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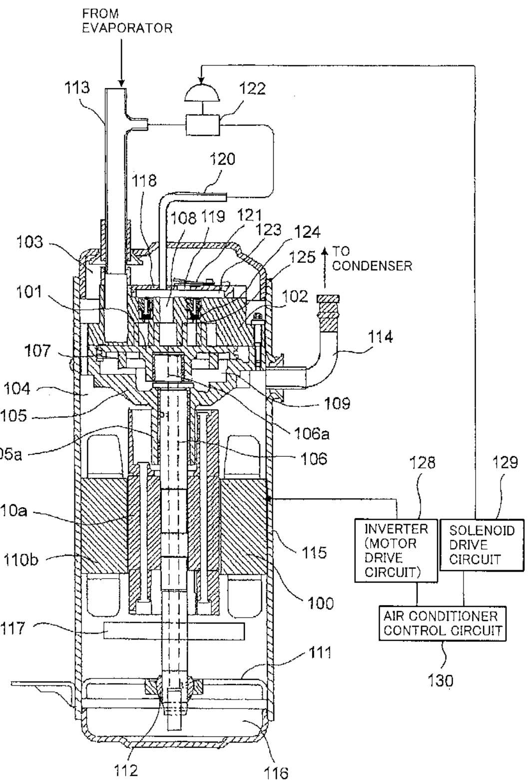
(54) SCROLL COMPRESSOR

(57) [Problem] To provide a scroll compressor that can be easily mass-produced as a compact and light-weight structure at a low cost, and in which efficient low-capacity control is possible in a super-low speed operation mode.

[Means for Resolution] In the compressor, a discharge guide pipe 120 that guides a refrigerant gas in a discharge head space 123 within a discharge head cover 118, which is disposed on a top plate of a fixed scroll 102 equipped with a release mechanism on an outer circumference of a discharge port 108, from the space 123 to the outside of a sealed case 115, and a suction pipe 113 for sucking in the refrigerant gas are coupled to each other and communicated with each other by a solenoid valve 122 whose opening and closing are controlled in accordance with a pulse-width modulation control signal, and a bypass passage that guides the refrigerant gas within the space 123 from the guide pipe 120 to the suction pipe 113 is formed. When low-capacity control is required in a low-speed rotation range, a motor 100 is driven by an inverter 128 and an operation is performed in which the ratio between the operation for closing the valve 122 and the operation for opening the valve 122 in accordance with the pulse-width modulation control signal from a solenoid drive circuit 129 has been altered.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a scroll compressor with a compact and lightweight structure, which is suitably used as a compressor for a refrigerating cycle in an air-conditioning and hot-water-supply system for new-generation housings having high eco (ecological) effects and which can use a new refrigerant with a low global warming potential (GWP) so that wide-range operation in a motor drive signal frequency can be made and low-capacity control can be performed efficiently particularly in a super-low speed operation mode.

BACKGROUND ART

[0002] In a viewpoint of reducing energy consumed in a general housing, that is, energy consumed in an air conditioner or energy consumed in a hot water supply device, there is a recently strong tendency toward use of a highly heat insulating material as a heat insulating material of a building to reduce heat load. There is also an idea of equipping a housing with a solar photovoltaic power generator or a solar water heater so as to put a fossil fuel-free housing requiring zero annual integral power consumption into practice.

[0003] In such an idea, a scroll compressor used in an air conditioner or a hot water supply device is required to be capable of performing capacity control in a wide range singly. For example, in an air-cooling operation in an air conditioner, rapid operation is required because it is general that the room temperature is high at the time of start of the operation. In this case, high speed operation (high speed rotation) in high capacity is performed at the time of start but low speed operation (low speed rotation) in low capacity is performed after the room is cooled to some degree so that operation is shifted from the start to a steady operation state. The low speed operation in this steady operating state means operation at a very low rotation speed on the assumption that the scroll compressor is used in an air conditioner provided in a building equipped with a highly heat insulating material particularly for recent energy saving.

[0004] However, when the scroll compressor is operated in excessively low speed rotation, it is difficult to operate the scroll compressor stably because oil film breaking occurs in a sliding bearing structurally to damage the bearing easily or motor drive for rotating a crankshaft is not performed smoothly because of low speed rotation. Therefore, in a low-capacity operation mode, rotation speed is generally kept to some degree to perform capacity control and, for example, an operation pattern in which the scroll compressor is stopped when the room is cooled to some degree and in which the scroll compressor is restarted when the room temperature increases is repeated.

[0005] However, in such a low-capacity operation mode, because the operation pattern based on repetition of stop and start is poor in efficiency and air conditioning cannot be performed comfortably, a technique for devising capacity control has been proposed. Generally, when capacity control is performed in the scroll compressor, a technique of controlling rotation speed based on motor drive, a technique of improving a part of the structure for controlling the discharge amount variably while keeping the rotation speed constant, or a technique using these techniques in combination is used. For example, techniques of controlling the discharge amount variably include a scroll machine (see Patent Literature 1) having a capacity adjusting mechanism as a structure in which sealing is cancelled in an axial direction of a crankshaft to avoid compression, and a capacity control mechanism (see Patent Literature 2) of a scroll compressor formed so that a refrigerant gas in the middle of compression is discharged to the suction side to delay the start of compression when control pressure is low.

[0006] In Patent Literature 1, a high pressure chamber, a discharge chamber and a low pressure suction pipe formed between an outer shell connecting fitting provided on one end side of the compressor and a piston connected to a non-orbiting scroll member are connected to one another by pipe arrangement with interposition of a solenoid valve. When the solenoid valve is turned on (opened) by pulse width modulation (PWM), pipes from the high pressure chamber to the low pressure suction pipe communicate with each other and the non-orbiting scroll member is moved to the outer shell connecting fitting side so that sealing in the axial direction of the crankshaft is cancelled to avoid compression. When the solenoid valve is turned off (shut), pipes from the high pressure chamber to the discharge chamber communicate with each other and the non-orbiting scroll member is moved to the crankshaft side opposite to the outer shell connecting fitting so that sealing in the axial direction of the crankshaft is performed for an ordinary compressing operation.

[0007] According to the scroll compressor disclosed in Patent literature 1, capacity control in a wide range of 0 to 100% can be performed in such a manner that the solenoid valve is turned off (shut) and operation is made at the time of ordinary capacity control but the solenoid valve is turned on (opened) at the time of low-capacity control to adjust the discharge amount of the refrigerant gas returned to the low pressure suction pipe. As a result, a compressing operation can be performed in low-capacity control which cannot be actually performed because of the problem of oil film breaking in the sliding bearing or torque variation and which is equivalent to the case where super-low speed operation is performed at a value not higher than a lower limit set value (which is a frequency of about 5 Hz in terms of drive signal to a motor but is actually designed and set at a value higher than the frequency) of rotation speed based on motor drive. Accordingly, the compressed refrigerant gas can be guided to the discharge pipe so that the refrigerant gas can be circulated slowly in a refrigerant cycle.

[0008] In Patent Literature 2, a bypass hole is provided in the fixed scroll so as to be connected to the compression chamber, and an unloader valve block having an unloader piston connected to the bypass hole is attached to the fixed scroll, so that the unloader piston is operated based on control pressure introduced from the outside of the compressor to the unloader valve block. When the control pressure is high, the bypass hole is shut to obtain full-load operation. When the control pressure is low, the bypass hole is opened to bypass the refrigerant gas within the compression chamber to the suction chamber to obtain capacity control.

[0009] According to the scroll compressor disclosed in Patent Literature 2, capacity control can be performed in a range of about 50 to 100% because the refrigerant gas in the middle of compression is discharged to the suction chamber to reduce containment volume at the time of completion of suction when the compression pressure is low.

CITATION LIST

PATENT LITERATURE

[0010]

Patent Literature 1: JP-A-2001-99078
Patent Literature 2: Japanese Patent No.2550612
Patent Literature 3: JP-A-2006-200455

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0011] In the aforementioned technique according to Patent Literature 1, a function of canceling sealing in the axial direction of the crankshaft by the function of the capacity adjusting mechanism to avoid compression is provided. At the time of low-capacity control in a super-low speed operation mode, compressing operation can be performed in low-capacity control equivalent to the case where super-low speed operation is performed at a value not higher than the lower limit set value of rotation speed based on motor drive. Such excellent performance that wide-range capacity control is possible is provided.

[0012] However, in the technique according to Patent Literature 1, labor for assembling is required because of a complex structure to cause increase in cost unavoidably because a considerably large number of places for altering the compressor body (sealed case) are required for providing the capacity adjusting mechanism, a large number of exclusive parts and a large number of pipes for connecting respective parts are required of the capacity adjusting mechanism per se, and troublesome processing or work is required for joining opposite end portions of pipes in respective parts. As a result, there is a problem that it is impossible to easily mass-produce the scroll compressor as a compact and lightweight structure at a low cost.

[0013] In the technique according to Patent Literature 2, there is provided a function of discharging the refrigerant gas in the middle of compression to the suction chamber to reduce containment volume at the time of completion of suction to delay the start of compression when the control pressure introduced from the outside is low. Because the number of places for altering the compressor body (sealed case) and the number of exclusive parts required for capacity adjustment are so small that the scroll compressor can be provided as a relatively simple structure, it is possible to easily mass-produce the scroll compressor as a compact and lightweight structure at a low cost.

[0014] However, the technique according to Patent Literature 2 is unsuitable for wide-range operation because the capacity control range in the technique according to Patent Literature 2 is greatly narrower than that in the technique according to Patent Literature 1 provided with the capacity adjusting mechanism. As a result, there is a basic performance problem that low-capacity control in a super-low speed operation mode cannot be performed exactly.

[0015] The invention is accomplished to solve such a problem. A technical object of the invention is to provide a scroll compressor which can be easily mass-produced as a compact and lightweight structure at a low cost and in which low-capacity control can be performed efficiently in a super-low speed operation mode.

SOLUTION TO PROBLEM

[0016] To solve the aforementioned technical problem, according to the invention, there is provided a scroll compressor in which a spiral body of an orbiting scroll and a spiral body of a fixed scroll are engaged with each other in a sealed case to form a compression chamber and in which the fixed scroll has a discharge port formed in its central portion, and a release valve provided on an outer circumferential side of the discharge port so as to be connected to a release port communicating with the compression chamber, the scroll compressor including: a discharge head cover which is attached to a top plate of the fixed scroll to cover the discharge port and the release valve to form a discharge head space and which has a discharge valve for opening or shutting a through-hole provided in a predetermined place; a discharge guide pipe which guides a refrigerant gas within the discharge head space from the discharge head space to an outside of the sealed case; and a solenoid valve which is connected to a suction pipe for sucking in the refrigerant gas and to the discharge guide pipe so as to connect with the suction pipe and the discharge guide pipe and in which an opened state and a shut state are controlled to be driven based on a pulse width modulation control signal; wherein the discharge head cover, the discharge guide pipe and the solenoid valve form a bypass passage for guiding the refrigerant gas within the discharge head space from the discharge guide pipe to the suction pipe when the solenoid valve is opened. Preferably, the scroll compressor further includes a solenoid drive circuit which generates the pulse width modulation control signal.

[0017] Preferably, the scroll compressor further includes a crankshaft which serves as a rotary main shaft having a substantially central portion to which a rotating portion of a motor is attached, one axially end side to which the orbiting scroll is attached with interposition of a frame, and an opposite end side to which a shaft bearing is attached, wherein a flywheel is provided in a place of the crankshaft between the rotating portion of the motor and the shaft support member. Further preferably, in the scroll compressor, the motor has the rotor and a fixed stator and is driven by a motor drive circuit to rotate the rotor and the crankshaft. Further preferably, the scroll compressor further includes an operation instruction control unit which controls operation of the motor drive circuit and operation of the solenoid drive circuit for generating the pulse width modulation control signal based on an operation instruction.

ADVANTAGEOUS EFFECTS OF INVENTION

[0018] According to the scroll compressor in the invention, a compressing operation based on low-capacity control equivalent to super-low speed operation at a value not higher than a lower limit set value of rotation speed based on motor drive can be executed without deterioration of motor drive efficiency because a capacity adjusting mechanism for performing low-capacity control efficiently in a super-low speed operation mode is provided as a simple structure without great change of an existing basic structure. As a result, a product having such excellent performance that capacity control in a wide range of 0 to 100% is possible can be easily mass-produced as a compact and lightweight structure at a low cost.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

[Fig. 1] A side view showing the schematic configuration of a scroll compressor according to Example 1 of the invention as a section along a direction of extension of a rotary main shaft.

[Fig. 2] An enlarged side sectional view of important part showing a flow of a refrigerant gas in a first operation mode in which a solenoid valve of a capacity adjusting mechanism provided in the scroll compressor shown in Fig. 1 is shut.

[Fig. 3] An enlarged side sectional view of important part showing a flow of the refrigerant gas in a second operation mode in which the solenoid valve of the capacity adjusting mechanism provided in the scroll compressor shown in Fig. 1 is opened.

[Fig. 4] A characteristic graph showing the relation between motor rotation speed and load (capacity) at the time of capacity control inclusive of the function of the capacity adjusting mechanism provided in the scroll compressor shown in Fig. 1.

DESCRIPTION OF EMBODIMENTS

[0020] Fig. 1 is a side view showing the schematic configuration of a scroll compressor according to Example 1 of the invention as a section along a direction of extension of a rotary main shaft.

[0021] The scroll compressor has a structure as a conventional basic structure in which: a fixed scroll 102 having a spiral body is attached on an end side in a sealed case (chamber) 115 having a suction port for mounting a suction pipe 113 for sucking in a refrigerant gas and a discharge port for mounting a discharge pipe 114 for discharging the refrigerant gas; an assembly formed in such a manner that an orbiting scroll 101 having a counterpart spiral body is attached, with interposition of a frame 105, on one end side of a crankshaft 106 serving as a rotary main shaft in which a rotor 100a of a motor 100 (having the rotor (rotating portion) 100a and a stator (fixed portion) 100b) is attached to its substantially central portion, and a shaft support member based on a shaft bearing support plate 111 and a sub shaft bearing 112 is attached on the other end side of the crankshaft 106 is put in the remaining space portion in the sealed case 115 so that the spiral body of the orbiting scroll 101 and the spiral body of the fixed scroll 102 are engaged with each other; and the respective parts are attached, sealed and housed.

[0022] As for a detailed structure, in the sealed state, an eccentric portion 106a of the crankshaft 106 supported by a main shaft bearing 105a of the frame 105 is inserted in an orbiting bearing attached to the back of the orbiting scroll 101 so that an Oldham-coupling ring 107 disposed between the orbiting scroll 101 and the frame 105 arrests rotary motion of the orbiting scroll 101 but promotes orbital motion of the orbiting scroll 101 when the crankshaft 106 rotates. Each of the orbiting scroll 101 and the fixed scroll 102 has a spiral body provided so as to be erected on an end plate. Winding angles of the spiral bodies differ from each other to thereby form such an asymmetric scroll shape that two compression chambers each formed by the end plate and a wall surface of the spiral body are different in maximum sealed volume in an assembled state.

[0023] The asymmetric scroll shape means a structure in which when the respective spiral bodies formed from involute curves of the orbiting scroll 101 and the fixed scroll 102 are engaged with each other, the compression chamber formed outside a winding end side lap of the orbiting scroll 101 and the compression chamber formed inside the lap are different in size so that a phase shift of about 180 degrees is formed with respect to axial rotation of the crankshaft 106.

[0024] Specifically, the fixed scroll 102 has a discharge port 108 opened near its center so that the winding end of an inner curve of the spiral body is extended by about 180 degrees to the vicinity of the winding end of the spiral body of the orbiting scroll 101. For this reason, when the respective spiral bodies of the orbiting scroll 101 and the fixed scroll 102 are combined to form compression chambers, the first compression chamber formed so as to be closed by the outer curve of the spiral body of the orbiting scroll 101 and the inner curve of the spiral body of the fixed scroll 102 and the second compression chamber formed so as to be closed by the inner curve of the spiral body of the orbiting scroll 101 and the outer curve of the spiral body of the fixed scroll 102 are different in size so that a phase shift of about 180 degrees is formed with respect to rotation of the crankshaft 106.

[0025] In the scroll compressor, a release valve 124 which is an over-compression preventing valve connected to a release port 125 communicating with the compression chamber is provided on an outer circumferential side of the discharge port 108 in the fixed scroll 102. In other respects, the discharge port 108 and the release valve 124 are covered with a discharge head cover 118 attached to a top plate of the fixed scroll 102 to thereby form a discharge head space 123, and the discharge head cover 118 is provided with a discharge valve 121 having a check valve function for opening or shutting a through-hole 119 provided in a predetermined place.

[0026] In addition, a discharge guide pipe 120 is provided to guide a refrigerant gas in the discharge head space 123 from the discharge head space 123 to the outside of the sealed case 115. The discharge guide pipe 120 has one end connected to the discharge head cover 118, an intermediate portion passing through the sealed case 115, and the other end pulled out of the sealed case 115. The suction pipe 113 for sucking in the refrigerant gas and the other end side of the discharge guide pipe 120 are connected by a solenoid valve 122 an opened state and a shut state of which are controlled to be driven based on a pulse width modulation (PWM) control signal, so that the suction pipe 113 and the other end side of the discharge guide pipe 120 communicate with each other.

[0027] The discharge head cover 118, the discharge guide pipe 120 and the solenoid valve 122 form a bypass passage for guiding the refrigerant gas in the discharge head space 123 from the discharge guide pipe 120 to the suction pipe 113 when the solenoid valve 122 is opened. In a super-low speed operation mode, the opened state and the shut state of the solenoid valve 122 are operated repetitively to repeat use/not-use of the bypass passage so that the solenoid valve 122 serves as a capacity adjusting mechanism for performing low-capacity control.

[0028] The suction pipe 113 is provided for sucking in the refrigerant gas and communicates with the fixed scroll 102. The discharge pipe 114 is provided for discharging the compressed refrigerant gas to the outside. The sub shaft bearing 112 attached to the shaft bearing support plate 111 in the lower portion of the motor 100 operates with the main shaft bearing 105a of the frame 105 to support the crankshaft 106. Incidentally, the room in the sealed case 115 on the other end side of the crankshaft 106 is used as an oil reservoir chamber 116 for reserving oil. A flywheel 117 for keeping rotation safe is provided in a place between the rotor 100a of the motor 100 and the sub shaft bearing 112 of the shaft support member in the crankshaft 106.

[0029] Oil supplied from the oil reservoir chamber 116 is guided to a back-pressure chamber (intermediate chamber) 109 formed by the fixed scroll 102, the orbiting scroll 101 and the frame 105, through an orbiting shaft bearing provided around the eccentric portion 106a of the crankshaft 106. When the refrigerant gas in the oil foams to increase pressure in the back-pressure chamber 109, the increasing pressure is made to escape to the suction side by a control valve to keep the pressure level at a predetermined value. Although the suction side communicates with a fixed outer circumferential groove provided in the outer circumference of the spiral body of the fixed scroll 102, the fixed outer circumferential groove communicates with the refrigerant gas suction port so that the inside pressure of the fixed outer circumferential groove is always a suction pressure. In the orbiting scroll 101, discharge pressure acts on its central portion and intermediate pressure acts on its outer circumferential portion. For this reason, the orbiting scroll 101 is pressed against the fixed scroll 102 by proper pressure, so that axial sealing between scroll laps can be held.

[0030] The scroll compressor has a widely known high-pressure chamber type structure in which the refrigerant gas compressed in the compression chamber is discharged to the discharge chamber 103 through the release port 125 and the release valve 124 when the pressure of the refrigerant gas is not lower than the discharge pressure, but the release valve 124 is shut to discharge the refrigerant gas from the discharge port 108 when the pressure of the refrigerant gas is lower than the discharge pressure.

[0031] In addition, an inverter 128 which is a motor drive circuit for driving the motor 100, a solenoid drive circuit 129 which generates a pulse width modulation control signal for controlling drive of the opened state and the shut state of the solenoid valve 122 and an air conditioner control circuit 130 as an operation instruction control unit for controlling operation of the inverter 128 and the solenoid drive circuit 129 based on an operation instruction are provided outside a body of the scroll compressor.

[0032] In the scroll compressor having such a structure, there are four different pressures in the sealed case 115. The first pressure is a pressure in the discharge chamber 103 or 104, around the motor 100 or in the oil reservoir chamber 116 which is a high discharge pressure. The second pressure is a pressure in a space in the suction pipe 113 and a space connecting the suction pipe 113 to the fixed scroll 102 which is a low suction pressure. The third pressure is a pressure in the back-pressure chamber 109 which is an intermediate pressure to be about intermediate between the discharge pressure and the suction pressure. The fourth pressure is a pressure in the discharge head space 123 which is set as discharge pressure or suction pressure in accordance with operation of the solenoid valve 122 with respect to the shut state or the opened state.

[0033] The compressing operation of the scroll compressor is classified into a first operation mode in the shut state of the solenoid valve 122 and a second operation mode in the opened state of the solenoid valve 122.

[0034] Fig. 2 is an enlarged side sectional view of important part showing a flow of a refrigerant gas in a first operation mode in which the solenoid valve 122 of the capacity adjusting mechanism provided in the scroll compressor is shut.

[0035] In the first operation mode, when the solenoid drive circuit 129 shuts the solenoid valve 122 in a period T1 of a rectangular wave trailing edge of a pulse width modulation control signal and the inverter 128 drives the motor 100 to rotate the rotor 100a and the crankshaft 106, the orbiting scroll 101 starts orbital motion in accordance with the rotation of the rotor 100a and the crankshaft 106. By this operation, the spiral bodies of the orbiting scroll 101 and the fixed scroll 102 are engaged with each other to form the first compression chamber and the second compression chamber.

[0036] On this occasion, the refrigerant gas flowing in from the suction pipe 113 is compressed in the first compression chamber and the second compression chamber. In the first compression chamber and the second compression chamber, a compressing operation is performed while volume is reduced toward the center in accordance with the rotation of the crankshaft 106, so that the refrigerant gas highly pressurized thus is discharged into the discharged head space 123 from the discharge port 108 formed in the fixed scroll 102. In this compressing process, the highly pressurized refrigerant gas is discharged into the discharge head space 123 through the release port 125 and the release valve 124 in accordance with the discharge pressure level. Although the release valve 124 means a cover portion attached to a front end of a coil spring 127 mounted on a front end side of a pressing portion 126, a release valve mechanism portion including respective portions may be called release valve.

[0037] In any case, because the pressure of the refrigerant gas in the discharge head space 123 is slightly higher than the discharge pressure and higher than the pressure in the discharge chamber 103, the discharge valve 121 covering the through-hole 119 of the discharge head cover 118 is pushed open so that the refrigerant gas is discharged into the discharge chamber 103. Then, the refrigerant gas is finally discharged from the discharge chamber 104 to the outside through the discharge pipe 114.

[0038] Here, the aforementioned first operation mode in which the refrigerant gas is made to flow without use of the bypass passage while the solenoid valve 122 is shut may be called full-load operation. The bypass passage means a circulatory path which goes from the discharge guide pipe 120 connected to the discharge head space 123, passes through the opened solenoid valve 122, and communicates with the suction pipe 113.

[0039] Fig. 3 is an enlarged side sectional view of important part showing a flow of the refrigerant gas in the second operation mode in which the solenoid valve 122 of the capacity adjusting mechanism provided in the scroll compressor is opened.

[0040] In the second operation mode, when the solenoid drive circuit 129 opens the solenoid valve 122 in a period T2 of a rectangular wave leading edge of the pulse width modulation control signal and the inverter 128 drives the motor 100 to rotate the rotor 100a and the crankshaft 106, the orbiting scroll 101 starts orbital motion in accordance with the rotation of the rotor 100a and the crankshaft 106. By this operation, the spiral bodies of the orbiting scroll 101 and the fixed scroll 102 are engaged with each other to form the first compression chamber and the second compression chamber.

[0041] However, in the second operation mode, because the solenoid valve 122 is opened, a bypass passage which goes from the discharge guide pipe 120 connected to the discharge head space 123, passes through the opened solenoid valve 122 and communicates with the suction pipe 113 is formed. Consequently, the refrigerant gas in the discharge head space 123 flows into the suction pipe 113 through the bypass passage, so that the pressure of the refrigerant gas becomes slightly higher than the suction pressure. Accordingly, the pressure in the discharge head space 123 is reduced so as to be set to be equal to the suction pressure.

[0042] On this occasion, because the pressure in the discharge head space 123 is lower than that in the discharge chamber 103, the discharge valve 121 covering the through-hole 119 of the discharge head cover 118 is blocked so that the refrigerant gas is not discharged into the discharge chamber 103. When the refrigerant gas flowing in from the suction pipe 113 in this state is compressed in the first compression chamber and the second compression chamber, the refrigerant gas is discharged into the discharge head space 123 through the release port 125 and the release valve 124 so that the refrigerant gas compressed hereafter is discharged from the discharge port 108 into the discharge head space 123.

[0043] The refrigerant gas discharged into the discharge head space 123 flows into the suction pipe 113 through the opened solenoid valve 122 from the discharge guide pipe 120 connected to the discharge head space 123.

[0044] The aforementioned second operation mode in which the refrigerant gas is made to flow by use of the bypass passage in the condition that the solenoid valve 122 is opened may be called unload operation. Incidentally, it is desirable that the release port 125 and the release valve 124 are provided so as to communicate with the discharge head space 123 in a range of all rotation angles. This is because internal compression in scroll laps can be avoided to reduce the compressing operation in the unload operation.

[0045] In the scroll compressor according to Example 1, capacity control can be performed in such a manner that the full-load operation in which the solenoid valve 122 is shut in the period T1 of a rectangular wave trailing edge of the pulse width modulation control signal from the solenoid drive circuit 129 is switched to the unload operation in which the solenoid valve 122 is opened in the period T2 of a leading edge thereof or vice versa while the motor 100 is driven by the inverter 128. In the scroll compressor, capacity control can be performed even in a high speed operation mode but it is preferable that operation is performed while the ratio between the full-load operation and the unload operation is changed in such a manner that an ordinary operation mode in which the motor 100 is driven by the inverter 128 is performed in a range of from high speed rotation to low speed rotation up to a predetermined set value slightly higher than a lower limit set value of rotation speed based on motor drive but a super-low speed operation mode is performed by the capacity adjusting mechanism applied when low-capacity control is required in a range of low speed rotation not higher than the predetermined set value.

[0046] Fig. 4 is a characteristic graph showing the relation between motor rotation speed and load (capacity) at the time of capacity control inclusive of the function of the capacity adjusting mechanism provided in the scroll compressor according to Example 1.

[0047] In the scroll compressor according to Example 1, capacity can be changed up to T1/(T1+T2) relative to the full-load operation. As shown in Fig. 4, when the period T1 in which the solenoid valve 122 is shut is set to be zero (i.e. the period T2 in which the solenoid valve 122 is opened is set to be 100%), the load (discharge capacity) becomes zero as represented by a point c. When the period T1 is set to be 50% (the period T2 is set to be 50%), the load (discharge capacity) becomes 50% as represented by a point b. When the period T2 is set to be zero (the period T1 is set to be 100%), the load (discharge capacity) becomes 100% as represented by a point a.

[0048] That is, the scroll compressor can perform capacity control in a wide range of 0 to 100% and has a function of performing capacity control based on the capacity adjusting mechanism (capacity control based on the solenoid valve 122) in a range of low rotation speed below the point a (super-low speed operation mode). Incidentally, the region represented by the dotted line on characteristic in Fig. 4 does not show a result of operation performed at a value not higher than a lower limit set value (practically a predetermined set value slightly higher than the lower limit set value) of rotation speed based on the motor 100 driven by the inverter 128 in the scroll compressor but shows that a compressing operation can be performed based on low-capacity control equivalent to the case where super-low speed operation is performed at a value not higher than the lower limit set value, as a result of use of operation at a predetermined set value higher than the lower limit set value of rotation speed in combination with capacity control based on the capacity adjusting mechanism (capacity control based on the solenoid valve 122).

[0049] Incidentally, performing the unload operation and the full-load operation based on switching control of the opened state and the shut state of the solenoid valve 122 is generally made. In the scroll compressor according to Example 1, the unload operation and the full-load operation can be switched based on the function of the discharge valve 21 for opening/shutting the through-hole 119 of the discharge head cover 118 forming the discharge head space 123.

[0050] By shutting the solenoid valve 122, the refrigerant gas sucked in from the suction pipe 113 is compressed and then discharged into the discharge head space 123 to push the discharge valve 121 open so that the refrigerant gas is discharged into the discharge chamber 103. However, when the solenoid valve 122 is opened, the compressed refrigerant gas flows in the suction pipe 113 side to reduce the pressure in the discharge head space 123. As a result, the discharge valve 121 cannot be pushed open so that the refrigerant gas is not discharged into the discharge chamber 103. The amount of the refrigerant gas discharged into the discharge chamber 103 in the operating state (rotation operating state) of the compressor can be switched on and off based on the shut state and the opened state of the solenoid valve 122.

[0051] By changing the ratio between the time (period T1) of shutting of the solenoid valve 122 and the time (period T2) of opening the solenoid valve 122, the discharge amount can be changed in a range of 0 to 100%. However, in the scroll compressor, a one-operation switching period (T1+T2) indicating the time required for switching operation between the shut state and the opened state cannot be set to be so long because suction pressure (evaporation temperature) from an evaporator and discharge pressure to a condenser in a refrigerating cycle vary. When the one-operation switching period (T1+T2) is set to be long, the suction pressure and the discharge pressure vary respectively and the amplitude of each variation increases in proportion to the length of time to thereby cause instability of the compressing operation. It is therefore necessary to set the one-operation switching period (T1+T2) so that the amplitude of each variation does not increase.

[0052] The scroll compressor according to Example 1 is of a high pressure chamber type in which the inside pressure of the sealed case 115 as a whole is a high pressure and the volume occupied by the sealed case 115 is large, and has a structure in which volume of the discharge head space 123 serves as a buffer to perform compression excessively while pressure in the discharge head space 123 changes in accordance with switching control of the shut state and the opened state of the solenoid valve 122. It is therefore important to reduce the volume of the discharge head space 123 as sufficiently as possible in consideration of the fact that a delay in the compressing operation due to the volume of the discharge head space 123 may cause increase in motive power for switching control of the shut state and the opened state of the solenoid valve 122.

[0053] In addition, in the aforementioned scroll compressor, it is desirable that the size of pipe arrangement for guiding the refrigerant gas from the discharge head space 123 to the suction pipe 113 in the bypass passage and the size of the release port 125 are set suitably in accordance with the rotation speed because a pressure loss in the pipe arrangement and a pressure loss in the release port 125 occur. The size of the release port 125 is little relevant in the case where capacity control is performed mainly at low speed rotation, but it is preferable that the size of the release port 125 is increased in the case where capacity control is performed at relatively high speed rotation. However, when the size of the release port 125 is increased, it is necessary to pay attention to the fact that the pressure loss increases because the refrigerant gas in the release port 125 is expanded again at the time of full-load operation.

[0054] In any case, in the scroll compressor having the capacity adjusting mechanism according to Example 1, by providing the capacity adjusting mechanism having a simple structure for performing low-capacity control efficiently in the super-low speed operation mode, the compressing operation based on low-capacity control equivalent to the case where super-low sped operation is performed at a value not higher than the lower limit set value (a frequency of about 5 Hz in terms of the drive signal to the motor 100) of rotation speed based on motor drive can be executed without deterioration of motor drive efficiency to thereby provide such excellent performance that capacity control in a wide range of 0 to 100% is possible. As a result, the scroll compressor can be easily mass-produced as a compact and lightweight structure at a low cost when it is provided as a product.

DESCRIPTION OF REFERENCE SIGNS LIST

[0055]

101	orbiting scroll
102	fixed scroll
103, 104	discharge chamber
105	frame
105a	main shaft bearing
106	crankshaft
106a	eccentric portion
107	Oldham-coupling ring
108	discharge port
109	back-pressure chamber (intermediate chamber)
110	motor
110a	rotor
110b	stator
111	shaft bearing support plate
112	sub bearing
113	suction pipe
114	discharge pipe
115	sealed case (chamber)
116	oil reservoir chamber
117	flywheel
118	discharge head cover
119	through-hole
120	discharge guide pipe
121	discharge valve (check valve)
122	solenoid valve
123	discharge head space
124	release valve
125	release port
126	spring base
127	coil spring
128	inverter (motor drive circuit)
129	solenoid drive circuit
130	air conditioner control circuit

Claims

1. A scroll compressor in which a spiral body of an orbiting scroll and a spiral body of a fixed scroll are engaged with each other in a sealed case to form a compression chamber and in which the fixed scroll has a discharge port formed in its central portion, and a release valve provided on an outer circumferential side of the discharge port so as to be connected to a release port communicating with the compression chamber, the scroll compressor comprising: a discharge head cover which is attached to a top plate of the fixed scroll to cover the discharge port and the release valve to form a discharge head space and which has a discharge valve for opening or shutting a through-hole provided in a predetermined place; a discharge guide pipe which guides a refrigerant gas within the discharge head space from the discharge head space to an outside of the sealed case; and a solenoid valve which is connected to a suction pipe for sucking in the refrigerant gas and to the discharge guide pipe so as to communicate with the suction pipe and the discharge guide pipe and in which an opened state and a shut state are controlled to be driven based on a pulse width modulation control signal; **characterized in that**: the discharge head cover, the discharge guide pipe and the solenoid valve form a bypass passage for guiding the refrigerant gas within the discharge head space from the discharge guide pipe to the suction pipe when the solenoid valve is opened.

2. A scroll compressor according to Claim 1, further comprising: a solenoid drive circuit which generates the pulse width modulation control signal.

3. A scroll compressor according to Claim 1, further comprising: a crankshaft which serves as a rotary main shaft having a substantially central portion to which a rotating portion of a motor is attached, one axially end side to which the orbiting scroll is attached with interposition of a frame, and an opposite end side to which a shaft support member is attached; **characterized in that**: a flywheel is provided in a place of the crankshaft between the rotating portion of the motor and the shaft support member.

4. A scroll compressor according to Claim 3, **characterized in that**: the motor has the rotating portion and a fixed portion and is driven by a motor drive circuit to rotate the rotating portion and the crankshaft.

5. A scroll compressor according to Claim 4, further comprising: an operation instruction control unit which controls operation of the motor drive circuit and operation of the solenoid drive circuit for generating the pulse width modulation control signal based on an operation instruction.

FIG. 1

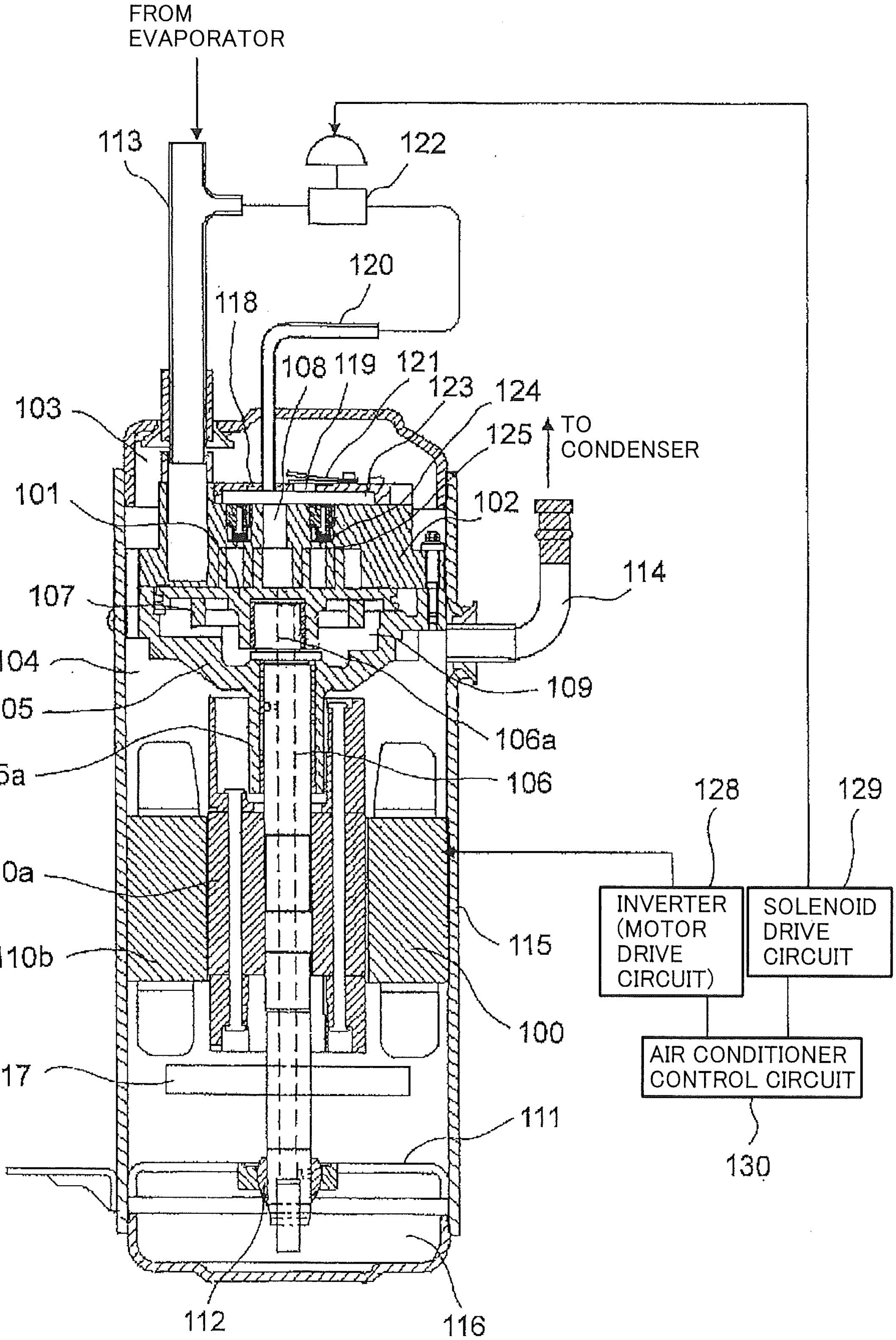

FROM
EVAPORATOR
113
122
120
118
108
119
121
123
124
125
TO
CONDENSER
103
101
102
114
107
104
109
105
106a
105a
106
128
129
110a
INVERTER
(MOTOR
DRIVE
CIRCUIT)
SOLENOID
DRIVE
CIRCUIT
115
110b
100
AIR CONDITIONER
CONTROL CIRCUIT
117
111
130
112
116

FIG. 2

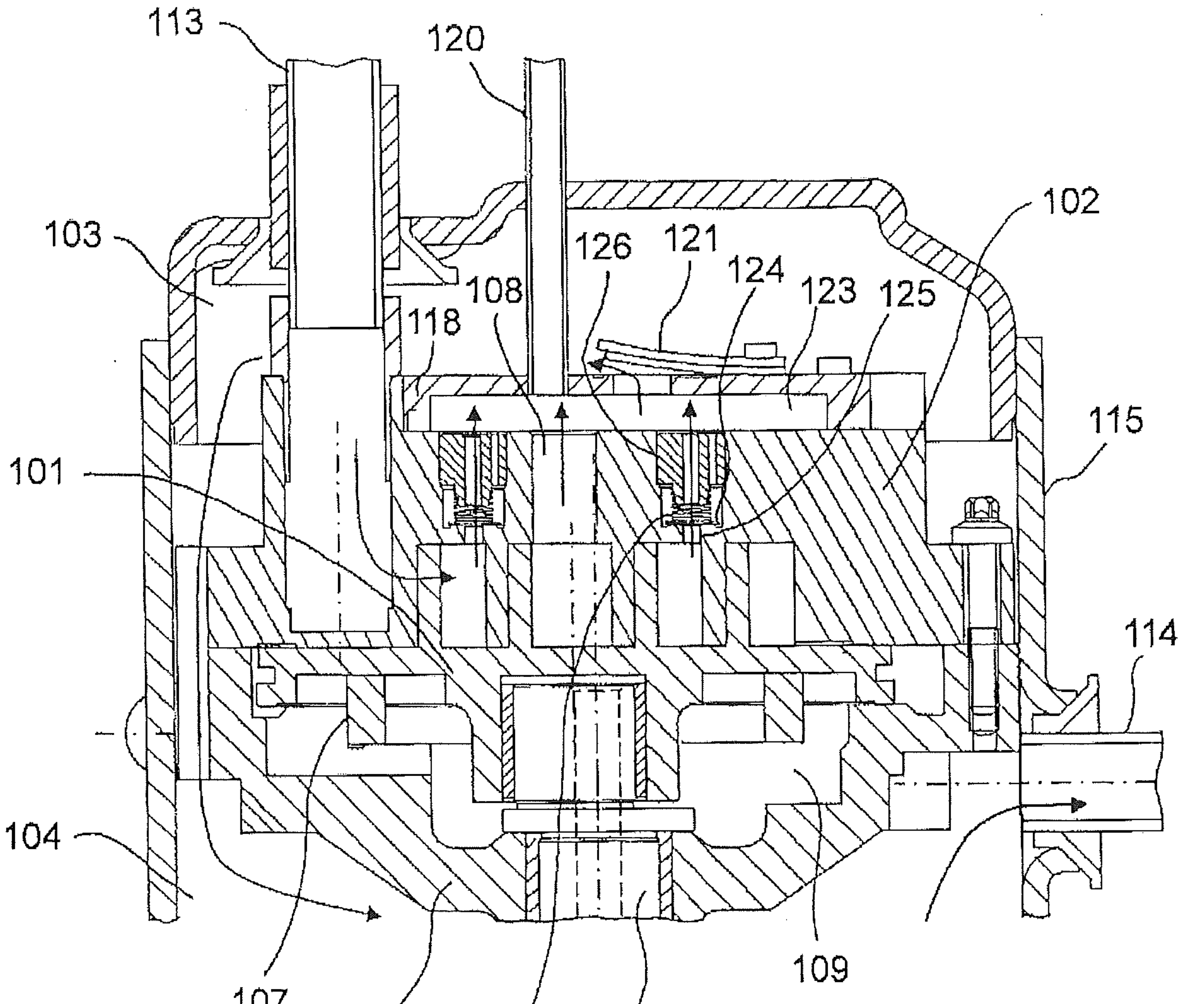
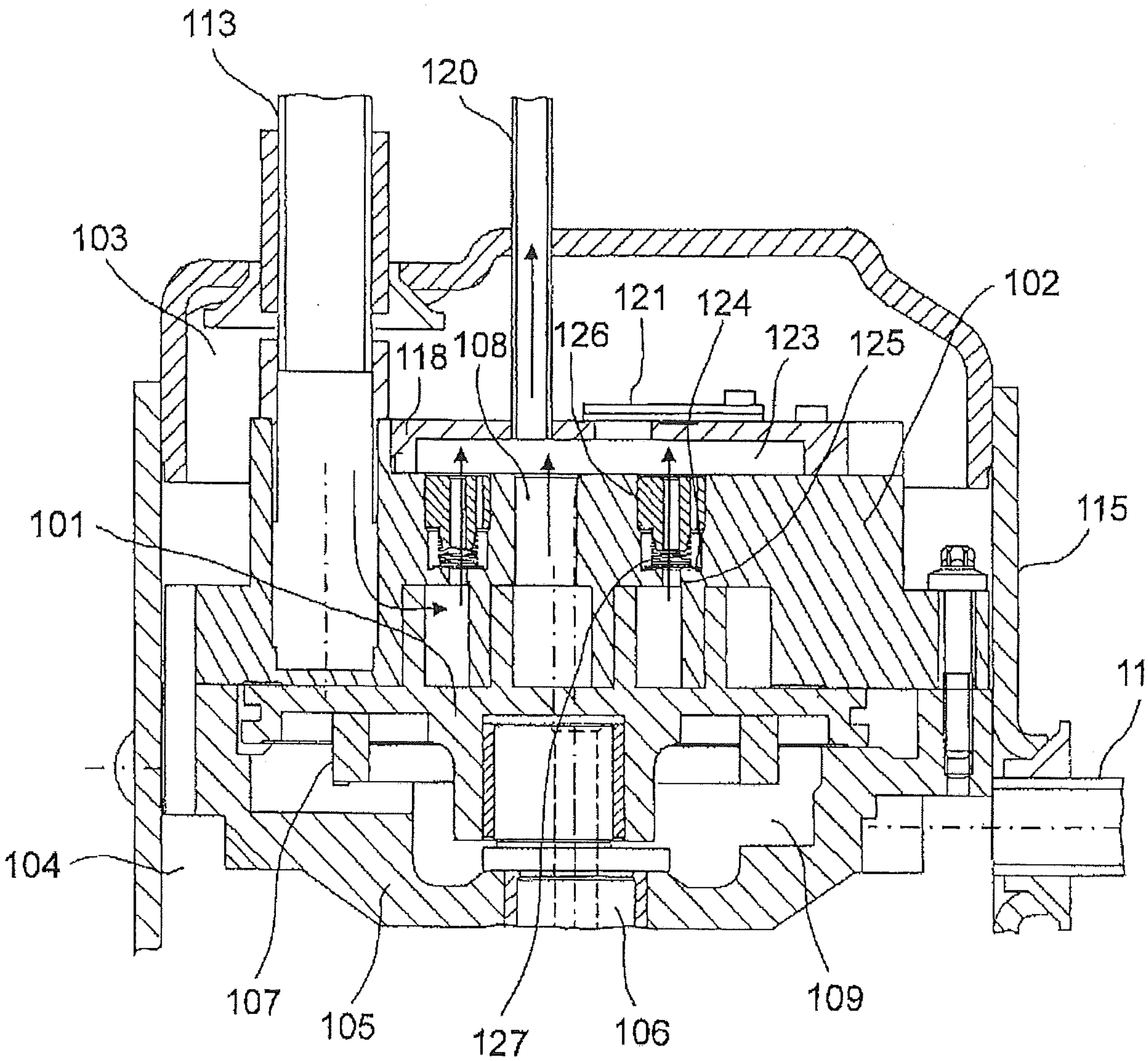

113
120
103
126
121
108
124
123
125
102
118
115
101
114
104
107
105
127
106
109

FIG. 3


113
120
103
121
124
102
118
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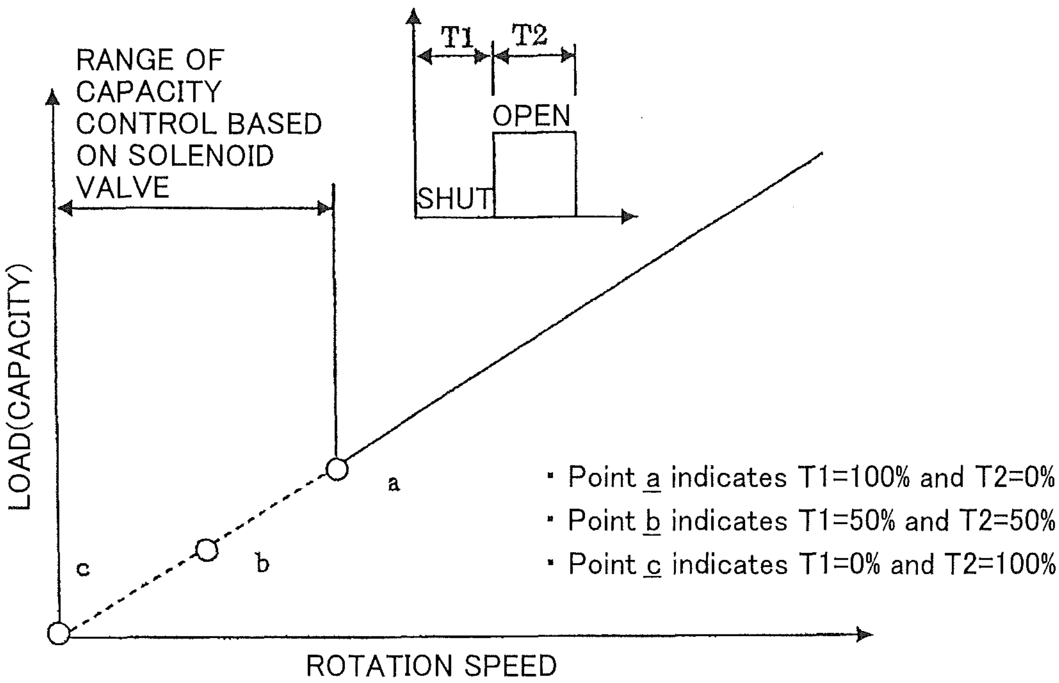
123
125
101
115
114
104
107
105
127
106
109

FIG. 4


RANGE OF CAPACITY CONTROL BASED ON SOLENOID VALVE
T1
T2
OPEN
SHUT
LOAD(CAPACITY)
a
b
c
ROTATION SPEED
・Point a indicates T1=100% and T2=0%
・Point b indicates T1=50% and T2=50%
・Point c indicates T1=0% and T2=100%

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/053143

A. CLASSIFICATION OF SUBJECT MATTER
F04C18/02(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)
F04C18/02

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 8-61269 A (Nippon Soken, Inc.), 08 March 1996 (08.03.1996), paragraphs [0033] to [0039]; fig. 15, 21 & US 5674058 A	1-5
A	JP 2004-239099 A (Daikin Industries, Ltd.), 26 August 2004 (26.08.2004), entire text; all drawings (Family: none)	3-5
A	JP 2009-97358 A (Mayekawa Mfg., Co., Ltd.), 07 May 2009 (07.05.2009), paragraph [0039]; fig. 1 (Family: none)	3-5

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 May, 2010 (06.05.10)	18 May, 2010 (18.05.10)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/053143

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2005-282936 A (Orion Machinery Co., Ltd.), 13 October 2005 (13.10.2005), claim 1; paragraph [0026]; fig. 1 (Family: none)	5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2001099078 A **[0010]**
- JP 2550612 B **[0010]**
- JP 2006200455 A **[0010]**