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(72) Inventors:
• **SATO, Hajime**
Nagoya-shi
Aichi 453-8515 (JP)
• **KIMATA, Yoshiyuki**
Kiyosu-shi
Aichi 452-8561 (JP)

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(74) Representative: **Intès, Didier Gérard André et al**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cedex 07 (FR)

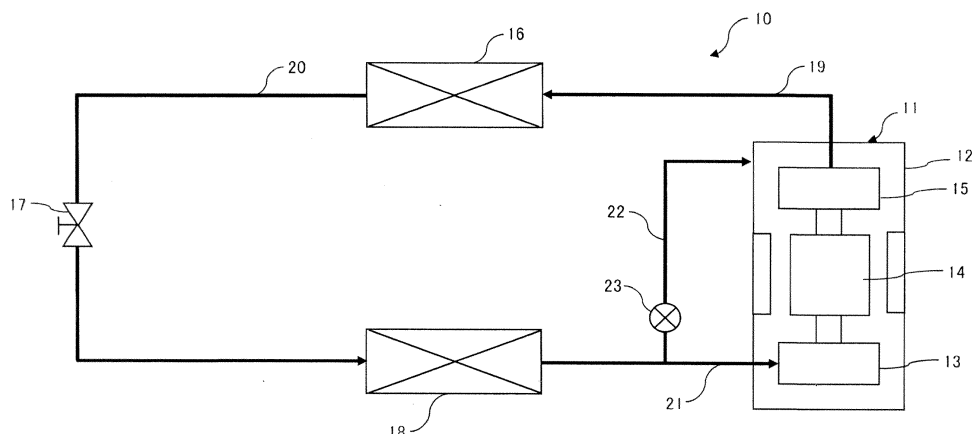
(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 108-8215 (JP)

(54) **MULTIPLE-STAGE COMPRESSOR**

(57) There is provided a highly efficient multiple-stage compressor provided with a bypass pipe. A multiple-stage compressor 11 comprises a sealed housing 12; a low-stage side compression mechanism 13 and a high-stage side compression mechanism 15, both being provided in the sealed housing 12; an electric motor 14 for driving the low-stage side compression mechanism 13 and the high-stage side compression mechanism 15; a suction pipe 21 for supplying a refrigerant to the low-

stage side compression mechanism 13; a discharge pipe 19 connected to the sealed housing 12 to discharge the refrigerant compressed by the high-stage side compression mechanism 15; a bypass pipe 22 branched from the suction pipe 21 to allow a cavity 12a on the refrigerant passage downstream side of the electric motor 14 and the suction pipe 21 to communicate with each other; and a valve 23 provided in the bypass pipe 22 to selectively permit or inhibit the supply of refrigerant to an intermediate-pressure chamber. Figure 2

Figure 1



Description

Technical Field

5 **[0001]** The present invention relates to a multiple-stage compressor provided with two compression mechanisms.

Background Art

10 **[0002]** A multiple-stage compressor provided with two compression mechanisms of a rotary compression mechanism and a scroll compression mechanism has been proposed. For example, Patent Document 1 discloses a multiple-stage compressor in which an electric motor is provided in the cavity of one sealed housing, two compression mechanisms driven by the rotating shaft of the electric motor are provided, and one of the two compression mechanisms is a rotary compression mechanism and the other thereof is a scroll compression mechanism, the one being on the low-stage side and the other being on the high-stage side. According to this multiple-stage compressor, compression from a low pressure to an intermediate pressure is effected by the low-stage side compressor, and compression from the intermediate pressure to a high pressure is effected by the high-stage side compressor. Therefore, as compared with the case where compression from a low pressure to a high pressure is effected by using the rotary compression mechanism or the scroll compression mechanism singly, the drawbacks of individual compressors can be eliminated, and a small-size and high-performance compressor can be provided.

Prior Art Document

Patent Document

25 **[0003]**

Patent Document 1: Japanese Patent Laid-Open No. 05-87074

30 **[0004]** The scroll compression mechanism used as one compression mechanism of the above-described multiple-stage compressor has a fixed capacity ratio. Therefore, if both of the rotary compression mechanism and the scroll compression mechanism are used when the load is low, that is, when the multiple-stage compressor must be operated at a low pressure ratio, the compression becomes excessive, which results in a large power loss and decreased efficiency of the compression mechanisms. Accordingly, Patent Document 1 proposes a technique in which a bypass pipe is provided to allow an intermediate-pressure chamber and a low-pressure side suction section to communicate with each other, and an openable/closable control valve is provided in this bypass pipe. According to this proposal, in an operating condition in which the pressure ratio is low, the control valve is opened so that the housing cavity having functioned as an intermediate-pressure chamber and a suction pipe on the low-stage side are allowed to communicate with each other by the bypass pipe to allow a refrigerant to bypass the rotary compression mechanism. Thereby, the cavity is caused to function substantially as a low-pressure section, and compression is effected by only the scroll compression mechanism on the high-stage side. Since the low-stage side does not effect compression, excessive compression can be avoided. Also, since the low-stage side does not perform compressing work, only a very small loss occurs, and capacity control can be carried out with high efficiency.

Summary of Invention

Technical Problem

45 **[0005]** Although the multiple-stage compressor offers high efficiency, as the recent tendency, it has also been demanded that the multiple-stage compressor have a still higher efficiency. Accordingly, an object of the present invention is to provide a highly efficient multiple-stage compressor provided with a bypass pipe.

Solution to Problem

55 **[0006]** In the multiple-stage compressor described in Patent Document 1, the bypass pipe is connected to a position distant from the high-stage side compression mechanism, more specifically, to the refrigerant passage upstream side of the electric motor. Therefore, the refrigerant supplied through the bypass pipe passes through the electric motor, and arrives at the high-stage side compression mechanism. The electric motor generates heat by being operated. Therefore, in the refrigerant passing through the electric motor, an overheat loss occurs. Also, the refrigerant arrives at the high-

stage side compression mechanism after passing through a gap in the electric motor or a gap between the electric motor and the housing, and this gap is narrow. Therefore, in the refrigerant passing through the electric motor, a pressure loss occurs. Thus, the multiple-stage compressor described in Patent Document 1 has causes of decreased efficiency based on the connecting position of the bypass pipe. However, the bypass pipe need not be connected to the refrigerant passage upstream side of the electric motor if the bypass pipe communicates with the cavity.

[0007] To solve the above problems, the multiple-stage compressor of the present invention comprises a sealed housing; a low-stage side compression mechanism and a high-stage side compression mechanism, both being provided in a cavity of the sealed housing; an electric motor provided between the low-stage side compression mechanism and the high-stage side compression mechanism to drive the low-stage side compression mechanism and the high-stage side compression mechanism; a suction pipe connected to the sealed housing to supply a refrigerant to the low-stage side compression mechanism; a discharge pipe connected to the sealed housing to discharge the refrigerant compressed by the high-stage side compression mechanism; a bypass pipe branched from the suction pipe to allow the cavity on the refrigerant passage downstream side of the electric motor and the suction pipe to communicate with each other; and a valve provided in the bypass pipe to selectively permit or inhibit the supply of refrigerant to the cavity.

[0008] In the multiple-stage compressor of the present invention, since the bypass pipe is provided so that the suction pipe and the cavity on the refrigerant passage downstream side of the electric motor communicate with each other, the refrigerant supplied through the bypass pipe does not pass through the electric motor. Therefore, according to the multiple-stage compressor of the present invention, the refrigerant supplied through the bypass pipe arrives at the high-stage side compression mechanism without the occurrence of overheat loss and pressure loss caused by the passing-through of the electric motor.

[0009] An accumulator is sometimes provided on the suction pipe of the multiple-stage compressor. In this case, it is preferable that the bypass pipe be branched from the suction pipe on the refrigerant passage upstream side of a position at which the accumulator is provided. The reason for this is that the occurrence of pressure loss in the refrigerant sent through the bypass pipe is avoided by the passing-through of the accumulator.

[0010] The multiple-stage compressor is sometimes provided with an injection pipe for supplying an intermediate-pressure refrigerant, which is drawn from a refrigerant circuit, to the cavity. In this case, it is preferable that the injection pipe be joined to the bypass pipe.

[0011] The reason for this is that the number of pipes connected to the sealed housing of the multiple-stage compressor is decreased, and therefore, the breakage risk of pipe caused by vibrations of the multiple-stage compressor is reduced.

[0012] In the case where the injection pipe is joined to the bypass pipe, it is preferable that the valve be provided at the joint point of the two pipes. This configuration can decrease the number of parts, which contributes to the reduction in cost. Also, in this case, the valve can be switched over selectively from a first position at which the refrigerant sent through the injection pipe is permitted to be supplied to the cavity but the refrigerant sent through the bypass pipe is inhibited from being supplied to the cavity to a second position at which the refrigerant sent through the injection pipe is inhibited from being supplied to the cavity but the refrigerant sent through the bypass pipe is permitted to be supplied to the cavity, and vice versa. Generally, injection is used when the load on the multiple-stage compressor is high. At this time, bypass operation need not be performed. Inversely, bypass operation is generally performed when the load on the multiple-stage compressor is low. At this time, injection need not be used. Therefore, a single valve for switching over from the first position to the second position and vice versa suffices.

[0013] In the present invention, it is preferable that the valve permits the refrigerant to be supplied to the cavity within a predetermined time period at the start-up time of the multiple-stage compressor so that the refrigerant is supplied to the high-stage side compression mechanism by bypassing the low-stage side compression mechanism. The reason for this is that the pressure fluctuations at the start-up time of the multiple-stage compressor are reduced to secure safe operation of the multiple-stage compressor.

[0014] This configuration is effective also in the case where the injection pipe is provided. That is, it is preferable that the valve be set at the first position within a predetermined time period at the start-up time of the multiple-stage compressor so that the refrigerant is supplied to the high-stage side compression mechanism by bypassing the low-stage side compression mechanism.

Advantageous effects of Invention

[0015] According to the multiple-stage compressor of the present invention, the refrigerant supplied through the bypass pipe arrives at the high-stage side compression mechanism without the occurrence of overheat loss and pressure loss caused by the passing-through of the electric motor. Therefore, the multiple-stage compressor of the present invention enables highly efficient operation.

Brief Description of Drawings

[0016]

[Figure 1] Figure 1 is a schematic diagram of a refrigerating cycle of a first embodiment.

[Figure 2] Figure 2 is a sectional view of a multiple-stage compressor used for a refrigerating cycle of a first embodiment.

[Figure 3] Figure 3 is a schematic diagram of a refrigerating cycle of a second embodiment.

[Figure 4] Figure 4 is a schematic diagram of a refrigerating cycle of a third embodiment.

[Figure 5] Figure 5 is a schematic diagram of a refrigerating cycle of a fourth embodiment, showing a state in which the supply of a gas refrigerant to an intermediate-pressure chamber of a multiple-stage compressor through an injection pipe is permitted, but the supply of a refrigerant gas to the intermediate-pressure chamber of the multiple-stage compressor through a bypass pipe is inhibited.

[Figure 6] Figure 6 is a schematic diagram of a refrigerating cycle of a fourth embodiment, showing a state in which the supply of a gas refrigerant to an intermediate-pressure chamber of a multiple-stage compressor through an injection pipe is inhibited, but the supply of a refrigerant gas to the intermediate-pressure chamber of the multiple-stage compressor through a bypass pipe is permitted.

[Figure 7] Figure 7 is a schematic diagram of a refrigerating cycle of a fifth embodiment.

[Figure 8] Figure 8 is a control flow chart of a refrigerating cycle of a fifth embodiment.

Description of Embodiments

First embodiment

[0017] A first embodiment of the present invention will now be described with reference to Figures 1 and 2.

[0018] As shown in Figure 1, a refrigerating cycle 10 in accordance with the first embodiment has a multiple-stage compressor 11 accommodating two compression mechanisms of a rolling piston compression mechanism 13 serving as a low-stage side compression mechanism and a scroll compression mechanism 15 serving as a high-stage side compression mechanism in the cavity of one sealed housing 12. The details of this multiple-stage compressor 11 will be described later.

[0019] To the scroll compression mechanism 15 of the multiple-stage compressor 11, one end of a discharge pipe 19 is connected. The other end of the discharge pipe 19 is connected to a first condenser 16. To the downstream side of the first condenser 16, one end of a refrigerant pipe 20 is connected, and the other end thereof is connected to an evaporator 18. In the refrigerant pipe 20 between the first condenser 16 and the evaporator 18, a first expansion valve 17 is provided. The evaporator 18 and the rolling piston compression mechanism 13 of the multiple-stage compressor 11 are connected to each other by a suction pipe 21. From the suction pipe 21, a bypass pipe 22 is branched. The bypass pipe 22 is provided so as to communicate with the suction pipe 21 and the cavity of the multiple-stage compressor 11. In the bypass pipe 22, a first regulating valve 23 for permitting or inhibiting the supply of refrigerant to the cavity is provided. The terms of upstream and downstream are identified on the basis of the direction of flow of the refrigerant of the refrigerating cycle 10.

[0020] Next, the configuration of the multiple-stage compressor 11 is explained with reference to Figure 2.

[0021] In Figure 1, the rolling piston compression mechanism 13 is provided on one end side in the sealed housing 12, and the scroll compression mechanism 15 is provided on the other end side. Between the rolling piston compression mechanism 13 and the scroll compression mechanism 15, an electric motor 14 for driving both the compression mechanisms 13 and 15 is provided.

[0022] The sealed housing 12 is formed into a cylindrical shape extending along the up and down directions. To the upper part of the sealed housing 12 is connected the bypass pipe 22 that is open to the cavity on the refrigerant passage downstream side of the electric motor 14 of the multiple-stage compressor 11. Since the bypass pipe 22 is branched from the suction pipe 21, the cavity communicates with the suction pipe 21. The cavity is a portion that serves as an intermediate-pressure chamber when both of the low-stage side compression mechanism and the high-stage side compression mechanism are operated.

[0023] In a cavity 12a of the sealed housing 12, the rolling piston compression mechanism 13 is accommodated on the lower side, and the scroll compression mechanism 15 is accommodated on the upper side. Between the rolling piston compression mechanism 13, the electric motor 14, and the scroll compression mechanism 15, a rotating shaft 110 is provided. The electric motor 14 comprises a stator 14a press fitted in and supported on the inner peripheral part of the sealed housing 12 and a rotor 14b provided on the inside of the stator 14a. The rotor 14b is fixed to the rotating shaft 110 coaxially, and the rotation thereof is outputted through the rotating shaft 110.

[0024] The scroll compression mechanism 15 comprises a fixed scroll 151 the whole of which is formed of a ferrous

material such as cast iron or carbon steel and an orbiting scroll 156 made of a ferrous material, which engages with the fixed scroll 151.

[0025] The fixed scroll 151 and the orbiting scroll 156 are disposed on a casing-like frame 160 in such a manner that the fixed scroll 151 is located on the upside, and the orbiting scroll 156 is located on the downside.

[0026] The back surface of an end plate 157 of the orbiting scroll 156 is slidably received by a horizontal receiving surface 161 formed on the upper surface of the frame 160.

[0027] The fixed scroll 151 comprises an end plate 152, a spiral wrap 153 erected on the inner surface of the end plate 152, and a peripheral wall 154 erected so as to surround the wrap 153. In the central part of the end plate 152, a discharge port 155 is provided.

[0028] The orbiting scroll 156 comprises the end plate 157 and a spiral wrap 158 erected on the inner surface of the end plate 157. In the central part of the back surface (outer surface) of the end plate 157, a cylindrical boss part 159 is projectingly provided.

[0029] The fixed scroll 151 and the orbiting scroll 156 are assembled to each other so that the wraps 153 and 158 engage with each other in a state of being shifted through 180 degrees (a predetermined angles. Between the wrap 153 and the wrap 158 held by the end plate 152 and the end plate 157 in the up and down directions, a plurality of crescent-shaped enclosed spaces SA are formed to establish a compressing process.

[0030] The upper end of the rotating shaft 110 penetrates the frame 160 and extends toward the center of the end plate 157 of the orbiting scroll 156. The upper end part of the rotating shaft 110 is rotatably supported by a bearing 162 provided in the penetration part of the frame 160. At the upper end of the rotating shaft 110, an eccentric pin 163 is projectingly provided at a position eccentric from the axis of the rotating shaft 110.

[0031] The eccentric pin 163 is slidably inserted into the boss part 159. Due to a driving system configured by the connection of the eccentric pin 163 and the boss part 159, the orbiting scroll 156 orbits around the axis of the fixed scroll 151 when the rotating shaft 110 is rotated.

[0032] Between the peripheral wall 154 of the fixed scroll 151 and the end plate 157 of the orbiting scroll 156 opposed to the peripheral wall 154, a rotation inhibiting mechanism, for example, an Oldham's ring (not shown), which permits the orbiting motion of the orbiting scroll 156 but inhibits the rotation of the orbiting scroll 156, is interposed. With the orbiting motion of the orbiting scroll 156 imparted by the Oldham's ring and the eccentric pin 163, the volume of the enclosed spaces SA decreases gradually. A refrigerant gas can be compressed by utilizing the enclosed spaces SA.

[0033] From the upper surface of the end plate 152 of the fixed scroll 151, two large and small cylindrical flanges 164, the center of which is the axis of the end plate 152, project upward. Above the flanges 164, a cover 166 is provided, and a discharge cavity 167 is formed between the cover 166 and the flanges 164. The discharge cavity 167 communicates with the discharge port 155. Also, the discharge cavity 167 communicates with the discharge pipe 19 connected to the upper wall of the sealed housing 12 so that the discharged gas discharged into the discharge cavity 167 can be discharged to the outside of the sealed housing 12. The discharge port 155 is provided with a check valve 168 for preventing reversed flow.

[0034] The rolling piston compression mechanism 13 comprises a main bearing body 131 and a subsidiary bearing body 132 provided so as to hold a cylinder 130 therebetween on both sides in the up and down directions of the cylinder 130. By utilizing a circular space formed in the cylinder 130, a cylinder chamber 133 is formed in a portion held between the main bearing body 131 and the subsidiary bearing body 132. In the circular cylinder chamber 133, a rotor 134 and a blade (not shown) for partitioning the cylinder chamber 133 into the suction side and the discharge side are disposed. The rotor 134 is connected to one end part of the rotating shaft 110, which is the output shaft of the electric motor 14, via an eccentric cam part 135, so that the rotor 134 is eccentrically rotated in the cylinder chamber 133 by the driving force generated by the electric motor 14.

[0035] When the electric motor 14 is energized, the rotational force of the electric motor 14 is transmitted to the rolling piston compression mechanism 13 and the scroll compression mechanism 15 through the rotating shaft 110.

[0036] In the rolling piston compression mechanism 13, on receipt of the rotational force from the rotating shaft 110, the rotor 134 eccentrically rotates in the cylinder chamber 133 according to the eccentric motion of the eccentric cam part 135. Thereby, the refrigerant gas is sucked into the cylinder chamber 133 through the suction pipe 21 and a suction port 136 of the cylinder chamber 133, and is once discharged from a discharge port (not shown) into the cavity 12a of the sealed housing 12 after being compressed in the cylinder chamber 133. By the compressing process therein, the refrigerant gas is compressed from a low pressure to an intermediate pressure (low-stage compression). The cavity 12a is usually called an intermediate-pressure chamber.

[0037] On the other hand, in the scroll compression mechanism 15, on receipt of the rotational force from the rotating shaft 110, the eccentric pin 163 eccentrically turns. Thereby, the orbiting scroll 156 orbits relative to the fixed scroll 151. Then, the crescent-shaped enclosed spaces SA formed between the wrap 153 and the wrap 158 change to the volume decreasing side. Therefore, the refrigerant gas in the cavity 12a is sucked into the enclosed spaces SA through a passage 137 provided in the peripheral walls of the frame 160 and the fixed scroll 151, and is compressed by the change (decrease) in volume of the enclosed spaces SA.

[0038] Then, the refrigerant gas having finished predetermined compression is discharged to the outside of the sealed housing 12 through the discharge port 155 provided in the central part of the fixed scroll 151, the check valve 168, the discharge cavity 167, and the discharge pipe 19. By the compressing process therein, the refrigerant gas is compressed from the intermediate pressure to a high pressure (high-stage compression).

[0039] Next, the operation of the refrigerating cycle 10 is explained. In the following explanation, it is assumed that the first regulating valve 23 provided in the bypass pipe 22 is being closed.

[0040] In the rolling piston compression mechanism 13 of the multiple-stage compressor 11, a low-pressure refrigerant gas is sucked directly into the cylinder chamber 133 via the suction pipe 21. By the rotor 134 rotated via the electric motor 14 and the rotating shaft 110, this refrigerant gas is compressed to the intermediate pressure, and thereafter is discharged into the cavity 12a through a discharge port. Thereby, the cavity 12a is caused to have an intermediate-pressure atmosphere.

[0041] An intermediate-pressure refrigerant gas is sucked into the enclosed spaces SA of the high-stage side scroll compression mechanism 15 via the passage 137 that is open in the sealed housing 12. In the scroll compression mechanism 15, with the drive of the electric motor 14, the orbiting scroll 156 orbits relative to the fixed scroll 151, whereby compressing action is accomplished. The refrigerant gas compressed to a high-pressure state in the enclosed spaces SA is discharged into the discharge cavity 167 through the check valve 168.

[0042] The high-temperature and pressure refrigerant gas discharged into the discharge cavity 167 goes to the first condenser 16 through the discharge pipe 19 connected to the discharge cavity 167 as indicated by a solid-line arrow mark in Figure 1. In the first condenser 16, the refrigerant gas is heat-exchanged with the air blown by a condenser fan, and heat is dissipated to the air side, whereby the refrigerant is condensed and liquefied. This liquid refrigerant goes to the evaporator 18 through the refrigerant pipe 20 after being decompressed by the first expansion valve 17.

[0043] The low-pressure gas/liquid two-phase refrigerant flowing into the evaporator 18 is heat-exchanged with the air blown by an evaporator fan during the time when the refrigerant flows in the evaporator 18, and is evaporated and gasified by the heat absorption from the air side. This low-pressure refrigerant gas is sucked into the low-stage side rolling piston compression mechanism 13 via the suction pipe 21, and is compressed again.

[0044] During the time when the above-described cycle is repeated, the refrigerating cycle 10 can perform heating by utilizing heat dissipation from the first condenser 16 and can perform cooling by utilizing heat absorbing action in the evaporator 18.

[0045] In the case where the multiple-stage compressor 11 is operated at a low pressure ratio when the load on the multiple-stage compressor 11 is low, that is, at an intermediate season such as spring or autumn, the use of both of the scroll compression mechanism 15 and the rolling piston compression mechanism 13 results in excessive compression, so that a large power loss is created, and the efficiency of compression mechanism parts is lowered. Therefore, in such a case, the first regulating valve 23 of the bypass pipe 22 is opened to allow the refrigerant gas to bypass the rolling piston compression mechanism 13 (bypass operation). In this case, compression is effected by the high-stage side scroll compression mechanism 15 alone, and compression is not effected in the rolling piston compression mechanism 13, so that excessive compression can be avoided.

[0046] For the multiple-stage compressor 11, the bypass pipe 22 is connected to the cavity 12a on the refrigerant passage downstream side of the electric motor 14. Therefore, the refrigerant gas flowing into the sealed housing 12 through the bypass pipe 22 does not pass through the electric motor 14. Therefore, the refrigerant supplied through the bypass pipe 22 arrives at the high-stage side scroll compression mechanism 15 without the occurrence of overheat loss and pressure loss. As a result, the suction efficiency of the scroll compression mechanism 15 can be increased, and the performance of the multiple-stage compressor 11 at the time of bypass operation can be improved.

[0047] In the present invention, if the bypass pipe 22 is open to the cavity 12a on the refrigerant passage downstream side of the electric motor 14, an effect of being capable of performing highly efficient operation without the occurrence of overheat loss and pressure loss can be achieved. Preferably, the opening is provided above the scroll compression mechanism 15. The reason for this is that the refrigerant gas supplied from the bypass pipe 22 can be prevented from taking in a lubricating oil.

[0048] Whether the bypass operation is performed or not can be judged, for example, by the method described below. A suction-side pressure (P1) and a discharge-side pressure (P2) are detected. If the differential pressure (P2 - P1) is lower than a predefined threshold value (Ps), the first regulating valve 23 is opened to perform the bypass operation in which the refrigerant is compressed by the scroll compression mechanism 15 alone. On the other hand, if the differential pressure (P2 - P1) is not lower than the predefined threshold value (Ps), the first regulating valve 23 is closed to perform ordinary operation in which the refrigerant is compressed by the rolling piston compression mechanism 13 and the scroll compression mechanism 15. The judgment of whether the bypass operation is performed or not that is made by using the differential pressure (P2 - P1) is entirely one example.

[0049] In this embodiment, an example in which the rolling piston compression mechanism 13 is used on the low-stage side and the scroll compression mechanism 15 is used on the high-stage side has been explained. However, the present invention is not limited to this example, and, for example, the rolling piston compression mechanism 13 that is

the same as one on the low-stage side may also be used on the high-stage side.

[0050] Also, only the minimum necessary configuration of the refrigerating cycle 10 has been described. However, the present invention embraces any modified example, for example, of a heat pump cycle in which an oil separator is provided between the multiple-stage compressor 11 and the first condenser 16, or a four-way selector valve is provided between the discharge pipe 19 and the suction pipe 21 of the multiple-stage compressor 11. Second embodiment ... position of accumulator

[0051] A refrigerating cycle 200 in accordance with a second embodiment of the present invention is explained with reference to Figure 3.

[0052] The refrigerating cycle 200 has the same configuration as that of the refrigerating cycle 10 of the first embodiment except that an accumulator 24 is provided. Therefore, the same reference numerals that are the same as those in Figure 1 are applied to the same components as those of the refrigerating cycle 10, and the explanation of the components is omitted.

[0053] As shown in Figure 3, the bypass pipe 22 is branched from the suction pipe 21 on the refrigerant passage upstream side of a position at which the accumulator 24 is provided.

[0054] The accumulator 24 receives the low-pressure refrigerant gas discharged from the evaporator 18, and separates liquid (containing oil). A refrigerant consisting gas only from which liquid has been separated is sucked into the low-stage side rolling piston compression mechanism 13 via the suction pipe 21. The reason for this is that for the rolling piston compression mechanism 13, it is desirable to exclude liquid to directly suck the refrigerant. On the other hand, if the refrigerant passes through the accumulator 24, a pressure loss occurs in the refrigerant.

[0055] The refrigerant supplied via the bypass pipe 22 is sucked into the cavity in the sealed housing 12. At this time, the sealed housing 12 functions as an accumulator, so that after liquid has been separated, the refrigerant gas is compressed by the high-stage side scroll compression mechanism 15. Therefore, the accumulator 24 should not be provided on the bypass pipe 22 to prevent a pressure loss from occurring.

[0056] Thus, in the second embodiment, the bypass pipe 22 is branched from the suction pipe 21 on the refrigerant passage upstream side of the position at which the accumulator 24 is provided so that the refrigerant is prevented from passing through the accumulator 24 at the time of bypass operation.

[0057] Therefore, according to the second embodiment, the operation efficiency of the multiple-stage compressor 11 can be improved by eliminating a pressure loss caused by the accumulator 24 at the time of bypass operation. Third embodiment ... joining of injection pipe

[0058] A refrigerating cycle 300 in accordance with a third embodiment of the present invention is explained with reference to Figure 4.

[0059] The refrigerating cycle 300 has the same configuration as that of the refrigerating cycle 200 of the second embodiment except that a gas injection circuit 25 is provided. Therefore, the same reference numerals that are the same as those in Figure 3 are applied to the same components as those of the refrigerating cycle 200, and the explanation of the components is omitted.

[0060] The gas injection circuit 25 is configured as described below.

[0061] On the refrigerant pipe 20 between the first condenser 16 and the first expansion valve 17, a second condenser 26 is provided. Also, an injection pipe 28 penetrating the second condenser 26 is configured so that one end thereof is connected to between the first condenser 16 and the second condenser 26, and the other end thereof is joined to the bypass pipe 22. In the injection pipe 28, a second expansion valve 27 is provided on the upstream side of the second condenser 26. Also, in the injection pipe 28, a second regulating valve 29 is provided on the downstream side of the second condenser 26.

[0062] Some of the liquid refrigerant condensed and liquefied by the first condenser 16 is decompressed by the second expansion valve 27 after passing through the injection pipe 28, and thereafter goes to the second condenser 26. The low-pressure gas/liquid two-phase refrigerant flowing into the second condenser 26 is evaporated and gasified by heat absorption from the liquid refrigerant passing through the refrigerant pipe 20 during the time of flowing in the second condenser 26 and turns to an intermediate-pressure refrigerant gas. This refrigerant gas is supplied to the cavity of the sealed housing 12 through the injection pipe 28. It is assumed that the second regulating valve 29 is open, but the first regulating valve 23 is closed. Thereby, this intermediate-pressure injection gas and the intermediate-pressure gas compressed by the low-stage side rolling piston compression mechanism 13 are sucked into the high-stage side scroll compression mechanism 15, so that the refrigerating capacity can be increased by two-stage compression.

[0063] For the refrigerating cycle 300, since the injection pipe 28 is joined to the bypass pipe 22, the number of pipes connected directly to the sealed housing 12 can be decreased by one. Therefore, the breakage risk of pipe caused by vibrations of the multiple-stage compressor 11 can be reduced. Also, the work for installing pipes to the multiple-stage compressor 11 is facilitated, which contributes to the decrease in cost.

[0064] Also, for the refrigerating cycle 300, since the injection pipe 28 is joined to the bypass pipe 22, the intermediate-pressure gas refrigerant supplied by gas injection also does not pass through the electric motor 14. Therefore, no pressure loss and overheat loss occur in this gas refrigerant.

[0065] The present invention can be applied to not only the gas injection of the system described above but also the gas injection of any other system.

[0066] Also, the present invention can be applied to not only gas injection but also liquid injection.

5 Fourth embodiment

[0067] A refrigerating cycle 400 in accordance with a fourth embodiment of the present invention is explained with reference to Figures 5 and 6.

10 **[0068]** The refrigerating cycle 400 has the same configuration as that of the refrigerating cycle 300 of the third embodiment except that the second regulating valve 29 is made common to the first regulating valve 23 of the bypass pipe 22. Therefore, the same reference numerals that are the same as those in Figure 4 are applied to the same components as those of the refrigerating cycle 300, and the explanation of the components is omitted.

15 **[0069]** For the refrigerating cycle 400, a switching valve 30 is provided at the joint point of the bypass pipe 22 and the injection pipe 28. The switching valve 30 is switched over from a first position (Figure 5) at which the gas refrigerant sent through the injection pipe 28 is permitted to be supplied to the intermediate-pressure chamber of the multiple-stage compressor 11 but the refrigerant gas sent through the bypass pipe 22 is inhibited from being supplied to the intermediate-pressure chamber of the multiple-stage compressor 11 to a second position (Figure 6) at which the gas refrigerant sent through the injection pipe 28 is inhibited from being supplied to the intermediate-pressure chamber of the multiple-stage compressor 11 but the refrigerant gas sent through the bypass pipe 22 is permitted to be supplied to the intermediate-pressure chamber of the multiple-stage compressor 11, and vice versa.

20 **[0070]** Generally, gas injection is used when the load on the multiple-stage compressor 11 is high. At this time, bypass operation need not be performed. Inversely, bypass operation is performed when the load on the multiple-stage compressor 11 is low. At this time, gas injection need not be used. Therefore, as in the refrigerating cycle 400, gas injection can be used or bypass operation can be performed only when necessary while the cost is reduced by providing one switching valve 30 at the joint point of the bypass pipe 22 and the injection pipe 28.

25 **[0071]** The switching valve 30 detects a suction-side pressure (P1) and a discharge-side pressure (P2), and, if the differential pressure (P2 - P1) is not lower than a predefined threshold value (Ps), is set at the first position, at which the gas refrigerant sent through the injection pipe 28 is permitted to be supplied to the intermediate-pressure chamber of the multiple-stage compressor 11 but the refrigerant gas sent through the bypass pipe 22 is inhibited from being supplied to the intermediate-pressure chamber of the multiple-stage compressor 11. Also, if the differential pressure (P2 - P1) is lower than the predefined threshold value (Ps), the switching valve 30 is set at the second position at which the gas refrigerant sent through the injection pipe 28 is inhibited from being supplied to the intermediate-pressure chamber of the multiple-stage compressor 11 but the refrigerant gas sent through the bypass pipe 22 is permitted to be supplied to the intermediate-pressure chamber of the multiple-stage compressor 11.

35 Fifth embodiment

[0072] A refrigerating cycle 500 in accordance with a fifth embodiment of the present invention is explained with reference to Figures 7 and 8.

40 **[0073]** The first to fourth embodiments depend on the assumption that bypass operation is performed when the load on the multiple-stage compressor 11 is low. The refrigerating cycle 500 in accordance with the fifth embodiment reveals that the performance of bypass operation in other cases is useful for the multiple-stage compressor 11.

[0074] The refrigerating cycle 500 is configured by adding a control system including a controller 31 to the refrigerating cycle 400.

45 **[0075]** On receipt of a command signal sent from a main controller (not shown), the controller 31 controls the operation of the refrigerating cycle 500.

[0076] Also, the refrigerating cycle 500 comprises a pressure sensor 32 for detecting the suction-side pressure (P1) and a pressure sensor 33 for detecting the discharge-side pressure (P2). The pressure (P1) information and the pressure (P2) information detected by the pressure sensor 32 and the pressure sensor 33, respectively, are sent to the controller 31. The controller 31 determines a differential pressure (P2 - P1) between the two pressures from the obtained pressure (P1) information and pressure (P2) information. Based on this differential pressure, the controller 31 controls the operation of the switching valve 30.

[0077] The control procedure for controlling the multiple-stage compressor 11 using the controller 31 is explained with reference to Figure 8.

55 **[0078]** When receiving a start command for the multiple-stage compressor 11 as a command signal from the main controller (Figure 8 S101), the controller 31 operates the switching valve 30 (Figure 8 S103) so that the switching valve 30 becomes at the position of bypass operation (Figure 6). Then, the refrigerant gas sent through the bypass pipe 22 is permitted to be supplied to the cavity of the multiple-stage compressor 11, but the gas refrigerant sent through the

injection pipe 28 is inhibited from being supplied to the intermediate-pressure chamber of the multiple-stage compressor 11.

The reason why the bypass operation is performed after the start command is that the pressure fluctuations of the multiple-stage compressor 11 at the start-up time are kept small.

[0079] The bypass operation after the start command is performed for a predetermined time period (Figure 8 S105), and after the predetermined time period has elapsed, the controller 31 obtains the pressure (P1) information and the pressure (P2) information detected by the pressure sensor 32 and the pressure sensor 33, respectively. The controller 31 calculates the differential pressure (P2 - P1) between the two pressures from the obtained pressure (P1) information and pressure (P2) information (Figure 8 S107).

[0080] Next, the controller 31 compares the obtained differential pressure (P2 - P1) with the predetermined threshold value Ps (Figure 8 S109). If the differential pressure (P2 - P1) is lower than the predetermined threshold value Ps, the bypass operation is continued (Figure 8 S111). Therefore, the switching valve 30 is controlled as before. On the other hand, if the differential pressure (P2 - P1) is not lower than the predetermined threshold value Ps, gas injection is used (Figure 8 S113). The controller 31 switches over the switching valve 30 so that the refrigerant gas sent through the bypass pipe 22 is inhibited from being supplied to the intermediate-pressure chamber of the multiple-stage compressor 11 but the gas refrigerant sent through the injection pipe 28 is permitted to be supplied to the intermediate-pressure chamber of the multiple-stage compressor 11.

[0081] In both of the bypass operation and the gas injection using operation, the controller 31 compares the obtained differential pressure (P2 - P1) with the predetermined threshold value Ps, and controls the operation of the switching valve 30 until receiving a stop command for the multiple-stage compressor 11 from the main controller (Figure 8 S115, S117).

[0082] As described above, the multiple-stage compressor 11 of the refrigerating cycle 500 performs bypass operation at the start-up time. Therefore, the pressure fluctuations at the start-up time are restrained, so that the multiple-stage compressor 11 can be operated safely. Also, after the bypass operation at the start-up time, the bypass operation and the gas injection using operation are performed selectively according to the load on the multiple-stage compressor 11. Therefore, the operation efficiency is high.

Description of Symbols

[0083]

10, 200, 300, 400, 500	... refrigerating cycle
11	... multiple-stage compressor
12	... sealed housing
13	... rolling piston compression mechanism
14	... electric motor
15	... scroll compression mechanism
16	... first condenser
17	... first expansion valve
18	... evaporator
19	... discharge pipe
20	... refrigerant pipe
21	... suction pipe
22	... bypass pipe
23, 29	... regulating valve
24	... accumulator
25	... gas injection circuit
26	... second condenser
27	... second expansion valve
28	... injection pipe
30	... switching valve
31	... controller

Claims

1. A multiple-stage compressor comprising:

a sealed housing;
a low-stage side compression mechanism and a high-stage side compression mechanism, both being provided in a cavity of the sealed housing;
an electric motor provided between the low-stage side compression mechanism and the high-stage side compression mechanism to drive the low-stage side compression mechanism and the high-stage side compression mechanism;
a suction pipe connected to the sealed housing to supply a refrigerant to the low-stage side compression mechanism;
a discharge pipe connected to the sealed housing to discharge the refrigerant compressed by the high-stage side compression mechanism;
a bypass pipe branched from the suction pipe to allow the cavity on the refrigerant passage downstream side of the electric motor and the suction pipe to communicate with each other; and
a valve provided in the bypass pipe to selectively permit or inhibit the supply of refrigerant to the cavity.

2. The multiple-stage compressor according to claim 1, wherein
an accumulator is provided on the suction pipe; and the bypass pipe is branched from the suction pipe on the refrigerant passage upstream side of a position at which the accumulator is provided.

3. The multiple-stage compressor according to claim 1 or 2, wherein
an injection pipe is provided to supply an intermediate-pressure refrigerant, which is drawn from a refrigerant circuit, to the cavity; and
the injection pipe is joined to the bypass pipe.

4. The multiple-stage compressor according to claim 3, wherein the valve is provided at the joint point of the injection pipe and the bypass pipe, and is switched over selectively from a first position at which the refrigerant sent through the injection pipe is permitted to be supplied to the cavity but the refrigerant sent through the bypass pipe is inhibited from being supplied to the cavity to a second position at which the refrigerant sent through the injection pipe is inhibited from being supplied to the cavity but the refrigerant sent through the bypass pipe is permitted to be supplied to the cavity, and vice versa.

5. The multiple-stage compressor according to claim 1, wherein the valve permits the refrigerant to be supplied to the cavity within a predetermined time period at the start-up time of the multiple-stage compressor so that the refrigerant is supplied to the high-stage side compression mechanism by bypassing the low-stage side compression mechanism.

6. The multiple-stage compressor according to claim 4, wherein the valve is set at the first position within a predetermined time period at the start-up time of the multiple-stage compressor so that the refrigerant is supplied to the high-stage side compression mechanism by bypassing the low-stage side compression mechanism.

7. A refrigerating cycle in which a refrigerant circuit is configured by a compressor, a condenser, an expansion valve, and an evaporator, which are connected successively; wherein
the compressor is a multiple-stage compressor comprising:

a sealed housing;
a low-stage side compression mechanism and a high-stage side compression mechanism, both being provided in a cavity of the sealed housing;
an electric motor provided between the low-stage side compression mechanism and the high-stage side compression mechanism to drive the low-stage side compression mechanism and the high-stage side compression mechanism;
a suction pipe connected to the sealed housing to supply a refrigerant sent through the evaporator to the low-stage side compression mechanism;
a discharge pipe connected to the sealed housing to discharge the refrigerant compressed by the high-stage side compression mechanism toward the condenser;
a bypass pipe branched from the suction pipe to allow the cavity on the refrigerant passage downstream side of the electric motor and the suction pipe to communicate with each other; and
a valve provided in the bypass pipe to selectively permit or inhibit the supply of refrigerant to the cavity.

8. The refrigerating cycle according to claim 7, wherein
an accumulator is provided on the suction pipe; and the bypass pipe is branched from the suction pipe on the

refrigerant passage upstream side of a position at which the accumulator is provided.

9. The refrigerating cycle according to claim 7, wherein
an injection pipe is provided to supply an intermediate-pressure refrigerant, which is drawn from the refrigerant
circuit, to the cavity; and
the injection pipe is joined to the bypass pipe.

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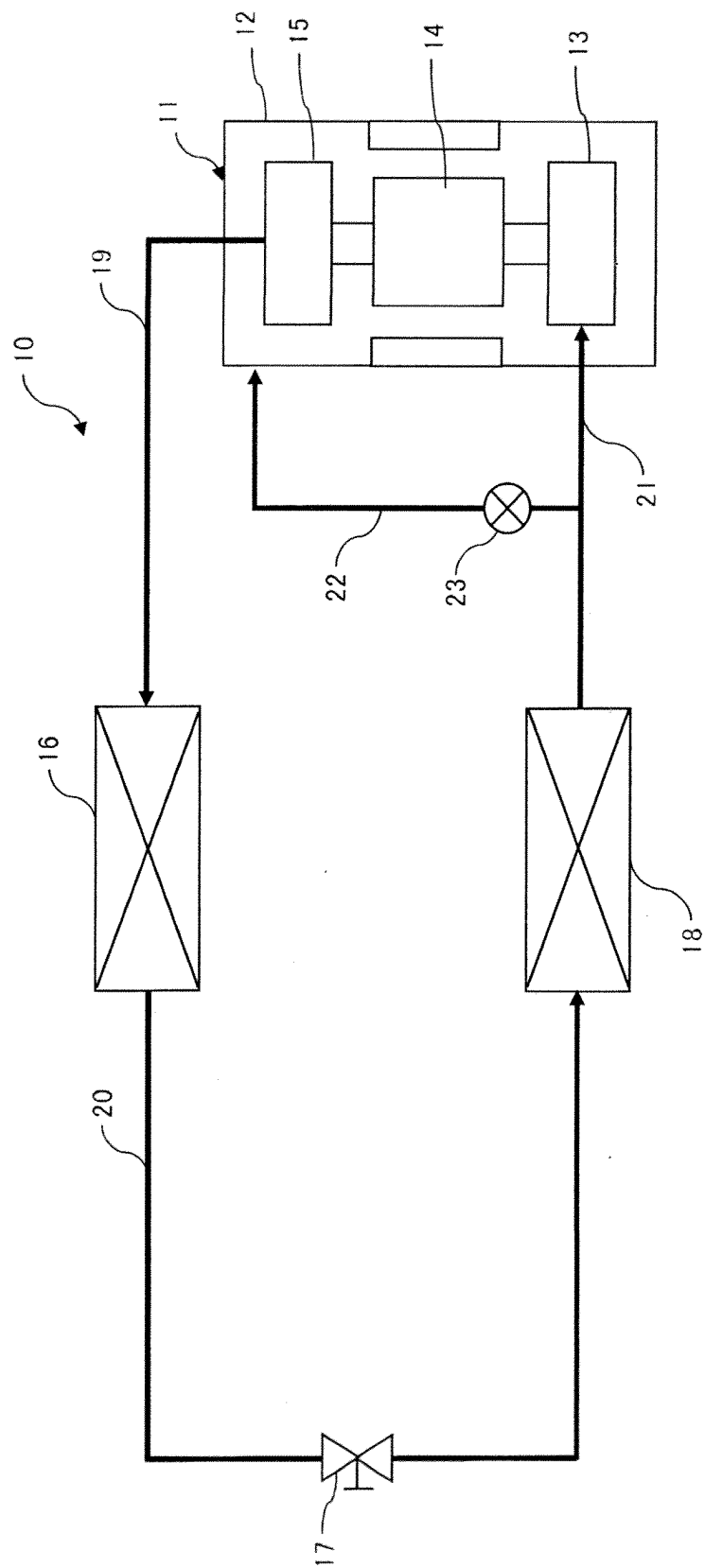
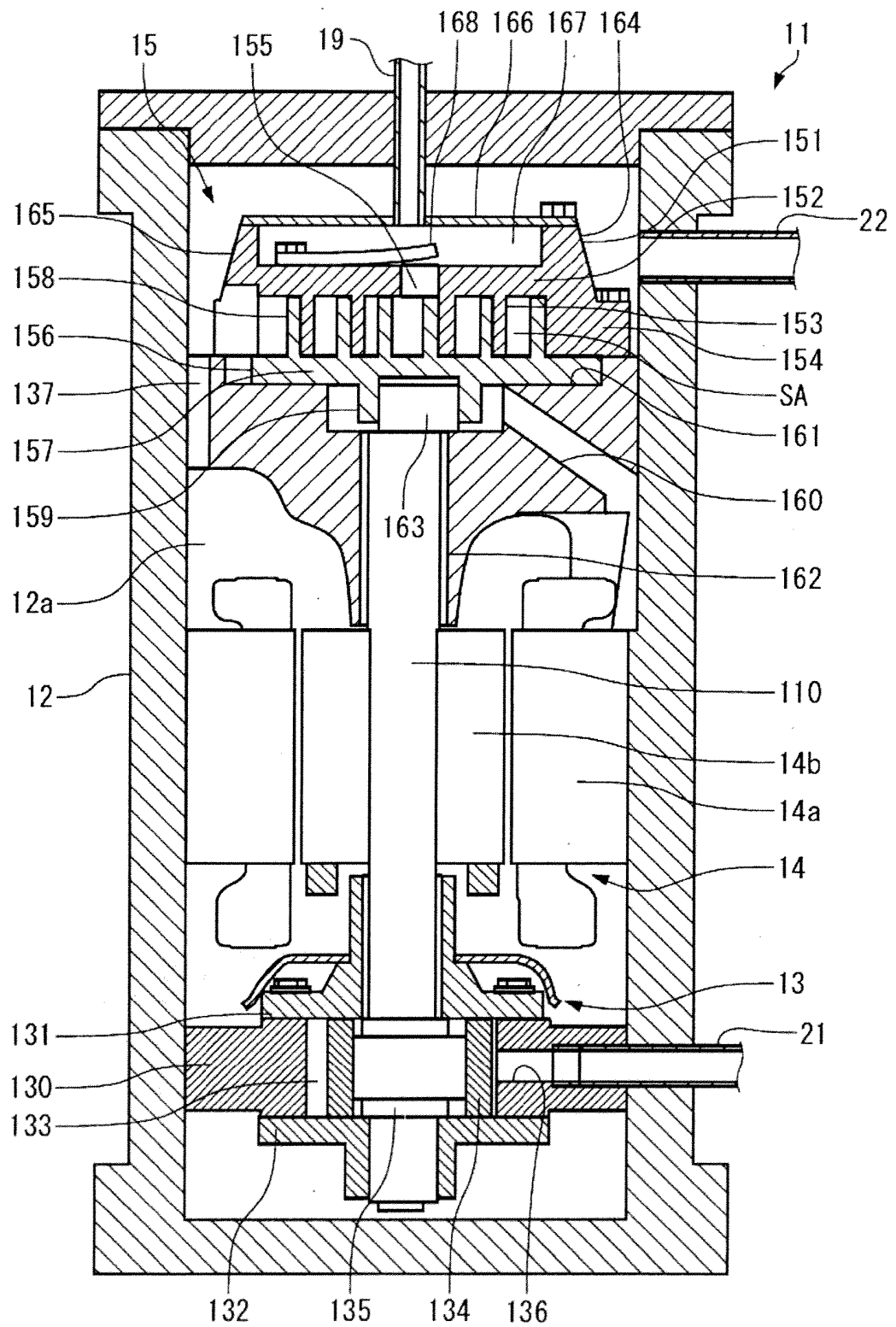


Figure 1

Figure 2



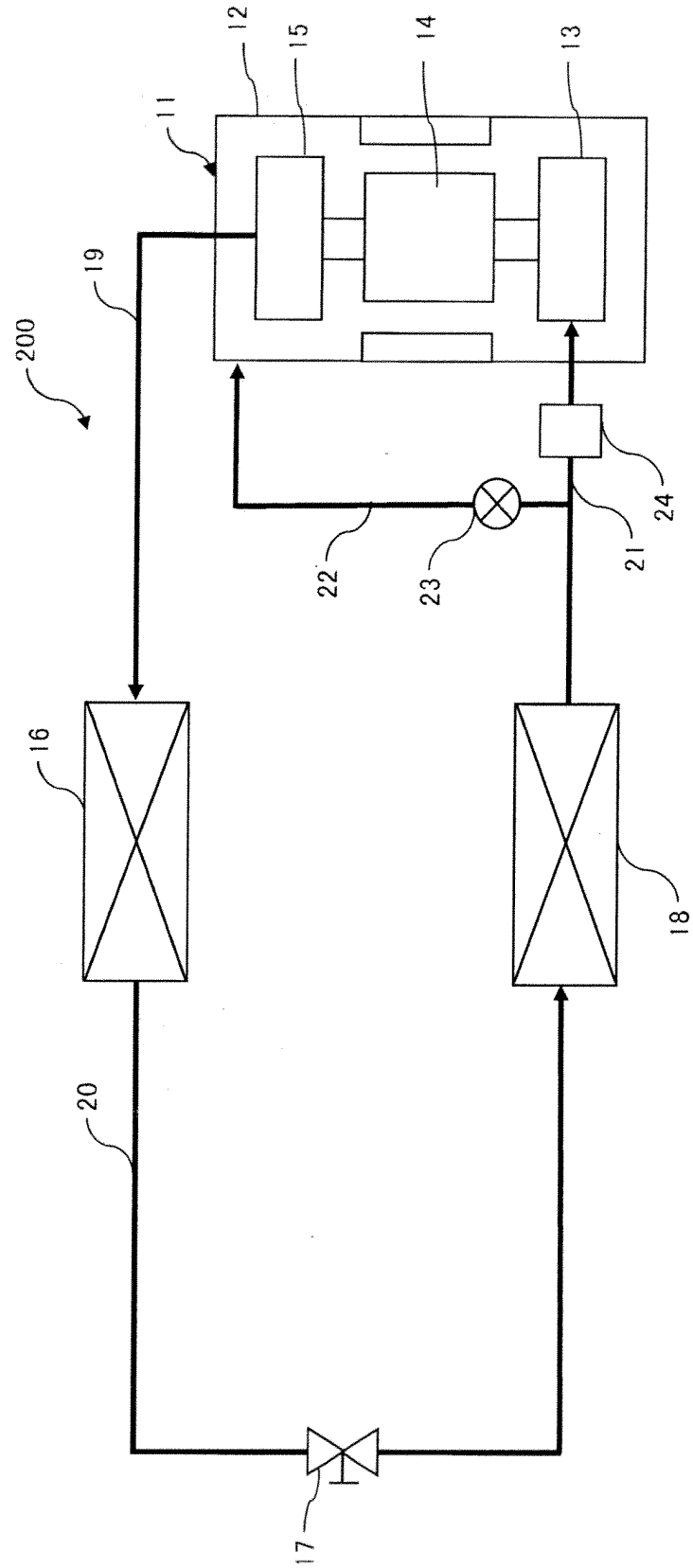


Figure 3

Figure 4

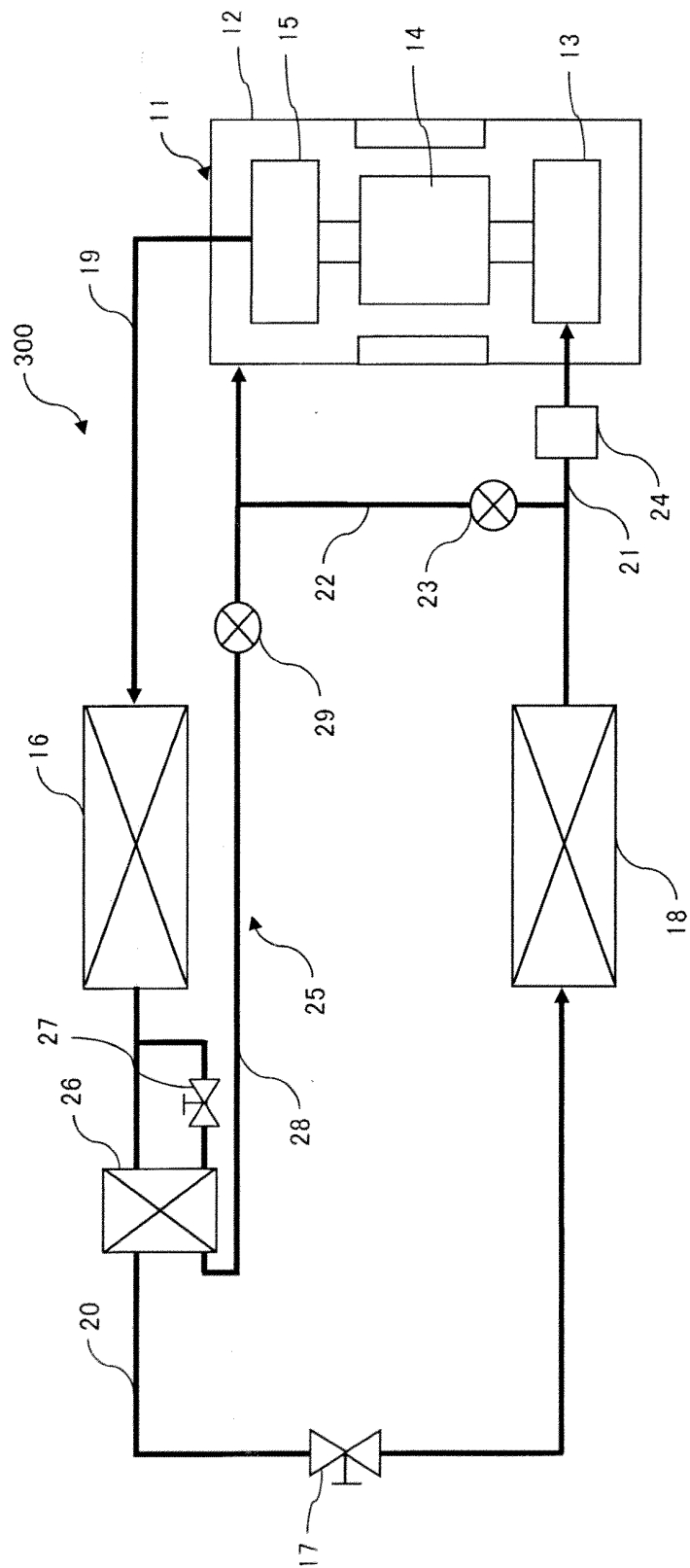


Figure 5

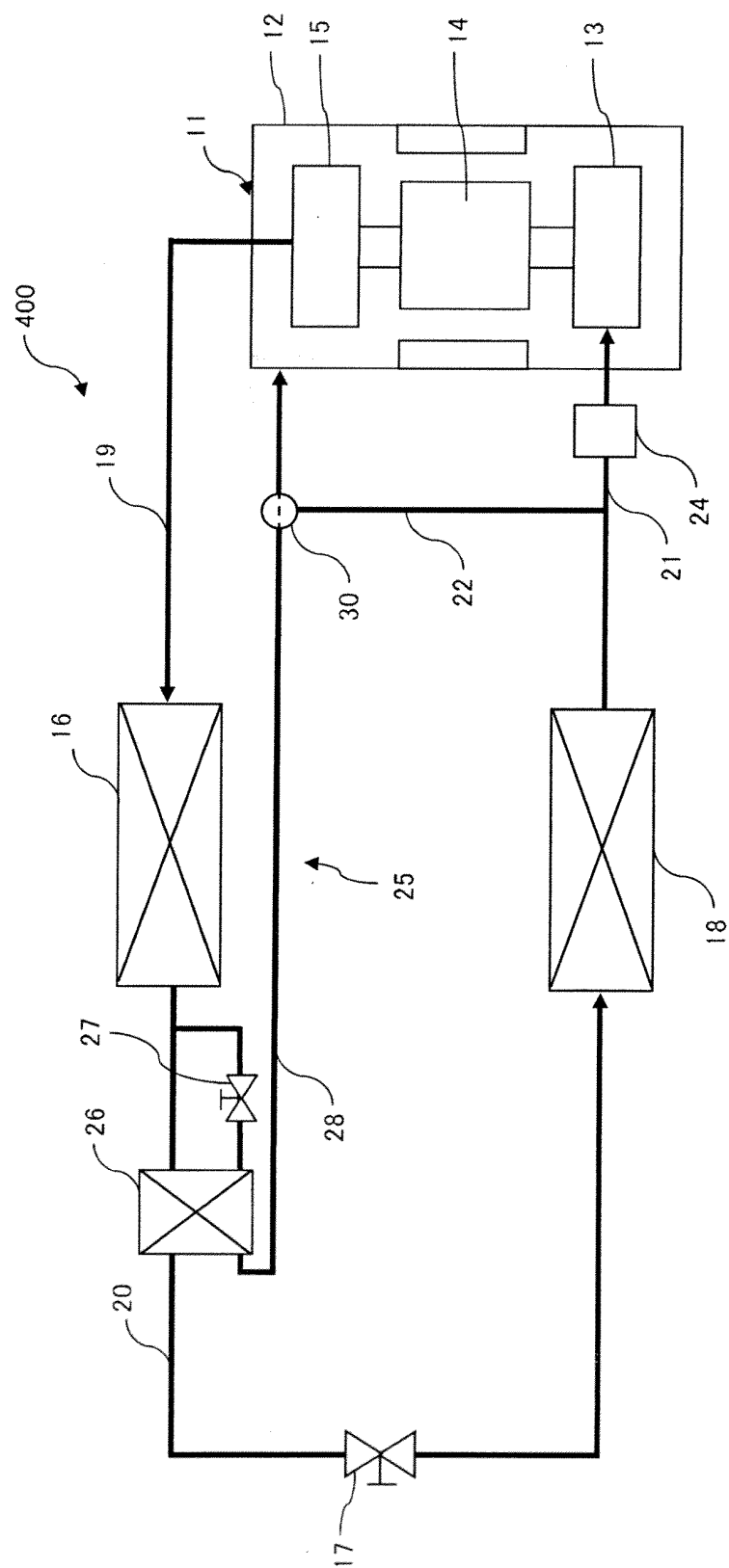


Figure 6

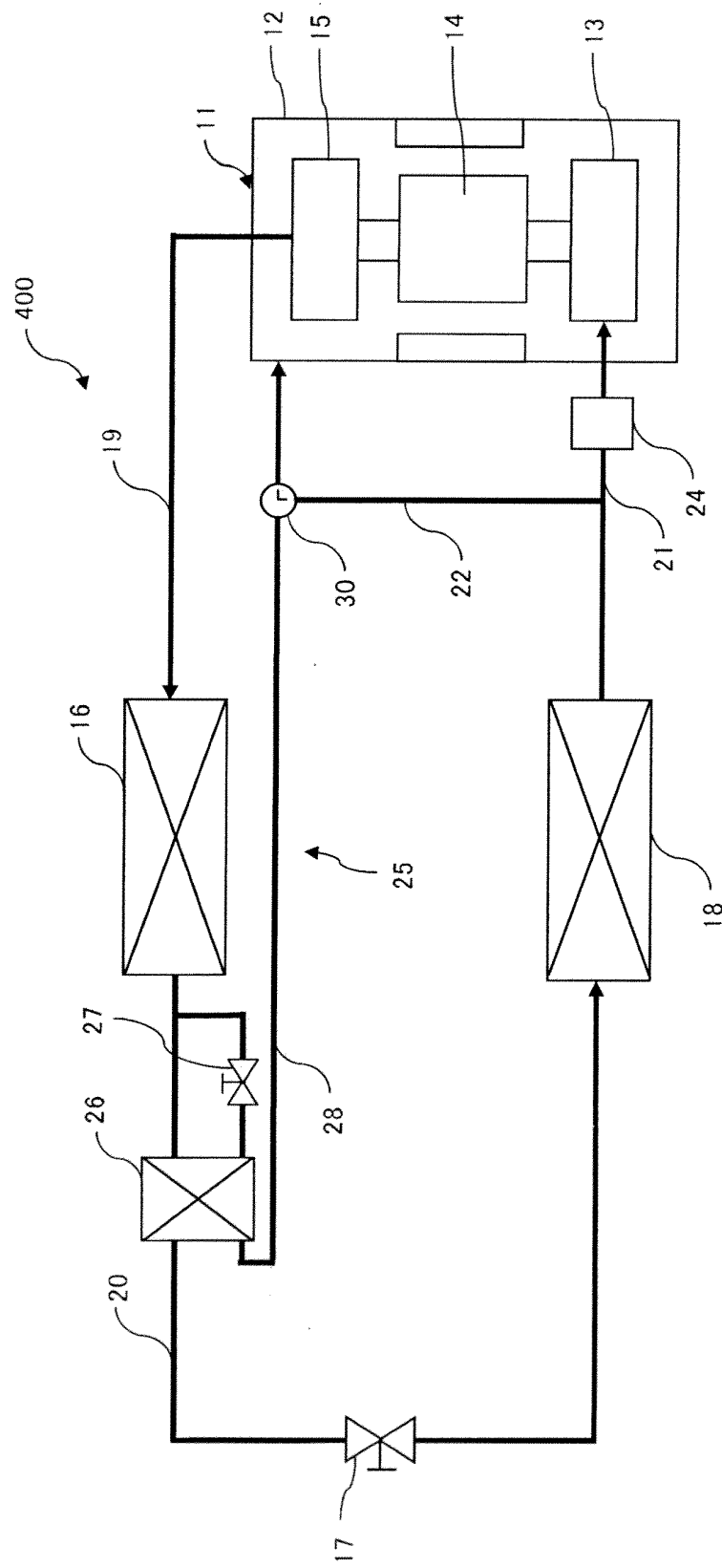


Figure 7

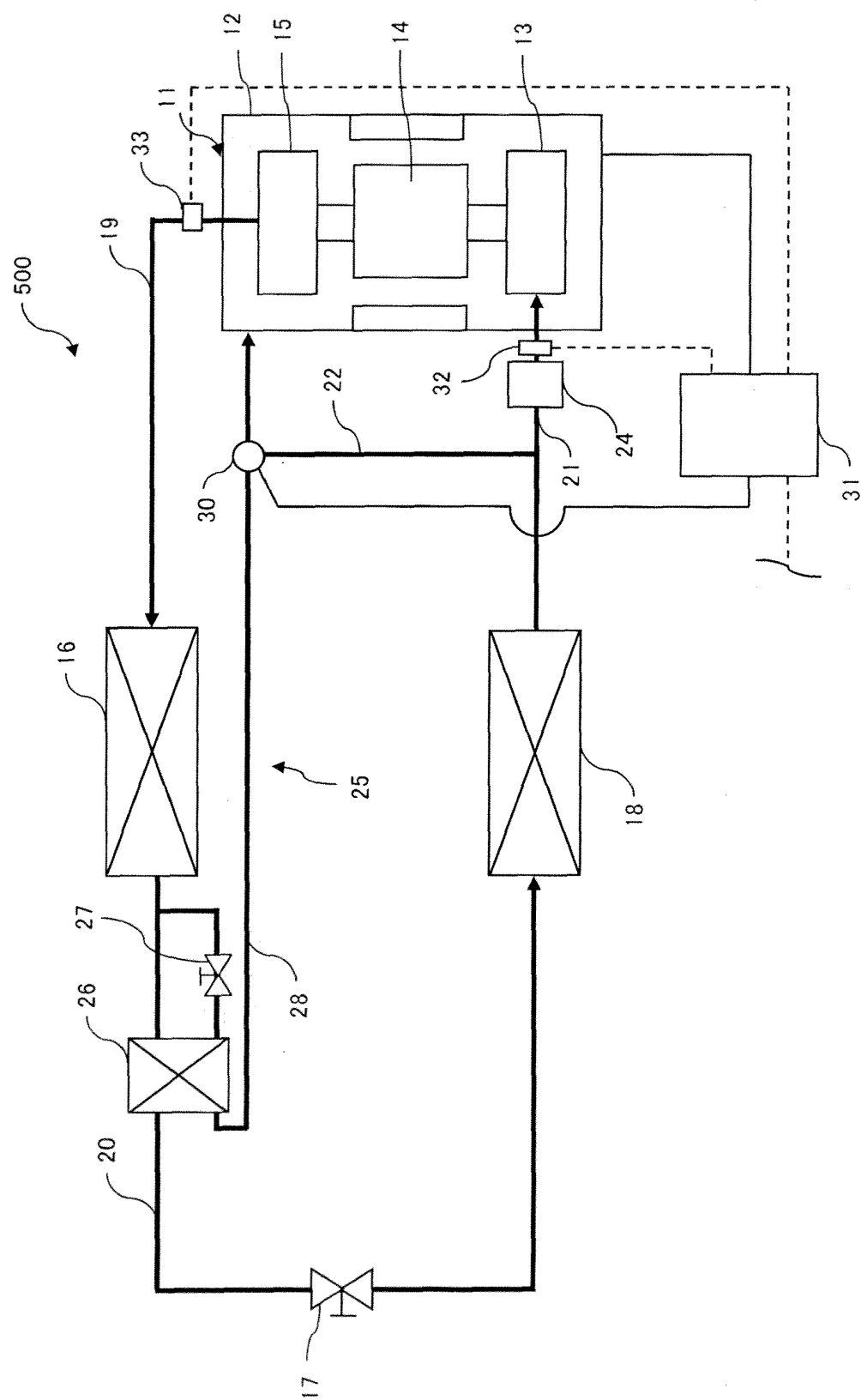
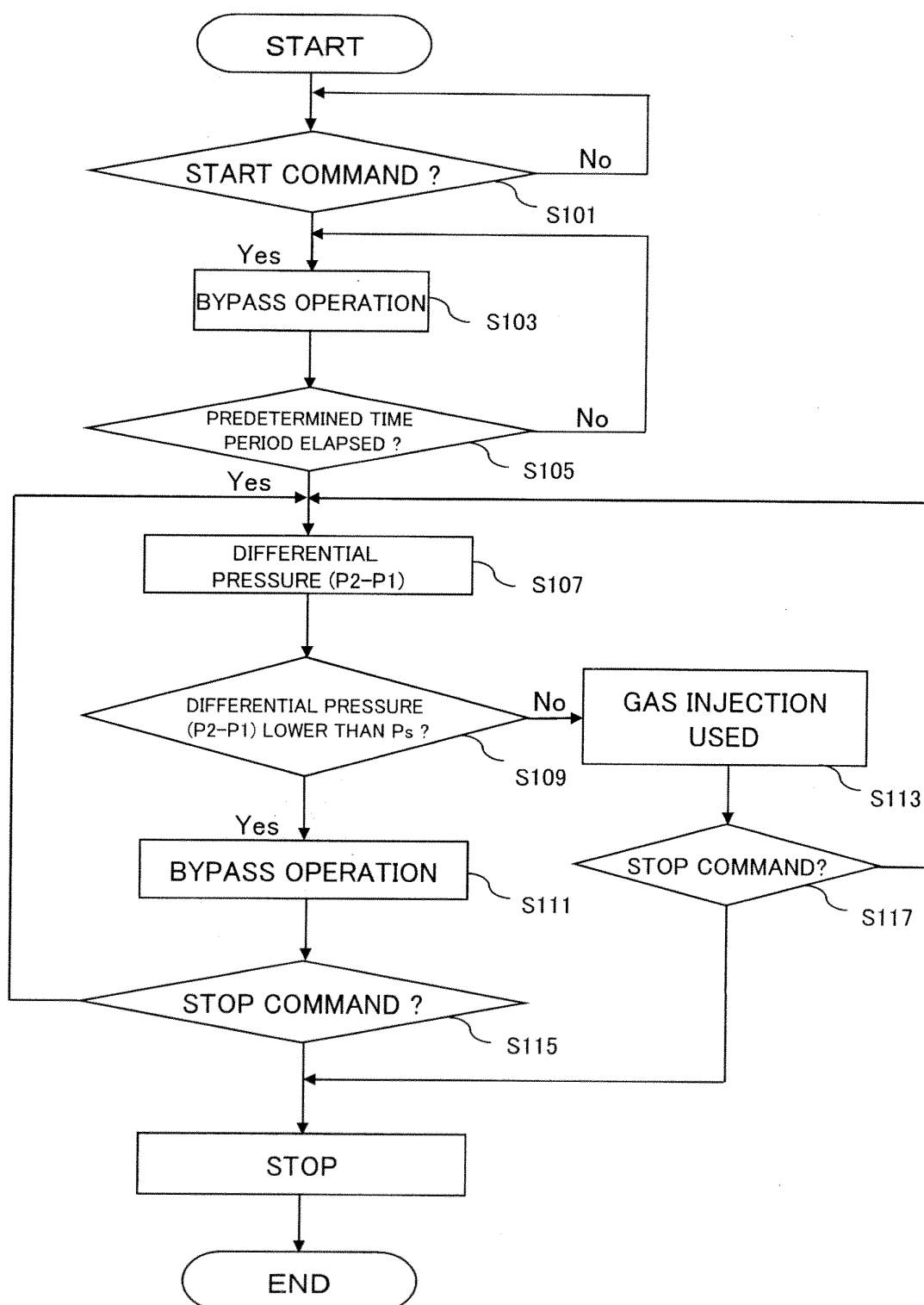


Figure 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/004416

A. CLASSIFICATION OF SUBJECT MATTER

F04C23/00(2006.01)i, F04B39/12(2006.01)i, F04C29/12(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)

F04C23/00, F04B39/12, F04C29/12

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009

Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

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.
Y A	JP 5-087074 A (Mitsubishi Heavy Industries, Ltd.), 06 April 1993 (06.04.1993), claims 1, 2; paragraph [0012]; fig. 2 (Family: none)	1, 7 2-6, 8-9
Y A	JP 2004-218536 A (Mitsubishi Heavy Industries, Ltd.), 05 August 2004 (05.08.2004), claim 1; paragraphs [0012], [0030] to [0036], [0070] to [0075]; fig. 1, 8 (Family: none)	1, 7 2-6, 8-9

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

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Date of the actual completion of the international search
06 October, 2009 (06.10.09)Date of mailing of the international search report
20 October, 2009 (20.10.09)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/004416

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 023591/1993 (Laid-open No. 083984/1994) (Mitsubishi Heavy Industries, Ltd.), 02 December 1994 (02.12.1994), entire text; all drawings (Family: none)	1-9
A	JP 2008-144643 A (Mitsubishi Heavy Industries, Ltd.), 26 June 2008 (26.06.2008), entire text; all drawings (Family: none)	1-9
A	JP 2001-082368 A (Sanyo Electric Co., Ltd.), 27 March 2001 (27.03.2001), entire text; all drawings (Family: none)	1-9

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REFERENCES CITED IN THE DESCRIPTION

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