



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
27.06.2012 Bulletin 2012/26

(51) Int Cl.:
F04B 49/20 (2006.01) **F04B 53/02** (2006.01)
F04B 53/14 (2006.01) **F04B 35/04** (2006.01)
F04B 49/06 (2006.01)

(21) Application number: **11009552.8**

(22) Date of filing: **02.12.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **Max Co., Ltd.**
Chuo-ku
Tokyo 103-8502 (JP)

(72) Inventor: **Asai, Masatoshi**
Tokyo 103-8502
(JP)

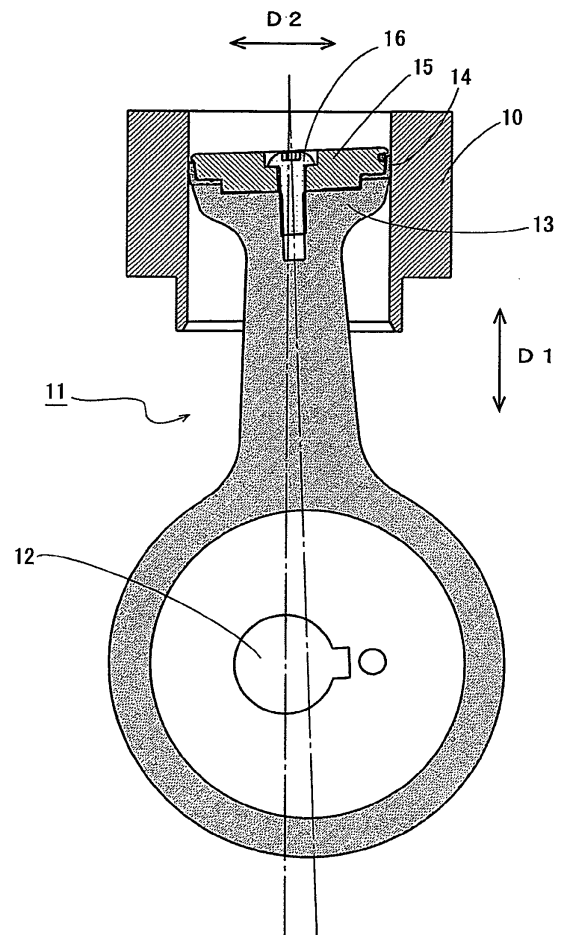
(30) Priority: **25.12.2010 JP 2010289019**

(74) Representative: **Samson & Partner**
Widenmayerstrasse 5
80538 München (DE)

(54) **Compressor and operation method of compressor**

(57) A compressor is provided with: a motor (30); a piston rod (11) which is driven by the motor (30) and reciprocable within a cylinder (10); a seal member (14) adapted to seal between the piston rod (11) and the cylinder (10); a cold state determining unit (110) adapted to determine whether the compressor is in a cold state or not; and a rotating speed control unit (120) adapted to control a rotating speed of the motor (30) to increase so that a warm-up operation is executed when the cold state determining unit (110) determines that the compressor is in the cold state.

FIG. 1



Description**BACKGROUND OF THE INVENTION**

<FIELD OF THE INVENTION>

[0001] The present invention relates to a compressor and an operation method of compressor.

<RELATED ART>

[0002] Conventionally, as a piston of a compressor, there is known a locking piston which is driven by a connecting rod connected to a crankshaft and reciprocates in a cylinder while oscillating. In this type locking piston, a lip ring is provided in a leading end portion of a piston rod as a seal member and the lip ring is used to seal between the cylinder and the piston rod (for example, see Patent Document 1).

Patent Document 1: JP-A-09-068279

[0003] Since a dimension of the lip ring serving as the seal member varies due to thermal expansion, in a state where the compressor is cold, the lip ring is also cold and is thus shrunk, thereby failing to fulfill its sufficient sealing performance. Therefore, when the compressor is not operated for a long time, or when it is used in a cold region, the sealing performance of the lip ring is degraded.

[0004] Also, the lip ring can be deformed due to compression heat, or due to its pressing load against the wall surface of the cylinder, and it also wears when it is used continuously. In such deformed or worn lip ring, the degradation of the sealing performance before thermal expansion is great.

[0005] If the compressor is operated in a high rotating speed of a motor, the amounts of generation of friction heat and compression heat are caused to increase, so that the thermal expansion of the lip ring can be promoted. However, when the rotating speed of the motor is decreased for the purpose of power saving or silent operation, the lip ring is hard to warm, thereby being unable to cause the lip ring to thermally expand to a state where it can perform its sufficient sealing performance.

SUMMARY OF THE INVENTION

[0006] An embodiment of the invention relates to a compressor which, even when a rotating speed of a motor is decreased for a power saving or a silent operation, can promote a thermal expansion of a lip ring by temporarily increasing the rotating speed of the motor and thus can quickly enhance a sealing performance of the lip ring, thereby being able to enhance a compression efficiency of the compressor.

BRIEF DESCRIPTION OF THE DRAWINGS**[0007]**

- 5 Fig. 1 is a section view of a locking piston included in a compressor.
 Fig. 2 is a block diagram of the structure of a control apparatus for the compressor.
 Fig. 3 is a flow chart when the compressor is operated in a low speed running mode.
 10 Fig. 4 is a flow chart of a first example for determining the cold state of the compressor.
 Fig. 5 is a flow chart of a second example for determining the cold state.
 15 Fig. 6 is a flow chart of a third example for determining the cold state.
 Fig. 7 is a flow chart when the compressor is operated in a high speed running mode.

20 DETAILED DESCRIPTION OF THE EMBODIMENTS

[0008] Description will be given below of an embodiment of the invention with reference to the accompanying drawings. Further, the embodiment and modifications thereof described herein are not intended to limit the invention but only to exemplify the invention, and all features or combinations of the features of the embodiment and/or the modifications are not always essential to the invention.

25 **[0009]** A compressor according to this embodiment includes a locking piston with a piston rod 11 stored within a cylinder 10 and stores within a compressed air storage tank (not shown) the air compressed by the locking piston to thereby be able to supply the compressed air to a nail-
 30 ing machine or the like.

35 **[0010]** The locking piston can be operated by a motor 30 provided within the compressor. Specifically, when a crank mechanism (not shown) is operated using this motor 30, the piston rod 11 is caused to reciprocate within the cylinder 10 to thereby compress the air.

40 **[0011]** The piston rod 11, as shown in Fig. 1, is able to slide within the cylinder 10 while being oscillated and includes a dish-shaped piston portion in the leading end portion 13 thereof. The piston rod 11 includes a bearing hole 12 formed at an eccentric position of the base portion (large end portion) thereof and, in the bearing hole 12, there is pivotally received a crankshaft (not shown) provided in the main body of the compressor, while the crankshaft is operatively connected to the motor 30 provided in the compressor main body.

45 **[0012]** Thus, by actuating the motor 30, the crankshaft is rotated to eccentrically move the base portion of the piston rod 11, thereby allowing the leading end portion of the piston rod 11 to reciprocate in the sliding direction (the direction D1 in Fig. 1). That is, the compressor of this embodiment, using the rotation of the crankshaft, reciprocates the piston rod 11 to thereby compress the air taken into the cylinder 10 and sends the compressed
 50

air toward various equipment and tools which can operate on the compressed air.

[0013] Here, the piston rod 11 of this embodiment, as shown in Fig. 1, includes the piston portion formed integrally therewith. Therefore, as the above piston rod 11 reciprocates, the leading end portion 13 of the piston rod 11 is oscillated in a direction (a direction D2 in Fig. 1) perpendicular to the sliding direction, whereby there is generated a clearance between the cylinder 10 and piston rod 11.

[0014] On the outer periphery of the leading end portion 13 of the piston rod 11, as shown in Fig. 1, there is mounted a lip ring 14 serving as a seal member for sealing between the piston rod 11 and cylinder 10. The lip ring 14 can seal the clearance between the cylinder 10 and piston rod 11. That is, the clearance to be generated due to the oscillation of the leading end portion 13 of the piston rod 11 can be sealed by the elastic deformation of the lip ring 14.

[0015] The lip ring 14 is made of synthetic resin, synthetic rubber or the like. Specifically, it is made of non-metallic material constituted of poly or denatured poly (tetrafluoroethylene), copper or bronze powder, spherical carbon or carbon fiber, and molybdenum dioxide. And, the lip ring 14 is a ring-shaped member with no break over its whole periphery. Specifically, the lip ring 14 has a shape in which its lip portion rises up from the whole peripheral edge of its ring-plate-shaped bottom portion.

[0016] Here, the lip ring 14, as shown in Fig. 1, is fixed to the upper surface of the piston rod 11 by a ring holder 15. That is, the ring holder 15 is fitted into a recess portion formed in the upper surface of the piston rod 11 and is also fixed to the upper surface of the piston rod 11 by a fixing bolt 16 inserted therethrough from above. And, the lip ring 14 is fixed while it is sandwiched between the ring holder 15 and piston rod 11.

[0017] In the case of the lip ring 14, since its dimension is caused to vary due to thermal expansion, in a state where the compressor is cold, there is a possibility that the lip ring 14 also can be cold and shrunk and thus it cannot fulfill its sufficient sealing performance. Especially, when the lip ring 14 is worn and deformed due its continuous use or the like, the degradation of its sealing performance is great.

[0018] In view of this, in the compressor of this embodiment, by temporarily increasing the rotating speed of the motor, that is, by executing the warm-up operation of the motor, the amounts of generation of frictional heat and compression heat of the compressor are increased to promote the thermal expansion of the lip ring 14, thereby enhancing the sealing performance of the lip ring 14 and thus the compression efficiency of the compressor.

[0019] Here, the compressor of this embodiment has two operation modes, while one is a low speed operation mode where the upper limit of the rotating speed of the motor 30 is set low, the other is a high speed operation mode where the upper limit of the rotating speed of the

motor 30 is set high. These operations can be switched over to each other. Since, the problem that the thermal expansion of the lip ring 14 cannot be promoted occurs mainly in the low speed operation mode, in this embodiment, the warm-up operation is executed in the low speed operation mode. However, the invention is not limited to this but it may also have other operation modes than the low speed and high speed operation modes, while a mode for execution of the warm-up operation can also be executed in an arbitrary mode.

[0020] The warm-up operation is controlled by a control apparatus 100 (see Fig. 2) incorporated within the compressor 1, while the control apparatus 100 is used to control not only the warm-up operation but also the operation of the whole of the compressor.

[0021] The control apparatus 100, although not illustrated specially, is constituted mainly of a CPU and includes a Rom, a RAM, an I/O and the like. As the CPU reads in programs stored in the ROM, there are constituted a cold state determining unit 110 for determining whether the compressor is in a cold state or not, and a rotating speed control unit 120 for controlling the rotating speed of the motor 30. Here, the control apparatus 100 is not limited to the above-mentioned units but may also include other units.

[0022] As input devices, as shown in Fig. 2, there are connected to the control apparatus 100 a temperature sensor 20, a pressure sensor 21, an ammeter 22, a warm-up operation switch 23 and a turbo switch 24.

[0023] As output devices to the control apparatus 100, as shown in Fig. 2, there are connected the motor 30 and display device 31.

[0024] Here, the input and output devices to be connected to the control apparatus 100 are not limited to the above devices but other devices may also be connected. Also, depending on a cold state determining mode (which will be discussed later), it is also possible to omit the input and output devices which are not used.

[0025] Now, description will be given below specifically of the above-mentioned composing parts.

[0026] The temperature sensor 20 is used to measure the ambient temperature of the lip ring 14 and compressor (or the temperature of compressor). The temperature measured by the temperature sensor 20 is output to a cold state determining unit 110 according to a signal output from the cold state determining unit 110 and is used to determine the cold state (which will be discussed later).

[0027] The pressure sensor 21 is used to measure the pressure within the compressed air storage tank. The pressure measured by the pressure sensor 21 is output to the cold state determining unit 110 according to a signal output from the cold state determining unit 110 and is used to determine the cold state (which will be discussed later).

[0028] The ammeter 22 is used to measure a current value to be supplied to the motor 30. The current value measured by the ammeter 22 is output to the cold state determining unit 110 according to a signal output from

the cold state determining unit 110 and is used to determine the cold state (which will be discussed later).

[0029] The warm-up operation switch 23 is a pressure switch used to execute the warm-up operation. By depressing the warm-up operation switch 23, the execution and non-execution of the warm-up operation can be switched over to each other. In this embodiment, the warm-up operation switch 23 is used only in the low speed operation mode.

[0030] The turbo switch 24 is a pressure switch used to execute the high speed operation mode while increasing further the rotating speed of the motor 30 in the high speed operation mode. By depressing the turbo switch 24, as will be discussed later, the motor can be operated for a given period in a rotating speed increasing mode and thus, in the high speed operation mode, the output of the motor can be increased further.

[0031] The display device 31 is used to display thereon that, in the warm-up operation and high speed operation mode, the motor is currently during a warm-up operation or in a rotating speed increasing mode. For example, as the display device 31, a lamp may be used and the lamp may be turn on or flickered. Besides, as the display device 31, a 7-segment device or a liquid crystal device may also be provided so as to show specified displays. As the display device 31, there may also be provided a speaker, so that the warm-up operation and rotating speed increasing mode can be determined using the output of sounds and voices from the speaker.

[0032] The cold state determining unit 110 is used to determine whether the compressor is in a cold state or not, while it is constituted as a program which, according to inputs or the like from various sensors, can determine whether the compressor is in a cold state or not. When the cold state determining unit 110 determines that the compressor is in a cold state, a signal based on this determination result is output to a rotating speed control unit 120 (which will be discussed later). On receiving this signal, the rotating speed control unit 120 increases the rotating speed of the motor 30 to thereby carry out the warm-up operation.

[0033] The rotating speed control unit 120 is constituted as a program for controlling the rotating speed of the motor 30 and is used to rotate the motor 30 with the optimum rotating speed. For example, the control unit 120 adjusts the voltage to be supplied to the motor 30 according to the execution mode such as the low speed operation mode and high speed operation mode to thereby control the rotating speed of the motor 30. In this embodiment, the rotating speed control unit 120, as described above, can increase the rotating speed of the motor 30 according to the determination result of the cold state determining unit 110 to thereby execute the warm-up operation.

(Description of Warm-up Operation)

[0034] Next, description will be given below specifically

of the warm-up operation of this embodiment.

(Low speed operation mode execution flow)

[0035] Since the warm-up operation of this embodiment is executed in the low speed operation mode, firstly, description will be given of the execution flow of the low speed operation mode.

[0036] The low speed operation mode, as shown in Fig. 3, is executed in the following flow.

[0037] That is, as shown in Step 100 in Fig. 3, firstly, a power switch is turn on to start the compressor. And, the processing advances to Step 101.

[0038] In Step 101, it is determined whether the warm-up operation switch 23 is depressed or not and, when it is depressed, the processing advances to Step 102. Also, when the warm-up operation switch 23 is not depressed, the processing advances to Step 105.

[0039] In Step 102, the rotating speed control unit 120 controls the motor 30 to increase its rotating speed to thereby execute the warm-up operation. In this case, the display device 31 displays that the motor is currently during its warm-up operation (for example, a lamp is turned on). And, the processing advances to Step 103.

[0040] In Step 103, the cold state determining unit 110 determines the compressor for its cold state. The details of this cold state determination will be described later. And, the processing advances to Step 104.

[0041] In Step 104, the cold state determining unit 110 determines whether the compressor is in a cold state or not and, when the compressor is determined to be in a cold state, the processing goes back to Step 102 and the warm-up operation is executed until the compressor is determined to be not in a cold state. On the other hand, when it is determined that the compressor is not in a cold state, the warm-up operation is stopped and the processing goes to Step 105. Here, when the warm-up operation is stopped, the display by the display device 31 is also ended (for example, the lamp is turned off).

[0042] In Step 105, the rotating speed control unit 120 controls the rotating speed of the motor 30 to provide a normal rotating speed (a rotating speed specified for the low speed operation mode) and, in this state, the operation is executed. This operation is executed until the pressure sensor 21 detects that the pressure reaches a given stop pressure. Here, when the pressure is detected to have reached a given stop pressure, it is determined that a sufficient amount of air has been compressed for the compressed air storage tank, and the operation of the motor 30 is stopped. And, the processing advances to Step 106.

[0043] In Step 106, it is determined whether the pressure within the compressed air storage tank is reduced due to use of the compressed air within the compressed air storage tank by a nailing machine or the like. When the pressure has reached the re-operation pressure due to the reduced pressure within the compressed air storage tank, the processing advances to Step 107. On the

other hand, when not reached the re-operation pressure, the processing waits until the pressure reaches the re-operation pressure.

[0044] In Step 107, it is determined whether the operation has been stopped for a previously set time (for example, 45 minutes) or longer. When the operation has been stopped for a previously set time or longer, the processing advances to Step 108. When not, the processing goes to Step 105, where the operation is executed with a normal rotating speed (a rotating speed specified for the low speed operation mode).

[0045] In Step 108, it is determined whether the warm-up operation switch 23 is depressed or not and, when it is depressed, the processing goes to Step 103, where the cold state determination is made. Also, when the warm-up operation switch 23 is not depressed, the processing goes to Step 105, where the operation is executed with a normal rotating speed (a rotating speed specified for the low speed operation mode).

(Flow of cold state determination)

[0046] Next, description will be given below of the flow of the cold state determination of this embodiment with reference to Figs. 4 to 6, while using three examples. Here, the cold state determinations to be described below are just examples, while any one of the following cold state determinations may be used or they may be used in combination. Also, part of the processings may be omitted or may be replaced.

(First cold state determination flow)

[0047] Fig. 4 is a flow chart of a first example for determining the cold state of the compressor.

In this cold state determination, the cold state determining unit 110 determines whether a given time has elapsed after execution of the warm-up operation or not, thereby determining the compressor for its cold state.

[0048] That is, as shown in Step 200 in Fig. 4, the time after end of the last operation (normal operation or warm-up operation) is measured, and the measured value is checked whether it is a given value or larger, thereby determining whether a given time has elapsed since execution of the operation. And, when a given time has elapsed, the processing advances to Step 202, where it is determined that the compressor is not in a cold state, ending the cold state determination processing. On the other hand, when a given time has not elapsed, the processing advances to Step 201, where it is determined that the compressor is in a cold state, ending the cold state determination processing.

[0049] According to this cold state determination flow, without executing a complicate processing, the cold state can be determined uniformly and also the execution time of the warm-up operation can be reduced.

(Second cold state determination flow)

[0050] Fig. 5 is a flow chart of a second example for determining the cold state. In this cold state determination, according to the ambient temperature or compressor temperature, the pressure increase rate in a given time, the current value (secondary current value) to be supplied to the motor 30, the current value (primary current value) to be supplied to a electric power source plug of the compressor, the rotating speed of the motor 30 and the like, the cold state determining unit 110 determines the compressor for its cold state.

[0051] That is, as shown in Step 300 in Fig. 5, firstly, the temperature sensor 20 measures the ambient temperature of the lip ring 14 and compressor (or the temperature of the compressor) and the measured temperature is checked whether it is a given value or less or not. And, when the temperature is found to be a given value or less, the processing advances to Step 305, where the compressor is determined to be in a cold state, thereby ending the cold state determination processing. On the other hand, when the temperature is not a given value or less, the processing advances to Step 301.

[0052] In Step 301, using the pressure sensor 21, it is checked whether the pressure within the compressed air storage tank is reduced or not. When the pressure is increasing, the processing advances to Step 302. On the other hand, when the pressure is not increasing, the processing advances to Step 303.

[0053] In Step 302, according to a pressure variation measured by the pressure sensor 21, a pressure increase rate per time is calculated and it is checked whether the pressure increase rate is a threshold value or less or not. That is, by determining whether the pressure within the compressed air storage tank is increasing efficiently or not, it is checked whether the air leaks from the lip ring 14 or not. When the check result shows that the pressure increase rate is a threshold value or less, the processing advances to Step 305, where it is determined that the compressor is in a cold state, thereby ending the cold state determination processing. On the other hand, when not a threshold value or less, the processing goes to Step 304, where the compressor is determined to be not in a cold state, thereby ending the cold state determination processing.

[0054] In Step 303, it is checked whether the current value to be supplied to the motor 30 is a threshold value or less or not, or whether the rotating speed of the motor 30 is a threshold value or more or not. That is, when the air leaks from the lip ring 14, since the load of the compressor is reduced and the current value to be supplied to the motor 30 is reduced, the current value to be supplied to the motor 30 is obtained using the ammeter 22, it is checked whether the current value is a threshold value or less or not, thereby being able to check whether the air leaks from the lip ring 14 or not. Also, when the air leaks from the lip ring 14, since the compression efficiency of the compressor is reduced and a processing

to increase the rotating speed of the motor 30 is executed in order to compensate the reduced compression efficiency, by determining whether the rotating speed of the motor 30 is a threshold value or more or not, the leakage of the air from the lip ring 14 can also be checked.

[0055] Here, since the current value and the rotating speed are checked in combination, when the compressor is operated while limiting the rotating speed of the motor 30, by determining the current value, the air leakage can be checked. And, when the compressor is operated while limiting the current value, by determining the rotating speed of the motor 30, the air leakage can be checked.

[0056] When the current value is a threshold value or less or when the rotating speed is a threshold value or more, the processing goes to Step 305, where it is determined that the compressor is in a cold state, thereby ending the cold state determination processing. On the other hand, when the current value is not a threshold value or less and the rotating speed is not a threshold value or more, the processing goes to Step 304, where it is determined that the compressor is not in a cold state, thereby ending the cold state determination processing.

[0057] According to this cold state determination flow, since, by determining the compression efficiency mainly, it is determined whether the compressor is in a cold state or not, direct enhancement in the compression efficiency can be expected using the warm-up operation.

[0058] Here, although, in the above case, the current value to be supplied to the motor 30 is checked, the current value to be supplied to the socket of the compressor may be checked, or, instead of the current value, the voltage value may be checked.

(Third cold state determination flow)

[0059] Fig. 6 is a flow chart of a third example for determining the cold state. In this cold state determination, it is checked whether the motor 30 is driven or not after the power is supplied, and, based on the cessation time of the motor 30 or the like, it is determined whether the compressor is in a cold state or not.

[0060] That is, as shown in Step 400 in Fig. 6, it is checked whether the motor is driven first after supply of the power or not. Here, since, when the motor is driven first after supply of the power, it can be assumed that the compressor is cold, the processing advances to Step 404, where the compressor is determined to be in a cold state, thereby ending the cold state determination processing. On the other hand, when the motor is not driven first after supply of the power, the processing advances to Step 401.

[0061] In Step 401, it is checked whether the operation has been stopped for a given time or more or not and also whether the motor 30 has not been rotated or not. When the operation has been stopped for a given time or more, since the compressor can be assumed to be cold, the processing advances to Step 404, where it is determined that the compressor is in a cold state, thereby

ending the cold state determination processing. On the other hand, when the operation has not been stopped for a given time or more, the processing advances to Step 402.

[0062] In Step 402, the relative ratio between the operation time and cessation time is checked and it is checked whether the ratio of the cessation time is a given ratio or more or not. When the ratio of the cessation time is a given ratio or more, it can be assumed that the compressor is cold because the cessation time is long. Therefore, the processing advances to Step 404, where the compressor is found to be in a cold state, thereby ending the cold state determination processing. On the other hand, when the ratio of the cessation time is not a given ratio or more, the processing advances to Step 403, where it is determined that the compressor is not in a cold state, thereby ending the cold state determination processing.

[0063] According to this cold state determination flow, since the cold state is determined based on the operation state of the motor 30, the cold state can be determined easily.

(Description of high speed operation mode)

[0064] Next, description will be given of a high speed operation mode.

[0065] This embodiment includes, besides the above-mentioned warm-up operation, a rotating speed increasing mode which increases the rotating speed of the motor 30 temporarily. This rotating speed increasing mode, in this embodiment, can be executed in a high speed operation mode.

[0066] That is, as shown in Step 500 in Fig. 7, firstly, the power switch is turned on to start the compressor. And, the processing advances to Step 501.

[0067] In Step 501, it is checked whether the turbo switch 24 is depressed or not. When it is depressed, the processing advances to Step 502. Also, when not depressed, the processing advances to Step 504.

[0068] In Step 502, it is checked whether the rotation of the motor 30 has been stopped for a given time or more or not. When the motor 30 is found to have been stopped for a given time or more, the processing advances to Step 503. Also, when not, the motor 30 can be assumed to be in a high temperature. The processing does not enter the rotating speed increasing mode but advances to Step 504.

[0069] In Step 503, the processing enters the rotating speed increasing mode until a given time has elapsed. That is, the rotating speed control unit 120 controls the motor 30 to increase its rotating speed. In this case, the display device 31, simultaneously with the start of the rotating speed increasing mode, starts its display (for example, a lamp is turned on) and displays that the processing is currently in the rotating speed increasing mode until the rotating speed increasing mode is ended. Then, the processing advances to Step 504.

[0070] In Step 504, the rotating speed of the motor 30 is controlled to provide a normal rotating speed (the rotating speed specified for the high speed operation mode) and, in this state, the operation is executed. Then, the processing goes to Step 501.

[0071] Here, in the above flow, although not described in order to simplify the description, similarly to the flow shown in Fig. 3, of course, the operation of the motor 30 is controlled according to a variation in the pressure within the compressed air storage tank.

[0072] As described above, according to this embodiment, since, even when the warm-up operation is not necessary, the rotating speed increasing mode can be executed, the compression efficiency can be enhanced temporarily.

(Summary)

[0073] As has been described heretofore, according to the present embodiment, when the compressor is found to be in a cold state, the rotating speed of the motor 30 is increased to carry out the warm-up operation. Therefore, even when the rotating speed of the motor 30 is reduced for purpose of a power saving and a silent operation, by increasing the rotating speed temporarily, the thermal expansion of the lip ring 14 can be promoted, thereby being able to enhance its sealing performance quickly and thus enhance the compression of the compressor efficiency. Also, only when the compressor is in a cold state, the warm-up operation is executed. Therefore, an unnecessary rotating speed increasing operation can be avoided and thus the sealing performance can be enhanced efficiently.

[0074] Also, since the warm-up operation is executed when the warm-up operation switch 23 is depressed, it is possible to select a mode where, unless the warm-up operation switch 23 is depressed, the warm-up operation will not be executed. Therefore, for example, when it is desired to always prevent noises from occurring in a reforming environment or the like, or when it is desired to reduce the current amount to thereby prevent a breaker against failure, the warm-up operation can be prevented against execution.

[0075] In the above description, when the warm-up operation switch 23 is depressed in the low speed operation mode, the warm-up operation is executed. However, this is not limitative but, whenever the cold state is determined, the warm-up operation may be executed.

[0076] According to the above embodiment, when it is determined that the compressor is in a cold state, the rotating speed of the motor can be increased so that the warm-up operation is carried out. Therefore, even when the rotating speed of the motor is reduced for purpose of a power saving or a silent operation, the rotating speed can be temporarily increased to promote the thermal expansion of the seal member, whereby the sealing performance of the seal member can be enhanced quickly and thus the compression efficiency of the compressor

can be enhanced. Further, the warm-up operation is executed only when the compressor is in a cold state and, when not necessary, an increase in the rotating speed of the motor is prevented. Thus, the sealing performance can be enhanced efficiently.

[0077] The cold state determining unit may determine the cold state based on an elapsed time since an execution of the warm-up operation. According to this structure, the determination of the cold state can be made with a simple structure and also the time of execution of the warm-up operation can be controlled.

[0078] The cold state determining unit may also determine the cold state based on the ambient temperature or the compressor temperature. According to this structure, the determination of the cold state can be made directly.

[0079] The cold state determining unit may also determine the cold state when the motor is driven at the first time after the power is supplied. That is, since, when the power is not supplied, it can be assumed that the operation has been stopped for a given time or more, it may be determined that the compressor is in the cold state.

[0080] The cold state determining unit may also determine the cold state based on the cessation time of the motor. For example, based on the continuous cessation time of the motor or based on a comparison result between the drive time and the cessation time of the motor, the determination of the cold state may be made. According to this structure, by measuring the cessation time of the motor, the cold state can be uniformly determined. Therefore, the determination of the cold state can be made using simple control.

[0081] The cold state determining unit may also determine the cold state based on a pressure increase rate within a given time. According to this structure, since the cold state of the compressor can be checked according to an actual compression efficiency of the compressor, the warm-up operation can be carried out at such timing as can provide a direct effect.

[0082] The cold state determining unit may also determine the cold state based on at least one of a current value to be supplied to the motor, a voltage value to be supplied to the motor and the rotating speed of the motor. According to this structure, since the cold state can be determined based on the actual compression efficiency or the like, enhancement in the sealing performance directly connected with the compression efficiency can be expected.

[0083] In the above structure, the compressor may include a switch for switching the execution and the non-execution of the warm-up operation. According to this structure, a choice of non-execution of the warm-up operation is also possible. For example, when it is desired to always control the generation of noises in a reforming environment or the like, or when it is desired to reduce a current amount and thus prevent a breaker against failure, the warm-up operation can also be prevented against execution.

[Description of Reference Numerals and Signs]

when the cold state determining unit (110) determines that the compressor is in the cold state.

[0084]

10:	Cylinder	5	2.	The compressor according to Claim 1, wherein the cold state determining unit (110) is adapted to determine the cold state based on an elapsed time since an execution of the warm-up operation.
11:	Piston rod			
12:	Bearing hole		3.	The compressor according to Claim 1 or 2, wherein the cold state determining unit (110) is adapted to determine the cold state based on an ambient temperature or a compressor temperature.
13:	Leading end portion	10		
14:	Lip ring (seal member)		4.	The compressor according to any one of Claims 1 to 3, wherein the cold state determining unit (110) is adapted to determine the cold state when the motor (30) is driven for the first time after a power is supplied.
15:	Ring holder	15		
16:	Fixing bolt			
20:	Temperature sensor		5.	The compressor according to any one of Claims 1 to 4, wherein the cold state determining unit (110) is adapted to determine the cold state based on a cessation time of the motor (30).
21:	Pressure sensor	20		
22:	Ammeter			
23:	Warm-up operation switch		6.	The compressor according to any one of Claims 1 to 5, wherein the cold state determining unit (110) is adapted to determine the cold state based on a pressure increase rate within a given time.
24:	Turbo switch	25		
30:	Motor		7.	The compressor according to any one of Claims 1 to 6, wherein the cold state determining unit (110) is adapted to determine the cold state based on at least one of a voltage value to be supplied to the motor (30), an electric current value to be supplied to the motor (30), and the rotating speed of the motor (30).
31:	Display device	30		
100:	Control apparatus			
110:	A cold state determining unit	35		
120:	Rotating speed control unit		8.	The compressor according to any one of Claims 1 to 7, further comprising: a switch (23) adapted to switch an execution and a non-execution of the warm-up operation over to each other.
D1:	Sliding direction of piston rod	40		
D2:	Oscillating direction of piston rod		9.	An operation method of a compressor, the method comprising:

Claims

1.	A compressor comprising:	45		determining whether the compressor is in a cold state or not; and
	a motor (30);			executing a warm-up operation by increasing a rotating speed of a motor (30) of the compressor when the cold state is determined.
	a piston rod (11) which is driven by the motor (30) and reciprocable within a cylinder (10);	50		
	a seal member (14) adapted to seal between the piston rod (11) and the cylinder (10);		10.	The method according to Claim 9, further comprising: determining the cold state based on an elapsed time since an execution of the warm-up operation.
	a cold state determining unit (110) adapted to determine whether the compressor is in a cold state or not; and			
	a rotating speed control unit (120) adapted to control a rotating speed of the motor (30) to increase so that a warm-up operation is executed	55	11.	The method according to Claim 9 or 10, further comprising: determining the cold state based on an ambient temperature or a compressor temperature.

12. The method according to any one of Claims 9 to 11,
further comprising: determining the cold state when
the motor (30) is driven for the first time after a power
is supplied.
- 5
13. The method according to any one of Claims 9 to 12,
further comprising: determining the cold state based
on a cessation time of the motor (30).
- 10
14. The method according to any one of Claims 9 to 13,
further comprising: determining the cold state based
on a pressure increase rate within a given time.
- 15
15. The method according to any one of Claims 9 to 14,
further comprising: determining the cold state based
on at least one of a voltage value to be supplied to
the motor (30), an electric current value to be sup-
plied to the motor (30), and the rotating speed of the
motor (30).
- 20

25

30

35

40

45

50

55

FIG. 1

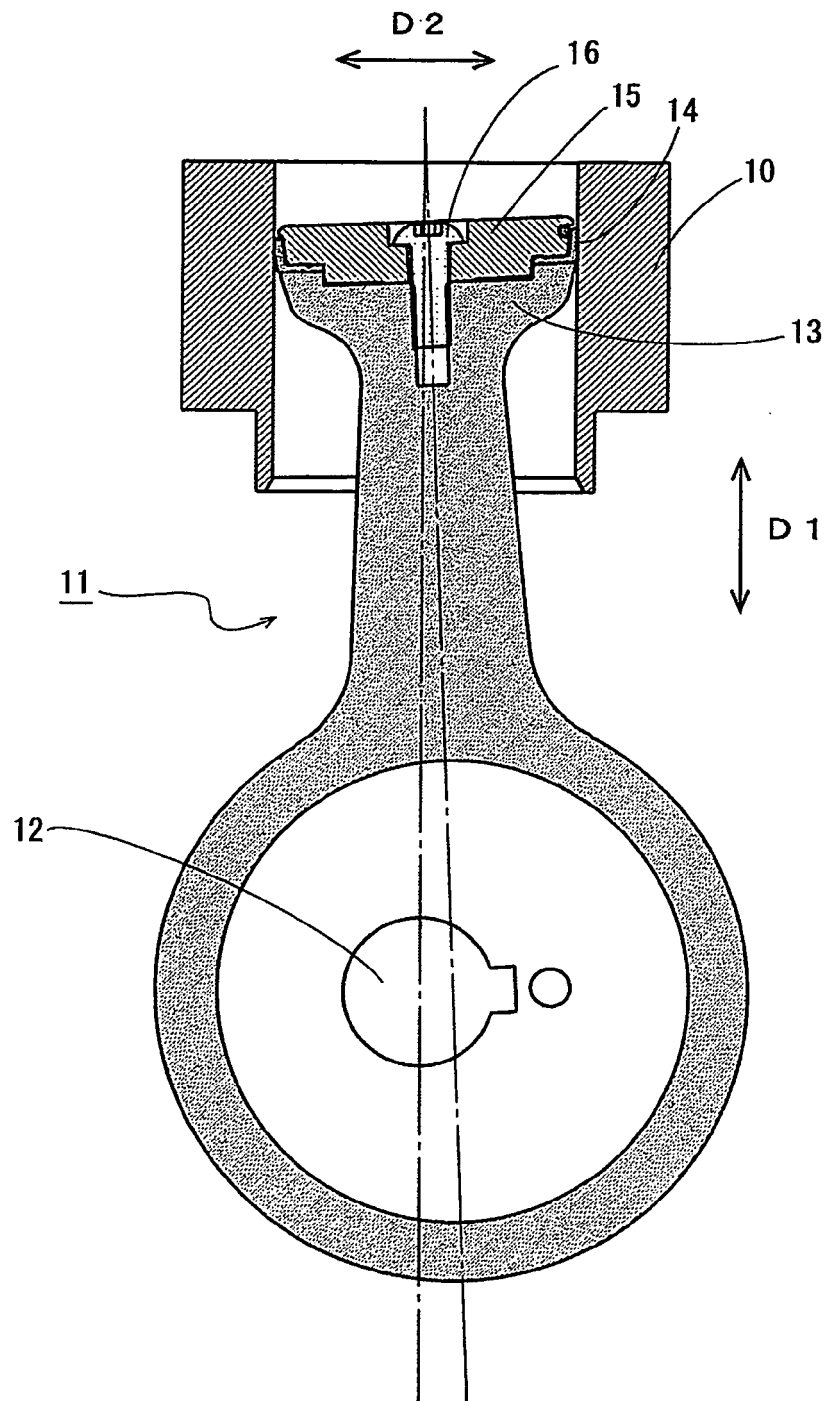


FIG.2

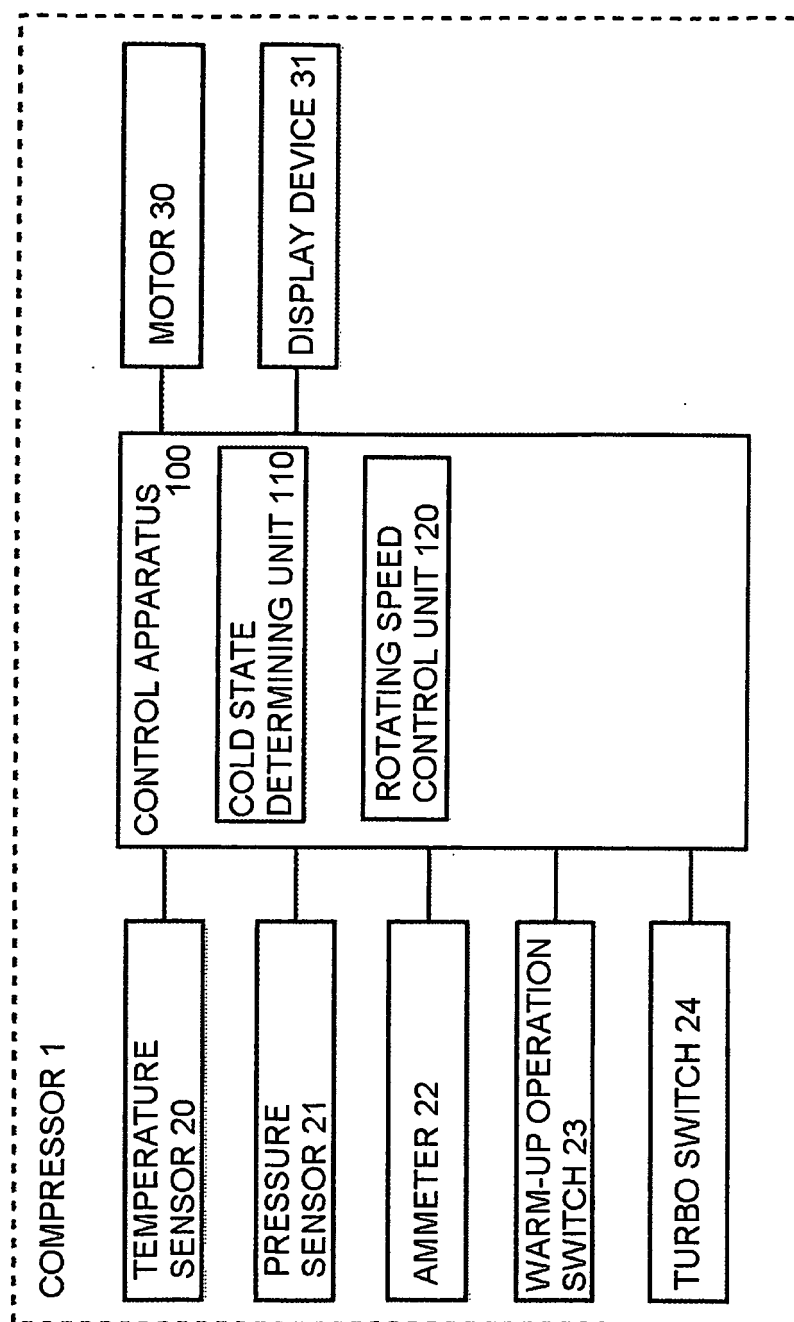


FIG.3

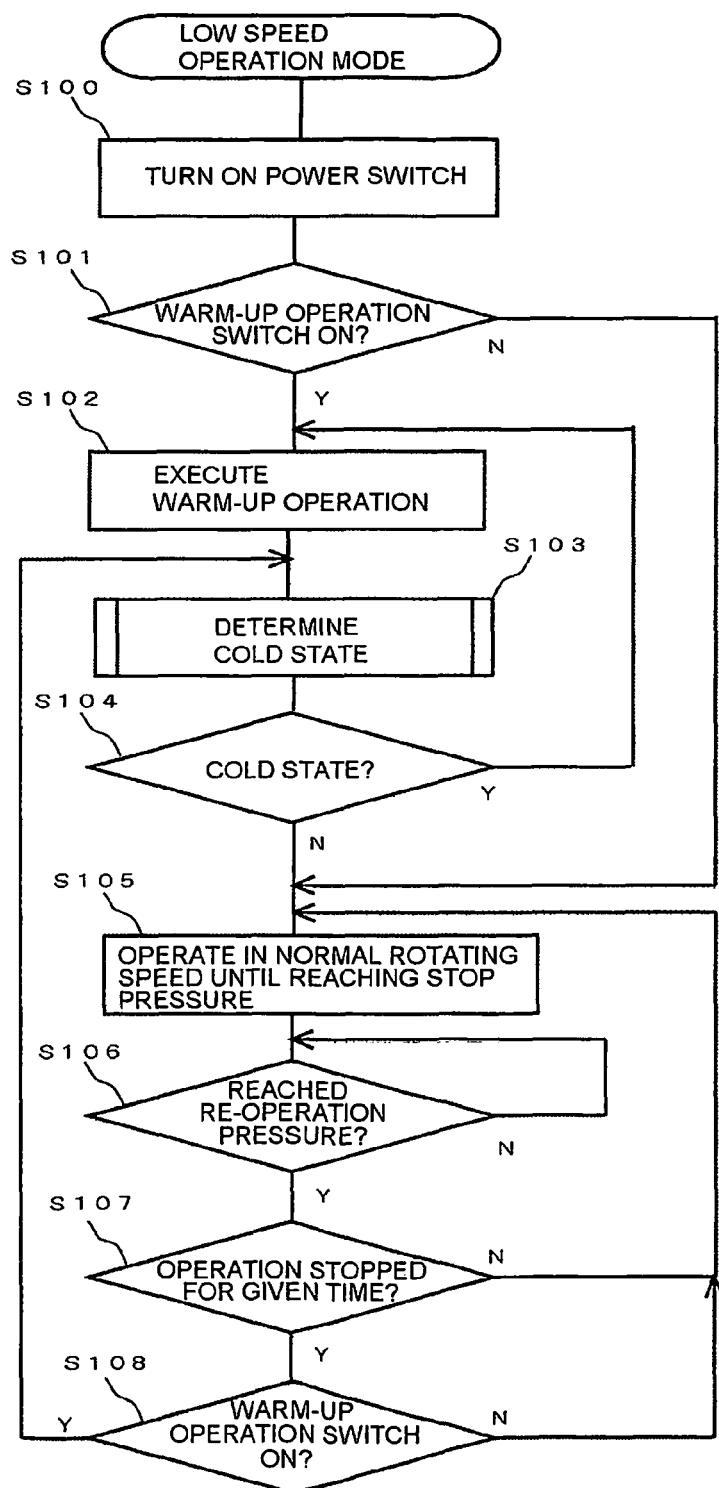


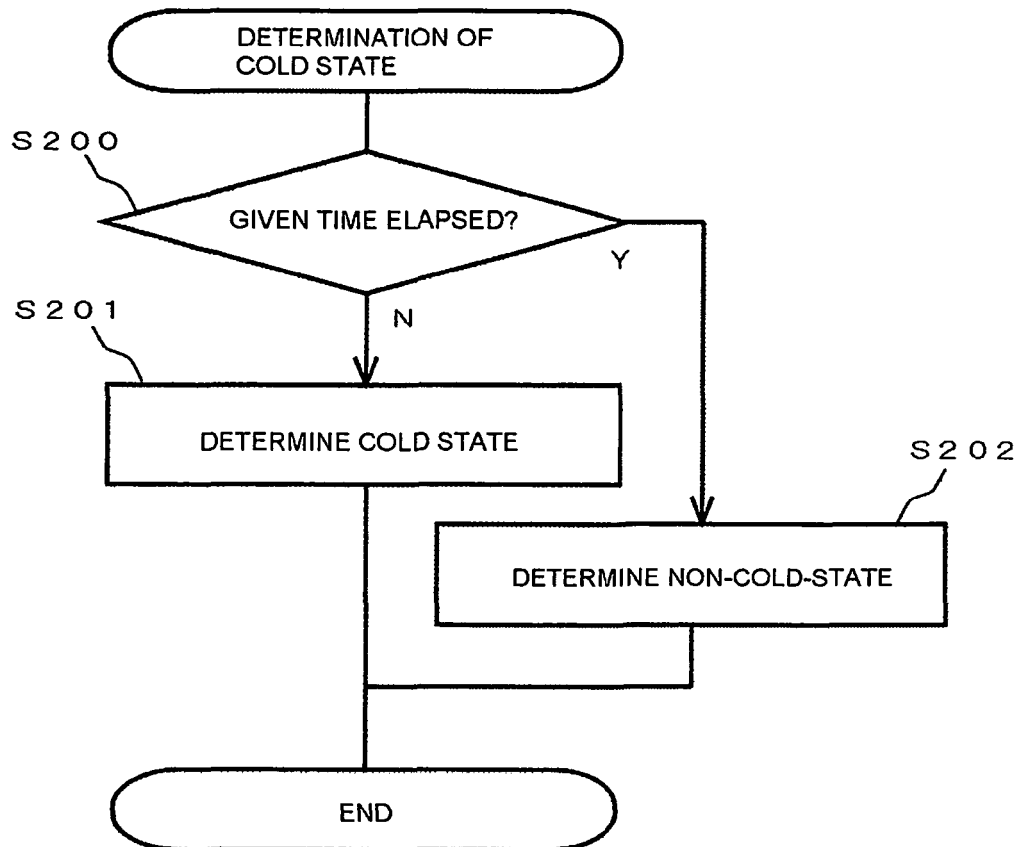
FIG.4

FIG. 5

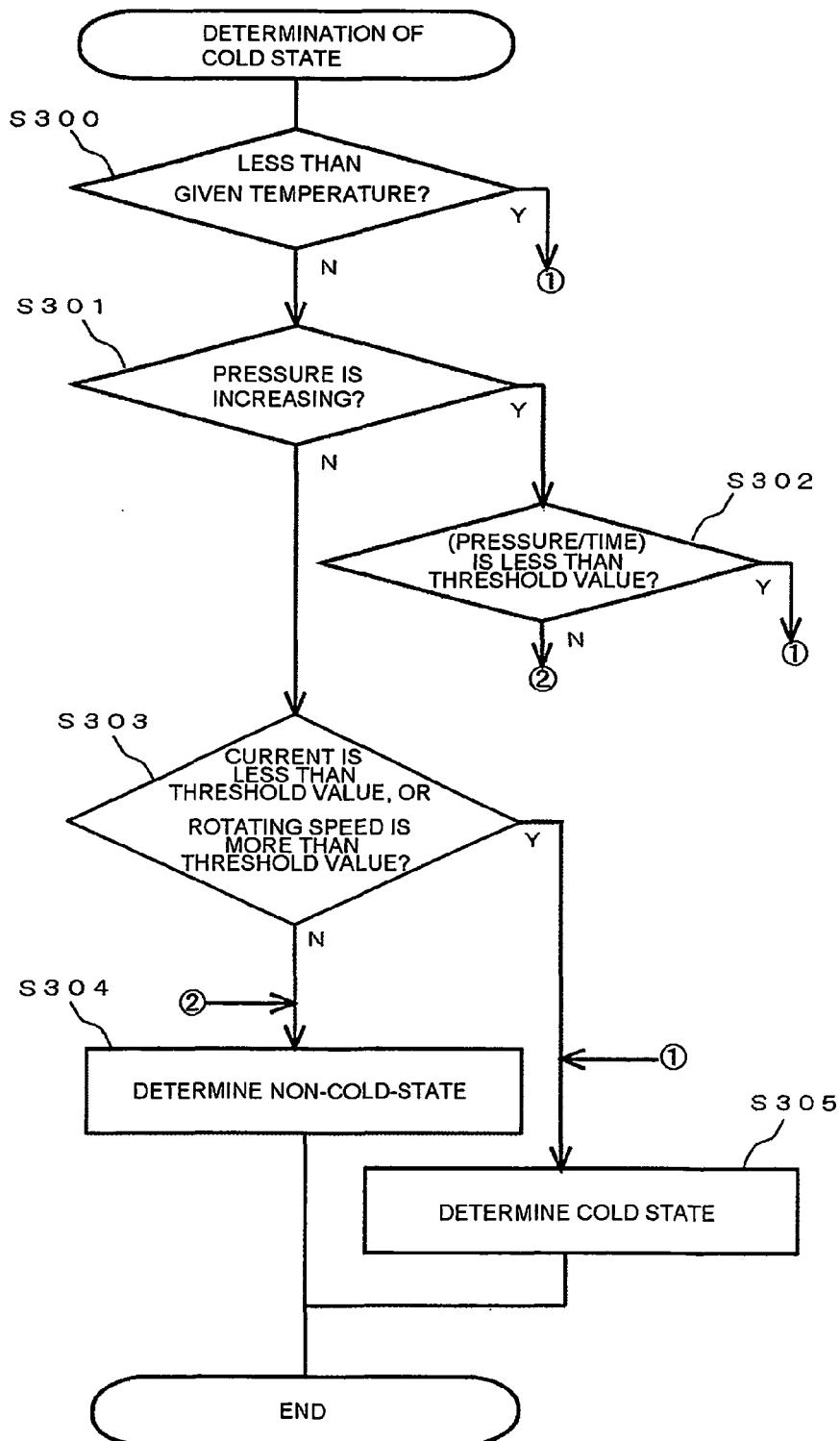


FIG.6

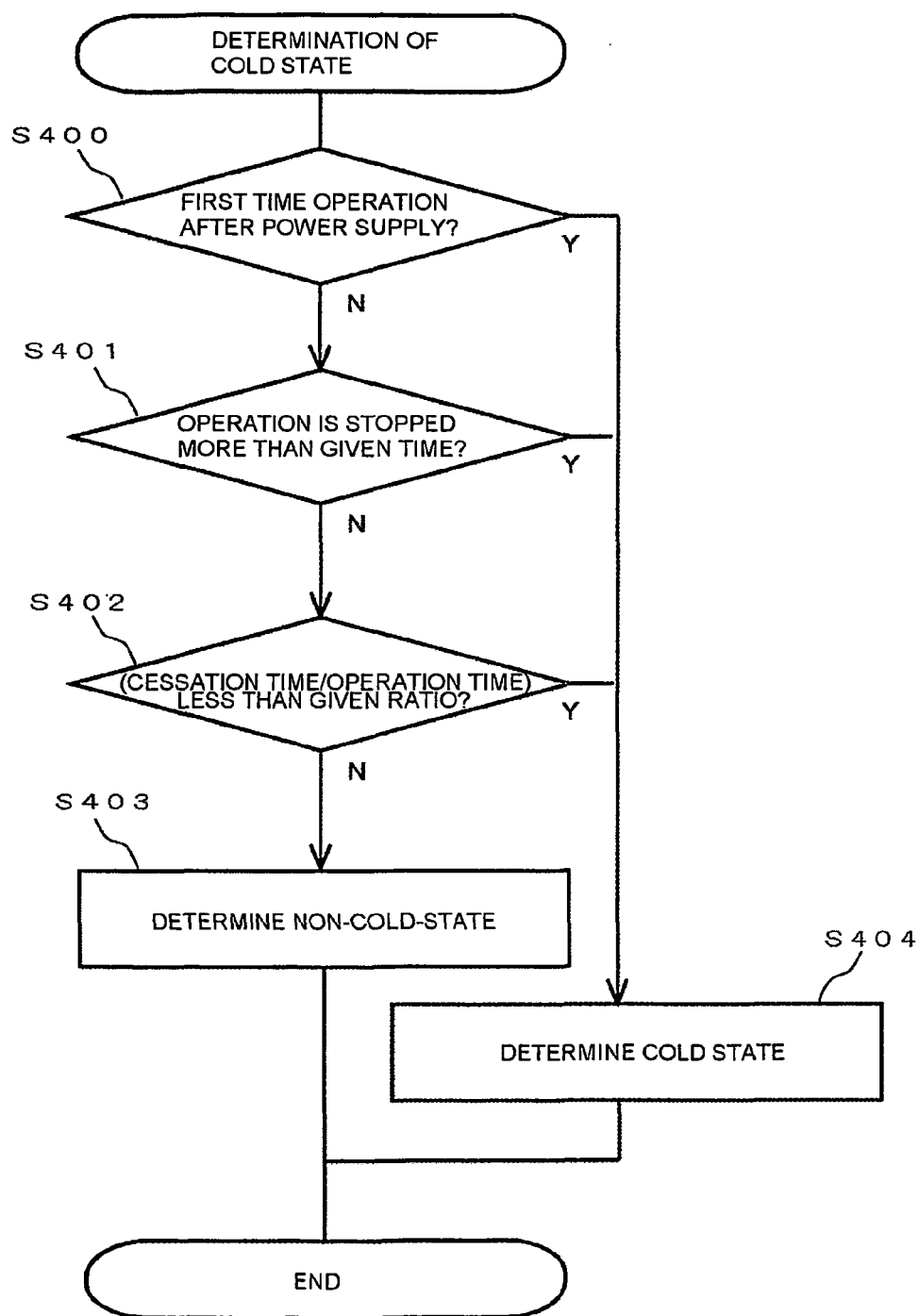
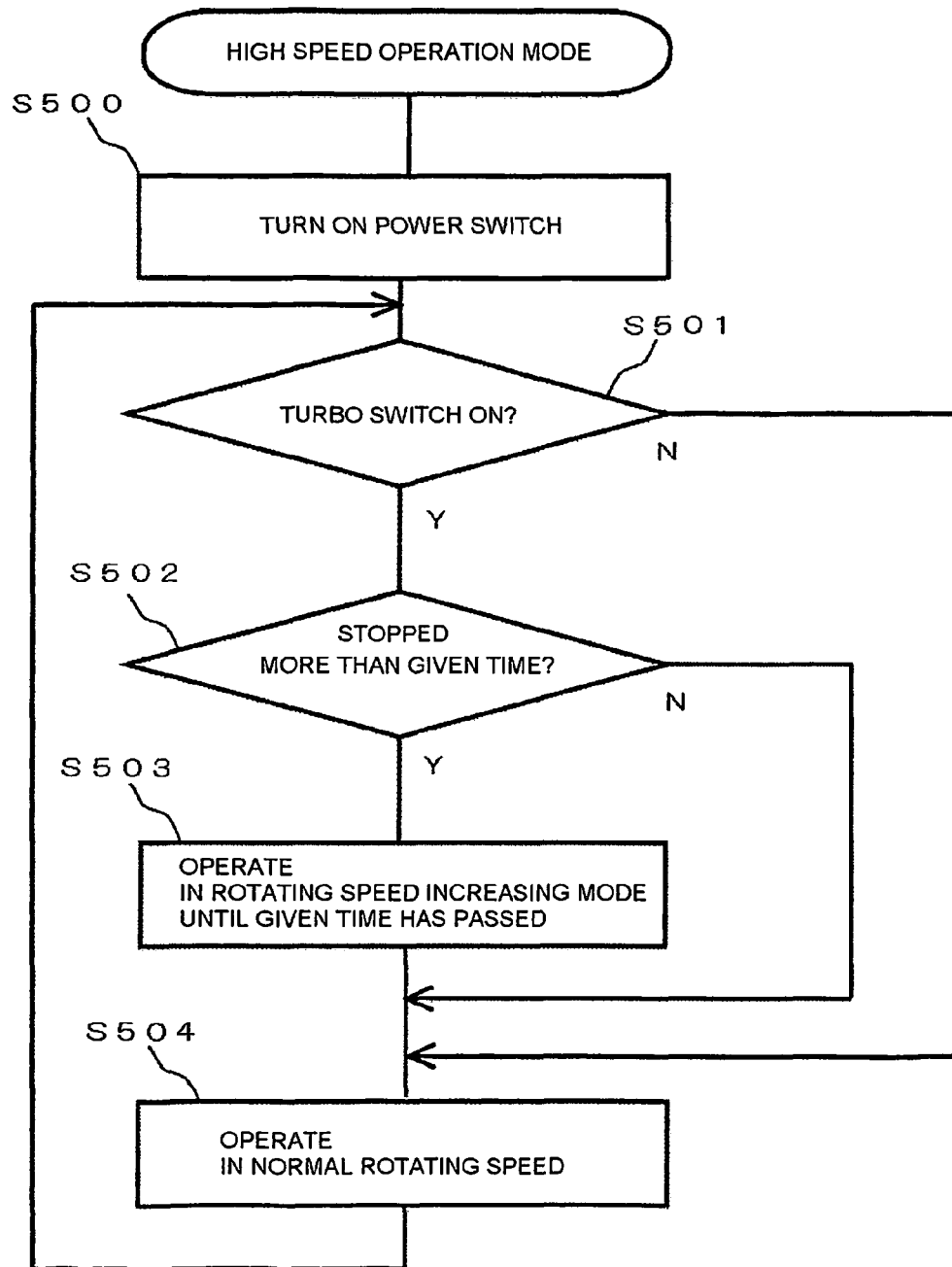


FIG.7



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 9068279 A [0002]