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(54) CONTROL VALVE FOR VARIABLE DISPLACEMENT COMPRESSOR

(57) To provide a control valve for variable displacement compressor employing ON/OFF control, which is capable of taking measures for occurrence of an abnormally high pressure.

When a solenoid is OFF, a spring (17) causes a movable core (16) to move a stopper (19) in a direction away from a stationary core (14) and to thereby separate a shaft (18) fixed to the stopper (19) from a valve seat (13), resulting in opening the control valve. When the solenoid is ON, the movable core (16) is attracted by the stationary core (14) by a stroke longer than that of the shaft (18), and a spring (20) causes the shaft (18) to seat on the valve seat (13), resulting in closing the control valve. If a discharge pressure Pd increases to an abnormally high pressure, a differential pressure between the discharge pressure Pd and a pressure Pc in a crankcase pushes the shaft (18) while compressing the spring (20), so that the discharge pressure Pd flows out to the crankcase. Therefore, the pressure Pc in the crankcase increases and the variable displacement compressor shifts to operate at a minimum discharge capacity, resulting in decreasing the abnormally high pressure.

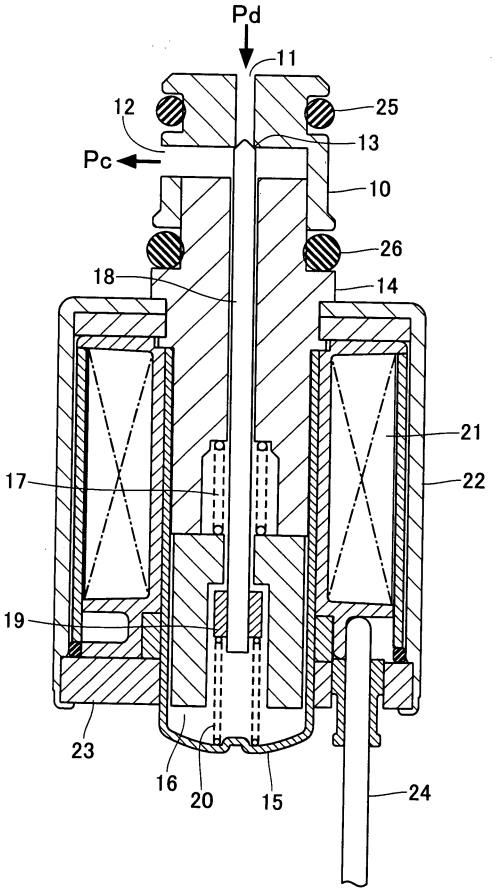

FIG. 2

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Description

Technical Field

[0001] This invention relates to a control valve for variable displacement compressor, and more particularly to a control valve for variable displacement compressor, which controls a discharge capacity of a variable displacement compressor of an automotive air conditioning system with ON/OFF control.

Background Art

[0002] A compressor that is used in a refrigeration cycle of an automotive air conditioning system is incapable of controlling the rotational speed because the compressor uses as a driving source an engine that varies its rotational speed according to a running condition. Therefore, in general, a variable displacement compressor is employed which is designed to be capable of changing a discharge capacity of refrigerant in order to secure an adequate cooling capacity, irrespective of the rotational speed of the engine.

[0003] In general, in a variable displacement compressor, a wobbling plate, which is provided at a variable inclination angle in an airtight crankcase, is driven and wobbles by rotations of a rotating shaft, this wobbling plate wobbling makes a piston move back and forth in parallel to the rotating shaft, and this moving piston introduces refrigerant of a suction chamber into a cylinder where the refrigerant is compressed and is discharged to a discharge chamber. In this operation, by controlling the pressure in the crankcase, the inclination angle of the wobbling plate can be changed by a pressure difference received on the both ends of the piston. This angle change causes the stroke of the piston to vary, thereby changing the discharge capacity of the refrigerant. A control valve for variable displacement compressor has a function of changing the pressure in the crankcase.

[0004] In general, such a control valve for controlling a discharge capacity of a variable displacement compressor partly introduces refrigerant of a discharge pressure Pd discharged from a discharge chamber, into an airtight crankcase. By controlling the introducing rate of the refrigerant, a pressure Pc in the crankcase is controlled. For example, a known control valve for variable displacement compressor controls a flow rate of refrigerant to be introduced into a crankcase according to a differential pressure between a discharge pressure Pd in a discharge chamber and a suction pressure Ps in a suction chamber (For example, refer to Patent Literature 1).

[0005] This control valve for variable displacement compressor senses a differential pressure between the discharge pressure Pd in the discharge chamber and the suction pressure Ps in the suction chamber, and controls a flow rate of refrigerant of the discharge pressure Pd to be introduced from the discharge chamber to the crankcase such that the differential pressure becomes equal to a differential pressure which is set by a solenoid, resulting in maintaining a fixed discharge capacity of refrigerant discharged from the variable displacement compressor.

Patent Literature 1: Japanese Unexamined Patent Publication No. 2001-132650 (paragraphs [0043] to [0045], FIG. 4).

Disclosure of the Invention

Problems that the Invention is to solve

[0006] However, there arises a problem that such a control valve for variable displacement compressor has a complex structure and is therefore expensive. Another problem is that, in the refrigeration cycle which uses carbon dioxide whose working pressure is very high as a refrigerant, the variable displacement compressor may be broken when the high pressure section in the refrigeration cycle has become an abnormal high pressure, in the case where a failure in a control circuit for controlling the control valve for variable displacement compressor or a pressure sensor for sensing a refrigerant pressure, for example, ahs caused a malfunction of the control valve for variable displacement compressor.

[0007] This invention has been made in view of the foregoing and intends to provide a control valve for variable displacement compressor, which has a simple structure and is capable of preventing the variable displacement compressor from being broken due to an abnormally high pressure.

Means for Solving Problems

[0008] To solve the above problems, there has been provided a control valve for variable displacement compressor that controls a flow rate of refrigerant to be introduced from a discharge chamber to a crankcase of the variable displacement compressor with ON/OFF control in order to thereby change a discharge capacity. This control valve comprises: a valve section where a valve element is arranged on a downstream side of a valve hole for opening and closing the valve hole, into which the refrigerant that is discharged from the discharge chamber is introduced; and a solenoid for opening the valve section in a deenergized state and for closing the valve section in an energized state. In the solenoid, the valve element that receives a discharge pressure of the refrigerant introduced from the discharge chamber in a valve-opening direction is held at a valve-opening position by a first spring imposing an urging force in the valve-opening direction in the deenergized state and a second spring imposing an urging force in a valve-closing diction, and the valve element is held at a valve-closing position by the second spring in the energized state.

[0009] This control valve for variable displacement compressor is designed so that the second spring closes the valve section against the discharge pressure that the

valve element receives in the valve-opening direction, in the energized state. Thereby, even if the discharge pressure increases to an abnormally high pressure, the valve section opens against the urging force of the second spring. That is to say, if the refrigeration cycle has an abnormally high pressure at a high pressure section due to malfunctioning, the control valve for variable displacement compressor automatically opens the valve section, thereby causing the abnormally high pressure to flow out to the crankcase. Then, the variable displacement compressor shifts to operate at a minimum discharge capacity and the discharge pressure decreases, with the result that the variable displacement compressor can be prevented from being broken due to the abnormally high pressure.

Advantages of the Invention

[0010] A control valve for variable displacement compressor of the present invention opens a valve section by a differential pressure between a discharge pressure and a pressure to be introduced into a crankcase when the discharge pressure increases to an abnormally high pressure. Therefore, the high pressure flows out to the crankcase, which shifts the variable displacement compressor to operate at a minimum discharge capacity and decreases the abnormally high pressure. As a result, at least the variable displacement compressor can be prevented from being broken due to the abnormally high pressure, which is an advantage.

[0011] The above and other objects, features and advantages of the present invention will becomes apparent from the following description when taken in conjunction with the accompanying drawings which illustrate preferred embodiments of the present invention by way of example.

Brief Description of the Drawings

[0012]

[FIG. 1] A central longitudinal cross-sectional view showing a construction of a control valve for variable displacement compressor.

[FIG. 2] A central longitudinal cross-sectional view showing an operating state of the control valve for variable displacement compressor when a solenoid is energized.

Best Mode for Carrying out the Invention

[0013] Hereinafter, a preferred embodiment of the present invention will be described with reference to accompanying drawings in detail.

[0014] FIG. 1 is a central longitudinal cross-sectional view showing a construction of a control valve for variable displacement compressor. FIG. 2 is a central longitudinal cross-sectional view showing an operating state of the control valve for variable displacement compressor when a solenoid is energized.

[0015] This control valve for variable displacement compressor has a body 10 of a valve section, as illustrated on the upper side of the figure. This body 10 has a port 11 for receiving a discharge pressure Pd at the upper central part of the body 10, and a port 12 through which a controlled pressure Pc is delivered to a crankcase. The port 11 and the port 12 communicate with each other inside the body 10. An extending portion from the port 11 forms a valve hole, and a portion that is open in an internal space where the valve hole communicates with the port 12 serves as a valve seat 13.

[0016] Under the body 10, a solenoid is disposed. This solenoid has a stationary core 14 which is press-fitted to the body 10 from the bottom side of the figure. The lower part of this stationary core 14 is engaged with a bottomed sleeve 15. The bottomed sleeve 15 is welded to the stationary core 14 and the inside of the bottomed sleeve 15 is held at the airtight condition. Inside the bottomed sleeve 15, a movable core 16 is disposed in an axially movable manner and is urged by a spring 17 in a direction away from the stationary core 14.

[0017] In addition, in this solenoid, a shaft 18 is loosely fitted in the stationary core 14 and the movable core 16 in a manner axially extending therethrough. The top end of the shaft 18, as viewed in the figure, forms a valve element of the valve section that can be moved to and away from the valve seat 13 of the valve section. To the bottom end of the shaft 18, as viewed in the figure, a stopper 19 is fixed. Between the stopper 19 and the bottom of the bottomed sleeve 15, a spring 20 is disposed to urge the shaft 18 in a direction toward the valve seat 13. The stopper 19 has an outer diameter larger than the inner diameter of the central opening of the movable core 16 where the shaft 18 is loosely fitted. Therefore, while the movable core 16 is separated from the stationary core 14 by the urging force of the spring 17, the stopper 19 is brought into contact with the movable core 16 by the urging force of the spring 20. While the movable core 16 is attracted by the stationary core 14, the top end of the shaft 18 (valve element) is seated on the valve seat 13 by the urging force of the spring 20, so that the stopper 19 is separated from the movable core 16.

[0018] Then, a coil 21 is disposed around the outer circumference of the bottomed sleeve 15, a yoke 22 and a plate 23, both made of magnetic material, are disposed so as to cover the coil 21, and a harness is drawn to outside through the plate 23 for power supply to the coil 21. When this control valve for variable displacement compressor is mounted in the variable displacement compressor, an O-ring 25 disposed around the body 10 at an upper position than the port 12 prevents a high discharge pressure Pd from leaking to the medium pressure port 12, and an O-ring 26 disposed around the stationary core 14 seals between the medium pressure port 12 and atmosphere.

[0019] The control valve for variable displacement

compressor as constructed above operates as an ON/OFF valve where the valve section is opened and closed according to the supply of pulse current to the solenoid. That is, when the solenoid is deenergized where no current is present in the coil 21, the movable core 16 is separated from the stationary core 14 by the spring 17 having a stronger spring force than the spring 20, as shown in FIG. 1. At this time, the movable core 16 pushes the stopper 19 downward, as viewed in the figure, against the urging force of the spring 20, and the top end of the shaft 18 (valve element) is separated from the valve seat 13, so that the control valve for variable displacement compressor is in open state.

[0020] When the solenoid is energized where the coil 21 carries current, the movable core 16 is attracted by the stationary core 14 against the urging force of the spring 17, as shown in FIG. 2. Thereby, the shaft 18 is pushed upward by the spring 20, as viewed in the figure, and the valve element of its top end is seated on the valve seat 13, so that the control valve for variable displacement compressor is in closed state. At this time, a stroke of the movable core 16 moving to be attracted by the stationary core 14 is set longer than a stroke of the top end of the shaft 18 moving to be seated on the valve seat 13. Therefore, while the control valve for variable displacement compressor is in closed state, the stopper 19 fixed to the shaft 18 is separated from the movable core 16.

[0021] As described above, this control valve for variable displacement compressor operates by ON/OFF pulse current supplied to the coil 21. When the solenoid is deenergized, the shaft 18 moves to a position where the spring 17 is balanced with the spring 20, so that the control valve is in open state. When the solenoid is energized, the control valve is in closed state by the urging force of the spring 20. A flow rate of refrigerant to be supplied to the crankcase is controlled by changing a duty cycle of pulse current.

[0022] Next explanation is about how the control valve for variable displacement compressor operates under the abnormal condition due to some trouble in a control device controlling the control valve for variable displacement compressor or a sensor connected to the control device.

[0023] If the trouble causes the solenoid to keep the OFF state, the control valve for variable displacement compressor is held in the open state. In this case, the variable displacement compressor operates at a minimum discharge capacity, and therefore the pressure of the refrigeration cycle does not abnormally increase.

[0024] If the trouble causes the solenoid to keep the ON state, on the contrary, the control valve for variable displacement compressor is held in the closed state. Therefore, the continuous operation of the variable displacement compressor at a maximum discharge capacity makes pressure high abnormally at a high pressure section in the refrigeration cycle. At this time, in the control valve for variable displacement compressor, the port 11 receives a high discharge pressure Pd while the port 12 has a medium pressure Pc. Since the port 12 communicates with the inside of the bottomed sleeve 15 with the movable core 16 contained therein, through a clearance between the stationary core 14 and the shaft 18, the pressure in the bottomed sleeve 15 is equal to the pressure Pc. That is, the shaft 18 receives the discharge pressure Pd in the valve-opening direction at its top end serving as the valve element, and also receives the load of the spring 20 and the pressure Pc in the valve-closing direction.

[0025] As a result of the variable displacement compressor operating at the maximum discharge capacity in this condition, the discharge pressure Pd increases to an abnormally high pressure such that a differential pressure between the discharge pressure Pd and the pressure Pc in the crankcase exceeds a predetermined pressure (for example, 10MPa), and a force pushing the shaft 18 in the valve-opening direction becomes larger. Thereby the shaft 18 moves in the valve-opening direction while compressing the spring 20, with the result that the control valve for variable displacement compressor is in open state.

[0026] In short, in the control valve for variable displacement compressor, when the discharge pressure Pd in the variable displacement compressor abnormally increases, the shaft 18 senses it and moves in the valve-opening direction, so that the high pressure flows out to the crankcase. Thereby, the variable displacement compressor shifts to operate at the minimum discharge capacity, which decreases the discharge pressure Pd, thus making it possible to prevent breakdown caused by the abnormally high pressure.

[0027] The above embodiment shows an example where the shaft 18 is loosely fitted in the stationary core 14 and the movable core 16 in a manner axially extending therethrough. It is preferable that bearings are disposed in the vicinity of both ends of the shaft 18 for positioning the shaft 18 on the same axis as the port 11 and the stationary core 14.

[0028] The foregoing is considered as illustrative only of the principles of the present invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and applications shown and described, and accordingly, all suitable modifications and equivalents may be regarded as falling within the scope of the invention in the appended claims and their equivalents.

Description of Reference Numerals

[0029]

10	body
11, 12	port
13	valve seat
14	stationary core

15	bottomed sleeve
16	movable core
17	spring
18	shaft
19	stopper
20	spring
21	coil
22	yoke
23	plate
24	harness
25, 26	O-ring

Claims

1. A control valve for variable displacement compressor for changing a discharge capacity by controlling a flow rate of refrigerant to be introduced from a discharge chamber to a crankcase of the variable displacement compressor with ON/OFF control, the control valve comprising:

a valve section where a valve element is arranged on a downstream side of a valve hole for opening and closing the valve hole into which the refrigerant that is discharged from the discharge chamber is introduced; and
a solenoid for opening the valve section in a deenergized state and for closing the valve section in an energized state, wherein, in the solenoid, the valve element is held at a valve-opening position by a first spring imposing an urging force in a valve-opening direction in the deenergized state and a second spring imposing an urging force in a valve-closing direction, and is held at a valve-closing position by the second spring in the energized state, the valve element receiving a discharge pressure of the refrigerant introduced from the discharge chamber in the valve-opening direction.

2. The control valve for variable displacement compressor according to claim 1, wherein, in the solenoid, a stroke of a movable core moving to be attracted by a stationary core in the energized state from a position where the valve element is positioned at the valve-opening position is set longer than a stroke of the valve element moving to the valve-closing position from the valve-opening position in the energized state.

3. The control valve for variable displacement compressor according to claim 2, wherein, in the solenoid, the stationary core, the first spring, the movable core, a stopper, and the second spring are arranged from a side of the valve section in this order on a same axis as the valve hole, and a shaft that is loosely fitted in the stationary core and the movable core in a manner axially extending therethrough has one end serving as the valve element for opening and closing the valve hole and another end fixed to the stopper.

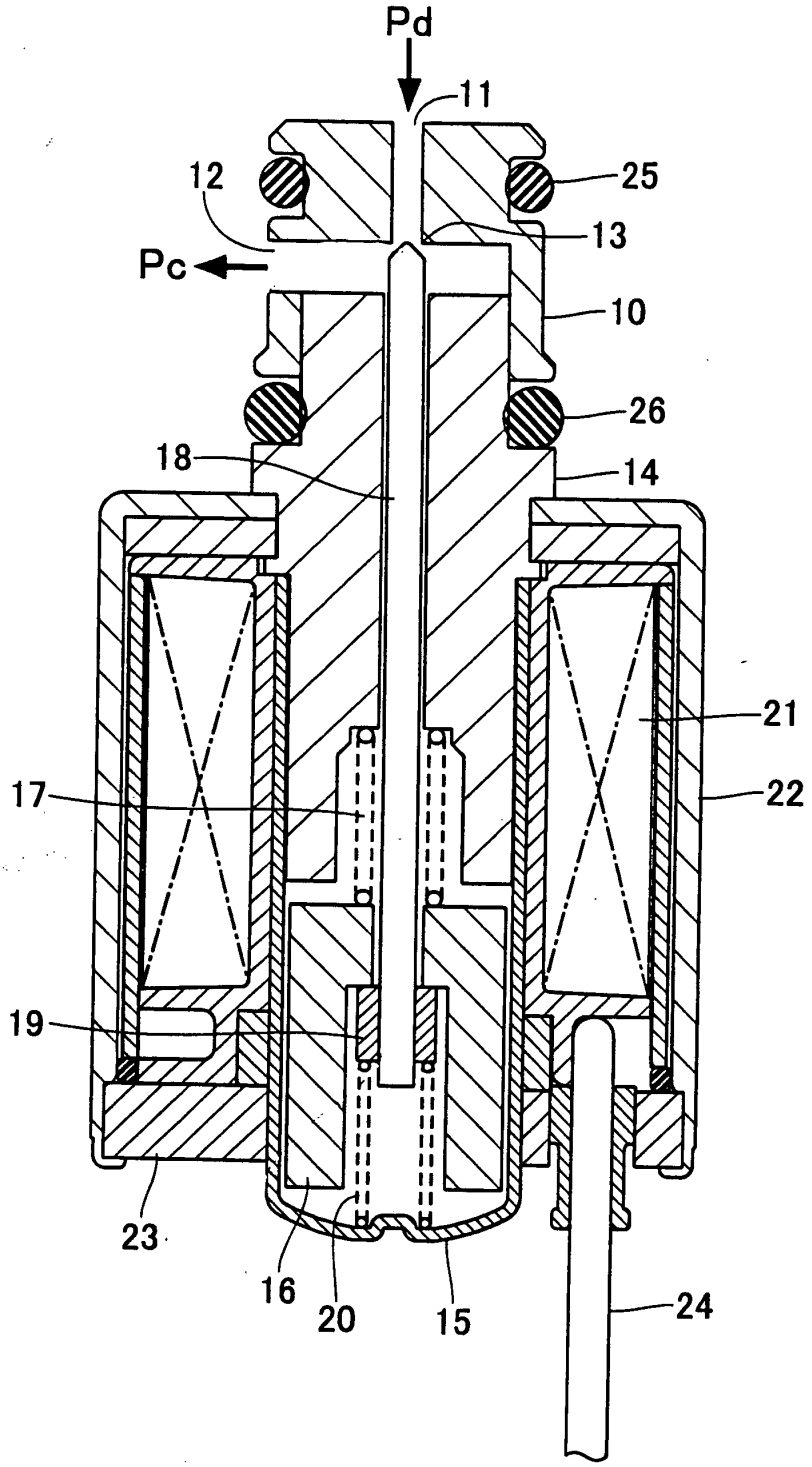

FIG. 1

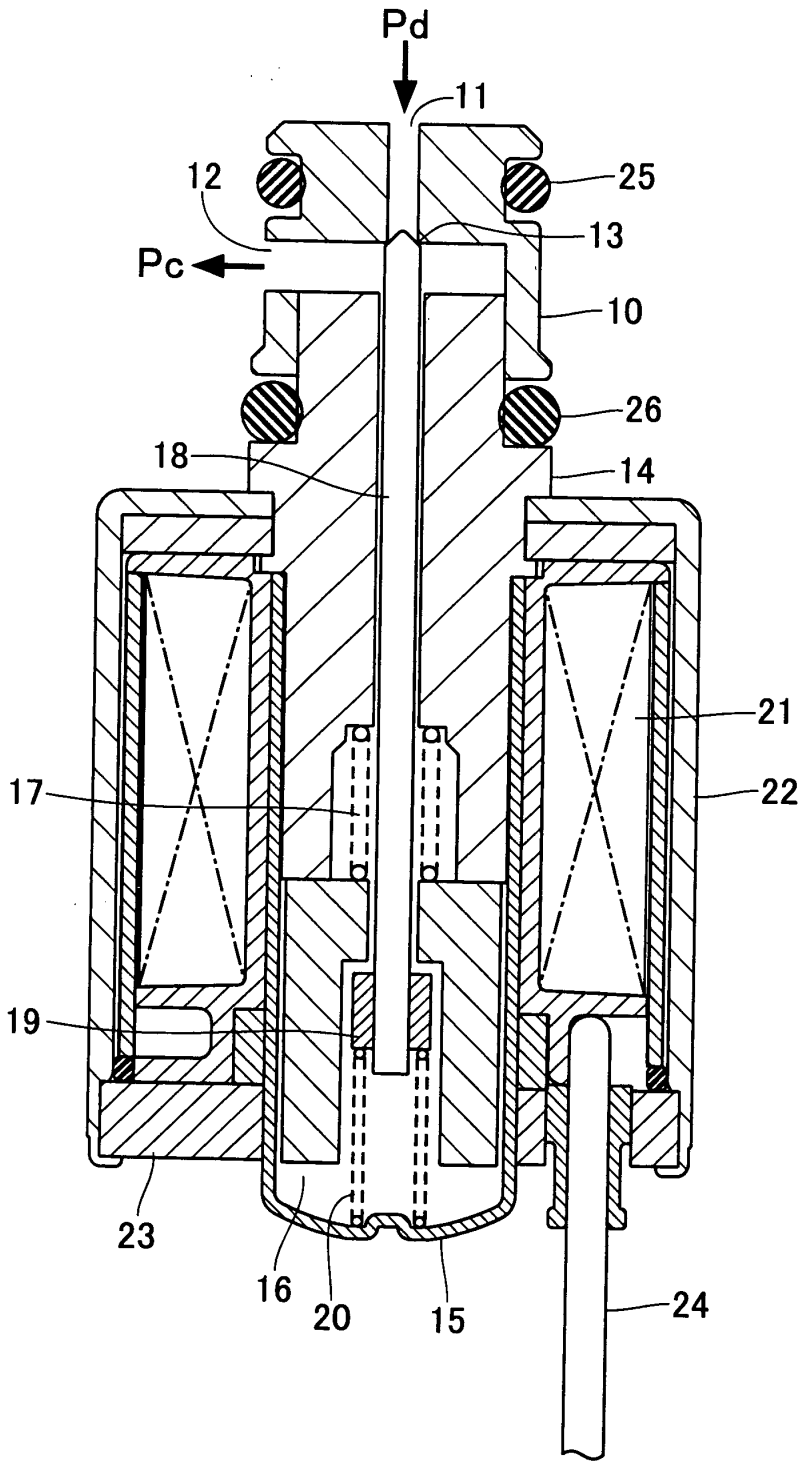

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/022845

A. CLASSIFICATION OF SUBJECT MATTER
F04B27/14(2006.01), ***F04B49/00***(2006.01)

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)
F04B27/14, F04B49/00

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 1996-2006
Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

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 A	JP 2000-120912 A (Kabushiki Kaisha Fuji Koki), 28 April, 2000 (28.04.00), Full text; all drawings (Family: none)	1 2-3
X A	JP 2001-82325 A (Kabushiki Kaisha Zekuseruvareokuraimeto Kontororu), 27 March, 2001 (27.03.01), Full text; Fig. 4 (Family: none)	1 2-3

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

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
09 March, 2006 (09.03.06)	20 March, 2006 (20.03.06)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2001132650 A **[0005]**