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(71) Applicant: **Kabushiki Kaisha Saginomiya Seisakusho**
Tokyo 165-0033 (JP)

(72) Inventor: **IKEDA, T.**
Kabushiki Kaisha Saginomiya Seisakusho
Sayama-shi Saitama 350-1327 (JP)

(74) Representative: **Weise, Reinhard, Dipl.-Ing.**
Reinhard-Skuhra-Weise & Partner
Patentanwälte
Postfach 44 01 51
80750 München (DE)

(54) **CONTROL VALVE FOR VARIABLE DISPLACEMENT COMPRESSOR**

(57) A control valve for a variable capacity compressor is provided, in which there is provided a valve element 15 driven by an action of a bellows device 22 arranged in a bellows receiving chamber 17 into which suction pressure Ps of the variable capacity compressor is introduced, generated load of an electromagnetic coil device 30 responds to generated load of the bellows device 22, setting pressure of the bellows device 22 is variably set in response to the generated load of the electromagnetic coil device 30, and pressure in a crankcase of the variable capacity compressor is controlled in response to opening of the valve element 15, thereby controlling capacity of the variable capacity compressor, the control valve being characterized in that a plunger chamber 53 of the electromagnetic coil device 30 communicates with the bellows receiving chamber 17 by an equalizing hole 49 and the suction pressure Ps is introduced into the plunger chamber 53.

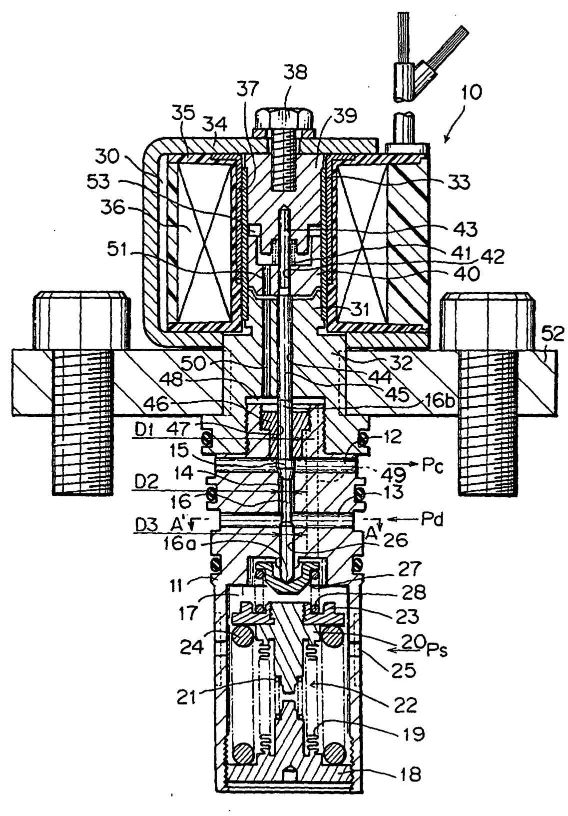

FIG. 1

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Description

[TECHNICAL FIELD]

[0001] The present invention relates to a control valve for a variable capacity compressor and, more specifically, to a capacity control valve for a swash plate-type variable capacity compressor, which is used in an on-vehicle air conditioner and so forth.

[BACKGROUND ART]

[0002] As shown in Japanese Patent Applications Laid-Open No. H10-205444 and No. H10-318414, a control valve for a variable capacity compressor has been known as a swash plate-type variable capacity compressor, in which there is provided a valve element driven by an action of a pressure sensitive element such as bellows, generated load of an electromagnetic coil device responds to that of the pressure sensitive element, the setting pressure of the pressure sensitive element is variably set in response to the generated load of the electromagnetic coil device, and pressure in a crankcase of the variable capacity compressor is controlled in response to the opening of the valve element, thereby controlling the capacity of the variable capacity compressor.

[0003] In the conventional control valve for a variable capacity compressor as described above, since a plunger chamber of an electromagnetic coil device having a plunger therein communicates with a delivery side or a crankcase of the variable capacity compressor and delivery pressure or pressure in a crankcase is introduced into the plunger chamber, therefore a plunger tube which forms the plunger chamber must have burst pressure strength resistant to the delivery pressure.

[0004] Consequently, in a supercritical vapor compression-type refrigerating cycle device in which a refrigerant such as CO_2 is used, the delivery pressure rises as high as 20 Mpa, resulting in that the burst pressure strength for the plunger tube must be 30 Mpa or higher, therefore a thick-walled plunger tube resistant to the high pressure becomes necessary, causing a high cost of plunger tube material. Further, when the plunger tube becomes thick-walled, a gap between an electromagnetic coil disposed outside the plunger tube and the plunger increases, causing a reduction in magnetic force which effectively affects the plunger and thereby causing a necessity of a large-sized electromagnetic coil.

[DISCLOSURE OF INVENTION]

[0005] It is therefore an objective of the present invention to solve the above problem and to provide a control valve for a variable capacity compressor, in which there is no need to make a plunger tube thick-walled not depending upon the rise in delivery pressure, there is no need to make an electromagnetic coil large, and the pressure balance can be attained.

[0006] In order to attain the above objective, a control valve for a variable capacity compressor of the present invention described in claim 1 is a control valve for a variable capacity compressor, in which there is provided a valve element driven by an action of a pressure sensitive element arranged in a pressure sensitive element chamber into which suction pressure of the variable capacity compressor is introduced, generated load of an electromagnetic coil device responds to generated load of the pressure sensitive element, setting pressure of the pressure sensitive element is variably set in response to the generated load of the electromagnetic coil device, and pressure in a crankcase of the variable capacity compressor is controlled in response to opening of the valve element, thereby controlling capacity of the variable capacity compressor, characterized in that the electromagnetic coil device comprises a plunger chamber having a plunger therein, the plunger chamber communicates with the pressure sensitive element chamber, and the suction pressure is introduced into the plunger chamber.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0007]

Figure 1 is a cross sectional view illustrating a first preferred embodiment of a control valve for a variable capacity compressor of the present invention;
Figure 2 is a cross sectional view taken along A - A line in Fig. 1;
Figure 3 is a graph illustrating a bellows characteristic of the control valve for a variable capacity compressor according to the first preferred embodiment;
Figure 4 is a graph illustrating a set spring characteristic of the control valve for a variable capacity compressor according to the first preferred embodiment;
Figure 5 is a graph illustrating an electromagnetic coil characteristic of the control valve for a variable capacity compressor according to the first preferred embodiment;
Figure 6 is a graph illustrating a valve opening characteristic of the control valve for a variable capacity compressor according to the first preferred embodiment;
Figures 7A, 7B and 7C are a graph illustrating a characteristic of change in Ps set value versus change in Pd of the control valve for a variable capacity compressor according to the first preferred embodiment;
Figure 8 is a cross sectional view illustrating a second preferred embodiment of a control valve for a variable capacity compressor of the present invention; and

Figure 9 is a cross sectional view illustrating a third preferred embodiment of a control valve for a variable capacity compressor of the present invention.

[BEST MODE FOR CARRING OUT THE INVENTION]

(Structure of a control valve for a variable capacity compressor according to a first preferred embodiment of the present invention)

[0008] In the following, the structure of a control valve for a variable capacity compressor according to the first preferred embodiment of the present invention will be explained with reference to Figs. 1 - 7.

[0009] As shown in Fig. 1, the control valve 10 for a variable capacity compressor includes a cylindrical valve housing 11. In the valve housing 11, there are a passage 12 formed at a crankcase-side and a passage 13 formed at a delivery port-side, both of which extend crossing intermediate portion of the valve housing 11 in the direction of diameter of the valve housing 11, and there is formed a valve port 14 which communicates the passage 12 to the passage 13.

[0010] In the valve housing 11, there is provided a valve rod 16 movable up-and-down integrally including a valve element 15, which opens or closes the valve port 14, that is, communicates or shuts the passage 12 to the passage 13 quantitatively controlling the communication between the passage 12 and the passage 13 in response to the movement of the valve rod 16 in the direction of the valve axis (i.e. up-and-down direction).

[0011] A bellows receiving chamber 17 is formed at the lower end of the valve housing 11. In the bellows receiving chamber 17, there is arranged a bellows device 22 having a sealing structure as a pressure sensitive element, which is screwed to the valve housing 11 and includes an adjusting screw member 18 functioning as one end member and an inner stopper of the bellows device 22, a bellows body 19 linked integrally with the adjusting screw member 18 at one end (fixed end) thereof, an opposite end member 20 linked integrally with an opposite end (movable end) of the bellows body 19 functioning as an inner stopper, and an internal compensating spring 21 made of a compression coil spring. A spring retainer 23 is fixed to the end member 20, and a main spring 24 made of a compression coil spring is provided between the spring retainer 23 and the adjusting screw member 18.

[0012] In the valve housing 11, there is provided a suction pressure introducing port 25, from which suction pressure Ps of a swash plate-type variable capacity compressor is introduced into the bellows receiving chamber 17. The interior of the bellows device 22 is a vacuum, therefore the bellows device 22 responds to the suction pressure Ps as absolute pressure. As shown in Fig. 3, stretching quantity (LbA to LbB) and generated load (WbA to WbB) correspond to a working pressure range of the suction pressure Ps of a compressor in a supercritical vapor compression-type refrigerating cycle device.

[0013] An lower end 16a of the valve rod 16 penetrates through a hole 26 formed in the valve housing 11 and protrudes in the bellows receiving chamber 17. The lower end 16a engages with a spring retainer 27. A set spring 28 made of a compression coil spring is provided between the spring retainer 27 and the spring retainer 23 at the bellows device 22-side. The set spring 28 converts a pressure-sensitive action (stretching displacement) to elastic deformation action and transfer it to the valve rod 16. A generated load characteristic of the set spring 28 is shown in Fig. 4, wherein the generated load (WhA to WhB) of the set spring 28 in the variable setting range is as low as about 1/15 of the generated load (WbA to WbB) of the bellows device 22 in the variable setting range.

[0014] An electromagnetic coil device 30 is mounted on the upper end of the valve housing 11. The electromagnetic coil device 30 includes a body 32 fixed to the valve housing 11 having integrally a suction part 31, a plunger tube 33 and an outer box 34 fixed to the body 32, a coil bobbin 35, winding 36 and magnetic guide member 37 fixed to the outer box 34, a plug member 39 fixed to the outer box 34 with a bolt 38 covering the plunger tube 33, a plunger 40 provided in the plunger tube 33 (plunger chamber 53) movable up-and-down, a plunger spring 41 provided between the plug member 39 and the plunger 40, and a guide pin 43 fixed to the plug member 39 slidably fitting into a guide hole 42 formed in the plunger 40 so as to carry out the centering.

[0015] Figure 5 illustrates a generated load characteristic of the plunger 40 and the plunger spring 41, in which the generated load (WcA - WcB) in the control range is approximately in proportion to a coil current.

[0016] The generated load (WcA to WcB) in the control range becomes equal to the generated load (WhA to WhB) of the set spring 28 in the variable setting range and is as low as about 1/15 of the generated load (WbA to WbB) of the bellows device 22 in the variable setting range.

[0017] In the body 32, there is a central hole 44 formed penetratingly, into which a connecting rod 45 fits movably up-and-down connecting the plunger 40 to the valve rod 16.

[0018] The body 32 is screwed to the valve housing 11, into which a valve rod guide member 46 is screwed. The upper end side of the valve rod 16 fits movably up-and-down into a guide hole 47, which is formed in the central portion of the valve rod guide member 46. The upper end 16b of the valve rod 16 protrudes from the valve rod guide member 46 in a space 48 formed between the valve rod guide member 46 and the body 32.

[0019] In the valve housing 11, there is provided an equalizing hole (through hole) 49 which communicates the bellows receiving chamber 17 to the space 48. There are also provided equalizing holes (through holes) 50 and 51 in the body 32 and the plunger 40, respectively.

[0020] A mounting flange 52 for mounting the control valve 10 on a variable capacity compressor engages with the outside of the body 32.

[0021] In the following, the operation of the control valve 10 for a variable capacity compressor as described above will be explained.

[0022] The suction pressure Ps of the compressor is introduced from the suction pressure introducing port 25 into the bellows receiving chamber 17 so as to actuate the bellows device 22, which expands and contracts in response to a pressure difference between the suction pressure Ps of the compressor and an internal pressure (vacuum pressure) of the bellows device 22. The set spring 28 is elastically deformed in relation to the amount Lb of the expansion and contraction of the bellows device 22. As a result thereof, the pressure-sensitive action of the bellows device 22 is converted to the elastic deformation action of the set spring 28, the adjustment of the position of the up-and-down motion (that is, adjustment of valve opening) of the valve rod 16 including the valve element 15 is carried out according the balance between the generated load Wh due to the elastic deformation of the set spring and the genarating load Wc due to the conduction current of the electromagnetic coil device 30, and in response to the valve opening, the delivery pressure Pd of the passage 13 at the delivery port-side is introduced into the passage 12 at the crankcase-side by way of the valve port 14 so as to be introduced into the crankcase of the compressor. Figure 6 is a graph illustrating a valve opening characteristic of the control valve 10 for a variable capacity compressor.

[0023] The suction pressure Ps of the compressor is introduced from the suction pressure introducing port 25 into the bellows receiving chamber 17, introduced into the space 48 by way of the equalizing hole 49, and introduced into the plunger chamber 53 by way of the equalizing holes 50 and 51. As a result thereof, the suction pressure Ps of the compressor is introduced into the plunger chamber 53 and therefore the pressure in the plunger chamber 53 never becomes high due to the delivery pressure Pd.

[0024] Accordingly, even if the delivery pressure becomes high in a supercritical vapor compression-type refrigerating cycle device in which a refrigerant such as CO_2 is used, the plunger tube 33 is not necessary to be thick-walled, a gap between the winding 36 disposed outside the plunger tube 33 and the plunger 40 does not increase, and there is no necessity of enlarging the electromagnetic coil device 30.

[0025] The lower end 16a of the valve rod 16 is located in the bellows receiving chamber 17, the upper end 16b of the valve rod 16 is located in the space 48, and the suction pressure Ps is introduced into the bellows receiving chamber 17 and the space 48, therefore the upper and lower ends of the valve rod 16 are affected by the same suction pressure Ps. If it is set that D1=D2=D3, wherein D1 is the outer diameter of the valve rod 16 for its portion between Ps and Pc, D2 is the outer diameter of the valve rod 16 for its portion between Pc and Pd, and D3 is the outer diameter of the valve rod 16 for its portion between Pd and Ps, and therefore the valve rod is constituted so as not to be affected by another pressure in the axial force direction on an intermediate portion of the valve rod 16, the action forces applied to the valve rod 16 by the pressure are all canceled out and therefore a capacity control valve can be obtained, in which the valve opening characteristic (Ps set value) is not affected by the delivery pressure Pd, as shown in Fig. 7A.

[0026] Instead, if it is set that D2>D1=D3 or D1=D2>D3 for the outer diameter of the valve rod 16, the valve rod 16 receives the delivery pressure Pd as the axial force in the direction of valve-opening on its intermediate portion and therefore the Ps set value can be controllably adjusted to be increased in response to the rise in the delivery pressure Pd as shown in Fig. 7B. On the other hand, if it is set that $D2<D1=D3$ or $D1=D2<D3$ for the outer diameter of the valve rod 16, the valve rod 16 receives the delivery pressure Pd as the axial force in the direction of valve-closing on its intermediate portion and therefore the Ps set value can be controllably adjusted to be decreased in response to the rise in the delivery pressure Pd as shown in Fig. 7C.

[0027] Moreover, since the generated load (WcA to WcB) by the plunger 40 and plunger spring 41 in the control range is as low as about 1/15 of the generated load (WbA to WbB) of the bellows device 22 in the variable setting range, therefore there is no necessity of enlarging the electromagnetic coil device 30 even in a refrigerating cycle using CO_2.

[0028] The valve opening characteristic and the controllable adjustment described above can be optionally set according to the desired control characteristic.

[0029] In the aforementioned description, the generated load of the set spring 28 in the variable setting range is as low as about 1/15 of the generated load of the bellows device 22 in the variable setting range. However, this value can be optionally adjusted by changing the spring constant of the set spring 28 and the generated load by the electromagnetic coil device 30 (i.e., magnitude of the electromagnetic coil device 30) can be optionally adjusted according thereto.

(Structure of a control valve for a variable capacity compressor according to a second preferred embodiment of the present invention)

[0030] In the following, a control valve for a variable capacity compressor according to the second preferred embodiment of the present invention will be explained with reference to Fig. 8.

[0031] Figure 8 is a cross sectional view illustrating the second preferred embodiment of a control valve for a variable capacity compressor of the present invention. In Fig. 8, the same reference numerals are used as those in Fig. 1 if the pertinent element in Fig. 8 is equivalent to or the same as that in Fig. 1.

[0032] In the second preferred embodiment as shown in Fig. 8, the main spring (24) is omitted by increasing the spring constant of the bellows body 19 of the bellows device 22 and that of the internal compensating spring 21, so that the outer diameter of the valve housing 11 becomes slim. In addition, the mounting measure of the control valve 10 on the variable capacity compressor is changed from the fixing with a flange to the fixing with a retaining ring 54.

[0033] Except for those as described above, the control valve 10 in the second preferred embodiment is constructed similarly to that in the first preferred embodiment. Therefore, in the second preferred embodiment shown in Fig. 8, the same function and effect can be attained as those in the first preferred embodiment.

(Structure of a control valve for a variable capacity compressor according to a third preferred embodiment of the present invention)

[0034] In the following, a control valve for a variable capacity compressor according to the third preferred embodiment of the present invention will be explained with reference to Fig. 9.

[0035] Figure 9 is a cross sectional view illustrating the third preferred embodiment of a control valve for a variable capacity compressor of the present invention. In Fig. 9, the same reference numerals are used as those in Fig. 1 if the pertinent element in Fig. 9 is equivalent to or the same as that in Fig. 1.

[0036] In the third preferred embodiment as shown in Fig. 9, the electromagnetic coil device 30 is further made slim in comparison with that in the second preferred embodiment shown in Fig. 8, that is, the control valve 10 for a variable capacity compressor together with the electromagnetic coil device 30 can be embedded in the compressor.

[0037] Except for those as described above, the control valve 10 in the third preferred embodiment is constructed similarly to that in the first preferred embodiment. Therefore, in the third preferred embodiment shown in Fig. 9, the same function and effect can be attained as those in the first preferred embodiment.

[INDUSTRIAL APPLICABILITY]

[0038] As is clearly seen from the first to third preferred embodiments as described above, as for the control valve for a variable capacity compressor of the present invention, since the suction pressure of the compressor is introduced into the plunger chamber and therefore the pressure in the plunger chamber never becomes high due to the delivery pressure Pd, therefore even if the delivery pressure becomes high in a supercritical vapor compression-type refrigerating cycle device in which a refrigerant such as CO_2 is used, the plunger tube is not necessary to be thick-walled, there is no necessity of enlarging the electromagnetic coil device 30, and a compact designing can be possible without raising the cost of materials.

[0039] Further, as for the control valve for a variable capacity compressor of the present invention, since the valve rod is affected by the suction pressure of the variable capacity compressor on both ends of the valve rod and not affected by other pressure in the axial force direction on an intermediate portion of the valve rod, therefore the set value of the suction pressure is never affected by the delivery pressure and the electromagnetic coil device can be made compact due to the decrease in the driving force of the valve.

[0040] Furthermore, as for the control valve for a variable capacity compressor of the present invention, the valve rod is affected by the suction pressure of the variable capacity compressor on both ends of the valve rod, the valve rod receives delivery pressure of the variable capacity compressor on an intermediate portion of the valve rod as an axial force in the direction of valve-opening, and the set value of the suction pressure can be controllably adjusted to be increased in response to the rise in the delivery pressure.

[0041] Furthermore, as for the control valve for a variable capacity compressor of the present invention, the valve rod is affected by the suction pressure of the variable capacity compressor on both ends of the valve rod, the valve rod receives delivery pressure of the variable capacity compressor on an intermediate portion of the valve rod as an axial force in the direction of valve-closing, and the set value of the suction pressure can be controllably adjusted to be decreased in response to the rise in the delivery pressure.

Claims

1. A control valve for a variable capacity compressor, in which there is provided a valve element driven by an action of a pressure sensitive element arranged in a pressure sensitive element chamber into which suction pressure of the variable capacity compressor is introduced, generated load of an electromagnetic coil device responds to generated load of the pressure sensitive element, setting pressure of the pressure sensitive element is variably set in response to the generated load of the electromagnetic coil device, and pressure in a crankcase of the variable capacity compressor is controlled in response to opening of the valve element, thereby controlling capacity of the variable capacity compressor, **characterized in that** the electromagnetic coil device comprises a plunger chamber having a plunger therein, the plunger chamber communicates with the pressure sensitive element chamber, and the suction pressure is introduced into the plunger chamber.

2. The control valve for a variable capacity compressor according to claim 1, wherein there is provided a valve rod formed integrally with the valve element, and the valve rod is affected by the suction pressure of the variable capacity compressor on both ends of the valve rod and not affected by other pressure in the axial force direction on an intermediate portion of the valve rod.

3. The control valve for a variable capacity compressor according to claim 1, wherein there is provided a valve rod formed integrally with the valve element, the valve rod is affected by the suction pressure of the variable capacity compressor on both ends of the valve rod, and the valve rod is provided with a difference in axial diameter thereof so that the valve rod receives delivery pressure of the variable capacity compressor on an intermediate portion of the valve rod as an axial force in the direction of valve-opening.

4. The control valve for a variable capacity compressor according to claim 1, wherein there is provided a valve rod formed integrally with the valve element, the valve rod is affected by the suction pressure of the variable capacity compressor on both ends of the valve rod, and the valve rod is provided with a difference in axial diameter thereof so that the valve rod receives delivery pressure of the variable capacity compressor on an intermediate portion of the valve rod as an axial force in the direction of valve-closing.

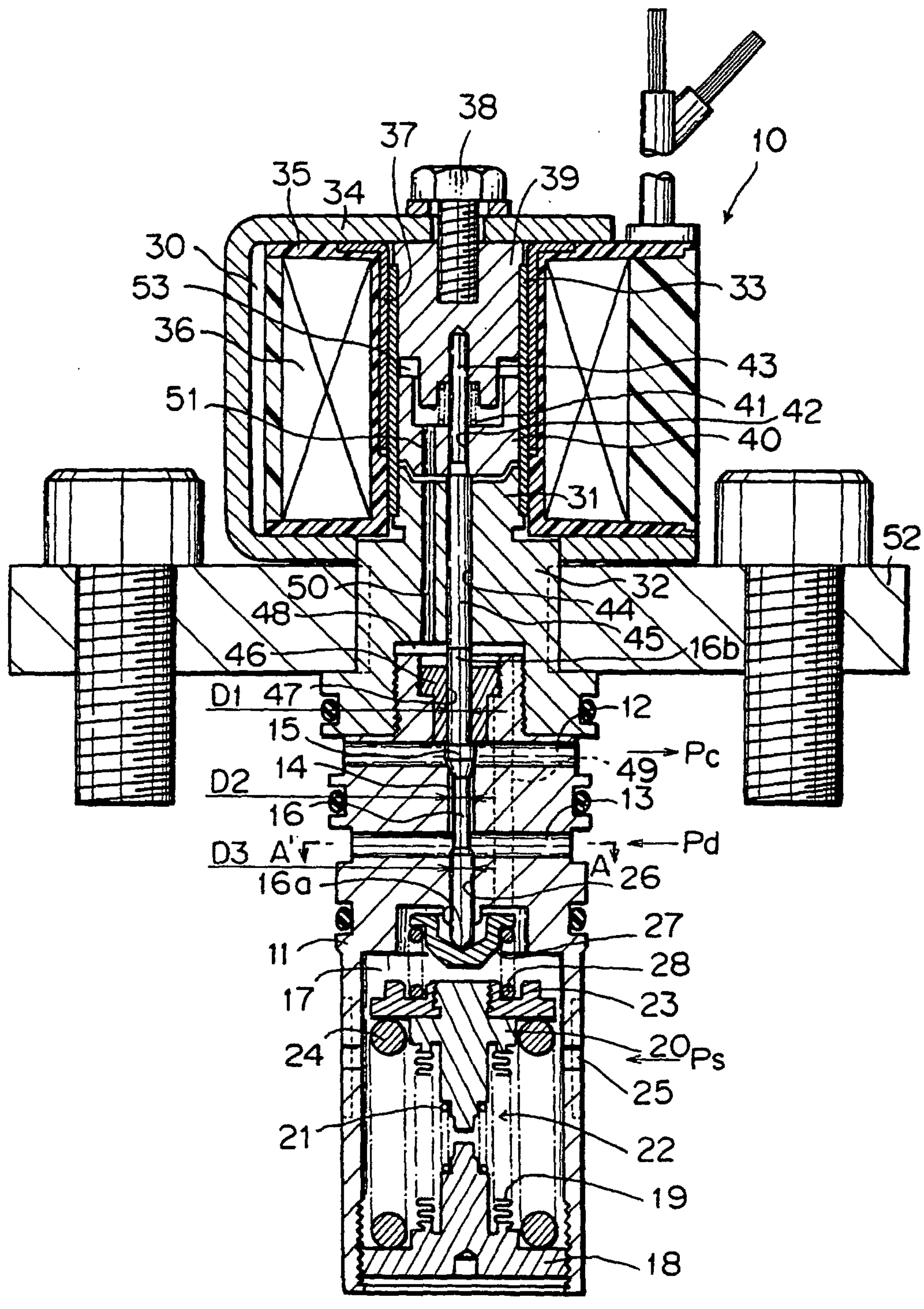
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FIG. 1

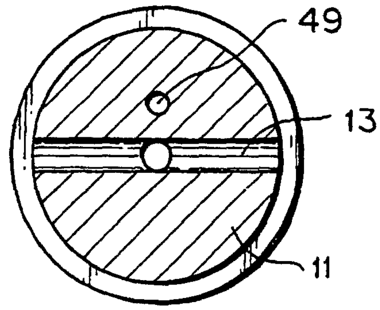


FIG. 2

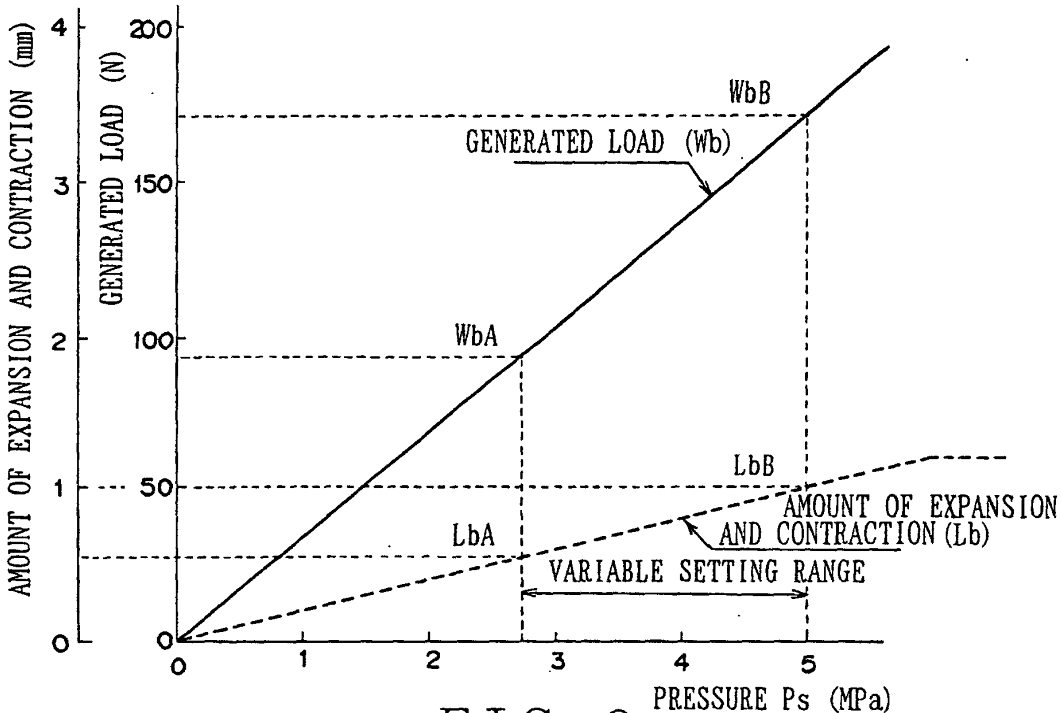


FIG. 3

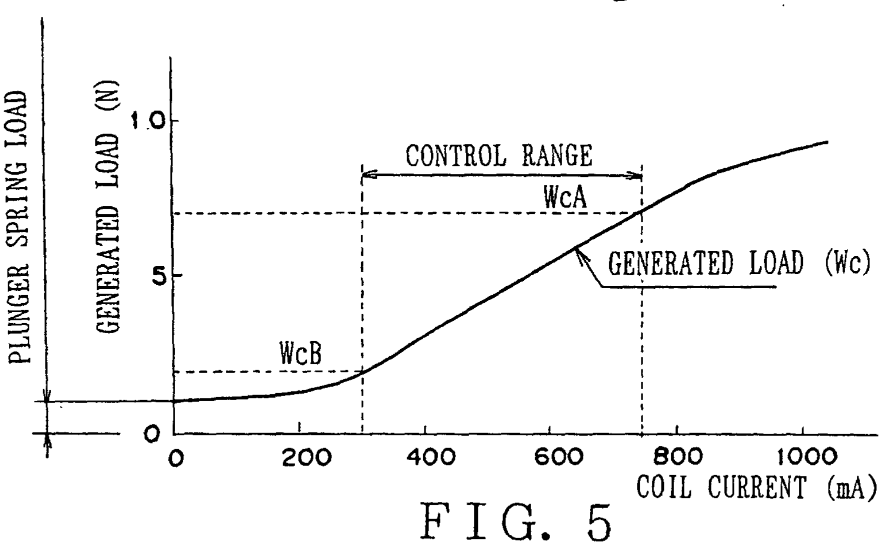
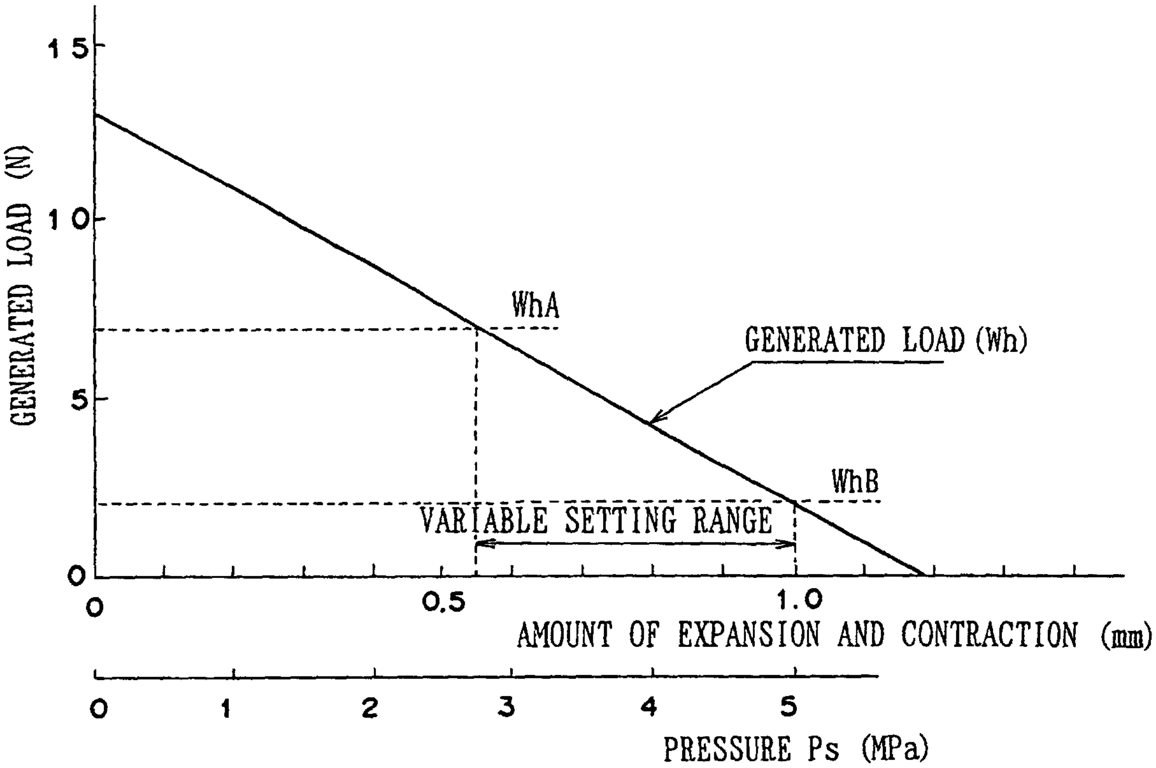


FIG. 5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GENERATED LOAD (N)
WhA
GENERATED LOAD (Wh)
WhB
VARIABLE SETTING RANGE
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AMOUNT OF EXPANSION AND CONTRACTION (mm)
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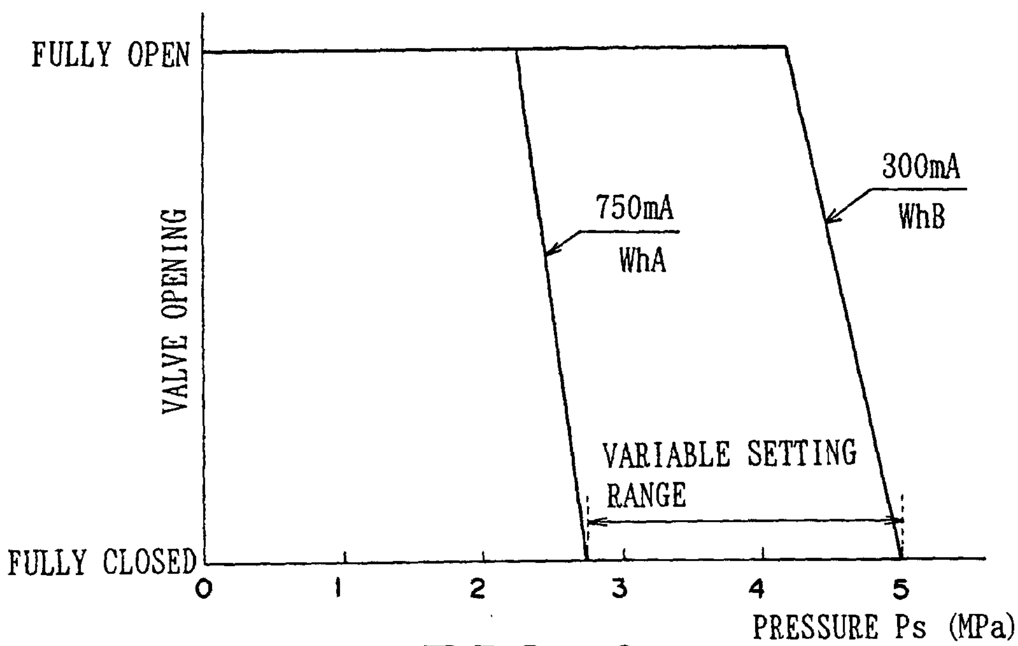
5
PRESSURE Ps (MPa)

FIG. 4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VALVE OPENING
FULLY CLOSED
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PRESSURE Ps (MPa)

FIG. 6

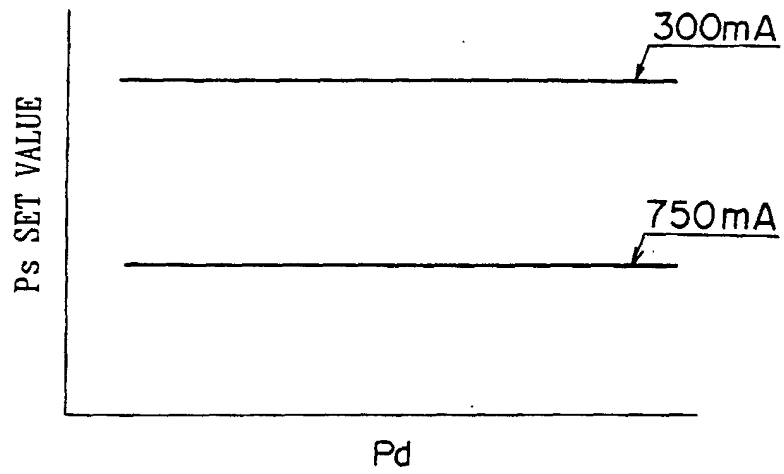

FIG. 7A

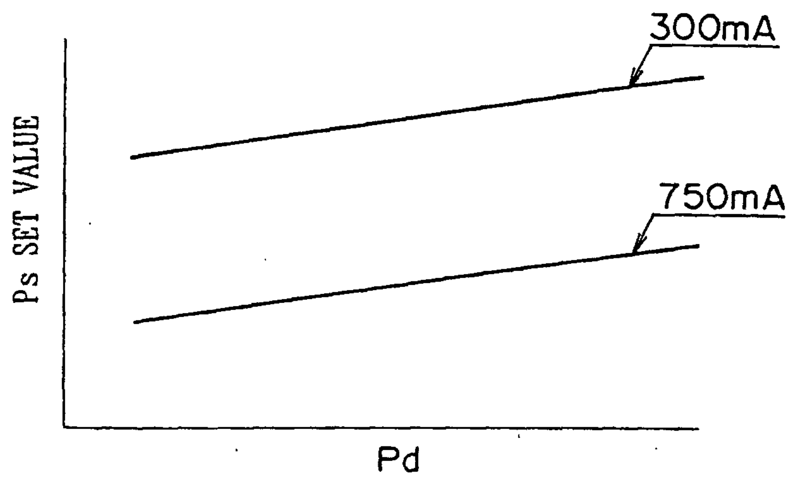

FIG. 7B

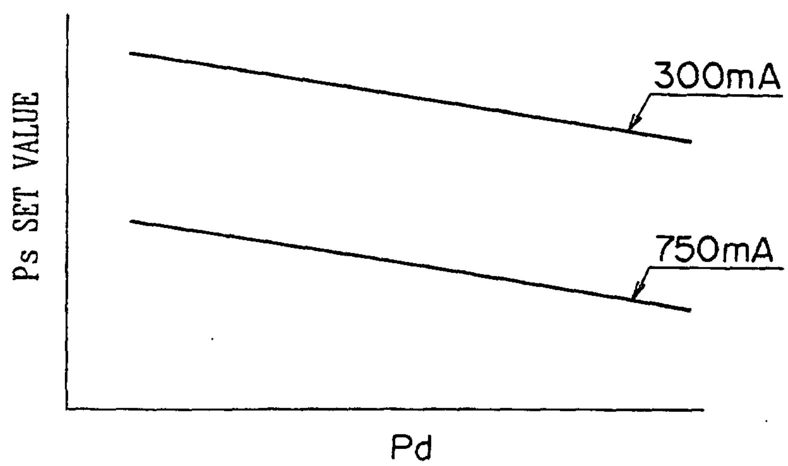

FIG. 7C

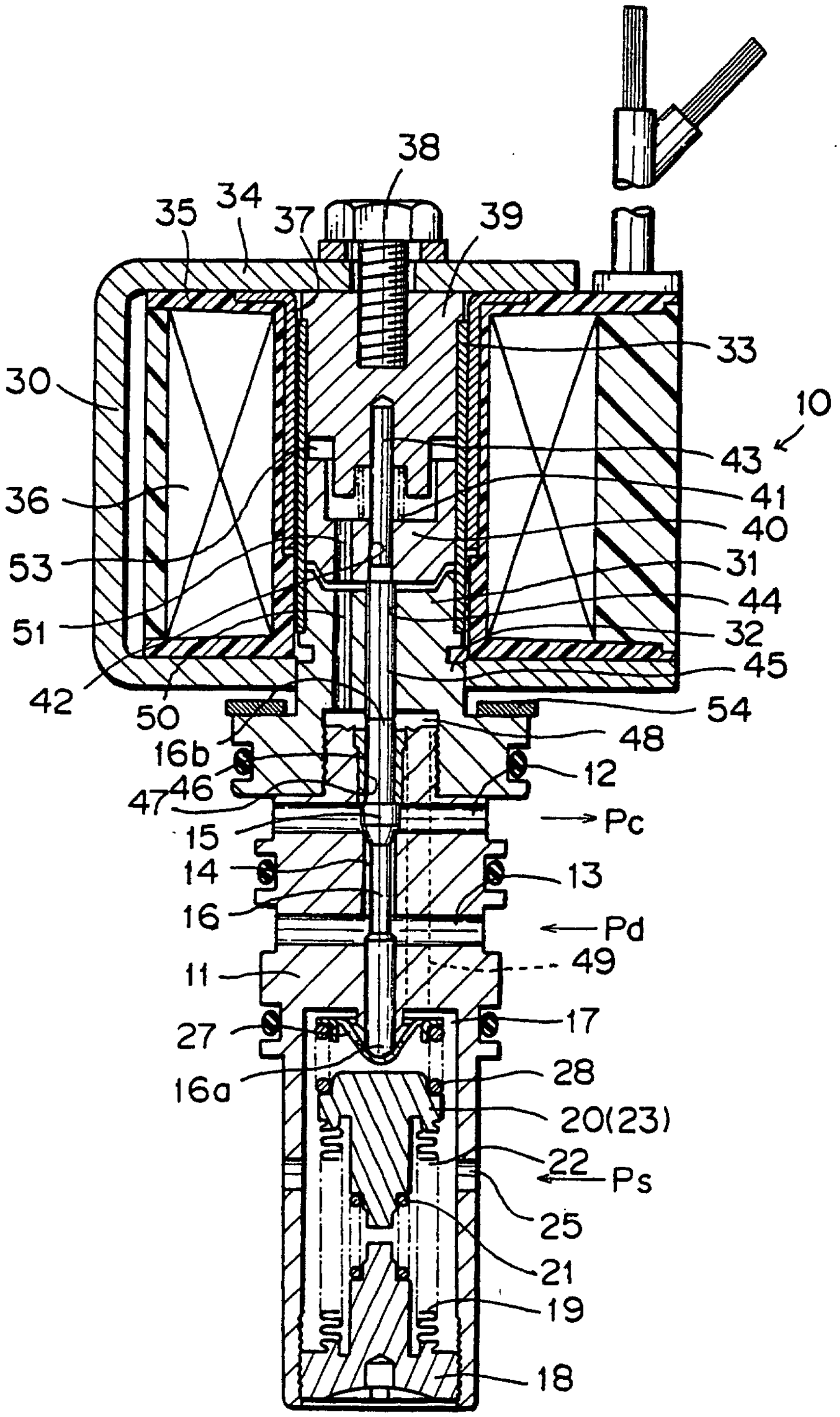
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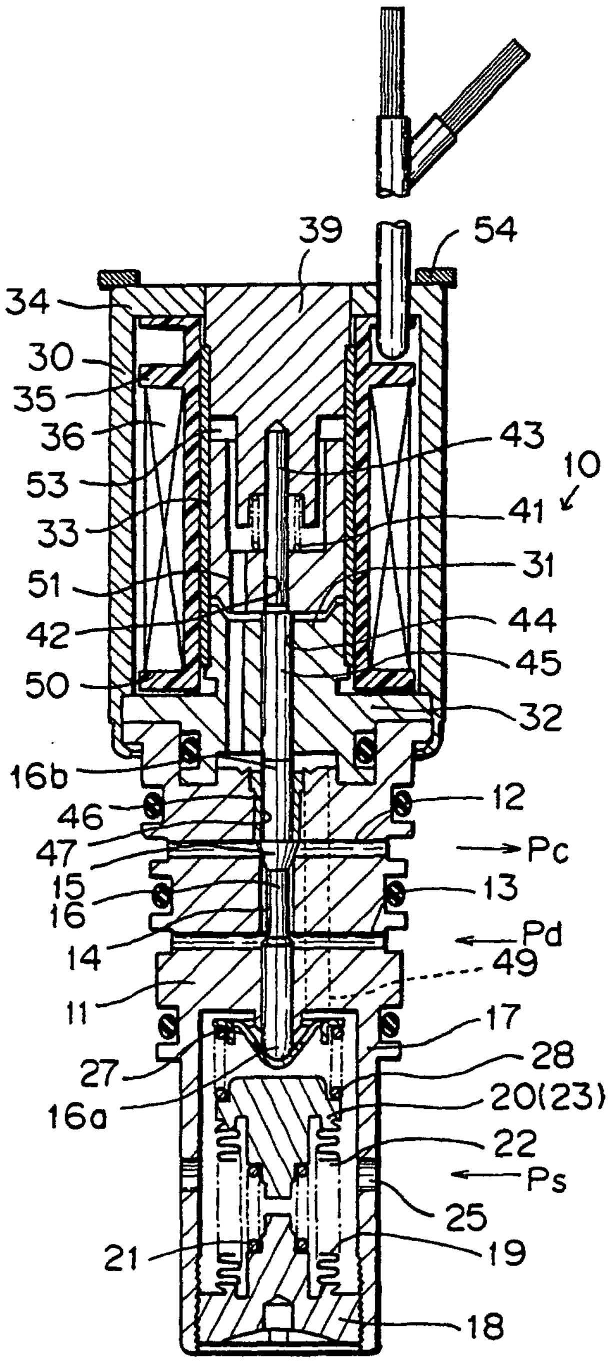
FIG. 8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Pd
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FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/04107

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F04B27/14

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] F04B27/14-27/22

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 1994-2001
Kokai Jitsuyo Shinan Koho 1971-2001 Jitsuyo Shinan Toroku Koho 1996-2001

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 2000-18172 A (Sanden Corporation), 18 January, 2000 (18.01.00), Par. Nos. [0018], [0036] & DE 19931075 A & US 6196808 A	1
A	JP 11-324910 A (Toyoda Automatic Loom Works, Ltd.), 26 November, 1999 (26.11.99), Full text & BR 9902083 A	1-4
A	JP 10-205444 A (Toyoda Automatic Loom Works, Ltd.), 04 August, 1998 (04.08.98), Full text & EP 854288 A & US 6200105 A	1-4
A	JP 2000-18420 A (Toyoda Automatic Loom Works, Ltd.), 18 January, 2000 (18.01.00), Full text & EP 953766 A & US 6062824 A	1-4

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

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of the actual completion of the international search	Date of mailing of the international search report
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