression loss S2 that is smaller than a recompression loss S1 of the symmetric-type scroll compressor.

**[0038]** The configuration of the asymmetric-type scroll compressor is applicable to the two-stage compression two-stage expansion cycle of the first embodiment and to a two-stage compression single-stage expansion cycle. Specifically, it is not necessary to employ a configuration in which the heights h2 of the fixed scroll plate-like spiral tooth 31 and the orbiting scroll plate-like spiral tooth 33 forming the inner compression area 41 is larger than the heights h1 of the fixed scroll plate-like spiral tooth 30 and the orbiting scroll plate-like spiral tooth 32 forming the outer compression area 40.

Third Embodiment

Mechanism to Prevent Leakage of Refrigerant

**[0039]** In the housing 10, the medium-pressure chamber 16 has medium pressure PM. When the pressure of the housing 10 is the medium pressure PM, the medium pressure PM is applied to the back surface of the orbiting scroll 12, which reduces the thrust load of the orbiting scroll 12. Reducing the mechanical loss and protecting the thrust bearing 14 from wearing can therefore enhance reliability of the scroll compressor 2.

**[0040]** As illustrated in FIG. 13, however, the orbiting scroll plate-like spiral tooth 12b of the orbiting scroll 12 receives load in a radial direction A2. The load may cause the orbiting scroll 12 to oscillate when orbiting at a small slant angle. In this state, a gap d is formed between the front end surface, closer to the orbiting scroll 12, of the outer peripheral portion of the fixed scroll 11 and the upper surface of the base plate 12a of the orbiting scroll 12. The gap d permits the medium-pressure refrigerant RM in the medium-pressure chamber 16 to leak into the outer compression area 40 where the low-pressure refrigerant RL is compressed. Leakage of the medium-pressure refrigerant RM into the outer compression area 40 reduces the efficiency of compression in the outer compression area 40.

**[0041]** The compression efficiency in the outer compression area 40 is reduced, as illustrated in FIG. 14, with an increase in the amount of the medium-pressure refrigerant RM in the outer compression area 40. The increase raises the pressure of the outer compression area 40, and power necessary for compression is increased by a region E10. Furthermore, as illustrated in FIG. 15, when the medium-pressure refrigerant, the temperature of which is higher than that of the low-pressure refrigerant in the outer compression area 40, leaks into the outer compression area 40, the low-pressure refrigerant is heated as indicated by an arrow A10. The temperature of the medium-pressure refrigerant compressed in the outer compression area 40 is accordingly increased relative to the temperature of ideal medium-pressure refrigerant, as indicated by an arrow A11. The high-temperature medium-pressure refrigerant introduced into the inner compression area 41 reduces the density of the medium-pressure refrigerant in the inner compression area 41, which reduces the volumetric efficiency of the inner compression area 41.

**[0042]** In a third embodiment, as illustrated in FIG. 13, the fixed scroll 11 has an outer wall 11c formed such that the sectional surface of the orbiting scroll 12 in the axial direction is in a U shape. An annular seal is disposed on a sliding surface between the front end surface of the outer wall 11c and the base plate 12a of the orbiting scroll 12. In FIG. 16 and FIG. 17, an annular seal 70 is mounted on the front end surface of the outer wall 11c.

**[0043]** The annular seal 70 may be mounted on the base plate 12a of the orbiting scroll 12, as illustrated in FIG. 18. Without being limited to a circular shape, the annular seal 70 may be oval, polygonal, or the like depending on the purpose.

Thermal Expansion Absorbing Portion of Annular Seal

**[0044]** The annular seal 70 is made of resin, metal, or other materials. The annular seal 70 is subjected to thermal expansion with an increase in the temperature occurring upon operation of the scroll compressor 2. In particular, the annular seal 70 has a long circumferential length relative to the width and the thickness, and when being subjected to thermal expansion, the annular seal 70 is stretched in the circumferential direction to be constrained by the channel, causes thermal stress to occur, and also generates scuffing due to deformation in the axial direction, and thus may be broken.

**[0045]** The annular seal 70 therefore preferably has a thermal expansion absorbing portion for absorbing thermal expansion on the occasion of thermal expansion. For example, as illustrated in FIG. 19, a separation gap 71 functioning as a clearance during thermal expansion is provided on a part of the annular seal 70. The separation gap 71 of FIG. 19 is slanted with respect to the axial direction of the orbiting scroll 12. A width d10 of the separation gap 71 in the circumferential direction is determined based on the amount of thermal expansion when thermal expansion occurs. Since the separation gap 71 is constrained by the channel, a plurality of the separation gaps 71 are preferably formed in the circumferential direction. Providing the separation gap 71 can prevent scuffing during thermal expansion and can certainly block leakage of refrigerant.

**[0046]** As illustrated in FIG. 20, the separation gap 71 may be replaced by a separation gap 72. The separation gap 72 is slanted with respect to the circumferential direction of the orbiting scroll 12 or the fixed scroll 11. A width d20 of the separation gap 72 in the circumferential direction is determined based on the amount of thermal expansion during thermal expansion. Since the separation gap 72 is constrained by the channel, a plurality of the separation gaps 72 are preferably formed in the circumferential direction. Formation of the separation gap 72 can prevent scuffing during thermal expansion and can certainly block leakage of refrigerant.

**[0047]** As illustrated in FIG. 21, the separation gaps 71 and 72 may be replaced by one or a plurality of hollow portions 73 formed in the area between, but not including, an outer peripheral surface 70a and an inner peripheral surface 70b of the annular seal 70. During thermal expansion, the hollow portion 73 breaks to absorb the thermal expansion, thereby reducing deformation of the outer shape of the annular seal 70. The hollow portion 73 can more certainly block leakage of refrigerant than an annular seal having a separation gap can.

**[0048]** The third embodiment is applicable to the two-stage compression scroll compressor of the above-described first embodiment and, other than this, applicable to a common scroll compressor. For example, the third embodiment is applicable to a single-stage compression scroll compressor.

## Example of Applicable Thermal Cycle

**[0049]** The above first to third embodiments describe the thermal cycle system illustrated in FIG. 1 and FIG. 2 as an example thermal cycle system using a two-stage compression two-stage expansion cycle. The scroll compressor 2 of the first to the third embodiments is applicable to thermal cycle systems other than the thermal cycle system of FIG. 1 and FIG. 2.

**[0050]** For example, as illustrated in FIG. 22 and FIG. 23, the supercooling device 4 may be removed from the thermal cycle system 1 of FIG. 1.

**[0051]** As illustrated in FIG. 24 and FIG. 25, an internal heat exchanger 9 may be provided to the thermal cycle system of FIG. 22 and FIG. 23. The internal heat exchanger 9 transfers heat between the medium-pressure refrigerant RM2 separated by the gas-liquid separator 6 and the low-pressure refrigerant RL ejected from the evaporator 8.

**[0052]** As illustrated in FIG. 26 and FIG. 27, the thermal cycle system of FIG. 1 and FIG. 2 may include an internal heat exchanger 9a for transferring heat between the high-pressure refrigerant RH right before introduction to the high-stage expansion valve 5 and the low-pressure refrigerant RL ejected from the evaporator 8.

**[0053]** As illustrated in FIG. 28 and FIG. 29, the gas-liquid separator 6 included in the thermal cycle system 1 of FIG. 1 is removed, the high-pressure refrigerant RH ejected from the supercooling device 4 is branched at a separation point PS, one part of the branched high-pressure refrigerant RH is introduced into an intermediate expansion valve 5a, so as to be depressurized and expanded, and an internal heat exchanger 9b is provided that performs heat exchange between the depressurized and expanded medium-pressure refrigerant and the other part of the separated high-pressure refrigerant that is not depressurized and expanded. The internal heat exchanger 9b uses heat of the other part of the high-pressure refrigerant that is not depressurized and expanded to heat the insulated and expanded medium-pressure refrigerant. The heated medium-pressure refrigerant is then directly introduced to the high-stage compression chamber of the scroll compressor 2. Meanwhile, the high-pressure refrigerant that is not insulated and expanded passing the internal heat exchanger 9b is introduced into the low-stage expansion valve 7 and turns into medium-pressure refrigerant by being depressurized and expanded.

## Fourth Embodiment

**[0054]** A fourth embodiment will now be described. FIG. 30 is a vertical sectional view of a scroll compressor 102 of a fourth embodiment. FIG. 31 is a perspective view of the scroll compressor 102 of FIG. 30 viewed diagonally from the right. FIG. 32 is a perspective view of the scroll compressor 102 of FIG. 30 viewed diagonally from the left. FIG. 33 is a perspective view of a refrigerant connection cover 100 of FIG. 30 viewed from the back (in the Y direction) thereof. FIG. 34 is a front view with the refrigerant connection cover 100 mounted. FIG. 35 is a front view with the refrigerant connection cover 100 removed.

**[0055]** In the first to the third embodiments, a housing 10a including the medium-pressure chamber 16 and the high-pressure chamber 17 covers the back surface, facing outside, of the fixed scroll 11. The housing 10a is connected to the housing 10b. As illustrated in FIG. 30 to FIG. 35, in the fourth embodiment, the refrigerant connection cover 100 including a medium-pressure refrigerant chamber 116 and a high-pressure refrigerant chamber 117 is directly mounted on the back surface facing the outside (in the Y direction) of the fixed scroll 11. The medium-pressure refrigerant chamber 116 sucks the medium-pressure refrigerants RM1 and RM3 and discharges a medium-pressure refrigerant RM4 into which the medium-pressure refrigerants RM1 and RM3 have been merged. The high-pressure refrigerant chamber 117 sucks and discharges the high-pressure refrigerant RH. The medium-pressure refrigerant chamber 116 and the high-pressure refrigerant chamber 117 that are formed between the refrigerant connection cover 100 and the fixed scroll 11 are each sealed with O-rings or similar members. A thrust bearing mechanism 114 includes a thrust bearing mechanism and a rotation control mechanism to control rotation of the orbiting scroll 12. More specifically, three units of the thrust bearing mechanisms 114 are disposed on the XZ plane. The refrigerant connection cover 100 is detachably mounted on the housing 10.

**[0056]** When the refrigerant connection cover 100 is directly mounted on the fixed scroll 11, the refrigerant connection cover 100 can be removed independently from the housing 10 (a housing 10c) including housings 10c and 10d, without being affected by the housing 10. This structure is therefore beneficial in maintainability and compactness. As illustrated in FIG. 30, the housing 10c is fixed to the fixed scroll 11, and the fixed scroll 11 constitutes a part of the housing 10. Because the refrigerant connection cover 100 has no necessity of functioning as a housing, a number of valves, openings, and tubes necessary for two-stage compression, can be arranged in an integrated manner.

**[0057]** The medium-pressure refrigerant chamber 116 includes a recess portion 105 of the fixed scroll 11 and a recess portion 106 of the refrigerant connection cover 100 that are facing each other. Likewise, the high-pressure refrigerant chamber 117 includes a recess portion 107 of the fixed scroll 11 and a recess portion 108 of the refrigerant connection cover 100 that are facing each other. The medium-pressure refrigerant chamber 116 and the high-pressure refrigerant chamber 117 are partitioned from each other by a partition wall 101.

**[0058]** The recess portion 105 has a medium-pressure refrigerant discharge port 123 corresponding to the medium-pressure refrigerant discharge port 23 communicating with the outer compression area 40, a medium-pressure refrigerant suction port 122 corresponding to the medium-pressure refrigerant suction port 22 communicating with the inner compression area 41, and an outlet opening 151 of a medium-pressure relief hole 141 communicating with the outer compression area 40. The recess portion 106 has an external medium-pressure refrigerant connection induction port 126 to suck gaseous medium-pressure refrigerant RM1 introduced from the external gas-liquid separator 6.

**[0059]** As illustrated in FIG. 30 to FIG. 32, the medium-pressure refrigerant RM1 is introduced into the housing 10d through an external medium-pressure refrigerant suction port 130 along with oil, and reaches a housing medium-pressure refrigerant suction port 131 through a seal in the housing 10. The housing medium-pressure refrigerant suction port 131 and the external medium-pressure refrigerant connection induction port 126 are connected with each other through an intermediate tube LM. The medium-pressure refrigerant RM1 sucked through the housing medium-pressure refrigerant suction port 131 is introduced to the medium-pressure refrigerant chamber 116 through the external medium-pressure refrigerant connection induction port 126. The intermediate tube LM (see FIG. 1) is a tube to introduce gaseous medium-pressure refrigerant RM1 separated by the gas-liquid separator 6 into the medium-pressure refrigerant chamber 116. The intermediate tube LM passes the housing 10 in the middle thereof.

**[0060]** The medium-pressure refrigerant RM1 introduced in the medium-pressure refrigerant chamber 116 and the medium-pressure refrigerant RM3 discharged through the medium-pressure refrigerant discharge port 123 merge with each other in the medium-pressure refrigerant chamber 116, and are discharged to the inner compression area 41 through the medium-pressure refrigerant suction port 122 as the medium-pressure refrigerant RM4.

**[0061]** The fixed scroll 11 has a low-pressure refrigerant suction port 121 corresponding to the low-pressure refrigerant suction port 21. The low-pressure refrigerant RL is sucked into the outer compression area 40 through the low-pressure refrigerant suction port 121.

**[0062]** The recess portion 107 has a high-pressure refrigerant discharge port 124 corresponding to the high-pressure refrigerant discharge port 24 and an outlet opening 152 of a high-pressure relief hole 151 communicating with the outer compression area 40. The recess portion 108 has a high-pressure refrigerant ejection port 125 to discharge the high-pressure refrigerant RH in the high-pressure refrigerant chamber 117 outside.

**[0063]** The recess portion 105 of the medium-pressure refrigerant chamber 116 is provided with a check valve V1 for preventing the medium-pressure refrigerant RM3 from circulating back into the outer compression area 40 through the medium-pressure refrigerant discharge port 123. The recess portion 107 of the high-pressure refrigerant chamber 117 is provided with a check valve V2 for preventing the high-pressure refrigerant RH from circulating back into the inner compression area 41 through the high-pressure refrigerant discharge port 124.

**[0064]** The recess portion 105 of the medium-pressure refrigerant chamber 116 is provided with a medium-pressure relief valve V11 serving as a medium-pressure relief unit, at the outlet opening 151 of the medium-pressure relief hole 141 (see FIG. 6 and FIG. 35) to control the pressure of refrigerant in the outer compression area 40 under a first predetermined pressure. The recess portion 107 of the high-pressure refrigerant chamber 117 is provided with a high-pressure relief valve V12, serving as a high-pressure relief unit, at the outlet opening 152 of a high-pressure relief hole 142 (see FIG. 6 and FIG. 35) to control the pressure of refrigerant in the inner compression area 41 under a second predetermined pressure.

**[0065]** The medium-pressure refrigerant discharge port 123, the medium-pressure refrigerant suction port 122, and the high-pressure refrigerant discharge port 124 are arranged on the housing 10. The refrigerant connection cover 110 including an external medium-pressure refrigerant connection induction port 126 and a high-pressure refrigerant ejection port 125 is mounted on the housing 10, whereby the medium-pressure refrigerant chamber 116 and the high-pressure refrigerant chamber 117 are formed.

**[0066]** The medium-pressure refrigerant suction port 122, the medium-pressure refrigerant discharge port 123, and the external medium-pressure refrigerant connection induction port 126 communicate with the medium-pressure refrigerant chamber 116. The high-pressure refrigerant discharge port 124 and the high-pressure refrigerant ejection port 125 communicate with a high-pressure refrigerant chamber 127. The medium-pressure refrigerant suction port 122 and the high-pressure refrigerant discharge port 124 are open in the same direction as the medium-pressure refrigerant discharge port 123. The housing medium-pressure refrigerant suction port 131 and the medium-pressure refrigerant discharge port 123 are open in the same direction to discharge medium-pressure refrigerant through a seal in the housing 10.

**[0067]** The above medium-pressure relief valve V11, the high-pressure relief valve V12, the check valve V1, and the check valve V2 are exposed on the surface of the housing 10 when the refrigerant connection cover 100 is removed, whereby maintainability is enhanced.

**[0068]** The medium-pressure refrigerant chamber 116 has a larger capacity than that of the high-pressure refrigerant chamber 117. The medium-pressure refrigerants RM1, RM3, and RM4 have smaller density than that of the high-pressure refrigerant RH and easily cause pressure loss. The medium-pressure refrigerant chamber 116 is increased in a capacity to reduce the pressure loss.

**[0069]** In FIG. 30 to FIG. 35, the medium-pressure refrigerant chamber 116 has an increased capacity by making the cross-sectional area of the medium-pressure refrigerant chamber 116 larger than that of the high-pressure refrigerant chamber 117 with a depth d1 of the medium-pressure refrigerant chamber 116 being the same as a depth d2 of the high-pressure refrigerant chamber 117. Without being limited thereto, the medium-pressure refrigerant chamber 116 may have an increased capacity by making the depth d1 of the medium-pressure refrigerant chamber 116 larger than the depth d2 of the high-pressure refrigerant chamber 117. The pressure of the medium-pressure refrigerant is smaller than that of the high-pressure refrigerant, and the refrigerant connection cover 100 is allowed to reduce the thickness of a portion around the medium-pressure refrigerant chamber 116, which makes it easy to increase the depth d2.

**[0070]** When the capacity of the medium-pressure refrigerant chamber 116 or the high-pressure refrigerant chamber 117 is to be changed, the capacity (the depth) of the recess portion 106 or the recess portion 108 formed on the refrigerant connection cover 100 is controlled. The capacity of the medium-pressure refrigerant chamber 116 or the high-pressure refrigerant chamber 117 can be thus changed without changing the structure of the housing 10 side.

**[0071]** Notches 140 formed in the refrigerant connection cover 100 are used for positioning the refrigerant connection cover 100 to be mounted.

**[0072]** The thermal cycle system is a heat pump system in the case of heating using the above-described condenser 3 and the thermal cycle system is an ordinary freezing system in the case of cooling using the evaporator 8.

**[0073]** Although the above-described scroll compressor 2 is a two-stage compressor including the outer compression area 40 and the inner compression area 41, it is not limited thereto, and the scroll compressor 2 may be a multi-stage compressor.

Reference Signs List

**[0074]**

1 THERMAL CYCLE SYSTEM
2, 102 SCROLL COMPRESSOR
3 CONDENSER
4 SUPERCOOLING DEVICE
5 HIGH-STAGE EXPANSION VALVE
5a INTERMEDIATE EXPANSION VALVE
6 GAS-LIQUID SEPARATOR
7 LOW-STAGE EXPANSION VALVE

8 EVAPORATOR
9, 9a, 9b INTERNAL HEAT EXCHANGER
10, 10a, 10b, 10c, 10d HOUSING
11 FIXED SCROLL
11a, 12a BASE PLATE
11b FIXED SCROLL PLATE-LIKE SPIRAL TOOTH
11c OUTER WALL
12 ORBITING SCROLL
12b ORBITING SCROLL PLATE-LIKE SPIRAL TOOTH
13 CRANKSHAFT
14 THRUST BEARING
15 BALANCE WEIGHT
16 MEDIUM-PRESSURE CHAMBER
17 HIGH-PRESSURE CHAMBER
18 DISCHARGE VALVE
20 PARTITION WALL
21, 121 LOW-PRESSURE REFRIGERANT SUCTION PORT
22, 122 MEDIUM-PRESSURE REFRIGERANT SUCTION PORT (MEDIUM-PRESSURE REFRIGERANT EJECTION PORT)
23, 123 MEDIUM-PRESSURE REFRIGERANT DISCHARGE PORT (MEDIUM-PRESSURE REFRIGERANT INDUCTION PORT)
24, 124 HIGH-PRESSURE REFRIGERANT DISCHARGE PORT (HIGH-PRESSURE REFRIGERANT INDUCTION PORT)
30, 31 FIXED SCROLL PLATE-LIKE SPIRAL TOOTH
32, 33 ORBITING SCROLL PLATE-LIKE SPIRAL TOOTH
40 OUTER COMPRESSION AREA
41 INNER COMPRESSION AREA
51, 52 TIP SEAL
60-1 FIRST INNER COMPRESSION CHAMBER
60-2 SECOND INNER COMPRESSION CHAMBER
61-0 OUTER COMPRESSION CHAMBER
61-1 FIRST OUTER COMPRESSION CHAMBER
61-2 SECOND OUTER COMPRESSION CHAMBER
70 ANNULAR SEAL
70a OUTER PERIPHERAL SURFACE
70b INNER PERIPHERAL SURFACE
71, 72 SEPARATION GAP
73 HOLLOW PORTION
100 REFRIGERANT CONNECTION COVER
101 PARTITION WALL
105 to 108 RECESS PORTION
116 MEDIUM-PRESSURE REFRIGERANT CHAMBER
117 HIGH-PRESSURE REFRIGERANT CHAMBER
114 THRUST BEARING MECHANISM
125 HIGH-PRESSURE REFRIGERANT EJECTION PORT
126 EXTERNAL MEDIUM-PRESSURE REFRIGERANT CONNECTION INDUCTION PORT
130 EXTERNAL MEDIUM-PRESSURE REFRIGERANT SUCTION PORT
131 HOUSING MEDIUM-PRESSURE REFRIGERANT SUCTION PORT
141 MEDIUM-PRESSURE RELIEF HOLE
142 HIGH-PRESSURE RELIEF HOLE
151, 152 OUTLET OPENING
AL ROTATIONAL DIRECTION
d GAP
E SEPARATION AREA
GH, GL, GM CIRCULATING REFRIGERANT AMOUNT
L1 LOW-PRESSURE REFRIGERANT SUCTION TUBE
L2 MEDIUM-PRESSURE REFRIGERANT SUCTION TUBE
L3 HIGH-PRESSURE REFRIGERANT DISCHARGE TUBE

LM INTERMEDIATE TUBE
V1, V2 CHECK VALVE
V11 MEDIUM-PRESSURE RELIEF VALVE (MEDIUM-PRESSURE RELIEF UNIT)
V12 HIGH-PRESSURE RELIEF VALVE (HIGH-PRESSURE RELIEF UNIT)
θA COMMUNICATION ANGLE

## Claims

**1.** A multi-stage compressor, comprising:

a plurality of compression chambers formed in a housing;
a medium-pressure refrigerant discharge port that discharges medium-pressure refrigerant from a low-stage compression chamber of the compression chambers;
a medium-pressure refrigerant suction port that is open in a same direction as the medium-pressure refrigerant discharge port and induces the medium-pressure refrigerant into a high-stage side of the compression chambers;
a high-pressure refrigerant discharge port that is open in a same direction as the medium-pressure refrigerant discharge port and discharges high-pressure refrigerant discharged from a high-stage compression chamber of the compression chambers; and
a refrigerant connection cover that is detachably mounted on the housing, and that forms a medium-pressure refrigerant chamber, which communicates with the medium-pressure refrigerant suction port and the medium-pressure refrigerant discharge port and which has an external medium-pressure refrigerant connection induction port that is open toward an outside and a high-pressure refrigerant chamber, which communicates with the high-pressure refrigerant discharge port and which has a high-pressure refrigerant ejection port open toward an outside.

**2.** The multi-stage compressor according to claim 1, wherein
the housing has a housing medium-pressure refrigerant suction port that is open in a same direction as the medium-pressure refrigerant discharge port and that discharges medium-pressure refrigerant through a seal in the housing, and
the medium-pressure refrigerant suction port and the external medium-pressure refrigerant connection induction port are connected with each other with a tube.

**3.** The multi-stage compressor according to claim 1, wherein a high-pressure relief unit that allows the high-stage compression chamber and the high-pressure refrigerant chamber to communicate with each other when an inner pressure of the high-stage compression chamber becomes equal to or greater than a predetermined value is provided in the high-pressure refrigerant chamber of the housing.

**4.** The multi-stage compressor according to claim 1, wherein a medium-pressure relief unit that allows the low-stage compression chamber and the medium-pressure refrigerant chamber to communicate with each other when an inner pressure of the low-stage compression chamber becomes equal to or greater than a predetermined value is provided in the medium-pressure refrigerant chamber of the housing.

**5.** The multi-stage compressor according to claim 1, wherein a check valve for preventing circulating back to a compression chamber through the medium-pressure refrigerant discharge port is provided in the medium-pressure refrigerant chamber of the housing.

**6.** The multi-stage compressor according to claim 1, wherein a check valve for preventing circulating back to a compression chamber through the high-pressure refrigerant discharge port is provided in the high-pressure refrigerant chamber of the housing.

**7.** The multi-stage compressor according to claim 1, wherein
the multi-stage compressor is a scroll compressor including an orbiting scroll and a fixed scroll, and
the fixed scroll constitutes a part of the housing, and the refrigerant connection cover is mounted on the fixed scroll.

**8.** The multi-stage compressor according to claim 1, wherein a capacity of the medium-pressure refrigerant chamber is larger than a capacity of the high-pressure refrigerant chamber.

**9.** The multi-stage compressor according to claim 1, wherein a notch for positioning is formed on the refrigerant connection cover.

**10.** A multi-stage compressor, wherein the multi-stage compressor according to any one of claims 1 to 9 is used for a two-stage compression two-stage expansion thermal cycle system.

FIG.1

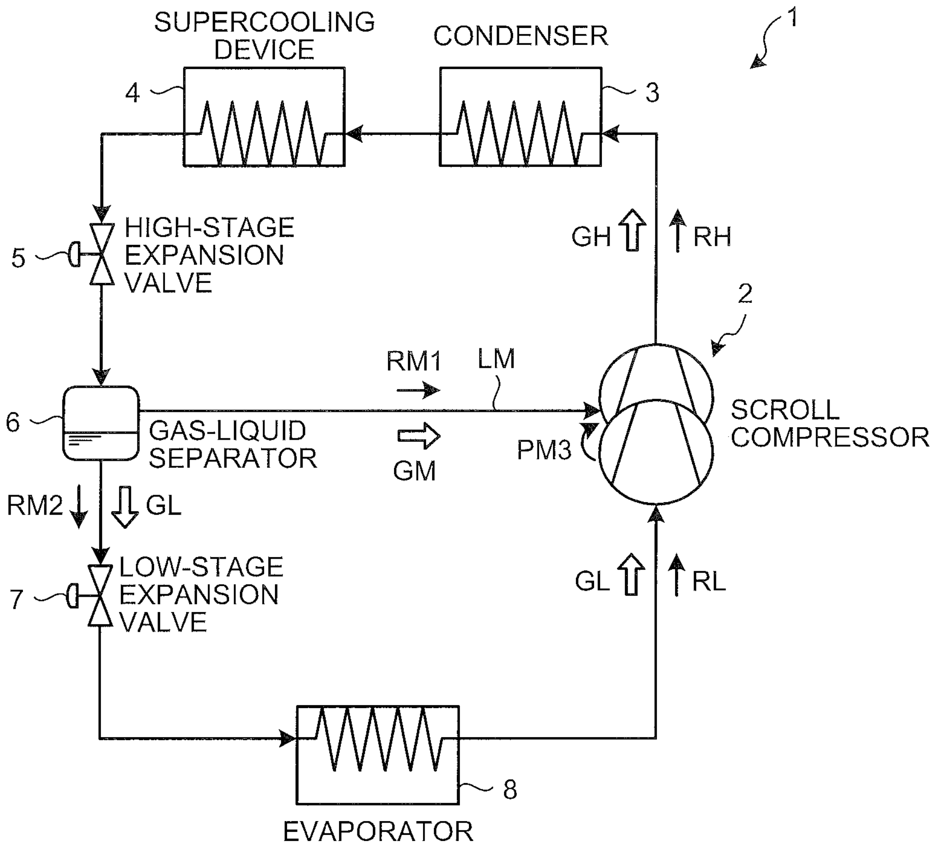

SUPERCOOLING DEVICE
CONDENSER
1
4
3
HIGH-STAGE EXPANSION VALVE
5
GH
RH
2
RM1
LM
6
GAS-LIQUID SEPARATOR
GM
PM3
SCROLL COMPRESSOR
RM2
GL
LOW-STAGE EXPANSION VALVE
7
GL
RL
8
EVAPORATOR

FIG.2

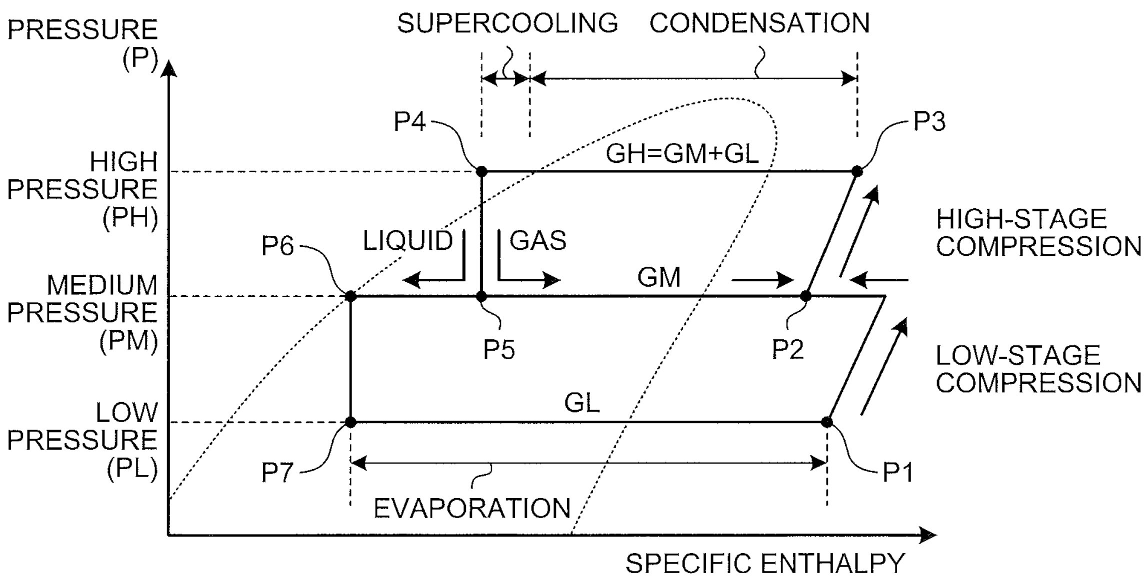

PRESSURE (P)
SUPERCOOLING
CONDENSATION
P4
P3
HIGH PRESSURE (PH)
GH=GM+GL
HIGH-STAGE COMPRESSION
P6
LIQUID
GAS
MEDIUM PRESSURE (PM)
GM
P5
P2
LOW-STAGE COMPRESSION
LOW PRESSURE (PL)
GL
P7
P1
EVAPORATION
SPECIFIC ENTHALPY

FIG.3

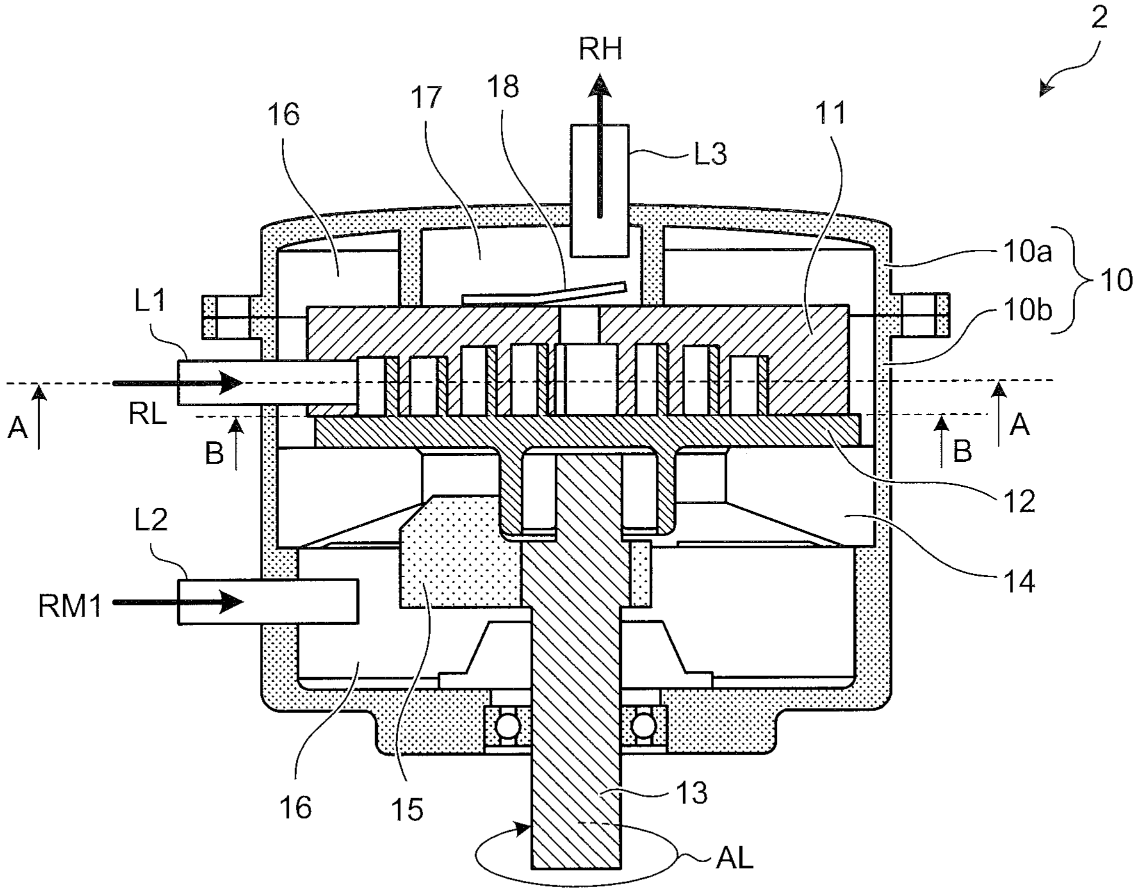


FIG.4

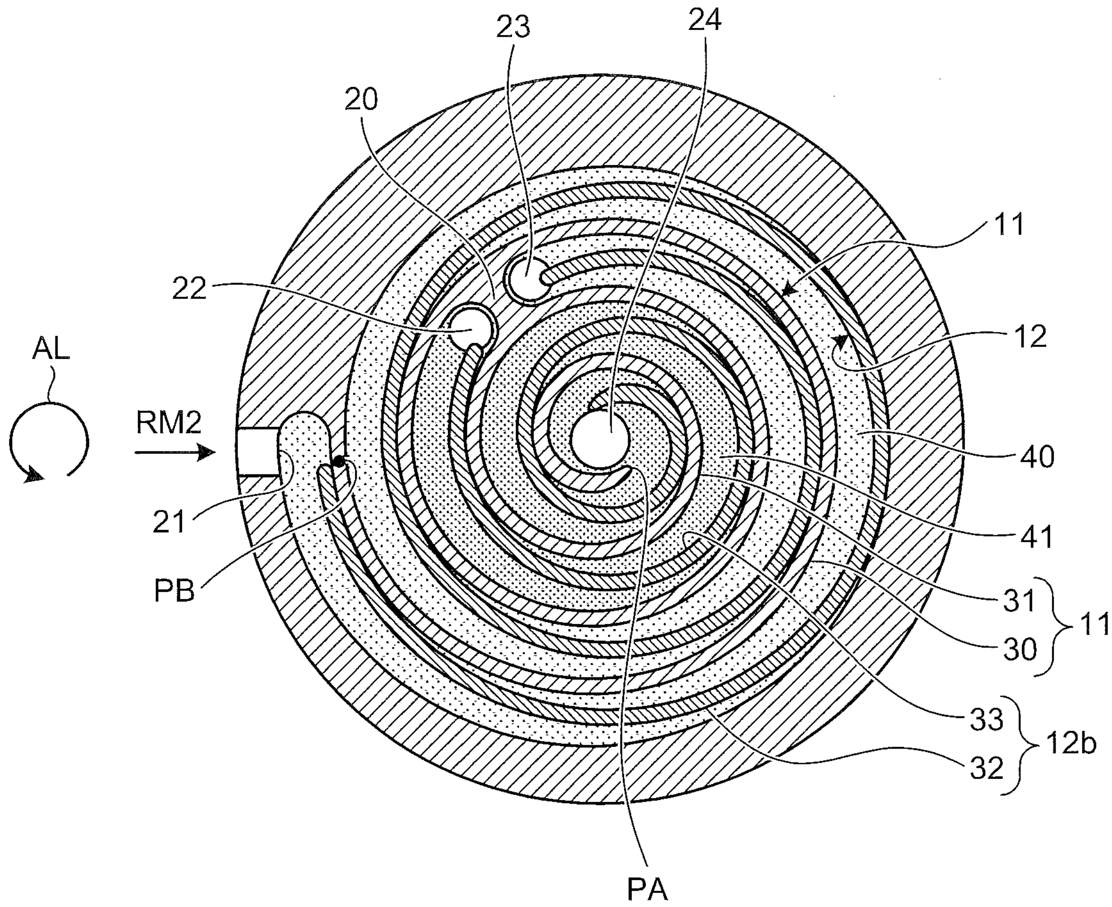


FIG.5

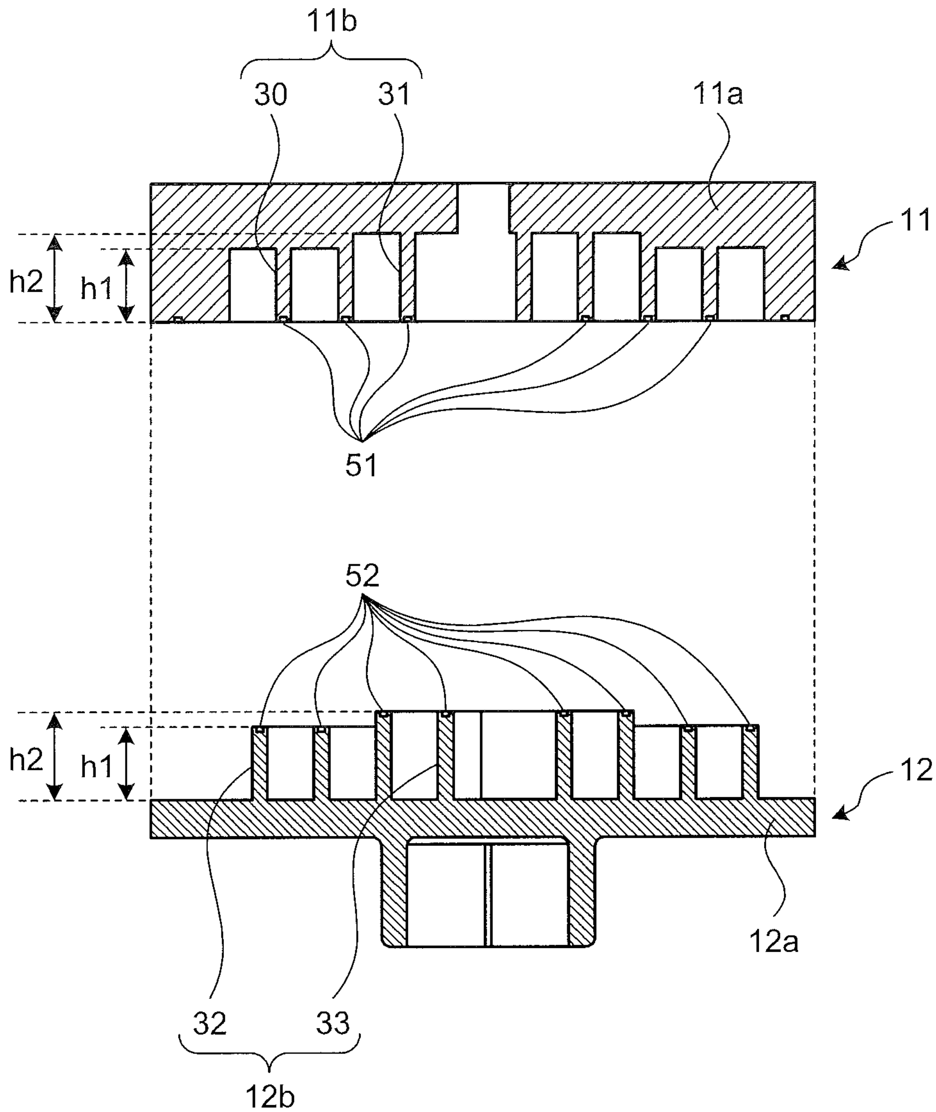


FIG.6

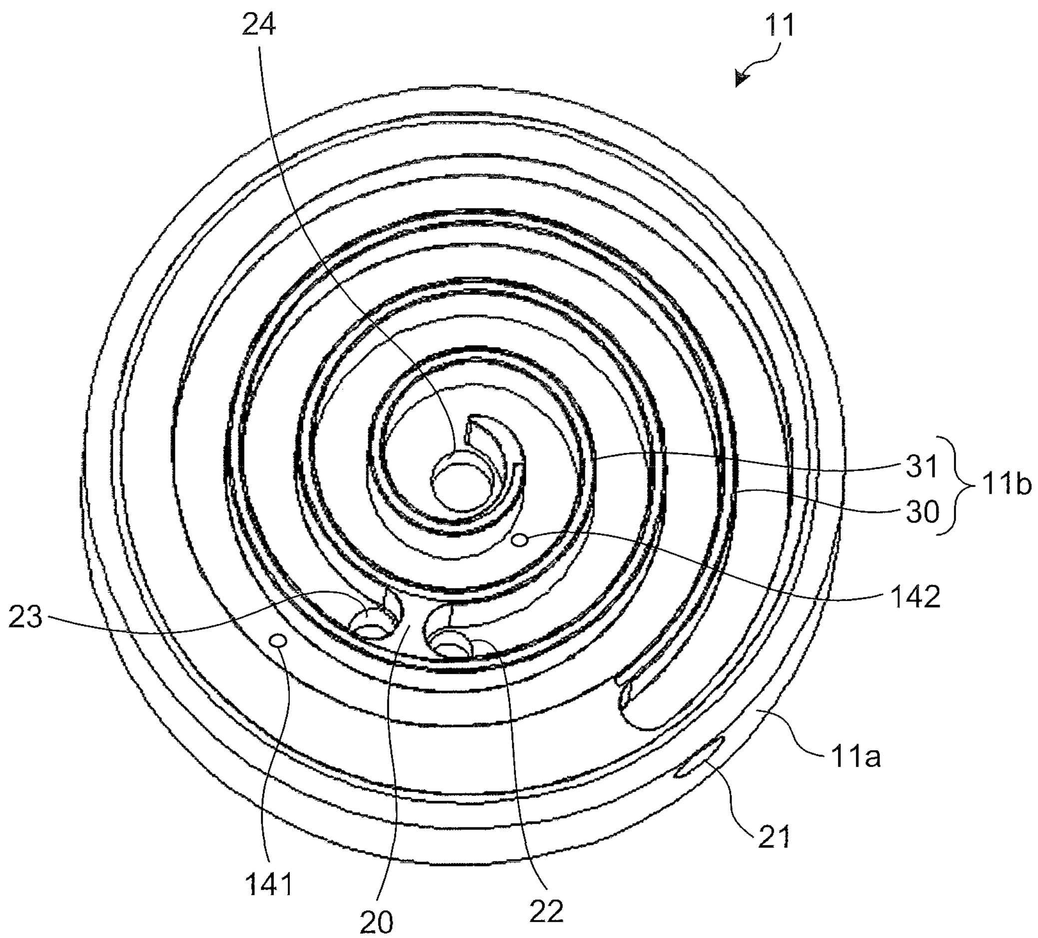
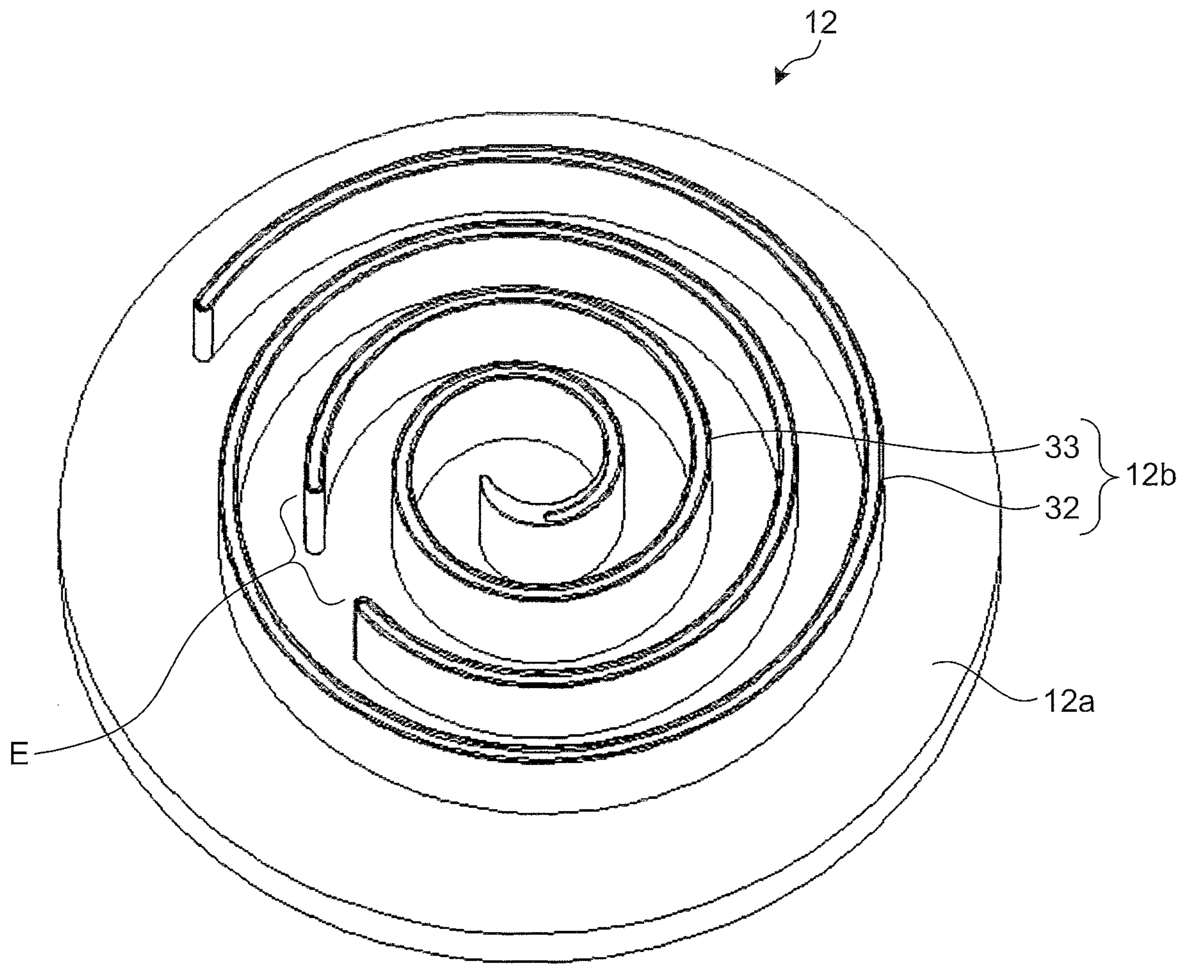


FIG.7



# FIG.8

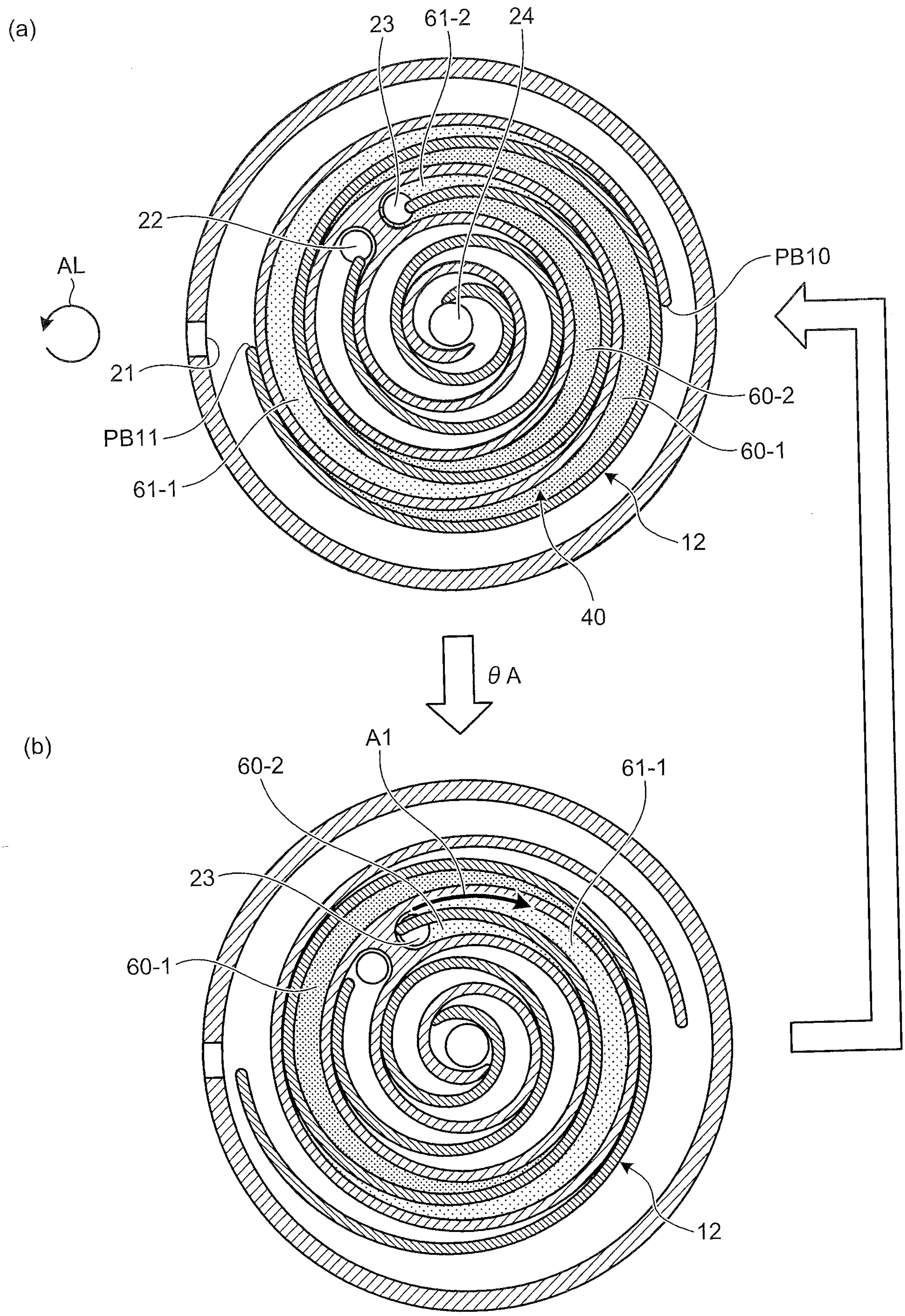

(a)
23
61-2
24
22
AL
21
PB11
61-1
PB10
60-2
60-1
12
40
θ A
(b)
A1
60-2
61-1
23
60-1
12

FIG.9

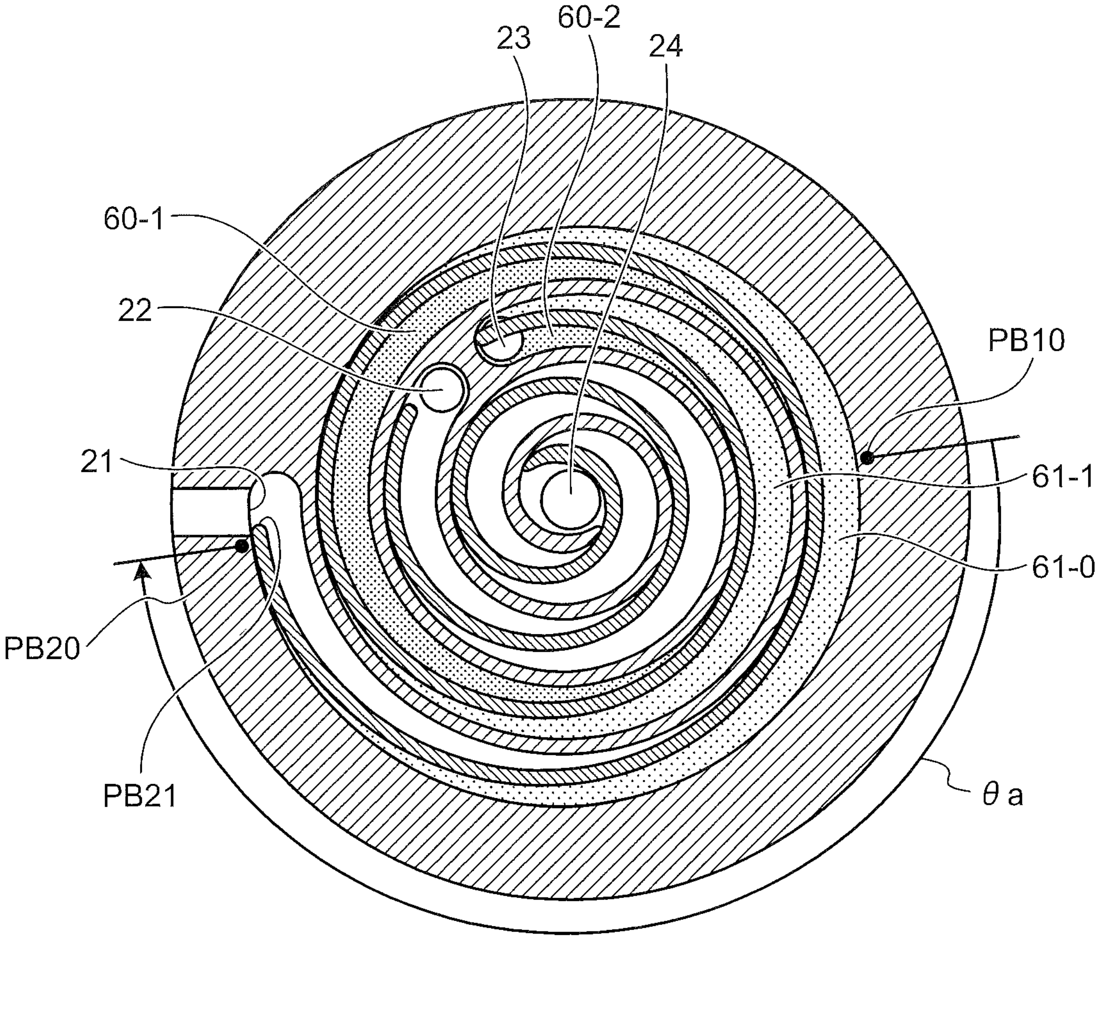


FIG.10

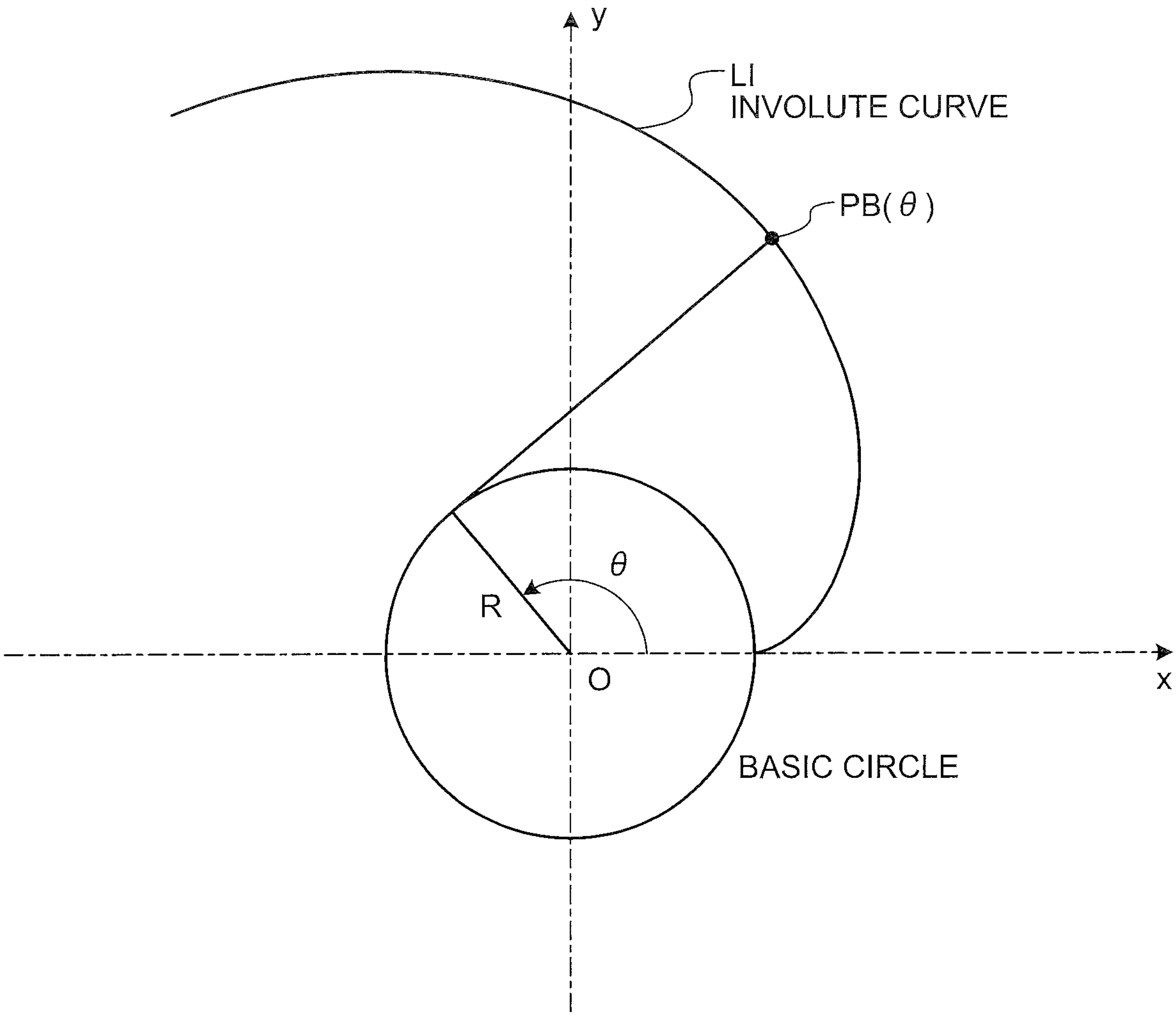


FIG.11

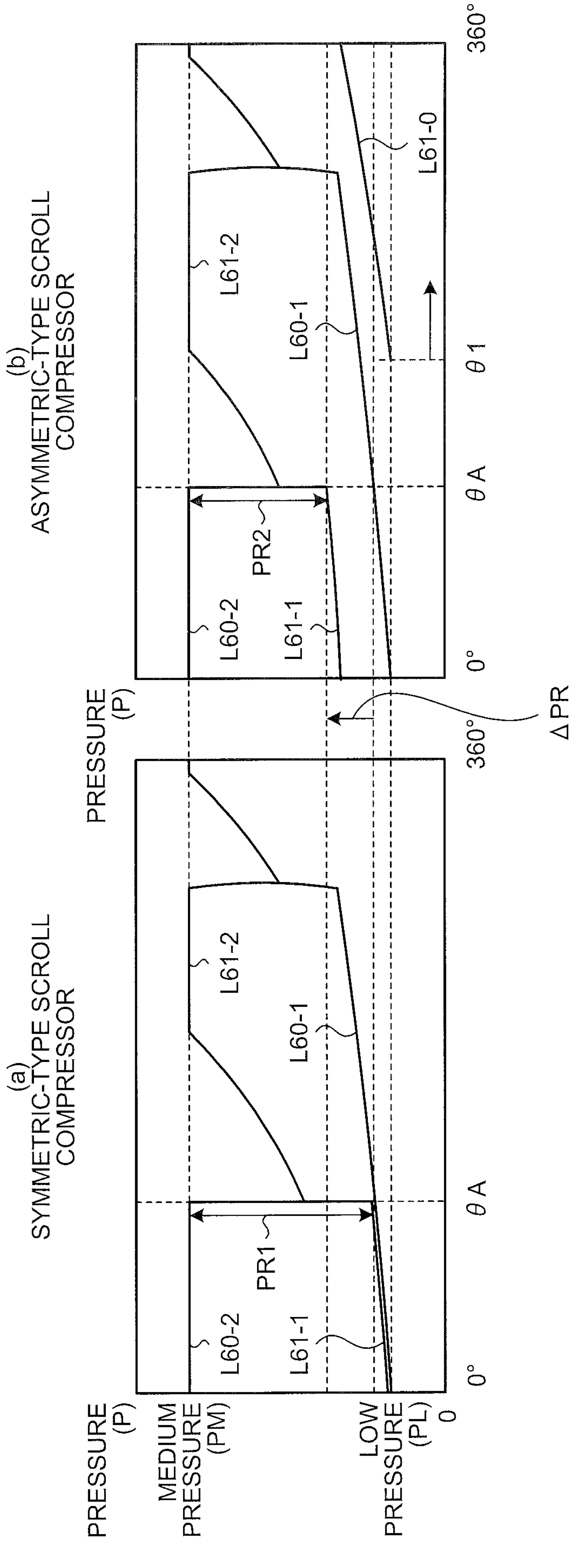

(a)
SYMMETRIC-TYPE SCROLL
COMPRESSOR
(b)
ASYMMETRIC-TYPE SCROLL
COMPRESSOR
PRESSURE
(P)
MEDIUM
PRESSURE
(PM)
LOW
PRESSURE
(PL)
0
0°
θA
360°
θ1
L60-2
L61-1
PR1
L61-2
L60-1
PR2
L61-0
ΔPR

FIG.12

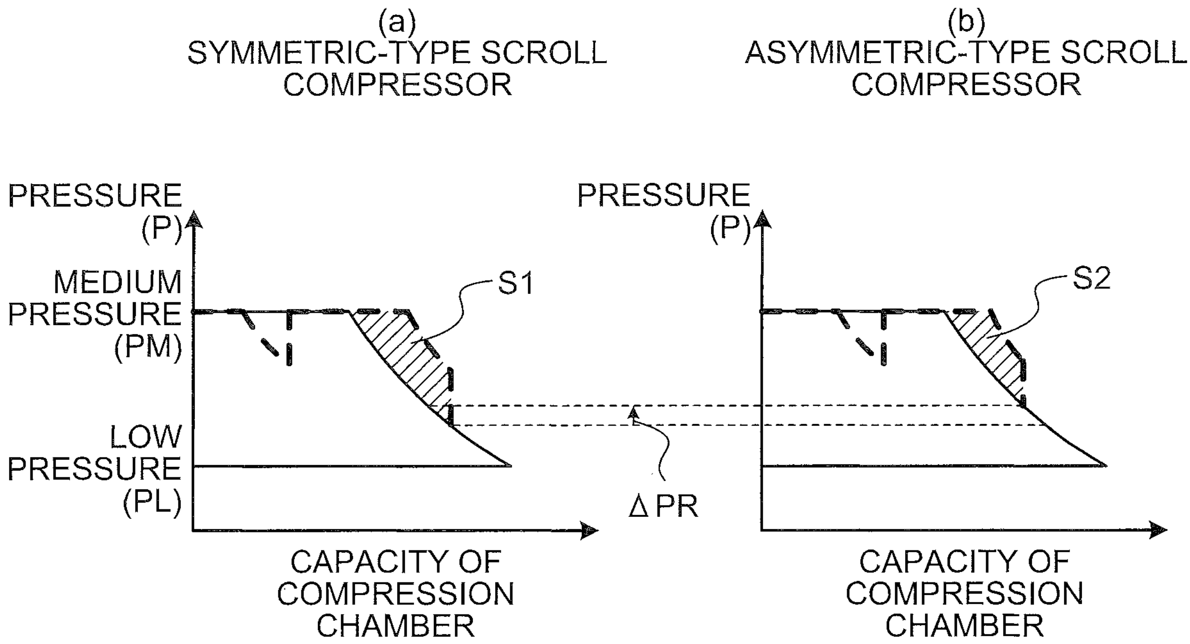

(a)
SYMMETRIC-TYPE SCROLL COMPRESSOR
(b)
ASYMMETRIC-TYPE SCROLL COMPRESSOR
PRESSURE (P)
MEDIUM PRESSURE (PM)
LOW PRESSURE (PL)
S1
S2
Δ PR
CAPACITY OF COMPRESSION CHAMBER

FIG.13

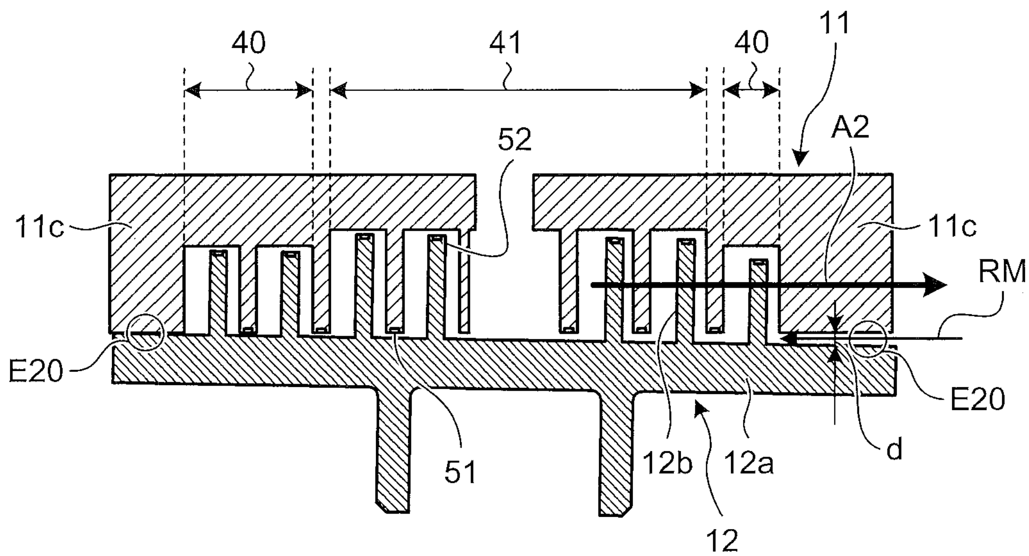

40
41
40
11
52
A2
11c
11c
RM
E20
E20
d
51
12b
12a
12

FIG.14

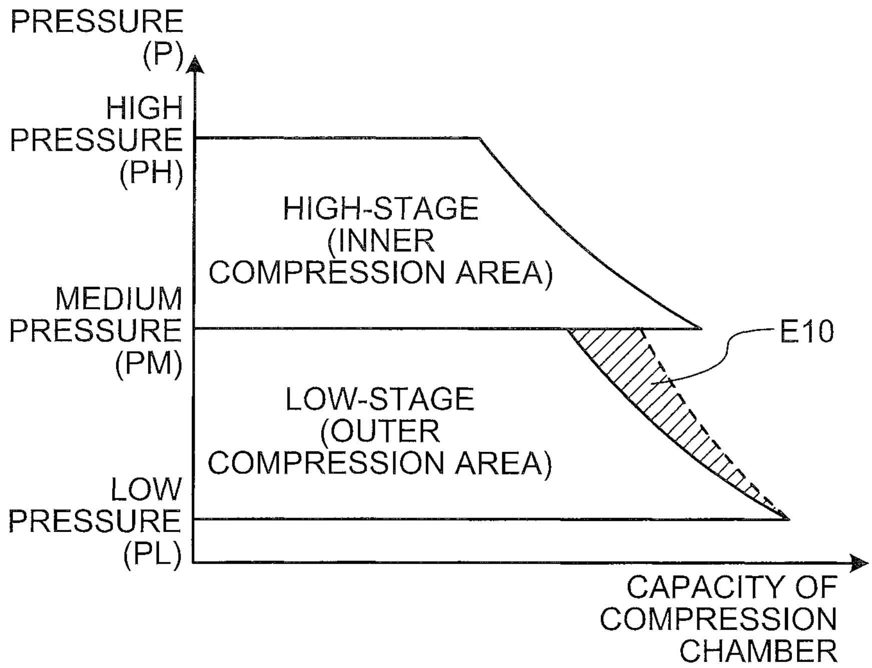

PRESSURE (P)
HIGH PRESSURE (PH)
HIGH-STAGE (INNER COMPRESSION AREA)
MEDIUM PRESSURE (PM)
E10
LOW-STAGE (OUTER COMPRESSION AREA)
LOW PRESSURE (PL)
CAPACITY OF COMPRESSION CHAMBER

FIG.15

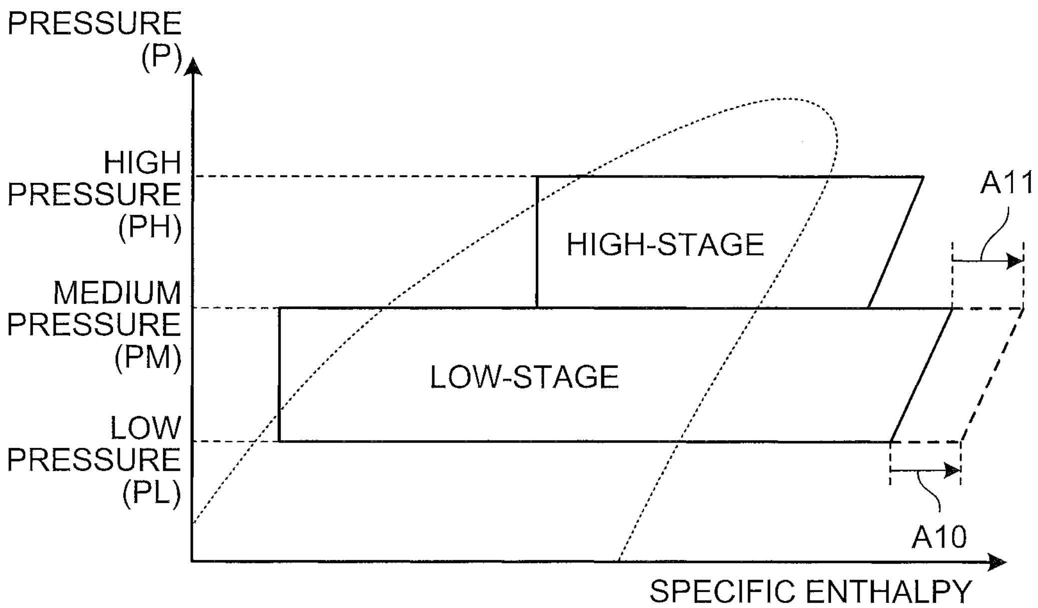

PRESSURE (P)
HIGH PRESSURE (PH)
HIGH-STAGE
A11
MEDIUM PRESSURE (PM)
LOW-STAGE
LOW PRESSURE (PL)
A10
SPECIFIC ENTHALPY

FIG.16

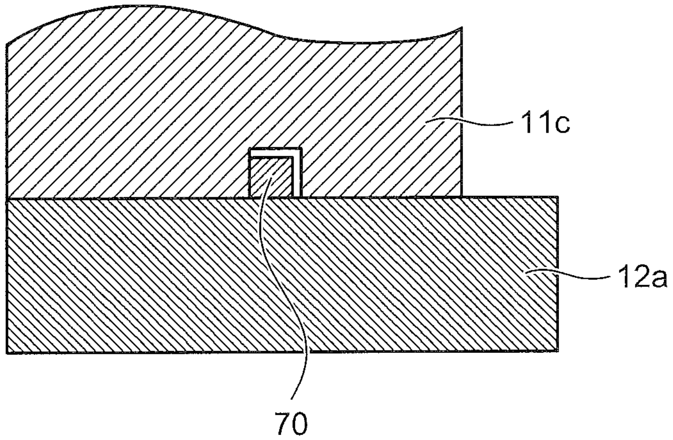



FIG.17

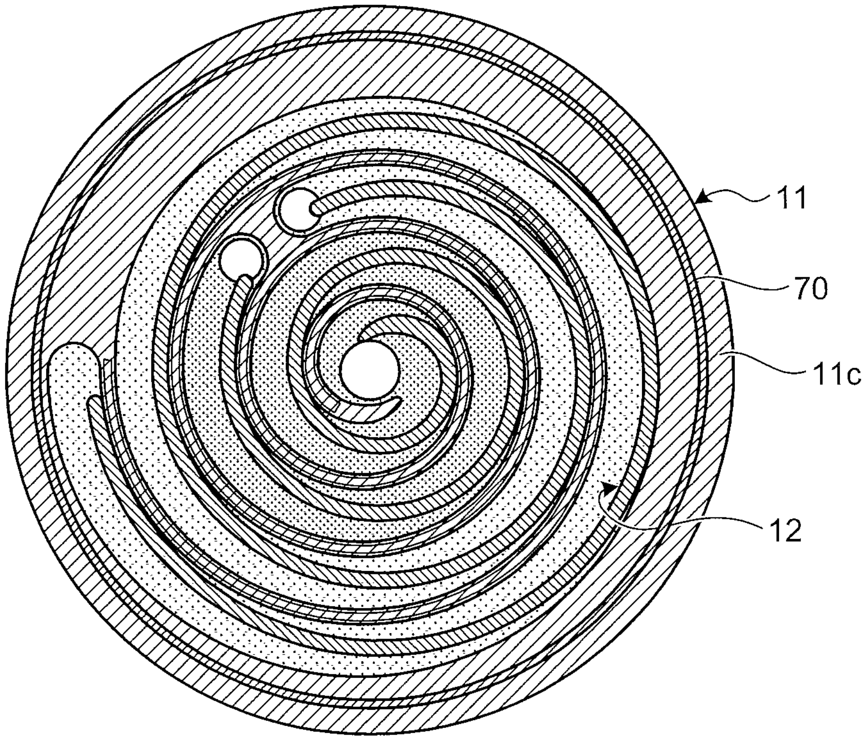


FIG.18

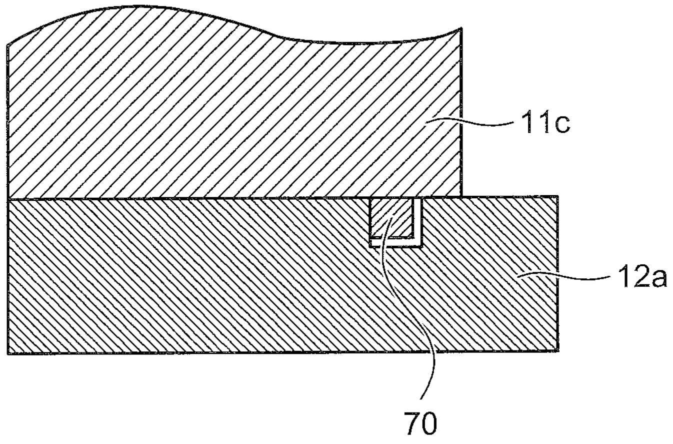



FIG.19

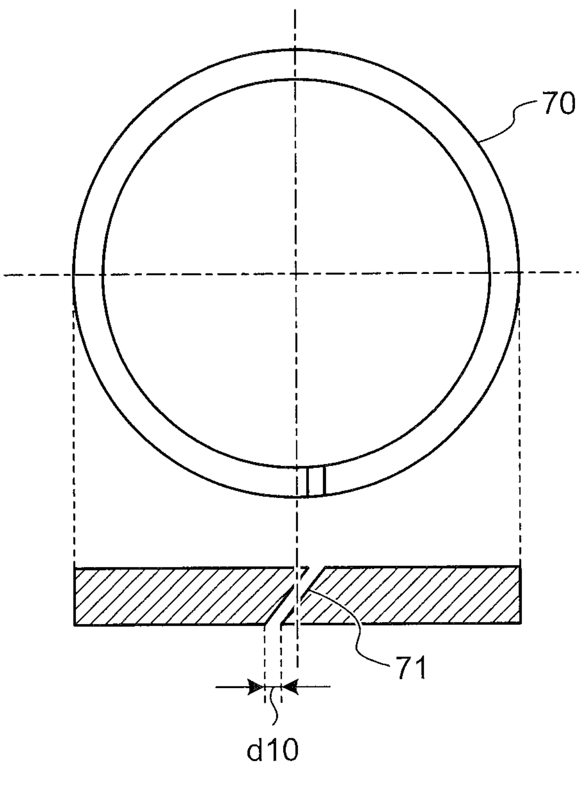


FIG.20

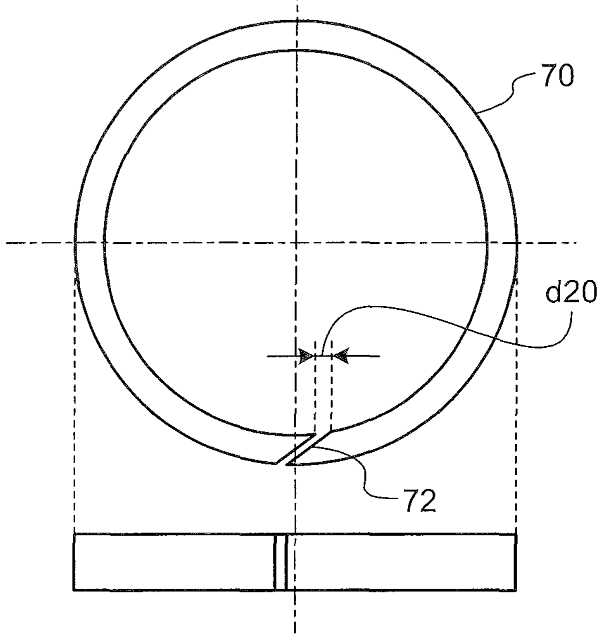



FIG.21

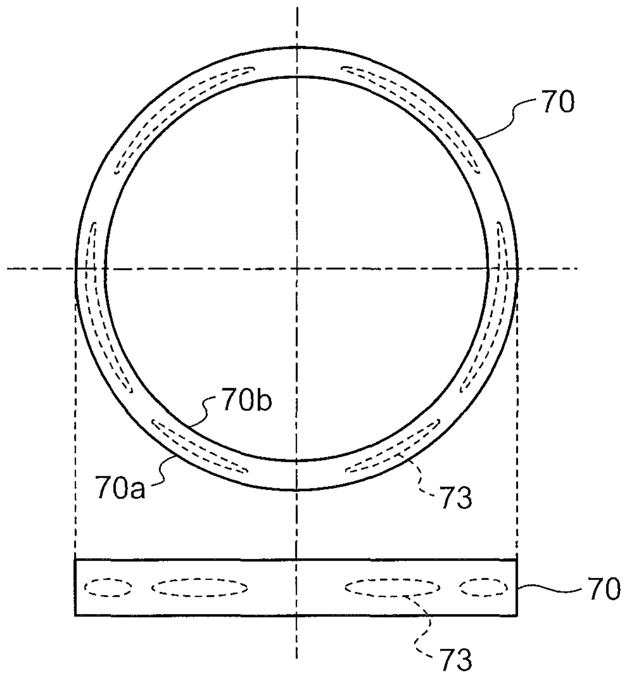


FIG.22

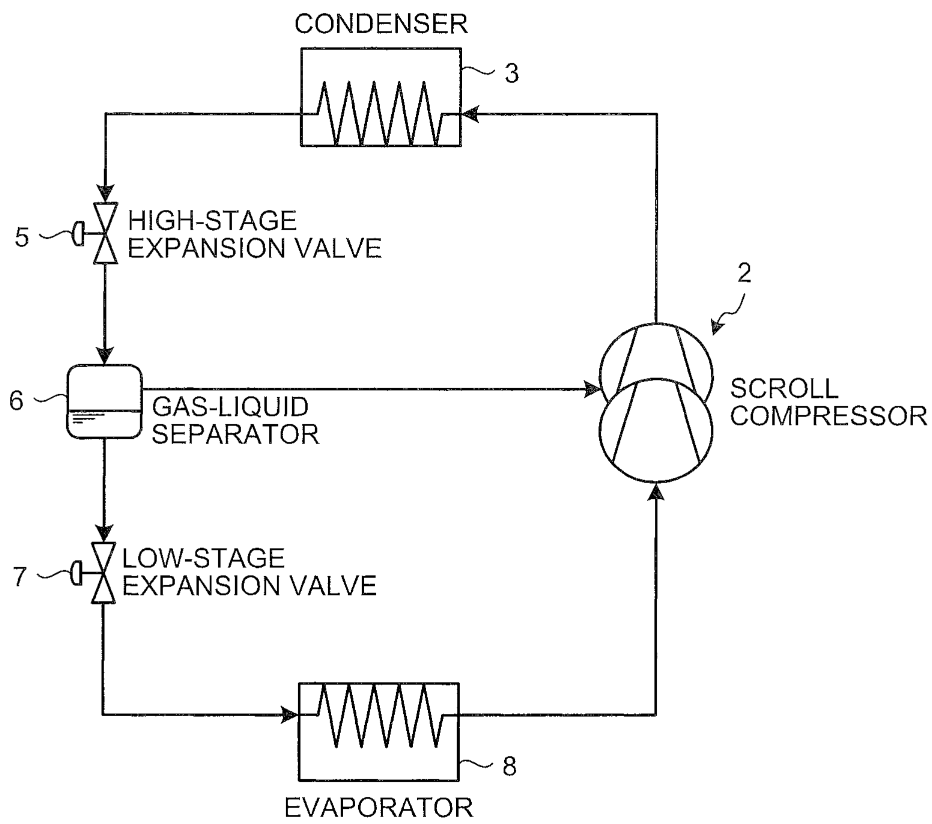
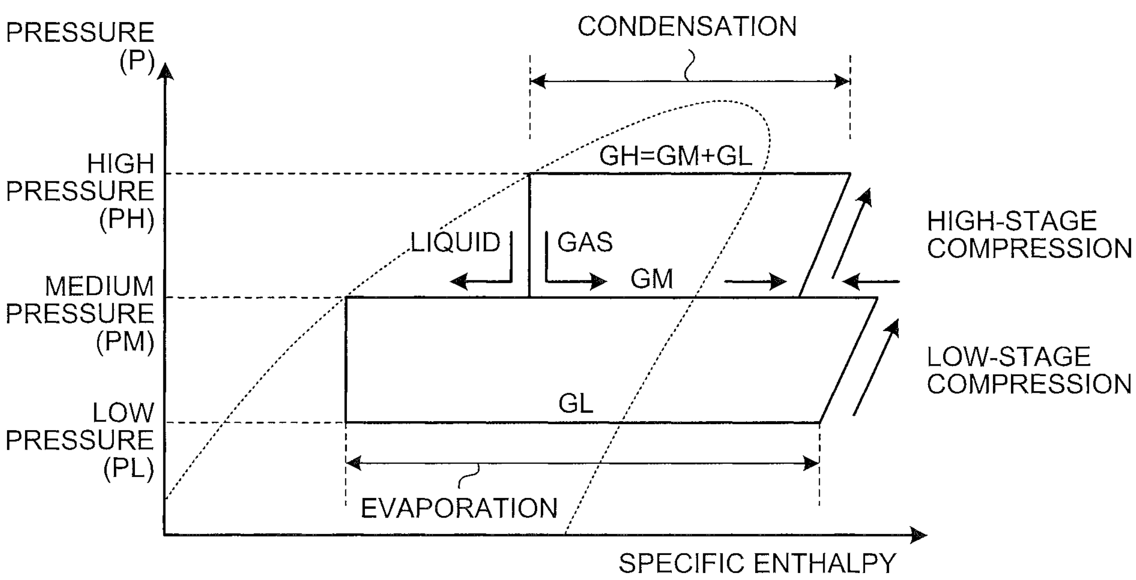
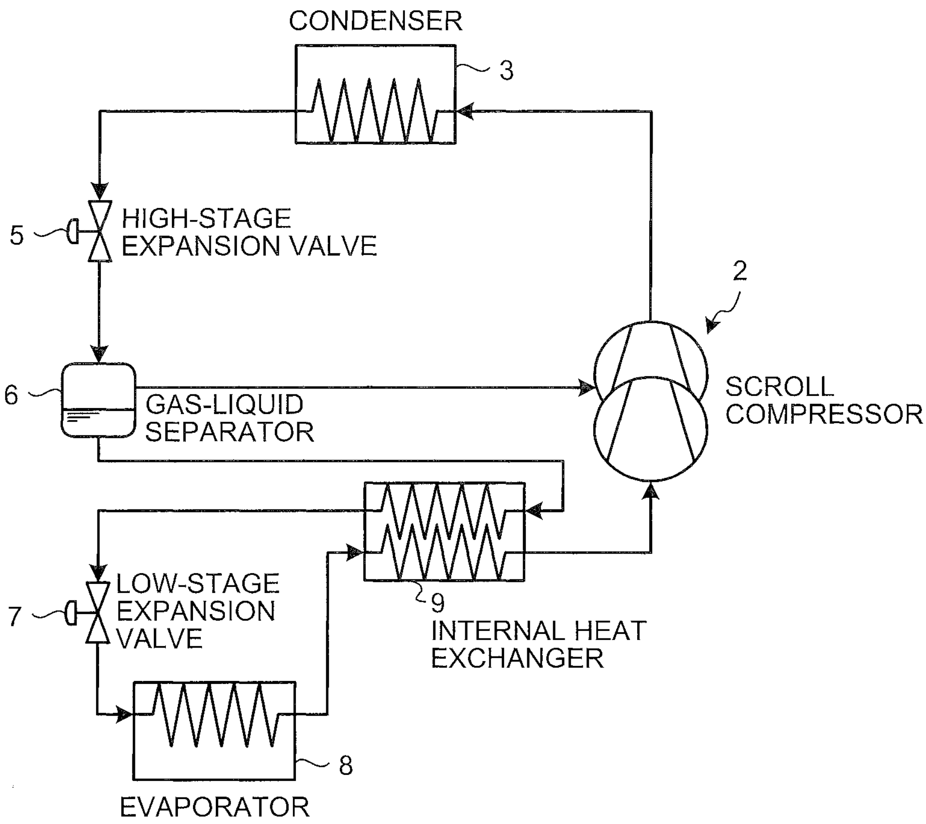

CONDENSER
3
5
HIGH-STAGE
EXPANSION VALVE
2
6
GAS-LIQUID
SEPARATOR
SCROLL
COMPRESSOR
7
LOW-STAGE
EXPANSION VALVE
8
EVAPORATOR

FIG.23


PRESSURE
(P)
CONDENSATION
HIGH
PRESSURE
(PH)
GH=GM+GL
HIGH-STAGE
COMPRESSION
LIQUID
GAS
GM
MEDIUM
PRESSURE
(PM)
LOW-STAGE
COMPRESSION
LOW
PRESSURE
(PL)
GL
EVAPORATION
SPECIFIC ENTHALPY

# FIG.24


CONDENSER
3
5
HIGH-STAGE
EXPANSION VALVE
2
6
GAS-LIQUID
SEPARATOR
SCROLL
COMPRESSOR
7
LOW-STAGE
EXPANSION
VALVE
9
INTERNAL HEAT
EXCHANGER
8
EVAPORATOR

# FIG.25

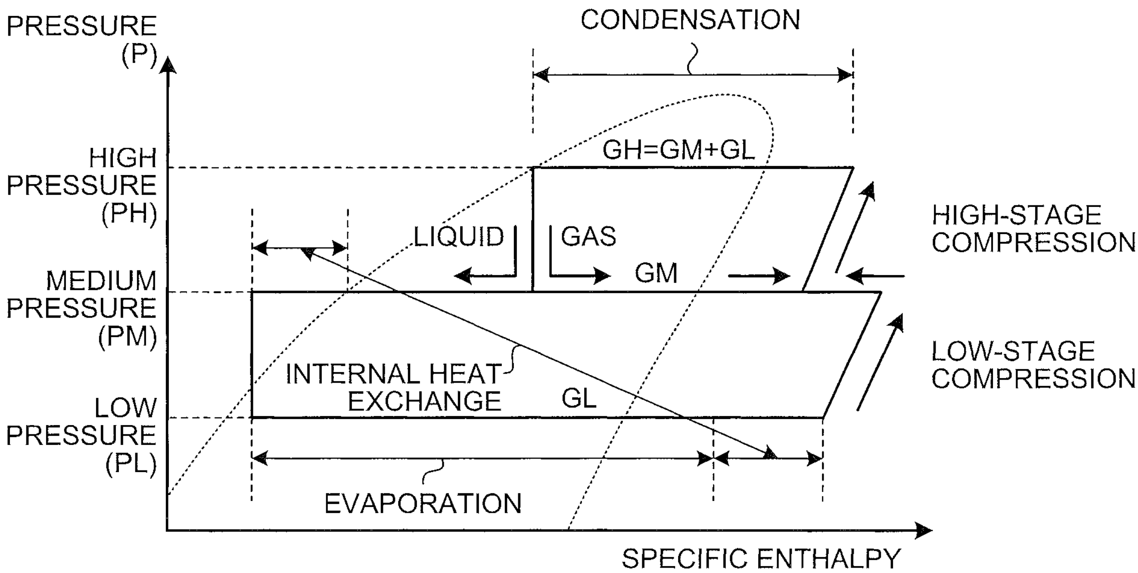

PRESSURE
(P)
CONDENSATION
HIGH
PRESSURE
(PH)
GH=GM+GL
LIQUID
GAS
GM
HIGH-STAGE
COMPRESSION
MEDIUM
PRESSURE
(PM)
LOW-STAGE
COMPRESSION
INTERNAL HEAT
EXCHANGE
GL
LOW
PRESSURE
(PL)
EVAPORATION
SPECIFIC ENTHALPY

FIG.26

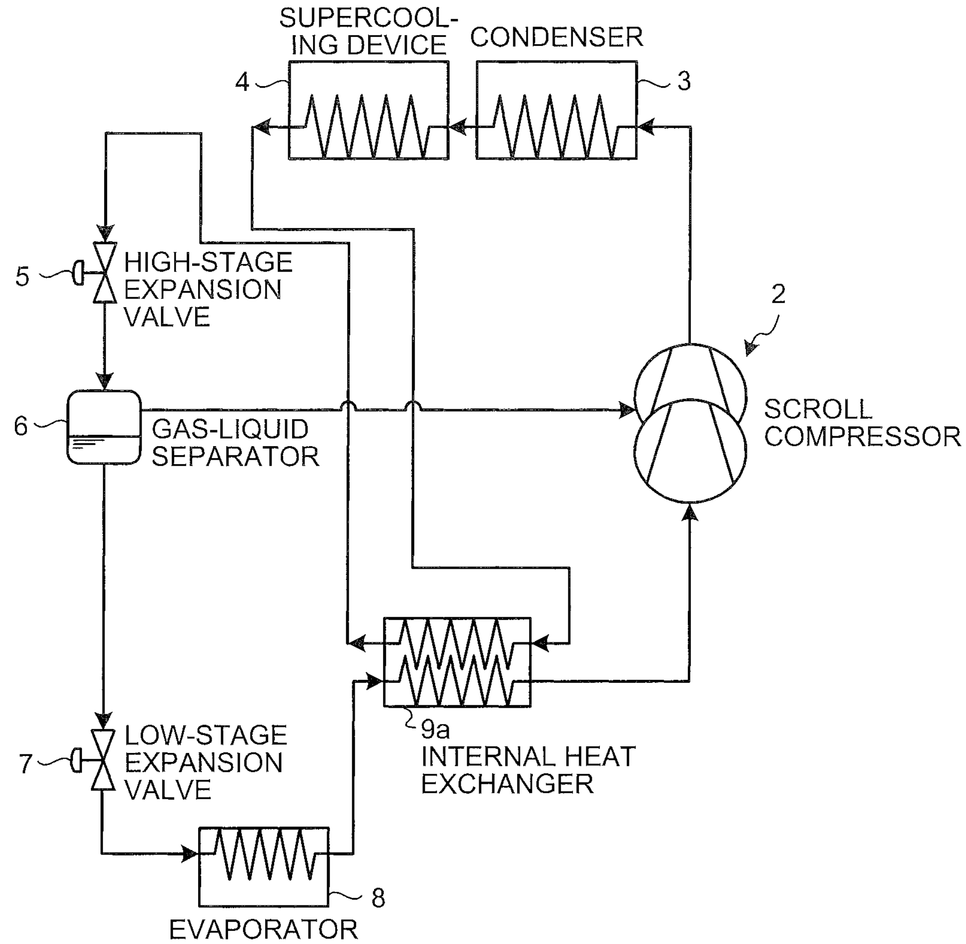

SUPERCOOL-
ING DEVICE
CONDENSER
4
3
2
5
HIGH-STAGE
EXPANSION
VALVE
6
GAS-LIQUID
SEPARATOR
SCROLL
COMPRESSOR
9a
INTERNAL HEAT
EXCHANGER
7
LOW-STAGE
EXPANSION
VALVE
8
EVAPORATOR

FIG.27

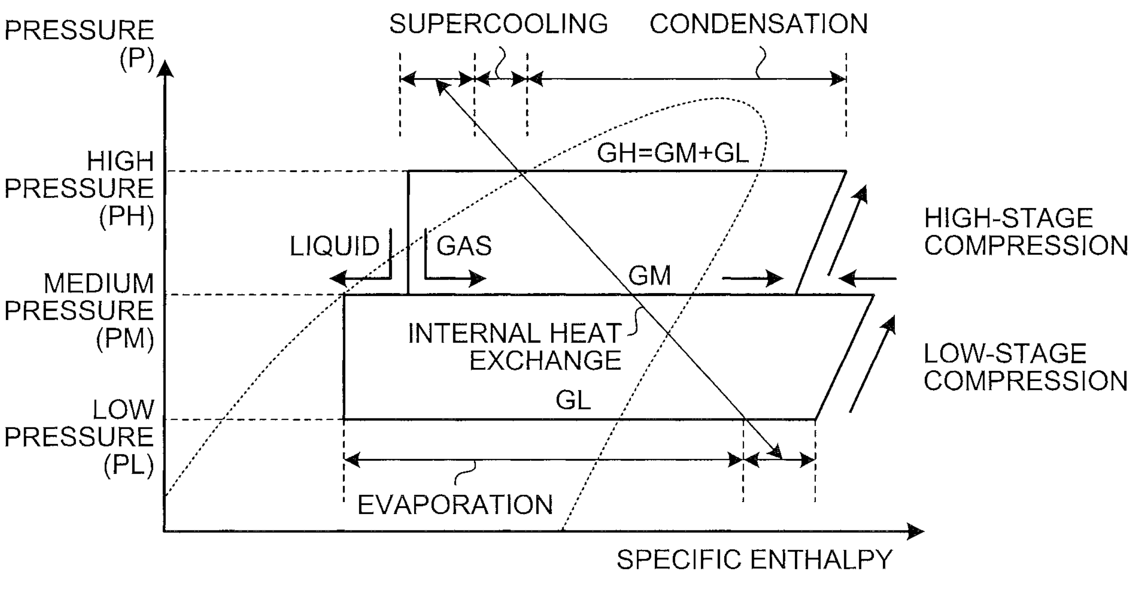

PRESSURE
(P)
SUPERCOOLING
CONDENSATION
GH=GM+GL
HIGH
PRESSURE
(PH)
LIQUID
GAS
HIGH-STAGE
COMPRESSION
MEDIUM
PRESSURE
(PM)
GM
INTERNAL HEAT
EXCHANGE
LOW-STAGE
COMPRESSION
LOW
PRESSURE
(PL)
GL
EVAPORATION
SPECIFIC ENTHALPY

FIG.28

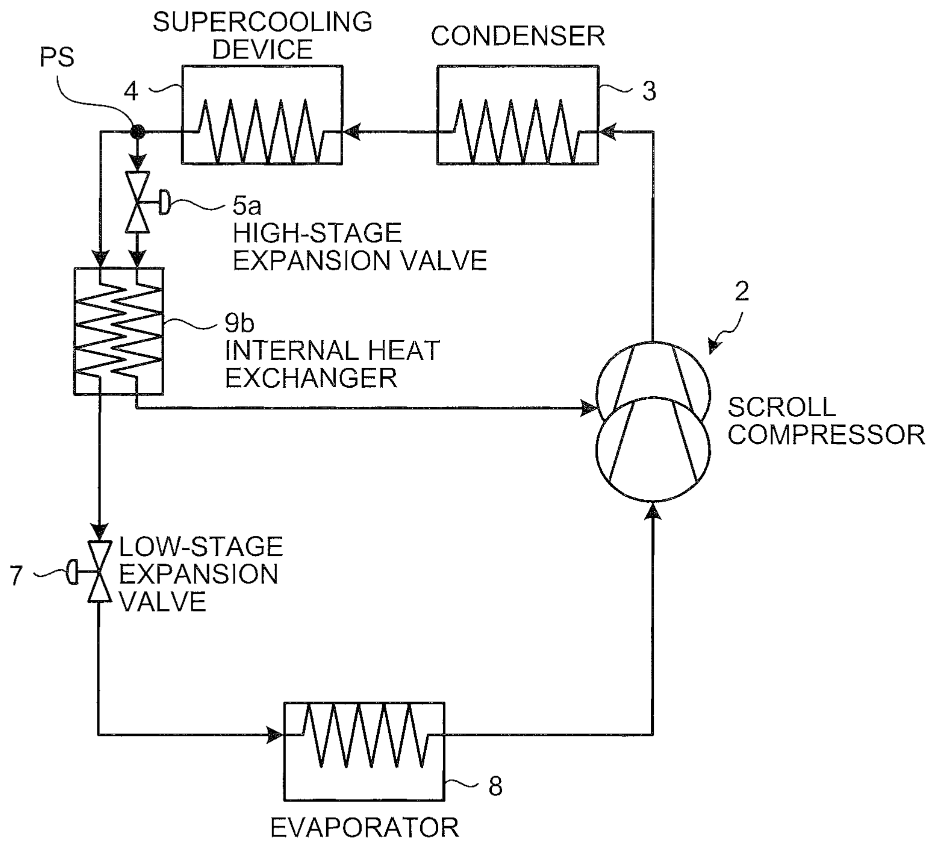

SUPERCOOLING DEVICE
CONDENSER
PS
4
3
5a
HIGH-STAGE EXPANSION VALVE
2
9b
INTERNAL HEAT EXCHANGER
SCROLL COMPRESSOR
7
LOW-STAGE EXPANSION VALVE
8
EVAPORATOR

FIG.29

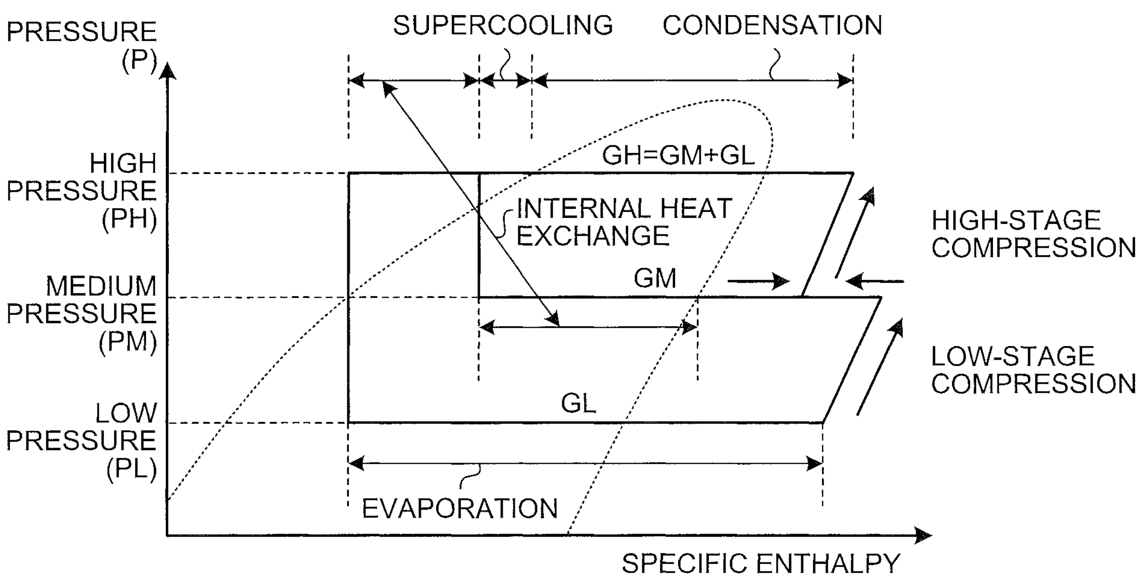

PRESSURE (P)
SUPERCOOLING
CONDENSATION
HIGH PRESSURE (PH)
GH=GM+GL
INTERNAL HEAT EXCHANGE
HIGH-STAGE COMPRESSION
MEDIUM PRESSURE (PM)
GM
LOW-STAGE COMPRESSION
LOW PRESSURE (PL)
GL
EVAPORATION
SPECIFIC ENTHALPY

FIG.30

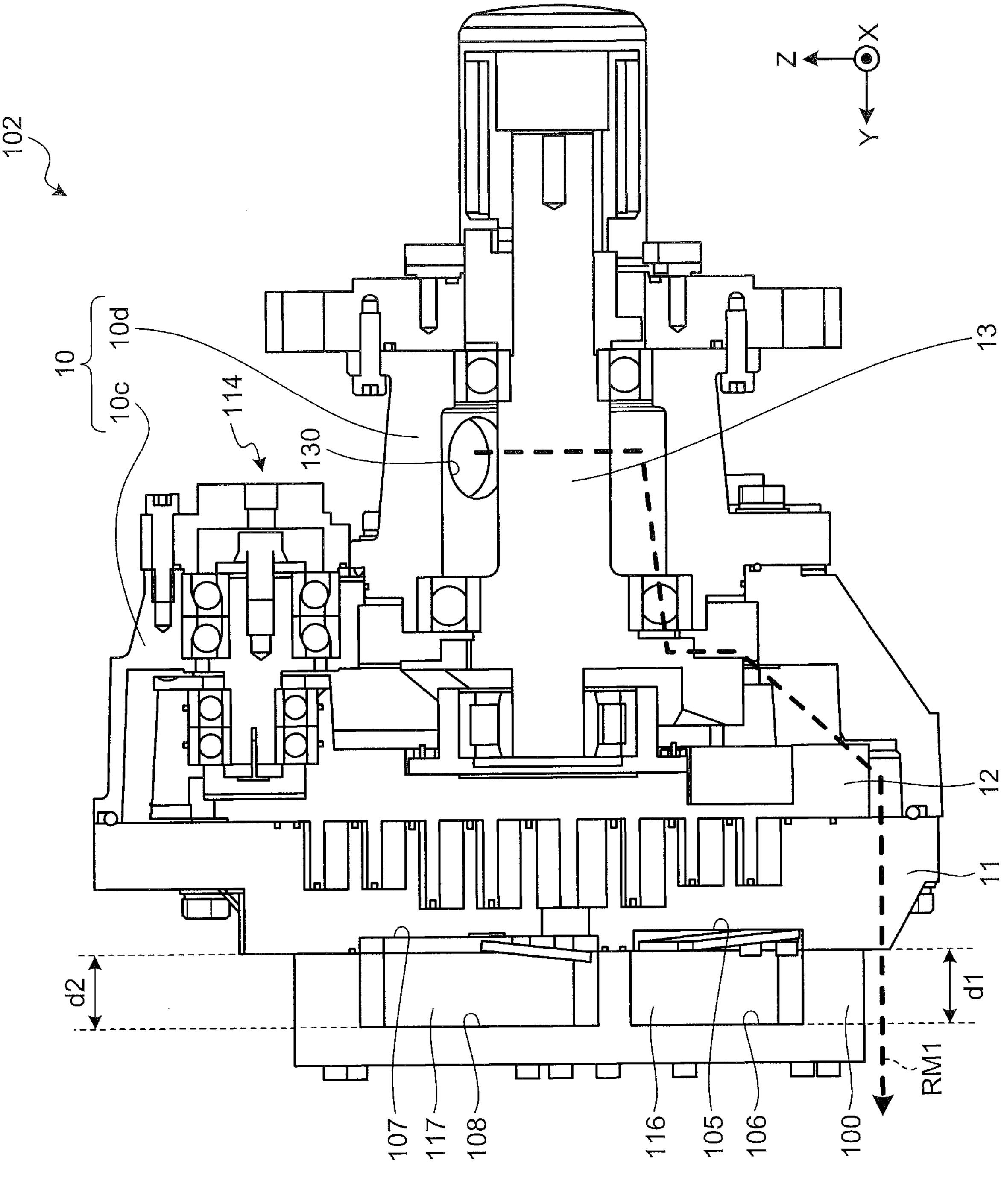

102
10
10c
10d
114
130
13
12
11
d2
d1
RM1
107
117
108
116
105
106
100
Z
X
Y

FIG.31

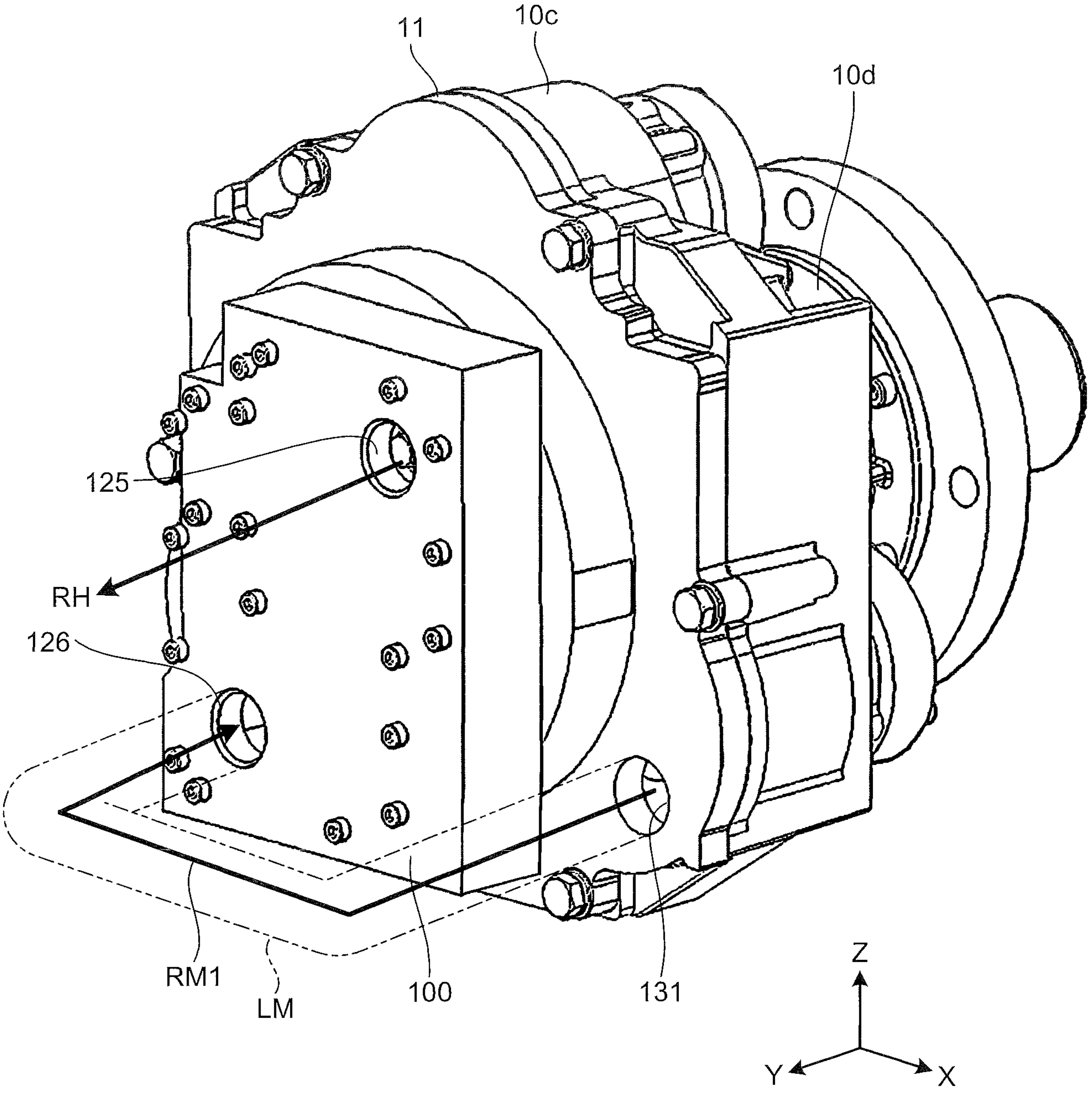


FIG.32

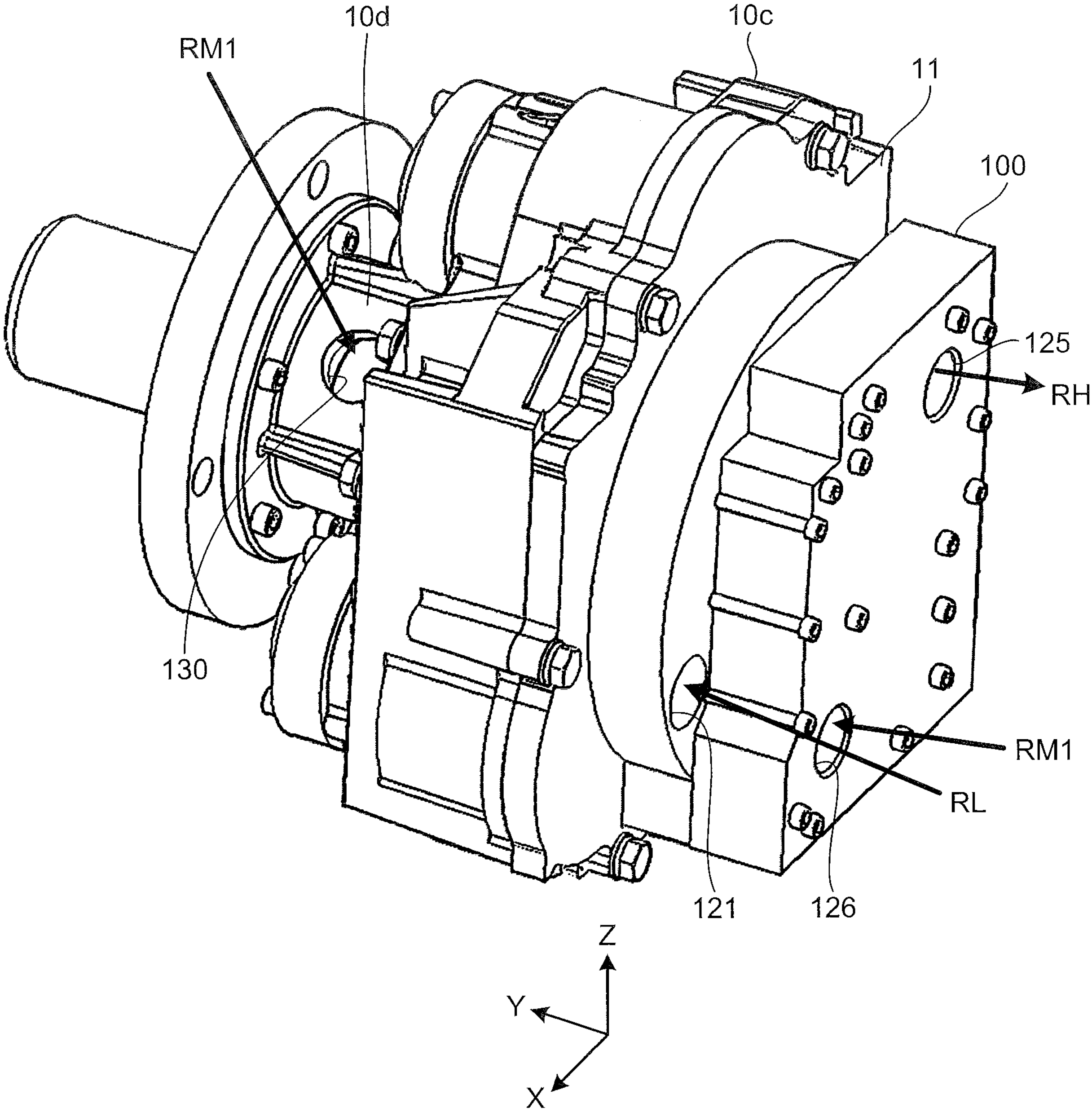


FIG.33

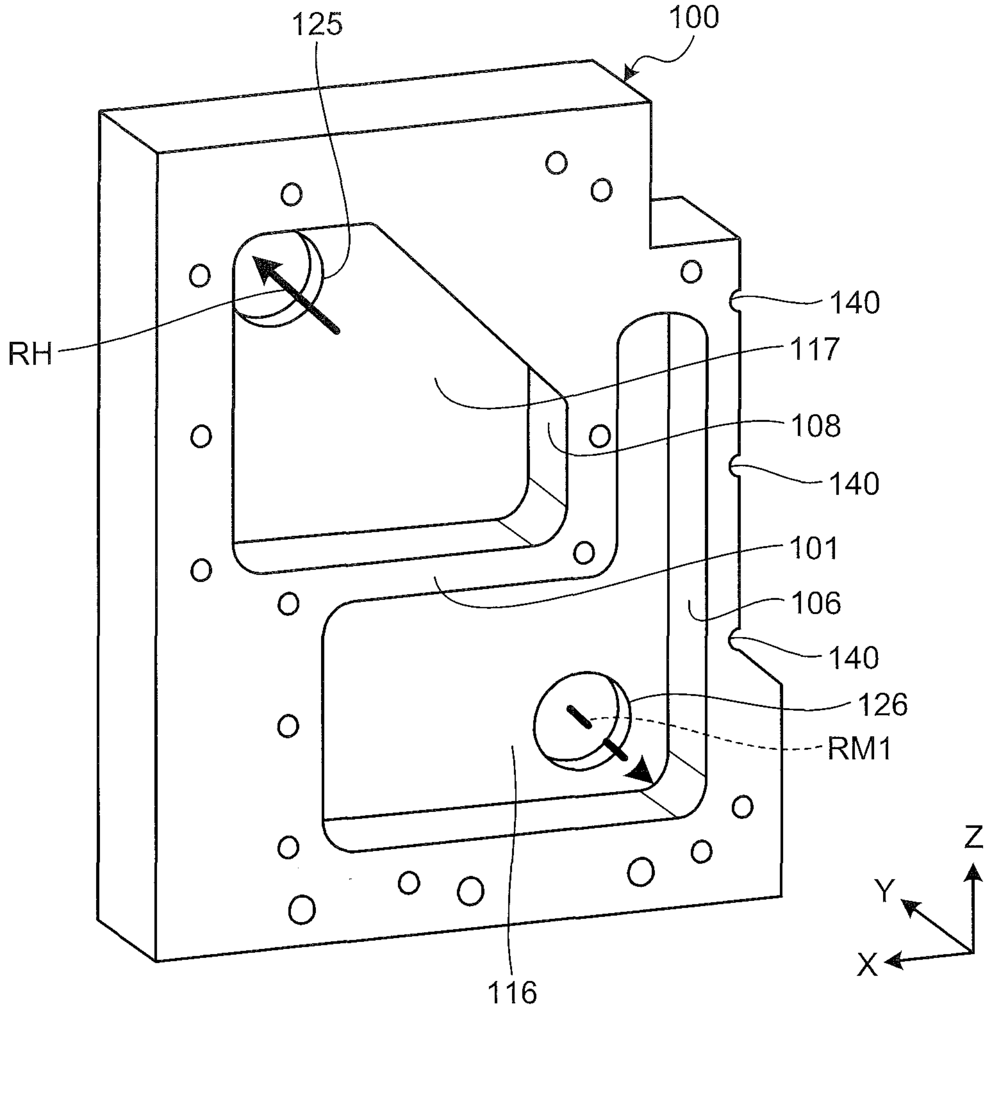


FIG.34

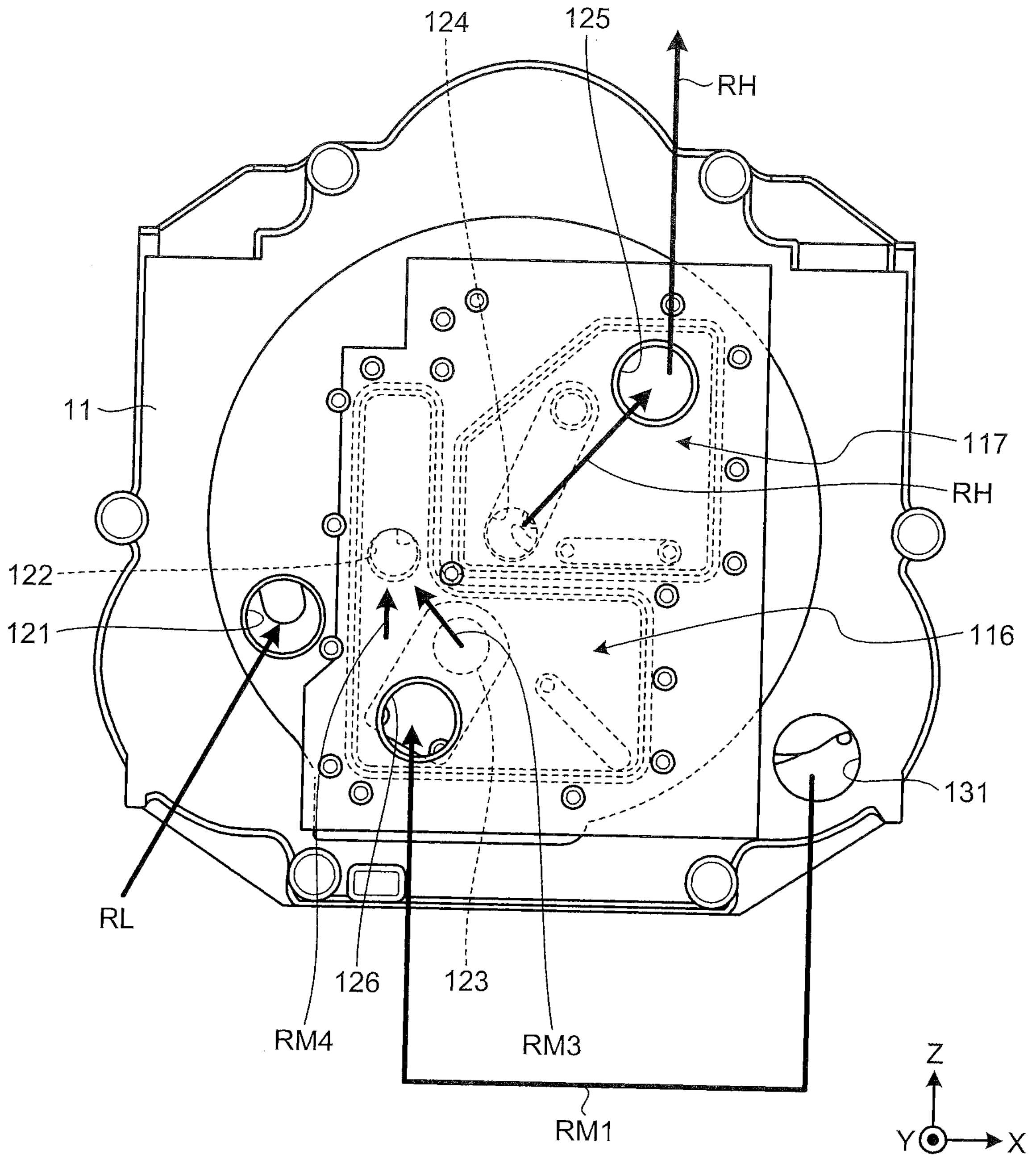
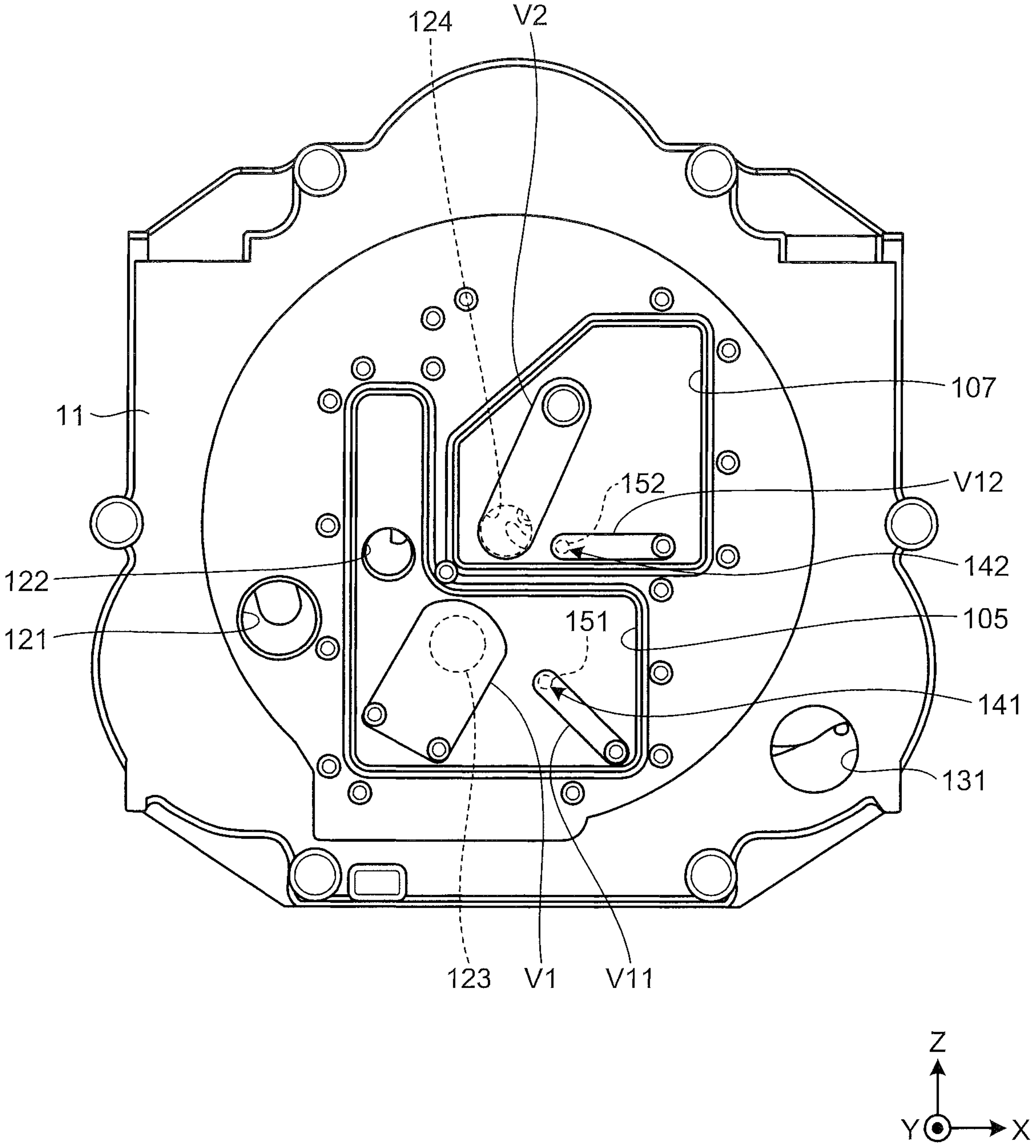


FIG.35



## INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2019/035772

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F04C18/02(2006.01)i, F04C23/00(2006.01)i, F04C28/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. F04C18/02, F04C23/00, F04C28/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

| | |
|---|---|
| Published examined utility model applications of Japan | 1922-1996 |
| Published unexamined utility model applications of Japan | 1971-2019 |
| Registered utility model specifications of Japan | 1996-2019 |
| Published registered utility model applications of Japan | 1994-2019 |

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>Y | JP 6-159278 A (NIPPON SOKEN, INC.) 07 June 1994, paragraphs [0010]-[0018], [0030], fig. 1-4, 12-13 & US 5399076 A, column 3, line 55 to column 7, line 28, column 10, lines 5-31, fig. 1-4, 12-13 | 1, 5-6<br>2-4, 7-10 |
| Y | WO 2011/055444 A1 (MITSUBISHI ELECTRIC CORP.) 12 May 2011, paragraph [0016], fig. 1-4 & EP 2497955 A1, paragraph [0023], fig. 1-4 & KR 10-2012-0048039 A & CN 102597524 A | 2 |

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

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- "O" document referring to an oral disclosure, use, exhibition or other means
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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 05 November 2019 (05.11.2019) | 19 November 2019 (19.11.2019) |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| Japan Patent Office<br>3-4-3, Kasumigaseki, Chiyoda-ku,<br>Tokyo 100-8915, Japan | Telephone No. |

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## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/035772

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | JP 2018-9565 A (DENSO CORP.) 18 January 2018, paragraphs [0075], [0079], [0083]-[0106], fig. 21-26 & WO 2018/003431 A1 | 3-4, 7-8 |
| Y | JP 2018-127903 A (SOKEN, INC.) 16 August 2018, paragraphs [0013]-[0093], fig. 1-7 (Family: none) | 3-4, 7, 10 |
| Y | JP 2007-9772 A (KEIHIN CORP.) 18 January 2007, paragraph [0060], fig. 1, 5 (Family: none) | 9 |

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## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description

- JP 2004332556 A **[0003]**