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(54) COMPRESSION DISPLACEMENT CONTROLLER OF REFRIGERATING CYCLE

(57) In a compression capacity control device for a refrigeration cycle including a variable displacement compressor (10) that compresses refrigerant sucked from a suction chamber (3) communicating with a suction line (1), and discharges the refrigerant into a discharge chamber (4) communicating with a discharge line (2), while varying the delivery quantity of the refrigerant by changing pressure in a pressure-regulating chamber (12) which has the pressure therein controlled by an electromagnetic control valve (20), the electromagnetic control valve (20) arranged between the discharge chamber (4) and the pressure-regulating chamber (12) is held in an open state to place the variable displacement compressor (10) in a state with the minimum delivery quantity within a variable range, when the electromagnetic control valve (20) is in a deenergized state. This makes it possible to dispense with a clutch for inhibiting operation of the compressor, thereby largely reducing the device cost.

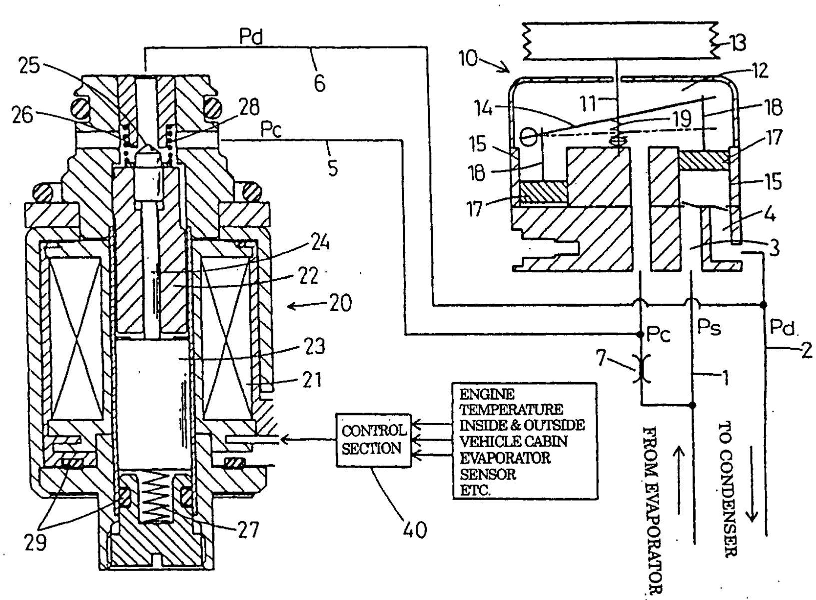

FIG. 1

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Description

Technical Field

[0001] This invention relates to a compression capacity control device for a refrigeration cycle used in an automotive air conditioner or the like.

Background Art

[0002] A compressor used in a refrigeration cycle for an automotive air conditioner is directly connected to an engine by a belt, and hence is not capable of controlling the rotational speed thereof. For this reason, a variable displacement compressor capable of changing the compression capacity (delivery quantity) is employed so as to obtain an adequate refrigerating capability without being constrained by the rotational speed of the engine.

[0003] Such a variable displacement compressor is generally configured such that it compresses a refrigerant sucked from a suction chamber communicating with a suction line, and discharges the refrigerant into a discharge chamber communicating with a discharge line, while varying a delivery quantity of the refrigerant by changing pressure in a pressure-regulating chamber which has the pressure therein controlled by an electromagnetic control valve or the like.

[0004] In the conventional device, a pulley receiving the rotation of the belt directly connected to the engine is provided with an electromagnetic clutch or the like so as to inhibit the compressor from being driven when it is in an operating condition in which compression of the refrigerant is not required. Thus, the trouble of increasing the device cost is taken only for inhibiting operation of the compressor.

Disclosure Of Invention

[0005] It is an object of the invention to provide a compression capacity control device for a refrigeration cycle, which is capable of dispensing with a clutch for inhibiting operation of a compressor, thereby largely reducing the device cost.

[0006] To attain the above object, there is provided a compression capacity control device for a refrigeration cycle including a variable displacement compressor that compresses refrigerant sucked from a suction chamber communicating with a suction line, and discharges the refrigerant into a discharge chamber communicating with a discharge line, while varying a delivery quantity of the refrigerant by changing pressure in a pressure-regulating chamber, the pressure in the pressure-regulating chamber being controlled by an electromagnetic control valve, characterized in that the compression capacity control valve is configured to place the variable displacement compressor in a state with a minimum delivery quantity within a variable range, when the electromagnetic control valve is in a deenergized state.

[0007] Further, the compression capacity control device may be configured such that the electromagnetic control valve opens and closes communication between pressure in the discharge chamber and the pressure-regulating chamber and the discharge chamber such that differential pressure between at least one of pressure in the pressure-regulating chamber and pressure in the suction chamber is held at a predetermined differential pressure, and that an electromagnetic force of the electromagnetic control valve is changed to thereby change the differential pressure to change the pressure in the pressure-regulating chamber, whereby the delivery quantity of the refrigerant is controlled.

[0008] Further, the compression capacity control device may be configured such that urging means is arranged for holding the electromagnetic control valve in an open state when the electromagnetic control valve is in the deenergized state, whereby by controlling the electromagnetic control valve in the open state, the variable displacement compressor is placed in the state with the minimum delivery quantity within the variable range.

[0009] Still further, the compression capacity control device may be configured such that a suction line opening/closing valve is arranged for closing communication between the suction line and the suction chamber when the differential pressure between the pressure in the discharge chamber and the pressure in the suction chamber becomes equal to or smaller than a predetermined value.

[0010] The above and other objects, features and advantages of the present invention will become 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

[0011]

FIG. 1 is a longitudinal sectional view showing the whole arrangement of a compression capacity control device for a refrigeration cycle, according to a first embodiment of the invention;

FIG. 2 is a longitudinal sectional view showing a capacity control electromagnetic valve according to a second embodiment of the invention; and

FIG. 3 is a longitudinal sectional view showing the whole arrangement of a compression capacity control device for a refrigeration cycle, according to a third embodiment of the invention.

Best Mode for Carrying Out the Invention

[0012] The present invention will now be described hereafter with reference to the accompanying drawings.

[0013] In FIG. 1, reference numeral 10 denotes a swash plate variable displacement compressor which is used in a refrigeration cycle for air conditioning of an automotive vehicle. Although R134A or the like is used as refrigerant, the invention may be applied to a refrigeration cycle using carbon dioxide as refrigerant.

[0014] Reference numeral 11 denotes a rotational shaft arranged in a hermetically sealed crankcase 12 (pressure-regulating chamber). The rotational shaft 11 is connected to an axial portion of a pulley 13 which is driven for rotation by a drive belt, not shown, directly connected to an engine. As the rotational shaft 11 rotates, a wobble plate 14 performs wobbling motion which is arranged in the crankcase 12 in a manner inclined with respect to the rotational shaft 11.

[0015] The crankcase 12 has cylinders 15 arranged at a peripheral portion thereof. Each cylinder 15 has a piston 17 arranged therein such that the piston 17 can perform reciprocating motion. The piston 17 and the wobble plate 14 are connected to each other by a rod 18.

[0016] As a result, when the wobble plate 14 performs wobbling motion, each piston 17 is caused to reciprocate within the cylinder 15, whereby a low-pressure (suction pressure Ps) refrigerant is sucked from a suction chamber 3 into the cylinder 15 to be compressed therein. The refrigerant compressed to a high-pressure (discharge pressure Pd) is delivered into a discharge chamber 4.

[0017] The suction chamber 3 has a refrigerant supplied therein from an evaporator, not shown, which is arranged at a location upstream thereof, via a suction line 1. The discharge chamber 4 delivers the high-pressure refrigerant to a condenser, not shown, which is arranged at a location downstream thereof, via a discharge line 2.

[0018] The degree of inclination of the wobble plate 14 is changed according to pressure (crankcase pressure Pc) in the crankcase 12, and the quantity (delivery quantity, i.e. compression capacity) of the refrigerant delivered from the cylinder 15 is changed according to the degree of inclination of the wobble plate 14.

[0019] The delivery quantity is increased when the wobble plate 14 is inclined as indicated by a solid line, whereas when the wobble plate 14 is not inclined as indicated by a two-dot chain line, the delivery quantity is small. The delivery quantity is reduced to zero if the wobble plate 14 becomes perpendicular to the rotational shaft 11.

[0020] However, as the wobble plate 14 is progressively brought into a state in which the degree of inclination thereof is being reduced to zero (state in which the wobble plate 14 is approaching the two-dot chain line), a minimum-securing spring 19 mounted in the manner surrounding the rotational shaft 11 is progressively compressed by the wobble plate 14.

[0021] As a result, a reaction force exerted from the minimum-securing spring 19 to the wobble plate 14 is progressively increased whereby the wobble plate 14 is inhibited from becoming perpendicular to the rotational shaft 11 to prevent the delivery quantity from being smaller than e.g. approximately 3 to 5 % of the maximum delivery quantity.

[0022] The above operating condition in which the delivery quantity is controlled to be minimum is referred to as "the minimum operation". It should be noted that the minimum-securing spring 19 is known in the art and formed e.g. by a combination of a wavy spring and a coil spring.

[0023] Reference numeral 20 denotes a capacity control electromagnetic valve which is controlled by an electromagnetic solenoid (electromagnetic control valve) for carrying out compression capacity control by automatically controlling the crankcase pressure (Pc). Reference numerals 21 and 22 denote an electromagnetic coil and a fixed core, respectively.

[0024] A movable core 23 and a valve element 25 are connected to each other by an axially movable rod 24 that is arranged in a state extending through the fixed core 22, and are urged from opposite ends thereof by respective compression coil springs 27, 28.

[0025] Reference numeral 29 denotes O rings as sealing members. It should be noted that the urging forces of the two compression coil springs 27, 28 are set such that the urging force of the spring 28 for opening the valve is larger than that of the spring 27 for closing the valve.

[0026] A valve seat 26 is formed between a crankcase communication passage 5 for communication with the crankcase 12, and a discharge chamber communication passage 6 for communication with the discharge chamber 4. The valve element 25 is arranged in a manner opposed to the valve seat 26 from the side of the crankcase communication passage 5. The crankcase communication passage 5 and the suction line 1 are communicated with each other via a thin leak passage 7.

[0027] The above construction permits the differential pressure (Pd - Pc) between the discharge pressure (Pd) and the crankcase pressure (Pc) to act on the valve element 25 in the valve-opening direction, and the electromagnetic force (including the urging forces of the compression coil springs 27, 28) of the capacity control electromagnetic valve 20 to act on the valve element 25 in the valve-closing direction.

[0028] Therefore, when the current value of current for energizing the electromagnetic coil 21 is constant and hence the electromagnetic force of the capacity control electromagnetic valve 20 is constant, the valve element 25 is opened and closed in accordance with changes in the differential pressure (Pd - Pc) between the discharge pressure (Pd) and the crankcase pressure (Pc) such that the differential pressure (Pd - Pc) is held constant, whereby the crankcase pressure (Pc) is controlled to have a value corresponding to a value of the discharge pressure (Pd), for holding constant the compression capacity (delivery quantity).

[0029] Then, when the current value of the current for energizing the electromagnetic coil 21 is changed to change the electromagnetic force of the capacity control electromagnetic valve 20, the differential pressure (Pd - Pc) to be held constant is varied in a manner corresponding to the change, whereby the compression capacity (delivery quantity) is held constant at a level different from that of the above compression capacity (delivery quantity).

[0030] More specifically, when the electromagnetic force of the capacity control electromagnetic valve 20 is reduced, the differential pressure (Pd - Pc) to be held constant is reduced, so that the crankcase pressure (Pc) is increased to become closer to the discharge pressure (Pd), and the wobble plate 14 becomes closer to a position where it is perpendicular to the rotational shaft 11, resulting in a reduced delivery quantity of refrigerant.

[0031] Inversely, when the electromagnetic force of the capacity control electromagnetic valve 20 is increased, the differential pressure (Pd - Pc) to be held constant is increased, so that the crankcase pressure (Pc) is decreased to be increasingly different from the discharge pressure (Pd), whereby the degree of inclination of the wobble plate 14 toward the rotational shaft 11 is increased, which results in an increased delivery quantity of refrigerant.

[0032] It should be noted that to control the current value of the current for energizing the electromagnetic coil 21, signals from a plurality of sensors for detecting various conditions, such as conditions of an engine, temperatures inside and outside the vehicle cabin, and an evaporator sensor, are input to a control section 40 incorporating a CPU, etc., and a control signal based on results of computations thereof is delivered from the control section 40 to the electromagnetic coil 21. The drive circuit of the electromagnetic coil 21 is omitted from illustration.

[0033] If energization of the electromagnetic coil 21 is stopped, the valve element 25 is moved away from the valve seat 26 to open the capacity control electromagnetic valve 20, due to the difference between the urging forces of the two compression coil springs 27, 28 urging the valve element 25 of the capacity control electromagnetic valve 20.

[0034] Then, the differential pressure between the discharge pressure (Pd) and the crankcase pressure (Pc) is reduced to zero (i.e. $Pd - PC \fallingdotseq 0$), so that the wobble plate 14 is about to be perpendicular to the rotational shaft 11. However, before this position, the inclination of the wobble plate 14 is balanced with the reaction force from the minimum-securing spring 19, whereby the compressor 10 is placed in a state maintaining the minimum operation.

[0035] As described above, if energization of the electromagnetic coil 21 of the capacity control electromagnetic valve 20 is stopped, the compressor 10 starts the minimum operation, so that even if it is not necessary to operate the compressor 10, the rotational shaft 11 can continue to be driven for rotation.

[0036] FIG. 2 shows a capacity control electromagnetic valve 20 according to a second embodiment of the invention. Since a compressor 10 is similar to the compressor of the first embodiment, it is omitted from illustration. Further, the leak passage is arranged as appropriate.

[0037] In this embodiment, the valve element 25 has a piston rod 25p integrally formed therewith on a rear side thereof. The piston rod 25p has a pressure-receiving area equal to that of the valve seat 26. The piston rod 25p has a rear surface facing a space which is communicated with a suction chamber communication passage 8, and a side surface facing a space which is communicated with the crankcase communication passage 5. Further, a space on a rear side of the valve seat 26 as viewed from a valve element side is communicated with the discharge chamber communication passage 6.

[0038] As a result, the crankcase pressure (Pc) applied to the piston rod 25p, the valve element 25, and so forth is canceled out, and the valve element 25 is opened and closed by the differential pressure (Pd - Ps) between the discharge pressure (Pd) and the suction pressure (Ps), whereby communication between the crankcase 12 and the discharge chamber 4 is opened and closed for execution of compression capacity control.

[0039] If energization of the electromagnetic coil 21 is stopped, the valve element 25 is moved away from the valve seat 26 to open the capacity control electromagnetic valve 20, by the difference between the urging forces of the two compression coil springs 27, 28, which maintains the minimum operation of the compressor 10.

[0040] As described above, the present invention can be applied to a device in which communication between the crankcase 12 and the discharge chamber 4 is opened and closed such that differential pressure between the pressure (Pd) in the discharge chamber 4 and at least one of the pressure (Pc) in the crankcase 12 and the pressure (Ps) in the suction line 1 is held at a predetermined differential pressure, and the electromagnetic force of the capacity control electromagnetic valve 20 is changed to thereby change the above differential pressure to change the pressure (Pc) in the crankcase 12 whereby the delivery quantity is varied. Further, it is also possible to apply the present invention to a device which is controlled by a method other than the above.

[0041] FIG. 3 shows a third embodiment of the invention. In this embodiment, the device having the same construction as the device according to the first embodiment further includes a suction line opening/closing valve 30 for closing communication between the suction line 1 and the suction chamber 3 when the differential pressure between the pressure in the discharge chamber 4 and the pressure in the suction chamber 3 becomes equal to or lower than a predetermined value.

[0042] In this embodiment, a valve element 32 is arranged in a manner opposed to a valve seat 31 which is formed between the suction line 1 and the suction chamber 3, from the suction line side. The valve element 32 is urged by a compression coil spring 33 in the valve-closing direction. Reference numeral 34 denotes a spring receiver having a large cut-away portion formed such that it does not obstruct passing of the refrigerant.

[0043] A pressure-receiving piston 35, which receives the pressure (Pd) from the discharge chamber 4 and the pressure (Ps) in the suction chamber 3 from a front side and a rear side thereof, respectively, is connected to the valve element 32. When then differential pressure (Pd - Ps) between the pressure (Pd) in the discharge chamber 4 and the pressure (Ps) in the suction chamber 3 is larger than a predetermined value, the valve element 32 is away from the valve seat 31 to open the suction line opening/closing valve 30, whereas when the compressor 10 starts the minimum operation and the differential pressure (Pd - Ps) becomes smaller than the predetermined value, the valve element 32 is pressed against the valve seat 31 to close the suction line opening/closing valve 30.

[0044] The above construction makes it possible to prevent fins of the evaporator from collecting ice during the minimum operation under a low operating load e.g. in winter, since a low-pressure refrigerant in the suction line 1 is not sucked into the compressor 10.

[0045] According to the present invention, the variable displacement compressor maintains the minimum delivery quantity within a variable range when the electromagnetic control valve is not energized. This makes it possible to dispense with a clutch for inhibiting operation of the compressor, thereby largely reducing the device cost.

[0046] 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.

Claims

1. A compression capacity control device for a refrigeration cycle including a variable displacement compressor that compresses refrigerant sucked from a suction chamber communicating with a suction line, and discharges the refrigerant into a discharge chamber communicating with a discharge line, while varying a delivery quantity of the refrigerant by changing pressure in a pressure-regulating chamber, the pressure in the pressure-regulating chamber being controlled by an electromagnetic control valve,

   wherein the compression capacity control device is configured to place the variable displacement compressor in a state with a minimum delivery quantity within a variable range, when the electromagnetic control valve is in a deenergized state.

2. The compression capacity control device according to claim 1, wherein the electromagnetic control valve opens and closes communication between the pressure-regulating chamber and the discharge chamber such that differential pressure between pressure in the discharge chamber and at least one of pressure in the pressure-regulating chamber and pressure in the suction chamber is held at a predetermined differential pressure, and wherein an electromagnetic force of the electromagnetic control valve is changed to thereby change the differential pressure to change the pressure in the pressure-regulating chamber, whereby the delivery quantity of the refrigerant is controlled.

3. The compression capacity control device according to claim 1 or 2, wherein urging means is arranged for holding the electromagnetic control valve in an open state when the electromagnetic control valve is in the deenergized state, whereby by holding the electromagnetic control valve in the open state, the variable displacement compressor is placed in the state with the minimum delivery quantity within the variable range.

4. The compression capacity control device according to claims 1, 2, or 3, wherein a suction line opening/closing valve is arranged for closing communication between the suction line and the suction chamber when the differential pressure between the pressure in the discharge chamber and the pressure in the suction chamber becomes equal to or smaller than a predetermined value.

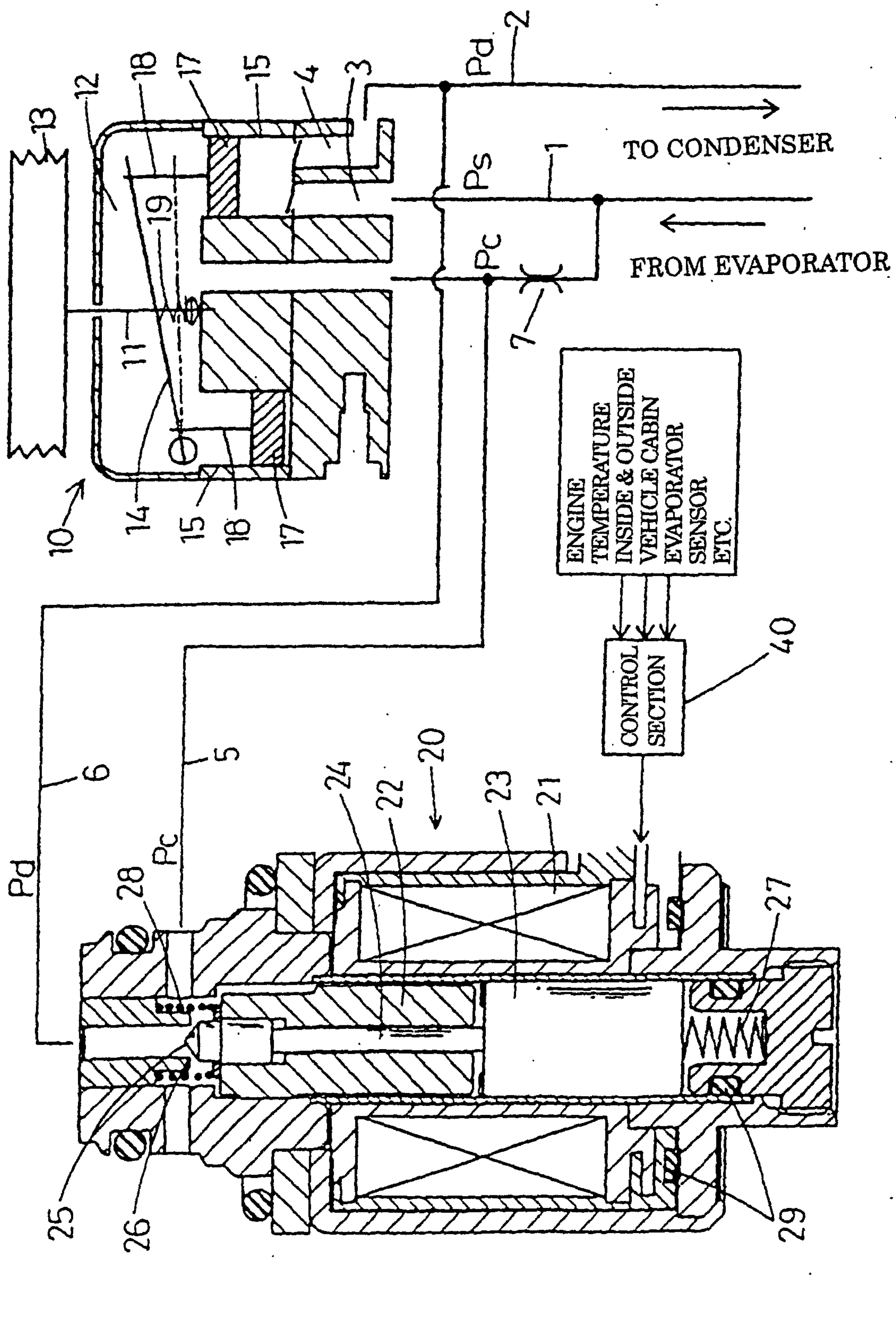
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FIG. 1

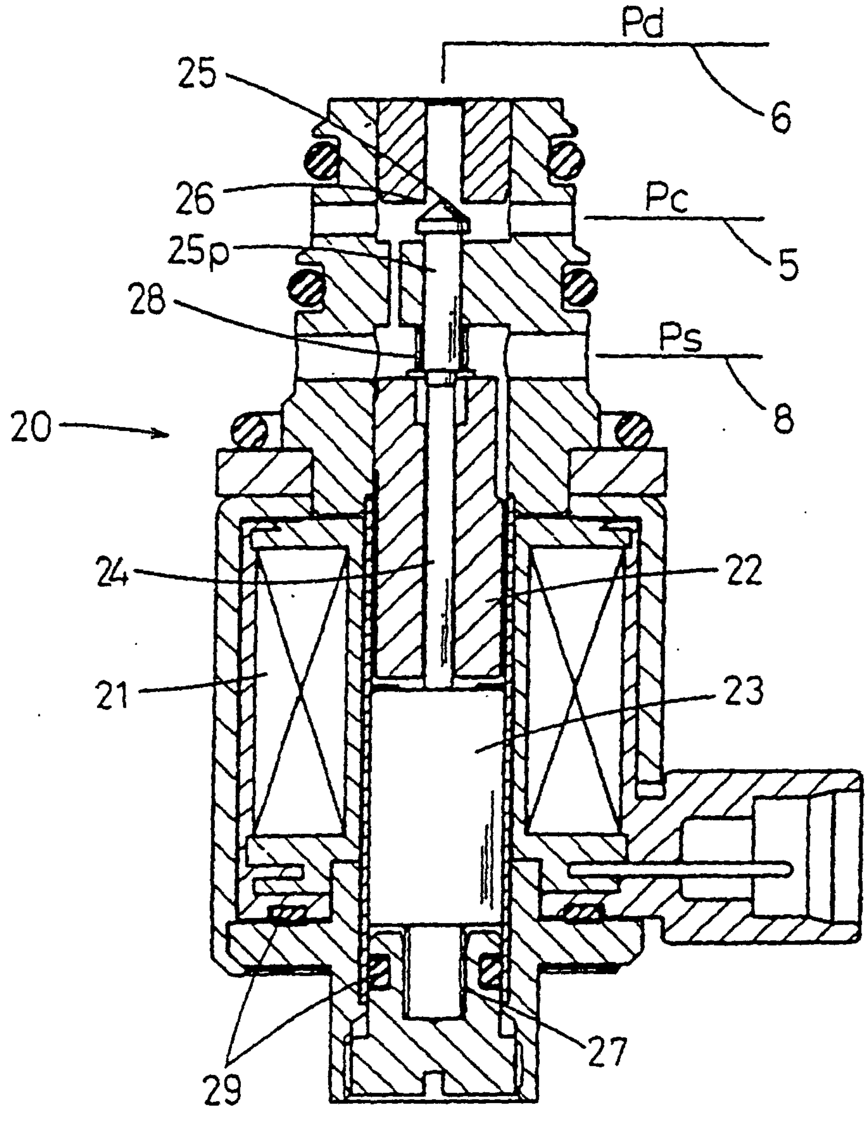

FIG. 2

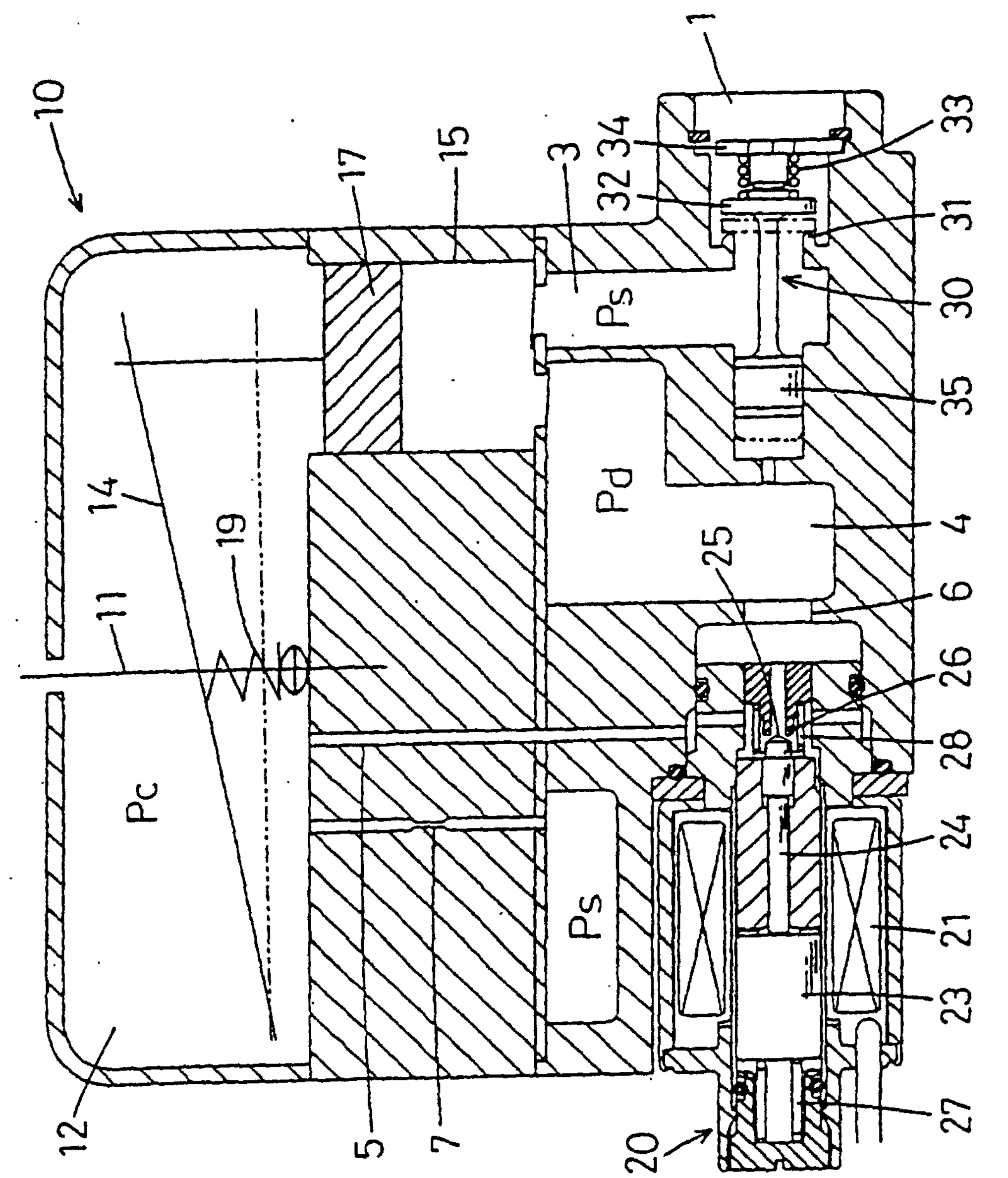
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FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/00364

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F04B27/08, 49/00, 49/06

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] F04B27/00-27/08, 49/00-49/10

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

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

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 Y	EP, 953765, A2 (k.k. Toyoda Jidoshokki Seisakusyo), 03 November, 1999 (03.11.99), Full text; Figs. 1 to 24 & JP 2000-2180 A & BR 9901613 A	1-3 4
X Y	JP, 7-189899, A (Toyoda Automatic Loom Works, Ltd.), 28 July, 1995 (28.07.95), Full text; Figs. 1 to 7 (Family: none)	1-3 4
Y	EP, 881387, A2 (Zexel Corp.), 02 December, 1988 (02.12.88), Full text; Figs. 1 to 5 & JP 10-325393 A & WO 99/052429 A1 & US 6045337 A1 & EP 1071367 A	4
Y	JP, 2000-161209, A (Calsonic Corp.), 13 June, 2000 (13.06.00), Full text; Figs. 1 to 3 (Family: none)	4

[X] 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
15 March, 2002 (15.03.02)	26 March, 2002 (26.03.02)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/00364

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, 10-153178, A (Toyoda Automatic Loom Works, Ltd.), 09 June, 1998 (09.06.98), Full text; Figs. 1 to 6 (Family: none)	1-4
A	JP, 7-189895, A (Toyoda Automatic Loom Works, Ltd.), 28 July, 1995 (28.07.95), Full text; Figs. 1 to 7 & DE 4446832 A1 & US 5584670 A1 & US 5603610 A1 & US 5681150 A1 & US 5713725 A1 & KR 9705980 A1	1-4

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